HANDBOOK

For the
Design and Specification of
Hose Assemblies

Version 1.2
August, 2015
Table of Contents

Section 1 – Scope & Use of This Document .................. 1
  1.1 Scope .................................................................... 1
  1.2 Important Notice About This Document ................. 2
  1.3 How to Use This Document .................................. 3
  1.4 Thanks and Recognition ....................................... 3
  1.5 History of Changes ............................................. 4

Section 2 – Application Requirements – STAMPED ....... 1
  2.1 Purpose .............................................................. 1
  2.2 General ............................................................. 1
  2.3 Directions .......................................................... 1
  2.4 Critical and Custom Applications .......................... 6

Section 3 - Hose Assembly General Information .......... 1
  3.1 Scope ................................................................... 1
  3.2 Hose Constructions .............................................. 1
  3.3 Hose Characteristics ........................................... 3
  3.4 Hose Routing ..................................................... 4

Section 4 – Corrugated Metal Hose ............................ 1
  4.1 General .............................................................. 1
  4.2 STAMPED .......................................................... 4
  4.3 Hose Construction ............................................... 7
  4.4 Pressure Rating ................................................... 10
  4.5 Corrugated Metal Hose Assembly Dimensions ........ 12
  4.6 Corrugated Metal Hose Fittings ............................. 17
  4.7 Corrugated Metal Hose Attachments & Common Accessories ........................................ 20
  4.8 Attachment Methods .......................................... 22
  4.9 Testing Procedures for Corrugated Metal Hose ....... 24

Section 5 - Industrial Hose ......................................... 1
  5.1 General .............................................................. 1
  5.2 STAMPED .......................................................... 3
  5.3 Industrial Hose Assembly – Component Selection Chart ........................................ 5
  5.4 Hose Data Sheets ................................................ 7
  5.5 Industrial Hose Fittings ......................................... 23
  5.6 Industrial Hose Attachments ................................. 35
  5.7 Testing Procedures for Industrial Hose .................. 42
  5.8 Custom-Made Hose ............................................. 49
  5.9 Ducting .............................................................. 61

Section 6 - Composite Hose ........................................ 1
  6.1 General .............................................................. 2
  6.2 STAMPED .......................................................... 2
  6.3 Hose Materials and Construction ......................... 5
  6.4 Composite Adapter Fittings ................................ 6
  6.5 Testing Procedures for Composite Hose ................ 7
  6.6 Installation and Usage for Composite Hose ............ 11

Section 7 - Hydraulic Hose ......................................... 1
## Section 8 Fluoropolymer Hose

8.1 General .................................................................................................................. 1
8.2 STAMPED ............................................................................................................... 4
8.3 Measurements for Fluoropolymer Hose Assemblies .............................................. 6
8.4 Coupling Terminal End (Thread) Identification .................................................. 8
8.5 Performance Characteristics .................................................................................. 23
8.6 Hose Assembly Length Determination For Various Movements ......................... 24
8.7 Hose Routing – Fluoropolymer Hose .................................................................. 30
8.8 Assembly Methods ............................................................................................... 33
8.9 Testing Procedures for Fluoropolymer Hose ....................................................... 34

## Section 9 – Testing Procedures

9.1 Purpose .................................................................................................................. 1
9.2 Testing Procedures for Corrugated Metal Hose ................................................... 1
9.3 Testing Procedures for Industrial Hose ................................................................. 5
9.4 Testing Procedures for Composite Hose ............................................................. 12
9.5 Testing Procedures for Hydraulic Hose ............................................................... 16
9.6 Testing Procedures for Fluoropolymer Hose ....................................................... 19
9.7 Calibrations .......................................................................................................... 2
9.8 Test Documentation .............................................................................................. 2
9.9 Other Documentation ........................................................................................... 2

## Section 10 – Quality Plan

10.1 Purpose .................................................................................................................. 1
10.2 Sampling Plan ....................................................................................................... 1
10.3 Material Receiving Inspection ........................................................................... 2
10.4 Hose Assembly Dimensional Inspection (if applicable) .................................... 3
10.5 Storage (Labeling, Environment, Time) ............................................................... 3

## Section 11 – Assembly Identification, Cleaning and Packaging

11.1 Purpose .................................................................................................................. 1
11.2 Hose Assembly Markings .................................................................................... 1
11.3 Cleaning ................................................................................................................ 2
11.4 Packaging ............................................................................................................. 6

## Section 12 – Installation and Handling

12.1 General .................................................................................................................. 1
12.2 Safety & Environmental Considerations ............................................................ 1
12.3 Hose Routing ....................................................................................................... 3
12.4 Hose Installation and Replacement .................................................................... 6
12.5 Maintenance Inspection ...................................................................................... 10

## Section 13 – Definitions

..........................
Section 14 – Appendices .................................................. 1
Appendix A – Pressure Conversion Chart .......................................................... 1
Appendix B – Additional Conversion Charts ...................................................... 11
Appendix C – Hose Materials ........................................................................... 12
Appendix D – Nomographic Flow Chart ............................................................. 18
Appendix E – Coupling Thread Configurations ................................................... 19
Appendix F – Hydraulic Audit List ..................................................................... 23
Appendix G – Relevant ARPM (was RMA) Publications ..................................... 24
Appendix H – References ................................................................................... 25
Appendix I – Industrial Hose, Coupling and Attachment Chart ......................... 27
Section 1 – Scope & Use of This Document

1.1 Scope

The NAHAD Hose Safety Institute Handbook for the Design and Specification of Hose Assemblies is intended to complement existing industry specifications, standards and government regulations. This document is for the voluntary use of industry and end users as an aid in the selection and recognition of suitable hose assemblies, including those using industrial, hydraulic, composite, corrugated metal and fluoropolymer hose.

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

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

There are specific applications that require additional design, engineering, fabrication, testing, installation and maintenance considerations over and above the requirements set forth in these Hose Assembly Guidelines. This includes applications where custom design, engineering, fabrication, testing, installation and maintenance are specified or required. Please see Section 2.4 and Appendix G of this document for further information.

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

NAHAD (including its members, officers, directors, volunteers, staff and those participating in its activities) disclaims liability for any personal injury, property or other damage of any nature whatsoever, directly or indirectly resulting from the publication, use of, or reliance on this document or for compliance with the provisions herein. NAHAD makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

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.
1.3 How to Use This Document

The following are the recommended procedures on how to use the NAHAD Hose Assembly Specification Guidelines:

<table>
<thead>
<tr>
<th>Description</th>
<th>Section Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 This document recognizes that all hose assemblies are made up of at least two to three components: the hose, end connections, and method of attachment. The method of attachment and end connection varies depending on the hose selected. The end user/customer/customer service/sales person should use STAMPED to gather all the required application information to proceed with an assembly selection.</td>
<td>Section 2 STAMPED</td>
</tr>
<tr>
<td>2 For Industrial Hose assemblies, proceed to the Component Selection Chart. Use the chart to select the appropriate hose, end connections and method of attachment recommended. Note: Hose assembly pressure ratings vary by hose, fitting, and attachment combinations, and are always rated at the lesser of the hose, fittings, and attachment method used. *</td>
<td>Section 5 Hose Assembly Component Selection Chart</td>
</tr>
<tr>
<td>3 More detailed information on hose, couplings, attachments, etc. for all hose groups can be found in Sections 4-8, Hose Assembly Components and Data Sheets.</td>
<td>Sections 4-8 Hose Assembly Components and Data Sheets</td>
</tr>
<tr>
<td>4 Once the assembly is selected, additional information on fabrication processes can be found in the NAHAD Hose Assembly Fabrication Guides, which include recommended assembly procedures, limitations, and warnings. The rest of this document includes related information on assembly testing, quality plan, shipping &amp; handling, safety issues, etc.</td>
<td>Sections 9 - 12 Assembly testing, quality plan, shipping, handling, labeling, etc.</td>
</tr>
</tbody>
</table>

* The ARPM requires that hose working pressures include a design factor commensurate with their intended application. Most hoses are required to meet a 4:1 design ratio, except the following: Water hose rated under 150 PSI requires a 3:1 design ratio; Steam hose requires a 10:1 design ratio; and hose conveying gas in a liquid state requires a 5:1 design ratio, or otherwise controlled by other industrial standards. (For example: a 150 PSI-rated air hose has a 4:1 design ratio and must be successfully burst 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.)

1.4 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 to Section 7 Hydraulic Hose; many portions of their Connector and Conductor Study Manual (rev. 4/1/11) were used by permission in whole, or in part. We also wish to acknowledge and thank the Association for Rubber Products Manufacturers (ARPM) for content used or referenced in this document.
1.5 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** 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 this document, the **Hose Safety Institute Handbook**.

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.

2015
Updates and reconciliation between the Handbook and the five Fabrication Guides completed; version 1.2 of the Handbook created.
Section 2 – Application Requirements – STAMPED

2.1 Purpose

The purpose of this section is to provide a simple to use guide to assist in determining the correct hose, coupling and attachment method that will satisfy the customer’s needs. Please note that Section 2.4 addresses Critical Applications which may require special attention.

2.2 General

If the governing standard for a hose assembly is unknown, further application detail must be identified. An effective way to identify application factors that need reviewing prior to defining the proper specifications of a hose assembly is to remember the simple acronym STAMPED.

2.3 Directions

Using the form:

1. Inform the customer you will be using an application format called STAMPED.
2. Ask your customer the pertinent questions outlined on the form, in sequence.
3. After completing the form, ask your customer to confirm their answers as you repeat them, in sequence.
4. Provide the completed format to your assembly area or order entry as required.

The following list of special considerations may help to clarify application parameters:

1. Abrasion
2. Additional protections (need for guards or covers)
3. Electrical conductivity
4. Environment
5. Fitting orientation, flange alignment
6. Flammability
7. Flow rate
8. Fluid velocity – for metal hose, very high velocities may require the use of a liner
9. Movement (type, distance, frequency)
10. Ozone
11. Permeation (vapor conveying hose)
12. Routing (tight bend radius); physical space limitations
13. Salt water
14. Static electricity
15. Ultraviolet light
16. Vibration (frequency rate – Hz, amplitude – "G" load)
17. Special marking or branding requirements

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Control Parameters

Information should include:
- Drawing or print if applicable and proper revision of drawing or print.
- Agency standard(s) applicable.
- Test requirements, customer.
- Documentation requirements, customer.
- Special branding requirement and cover color.
- Information of past performance of present hose in place.
- Special cleaning procedure in use.

Contract Parameters

Information should include:
- Quantity
- Delivery schedule
- Cleaning requirements
- Packaging requirements
- Other items per manufacturer guidelines

Length Tolerances (see individual hose group chapters)

(See STAMPED Form on next page)
### Customer Information:

- **Company:** _________________________
- **Fax:** ______________________
- **Contact:** __________________________
- **E-mail:** _______________________
- **Address:** __________________________
- **P.O.#:** _______________________
- **Phone:** ___________________________
- **Terms:** _______________________

### Size

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<tr>
<th>Size</th>
<th>I.D.</th>
<th>O.D.</th>
<th>Overall Length*</th>
<th>Tolerance</th>
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</table>

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<th>Environmental Temperature</th>
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<td>Max</td>
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<tr>
<td></td>
<td>°F/°C</td>
<td>°F/°C</td>
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### Application

<table>
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### Material/Media

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<th>Material Conveyed</th>
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<td>Internal Media</td>
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<tr>
<td>External Environment</td>
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### Pressure

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<th>Max Working Pressure</th>
<th>Spikes</th>
<th>Vacuum</th>
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<tbody>
<tr>
<td>PSI/kPa</td>
<td>PSI/kPa</td>
<td>Inches of Hg/kPa</td>
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### Ends

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<th>End</th>
<th>Style/Material</th>
<th>Size</th>
<th>Threads/Bolts</th>
<th>Hole Alignment</th>
<th>Orientation</th>
<th>Attachment Methods</th>
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<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

### Delivery

- **Quantity Required:** _________________________
- **Date Required:** _________________________
- **Package Type:** _________________________
- **Pick Up Date:** _________________________
- **Ship Via:** _________________________
- **Testing Required:** Y N
- **Type:** _________________________
- **Certification Required:** Y N
- **Type:** _________________________

*see glossary for specific definitions

**Special Requirements:**

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The STAMPED acronym stands for the 7 major information areas required to provide a quality hose assembly for the customer, as follows:

**S** stands for **SIZE**; I.D. and length; any O.D. constraints
- overall length should be specified to include fittings
- tolerances need to be specified if special requirements exist

**I.D., O.D. and overall length of the assembly**
- To determine the replacement hose I.D., read the layline printing on the side of the original hose. If the original hose layline is painted over or worn off, the original hose must be cut and inside diameter measured for size.
- The inside diameter of the hose must be adequate to keep pressure loss to a minimum, maintain adequate flow, and avoid damage to the hose due to heat generation or excessive turbulence. The hose should be sized according to the nomographic chart in appendix D.
- Length tolerances should be considered for all types of hose assemblies. See individual hose sections for specifics.
- **Flow Rate / Fluid Velocity** - The flow rate of the system in conjunction with the inside diameter of the hose will dictate the fluid velocity through the hose. Typical fluid velocities can be seen in the nomographic chart in Appendix D. Please consult your hose supplier for specific recommended velocity ranges. Please note that suction line recommendations are different than pressure lines.

**T** stands for **TEMPERATURE** of the material conveyed and environmental conditions
- Are there factors such as heat sources in the environment in which the hose will be used
- Continuous (average) and minimum and maximum temperatures have to be specified for both the environment and material conveyed
- Note if flame resistance or flammability will be an issue
- Sub-zero exposure
- Care must be taken when routing near hot manifolds and in extreme cases a heat shield may be advisable.
- Other things to consider: maximum intermittent ambient temperature, fluid temperature, ambient temperature and maximum temperature.
- Maximum assembly working pressures will decrease as temperatures increase.

**A** stands for the **APPLICATION**, the conditions of use
- Configuration/routing (add a sketch or drawing if applicable)
  - is the hose hanging, laying horizontally, supported, unsupported (orientation and aspect of the hose)
  - what else is attached to the hose, any external load on the hose
  - bend radius requirements, flexibility
  - elongation considerations with working pressure
- Quantify anticipated movement and geometry of use requirements
- Intermittent or continuous service
- Indoor and outdoor use
- Unusual mechanical loads
- Excessive abrasion
- Electrical conductivity requirements
- Equipment type
- External conditions – abrasion, oil (specify type), solvents (specify type), acid (specify type and concentration), ozone, salt water
- Hose now in use
  - Type of hose
  - Service life being obtained and description of failure or source of customer dissatisfaction
• strength and frequency of impulsing or pressure spikes
• non-flexing applications (static), flexing applications (dynamic)
• vacuum requirements
• Can also refer to Alloy when working with Metal Hose

**M** stands for the **MATERIAL or MEDIA** being conveyed, type and concentration

- Are there special requirements for this hose tube
  - Any special specifications (or agency requirements) that need to be considered (e.g., FDA, API)
  - Will the material be continuously flowing, or sit in the hose for long periods of time (specify)
- Media velocity, flow rate
- Chemical name/concentration (MSDS)
- Solids, description and size
- Fluid Compatibility - Some applications require specialized oils or chemicals to be conveyed through the system. Hose selection must assure compatibility of the hose tube. In addition to the hose materials, all other components, which make up the hose assembly (hose ends, o-rings, etc...), must also be compatible with fluid being used. Depending on the fluid, your hose supplier may lower the maximum temperature or pressure rating of the assembly. When selecting any hose assembly, always consult your hose supplier’s recommendations.
- Can also refer to Motion when working with Metal Hose

**P** stands for the **PRESSURE** to which the assembly will be exposed

- System pressure, including pressure spikes. Hose assembly working pressures must be equal to or greater than the system pressure. Pressure spikes greater than the maximum working pressure will shorten hose life and must be taken into consideration.
- Temperature implications
- Vacuum considerations
- **Maximum Operating Pressure** - This is the maximum pressure that the system should be exposed to in normal operating conditions. For hydraulic hose assemblies, this pressure should be dictated by the relief setting of the system. Both the hose and hose end should not be rated to a pressure less than the maximum operating pressure of the system.
- **Pressure Spikes** - When a hydraulic system is subjected to a large load in a short period of time, the system pressure can overshoot the relief setting and exceed the maximum operating pressure. Frequent pressure spikes can reduce the life of hydraulic hose assemblies. In general, spiral hose constructions are better suited to high impulse applications, which involve flexing and large pressure spikes. However, there are specialized braided hoses available from various manufacturers. Please consult your hose supplier if there are multiple constructions which meet your application needs.
  - Impulsing – exposure of the assembly to changing pressures over time
  - Maximum assembly working pressures will decrease as temperatures increase.

**E** stands for **ENDS**; style, type, orientation, attachment methods, etc.

- Uncoupled or coupled hose; hose with built-in fittings
- Specify end style (see charts and pictures in Section 5)
- Materials and dimensions (steel, stainless, etc.) (Note: potable water applications would require lead-free fittings)
- Conductivity requirements

**D** stands for **DELIVERY**

- Specific to customer requirements
• Testing requirements
  o certification requirements (e.g., Coast Guard)
• any special packaging requirements
• any special shipping requirements
• tagging requirements
• can also refer to Determined Overall Length when working with Metal Hose

2.4 Critical and Custom Applications

There are specific applications that require additional design, fabrication installation and maintenance considerations over and above the requirements set forth in these Hose Assembly Guidelines. This includes applications where custom design, engineering, fabrication, testing, installation and maintenance are specified or required. Please see Appendix G of this document for additional information. The following is a non-inclusive list.

2.4.1 Chlorine
For hose assemblies used to transport chlorine, there are specific requirements set forth in the Chlorine Institute Pamphlet #6 (edition 15), “Piping Systems for Dry Chlorine”, Appendix A, Section 9. Please note that Chlorine transfer hose (CTH) must be clearly and permanently marked as per Chlorine Institute Pamphlet #6 (edition 15), Appendix A, Section 9. These permanent markings (e.g. stamping, stenciling or coding) should be utilized throughout the supply chain for purposes of continuous positive identification.

2.4.2 Anhydrous Ammonia – reference ARPM publication no. IP 11-2, IP-14

2.4.3 Aircraft Fueling – see Energy Institute EI 1529, and EI 1540 part 7

2.4.4 Welding Hose - reference ARPM publication no. IP 11-7, IP 11-5

2.4.5 LP Gas - reference UL 21 and UL 569.

2.4.6 Water Blast Hose and Hydroblast Hose

Water blast hoses are typically designed for very high pressure water applications. Typically used for paint removal, unplugging and cleaning exchanger tubes, off-shore deep water applications, and water blasting. Burst pressures may vary by manufacturer. Applications entail very high internal pressures. Consult manufacturer for safety factors.

2.4.7 Airless Paint Spraying. Available in 1000-10,000 psi. Contact hose manufacturer for more information.

2.4.8 Natural Gas - Natural Gas molecules will permeate through Rubber or PVC hose constructions and create potentially dangerous consequences. Contact hose manufacturer for information.
Section 3 - Hose Assembly General Information

3.1 Scope

The sections pertaining to hose assemblies have been compiled to provide authoritative information on hose, end connections, attachment methods and accessories selection. This information is intended to help those that are responsible for selecting the components.

The user of this document is cautioned that the information contained herein is for general guidance only. The document reflects the most commonly used equipment and procedures to make assemblies. It does not reflect new developments or products developed for specific applications. The user is encouraged to contact a NAHAD Hose Safety Institute Distributor in order to obtain the latest information.

Because there are many combinations of hose, end connections and attachment methods, the user should not assume that all combinations listed in the guide have been tested for acceptability. The information that is provided is based on an environment of +72°F (+22.2°C). The reader is cautioned to contact a NAHAD Hose Safety Institute Distributor when dealing with temperature extremes.

3.2 Hose Constructions

A hose is a reinforced, flexible conduit used to move materials from one point to another or to transmit energy. It is flexible to accommodate motion, alignment, vibration, thermal expansion and contraction, portability, ease of routing, and ease of installation.

Most hoses are made up of three elements: (1) a tube, (2) reinforcement, and (3) an outer cover. Each of these components is usually adhered to the adjacent components by bonding agents or thin layers of specially compounded rubber.

The basic materials in the manufacture of hose are rubber, metal, plastic, fluoropolymer, textile yarn, textile fabric, and metal or plastic wire, helix and cable. These materials are used in their broadest sense, and can consist of all compounds and combinations of the above.

(See Appendix C for a full listing of hose materials.)
Tube

The tube is the innermost element of the hose. For suitable service, the tube must be resistant to the materials it is intended to convey. The characteristics of the material from which the tube is made and the thickness of the tube are based on the service for which the hose is designed.

The basic tube materials are rubber, metal, plastic, and fluoropolymer; these materials are used in their broadest sense, and can consist of all compounds and combinations of the above.

(See Appendix C for a full listing of hose materials.)

Reinforcement

Reinforcement can be textile, plastic, or metal, alone or in combination, which can be built into the body of the hose to withstand internal pressures, external forces, or a combination of both. The type and amount of reinforcing material used depends on the method of manufacture and on the service requirements. For example, a residential garden hose does not need the same level of reinforcement as required for high pressure hydraulic hose used in construction and off-shore applications.

The basic reinforcement materials are braided or spiraled textiles, metal or plastic helix, braided or spiraled wire, and cable. These materials are used in their broadest sense, and can consist of all compounds and combinations of the above.

(See Appendix C for a full listing of hose materials.)

Cover

The cover is the outer element and can be made of various materials; its prime function is to protect the reinforcement from damage and the environment in which the hose will be used. Covers are designed for specific applications and can be made to be resistant to oils, acids, abrasion, flexing, sunlight, ozone, etc.

The basic cover materials are rubber, metal and plastic. The cover of a corrugated metal or fluoropolymer-lined hose, by nature, is a wire-braided reinforcement. Additional accessories can be applied to protect the reinforcing exterior.

(See Appendix C for a full listing of hose materials.)
3.3 Hose Characteristics

3.3.1 Flexibility and Bend Radius

Flexibility and minimum bend radius are important factors in hose design and selection if it is known that the hose will be subjected to sharp curvatures in normal use. When bent at too sharp an angle, hose may kink or flatten in the cross-section. The reinforcement may also be unduly stressed or distorted and the hose life compromised.

The hose should be able to conform to the smallest anticipated bend radius without overstress. The minimum bend radius is generally specified by the manufacturer and is the radius to which the hose can be bent in service without damage or appreciably shortening its life. The radius is measured to the inside of the curvature. If the application entails dynamic bending, the minimum bend radius may need to be larger – consult with the manufacturer.

Textile reinforced hoses have a tendency to kink as the bend radius is reduced. Generally for hose assemblies, a helix wire is used when a hose must withstand severe bends without flattening or kinking.

Some indication of relative hose flexibility can be determined from the manufacturer’s minimum bend radius recommendations. The bend radius does not necessarily reflect the force required to bend the hose to this radius, which is a major factor in flexibility. Different hose constructions may require significantly different forces to attain the same minimum bend radius.

Generally, the preferred hose is the more flexible hose, provided all other properties are essentially equivalent. There are exceptions to this as in sand blast hose where minimizing the bending in service increases hose life.

3.3.2 Suction and Vacuum

Some applications require the hose to resist collapse in suction and vacuum service. Such hose is subjected to crushing forces because the atmospheric pressure outside the hose is greater than the internal pressure. The hose can collapse and restrict the flow unless the hose is constructed to resist these pressure differentials.

The most common method of preventing hose collapse is to build a steel or plastic helical wire reinforcement into the hose body. The size and spacing of the wire reinforcement depends on the size of the hose and the expected pressure differential for the application. In suction applications approaching a full vacuum, most of the carcass plies are applied over the wire reinforcement. The hose is constructed with high adhesion between the tube and the carcass to prevent tube separation. Suction hose must be specifically designed for the service for which it is used. Each element – tube, reinforcement, size, spacing, and location of the helix – must be carefully planned.

While suction hose is generally used to convey liquids, vacuum hose carries air under a partial vacuum. Vacuum hose is reinforced to resist collapse and maintain its shape under rough handling and/or mechanical abuse. It does not require the heavy construction of suction hose because the dry materials generally conveyed are much lighter in weight than liquids and the vacuum is usually less than for normal suction service. (See ducting section for additional detail.)

3.3.3 Electrical Characteristics of Hose

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**Conductive Hose**

Static wires and conductive rubber components are used in hose to help prevent static electricity build-up and subsequent discharge as a spark. Electrical engineers differ in opinion on the effects of static electricity and the means of dissipating it.

In handling gasoline and other petroleum-based liquids, recognized national associations and companies have conflicting opinions on the need for conductive hoses.

Until a consensus is reached among all associations, laboratories, and users and a standard practice is established, it is essential that the user determine the need for static bonded hose based on: (a) the intended use of the hose; (b) instructions from the company’s Safety Division; (c) the insurer; and, (d) the laws of the States in which the hose will be used.

Some types of hose include a body reinforcing wire. This wire can be used for electrical continuity provided that proper contact is made between it and the hose coupling. This can be done by extending the body wire to the ends of the hose, or by attaching a light static wire to the outermost coils of the body wire. This lighter wire is led through the ends of the hose and attached to the couplings. In non-wire reinforced hose, a static wire can be included in the hose body.

The tendency has been toward a grounding connection completely separate from the hose or to have the tube or cover of the hose conducting. Examples would be sand blast hose with conducting tube or aircraft fueling hose with a conducting cover. An internal static wire could break or lose contact with the couplings and not be detected visually. This could occur from an unusual stress imposed on the hose.

**Non-Conductive Hose**

In some specific applications, especially around high voltage electrical lines, it is imperative for safety that the hose be non-conductive. Unless the hose is designed particularly to be non-conductive and is so branded, one cannot conclude that it is non-conductive. Non-conductive hose is usually made to a qualifying standard that requires it to be tested to verify the desired electrical properties. The hose is usually non-black in color and clearly branded to indicate it is designed for non-conductive applications.

**WARNING:** unless a hose is described specifically and clearly branded to be conducting or non-conducting, it must be assumed that the electrical properties are uncontrolled.

**3.4 Hose Routing**

When planning the hose routing use the following practices for optimum performance and more consistent and predictable service life.

Routing at less than minimum bend radius, will reduce the service life of the hose and/or cause premature hose failure. Use the static or dynamic minimum bend radius according to service conditions. Sharp bends at the hose to fitting juncture should be avoided.

Hose assemblies subject to movement while operating should be installed in such a way that flexing occurs in the same plane.

Hose assemblies shall not be installed or operated in a twisted or torqued condition. Swivel fittings or a lay line may be used to aid in torque-free installation. Also flanged hose assemblies should ideally have one end secured with a floating flange.

Flange to flange bolt hole alignment is critical for proper installation.
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Section 4 – Corrugated Metal Hose

Section Contents:
  4.1 General Information
  4.2 STAMPED
  4.3 Hose Construction
  4.4 Pressure Rating
  4.5 Corrugated Metal Hose Assembly Dimensions
  4.6 Corrugated Metal Hose Fittings
  4.7 Corrugated Metal Hose Attachments & Common Accessories
  4.8 Attachment Methods
  4.9 Testing

4.1 General

Old Rule of thumb: Use a metal hose when no other hose type will do.

This was the rule in the past. Today, we consider additional information before making the final decision on the proper hose to use:

If there is interest in improving safety, increasing performance and/or reducing potential for catastrophic failure, consider metal hose. Metal hose is used for extreme temperature service, from Hot Tar & Asphalt to cryogenic service in the transfer of liquid nitrogen or oxygen, when cleaned properly. If permeation is a concern (i.e. Chlorine transfer), metal hose does not allow gas to penetrate the hose wall thereby eliminating any problems. If compatibility is a concern (i.e. hydrochloric acid or other aggressive chemicals), having a large selection of metals available is the right solution so that appropriate materials can be selected for each application. Safety is always a major concern; metal hose usually shows a sign of failure through small holes or cracks, giving warning to remove the hose before a catastrophic event happens. Metal hose should also be considered if adaptability is a concern. Since ends are welded, no special hose nipple has to be created to fit in a hose. Properly designed, a metal hose can reduce vibration and/or noise in a piping system making it more efficient with a longer working life. Additionally, this makes for a quieter work environment for personnel, reducing the chance of hearing loss. Metal hose can be adapted to just about any application today with a variety of styles covering flexibility, pressure, media, and temperature and end fittings. Metal hose just may be your best solution.
The standard flexible tube starts its life as a coil of stainless steel strip which is mechanically formed into a tube and then longitudinally butt welded. Considerable care is taken to ensure that the strength of the butt weld is greater than that of the parent material. This rigid tube is then transferred to the corrugating machine where the corrugations are formed. Although the tube is generally produced with a standard corrugation pitch, it can be varied to suit the flexibility required. The tube can be left with an “open pitch” which is ideal for “stay put” applications, especially if the tube is annealed.

Compressing the tube to give it a “close pitch” will increase the flexibility. After the tube has been corrugated, it is pressure tested to ensure that there are no leaks.

A plain corrugated hose will try to elongate when pressurized above a certain level. This is due to the internal pressure thrust which is equal to the cross sectional area multiplied by the pressure. To restrain this, the hose is fitted with an external wire braiding which can be either a single or double layer according to the working conditions. The braid design is carefully calculated to ensure that the number of wires, the wire gauge, and the angle of lay give optimum performance. Fitting the braid to the corrugated tube also increases the hoop strength, stabilizes movement, and offers a form of protection.

Each hose is designed to have a maximum working pressure which is generally less than a quarter of the burst pressure. After the attachment of the end fittings, the hose is pressure tested to 1 ½ times the working or design pressure and test certificates can be supplied if required. It is not advisable to pressurize any hose above 1 ½ times the maximum working pressure otherwise the corrugations can become deformed and reduce the hose life.

Advantages of flexible metal hose:
1. High physical strength
2. Suitable for elevated temperatures (up to 1400° F)
3. Fire resistant
4. Good corrosion characteristics
5. Long life (when installed correctly)
6. Resistance to penetration and damage

Flexible metal hoses are used for the following modes of movement:
- **Static installations**: when the flexible hose is used to connect pipe-work out of alignment and remain in a static position
- **Occasional flexing**: when the hose is only required to flex occasionally, such as manual handling
- **Constant flexing**: when the hose is required to flex continuously, usually on moving machinery
- **Vibration**: high frequency, low amplitude movement, i.e., on a compressor.

*Markets using metal hose:*

Flexible metal hoses are used on a wide range of applications such as nuclear, steam, lubrication, fuel oil, exhaust and cryogenics. However, the list is endless; what is critical is that all the details of the application and installation must be seriously considered before the type of hose is selected. The main areas of concern are pressure, temperature, media, flexing requirements, and the environment.

Typical Markets: Power Generation; Refining and Petrochemical; Marine; OEM; Oil & Gas; Rental and Construction; Primary Metal to name a few.

The rest of this section pertains to nominal diameters from 1/4 inch (DN6) to 12 inches (DN300), except where limited by section.

Metal hose is made from several different materials, depending on application. When selecting the
material, proper consideration must be given to corrosion resistance, service temperature and material strength. Components typically found in a metal hose assembly include the following; Table 4.1 lists some common materials used for each of these components.

A. Corrugated Flexible Hose  
B. One or more layers of Wire Braid  
C. Braid Sleeves  
D. Fitting(s)  
E. Optional: Flexible Guard and/or Liner

<table>
<thead>
<tr>
<th>Component (see above)</th>
<th>Material Type</th>
<th>Description</th>
<th>UNS(1)</th>
<th>Specifications</th>
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<tr>
<td>A</td>
<td>1008 AKDQ</td>
<td>Low Carbon Steel</td>
<td>G10080</td>
<td>ASTM A620(2)</td>
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<td>SAE1010(3)</td>
<td>Carbon Steel</td>
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<td>ASTM A240/A478</td>
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<td>ASTM A240/A269</td>
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<td>A,B,C,D</td>
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<td>Nickel Copper Alloy</td>
<td>NO4400</td>
<td>ASTM B127/B164</td>
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<tr>
<td>A,B,C,D</td>
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<td>Nickel Alloy</td>
<td>NO6600</td>
<td>ASTM B168/B167</td>
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<td>Nickel Alloy</td>
<td>NO6625</td>
<td>ASTM B443/B443</td>
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<td>Nickel Alloy</td>
<td>N10276</td>
<td>ASTM B575/B619/B622</td>
</tr>
<tr>
<td>A,B,C,D</td>
<td>C22</td>
<td>Nickel Alloy</td>
<td>NO4400</td>
<td>ASTM B575/B619/B622</td>
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<tr>
<td>A,B</td>
<td>CA510</td>
<td>Bronze, Phosphor</td>
<td>C51000</td>
<td>ASTM B100/B103/B139</td>
</tr>
</tbody>
</table>

(1) Unified Numbering System  
(2) American Society for Testing Materials  
(3) Society of Automotive Engineers  
(4) Deutsches Institut fur Normung
4.2 STAMPED

As previously noted, the STAMPED acronym stands for the 7 major information areas required to provide a quality hose assembly for the customer, as follows:

S stands for SIZE; I.D. and length; any O.D. constraints
- overall length should be specified to include fittings
- tolerances need to be specified if special requirements exist

I.D., O.D. and overall length of the assembly
- To determine the replacement hose I.D., read the layline printing on the side of the original hose. If the original hose layline is painted over or worn off, the original hose must be cut and inside diameter measured for size.
- The inside diameter of the hose must be adequate to keep pressure loss to a minimum, maintain adequate flow, and avoid damage to the hose due to heat generation or excessive turbulence. The hose should be sized according to the nomographic chart in appendix D.
- Length Tolerances - the OAL of an assembly shall be as requested by the customer with acceptable tolerances as agreed between the customer and provider. Unless otherwise specified, the tolerances shall be as defined in the following Table.

<table>
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<th>Overall Length of Assembly</th>
<th>0” thru &lt;8”</th>
<th>8” thru &lt;18”</th>
<th>18” thru &lt;3’</th>
<th>3’ thru &lt;6’</th>
<th>6’ thru &lt;12’</th>
<th>≥12’</th>
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</thead>
<tbody>
<tr>
<td>Hose I.D.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1”</td>
<td>+/- 1/4”</td>
<td>+/- 5/16”</td>
<td>+/- 3/8”</td>
<td>+/- 1/2”</td>
<td>+/- 1”</td>
<td>+/- 1%</td>
</tr>
<tr>
<td>1” thru &lt;4”</td>
<td>+/- 3/8”</td>
<td>+/- 1/2”</td>
<td>+/- 5/8”</td>
<td>+/- 3/4”</td>
<td>+/- 1 1/4”</td>
<td>+/- 1.5%</td>
</tr>
<tr>
<td>4” thru 12”</td>
<td>+3%</td>
<td>+3%</td>
<td>+3%</td>
<td>+3%</td>
<td>+3%</td>
<td>+3%</td>
</tr>
</tbody>
</table>

- Flow Rate / Fluid Velocity - The flow rate of the system in conjunction with the inside diameter of the hose will dictate the fluid velocity through the hose. Typical fluid velocities can be seen in the nomographic chart in Appendix D. Please consult your hose supplier for specific recommended velocity ranges. Please note that suction line recommendations are different than pressure lines.

T stands for TEMPERATURE of the material conveyed and environmental conditions
- Are there factors such as heat sources in the environment in which the hose will be used
- Continuous (average) and minimum and maximum temperatures have to be specified for both the environment and material conveyed
- Note if flame resistance or flammability will be an issue
- Sub-zero exposure
- Care must be taken when routing near hot manifolds and in extreme cases a heat shield may be advisable.
- Other things to consider: maximum intermittent ambient temperature, fluid temperature, ambient temperature and maximum temperature.

A stands for the APPLICATION, the conditions of use
- Configuration/routing (add a sketch or drawing if applicable)
  - is the hose hanging, laying horizontally, supported, unsupported (orientation and aspect of the hose)
  - what else is attached to the hose, any external load on the hose
  - bend radius requirements, flexibility
  - elongation considerations with working pressure
• Quantify anticipated movement and geometry of use requirements
• Intermittent or continuous service
• Indoor and outdoor use
• Unusual mechanical loads
• Excessive abrasion
• Electrical conductivity requirements
• Equipment type
• External conditions – abrasion, oil (specify type), solvents (specify type), acid (specify type and concentration), ozone, salt water
• Hose now in use
  o Type of hose
  o Service life being obtained and description of failure or source of customer dissatisfaction
• Strength and frequency of impulsing or pressure spikes
• Non-flexing applications (static), flexing applications (dynamic)
• Vacuum requirements
• Also refers to Alloy when working with Metal Hose

M stands for the MATERIAL or MEDIA being conveyed, type and concentration, and MOTION
• Are there special requirements for this hose tube
  o Any special specifications (or agency requirements) that need to be considered (e.g., FDA, API)
  o Will the material be continuously flowing, or sit in the hose for long periods of time (specify)
• Media velocity, flow rate
• Chemical name/concentration (MSDS)
• Solids, description and size
• Fluid Compatibility - Some applications require specialized oils or chemicals to be conveyed through the system. Hose selection must assure compatibility of the hose tube. In addition to the hose materials, all other components, which make up the hose assembly (hose ends, o-rings, etc...), must also be compatible with fluid being used. Depending on the fluid, your hose supplier may lower the maximum temperature or pressure rating of the assembly. When selecting any hose assembly, always consult your hose supplier’s recommendations.
• Motion; types of motion likely to be associated with the hose assembly

P stands for the PRESSURE to which the assembly will be exposed
• System pressure, including pressure spikes. Hose assembly working pressures must be equal to or greater than the system pressure. Pressure spikes greater than the maximum working pressure will shorten hose life and must be taken into consideration.
• Temperature implications
• Vacuum considerations
• Maximum Operating Pressure - This is the maximum pressure that the system should be exposed to in normal operating conditions. For hydraulic hose assemblies, this pressure should be dictated by the relief setting of the system. Both the hose and hose end should not be rated to a pressure less than the maximum operating pressure of the system.
• Pressure Spikes - When a hydraulic system is subjected to a large load in a short period of time, the system pressure can overshoot the relief setting and exceed the maximum operating pressure. Frequent pressure spikes can reduce the life of hydraulic hose assemblies. In general, spiral hose constructions are better suited to high impulse applications, which involve flexing and large pressure spikes. However, there are specialized braided hoses available from various manufacturers. Please consult your hose supplier if there are multiple constructions which meet your application needs.

E stands for ENDS: style, type, orientation, attachment methods, etc.
• Uncoupled or coupled hose
• Specify end style (see charts and pictures in Section 5)
• Materials and dimensions (steel, stainless, etc.)
• Conductivity requirements

D stands for DELIVERY
• Specific to customer requirements
• Testing requirements
  o certification requirements (e.g., Coast Guard)
• any special packaging requirements
• any special shipping requirements
• tagging requirements
• Also refers to Determined Overall Length when working with Metal Hose
4.3 Hose Construction

Types of Hose Construction

Corrugated hose shall be manufactured from seamless or welded tube, or from preformed and welded steel strip. Seams may be butt welded or lap welded, in either a straight or spiral seam configuration. Corrugations may be annular or helical and shall be of uniform pitch and profile throughout the hose length.

Heat Treatment

The customer shall specify if heat treatment of the metal hose is required. All production testing shall be performed after heat treatment.

Joining or Splicing Unbraided Hose

Corrugated hose may be spliced using either of the two methods illustrated in Figures 6A (Butt Weld Splice) or 6B (Edge Weld Splice).

![Figure 6A](image)

Butt Weld Splice

![Figure 6B](image)

Edge Weld Splice

Traverse joining of strip or circumferential joining of tube prior to forming the corrugations is not permitted.

Braid

Braid is a sleeve of woven wires that covers the exterior of the corrugated hose. Braid not only enhances the ability of the corrugated hose to withstand pressure, it also provides protection against abrasion and contamination.

Multiple Braided Hose

Multiple layers of braid are frequently used to enhance the strength and coverage of a hose assembly beyond the strength and coverage of a single layer of braid. The hose manufacturer must be consulted when rating the performance of a corrugated hose with multiple layers of braid.

Corrosion Resistance

When designing a metal hose assembly for service in a potentially corrosive application, both the media conveyed and the external environment must be considered. The assembly wetted surfaces, those internal surfaces which come into contact with the media, include the hose and fittings. A corrosive external environment would typically require adequate resistance from all of the assembly components, including the braid. For each specific application, the designer must determine:

- All of the potential corrosives which may contact the assembly
- The concentration of each corrosive
- The temperature of the media and environment
The concentration of a corrosive can have a dramatic effect on the expected corrosion rate of a metal hose assembly component. A substance which exhibits a very high corrosion rate at 50% might have a negligible rate at 20%. Conversely, some common substances may be very aggressive at 90% but have the corrosion rate drop off significantly at 98%. Temperature also plays a major factor in accelerating or inhibiting corrosion rates. Generally, the higher the temperature the more aggressive is any corrosive action. See Table 4.1 at the beginning of this section for a listing of common materials.

The relative corrosion resistance of most alloys to specific potential corrosives can be determined by referencing one of the many available corrosion resistance reference publications including:

- Corrosion Data Survey (National Association of Corrosion Engineers, www.nace.org)

In addition, many alloy manufacturers and educational institutes have corrosion resistance tables and guides on the web.

Corrosion rates are typically referenced as mils/year (thousandths of an inch of the alloy thickness that would be expected to corrode in one year). The thickness of the hose, fittings and other potentially affected assembly components must be compared with the expected corrosion rates listed in the guides. As a rule of thumb, refer to the Chart A for a guide of acceptable corrosion rates. For critical applications, the corrosion rates for the assembly components must be accurately determined and an acceptable service life and safety factor calculated.

<table>
<thead>
<tr>
<th>Assembly Component</th>
<th>Corrosion Rate (mils/yr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hose</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Braid</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Fittings</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>

Example: An assembly is conveying a 20% sodium sulfate solution at 120°F. There are no external corrosion concerns. T321, T304 and T316 stainless steels all exhibit corrosion rates <2 mils/yr. Carbon steel, however, can be expected to corrode at a rate exceeding 50 mils/yr. An assembly consisting of T321 hose/braid, T304 male, T304 stub end and a carbon steel lap joint flange would provide acceptable corrosion resistance. Note that the carbon steel flange, which is not resistant to the media, is not a wetted surface since it does not come into contact with the media.
Special Constructions

There are a number of common special derivatives of a metal hose assembly.

A Jacketed Assembly is a hose inside of another hose (the jacket). This type of assembly can be used to:

- control the temperature of the media in the inner hose by circulating a thermal conductor (like steam or water) through the jacket.
- insulate the inner hose by use of a vacuum in the jacket.
- monitor leakage of the inner hose with sensors on the jacket that can temporarily provide secondary containment.
A Traced Assembly is a hose with a very small trace hose running through it. A thermal conductor (like steam or water) runs through the trace hose to control the temperature of the medium in the main assembly.

4.4 Pressure Rating

A corrugated metal hose is only as strong as its weakest component. The maximum allowable working pressure (strength) for each component must be known, and derated respecting the parameters of the installation. The maximum allowable working pressure (MAWP) of each fitting must be derated for elevated operating temperatures. Temperature derating factors are a function of temperature and the material of the component. (See below.)

The MAWP of the hose must also be derated for temperature, as well as for pressure fluctuations and welding techniques. Rapid pressure changes reduce the strength of the hose. Use the table below for the appropriate derating factor. Welding of the hose assembly may also lead to a reduction in strength. This information should be provided by the assembly fabricator. Unless otherwise established, an attachment method derating factor of 0.85 is common for a T.I.G. welded standard fitting attachment.

<table>
<thead>
<tr>
<th>Pressure Fluctuation</th>
<th>Derating Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>1.00</td>
</tr>
<tr>
<td>pulsating</td>
<td>0.50</td>
</tr>
<tr>
<td>spike</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Example: What is the MAWP for the following assembly to be used in an installation with pulsating pressure at a temperature of 700°F?

- Hose and braid: T316L stainless steel
  - MAWP (70°F) = 600 psi
- Fitting #1: T304 stainless steel raised face slip on flange
  - MAWP (70°F) = 230 psi
- Fitting #2: Carbon steel pipe nipple
  - MAWP (70°F) = 550 psi

With standard T.I.G. welded fitting attachment techniques.
The following derating factors apply:

Pressure Fluctuation Derating Factor = 0.50
Attachment Method Derating Factor = 0.85
Temperature Derating Factor (T316L stainless steel at 700° F) = 0.77
Temperature Derating Factor (T304 stainless steel at 700° F) = 0.80
Temperature Derating Factor (carbon steel at 700° F) = 0.83

Derated MAWP (hose) = 600 psi \times (0.50) \times (0.85) \times (0.77) = 196 psi
Derated MAWP (fitting #1) = 230 psi \times (0.80) = 184 psi
Derated MAWP (fitting #2) = 550 psi \times (0.83) = 456 psi

The derated MAWP for the assembly in this specific installation = 184 psi

**Temperature Derating Factors**

The strength of a component is reduced at elevated temperatures. For metal hose, unless already defined by the component supplier or relevant standard, use the derating factors listed below. Multiply the maximum allowable working pressure (at 70° F) by the appropriate derating factor for the application temperature and component material.

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<th>MATERIAL</th>
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<td>Carbon Steel*</td>
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</tbody>
</table>

* Do not use for temperatures lower than -20° F
4.5 Corrugated Metal Hose Assembly Dimensions

**Inside Diameter of the Hose**

The minimum inside diameter of the hose shall be at least ninety-eight percent (98%) of its nominal diameter.

**Overall Length (OAL)**

The OAL of an assembly shall be as requested by the customer with acceptable tolerances as agreed between the customer and provider. Unless otherwise specified, the tolerances shall be as defined in the following Table.

<table>
<thead>
<tr>
<th>Assembly Overall Length Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Length of Assembly</td>
</tr>
<tr>
<td>0” thru &lt;8”</td>
</tr>
<tr>
<td>8” thru &lt;18”</td>
</tr>
<tr>
<td>18” thru &lt;3’</td>
</tr>
<tr>
<td>3’ thru &lt;6’</td>
</tr>
<tr>
<td>6’ thru &lt;12’</td>
</tr>
<tr>
<td>≥12’</td>
</tr>
<tr>
<td>Hose I.D.</td>
</tr>
<tr>
<td>&lt; 1”</td>
</tr>
<tr>
<td>+/- 1/4”</td>
</tr>
<tr>
<td>+/- .5/16”</td>
</tr>
<tr>
<td>+/- 3/8”</td>
</tr>
<tr>
<td>+/- 1/2”</td>
</tr>
<tr>
<td>+/- 1”</td>
</tr>
<tr>
<td>+/- 1%</td>
</tr>
<tr>
<td>1” thru &lt; 4”</td>
</tr>
<tr>
<td>+/- 3/8”</td>
</tr>
<tr>
<td>+/- 1/2”</td>
</tr>
<tr>
<td>+/- 5/8”</td>
</tr>
<tr>
<td>+/- 3/4”</td>
</tr>
<tr>
<td>+/- 1 1/4”</td>
</tr>
<tr>
<td>+/- 1.5%</td>
</tr>
<tr>
<td>4” thru 12”</td>
</tr>
<tr>
<td>+3%</td>
</tr>
<tr>
<td>-1.5%</td>
</tr>
<tr>
<td>+3%</td>
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<tr>
<td>-1.5%</td>
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<tr>
<td>+3%</td>
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<td>-1.5%</td>
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<tr>
<td>+3%</td>
</tr>
<tr>
<td>-1.5%</td>
</tr>
</tbody>
</table>
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 (see Figure A). 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 (see Figure B). Elbow fittings are measured as illustrated in Figure C.
Length Calculations

Below are illustrations of some of the most common hose installations. Use the formula to determine the appropriate live length (L) for that assembly. Then confirm that the installed radius (R) of that configuration is greater than the published minimum (dynamic/static) bend radius of the hose selected. Also confirm that the center line of the hose always remains in one (the same) plane. Otherwise, detrimental torsional stresses may be induced on the hose during cycling.

Avoid axial hose compression. This may bulge the braid "off" the hose and ultimately induce squirm and failure. If any of these issues arise, consider adjusting the piping system to facilitate a more appropriate hose installation.

A-Loop
B-Loop

\[ L = 4R + 1.57T \]

Combination Loop

\[ L = 4R + 1.57T + \left( \frac{T_d}{2} \right) \]
**Lateral Offset**

\[ L = \sqrt{20R \times T} \]

Where: 
- \( R \) = published minimum bend radius (inches) 
- \( T \) = offset (inches)

**Angular Deflection**

\[ L = 2S + (\varnothing/57.3)R \]

Where: 
- \( R \) = published minimum bend radius (inches) 
- \( S \) = hose O.D. (inches) 
- \( \varnothing \) = deflection angle (degrees)
4.6 Corrugated Metal Hose Fittings

General

When selecting fittings for a metal hose assembly, care must be taken to ensure that the material and construction of the fittings permit them to be welded to the hose, and are compatible with the application and the existing piping system. As with the corrugated hose, the maximum allowable working pressure of the fittings must be derated for elevated temperatures (see Temperature Derating Table in Section 4.4.) Whenever possible, it is advisable to use a swivel, floating, or axially disconnectable fitting on a least one end of the hose assembly to avoid torsion during installation.

Fitting Orientation

Some fittings (e.g. fixed flanges, elbows, etc.) require specific orientation on the hose assembly in order to be properly installed into the piping system. These fittings should be oriented according to the following illustrations unless otherwise specified:

Standard Fitting Orientations

Bolt Hole Alignment

Angular Fitting Orientation
Illustrations of Common Fittings

Weld Nipple
Common Sizes: 1/4" through 12"
Common Materials: Carbon Steel, T304SS, T316SS
Common Schedules: 40, 80

Pipe Nipple
Common Sizes: 1/4" through 6"
Common Materials: Carbon Steel, T304SS, T316SS
Common Schedules: 40, 80

Female Pipe Coupling
Common Sizes: 1/4" through 4"
Common Materials: Carbon Steel, T304SS, T316SS
Common Classes: 150#, 3000#

Hex Male Nipple
Common Sizes: 1/4" through 2"
Common Materials: Carbon Steel, T304SS, T316SS

Female Union
Common Sizes: 1/4" through 4"
Common Materials: Malleable Iron, Carbon Steel, T304SS, T316SS
Common Classes: 150#, 3000#

Female JIC
Common Sizes: 1/4" through 2"
Common Materials: Carbon Steel, T316SS
Raised Face, Slip On Flange
Common Sizes: 1/2” through 12”
Common Materials: Carbon Steel, T304SS, T316SS
Common Classes: 150#, 300#

Raised Face, Slip On Flange (with Pipe Spacer)
Common Sizes: 1/2” through 12”
Common Materials: Carbon Steel, T304SS, T316SS
Common Classes: 150#, 300#

Type A-Stub End with Lap Joint Flange
Common Sizes: 1/2” through 12”
Common Materials - Stub: T304SS, T316SS
Common Materials – Flange: Carbon Steel, T304SS, T316SS
Common Schedule – Stub: 10, 40
Common Classes - Flange: 150#, 300#

Type C-Stub End with Slip On or Plate Flange
Common Sizes: 1/2” through 12”
Common Materials - Stub: T304SS, T316SS
Common Materials – Flange: Carbon Steel, T304SS, T316SS
Common Schedule – Stub: 10
Common Classes - Flange: 150#, 300#

Elbow
Common Types: 90 Deg, 45 Deg, Short and Long radius
Common Sizes: 1/4” through 12”
Common Materials: Carbon Steel, T304SS, T316SS
Common Schedules: 40, 80

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4.7 Corrugated Metal Hose Attachments & Common Accessories

Guards

Corrugated metal 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 welded 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.
Liner to Handle High Media Velocity

The height and shape of corrugated metal hose may induce turbulence, or resonant vibration, at high media velocity. This can be negated with the use of a flexible liner. This liner is typically made of stripwound metal hose. (See the illustration below.) The maximum media velocity for an unlined corrugated metal hose assembly is a function of the state of the media and the degree of bending of the hose. Use a liner when the media is a solid or when the media velocity exceeds the maximum velocities defined in the table below.

