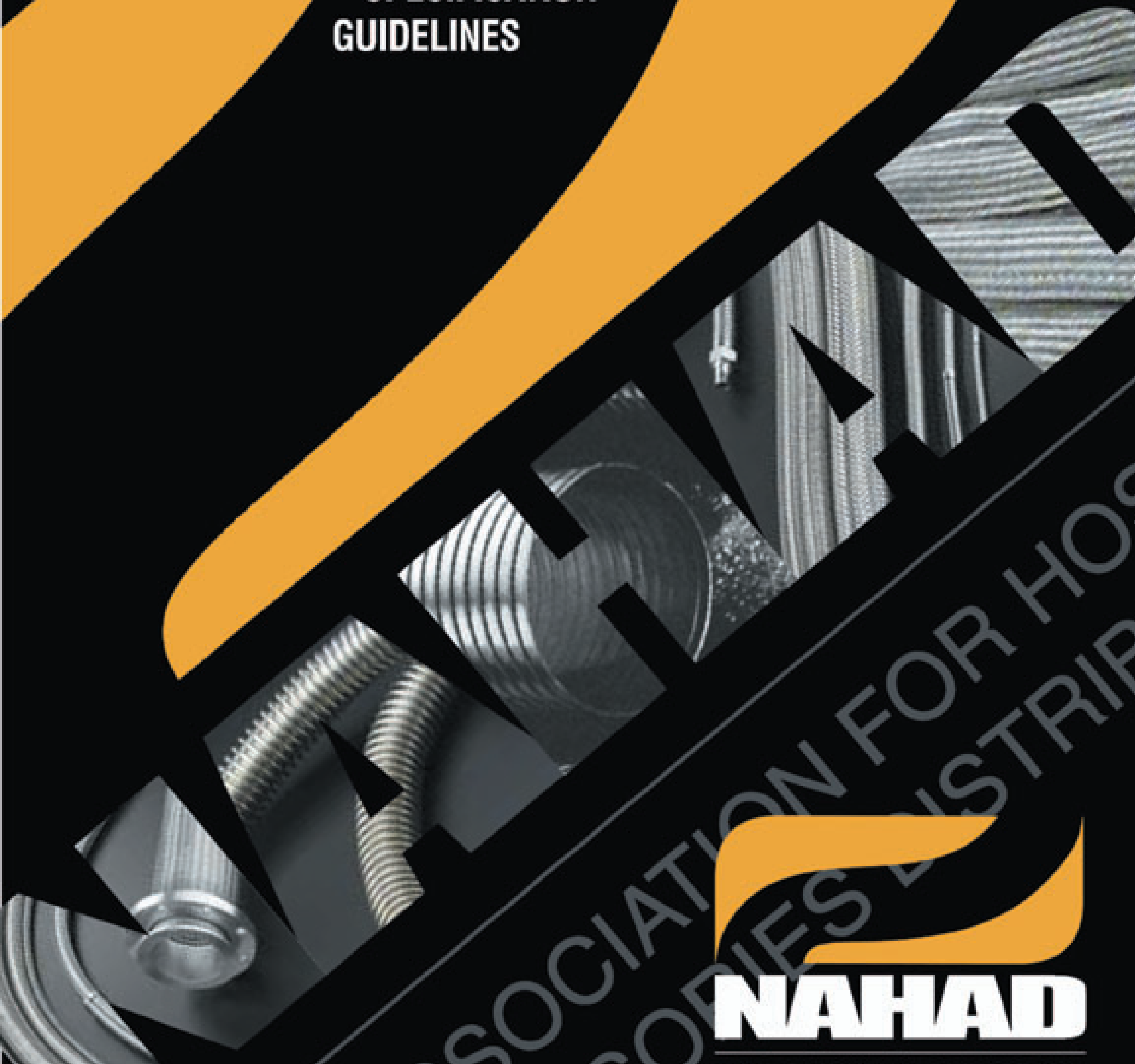
CORRUGATED METAL HOSE ASSEMBLY SPECIFICATION GUIDELINES



NAHAD

THE ASSOCIATION FOR HOSE AND ACCESSORIES DISTRIBUTION

NAHAD 400

2005

IMPORTANT NOTE TO READER:

NAHAD - The Association for Hose and Accessories Distribution - is pleased to provide this *comprehensive set of basic Hose Assembly Specification Guidelines* for customers seeking to acquire fabricated hose assemblies for various industrial applications. The information contained within this document has been developed through the concerted efforts of dozens of member volunteers, association staff and industry leaders, with the common goal of helping to improve the safety, quality and reliability of fabricated hose assemblies.

In addition to this document, NAHAD has produced four other Hose Assembly Specification Guidelines publications, addressing a total of five hose product groups, including: Composite Hose; Corrugated Metal Hose; Hydraulic Hose; Industrial Hose and Fluoropolymer Hose. These five publications are intended to complement existing industry and federal regulations. Aerospace and hydraulic brake hose assemblies are specifically excluded from this and the other four documents.

Hose, hose fittings and hose couplings come in various sizes and designs. Although there are standards published by manufacturers and independent testing organizations, such as ANSI, ASME, ASTM, ASQ, UL, ISO, SAE, RMA and others which relate to hoses and hose fittings, there are no generally recognized standards for hose assemblies. This publication is indebted to these organizations and, in specific cases, refers the reader to designated existing standards and recommendations provided by these other sources in an attempt to encourage the fabrication of safer, higher quality and more reliable hose assemblies.

NAHAD has published these Hose Assembly Specification Guidelines in order to create reference works that compile information of value to NAHAD members, manufacturers and customers in developing hose assemblies that meet specific individual needs. To the extent that each assembly has unique characteristics, it must be custom designed, engineered and tested. Hopefully, these Guidelines will be useful in the process.

In compiling standards and recommendations published by others and in developing these Guidelines, NAHAD has not and will not engage in independent testing or verification of the information provided to it. Users of these Guidelines should not, and cannot, rely on these Guidelines as a standard, certification or approval of the data published herein. NAHAD, and the member company volunteers, association staff and industry leaders who participated in the creation of these Guidelines do not assume, and expressly decline and deny, any and all liability for any product failures, damages or injuries that may result in any way from utilization of these Guidelines or products based on these Guidelines.

The NAHAD Hose Assembly Guidelines incorporate various technical recommendations published by other sources. NAHAD has not independently verified these recommendations and specifically disclaims any and all liability, direct or indirect, for any failures, damages or injuries resulting in whole or in part from the failure of any product, including hoses, fittings, and assemblies described in this publication or in the Guidelines.

Published by The Association For Hose & Accessories Distribution, Inc.
105 Eastern Avenue, Suite 104
Annapolis, Maryland 21403
www.nahad.org

Table of Contents

Section 1 – Scope **5**
Section 2 – Glossary **5**
Section 3 - Information to be Supplied by Customer **10**
Critical Applications 10
Chlorine 11
Section 4 – Materials **11**
4.1 General 11
4.2 Components 11
4.3 Welding and Brazing 12
Section 5 – Assembly Dimensions **12**
5.1 Inside Diameter of the Hose 12
5.2 Overall Length (OAL) 12
5.3 Measuring OAL of Hose Assemblies 13
Section 6 – Hose Construction **15**
6.1 Types of Hose Construction 15
6.2 Heat Treatment 15
6.3 Joining or Splicing Unbraided Hose 15
Section 7 – Braid **16**
7.1 General 16
7.2 Braid Coverage 16
7.3 Multiple Braided Hose 17
Section 8 – Common Fittings and Accessories **17**
8.1 General 17
8.2 Fitting Orientation 17
8.3 Illustrations of Common Fittings 18
8.4 Common Accessories 22
8.4.1 Guard 22
8.4.2 Liner 22
Section 9 – Attachment Methods and Components **23**
9.1 Attachment Methods 23
9.1.1 Direct Attachment Method 23
9.1.2 Braid-Over (Neck Down) Attachment Method 23
9.1.3 Smooth-Transition (ST) Attachment Method 24
9.2 Attachment Components 24
9.2.1 Braid Sleeves 24
9.2.2 Pipe Spacers 24
Section 10 – Production Testing **25**
10.1 General 25
10.2 Visual Inspection 25
10.3 Leak Testing 25
10.3.1 Pneumatic Test 25