### Lined Metal Hose Assembly

#### Velocity Table

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Unbraided</th>
<th>Braided</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry Gas</td>
<td>Liquid</td>
</tr>
<tr>
<td>straight</td>
<td>100 ft/s</td>
<td>50 ft/s</td>
</tr>
<tr>
<td>45° bend</td>
<td>75 ft/s</td>
<td>40 ft/s</td>
</tr>
<tr>
<td>90° bend</td>
<td>50 ft/s</td>
<td>25 ft/s</td>
</tr>
<tr>
<td>180° bend</td>
<td>25 ft/s</td>
<td>12 ft/s</td>
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</tbody>
</table>
4.8 Attachment Methods

Fittings are typically welded or brazed onto the ends of the metal hose. The most common welding methods are explained and illustrated below. With all assembly types, care should be taken to select the most appropriate method for the application’s requirements and to maximize the live length of the hose assembly.

Direct Attachment Method

The Direct Attachment Method has two steps. First, the hose, braid, and braid sleeve are welded together. This step is referred to as the “Cap Weld” (see below). The fitting is then welded onto the Cap Weld. This step is referred to as the “Attachment Weld” (see below).

Braid-Over (Neck Down) Attachment Method

This is also a two step process with the first step being to weld the fitting to the unbraided hose. The braid is then pulled over that attachment joint and the braid and braid sleeve are welded directly onto the fitting.
Smooth-Transition (ST) Attachment Method

Special fabrication techniques may be used to make a smooth transition between the hose ID and the fitting ID, free of crevices that could entrap contaminants. A smooth transition may be accomplished by either a direct attachment (See Figures A, B, and C) or with a braid-over attachment (See Figures D and E). With either method, care should be taken when attaching the fitting to the hose to avoid creating cavities (see Figure F).

Attachment Components

Braid Sleeves

Braid sleeves must be used at each end of a braided hose assembly. Braid sleeves can serve two functions: (1) to hold the braid tightly in place during fabrication; and (2) to protect the underlying corrugations from excess flexing. Ideally, braid sleeves should cover approximately three corrugations. They shall not be less than 3/8" long and are not required to be longer than 1”.

Pipe Spacers

Pipe spacers may be used for flanged or similar assemblies, when braid-over construction is used, or when flange bolts may interfere with the hose’s outside diameter.
4.9 Testing Procedures for Corrugated Metal Hose

Pneumatic Test

Unless otherwise specified, the hose assembly shall be subjected to a pneumatic test at a value defined in Table 4.9.1. Using a gaseous media, the assembly is immersed in a bath of water for a sufficient length of time to permit visual examination of all fabricated joints. Typical gas testing media are air, nitrogen, and helium. To guard against corrosion, the chloride content of the water used for testing austenitic stainless steel should be controlled to less than 50 ppm (parts per million). Minimum testing time should be twenty (20) seconds. Any evidence of leakage or permanent deformation is cause for rejection.

<table>
<thead>
<tr>
<th>Table 4.9.1 – Minimum Pneumatic Test Pressures</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Table" /></td>
</tr>
</tbody>
</table>

Hydrostatic Test

The hydrostatic test not only tests for leakage, it confirms the assembly’s structural integrity. The assembly shall be pressurized with water to the maximum test pressure of the assembly and maintained for a sufficient length of time to permit a visual examination. Contact the manufacturer for maximum test pressure for each hose. To guard against corrosion, the chloride content of the water used for testing austenitic stainless steel should be controlled to less than 50 ppm (parts per million). The minimum testing time should be one (1) minute. Any evidence of leakage or permanent deformation is cause for rejection.

Helium Mass Spectrometer Test

Helium mass spectrometer testing is the most accurate way of evaluating leakage (but not strength). Assemblies designed for critical applications should be leak tested with this method. All tested assemblies shall have a leak rate less than $1 \times 10^{-3}$ std/cc/sec. Helium mass spectrometer testing to smaller leak rates may be available – consult the assembly fabricator.

Cleaning for Oxygen

Oxygen can spontaneously ignite and explode in the presence of hydrocarbons or if solid particles are caught in its flow. Methods and parameters for both oxygen cleaning and cleanliness testing can be referenced in the Compressed Gas Association publication, “Cleaning Equipment for Oxygen Service”, CGA G-4.1. Breathable oxygen applications require special consideration. Consult the customer for appropriate requirements.

Additional Leakage Tests

Consult the fabricator for other testing methods. These may include, but are not limited to, the following: Pressure Decay, Vacuum Decay, Mass Flow, and Dye Penetrant Leak Test.
Section 5 - Industrial Hose

Section Contents:
5.1 General Information
5.2 STAMPED
5.3 Assembly Component Selection Chart (Chart is in Appendix I)
5.4 Industrial Hose Data Sheets
5.5 Industrial Hose Fittings
5.6 Industrial Hose Attachments
5.7 Testing
5.8 Custom Made Hose
5.9 Ducting

5.1 General

Industrial hose is normally constructed of rubber or plastic while being reinforced with textile fabric, tire cord fabric, and/or braided or spiraled wire. Industrial hoses are designed for transfer of a wide range of materials in various specialty applications. In general, some advantages of industrial hoses are increased hose flexibility, the ability to produce long lengths, large bore capabilities, and the ability of industrial hose to coexist with a wide range of end fittings and attachment methods. Some typical applications for industrial hose are listed below:

- air & multipurpose hose
- water hose
- fire suppression hose
- cleaning service hose
• water suction and discharge hose
• material handling hose
• specialty service hose
• food industry and transfer hose
• acid and chemical service hose
• petroleum service hose
• steam service hose
• aircraft refueling hose

Industrial hoses are manufactured with a wide variety of rubber, plastic, or thermoplastic compounds due to the wide variety of conveyed materials, solutions, and applications. The particular compounds and/or materials used for each industrial hose product depend on the specific application for each hose. See appendix C for a detailed description of hose materials. There are a number of factors that determine the appropriate materials used such as:

• amount of oil resistance needed (ARPM Class A, B, or C).
• amount of abrasion resistance needed
• amount of ozone and/or weathering resistance needed
• amount of heat resistance needed
• amount of chemical or acid resistance needed
• type of service – air, liquid, dry materials, or steam service

The two typical reinforcement methods of constructing industrial hose consist of braided or spiraled hose constructions. There are many factors that determine the reinforcement method. An example of a few factors that assist in determining the selected construction method are the elongation requirements, amount of flexibility required, vacuum resistance, crush resistance, or pressure requirements. Below is a brief description of each construction method:

• braided hose construction – hose reinforcement is attained by vertical or horizontal braiding of textile, wire, or other materials. Hoses may consist of a single braided layer to multiple braiding layers.
• Spiral or spiral-plied hose construction – hose reinforcement is attained by spiral wrapping of textile, wire, or tire cord materials at specified angles. Multi-layer constructions are applied with each spiral layer in opposing directions.

See Appendix C for a detailed description of reinforcement materials.
5.2 STAMPED

The STAMPED acronym stands for the 7 major information areas required to provide a quality hose assembly for the customer, as follows:

S stands for SIZE; I.D. and length; any O.D. constraints
- overall length should be specified to include fittings
- tolerances need to be specified if special requirements exist

I.D., O.D. and overall length of the assembly
- To determine the replacement hose I.D., read the layline printing on the side of the original hose. If the original hose layline is painted over or worn off, the original hose must be cut and inside diameter measured for size.
- The inside diameter of the hose must be adequate to keep pressure loss to a minimum, maintain adequate flow, and avoid damage to the hose due to heat generation or excessive turbulence. The hose should be sized according to the nomographic chart in appendix D.
- Flow Rate / Fluid Velocity - The flow rate of the system in conjunction with the inside diameter of the hose will dictate the fluid velocity through the hose. Typical fluid velocities can be seen in the nomographic chart in Appendix D. Please consult your hose supplier for specific recommended velocity ranges. Please note that suction line recommendations are different than pressure lines.

T stands for TEMPERATURE of the material conveyed and environmental conditions
- Are there factors such as heat sources in the environment in which the hose will be used
- Continuous (average) and minimum and maximum temperatures have to be specified for both the environment and material conveyed
- Note if flame resistance or flammability will be an issue
- Sub-zero exposure
- Care must be taken when routing near hot manifolds and in extreme cases a heat shield may be advisable.
- Other things to consider: maximum intermittent ambient temperature, fluid temperature, ambient temperature and maximum temperature.
- Maximum assembly working pressures will decrease as temperatures increase.

A stands for the APPLICATION, the conditions of use
- Configuration/routing (add a sketch or drawing if applicable)
  - is the hose hanging, laying horizontally, supported, unsupported (orientation and aspect of the hose)
  - what else is attached to the hose, any external load on the hose
  - bend radius requirements, flexibility
  - elongation considerations with working pressure
- Quantify anticipated movement and geometry of use requirements
- Intermittent or continuous service
- Indoor and outdoor use
- Unusual mechanical loads
- Excessive abrasion
- Electrical conductivity requirements
- Equipment type
- External conditions – abrasion, oil (specify type), solvents (specify type), acid (specify type and concentration), ozone, salt water
- Hose now in use
  - Type of hose
  - Service life being obtained and description of failure or source of customer
dissatisfaction

- Strength and frequency of impulsing or pressure spikes
- Non-flexing applications (static), flexing applications (dynamic)
- Vacuum requirements

M stands for the MATERIAL or MEDIA being conveyed, type and concentration
- Are there special requirements for this hose tube
  - Any special specifications (or agency requirements) that need to be considered (e.g., FDA, EI)
  - Will the material be continuously flowing, or sit in the hose for long periods of time (specify)
- Media velocity, flow rate
- Chemical name/concentration (MSDS)
- Solids, description and size
- Fluid Compatibility - Some applications require specialized oils or chemicals to be conveyed through the system. Hose selection must assure compatibility of the hose tube. In addition to the hose materials, all other components, which make up the hose assembly (hose ends, o-rings, etc…), must also be compatible with fluid being used. Depending on the fluid, your hose supplier may lower the maximum temperature or pressure rating of the assembly. When selecting any hose assembly, always consult your hose supplier’s recommendations.

P stands for the PRESSURE to which the assembly will be exposed
- System pressure, including pressure spikes. Hose assembly working pressures must be equal to or greater than the system pressure. Pressure spikes greater than the maximum working pressure will shorten hose life and must be taken into consideration.
- Temperature implications
- Vacuum considerations
- Maximum Operating Pressure - This is the maximum pressure that the system should be exposed to in normal operating conditions. For hydraulic hose assemblies, this pressure should be dictated by the relief setting of the system. Both the hose and hose end should not be rated to a pressure less than the maximum operating pressure of the system.
- Pressure Spikes - When a hydraulic system is subjected to a large load in a short period of time, the system pressure can overshoot the relief setting and exceed the maximum operating pressure. Frequent pressure spikes can reduce the life of hydraulic hose assemblies. In general, spiral hose constructions are better suited to high impulse applications, which involve flexing and large pressure spikes. However, there are specialized braided hoses available from various manufacturers. Please consult your hose supplier if there are multiple constructions which meet your application needs.
- Impulsing – exposure of the assembly to changing pressures over time
- Maximum assembly working pressures will decrease as temperatures increase.

E stands for ENDS: style, type, orientation, attachment methods, etc.
- Uncoupled or coupled hose; hose with built-in fittings
- Specify end style (see charts and pictures in Section 5)
- Materials and dimensions (steel, stainless, etc.)
- Conductivity requirements

D stands for DELIVERY
- Specific to customer requirements
- Testing requirements
  - certification requirements (e.g., Coast Guard)
- Any special packaging requirements
- Any special shipping requirements
- Tagging requirements
- Also refers to Determined Overall Length when working with Metal Hose
5.3 Industrial Hose Assembly – Component Selection Chart

Purpose

The purpose of this section is to provide a simple chart of the most common industry recognized hose, end connections, and attachment method combinations that will satisfy the customer’s needs from the application information gathered from the STAMPED process.

Procedures on how to use

This document recognizes that all hose assemblies are made up of at least two to three components. The hose, end connections and attachment method are the three recognized components. The following are the procedures on how to use the component selection chart:

STEP 1. Review STAMPED (Section 2) and gather all the required application information to proceed with an assembly selection.

STEP 2. Proceed to the Component Selection Chart, which has the hose type, fittings, and attachments categories down the left columns of the chart. Select the appropriate hose, fitting and attachment combination.

Note: These are typical industry combinations of hose, end connections, and attachment methods; this chart is used as a guideline for best industry practices for hose assembly fabrication. For assemblies or components that are not listed, it is strongly suggested to contact your local NAHAD Hose Safety Institute distributor for further information and recommendations.

Pressure Ratings

Hose assembly pressure ratings vary by hose, fitting, and attachment combinations, and are always rated at the lesser of the hose, fittings, and attachment method used.

Note: pressure ratings for individual components (e.g., hose, couplings) should be verified either by the distributor or the relevant manufacturer.

Establishing assembly pressure ratings

Establishing pressure ratings is different than proof testing and is not to be confused with proof testing. Proof testing is a nondestructive test to confirm the assembly is safe at the working pressure the assembly is rated to. Proof testing confirms the assembly method as valid and may point out any deficiencies in the components or methods used to create the assembly. Proof testing is generally done at the distributor level, but may be carried out by the end user or others as may be required.

Burst testing is the only method for establishing an assembly working pressure at 70°F. Any rating alteration due to operation at other temperatures is not considered in this procedure but must be addressed if the assembly is to be subjected to nonstandard temperature. Burst is a destructive test and in most cases, the parts used for the test are not suitable for further testing or use. Burst testing is generally carried out at the manufacturer level but may be accomplished by distributors as well or others with the qualified personnel and equipment.
The assembly to be burst tested shall be assembled by published procedures. These may be manufacturer’s procedures, NAHAD procedures or procedures created by the individual conducting the test. These procedures as well as the components used in the assembly creation shall be documented. The actual test shall be conducted to ASTM D380 procedures for a straight burst test except in this case the whole assembly is under scrutiny instead of only the hose. The test conditions shall include the assembly, room and media at 70°F +/- 2°. Failure in this case is defined as a burst of the hose, a leak from any of the components or relative hose movement. The hose burst is the most obvious, a leak can be more difficult to detect and the tester must be vigilant in the observation. Relative hose movement is the most difficult to determine. When using a sleeve or bands, the end of the hose is not obstructed and can be easily determined. Some hose movement relative to the fitting is expected when using bands as the hose "settles" into the correct location, this is especially true with shanks that have larger bumps and the band may not be fully effective if the band is not positioned perfectly. Even determining this perfect position can be difficult as hose behavior affects this. Similarly, movement at a ferrule can be difficult and cannot be determined at the open end of the ferrule and must be determined by the end of the hose. As the hose elongates, some of this elongation occurs under the ferrule as well, so viewing the open end may show some of this elongation while the hose has not moved at the hose end. If slots do not exist in the ferrule, other means of determining the end of the hose must be utilized. This can include making slots in the ferrules for viewing or perhaps using any holes that may exist in the ferrule for viewing. Another factor that may affect the observation is hose shear, where some of the layers move relative to each other but those layers with the most retention remain stationary. Documentation of the effects during testing shall be maintained and photos of any portion including the results are recommended.

The assembly maximum working pressure shall not exceed the working pressure of the lowest rated component of the assembly.

Temperature Derating Factors for Hose Assemblies

Temperature directly affects maximum allowable working pressure. Most manufacturers rate maximum operating pressures at an ambient temperature of 70 degrees F. If a hose is to be considered for use in an application that exceeds this ambient temperature, consult manufacturer for any pressure derating of the hose assembly.

The Industrial Hose Component Selection Chart can be found at the end of this document in Appendix I.
5.4 Hose Data Sheets

NAHAD and ARPM recommend the following minimum design ratios for newly manufactured hose:

- Water hose up to 150 psi WP 3:1
- Hoses for all other liquids, solid materials suspended in liquids or air, and water hose over 150 psi WP 4:1
- Hoses for compressed air and other gases 4:1
- Hoses for liquid media that immediately changes into gas under standard atmospheric conditions 5:1
- Steam hose 10:1
- Other industry design ratios exist – contact your Hose Safety Institute Distributor

5.4.1 Air/Multi Purpose Hose

*General Uses:*

There are typically three categories of air hose: oil resistant (see chart below), non-oil resistant, and non-conductive. The lower pressure hoses are generally used for applications such as air guns, service stations, industrial air lines in plants, and many other air services. High pressure air hoses which are considered to be hoses with working pressures above 300 psi (2069 kPa) are generally used in construction and mining where large volumes of air service are required. The non-conductive air hose is specifically made to meet one megohm resistance per inch when 1000 volts DC is applied.

Typical hose types include: Non-Oil Resistant Rubber Air Hose, Medium Oil-Resistant Rubber Air Hose, High Oil-Resistant Rubber Air Hose, Non-Conductive Air Hose, PVC Air Hose, Polyurethane Air Hose, Textile Braid Air Drill Hose, Wire Braid Air Hose.

*Limitations:*

Hoses that are non-oil resistant rubber should not be used in an oil environment. Consult hose manufacturer for material and compatibility recommendations.

### Physical Properties After Exposure to Oil

<table>
<thead>
<tr>
<th>Class</th>
<th>Volume Change Max.</th>
<th>Tensile Strength Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – High Oil Resistance</td>
<td>+25%</td>
<td>80%</td>
</tr>
<tr>
<td>B – Medium Oil Resistance</td>
<td>+65%</td>
<td>50%</td>
</tr>
<tr>
<td>C – Limited Oil Resistance</td>
<td>+100%</td>
<td>40%</td>
</tr>
</tbody>
</table>

*Disclaimer:* It is recommended that the user test the hose/fluid compatibility to their own standards. Since no industry standards exist for chemical resistance, the Compass “Chemical Resistance Guide for Elastomers” is used whenever possible. [www.compasspublications.com](http://www.compasspublications.com) (see Appendix H of this document for additional information.)

Note: Chart used with permission from ARPM Hose
Handbook.

Warnings:

Do not use non-oil resistant hoses in an oil environment. Non-conductive hoses should be used in high voltage areas. Use extreme caution with high pressure air applications and/or high temperature applications.

When utilizing the crimp method to fabricate high pressure air hose assemblies using a heavy ferrule, manufacturer crimp specifications MUST be used; further, it is critical that assembly components – hose, ferrule and hose insert systems – be explicitly intended for air applications, be explicitly intended for use together, and be provided by recognized HSI distributor and/or manufacturer members.

Safety cables (also known as whip-checks) should be used with high pressure air hose applications to minimize the risk of operator injury.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.

5.4.2 Asphalt and Hot Tar Hose

General Uses:

This hose is designed for the bulk transfer and delivery of hot petroleum products, such as tar, asphalt, and oil. This hose is generally designed for suction and discharge. Consult hose manufacturer for vacuum rating.

Typical hose types include: Hot Tar & Asphalt Hose, Asphalt Applicator or Wand Hose

Limitations:

Generally, the hoses are recommended for a maximum of +350° (+176.66°C) service. Consult hose manufacturer for specific temperature ratings.

Warnings:

Consult the hose, coupling, and/or attachment manufacturer if the application temperature is above +350°F (+176.66°C).

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt &amp; Hot Tar</td>
<td>Ground Joint</td>
<td>Interlocking Clamp</td>
</tr>
<tr>
<td>Asphalt &amp; Hot Tar</td>
<td>High Pressure Crimp</td>
<td>High Pressure Crimp Ferrule</td>
</tr>
<tr>
<td>Asphalt &amp; Hot Tar</td>
<td>Internal Expansion - Steel</td>
<td>Internal Expand Steel</td>
</tr>
</tbody>
</table>
5.4.3 Chemical Hose – Plastic Lined

General Uses:

This section covers Chemical rubber hoses manufactured from plastic liners such as Cross-Linked Polyethylene (XLPE) or Ultra-High Molecular Weight Polyethylene (UHMWPE) or (Fluoropolymer). Chemical hose should be inspected, tested and maintained per the guidelines of ARPM/IP-11-7.

Typical hose types include: XLPE Chemical Hose, UHMW Chemical Hose, Nylon Chemical Hose, conductive and non-conductive Rubber Covered Fluoropolymer (Teflon*) Hose

Limitations:

The hose and couplings, and gaskets or seals selected for use must be compatible with the chemical(s) to be conveyed under the stated service conditions. Refer to ARPM Hose Handbook, Chapter 8, “Chemical Recommendations”, for general information and/or consult with your hose and coupling suppliers for specific product recommendations. For more detailed information, please consult Compass Publication’s latest edition for Elastomer Chemical Resistance.

Refer to ARPM IP-11-7 Manual for Maintenance, Testing and Inspection of Chemical Hose.

Warning:

Hose assembly needs to be static grounded.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.

5.4.4 Chemical Hose – Rubber Lined

General Uses:

This section covers Chemical hoses manufactured from various types of thermoset rubber polymers such as Natural Rubber (NR), Chlorosulfonated Polyethylene Rubber (CSM), and Fluorocarbon Rubber (FKM).

Typical hose types include: Natural Rubber Chemical Hose, Viton® Chemical hose, Butyl Chemical Hose, EPDM Chemical Hose.
Limitations:

The hose and couplings, and gaskets or seals selected for use must be compatible with the chemical(s) to be conveyed under the stated service conditions. Refer to ARPM Hose Handbook - Chapter 8 - Chemical Recommendations for general information and/or consult with your hose and coupling suppliers for specific product recommendations. For more detailed information, please consult Compass Publication’s latest edition for Elastomer Chemical Resistance.

Refer to ARPM IP-11-7 Manual for Maintenance, Testing and Inspection of Chemical Hose.

Warning:

Hose assembly needs to be static grounded.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.

5.4.5 Fire and Booster Hose

![Fire and Booster Hose Image]

General Uses:

For firefighting and protection, usually high volume open end water discharge applications. See manufacturers and regulatory agencies for recommendations on pressures, end connections, and attachment methods. (See Appendix H for agencies such as NFPA.)

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire &amp; Booster</td>
<td>Reusable Fire</td>
<td>Reusable Ferrule</td>
</tr>
<tr>
<td>Fire &amp; Booster</td>
<td>Fire Hose Fitting</td>
<td>Internal Expansion</td>
</tr>
</tbody>
</table>

5.4.6 Food Handling Hose

![Food Handling Hose Image]

General Uses:

These requirements cover hose assemblies designed to convey food products – dry foods, liquid foods and fatty foods. The governing specifications are controlled by the FDA, 3A, NSF, and USDA. There are four classes of hose in the 3A standard. This application covers sizes up to and including nominal inside diameter of 6 inches (152.4 mm).

This standard would also encompass hose assemblies addressed by other agencies such as NSF,
which cover hot food oil hose that is used at +300°F (+148.88°C) and intermittent to +350°F (+176.66°C).

Typical hose types include: Rubber covered chlorobutyl, EPDM, Nitrile, and fluoropolymer (tube materials must be manufactured with FDA, 3A, and NSF approved materials); refer to manufacturers’ specific recommendations and approvals. There are also various thermoplastic hose constructions used in food handling and dry bulk applications.

**Warning:**

Dry bulk transfer applications must be static grounded.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.

### 5.4.7 Lay Flat Hose

**General Uses:**

This section covers General Purpose Lay Flat hose, i.e. hose that when empty, may be rolled onto itself, providing a neat compact package. Hoses of this type may be manufactured using various types of thermoplastics and or thermoset rubber polymers that provide some minor degree of oil resistance. Polymers that may be used are, but not limited to, Polyvinyl Chloride, Natural Rubber (NR), Styrene Butadiene Rubber, (SBR), Acrylonitrile Butadiene Rubber, (NBR), or Ethylene Propylene Diene Monomer, (EPDM), alone or in combination.

Hoses of this type are normally used as discharge hoses in construction, agriculture, mining and marine industries. It is used to transport water or water based material from point of supply to point of discharge. This includes but not limited to, sump or bilge drainage, stock pond water, flood drainage, process water, etc.

Typical hose types include: Water Discharge Hose, Temporary Water Pipeline Hose, and Irrigation Hose.

**Limitations:**

Lay Flat hoses must not be connected to the suction side of a pump system. General Purpose Lay Flat hoses are NOT intended to be used to transport water intended for human consumption (unless specifically designed for potable water), nor should they be used to transport steam or super hot water, such as a condensate collection line, above +140°F (+60°C). General Purpose Lay Flat hoses should not be used to transport oil or solvent-based liquids and should not be used to transport materials at temperatures below −20°F (-28.88°C). Contact hose manufacturer for specific applications outside of the listed parameters.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.
5.4.8 Material Handling Hose – Bulk Transfer

General Uses:

These hoses are typically used to convey products such as dust, limestone, wood chips, ores, coal, sand, gravel, grains, ground slate, asphalt roofing chips, metal shavings, flour, fish or shells, and/or slurries by means of suction, gravity feed, or pneumatic conveyance. Most products contain a means for static charge dissipation by incorporating a ground wire(s) in the hose wall and/or the use of a static-conducting black rubber in the tube.

 Typical hose types include: Natural Rubber Material Handling, Black Rubber SBR or CR Material Handling Hose, Cement Discharge, PVC Material Handling, Urethane Material Handling,

Limitations:

The hose and couplings selected for use must be compatible with the product(s) to be conveyed under the stated service conditions. For example, use a black static conductive SBR tube for extremely abrasive materials. Use a black static conductive CR tube for oil and abrasion resistance. The thickness of the tubes may vary from 1/16 inch (3.17 mm) to 1/2 inch (12.7 mm) depending on the severity of wear and service life expected.

Warning:

Hose assembly may need to be static grounded, depending on application.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.

5.4.9 Material Handling Hose – High Pressure Cement Handling

General Uses:

These hoses are typically used in plaster, grout, shotcrete and cement applications, handling a multitude of materials being pumped to concrete structures, tunnel faces, swimming pools, etc. at pressures from 700 to 1000 psi (4826 kPa to 6890 kPa). For use as a flexible connection between pumping equipment and hard piping or as discharge hose on the delivery end of high pressure concrete pumps.

Typical hose types include: Cement Placement Hose, Plaster & Grout Hose.
**Limitations:**

Typical operating temperature is –25°F (-32°C) to +150°F (65°C).

Note: Concrete Pumping Manufacturers Association 27-2000 specifies a 2:1 design ratio.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Cement</td>
<td>Crimp/ Swage</td>
<td>Heavy Ferrule</td>
</tr>
<tr>
<td>High Pressure Cement</td>
<td>Ground Joint</td>
<td>Interlocking Clamp</td>
</tr>
<tr>
<td>High Pressure Cement</td>
<td>Internal Expansion</td>
<td>Internal Expand Ferrule</td>
</tr>
</tbody>
</table>

**5.4.10 Petroleum – Fuel Oil Hose**

**General Uses:**

These hoses are typically used for transfer of fuel oil and other petroleum based products in home delivery, commercial and industrial service.

Typical hose types include: Fuel Oil Delivery Hose

**Limitations:**

This hose is designed for fuel oil service.

Hose usually ranges in inside diameters of 1 to 1½ inches (25.4 mm to 38.1 mm). The normal application temperature range is -40°F (-40°C) to +140°F (+60°C).

Hose is NOT to be used in a vacuum application.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum - Fuel Oil</td>
<td>Internal Expansion Brass</td>
<td>Internal Expand Ferrule</td>
</tr>
</tbody>
</table>
5.4.11 Petroleum Drop Hose

**General Uses:**

These hoses are typically used for transfer of gasoline and other petroleum based products under low pressure, gravity flow or suction.

**Limitations:**

This hose is designed for petroleum based products. Consult manufacturer for compatibility of blended fuels, such as biodiesel and E85 fuels.

Hose can be used in a vacuum if the hose is constructed with a helical wire or reinforcement that will support a vacuum.

The normal application temperature range is -20°F to +180°F (-29°C to +82°C).

**Warning:**

Hose assembly needs to be static grounded.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum Drop</td>
<td>Cam &amp; Groove</td>
<td>Crimp Sleeve</td>
</tr>
<tr>
<td>Petroleum Drop</td>
<td>Cam &amp; Groove</td>
<td>Crimp/ Swage Ferrule</td>
</tr>
<tr>
<td>Petroleum Drop</td>
<td>Cam &amp; Groove</td>
<td>Preformed Clamp</td>
</tr>
</tbody>
</table>

5.4.12 Petroleum Vapor Recovery Hose

**General Uses:**

These hoses are typically used for recovering gasoline vapors in tank truck loading at bulk terminals and in tank truck unloading at service stations.

Typical hose types include: Stage I Vapor Recovery
Limitations:

This hose is designed for petroleum based products. Consult manufacturer for compatibility of blended fuels, such as biodiesel and E85 fuels.

The normal application temperature range is -20°F (-29°C) to +180°F (+82°C) for rubber products or -20°F (-29°C) to 140°F (60°C) for Urethane and PVC products.

Warnings:

Hose is designed for VAPOR RECOVERY ONLY. Hose needs to be static grounded.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vapor Recovery</td>
<td>Cam &amp; Groove</td>
<td>Crimp Sleeve</td>
</tr>
<tr>
<td>Vapor Recovery</td>
<td>Cam &amp; Groove</td>
<td>Crimp/ Swage Ferrule</td>
</tr>
<tr>
<td>Vapor Recovery</td>
<td>Cam &amp; Groove</td>
<td>Preformed Clamp</td>
</tr>
</tbody>
</table>

5.4.13 Petroleum Discharge Hose

General Uses:

These hoses are typically used for transfer of gasoline and other petroleum based products under pressure or gravity flow.

Typical hose types include: Petroleum Discharge Hose

Limitations:

This hose is designed for petroleum based products. Consult manufacturer for compatibility of blended fuels, such as biodiesel and E85 fuels.

Hose is usually designed for a maximum of 150 psi (1034.24 kPa) working pressure. Hose should NOT be used in a vacuum application.

The normal application temperature range is -20°F (-29°C) to +180°F (+82°C).

Refer to ARPM IP-11-4 Manual for Maintenance, Testing and Inspection of Oil Suction and Discharge Hose and ARPM IP-8 Specifications for Oil Suction and Discharge Hose.

Warning:

Hose assembly needs to be static grounded.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.
5.4.14 Petroleum Suction and Discharge Hose

**General Uses:**

These hoses are typically used for transfer of gasoline and other petroleum based products under pressure, gravity flow or suction.

Typical hose types include: Oil, Gasoline, Petroleum and Biodiesel Suction and Discharge, Oilfield Suction and Discharge

**Limitations:**

This hose is designed for petroleum based products. Consult manufacturer for compatibility of blended fuels, such as biodiesel and E85 fuels.

Hose is typically designed for a maximum of 150 psi (1034.24 kPa) working pressure, consult manufacturer for higher pressure and temperature applications.

Hose can be used in a vacuum application, if the hose is constructed with a helical wire or reinforcement that will support a vacuum.

The normal application temperature range is -20°F (-29°C) to +180°F (+82 °C).

Refer to ARPM IP-11-4 Manual for Maintenance, Testing and Inspection of Oil Suction & Discharge Hose, and ARPM IP-8 Specifications for Oil Suction & Discharge Hose.

**Warning:**

Hose assembly needs to be static grounded.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.

5.4.15 Petroleum Curb Pump Dispensing Hose

**General Uses:** These hoses are used for the dispensing of petroleum-based products at automotive, marine and agricultural fueling facilities.

**Limitations:** Some applications may be regulated by agencies such as U.S. Coast Guard, California Air Resource Board (CARB), UL, or State and local governments, and NFPA.

Reference ARPM IP-11-8 Manual for Maintenance, Testing and Inspection of Petroleum Service
Suction Gasoline Dispensing Hose and Hose Accessories.

**Warning:** there are many types of fuels including bio-fuels, and ethanol-based fuels that can cause degradation of the hose tube causing premature failure of the assembly. Consult the manufacturer for recommendations of proper hose, end connections and attachment methods to be used.

Hose assembly needs to be static grounded.

Only the highest quality UL tested hose should be selected for this service.

### 5.4.16 Push On Hose

#### General Uses:

These hoses are typically used for air tools, to convey water, mild chemicals, and various petroleum products. These hoses are generally used for air applications up to a maximum of 350 psi (2413.25 kPa). The size range is typically ¼ inch (6.35 mm) to 1 inch (25.4 mm).

Typical hose types include: Push-On Hose

#### Limitations:

These hoses are used with push on couplings, although some manufacturers offer a crimp fitting for specific applications. Service temperature range is normally -40°F (4°C) to +190°F, please check with the hose manufacturer for temperatures above +120°F (+49°C) and compatibility with various chemicals.

#### Warnings:

Due to the risk of tube damage, external clamp should never be used in combination with push on style fittings.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push On</td>
<td>Push On</td>
<td></td>
</tr>
</tbody>
</table>
5.4.17 Sandblast Hose

**General Uses:**

These hoses are typically used for sandblasting of metal castings, steel, stone, and cement - wherever abrasive materials are carried at a high velocity.

**Limitations:**

Hose is designed with materials that do not have a high temperature rating. The typical temperature range is -40°F (4.0°C) to +160°F (+71.1°C).

**Warnings:**

This hose requires special couplings for the application. Sandblasting hoses do not have a long service life due to extreme application. Hoses should be inspected periodically to insure integrity of the assembly.

Fitting and attachment recommendations.

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand Blast</td>
<td>Sand Blast</td>
<td></td>
</tr>
</tbody>
</table>

5.4.18 Steam Hose

**General Uses:**

These hoses are typically used for the transport of pressurized saturated steam, pressurized superheated steam, or pressurized hot water from point of supply to point of use.

Typical hose types include: Steam Hose, Refinery Steam Hose

**Limitations:**

Steam hoses must not be used for service above their rated working pressures or temperatures. Steam hoses should not be used to transport any material other than those listed in the General Use section above. Steam or hot water contaminated with hydrocarbons or chemicals may shorten service life. Hoses should always be drained after use and prior to storage.

Refer to ARPM IP11-1, Guide for Use, Maintenance, Testing and Inspection of Steam Hose.

These hoses are NOT intended to connect a steam supply point and a pressurized steam vessel or autoclave.
Use only hose specifically recommended for steam service. ARPM specifies a 10:1 design ratio for steam hoses.

Warning:

When utilizing the crimp method to fabricate steam hose assemblies, manufacturer crimp specifications MUST be used; further, it is critical that assembly components – hose, ferrule and hose insert systems – be explicitly intended for steam applications, be explicitly intended for use together, and be provided by recognized HSI distributor and/or manufacturer members.

Hose assembly needs to be static grounded.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>Ground Joint</td>
<td>Interlocking Clamp</td>
</tr>
</tbody>
</table>

5.4.19 Water – General Purpose

General Uses:

These lower pressure hoses are typically used to transport water, or water based materials from point of supply to point of use.

High pressure water hoses which are considered to be hoses with working pressures above 300 psi (2069 kPa) are generally used in construction and mining where large volume or high pressure water service is required.

Typical hose types include: Water Hose, Garden Hose, Jetting Hose

Limitations:

Hoses used to transport hot water MUST NOT be used to transport pressurized steam. General purpose water hoses are NOT intended to transport water for human consumption.

Warnings:

Do not use non-oil resistant hoses in an oil environment. Use extreme caution with high pressure water applications.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.
5.4.20 Water - Suction and Discharge Hose (Rubber)

**General Uses:**

These hoses are typically used for suction and discharge of water at low to medium pressures. Suction hoses will normally have a helical reinforcement to handle vacuum applications. Typical hose types include: Water Suction and Discharge Hose.

**Limitations:**

Hoses used to transport hot water MUST NOT be used to transport pressurized steam. Suction and discharge hoses are NOT intended to transport water for human consumption.

**Warnings:**

Do not use non-oil resistant hoses in an oil environment. Use extreme caution with high pressure water applications.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.

5.4.21 Water – Suction Hose (Plastic)

**General Uses:**

These hoses are typically used for suction of water, or open ended low pressure discharge. Suction hoses will normally have a helical reinforcement to handle vacuum applications.

**Limitations:**

Generally not suited for high temperature applications.

**Warnings:**

Do not use non-oil resistant hoses in an oil environment. Use extreme caution with high pressure water applications.

Refer to Appendix I Hose Assembly Component Selection Chart for fitting and attachment recommendations.
5.4.22 Water – Pressure Washer

*General Uses:*

These hoses are typically used for the transfer of water at high pressure.

*Limitations:*

Not all pressure washer hoses are designed to handle steam applications.

*Warnings:*

Do not exceed manufacturer’s recommended pressure and temperature specifications.

Fitting and attachment recommendations.

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-Pressure Washer</td>
<td>High Pressure Crimp</td>
<td>High Pressure Crimp Ferrule</td>
</tr>
</tbody>
</table>

5.4.23 Water – Sewer Cleaning Hose

*General Uses:*

These hoses are typically used for high pressure open end sewer and water jetting applications. Typically used in long, one piece lengths.

*Limitations:*

Burst pressures may vary by manufacturer; consult manufacturer for design ratios.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water - Sewer Cleaning</td>
<td>High Pressure Crimp/ Swage</td>
<td>High Pressure Ferrule</td>
</tr>
</tbody>
</table>
5.4.24 Water - Washdown

**General Uses:**

These hoses are typically used for medium to high pressure water applications, typically for cleanup of food processing plants, oil rigs, paper mills, breweries, and other industrial facilities.

**Limitations:**

Not all washdown hoses are designed to handle steam applications. These hoses are available with a variety of pressure ratings.

Fitting and attachment recommendations:

<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water - Washdown</td>
<td>Machined, Long</td>
<td>Preformed Clamp</td>
</tr>
<tr>
<td>Water - Washdown</td>
<td>Machined, Medium</td>
<td>Crimp Sleeve</td>
</tr>
<tr>
<td>Water - Washdown</td>
<td>Machined, Medium</td>
<td>Preformed Clamp</td>
</tr>
</tbody>
</table>
5.5 Industrial Hose Fittings

5.5.1 Cam and Groove (Metallic Only)

**General Uses:**

Cam and Groove female couplers and male adapters are used as a means of quickly coupling small to large hose assemblies. They connect hose to hose or hose to a pipe system for the purpose of transferring liquids or dry bulk products. Connections are made by inserting the male into the female coupler and rotating ALL the cam arms into their locked positions.

Cam and Groove couplings are available in both locking and non-locking cam arm designs. Sizes range from 1/2 inch to 12 inch nominal size.

**Limitations:**

Care must be used to select a body material, arm material and gasket material that is compatible with the material being transferred through the coupling. Various hose shank styles are available to accommodate different hose attachment methods and hose configurations. Care should be taken in hose shank selection to prevent damage to the hose tube while maintaining retention integrity. For maximum coupling retention, an interlocking collar should be used.

Cam and Groove fittings are interchangeable among manufacturers, with the exception of ½ inch, 5 inch, 8 inch, 10 inch or 12 inch which may not be interchangeable.

Pressure ratings of cam and groove fittings vary from manufacturer to manufacturer. Be sure to select a Cam and Groove fitting that will meet the application requirements.

Contact your NAHAD Hose Safety Institute Distributor or Manufacturer for more information on material and hose shank selection, interchangeability, and pressure rating capabilities.

**Warnings:**

Cam and Groove couplings must never be used for compressed gas or steam service.

When replacement of cam arms is necessary, use only original manufacturer’s replacement arms.
When using band style clamps, cam and groove couplings are designed for evenly spaced clamps, with buckles rotated 180 degrees from each other.

5.5.2 Universal Coupling (Chicago, Claw, Crowsfoot)

**General Uses:**

This fitting is designed for air and water service and provides a quick connection between two lengths of hose; or length of hose and a male or female NPT outlet. In sizes ¼ inch (6.35 mm) to 1 inch (25.4 mm), all heads are the same and are interchangeable regardless of the hose shank or NPT thread size. Sizes 1-1/4 inch (31.75 mm) to 2 inch (50.8 mm) use a 4-lug connection. Connections made by pressing the two heads together and applying a quarter-turn. The locking pin is placed in the holes to provide a safe connection.

**Limitations:**

The universal fittings through 1” size have a working pressure rating of 150 psi. Consult fitting manufacturer for working pressures for sizes 1-1/4 through 2”.

**Warnings:**

Safety pins, clips or wires should always be installed in couplings. The universal fitting should never be used for steam service.

5.5.3 Short Shank Machined Fittings

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>Shank Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4” (6.35 mm)</td>
<td>15/16” (23.8 mm)</td>
</tr>
<tr>
<td>3/8” (9.53 mm)</td>
<td>15/16” (23.8 mm)</td>
</tr>
<tr>
<td>1/2” (12.7 mm)</td>
<td>15/16” (23.8 mm)</td>
</tr>
<tr>
<td>5/8” (15.9 mm)</td>
<td>15/16” (23.8 mm)</td>
</tr>
<tr>
<td>3/4” (19 mm)</td>
<td>15/16” (23.8 mm)</td>
</tr>
<tr>
<td>1” (25.4 mm)</td>
<td>1-1/4” (31.8 mm)</td>
</tr>
</tbody>
</table>
**General Uses:**

Low-pressure air, water and fluid transfer. Fitting styles include inserts, barbed quick disconnects, single bump nipples and small bore barbed inserts of other metallic and non-metallic materials. Examples include brass, stainless steel, carbon steel, polypropylene, nylon, and PVDF. Lead-free brass fittings are now available and should be used for potable water applications.

**Limitations:**

Careful consideration must be given to dangerous or volatile fluids. Types of end connections may affect pressure ratings; consult a NAHAD Hose Safety Institute distributor for pressure ratings.

### 5.5.4 Medium Shank Machined Fittings

Minimum shank lengths and serration depths:

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>Shank Length</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4&quot; (6.35 mm)</td>
<td>1-3/8&quot; (34.9 mm)</td>
<td>.025&quot; (.64 mm)</td>
</tr>
<tr>
<td>3/8&quot; (9.35 mm)</td>
<td>1-3/8&quot; (34.9 mm)</td>
<td>.025&quot; (.64 mm)</td>
</tr>
<tr>
<td>1/2&quot; (12.7 mm)</td>
<td>1-3/8&quot; (34.9 mm)</td>
<td>.030&quot; (.64 mm)</td>
</tr>
<tr>
<td>5/8&quot; (15.9 mm)</td>
<td>1-3/8&quot; (34.9 mm)</td>
<td>.030&quot; (.64 mm)</td>
</tr>
<tr>
<td>3/4&quot; (19 mm)</td>
<td>1-3/8&quot; (34.9 mm)</td>
<td>.030&quot; (.64 mm)</td>
</tr>
<tr>
<td>1&quot; (25.4 mm)</td>
<td>1-3/8&quot; (34.9 mm)</td>
<td>.030&quot; (.64 mm)</td>
</tr>
<tr>
<td>1-1/4&quot; (31.8 mm)</td>
<td>1-11/16&quot; (42.9 mm)</td>
<td>.035&quot; (.89 mm)</td>
</tr>
<tr>
<td>1-1/2&quot; (38.1 mm)</td>
<td>1-11/16&quot; (42.9 mm)</td>
<td>.035&quot; (.89 mm)</td>
</tr>
<tr>
<td>2&quot; (50.8 mm)</td>
<td>2-1/4&quot; (57.2 mm)</td>
<td>.045&quot; (1.1 mm)</td>
</tr>
</tbody>
</table>

**General Uses:**

Low pressure air, water and fluid transfer by suction or discharge. Fitting styles include: double bump (grooved) nipples, and Bowes & Thor style.

**Limitations:**

Careful consideration must be given to dangerous or volatile fluids. Types of end connections may affect pressure ratings; consult a NAHAD Hose Safety Institute distributor for pressure ratings.
5.5.5 Long Shank Machined Fittings

Minimum shank lengths and serration depths:

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>Shank Length</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; (12.7mm)</td>
<td>2&quot; (50.8mm)</td>
<td>.030&quot; (.76mm)</td>
</tr>
<tr>
<td>5/8&quot; (15.9mm)</td>
<td>2&quot; (50.8mm)</td>
<td>.030&quot; (.76mm)</td>
</tr>
<tr>
<td>3/4&quot; (19mm)</td>
<td>2-7/16&quot; (61.9mm)</td>
<td>.030&quot; (.76mm)</td>
</tr>
<tr>
<td>1&quot; (25.4mm)</td>
<td>2-13/16&quot; (71.4mm)</td>
<td>.030&quot; (.76mm)</td>
</tr>
<tr>
<td>1-1/4&quot; (31.8mm)</td>
<td>3-5/8&quot; (92mm)</td>
<td>.035&quot; (.89mm)</td>
</tr>
<tr>
<td>1-1/2&quot; (38.1mm)</td>
<td>3-3/4&quot; (95mm)</td>
<td>.035&quot; (.89mm)</td>
</tr>
<tr>
<td>2&quot; (50.8mm)</td>
<td>4-1/4&quot; (108mm)</td>
<td>.045&quot; (1.14mm)</td>
</tr>
<tr>
<td>2-1/2&quot; (63.5mm)</td>
<td>4-5/8&quot; (117mm)</td>
<td>.045&quot; (1.14mm)</td>
</tr>
<tr>
<td>3&quot; (76.2mm)</td>
<td>5-1/4&quot; (133mm)</td>
<td>.045&quot; (1.14mm)</td>
</tr>
<tr>
<td>4&quot; (102mm)</td>
<td>5-1/4&quot; (133mm)</td>
<td>.045&quot; (1.14mm)</td>
</tr>
</tbody>
</table>

General Uses:

Low pressure fluid transfer by suction or discharge. Fitting styles include: long shank combination nipples and long shank menders.

Limitations:

Careful consideration must be given to dangerous or volatile fluids. Types of end connections may affect pressure ratings; consult a NAHAD Hose Safety Institute distributor for pressure ratings.

5.5.6 Combination Nipples

Nipple  Ball and Socket – Female  Ball and Socket – Male
**General Uses:**

Low pressure discharge and suction for compatible liquids. Made from stainless steel, carbon steel, and brass. Fitting styles include: male NPT, beveled end, grooved end, ball and socket, flanged, and flange retainers, as well as menders.

**Limitations:**

Not for use with compressible products such as air or nitrogen on sizes 1 ¼” or above. Not for use with steam.

Ball & Socket Couplings are designed for low pressure water applications only. This section covers Ball & Socket Couplings with a serrated shank design only. Refer to manufacturer for pressure ratings for irrigation style shank designs.

### 5.5.7 Cast Shank Fittings

**General Uses:**

Low pressure liquid transfer by suction, and discharge. Fitting styles include: shank couplings, suction couplings, pin lug couplings, and other shank fittings not meeting the specific requirements of the other categories.

**Limitations:**

Careful consideration must be given to dangerous or volatile fluids. Types of end connections may affect pressure ratings; consult a NAHAD Hose Safety Institute distributor for pressure ratings.
5.5.8 Ground Joint Fittings

**General Uses:**

High pressure air, water; steam; other high pressure, elevated temperature applications. Fitting styles include: tapered seat and washer seal ground joints, interlocking male stems, and interlocking hose menders.

Ground joints will always connect to spud adaptors (female spud, male spud, or double spud.)

**Limitations:**

For ASME B31.1 applications:

A. Ground joints, malleable or ductile interlocking male stems not to be used for toxic fluids or flammable gases.

B. Steel interlocking male stems limited to +775°F (+412.8°C). Malleable or ductile ground joints or interlocking male stems limited to 350 psi (2413 kPa) and +450°F (+232.2°C).

C. Steel or ductile ground joints or interlocking male stems limited to 400°F (204.4°C) for flammable or combustible liquids. Malleable ground joints or interlocking male stems may not be suitable for flammable or combustible fluids.

D. Further code consultation is recommended.
For ASME B31.3 applications:

A. Steel ground joints or interlocking male stems are not suitable.
B. Malleable or ductile ground joints or interlocking male stems limited to -20°F (-8.9°C) to +650°F (+343°C) temperature range.
C. Malleable ground joints or interlocking male stems not suitable for severe cyclic conditions.
D. Malleable ground joints or interlocking male stems not suitable for flammable fluid service above +300°F (+148.9°C) or 400 psi. (2758 kPa).
E. Ground joints or interlocking male stems not suitable for category K fluid service. Category K fluid service is defined by the owner of the piping system as high pressure, typically above 2500 psi (17237 kPa).
F. Further code consultation is recommended.

Warnings:

When using ground joint type fittings and heavy ferrules for high pressure applications, use only components approved for use together by the hose and coupling manufacturer(s). When utilizing the crimp method to fabricate steam hose assemblies, manufacturer crimp specifications MUST be used; further, it is critical that assembly components – hose, ferrule and hose insert systems – be explicitly intended for steam applications, be explicitly intended for use together, and be provided by recognized HSI distributor and/or manufacturer members.

5.5.9 Internally Expanded Permanent Fitting

General Uses:

An internally expanded coupling provides a permanent interlocked connection between coupling and hose where full flow is desired.

These do not include internally expanded brass short shank fittings.

Limitation:

Special expanding equipment is necessary to attach fittings to hose. Be sure to measure both ends of the hose in order to select the proper size ferrule to match the outside diameter of each end of the hose.

It is recommended to utilize ferrules and inserts from the same manufacturer for assembly.

Warnings:

Not intended for hoses lined with Cross-Linked Polyethylene, Ultra High Molecular Weight Polyethylene, Nylon or any type of Fluoropolymer.
5.5 10 Internally Expanded Brass Short Shank

General Uses:

The internally expanded short shank brass couplings are typically recommended for low-pressure discharge and suction service. Commonly used in the transfer of fuel to homes, airplanes, ships, etc. The working pressure of these fittings varies with the size of the fitting, the size and construction of the hose and the media being conveyed. Consult your Hose Safety Institute Distributor for recommendations.

Limitations:

Body and gasket material must be compatible with the material being transferred through the coupling.

Special internal expanding coupling machinery is required to properly install these fittings. Be sure to measure the hose OD of both ends of the hose in order to select the proper size ferrule to match the OD of each end of the hose. It is recommended to use inserts and ferrules from the same manufacturer for assembly.

Where the final hose assembly must comply with API 1529 specifications, the couplings must be manufactured to comply with API 1529.

Warnings:

Internally expanded brass short couplings are not intended for air service.

5.5.11 Sanitary – Internal Expansion
General Uses:

Internally expanded sanitary stainless steel food grade fittings are designed for various food hose applications, including the processing of wine, beer, juice, vegetables and dairy products; also included are cosmetics, lotions, etc.

Limitations:

If utilizing internal expanded fittings, special internal expanding equipment is required to attach fittings to hose. Be sure to measure the hose OD of both ends of the hose in order to select the proper size ferrule to match the outside diameter of each end of the hose.

It is recommended to utilize ferrules and inserts from the same manufacturer for assembly.

The following governing bodies may have applicable standards: 3-A, FDA, USP, USDA, NSF, CFIA; be sure you have an understanding of your customers specific requirements.