10.3.2 Hydrostatic Test 26
10.3.3 Helium Mass Spectrometer Test 26
10.4 Additional Leakage Tests 26
Section 11 – Marking, Cleaning, and Packaging 26
11.1 Marking 26
11.2 Cleaning 26
11.3 Packaging 27
Section 12 – Documentation 27
12.1 General 27
12.2 Certificate of Conformance (C of C) 27
12.3 Test Report 27
12.4 Material Test Report (MTR) 28
12.5 Positive Material Identification 28
12.6 Third Party Certification 28
Section 13 – Safety Issues, Inspections, and Installation and Handling 28
13.1 General 28
13.2 Safety Issues 29
13.2.1 Fluid/Gas Injections 29
13.2.2 Fire and Explosions from Conveyed Media 29
13.2.3 Burns from Conveyed Fluids 29
13.2.4 Fluid Controlled Mechanisms 29
13.2.5 Whipping Hose 29
13.2.6 Burns from Contact with the Hose 30
13.2.7 Electrical Shock 30
13.3 Inspections 30
13.3.1 Pre-installation Inspection 30
13.3.2 Preventative Maintenance Inspections 31
13.4 Installation and Handling 32
APPENDIX 33
i. Test to Establish Maximum Allowable Working Pressure (MAWP) 33
ii. Test to Establish Minimum Static Bend Radius (MSBR) 34
iii. Test to Establish Minimum Dynamic Bend Radius (MDBR) 35
a) U-Bend Test 35
b) Cantilever Test 36
iv. Temperature Derating 37
v. References 38

Section 1 – Scope

This Specification Manual applies to corrugated metal hose assemblies with inside diameters ranging from 1/4òthrough 12ò. It is intended as a guide to assist in defining the design, fabrication, and performance of an assembly.

This manual should be used to compliment, not replace, other assembly guidelines. It is suitable for the majority of general industrial applications. However, users are encouraged to share the parameters of the particular installation with the provider, and jointly define additional specifications as necessary.

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. Please see Section 3 of this document for further information.

Section 2 – Glossary

air under water test - see pneumatic test

angular displacement - motion that occurs when the assembly is bent into a single curve.

annular - used to describe a type of corrugated hose having many individual parallel convolutions located at right angle to the longitudinal axis of the hose. *also see: corrugation*

armor - see guard

assembly - a general term referring to any hose with fittings attached.

attachment weld - see Section 9.1

axial movement - compression or elongation along the longitudinal axis of the assembly.

basket weave - a braid pattern in which the carriers alternately cross over and under two carriers.

beamed braid - braid construction in which the wires in a carrier are parallel.

bend radius - the radius of the bent section of hose measured to the centerline of the curved portion. *also see: dynamic bend radius, minimum dynamic bend radius, minimum static bend radius, static bend radius*

braid - see Section 7

braid angle - see Section 7.2

braid construction - see Section 7.2
braid coverage - see Section 7.2

braid make-up - see braid construction

braid-over attachment - see Section 9.1

braid sleeve - see Section 9.2

braided braid - a braid where the strands of wire in each carrier are braided together.

burst pressure - the pressure at which rupture occurs. *also see: pressure*

butt weld splice - see Section 6.3

cap weld - see Section 9.1

casing ï see guard

convolution - see corrugation

corrugation - the annular or helical formed profile of a corrugated metal hose that provides the ability of the hose to bend. *also see: annular, helical*

corrugated metal hose - a pressure-tight metal hose with formed corrugations to provide flexibility.

coverage - see braid coverage

cycle life - the number of motion cycles completed by an assembly before failure.

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

design pressure ï see maximum allowable working pressure

developed length - see overall length

diamond weave - a braid pattern in which the carriers alternately cross over and under one carrier.

direct attachment - see Section 9.1

dog-leg assembly - two hose assemblies joined by a common elbow.

double braided - a corrugated metal hose covered by two layers of braid.
dye penetrant test ï a visual, non-destructive inspection method for detecting leaks and surface defects that uses a colored dye capable of highlighting them.

dynamic bend radius - the centerline radius at which constant or continuous flexing occurs. *also see: bend radius, minimum dynamic bend radius*

edge weld splice - see Section 6.3

end fitting - see fitting

fabrication - the act of constructing a metal hose assembly.

ferrule - see braid sleeve

fitting - coupling attached to the end of the hose to facilitate connection to the piping system.

full penetration weld - see smooth transition attachment

guard - see Section 8.4

helical - used to describe a type of corrugated hose in which a corrugation spirals the length of the hose, similar to a screw thread. *also see: corrugation*

helium mass spectrometer test - see Section 10.3

hydrostatic test - see Section 10.3

ID - the abbreviation for inside diameter.

interlocked metal hose - a stripwound metal hose whose strip edges are overlapped and engaged with the adjacent wraps. *also see: stripwound metal hose*

liner - see Section 8.4

live length - the flexible length of a hose assembly. *also see: Section 5.3*

MAWP ï see maximum allowable working pressure

MDBR - see minimum dynamic bend radius

MSBR - see minimum static bend radius

maximum allowable working pressure - the maximum pressure at which a hose or hose assembly is designed to be used. *also see: pressure, Appendix i.*
maximum test pressure ï Unless otherwise specifically defined by the provider, 1.5 times the maximum allowable working pressure of the lowest rated component in the assembly. a*lso see*: *pressure, test pressure.*

medium (media) - the substance(s) being conveyed through a system.

minimum dynamic bend radius - the smallest centerline bend radius that a hose is rated to perform in dynamic applications. *also see: bend radius, dynamic bend radius, Appendix iii*

minimum static bend radius - the smallest centerline bend radius that a hose is rated to perform in static applications. *also see: bend radius, static bend radius, Appendix ii*

neck-down - see braid-over

nominal - approximation. *also see: nominal diameter*

nominal diameter - an approximation of the hose ID normally rounded to the closest standard.

OAL ï see overall length

OD - the abbreviation for outside diameter.

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

operating pressure - see working pressure

overall length - see Section 5

pipe spacer - a section of pipe used to facilitate the connection of a fitting to a hose. *also see: Section 9.2*

pitch - the distance between the crests of adjacent corrugations.

pneumatic test - see Section 10.3

pressure - see burst pressure, deformation pressure, maximum allowable working pressure, maximum test pressure, pulsation, spike, test pressure, working pressure.

proof pressure - see test pressure

pulsation - rapid cyclic fluxuations in pressure. *also see: pressure*
STAMPED - see Section 3

smooth-transition attachment - see Section 9.1

spike - a sudden increase of pressure. *also see: pressure*

splice - see Section 6.3

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.

static bend radius - the centerline radius to which a hose is bent in a stationary installation. *also see: bend radius, minimum static bend radius*

stripwound metal hose - a flexible metal hose constructed of a non-welded continually wrapped profiled strip. *also see: interlocked metal hose*

test pressure - the pressure used to test an assembly. *also see: pressure, maximum test pressure*

working pressure - the maximum pressure to which a hose will be subjected, including the momentary surges in pressure, which can occur during service. *also see: maximum allowable working pressure, pressure*

Section 3 - Information to be Supplied by Customer

To begin specifying a corrugated metal hose assembly, there is some information that must be gathered regarding the application. To help remember these parameters, they have been arranged to form the acronym ñSTAMPED.ò

[**S**]ize:	Diameter of the fittings to be used on the assembly.
[**T**]emperature:	Minimum and maximum temperatures to which the assembly will be exposed.
[**A**]lloy:	Material of each assembly component. If the materials are not known then both the media (along with their concentrations) that will be conveyed through the assembly as well as to which the assembly may be exposed.
[**M**]otion:	Type of motion (bending, flexing, vibration, etc.) with magnitude and frequency.
[**P**]ressure:	Maximum pressure to which the assembly will be exposed, noting spikes, pulsation, and vacuum.
[**E**]nd Fittings:	Fitting types compatible with the hose and existing piping system.
[**D**]eveloped Length:	Overall length of the assembly. If the overall length is not known than the dimensions of the installation including all movements must be defined.

In addition to the ñSTAMPEDò parameters, there are other factors that should be considered:

- Flow. Very high velocities may require the use of a liner.
- Additional protections (i.e. guards and covers).
- Conformance to other standards.
- Physical space limitations.
- Enhanced cycle life requirements.
- Heat treatment.
- Special requests including hose constructions, attachment methods, fitting orientations, tolerances, testing, cleaning, packaging, or documentation.

Critical 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. The following is a non-inclusive list.

Chlorine

For hose assemblies used to transport chlorine, there are specific requirements set forth in the Chlorine Institute Pamphlet #6 (edition 15), ñPiping Systems for Dry Chlorineò, 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.

Anhydrous Ammonia
Aircraft Fueling
Welding Hose
LP Gas

Section 4 – Materials

4.1 General

Metal hose, as well as the other assembly components, are available in several different materials. When specifying components, proper consideration must be given to selecting materials that are compatible with the application ï specifically, selecting materials that have the appropriate corrosion resistance and can withstand the temperatures to which they will be exposed and provide adequate strength.

4.2 Components

The components typically found in a metal hose assembly are:

A. Corrugated flexible hose
B. One or more layers of wire braid
C. Braid sleeves
D. Fitting(s)
E. Flexible guard and/or liner

Table 4A lists some common materials used for each of these components.

Table 4A – Component Specifications

Component	Type	Description	UNS[(1)]	Specifications
A	1008 AKDQ	Low Carbon Steel	G10080	ASTM A620[(2)]
b,d	SAE1010[(3)]	Carbon Steel	G10100	Commercial Grade
a,b,c,d	T304L	Corrosion Resist. Steel	S30403	ASTM A240/A478
a,b,c,d,e	T304	Corrosion Resist. Steel	S30400	ASTM A240/A269
a,b,c,d	T316L	Corrosion Resist. Steel	S31603	ASTM A240/A478

a,b,c,d,e	T316	Corrosion Resist. Steel	S31600	ASTM A240/A478
a,b,c,d	T316Ti	Corrosion Resist. Steel	S31635	DIN1.4571[(4)]
a,b,c,d	T321	Corrosion Resist. Steel	S32100	ASTM A240/A580
a,b,c,d	Monel 400	Nickel Copper Alloy	NO4400	ASTM B127/B164
a,b,c,d	Inconel 600	Nickel Alloy	NO6600	ASTM B168/B167
a,b,c,d	Inconel 625	Nickel Alloy	NO6625	ASTM B443/B443
a,b,c,d	C276	Nickel Alloy	N10276	ASTM B575/B619/B622
a,b,c,d	C22	Nickel Alloy	NO4400	ASTM B575/B619/B622
a,b	CA510	Bronze, Phosphor	C51000	ASTM B100/B103/B139

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

4.3 Welding and Brazing

Welding and brazing are the most common methods of attaching assembly components. It is the fabricatorõs responsibility to ensure that these processes are performed by qualified personnel following qualified welding/brazing procedures. The qualification, documentation, and acceptance criteria shall meet industry standards (e.g. ASME IX).

Section 5 – Assembly Dimensions

5.1 Inside Diameter of the Hose

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

5.2 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 Table 5A.

Table 5A – Assembly Overall Length Tolerances

		Overall Length of Assembly					
		0òthru <8ò	8òthru <18ò	18òthru <3ô	3ôthru <6ô	6ôthru <12ô	Ó12ô
Ho	< 1ò	+/- 1/4ò	+/- 5/16ò	+/- 3/8ò	+/- 1/2ò	+/- 1ò	+/- 1%

	1ò thru < 4ò	+/- 3/8ò	+/- 1/2ò	+/- 5/8ò	+/- 3/4ò	+/- 1 ¼ò	+/- 1.5%
	4ò thru 12ò	+3% -1.5%	+3% -1.5%	+3% -1.5%	+3% -1.5%	+3% -1.5%	+3% -1.5%

5.3 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 5A). 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 5B). Elbow fittings are measured as illustrated in Figure 5C.

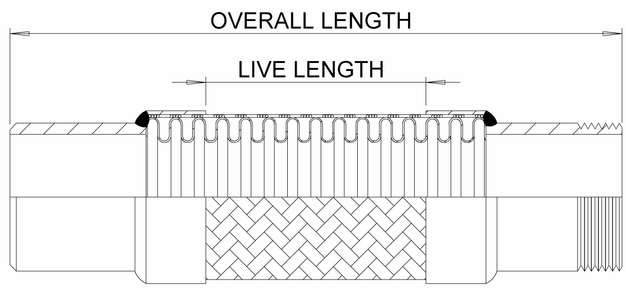


Figure 5A
OAL – End to End

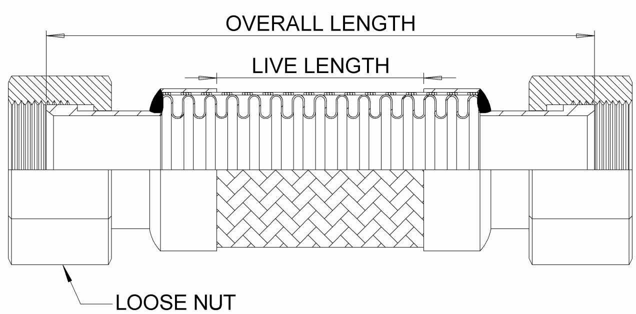


Figure 5B
OAL – Seat to Seat

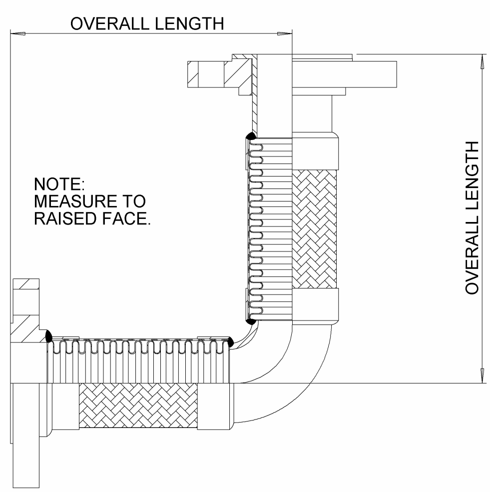


Figure 5C
OAL – Elbowed Assembly

Section 6 – Hose Construction

6.1 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.

6.2 Heat Treatment

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

6.3 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).

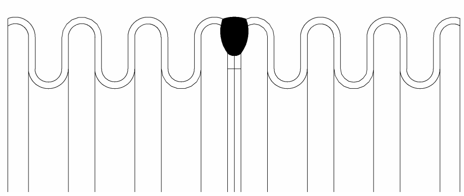


Figure 6A
Butt Weld Splice

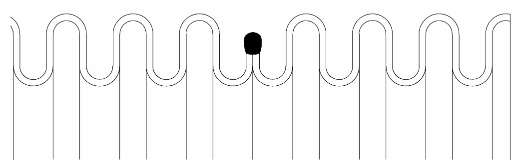


Figure 6B
Edge Weld Splice

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

Section 7 – Braid

7.1 General

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.

7.2 Braid Coverage

Braid Coverage (V) is the percentage of the outside diameter of the corrugated hose that is covered by the braid.

Capacity (P) is the percentage of the outside diameter of the corrugated hose that is covered by only the braid from carriers traveling in the same direction (i.e. one half of the total number of carriers).