5.5.12 Sanitary – External Crimp

General Uses:

Externally crimped sanitary stainless steel food grade fittings are designed for various food hose applications, including the processing of wine, beer, juice, vegetables and dairy products; also included are cosmetics, lotions, etc.

Limitations:

The following governing bodies may have applicable standards: 3-A, FDA, USP, USDA, NSF; be sure you have an understanding of your customer’s specific requirements. Also check with the coupling manufacturer to ensure the couplings are recommended for food applications.

5.5.13 Interlocking Crimp Stem with Ferrule
**General Uses:**

A crimp stem with ferrule provides a connection between coupling and hose allowing for higher-pressure assemblies. These fittings include an interlocking groove or shoulder that is specifically designed to be used with an interlocking ferrule.

**Limitations:**

Crimping equipment is necessary to attach fittings to the hose. It is recommended to utilize ferrules and inserts from the same manufacturer for assembly.

---

### 5.5.14 Sand Blast

![Image of Sand Blast fitting]

**General Uses:**

Designed for use on Sand Blast hose. Materials may include Aluminum, Brass, and Plastic.

**Limitations:**

Since these fittings attach to the outside of the hose with screws, they are to be used only with Sand Blast hose. Special care must be taken not to let the screws penetrate the hose tube.

**Warnings:**

These fittings are designed to be used with Sand Blast hose only.

---

### 5.5.15 Push-On

![Image of Push-On fitting]

**General Uses:**

Push-On fittings are specifically designed for Push-On style hose. These fittings are commonly used for air, water, petroleum based fluids, etc.

**Limitations:**

Fittings are designed to be used **without** hose ferrules or clamps.

**Warnings:**

These fittings are designed for Push-On hose only. The barbs of the fitting are larger in diameter and may cut the tube if used on other hoses. Not to be used with any type of hose clamp.
5.5.16 High Pressure Crimp

*General Uses:*

High pressure crimped fittings are typically utilized to obtain higher working pressure hose assemblies.

Permanent crimped hydraulic fittings require crimping or swaging equipment to assemble to a hose. They are available in either pre-assembled into a one piece coupling, or offered in a two-piece configuration. Two-piece configurations consist of a stem with a groove or shoulder that is specifically designed to be used with an interlocking ferrule. When using two-piece fittings, it is important to match the ferrule with its appropriate stem and hose.

*Limitation:*

Special crimping equipment is necessary to attach fittings to the hose. If using a two-piece hydraulic coupling, it is recommended to utilize ferrules and inserts from the same manufacturer for assembly. Generally available in sizes up to 2 inch. See Hydraulic Fittings section of this manual for available thread types and end configurations.

*Warnings:*

Care should be taken to crimp to the recommended crimp specification provided by the coupling or hose manufacturer.

Aggressive ferrule constructions may cause damage to the hose wall and reinforcement. Consult fitting manufacturer for proper fitting types.

5.5.17 Field Attachable/Reusable

*General Uses:*

For applications requiring reattachment of hose in the field or requirement to reuse the fittings. Can usually be attached with only a vise and a wrench.

*Limitations:*

Generally available in sizes up to 1/2 inch. Be sure to measure the OD of each end of the hose to select the proper size ferrule to match the outside diameter of each end of the hose.
**Warnings:**

Make sure to review manufacturer’s assembly procedures and do not miss-match manufacturer’s components.

5.5.18 Fire Hose Fitting

**General Uses:**

Brass or Aluminum internally expanded coupling used on open end water discharge hose or internally expanded hard wall fire engine suction hose. The working pressure of these fittings varies with the size of the fitting, the size and construction of the hose. Generally used for water service. Most common thread types are NPSH and NST. Various municipalities have their own thread types.

Consult your NAHAD Hose Safety Institute Distributor for recommendations.

**Limitations:**

Special internal expanding equipment is required to assemble these couplings with internal expansion rings. Be sure to measure the OD of both ends of the hose to select the proper size bowl to match the OD of each end of the hose.

**Warnings:**

The selection of the bowl size is critical to proper hose performance.
5.6 Industrial Hose Attachments

5.6.1 Crimp Ferrule

General Uses:
Properly interlocked crimped stems and ferrules can provide greater fitting retention, and improved resistance to higher pressures, fitting blow-offs and leaks.

Limitations:
Crimp stems and the ferrules have to properly interlock. Ferrule material thickness has a direct impact on assembly working pressure.

The material of the ferrule must be compatible with all materials to which it may be exposed. This includes both the material being transferred as well as external materials.

Proper equipment is required to crimp the ferrule onto the assembly. For maximum coupling retention, the ferrule must lock into the hose shank locking collar.

Warnings:
For proper component selection and crimping instructions, refer to your NAHAD Hose Safety Institute Distributor.

5.6.2 Crimp Sleeve

General Uses:
Crimped Sleeves may be used on virtually any stem that is designed for crimping. These sleeves do not interlock with the stem, however they provide 360 degree compression of the hose wall creating a leak-free assembly if properly assembled.
Limitations:

The material of the sleeve must be compatible with all materials to which it may be exposed. This includes both the material being transferred as well as external materials. Proper equipment is required to crimp the sleeve onto the assembly.

5.6.3 Heavy Ferrule - Swaged

General Uses:

Swaged ferrules are designed to be used with fittings with a collar to provide a high pressure hose assembly where an interlocked connection is required between fitting and ferrule.

Limitations:

For purposes of this document, the assembly pressure charts in Section 5 are based on Swaged Ferrules with a minimum wall of .085” (2.16 mm). Contact coupling manufacturer for pressure recommendations of the use of thinner wall ferrules.

It is recommended that the fittings and the ferrules be from the same manufacturer.

Special equipment is required to assemble these ferrules. The proper swage diameter, die and ferrule selection are critical for the fabrication of a safe hose assembly.

5.6.4 Light Duty Crimp Ferrules for Small Diameter Hose

General Uses:

Small, light-weight crimped ferrules provide fitting retention for general multi-purpose hose with fabric braid or spiral reinforcement. Usually supplied in brass, aluminum, steel and stainless steel.

Limitations:

Proper equipment is required to crimp the ferrule onto the assembly.
Warnings:

For proper component selection and crimping instructions, refer to your NAHAD Hose Safety Institute Distributor.

5.6.5 Clamp, Interlocking

General Uses:

High pressure and/or high temperature clamping on ground joint coupling, interlocking male stems and other fittings with an interlocking collar.

Limitations:

Not designed for use with fittings without an interlocking collar.

Warnings:

Re-tightening of clamps is necessary before each use. Regular inspection of the assembly is recommended. Refer to manufacturer’s recommendations for torque and tightening sequence.

5.6.6 Clamp, Pinch

General Uses:

Metal pinch clamps are manufactured in a variety of styles. These styles include: 1-ear, 2-ear and stepless.

The two-ear clamps discussed in this document are manufactured out of 1008 carbon steel which is zinc plated, or stainless steel. Depending upon the size of the clamps, the physical dimensions of these clamps may vary.

These clamps are designed to attach machined or cast barbed fittings to general multi-purpose hose with fabric braid or spiral reinforcement.
Limitations:

Pinch clamps should not be used for service on high pressure applications. Proper tools are required for installation and removal of pinch clamps.

Warnings:

Sizing of the materials to be clamped is of utmost importance. Proper sizing is achieved by measuring the outside diameter (OD) of the hose after the appropriate fitting (coupling) is inserted firmly and squarely into the hose.

5.6.7 Band & Buckles

General Uses:

To secure medium and heavy wall hose to grooved or serrated fitting shanks. Band and buckle is applied with manual tools only, and therefore may be too time consuming for high volume production. On the other hand, the band & buckle method gives complete diameter versatility. This versatility makes this attachment method especially suitable for field installation and repairs.

Suggested band clamp selection chart:

<table>
<thead>
<tr>
<th>Hose ID</th>
<th>Clamp Band Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>3/8 - 3/8&quot;</td>
</tr>
<tr>
<td>1 1/4 - 2&quot;</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>2 - 12&quot;</td>
<td>3/4&quot;</td>
</tr>
</tbody>
</table>

Limitations:

Not suited for very small diameter hose.

Warnings:

Improperly tightened bands or an insufficient number of bands used per fitting may result in a potentially dangerous hose assembly. A tighter band keeps the fitting more secure, but excess tension could damage the hose and/or fitting.
5.6.8 Internal Expansion Ferrule

**General Uses:**

Internal expanded ferrules are designed to be used with interlocking internally expanded stems to provide high fitting retention and a full flow hose assembly.

**Limitations:**

Special internal expanding equipment is required to assemble these ferrules with internal expanding inserts or pull mandrels.

It is recommended that the fittings and the ferrules be from the same manufacturer. Be sure to measure the OD of each end of the hose to select the proper size ferrule to match the OD of each end of the hose.

5.6.9 Internal Expansion Short Brass or Stainless Ferrule

**General Uses:**

Brass or Stainless Steel Ferrules are used exclusively on internally expanded permanent couplings. Recommended for low pressure discharge and suction service. Commonly used in the transfer of fuel in industry such as homes, airplanes, ships, etc. The working pressure of these fittings may vary with the size of the fitting, the size and construction of the hose and the media being conveyed. Consult your NAHAD Hose Safety Institute Distributor for recommendations.

**Limitations:**

Special internal expanding equipment is required to assemble these ferrules with internal expanding inserts.

It is recommended that the fittings and the ferrules be from the same manufacturer. Be sure to measure the OD of each end of the hose to select the proper size ferrule to match the OD of each end of the hose.

**Warnings:**

These internally expanded short brass or stainless ferrules are not intended for air service.
5.6.10 Clamp, Bolt

*Double Bolt*  
*Single Bolt*  
*Spiral Clamp*

**General Uses:**

These clamps provide a means to secure fittings in heavy or light wall hose. For use with low pressure couplings for suction and discharge service, and for light duty material handling applications.

**Limitations:**

Hose outside diameter determines the proper size clamp to use. Single bolt clamps have hose range of 7/8 inch (22.22 mm) to 5-1/4 inches (133.35 mm). Double bolt clamps have hose range of 3-1/2 inches (88.9 mm) to 17-1/2 inches (444.5 mm).

Malleable iron construction restricts use under certain conditions. Check compatibility with media used as well as the environment.

**Warning:**

When using bolt style clamps on helical wire hose, consult your NAHAD Hose Safety Institute Distributor.

5.6.11 Clamp, Preformed

**General Uses:**

Versatile and commonly used to secure hose to many types of fittings, including short, medium and long shank fittings, as well as cam and groove fittings. Can be used with a hand tool in the field, or on site with a hand or automatic production hose clamping machine.

Suggested Band Clamp Selection Chart, Punch Style:
Suggested Band Clamp Selection Chart, Punch Style:

<table>
<thead>
<tr>
<th>Hose ID</th>
<th>Clamp Band Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8- 5/8&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>¾ - 6&quot;</td>
<td>5/8&quot;</td>
</tr>
</tbody>
</table>

Suggested Band Clamp Selection Chart, Rollover Style:

<table>
<thead>
<tr>
<th>Hose ID</th>
<th>Clamp Band Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8- ½”</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>½ - ¾”</td>
<td>½&quot;</td>
</tr>
<tr>
<td>¾ - 2”</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>2 – 6”</td>
<td>¾“</td>
</tr>
</tbody>
</table>

Limitations:

Do not use for steam or other applications where clamp re-tightening is required.

Warnings:

It is recommended that more than one clamp be used if the hose shank length or fitting design will allow.

It is necessary to properly offset buckles 180 degrees to avoid potential leak paths.

Improperly tightened clamps or an insufficient number of clamps used per fitting may result in a potentially dangerous hose assembly. A tighter clamp keeps the fitting more secure, but excess tension could damage the hose, and/or fitting.

Preformed clamp design, metal thickness, band width, material and tension will all have an effect on assembly pressure ratings. Please contact your NAHAD Hose Safety Institute Distributor for guidance.
5.7 Testing Procedures for Industrial Hose

5.7.1 Hydrostatic Proof Pressure Tests (Non-destructive)

A proof test is typically conducted for 5 minutes under pressure at one and a half times (1.5x) the working pressure for new or used assemblies.

Proof or hydrostatic testing refers to testing that “proves” the finished hose assembly meets the pressure rating required by the application for which it will be used, and that the end fittings have been correctly fitted and the assembly is leak free.

- For assembly testing, the rating of the component with the lowest rated working pressure determines the working pressure of the assembly.
- Pressurize hose to 10 psi for 60 seconds prior to conducting the hydrostatic test.
- Hose assembly should be secured in an encapsulated tank that will withstand the pressure; at a minimum, make sure that the hose is sufficiently shielded during pressure testing to stop a coupling in case of a coupling blow-off.
- If applicable, secure hose with steel rods or straps close to each end and at ten-foot intervals along the length of the hose. This will prevent it from “whipping” if a failure occurs. The securing rods or straps must be anchored firmly to the test structure, but should not contact the hose. The hose must be free to move slightly when pressure is applied.
- Hoses must be properly cleaned prior to inspection and testing; this will prevent unexpected reactions between conveyants and the test media.
- 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.
- It is recommended to never stand in front of, over, or behind the ends of a hose assembly during pressure testing.

All hydrostatic testing should be conducted with liquid media. Pneumatic testing with gasses such as air or nitrogen is prohibited. The energy stored when pressure testing with gasses creates a very dangerous system, where product failure may cause injury or death.

Equipment:
- hand pump, a power driven hydraulic pump, or an accumulator system
- outlet valve
- test tank (if applicable)
- Unless otherwise stated by the purchaser, the test medium should be water.

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; take particular care to ensure that all trapped air is released from the hose. This is a critical safety measure because expansion of air compressed in the hose, when suddenly released by bursting or other failure, might result in a serious accident.
2. For reference, mark a line behind the coupling which is at the end of the ferrule, clamp, band, etc.
3. Then gradually raise the pressure to the desired pressure rating. Hold the pressure for the time dictated by hose type and conduct a visual inspection. As the pressure is raised, watch for visual...
indications of permanent deformation, leakage, and coupling slippage. If any of these are noted it is cause for rejection*. After the test is complete, relieve the test pressure before disconnecting the hose assembly from the test equipment and drain the water from the hose. The hose may be flushed with alcohol if all of the water must be removed.

4. When tested in accordance with the above, the assembly under test should be totally leak free for the duration of the test; leakage is defined as a continuous stream of water droplets emitted from a single or multiple locations.

*For industrial hose and depending on coupling design, a minimal amount of hose coupling slippage may be acceptable if the hose does not show any leakage at any time during the test; a second test is recommended in that case to confirm assembly integrity. Contact the manufacturer with any concerns.

5.7.2 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 Helium Leak Test.

5.7.3 Electrical Continuity Test

Electrical continuity testing determines if an electrical path can be established between two points; for hose assemblies, refers to testing the assembly to determine if there is a grounding path between end fittings, which would allow for an electric charge to discharge through the hose to a ground source if necessary. Electrical continuity is accomplished by terminating all metallic components in the hose to the metallic couplings at both ends. Hoses should be tested with a calibrated multi-meter from end fitting to end fitting to determine if the assembly is electrically continuous. If continuity is required and not present, then the hose should be reassembled or rebuilt.

Grounding – Refers to the ability of the static charge to trace a path to a grounding point to “mother earth” for dissipation, and should be monitored to a level of <1000ohms.

Testing for continuity

1. Make sure the hose is fabricated in accordance with HSI procedures and the hose helix or ground wire makes positive contact with the hose fittings. In the case of a wire braided hose a tack or staple may be required to assure the braid is contacting the hose shank.

2. It is recommended that continuity be checked prior to and after hydrostatic testing to assure that wires have not become dislodged during the test.

3. Select the ohm setting on the meter. Be sure to set unit to ohms, not mega ohms.

4. Place the hose ends close enough so that the 2 contacts wires on the meter can reach each end fitting or seat.

5. Hold the meter contacts firmly on each end and read the meter.

6. If the meter reads below 10 ohms, the hose passes the conductivity test. (In general, acceptable levels are less than 100 ohms, unless otherwise specified by industry standards. Check with manufacturer for acceptable ohm readings.)

5.7.4 Electrical Resistance Test

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

Elongation testing is a non-destructive method for determining a hose condition at different pressure ratings. Except for Oil Suction & Discharge Hose (Dock Hose) covered by ARPM (RMA IP-8), elongation tests are not typical. The end user would specify the need and frequency of testing.

Per ARPM IP-8: With some type of hose, it is useful to know how a hose will act under pressure. All change in length tests, except when performed on wire braid or wire spiraled hose, are made with original length measurements taken under a pressure of 10 psi (0.07 MPa). The specified pressure is applied and immediate measurement of the characteristics desired are taken and recorded.

Percent length change (elongation or contraction) is the difference between the length at 10 psi (0.07 MPa) and that at the specified pressure times 100 divided by the length at 10 psi (0.07 MPa). Elongation occurs if the length of the hose under the specified pressure is greater than at a pressure of 10 psi (0.07 MPa). Contraction occurs if the length at the specified pressure is less than at 10 psi (0.07 MPa). Reference marks are applied on the hose 20 inches (500 mm) apart (original length.) The hose is then repressurized to the maximum working pressure for 30 seconds and the reference marks are measured (final length.) The percentage change in length is the difference between the final and original lengths, divided by the original length, times 100.

% Length Change Formula:

\[ \% \text{ Length Change} = \frac{L_o - L_p}{L_o} \times 100 \]

Where:

- \( L_o \) = Original measured length at 10 psi (0.07 MPa)
- \( L_p \) = Pressurized measured length at the specified pressure.

In the event that elongation length measurement is required, the following is an accepted process and may be incorporated into your test procedure.

A. Pressurize the hose to one time working pressure, hold for 30 seconds, release pressure to 10 psi and take the initial length measurement at 10 psi. Initial length: \( L_o = \) _____.

B. Measure the hose length under pressure (Test Pressure Length), \( L_t = \) _____. Calculate the temporary elongation as follows:

\[ L_t - L_o \times 100 = \% \, L_o. \]

C. Release the pressure, wait 30 seconds, measure and record the Overall Final Length, and drain hose.

Requirements for elongation of **new dock hose** per ARPM IP-8:

**NOTE 1:** The hose shall not elongate more than 7.5% at 150% of working pressure as determined by the formula \( \frac{L_{tp} - L_o}{L_o} \times 100 \).

Testing of **used hose** needs to meet the following per ARPM IP-11-4

Calculations:

a. Test pressure elongation, percent:

\[ \frac{L_t - L_o}{L_o} \times 100 = (A) \]
b. Immediate release elongation, percent:
\[
\frac{L_i - L_o}{L_o} \times 100 = (B)
\]

c. Permanent release elongation, percent:
\[
\frac{L_p - L_o}{L_o} \times 100 = (C)
\]

Examination of Elongations – After each periodic pressure test, the elongation results will be compared to those obtained in the testing of the hose when new.

An increase over the original value at the end of any periodic testing greater than shown below requires that hose to be removed from service.

a. When tested at 1 ½ times rated working pressure, test pressure elongations at any periodic test shall not be greater than the new hose test pressure elongation (A) plus 4% or twice (A), whichever is greater.
b. Immediate release elongation at any periodic test shall not be greater than the new hose immediate release elongation (B), plus 4% or twice (B) whichever is greater.
c. Permanent release elongation at any periodic test shall not be greater than the new hose permanent elongation (C), plus 4% or twice (C) whichever is greater.

5.7.6 Special requirements: Coast Guard testing requirements

From Coast Guard document 33 CFR Ch. 1 (7-1-07 Edition); Subpart C – Equipment Requirements: 154.500 Hose Assemblies

Each hose assembly used for transferring oil or hazardous material must meet the following requirements:
(a) The minimum design burst pressure for each hose assembly must be at least four times the sum of the pressure of the relief valve setting (or four times the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(b) The maximum allowable working pressure (MAWP) for each hose assembly must be more than the sum of the pressure of the relief valve setting (or the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(c) Each nonmetallic hose must be usable for oil or hazardous material service.
(d) Each hose assembly must either have:
   (1) full threaded connections,
   (2) Flanges that meet standard B16.5 *Steel Pipe Flanges and Flange Fittings*, or standard B16.24 *Brass or Bronze Pipe Flanges*, of the American National Standards Institute (ANSI), or
   (3) Quick-disconnect couplings that meet ASTM F1122
(e) Each hose must be marked with one of the following:
   (1) The name of each product for which the hose may be used, or
   (2) For oil products, the words “OIL SERVICE”, or
   (3) For hazardous materials, the words “HAZMAT SERVICE – SEE LIST” followed immediately by a letter, number or other symbol that corresponds to a list or chart contained in the facility’s operation manual or the vessel’s transfer procedure documents which identifies the products that may be transferred through a hose bearing that symbol.
(f) Each hose also must be marked with the following, except that the information required by paragraphs (f) (2) and (3) of this section need not be marked on the hose if it is recorded in the hose records of the vessel or facility, and the hose is marked to identify it with that information:
   (1) Maximum allowable working pressure;
(2) Date of manufacture; and
(3) Date of the latest test required by section 156.170.

(g) The hose burst pressure and the pressure used for the test required by 156.170 of this chapter must not be marked on the hose and must be recorded elsewhere at the facility as described in paragraph (f) of this section.

(h) Each hose used to transfer fuel to a vessel that has a fill pipe for which containment cannot practically be provided must be equipped with an automatic back pressure shutoff nozzle.


33 CFR 156.170 - Equipment tests and inspections

(a) Except as provided in paragraph (d) of this section, no person may use any equipment listed in paragraph (c) of this section for transfer operations unless the vessel or facility operator, as appropriate, tests and inspects the equipment in accordance with paragraphs (b), (c) and (f) of this section and the equipment is in the condition specified in paragraph (c) of this section.

(b) During any test or inspection required by this section, the entire external surface of the hose must be accessible.

(c) For the purpose of paragraph (a) of this section:
   (1) Each nonmetallic transfer hose must:
      (i) Have no unrepaired loose covers, kinks, bulges, soft spots or any other defect which would permit the discharge of oil or hazardous material through the hose material, and no gouges, cuts or slashes that penetrate the first layer of hose reinforcement as defined in Sec. 156.120(i).
      (ii) Have no external deterioration and, to the extent internal inspection is possible with both ends of the hose open, no internal deterioration;
      (iii) Not burst, bulge, leak, or abnormally distort under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and
      (iv) Hoses not meeting the requirements of paragraph (c)(1)(i) of this section may be acceptable after a static liquid pressure test is successfully completed in the presence of the COTP. The test medium is not required to be water.
   (2) Each transfer system relief valve must open at or below the pressure at which it is set to open;
   (3) Each pressure gauge must show pressure within 10 percent of the actual pressure;
   (4) Each loading arm and each transfer pipe system, including each metallic hose, must not leak under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and
   (5) Each item of remote operating or indicating equipment, such as a remotely operated valve, tank level alarm, or emergency shutdown device, must perform its intended function.

(d) No person may use any hose in underwater service for transfer operations unless the operator of the vessel or facility has tested and inspected it in accordance with paragraph (c)(1) or (c)(4) of this section, as applicable.

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(e) The test fluid used for the testing required by this section is limited to liquids that are compatible with the hose tube as recommended by the hose manufacturer.

(f) The frequency of the tests and inspections required by this section must be:

(1) For facilities, annually or not less than 30 days prior to the first transfer conducted past one year from the date of the last tests and inspections;

(2) For a facility in caretaker status, not less than 30 days prior to the first transfer after the facility is removed from caretaker status; and

(3) For vessels, annually or as part of the biennial and mid-period inspections.

5.7.7 Aircraft Fueling Hose, Ground Support

Please refer to API 1529 for detailed requirements.

Section 7.2.2 of the API 1529 standard states:

1.2.2 Hose assembly

The following tests shall be conducted on each hose assembly:

(a) Complete visual inspection
(b) Proof pressure in accordance with section 6.5.3
(c) Electrical continuity in accordance with section 6.5.3.2

These tests are conducted by the one who “assembles” the product. Section 7.3 follows with the identification requirements for each assembly including a test certificate that shows testing was performed and marking the couplings via serial numbers that link to the test certificate.
5.7.8 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:

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

**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.
- Restrictions in the tube.
- Rusted Couplings
- Ferrule interlocks properly with hose stem

Visual inspections are also an important component of a hose maintenance program. In-service hose assemblies should be periodically checked for:

- Leaks at the hose fittings or in the hose.
- Damaged, separated or pulled back covers.
- Cracked, damaged, deformed or badly corroded fittings.
- Other signs of significant deterioration such as blisters.
- Compromised reinforcement where the wires are exposed and show signs such as unwrapped, broken or corroded.
- Dents, twists, or kinks
- Discoloration of color coded hose cover
- Verify test date and pressure are in conformity with requirements for the application.
- Fitting Thread and seat condition

See Section 12.5 for additional detail.
5.8 Custom-Made Hose

Custom Made hose is generally hose that is manufactured to meet the requirements of a specific application. Application of hose components (tube reinforcement/cover etc.) is typically by hand. Applications requiring hose attributes that are not typically available with standard hose assembly components are usually considered custom. Application considerations requiring non-standard solutions include: required bend radius, chemical, heat or abrasion resistance (both interior and external), end fittings, working pressure/vacuum, bore size, made to order length, and built on ends.

Many people refer to these applications as hand built hose. For the purposes of this document, the terms "hand built hose" and "custom made hose" can be used interchangeably.

5.8.1 Background

(Taken from the Hose Handbook, published by the Association of Rubber Products Manufacturers.)

The term “hand built hose” applies to two general types of hose, i.e., non-wire reinforced and wire reinforced, which are made by hand on a steel mandrel.

The mandrel is mounted on a series of double roller stands and one end of the mandrel is held in the jaws of a power driven chuck in order to rotate the mandrel during the making operations.
Non-Wire Reinforced Hose is made of the same components as machine wrapped ply hose, namely, a rubber tube, plies of fabric reinforcement wrapped around the tube and a rubber cover. The hose is made by hand when it is too large in diameter, too long to fit in the three roll Making Machine, or when the hose is made with special ends. The hand method is also used frequently when the fabric reinforcement must be applied one ply at a time.

The tube for hose up to 8” internal diameter is either extruded or spiraled and mounted on a mandrel. The tube for hose larger than 8” diameter is formed by wrapping calendered tube stock around the mandrel with an overlapping seam running the length of the tube. The frictioned and cut fabric is applied to the tube by hand and rolled down progressively as the mandrel is turned.

Tire cord fabric when cut and spliced in bias lengths only has strength in the cord direction of the bias. In order to compensate for the unidirectional strength and to have a balanced hose construction, the tire cord fabric is applied one ply at a time and the direction of the cord lay is reversed with each succeeding ply. Cord hose is always made with two or more plies. Tire cord fabric can also be cut into strips and applied as a spiral from end to end.

A calendered sheet of cover stock is applied to the carcass to complete the construction of the hose. The hose is cross wrapped with one or more layers of nylon or cotton tape in a power chuck before vulcanization. The wrapping tape is removed after vulcanization and the mandrel withdrawn from the hose.

Wire Reinforced Hand-Built Hose, as the name indicates, has wire added to the reinforcement component of the construction. The wire may be present to prevent the hose from collapsing in suction service, to prevent kinking of pressure hose which must be curved in a small radius loop, or to obtain the strength necessary for high pressure service.

The wire in suction hose is located underneath the main plies of fabric reinforcement to provide rib support against the external pressure. In fact, rough bore suction hose is made with one helix of flat wire forming the bore of the hose and thus is located underneath the tube member of the construction.

Combination pressure and suction is made with the wire placed approximately midway in the plies of the fabric. In pressure hose, the wire is positioned over the main plies of fabric to provide hoop strength against high internal pressure. Flat wire is used for the inner wire of rough bore hose and round or flat wire may be used in the body of pressure or suction hose. The wire is present in most wire reinforced hose in the form of a close spaced helix or spring which opposes inward or outward radial stresses but does not add any significant strength to the hose in the axial direction. When high strength is needed in both axial and radial directions, the hose is built with two or more even numbers of layers of wire. Each layer is composed of many strands of solid round wire or wire cable applied in a spiral from end to end.
over the fabric reinforcement. The wire lays on the hose in a spiral forming an angle greater than 45 degrees with the axis of the hose. The direction of the wire spiral is reversed with each layer of wire for balanced strength.

Hand-built hose is produced with various types of ends, depending upon use, as follows:

- **Straight ends** – hose has same inside diameter at ends as body
- **Enlarged ends** – to provide full-flow characteristics, an end can be manufactured with a larger I.D. than the bore of the hose. This special end is generally restricted to hand-made hose where the special mandrels can be handled in a practical manner.
- **Soft ends** – generally restricted to suction-type hoses that contain a close-spaced helical wire throughout the hose. To facilitate coupling, the helix is terminated before the end of the hose and the end is completed with suitable fabric reinforcement to provide adequate strength and wall thickness. Available on either straight or enlarged end hose.
- **Flanged ends** – many installations are best suited for hose with flanged connections. Certain styles of hose can be made with rubber flanges molded as an integral part of the hose. These flanges can be drilled to match standard ratings. Metal inserts are sometimes used to provide the necessary rigidity and bolting strength. Another style of flanged end utilizes a partial flange molded as an integral part of the hose which is used in conjunction with metal back-up rings for bolting purposes. This permits alignment of bolt holes without rotating the hose.
- **Built-in nipples** – these nipples are used for high pressure service or for hose handling hazardous liquids.

### 5.8.2 Applications and Markets

**General**
Applications and markets for Custom Made hose are extensive. These include but are certainly not limited to:

- **Chemical**
  - Acid discharge hose
  - Acid suction hose
  - Chemical transfer hose
- **Marine**
  - Hardwall marine industrial hose
  - Softwall marine industrial hose
- **Water**
  - Fire engine suction hose
  - Furnace door hose
  - Water discharge hose
  - Water suction hose
  - Water jetting hose
- **Dock/ O.S. & D.**
  - Flex barge dock hose
  - Hot tar and asphalt hose
  - Molten sulphur dock hose
  - Oil suction and discharge hose
  - Rough bore dock hose
  - Vapor recovery hose
  - Viton dock hose
- **Petroleum**
  - Mud pump suction hose
  - Petroleum transfer hose
  - Sewage digester hose
  - Tank truck hose
- **Dredge**
  - Dredge sleeve
  - Sand suction hose
- **Material Handling**
  - Clam jetting hose
  - Concrete hose
  - Debris handling hose
  - Dry material discharge hose
  - Elephant trunk hose
  - Fish suction hose
  - Furnace intake and discharge
  - Hot air blower hose
  - Industrial vacuum hose
  - Slurry handling hose
Dredging Application:

Application Considerations

Material handling hose

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.

There are many parameters which will affect the hose life: the material type and size, flow rated velocity, % solid, turbulence, temperature of the product and ambient environment, bend radius, angle of impact of material transferred, chemical attack, static electricity and others.

Reasons to use rubber hoses over rigid piping are flexibility, ability to reduce vibration and mostly that rubber often outperforms steel in abrasion resistance. Abrasion is mainly the result of the change in momentum of the product (Mass x Velocity) in bends, thus inducing high localized wear. So to maximize hose longevity we recommend the end user install the hose with the largest possible bend radius; this will spread the wear over a large section of the hose.

Non-Conductive, static dissipating, electrically continuous and electrically discontinuous assemblies

There has always been much confusion involved with the terms applied to industrial hoses regarding the capabilities of being non-conductive, static dissipating, and electrically continuous or discontinuous. This confusion primarily originates because we do not properly relate these terms to the HOSE APPLICATIONS and WHAT THE HOSE IS EXPECTED TO DO IN APPLICATION. To determine the proper hose to use when the possibility of any electrical build-up is involved, it is most important to know and understand the application and what is expected of the hose performance in the application.

Non-conductive hose

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.

**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 the rubber material to the hose ends, provided the correct coupling type is used.

Note: Non-black and many black rubber compounds will not dissipate static electricity. Only black compounds formulated with high carbon black content will dissipate static electricity.

**Electrically continuous assembly**

Electrically continuous 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 necessary a static dissipating hose

**Electrically discontinuous assembly**

Electrically discontinuous 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 thousands of Ohms (electrical resistance typically > 25,000 Ohms)

**Hose & Hose Assembly Working Pressure/Temperature - Guidelines**

*It is important to understand that maximum assembly working pressures will decrease as temperatures increase.*

Hose working pressure ratings are recommended in accordance with ARPM design factors at ambient temperatures. Do not operate outside of hose temperature limits specified by the hose manufacturer. Even within hose temperature limits, end fittings and hose size can impact performance at higher temperatures. Contact each component’s manufacturer for recommendations.

Note: Hose and hose assemblies should also not be subjected to storage conditions or used in service applications at temperatures below the minimum specified temperature rating (Example: -40°F (-40°C)) of the hose manufacturer. Hose may be stored at lower temperatures, but must be warmed before working with it.
5.8.3 Application Requirements – STAMPED (Custom Made Hose)

Purpose

The purpose of this section is to provide a concise guide to assist in determining the correct hose, coupling and attachment method that will satisfy the customer’s needs. This should be used as the basis for collecting ALL information critical to the proper design of the hose for the desired application.

General

The guide uses the STAMPED process. STAMPED is an acronym and stands for the 7 major information areas required to provide a quality hose assembly for the customer, as follows:

S stands for **SIZE**; I.D. and length; any O.D. constraints
- overall length should be specified to include fittings
- tolerances need to be specified if special requirements exist

T stands for **TEMPERATURE** of the material conveyed and environmental
- Are there factors such as heat sources in the environment in which the hose will be used
- Continuous (average) and minimum and maximum temperatures have to be specified for both the environment and material conveyed
- Note if flame resistance or flammability will be an issue
- Sub-zero exposure

A stands for the **APPLICATION**, the conditions of use
- Configuration/routing (add a sketch or drawing if applicable)
  - is the hose hanging, laying horizontally, supported, unsupported (orientation and aspect of the hose)
  - what else is attached to the hose, any external load on the hose
  - bend radius requirements, flexibility
  - elongation considerations with working pressure
- Quantify anticipated movement and geometry of use requirements
- Intermittent or continuous service
- Indoor and outdoor use
- External conditions – abrasion, oil (specify type), solvents (specify type), acid (specify type and concentration), ozone, salt water
- Hose now in use
  - Type of hose
  - Service life being obtained and description of failure or source of customer dissatisfaction

M stands for the **MATERIAL** being conveyed, type and concentration
- Are there special requirements for this hose tube
  - Any special specifications (or agency requirements) that need to be considered (e.g., FDA, API)
  - Will the material be continuously flowing, or sit in the hose for long periods of time (specify)
- Media velocity, flow rate
- Chemical name/concentration (MSDS)
- Salt water
- Solids, description and size

P stands for the **PRESSURE** to which the assembly will be exposed
- Temperature implications
• Vacuum considerations

E stands for ENDS: style, type, orientation, attachment methods, etc.
• Uncoupled or coupled hose; hose with built-in fittings
• Specify end style (see chart)
• Materials and dimensions (steel, stainless, etc.)
• Conductivity requirements

D stands for DELIVERY; testing, packaging, and delivery requirements
• Testing requirements
  o certification requirements (e.g., Coast Guard)
• Any special packaging requirements
• Any special shipping requirements

Directions

Using the form:

1. Inform the customer you will be using an application form titled STAMPED Information Required for Custom Made Hose.

2. Ask your customer the pertinent questions outlined on the form, in sequence.

3. After completing the form, ask your customer to confirm their answers as you repeat them, in sequence.

4. The following list of special considerations may help to clarify application parameters:
   1. Abrasion – tube, cover, thickness, internal/external
   2. Electrical conductivity requirements
   3. Environment
   4. Flammability
   5. Flow rate
   6. Fluid velocity
   7. Movement (type, distance, frequency)
   8. Ozone
   9. Permeation (vapor conveying hose)
   10. Routing/configuration
   11. Salt water
   12. Static electricity
   13. Ultraviolet light
   14. Vibration considerations
   15. Special marking or branding requirements

5. Provide the completed form to a qualified NAHAD manufacturer.

(See STAMPED Form on next page)
STAMPED Information Required for Custom Made Hose

**Customer Information:**
- Company: _________________________
- Contact: _________________________
- Address: _________________________
- Phone: __________________________
- Quote needed by: ________________
- Fax: ____________________________
- E-mail: _________________________
- P.O.#: __________________________
- Terms: _________________________
- Date Required: ________________

**Quantity Required:**

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<td>End 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging/packing requirements:</td>
</tr>
<tr>
<td>Any special shipping requirements:</td>
</tr>
<tr>
<td>Ship Via:</td>
</tr>
<tr>
<td>Testing Required: Y N</td>
</tr>
<tr>
<td>Certification Required: Y N</td>
</tr>
</tbody>
</table>

**Application considerations:** Abrasion – tube, cover, thickness, internal/external; Electrical conductivity requirements; Environment; Flammability; Flow rate; Fluid velocity; Movement (type, distance, frequency); Ozone; Permeation (vapor conveying hose); Routing/configuration; Salt water; Static electricity; Ultraviolet light; Vibration considerations; Special marking or branding requirements

**Special Requirements:** (tube, cover, etc.)
5.8.4 Custom Hose

General

In the custom made hose business, the distributor works directly with the end-user to understand the application and environment, and will typically specify all aspects of the STAMPED process (Size, Temperature, Application, Material, Pressure, Ends, and Delivery). The distributor works with the customer to define and qualify the opportunity, oversee delivery, help with problem resolution, and is instrumental in assisting with final installation. The distributor is the primary point of contact for the customer, the first line of resources for the customer, and is backed by the manufacturer. The distributor also can provide packaging and handling support in their work with end-users. They should recognize any risk in leaving the customer to install the hose, and educate the customer on proper care and handling of the hose. Finally, the distributor should assess any post-installation issues or problems, and answer any questions.

The manufacturer typically specifies and/or recommends the materials used for actual hose construction based on information provided from the STAMPED process and fabricates an appropriate hose. Hose material information is included elsewhere in this document for informational purposes.

Hose Construction – overview

A hose is a reinforced, flexible conduit used to move materials from one point to another or to transmit energy. It is flexible to accommodate motion, alignment, vibration, thermal expansion and contraction, portability, ease of routing, and ease of installation.

Most hoses are made up of three elements: (1) a tube, (2) reinforcement, and (3) an outer cover. Each of these components is usually adhered to the adjacent components by bonding agents or thin layers of specially compounded rubber.

Tube

The tube is the innermost rubber or plastic element of the hose. The tube may be placed over reinforcing elements. For suitable service, the tube must be resistant to the materials it is intended to convey. The characteristics of the rubber or plastic compound from which the tube is made and the thickness of the tube are based on the service for which the hose is designed.

Reinforcement

Reinforcement can be textile, plastic, or metal, alone or in combination, built into the body of the hose to withstand internal pressures, external forces, or a combination of both. The type and amount of reinforcing material used depends on the method of manufacture and on the service requirements. For example, a residential garden hose does not need the same level of reinforcement as required for high pressure air hose used in construction and mining applications.

Cover

The cover is the outer element and can be made of various materials; its prime function is to protect the reinforcement from damage and the environment in which the hose will be used. Covers are designed for specific applications and can be made to be resistant to oils, acids, abrasion, flexing, sunlight, ozone, etc.
Hose Materials

The basic materials in the manufacture of hose are rubber, plastics, textile yarns, textile fabrics, and metal in the form of wires and cables. The term “rubber” will be used in its broadest sense, and will include all elastomeric materials that are compounds of natural or synthetic elastomers, or combinations of these materials.

Note: For specific rubbers, plastics, wires and yarns used in hose – see Appendix C

Rubber

To provide a wide range of physical properties for specific service needs, elastomers are mixed with various chemicals. There are many compounding ingredients and compounding methods available to the hose manufacturer, and many types can be blended in almost unlimited combinations to obtain the most desirable properties for the application.

The reader is cautioned that the “General Properties” described are just that, properties which have been found to be generally applicable in the experience of persons familiar with rubber chemistry. However, the reader should always follow the manufacturer’s recommendation as to the use of any particular rubber composition, especially with respect to the resistance of the rubber composition to the materials it is intended to carry or protect against. Failure to do so may result in possible damage to property and/or serious bodily injury.

Fabrics

Overview: Textile fabrics used as reinforcement in hose construction provide the strength to achieve the desired resistance to internal pressure or to provide resistance to collapse, or both.

The properties of a fabric depend on the construction and the material from which the yarn is made and on the type of weave used.

One common hose fabric is woven from warp yarns, which run lengthwise, and fill yarns, which run cross-wise. Usually they are woven at right angles to each other. The most common weave is known as “plain weave” where the warp and fill yarns cross each other alternatively. Other weaves used, though to a lesser degree, are twill, basket weave, and leno. Leno weave is used mainly where the fabric must be distorted in the hose as in certain types of curved hose. Leno also provides a means for better adhesion than other patterns. Woven Cord is a special type of hose reinforcement. The warp cords are strong while the fill yarn is very fine and merely holds the cords in position. This is often called “tire cord” because this type of construction is commonly used in reinforcing tires. Woven cord provides strength in one direction only. When woven cord is used, a minimum of two layers are applied in alternate directions.

To adhere to the tube and cover of the hose, the fabric must be rubberized. The fabric is either frictioned or coated with a thin layer of rubber. Before rubberizing, some fabrics are treated with liquid adhesive.
5.8.5 Custom Hose Ends

The ends of hose can be provided in a variety of ways. The selection of the end configurations is dependent on the application and the input/desire of the end user. Not all end options are appropriate for all applications - this will be determined by the manufacturer. Each manufacturer has their own end configuration availability. The end options may vary between manufacturers depending on their process and/or design parameters. It is not uncommon for a hose to have different end styles on each end.

<table>
<thead>
<tr>
<th>Fittings/Couplings</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-In Nipple (See Illustration Below)</td>
<td>Steel nipple is built into the hose during fabrication providing maximum holding power and a full flow unrestricted transition area. Available in threaded, fixed flange, floating flange, beveled for weld, or grooved end styles. Recommended for heavy duty, high pressure applications.</td>
</tr>
<tr>
<td>Built-In Nipple/Rubber Lined</td>
<td>Hose tube extends through the nipple and up the face of the flange providing a full flow unrestricted transition area. Extends service life by protecting the steel nipple from contact with conveyed material. Recommended for heavy duty, high pressure abrasive applications. (Provides added abrasion resistance and extended service life. Recommended for highly abrasive or corrosive applications.)</td>
</tr>
<tr>
<td>Built-In Rubber Flange (B.I.R.F.) (See Illustration Below)</td>
<td>Fabric plies and hose tube turn up the face of the flange. Steel back-up flange and rubber flange are molded together. Recommended for light to medium duty, low pressure, abrasive applications. Sometimes known as Duck &amp; Rubber Flange or integral rubber flange.</td>
</tr>
<tr>
<td>Enlarged</td>
<td>Hose end is enlarged to accommodate the outside diameter of pipe. Used in typically lower pressure rated applications with soft cuffs. Consideration must be given to enlarged i.d. and length.</td>
</tr>
<tr>
<td>Split Bolted Flange</td>
<td>Two piece reusable coupling system is attached externally with compression bolts and allows the user to fabricate assemblies in the field. Designed for large bore material transfer hose.</td>
</tr>
<tr>
<td>Beaded End (B.E.) (See Illustration Below)</td>
<td>Hose tube and reinforcement extends through the steel ring and up the face of the stub end providing a full flow. Either full floating or split ring flanges are used to ensure proper bolt hole alignment. Recommended for abrasive applications.</td>
</tr>
<tr>
<td>Soft Cuff</td>
<td>Internal wire reinforcement is eliminated from the end of the hose providing a soft and flexible section for ease of attaching. Consideration must be given to cuff length and cuff o.d.</td>
</tr>
<tr>
<td>Capped ends</td>
<td>Hose end covered to protect its internal elements</td>
</tr>
</tbody>
</table>

**End Styles**

- Custom ends
  - Hose couplings designed specifically to engineered specifications; sanitary fittings; tapered ends
- Straight or plain ends
  - End of hose is square and cut straight with no end fittings or cuffs.

**Built-in Nipple Attachments**

- Fixed / floating flanges
  - 150# and 300# drilling ANSI forged steel flanges. Metric sizes also available. Also available in stainless steel. Can also be reducing.
- Beveled for weld
  - Plain end nipple ready for welding.

Other styles of built-in fittings available on request
Built-In Rubber Flange (BIRF)

Built-In Nipple Flange (BINF)

Beaded End
5.9 Ducting

5.9.1 General

All types of ducts are classified into two general groups by Positive or Negative Pressure. Positive Air Ducts tend to have wider pitch while Negative pressure Air Ducts typically need a narrow pitch to handle vacuum.

*General warning:* these are general guidelines; please consult Section 3 (STAMPED) for more specific guidance. For application-specific uses, please check with the manufacturer.

Air Ducting

*General Uses:*

Air ducts tend to be lighter in weight as they are designed to transport air. Their pitch will be determined by either a negative or positive air application. The products tend to have lighter weight fabric and helix. Lay flat duct is also used for positive pressure air handling. Some typical applications are:

- Heating and Cooling
- Drying
- Dehumidifying
- Cleaning
- Dust Covers
- Supply
- Connectors
- Air Filter Intake
- General purpose

*Limitations:*

Not recommended for heavy particulate media.

Fume Ducting

*General Uses:*

Fume ducts are designed to carry gaseous or other types of non-particulate media so they tend to be lighter in weight. Material selection for fume ducts is important because chemical resistance of the media needs to be taken into consideration. Chemical resistant materials such as TPV, TPR,
EPDM, Hypalon®, Polyethylene, Polypropylene or Fluoropolymer are some typical material types. Some typical applications are:

- Laboratory
- Industrial
- Automotive
- Painting
- Welding
- Soldering
- Plating

**Dust Ducting**

**General Uses:**

Dust ducts are generally medium weight as they are designed for light particulate media. Material selection for dust ducts is important so that abrasion resistant materials are used. Abrasion resistant materials such as Neoprene Coated Polyester, Neoprene Coated Nylon, TPU, TPV, EPDM, Polyethylene or Polypropylene are some typical material types. Dust ducts, as a negative air application, generally require a narrower pitch. Some typical applications are:

- Filtering
- Movement
- Exhaust
- Duct Cleaning
- Textile Fiber Collection
- Vacuum Cleaning
- Lint collection
- Loading (containment)
- Cutting
- Grinding

**Material Handling Ducting**

**General Uses:**

Material handling ducts are generally heavier in weight with thicker wall sections because they are designed to handle heavier particulate media. Material selection, wall thickness, pitch and wire gauge are critical components for the duct design. Abrasion resistant materials such as Neoprene Coated Polyester, Neoprene Coated Nylon, TPU, TPV, EPDM, Polyethylene or Polypropylene are some typical material types. Some typical applications are:

- Shavings
- Chips
- Powders
- Debris
- Leaf Collection
- Street Sweeping
- Lawn Vacuum
- Slurries
- Sawdust Collection
- Drains
- Packing Popcorn
5.9.2 Types of Duct Construction

*Flexible PVC with Helix*

Flexible PVC with rigid PVC helix - for use in dust and fume ducting applications up to 150° F

Flexible PVC ducting with wire helix.

Unique wire reinforced/polypropylene construction; allows full contractility with extendibility; for use in air, dust and fume ducting applications up to 175° F
**Metal Ducting**

**Metal Ducting: flexible interlocked metal duct** A single metal strip is formed to create a duct that can be used for dust, fume and hot air ducting applications up to 750° F for Galvanized material and 1500° F for Stainless Steel.

This type of ducting can be used in packed or unpacked configurations.

**Metal Ducting: flexible gas-tight metal duct** A single metal strip is corrugated and helically-wound to form a duct that can be used for air supply and fume exhaust ducting applications up to 600° F for Aluminum material and 1500° F for Stainless Steel.
Crushproof type ducting

Crushproof-type ducting hoses are custom designed to handle vacuum, air intake and industrial bellows applications. They are made to accommodate applications requiring flexibility or stretching using Butyl, EPDM, Nitrile and Neoprene rubber materials.

Wire Reinforced Neoprene Ducting

Neoprene wire reinforced ducting hoses offer flexibility combined with excellent crush resistance and tensile strength. Can be used for all air handling applications, dust and fume control and light material handling.

Wire Reinforced Thermoplastic Rubber Ducting

Thermoplastic rubber wire reinforced ducting hoses provide flexibility with compressibility for demanding and difficult applications. They can be used for air transfer, venting systems, fume control, exhaust gases, dust collection and light abrasion transfer.
**Custom Ducting**

Certain applications may require ducting manufactured to custom specifications. Custom ducting may involve special shapes, raw materials, special sizes and configurations. Custom ducting can be used in all four application areas listed above. Contact manufacturers with specific requirements.

Below are examples of custom ducting.
5.9.3 Ends for Ducting

When working with duct assemblies, there are a number of end finishes that can be considered. Based on the application or use, the customer will determine what type of end finish is required. The following are a sampling of a variety of end finishings that are available and typically used. Typical end finishes are usually provided by the manufacturer; specialty end finishes can be provided by either the manufacturer or the distributor.

In general, the larger the duct size, the fewer end finish options available. Sewn or fabric type cuffs are typically used on larger diameter ducts. Molded cuffs would typically be used for smaller diameter vacuum hoses below six inches in diameter. See section 5.8 for specialty or custom end finishes. Consult the manufacturer for specific requirements.

Standard end fittings and finishings:

**Sewn Cuff** – provides a smooth surface that can be used with banded clamps. If the customer needs to fit the cuff over piping or a round port and secure clamps this end configuration offers a soft cuff which can easily be clamped over. It is also known as a factory made “soft cuff.”

**Standard/Enclosed Belted Cuff** – creates an easy attachment method or quick connection capability. It includes a belt with a spring clamp that can be cinched around the connection.

**Pull Tabs** – Used to pull the duct onto the connector, or to pull through enclosed areas; good for applications where the ducting must be pulled through a man-hole (utility applications) these belt loops and pull tabs allow easy routing through a man-hole.

**Flat Band/Nylon or Steel Ring/Wire Rope** – Keeps the end open for easy air flow; also used for interlocked duct connections; gives the end of the hose form so it won’t collapse and makes it easier to fit over pipe or ports.

**Funnel Cuff (reducer)** – Sewn transition piece to adapt to larger or smaller connection points; allows for a soft cuff that can slip easily over a pipe to transition from one ID up to a larger pipe OD.
**Enlarged Cuff (belled end)** – transition piece used when cuff ID is larger than hose or duct ID

**Fabric Cuff** - provides an integral smooth surface that can be used for use with banded clamps

**Reduced Cuff** – transition piece used when cuff ID is smaller than duct ID

**Flange** – can be made from steel, aluminum, or felt; also can have hole patterns drilled for custom connection purposes.

**Screw on Cuff** - Screw on cuffs are produced from a multitude of materials such as PVC, Urethane, Polypro or Polyeth and simply provide a means to plug into or slip or fittings in existing vacuum system or create a finished end for vacuum applications. These cuffs can also be sealed on to provide air tight/water tight seal with the appropriate adhesive or sealer.
Specialty End Finishings for Ducting

At times, OEM customers will request custom made cuffs, made to print for their application. Custom made cuffs can be injection molded, or over molded from a variety of materials including TPE, PVC, and EVA. In this instance, careful consideration must be given to the pitch and diameter of the wire helix and the design of the particular duct cuff. Consult the manufacturer with specific application requirements.

Below is a duct with a custom specialty end: cuff is overmolded onto a custom hose; below that is another custom specialty end: Santoprene molded 90 degree elbow in a screw on cuff
5.9.4 Ducting Accessories

**Screw Clamps** – also called worm gear clamps; used to secure duct.

**Bridge Clamps** – typically used in applications without a cuff; used to secure duct and bridge the wire; available in both clockwise or counter clockwise configurations.

**Spiral double bolt clamp** - These clamps provide a means to secure heavy or light wall ducting with the wire on the clamp located on both sides of the duct outer helix; available in both clockwise and counter clockwise helix configurations.
Clamp, Preformed - To permanently secure ducting to barbed or beaded connectors

![Clamp Images]

Aluminum or stainless steel sleeves Used to connect two ducts with band clamps; used to extend the length of the overall duct, or to repair existing duct.

Duct Coupler: Standard duct coupler to minimum on 24 gauge sheet metal construction with rolled containment bead in middle of coupling or on ends of coupling. The coupler slips into the ID of two duct lengths and are simply attached with worm drive clamps to create extended lengths.

![Duct Coupler Image]
**J Lock connector** – used for quick connection of two ducts, or connecting a duct to equipment.

![J Lock connector image](image1)

**Pin lock connector** - used for quick connection of two ducts, or connecting a duct to equipment.

![Pin lock connector image](image2)

**Latch lock connector** - used for quick connection of two ducts, or connecting a duct to equipment.

![Latch lock connector image](image3)
Reducer – molded or metal alternative to the sewn reducer; used to adapt to larger or smaller connection points.

Transition – used to adapt duct to square shaped connectors; molded or metal.

T – used to connect multiple ducts

Y – used to connect multiple ducts.

Sto-sack: A handy sewn on loop makes transporting the hose from location to location easy for the operator.
Section 6 - Composite Hose

Section Contents:

6.1 General Information
6.2 STAMPED
6.3 Composite Hose Materials and Construction
6.4 Composite Hose Fittings
6.5 Testing
6.6 Installation & Usage for Composite Hose
6.1 General

This section pertains to hoses used in multi-layered, non-vulcanized, thermoplastic hose assemblies suitable for hydrocarbons products, aromatic hydrocarbons, solvents, cryogenic hydrocarbons and chemicals with nominal diameters from 1 to 12 inches (25.4mm to 304.8mm.)

General Uses:

Composite hose, consisting of thermoplastics and wire reinforcement, can be used in selective petroleum and chemical service where flexibility combined with strength is required.

Limitations:

The type of hose selected is dependent on application. The hose supplier or manufacturer should be consulted to determine the style of hose needed.

Warnings: Special attention needs to be given to the following:

- Composite hose should not be used to convey solids or abrasive slurries; consult a Hose Safety Institute distributor for an alternative hose type and construction. For applications of composite hose conveying gaseous products, consult the manufacturer for specific recommendations.
- Before cleaning or examining composite hose, it is important the MSDS sheets be supplied detailing all media transferred by that hose to avoid serious injury.
- All media should be thoroughly drained prior to cleaning to avoid chemical or exothermic reactions when the hose is returned to service.
- Pigging of lines should not be used with composite hose.
- Compressed air may be used but hose must be open-ended. Consult manufacturer for maximum pressure rating.
- Consult with the manufacturer for temperature limitations as composite is constructed with thermoplastics, which tend to weaken at elevated temperatures. Care must be taken when cleaning with hot water so as not to exceed the maximum working temperature of the hose. If steam must be used contact the manufacturer for any special recommended practices.
- During any cleaning operation, the assembly must be electrically grounded to avoid build-up of static charge.

6.2 STAMPED

The STAMPED acronym stands for the 7 major information areas required to provide a quality hose assembly for the customer, as follows:

S stands for SIZE: I.D. and length; any O.D. constraints
- Overall length should be specified to include fittings
- Tolerances need to be specified if special requirements exist

I.D., O.D. and overall length of the assembly
- To determine the replacement hose I.D., read the layline printing on the side of the original hose. If the original hose layline is painted over or worn off, the original hose must be cut and inside diameter measured for size.
- The inside diameter of the hose must be adequate to keep pressure loss to a minimum, maintain adequate flow, and avoid damage to the hose due to heat generation or excessive turbulence. The hose should be sized according to the nomographic chart in appendix D.
• **Length tolerances**: The length of hose ordered should be the OAL including the end fittings. OAL measurements should be from flange face to flange face, seat to seat, end of threads to end of threads, etc. If in question, this data should be added to the purchase order.
  - In the as fabricated condition, after testing, the overall length, (OAL), should be within +5%/-2% of the OAL.
  - The maximum change in length at the maximum test pressure should not exceed 10% of initial length.
  - Because of the elongation under pressure, the distributor may need to seek the advice of the manufacturer for applications where length in use is critical.

• **Flow Rate / Fluid Velocity** - The flow rate of the system in conjunction with the inside diameter of the hose will dictate the fluid velocity through the hose. Typical fluid velocities can be seen in the nomographic chart in Appendix D. Please consult your hose supplier for specific recommended velocity ranges. Please note that suction line recommendations are different than pressure lines.

T stands for **TEMPERATURE** of the material conveyed and environmental conditions

- Are there factors such as heat sources in the environment in which the hose will be used
- Continuous (average) and minimum and maximum temperatures have to be specified for both the environment and material conveyed
- Note if flame resistance or flammability will be an issue
- Sub-zero exposure
- Care must be taken when routing near hot manifolds and in extreme cases a heat shield may be advisable.
- Other things to consider: maximum intermittent ambient temperature, fluid temperature, ambient temperature and maximum temperature.
- Maximum assembly working pressures will decrease as temperatures increase.

A stands for the **APPLICATION**, the conditions of use

- Configuration/routing (add a sketch or drawing if applicable)
  - is the hose hanging, laying horizontally, supported, unsupported (orientation and aspect of the hose)
  - what else is attached to the hose, any external load on the hose
  - bend radius requirements, flexibility
  - elongation considerations with working pressure
- Quantify anticipated movement and geometry of use requirements
- Intermittent or continuous service
- Indoor and outdoor use
- Unusual mechanical loads
- Excessive abrasion
- Electrical conductivity requirements
- Equipment type
- External conditions – abrasion, oil (specify type), solvents (specify type), acid (specify type and concentration), ozone, salt water
- Hose now in use
  - Type of hose
  - Service life being obtained and description of failure or source of customer dissatisfaction
- Strength and frequency of impulsing or pressure spikes
- Non-flexing applications (static), flexing applications (dynamic)
- Vacuum requirements

M stands for the **MATERIAL or MEDIA** being conveyed, type and concentration

- Are there special requirements for this hose tube
  - Any special specifications (or agency requirements) to be considered (e.g., FDA, API)
  - Will the material be continuously flowing, or sit in the hose for long periods of time (specify)
- Media velocity, flow rate
- Chemical name/concentration (MSDS)

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• Solids, description and size
• Fluid Compatibility - Some applications require specialized oils or chemicals to be conveyed through the system. Hose selection must assure compatibility of the hose tube. In addition to the hose materials, all other components, which make up the hose assembly (hose ends, o-rings, etc...), must also be compatible with fluid being used. Depending on the fluid, your hose supplier may lower the maximum temperature or pressure rating of the assembly. When selecting any hose assembly, always consult your hose supplier’s recommendations.

P stands for the PRESSURE to which the assembly will be exposed
• System pressure, including pressure spikes. Hose assembly working pressures must be equal to or greater than the system pressure. Pressure spikes greater than the maximum working pressure will shorten hose life and must be taken into consideration.
• Temperature implications
• Vacuum considerations
• Maximum Operating Pressure - This is the maximum pressure that the system should be exposed to in normal operating conditions. For hydraulic hose assemblies, this pressure should be dictated by the relief setting of the system. Both the hose and hose end should not be rated to a pressure less than the maximum operating pressure of the system.
• Pressure Spikes - When a hydraulic system is subjected to a large load in a short period of time, the system pressure can overshoot the relief setting and exceed the maximum operating pressure. Frequent pressure spikes can reduce the life of hydraulic hose assemblies. In general, spiral hose constructions are better suited to high impulse applications, which involve flexing and large pressure spikes. However, there are specialized braided hoses available from various manufacturers. Please consult your hose supplier if there are multiple constructions which meet your application needs.
• Maximum assembly working pressures will decrease as temperatures increase.

E stands for ENDS; style, type, orientation, attachment methods, etc.
• Uncoupled or coupled hose; hose with built-in fittings
• Specify end style (see charts and pictures in Section 5)
• Materials and dimensions (steel, stainless, etc.)
• Conductivity requirements

D stands for DELIVERY
• Specific to customer requirements
• Testing requirements
  • certification requirements (e.g., Coast Guard)
• Any special packaging requirements
• Any special shipping requirements
• Tagging requirements
• Also refers to Determined Overall Length when working with Metal Hose

**Dimension and tolerance guidelines for composite assemblies:**
Size - The bore and bend radius of the hose should comply with the nominal dimensions given by the manufacturer.
Length - The length of hose ordered should be the OAL including the end fittings. OAL measurements should be from flange face to flange face, seat to seat, end of threads to end of threads, etc. If in question, this data should be added to the purchase order.
• In the as fabricated condition, after testing, the overall length, (OAL), should be within +5%/-2% of the OAL.
• The maximum change in length at the maximum test pressure should not exceed 10% of initial length.
• Because of the elongation under pressure, the distributor may need to seek the advice of the manufacturer for applications where length in use is critical.
Temperature Derating Factors for Hose Assemblies

Temperature directly affects maximum allowable working pressure. Most manufacturers rate maximum operating pressures at an ambient temperature of 70 degrees F. If a hose is to be considered for use in an application that exceeds this ambient temperature, consult manufacturer for any pressure derating of the hose assembly.

6.3 Hose Materials and Construction

Composite hoses are comprised of the following:

A. An internal metal wire helix. This may be stainless steel, galvanized carbon steel, aluminum, or carbon steel sheathed in a polymeric material resistant to the materials of service.
   - Stainless steel wire as specified and agreed between purchaser and manufacturer.
   - Galvanized carbon steel wire as specified and agreed between purchaser and manufacturer.
   - Aluminum wire as specified and agreed between purchaser and manufacturer.
   - Carbon wire sheathed in a polymeric material should be coated as required with material resistant to liquid hydrocarbon, aromatic hydrocarbon or liquid chemicals as specified and agreed between the purchaser and manufacturer.
   - Stainless steel wire with a fluoropolymer liner.
B. A multi-ply wall of thermoplastic films and reinforcing fabrics in proportions that give the required physical properties and provide a complete seal. The films may be a flat film, tube, and/or fabric.
C. A fabric cover with an abrasion and ozone resistant polymeric coating.
D. An external metal wire helix. Wire material should be as outlined above.

In all cases, they should be connected to the construction wire or bonding wire to provide electrical continuity. Care should be taken so that wire exposed if a poly-covering has been stripped does not come in contact with highly corrosive materials.

Consult manufacturer for chemical resistance recommendations for the application.

Sample Composite Hoses:
Pressure Ratings

The maximum working pressure of a composite hose should be equal to the Nominal Burst pressure divided by four as a minimum. This may change dependent upon customer requirements and/or regulatory/statutory requirements.

6.4 Composite Adapter Fittings

For all types of end connections used, the part of the fitting which enters the hose, and forms the means by which the fitting is connected to the hose, should be provided with scrolls or protrusions on the surface that correspond to the pitch of the inner reinforcing wire or the hose. Care should be taken to not compress the inner wire and make sure it is properly engaged with the scrolls and protrusions on the surface of the stem.

In all cases, they should be connected to the construction wire or bonding wire to provide electrical continuity. End fitting to end fitting continuity will not be possible when installing non-metallic end fittings.

Typical composite hose fittings:

- Male NPT (Stainless Steel, Carbon Steel, Polypropylene)
- Male and Female Cam and Groove (Stainless Steel, Aluminum, Polypropylene) Note: Gaskets in the female Cam and Groove must be specified based on the application
- Victaulic Groove (Stainless steel, Carbon Steel)
- TTMA Flange (Typically Carbon Steel, but may be Stainless Steel)
- ANSI Flanges (Fixed or Floating, Carbon Steel or Stainless Steel)

Crimp and/or Swage Ferrules: can be Stainless Steel, Carbon Steel or aluminum depending on the application.

Sample Composite Hose Fitting Adapters:
6.5 Testing Procedures for Composite Hose

Hydrostatic Pressure Tests

All fitted hose assemblies should be pressure tested to establish that the end fittings have been correctly fitted and the assembly is leak free.

When testing hose assemblies with epoxy-style end fittings the epoxy should be allowed to cure prior to hydrostatic testing. Consult Manufacturer for recommended cure time.

The following criteria should apply when pressure testing hose assemblies:

- Composite hose assemblies with 1 inch to 4 inches (25 mm to 100 mm) nominal bore composite “standard duty” or general purpose oil and chemical hose should be tested to a minimum of the rated working pressure of the end fittings, but must not exceed one and a half times the rated working pressure of the hose for a minimum period of five (5) minutes. Longer test times may be required, consult manufacturer for specific requirements. (Polypropylene, cam and groove, NPT males and flanges do not have the same test criteria.)
- Composite hose assemblies with 4 inch (100 mm) nominal bore “heavy duty” and 6 inches to 10 inches (150 mm to 250 mm) nominal bore composite hose should be tested to a minimum of the rated test pressure of the end fittings, but must not exceed one and a half times the rated working pressure of the hose for a minimum period of 30 minutes and/or regulatory statutory requirements. (Polypropylene, cam and groove, NPT males and flanges do not have the same test criteria.)
  - **Note:** Composite hose manufacturers may differentiate the 4 inch (100mm) nominal diameter between “standard duty” and “heavy duty”. It is common practice to suggest that “standard duty” hose is for general purpose in plant applications, whereas the “heavy duty” is used in either more rigorous or marine applications.
- Unless otherwise stated by the purchaser, the test medium should be water.

**Recommended Testing Procedure**

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 composite 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.

Hoses must be properly cleaned prior to inspection and testing. This will prevent unexpected reactions between conveyants and the test media. 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.
It is recommended to never stand in front of, over, or behind the ends of a hose assembly 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!

**Elongation Length Measurement**

A characteristic of composite hose is elongation. This characteristic should not be used solely as an assessment of the condition of the hose or an indication of failure. Consult manufacturer for more information. (See Section finished assembly dimension tolerances)

In the event that elongation length measurement is required, the following is an accepted process and may be incorporated into your test procedure.

A. Pressurize the hose to one time working pressure, hold for 30 seconds, release pressure to 10 psi and take the initial length measurement at 10 psi. \( L_0 = \ldots \).

B. Measure the hose length under pressure (Test Pressure Length), \( L_t = \ldots \). Calculate the temporary elongation as follows:

\[
\frac{L_t - L_0}{100} = \ldots \%
\]

C. Release the pressure, wait 30 seconds, measure and record the Overall Final Length, and drain hose.

**Special requirements: Coast Guard testing requirements**

From Coast Guard document 33 CFR Ch. 1 (7-1-07 Edition); Subpart C – Equipment Requirements: 154.500 Hose Assemblies

Each hose assembly used for transferring oil or hazardous material must meet the following requirements:
(a) The minimum design burst pressure for each hose assembly must be at least four times the sum of the pressure of the relief valve setting (or four times the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(b) The maximum allowable working pressure (MAWP) for each hose assembly must be more than the sum of the pressure of the relief valve setting (or the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(c) Each nonmetallic hose must be usable for oil or hazardous material service.
(d) Each hose assembly must either have:
   (1) full threaded connections,
   (2) Flanges that meet standard B16.5 *Steel Pipe Flanges and Flange Fittings*, or standard B16.24 *Brass or Bronze Pipe Flanges*, of the American National Standards Institute (ANSI), or
   (3) Quick-disconnect couplings that meet ASTM F1122
(e) Each hose must be marked with one of the following:
   (1) The name of each product for which the hose may be used, or
   (2) For oil products, the words “OIL SERVICE”, or
   (3) For hazardous materials, the words “HAZMAT SERVICE – SEE LIST” followed immediately by a letter, number or other symbol that corresponds to a list or chart contained in the facility’s operation manual or the vessel’s transfer procedure documents which identifies the products that may be transferred through a hose bearing that symbol.
(f) Each hose also must be marked with the following, except that the information required by paragraphs (e) (2) and (3) of this section need not be marked on the hose if it is recorded in the hose records of the vessel or facility, and the hose is marked to identify it with that information:
   (1) Maximum allowable working pressure;
   (2) Date of manufacture; and
(3) Date of the latest test required by section 156.170.

(g) The hose burst pressure and the pressure used for the test required by 156.170 of this chapter must not be marked on the hose and must be recorded elsewhere at the facility as described in paragraph (f) of this section.

(h) Each hose used to transfer fuel to a vessel that has a fill pipe for which containment cannot practically be provided must be equipped with an automatic back pressure shutoff nozzle.


33 CFR 156.170 - Equipment tests and inspections

Current as of: July 2010; [Check for updates](http://www.lawserver.com/law/country/us/cfr/33_cfr_156-170)

(a) Except as provided in paragraph (d) of this section, no person may use any equipment listed in paragraph (c) of this section for transfer operations unless the vessel or facility operator, as appropriate, tests and inspects the equipment in accordance with paragraphs (b), (c) and (f) of this section and the equipment is in the condition specified in paragraph (c) of this section.

(b) During any test or inspection required by this section, the entire external surface of the hose must be accessible.

(c) For the purpose of paragraph (a) of this section:

   (1) Each nonmetallic transfer hose must:

       (i) Have no unrepaired loose covers, kinks, bulges, soft spots or any other defect which would permit the discharge of oil or hazardous material through the hose material, and no gouges, cuts or slashes that penetrate the first layer of hose reinforcement as defined in Sec. 156.120(i).

       (ii) Have no external deterioration and, to the extent internal inspection is possible with both ends of the hose open, no internal deterioration;

       (iii) Not burst, bulge, leak, or abnormally distort under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and

       (iv) Hoses not meeting the requirements of paragraph (c)(1)(i) of this section may be acceptable after a static liquid pressure test is successfully completed in the presence of the COTP. The test medium is not required to be water.

   (2) Each transfer system relief valve must open at or below the pressure at which it is set to open;

   (3) Each pressure gauge must show pressure within 10 percent of the actual pressure;

   (4) Each loading arm and each transfer pipe system, including each metallic hose, must not leak under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and

   (5) Each item of remote operating or indicating equipment, such as a remotely operated valve, tank level alarm, or emergency shutdown device, must perform its intended function.

(d) No person may use any hose in underwater service for transfer operations unless the operator of the vessel or facility has tested and inspected it in accordance with paragraph (c)(1) or (c)(4) of this section, as applicable.

(e) The test fluid used for the testing required by this section is limited to liquids that are compatible with the hose tube as recommended by the hose manufacturer.
(f) The frequency of the tests and inspections required by this section must be:

1. For facilities, annually or not less than 30 days prior to the first transfer conducted past one year from the date of the last tests and inspections;

2. For a facility in caretaker status, not less than 30 days prior to the first transfer after the facility is removed from caretaker status; and

3. For vessels, annually or as part of the biennial and mid-period inspections.

**Electrical Continuity Test**

Unless otherwise specified, all lengths of composite hose that have been fitted with electrically conductive end fittings must have an electrical resistance not exceeding 10 ohms. The test should be made from end fitting to end fitting using a calibrated multi-meter to ensure that the hose is electrically continuous.

**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:
  - Hose Identification - Size and type must correspond to the fabrication order (work order).
  - 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.
  - Inspection Items -
    - Bulge behind the coupling.
    - Cocked couplings.
    - Cracked couplings.
    - Displacement of inner and outer reinforcing wires from normal pitch
    - General appearance of the assembly.
    - Freedom of swivels
    - Internal contaminants.
    - Protective caps or plugs.
    - Restrictions in the tube
    - Rusted Couplings

**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
6.6 Installation and Usage for Composite Hose

General

Hoses must be correctly supported during use. These supports should be arranged so that the hoses are never bent beyond the minimum bend radius. Hoses should never be supported along their live length by a single rope. Slings, saddles or some other means of proper support must be used. The support must be wide enough to spread the load sufficiently so that the hose is not deformed in the area of support. Incorrect installation can unduly stress hose assemblies leading to a shortened working life or premature failure.

A. Flanged hose assemblies should ideally have one end secured with a floating flange.
B. Hose assemblies must not be twisted either on installation or in use.
C. Hose assemblies subject to movement while operating should be installed in such a way that flexing occurs in the same plane.
D. When installing hose assemblies, careful attention should be paid to minimum bend radii specifications.

Transfer Hose Handling Guidelines while in Service

**DO'S**

a) Support all 4” thru 10” dock hoses within 3-4 ft. of flange connections, always maintaining horizontal plane. For small bore hoses, 1” thru 4”, it is recommended the hose assemblies be positioned to maintain a horizontal plane for 12” to 24”, depending on the id size.

b) Support the hose using recommended hose supports throughout the balance of the length.

c) Cushion the hose against sharp edges, dock edge, ships rail, etc.

d) Cushion the hose when the application demands use of reciprocating machinery. It is recommended that all points of contact be cushioned to avoid potential damage due to the pulsating effect of reciprocating machinery. (See Figure 6.1)

**DON'TS**

a) Do not use the hose unsupported.

b) Do not support the hose with a single rope or chain.

c) Do not allow the hose to hang unsupported between ship and quay. (See Figure 6.1)
Figure 6.1 Transfer Hose Handling Guide

**INCORRECT**

- NEVER USE HOSE UNSUPPORTED

**CORRECT**

- ALWAYS SUPPORT HOSE NEAR COUPLING
- ACCEPTABLE
- SUPPORT HOSE WITH SLINGS WHERE APPROPRIATE
- ACCEPTABLE

- PROTECT AGAINST SHARP EDGES, QUAY EDGES, SHIP'S GUARD RAIL ETC.
- NEVER USE HOSE UNSUPPORTED

- NEVER OVERBEND HOSE OR ALLOW HOSE TO HANG BETWEEN QUAY AND SHIP
- SUPPORT HOSE WITH SLINGS

- NEVER SUPPORT HOSE WITH SINGLE ROPE
Section 7 - Hydraulic Hose

Section Contents:

7.1 Introduction to Hydraulics
7.2 STAMPED
7.3 Hydraulic Hose and Hose Selection
7.4 Coupling Selection
7.5 Hose Assemblies: Length, Orientation Measurement & Testing
7.6 Accessories and Equipment
7.7 Cleanliness Considerations

7.1 Introduction to Hydraulics

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 hose assemblies and pertains to hydraulic hose and hydraulic hose assemblies.

Hydraulics can be simply defined as the science of using fluid, under pressure, to do work. Hydraulic hose assemblies are flexible, fluid power connectors used to convey and direct these fluids. Today, hydraulics has progressed to where it is used in agriculture, construction, metal working, marine, forestry, mining and practically any other industry you can name.

It is extremely important that the specific instructions of the hose and coupling manufacturers be followed. The intermixing of hose and couplings from different manufacturers is not typically acceptable. Couplings are engineered to only work with approved hoses and vice-versa. Do not use hose/coupling combinations that are not approved by the manufacturer. If the hose and coupling are supplied by different manufacturers, then both must approve of their use together. In no instance should the information printed in this section supersede a manufacturer's instructions.

Safety should be a paramount concern whenever working with a hydraulic system. The fluids conveyed are often at high temperatures and extremely high pressures which present unique dangers. Hydraulic fluid injuries are generally very severe and may come in several forms. Fluid injections wounds may occur
any time there is a leak in a hydraulic system. Never check for leaks or damage to a hydraulic system by feel, the best case scenario with a fluid injection wound is months of painful treatment to recover; additional risks include amputation and death. Due to the high temperatures any time a user is exposed to hydraulic fluids severe burns may result, this exposure may be a result of an assembly failure or even oil released during maintenance. Additionally there is a danger of fire or explosion if a hose fails around a hot engine or exhaust manifold, or if a static discharge takes place in a fluid spray. Unconstrained hoses may whip on pressurization or in the event of failure and are extremely dangerous. Additionally, during the release of pressure on the hydraulic system, improperly secured booms or other cylinder supported components may drop suddenly.

A sometimes less recognized risk is that of electrical shock. Any equipment used to work around live electrical lines (such as lifts, etc.) should be equipped with hydraulic hoses rated as non-conductive. This is because most hydraulic hoses have wire reinforcement and are inherently conductive. Also even when non-conductive hoses are used it is important to recognize that hydraulic fluids may also act as conductors.

### 7.1.1 Basic Components of Hydraulic Systems

#### Energy transmission systems

Motors supply mechanical energy. An electric motor gets its motion from an electric flow of energy, transforming it in mechanical power: supplying another form of energy to be used otherwise. Also chemical energy is transformed: a good example is diesel engines whose movements supply energy. Unfortunately this first transformation is often unsatisfactory for the actual needs of many applications. Not always the place where the action is required can be equipped with a motor and a proper operator. The solution to this problem can be found making energy flow from the prime mover to the application point. A common way to do this is by the use of hydraulic systems.

Any mass can have potential and kinetic energy; a fluid can also "transport" it from one point to another. For example, waterfalls take advantage of the potential energy linked to the different heights in which the water is before and after the transmission. Some turbines get their motion from the kinetic energy of the used fluid. Other systems (the ones we will deal with in this manual) use an energy flow under form of pressure.

#### Hydraulic circuits

A hydraulic circuit is a system to supply energy, transported by means of a fluid under pressure. A prime mover drives generally a pump whose task is to send a fluid into a circuit: it converts the mechanical energy of the motor into fluid power. The fluid moves along a pipeline and reaches an actuator: generally a cylinder but often also a hydraulic motor (rotary actuator). The described circuits can be represented by simple schemes related to a system with a linear actuator (cylinder), similarly in the case of rotative actuators (hydraulic motors).

#### Pipeline

The pipeline conveys the fluid; it may be built either with rigid steel pipes or with flexible hoses or also using a combined solution. Many applications would hardly accept a rigid pipeline; often the connected parts are in relative motion between themselves and a flexible hose suits at best the needs. Moreover, using fluid transmission mainly in engines operating at high speed, the systems have also a lot of vibrations; a flexible part in the system can better absorb them so to create a sort of insulation. Flexible hoses will be widely described in this manual; basically the hose consists in a rubber tube winded up by reinforcement and covered with a rubber or textile layer. The reinforcement consists in steel wires or textile yarns spiraled or braided around the tube (generally 4-6 wire spirals or 1-2 wire or textile braids).

#### Actuator

The most frequent actuator met in hydraulic systems is a cylinder. Cylinders may be single or double effect:
Single effect cylinders consist in a tube in which a piston is pushed by the pressurized fluid. These applications generally use gravity to end their cycle and return to the start position.

Double effect cylinders have a piston with a non-constant diameter: for the whole length the piston's diameter is smaller than the internal diameter of the cylinder; generally in the center of the piston the diameter is nearly equal so to have at disposal two surfaces to “convert” pressure in force. The circuit will direct the fluid to one or the other of the inlets moving the piston, in one or the other direction.

The cylinder bears two oil inlets at each end. Other types of actuators, for example hydraulic motors, are currently used to transform hydraulic energy into mechanical power.

**Fluids**

The most common fluid is certainly water; yet most of the circuits we are describing use oils to convey energy. Actually the first systems used water and only with increasing complexity of technology, oils started to be used. The necessity to change came because water couldn’t assure the required properties: first of all a lubricant action, but also the absence of corrosive action and sediments, no evaporation at higher temperature and therefore a higher boiling temperature. These properties can be found with mineral oils. An oil pump can work at about 2000 cycles/min. This means it can be directly connected to the motor. Using a water pump between it and the motor requires a speed reducer as the maximum number of cycles of this pump is about 200 (the motor can’t work directly at such a slow rate). The necessity of a reducer leads to greater sizes of the whole equipment creating space problems.

Furthermore while water causes oxidation and corrosion, oil protects the material of the pump assuring a longer life of the engines.

From a chemical point of view oils have generally higher boiling temperatures than water, so they can be used at higher intensity gaining productivity. The difference in price purchasing oil instead of water is certainly covered by the advantages here mentioned. The most common oil used in hydraulics is mineral based. Lately it is becoming necessary to use environment-friendly fluids. These fluids are bio-degradable and commonly called bio-oils. Their use is constantly increasing replacing mineral oils.

Also water is still used in certain applications but mainly where it is directly used as working fluid and its consumption is substantial: water cleaning and water blasting are examples where the pressurized fluid carries out its function and gets lost. The main difference between these two applications is the level of pressure at which the water is used.

Fluid compatibility with various tube compounds increases the complexity of the selection process; the relevant manufacturer(s) should be consulted in all cases for recommendations.

### 7.1.2 Main Applications

**Construction and Public Works**
- Road pavers
- Construction equipment
- Earth moving equipment

**Underground and Open Pit Mining**
- Long wall support
- Open pit mining equipment
- Drilling machine

**Agriculture**
- Tractors
- Combined harvester
- Implements

**Industrial Machines**
- Production machinery
- Injection molding
- Steel works
- Marine fleets

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7.1.3 Standards for Hydraulic Hose

It is important to understand the agency specification requirements that may be pertinent to your application. There are dozens of standards nationally and internationally. Only the more popular US standards will be listed here.

**SAE:** The Society of Automotive Engineers establishes the American standard for most hydraulic hose. SAE guidelines provide general properties of size, tolerances and minimum performance characteristics of each major hose type. SAE is made up of representatives from the major manufacturers. SAE does not test or certify hose and fitting performance. Note: SAE rated hoses from different manufacturers are not exactly the same. They are similar.

SAE J517 identifies the 100R hose series, which ranges from 100R1 to 100R19. The number designation following the “R” does not identify the number of reinforcement layers, but rather the specific requirement of a type of hose (See SAE 517 standards).

**MSHA:** Mine Safety and Health Administration specifies flame resistant properties required of hose used in underground mining applications. It’s also the recognized standard for flame resistance for many industries.

**DOT/FMVSS:** The Department of Transportation Federal Motor Vehicle Safety Standards describe the requirements for hydraulic, air and vacuum brake hose, hose assemblies and fittings for use on passenger vehicles, trucks, buses, trailers, and motorcycles.

**USCG:** The United States Coast Guard requirements are met through two SAE specifications for hose and fittings that are used on Marine vessels. They are SAE J1475 and J1492. Also J1942/1 lists manufacturers hose that is accepted (but not approved) by the USCG.

**DOD and MIL:** The United States Department of Defense has many specifications that identify dimensional and performance requirements for various hose types. Some specifications require a manufacturer to be listed as an approved source. Many specifications require a low temperature rating to -65° F.

Other industry agencies that have specific requirements:
- **ABS** – American Bureau of Shipping
- **DIN** – Deutsches Institut fur Normung (Germany)
- **IJS** – Industrial Jack Specifications
- **ISO** – International Organization for Standardization
- **Lloyds of London**
- **DNV** – Det Norske Veritas (for North Sea Floating Vessels)
Proper hose selection is critical in order to realize a safe hydraulic system. The first step in having a safe hydraulic system is selecting components that meet the needs. Compromises in hose selection may create situations of danger, as well as affect the performance and durability of the system. The choice may work for the short run, but may not be a good long-term decision. The guide uses the STAMPED process. STAMPED is an acronym and stands for the 7 major information areas required to provide a quality hose assembly for your customer, as follows:

**STAMPED**

S = Size  
T = Temperature  
A = Application  
M = Material to be conveyed  
P = Pressure  
E = Ends or couplings  
D = Delivery (volume and velocity)

**Size**: I.D. (Inside Diameter)

The hydraulics industry has adopted a measuring system called Dash Numbers to indicate hose and coupling size. The number which precedes the hose or coupling description is the dash size (see table). This industry standard number denotes hose I.D. in sixteenths of an inch. (The exception to this is the SAE100R5, SAE100R14, SAEJ51 and SAEJ2064 refrigerant hoses, where dash sizes denote hose I.D. equal to equivalent tube O.D.)

(Hose O.D. (Outside Diameter) can be a critical factor when hose routing clamps are used or hoses are routed through bulkheads.) Check manufacturers’ individual hose specification tables for O.D.’s.
The inside diameter of the hose must be adequate to keep pressure loss to a minimum and avoid damage to the hose due to heat generation or excessive turbulence. Note: for existing assemblies, to determine the replacement hose I.D., read the lay line printing on the side of the original hose. If the original hose lay line is painted over or worn off, the original hose must be cut and inside diameter measured for size.

**Flow Rate / Fluid Velocity**
The flow rate of the system in conjunction with the inside diameter of the hose will dictate the fluid velocity through the hose. Please consult your hose supplier for specific recommended velocity ranges. Please note that suction line recommendations are different than pressure lines.

**Inside Diameter**
The correct inside diameter should be determined for the hose required for the application. If the flow rate of the system allows two options for a suitable inside diameter, it is recommended that the larger be selected if pressure allows. High fluid velocities can contribute excessive noise and heat to hydraulic systems and can reduce efficiency.

**Temperature:** Temperature of both the fluid conveyed and environmental conditions

Two areas of temperature must be considered: fluid temperature and ambient temperature. The hose selected must be capable of withstanding the minimum and maximum temperature seen by the system. Care must be taken when routing near hot manifolds and in extreme cases a heat shield may be advisable.

- **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.
- **Fluid Temperature:** The fluid temperature is the temperature of fluid being conveyed inside of the hose during operation.
- **Ambient Temperature:** The ambient temperature is the temperature of the environment to which the hose assembly is exposed.
- **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.
- **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.
- Maximum assembly working pressures will decrease as temperatures increase.

**Application:** The conditions under which the hose assembly will be used

The type of application in which a hose assembly will be used is very important in determining what type of hose should be selected. The most common types of applications are listed below.

- **High Impulse:** Hydraulic system is subjected to frequent pressure spikes.
- **Low Impulse:** Hydraulic system is seldom subjected to pressure spikes.
- **Non-flexing Applications:** Hose assemblies are not subjected to bending or flexing from articulation of the equipment.
- **Flexing Applications:** Hose assemblies are subjected to bending or flexing due to articulation or movement of the equipment.
- **Vacuum:** Hose assembly is exposed to negative pressure (less than atmospheric).

Environmental conditions such as ultraviolet light, salt water, air pollutants, temperature, ozone, chemicals, electricity, abrasion and paint application will all negatively impact hose assembly life.
Static discharge can become an issue when non-polar liquids or mixtures including non-polar liquids are conveyed in non-conductive hose. A static charge will build and on discharge perforate the hose tube, to avoid this use conductive tube products when conveying non-polar, or mixtures of non-polar, liquids.

Electrical conductivity of hydraulic hoses or conveyed fluids is an issue with equipment used to work around electrical lines. If hydraulic equipment is to be used around electrical lines, always use hydraulic hoses rated as non-conductive.

Be sure to select products that will meet any regulatory standards required in the application. Examples of these standards would include: SAE, USCG, EN/DIN, ABS, etc.

Never place hoses in a position where they are pulled on. Hoses are designed to hold pressure and convey fluids, exposing them to axial loads will cause premature failure. Any special or unusual applications should always be approved by the hose manufacturer, otherwise additional independent testing may be required.

The following questions may need to be answered, such as:
- Where Will Hose be Used?
- Fluid and/or Ambient Temperature?
- Hose Construction?
- Equipment Type?
- Fluid Compatibility?
- Thread End Connection Type?
- Working and Surge Pressures?
- Environmental Conditions?
- Permanent or Field Attachable Couplings?
- Suction Application?
- Routing Requirements?
- Thread Type?
- Government and Industry Standards Being Met?
- Unusual Mechanical Loads?
- Minimum Bend Radius?
- Non-Conductive Hose Required?
- Excessive Abrasion?

**Material:** Fluid being conveyed, type and concentration

Some applications require specialized oils or chemicals to be conveyed through the system. Hose selections must assume compatibility of the hose inner tube and cover material. In addition to the hose materials, all other components, which make up the hose assembly (hose ends, o-rings, etc...), must also be compatible with fluid being used. Permeation or effusion is the movement of a substance through the hose tube walls which may degrade the hose tube, cause cover blistering, or other undesired effects, and must be considered especially when conveying compressed gasses.

Be sure to select a hose that is compatible and approved by the manufacturer for the fluid conveyed. Concentration, pressure, temperature and other factors may impact the compatibility of the hose and fluid. Depending on the fluid, your hose supplier may lower the maximum temperature or pressure rating of the assembly. When selecting any hose assembly, always consult your hose supplier’s recommendations.

Additional caution must be exercised in hose selection for gaseous applications such as refrigerants and LPG.
NOTE: All block type couplings contain nitrile O-rings which must be compatible with the fluids being used.

**Pressure**: Pressure to which the assembly will be exposed

The most important step in the hose selection process is knowing system pressure, including pressure spikes.

- **Maximum Operating Pressure**: This is the maximum pressure that the system should be exposed to in normal operating conditions. This pressure should be dictated by the relief setting of the system. Both the hose and hose end should not be rated to a pressure less than the maximum operating pressure of the system.

- **Pressure Spikes**: When a hydraulic system is subjected to a large load in a short period of time, the system pressure can overshoot the relief setting and exceed the maximum operating pressure. Frequent pressure spikes can reduce the life of hydraulic hose assemblies.

Hose assembly working pressures must be equal to or greater than the system pressure. Pressure spikes greater than the maximum working pressure will shorten hose life and must be taken into consideration.

Any time a hose assembly is to be exposed to external pressures, which may exceed the internal hose pressures, be sure to consult the hose manufacturer for recommendations.

Maximum assembly working pressures will decrease as temperatures increase.

**Ends**: Termination end style, type, orientation, attachment methods, etc. Always use manufacturer approved couplings for hose assemblies. Be sure to select the appropriate end termination for a system working pressure and other requirements such as vibration resistance.

**Delivery**: Testing, quality, cleanliness, packaging, and delivery requirements; define any special requirements needed. Always follow manufacturer recommendations for maximum fluid velocity within a hose. Excessive fluid velocity may cause excessive pressure loss, heat generation, hose movement or whipping, system noise, and hammer effects.

**Temperature Derating Factors for Hose Assemblies**

Temperature directly affects maximum allowable working pressure. Most manufacturers rate maximum operating pressures at an ambient temperature of 70 degrees F. If a hose is to be considered for use in an application that exceeds this ambient temperature, consult manufacturer for any pressure derating of the hose assembly.

### 7.3 Hose and Hose Selection

Many hydraulic hose types and constructions are available today regarding Pressure Lines, Return Lines and Suction lines of a typical hydraulic circuit. The most common and popular hydraulic hoses are manufactured per ISO, SAE & EN standards summarized in Figures 7-a, 7-b, and 7-c.

ISO (International Standards Organization) has become more recognized by the industry and manufacturers in recent years. ISO has incorporated general build and performance characteristics of SAE & EN specifications to help eliminate confusion associated with hydraulic hose, construction types and performance ratings.

ISO has adopted SAEJ517, “SAEJ517 Standard provides general, dimensional and performance specification for the most common hoses used in hydraulic systems on mobile and stationary equipment.
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*The SAE J517 100R9, 100R10 and 100R11 hoses are discontinued per SAE due to lack of demand.

Figure 7a
### ISO Hose Working Pressures (psi) per hose size

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**Figure 7b**

### EN Hose Working Pressures (psi)

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<th>Nominal Hose Inside Diameter in Inches and Dash Size</th>
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**Figure 7c**
### 7.3.1 Basics of Hydraulic Hose

Hydraulics allow the transfer of energy through an incompressible fluid (liquid), this gives a very high power density. Hydraulic hose assembly is a conduit to transfer energy from port-to-port or point A to point B within a hydraulic circuit. Hydraulic hose assembly consists of a flexible hose with connectors (Couplings, Fittings and/or Stems & Ferrules) at each end.

Hydraulic hoses are constructed of three main components, Tube, Reinforcement and Cover.

![Diagram of hydraulic hose components](image)

The innermost part of the hydraulic hose is the tube, wrapped up by reinforcement, which is encapsulated with a cover.

#### Tube

The tube is the innermost lining of a hydraulic hose and comes into contact with the fluid being conveyed, tube and fluid compatibility is most critical.

As described above the inner part of a hose is the tube; its function is to contain and convey the service fluid. Furthermore it also protects the outer elements of the hose from the possible aggression of the conveyed fluid. Additional caution must be exercised in hose selection for gaseous applications where permeation may occur. Permeation or effusion is seepage through the hose pores resulting in loss of fluid. This may occur when hose is used with fluids such as but not limited to; liquid and gas fuels, refrigerants, helium, fuel oil & natural gas. The material of the tube is chosen among a great number of synthetic rubbers. The chemical composition of the compounds should be selected to meet the requirements of the application.

#### Reinforcement

The tube itself cannot withstand the pressure of the conveyed fluid; in fact, as mentioned above, the design of the tube considers only its compatibility with the fluid to contain, while the very wide range of pressures present in hydraulic applications must be analyzed otherwise.

The reinforcement material is the “Muscle/Strength” to resist internal or external pressures. The three basic types of reinforcement are Spiral, Braid and Helical.
Spiral reinforcement is typically steel wire (Textile for lower pressure) and has four or six overlapping layers of reinforcement. Spiral wire hose can handle more severe applications with longer service impulse cycle life at extremely high pressures.

Braid reinforcement can be steel wire or textile, and can have single or multiple layers. Braided hose can handle low to high pressure impulse applications.

Helical coil monofilament reinforcement keeps the hose from collapsing in on itself when used in suction line applications. Helical hose can be rated to a full vacuum rating of 30Hg.

The pressure resistance of the hose must be higher than the working pressure. The safety factor is defined as the ratio between the burst pressure and the max working pressure; for the hydraulic applications the safety factor is set to 4:1 by International Standards, some special static applications as water cleaning for example (ISO 7751) have 2.5:1 safety factor. For low pressure applications (up to 100 bar for example), textile reinforcements may be used. So nylon, rayon or polyester fabrics are woven, braided or wrapped around the tube. When the pressure gets higher stronger materials are needed and steel wire spirals or braids are used.

Wire braided hoses bear generally one or two layers of reinforcement (in some cases even three) while spiral ones have commonly four or six spirals (layers). The application of braids and spirals can also be mixed depending on the most appropriate design. Between each layer of braids or spirals an interlayer or friction layer is installed to create a bonding effect and to prevent frictional wear between the wires.

In general, spiral hose constructions are better suited to high impulse heavy duty applications, which involve flexing and large pressure spikes. However, there are specialized braided hoses available from various manufacturers that can achieve significant impulse cycle life in a flexing application with a tight bend radius. Helical coil monofilament reinforcement hose is found primarily in suction line applications and low pressure return line applications. Please consult your hose supplier if there are multiple constructions required to meet your application needs.

**Cover**

Environment, machines and operators themselves can damage the reinforcement. The cover, outermost element of the hose, is used to protect it. There are several types of cover, each designed depending on specific requirements: economy, safety, abrasion resistance, chemical resistance, etc.; even aesthetics are features linked to the choice of the cover (e.g. color). Rubber cover can have wrapped finish: instead of the smooth finish a wet nylon tape is used around the hose during the vulcanization; at last the nylon tape is removed and leaves the hose bearing its imprint. Free steam vulcanization is also used: the hose is directly vulcanized without any wrapping or shaping method. The vapor steam at high temperature is directly in contact with the outer rubber cover of the hose. This allows saving some steps of the entire manufacturing cycle saving time and materials. Particular attention must be paid to maintain the tolerances and to avoid local defects on the cover. Cover finish is smooth.

Also fabric braided covers are still used: the cover is braided fabric, often impregnated with rubber adhesive. This is the best solution when minimum weight and heat dissipation are required. This solution is usually used on low or medium pressure hoses due to its relative weakness (e.g. R5 hose type). Coverless type is usually only used for stainless steel braided hoses, mostly PTFE hoses.
7.3.2 Hose Materials

The characteristics shown below are for the normal or usual range of these specific stocks. Stocks can be changed somewhat through different compounding to meet the requirements of specialized applications. Tube and cover stocks may occasionally be upgraded to take advantage of improved materials and technology.

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<th>Nitrile (Acrylonitrile and Butadiene) Type C</th>
<th>Hypalon* (Chlorosulfonated Polyethylene) Type M</th>
<th>EPDM (Ethylene Propylene Diene) Type P</th>
<th>CPE (Chlorinated Polyethylene) Type J</th>
<th>PTFE (Polytetrafluoroethylene) Type T</th>
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<td>Good to Excellent</td>
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<td>Poor</td>
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</tr>
<tr>
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<td>Excellent</td>
<td>Excellent</td>
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<td>Fair</td>
<td>Excellent</td>
<td>Very Good</td>
</tr>
<tr>
<td>Phosphate Esters</td>
<td>Fair (For Cover)</td>
<td>Poor</td>
<td>Excellent</td>
<td>Fair</td>
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<td>Fair</td>
<td>Very Good</td>
<td>Very Good</td>
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</tbody>
</table>
7.4 Coupling Selection

A hose end coupling is the connector attached at the end of the hose that connects with a port, adapter, another coupling, or attachment, such as a quick disconnect. Therefore, the coupling has two functional ends. These are the hose end, or “stem” which connects onto the hose; and the terminal end which connects the hose assembly to whatever it is that you are attaching the hose assembly to. Coupling selection refers to the choice of hose end coupling that attaches to the hose to form the hose assembly.

Choosing the proper stem and ferrule depends on the specific hose and terminal end to be used in the assembly. Check the manufacturer’s recommendations to ensure proper hose assembly components and crimp specifications.

NOTE: Care must be taken to determine proper compatibility between the hose and fitting. Hose from one manufacturer is not usually compatible with couplings from another. Do not intermix hose and fittings from two manufacturers without approval from both manufacturers.

It is imperative that the coupling selected is compatible and approved for use with the choice of hose.

7.4.1 Types of Couplings

There are two primary types of hose end couplings that are commonly used: permanent and field attachable (or reusable). There are different styles and method of attaching to the hose for each.

Permanent fittings can be:
1. One-piece (pre-crimped stem and ferrule assembly) or two-piece*
2. Crimped or swaged
3. Skive or no-skive

Field Attachable/Reusable can be:
1. Two-piece or three-piece screw-on
2. One-piece clamped or “push-on” (no ferrule)
3. Mandrel or mandrelless

* When using two-piece couplings it is important to match the ferrule with its appropriate stem and hose

7.4.2 Coupling Selection

Different hoses may require different coupling styles. To make your selection, determine the correct stem to be used. There are two functional ends of the stem to consider:

• The hose end for hose attachment;
• The terminal end for port/accessory/adapter attachment.
Coupling selection is determined by:

- The size of hose it is to attach to
- The type of hose it is to attach to
- The terminal end connection; typically threaded
- The coupling type (permanent/field attachable/clamped)
- The coupling configuration (straight, angled, drop dimensions, etc.)
- The system operating pressure
- The media being conveyed (in determining the coupling material selected)

It is important to keep in mind that the hose assembly (coupling and hose) is only one component of the system. In choosing the correct end terminations for the couplings attached to the hose, formal design standards and sound engineering judgment should be used. In the absence of formal design standards, consider the following factors in choosing the proper end termination:

- Pressure
- Impulse frequency, amplitude and wave form
- Vibration
- Corrosion
- Dissimilar metals (galvanic corrosion)
- Maintenance procedures and frequency
- Installation reliability
- Connection’s risk in the system
- Exposure to the elements
- Operator’s and/or bystander’s exposure to the connection
- Installation, operation and service activities and practices that affect safety

If there are any questions as to what end fittings should be used, consult your NAHAD Hose Safety Institute Distributor for assistance.

7.4.3 Coupling Material

Hydraulic hose couplings most commonly come in three basic materials:

- carbon steel (plated)
- stainless steel
- brass

More exotic materials, such as monel may also be available for some coupling types, as well as combinations of materials, such as couplings where the “wetted” parts which come into contact with the media being conveyed may be brass or stainless steel while the ferrule or threaded nut may be a standard carbon steel. Coupling choices in the exotic or multi-materials are usually limited as these have more specific applications that do not require a full range of connection type.

7.4.4 Coupling Sizing

Both the hose end (stem) and the terminal (threaded) end are measure by industry standard dash sizes. The hose end dash size refers to the inside diameter in 1/16” segments (except for SAE 100R5 and SAE 100R14 which are based on tube O.D.). The pneumatic industry uses the “inch” or “metric” sizing rather than the dash numbers.
7.4.5 Coupling Terminal End (Thread) Identification

It is always important to measure the threads since there are so many threads similar in measurement and which may look very similar. The proliferation of threads on the world market today makes it easy to mismatch threads resulting in leakage and possible serious accident. Each manufacturer has his own shell and stem markings to match the different hose types. This marking system can be part numbers stamped on the product, notches, lines, etc. For this reason it is recommended to consult the manufacturer if there is any question.

Identification of a coupling/end connection requires the correct tools and reference materials, such as a coupling suppliers catalog. The tools are available from most coupling manufacturers or your local tool store.

The recommended tools are:

- Thread pitch gauge capable of measuring inch and metric thread pitches.
- I.D./O.D. Caliper capable of measuring both inches and millimeters.
- Seat angle gauge capable of measuring different seating angles (i.e 37° or 45° flare and 60° or 24° inverted flares).
- Reference materials showing different threaded end charts (inch and metric systems).

It is important to know the three basic steps in identifying a coupling/end connection. Similarity of thread in measurement as well as appearance can result in a mismatch and possible serious consequences.

The three steps are as follows:

- Measure the thread pitch
- Measure the thread diameter
- Determine the seating angle if applicable

7.4.5 Measuring Thread Pitch

Use a thread pitch gauge to determine the number of threads per inch or the distance between two threads for a metric connection. In the inch thread system (NPT) the thread pitch is referred to as the number of threads per inch or, in other words, how many crests there are per inch. The metric system measures the distance between two threads or crests.

Using a thread pitch gauge designed for fluid connector threads, try different thread gauges looking for the tightest fit. Engage as many threads as possible, the more threads engaged the more accurate the reading.
Hold the fitting and thread gauge up to the light and look for gaps or light appearing between the gauge and the threads. This is easy on a male connection and more difficult to see on the female end connection. It should be a tight fit with very little light coming through. Keep in mind the tools may not be machinist quality, just a measuring device, so some light coming through is normal.

**Measuring the thread diameter**

Using the I.D./O.D. caliper measure the thread diameter. Male thread diameter is measured on the outside diameter of the thread. It is recommended to hold the caliper at a slight angle for a more accurate reading. Female thread diameter is measured on the inside diameter of the thread. For female thread it is recommended to hold the caliper perpendicular to the thread.

**Measuring the seating/sealing surface angle (when applicable)**

If the connection seals on a flared surface (example: 37° or 45° flare) or on an inverted angle seat (example: 60° or 24° inverted flares) the next step is to determine that angle of seal. Use a seat angle gauge on the male connection. Place the gauge on the sealing surface. If the centerlines of the connection and gauge are parallel the correct angle has been determined.

Measuring the female is accomplished in a similar manner by inserting the gauge into the connection and placing it on the sealing surface. If the centerlines of the connection and gauge are parallel, the correct angle has been determined.
One additional important step is required when identifying a metric 24° male connection and that is to determine if it is an L (light series) or S (heavy series). This is accomplished by measuring the inside diameter of the recessed counter bore at the base of the 24° inverted sealing surface (Fig. 17 and 18.) This measurement will be in millimeters and determines if the connection is L or S series (Fig. 15 “R” dimension). It is an important required measurement to determine the correct replacement fitting/end connection.