The variables that define a particular braid construction are as follows and illustrated in Figure 7A:

C = Number of carriers
W = Number of wires in each carrier
D = Wire diameter (inches)
A = Braid angle (in degrees)
O = Outside diameter of the unbraided corrugated hose (inches) which is the same as the inside diameter of the braid (inches)

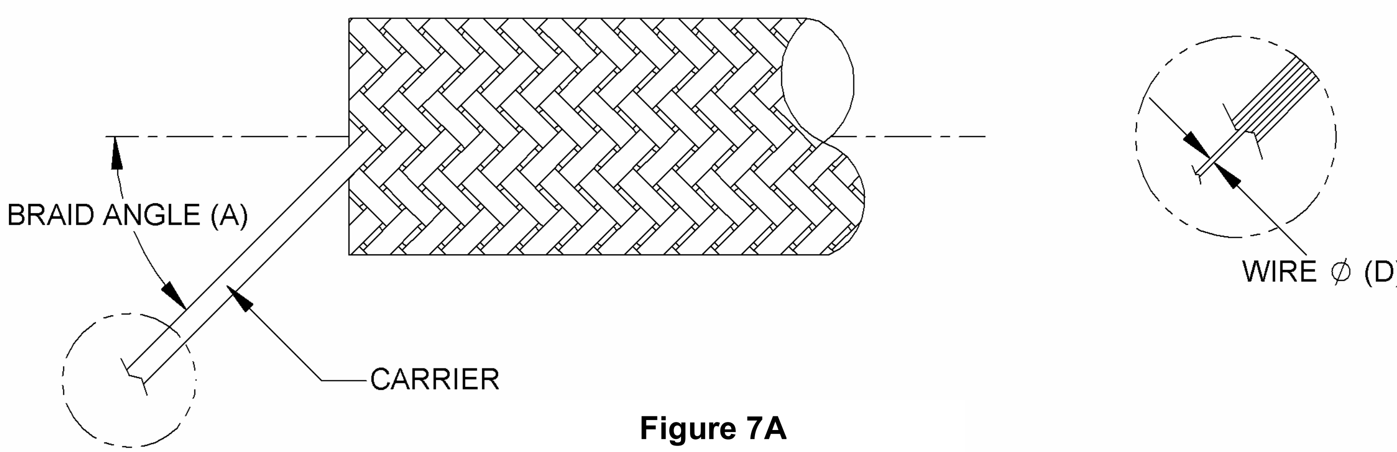


Figure 7A
Braid Construction

Braid Coverage (V) = 1 ï (1 ï P)^2

Where:

P = (C x W x D) / (2 x cos(A) x (O + 2D))´

For example, assume:

C = 48
W = 11
D = 0.016ò
A = 45^o
O = 2.60ò

Then:

P = (C x W x D) / (2 x cos(A) x (O + 2D))´
P = (48 x 11 x 0.016) / (2 x cos(45^o) x (2.60 x 2 x 0.016))´
P = 1.722 = 72.2%
V = 1 ï (1 ï P)^2
V = 1 ï (1 ï 0.722)^2
V = 0.923 = 92.3%

7.3 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.

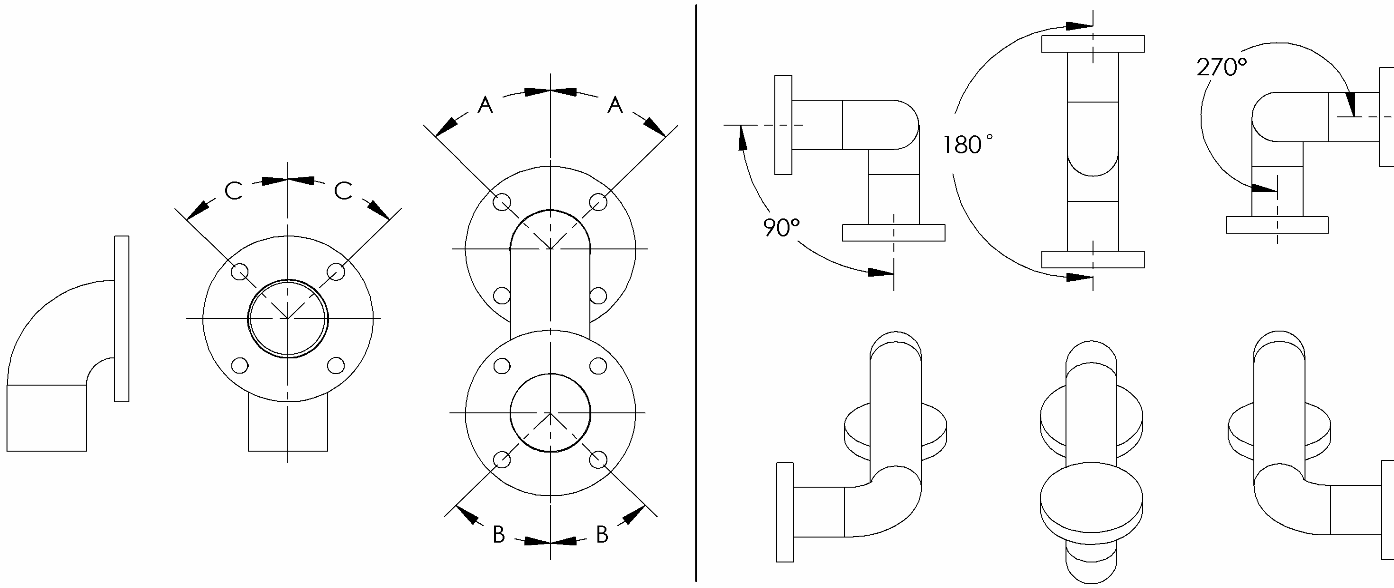
Section 8 – Common Fittings and Accessories

8.1 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 the Appendix). Whenever possible, it is advisable to use a swivel, floating, or axially disconnectable fitting on at least one end of the hose assembly to avoid torsion during installation.

8.2 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:



Bolt Hole Alignment

Angular Fitting Orientation

Figure 8A
Standard Fitting Orientations

8.3 Illustrations of Common Fittings

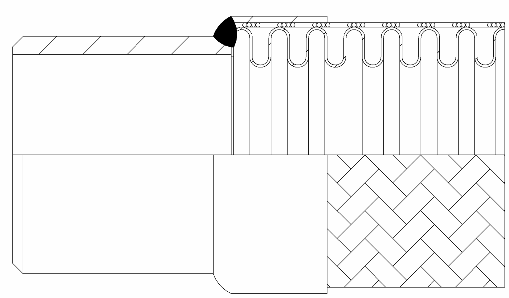


Figure 8B – Weld Nipple

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

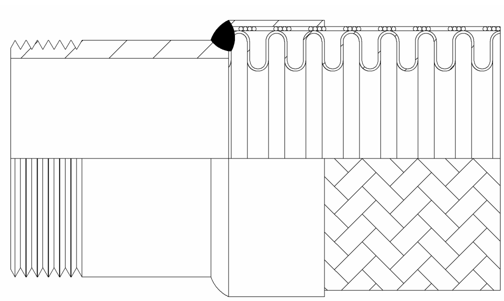


Figure 8C – Pipe Nipple

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

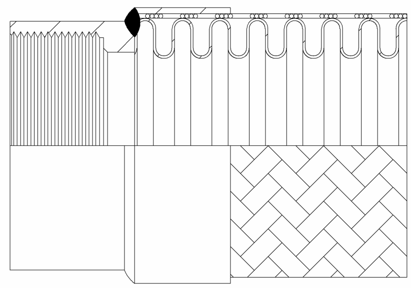


Figure 8D – Female Pipe Coupling
Common Sizes: 1/4ò through 4ò
Common Materials: Carbon Steel, T304SS, T316SS
Common Classes: 150#, 3000#

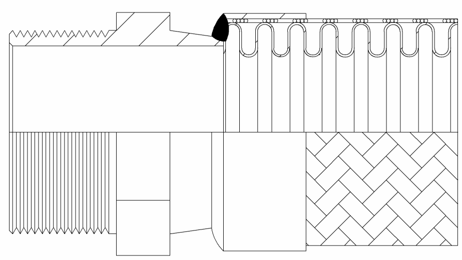


Figure 8E – Hex Male Nipple
Common Sizes: 1/4ò through 2ò
Common Materials: Carbon Steel, T304SS, T316SS

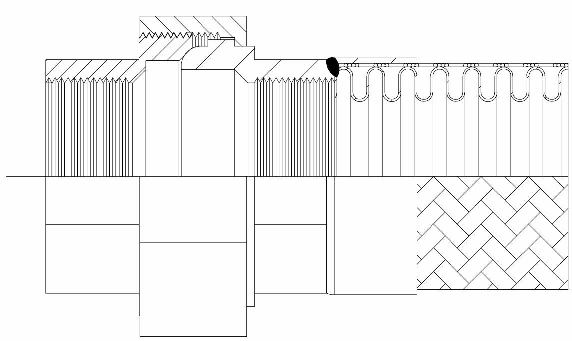


Figure 8F – Female Union
Common Sizes: 1/4ò through 4ò
Common Materials: Malleable Iron, Carbon Steel, T304SS, T316SS
Common Classes: 150#, 3000#

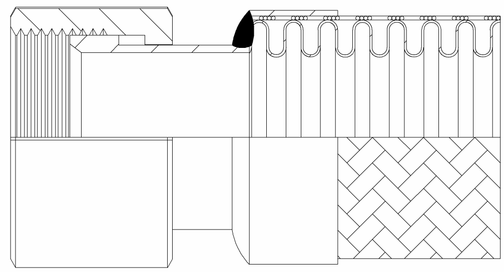


Figure 8G – Female JIC
Common Sizes: 1/4òthrough 2ò
Common Materials: Carbon Steel, T316SS

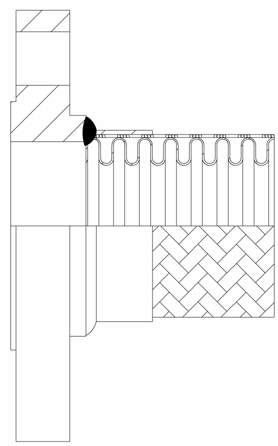


Figure 8H – Raised Face, Slip On Flange
Common Sizes: 1/2òthrough 12ò
Common Materials: Carbon Steel, T304SS, T316SS
Common Classes: 150#, 300#

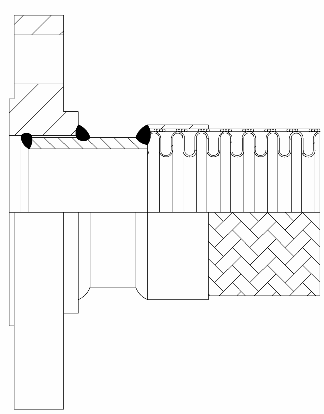


Figure 8I – Raised Face, Slip On Flange (with Pipe Spacer)
Common Sizes: 1/2òthrough 12ò
Common Materials: Carbon Steel, T304SS, T316SS
Common Classes: 150#, 300#

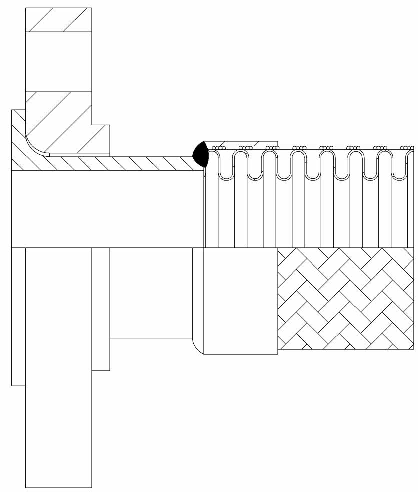


Figure 8J – Type A-Stub End with Lap Joint Flange

Common Sizes: 1/2ò through 12ò
Common Materials - Stub: T304SS, T316SS
Common Materials ï Flange: Carbon Steel, T304SS, T316SS
Common Schedule ï Stub: 10, 40
Common Classes - Flange: 150#, 300#

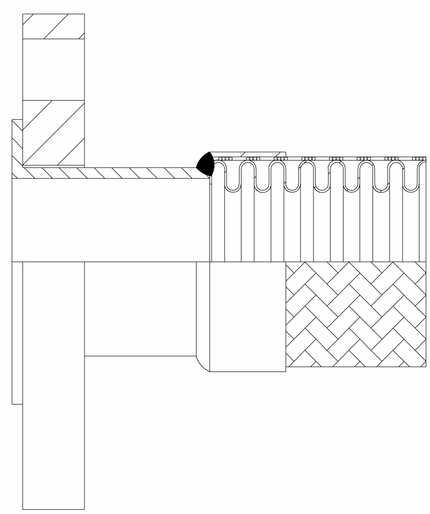


Figure 8K – Type C-Stub End with Slip On or Plate Flange

Common Sizes: 1/2ò through 12ò
Common Materials - Stub: T304SS, T316SS
Common Materials ï Flange: Carbon Steel, T304SS, T316SS
Common Schedule ï Stub: 10
Common Classes - Flange: 150#, 300#

8.4 Common Accessories

8.4.1 Guard

Assemblies can be furnished with an interlocked metal hose covering some or all of the outside of the corrugated hose. This guard helps to protect the assembly from damage and over-bending, and can be made from a variety of materials (*see* Figure 8L).

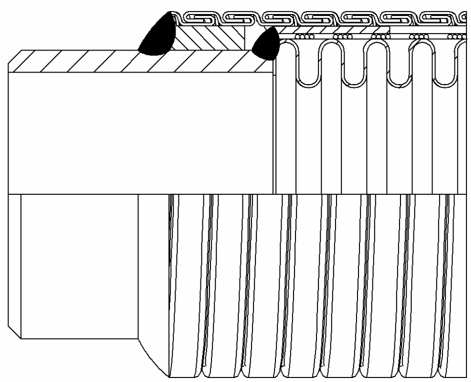


Figure 8L
Guarded Assembly

8.4.2 Liner

Assemblies can be furnished with an interlocked metal hose installed inside the corrugated hose. This liner reduces turbulence when high product velocity is a concern (*see* Figure 8M).

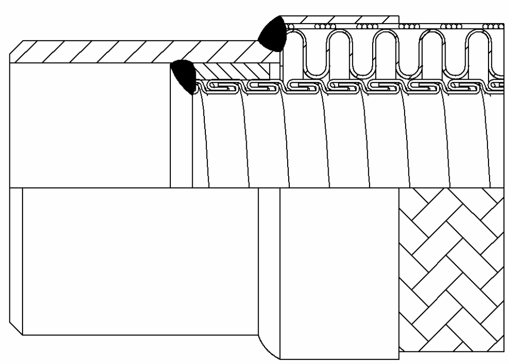


Figure 8M
Lined Assembly

Section 9 – Attachment Methods and Components

9.1 Attachment Methods

Fittings are usually 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 applicationõs requirements and to maximize the live length of the hose assembly.

9.1.1 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 ñCap Weldò (*see* Figure 9A). The fitting is then welded onto the Cap Weld. This step is referred to as the ñAttachment Weldò (*see* Figure 9B).

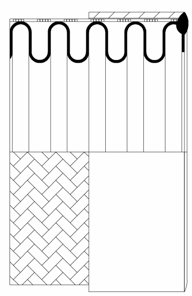


Figure 9A
Cap Weld

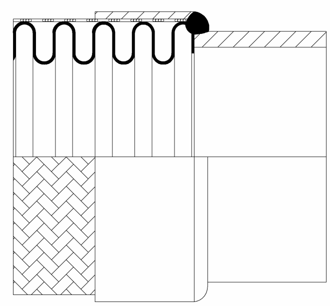


Figure 9B
Attachment Weld

9.1.2 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 (*see* Figure 9C). The braid is then pulled over that attachment joint and the braid and braid sleeve are welded directly onto the fitting (*see* Figure 9D).

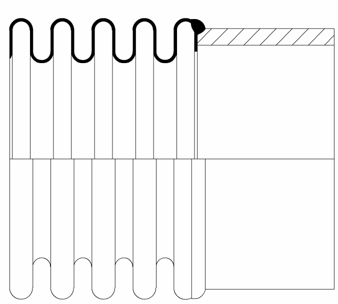


Figure 9C
Hose to Fitting Weld

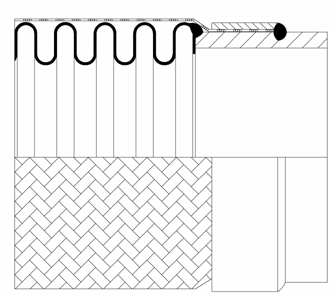


Figure 9D
Braid Attachment Weld

9.1.3 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 9E, 9F, and 9G) or with a braid-over attachment (See Figures 9H and 9I). With either method, care should be taken when attaching the fitting to the hose to avoid creating cavities (see Figure 9J).