Match the thread pitch, diameter, and seating angle measurements taken to the various threaded end charts in your reference materials.

The following pages list a variety of hydraulic hose ends.
7.4.5.1 37° Flare (JIC)

The Society of Automotive Engineers (SAE) specifies a 37° angle flare or seat be used with high pressure hydraulic tubing. These are commonly called JIC couplings.

The JIC 37° flare male will mate with a JIC female only. The JIC male has straight threads and a 37° flare seat. The JIC female has straight threads and a 37° flare seat. The seal is made on the 37° flare seat.

Some sizes have the same threads as the SAE 45° flare. Carefully measure the seat angle to differentiate.

*Note: Some couplings may have dual machined seats (both 37° and 45° seats).

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<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
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7.4.5.2 SAE (45° Flare)

A term usually applied to fittings having a 45° angle flare or seat. Soft copper tubing is generally used in such applications as it is easily flared to the 45° angle. These are for low pressure applications such as for fuel lines and refrigerant lines.

The SAE 45° flare male will mate with an SAE 45° flare female only. The SAE male has straight threads and a 45° flare seat. The SAE female has straight threads and a 45° flare seat. The seal is made on the 45° flare seat.

Some sizes have the same threads as the SAE 37° flare. Carefully measure the seat angle to differentiate.

*Note: Some couplings may have dual machined seats (both 37° and 45° seats).

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</tbody>
</table>
7.4.5.3 "O" Ring Boss

The O-ring boss male will mate with an O-ring boss female only. The female is generally found on ports. The male has straight threads and an O-ring. The female has straight threads and a sealing face. The seal is made at the O-ring on the male and the sealing face on the female.

<table>
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<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
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</table>
7.4.5.4 "O" Ring Flange -- SAE J518

The SAE Code 61 and Code 62 4-Bolt Split Flange is used worldwide, usually as a connection on pumps and motors. There are three exceptions.

1. The -10 size, which is common outside of North America, is not an SAE Standard size.

2. Caterpillar flanges, which are the same flange O.D. as SAE Code 62, have a thicker flange head ("C" dimension in Table).

3. Poclain flanges, which are completely different from SAE flanges.

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</table>
7.4.5.5 "O" Ring Face Seal SAE J1453

A seal is made when the O-ring in the male contacts the flat face on the female. Couplings are intended for hydraulic systems where elastomeric seals are acceptable to overcome leakage and leak resistance is crucial. The solid male O-ring face seal fitting will mate with a swivel female O-ring face seal fitting only. An O-ring rests in the O-ring groove in the male.

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</table>

7.4.5.6 Pipe Threads

NPTF -- This is a dryseal thread; the National pipe tapered thread for fuels. This is used for both male and female ends. The NPTF male will mate with the NPTF, NPSF, or NPSM female. The NPTF male has tapered threads and a 30° inverted seat. The NPTF female has tapered threads and no seat. The seal takes place by deformation of the threads. The NPSM female has straight threads and a 30° inverted seat. The seal takes place on the 30° seat. The NPTF connector is similar to, but not interchangeable with, the BSPT connector. The thread pitch is different in most sizes. Also, the thread angle is 60° instead of the 55° angle found on BSPT threads.

NPSF -- The National pipe straight thread for fuels. This is sometimes used for female ends and properly mates with the NPTF male end. However, the SAE recommends the NPTF thread in preference to the NPSF for female ends.
### Dash Size

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1/8</td>
<td>27</td>
<td>23/64</td>
<td>13/32</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>18</td>
<td>15/32</td>
<td>35/64</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>18</td>
<td>19/32</td>
<td>43/64</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>14</td>
<td>3/4</td>
<td>27/32</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>14</td>
<td>61/64</td>
<td>1-1/16</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>11-1/2</td>
<td>1-13/64</td>
<td>1-13/64</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>11-1/2</td>
<td>1-17/32</td>
<td>1-17/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>11-1/2</td>
<td>1-25/32</td>
<td>1-25/32</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>11-1/2</td>
<td>2-1/4</td>
<td>2-3/8</td>
</tr>
</tbody>
</table>

### 7.4.5.7 DIN 7631 (DIN 60° Cone)

This series combines an internal 60° seat with parallel metric Light series threads. This connection provides a metal-to-metal seal when tightened. This style can be identified by the internal, 60° seat on the male, metric threaded portion.

<table>
<thead>
<tr>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
<th>Pipe/Tube O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12 x 1.5</td>
<td>10.5</td>
<td>12.0</td>
<td>6</td>
</tr>
<tr>
<td>M14 x 1.5</td>
<td>12.5</td>
<td>14.0</td>
<td>8</td>
</tr>
<tr>
<td>M16 x 1.5</td>
<td>14.5</td>
<td>16.0</td>
<td>10</td>
</tr>
<tr>
<td>M18 x 1.5</td>
<td>16.5</td>
<td>18.0</td>
<td>12</td>
</tr>
<tr>
<td>M22 x 1.5</td>
<td>20.5</td>
<td>22.0</td>
<td>15</td>
</tr>
<tr>
<td>M26 x 1.5</td>
<td>24.5</td>
<td>26.0</td>
<td>18</td>
</tr>
<tr>
<td>M30 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
<td>22</td>
</tr>
<tr>
<td>M38 x 1.5</td>
<td>36.5</td>
<td>38.0</td>
<td>28</td>
</tr>
<tr>
<td>M45 x 1.5</td>
<td>43.5</td>
<td>45.0</td>
<td>35</td>
</tr>
<tr>
<td>M52 x 1.5</td>
<td>50.5</td>
<td>52.0</td>
<td>42</td>
</tr>
</tbody>
</table>
7.4.5.8 DIN 3902 (DIN 24° Cone Light and Heavy Duty)

This connection style consists of a common male and two female options. The male has a straight metric thread, a 24° included angle, and a recessed counterbore that matches the tube OD used with it. In the first female design, a metal-to-metal seal is accomplished as the female nose and male taper are forced against one another. The other option uses an o-ring on the female tapered nose. This creates an o-ring seal as the connection is tightened. Both a heavy and light-duty series are offered. The series can be determined by measuring the seat counterbore, which is the approximate tube outside diameter, and comparing it to the thread size.

<table>
<thead>
<tr>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
<th>Light Duty Pipe/Tube O.D. (mm)</th>
<th>Heavy Duty Pipe/Tube O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12 x 1.5</td>
<td>10.5</td>
<td>12.0</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>M14 x 1.5</td>
<td>12.5</td>
<td>14.0</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>M16 x 1.5</td>
<td>14.5</td>
<td>16.0</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>M18 x 1.5</td>
<td>16.5</td>
<td>18.0</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>M20 x 1.5</td>
<td>18.5</td>
<td>20.0</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>M22 x 1.5</td>
<td>20.5</td>
<td>22.0</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>M24 x 1.5</td>
<td>22.5</td>
<td>24.0</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>M26 x 1.5</td>
<td>24.5</td>
<td>26.0</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>M30 x 2.0</td>
<td>28.0</td>
<td>30.0</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>M36 x 2.0</td>
<td>34.0</td>
<td>36.0</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>M42 x 2.0</td>
<td>40.0</td>
<td>42.0</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>M45 x 2.0</td>
<td>43.0</td>
<td>45.0</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>M52 x 2.0</td>
<td>50.0</td>
<td>52.0</td>
<td>42</td>
<td>38</td>
</tr>
</tbody>
</table>
7.4.5.9 British Standard Pipe Parallel (BSPP)

The BSPP male has straight threads and a 30° seat. The female has straight threads and a 30° nose. An o-ring design is also available on the nose from some manufacturers. Sealing can either be metal-to-metal or via an o-ring depending on the design. If the female design is used as a port connection, then an o-ring must be utilized on the male similar in design to the o-ring boss.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1/8</td>
<td>1/8-28</td>
<td>11/32</td>
<td>3/8</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>17/32</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>5/8-14</td>
<td>13/16</td>
<td>29/32</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-11/32</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-17/32</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-7/32</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>

7.4.5.10 British Flat-Face Seal

A seal is made when the o-ring in the male contacts the flat face on the female. Couplings are intended for hydraulic systems where elastomeric seals are acceptable to overcome leakage and leak resistance in crucial. Although similar in design to the o-ring face seal, they are not interchangeable.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
</tbody>
</table>
The JIS inverted seat connection is available with two different thread styles. The parallel pipe thread design operates similarly to the BSPP connection. However, please consult your hose end supplier for interchangeability recommendations. The metric threaded design is identical to the parallel pipe design except for thread differences.

### Parallel Pipe Threads

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>17/32</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-11/32</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-17/32</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-7/32</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>

### Metric Threads

<table>
<thead>
<tr>
<th>Dash Size Equivalent</th>
<th>Nominal Size (mm)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>6</td>
<td>M14 x 1.5</td>
<td>12.5</td>
<td>14.0</td>
</tr>
<tr>
<td>-6</td>
<td>9</td>
<td>M18 x 1.5</td>
<td>16.5</td>
<td>18.0</td>
</tr>
<tr>
<td>-8</td>
<td>12</td>
<td>M22 x 1.5</td>
<td>20.5</td>
<td>22.0</td>
</tr>
<tr>
<td>-12</td>
<td>19</td>
<td>M30 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
</tr>
<tr>
<td>-16</td>
<td>25</td>
<td>M33 x 1.5</td>
<td>31.5</td>
<td>33.0</td>
</tr>
<tr>
<td>-20</td>
<td>32</td>
<td>M42 x 1.5</td>
<td>40.5</td>
<td>42.0</td>
</tr>
</tbody>
</table>
7.4.5.12 JIS 30° Cone Seat (Parallel Pipe Threads)

The JIS 30° flare is similar to the American SAE 37° flare connection in application as well as sealing principles. However, the flare angle and dimensions are different. The threads are similar to BSPP.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Tapered Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>33/64</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-5/16</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-9/16</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-1/4</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>

7.4.5.13 British Standard Pipe Tapered (BSPT) / Japanese Tapered Pipe Thread

The BSPT is similar to NPTF, but not interchangeable due to thread differences. Sealing, like the NPTF, is accomplished on the threads. BSPT is identical and fully interchangeable with Japanese Tapered Pipe Thread.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1/8</td>
<td>1/8-28</td>
<td>11/32</td>
<td>3/8</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>17/32</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>5/8-14</td>
<td>13/16</td>
<td>29/32</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-11/32</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-17/32</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-7/32</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>
This end connection is similar to the DIN 24° cone; however, they are not interchangeable. Even though the sealing angles are the same, the threads are different.

<table>
<thead>
<tr>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
<th>Pipe/Tube O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M20 x 1.5</td>
<td>18.5</td>
<td>20.0</td>
<td>13.25</td>
</tr>
<tr>
<td>M24 x 1.5</td>
<td>22.5</td>
<td>24.0</td>
<td>16.75</td>
</tr>
<tr>
<td>M30 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
<td>21.25</td>
</tr>
<tr>
<td>M36 x 2.0</td>
<td>34.5</td>
<td>36.0</td>
<td>26.75</td>
</tr>
<tr>
<td>M45 x 2.0</td>
<td>43.5</td>
<td>45.0</td>
<td>33.50</td>
</tr>
<tr>
<td>M52 x 2.0</td>
<td>50.5</td>
<td>52.0</td>
<td>42.25</td>
</tr>
<tr>
<td>M58 x 2.0</td>
<td>55.0</td>
<td>58.0</td>
<td>48.25</td>
</tr>
</tbody>
</table>
7.4.5.15 French GAZ Poclain 24° Flange

This flange differs from standard SAE flanges in that it has a lip that protrudes from the male flange face with a 24° angle. This lip fits into mating the female flange seat and provides the metal-to-metal seal when the bolts are tightened.

<table>
<thead>
<tr>
<th>Nominal Size (in.)</th>
<th>A (in.)</th>
<th>B (in.)</th>
<th>C (in.)</th>
<th>D (in.)</th>
<th>E (in.)</th>
<th>F (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>1.57</td>
<td>.72</td>
<td>2.20</td>
<td>1.89</td>
<td>.55</td>
<td>.35</td>
</tr>
<tr>
<td>5/8</td>
<td>1.57</td>
<td>.72</td>
<td>2.20</td>
<td>1.89</td>
<td>.55</td>
<td>.35</td>
</tr>
<tr>
<td>3/4</td>
<td>2.00</td>
<td>.94</td>
<td>2.75</td>
<td>2.38</td>
<td>.71</td>
<td>.43</td>
</tr>
</tbody>
</table>
7.4.5.16 Metric Standpipe Assembly

A metric standpipe assembly is comprised of three components attached to a male fitting. The components are: a Standpipe tube, Bite Sleeve, and Metric Nut. The nut is placed over the Standpipe, followed by the Bite Sleeve. For DIN light assemblies, a DIN light metric nut is used. For DIN heavy assemblies, a DIN heavy metric nut is used. The Bite Sleeve and Standpipe are selected on the basis of tube O.D. required.

<table>
<thead>
<tr>
<th>Metric Standpipe DIN Tube O.D. (mm)</th>
<th>Bite Sleeve DIN Tube O.D. (mm)</th>
<th>Metric Light Nut Thread</th>
<th>Metric Heavy Nut Thread</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>M12 x 1.5</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>M14 x 1.5</td>
<td>M16 x 1.5</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>M16 x 1.5</td>
<td>M18 x 1.5</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>M18 x 1.5</td>
<td>M20 x 1.5</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>M22 x 1.5</td>
<td>-</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>-</td>
<td>M24 x 1.5</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>M26 x 1.5</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>-</td>
<td>M30 x 2.0</td>
</tr>
<tr>
<td>22</td>
<td>22</td>
<td>M30 x 2.0</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>25</td>
<td>-</td>
<td>M36 x 2.0</td>
</tr>
<tr>
<td>28</td>
<td>28</td>
<td>M36 x 2.0</td>
<td>-</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>-</td>
<td>M42 x 2.0</td>
</tr>
<tr>
<td>35</td>
<td>35</td>
<td>M45 x 2.0</td>
<td>-</td>
</tr>
<tr>
<td>38</td>
<td>38</td>
<td>-</td>
<td>M52 x 2.0</td>
</tr>
<tr>
<td>42</td>
<td>42</td>
<td>M52 x 2.0</td>
<td>-</td>
</tr>
</tbody>
</table>
7.4.5.17 Komatsu 30° Flare Metric Threads

The Komatsu 30° flare is similar to the 37° JIC flare connection except for two things. The seat angle is 30° instead of 37°, and the threads are metric.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Nominal Size (mm)</th>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>3/8</td>
<td>9.5</td>
<td>M18 x 1.5</td>
<td>18.5</td>
<td>20.0</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>13</td>
<td>M22 x 1.5</td>
<td>22.5</td>
<td>24.0</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>16</td>
<td>M24 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>19</td>
<td>M30 x 1.5</td>
<td>34.5</td>
<td>36.0</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>25</td>
<td>M33 x 1.5</td>
<td>43.5</td>
<td>45.0</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>32</td>
<td>M36 x 1.5</td>
<td>50.5</td>
<td>52.0</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>38</td>
<td>M42 x 1.5</td>
<td>55.0</td>
<td>58.0</td>
</tr>
</tbody>
</table>

7.4.5.18 Kobelco Metric Bite Sleeve

These are similar to the German DIN 24° Cone, but the DIN style uses courser threads. Therefore, the Kobelco and DIN connections are not interchangeable.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-22</td>
<td>M30 x 1.5</td>
<td>28.0</td>
<td>30.0</td>
</tr>
<tr>
<td>-28</td>
<td>M36 x 1.5</td>
<td>34.0</td>
<td>36.0</td>
</tr>
<tr>
<td>-35</td>
<td>M45 x 1.5</td>
<td>43.0</td>
<td>45.0</td>
</tr>
</tbody>
</table>
7.4.6 Coupling Configuration

The variety of fitting configuration is quite large and in most cases fittings are selected based on the matching port or adapter connection and the routing requirements.

Figure 1 above shows a small sampling of the variety of fitting configurations and selection will vary between the various applications, installations and hose types.

7.4.7 Coupling Sealing Methods

There are a variety of hose ends, which are available when creating a hose assembly. There are typically three different methods of sealing. They are elastomeric seal, metal-to-metal, and sealing on threads. Connections, which use elastomeric seals, normally seal on an o-ring. Metal-to-metal hose ends force mating angled surfaces together causing the seal. Sealing on threads is accomplished by the distortion of the connection's threads when the male and female halves are tightened. The most common hose ends are described below.

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastomeric</td>
<td>Excellent sealing capability even at high pressures, reusable</td>
<td>O-rings can be lost or damaged, additional care is required for assembly, fluid compatibility and temperature are dependant on o-ring properties</td>
</tr>
<tr>
<td>Metal-to-Metal</td>
<td>Reusable, good sealing capability, simple to assemble, high temperature rating, excellent fluid compatibility</td>
<td>Sometimes difficult to identify, can exhibit weeping when reused</td>
</tr>
<tr>
<td>Seal on Threads</td>
<td>Simple to assembly, high temperature rating, excellent fluid compatibility, availability</td>
<td>Sometimes difficult to identify, lower maximum operating pressures, poor sealing capability, poor reusability</td>
</tr>
</tbody>
</table>

For additional information, contact your Hose Safety Institute Distributor.

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7.5 Hose Assemblies: Length, Orientation, Measurement & Testing

When establishing proper hose length, motion absorption, hose length changes due to pressure, as well as hose and machine tolerances must be considered. Typical length tolerances for assemblies are shown in the table below.

Note: SAE is the standards organization which originated in the United States and is predominantly a North American organization while ISO originated in Europe. For hose assembly tolerance length, either standard may be referenced and used unless stated otherwise.

### Hose Assembly Length Tolerances (SAE):

<table>
<thead>
<tr>
<th>Assembly Length</th>
<th>Tolerances (decimal in)</th>
<th>Tolerances (fraction in)</th>
<th>Tolerances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up through 12 inches (304.8 mm)</td>
<td>0.125</td>
<td>1/8</td>
<td>3.2</td>
</tr>
<tr>
<td>Over 12 through 18 inches (304.8 through 457.2 mm)</td>
<td>0.187</td>
<td>3/16</td>
<td>4.8</td>
</tr>
<tr>
<td>Over 18 through 36 inches (457.2 through 914.4 mm)</td>
<td>0.250</td>
<td>1/4</td>
<td>6.4</td>
</tr>
<tr>
<td>Over 36 inches (914.4 mm)</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
</tbody>
</table>

### Hose Assembly Length Tolerances (ISO):

<table>
<thead>
<tr>
<th>Assembly Length</th>
<th>Tolerances (mm)</th>
<th>Tolerances (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-16 and smaller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up through 24.8 inches (630 mm)</td>
<td>-3 to +7</td>
<td>-0.1 to +0.3&quot;</td>
</tr>
<tr>
<td>Over 24.8 through 49.2 inches (630 through 1250 mm)</td>
<td>-4 to +12</td>
<td>-0.2 to +0.5&quot;</td>
</tr>
<tr>
<td>Over 49.2 through 98.4 inches (1250 through 2500 mm)</td>
<td>-6 to +20</td>
<td>-0.2 to +0.8&quot;</td>
</tr>
<tr>
<td>Over 98.4 through 315.0 inches (2500 through 8000 mm)</td>
<td>-0.5% to +1.5%</td>
<td>-0.5% to +1.5%</td>
</tr>
<tr>
<td>Over 315 inches (8000 mm)</td>
<td>-1.0% to + 3.0%</td>
<td>-0.5 % to +3.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assembly Length</th>
<th>Tolerances (mm)</th>
<th>Tolerances (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Larger than -16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up through 24.8 inches (630 mm)</td>
<td>-4 to +12</td>
<td>-0.2 to +0.5&quot;</td>
</tr>
<tr>
<td>Over 24.8 through 49.2 inches (630 through 1250 mm)</td>
<td>-6 to +20</td>
<td>-0.2 to +0.8&quot;</td>
</tr>
<tr>
<td>Over 49.2 through 98.4 inches (1250 through 2500 mm)</td>
<td>-6 to +25</td>
<td>-0.2 to +1.0&quot;</td>
</tr>
<tr>
<td>Over 98.4 through 315.0 inches (2500 through 8000 mm)</td>
<td>-0.5% to +1.5%</td>
<td>-0.5% to +1.5%</td>
</tr>
<tr>
<td>Over 315 inches (8000 mm)</td>
<td>-1.0% to + 3.0%</td>
<td>-0.5 % to +3.0%</td>
</tr>
</tbody>
</table>

7.5.1 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 short high pressure hose assemblies.

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

The hose cut length for a hose assembly is calculated by subtracting the cut-off factor (distance from the bottom of the ferrule or collar to the end of the fitting, dimension “C” in Fig. 39). Typical length tolerance: Up to and including 12” +/- 3mm (.13in), up to 18” +/- 5mm (.19in), up to 36” +/- 7mm (.25in), over 36” +/- 1% of length.
Unless otherwise specified by the customer, the assembly’s overall length is measured from the extreme end of one fitting to the extreme end of the other; except for the O-ring face seal fittings which shall be measured from the sealing face. Where elbow fittings are used, the measurement shall be to the centerline of the sealing surface of the elbow end. For examples please see the illustrations below.

For male thread fittings (Fig. a), the cut-off is measured from the locking collar to the end of the threads (C) as shown.

For straight female fittings (Fig. b & c), the cut-off is measured from the locking collar to either the end of the nut or seat depending on whether the nut can be pulled back exposing the seating surface as shown.

All cut-off values are identified in the fitting tables found in the manufacturer’s catalog.
7.5.2 Hydraulic Hose Assembly Orientation for Offset Elbow Fittings

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**

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**

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.
7.5.3 Hose Routing Considerations for Hydraulic Hose Assemblies

Hose assemblies should be routed to prevent damage from the environment. Damage may come in the form of abrasion or excessive heat. Do not route assemblies in high-abrasion areas without proper protection. Similarly, do not place hoses near hot exhaust manifolds or other objects, which can expose the assembly to temperatures above its maximum rating, without proper shielding. The best practices described in this section represent corrections to some of the most common routing mistakes. A more complete guide can be found in SAE J1273.

Twisting

Hose assemblies should not be installed in a twisted condition. Swivel fittings and/or the layline may be used to aid in twist-free installation. When possible, a second “back-up” wrench should be used to prevent twisting while tightening the hose end swivel nut.

Minimum Bend Radius

Routing at less than minimum bend radius, will reduce the service life of the hose. Use the static or dynamic minimum bend radius according to service conditions. Sharp bends at the hose to fitting juncture should be avoided. Bending the hose to a radius tighter than the minimum bend radius can cause kinking of the hose and shorten the life of the assembly. The bending radius should not begin closer than one hose diameter to the ferrule.

Care should be taken when routing hoses to take into account any movement of the hose due to articulation of the equipment while in use. This may include cylinders extending/retracting or the rotation of hydraulic motors. Extra length may be required to prevent the hose from exceeding the rated minimum bend radius.
Angled Adapters and Fittings

The use of angled adapters and fittings can prevent the violation of the hose minimum bend radius. They can also improve appearance and accessibility to hose assemblies.

Minimum Free Length

When routing short hose assemblies, it is recommended that a minimum free hose length is always used. Minimum Free Length (MFL) is defined as equal to 4 times the hose OD plus half the hose minimum bend radius as a rule of thumb for hydraulic hose assemblies.
Length Change under Pressure

It is also important to ensure that hose assemblies have enough length to compensate for the change in length of the hose when pressurized. Enough slack should be provided, in case the hose contracts under pressure, to prevent creating tension into the hose assembly. In assemblies where the hose is bent, the hose length should be sufficient so that the minimum bend radius is not exceeded if the hose contracts under pressure.

Abrasion, Clamping, and Supports

Abrasion is the wearing of a hose through physical contact. This could be from another hose or other objects in the environment. To prevent abrasion, care should be taken when routing a hose assembly so that it will not come in contact with any object, which can cause abrasion. This includes: hoses, clamps, brackets, or structural components of the equipment. Such devices should not create additional stress or wear points.

To reduce the abrasion of a hose assembly, more abrasion resistant cover materials can be used. Most hose manufacturers offer hose cover materials which can provide increased abrasion resistance. For specific recommendations, please consult with your hose supplier.

In addition to cover materials, which offer increased abrasion resistance, external sleeves can also be added to hose assemblies to provide even greater abrasion resistance. These materials may also allow the replacement of the abrasion guard without replacing the hose assembly. These include, but are not limited to:

- UV-protected nylon fabric sleeving/wrap
- Spiral wraps (metal or plastic)
- Convoluted tubing (plastic)
- Spring guards
Articulation can also cause abrasion points that were not previously present.

Hose assemblies, subject to movement while operating, should be installed in such a way that flexing occurs in the same plane, to prevent twisting.

If flexing in multiple planes cannot be avoided, the hose should be clamped so that the planes are separated.

Clamps/supports should also be used to provide support to long hose assemblies, which may sag. This prevents the assembly from getting caught on the equipment itself or other objects.

7.5.4 Testing Hydraulic Hose Assemblies

Coupled hose assembly lots should be sampled and tested utilizing an acceptable burst and proof pressure procedure. It is recommended that proof and burst testing be performed in accordance with SAE J517 and SAE J343, as shown below, or an applicable industry standard or customer specification.
The SAE J343 standard gives methods for testing and evaluating the performance of the SAE 100R series hydraulic hose and hose assemblies (hose and attached end fittings) used in hydraulic systems.

**Proof Pressure Test** – This proof test is conducted at twice the working pressure of the hose unless otherwise specified by the customer. The test pressure shall be maintained for a period of not less than 30 seconds or more than 60 seconds. There shall be no indication of failure or leakage.

**Burst Test** - Hose assemblies on which the end fittings have been attached less than 30 days shall be subjected to a hydrostatic pressure increased at a constant rate so as to attain the specified minimum burst pressure within a period of not less than 15 seconds nor more than 30 seconds. There shall be no leakage, hose burst, or indication of failure below the specified minimum burst pressure.

**WARNING:** Water or another liquid suitable for the hose under test shall be used as the test medium. The use of air or other gaseous materials as testing media should be avoided because of the risk to operators. In special cases where such media are required for the tests, strict safety measures are imperative. Furthermore, it is stressed that when a liquid is used as the test medium, it is essential that all air is expelled from the test piece because of the risk of injury to the operator due to the sudden expansion of trapped air released when the hose bursts.

The hose assemblies to be bench tested must be inspected to ensure conformance to applicable test specifications. It is important to realize that, with the exception of proof test and change in length, all hose assemblies under pressure testing are to be destroyed after the test.

Specific test and performance criteria for evaluating hose assemblies used in hydraulic service are in accordance with requirements for hose in the respective specifications of SAE J517. It is recommended that every facility making hydraulic hose assemblies have a copy of the SAE HS-150 standards manual. Current issue is on disk and available from SAE Headquarters.

Test methods for threaded hydraulic fluid power connectors shall conform to SAE standard J1644. This is equivalent to ISO 8434-5 with the exception that the SAE standard includes “repeated assembly test” for male flare shaped fittings assembled to tube flare.

The same cautions apply to tube testing as with hose assemblies. Bursts and fine jets can penetrate the skin. Sudden energy release can be very hazardous.

**Salt Spray Standards and Testing**

**General**

Most steel fittings are required to meet minimum corrosion resistance requirements. Corrosion resistance is important to prevent the degradation of a part during transportation, storage, and service. Some examples of corrosion problems are listed below.

- Cosmetic issues
- Contamination due to corrosion of interior surfaces
- Thread interference from corrosion product build-up
- Degradation of surface finish in o-ring glands
- Part fracture

**Test Methods**

Typically, steel fittings are tested under accelerated conditions to ensure that the component will perform in the field. Most manufacturers subject parts to a neutral salt spray test per ASTM B117 or the ISO 9227. The two standards are considered equivalent for neutral salt spray. This method subjects parts to a controlled fog produced from a sodium chloride salt solution.
Coating Types

To meet corrosion resistance specifications, carbon steel parts have a coating or plating applied. Common finishes are:

- Zinc plating with a chromate conversion coating
- Organic coatings
- Zinc-nickel

Currently, zinc plating with a chromate conversion coating is the most common method. Zinc chromate plating replaced cadmium plating due to environmental reasons. Similarly, many manufacturers have eliminated hexavalent chrome from fittings in favor of trivalent for environmental reasons. The European Union has already banned hexavalent chromium from some vehicle applications. Hexavalent chromate can range from yellow/gold to olive green in color. In contrast, trivalent chromate is silver and can sometimes have a slight blue tint. Corrosion resistance can be changed by changing the thickness of the zinc and chromate layers or also the addition of topcoats.

Zinc-plated parts show two corrosion products. Initially, the zinc layer corrodes forming white corrosion (zinc oxide). After the zinc layer is penetrated, red corrosion (iron oxide) of the base carbon steel results. Since the zinc layer is sacrificial, not all customers or standards have requirements for white corrosion. Specifications without a white corrosion requirement typically only include one for red corrosion, as it indicates degradation of the base metal. Severe red corrosion of the base metal (carbon steel) can ultimately result in cracking and failure. However, white corrosion can still be problematic causing cosmetic, assembly, and sealing issues.

Organic coatings can also be used to prevent corrosion. These layers can be used either alone or in combination with other coatings. Zinc-nickel offers excellent corrosion resistance and does not contain hexavalent chromium. Additionally, a more resistant base material can be substituted to improve performance. In some applications, stainless steel or brass can be substituted to eliminate the use of carbon steel.

Specifications

ASTM B117 and ISO 9227 specify the evaluation of parts every 24 hours; therefore most specifications are in 24-hour increments. SAE J514/J516 and ISO 4520 specify that carbon steel fittings must not show signs of red corrosion prior to 72 hours with the following exceptions:

- Internal fluid passages
- Edges such as hex points, serrations, and crests of threads where there may be mechanical deformation of the plating or coating typical of mass-produced parts of shipping effects
- Areas where there is mechanical deformation of the plating or coating caused by crimping, flaring, bending, and other post-plate metal forming operations
- Areas where the parts are suspended or affixed in the test chamber where condensate can accumulate

Large OEM's and customers may also specify corrosion resistance specifications. Most include some or all of the following items:

- Test method (ASTM B117/ISO 9227 or different method)
- Hours to white corrosion
• Hours to red corrosion

• Plating thickness (typically referenced in ASTM B633)
• Exceptions to requirements (through hole corrosion, mechanical deformation, threads, etc…)
• Failure criteria for corrosion products (first sign of corrosion, < 5% of test surface, etc…)
7.6 Accessories and Equipment

Hydraulic Hose Attachments

O-Rings

In today’s market place, leaking components translates to money lost through loss of horsepower, reduced component life, increased system down time, and increased maintenance to name just a few factors. As such, tapered pipe thread connections are slowly being phased out of industry to be replaced with superior connections like flanges and straight thread, o-ring type fittings.

When choosing an o-ring for the first time or when replacing an existing o-ring the best source of information is the manufacturer’s catalog. This can be as simple as matching the part number if it is available or, if not available it will be necessary to identify the o-ring by measuring.

Different o-rings are required depending on the type of fitting or flange being used. Once you have determined the type and size of fitting, finding the correct o-ring is simply a matter of finding the part in the original manufacturer’s catalog and cross referencing the o-ring part number.

To determine the correct o-ring without the fitting, the size and material must be determined. This can be done by the following method:

- Measure the inside diameter
- Measure the thickness of the o-ring
- Determine the o-ring material required. (buna-n, viton®, ethylene propylene, etc. If you are unsure use a compatibility chart based on the fluid and temperature requirements).
- Determining the durometer may be necessary

With this information use SAE J515 standard or ISO 3601-1 o-ring charts in determining the correct replacement. The correct replacement is vitally important to ensure there are no compatibility issues that may cause leakage or component failure through contamination.

Temperature / Fluid compatibility: High temperature and fluid compatibility will vary by o-ring supplier and application. Increased pressure can also shorten o-ring life. For specific recommendations, please consult your hose end and/or o-ring supplier.

Replacement: Depending on the application, o-rings may need to be replaced. Factors which can reduce o-ring life, necessitating replacement, include: high temperature, high pressure, aggressive fluids, and frequent reconnections. O-rings, which have been damaged, should be discarded. Also, it is recommended that new o-rings be used when a hose assembly is replaced.

Sleeving

Abrasion in most cases is caused by continuous rubbing against equipment components, other hose or objects in the operating environment. Cover erosion may also be caused by non-compatible fluids, such as toxic chemicals, acids, detergents and non-compatible hydraulic fluids. Exposed hose reinforcement is susceptible to rust and accelerated damage leading to failure.

One solution is to bundle hose that flex in the same direction. Clamps, bent tube fittings, nylon ties (straps), spring guards and sleeving can be used to keep hose away from abrasion sources and exposure to non-compatible fluids. Remember:

- Group and bundle similarly constructed and sized hoses together using clamps, nylon straps or nylon sleeving.
- Never bundle high pressure hose with low pressure hose. Under pressure they can work against each other.
- Never bundle rubber hose with thermoplastic or fluoropolymer hose. Under pressure they can also work against each other.
- Always consider mechanical movement when bundling. Allow sufficient slack without pulling on a fitting or another hose. Bundles (like individual hose) should bend in one plane only.

Another solution is the use of covers or sleeves (see Figures below).

Wire Spring
Flat Armor Spring
Nylon Sleeve
Plastic Coil Sleeving
Bend Restrictors

7.7 Hydraulic Hose Cleanliness Considerations

Hydraulics:

Modern Hydraulics is defined as the use of confined liquid to transmit power, multiply force or produce motion. Clean hydraulic fluid is an integral part of a hydraulic system and contaminated fluid will reduce the service life of hydraulic systems. If contamination is left in the hose after the cutting and crimping process it is very likely that these particles will work their way into the hydraulic system and cause premature wear and tear or even catastrophic failure. Therefore hose cleaning and the removal of contamination is an important part of the fabrication process.

Reason for Cleaning:

The cleaning process ensures that contamination generated during the assembly process has been removed. The primary source of contamination in a hydraulic hose assembly is the result of the cutting process with either a metal blade or abrasive wheel. Therefore it is recommended that the hose be cleaned immediately after the cutting process and always before stem insertion.

The 3 main reasons for cleaning the hose after the cutting process are as follows. 1. Heat from the cutting process causes both rubber and metal particles to become very hot. As the particles cool they
may stick or adhere to the tube thus becoming much more difficult to remove. 2. If contaminants are
trapped between the O.D. of the stem and the I.D. of the tube they could act as an eventual leak path for
hydraulic fluid when the system is under pressure. 3. Stem insertion is much more difficult when trying to
push stems over or past the internal contamination. A clean tube is usually smooth and slippery in nature
which means stem lubrication may not be necessary.

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 meeting a specific ISO, NAS or SAE
cleanliness code is testing.

There are 3 methods of specifying cleanliness.

1. Gravimetric analysis (reference ISO 4405)
   ISO 4407 specifies a method to determine fluid contamination by filtering a volume of fluid under
   vacuum through 1 or 2 filter membranes.

2. Particle counting (reference ISO 4406)
   ISO 4406 specifies a code of 3 scale numbers to measure the particle level in a fluid sample.
The scale numbers are as follows:

- The first scale number represents the number of particles equal or larger to 4 microns per milliliter of fluid.
- The second scale number represents the number of particles equal or larger to 6 microns per milliliter of fluid.
- The third scale number represents the number of particles equal or larger to 14 microns per milliliter of fluid.

The scale code is represented, for example, as 18/16/12. The lower the scale code number, the cleaner the fluid. Table 1 illustrates particle counts to scale numbers.

<table>
<thead>
<tr>
<th>Number of particles per millilitre</th>
<th>Scale Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than</td>
<td>Up to and including</td>
</tr>
<tr>
<td>2 500 000</td>
<td>&gt;28</td>
</tr>
<tr>
<td>1 300 000</td>
<td>2 500 000</td>
</tr>
<tr>
<td>640 000</td>
<td>1 300 000</td>
</tr>
<tr>
<td>320 000</td>
<td>640 000</td>
</tr>
<tr>
<td>160 000</td>
<td>320 000</td>
</tr>
<tr>
<td>80 000</td>
<td>160 000</td>
</tr>
<tr>
<td>40 000</td>
<td>80 000</td>
</tr>
<tr>
<td>20 000</td>
<td>40 000</td>
</tr>
<tr>
<td>10 000</td>
<td>20 000</td>
</tr>
<tr>
<td>5 000</td>
<td>10 000</td>
</tr>
<tr>
<td>2 500</td>
<td>5 000</td>
</tr>
<tr>
<td>1 300</td>
<td>2 500</td>
</tr>
<tr>
<td>640</td>
<td>1 300</td>
</tr>
<tr>
<td>320</td>
<td>640</td>
</tr>
<tr>
<td>160</td>
<td>320</td>
</tr>
<tr>
<td>80</td>
<td>160</td>
</tr>
<tr>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>1.3</td>
<td>2.5</td>
</tr>
<tr>
<td>0.64</td>
<td>1.3</td>
</tr>
<tr>
<td>0.32</td>
<td>0.64</td>
</tr>
<tr>
<td>0.16</td>
<td>0.32</td>
</tr>
<tr>
<td>0.08</td>
<td>0.16</td>
</tr>
<tr>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>0.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**NOTE:** Reproducibility below scale number 8 is affected by the actual number of particles counted in the fluid sample. Raw counts should be more than 20 particles.

When the raw data in one of the size ranges results in a particle count of fewer than 20 particles, the scale number for that size range shall be labeled with the symbol >.
3. Maximum particle size (reference ISO 4407)
ISO 4407 specifies methods to determine contamination levels in a hydraulic system by counting the particles trapped on a membrane filter using an optical microscope. Particles to 2 microns can be counted using this method.
Section 8 Fluoropolymer Hose

Section Contents:
- 8.1 General Information
- 8.2 STAMPED
- 8.3 Measurements for Fluoropolymer Hose Assemblies
- 8.4 Fluoropolymer Hose Fittings & Attachments
- 8.5 Performance Characteristics
- 8.6 Hose Assembly Length Determination for Various Movements
- 8.7 Hose Routing
- 8.8 Assembly Methods
- 8.9 Testing Procedures for Fluoropolymer Hose

8.1 General

The fluoropolymer hose assemblies specified are suitable for the major portion of commercial and industrial applications.

This document is not intended to prohibit either supplier or customer from attaching additional requirements for fluoropolymer hose assemblies, if necessary to satisfy the application.

The following applications are excluded from the scope of this document:

- Installations involving torque, axial compression or extension
- Extreme working pressures (above 3,500 psi)
- Extreme Temperature (above 500 F)
- Chlorine or Bromine applications
- High Purity
- Compressed Gas

The purpose of this section is to identify the types of liners/inner cores most frequently used in the fabrication of fluoropolymer hose. This information will guide you in the selection of the proper fluoropolymer hose required for a specific application.

Fluoropolymer hoses are manufactured in several different configurations depending on the application. When selecting the hose, consideration must be given to corrosion resistance, service temperature, pressure ratings, end fittings, and exterior environmental conditions. (See S.T.A.M.P.E.D section)

NOTE: The manufacturer should identify which fluoropolymer is used in any product being referenced.

The following components comprise a fluoropolymer hose assembly. The hose construction may consist of one or more of the components listed below. Typically fluoropolymer hoses are reinforced by one of the
following outer covers such as an exterior braid; however some applications do not require any exterior reinforcement and the inner core alone may be adequate. (Consult NAHAD Hose Safety Institute Distributor for specific limits.)

It is necessary to select the appropriate construction materials for the specific application.

A. Fluoropolymer Innercore (tube)
   - Smooth tube, extruded
   - Convoluted
     - Extruded, vacuum formed construction
     - Tape wrapped, Fiberglass backed, molded convolution
   Materials:
     - PTFE – virgin and anti-static
     - PFA – virgin and anti-static
     - FEP

B. Reinforcements
   - Metallic (braided on, slip braided)
     - CRES (300 series)
     - Bronze
     - Monel ®
     - Hastelloy ®
   Others (consult manufacturer)
     - Non-Metallic (braided on or slip braided)
       - Polypropylene
       - PVDF
       - Nylon
       - Fiberglass
       - Aramide Fibers
     - Rubber covered, fluoropolymer core w/bonded rubber layers, w - w/o helix wire, fabric reinforced w/bonded rubber covering
     - Metal hose, stainless steel

High pressure (gang braid) hose 3000 to 6000 psi depending on size

Medium pressure smooth bore hose 1000 to 3500 psi

Low pressure hose (convoluted innercore) 1000 psi and below
Others available, consult your NAHAD Hose Safety Institute Distributor. The preceding specifications should be considered minimal and each manufacturer may suggest additional requirements to assure best results in fabrication, testing and service life.

Specialty hoses are typically supplied directly by the manufacturer; for special needs, consult your manufacturer.

- Electrically heated hose (viscosity control)
- Jacketed hose

C. Fittings

- Type 316 Stainless Steel or 316L
- Type 304 Stainless Steel
- Type 303/302 Stainless Steel
- Brass
- Carbon Steel (plated)
- Aluminum
- Non-Metallic
- Hastelloy ®
- Monel ®
- Alloy 20
- PFE Encapsulated
- coated

Smooth Bore Reusable Fittings

D. Collars/Ferrules

- Stainless Steel
- Carbon Steel (plated)
- Brass
- Monel ®
- Hastelloy ®
8.2 STAMPED

The STAMPED acronym stands for the 7 major information areas required to provide a quality hose assembly for the customer, as follows:

**S** stands for **SIZE**; I.D. and length; any O.D. constraints
- overall length should be specified to include fittings.
   Note: When gathering information for determining length of an assembly, NAHAD traditionally is "seat to seat", however many customers require an "OAL" (overall length) which is from fitting end to fitting end and is the normal SAE assembly length standard.
- tolerances need to be specified if special requirements exist

**I.D., O.D. and overall length of the assembly**
- To determine the replacement hose I.D., read the layline printing on the side of the original hose. If the original hose layline is painted over or worn off, the original hose must be cut and inside diameter measured for size.
- The inside diameter of the hose must be adequate to keep pressure loss to a minimum, maintain adequate flow, and avoid damage to the hose due to heat generation or excessive turbulence. The hose should be sized according to the nomographic chart in appendix D.
- Length tolerances:

<table>
<thead>
<tr>
<th>Assembly Length Tolerances</th>
<th>Inches</th>
<th>MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length &lt;= 18&quot;</td>
<td>+/- .125&quot;</td>
<td>Length &lt;= 450mm</td>
</tr>
<tr>
<td>Length &lt;18&quot; or &lt;= 36&quot;</td>
<td>+/- .250&quot;</td>
<td>Length &lt; 450mm or &lt;= 900mm</td>
</tr>
<tr>
<td>Length &lt;36&quot; or &lt;= 50&quot;</td>
<td>+/- .500&quot;</td>
<td>Length &lt; 900mm or &lt;= 1270mm</td>
</tr>
<tr>
<td>Length &gt; 50&quot;</td>
<td>+/- 1%</td>
<td>Length &gt; 1270mm</td>
</tr>
</tbody>
</table>

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

**Flow Rate / Fluid Velocity** - The flow rate of the system in conjunction with the inside diameter of the hose will dictate the fluid velocity through the hose. Typical fluid velocities can be seen in the nomographic chart in Appendix D. Please consult your hose supplier for specific recommended velocity ranges. Please note that suction line recommendations are different than pressure lines.

**T** stands for **TEMPERATURE** of the material conveyed and environmental conditions
- Are there factors such as heat sources in the environment in which the hose will be used
- Continuous (average) and minimum and maximum temperatures have to be specified for both the environment and material conveyed
- Note if flame resistance or flammability will be an issue
- Sub-zero exposure
- Care must be taken when routing near hot manifolds and in extreme cases a heat shield may be advisable.
- Other things to consider: maximum intermittent ambient temperature, fluid temperature, ambient temperature and maximum temperature.
- Maximum assembly working pressures will decrease as temperatures increase.

**A** stands for the **APPLICATION**, the conditions of use
- Configuration/routing (add a sketch or drawing if applicable)
  - is the hose hanging, laying horizontally, supported, unsupported (orientation and aspect of the hose)
  - what else is attached to the hose, any external load on the hose
  - bend radius requirements, flexibility
- elongation considerations with working pressure
- Quantify anticipated movement and geometry of use requirements
- Intermittent or continuous service
- Indoor and outdoor use
- Unusual mechanical loads
- Excessive abrasion
- Electrical conductivity requirements
- Equipment type
- External conditions – abrasion, oil (specify type), solvents (specify type), acid (specify type and concentration), ozone, salt water
- Hose now in use
  - Type of hose
  - Service life being obtained and description of failure or source of customer dissatisfaction
- Strength and frequency of impulsing or pressure spikes
- Non-flexing applications (static), flexing applications (dynamic)
- Vacuum requirements
- Ensure compatibility with cleaning requirements of the application

M stands for the MATERIAL or MEDIA being conveyed, type and concentration
- Are there special requirements for this hose tube
  - Any special specifications (or agency requirements) that need to be considered (e.g., FDA, API)
  - Will the material be continuously flowing, or sit in the hose for long periods of time (specify)
- Media velocity, flow rate
- Chemical name/concentration (MSDS)
- Solids, description and size
- Fluid Compatibility - Some applications require specialized oils or chemicals to be conveyed through the system. Hose selection must assure compatibility of the hose tube. In addition to the hose materials, all other components, which make up the hose assembly (hose ends, o-rings, etc…), must also be compatible with fluid being used. Depending on the fluid, your hose supplier may lower the maximum temperature or pressure rating of the assembly. When selecting any hose assembly, always consult your hose supplier’s recommendations.

P stands for the PRESSURE to which the assembly will be exposed
- System pressure, including pressure spikes. Hose assembly working pressures must be equal to or greater than the system pressure. Pressure spikes greater than the maximum working pressure will shorten hose life and must be taken into consideration.
- Temperature implications
- Vacuum considerations
- Maximum Operating Pressure - This is the maximum pressure that the system should be exposed to in normal operating conditions. For hydraulic hose assemblies, this pressure should be dictated by the relief setting of the system. Both the hose and hose end should not be rated to a pressure less than the maximum operating pressure of the system.
- Pressure Spikes - When a hydraulic system is subjected to a large load in a short period of time, the system pressure can overshoot the relief setting and exceed the maximum operating pressure. Frequent pressure spikes can reduce the life of hydraulic hose assemblies. In general, spiral hose constructions are better suited to high impulse applications, which involve flexing and large pressure spikes. However, there are specialized braided hoses available from various manufacturers. Please consult your hose supplier if there are multiple constructions which meet your application needs.
- Maximum assembly working pressures will decrease as temperatures increase.

E stands for ENDS; style, type, orientation, attachment methods, etc.
- Uncoupled or coupled hose; hose with built-in fittings
- Specify end style (see charts and pictures in Section 5)
• Materials and dimensions (steel, stainless, etc.)
• Conductivity requirements
• Media compatibility also needs to be considered

D stands for DELIVERY
• Specific to customer requirements
• Testing requirements
  o certification requirements (e.g., Coast Guard)
• Any special packaging requirements
• Any special shipping requirements
• Tagging requirements

8.3 Measurements for Fluoropolymer Hose Assemblies

Metric / English Measurement System
The hose manufacturer shall state in their brochures or documentation which system will be employed in their manufacturing process. All tolerances will be applied to their system of measurement. Optional cross-referencing of another system will be done in brackets. [e.g., 1/4 inch (6) means manufacture is in English and reference is to metric.]

Inside Diameter of the Hose
The inside diameter of the hose may be true bore or nominal bore as specified by the manufacturer.

Developed Lengths
Tolerances for the overall length of the hose assembly shall be observed according to the following table unless otherwise stated.

Table: Tolerances
This chart is intended for smooth bore hose. For other styles of hose, consult your manufacturer for actual tolerances.

<table>
<thead>
<tr>
<th>Assembly Length Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inches</strong></td>
</tr>
<tr>
<td>Length $\leq 18$&quot;</td>
</tr>
<tr>
<td>Length $&lt;18$&quot; or $\leq 36$&quot;</td>
</tr>
<tr>
<td>Length $&lt;36$&quot; or $\leq 50$&quot;</td>
</tr>
<tr>
<td>Length $&gt;50$&quot;</td>
</tr>
</tbody>
</table>

Method of Measurement
Length measurements shall be taken using a tape measure with the hose flat and straight. To sustain this layout, the hose should lie in a V channel or against a wall perpendicular to the holding surface. Hose assemblies should be supported if the OD of the coupling is significantly larger than the hose OD to prevent the hose from sagging. On most hose assemblies the developed length is the end to end dimension at the centerline (Figure 8.1). End connections with a seating face shall be measured from the seat face and not from the end of the fitting (e.g. JIC type end fittings) (Figure 8.2). Please refer to note above in Section 8.2 S stands for Size.

Hose assemblies using elbows shall be measured from the centerlines (Figure 8.3). Please note that when assemblies have two elbows installed that the drop measurement and orientation / rotation must be maintained; this should be accompanied by a drawing that is agreed upon with the customer. Note: a verbal agreement is sufficient if the customer approves that.
Figure 8.1 Measurement of Hose Assembly

Figure 8.2 Measurement of Hose Assembly having an End Connection with a Seating Face

Figure 8.3 Measurement of Hose Assembly having an Elbow Fitting

Drop Measurement:
Distance between elbow seat and hose centerline.
8.4 Coupling Terminal End (Thread) Identification

It is always important to measure the threads since there are so many threads similar in measurement and which may look very similar. The proliferation of threads on the world market today makes it easy to mismatch threads resulting in leakage and possible serious accident. Each manufacturer has his own shell and stem markings to match the different hose types. This marking system can be part numbers stamped on the product, notches, lines, etc. For this reason it is recommended to consult the manufacturer if there is any question.

Identification of a coupling/end connection requires the correct tools and reference materials, such as a coupling suppliers catalog. The tools are available from most coupling manufacturers or your local tool store.

The recommended tools are:
- Thread pitch gauge capable of measuring inch and metric thread pitches.
- I.D./O.D. Caliper capable of measuring both inches and millimeters.
- Seat angle gauge capable of measuring different seating angles (i.e 37° or 45° flare and 60° or 24° inverted flares).
- Reference materials showing different threaded end charts (inch and metric systems).

It is important to know the three basic steps in identifying a coupling/end connection. Similarity of thread in measurement as well as appearance can result in a mismatch and possible serious consequences.

The three steps are as follows:
- Measure the thread pitch
- Measure the thread diameter
- Determine the seating angle if applicable

Measuring Thread Pitch

Use a thread pitch gauge to determine the number of threads per inch or the distance between two threads for a metric connection. In the inch thread system (NPT) the thread pitch is referred to as the number of threads per inch or, in other words, how many crests there are per inch. The metric system measures the distance between two threads or crests.

Using a thread pitch gauge designed for fluid connector threads, try different thread gauges looking for the tightest fit. Engage as many threads as possible, the more threads engaged the more accurate the reading.
Hold the fitting and thread gauge up to the light and look for gaps or light appearing between the gauge and the threads. This is easy on a male connection and more difficult to see on the female end connection. It should be a tight fit with very little light coming through. Keep in mind the tools may not be machinist quality, just a measuring device, so some light coming through is normal.

Measuring the thread diameter

Using the I.D./O.D. caliper measure the thread diameter. Male thread diameter is measured on the outside diameter of the thread. It is recommended to hold the caliper at a slight angle for a more accurate reading. Female thread diameter is measured on the inside diameter of the thread. For female thread it is recommended to hold the caliper perpendicular to the thread.

Measuring the seating/sealing surface angle (when applicable)

If the connection seals on a flared surface (example: 37° or 45° flare) or on an inverted angle seat (example: 60° or 24° inverted flares) the next step is to determine that angle of seal. Use a seat angle gauge on the male connection. Place the gauge on the sealing surface. If the centerlines of the connection and gauge are parallel the correct angle has been determined. Measuring the female is accomplished in a similar manner by inserting the gauge into the connection and placing it on the sealing surface. If the centerlines of the connection and gauge are parallel, the correct angle has been determined.
One additional important step is required when identifying a metric 24° male connection and that is to determine if it is an L (light series) or S (heavy series). This is accomplished by measuring the inside diameter of the recessed counter bore at the base of the 24° inverted sealing surface (Fig. 17 and 18.) This measurement will be in millimeters and determines if the connection is L or S series (Fig. 15 “R” dimension). It is an important required measurement to determine the correct replacement fitting/end connection.

Match the thread pitch, diameter, and seating angle measurements taken to the various threaded end charts in your reference materials.

The following pages list a variety of hydraulic and/or fluoropolymer hose ends.
8.4.1 37° Flare (JIC)

The Society of Automotive Engineers (SAE) specifies a 37° angle flare or seat be used with high pressure hydraulic tubing. These are commonly called JIC couplings.

The JIC 37° flare male will mate with a JIC female only. The JIC male has straight threads and a 37° flare seat. The JIC female has straight threads and a 37° flare seat. The seal is made on the 37° flare seat.

Some sizes have the same threads as the SAE 45° flare. Carefully measure the seat angle to differentiate.

*Note: Some couplings may have dual machined seats (both 37° and 45° seats).

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1/8</td>
<td>5/16-24</td>
<td>17/64</td>
<td>5/16</td>
</tr>
<tr>
<td>-3</td>
<td>3/16</td>
<td>3/8-24</td>
<td>21/64</td>
<td>3/8</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>7/16-20</td>
<td>25/64</td>
<td>7/16</td>
</tr>
<tr>
<td>-5</td>
<td>5/16</td>
<td>1/2-20</td>
<td>29/64</td>
<td>1/2</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>9/16-18</td>
<td>1/2</td>
<td>9/16</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>3/4-16</td>
<td>11/16</td>
<td>3/4</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>7/8-14</td>
<td>13/16</td>
<td>7/8</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>1-1/16-12</td>
<td>31/32</td>
<td>1-1/16</td>
</tr>
<tr>
<td>-14</td>
<td>7/8</td>
<td>1-3/16-12</td>
<td>1-7/64</td>
<td>1-3/16</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-5/16-12</td>
<td>1-15/64</td>
<td>1-5/16</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-5/8-12</td>
<td>1-35/64</td>
<td>1-5/8</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-7/8-12</td>
<td>1-51/64</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-1/8-12</td>
<td>2-27/64</td>
<td>2-1/2</td>
</tr>
</tbody>
</table>

8.4.2 SAE (45° Flare)

A term usually applied to fittings having a 45° angle flare or seat. Soft copper tubing is generally used in such applications as it is easily flared to the 45° angle. These are for low pressure applications such as for fuel lines and refrigerant lines.

The SAE 45° flare male will mate with an SAE 45° flare female only. The SAE male has straight threads and a 45° flare seat. The SAE female has straight threads and a 45° flare seat. The seal is made on the
45° flare seat. Some sizes have the same threads as the SAE 37° flare. Carefully measure the seat angle to differentiate.

*Note: Some couplings may have dual machined seats (both 37° and 45° seats).

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1/8</td>
<td>5/16-24</td>
<td>17/64</td>
<td>5/16</td>
</tr>
<tr>
<td>-3</td>
<td>3/16</td>
<td>3/8-24</td>
<td>21/64</td>
<td>3/8</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>7/16-20</td>
<td>25/64</td>
<td>7/16</td>
</tr>
<tr>
<td>-5</td>
<td>5/16</td>
<td>1-2-20</td>
<td>29/64</td>
<td>1/2</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>5/8-18</td>
<td>9/16</td>
<td>5/8</td>
</tr>
<tr>
<td>-7</td>
<td>7/16</td>
<td>11/16-6</td>
<td>5/8</td>
<td>11/16</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>3/4-16</td>
<td>11/16</td>
<td>3/4</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>7/8-14</td>
<td>13/16</td>
<td>7/8</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>1-1/16-14</td>
<td>63/64</td>
<td>1-1/16</td>
</tr>
<tr>
<td>-14</td>
<td>7/8</td>
<td>1-1/4-12</td>
<td>1-11/64</td>
<td>1-1/4</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-3/8-12</td>
<td>1-19/64</td>
<td>1-3/8</td>
</tr>
</tbody>
</table>

8.4.3 "O" Ring Boss

The O-ring boss male will mate with an O-ring boss female only. The female is generally found on ports. The male has straight threads and an O-ring. The female has straight threads and a sealing face. The seal is made at the O-ring on the male and the sealing face on the female.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>3/16</td>
<td>3/8-24</td>
<td>21/64</td>
<td>3/8</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>7/16-20</td>
<td>25/64</td>
<td>7/16</td>
</tr>
<tr>
<td>-5</td>
<td>5/16</td>
<td>1-2-20</td>
<td>29/64</td>
<td>1/2</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>9/16-18</td>
<td>1/2</td>
<td>9/16</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>3/4-16</td>
<td>11/16</td>
<td>3/4</td>
</tr>
<tr>
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<td>5/8</td>
<td>7/8-14</td>
<td>13/16</td>
<td>7/8</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>1-1/16-12</td>
<td>31/32</td>
<td>1-1/16</td>
</tr>
<tr>
<td>-14</td>
<td>7/8</td>
<td>1-3/16-12</td>
<td>1-7/64</td>
<td>1-3/16</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-5/16-12</td>
<td>1-15/64</td>
<td>1-5/16</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-5/8-12</td>
<td>1-35/64</td>
<td>1-5/8</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-7/8-12</td>
<td>1-51/64</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-1/2-12</td>
<td>2-27/64</td>
<td>2-1/2</td>
</tr>
</tbody>
</table>
The SAE Code 61 and Code 62 4-Bolt Split Flange is used worldwide, usually as a connection on pumps and motors. There are three exceptions.

4. The -10 size, which is common outside of North America, is not an SAE Standard size.

5. Caterpillar flanges, which are the same flange O.D. as SAE Code 62, have a thicker flange head ("C" dimension in Table).

6. Poclain flanges, which are completely different from SAE flanges.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>1.188</td>
<td>.688</td>
<td>1.500</td>
<td>.265</td>
<td>1.250</td>
<td>.718</td>
<td>1.574</td>
<td>.305</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5/8</td>
<td>1.338</td>
<td>.265</td>
<td>-</td>
<td>.265</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3/4</td>
<td>1.500</td>
<td>.875</td>
<td>1.875</td>
<td>.265</td>
<td>1.625</td>
<td>.937</td>
<td>2.000</td>
<td>.345</td>
<td>1.625</td>
<td>.938</td>
<td>2.000</td>
<td>.560</td>
</tr>
<tr>
<td>1</td>
<td>1.750</td>
<td>1.031</td>
<td>2.062</td>
<td>.315</td>
<td>1.875</td>
<td>1.093</td>
<td>2.250</td>
<td>.375</td>
<td>1.875</td>
<td>1.094</td>
<td>2.250</td>
<td>.560</td>
</tr>
<tr>
<td>1-1/4</td>
<td>2.000</td>
<td>1.188</td>
<td>2.312</td>
<td>.315</td>
<td>2.125</td>
<td>1.250</td>
<td>2.625</td>
<td>.405</td>
<td>2.125</td>
<td>1.250</td>
<td>2.625</td>
<td>.560</td>
</tr>
<tr>
<td>1-1/2</td>
<td>2.375</td>
<td>1.406</td>
<td>2.750</td>
<td>.315</td>
<td>2.500</td>
<td>1.437</td>
<td>3.125</td>
<td>.495</td>
<td>2.500</td>
<td>1.438</td>
<td>3.125</td>
<td>.560</td>
</tr>
<tr>
<td>2-1/2</td>
<td>3.312</td>
<td>2.000</td>
<td>3.500</td>
<td>.375</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>4.000</td>
<td>2.438</td>
<td>4.188</td>
<td>.375</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3-1/2</td>
<td>4.500</td>
<td>2.750</td>
<td>4.750</td>
<td>.442</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>5.000</td>
<td>3.062</td>
<td>5.125</td>
<td>.442</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>6.000</td>
<td>3.625</td>
<td>6.000</td>
<td>.442</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
8.4.5 "O" Ring Face Seal SAE J1453

A seal is made when the O-ring in the male contacts the flat face on the female. Couplings are intended for hydraulic systems where elastomeric seals are acceptable to overcome leakage and leak resistance is crucial. The solid male O-ring face seal fitting will mate with a swivel female O-ring face seal fitting only. An O-ring rests in the O-ring groove in the male.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>1/4</td>
<td>9/16-18</td>
<td>9/16</td>
<td>1/2</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>11/16-16</td>
<td>11/16</td>
<td>5/8</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>13/16-16</td>
<td>13/16</td>
<td>3/4</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>1-14</td>
<td>1</td>
<td>15/16</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>1-3/16-12</td>
<td>1-3/16</td>
<td>1-1/8</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-7/16-12</td>
<td>1-7/16</td>
<td>1-11/32</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-11/16-12</td>
<td>1-11/16</td>
<td>1-19/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>2-12</td>
<td>2</td>
<td>1-29/32</td>
</tr>
</tbody>
</table>

8.4.6 Pipe Threads

NPTF -- This is a dryseal thread; the National pipe tapered thread for fuels. This is used for both male and female ends. The NPTF male will mate with the NPTF, NPSF, or NPSM female. The NPTF male has tapered threads and a 30° inverted seat. The NPTF female has tapered threads and no seat. The seal takes place by deformation of the threads. The NPSM female has straight threads and a 30° inverted seat. The seal takes place on the 30° seat. The NPTF connector is similar to, but not interchangeable with, the BSPT connector. The thread pitch is different in most sizes. Also, the thread angle is 60° instead of the 55° angle found on BSPT threads.

NPSF -- The National pipe straight thread for fuels. This is sometimes used for female ends and properly mates with the NPTF male end. However, the SAE recommends the NPTF thread in preference to the NPSF for female ends.
### 8.4.7 DIN 7631 (DIN 60° Cone)

This series combines an internal 60° seat with parallel metric Light series threads. This connection provides a metal-to-metal seal when tightened. This style can be identified by the internal, 60° seat on the male, metric threaded portion.

<table>
<thead>
<tr>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
<th>Pipe/Tube O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12 x 1.5</td>
<td>10.5</td>
<td>12.0</td>
<td>6</td>
</tr>
<tr>
<td>M14 x 1.5</td>
<td>12.5</td>
<td>14.0</td>
<td>8</td>
</tr>
<tr>
<td>M16 x 1.5</td>
<td>14.5</td>
<td>16.0</td>
<td>10</td>
</tr>
<tr>
<td>M18 x 1.5</td>
<td>16.5</td>
<td>18.0</td>
<td>12</td>
</tr>
<tr>
<td>M22 x 1.5</td>
<td>20.5</td>
<td>22.0</td>
<td>15</td>
</tr>
<tr>
<td>M26 x 1.5</td>
<td>24.5</td>
<td>26.0</td>
<td>18</td>
</tr>
<tr>
<td>M30 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
<td>22</td>
</tr>
<tr>
<td>M38 x 1.5</td>
<td>36.5</td>
<td>38.0</td>
<td>28</td>
</tr>
<tr>
<td>M45 x 1.5</td>
<td>43.5</td>
<td>45.0</td>
<td>35</td>
</tr>
<tr>
<td>M52 x 1.5</td>
<td>50.5</td>
<td>52.0</td>
<td>42</td>
</tr>
</tbody>
</table>

### 8.4.8 DIN 3902 (DIN 24° Cone Light and Heavy Duty)

Male 24° Cone
This connection style consists of a common male and two female options. The male has a straight metric thread, a 24° included angle, and a recessed counterbore that matches the tube OD used with it. In the first female design, a metal-to-metal seal is accomplished as the female nose and male taper are forced against one another. The other option uses an o-ring on the female tapered nose. This creates an o-ring seal as the connection is tightened. Both a heavy and light-duty series are offered. The series can be determined by measuring the seat counterbore, which is the approximate tube outside diameter, and comparing it to the thread size.

<table>
<thead>
<tr>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
<th>Light Duty Pipe/Tube O.D. (mm)</th>
<th>Heavy Duty Pipe/Tube O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12 x 1.5</td>
<td>10.5</td>
<td>12.0</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>M14 x 1.5</td>
<td>12.5</td>
<td>14.0</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>M16 x 1.5</td>
<td>14.5</td>
<td>16.0</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>M18 x 1.5</td>
<td>16.5</td>
<td>18.0</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>M20 x 1.5</td>
<td>18.5</td>
<td>20.0</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>M22 x 1.5</td>
<td>20.5</td>
<td>22.0</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>M24 x 1.5</td>
<td>22.5</td>
<td>24.0</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>M26 x 1.5</td>
<td>24.5</td>
<td>26.0</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>M30 x 2.0</td>
<td>28.0</td>
<td>30.0</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>M36 x 2.0</td>
<td>34.0</td>
<td>36.0</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>M42 x 2.0</td>
<td>40.0</td>
<td>42.0</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>M45 x 2.0</td>
<td>43.0</td>
<td>45.0</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>M52 x 2.0</td>
<td>50.0</td>
<td>52.0</td>
<td>42</td>
<td>38</td>
</tr>
</tbody>
</table>

**8.4.9 British Standard Pipe Parallel (BSPP)**

The BSPP male has straight threads and a 30° seat. The female has straight threads and a 30° nose. An o-ring design is also available on the nose from some manufacturers. Sealing can either be metal-to-metal or via an o-ring depending on the design. If the female design is used as a port connection, then an o-ring must be utilized on the male similar in design to the o-ring boss.
# British Flat-Face Seal

A seal is made when the o-ring in the male contacts the flat face on the female. Couplings are intended for hydraulic systems where elastomeric seals are acceptable to overcome leakage and leak resistance in crucial. Although similar in design to the o-ring face seal, they are not interchangeable.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1/8</td>
<td>1/8-28</td>
<td>11/32</td>
<td>3/8</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>17/32</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>5/8-14</td>
<td>13/16</td>
<td>29/32</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-11/32</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-17/32</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-7/32</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>

# JIS 30° Inverted Seat (Parallel Pipe and Metric Threads)

The JIS inverted seat connection is available with two different thread styles. The parallel pipe thread design operates similarly to the BSPP connection. However, please consult your hose end supplier for interchangeability recommendations. The metric threaded design is identical to the parallel pipe design except for thread differences.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
</tbody>
</table>
### Parallel Pipe Threads

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>17/32</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-11/32</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-17/32</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-7/32</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>

#### JIS 30° Inverted Seat (Parallel Pipe)

### Metric Threads

<table>
<thead>
<tr>
<th>Dash Size Equivalent</th>
<th>Nominal Size (mm)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>6</td>
<td>M14 x 1.5</td>
<td>12.5</td>
<td>14.0</td>
</tr>
<tr>
<td>-6</td>
<td>9</td>
<td>M18 x 1.5</td>
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<td>18.0</td>
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<tr>
<td>-8</td>
<td>12</td>
<td>M22 x 1.5</td>
<td>20.5</td>
<td>22.0</td>
</tr>
<tr>
<td>-12</td>
<td>19</td>
<td>M30 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
</tr>
<tr>
<td>-16</td>
<td>25</td>
<td>M33 x 1.5</td>
<td>31.5</td>
<td>33.0</td>
</tr>
<tr>
<td>-20</td>
<td>32</td>
<td>M42 x 1.5</td>
<td>40.5</td>
<td>42.0</td>
</tr>
</tbody>
</table>

#### JIS 30° Inverted Seat (Metric Threads)

### 8.4.12 JIS 30° Cone Seat (Parallel Pipe Threads)

The JIS 30° flare is similar to the American SAE 37° flare connection in application as well as sealing principles. However, the flare angle and dimensions are different. The threads are similar to BSPP.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Tapered Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>33/64</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-5/16</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-9/16</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-1/4</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>
8.4.13 British Standard Pipe Tapered (BSPT) / Japanese Tapered Pipe Thread

The BSPT is similar to NPTF, but not interchangeable due to thread differences. Sealing, like the NPTF, is accomplished on the threads. BSPT is identical and fully interchangeable with Japanese Tapered Pipe Thread.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Thread Size</th>
<th>Female Thread I.D. (in.)</th>
<th>Male Thread O.D. (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>1/8</td>
<td>1/8-28</td>
<td>11/32</td>
<td>3/8</td>
</tr>
<tr>
<td>-4</td>
<td>1/4</td>
<td>1/4-19</td>
<td>15/32</td>
<td>17/32</td>
</tr>
<tr>
<td>-6</td>
<td>3/8</td>
<td>3/8-19</td>
<td>19/32</td>
<td>21/32</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>1/2-14</td>
<td>3/4</td>
<td>13/16</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>5/8-14</td>
<td>13/16</td>
<td>29/32</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>3/4-14</td>
<td>31/32</td>
<td>1-1/32</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>1-11</td>
<td>1-7/32</td>
<td>1-11/32</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>1-1/4-11</td>
<td>1-17/32</td>
<td>1-21/32</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>1-1/2-11</td>
<td>1-25/32</td>
<td>1-7/8</td>
</tr>
<tr>
<td>-32</td>
<td>2</td>
<td>2-11</td>
<td>2-7/32</td>
<td>2-11/32</td>
</tr>
</tbody>
</table>

8.4.14 French GAZ 24° Cone

This end connection is similar to the DIN 24° cone; however, they are not interchangeable. Even though the sealing angles are the same, the threads are different.
### Metric Thread Size

<table>
<thead>
<tr>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
<th>Pipe/Tube O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M20 x 1.5</td>
<td>18.5</td>
<td>20.0</td>
<td>13.25</td>
</tr>
<tr>
<td>M24 x 1.5</td>
<td>22.5</td>
<td>24.0</td>
<td>16.75</td>
</tr>
<tr>
<td>M30 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
<td>21.25</td>
</tr>
<tr>
<td>M36 x 2.0</td>
<td>34.5</td>
<td>36.0</td>
<td>26.75</td>
</tr>
<tr>
<td>M45 x 2.0</td>
<td>43.5</td>
<td>45.0</td>
<td>33.50</td>
</tr>
<tr>
<td>M52 x 2.0</td>
<td>50.5</td>
<td>52.0</td>
<td>42.25</td>
</tr>
<tr>
<td>M58 x 2.0</td>
<td>55.0</td>
<td>58.0</td>
<td>48.25</td>
</tr>
</tbody>
</table>

### 8.4.15 French GAZ Poclain 24° Flange

This flange differs from standard SAE flanges in that it has a lip that protrudes from the male flange face with a 24° angle. This lip fits into mating the female flange seat and provides the metal-to-metal seal when the bolts are tightened.

### Flange Clamp

<table>
<thead>
<tr>
<th>Nominal Size (in.)</th>
<th>A (in.)</th>
<th>B (in.)</th>
<th>C (in.)</th>
<th>D (in.)</th>
<th>E (in.)</th>
<th>F (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>1.57</td>
<td>.72</td>
<td>2.20</td>
<td>1.89</td>
<td>.55</td>
<td>.35</td>
</tr>
<tr>
<td>5/8</td>
<td>1.57</td>
<td>.72</td>
<td>2.20</td>
<td>1.89</td>
<td>.55</td>
<td>.35</td>
</tr>
<tr>
<td>3/4</td>
<td>2.00</td>
<td>.94</td>
<td>2.75</td>
<td>2.38</td>
<td>.71</td>
<td>.43</td>
</tr>
</tbody>
</table>
8.4.16 Metric Standpipe Assembly

A metric standpipe assembly is comprised of three components attached to a male fitting. The components are: a Standpipe tube, Bite Sleeve, and Metric Nut. The nut is placed over the Standpipe, followed by the Bite Sleeve. For DIN light assemblies, a DIN light metric nut is used. For DIN heavy assemblies, a DIN heavy metric nut is used. The Bite Sleeve and Standpipe are selected on the basis of tube O.D. required.

<table>
<thead>
<tr>
<th>Metric Standpipe DIN Tube O.D. (mm)</th>
<th>Bite Sleeve DIN Tube O.D. (mm)</th>
<th>Metric Light Nut Thread</th>
<th>Metric Heavy Nut Thread</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>M12 x 1.5</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>M14 x 1.5</td>
<td>M16 x 1.5</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>M16 x 1.5</td>
<td>M18 x 1.5</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>M18 x 1.5</td>
<td>M20 x 1.5</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>M22 x 1.5</td>
<td>-</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>-</td>
<td>M24 x 1.5</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>M26 x 1.5</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>-</td>
<td>M30 x 2.0</td>
</tr>
<tr>
<td>22</td>
<td>22</td>
<td>M30 x 2.0</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>25</td>
<td>M36 x 2.0</td>
<td>-</td>
</tr>
<tr>
<td>28</td>
<td>28</td>
<td>M36 x 2.0</td>
<td>-</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>-</td>
<td>M42 x 2.0</td>
</tr>
<tr>
<td>35</td>
<td>35</td>
<td>M45 x 2.0</td>
<td>-</td>
</tr>
<tr>
<td>38</td>
<td>38</td>
<td>-</td>
<td>M52 x 2.0</td>
</tr>
<tr>
<td>42</td>
<td>42</td>
<td>M52 x 2.0</td>
<td>-</td>
</tr>
</tbody>
</table>
8.4.17 Komatsu 30° Flare Metric Threads

The Komatsu 30° flare is similar to the 37° JIC flare connection except for two things. The seat angle is 30° instead of 37°, and the threads are metric.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Nominal Size (in.)</th>
<th>Nominal Size (mm)</th>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>3/8</td>
<td>9.5</td>
<td>M18 x 1.5</td>
<td>18.5</td>
<td>20.0</td>
</tr>
<tr>
<td>-8</td>
<td>1/2</td>
<td>13</td>
<td>M22 x 1.5</td>
<td>22.5</td>
<td>24.0</td>
</tr>
<tr>
<td>-10</td>
<td>5/8</td>
<td>16</td>
<td>M24 x 1.5</td>
<td>28.5</td>
<td>30.0</td>
</tr>
<tr>
<td>-12</td>
<td>3/4</td>
<td>19</td>
<td>M30 x 1.5</td>
<td>34.5</td>
<td>36.0</td>
</tr>
<tr>
<td>-16</td>
<td>1</td>
<td>25</td>
<td>M33 x 1.5</td>
<td>43.5</td>
<td>45.0</td>
</tr>
<tr>
<td>-20</td>
<td>1-1/4</td>
<td>32</td>
<td>M36 x 1.5</td>
<td>50.5</td>
<td>52.0</td>
</tr>
<tr>
<td>-24</td>
<td>1-1/2</td>
<td>38</td>
<td>M42 x 1.5</td>
<td>55.0</td>
<td>58.0</td>
</tr>
</tbody>
</table>

8.4.18 Kobelco Metric Bite Sleeve

These are similar to the German DIN 24° Cone, but the DIN style uses courser threads. Therefore, the Kobelco and DIN connections are not interchangeable.

<table>
<thead>
<tr>
<th>Dash Size</th>
<th>Metric Thread Size</th>
<th>Female Thread I.D. (mm)</th>
<th>Male Thread O.D. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-22</td>
<td>M30 x 1.5</td>
<td>28.0</td>
<td>30.0</td>
</tr>
<tr>
<td>-28</td>
<td>M36 x 1.5</td>
<td>34.0</td>
<td>36.0</td>
</tr>
<tr>
<td>-35</td>
<td>M45 x 1.5</td>
<td>43.0</td>
<td>45.0</td>
</tr>
</tbody>
</table>
8.5 Performance Characteristics

Purpose

The purpose of this section is to establish various performance characteristics of fluoropolymer hose assemblies.

Maximum Allowable Working Pressure (MAWP)

The typical MAWP for fluoropolymer hoses is 4:1 ratio of its burst pressure to working pressure. Some manufacturers state this as 3:1 ratio as well. End users must validate the appropriate MAWP to the application. Please note that the MAWP of the assembly is that of the lowest WP spec of either the fitting or the hose.

Temperature

Unless otherwise stated, hose of fluoropolymer assemblies are suitable for applications up to 300°F - 500°F depending on style of hose and manufacturer. Most manufacturers rate maximum operating pressures at 70°F temperatures. If a hose is to be considered for use in an application that exceeds 70°F, consult manufacturer for any pressure de-rating of the hose of fluoropolymer assembly. The type of chemical being conveyed through the hose will impact temperature considerations as well.

Chemical Compatibility

For the corrosion resistance of the non-fluoropolymer components of a hose assembly, consult the component manufacturer or the following trusted handbooks:

National Association of Corrosion Engineers Handbook
1440 South Creek Drive
Houston, TX 77084

Compass Guide
Compass Publications
7731 Lookout Drive
La Jolla, CA 92037
Phone: (858) 551-9240
Fax: (858) 551-9340
Internet: http://www.compasspublications.com/

Minimum Bend Radius

A sphere with a diameter equal to 85% of the internal diameter of the hose must be able to roll freely (from end to end) in an unpressurized assembly bent 180 degrees at the hose’s stated minimum bend radius.

Vacuum Rating

The maximum amount of vacuum that can be drawn on the inside of a hose assembly without causing the assembly to fail the minimum bend test as specified by the hose manufacturer.
8.6 Hose Assembly Length Determination For Various Movements

Purpose
The information in this section is provided as a guide to determine the overall length of hose assemblies for the conditions shown. All formulas determine the minimum live length required. To obtain the overall length, the length of the fittings including braid sleeves, must be added to the live length.

Definitions of Symbols
The following definitions of symbols shall be used in all formulas:

- \( T \) = Travel
- \( R \) = Radius of the installation.
- \( L \) = Live length
- \( S \) = Outside diameter of the hose
- \( OAL \) = Overall length of the assembly
- \( MBR \) = Minimum bend radius of the hose

Example Values
In all calculations, the following example values are assigned:

- Hose outside diameter (\( S \)) = 2.75”
- Minimum bend radius of hose (\( MBR \)) = 14”
- Fitting length including braid sleeve = 3.50”

Constant Radius Traveling Loop

![Figure 8.4 Constant Radius Traveling Loop - Vertical Travel](image)

*Figure 8.4 Constant Radius Traveling Loop - Vertical Travel*
Figure 8.5 Constant Radius Traveling Loop - Horizontal Travel

**Formula:**

\[ L = 4(R) + (T)/2 \]

Example: Travel (T) = 6.00"

2R = 40"

\[ R = 40"/2 = 20" \]

\[ L = 4(20") + (6")/2 \]

L = 83.00"

OAL = 83.00" + 2(3.5") = 90.00"

**Note:**

For fluoropolymer hose, R must be \( \geq (MBR + S/2) \)
Variable Radius Traveling Loop

*Figure 8.6 Variable Radius Traveling Loop - Vertical Travel*

**Formula:**

\[ L = 4(R) + 1.57(T) \]

Example: Travel (T) = 6.00"

\[ 2R = 40" \]

\[ R = \frac{40"}{2} = 20" \]

\[ L = 4(20") + 1.57(6") \]

\[ L = 89.42" \]

\[ \text{OAL} = 89.42" + 2(3.5") = 96.42" \]

**Note:**

For fluoropolymer hose R must be \( \geq \) (MBR + S/2)
Offset Motion

Formula:

\[ L = (20R \times T)^{1/2} \]

For fluoropolymer hose \( R = (MBR) + S/2 \)

Example:
Travel \( (T) = 3.00" \) Metal Hose
\( R = MBR = 14" \)
\( L = (20 \times 14" \times 3")^{1/2} \)
\( L = 28.98" \)
\( \text{OAL} = 28.98" + 2(3.5") = 35.98" \) Live Straight Length – \( L_p \)

\[ L_p = (L^2 - T^2)^{1/2} \]
\[ L_p = (28.98"^2 - 3"^2)^{1/2} \]
\( L_p = 28.92" \)

Overall straight installed length = 28.82" + 2(3.5") = 35.82"

Note 1:
When the offset motion occurs on both sides of the centerline, \( T = \text{total travel} = (T_1 + T_2) \).

Note 2:
The offset distance “T” for constant flexing should never exceed 25% of the hose’s stated minimum bend radius.
Angular Motion

Figure 8.9 Angular Motion

Formula:

\[ L = 2(S) + (0/57.3)R \]

For fluoropolymer hose, \( R = (MBR + S/2) \) Example: \( \theta = 15 \) Degrees

OAL = 9.17" + 2(3.5") = 16.17"
Vertical Loop with Movement in Two Directions

Formula:

\[ L = 4(R) + 1.57(Th) + \frac{(Tv)}{2} \]

Example: \(2R = 40\)" Th = 6
\(Tv = 8\)" \(R = 40\)"/2 = 20"

\[ L = 4(20)" + 1.57(6)" + (8)"/2 \]
\[ L = 93.42" \]

OAL = 93.42" + 2(3.5") = 100.42"

Note:

For fluoropolymer hose, \(R\) must be \(\geq\) (MBR + S/2)
8.7 Hose Routing – Fluoropolymer Hose

When planning the hose routing use the following practices for optimum performance and more consistent and predictable service life.

Caution: When determining the overall lengths for the final routed length of an assembly it must be noted that hose lengths in these assemblies can, by design, grow in length +2% or shrink in length -4%! If this is not accounted for, severe damage can occur to the hose assembly.

Routing at less than minimum bend radius, will reduce the service life of the hose and/or cause premature hose failure. Use the static or dynamic minimum bend radius according to service conditions. Sharp bends at the hose to fitting juncture should be avoided.

Hose assemblies subject to movement while operating should be installed in such a way that flexing occurs in the same plane.

Hose assemblies shall not be installed or operated in a twisted or torqued condition. Swivel fittings or a lay line may be used to aid in torque-free installation. Also flanged hose assemblies should ideally have one end secured with a floating flange.

Flange to flange bolt hole alignment is critical for proper installation.

![Figure 8.11](image_url)
Figure 8.12

Right  | Wrong
---|---
Do Not Kink Hose
Adjust Piping to Avoid Kinking
Keep Hose in One Plane to Avoid Torsion
Do Not Torque Hose

Right  | Wrong
---|---
Use the Correct Length
Do Not Axially Compress Hose
Avoid Contact with Other Items
* Do Not Apply Wrench to Hose or Braid Sleeve
When planning the hose routing use the following practices for optimum performance and more consistent and predictable service life.

Routing at less than minimum bend radius, will reduce the service life of the hose. Use the static or dynamic minimum bend radius according to service conditions. Sharp bends at the hose to fitting juncture should be avoided. Bending radius should not begin closer than one hose diameter to the ferrule. Typical bend radius is measured from the inside, but confirm with the manufacturer.

![Diagram](image-url)

**Figure 8.13**
8.8 Assembly Methods

The purpose of this section is to identify the most common types of assembly methods typically used to fabricate fluoropolymer hose assemblies.

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 8.14 Typical Crimped Collar

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 8.15 Typical Swaged Collar

Flared Over Tubes of Fluoropolymer (Convoluted & Smooth)

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.

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

A. Metal hose assembled to NAHAD Flexible Metal Hose Standard.

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 liner as above.

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

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 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. 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.

NOTE: Not every fluoropolymer hose is or should be hydrostatically tested; pneumatic testing is perfectly appropriate in certain situations, and in all cases should be conducted under water at a pressure below 500 psi in a closed container. Using a gaseous media, the assembly is immersed in a bath of water for a sufficient length of time to permit visual examination of all fabricated joints. Typical gas testing media are air, nitrogen, and helium. 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.

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 manufacturers 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. This is very important as a safety measure because expansion of air compressed in the hose, when suddenly released by bursting or other failure might result in a serious accident.

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. Steadily increase the pressure, using water or other suitable test liquid. Maintain pressure for the length of the test. 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.

5. When tested using the procedure above, the tested assembly should be totally leak free for the duration of the test (one minute).

6. 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

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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 Helium 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.
Section 9 – Testing Procedures

9.1 Purpose

The purpose of this section is to define minimum test requirements, which should be routinely carried out on all new hose assemblies before use.

The following testing methods may or may not be required. Refer to the customer requirements and/or the appropriate assembly data sheets for recommended testing and documentation needed.

9.2 Testing Procedures for Corrugated Metal Hose

Pneumatic Test

Unless otherwise specified, the hose assembly shall be subjected to a pneumatic test at a value defined in Table 9.1. Using a gaseous media, the assembly is immersed in a bath of water for a sufficient length of time to permit visual examination of all fabricated joints. Typical gas testing media are air, nitrogen, and helium. To guard against corrosion, the chloride content of the water used for testing austenitic stainless steel should be controlled to less than 50 ppm (parts per million). Minimum testing time should be twenty (20) seconds. Any evidence of leakage or permanent deformation is cause for rejection.

<table>
<thead>
<tr>
<th>Table 9.1 – Minimum Pneumatic Test Pressures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal I.D.</td>
</tr>
<tr>
<td>1/4” through &lt;3/4”</td>
</tr>
<tr>
<td>3/4” through &lt;1-1/4”</td>
</tr>
<tr>
<td>1-1/4” through &lt;4”</td>
</tr>
<tr>
<td>4” through 6”</td>
</tr>
<tr>
<td>&gt;6”</td>
</tr>
</tbody>
</table>

Hydrostatic Test

The hydrostatic test not only tests for leakage, it confirms the assembly’s structural integrity. The assembly shall be pressurized with water to the maximum test pressure of the assembly and maintained for a sufficient length of time to permit a visual examination. To guard against corrosion, the chloride content of the water used for testing austenitic stainless steel should be controlled to less than 50 ppm (parts per million). The minimum testing time should be one (1) minute. Any evidence of leakage or permanent deformation is cause for rejection.

Helium Mass Spectrometer Test

Helium mass spectrometer testing is the most accurate way of evaluating leakage (but not strength). Assemblies designed for critical applications should be leak tested with this method. All tested assemblies shall have a leak rate less than 1 x 10^{-3} std/cc/sec. Helium mass spectrometer testing to smaller leak rates may be available – consult the assembly fabricator.
Cleaning for Oxygen

Oxygen can spontaneously ignite and explode in the presence of hydrocarbons or if solid particles are caught in its flow. Methods and parameters for both oxygen cleaning and cleanliness testing can be referenced in the Compressed Gas Association publication, “Cleaning Equipment for Oxygen Service”, CGA G-4.1. Breathable oxygen applications require special consideration. Consult the customer for appropriate requirements.

Additional Leakage Tests

Consult the fabricator for other testing methods. These may include, but are not limited to, the following: Pressure Decay, Vacuum Decay, Mass Flow, and Dye Penetrant Leak Test.
Test to Establish Minimum Static Bend Radius (MSBR)

A hose assembly having one of its end fittings rigidly fixed shall be placed between a cylindrical former and a fixed perpendicular restraint. The diameter of the cylindrical former shall be equal to twice the manufacturer’s static bend radius minus the outside diameter of the hose being tested. The horizontal axis of the former shall be in the same plane as the second hose convolution when testing unbraided hose assemblies. When testing braided hose assemblies, the axis must be as close to the braid sleeve as possible. The Hose Assembly shall be bent over the former, making full contact with a minimum of 90 degrees of the former’s circumference (see below).

Figure - 1
Static Bend Radius Test

One cycle includes one, 90 degree bend and the return movement to the perpendicular position. The test shall consist of the assembly being flexed through 10 cycles at a rate of 10 to 30 cycles per minute, without internal pressure. At the conclusion of the bend test, the assembly shall be pneumatically tested as defined in Section 9.2.1.
Test to Establish Minimum Dynamic Bend Radius (MDBR)

An assembly shall be cycle tested to determine its minimum dynamic bend radius. No additional lubrication is permitted for this test. The sample hose assembly shall be pressurized to its MAWP and must withstand at least 10,000 cycles without failure. Failure is defined as:

- Leakage; or
- A localized reduction of the installed radius of more than 50% during the test.

Hose of nominal diameters less than or equal to 4" shall be tested with the U-Bend Test. Hoses greater than 4" shall be tested with the Cantilever Test.

**U-Bend Test**

The assembly shall be installed in a vertical loop as illustrated in Figure 2A.

![Figure 2A Dynamic Bend Radius “U” Test](image)

- \( r = \text{MDBR} \)
- \( x = 4 \times \text{the nominal hose diameter, or } 5" \text{ whichever is greater} \)
- \( \text{Hose Live Length} = (4 \times \text{MDBR}) + x \)
- \( \text{Cycle Rate} = 3 \text{ to } 30 \text{ cycles per minute} \)

One Cycle equals the movement from the starting point up a distance of “x”, then down a distance of “x” past the starting point, and then back up to the starting point.
Cantilever Test

The assembly shall be installed in a straight configuration as illustrated in Figure 2B.

\[ \text{Cycle Rate} = 3 \text{ to } 15 \text{ cycles per minute} \]

One Cycle equals the movement starting from the horizontal position, then deflecting down a distance of "a", and then the return to the starting point.

\[ l = 6 \times \text{Nominal Hose Diameter} \]
\[ a = R - R \times \cos(57.3^\circ \times (2 \times D + 4") \div R) \]

Where:
- \( R \) = Minimum dynamic bend radius (inches)
- \( D \) = Nominal hose diameter (inches)

9.3 Testing Procedures for Industrial Hose

Hydrostatic Proof Pressure Tests (Non-destructive)

A proof test is typically conducted for 5 minutes under pressure at one and a half times (1.5x) the working pressure for new or used assemblies.

Proof or hydrostatic testing refers to testing that “proves” the finished hose assembly meets the pressure rating required by the application for which it will be used, and that the end fittings have been correctly fitted and the assembly is leak free.

- For assembly testing, the rating of the component with the lowest rated working pressure determines the working pressure of the assembly.
- Pressurize hose to 10 psi for 60 seconds prior to conducting the hydrostatic test.
- Hose assembly should be secured in an encapsulated tank that will withstand the pressure; at a minimum, make sure that the hose is sufficiently shielded during pressure testing to stop a coupling in case of a coupling blow-off.
- If applicable, secure hose with steel rods or straps close to each end and at ten-foot intervals along the length of the hose. This will prevent it from "whipping" if a failure occurs.
The securing rods or straps must be anchored firmly to the test structure, but should not contact the hose. The hose must be free to move slightly when pressure is applied.

- Hoses must be properly cleaned prior to inspection and testing; this will prevent unexpected reactions between conveyants and the test media.
- 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.
- It is recommended to never stand in front of, over, or behind the ends of a hose assembly during pressure testing.

All hydrostatic testing should be conducted with liquid media. Pneumatic testing with gasses such as air or nitrogen is prohibited. The energy stored when pressure testing with gasses creates a very dangerous system, where product failure may cause injury or death.

**Equipment:**
- hand pump, a power driven hydraulic pump, or an accumulator system
- outlet valve
- test tank (if applicable)
- Unless otherwise stated by the purchaser, the test medium should be water.

**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; take particular care to ensure that all trapped air is released from the hose. *This is a critical safety measure because expansion of air compressed in the hose, when suddenly released by bursting or other failure, might result in a serious accident.*
2. For reference, mark a line behind the coupling which is at the end of the ferrule, clamp, band, etc.
3. Then gradually raise the pressure to the desired pressure rating. Hold the pressure for the time dictated by hose type and conduct a visual inspection. As the pressure is raised, watch for visual indications of permanent deformation, leakage, and coupling slippage. If any of these are noted it is cause for rejection*. After the test is complete, relieve the test pressure before disconnecting the hose assembly from the test equipment and drain the water from the hose. The hose may be flushed with alcohol if all of the water must be removed.
4. When tested in accordance with the above, the assembly under test should be totally leak free for the duration of the test; leakage is defined as a continuous stream of water droplets emitted from a single or multiple locations.

*For industrial hose and depending on coupling design, a minimal amount of hose coupling slippage may be acceptable if the hose does not show any leakage at any time during the test; a second test is recommended in that case to confirm assembly integrity. Contact the manufacturer with any concerns.

**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 Helium Leak Test.
Electrical Continuity Test

Electrical continuity testing determines if an electrical path can be established between two points; for hose assemblies, refers to testing the assembly to determine if there is a grounding path between end fittings, which would allow for an electric charge to discharge through the hose to a ground source if necessary. Electrical continuity is accomplished by terminating all metallic components in the hose to the metallic couplings at both ends. Hoses should be tested with a calibrated multi-meter from end fitting to end fitting to determine if the assembly is electrically continuous. If continuity is required and not present, then the hose should be reassembled or rebuilt.

Grounding – Refers to the ability of the static charge to trace a path to a grounding point to “mother earth” for dissipation, and should be monitored to a level of <1000 ohms.

Testing for continuity

1. Make sure the hose is fabricated in accordance with HSI procedures and the hose helix or ground wire makes positive contact with the hose fittings. In the case of a wire braided hose a tack or staple may be required to assure the braid is contacting the hose shank.
2. It is recommended that continuity be checked prior to and after hydrostatic testing to assure that wires have not become dislodged during the test.
3. Select the ohm setting on the meter. Be sure to set unit to ohms, not mega ohms.
4. Place the hose ends close enough so that the 2 contacts wires on the meter can reach each end fitting or seat.
5. Hold the meter contacts firmly on each end and read the meter.
6. If the meter reads below 10 ohms, the hose passes the conductivity test. (In general, acceptable levels are less than 100 ohms, unless otherwise specified by industry standards. Check with manufacturer for acceptable ohm readings.)

Electrical Resistance Test

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

Elongation Tests

Elongation testing is a non-destructive method for determining a hose condition at different pressure ratings. Except for Oil Suction & Discharge Hose (Dock Hose) covered by ARPM (RMA IP-8), elongation tests are not typical. The end user would specify the need and frequency of testing.

Per ARPM IP-8: With some type of hose, it is useful to know how a hose will act under pressure. All change in length tests, except when performed on wire braid or wire spiraled hose, are made with original length measurements taken under a pressure of 10 psi (0.07 MPa). The specified pressure is applied and immediate measurement of the characteristics desired are taken and recorded.

Percent length change (elongation or contraction) is the difference between the length at 10 psi (0.07 MPa) and that at the specified pressure times 100 divided by the length at 10 psi (0.07 MPa). Elongation occurs if the length of the hose under the specified pressure is greater than at a pressure of 10 psi (0.07 MPa). Contraction occurs if the length at the specified pressure is less than at 10 psi (0.07 MPa). Reference marks are applied on the hose 20 inches (500 mm) apart (original length.) The hose is then repressurized to the maximum working pressure for 30 seconds and the reference marks are measured (final length.) The percentage change in length is the difference between the final and original lengths, divided by the original length, times 100.

% Length Change Formula: \[
\frac{L_0 - L_p}{L_0} \times 100
\]

Where:

L_0 = Original measured length at 10 psi (0.07 MPa)

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$L_p =$ Pressurized measured length at the specified pressure.

In the event that elongation length measurement is required, the following is an accepted process and may be incorporated into your test procedure.

A. Pressurize the hose to one time working pressure, hold for 30 seconds, release pressure to 10 psi and take the initial length measurement at 10 psi. Initial length: $L_0 = \underline{\text{________}}$.

B. Measure the hose length under pressure (Test Pressure Length), $L_t = \underline{\text{______}}$. Calculate the temporary elongation as follows:

$$\frac{L_t - L_0}{L_0} \times 100 = \underline{\text{______}}\% \ L_0.$$

C. Release the pressure, wait 30 seconds, measure and record the Overall Final Length, and drain hose.

Requirements for elongation of new dock hose per ARPM IP-8:

**NOTE 1:** The hose shall not elongate more than 7.5% at 150% of working pressure as determined by the formula $\frac{L_{tp} - L_o}{L_o} \times 100$.

Testing of used hose needs to meet the following per ARPM IP-11-4

Calculations:

a. Test pressure elongation, percent:

$$\frac{L_t - L_0}{L_o} \times 100 = \underline{(A)}$$

b. Immediate release elongation, percent:

$$\frac{L_i - L_0}{L_o} \times 100 = \underline{(B)}$$

c. Permanent release elongation, percent:

$$\frac{L_p - L_0}{L_o} \times 100 = \underline{(C)}$$

Examination of Elongations – After each periodic pressure test, the elongation results will be compared to those obtained in the testing of the hose when new.

An increase over the original value at the end of any periodic testing greater than shown below requires that hose to be removed from service.

a. When tested at 1 ½ times rated working pressure, test pressure elongations at any periodic test shall not be greater than the new hose test pressure elongation (A) plus 4% or twice (A), whichever is greater.

b. Immediate release elongation at any periodic test shall not be greater than the new hose immediate release elongation (B), plus 4% or twice (B) whichever is greater.

c. Permanent release elongation at any periodic test shall not be greater than the new hose permanent elongation (C), plus 4% or twice (C) whichever is greater.
Special requirements: Coast Guard testing requirements

From Coast Guard document 33 CFR Ch. 1 (7-1-07 Edition); Subpart C – Equipment Requirements:
154.500 Hose Assemblies

Each hose assembly used for transferring oil or hazardous material must meet the following requirements:
(a) The minimum design burst pressure for each hose assembly must be at least four times the sum of the pressure of the relief valve setting (or four times the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(b) The maximum allowable working pressure (MAWP) for each hose assembly must be more than the sum of the pressure of the relief valve setting (or the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(c) Each nonmetallic hose must be usable for oil or hazardous material service.
(d) Each hose assembly must either have:
   (1) full threaded connections,
   (2) Flanges that meet standard B16.5 Steel Pipe Flanges and Flange Fittings, or standard B16.24 Brass or Bronze Pipe Flanges, of the American National Standards Institute (ANSI), or
   (3) Quick-disconnect couplings that meet ASTM F1122
(e) Each hose must be marked with one of the following:
   (1) The name of each product for which the hose may be used, or
   (2) For oil products, the words “OIL SERVICE”, or
   (3) For hazardous materials, the words “HAZMAT SERVICE – SEE LIST” followed immediately by a letter, number or other symbol that corresponds to a list or chart contained in the facility’s operation manual or the vessel’s transfer procedure documents which identifies the products that may be transferred through a hose bearing that symbol.
(f) Each hose also must be marked with the following, except that the information required by paragraphs (f) (2) and (3) of this section need not be marked on the hose if it is recorded in the hose records of the vessel or facility, and the hose is marked to identify it with that information:
   (1) Maximum allowable working pressure;
   (2) Date of manufacture; and
   (3) Date of the latest test required by section 156.170.
(g) The hose burst pressure and the pressure used for the test required by 156.170 of this chapter must not be marked on the hose and must be recorded elsewhere at the facility as described in paragraph (f) of this section.
(h) Each hose used to transfer fuel to a vessel that has a fill pipe for which containment cannot practically be provided must be equipped with an automatic back pressure shutoff nozzle.


33 CFR 156.170 - Equipment tests and inspections

(a) Except as provided in paragraph (d) of this section, no person may use any equipment listed in paragraph (c) of this section for transfer operations unless the vessel or facility operator, as appropriate, tests and inspects the equipment in accordance with paragraphs (b), (c) and (f) of this section and the equipment is in the condition specified in paragraph (c) of this section.
(b) During any test or inspection required by this section, the entire external surface of the hose must be accessible.
(c) For the purpose of paragraph (a) of this section:
   (1) Each nonmetallic transfer hose must:
      (i) Have no unrepaired loose covers, kinks, bulges, soft spots or any other defect which would permit the discharge of oil or hazardous material through the hose material, and no gouges, cuts or slashes that penetrate the first layer of hose reinforcement as defined in Sec. 156.120(i).
(ii) Have no external deterioration and, to the extent internal inspection is possible with both ends of the hose open, no internal deterioration;

(iii) Not burst, bulge, leak, or abnormally distort under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and

(iv) Hoses not meeting the requirements of paragraph (c)(1)(i) of this section may be acceptable after a static liquid pressure test is successfully completed in the presence of the COTP. The test medium is not required to be water.

(2) Each transfer system relief valve must open at or below the pressure at which it is set to open;

(3) Each pressure gauge must show pressure within 10 percent of the actual pressure;

(4) Each loading arm and each transfer pipe system, including each metallic hose, must not leak under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and

(5) Each item of remote operating or indicating equipment, such as a remotely operated valve, tank level alarm, or emergency shutdown device, must perform its intended function.

(d) No person may use any hose in underwater service for transfer operations unless the operator of the vessel or facility has tested and inspected it in accordance with paragraph (c)(1) or (c)(4) of this section, as applicable.

(e) The test fluid used for the testing required by this section is limited to liquids that are compatible with the hose tube as recommended by the hose manufacturer.

(f) The frequency of the tests and inspections required by this section must be:

(1) For facilities, annually or not less than 30 days prior to the first transfer conducted past one year from the date of the last tests and inspections;
(2) For a facility in caretaker status, not less than 30 days prior to the first transfer after the facility is removed from caretaker status; and
(3) For vessels, annually or as part of the biennial and mid-period inspections.

Aircraft Fueling Hose, Ground Support

Please refer to API 1529 for detailed requirements.

Section 7.2.2 of the API 1529 standard states:

1.2.3 Hose assembly

The following tests shall be conducted on each hose assembly:

(d) Complete visual inspection
(e) Proof pressure in accordance with section 6.5.3
(f) Electrical continuity in accordance with section 6.5.3.2

These tests are conducted by the one who “assembles” the product. Section 7.3 follows with the identification requirements for each assembly including a test certificate that shows testing was performed and marking the couplings via serial numbers that link to the test certificate.
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:
  - Hose Identification - Size and type must correspond to the fabrication order (work order).
  - 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.
- 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.
  - Restrictions in the tube.
  - Rusted Couplings.
  - Ferrule interlocks properly with hose stem.

Visual inspections are also an important component of a hose maintenance program. In-service hose assemblies should be periodically checked for:

- Leaks at the hose fittings or in the hose.
- Damaged, separated or pulled back covers.
- Cracked, damaged, deformed or badly corroded fittings.
- Other signs of significant deterioration such as blisters.
- Compromised reinforcement where the wires are exposed and show signs such as unwrapped, broken or corroded.
- Dents, twists, or kinks.
- Discoloration of color coded hose cover.
- Verify test date and pressure are in conformity with requirements for the application.
- Fitting Thread and seat condition.

See Section 12.5 for additional detail.
9.4 Testing Procedures for Composite Hose

Hydrostatic Pressure Tests

All fitted hose assemblies should be pressure tested to establish that the end fittings have been correctly fitted and the assembly is leak free.

When testing hose assemblies with epoxy-style end fittings the epoxy should be allowed to cure prior to hydrostatic testing. Consult Manufacturer for recommended cure time.

The following criteria should apply when pressure testing hose assemblies:

- Composite hose assemblies with 1 inch to 4 inches (25 mm to 100 mm) nominal bore composite “standard duty” or general purpose oil and chemical hose should be tested to a minimum of the rated working pressure of the end fittings, but must not exceed one and a half times the rated working pressure of the hose for a minimum period of five (5) minutes. Longer test times may be required, consult manufacturer for specific requirements. (Polypropylene, cam and groove, NPT males and flanges do not have the same test criteria.)