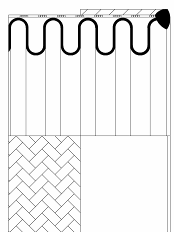


Figure 9E
ST - Cap Weld

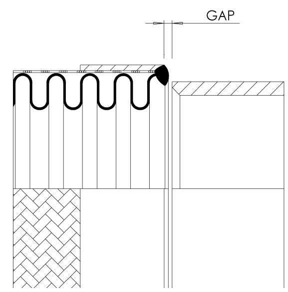


Figure 9F
ST - Fitting Spacing

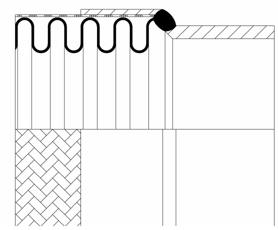


Figure 9G
ST - Attachment Weld

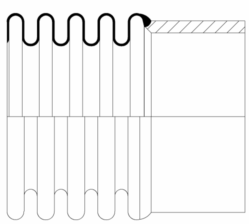


Figure 9H
ST - Hose to Fitting Weld

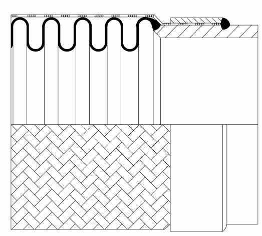


Figure 9I
ST - Braid Attachment Weld

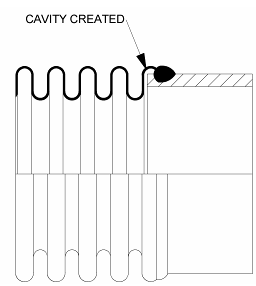


Figure 9J
Incorrect Fit-Up

9.2 Attachment Components

9.2.1 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 3/8ò long and are not required to be longer than 1ò.

9.2.2 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 hoseõs outside diameter.

Section 10 – Production Testing

10.1 General

Every corrugated metal hose must be visually inspected and leak tested.

10.2 Visual Inspection

Every assembly must be visually inspected to verify that:

- The assembly length and construction are as requested by the customer;
- All components are properly aligned;
- There are no obvious signs of defects; and
- The assembly is clean and cosmetically acceptable.

10.3 Leak Testing

10.3.1 Pneumatic Test

Unless otherwise specified, the hose assembly shall be subjected to a pneumatic test at a value defined in Table 10A. 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 10A – Minimum Pneumatic Test Pressures

Unbraided Assemblies	
Nominal I.D.	Pressure
1/4òthrough <3/4ò	25 psig
3/4òthrough <1-1/4ò	10 psig
1-1/4òthrough <4ò	5 psig
4òthrough 6ò	3 psig
>6ò	2 psig
Braided Assemblies	
Nominal I.D.	Pressure
1/4òthrough 4ò	75 psig
>4òthrough 6ò	50 psig
>6ò	15 psig

10.3.2 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.

10.3.3 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 1×10^{-3} std/cc/sec. Helium mass spectrometer testing to smaller leak rates may be available – consult the assembly fabricator.

10.4 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 11 – Marking, Cleaning, and Packaging

11.1 Marking

Permanent marking on a metal hose assembly is commonly achieved in two ways:

A. Pre-stamping the information in legible characters on a metal tag or band and affixing the tag/band to the assembly by a durable method; or
B. Stamping or etching the information in legible characters directly onto the braid sleeve or fitting.

11.2 Cleaning

Each assembly shall be supplied to the customer free of water and debris. Air may be blown through the assembly to remove loose particles. Some applications have more stringent levels of cleanliness that may require special cleaning procedures. Consult provider for other cleaning options.

11.3 Packaging

Hose assemblies shall be packaged in such a manner to prevent damage during shipping and handling. The assembly should be packed while it is clean and dry in a way to prevent internal contamination. The assembly should not be coiled tighter than its specified dynamic minimum bend radius. All containers, boxes, banding, and pallets shall be of sufficient size and strength to withstand the abuses of normal handling and transit.

Section 12 – Documentation

12.1 General

Customers may require documentation stating that the hose assembly meets specific criteria. There are several common types of documentation outlined below. In addition to the specific requirements, each document should contain the following information:

- Customer's name, address, and Purchase Order number
- Supplier's name and address
- Complete description of the hose assembly including type of hose, I.D., length, fittings and accessories
- Date
- Supplier's authorized signature

12.2 Certificate of Conformance (C of C)

A C of C is a statement by the supplier that the hose assembly(ies) or its fabrication method conforms to specific standards or documents. In addition to the information listed in 12.1, a C of C should also:

- Identify the standard or document to which the C of C is being supplied; and
- Contain a statement by the supplier that the assembly(ies) conforms to the specified standard or document.

12.3 Test Report

A Test Report is issued at a customer's request to document that the assembly(ies) has passed a specific test. In addition to the information listed in 12.1, a Test Report should also:

- Identify the test to which the assembly(ies) was tested giving a detailed explanation of the test and testing procedure; and
- Contain a statement by the supplier that the assembly(ies) has been tested and pass the test.

12.4 Material Test Report (MTR)

A Material Test Report shows that the materials for which the report was requested meet the customer’s specifications. Typically, MTRs are copies of the raw material MTRs that were supplied to the assembly provider by their raw materials vendor along with the information listed in 12.1.

12.5 Positive Material Identification

For Positive Material Identification, the provider validates the material by performing a non-destructive test using an X-Ray Fluorescence alloy analyzer and provides the results to the customer. In addition to the information listed in 12.1, a Positive Material Identification report should also contain a statement by the supplier that the material has been tested and meets the customer’s specification.

12.6 Third Party Certification

When required by the customer, an independent third party shall inspect and/or test the assembly(ies) and certify that it conforms to the customer’s specifications. In addition to the information listed in 12.1, a Third Party Certification should also:

- Identify the standard or document to which the certification is being supplied; and
- Contain a statement by the third party that the assembly(ies) conforms to the specified standard or document.

Section 13 – Safety Issues, Inspections, and Installation and Handling

13.1 General

There are several factors to consider when using metal hose assemblies. The most crucial is safety, as the assemblies are often used in applications that can pose significant risk to people and property in the event of a failure. Another important factor is the manner in which the assembly is installed since installation procedures have a significant effect on the performance and service life of the assembly. This section will address these issues and give practical advice on ways to maximize the performance and service life of the assembly, while minimizing the risk of injury and property damage. Employees who work with or around these assemblies should be adequately trained about the potential risks as well as proper installation, handling, and maintenance procedures.

13.2 Safety Issues

Below are listed some of the potential safety risks that can lead to injury or property damage. This is not a complete list of all possible safety concerns. All users of hose assemblies must evaluate their particular hose applications, assess the potential risks, and take preventative steps to address these risks.

13.2.1 Fluid/Gas Injections

Fine streams of fluid or gas can penetrate skin and enter the body. These wounds may cause severe damage. Consider the use of guards and shields to reduce the risk of these injections.

13.2.2 Fire and Explosions from Conveyed Media

Many of the media conveyed through hose assemblies are flammable. Media that escapes from the assembly can explode upon contact with a source of ignition (e.g. open flames, sparks, and hot manifolds). These explosions can be very severe, causing injury, death, or serious property damage. Care should be taken to eliminate all possible ignition sources from contact with escaping media. Select and route hose assemblies in a way that minimizes the risk of combustion.

13.2.3 Burns from Conveyed Fluids

Media conveyed may reach temperatures or may be of a chemical composition that can cause burns. If there is a risk of burns, consider guards or shields to prevent exposure to escaping media.

13.2.4 Fluid Controlled Mechanisms

Mechanisms controlled by fluids in hose assemblies can become hazardous if the assembly fails. For example, if a hose assembly fails, objects supported by the fluid pressure within the hose assembly will no longer be supported and may fall.

13.2.5 Whipping Hose

If a pressurized hose assembly is disconnected or comes apart, it can flail or whip with great force, throwing fittings at high speeds. This risk is particularly great in compressed gas systems. If the risk of hose whipping exists, consider the use of guards, whip checks, or other restraints.

13.2.6 Burns from Contact with the Hose

Metal hose assemblies conduct heat. Care should be taken to avoid contact with the hose assembly since the temperature of the hose assembly may be similar to that of the media being conveyed. The use of sleeves should be considered if contact with the hose assembly is possible.

13.2.7 Electrical Shock

Metal hose assemblies are electrically conductive. Always use proper grounding to minimize the risk of electrical discharge and electrocution.