- Composite hose assemblies with 4 inch (100 mm) nominal bore “heavy duty” and 6 inches to 10 inches (150 mm to 250 mm) nominal bore composite hose should be tested to a minimum of the rated test pressure of the end fittings, but must not exceed one and a half times the rated working pressure of the hose for a minimum period of 30 minutes and/or regulatory statutory requirements. (Polypropylene, cam and groove, NPT males and flanges do not have the same test criteria.)

  Note: Composite hose manufacturers may differentiate the 4 inch (100mm) nominal diameter between “standard duty” and “heavy duty”. It is common practice to suggest that “standard duty” hose is for general purpose in plant applications, whereas the “heavy duty” is used in either more rigorous or marine applications.

- Unless otherwise stated by the purchaser, the test medium should be water.

Recommended Testing Procedure

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 composite 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.

Hoses must be properly cleaned prior to inspection and testing. This will prevent unexpected reactions between conveyants and the test media. 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.

It is recommended to never stand in front of, over, or behind the ends of a hose assembly 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!
Elongation Length Measurement

A characteristic of composite hose is elongation. This characteristic should not be used solely as an assessment of the condition of the hose or an indication of failure. Consult manufacturer for more information. (See Section finished assembly dimension tolerances)

In the event that elongation length measurement is required, the following is an accepted process and may be incorporated into your test procedure.

A. Pressurize the hose to one time working pressure, hold for 30 seconds, release pressure to 10 psi and take the initial length measurement at 10 psi. $L_o = \_\_\_\_.$

B. Measure the hose length under pressure (Test Pressure Length), $L_t = \_\_\_\_. $ Calculate the temporary elongation as follows:
$$\frac{L_t - L_o}{L_o} \times 100 = \_\_\_\%L_o.$$

C. Release the pressure, wait 30 seconds, measure and record the Overall Final Length, and drain hose.

Special requirements: Coast Guard testing requirements

From Coast Guard document 33 CFR Ch. 1 (7-1-07 Edition); Subpart C – Equipment Requirements:
154.500 Hose Assemblies

Each hose assembly used for transferring oil or hazardous material must meet the following requirements:
(a) The minimum design burst pressure for each hose assembly must be at least four times the sum of the pressure of the relief valve setting (or four times the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(b) The maximum allowable working pressure (MAWP) for each hose assembly must be more than the sum of the pressure of the relief valve setting (or the maximum pump pressure when no relief valve is installed) plus the static head pressure of the transfer system, at the point where the hose is installed.
(c) Each nonmetallic hose must be usable for oil or hazardous material service.
(d) Each hose assembly must either have:
   (1) full threaded connections,
   (2) Flanges that meet standard B16.5 Steel Pipe Flanges and Flange Fittings, or standard B16.24 Brass or Bronze Pipe Flanges, of the American National Standards Institute (ANSI), or
   (3) Quick-disconnect couplings that meet ASTM F1122
(e) Each hose must be marked with one of the following:
   (1) The name of each product for which the hose may be used, or
   (2) For oil products, the words “OIL SERVICE”, or
   (3) For hazardous materials, the words “HAZMAT SERVICE – SEE LIST” followed immediately by a letter, number or other symbol that corresponds to a list or chart contained in the facility’s operation manual or the vessel’s transfer procedure documents which identifies the products that may be transferred through a hose bearing that symbol.
(f) Each hose also must be marked with the following, except that the information required by paragraphs (f) (2) and (3) of this section need not be marked on the hose if it is recorded in the hose records of the vessel or facility, and the hose is marked to identify it with that information:
   (1) Maximum allowable working pressure;
   (2) Date of manufacture; and
   (3) Date of the latest test required by section 156.170.
(g) The hose burst pressure and the pressure used for the test required by 156.170 of this chapter must not be marked on the hose and must be recorded elsewhere at the facility as described in paragraph (f) of this section.
(h) Each hose used to transfer fuel to a vessel that has a fill pipe for which containment cannot practically be provided must be equipped with an automatic back pressure shutoff nozzle.
(a) Except as provided in paragraph (d) of this section, no person may use any equipment listed in paragraph (c) of this section for transfer operations unless the vessel or facility operator, as appropriate, tests and inspects the equipment in accordance with paragraphs (b), (c) and (f) of this section and the equipment is in the condition specified in paragraph (c) of this section.

(b) During any test or inspection required by this section, the entire external surface of the hose must be accessible.

(c) For the purpose of paragraph (a) of this section:
   (1) Each nonmetallic transfer hose must:
      (i) Have no unrepaired loose covers, kinks, bulges, soft spots or any other defect which would permit the discharge of oil or hazardous material through the hose material, and no gouges, cuts or slashes that penetrate the first layer of hose reinforcement as defined in Sec. 156.120(i).
      (ii) Have no external deterioration and, to the extent internal inspection is possible with both ends of the hose open, no internal deterioration;
      (iii) Not burst, bulge, leak, or abnormally distort under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and
      (iv) Hoses not meeting the requirements of paragraph (c)(1)(i) of this section may be acceptable after a static liquid pressure test is successfully completed in the presence of the COTP. The test medium is not required to be water.
   (2) Each transfer system relief valve must open at or below the pressure at which it is set to open;
   (3) Each pressure gauge must show pressure within 10 percent of the actual pressure;
   (4) Each loading arm and each transfer pipe system, including each metallic hose, must not leak under static liquid pressure at least 1 1/2 times the maximum allowable working pressure; and
   (5) Each item of remote operating or indicating equipment, such as a remotely operated valve, tank level alarm, or emergency shutdown device, must perform its intended function.

(d) No person may use any hose in underwater service for transfer operations unless the operator of the vessel or facility has tested and inspected it in accordance with paragraph (c)(1) or (c)(4) of this section, as applicable.

(e) The test fluid used for the testing required by this section is limited to liquids that are compatible with the hose tube as recommended by the hose manufacturer.

(f) The frequency of the tests and inspections required by this section must be:
   (2) For facilities, annually or not less than 30 days prior to the first transfer conducted past one year from the date of the last tests and inspections;
   (2) For a facility in caretaker status, not less than 30 days prior to the first transfer after the
facility is removed from caretaker status; and

(3) For vessels, annually or as part of the biennial and mid-period inspections.

Electrical Continuity Test

Unless otherwise specified, all lengths of composite hose that have been fitted with electrically conductive end fittings must have an electrical resistance not exceeding 10 ohms. The test should be made from end fitting to end fitting using a calibrated multi-meter to ensure that the hose is electrically continuous.

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:
- Hose Identification - Size and type must correspond to the fabrication order (work order).
- 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.
- Inspection Items -
  - Bulge behind the coupling.
  - Cocked couplings.
  - Cracked couplings.
  - Displacement of inner and outer reinforcing wires from normal pitch
  - General appearance of the assembly.
  - Freedom of swivels
  - Internal contaminants.
  - Protective caps or plugs.
  - Restrictions in the tube
  - Rusted Couplings

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:

K. Test Certificate Number
L. Customers Name and Purchase Order Number
M. Suppliers Name and Job Number
N. Hose Serial Number(s)
O. Hose details including length, type of hose and diameter
P. End fitting details with types of ferrules and seals used
Q. Test Date
R. Test Pressure
S. Electrical Continuity Conformance
T. Suppliers Authorization Signature
9.5 Testing Procedures for Hydraulic Hose

Coupled hose assembly lots should be sampled and tested utilizing an acceptable burst and proof pressure procedure. It is recommended that proof and burst testing be performed in accordance with SAE J517 and SAE J343, as shown below, or an applicable industry standard or customer specification.

The SAE J343 standard gives methods for testing and evaluating the performance of the SAE 100R series hydraulic hose and hose assemblies (hose and attached end fittings) used in hydraulic systems.

Proof Pressure Test – This proof test is conducted at twice the working pressure of the hose unless otherwise specified by the customer. The test pressure shall be maintained for a period of not less than 30 seconds or more than 60 seconds. There shall be no indication of failure or leakage, and no indication of coupling slippage.

Burst Test - Hose assemblies on which the end fittings have been attached less than 30 days shall be subjected to a hydrostatic pressure increased at a constant rate so as to attain the specified minimum burst pressure within a period of not less than 15 seconds nor more than 30 seconds. There shall be no leakage, hose burst, or indication of failure below the specified minimum burst pressure.

WARNING: Water or another liquid suitable for the hose under test shall be used as the test medium. The use of air or other gaseous materials as testing media should be avoided because of the risk to operators. In special cases where such media are required for the tests, strict safety measures are imperative. Furthermore, it is stressed that when a liquid is used as the test medium, it is essential that all air is expelled from the test piece because of the risk of injury to the operator due to the sudden expansion of trapped air released when the hose bursts.

The hose assemblies to be bench tested must be inspected to ensure conformance to applicable test specifications. It is important to realize that, with the exception of proof test and change in length, all hose assemblies under pressure testing are to be destroyed after the test.

Specific test and performance criteria for evaluating hose assemblies used in hydraulic service are in accordance with requirements for hose in the respective specifications of SAE J517. It is recommended that every facility making hydraulic hose assemblies have a copy of the SAE HS-150 standards manual. Current issue is on disk and available from SAE Headquarters.

Test methods for threaded hydraulic fluid power connectors shall conform to SAE standard J1644. This is equivalent to ISO 8434-5 with the exception that the SAE standard includes “repeated assembly test’ for male flare shaped fittings assembled to tube flare.

The same cautions apply to tube testing as with hose assemblies. Bursts and fine jets can penetrate the skin. Sudden energy release can be very hazardous.

Salt Spray Standards and Testing

General
Most steel fittings are required to meet minimum corrosion resistance requirements. Corrosion resistance is important to prevent the degradation of a part during transportation, storage, and service. Some examples of corrosion problems are listed below.

- Cosmetic issues
- Contamination due to corrosion of interior surfaces
- Thread interference from corrosion product build-up
- Degradation of surface finish in o-ring glands
- Part fracture
Test Methods

Typically, steel fittings are tested under accelerated conditions to ensure that the component will perform in the field. Most manufacturers subject parts to a neutral salt spray test per ASTM B117 or the ISO 9227. The two standards are considered equivalent for neutral salt spray. This method subjects parts to a controlled fog produced from a sodium chloride salt solution.

Coating Types

To meet corrosion resistance specifications, carbon steel parts have a coating or plating applied. Common finishes are:

- Zinc plating with a chromate conversion coating
- Organic coatings
- Zinc-nickel

Currently, zinc plating with a chromate conversion coating is the most common method. Zinc chromate plating replaced cadmium plating due to environmental reasons. Similarly, many manufacturers have eliminated hexavalent chrome from fittings in favor of trivalent for environmental reasons. The European Union has already banned hexavalent chromium from some vehicle applications. Hexavalent chromate can range from yellow/gold to olive green in color. In contrast, trivalent chromate is silver and can sometimes have a slight blue tint. Corrosion resistance can be changed by changing the thickness of the zinc and chromate layers or also the addition of topcoats.

Zinc-plated parts show two corrosion products. Initially, the zinc layer corrodes forming white corrosion (zinc oxide). After the zinc layer is penetrated, red corrosion (iron oxide) of the base carbon steel results. Since the zinc layer is sacrificial, not all customers or standards have requirements for white corrosion. Specifications without a white corrosion requirement typically only include one for red corrosion, as it indicates degradation of the base metal. Severe red corrosion of the base metal (carbon steel) can ultimately result in cracking and failure. However, white corrosion can still be problematic causing cosmetic, assembly, and sealing issues.

Organic coatings can also be used to prevent corrosion. These layers can be used either alone or in combination with other coatings. Zinc-nickel offers excellent corrosion resistance and does not contain hexavalent chromium. Additionally, a more resistant base material can be substituted to improve performance. In some applications, stainless steel or brass can be substituted to eliminate the use of carbon steel.

Specifications

ASTM B117 and ISO 9227 specify the evaluation of parts every 24 hours; therefore most specifications are in 24-hour increments. SAE J514/J516 and ISO 4520 specify that carbon steel fittings must not show signs of red corrosion prior to 72 hours with the following exceptions:

- Internal fluid passages
- Edges such as hex points, serrations, and crests of threads where there may be mechanical deformation of the plating or coating typical of mass-produced parts of shipping effects
- Areas where there is mechanical deformation of the plating or coating caused by crimping, flaring, bending, and other post-plate metal forming operations
- Areas where the parts are suspended or affixed in the test chamber where condensate can accumulate

Large OEM’s and customers may also specify corrosion resistance specifications. Most include some or all of the following items.

- Test method (ASTM B117/ISO 9227 or different method)
- Hours to white corrosion
• Hours to red corrosion

• Plating thickness (typically referenced in ASTM B633)
• Exceptions to requirements (through hole corrosion, mechanical deformation, threads, etc…)
• Failure criteria for corrosion products (first sign of corrosion, < 5% of test surface, etc…)
9.6 Testing Procedures for Fluoropolymer Hose

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 manufacturers 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. *This is very important as a safety measure because expansion of air compressed in the hose, when suddenly released by bursting or other failure might result in a serious accident.*
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. Steadily increase the pressure, using water or other suitable test liquid. Maintain pressure for the length of the test. 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.
5. When tested using the procedure above, the tested assembly should be totally leak free for the duration of the test (one minute).

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**

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 Helium 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.

9.7 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.

9.8 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)
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

9.9 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:
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 10 – Quality Plan

10.1 Purpose

The purpose of this section is to outline a quality plan for fabricating 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.

10.2 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.

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?

The “Zero Acceptance Number Sampling Plans” by Nicholas L. Squeglia is a current, effective sampling system and is recommended should sampling rather than 100% testing be selected.

There are many areas or processes that may be sampled. These may vary from operation to operation, but there are some constants that should probably 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. Regardless of what is being sampled, inspection characteristics, the corresponding documentation and the personnel responsible for carrying for inspecting these characteristics, must be defined.
Inspection characteristics, the corresponding documentation, and the personnel responsible must be defined, regardless of what is being sampled.

When establishing the frequency of sampling, there are many factors that 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.

10.3 Material Receiving Inspection

Couplings

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

2. Compare the couplings received with the purchase order by making sure part numbers agree between order and packing slip.

3. Check the count between packing slip and actual quantity received.

4. Check the product in the package to make sure it agrees with the part number on the package. Supplier catalogs are a good reference.

5. 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.

6. 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.
10.4 Hose Assembly Dimensional Inspection (if applicable)

a) Length - Measure the length of a coupled assembly laid out on a flat surface. Unless otherwise shown on the fabrication order (work order), hose assembly length includes the couplings.

b) Crimped Outside Diameter – With a micrometer or caliper, measure the diameter of the crimped ferrule, in the center between two opposite die faces.

c) Coupling Orientation - Coupling orientation should be as specified on customer blueprints or fabrication order (work order).

10.5 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.

The ideal storage temperature for rubber hose is +50°F to +70°F with the maximum of +100°F. Care should be taken to keep rubber hoses from being stored next to heat sources. Rubber hose should not be stored near electrical equipment that generates ozone. Exposure to high concentrations of ozone will cause damage to the hose.

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.

After service, hose assemblies should be flushed out and drained. Ideally, stored hoses should be dry and kept off the ground in a straight line, out of direct sunlight.
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Section 11 – Assembly Identification, Cleaning and Packaging

11.1 Purpose

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

11.2 Hose Assembly Markings

Customers may require specific markings be applied to the hose assemblies for identification purposes, labeling and marking requirements should be communicated by the end user. These may include, but are not limited to:

1. Fabrication date
2. Part number(s)
3. Assembly description
4. Etc.

For composite hose, the following information should be included:

1. The manufacturer’s name, trademark or other identification
2. The hose serial number or manufacturer’s lot/I.D. number.
3. The nominal bore size
4. The month and year of hose assembly
5. The maximum working pressure.

Example: Manname/CH12/3"Aug97/150psi

Note: Excluded from this document are acceptable marking methods for chlorine hose. Refer to Pamphlet #6 from the Chlorine Institute Pamphlet #6 (edition 15), Appendix A, Section 9

Method of Marking

The marking of hose assemblies may be achieved in two ways:

1. Information pre-stamped in legible characters on metal tag or band affixed to the assembly by approved durable method.
2. Information in legible characters stamped directly onto the ferrule, braid sleeve, fitting, or printed heat shrink.
3. Branding may be achieved with colored stripes on the hose, embossed brands, stenciling, printing, labels, etc.
11.3 Cleaning

General

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 some of the loose particles. Some customers have stringent cleanliness requirements that may require fluid flushing or projectile cleaning of the assembly. End connection openings should be sealed or capped to maintain cleanliness and protect external threads.

Note: when an assembly is being used for oxygen service, special cleaning is typically required. Consult the provider for requirements.

Contamination in hose assemblies starts with the storage methods. Hose in storage that is left uncapped will have dust, dirt, bugs and even small animals inside. In addition there is a certain amount of chaff (bits of rubber, wire, etc) from the cutting process.

Cleaning hose and tube assemblies is vital to the life of the system and generally done by using compressed air. In most cases this is not adequate and special cleaning fluids, projectiles and even pressure cleaning can be used. It is the responsibility of the system designer or ultimate customer to specify the ISO code cleanliness level requirements. All assemblies must be capped or plugged.

Unless a specific cleanliness level has been specified, either by the customer or by an agency standard, the assembly shall be blown with clean, dry compressed air and capped before delivery.

Caution: always wear eye protection when using compressed air.

Hydraulic Hose Cleanliness Considerations

Modern Hydraulics is defined as the use of confined liquid to transmit power, multiply force or produce motion. Clean hydraulic fluid is an integral part of a hydraulic system and contaminated fluid will reduce the service life of hydraulic systems. Therefore hose cleanliness is an important part of the fabrication of a hydraulic hose assembly. If contamination is left in the hose after the cutting and crimping procedure it is very likely that these particles will work their way into the hydraulic system and cause premature wear and tear or even catastrophic failure.

Customer requirements and the specific application will dictate the required cleanliness level. Finished hose assemblies should be capped immediately to maintain the specified cleanliness level until the assembly is installed.

The primary source of contamination in a hose assembly is a result of the cutting process with either a metal blade or abrasive wheel. Therefore it is recommended that the hose be cleaned immediately after cutting and always before stem insertion.

There are 3 main reasons for cleaning the hose after the cutting process and before stem insertion and they are as follows. 1. Heat from the cutting process causes both rubber and metal particles to become very hot. If they are allowed to cool they cans stick or adhere to the tube thus becoming much more difficult to remove. 2. If contaminants are trapped between the O.D. of the stem and the I.D. of the tube they could act as an eventual leak path for hydraulic fluid when the system is under pressure. 3. Stem insertion is much more difficult when trying to push stems over or past the internal contamination. A clean tube is usually smooth and slippery in nature which means stem lubrication may not be necessary.

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 it. 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 process there is stem deformation to insure the proper coupling retention. This process causes metal and plating flash to occur inside of the stem. The hose assembly should go
through a final cleaning process. Immediately cap or plug each end of the hose assembly. This will
insure that the hose remains clean and external threads on the fittings will be protected.

The cleaning process insures that the all the contamination generated during shop assembly has
been removed.

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

There are 3 methods of specifying cleanliness.

4. Gravimetric analysis (reference ISO 4405)
   ISO 4407 specifies a method to determine fluid contamination by filtering a volume of fluid under
   vacuum through 1 or 2 filter membranes.

5. Particle counting (reference ISO 4406)
   ISO 4406 specifies a code of 3 scale numbers to measure the particle level in a fluid sample.

   The scale numbers are as follows:
   - The first scale number represents the number of particles equal or larger to 4
     microns per milliliter of fluid.
   - The second scale number represents the number of particles equal or larger to
     6 microns per milliliter of fluid.
   - The third scale number represents the number of particles equal or larger to 14
     microns per milliliter of fluid.

   The scale code is represented, for example, as 18/16/12. The lower the scale code number, the
cleaner the fluid. Table 1 illustrates particle counts to scale numbers.
### Table 1 – Allocation of scale numbers

<table>
<thead>
<tr>
<th>Number of particles per millilitre</th>
<th>Scale Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 2,500,000</td>
<td>&gt;28</td>
</tr>
<tr>
<td>1,300,000</td>
<td>28</td>
</tr>
<tr>
<td>640,000</td>
<td>27</td>
</tr>
<tr>
<td>320,000</td>
<td>26</td>
</tr>
<tr>
<td>160,000</td>
<td>25</td>
</tr>
<tr>
<td>80,000</td>
<td>24</td>
</tr>
<tr>
<td>40,000</td>
<td>23</td>
</tr>
<tr>
<td>20,000</td>
<td>22</td>
</tr>
<tr>
<td>10,000</td>
<td>21</td>
</tr>
<tr>
<td>5,000</td>
<td>20</td>
</tr>
<tr>
<td>2,500</td>
<td>19</td>
</tr>
<tr>
<td>1,300</td>
<td>18</td>
</tr>
<tr>
<td>640</td>
<td>17</td>
</tr>
<tr>
<td>320</td>
<td>16</td>
</tr>
<tr>
<td>160</td>
<td>15</td>
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<tr>
<td>80</td>
<td>14</td>
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<td>40</td>
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<td>20</td>
<td>12</td>
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<tr>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2.5</td>
<td>9</td>
</tr>
<tr>
<td>1.3</td>
<td>8</td>
</tr>
<tr>
<td>0.64</td>
<td>7</td>
</tr>
<tr>
<td>0.32</td>
<td>6</td>
</tr>
<tr>
<td>0.16</td>
<td>5</td>
</tr>
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<td>4</td>
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<td>3</td>
</tr>
<tr>
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<td>2</td>
</tr>
<tr>
<td>0.01</td>
<td>1</td>
</tr>
<tr>
<td>0.00</td>
<td>0</td>
</tr>
</tbody>
</table>

NOTE: Reproducibility below scale number 8 is affected by the actual number of particles counted in the fluid sample. Raw counts should be more than 20 particles.

When the raw data in one of the size ranges results in a particle count of fewer than 20 particles, the scale number for that size range shall be labeled with the symbol >.

6. **Maximum particle size (reference ISO 4407)**

ISO 4407 specifies methods to determine contamination levels in a hydraulic system by counting the particles trapped on a membrane filter using an optical microscope. Particles to 2 microns can be counted using this method.

The primary source of contamination in a hose assembly is a result of cutting the hose with both metal and abrasive blades. Therefore it is recommended that the hose be cleaned immediately after cutting and again after the assembly because the secondary source of contamination is the fittings. This insures that the all the contamination generated during shop assembly has been removed.

Other sources of contamination include dust, moisture and any airborne particles that can enter a completed hose assembly. Immediately after cleaning the hose assembly it is strongly recommended to cap or seal each end of the assembly to maintain the cleanliness level attained until the assembly is installed. Customer requirements and the specific application will dictate the required cleanliness level.
Composite Hose Cleanliness Considerations

It is important that any media be thoroughly drained prior to cleaning to avoid chemical or exothermic reactions when the hose is returned into service.

A. Typically, composite hose assemblies are cleaned by flushing thoroughly with clean water.

B. Other media which can be used, depending on the media that has been passing through the hose, include hot water, sea water, detergents and common solvents at ambient temperature. If sea water is used the hose must be well drained after cleaning to minimize corrosion.

C. **WARNING:** Due to the inherent nature of the hose internally, any form of mechanical method of cleaning such as pigging should not be used under any circumstances.

D. Also, due to the fact that the hose is constructed using plastics which tend to weaken at elevated temperatures, care must be taken when cleaning with hot water so as not to exceed the maximum working temperature of the hose. If steam is to be used, contact the manufacturer for any recommended practices.

E. Compressed air may be used but the hose must be open-ended.

F. During any cleaning operation, the assembly must be electrically grounded to avoid build up of static charge.
11.4 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.

Packaging Options (check with the manufacturer for recommendations)

Coiled
- Protective wrap; palletized
- in crates
- on reels
- poly-bagged in bales

Straight
- Slat packing
- Plastic tubes
- Metal rack (dedicated truck)
- Poly-bagged
- Skids

Slat Packing

Packaging and Handling Considerations for Large Diameter Hose and Assemblies

Handling in transit and during installation needs to be considered in order to reduce or eliminate potential damage. Care should be taken not to kink the hose, damage the hose cover, or stress it in ways it wasn’t designed to handle. (Any questions should be referred to the manufacturer.) Some considerations include:

- Do not drag the hose over docks or decks, or sharp, abrasive surfaces
- Never lift long length or large bore hose from the middle of its length with the ends hanging down
- Support the hose with wide slings or saddles to limit the curvature of the hose. In order to increase the service life of the hose, NAHAD recommends that proper support be given to the hose during lifting; the use of chains, rope or cable should be avoided.
- Do not kink hose or run over it with equipment

For additional information, see the ARPM manuals for hose maintenance, testing, and inspection.
Section 12 – Installation and Handling

12.1 General

The purpose of this section is to increase awareness on the proper installation and handling of hose assemblies, and to alert fabricators, installers and end-users to the safety hazards in the field.

Hoses and hose assemblies are used interchangeably in this document. Hoses are used to convey fluids, gases and other media. Hose constructions are available in a variety of materials and styles depending on the intended application.

All hose has a finite life and there are a number of factors which will reduce its life. The design and use of systems, which contain hoses, require consideration of factors related to specific application requirements.

12.2 Safety & Environmental Considerations

Below are some potential conditions that can lead to personal injury and property damage. This list is not inclusive. Consider reasonable and feasible means, including those described in this section to reduce the risk of injuries or property damage.

Employers with hose assemblies in fluid systems are encouraged to provide training, including the information in this document, for maintenance personnel and other employees working with and around hoses under pressure.

Media Permeation

Hoses should always be used in well-ventilated areas. Certain media will permeate through hoses that can displace breathable air in confined spaces. Consult the manufacturer if in question.

Fluid Injections

Fine streams of pressurized fluid can penetrate skin and enter a human body. Fluid injection wounds may cause severe tissue damage and loss of limb. Consider the use of guards and shields to reduce the risk of fluid injections.

If a fluid injection occurs, contact a doctor or medical facility at once. Do not delay or treat as a simple cut. Fluid injections are serious injuries and prompt medical treatment is essential. Be sure the doctor knows how to treat this type of injury.

Avoid all contact with escaping fluids. Treat all leaks as though they are pressurized and hot or caustic enough to burn skin.

Whipping Hose

If a pressurized hose or hose fitting comes apart, the loose hose end can flail or whip with great force, and fittings can be thrown off at a high speed. This is particularly true in compressible gas or fluid systems. If the risk of hose whipping exists, consider the use of guards and restraints.

Fire and Explosions from Conveyed Fluids

All hydraulic fluids, including many designated as “Fire Resistant”, are flammable (will burn) when exposed to the proper conditions.

Fluids under pressure which escape from system containment may develop a mist or fine spray that can explode upon contact with a source of ignition (e.g.: open flames, sparks, and hot manifolds.) These explosions can be very severe and could cause extensive property damage, serious injury or
death. Care should be taken to eliminate all possible ignition sources from contact with escaping fluids, fluid spray or mist, resulting from hydraulic system failures. Select and route hoses to minimize the risk of combustion.

**Fire and Explosions from Static-Electric Discharge**

Fluid passing through hose can generate static electricity, resulting in static-electric discharge. This may create sparks that can ignite system fluids or gases in the surrounding atmosphere. Use hose rated for static conductivity or a proper grounding device. Consult manufacturer for proper hose and coupling selection.

**Burns from Conveyed Fluids**

Fluid media conveyed in certain applications may reach temperatures that can burn human skin. If there is risk of burns from escaping fluid, consider guards and shields to prevent injury, particularly in areas normally occupied by operators.

**Electrical Shock**

Electrocution could occur when a hose assembly conducts electricity to a person. Most hoses are conductive. Many have metal fittings. Even nonconductive hoses can be conduits for electricity if they carry conductive fluids. Certain applications require hose to be nonconductive to prevent electrical current flow. Other applications require the hose to be sufficiently conductive to drain off static electricity. Hose and fittings must be chosen with these needs in mind. Consult manufacturer with any questions.

Metal hoses are conductive; always use proper grounding to minimize the risk of electrical discharge.

Caution: when routing hydraulic hose near an electrical source cannot be avoided, nonconductive hoses should be considered. SAE J517-100R7 and 100R8 hoses with orange covers marked “nonconductive” are available for applications requiring nonconductive hose.

**Fluid Controlled Mechanisms**

Mechanisms controlled by fluids in hoses can become hazardous if a hose fails. For example, when a hose bursts, objects supported by the fluid pressure may fall. If mechanisms are controlled by fluid power, use hose with design characteristics sufficient to minimize the potential risks of property damage or injury.

**Air and Gaseous Applications**

Consult manufacturer for proper hose and coupling selection. The covers of hose assemblies that are to be used to convey air and other gaseous materials must be pin perforated.

**CAUTION:** Exercise care not to perforate beyond the cover. These perforations allow gas that has permeated through the inner tube of the hose to escape into the atmosphere. This prevents gases from accumulating and blistering the hose.

**Hand-held Operated Tools**

Extreme care is necessary when connecting hand-held or portable powered tools to a power source with a hose assembly.

A. Always use a strain reliever at both ends of the hose assembly to prevent excessive bending, kinking and stress at the coupling to hose interface.

B. Never use the hose assembly as a means to carry, pull, lift or transport the tool or power unit.

C. Exposed hose near the operator should be covered with a fluid deflection apparatus such as nylon sleeving, for protection against injection injuries should a hose rupture occur.
D. Operators should be protected with the proper safety equipment such as face masks, leather gloves and safety clothing as dictated by the job, fluid and tools being used.
E. If the connecting hose assembly could be subjected to external forces that may inflict damage, an appropriate guard should be used.

12.3 Hose Routing

When planning the hose routing use the following practices for optimum performance and more consistent and predictable service life.

Caution: When determining the overall lengths for the final routed length of an assembly it must be noted that hose lengths in these assemblies can, by design, grow in length +2% or shrink in length -4%! If this is not accounted for, severe damage can occur to the hose assembly.

Routing at less than minimum bend radius, will reduce the service life of the hose and/or cause premature hose failure. Use the static or dynamic minimum bend radius according to service conditions. Sharp bends at the hose to fitting juncture should be avoided.

Hose assemblies subject to movement while operating should be installed in such a way that flexing occurs in the same plane.

Hose assemblies shall not be installed or operated in a twisted or torqued condition. Swivel fittings or a lay line may be used to aid in torque-free installation. Also flanged hose assemblies should ideally have one end secured with a floating flange.

Flange to flange bolt hole alignment is critical for proper installation.

Figure 12.1
When planning the hose routing use the following practices for optimum performance and more consistent and predictable service life.

Figure 12.2

Do Not Kink Hose

Use the Correct Length

Adjust Piping to Avoid Kinking

Do Not Axially Compress Hose

Keep Hose in One Plane to Avoid Torsion

Avoid Contact with Other Items

Do Not Torque Hose

* Do Not Apply Wrench to Hose or Braid Sleeve
Routing at less than minimum bend radius, will reduce the service life of the hose. Use the static or dynamic minimum bend radius according to service conditions. Sharp bends at the hose to fitting juncture should be avoided. Bending radius should not begin closer than one hose diameter to the ferrule. Typical bend radius is measured from the inside, but confirm with the manufacturer.

Figure 12.3
12.4 Hose Installation and Replacement

The following practices shall be used when installing hose assemblies in new systems or replacing hose assemblies in existing systems.

Pre-Installation Inspection
Before installing hose assemblies, the following shall be examined:
A. Hose length and routing should be compliant with original design.
B. Correct style, size, length, and visible non-conformity of assembly should be confirmed.
C. Check fitting seats and threads for burrs, nicks or other damage.
D. Kinked, crushed, flattened, abraided, deformed, or twisted hose should be discarded.
E. Check for correct fitting alignment or orientation.
F. Hose should be visually inspected for cleanliness, and any contaminants removed.

Handling During Installation
Handle hose with care during installation; bending beyond the minimum bend radius will reduce hose life. Sharp bends at the hose to fitting juncture should be avoided. Selecting the proper handling equipment (slings, cradles, hose saddles, and spreader bars) is critical. Chains or wire ropes should never be used during installation to support the hose. Slings, cradles, spreader bars or other equipment can be used. Hoses of large enough girth may require cranes or other appropriate material handling equipment, but forklift forks should never be inserted inside the hose. The hose should never be lifted, moved or maneuvered from the inside.

Please see the following page for additional handling Do’s and Don’t’s.

Hoses must be correctly supported during use. These supports should be arranged so that the hoses are never bent beyond the minimum bend radius. Hoses should never be supported along their live length by a single rope. Slings, saddles or some other means of proper support must be used. The support must be wide enough to spread the load sufficiently so that the hose is not deformed in the area of support. Incorrect installation can unduly stress hose assemblies leading to a shortened working life or premature failure.

A. Flanged hose assemblies should ideally have one end secured with a floating flange.
B. Hose assemblies must not be twisted either on installation or in use.
C. Hose assemblies subject to movement while operating should be installed in such a way that flexing occurs in the same plane.
D. When installing hose assemblies, careful attention should be paid to minimum bend radii specifications.
Composite Hose Transfer Hose Handling Guidelines While in Service

Do’s
A. Support the hose within 3 to 4 feet of flange connections always maintaining horizontal plane.
B. Support the hose using recommended hose supports throughout the balance of the length.
C. Cushion the hose against sharp edges, dock edge, ships rail, etc.
D. Cushion the hose when the application demands use of reciprocating machinery. It is recommended that all points of contact be cushioned to avoid potential damage due to the pulsating effect of reciprocating machinery. (See Figure 10.3.3)

Don’ts
A. Do not use the hose unsupported
B. Do not support the hose with a single rope.
C. Do not allow the hose to hang unsupported between ship and quay. (See Figure 12.3.3)
Figure 12.4 Composite Hose Transfer Hose Handling Guide

**INCORRECT**

- NEVER USE HOSE UNSUPPORTED

**CORRECT**

- ALWAYS SUPPORT HOSE NEAR COUPLING
- ACCEPTABLE

- PROTECT AGAINST SHARP EDGES, QUAY EDGES, SHIP’S GUARD RAIL ETC.

- NEVER USE HOSE UNSUPPORTED

- ACCEPTABLE

- SUPPORT HOSE WITH SLINGS WHERE APPROPRIATE

- NEVER OVERTURN HOLE OR ALLOW HOSE TO HANG BETWEEN QUAY AND SHIP

- SUPPORT HOSE WITH SLINGS

- NEVER SUPPORT HOSE WITH SINGLE ROPE
Securement and Protection

Necessary restraints and protective devices shall be installed. Such devices shall not create additional stress or wear points.

System Checkouts

In some liquid systems, it may be necessary to eliminate all entrapped air after completing the installation. Follow the test equipment manufactures’ instructions to test the system for possible malfunctions and leaks.

To avoid injury during system checkouts, do not touch any part of the hose assembly when checking for leaks and stay out of potentially hazardous areas while testing hose systems. (See Safety Considerations above.)
12.5 Maintenance Inspection

A hose and fitting maintenance program can reduce equipment down time and maintain peak operating performance.

Inspection Frequency

The nature and severity of the application, past history and manufacturer’s recommendations shall be evaluated to determine the frequency of the visual inspections and functional tests. However, in the absence of this information, we recommend a visual inspection be conducted before each shift or at least once a day. For more critical applications, hoses should be inspected and pressure tested in house, or by a third party whenever a defect is suspected or at a minimum of annually.

To avoid injury during system checkouts, do not touch any part of the hose assembly when checking for leaks and stay out of potentially hazardous areas while testing hose systems. (See Safety Considerations in Section 12.2)

If required, verify test date and pressure are in conformity with statutory requirements for the application.

Inspections should include

- Visual inspection
- Pressure testing
  - New hoses and hoses for re-certification should be pressure tested at 1.5 times maximum allowable working pressure for a minimum of 5 minutes; consult manufacturer for specific requirements. Note: the maximum allowable working pressure for a hose assembly is dictated by the component of the assembly (hose, fitting, etc.) with the LOWEST pressure rating.
  - Hose assemblies shall be inspected and tested immediately after the hose is subjected to abnormal abuse such as: severe end pull, flattening or crushing or sharp kinking. Any hose that has been recoupled shall be proof tested and inspected before being placed in service.
- Inspection Results Documentation

Visual Inspections

When inspecting hoses in service, attention should be paid to:

- Removable protective covers
  - Any cuts, gouges or tears in the cover which do not expose the reinforcement should be repaired before the hose is returned to service. If the reinforcement is exposed, retire the hose from service.
  - Covers may show surface cracking or crazing due to prolonged exposure to sunlight or to ozone. Such deterioration, which does not expose reinforcing material, is not cause for retirement.
- Carcass
  - Look for any indication of kinking or broken reinforcement as evidenced by any permanent distortion, longitudinal ridges, or bulges. Crushed or kinked spots where the outside diameter of the hose is reduced by 20% or more of the normal outside diameter shall require that the hose be retired from any service. Hose containing kinked or crushed spots where the outside diameter is reduced less than 20% may be used if the hose passes the hydrostatic tests.
- Fittings
  - All metals are subject to attack by various chemicals. Check with the manufacturer to make sure that suitable end fittings, appropriate to both the hose and the chemical being handled, are being used.
  - Exposed surfaces of couplings, flanges and nipples shall be examined for cracks or excessive corrosion. Either condition shall cause the hose to be retired from service. Any evidence of coupling or nipple slippage on the hose is cause for removing the hose from service.
The hose and fittings shall be visually inspected for:

- A. Leaks at the hose fittings or in the hose.
- B. Damaged, abraded, or corroded braid; or broken braid wires.
- C. Cracked, damaged, deformed or badly corroded fittings.
- D. Other signs of significant deterioration such as blisters.
- E. Compromised reinforcement where the wires are exposed and show signs such as unwrapped, broken or corroded.
- F. Damaged or missing hose clamps, guards, or shields.
- G. Dents, twists or kinks
- H. Abrasion or corrosion of the hose outer wire
- I. Damage or displacement of end fittings and/or deformity of end fittings.
- J. Fitting thread and seat condition
- K. Evidence of leakage from end fittings or elsewhere in the body of the hose.
- L. Condition and seating of gaskets, as applicable
- M. If applicable, verify test date and pressure are in conformity with statutory requirements for the application.

If any of these conditions exist, the hose assemblies shall be evaluated for replacement.

The surrounding area shall be visually inspected for:

- A. Leaking ports.
- B. Excessive dirt and debris around hose.
- C. System fluid.
- D. Level, type, contamination, condition, and air entrapment or blockage. If any of these conditions are found, appropriate action shall be taken.
- E. Hose assembly rubbing or making contact with adjacent machinery or piping.

Failure Modes and Analysis

**Improper application**

Beginning with the most common cause of hose failures – Improper Application – compare the hose specifications with the requirements of the application. Pay particular attention to the following areas:

1. The maximum operating pressure of the hose.
2. The recommended temperature range of the hose.
3. Whether the hose is rated for vacuum service.
4. The fluid compatibility of the hose.

Check all of these areas against the requirements of the application. If they don’t match up, you need to select another hose. If your problem is particularly difficult, you can call on the services of the manufacturer to assist in the proper selection.

**Improper assembly and installation**

The second major cause of premature hose failure is improper assembly and installation procedures. This can involve anything from using the wrong fitting on a hose, to poor routing of the assembly. Manufacturers provide excellent training material that you can use to combat this problem. A little time spent in training can pay big dividends in reduced downtime.
**External damage**

External damage can range from abrasion and corrosion, to hose that is crushed by a lift truck. These are problems that can normally be solved simply once the cause is identified. The hose can be rerouted or clamped, or a fire sleeve or abrasion guard can be used. In the case of corrosion, the answer may be as simple as changing to a hose with a more corrosion resistant cover or rerouting the hose to avoid the corrosive element.

**Faulty equipment**

Frequent or premature hose failure can be the symptom of a malfunction in your equipment. This is a factor that should be considered since prompt corrective action can sometimes avoid serious and costly equipment breakdown.

**Faulty hose**

Occasionally a failure problem will lie in the hose itself. The most likely cause of a faulty rubber hose is old age. Check the lay line on the hose to determine the date of manufacture. (1Q08 means first quarter 2008). The hose may have exceeded its recommended shelf life. Until you have exhausted all the other possibilities don’t jump to the conclusion that the problem lies in the manufacture of the hose. Given effective quality control methods, the odds of a faulty batch of hose being released for sale are extremely small. So make sure that you haven’t overlooked some other problem area.

**Physical Examination**

A physical examination of the failed hose can often offer a clue to the cause of the failure. Following are 22 symptoms to look for along with the conditions that could cause them:

1. **Symptom:** The hose tube is very hard and has cracked.

   ![Hose Tube](image)

   **Cause:** Heat has a tendency to leach the plasticizers out of the tube. This is a material that gives the hose its flexibility or plasticity. Aerated oil causes oxidation to occur in the tube. This reaction of oxygen on a rubber product will cause it to harden. Any combination of oxygen and heat will greatly accelerate the hardening of the hose tube. Cavitation occurring inside the tube would have the same effect.
2. **Symptom:** The hose is cracked both externally and internally but the elastomeric materials are soft and flexible at room temperature.

![Image of cracked hose]

**Cause:** The probable reason is intense cold ambient conditions while the hose was flexed. Generally most hoses are rated to \(-40^\circ°F (\sim-40^\circ°C).\) Some specialty hoses are rated at \(-57^\circ°F (\sim-49^\circ°C).\) PTFE hose are normally rated to \(-100^\circ°F (\sim-73^\circ°C).\)

3. **Symptom:** The hose has burst and examination of the wire reinforcement after stripping back the cover reveals random broken wires the entire length of the hose.

![Image of burst hose with wire reinforcement]

**Cause:** This would indicate a high frequency pressure impulse condition. SAE impulse test requirements for double wire braid reinforcement are 200,000 cycles at 133\% of recommended working pressure. The SAE impulse test requirements for a four spiral wrapped reinforcement (100R12) are 500,000 cycles at 133\% maximum operating and at +250°F (121°C). If the extrapolated impulses in a system amount to over a million in a relatively short time a spiral-reinforced hose would be the better choice.

4. **Symptom:** The hose has burst, but there is no indication of multiple broken wires the entire length of the hose. The hose may have burst in more than one place.

![Image of burst hose with hand holding]

**Cause:** This would indicate that the pressure has exceeded the minimum burst strength of the hose. Either a stronger hose is needed or the hydraulic circuit has a malfunction, which is causing unusually high-pressure conditions.
5. **Symptom:** Hose has burst. An examination indicates the wire braid is rusted and the cover has been cut, abraded or deteriorated badly.

![Image of burst hose]

**Cause:** The primary function of the cover is to protect the reinforcement. Elements that may destroy or remove the hose covers are:
1. Abrasion
2. Cutting
3. Battery Acid
4. Steam Cleaners
5. Chemical Cleaning Solutions
6. Muriatic Acid (for cement clean-up)
7. Salt Water
8. Heat
9. Extreme Cold
10. Ozone

Once the cover protection is gone the wire reinforcement is susceptible to attack from moisture or other corrosive matter.

6. **Symptom:** Hose has burst on the outside bend and appears to be elliptical in the bent section. In the case of a pump supply line, the pump is noisy and very hot. The exhaust line on the pump is hard and brittle.

**Cause:** Violation of the minimum bend radius is most likely the problem in both cases. Check the minimum bend radius and make sure that the application is within specifications. In the case of the pump supply line partial collapse of the hose is causing the pump to cavitate creating both noise and heat. This is a most serious situation and will result in catastrophic pump failure if not corrected.

7. **Symptom:** Hose appears to be flattened out in one or two areas and appears to be kinked. It has burst in this area and also appears to be twisted.

![Image of flattened hose]

**Cause:** Torque on a hydraulic control hose will tear loose the reinforcement layers and allow the hose to burst through the enlarged gaps between the braided plaits of wire strands. Use swivel fittings or joints to be sure there is no twisting force on a hydraulic hose.

8. **Symptom:** Hose tube has broken loose from the reinforcement and piled up at the end of the hose. In some cases it may protrude from the end of the hose fitting.

**Cause:** The probable cause is high vacuum or the wrong hose for vacuum service. No vacuum is recommended for double wire braid, 4 and 6-spiral wire hose unless some sort of internal coil support is used. Even though a hose is rated for vacuum service, if it is kinked, flattened out or bent too sharply this type of failure may occur.
9. **Symptom:** Hose has burst about six to eight inches away from the end fitting. The wire braid is rusted. There are no cuts or abrasions of the outer cover.

**Cause:** Improper assembly of the hose end fitting allowing moisture to enter around the edge of the fitting socket. The moisture will wick through the reinforcement. The heat generated by the system will drive it out around the fitting area but six to eight inches away it will be entrapped between the inner lining and outer cover causing corrosion of the wire reinforcement.

10. **Symptom:** There are blisters in the cover of the hose. If one pricks the blisters, oil will be found in them.

**Cause:** A minute pinhole in the hose tube is allowing the high-pressure oil to seep between it and the cover. Eventually it will form a blister wherever the cover adhesion is weakest. In the case of a screw together reusable fitting insufficient lubrication of the hose and fitting can cause this condition because the dry tube will adhere to the rotating nipple and tear enough to allow seepage. Faulty hose can also cause this condition.

11. **Symptom:** Blistering of the hose cover where a gaseous fluid is being used.

**Cause:** The high-pressure gas is effusing through the hose tube, gathering under the cover and eventually forming a blister wherever the adhesion is weakest. Specially constructed hoses are available for high-pressure gaseous applications. The manufacturer can advise which is the proper hose to use in these cases.

12. **Symptom:** Fitting blew off of the end of the hose.

**Cause:** It may be that the wrong fitting has been put on the hose. Recheck manufacturer’s specifications and part numbers. In the case of a crimped fitting the wrong machine setting may have been used resulting in over or under crimping. The socket of a screw together fitting for multiple wire-braided hose may be worn beyond its tolerance. The swaging dies in a swaged hose assembly may be worn beyond the manufacturer’s tolerances. The fitting may have been applied improperly to the hose. Check manufacturer’s instructions. The hose may have been installed without leaving enough slack to compensate for the possible 4% shortening that may occur when the hose is pressurized. This will impose a great force on the fitting. The hose itself may be out of tolerance.

13. **Symptom:** The tube of the hose is badly deteriorated with evidences of extreme swelling. In some cases the hose tube may be partially “washed out.”

**Cause:** Indications are that the hose tube is not compatible with the agent being carried. Even though the agent is normally compatible, the addition of heat can be the catalyst that can cause
inner liner deterioration. Consult the hose manufacturer for a compatibility list or present them with a sample of the fluid being conducted by the hose for analysis. Make sure that the operating temperatures both internal and external do not exceed recommendations.

14. **Symptom:** Hose has burst. The hose cover is badly deteriorated and the surface of the rubber is crazed.

**Cause:** This could be simply old age. The crazed appearance is the effect of weathering and ozone over a period of time. Try to determine the age of the hose. Some manufacturers print or emboss the cure date on the outside of the hose. As an example, “1Q08” would mean that the hose was manufactured during the first quarter (January, February or March) of 2008.

15. **Symptom:** Hose is leaking at the fitting because of a crack in the metal tube adjacent to the braze on a split flange head.

**Cause:** Because the crack is adjacent to the braze and not in the braze this is a stress failure brought on by a hose that is trying to shorten under pressure and has insufficient slack in it to do so. Typically lengthening the hose assembly or changing the routing to relieve the forces on the fitting cures these problems.

16. **Symptom:** A spiral-reinforced hose has burst and literally split open with the wire exploded out and badly entangled.

**Cause:** The hose is too short to accommodate the change in length occurring while it is pressurized.

17. **Symptom:** Hose is badly flattened out in the burst area. The tube is very hard down stream of the burst but appears normal up stream of the burst.

**Cause:** The hose has been kinked either by bending it too sharply or by squeezing it in some way so that a major restriction was created. As the velocity of the fluid increases through the restriction the pressure decreases to the vaporization point of the fluid being conveyed. This is commonly called cavitation, and causes heat and rapid oxidation to take place, which hardens the tube of the hose down stream of the restriction.
18. **Symptom:** Hose has not burst but it is leaking profusely. A bisection of the hose reveals that the tube has been gouged through to the wire braid for a distance of approximately two inches.

**Cause:** This failure would indicate that erosion of the hose tube has taken place. A high velocity needle like fluid stream being emitted from an orifice and impinging at a single point on the hose tube will hydraulically remove a section of it. Be sure that the hose is not bent close to a port that is orificed. In some cases where high velocities are encountered, particles in the fluid can cause considerable erosion in bent sections of the hose assembly.

19. **Symptom:** The hose fitting has been pulled out of the hose. The hose has been considerably stretched out in length. This may not be a high-pressure application.

**Cause:** Insufficient support of the hose. It is very important to support long lengths of hose, especially if they are vertical. The weight of the hose along with the weight of the fluid inside the hose in these cases is being imposed on the hose fitting. This force can be transmitted to a wire rope or chain by clamping the hose to it much like the utilities support bundles of wire from pole to pole. Be sure to leave sufficient slack in the hose between clamps to make up for the possible 4% shortening that could take place when the hose is pressurized.

20. **Symptom:** The hose has not burst but it is leaking profusely. An examination of the bisected hose reveals that the tube has burst inwardly.

**Cause:** This type of failure is caused by explosive decompression commonly referred to as hose tube blow down. It is usually associated with very low viscosity fluids such as air, nitrogen, freon and other gases. Under high pressure conditions the gases will effuse into the pores of the hose tube charging them up like miniature accumulators. If the pressure is very suddenly reduced to zero the entrapped gases literally explode out of the tube often tearing holes in it.

21. **Symptom:** PTFE hose assembly has collapsed internally in one or more places.

**Cause:** One of the most common causes for this is improper handling of the PTFE assembly. PTFE does not have the same flexibility as rubber and when it is bent sharply it simply collapses. This type of collapse is localized in one area and is radial. When the PTFE tube is folded longitudinally in one or more places this could be the result of heat (which softens the hose tube) along with vacuum conditions inside of it. Because of the additional tension of the wire braid reinforcement inherent with this type of hose, there is always a radial tension on the tube trying to push it in. Rapid cycling from a very hot agent in the hose to a very cold agent in the hose can produce the same type of failure. Manufacturers offer an internal support coil that will eliminate this problem.

22. **Symptom:** A PTFE hose assembly has developed a pinhole leak or several pinhole leaks.

**Cause:** This situation occurs when a petroleum base fluid, with a low viscosity, is flowing at a high velocity. This condition can generate high voltage due to static electricity. The high voltage is seeking a ground connection and the only ground connection available is the braided stainless steel reinforcement. This causes an electric arc, which penetrates through the PTFE tube as it travels to the reinforcement. Specially constructed PTFE tubes are available that have enough carbon black in them so as to be conductive. They will "drain off" the static electricity and preclude this problem.

**Functional Tests**

Functional tests shall be conducted to determine if systems with hose are leak-free and operating properly. Such tests should be conducted in accordance with the manufacturers’ recommendations.
Section 13 – 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); see static conductive.

**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:** American Society for Testing and Materials.
**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.
**band:** (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.
braid 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 +800ºF.
braker 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.
cclamp: see hose clamp.
cloth impression: see fabric impression.
coefficiency of flow: When calculating the measure of the loss of air flow through a duct due to
length, bends or any restriction, the coefficiency 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 innercore having annular or helical ridges formed to enhance
flexibility.
convolution/corrugation: the annular or helical flexing member in corrugated or strip wound
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.

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**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.

**deburr:** 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-chlorotrichloroethylene.
effective inside diameter: minimum inside diameter of a duct
effective thrust area-hose: cross-sectional area described by the mean diameter of the hose.
effusion: the escape, usually of gases, through a material. See permeation.
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 thousands 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.

**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 thermostatic 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 a Reusable 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”. Pressure-Temperature ratings can be obtained by consulting the ANSI specification or ASME B16.5 (American Society of Mechanical Engineers). Designs vary by neck and face style, or other dimensional changes based on use. Various finishes or grooves may be applied to the face for sealing on a gasket or o-ring. Bolt holes and other dimensions are per the ANSI standard.
- **Slip-on Flange** - a flange designed to slip over a flange retainer and float freely in place for bolt alignment. Similar to a lap joint flange except with a very small radius on the face side of the inside diameter to mate with a machined flange retainer. May have a flat or raised face.
- **Lap Joint Flange** - a flange designed to float freely on the flange retainer for bolt alignment. Made with a flat face and having a large radius on the I.D. to mate with a flared pipe style flange retainer.
- **Threaded Flange** - a flange, the inside diameter of which is threaded to attach to a male pipe fitting. A leak proof seal, made with thread sealant, usually does not allow for bolt hole alignment.
- **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** -
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 male 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.

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)
highbee: 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 indenter point of any one of a number of standard hardness testing instruments; 2) a recess in the surface of a hose.
inncore: 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.

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")

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 Pharmacopoeia 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 *polypropene,* 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 test pressure
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.
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.
shelf/storage life: the period of time prior to use during which a product retains its intended performance capability.

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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.
spline: 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 the rubber material to the hose ends, provided the correct coupling type is used. Note: Non-black and many black rubber compounds will not dissipate static electricity. Only black compounds formulated with high carbon black content 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

thermoplastic: A polymer that softens and becomes a liquid 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 referred 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 vulcanize, 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 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 Pharmacopia

**UV resistance:** Ability to withstand decay due to the damaging effect of 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 hose’s 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.
Section 14 – Appendices

Appendix A – 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 (N/m²)</th>
<th>kPa</th>
<th>MPa</th>
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</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 = 30.48 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 MPa
Pressure Conversions:
Metrication is slow to be realized in the United States; its importance, however, cannot be denied. Learning to convert from one form to another can be accomplished by calculation or memory. Frequent use of metric measurements is the best solution. Use the following as a starting point for conversions.
1. one bar = 14.5 psi
2. one kilopascal (kPa) = .145 psi
3. one Megapascal (MPa) = 145 psi
If we divide 1 by .145 it equals 6.90, thus 1psi = 6.90 kPa. Or we can use charts (see below).

An alternative to using the conversion factors is to calculate between chart pressures (see chart below). Simply break the numbers into known chart listings.

Examples:
Convert 3760 psi to the equivalent pressure in bar and MPa

<table>
<thead>
<tr>
<th>Convert 3760 psi to the equivalent pressure in bar and MPa</th>
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<tr>
<td>3000 psi = 206.9 bar</td>
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<td>700 psi = 48.3 bar</td>
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<td>60 psi = 4.1 bar</td>
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<td>3760 psi = 259.3 bar</td>
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<tr>
<td>3000 psi = 20.7 MPa</td>
</tr>
<tr>
<td>700 psi = 4.8 MPa</td>
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<tr>
<td>60 psi = .41 MPa</td>
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<tr>
<td>3760 psi = 25.91 MPa</td>
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Note the relationship between Bar and MPa is 10:1

Metric Conversion Charts:

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<th>English to Metric Equivalents</th>
<th>Metric to English</th>
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<tr>
<td>inches x 25.4 = millimeters (mm)</td>
<td>millimeter x .03937 = inch (in)</td>
</tr>
<tr>
<td>inches x 2.54 = Centimeters (cm)</td>
<td>centimeters x .3937 = inch (in)</td>
</tr>
<tr>
<td>feet x .3048 = meters (m)</td>
<td>meters x 3.281 = feet (ft)</td>
</tr>
<tr>
<td>yard x .9144 = meters (m)</td>
<td>meters x 1.0936 = yard (yd)</td>
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<tr>
<td>psi x .0689 = bar</td>
<td>bar x 14.5 = psi</td>
</tr>
<tr>
<td>psi / .145 = kPa</td>
<td>kPa x .145 = psi</td>
</tr>
<tr>
<td>psi x .0069 = Megapascals (MPa)</td>
<td>Megapascal x 145.0 = psi</td>
</tr>
<tr>
<td>psi x .703 = Kilogram force per sq. centimeter (Kgf/cm2)</td>
<td>Kilogram force per sq. cm x 14.22 = psi</td>
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<tr>
<td>pound force x 4.448 = Newtons</td>
<td>Newtons x .2248 = pounds force (lbf)</td>
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<tr>
<td>pound-inch x .113 = Newton-meters (N-m)</td>
<td>Newton-meter x 8.850 = pound-inches(lb-in)</td>
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<td>pound-foot x 1.356 = Newton-meters (N-m)</td>
<td>Newton-meter x .737 = pound-feet (lb-ft)</td>
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<td>kilopascals (kPa)</td>
<td>megapascals (MPa)</td>
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Note: A special thanks to Dixon Valve & Coupling for the charts on the following pages.
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# Steam Temperature - Pressure Conversion Guide

Temperature - Pressure Equivalents of Saturated Steam

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<th>Lbs. per Sq. Inch</th>
<th>Temperature °F</th>
<th>Lbs. per Sq. Inch</th>
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Degrees Celsius = 5/9 (Degrees F - 32)
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### Fittings Size Chart

**Male NPT Thread Sizes**

- 1/8
- 1/4
- 3/8
- 1/2
- 3/4
- 1

**Male NST Thread Sizes**

- 2½
- 1½

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Water Data and Formulas

1 gallon water = 231 cubic inches = 8.333 pounds
1 pound of water = 27.7 cubic inches
1 cubic foot water = 7.5 gallons = 62.5 pounds (salt water weighs approximately 64.3 pounds per cubic foot)

Pounds per square inch at bottom of a column of water = height of column in feet x .434
1 miner’s inch = 9 to 12 gallons per minute

Horsepower to Raise Water
If pumping liquid other than water, multiply the gallons per minute below by the liquid’s specific gravity.
Horsepower = \frac{\text{gallons per minute} \times \text{total head in feet}}{3960}

Gallons Per Minute through a Pipe
GPM = \frac{.0408 \times \text{pipe diameter inches}^2 \times \text{feet/minute water velocity}}{1}

Weight of Water in a Pipe
Pounds water = \text{pipe length feet} \times \text{pipe diameter inches}^2 \times .34

Water Discharge Table
This table is intended for general reference and general applicability only, and should not be relied upon as the sole or precise source of information available with respect to the subject covered. The user should also refer to and follow manufacturer’s specific instructions and recommendations with regard to such information, where they exist.

Flow of water through 100 foot lengths of hose, Straight-Smooth Bore - U.S. Gallons per minute

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Figures are to be used as a guide since the hose inside diameter tolerance, the type of fittings used, and orifice restriction all influence the actual discharge. Thus, variations plus or minus from the table may be obtained in actual service.

Conversion Table - Feet of Water to Inches of Mercury

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<td>23.0</td>
<td>24.8</td>
<td>26.5</td>
<td>28.3</td>
<td>30.0</td>
</tr>
</tbody>
</table>

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## Feet Head of Water to PSI

<table>
<thead>
<tr>
<th>Feet Head</th>
<th>Pounds per Square Inch</th>
<th>Feet Head</th>
<th>Pounds per Square Inch</th>
<th>Feet Head</th>
<th>Pounds per Square Inch</th>
<th>Feet Head</th>
<th>Pounds per Square Inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.43</td>
<td>15</td>
<td>6.50</td>
<td>100</td>
<td>43.31</td>
<td>250</td>
<td>108.27</td>
</tr>
<tr>
<td>2</td>
<td>0.87</td>
<td>20</td>
<td>8.66</td>
<td>110</td>
<td>47.64</td>
<td>300</td>
<td>120.63</td>
</tr>
<tr>
<td>3</td>
<td>1.30</td>
<td>25</td>
<td>10.83</td>
<td>120</td>
<td>51.97</td>
<td>350</td>
<td>151.58</td>
</tr>
<tr>
<td>4</td>
<td>1.73</td>
<td>30</td>
<td>12.99</td>
<td>130</td>
<td>56.30</td>
<td>400</td>
<td>173.24</td>
</tr>
<tr>
<td>5</td>
<td>2.17</td>
<td>40</td>
<td>17.32</td>
<td>140</td>
<td>60.63</td>
<td>500</td>
<td>216.55</td>
</tr>
<tr>
<td>6</td>
<td>2.60</td>
<td>50</td>
<td>21.65</td>
<td>150</td>
<td>64.96</td>
<td>600</td>
<td>250.85</td>
</tr>
<tr>
<td>7</td>
<td>3.03</td>
<td>60</td>
<td>25.99</td>
<td>160</td>
<td>69.29</td>
<td>700</td>
<td>303.16</td>
</tr>
<tr>
<td>8</td>
<td>3.46</td>
<td>70</td>
<td>30.32</td>
<td>170</td>
<td>73.63</td>
<td>800</td>
<td>346.47</td>
</tr>
<tr>
<td>9</td>
<td>3.90</td>
<td>80</td>
<td>34.65</td>
<td>180</td>
<td>77.86</td>
<td>900</td>
<td>389.78</td>
</tr>
<tr>
<td>10</td>
<td>4.33</td>
<td>90</td>
<td>38.98</td>
<td>200</td>
<td>82.02</td>
<td>1000</td>
<td>433.00</td>
</tr>
</tbody>
</table>

Note: One foot of water at 62°F equals 0.433 PSI. To find the PSI for any feet head not given in the table, multiply the feet head by 0.433.

## Maximum Recommended Air Flow (SCFM) Through ANSI Standard Weight Schedule 40 Metal Pipe

The flow values in the table below are based on a pressure drop of 10% of the applied pressure per 100 feet of pipe for 1/8”, 1/4”, 3/8”, and 1/2” pipe sizes, and a pressure drop of 5% of the applied pressure per 100 feet of pipe for 3/4”, 1”, 1-1/4”, 2”, 2-1/2”, and 3” pipe sizes. The table gives recommended flows for pipe sizes at listed pressures and should be used to determine appropriate piping for air systems.

<table>
<thead>
<tr>
<th>Applied Pressure PSI</th>
<th>Nominal Standard Pipe Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8”</td>
<td>1/4”</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>0.8</td>
</tr>
<tr>
<td>20</td>
<td>1.3</td>
</tr>
<tr>
<td>40</td>
<td>2.5</td>
</tr>
<tr>
<td>60</td>
<td>3.5</td>
</tr>
<tr>
<td>80</td>
<td>4.7</td>
</tr>
<tr>
<td>100</td>
<td>5.8</td>
</tr>
<tr>
<td>150</td>
<td>8.6</td>
</tr>
<tr>
<td>200</td>
<td>11.5</td>
</tr>
</tbody>
</table>

## Air Supply Requirements (operating pressure: 90 PSI)

<table>
<thead>
<tr>
<th>Tool</th>
<th>Class</th>
<th>Typical Air Consumption (CFM)</th>
<th>Hose Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0-10 ft.</td>
</tr>
<tr>
<td>Paving Breakers</td>
<td>25 lb.</td>
<td>45</td>
<td>1/2</td>
</tr>
<tr>
<td>Hand Drills</td>
<td>15 lb.</td>
<td>32</td>
<td>3/8</td>
</tr>
<tr>
<td>Rock (Sinker) Drills</td>
<td>45 lb.</td>
<td>105</td>
<td>3/4</td>
</tr>
<tr>
<td>Tampers</td>
<td>6” butt</td>
<td>30</td>
<td>3/8</td>
</tr>
<tr>
<td>Sump Pump Ejector</td>
<td>3 HP</td>
<td>100</td>
<td>3/4</td>
</tr>
<tr>
<td>Vibrators</td>
<td>2-1/2”</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>Chipping Hammers</td>
<td>25</td>
<td>3/8</td>
<td>1/2</td>
</tr>
<tr>
<td>Impact Wrenches</td>
<td>3/8” sq. dr.</td>
<td>10</td>
<td>5/16</td>
</tr>
<tr>
<td>Drills</td>
<td>1/4”</td>
<td>22</td>
<td>3/8</td>
</tr>
<tr>
<td>Grinders</td>
<td>3/4”</td>
<td>20</td>
<td>3/8</td>
</tr>
</tbody>
</table>

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### Suggested Pipe Size for Compressed Air Flow
at 100 PSI Length of Run, Feet

<table>
<thead>
<tr>
<th>SCFM Air Flow</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>300</th>
<th>500</th>
<th>1000</th>
<th>Compressor HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>½</td>
<td>½</td>
<td>½</td>
<td>½</td>
<td>½</td>
<td>½</td>
<td>½</td>
<td>½</td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>12</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
</tr>
<tr>
<td>20</td>
<td>1½</td>
<td>1½</td>
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<td>1½</td>
<td>1½</td>
<td>1½</td>
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<td>1½</td>
<td>1½</td>
</tr>
<tr>
<td>30</td>
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<td>2½</td>
<td>2½</td>
<td>2½</td>
<td>2½</td>
<td>2½</td>
<td>2½</td>
<td>2½</td>
<td>2½</td>
</tr>
<tr>
<td>40</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
<td>3½</td>
</tr>
<tr>
<td>60</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
<td>4½</td>
</tr>
<tr>
<td>80</td>
<td>5½</td>
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<td>5½</td>
<td>5½</td>
<td>5½</td>
<td>5½</td>
<td>5½</td>
<td>5½</td>
<td>5½</td>
<td>5½</td>
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<tr>
<td>100</td>
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<td>6½</td>
<td>6½</td>
<td>6½</td>
<td>6½</td>
<td>6½</td>
<td>6½</td>
<td>6½</td>
<td>6½</td>
</tr>
<tr>
<td>120</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
<td>7½</td>
</tr>
<tr>
<td>160</td>
<td>8½</td>
<td>8½</td>
<td>8½</td>
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<td>200</td>
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<td>9½</td>
<td>9½</td>
</tr>
<tr>
<td>240</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
<td>10½</td>
</tr>
<tr>
<td>300</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
<td>11½</td>
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<tr>
<td>400</td>
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<tr>
<td>500</td>
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<td>13½</td>
<td>13½</td>
<td>13½</td>
<td>13½</td>
<td>13½</td>
</tr>
</tbody>
</table>

On a compressed air distribution system, pressure losses greater than 3% are considered excessive, and a well-designed system having a steady rate of air flow is usually designed for not more than a 1% loss or 1 PSI for a 100 PSI system. The pipe size depends not only on the volume of air flow but how far it must be carried. To hold the distribution loss to 1 PSI, pipes of larger diameter must be used on longer runs to carry the same flow that can be handled by smaller pipes on shorter runs.

Figures in the body of the chart above are pipe sizes recommended on a 100 PSI system to carry air with less than 1 PSI loss. When measuring lengths of runs, add 5' of length for each pipe fitting. If carrying 120 PSI pressure these sizes will carry slightly more air than shown, or pressure loss will be slightly less than 1 PSI. If carrying 80 PSI pressure these pipes will carry slightly less air at 1 PSI pressure loss than shown in the chart.

The left column of the chart shows the volume of air to be carried. It is difficult to estimate the air flow volume to be carried in each leg of the distribution system. This varies with the application. On some applications, like in a large plant with many legs in the distribution system serving dozens of air-operated machines, the air usage may be at a fairly steady rate. Other applications, usually on small systems, may have to carry a high surge of air if several machines happen to be operated at the same time. Then there may be a period with almost no flow.

To make a realistic estimate of air flow volume, the far right column of the chart showing compressor HP may be used. On steady pumping, a compressor will produce a minimum of 4 SCFM air flow for each 1 HP of capacity. This is a conservative figure, as most compressors will produce 5 or 6 SCFM.

For example, a 25 HP compressor will produce at least 100 SCFM of air as shown in the far left column on the same line as 25 HP.

# Air Hose Friction

<table>
<thead>
<tr>
<th>Hose Size (inches)</th>
<th>CFM thru 50' Hose</th>
<th>Gauge Pressure - Pounds/sq inch</th>
<th>PSI Loss Over 50' Hose Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>⅛''</td>
<td>20</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>5.0</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>10.1</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>18.1</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>+</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>+</td>
<td>28.4</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>+</td>
<td>+</td>
</tr>
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<td></td>
<td>10</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>¼''</td>
<td>20</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
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<td>40</td>
<td>2.4</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>4.4</td>
<td>3.2</td>
</tr>
<tr>
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<td>60</td>
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<td>4.2</td>
</tr>
<tr>
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<td>70</td>
<td>8.5</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>11.4</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>14.2</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>+</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>½''</td>
<td>20</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>40</td>
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<td>1.3</td>
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<td>2.0</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>4.8</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>7.0</td>
<td>3.1</td>
</tr>
</tbody>
</table>

PSI = pressure in pounds/square inch  
CFM = air flow in cubic feet/minute  
+ pressure loss is too great and therefore the combination of Hose Size, CFM, and Gauge Pressure is not recommended. Gauge Pressures the indicated air pressure in pounds/square inch, at the source (i.e. the air compressor receiver tank)
Appendix B – Additional Conversion Charts

**Length Conversion Constants**

**Metric to U.S.**

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millimeters</td>
<td>x 0.039370 = inches</td>
</tr>
<tr>
<td>Meters</td>
<td>x 39.370 = inches</td>
</tr>
<tr>
<td>Meters</td>
<td>x 3.2808 = feet</td>
</tr>
<tr>
<td>Meters</td>
<td>x 1.09361 = yards</td>
</tr>
<tr>
<td>Kilometers</td>
<td>x 3.280.8 = feet</td>
</tr>
<tr>
<td>Kilometers</td>
<td>x 0.62137 = Statute Miles</td>
</tr>
<tr>
<td>Kilometers</td>
<td>x 0.53959 = Nautical Miles</td>
</tr>
</tbody>
</table>

**U.S. to Metric**

<table>
<thead>
<tr>
<th>U.S.</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>x 25.4001 = millimeters</td>
</tr>
<tr>
<td>Inches</td>
<td>x 0.0254 = meters</td>
</tr>
<tr>
<td>Feet</td>
<td>x 0.30480 = meters</td>
</tr>
<tr>
<td>Yards</td>
<td>x 0.91440 = meters</td>
</tr>
<tr>
<td>Feet</td>
<td>x 0.003048 = kilometers</td>
</tr>
<tr>
<td>Statute Miles</td>
<td>x 1.60935 = kilometers</td>
</tr>
<tr>
<td>Nautical Miles</td>
<td>x 1.85325 = kilometers</td>
</tr>
</tbody>
</table>

**Weight Conversion Constants**

**Metric to U.S.**

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grams</td>
<td>x 981 = dynes</td>
</tr>
<tr>
<td>Grams</td>
<td>x 15.432 = grains</td>
</tr>
<tr>
<td>Grams</td>
<td>x 0.03527 = ounces (Avd.)</td>
</tr>
<tr>
<td>Grams</td>
<td>x 0.033818 = fluid ounces (water)</td>
</tr>
<tr>
<td>Kilograms</td>
<td>x 35.27 = ounces (Avd.)</td>
</tr>
<tr>
<td>Kilograms</td>
<td>x 2.20462 = pounds (Avd.)</td>
</tr>
<tr>
<td>Metric Tons</td>
<td>x 1.10231 =</td>
</tr>
<tr>
<td>Net Ton</td>
<td>x (2000 lbs.)</td>
</tr>
<tr>
<td>Metric Tons</td>
<td>x 0.98421 =</td>
</tr>
<tr>
<td>Gross Ton</td>
<td>x (2240 lbs.)</td>
</tr>
</tbody>
</table>

**U.S. to Metric**

<table>
<thead>
<tr>
<th>U.S.</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynes</td>
<td>x 0.0010193 = grams</td>
</tr>
<tr>
<td>Grains</td>
<td>x 0.0648 = grams</td>
</tr>
<tr>
<td>Ounces (Avd.)</td>
<td>x 28.35 = grams</td>
</tr>
<tr>
<td>Fluid Ounces (Water)</td>
<td>x 29.57 = grams</td>
</tr>
<tr>
<td>Ounces (Avd.)</td>
<td>x 0.02835 = kilograms</td>
</tr>
<tr>
<td>Pounds (Avd.)</td>
<td>x 0.45359 = kilograms</td>
</tr>
<tr>
<td>Net Ton (2000 lbs.) x .90719 =</td>
<td>Metric Tons (1000 Kg.)</td>
</tr>
<tr>
<td>Gross Ton (2240 lbs.) x 1.101605 =</td>
<td>Metric Tons (1000 Kg.)</td>
</tr>
</tbody>
</table>

**Area Conversion Constants**

**Metric to U.S.**

<table>
<thead>
<tr>
<th>Metric</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square Millimeters</td>
<td>x 0.0155 = square inches</td>
</tr>
<tr>
<td>Square Centimeters</td>
<td>x 155 = square inches</td>
</tr>
<tr>
<td>Square Meters</td>
<td>x 10.76387 = square feet</td>
</tr>
<tr>
<td>Square Meters</td>
<td>x 1.19599 = square yards</td>
</tr>
<tr>
<td>Hectares</td>
<td>x 2.47104 = acres</td>
</tr>
<tr>
<td>Square Kilometers</td>
<td>x 247.104 = acres</td>
</tr>
<tr>
<td>Square Kilometers</td>
<td>x 0.3861 = square miles</td>
</tr>
</tbody>
</table>

**U.S. to Metric**

<table>
<thead>
<tr>
<th>U.S.</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square Inches x 645.163 = square millimeters</td>
<td></td>
</tr>
<tr>
<td>Square Inches x 6.45163 = square centimeters</td>
<td></td>
</tr>
<tr>
<td>Square Feet x .0929 = square meters</td>
<td></td>
</tr>
<tr>
<td>Square Yards x .83613 = square meters</td>
<td></td>
</tr>
<tr>
<td>Acres x .40469 = hectares</td>
<td></td>
</tr>
<tr>
<td>Acres x .0040469 = square kilometers</td>
<td></td>
</tr>
<tr>
<td>Square Miles x 2.5899 = square kilometers</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C – Hose Materials

Rubber

To provide a wide range of physical properties for specific service needs, elastomers are mixed with various chemicals. There are many compounding ingredients and compounding methods available to the hose manufacturer, and many types can be blended in almost unlimited combinations to obtain the most desirable properties for the application.

The reader is cautioned that the “General Properties” described are just that, properties which have been found to be generally applicable in the experience of persons familiar with rubber chemistry. However, the reader should always follow the manufacturer’s recommendation as to the use of any particular rubber composition, especially with respect to the resistance of the rubber composition to the materials it is intended to carry or protect against. Failure to do so may result in possible damage to property and/or serious bodily injury.

Rubbers Used In Hose

<table>
<thead>
<tr>
<th>ASTM Designation D1418</th>
<th>Common Name</th>
<th>Composition</th>
<th>General Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABR Acrylics</td>
<td>Acrylate-butadiene</td>
<td>Excellent for high temperature oil and air resistance. Poor cold flow and low temperature resistance. Not recommended for water service.</td>
<td></td>
</tr>
<tr>
<td>AEM Ethylene acrylic</td>
<td>Ethylene methyl acryl- ate copolymer</td>
<td>Excellent high temperature, ozone, and oil resistance</td>
<td></td>
</tr>
<tr>
<td>AU Urethane</td>
<td>Polyester</td>
<td>Excellent abrasion, tear and solvent resistance, good aging. Poor high temperature properties.</td>
<td></td>
</tr>
<tr>
<td>BIIR Bromobutyl</td>
<td>Brominated isobutylene-isoprene</td>
<td>Same general properties as Butyl (see IIR below)</td>
<td></td>
</tr>
<tr>
<td>BR Polybutadiene</td>
<td>Butadiene</td>
<td>Excellent low temperature and abrasion properties. High resilience.</td>
<td></td>
</tr>
<tr>
<td>CIIR Chlorobutyl</td>
<td>Chlorinated isobutylene-isoprene</td>
<td>Same general properties as Butyl (see IIR below)</td>
<td></td>
</tr>
<tr>
<td>CM Chlorinated polyethylene</td>
<td>Chlorinated polyethylene</td>
<td>Good long term resistance to UV and weathering. Good oil and chemical resistance. Excellent flame resistance. Good low temperature impact resistance.</td>
<td></td>
</tr>
<tr>
<td>CO Epichlorohydrin Rubber</td>
<td>Polychloromethyl oxirane</td>
<td>Excellent oil and ozone resistance. Good flame resistance and low permeability to gases. Fair low temperature properties.</td>
<td></td>
</tr>
<tr>
<td>CR Neoprene</td>
<td>Polychloroprene</td>
<td>Good weathering resistance, flame retarding. Moderate resistance to petroleum based fluids. Good physical properties.</td>
<td></td>
</tr>
<tr>
<td>CSM Hypalon</td>
<td>Chlorosulfonyl-Polyethylene</td>
<td>Excellent ozone, weathering and acid resistance. Good abrasion and heat resistance. Good resistance to petroleum based fluids.</td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Properties</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>EAM</td>
<td>Ethylene vinyl acetate</td>
<td>Excellent high temperature and ozone resistance. Good resistance to petroleum based fluids as vinyl acetate content increases.</td>
<td></td>
</tr>
<tr>
<td>ECO</td>
<td>Epichlorhydrin copolymer</td>
<td>Excellent oil and ozone resistance. Fair flame and low permeability to gases. Good low temperature properties.</td>
<td></td>
</tr>
<tr>
<td>EPDM</td>
<td>Ethylene-Propylene Rubber</td>
<td>Excellent ozone, chemical and aging characteristics. Good heat resistance. Poor resistance to petroleum based fluids.</td>
<td></td>
</tr>
<tr>
<td>EPM</td>
<td>Ethylene-Propylene Rubber</td>
<td>Excellent ozone, chemical and aging characteristics. Good heat resistance. Poor resistance to petroleum based fluids.</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>Urethane</td>
<td>Excellent abrasion, tear, and solvent resistance. Good aging. Poor high temperature properties.</td>
<td></td>
</tr>
<tr>
<td>FKM</td>
<td>Fluoroelastomer</td>
<td>Excellent high temperature resistance, particularly in air or oil. Very good chemical resistance.</td>
<td></td>
</tr>
<tr>
<td>HNBR</td>
<td>Hydrogenated nitrile</td>
<td>Excellent high temperature and oil resistance.</td>
<td></td>
</tr>
<tr>
<td>IIR</td>
<td>Butyl</td>
<td>Very good weathering resistance. Low permeability to air. Good physical properties. Poor resistance to petroleum based fluids.</td>
<td></td>
</tr>
<tr>
<td>IR</td>
<td>Polyisoprene</td>
<td>Same properties as natural rubber (see NR below)</td>
<td></td>
</tr>
<tr>
<td>MQ</td>
<td>Silicone</td>
<td>Excellent high and low temperature resistance. Fair physical properties.</td>
<td></td>
</tr>
<tr>
<td>NBR</td>
<td>Nitrile</td>
<td>Excellent resistance to petroleum based fluids. Moderate resistance to aromatics. Good physical properties.</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>Natural Rubber</td>
<td>Excellent physical properties including abrasion and low temperature resistance. Poor resistance to petroleum based fluids.</td>
<td></td>
</tr>
<tr>
<td>SBR</td>
<td>SBR</td>
<td>Good physical properties, including abrasion resistance. Poor resistance to petroleum based fluids.</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>Thiokol</td>
<td>Outstanding solvent resistance and weathering resistance. Other properties are poor.</td>
<td></td>
</tr>
<tr>
<td>XLPE</td>
<td>Cross-linked polyethylene</td>
<td>Excellent chemical resistance with good heat and electric properties</td>
<td></td>
</tr>
<tr>
<td>XNBR</td>
<td>Carboxylated nitrile</td>
<td>Excellent oil and abrasion resistance.</td>
<td></td>
</tr>
</tbody>
</table>
### Plastics Used in Hose

<table>
<thead>
<tr>
<th>ASTM Designation D1600</th>
<th>Common Name</th>
<th>Composition</th>
<th>General Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>Nylon</td>
<td>Polyamide</td>
<td>Good abrasion, chemical and fatigue resistance. Good long term resistance to high temperature. Low gas permeation and low coefficient of friction</td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene</td>
<td>Polyethylene</td>
<td>Excellent dielectric properties. Excellent resistance to water, acids, alkalis, and solvents. Good abrasion and weathering resistance.</td>
</tr>
<tr>
<td>UHMWPE</td>
<td>Ultra high molecular weight polyethylene</td>
<td></td>
<td>Excellent resistance to a broad range of chemicals, excellent abrasion resistance.</td>
</tr>
<tr>
<td>PVC</td>
<td>PVC</td>
<td>Polyvinyl chloride</td>
<td>Good weathering, moisture and flame resistance. General resistance to alkalis and weak acids. Good abrasion resistance.</td>
</tr>
<tr>
<td>Polyester</td>
<td>Thermoplastic polyester resin</td>
<td></td>
<td>Good flex fatigue and low temperature properties. High resistance to deformation. Good resistance to abrasion, chemicals, hydraulic fluids and aromatic fuels.</td>
</tr>
<tr>
<td>Thermoplastic Rubber</td>
<td>Thermoplastic polyolefins and block copolymers of styrene and butadiene</td>
<td></td>
<td>Good weather and aging resistance. Good for water and dilute acids and bases.</td>
</tr>
<tr>
<td>PTFE</td>
<td>Fluoropolymer</td>
<td>Fluorocarbon resin</td>
<td>Excellent high temperature properties and chemical resistance.</td>
</tr>
</tbody>
</table>

#### Fabrics

**Overview:** Textile fabrics used as reinforcement in hose construction provide the strength to achieve the desired resistance to internal pressure or to provide resistance to collapse, or both.

The properties of a fabric depend on the construction and the material from which the yarn is made and on the type of weave used.

One common hose fabric is woven from warp yarns, which run lengthwise, and fill yarns, which run cross-wise. Usually they are woven at right angles to each other. The most common weave is known as “plain weave” where the warp and fill yarns cross each other alternatively. Other weaves used, though to a lesser degree, are twill, basket weave, and leno. Leno weave is used mainly where the fabric must be distorted in the hose as in certain types of curved hose. Leno also provides a means for better adhesion than other patterns. Woven Cord is a special type of hose reinforcement. The warp cords are strong while the fill yarn is very fine and merely holds the cords in position. This is often called “tire cord” because this type of construction is commonly used in reinforcing tires. Woven cord provides strength in one direction only. When woven cord is used, a minimum of two layers are applied in alternate directions.
To adhere to the tube and cover of the hose, the fabric must be rubberized. The fabric is either frictioned or coated with a thin layer of rubber. Before rubberizing, some fabrics are treated with liquid adhesive.

### Fibers Used in Hose

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Composition</th>
<th>General Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aramid</td>
<td>Meta-Aramid</td>
<td>Exceptional heat resistance with low shrinkage.</td>
</tr>
<tr>
<td>Aramid</td>
<td>Para-Aramid</td>
<td>Exceptional strength with low elongation. High heat resistance.</td>
</tr>
<tr>
<td>Cotton</td>
<td>Natural cellulose</td>
<td>Natural vegetable fiber used in hose. Gains strength with increased moisture content. Requires protection against chemical and fungal activity.</td>
</tr>
<tr>
<td>Glass</td>
<td>Glass</td>
<td>Very high strength compared to other fibers. Low elongation; mainly used in high temperature applications.</td>
</tr>
<tr>
<td>Nylon</td>
<td>Polyamide</td>
<td>High strength and elongation with good resistance to abrasion, fatigue, and impact. Low moisture absorption and excellent moisture stability. High resistance to fungal activity.</td>
</tr>
<tr>
<td>Polyester</td>
<td>Polyester</td>
<td>High strength, good resistance to abrasion, fatigue, and impact. Low moisture absorption and excellent moisture stability. High resistance to fungal activity.</td>
</tr>
<tr>
<td>PVA</td>
<td>Polyvinyl alcohol</td>
<td>High strength, low shrinkage, and good chemical resistance.</td>
</tr>
<tr>
<td>Rayon</td>
<td>Regenerated cellulose</td>
<td>Similar to cotton in chemical and fungal resistance. Moisture absorption higher than cotton. Dry strength is substantially greater than cotton. Strength is reduced with increased moisture content but retains a wet strength level above cotton.</td>
</tr>
</tbody>
</table>

### Yarns

Yarns are used in hose for reinforcement of the tube material to provide the strength to achieve the desired resistance to internal pressure or to provide resistance to collapse, or both. The basic yarn properties required for hose reinforcement are: adequate strength, acceptable heat resistance, dynamic fatigue resistance, and satisfactory processability for the various methods of reinforcing hose. Other special properties such as stiffness, adhesion, conductivity, etc., may be developed depending upon the specific hose application. Yarn is available in two basic forms: staple (sometimes referred to as spun yarn) and filament.

**Staple:** Staple yarn is made by twisting bundles of short fibers to form a continuous yarn. The staple obtains its strength from the binding effect of the twist imparted to the individual fibers. The base staple yarn is called “singles”. It is made from fiber bundles twisted together in one direction to form a singles strand. If two or more single yarns are twisted together, usually in a direction opposite that of the singles yarn, the result is a plied yarn. Two or more plied yarns may be twisted to form a cable cord. The strength, elongation, and thickness of yarn are a function of the twist level and the number of fibers in the bundle. Staple yarns may be made from natural or synthetic fibers or a blend of the two. The cotton count system is normally used to designate staple yarn size. The number of “hanks” in one pound is the yarn number. A cotton hank is 840 yards. Therefore, a 2’s staple yarn contains approximately 1680 yards in one pound. The cotton count system is an inverse measure of the linear density of the yarn, i.e., as the yarn number increases the yarn size is decreased.
**Filament Yarns:** Filament yarn is produced by extruding synthetic material through a spinnerette containing hundreds of orifices. The mono-filaments from each of the orifices are brought together to form a multifilament yarn.

Filament yarns have higher tenacity (strength per unit of weight – grams per denier), in the range of 2 to 3 times that of staple yarn on the same material type and size. Yarn size is normally designated using the *denier* system (weight in grams of 9000 meters of yarn.) The *TEX* system (the weight in grams of 1000 meters of yarn) is also widely used. Both are direct yarn measurements, i.e., as the number increases, the yarn size increases.

**Wires**

Reinforcing wire is used in a wide variety of hydraulic and industrial hose, primarily where textiles alone do not satisfy the special engineering requirements or the service conditions for which the hose is designed.

**Steel wire:** Steel wire has strength, high modulus for dimensional stability, fatigue resistance, and low cost, and is the major reinforcement used in high pressure hose and in most suction hose.

**Steel wire (High Tensile Low Carbon):** Small diameter high tensile steel wire is most commonly used for reinforcement in braided or spiral-wound hose for high pressure and high temperature applications. The wire normally used ranges in size from 0.008 inch to 0.037 inch (0.20 mm to 0.94 mm) in diameter.

**Flat Wire Braid:** This consists of an odd number of steel wires interwoven to produce a flexible reinforcement. It is used in specialized types of hose, either by itself, or in combinations with other shapes of steel wire. Flat braids of standard sizes are composed of 9, 13, 17, or 21 strands of wire in an “over two, under two” plain braid pattern.

**Wire Cable:** Wire cable consists of multiple strands of round wire. It provides high bursting strength without undue loss of flexibility or crush resistance. Sizes range from 0.047 inch to 0.25 inch (1.19 mm to 6.4 mm) in diameter and are made from high tensile carbon steel wire.

**Round Wire:** Round is the most commonly used wire shape in hose fabrication. It ranges in size from 0.013 inch to 0.875 inch (0.79 mm to 22.2 mm) in diameter. Round wire is generally made of high tensile carbon steel.

**Rectangular Wire:** Rectangular wire is most commonly used as a helical reinforcement on the interior of rough bore suction hoses to prevent collapse. It is sometimes used in the body of the hose. Occasionally this type of wire is also used as an external helix embedded in and flush with the rubber cover to provide protection against cutting and abrasion and to increase crush resistance. Rectangular wire is generally steel, although aluminum may also be used.

**Half-round Wire:** Half-round steel wire is used mainly as a protective spiral armor on the exterior of a hose. It is wound with the flat side against the hose cover to provide maximum surface contact. It is available in stainless steel or steel with tin-coated or galvanized finishes.

**Wire finishes:** Wire finishes for steel wire can be either one of two types, (1) brass drawn finish, or (2) coated finish. The most commonly used finish in the hose industry is brass (drawn finish), or galvanized (coated finish.) Other finishes include bronze, liquor, and tin. Helical round wires used as helical wound in the body of a hose may have a drawn copper finish, or may be unfinished (bright). Rectangular steel wires used in the bore of a hose usually have a galvanized finish.

**Alloy and Non-Ferrous Wires:** Under certain service conditions, carbon steel wire is not suitable. An alloy wire is used instead. One of the most commonly used is stainless steel which offers
exceptional resistance to corrosion and heat. Where light weight is essential, alloys of aluminum are used.

Static Wires: Static wires and other conductive materials are used in hose to prevent static electricity buildup. Wires can be made from many metals including copper, steel, Monel, aluminum and tin-coated copper. Static wires may be solid, stranded, or braided.
Appendix D – Nomographic Flow Chart

Nomographic Chart
Flow Capacity of Hose Assemblies at Recommended Flow Velocities

Based on Formula:

\[ \text{Area (Sq.In.)} = \frac{0.321 \times \text{(GPM)}}{\text{Velocity (Ft./Sec.)}} \]

Example: To determine the I.D. needed to transport 20 Gallons Per Minute (GPM) fluid volume...

Draw a straight line from 20 GPM on the left to maximum recommended velocity for pressure lines. The line intersects with the middle vertical column indicating a 3/4” I.D. (-12) hose. This is the smallest hose that should be used.

Recommendations are for oils having a maximum viscosity of 315 S.S.U. at 100°F, operating at temperatures between 65°F and 155°F.

*Maximum pressure line velocity suggestions may vary. Please consult your hose manufacturer for specific recommendations. *(Chart not to scale)*
Appendix E – Coupling Thread Configurations

Note: Special thanks to Dixon Valve & Coupling for the following information.

Identifying Threads

It is important to identify the threads required before ordering couplings.

Identifying threads can sometimes be the most difficult and frustrating part of coupling selection. However, without the right combination of threads, you may not provide a functional or safe connection.

The diameters, threads per inch (TPI) and thread pitch, etc. are necessary to completely identify a thread. Ring, Plug and GO/NOGO gauges are required to accurately gauge or identify threads. In the field, in the absence of these gauges, thread leaf gauges can be used to identify the Threads Per Inch (TPI) and the thread pitch. On threads you have determined to be straight threads, a caliper can be used to measure the Outside Diameter of the Male (ODM) or the Inside Diameter of the Female (IDF). A caliper can also be used to take measurements of tapered thread diameters. However, these are more difficult to define because of the taper. Fortunately, there are few tapered threads to deal with and these can usually be identified from the nominal ODM and the TPI.

However, identifying the thread may not fully identify what is needed in a mating fitting. The application is the primary limiting factor on the thread type used.

When attempting to choose a fitting, it is always advisable to first identify the thread to which it must connect. This may entail checking with a fitting or equipment manufacturer.

The fire hose thread specifications for some local municipal fire equipment and hydrants may vary according to local specifications. These can generally be most easily identified by contacting the local fire department responsible for the hydrant. The most common thread used on fire equipment is National Standard Thread (NST), also known as National Hose thread (NH).

When it is not possible to identify the thread:

1. Determine the number of threads per inch by measuring the distance from peak of thread to peak of thread across the largest number of whole threads. Then divide the number of threads by the measurement (This will provide the TPI).
2. Check to see if the thread is straight or tapered.
   a) Straight Threads
      Measure the Outside Diameter of the Male (ODM) or the Inside Diameter of the Female (IDF), from peak of thread to peak of thread.
   b) Tapered Threads
      Measure the Outside Diameter of the Male (ODM) at the large end and the small end, or the Inside Diameter of the Female (IDF) at the large end and the small end, from peak of thread to peak of thread. Then measure the Outside Diameter (OD) of the unthreaded pipe.

Once the application and these two pieces of information have been determined, the thread can generally be determined. When in doubt, contact the factory.
# Thread Dimensions

**Nominal Dimensions of Standard Threads**

<table>
<thead>
<tr>
<th>Size</th>
<th>OD</th>
<th>Tapered Threads</th>
<th></th>
<th>Straight Threads</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TPI</td>
<td>TPI</td>
<td>TPI</td>
<td>OD (max)</td>
<td>IDF (min)</td>
</tr>
<tr>
<td>1/8&quot;</td>
<td>.405</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>0.397</td>
<td>0.358</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>.540</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>0.526</td>
<td>0.468</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>.675</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>0.662</td>
<td>0.603</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>.840</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>0.824</td>
<td>0.739</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>1.050</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>1.033</td>
<td>0.950</td>
</tr>
<tr>
<td>1&quot;</td>
<td>1.315</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>1.295</td>
<td>1.192</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>1.660</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>1.639</td>
<td>1.539</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>1.900</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>1.878</td>
<td>1.775</td>
</tr>
<tr>
<td>2&quot;</td>
<td>2.375</td>
<td>11.5</td>
<td>11.5</td>
<td>11.5</td>
<td>2.358</td>
<td>2.248</td>
</tr>
<tr>
<td>2-1/2&quot;</td>
<td>2.875</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>2.843</td>
<td>2.693</td>
</tr>
<tr>
<td>3&quot;</td>
<td>3.500</td>
<td>8</td>
<td>11</td>
<td>8</td>
<td>3.467</td>
<td>3.334</td>
</tr>
<tr>
<td>4&quot;</td>
<td>4.500</td>
<td>8</td>
<td>11</td>
<td>8</td>
<td>4.466</td>
<td>4.333</td>
</tr>
<tr>
<td>4-1/2&quot;</td>
<td>5.563</td>
<td>8</td>
<td>11</td>
<td>8</td>
<td>5.528</td>
<td>5.395</td>
</tr>
<tr>
<td>8&quot;</td>
<td>8.625</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8.625</td>
<td>8</td>
</tr>
<tr>
<td>10&quot;</td>
<td>10.750</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>10.750</td>
<td>8</td>
</tr>
<tr>
<td>12&quot;</td>
<td>12.750</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>12.750</td>
<td>8</td>
</tr>
</tbody>
</table>

GHT (3/4") = 1.0625 OD, 11-1/2 TPI

Note: Female NPT (Tapered Pipe) thread is not available on hose swivel nuts.

---

**Normal Engagement Length of NPT Thread in Inches (A)***

*Dimensions given do not allow for variations in tapping or threading.*

<table>
<thead>
<tr>
<th>Thread Size</th>
<th>Dimension A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8&quot;</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>1/4&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>7/16&quot;</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>9/32&quot;</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>11/32&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>13/32&quot;</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>15/32&quot;</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>17/32&quot;</td>
</tr>
<tr>
<td>2&quot;</td>
<td>21/32&quot;</td>
</tr>
<tr>
<td>2-1/2&quot;</td>
<td>25/32&quot;</td>
</tr>
<tr>
<td>3&quot;</td>
<td>1 1/16&quot;</td>
</tr>
<tr>
<td>4&quot;</td>
<td>1 1/8&quot;</td>
</tr>
<tr>
<td>5&quot;</td>
<td>1 1/4&quot;</td>
</tr>
<tr>
<td>6&quot;</td>
<td>1 1/2&quot;</td>
</tr>
<tr>
<td>8&quot;</td>
<td>1 7/16&quot;</td>
</tr>
<tr>
<td>10&quot;</td>
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<td>1 3/4&quot;</td>
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Identifying Threads

Pipe Threads

Pipe threads are either tapered or straight (parallel). The two styles are not compatible except for NPSL (National Pipe Straight Locknut), which is compatible with NPT.

Tapered threads

Tapered threads are the most common type of thread available. As the name implies, they have a slight taper. When mated together and tightened, the threads compress to form a seal. The mating threads both hold the fitting in place and seal the connection. The most widely used pipe threads in North America are NPT (National Pipe Taper). Some confusion may result from the use of NPT, FPT, and MPT in describing threads. Both FPT and MPT are NPT threads, with FPT meaning female threads (internal) and MPT meaning male threads (external).

NPTF (Dryseal) threads are modified NPT threads, which are less likely to leak without a sealant. For a leak-free seal, we recommend using a sealant compound or PTFE tape. You can use NPTF threads with NPT threads, but you'll lose some of the leak-free characteristics.

Straight threads

Straight (parallel) threads are used for mechanical joining. They serve one purpose - to hold a fitting in place. As a result, an O-ring (elastomer), hard metal seal or a soft seat seal is required. When used together, the threads and sealing method provide a better overall seal than tapered threads. Straight pipe threads include NPSM (National Pipe Straight Mechanical), NPSL (National Pipe Straight Locknut) and NPSH (National Pipe Straight Hose) conform to SAE (Society of Automotive Engineers) specifications. Sizing and pitches differ from the NPT threads.

Less common straight threads are GHT (Garden Hose) and NST (fire hose coupling).

NPT vs. BSP (British Standard Pipe)

BSP threads are common in many countries outside the United States. BSP consists of two types of threads - BSPT (British Standard Pipe Taper) and BSPP (British Standard Pipe Parallel).

BSPT threads have a slight taper similar to NPT. BSPP threads are straight (parallel) threads and have the same thread angle, shape and threads per inch (pitch) as BSPT threads. BSPT and BSPP threads should not be substituted for NPT threads.

NPT and BSPT/BSPP threads have different angles, shape, and (in most cases) threads per inch (pitch). The thread angle is 60° for NPT threads; 55° for BSPT/BSPP threads. NPT threads are flattened at the peaks and valleys, while BSPT/BSPP threads are rounded.

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<th>Nominal Pipe Size</th>
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<td>1/4&quot;</td>
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<tr>
<td>1&quot;</td>
<td>11 ½</td>
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<tr>
<td>1-1/4&quot;</td>
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Appendix F – Hydraulic Audit List

Product Information

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<td>COUPLING B</td>
<td>SLEEVE/GUARD</td>
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**Inspection and Audit Data**

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<th>METHOD</th>
<th>SPEC</th>
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<td></td>
<td>Corrosion</td>
<td>Visual</td>
<td>Go/No Go</td>
<td></td>
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<td></td>
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<td>Visual</td>
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<tr>
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<td>Hands</td>
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<td>Internal Dirt or Damage</td>
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<td>Visual</td>
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Appendix G – Relevant ARPM (was RMA) Publications

To purchase copies of ARPM hose publications, as listed below, go to http://www.arpminc.com/publications-menu.

<table>
<thead>
<tr>
<th>Publication No.</th>
<th>Specifications – Provides complete information on the construction, application, and testing of the respective hose type</th>
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<tbody>
<tr>
<td>IP-7</td>
<td>Specifications for Rubber Welding Hose</td>
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<tr>
<td>IP-8</td>
<td>Specifications for Rubber Hose for Oil Suction and Discharge</td>
</tr>
<tr>
<td>IP-14</td>
<td>Specifications for Anhydrous Ammonia Hose</td>
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<tr>
<td><strong>IP-11</strong></td>
<td><strong>Hose Technical Bulletins – Provides Summary requirements for the maintenance, testing and inspection of the respective hose type</strong></td>
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<td>Anhydrous Ammonia Hose</td>
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<tr>
<td>IP-11-4</td>
<td>Oil Suction and Discharge Hose</td>
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<tr>
<td>IP-11-5</td>
<td>Welding Hose</td>
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<tr>
<td>IP-11-7</td>
<td>Chemical Hose</td>
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<tr>
<td>IP-11-8</td>
<td>Petroleum Service Station Gasoline Dispensing Hose and Hose Assemblies</td>
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</table>
Appendix H – References

**ANSI**
American National Standards Institute  
Attn: Customer Service  
25 West 43rd Street  
New York, NY 10036  
Phone: (212) 642-4900  
Fax: (212) 398-0023  
E-mail: info@ansi.org  
Internet: http://www.ansi.org

**ARPM**
Association for Rubber Products Manufacturers  
7321 Shadeland Station Way, Suite 285  
Indianapolis, IN 46256  
Phone: 317-863-4072  
Internet: http://www.aarminc.org/

**ASME**
American Society for Mechanical Engineers  
22 Law Drive  
Box 2900  
Fairfield, NJ 07007-2900  
Phone: (800) 843-2763; (973) 882-1167  
Fax: (973) 882-1717; (973) 882-5155  
E-mail: infocentral@asme.org  
Internet: http://www.asme.org

**ASQ**
American Society for Quality  
600 North Plankinton Avenue  
Milwaukee, WI 53203  
Phone: (800) 248-1946  
Fax: (414) 272-1734  
E-mail: help@asq.org  
Internet: http://www.asq.org

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West Conshohocken, PA 19428-2959  
Phone: (610) 832-9585  
Fax: (610) 832-9555  
E-mail: service@astm.org  
Internet: http://www.astm.org

**CFIA**
Canadian Food Inspection Agency  
Phone 1-800-442-2342  
Email: cfiamaster@inspection.gc.ca  

**CSB**
Chemical Safety Board  
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Internet: http://www.ihs.com

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Washington, DC 20401  
Phone: (202) 512-0000  
Email: webteam@gpo.gov  
Internet: http://www.gpo.gov

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Appendix I – Industrial Hose, Coupling and Attachment Chart

Notes:

1. See hose and fittings manufacturers for specific pressure rating suggestions. The pressure rating for the assembly should always be equal to the lowest pressure-rated component. It is suggested that the hose couplings and attachment methods used in the assembly meet or exceed the working pressure of the hose. In cases where this is not followed, it is suggested that a tag be used identifying the actual working pressure of the hose assembly based on the lowest pressure rating of the various components.

2. Please note that assembly testing should be used to verify expected pressure ratings. Variations in assembly component materials or fabrication techniques will impact the resultant pressure ratings for the finished assembly.

3. When using Preformed Clamps, use the correct type and number of bands or clamps as recommended by the manufacturer and/or as many preformed clamps on the assembly as the design and length of the shank will allow. Working pressure may also depend on band width, thickness and material. This rating is also dependent on the type of hose barb design used with the clamp or bands used.

4. The use of Band & Buckle should typically offer a slightly higher assembly working pressure depending on band width, thickness, material and number of bands.
<table>
<thead>
<tr>
<th>Hose</th>
<th>Fitting</th>
<th>Attachment</th>
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</thead>
<tbody>
<tr>
<td>Air &amp; Multi-Purpose</td>
<td>Ground Joint</td>
<td>Interlocking Clamp</td>
</tr>
<tr>
<td>Air &amp; Multi-Purpose</td>
<td>Ground Joint</td>
<td>Interlocking Clamp</td>
</tr>
<tr>
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<td>High Pressure Crimp</td>
<td>High Pressure Crimp Ferrule</td>
</tr>
<tr>
<td>Air &amp; Multi-Purpose</td>
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<td>Pinch Clamp</td>
</tr>
<tr>
<td>Air &amp; Multi-Purpose</td>
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<td>Preformed Clamp</td>
</tr>
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<th>Attachment</th>
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