13.3 Inspections

13.3.1 Pre-installation Inspection

Before installing the hose assembly check for:

13.3.1.1 Damage

The assembly should be inspected for the following damage:

- Deformed or twisted braid
- Braid is excessively loose on the hose
- Broken or unattached braid wires
- Kinks or sharp bends in the hose, particularly behind the fittings
- Damaged fitting threads
- Nicked or out-of-round sealing surfaces
- Damaged flange gasket surfaces
- Incorrect fitting alignment, particularly flanged or elbow fittings
- Improper fitting orientation
- Swivels or loose nuts not rotating freely

13.3.1.2 Dimensions

Verify the following dimensions:

- Assembly OAL
- Fitting size

13.3.1.3 Correct Components

Verify that the hose assembly's components are as specified:

- Fitting type
- Required guard, covers, liners

- Required tagging

13.3.1.4 Other checks:

- No solid debris in fittings or hose (e.g. dirt, metal shavings)
- No fluid contamination in hose (e.g. water, grease, oil)

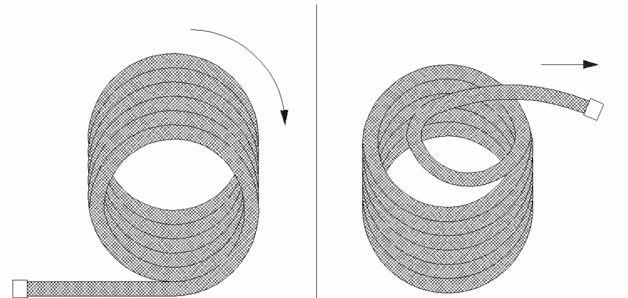
13.3.2 Preventative Maintenance Inspections

After the hose assembly has been installed, it should be periodically inspected. The frequency of the inspection is based upon the nature and severity of the application, past history, and any manufacturer's recommendations. If an appropriate inspection schedule has not been established, the assembly should be inspected daily. When conducting an inspection, look for the following:

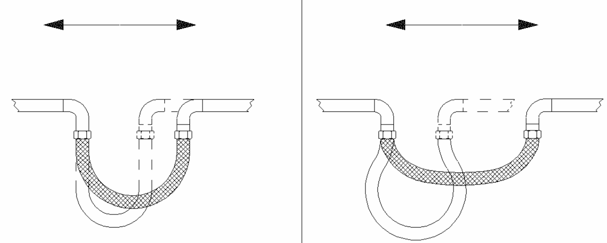
- Loose, broken, bulged, frayed, or worn braid
- Deformation of the hose, including twisting
- Traces of media on or around the assembly
- Loose or damaged guard or covers
- Indications of corrosion on hose assembly
- Loose fitting attachments
- Hose assembly rubbing or making contact with adjacent machinery or piping
- Fluids or solids accumulating on the assembly

13.4 Installation and Handling

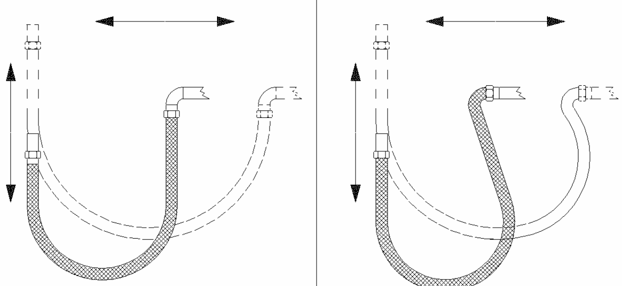
Right	Wrong	Right	Wrong



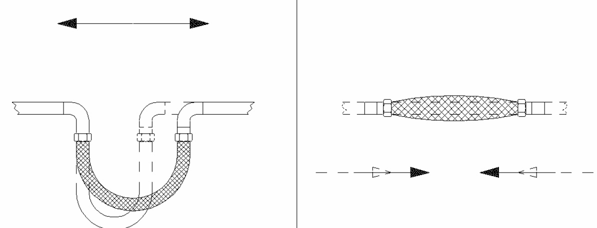
Do Not Kink Hose



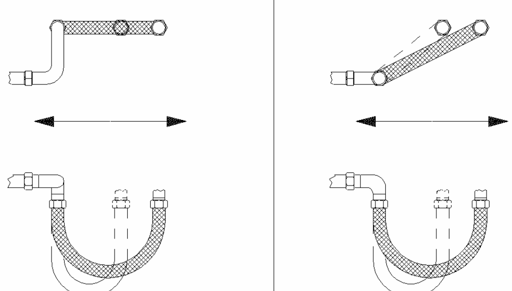
Use the Correct Length



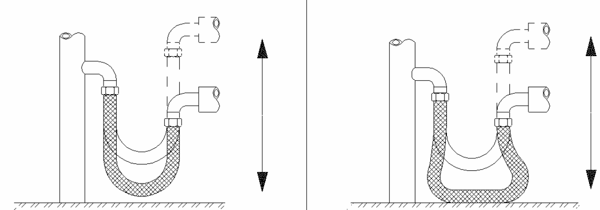
Adjust Piping to Avoid Kinking



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

APPENDIX

i. Test to Establish Maximum Allowable Working Pressure (MAWP)

A straight hose assembly having a live length equal to ten (10) times its nominal diameter, but not less than twenty (20) inches, shall be subjected to gradually increasing hydrostatic pressure. During the test, increases in volume and live length shall be recorded for each increase in pressure. The following criteria must be satisfied:

a) At one and a half (1.5) times the MAWP the increase in live length must be less then three percent (3%);
b) The pressure at which there is a marked permanent increase in internal volume without a corresponding increase in length (deformation pressure) must be greater than one and a half (1.5) times the MAWP; and
c) The pressure at which the assembly ruptures (burst pressure) must be greater than or equal to four (4) times the MAWP.

ii. 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 manufacturerõs 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 formerõs circumference (*see* Figure A1).

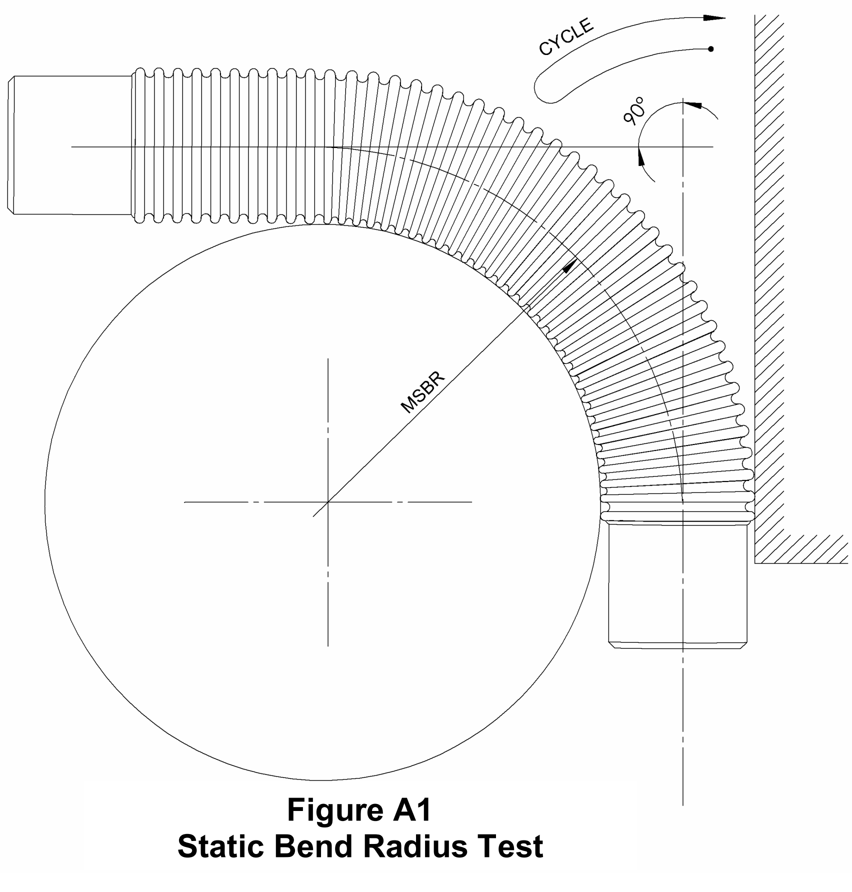


Figure A1
Static Bend Radius Test

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 10.3.1.

iii. 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 4ò shall be tested with the U-Bend Test. Hoses greater than 4ò shall be tested with the Cantilever Test.

a) U-Bend Test

The assembly shall be installed in a vertical loop as illustrated in Figure A2.

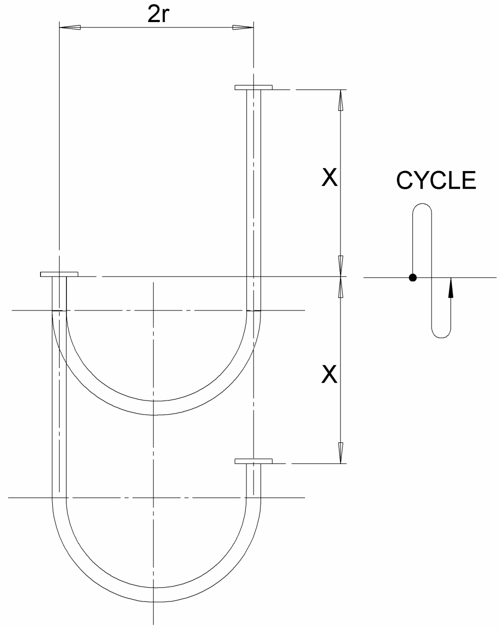


Figure A2
Dynamic Bend Radius “U” Test

r = MDBR
x = 4 times the nominal hose diameter, or 5ò whichever is greater
Hose Live Length = (4 x MDBR) + x
Cycle Rate = 3 to 30 cycles per minute
One Cycle equals the movement from the starting point up a distance of ñxò, then down a distance of ñxò past the starting point, and then back up to the starting point.

b) Cantilever Test

The assembly shall be installed in a straight configuration as illustrated in Figure A3.

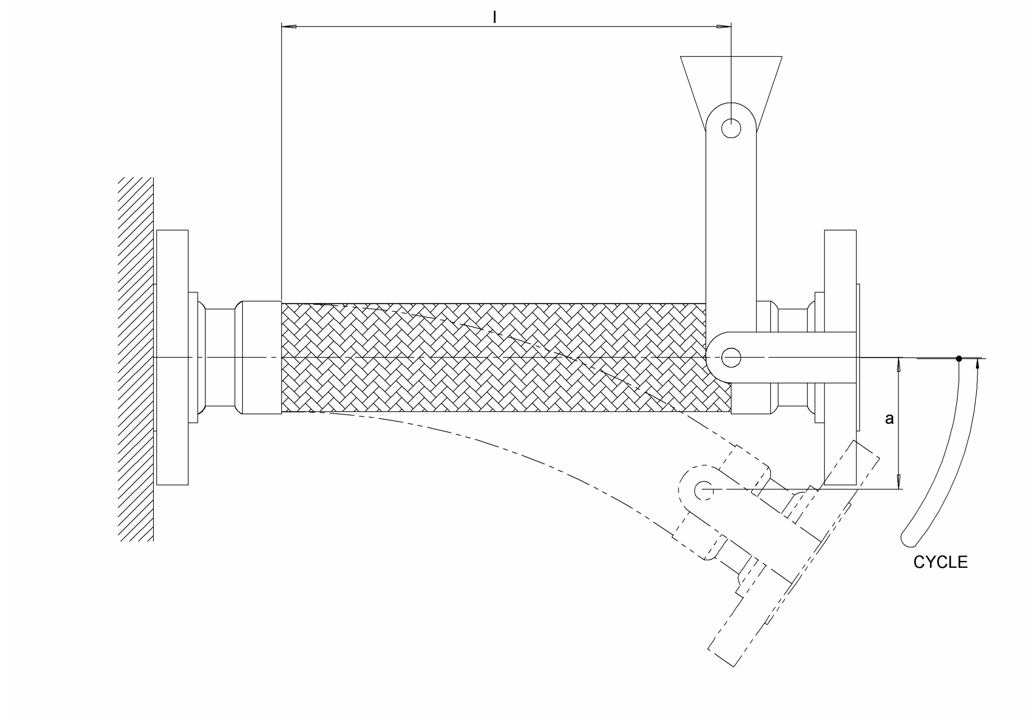


Figure A3
Dynamic Bend Radius Cantilever Test

l = 6 x Nominal Hose Diameter

a = R ï R x cos(57.3^{o} x (2 x D + 4ö) ÷ R)

Where: R = Minimum dynamic bend radius (inches)

D = Nominal hose diameter (inches)

Cycle Rate = 3 to 15 cycles per minute

One Cycle equals the movement starting from the horizontal position, then deflecting down a distance of ñaò, and then the return to the starting point.

iv. Temperature Derating

The strength of a component is reduced at elevated temperatures. Unless already defined by the component supplier or relevant standard, use the derating factors listed in Table A1. Multiply the maximum allowable working pressure (at 70^0 F) by the appropriate derating factor for the application temperature and component material.

Table A1 – Temperature Derating Factors

	MATERIAL									
Temp °F	**T304**	**T304L**	**T316**	**T316L**	**T321**	**C276**	**Monel 400 & C22**	**Inconel 600**	**Inconel 625**	**Carbon Steel***
100	1.0	1.0	1.0	1.0	1.0	1.00	1.0	1.0	1.0	1.00
200	1.0	1.0	1.0	1.0	1.0	1.00	.88	1.0	1.0	1.00
300	1.0	1.0	1.0	1.0	1.0	1.00	.82	1.0	1.0	1.00
400	.94	.93	.97	.93	1.0	1.00	.79	1.0	1.0	1.00
500	.88	.86	.90	.86	.96	.99	.79	1.0	.97	.95
600	.82	.81	.85	.81	.91	.93	.79	1.0	.95	.87
650	.81	.79	.84	.79	.89	.90	.79	1.0	.94	.85
700	.80	.77	.82	.77	.87	.88	.79	1.0	.93	.83
750	.78	.75	.81	.75	.86	.86	.79	1.0	.93	.65
800	.76	.74	.80	.74	.84	.84	.79	1.0	.93	.54
850	.75	.72	.79	.72	.84	.83	.79	.99	.93	.44
900	.73	.71	.78	.71	.83	.82	.76	.95	.93	.33
950	.72	.69	.77	.69	.81	.81	.71	.95	.93	.23
1000	.69	.67	.77	.67	.81	.80	.48	.42	.93	
1050	.61	.65	.73	.65	.70	.68		.27	.93	
1100	.49	.61	.62	.61	.55	.55		.20	.69	
1150	.39	.53	.49	.52	.41	.47			.57	
1200	.30	.38	.37	.38	.32	.36			.36	
1250	.24	.28	.28	.28	.25	.29				
1300		.21	.21	.21						

* Do not use for temperatures lower than 32^0 F

v. 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

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

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
Phone: (610) 832-9585
Fax: (610) 832-9555
E-mail: service@astm.org
Internet: http://www.astm.org

Document Center, Inc.
111 Industrial Road, Suite 9
Belmont, CA 94002
Phone: (650) 591-7600
Fax: (650) 591-7617
E-mail: mailto:info@document-center.com
Internet: http://www.document-center.com/

Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112
Phone: (800) 854-7179; (303) 397-7956
Fax: (303) 397-2740
Email: global@ihs.com
Internet: http://www.ihs.com

Government Printing Office
732 North Capitol St. NW
Washington, DC 20401
Phone: (202) 512-0000
Email: webteam@gpo.gov
Internet: http://www.gpo.gov

ISO
International Organization for Standardization (ISO)
1, rue de Varembé, Case postale 56
CH-1211 Geneva 20, Switzerland
Phone: +41 22 749 01 11
Fax: +41 22 733 34 30
Internet: http://www.iso.org

NAHAD
The Association for Hose and Accessories Distribution
105 Eastern Ave. Suite 104
Annapolis, MD 21403-3300
Phone: (410) 263-1014
Fax: (410) 263-1659
E-mail: nahad@nahad.org
Internet: http://www.nahad.org

RMA
Rubber Manufacturers Association c/o The Mail Room
P.O. Box 3147
Medina, OH 44258-3147
Phone: (800) 325-5095; (330) 723-2978
Fax: (330) 725-0576
E-mail: info@rma.org
Internet: http://www.rma.org

SAE
Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096-0001
Phone: (877) 606-7323;
Fax: (724) 776-0790
Email: customerservice@sae.org
Internet: http://www.sae.org

UL
Underwriters Laboratory
333 Pfingsten Road
Northbrook, IL 60062-2096 USA
Telephone: (847) 272-8800
Fax: (847) 272-8129

NOTES: