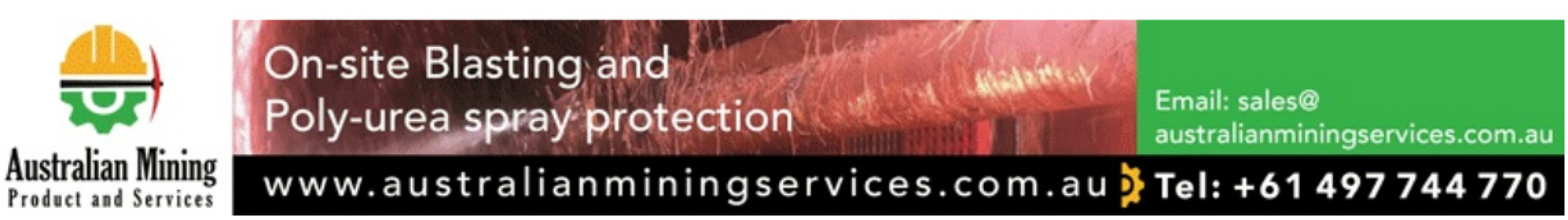
Australian Mining
Product and Services
It's What We Do!

AMPSflo

AUSTRALIAN OWNED #02107 CERTIFIED

Material Handling slurry hoses

Rubber or ceramic lined



If you offer solutions —they are just that— another solution

We offer end-users a range of options to empower them with sufficient and relevant information to assist in the selection of a product and it's design.

This selection allows for a measurable result that can be used to aid continuous improvement and a reduction in maintenance costs

We make the process simple

"It's what we do"

Every product is designed to improve plant production and reliability, ensure safety and facilitate a reduction in unscheduled maintenance stoppages

Operational areas that we service

- Mineral ore extraction e.g. chalcopyrite, rare metals, coal, iron ore, gold, lithium
- Quarrying
- Mineral ore beneficiation and processing plants – water/slurry lines and process equipment
- Oil & Gas supply lines and process equipment
- Water and Waste: supply & transfer lines, potable, slurry
- Power generation: cooling water, ash transfer, and process lines
- Pulp and Paper: supply & transfer lines
- Sugar Mills: supply & transfer lines; process industries
- Ore transfer: rail, road and sea material handling plant and equipment

Material Handling Slurry Mine hose

Suction and delivery flanged to suit—Table E. D , ANSI—Victaulic, plian ends to suit split muff coupling

Safety generally 4:1 as our standard hoses are a suction and delivery rated at a working pressure of 740 Kpa

Material lining Our standard hoses come with a 6 to 8 mm inner lining

Lining are generally tailored to the application but a high quality—wear, and abrasion resistant natural rubber is the industry standard ‘

Absorbs system vibration and saves wear on equipment. Compensates f or thermal expansion and contraction, reduces noise.

Flexible connection for hard piping misalignment. In mining and other highly abrasive applications, slurry hoses have internal linings to mitigate abrasive wear on the hose. Additionally, the main pipelines used in high abrasive pumping operations are also usually lined with rubber or other material to reduce wear.

Mining Slurry Hose Construction:

Inner wear Tube: is an NR/SBR rubber compound.

Other linings are Butyl, etc to suit the application

Reinforcement: Multi ply mild steel , stainless steel or Nylon wire helix.

Cover: wear and UV resistant EPDM , Natural or Styrene butadiene rubber

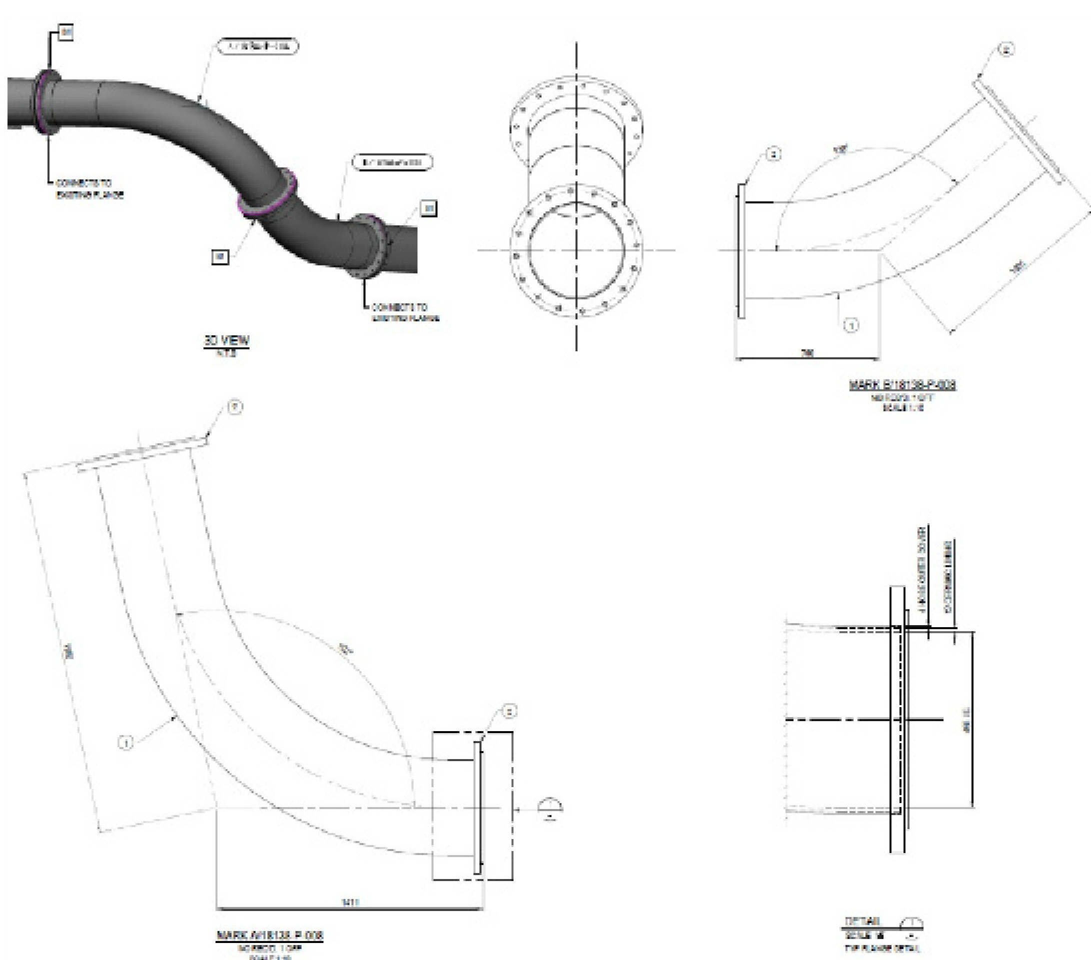
Mining Slurry Hose Application:

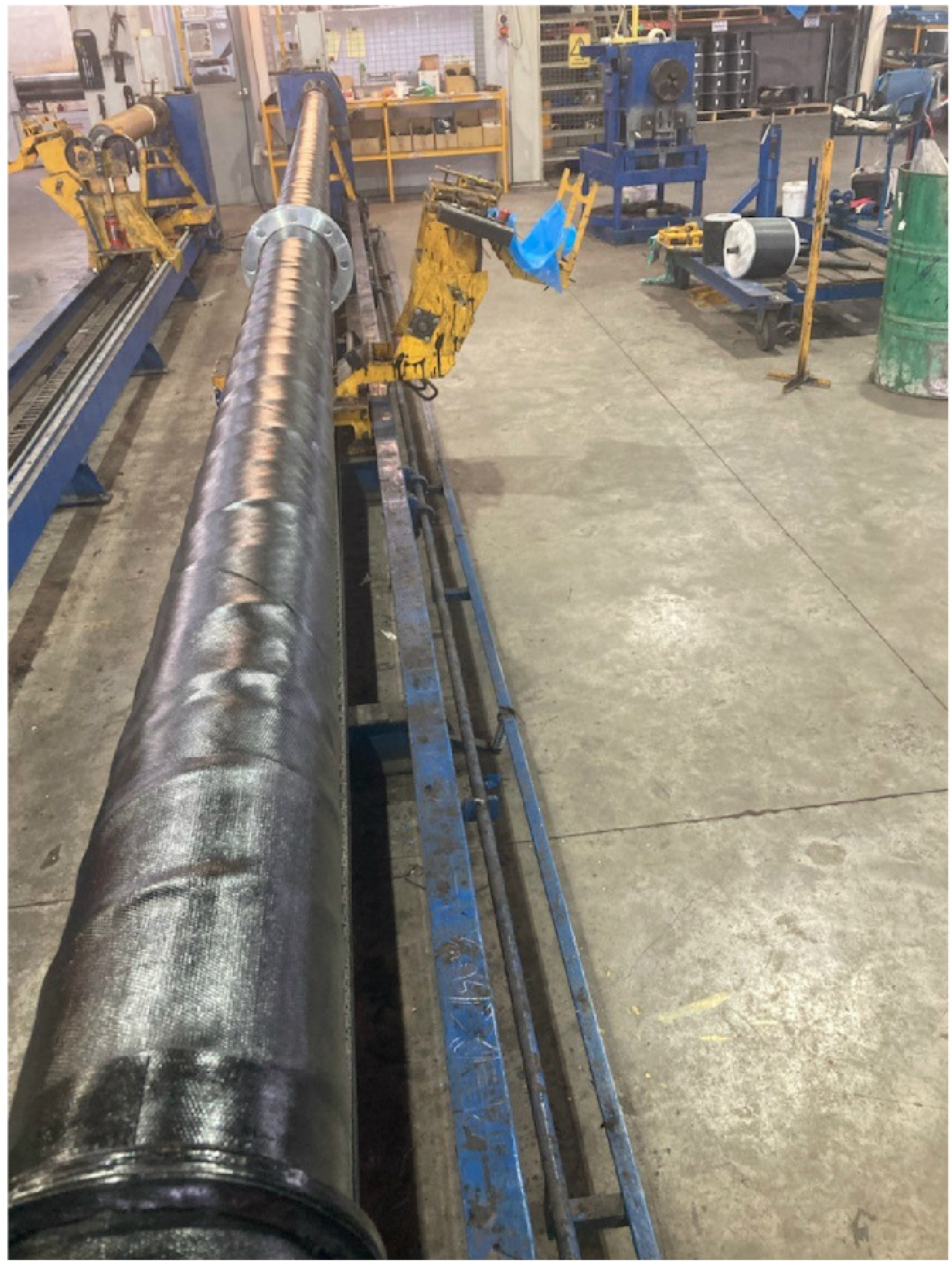
Slurry hoses are designed primarily for handling abrasive and viscous slurries from mine and quarries. They can also be used for handling dry materials such as sand, gravel and grains. The external bolt on the flanges allow for easy installation and uninterrupted free flow.

Mining Slurry Hose Temperature:

-40 degrees C to 70 Degrees C in most cases


Slurry Hose www.australianminingservices.com.au






AUSTIN

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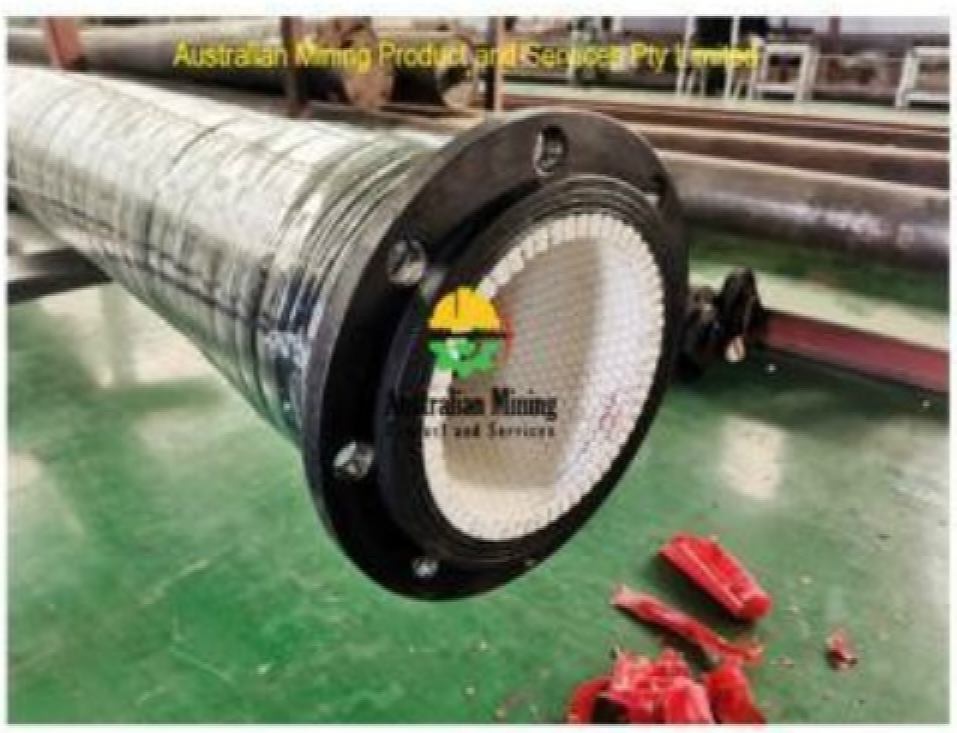
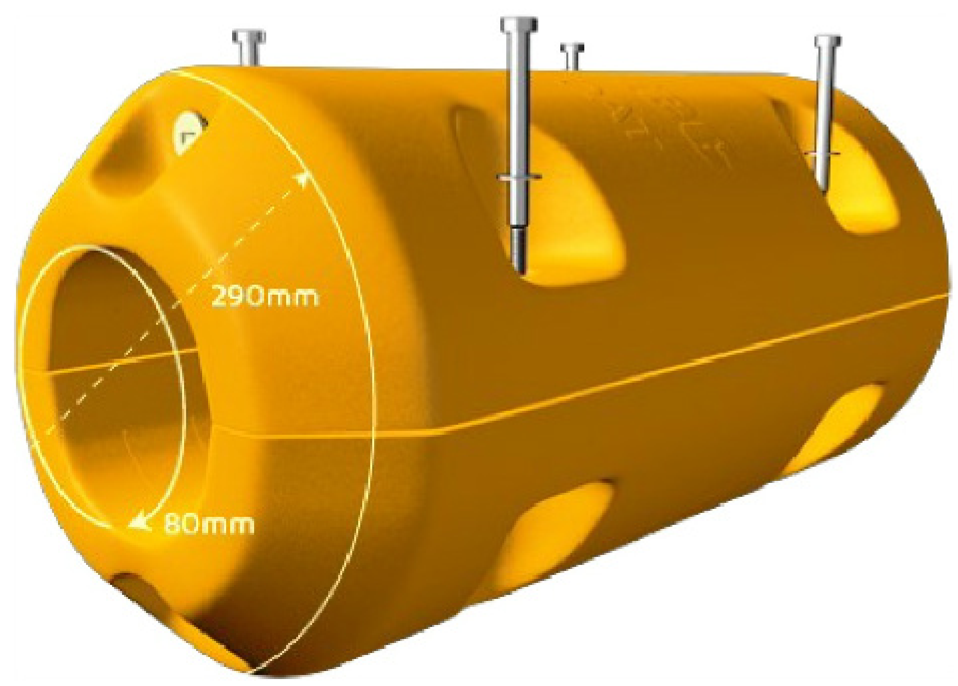
Ceramic Lined Hoses—straights and bends

Custom designed to suit from 38 mm and to 60 meters long



Material Handling Slurry and floating hoses and accessories with rubber or ceramic inner lining



Ceramic rubber   lined material handling slurry suction and delivery hoses

Our technology started in 2016 not only has excellent abrasion resistance, but also now can add great flexibility where required. Our ceramic rubber mine hose has vulcanized wear resistant ceramic tiles impregnated by vulcanisation onto a abrasion and wear resistant rubber.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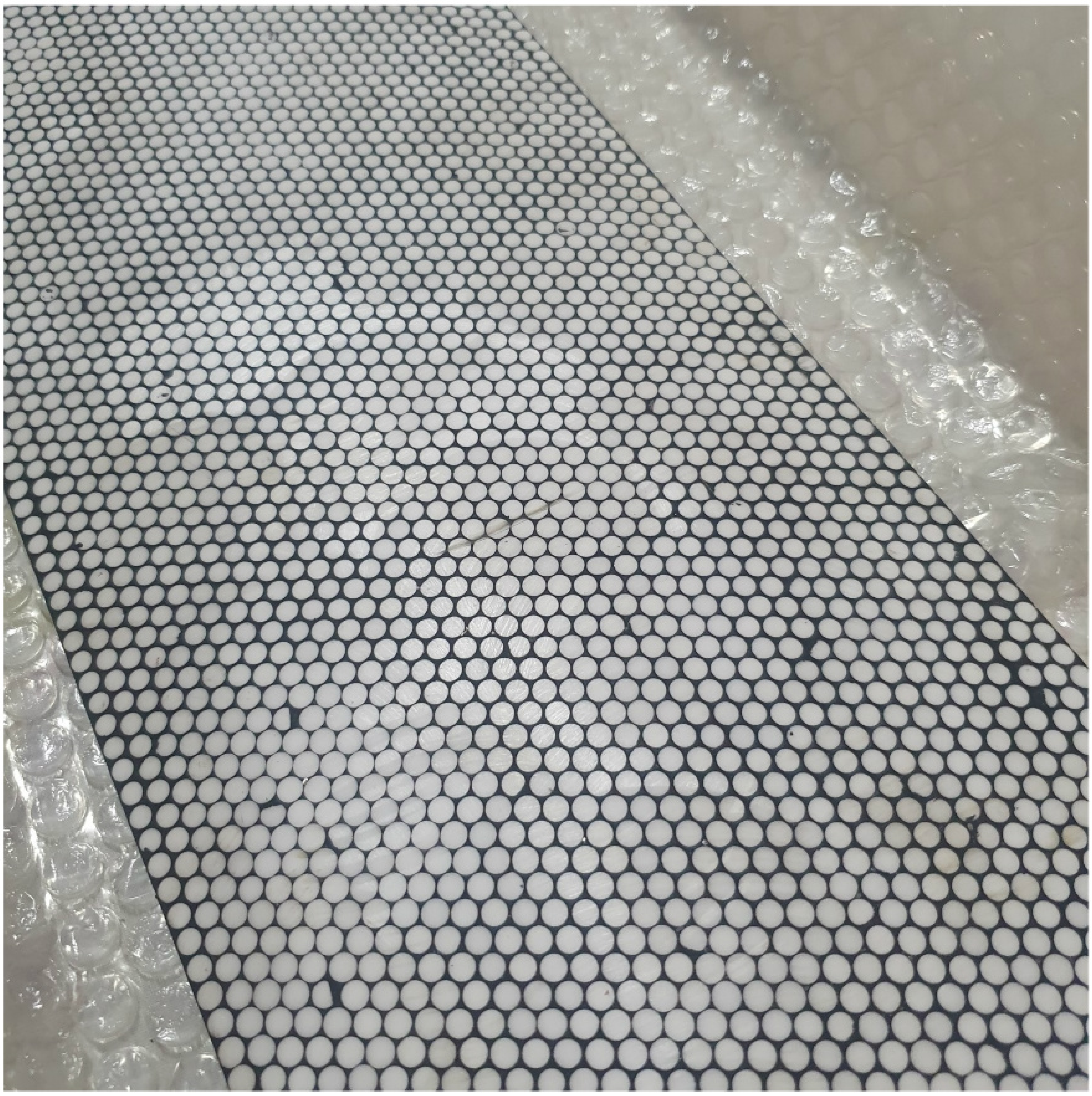
New ceramic lined hoses inner liners replace rubber lined hoses with a light wall ceramic lining using buttons



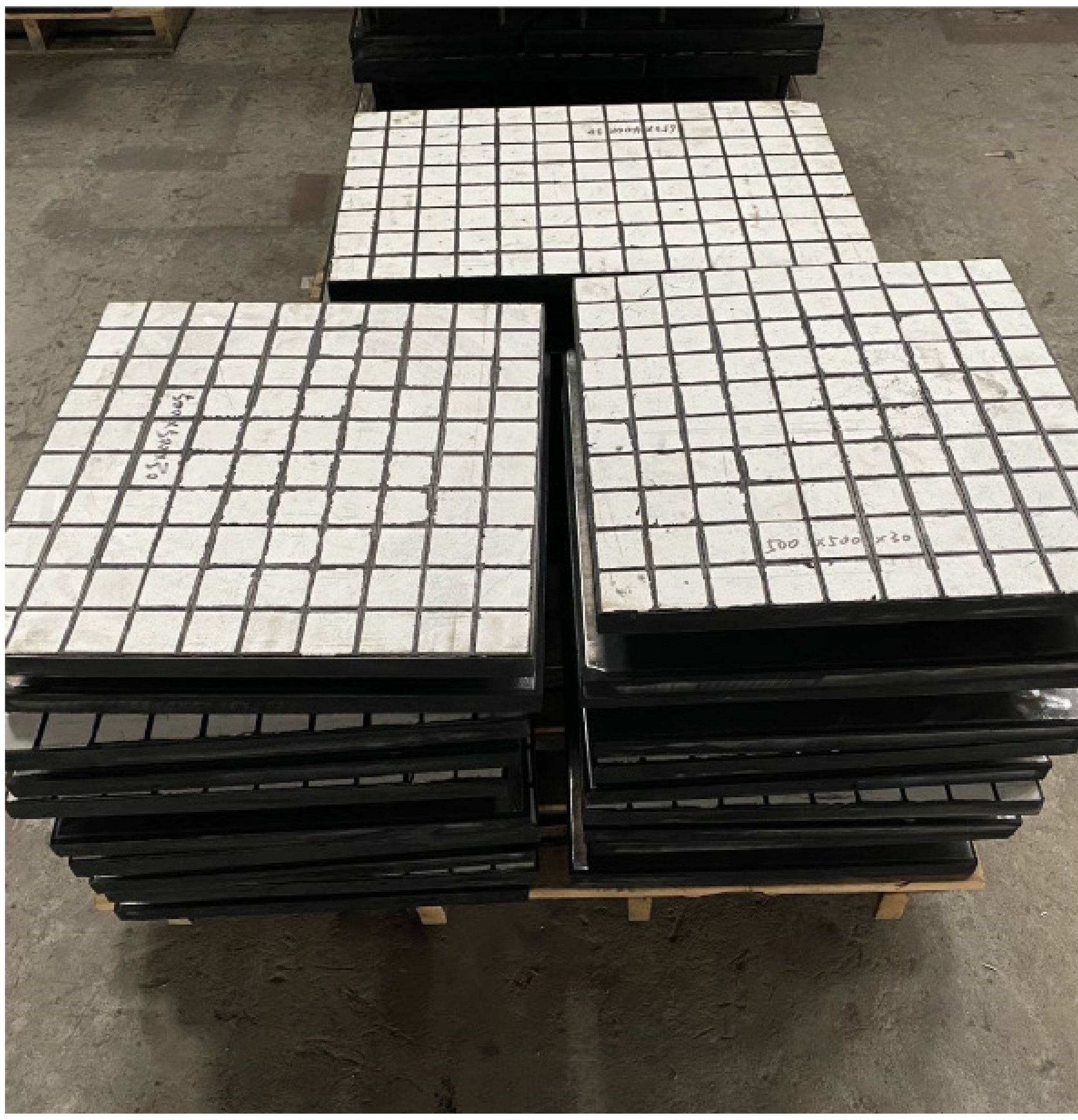
- **Offering a fair and competitive price point**
- **Reliable**
- **Life expectancy 4 times that of standard wall rubber**
- **4 : 1 ration bending ability**

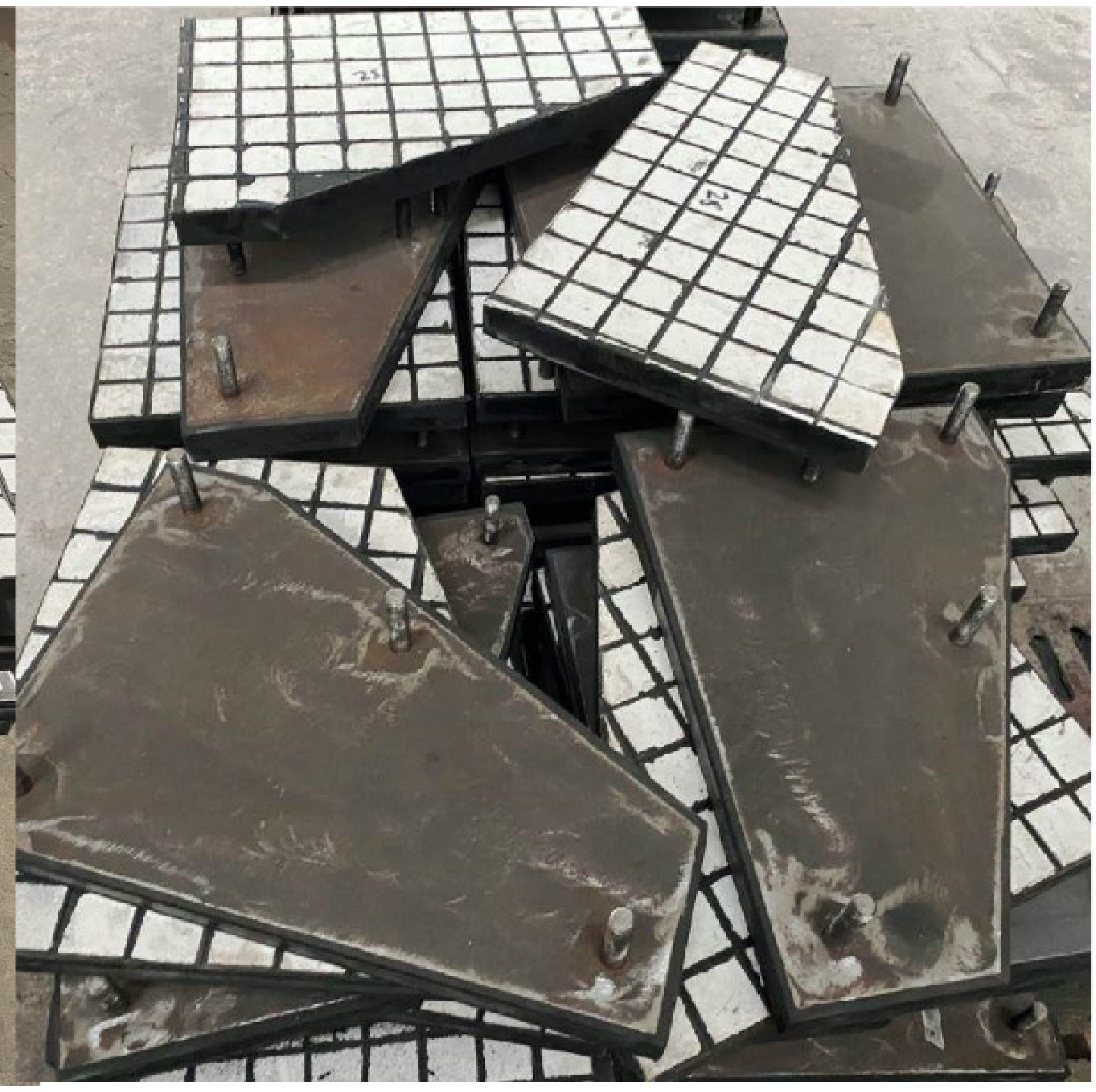

Australian Mining
Repair Clamp


CCCO 50 thick -300 -300
Australian Mining
Product and Services

Ceramic wear liners and tiles

Direct bond, CN, plain or steel backed





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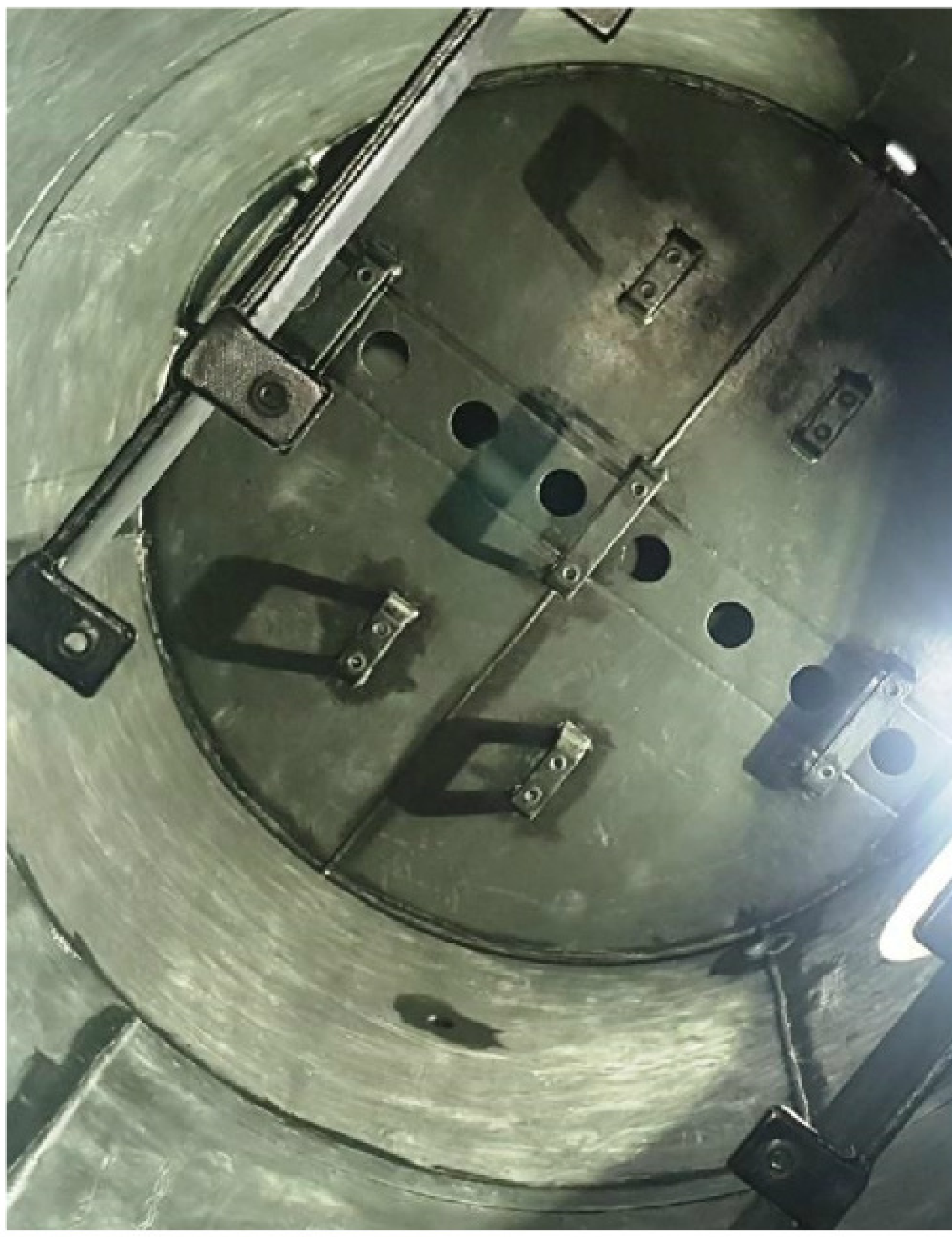
one source supply of all fluid handling, pipe repair and wear consumables

outlets nationally

- Pipe repair bandages and pipe leak seal epoxy - 49% polyurethane impregnated fibre glass and leak seal epoxy– 6 Mpa tested with MSDS
- Magnetic wear liners and wear patches specifically designed to keep production in process and eliminate most unscheduled maintenance shutdowns—1500 kgs pull force per sq meter
- Pipe Repair Clamps, Couplings, Seals/gaskets and accessories
- Ceramic—wear liners– buffed, CN, Magnetic or steel backed
- HDPE / UHMW/ Polyurethane, Hot Vulcanised or Sheet Rubber linings
- Stainless steel leak arrest clamps with Nitrile inner or fire proofed will instantly stop most leaks
- Material Handling Slurry Hoses– ceramic or rubber lined
- Slurry Handling pipes & accessories - Ceramic, rubber, steel, HDPE lined
- We fabricate and line metal spools and bends
- Valves - pinch, Gate, Butterfly, Diaphragm, - Pneumatic, Manual, electric operated, Lugged or flanged Controllers and one-way valves
- Specialist Brushable or trowable Ceramic or polyurethane epoxies
- Ceramic pipe and chute tiles
- Expansion and vibration Joints, rubber, PTFE or metallic
- Ductile iron pipe repair clamps
- Pumps and gaskets
- Stainless steel pipe grip clamps and couplings
- Pipe tapping machinery
- Pipe Tapping saddles flanges - Table E, Table D, ANSI - galvanized, zinc alloy or stainless steel
- Quick grip pipe clamps Gaskets and pipe seals
- Steel galvanized pipes with Victaulic or flanged ends
- Flexible metal hoses

Hot Lining, on site tank lining and refurbishments



Expansion Joints—flanges

Sealing — Rubber, SS Spiral wound - Fabric or Fiber Gaskets and extruded rubber

Our **composite hose** can handle hydrocarbon, chemical and cryogenic fluids:

Utilizing multiple tight-wound component layers that create a very long and complex course for fluids. The unique manufacturing process assures the proper gauge and pitch of the inner and outer wires at all times.

Our composite hose is rated for both positive pressure and full vacuum, it will not kink with ease of daily handling it will provide excellent service life and performance.

Other hoses available are :

- Air hose
- Water hoses
- Oil Hoses includes—**Frack Oilfield Fuel Discharge Hose** designed and engineered specifically for constant contact use in the transfer of alternative fuels such as bio-diesel, bio-diesel blends, ethanol and ethanol blends.
- Chemical handling Hoses
- FDA approved food handling hoses for dairy and wine including our UHMWPE hoses
- Welding hoses
- Dredging hoses— Floating Dredging Hose

  Floating Dredging Hose and dredge pipe are mainly used for waterway dredging. These hoses, Suck and discharge the silt, slurry, sand and stone deposited in the waterway. Flexible floating rubber dredging suction hose can extend distance of dredging.

- LPG and LNG hoses
- Hose couplings and clamps
- Hydraulic hose protection
- Hose Sleeve

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A few of the Products we offer

- Wear liners
- Extruded components
- Skirting, Lagging and Conveyor Belts
- Material Handling Hoses—with rubber or Ceramic inner wear lining
- Repair Clamps
- Expansion Joints
- Quick couplings
  Straub equivalent
- Ceramic lined Valves
- Fabricated spools with rubber or
  Ceramic lining on inside
- Trommel Fabrication
- Screen media
- Mill Liners and Furnishing

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Product and Services

Services we offer

Site services at Shut down

On or Off site rubber or ceramic lining

Tank Lining

Remedial concrete repairs with Poly Urea spray on corrosion protection

Free Screen media assessment

Trommel screen media, Mill lining and Scrubber liner
installation and assessments

www.australianminingservices.com.au for more information or email me

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HOSE HANDBOOK

This Hose Handbook is intended for the general guidance and reference of persons interested in the selection and use of hose for various conditions of service, but readers are cautioned to follow manufacturers' instructions generally and to heed the safety warnings printed throughout this Hose Handbook.

This publication is presented as an industry service by the hose manufacturers and raw materials suppliers of the United States.

Eaton Global Hose
Hohenwald, Tennessee

Cooper Tire & Rubber Company
Auburn, Indiana

ExxonMobil Chemical
Houston, Texas

Gates Corporation
Denver, Colorado

The Goodyear Tire & Rubber Company
Akron, Ohio

HBD Industries, Inc.
Salisbury, NC

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FOREWARD

This Hose Handbook has been compiled to provide authoritative information on materials, constructions, tolerances, applications, fittings, storage, care and maintenance of hose.

This Handbook will help users to make an intelligent selection of hose for various conditions of service and to set up procedures to obtain satisfactory service life.

The reader of this Hose Handbook is cautioned, however, that the information contained herein is intended for general reference and general applicability only. The Hose Handbook also reflects the current state of the art in the design, manufacture and testing of hose products at the time of publication, but it cannot anticipate new developments or improvements in hose products. Therefore, the reader is urged to determine from informed sources whether there have been significant changes in the subject matter being considered before acting.

This Hose Handbook is not intended to cause or promote the selection or use of any type, construction or application of a particular hose product. With respect to specific hose products, their uses and applications, the reader should rely upon and closely follow the manufacturer's instructions as to the capability and limitations, as well as the proper use of the product. Especially with respect to critical application of hose products and the testing procedures described in this Hose Handbook, the reader is warned to follow the manufacturer's safety procedures with the utmost care. ***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 product or to other property and, more importantly, may also result in serious bodily injury.***

The functions performed by hose – the materials, liquids and gases it conveys, and the methods of handling it can vary widely. It is necessary to consider many factors when selecting a type and grade of hose.

While a given application may call for a hose of special characteristics, certain common standards have been established by the hose industry. These common standards, when properly used, provide both the hose user and the hose manufacturer with a common "language" which can be used to describe, develop, produce, and purchase hose of desired quality and suitability. It is to this purpose that this Handbook is dedicated.

This Handbook was written by the RMA Hose Technical Committee. The Rubber Manufacturers Association is a manufacturing trade association of more than 120 corporate members which produce finished rubber and TPE products. RMA is a member-driven, results-oriented, focused service organization which creates value for its members by addressing industry issues, and providing programs and services in an efficient and effective manner.

OTHER PUBLICATIONS

Other publications…

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Publication No.	Title
IP-7	Rubber Welding Hose, Specifications for
IP-8	Rubber Hose for Oil Suction and Discharge, Specifications for
IP-14	Anhydrous Ammonia Hose, Specifications for
IP-11	**HOSE TECHNICAL INFORMATION BULLETINS**
IP-11-1	Steam Hose; Guide for Maintenance, Testing and Inspection
IP-11-2	Anhydrous Ammonia Hose; Manual for Maintenance, Testing and Inspection
IP-11-4	Oil Suction and Discharge Hose; Manual for Maintenance, Testing and Inspection
IP-11-5	Welding Hose: Precautions for the Selection and Use of
IP-11-7	Chemical Hose; Manual for Maintenance, Testing and Inspection
IP-11-8	Fuel Dispensing Hose; Manual for Maintenance, Testing and Inspection

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CONTENTS (Continued)

GENERAL
Chapter 1

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. Figures 1-1 through 1-5 show five types of hose. Components are designated as follows: "A" - tube, "B" - reinforcement, "C" - cover.

Tube

The tube is the innermost rubber or plastic element of the hose (see Figures 1-1, 1-2, 1-4 and 1-5). The tube may be placed over reinforcing elements as in Figure 1-3. 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. Figures 1-1, 1-2 and 1-4 show reinforcement applied over the tube. Figure 1-3 is a good example of divided reinforcement with part under the tube and part over it.

Cover

The cover is the outer element and can be made Figure 1-5 shows how a layer of the reinforcement can also serve as a cover for fire hose. The prime function of the cover 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.

MANUFACTURING 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. Throughout this book, the term "rubber" will be used in its broadest sense. This will include all elastomeric materials that are compounds of natural or synthetic elastomers or combinations of these materials.

Rubber

To provide a wide range of physical properties for specific service needs, elastomers are mixed with various chemicals. Space does not permit discussion of the compounding ingredients or compounding methods, so only the basic elastomers will be discussed. There are many of these available to the hose manufacturer. In addition, many types may be blended in almost unlimited combinations to obtain the most desirable properties.

TYPICAL HOSE CONSTRUCTIONS

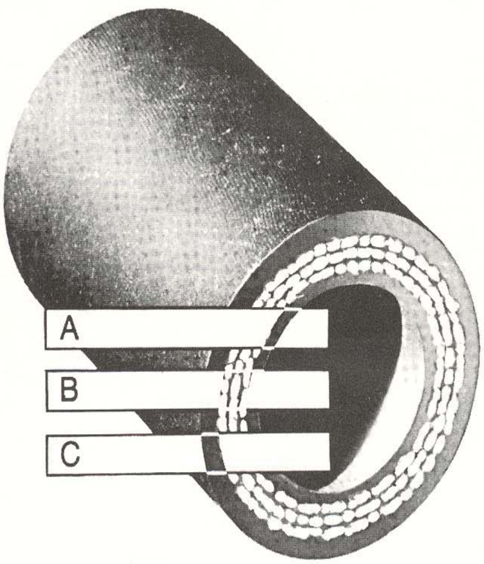


Figure 1 - 1

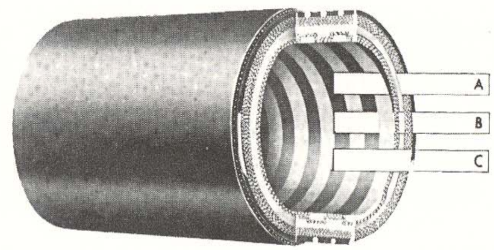


Figure 1 - 3

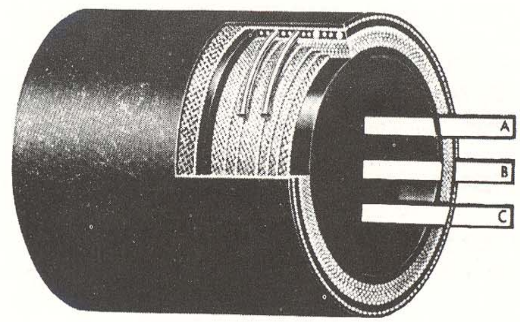


Figure 1-4

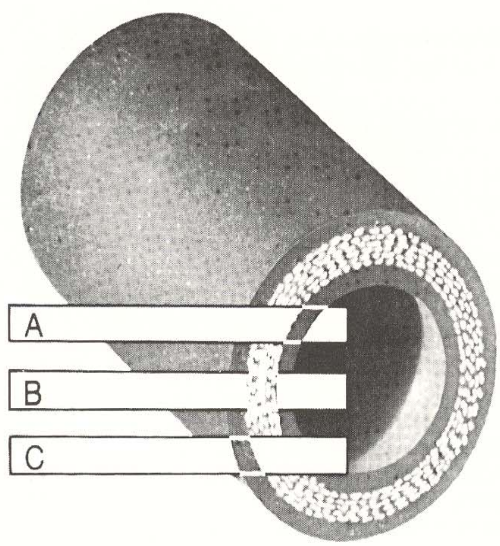


Figure 1-2

Figure 1-5

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 also result in failure of the product to fulfill its intended purpose and may result in possible damage to property and/or serious bodily injury.

Rubbers Used in Hose

ASTM Designation D1418	Common Name	Composition	General Properties
ABR	Acrylics	Acrylate-butadiene	Excellent for high temperature oil and air resistance. Poor cold flow and low temperature resistance. Not recommended for water service.
AEM	Ethylene acrylic	Ethylene methyl acrylate copolymer	Excellent high temperature, ozone, and oil resistance.
AU	Urethane	Polyester	Excellent abrasion, tear and solvent resistance, good aging. Poor high temperature properties.
BIIR	Bromobutyl	Brominated isobutylene-isoprene	Same general properties as Butyl (see IIR below).
BR	Polybutadiene	Butadiene	Excellent low temperature and abrasion properties. High resilience.
CIIR	Chlorobutyl	Chlorinated isobutylene-isoprene	Same general properties as Butyl (see IIR below).
CM	Chlorinated polyethylene	Chlorinated polyethylene	Good long term resistance to UV and weathering. Good oil and chemical resistance, Excellent flame resistance. Good low temperature impact resistance.
CO	Epichlorohydrin Rubber	Polychloromethyl oxirane	Excellent oil and ozone resistance. Good flame resistance and low permeability to gases. Fair low temperature properties.
CR	Neoprene®	Polychloroprene	Good weathering resistance, flame retarding. Moderate resistance to petroleum based fluids. Good physical properties.
CSM	Hypalon®	Chlorosulfonyl-Polyethylene	Excellent ozone, weathering and acid resistance. Good abrasion and heat resistance. Good resistance to petroleum based fluids.
EAM	Ethylene vinyl acetate	Ethylene vinyl acetate copolymer	Excellent high temperature and ozone resistance. Good resistance to petroleum based fluids as vinyl acetate content increases.
ECO	Epichlorohydrin copolymer	Ethylene oxide and chloromethyloxirane.	Excellent oil and ozone resistance. Fair flame resistance and low permeability to gases. Good low temperature properties.
EPDM	Ethylene Propylene Rubber	Ethylene-propylene diene-terpolymer	Excellent ozone, chemical and aging characteristics. Good heat resistance. Poor resistance to petroleum based fluids.
EPM	Ethylene Propylene Rubber	Ethylene-propylene copolymer	Excellent ozone, chemical and aging characteristics. Good heat resistance. Poor resistance to petroleum based fluids.
EU	Urethane	Polyether	Excellent abrasion, tear and solvent resistance, good aging. Poor high temperature properties.

FKM	Fluoroelastomer	Fluorocarbon rubber	Excellent high temperature resistance, particularly in air or oil. Very good chemical resistance.
HNBR	Hydrogenated nitrile	Hydrogenated acrylonitrile-butadiene	Excellent high temperature and oil resistance.
IIR	Butyl	Isobutylene-isoprene	Very good weathering resistance. Low permeability to air. Good physical properties. Poor resistance to petroleum based fluids.
IR	Polyisoprene	Polyisoprene, synthetic	Same properties as natural rubber (see NR below).
MQ	Silicone	Dimethylpolysiloxane	Excellent high and low temperature resistance. Fair physical properties.
NBR	Nitrile	Acrylonitrile-butadiene	Excellent resistance to petroleum based fluids. Moderate resistance to aromatics. Good physical properties.
NR	Natural rubber	Polyisoprene, natural	Excellent physical properties including abrasion and low temperature resistance. Poor resistance to petroleum based fluids.
SBR	SBR	Styrene-butadiene	Good physical properties, including abrasion resistance. Poor resistance to petroleum based fluids.
T	Thiokol	Organic polysulfide	Outstanding solvent resistance and weathering resistance. Other properties poor.
XLPE	Cross-linked polyethylene	Polyethylene and cross linking agent	Excellent chemical resistance with good heat and electrical properties.
XNBR	Carboxylated nitrile	Carboxylated acrylonitrile-butadiene	Excellent oil and abrasion resistance.

Plastics Used in Hose

ASTM Designation D1600	**Common Name**	**Composition**	**General Properties**
PA	Nylon	Polyamide	Good abrasion, chemical and fatigue resistance. Good long term resistance to high temperature. Low gas permeation and low coefficient of friction.
PE	Polyethylene	Polyethylene	Excellent dielectric properties. Excellent resistance to water, acids, alkalis and solvents. Good abrasion and weathering resistance.
	UHMWPE	Ultra high molecular weight polyethylene	Excellent resistance to a broad range of chemicals, excellent abrasion resistance.
PVC	PVC	Polyvinyl chloride	Good weathering, moisture and flame resistance. General resistance to alkalis and weak acids. Good abrasion resistance.
	Polyester	Thermoplastic polyester resin	Good flex fatigue and low temperature properties. High resistance to deformation. Good resistance to abrasion, chemicals, hydraulic fluids and aromatic fuels.
	Thermoplastic Rubber	Thermoplastic polyolefins and block copolymers of styrene and butadiene	Good weather and aging resistance. Good for water and dilute acids and bases.
PTFE	Fluoropolymer	Fluorocarbon resin	Excellent high temperature properties and chemical resistance.

Fibers Used in Hose

Common Name	Composition	General Properties
Aramid	Meta-Aramid	Exceptional heat resistance with low shrinkage.
Aramid	Para-Aramid	Exceptional strength with low elongation. High heat resistance.
Cotton	Natural cellulose	Natural vegetable fiber used in hose. Gains strength with increased moisture content. Requires protection against chemical and fungal activity.
Glass	Glass	Very high strength compared to other fibers. Low elongation; mainly used in high temperature applications.
Nylon	Polyamide	High strength and elongation with good resistance to abrasion, fatigue, and impact. Low moisture absorption and excellent moisture stability. High resistance to fungal activity.
Polyester	Polyester	High strength, good resistance to abrasion, fatigue, and impact. Low moisture absorption and excellent moisture stability. High resistance to fungal activity.
PVA	Polyvinyl alcohol	High strength, low shrinkage and good chemical resistance.
Rayon	Regenerated cellulose	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.

FABRICS

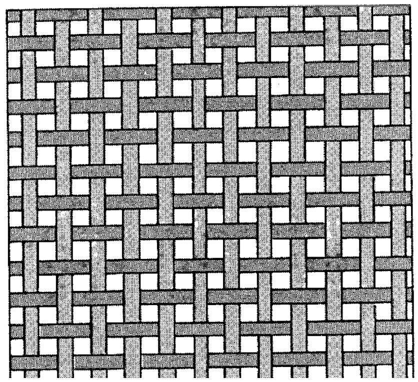
Textile fabrics used as reinforcement in hose construction provide the strength to achieve the desired resistance to internal pressure or to provide resistance to collapse, or both.

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.

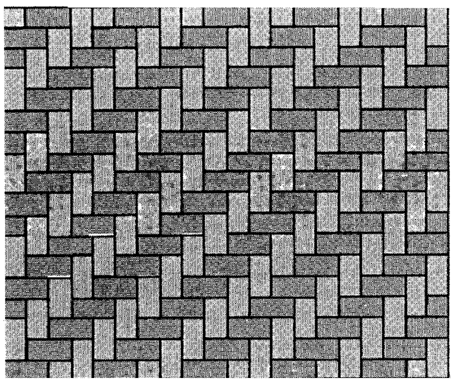
One common hose fabric is woven from warp yarns, which run lengthwise, and filling yarns, which run cross-wise. Usually they are woven at right angles to each other. The most common weave is known as “plain weave”, Figure 1-6. Notice that the warp and filling yarns cross each other alternately. This is done on a relatively simple loom. Other weaves used, though to a lesser degree, are twill, Figure 1-7; basket weave, Figure 1-8; and leno, Figure 1-9.

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, Figure 1-10, is a special type of hose reinforcement. The warp cords are strong while the filling 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.

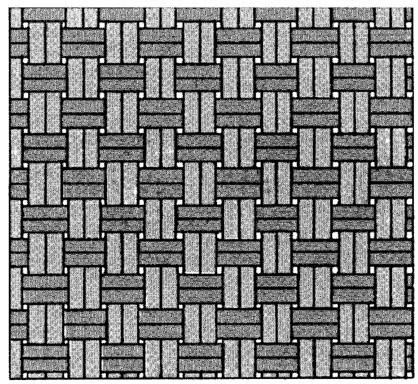
To adhere to the tube and cover of the hose, the fabric must be rubberized. The fabric is either frictioned or coated with a thin layer of rubber. Before rubberizing, some fabrics are treated with liquid adhesive.



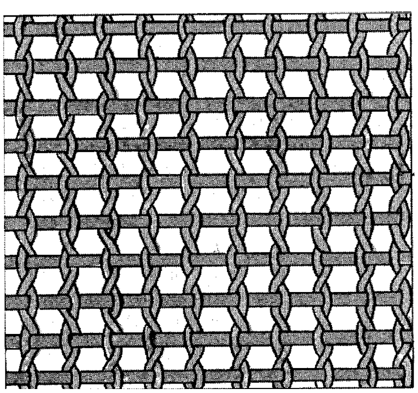
PLAIN WEAVE
Figure 1-6



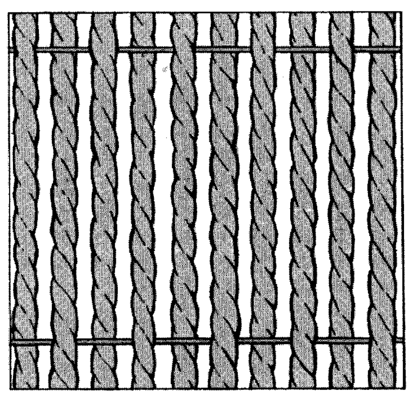
TWILL WEAVE
Figure 1-7



BASKET WEAVE
Figure 1-8



LENO WEAVE
Figure 1-9



WOVEN CORD
Figure 1-10

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 a 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 monofilaments 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 pressures 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 0.031 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.

PHYSICAL CHARACTERISTICS OF HOSE

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

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.

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

Some indication of relative hose flexibility can be determined from the manufacturers 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.

Suction and Vacuum

Most hose is used for pressure service; however, 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 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 perfect 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, textile reinforcement, size, spacing, and location of the wire reinforcement — must be carefully

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.

ELECTRICAL CHARACTERISTICS OF HOSE

Conductive Hose

Static wires and conductive rubber components are used in hose to help prevent static electricity build-up and subsequent a 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 dare not conclude that it is non-conductive. Many black rubber compounds are inherently and inadvertently conductive. Non-conductive hose is usually made to a qualifying standard that requires it to be tested to verify the desired electrical properties. An electrical resistance test method is described in Chapter 6. The hose is usually non-black in color and clearly branded to indicate it is designed for non-conductive applications.

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.

MANUFACTURING METHODS
Chapter 2

The principal methods used to manufacture hose will be described and illustrated in this chapter. The three basic methods: (1) non-mandrel, (2) flexible mandrel, and (3) rigid mandrel, describe how the various components of the hose are supported during processing into a finished product. The processing equipment used to fabricate the three typical hose components (tube, reinforcement, and cover) as discussed in Chapter 1 will be characterized herein. The advantages and disadvantages of each of these techniques will be overviewed with special consideration given to application, working pressure, diameter, production volume, and cost. Finally, rubber hose vulcanization techniques will be reviewed.

Hose manufacturing methods have been evolving for over 100 years. Some of the older techniques are still in use but with a variety of optimizations for specific needs. In addition, advanced concepts are continually being introduced for improved efficiency by a diversified array of well-qualified equipment manufacturers.

THREE BASIC METHODS OF MAKING HOSE

Hose is manufactured in the unvulcanized state by forming a cylindrical tube over which a reinforcement and cylindrical cover are applied. In its uncured form, a hose tube will often need support to maintain proper internal diameter (ID) and dimensional tolerances while being processed through the various stages of manufacture. Thus, the three basic methods of making hose have evolved: (1) non-mandrel, (2) flexible mandrel, and (3) rigid mandrel. In methods (2) and (3), the mandrels are used for support and as dimensional control devices for the hose tube during processing. Then after the hose building and, if necessary, the vulcanization are complete, the mandrels are removed, inspected and recycled.

Non-mandrel Style

The non-mandrel method of manufacture is generally used for lower working pressure (less than 500 psi), smaller diameter (2" and under), textile reinforced products not requiring stringent dimensional tolerances. Typical hose products in this category would include garden, washing machine inlet, and multipurpose air and water styles.

Essentially, the non-mandrel technique involves extruding the tube, applying the reinforcing, and extruding the cover in the unsupported mode (without a mandrel). Frequently low pressure air is used inside the tube for minimal support, keeping the tube from flattening during the reinforcing process. In some cases, especially 1" to 2" ID, the tube may be extruded with air injection along with an internal lubricant to prevent adherence to itself.

The non-mandrel tube extrusion process can be done continuously, if appropriate handling equipment is available, thus providing excellent length patterns for the finished product. In recent years with improvements in die design and cooling, dimensional control of non-mandrel rubber tube is approaching that of flexible mandrel style.

Most smooth bore thermoplastic hoses are extruded non-mandrel. The higher rigidity of most thermoplastics eliminates the need for mandrel support. In addition, with advanced cooling and dimensional sizing equipment, thermoplastic tube dimensions can be maintained quite accurately.

Flexible Mandrel Style

When moderate tube processing support is needed and more accurate dimensional tolerances are a concern, flexible mandrels may be utilized. These mandrels are rubber or thermoplastic extrusions, sometimes with a wire core to minimize distortion. This style process may be used for mid-range working pressures (up to 5000 psi) with ID’s of 1/8" to 1-1/2".

Of the three flexible mandrel styles, solid rubber offers minimal support, while rubber with wire core and thermoplastic versions provide good dimensional control. In all cases, the flexible mandrel is removed from the hose with either hydrostatic pressure or mechanical push/pull after processing. The mandrel is then inspected for dimensional and cosmetic imperfections, rejoined into a continuous length, and recycled into the hose making process. Although the flexible mandrel is continuous, limitations of expulsion from the finished hose rarely allow hose lengths above 1000 ft. Either textile or wire reinforcements may be used. Examples of this style product are power steering, hydraulic, wire braided and air conditioning hoses.

Rigid Mandrel Style

In larger hose sizes, where flexible mandrels become quite cumbersome to handle, working pressures are high, or stringent dimensional control is required, the rigid mandrel process is the preferred technique.

This method is used for any rubber hose larger than 2" ID and for 1/8" to 2" ID constructions that have higher working pressures, especially wire spiral reinforced products.

The rigid mandrels are normally aluminum or steel. For specialty applications where cleanliness is a necessity, stainless steel mandrels are used. Because of weight considerations the mandrels are usually hollow. Mandrel lengths vary from 10 ft. to 400 ft. with 100 ft. to 200 ft. being the most common. The hose tube may be either extruded on the mandrel, pneumatically pulled onto the mandrel, or wrapped in sheets onto the mandrel. As with the flexible mandrel style, when the hose manufacturing process is complete, the mandrel is removed and prepared for recycling.

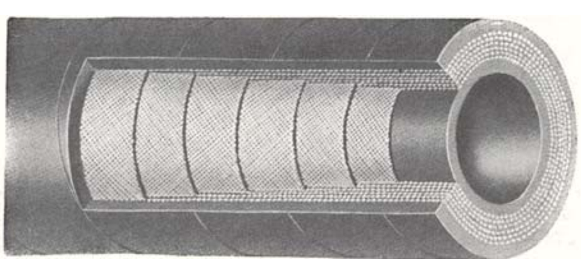


Figure 2-1

Manufacturing with rigid mandrels offers two unique production opportunities. Rigid mandrels can be (1) rotated on a stationary horizontal axis, similar to a lathe, so that material can be applied in bias style or (2) fed horizontally through the tubing, reinforcing and covering operations as the various hose components are spirally fed onto the mandrel. The former method is often referred to as Hand Built hose. The reference of Wrapped Ply hose can be associated with either method. Some hand built hoses, depending on the application, have special ends to accommodate its attachment to existing flanges in the field. Figure 2-1 shows a 6-ply wrapped hose.

One traditional method of making wrapped ply hose is on a three roll builder. This machine consists of three long steel rolls, two of which are in a fixed parallel position in the same horizontal plane.

The third or top roll is on pivotal mounts so that it can be raised or lowered. A mandrel supported hose tube is placed on the trough between the two bottom rolls.

Then the top roll is rotated down with sufficient pressure to cause the mandrel and tube to rotate. This enables the reinforcement and cover to be bias wrapped over the tube in uniform fashion. Figure 2-2 shows the end view of a section of the building machine with the top roll in its lowered position.

The hose is shown with the mandrel extending beyond the hose component as the cover is being applied.

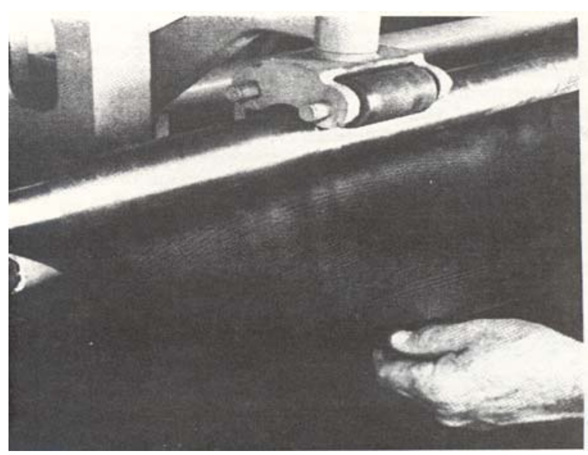


Figure 2-2

SPECIALTY METHODS

Although the three basic methods of hose manufacture just discussed encompass the vast majority of techniques currently in use, there are still a variety of specialty methods that deserve attention in this synopsis. Most of these pertain to thermoplastic hose styles.

Thermoplastic Hose Concepts

Thermoplastic products such as vacuum cleaner hoses, used for very low pressure applications are often manufactured with blow molded or tape forming techniques.

Blow molded products are shaped into a circumferentially corrugated profile at the tube extruder when the thermoplastic material is still in the molten state. The corrugations provide a tremendous improvement in product flexibility and stretch characteristics. The profiling is accomplished by injecting air into the tube pushing it into a series of metal die blocks corrugated with the intended profile. As the tube cools while traveling along the die block track, the tube becomes permanently corrugated circumferentially. A similar process, vacuum forming, uses the same technique of corrugated die blocks at the extruder, but instead of blowing air in the tube, a vacuum is drawn through the blocks pulling the molten tube into the corrugations. The appearance of the final product from each method is quite similar. However the vacuum forming process generally yields superior corrugation uniformity. Figure 2-3 shows a vacuum corrugator extruding thermoplastic tubing.

The corrugated tube from this process may be the final product or used in conjunction with other hose components. For instance, for higher pressure applications an adequate reinforcement may be applied and then a smooth cover extrusion. Combinations of rubber and plastic layers may provide the best appearance for a specific application.

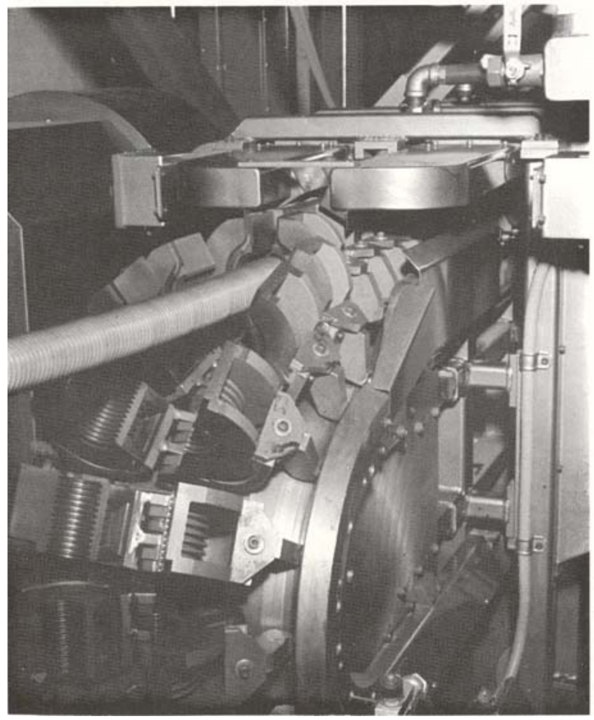


Figure 2-3

Tape forming process is a general term to describe a product composed of a narrow thermoplastic extruded profile helically wrapped with sufficient overlap and adequate bonding to create a continuous cylinder with hose-like characteristics. The profile can be varied for best flexibility. Typically swimming pool hoses are of this construction. Figure 2-4 provides a close-up of this process.

Helically applied wire at the thermoplastic extrusion point offers another product option that results in good crush resistance and flexibility.

Low pressure gasoline vapor recovery hoses may use this design.

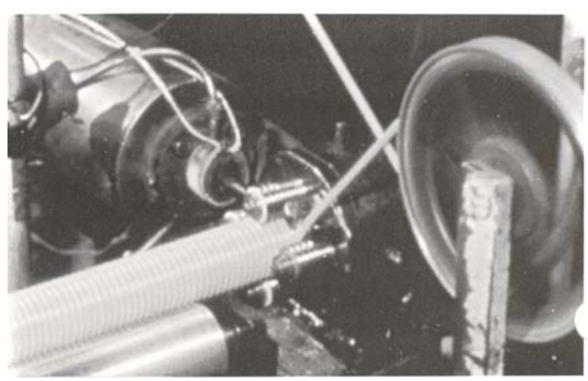


Figure 2-4

Continuous Systems

To minimize handling inventory and cost while maximizing throughput, the continuous process is common. This process combines tubing, reinforcing, covering and vulcanization into a single process. To do this, the equipment is merely installed in a tandem fashion thereby enabling the hose material to flow uninterrupted through each phase. Obviously the system controls are vitally important to minimize downtime. Since the line output is generally limited by the reinforcement unit capacity, textile spiraling is the common approach. Also, since the vulcanization portion of the line is often the most space consuming and expensive, it is frequently not included. Hoses up to 2" ID with working-pressures up to 400 psi are the most probable candidates for this process. Flexible mandrel or non-mandrel methods can be accommodated on the continuous process. Figure 2-5 illustrates a continuous operation manufacturing textile spiral hose.

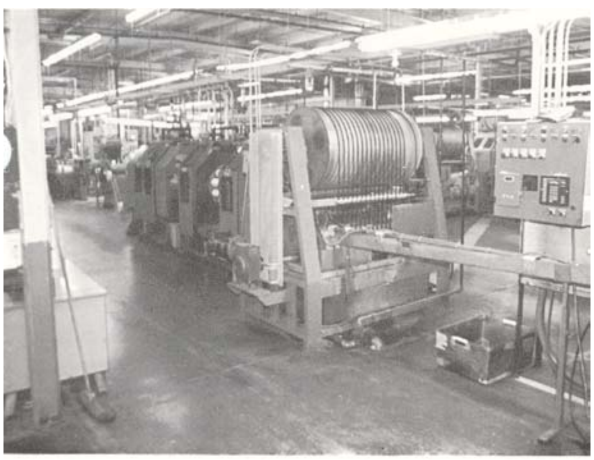


Figure 2-5

PROCESS CHARACTERISTICS

As previously mentioned, the basic hose components are the tube, reinforcement, and cover. In this section the process methods for each of these operations will be outlined.

TUBING OPERATION

The two common tube manufacturing techniques are extruded and wrapped.

Extruded Tubes

For the tube extrusion process, an uncured rubber or thermoplastic compound ribbon or pellets are fed into the extruder, through the screw or auger with proper temperature controls and finally forced through a pair of metal dies, where the cylindrical tube is formed. In the non-continuous process, the tube is then cooled, lubricated to minimize tackiness, and stored in coils on pans, reels, or rigid mandrel poles.

Dimensional control is critical when the tube is being formed. Traditional techniques for maintaining dimensions include die selection, temperature, and line speed adjustments. The latest innovations include a multi-axis laser micrometer measuring the tube outer diameter with feedback to the extruder to provide size control. Ultrasonic devices, that can measure tube ID and OD, are also available. Figure 2-6 shows the tube being formed as it comes through the dies with a laser measurement system for OD control.

Extrusion temperatures are typically between 200°F and 275°F for rubber compounds and 300F to 600°F for thermoplastics. Precise temperature controls are important to prevent scorch or partial cure of rubber compounds or burning of the thermoplastics during extrusion and provide good wall gauge concentricity. The various temperature zones of the extruder provide for a profile that can be varied for each type of compound to help optimize extrusion characteristics.

For certain applications, to minimize cost or improve flexibility, multiple tube layers may be desirable. In these instances, a tandem or co-extrusion may be preferred. For the tandem method, extruders are installed in series so one tube may be extruded over the other. For co-extrusions, several extruders are mounted in such a way to feed a central die-forming point (extruder head) so that the tubing operation is simultaneous. These extrusion advancements offer a good variety of alternatives to use unique polymers or to create hybrid products of thermoplastic and rubber.

Normally, extrusion is the preferred method for the tubing process on hoses with ID's up to 1-1/2" when built on a flexible mandrel, to 4" for rigid mandrel. Beyond these dimensions, wrapped is usually employed. For the larger diameter non-mandrel extrusions, the tube may be lubricated inside to prevent compound tackiness. Also, an air cushion can be used internally to prevent tube collapse during extrusion.

Extruders are often referred to as crosshead or straighthead. If the tube is formed in the same direction as the extruder's screw orientation, it is a straighthead design, whereas if there is an angle between the tube flow and the screw, it is a crosshead design. Common crosshead designs are 45° or 90° orientation. Crosshead designs offer more challenges for the process engineer or rubber chemists since the abrupt change in rubber flow direction can induce temperature and pressure anomalies, especially with sensitive compounds.

Hot feed and cold feed extruder terminology is common. In the Hot feed process the rubber is preheated before it is fed into the extruder, usually on a two-roll mill. This technique makes the extrusion easier for some compounds since there is less rapid temperature increase in the rubber. However with high equipment and labor cost, it is almost obsolete in favor of the cold feed process.

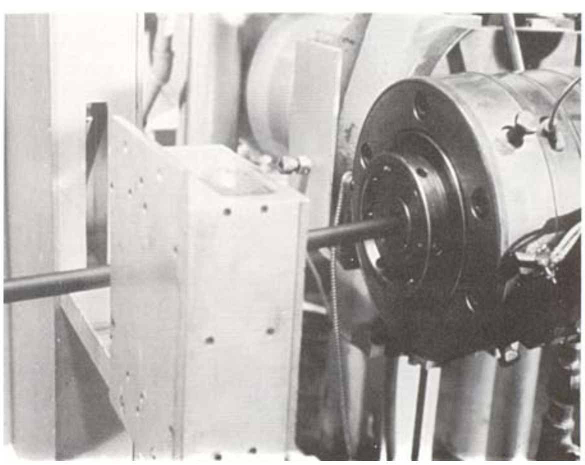


Figure 2-6

Wrapped Tubes

For the larger diameter rigid mandrel rubber hose constructions, the wrapped tube process is utilized. Here, the rubber compound is calendered to a specific thickness and width, then spirally wrapped on the rigid mandrel with sufficient overlap to form the tube. With the wrapped process, the challenge is to provide good bonding at the tube overlap area to prevent tube delamination.

COVERING OPERATION

The covering techniques used for rubber and thermoplastics are synonymous with the tubing techniques described previously. In most instances the same equipment is used. Frequently a hose may have an extruded tube and a wrapped cover. If extruded, covers must be applied with a crosshead design to allow the reinforced uncured tube to be fed properly into the extruder covering. The wrapped cover concept is shown in Figure 2-7.

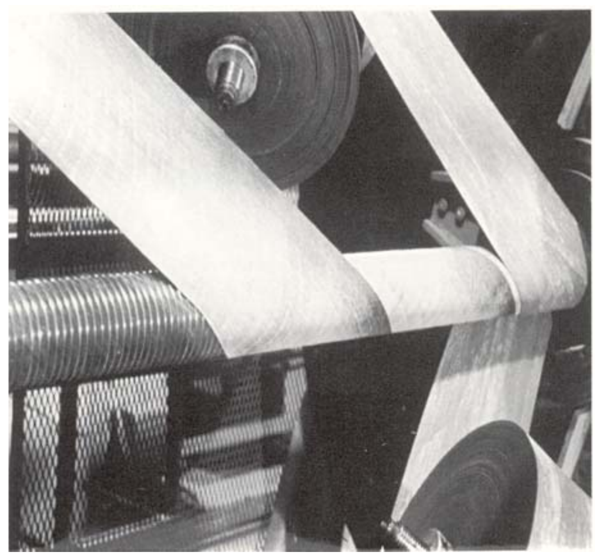


Figure 2-7

REINFORCEMENT

The strength component of the hose, designed to handle the entire pressure load with appropriate safety factors is the reinforcement. In most cases it is located between the tube and cover. Occasionally there are hose applications not requiring a cover, in which case the reinforcement also acts as the outer protective layer.

When multiple plies of reinforcement are required to meet working pressure performance levels, typically they are applied one over the other normally separated with a rubber layer (friction or jacket) to fill voids, prevent adjacent reinforcement abrasion, and to maintain adequate hose component adhesion levels. Multiple plies may be applied individually or in a single pass through a multiple deck unit.

Hose reinforcements are either textile, both synthetic polymeric and natural, or wire as briefly described in Chapter 1. Methods of applying these reinforcements are braid, spiral, knit, wrap, and woven. Combinations, such as spiral/knit, are available. Selection of reinforcing equipment is dependent on pressure rating, size, fitting requirements, flexibility, and crush resistance levels.

Braid Reinforcement

Braiding is probably the most common and traditional method of reinforcing hose. Braiding machines were available in France and Germany as early as the middle of the l9th century for braiding textiles used for rope and clothing products. The introduction of the first braiders for the fledgling hose industry came in America about 1900. Figure 2-8 shows a typical single ply braided hose.

Braiders are described as vertical or horizontal depending on the direction the tube progresses through the machine during braiding. The two major classifications of braiders are tubular or "maypole" type and rotary type.

Figure 2-8

Maypole Type

As the name implies, braid is formed from multiple carriers each carrying a reinforcement package traveling in a serpentine maypole fashion generally with a two over-two under pattern. The common carrier varieties available are 20, 24, 36, 48, and 64. They are utilized in vertical or horizontal, single or multiple deck arrangements.

Vertical set-ups are normally a maximum of two decks for convenience and handle non-mandrel or flexible mandrel hoses up to 1-1/2" ID. For vertical braiding, the tube is fed into the braider from underneath, passing through the center of the unit where the braid is applied and then over a rotating capstan wheel designed to pull the tube through the braider at a specified rate so the braid is applied at the optimum design angle. For non-mandrel style products, an air cushion is often used inside the tube to prevent collapse at the braid point. The vertical braider is the most old fashioned style with few recent advancements. Output speeds are about 30% less than the latest horizontal maypole braider innovations.

Horizontal braider equipment advancements have been substantial in the last 15 years. Improvements for tensioning wire and textile, as well as larger capacity packages, have provided significant improvements in hose output and quality, especially for wire braid products. The most common horizontal arrangements are 20, 24, 36, or 48 carriers in two or three deck combinations for handling hose up to 4" ID in flex or rigid mandrel constructions. Flow of the tube through the braider is similar to vertical style, except caterpillar pull units instead of capstan wheels are more common. Figure 2-9 shows a typical modern unit.

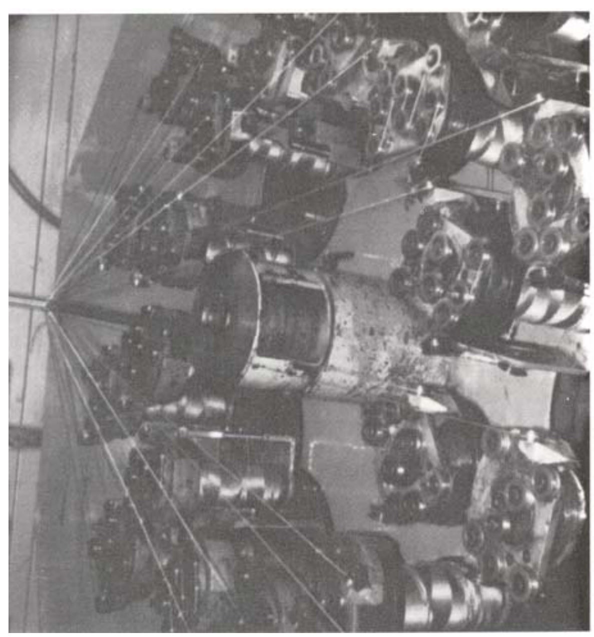


Figure 2-9

Rotary Type

The term rotary braider applies to units where the carriers holding the reinforcement package are fixed on two counter-rotating decks and do not move in and out in a serpentine path like the maypole type. The braiding pattern is achieved by deflecting the reinforcement strands from the outside deck under and over two carriers on the inside deck, repeating the motion continuously during rotation. Because of the simpler travel of the carriers, output speeds can be as much as 200% faster than an equivalent maypole type. Common arrangements are available in 20, 24, 36, 48 carriers, vertical and horizontal, one-, two- or three-deck setups for both textile and wire reinforcement. Figure 2-10 shows a 24-carrier horizontal rotary style unit.

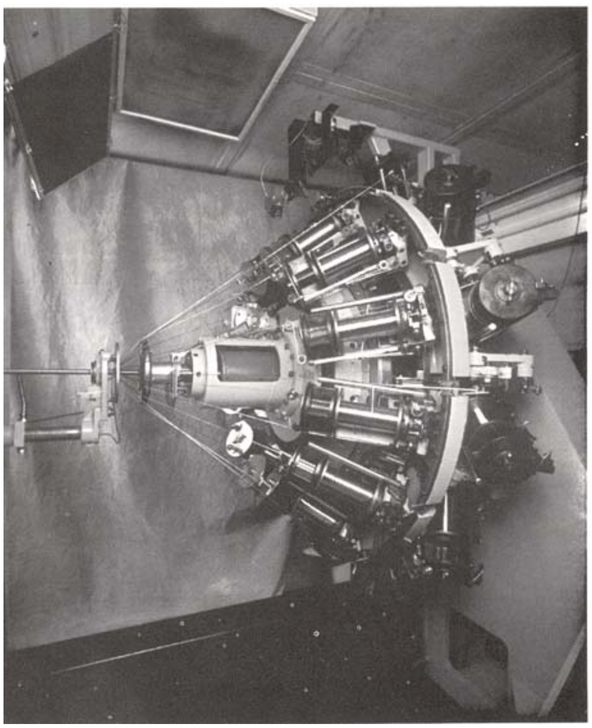


Figure 2-10

Spiral Reinforcement

Hose spiral reinforcement equipment first became available in the 1950's. Since then, it has evolved into the most economical and efficient method of making certain types of hose. Spiralling is done horizontally with two opposing decks revolving in opposite directions each holding clusters of reinforcement spindles. Figure 2-11 shows a four-spiral hydraulic hose.

Each strand of reinforcement is fed through an array of tensioning devices to the center point of the decks where they are applied to the tube in a parallel array. In all cases, to have a balanced hose construction capable of minimal distortion under pressure, the spirals are always in multiples of two. Because of the minimal number of moving parts, the spiral decks can turn at very high rates. State-of-the-art textile spiral units, available at 2000 rpm are commonly used in continuous lines where tubing, reinforcing and covering are all done in one pass. Textile spiral is well suited for non-mandrel or flexible mandrel constructions, with low to medium pressure ratings. Wire spiral is most common on rigid mandrel designs up to 2" ID with very high working pressures. A typical wire spiral unit is shown in Figure 2-12.

Single or double wire spiral applicators may be used in conjunction with a textile braid or spiral to form a "helix wire" in the hose wall to provide collapse resistance. These are common for large diameter suction hoses (over 1") or in gasoline pump hose where the "hardwall"

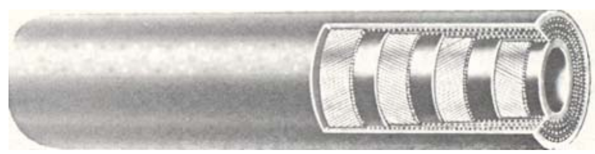


Figure 2-11

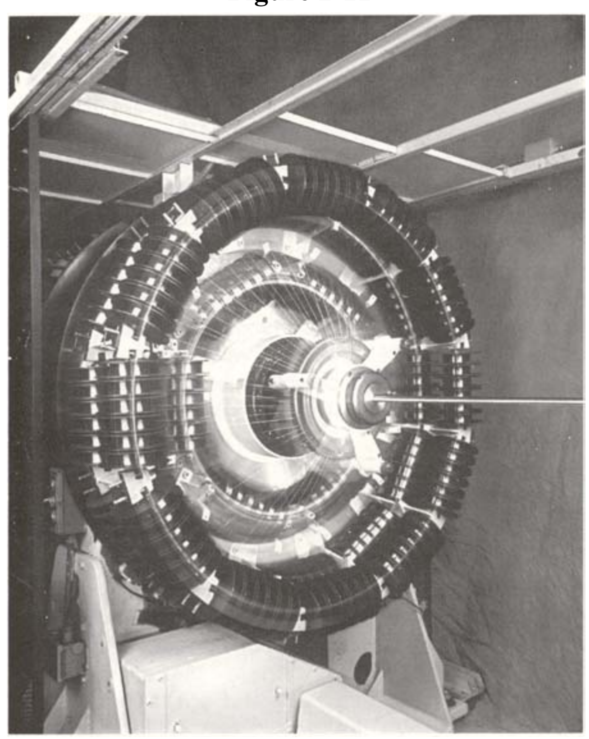


Figure 2-12

Knit Reinforcement

Rotary knitting machines used for hose reinforcement were first developed in the early 1900's. Today their use has declined significantly in favor of textile spiral, but are still the common method for reinforcing radiator hose because of its good torsional and circumferential flexibility needed for curved hose products.

Knitting can be horizontal or vertical with textile only. The yarn is fed from cone packages (usually 4 or 8) through a series of eyelets through latch-type needles onto the hose. Although the knitted hose is easily shapeable for coolant hose applications, it is a very inefficient reinforcing method restricted to low pressure applications. Figure 2-13 shows an 8-feed vertical knitter.

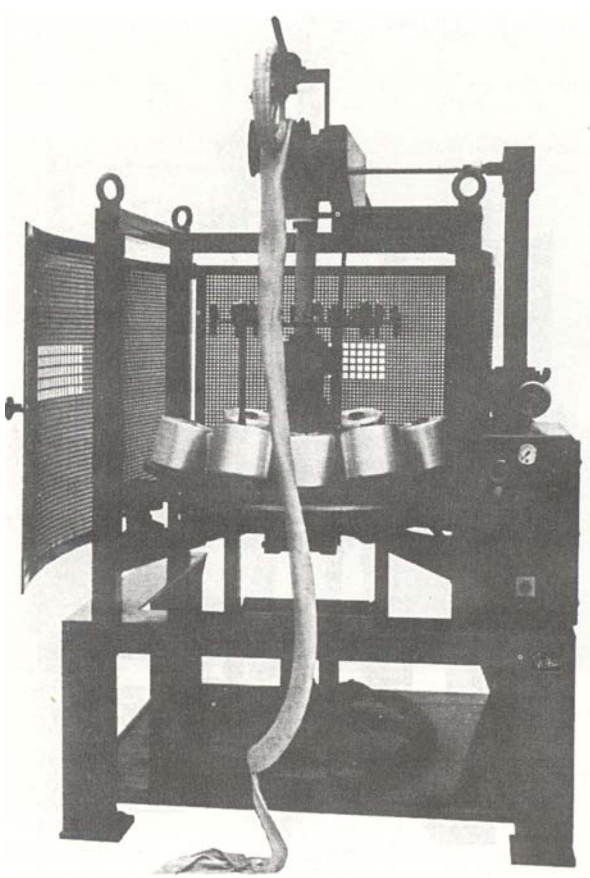


Figure 2-13

Wrap Reinforcement

Wrap reinforcement is applied spirally to rigid mandrel hose tube in multiple plies with the direction of lay reversed with each succeeding ply. The most common fabric reinforcement is tire cord, which has strength only in the cord direction. To compensate for its uni-directional strength, plies are usually applied in multiples of two. This may be done by rotating the mandrel or rotating the reinforcement around the mandrel as described previously in the "Three Basic Methods of Making Hose". Wrapping is generally done with rubberized fabric thereby resulting in hoses in the lower working pressure range. However for large diameter hoses, generally above 4", it's the only available technique. Figure 2-14 shows the wrap reinforcement being applied to a rigid mandrel hose.

When needed to prevent collapse or kinking, a wire or thermoplastic helix or helixes are added to the wrapped construction. These can be a wide variety of thicknesses, usually applied at a fairly high helix angle to oppose inward and outward radial stress, but which do not add significantly to the hose strength in the axial direction.

Figure 2-14

Woven Hose

The reinforcement for woven hose is a seamless, tubular textile jacket woven on a loom. This produces a strong, lightweight hose that is flexible for flat storage. Because the longitudinal warp yarns are parallel to the axis, woven hose tends to kink more easily than other hose constructions. Although sometimes used with a rubber cover for industrial applications, woven discharge hose finds its greatest use as a fire hose where lightweight and high strength are of great importance.

Fire hose consists of a tube and seamless circular woven jacket or jackets, either separate or interwoven. Figure 2-15 shows a typical single and double jacket hose. One of the types of looms used for the weaving of the fire hose jackets is shown in Figure 2-16. The tube may consist of a rubber or plastic compound.

The tube may be extruded, wrapped, or built up by depositing multiple layers of rubber latex. If compounded rubber has been used as a tube, it may be semi-cured and then backed with a supplemental layer of rubber. This step is eliminated in the case of plastic tubes. The tube is then drawn into the jacket or jackets and, when made with rubber compounds, it is cured by internal steam pressure, with the jackets being the pressure container.

Fire hose is normally made without an outer rubber cover or protection to the outer jacket. For certain applications, especially in the chemical industry and at refineries where damage to the jacket would occur from aggressive liquids, it is normal to use either a rubber covered hose or a hose where the outer jacket has been impregnated with a rubber type protective coating.

A great deal of rubber covered fire hose is made by weaving the jackets on a loom. Then the tube and cover are applied simultaneously by pulling the jacket through a special cross head extruder. This extruder forces the compound through the weave forming a one-piece tube and cover.

A common loom variety, a Chernack loom, is a four-shuttle circular loom in which every alternate fill member may be of different material. A hose made with this loom normally would be provided with an inner liner which would be drawn into the circular woven member simultaneously with the weaving procedure. The primary use of a hose from such a loom is for suction applications. This construction would normally have two alternate members of round wire or plastic rods having physical characteristics which would provide substantial crush resistance in the hose structure. The other two would be textile yarn. An illustration of the Chernack loom construction is shown in Figure 2-17.

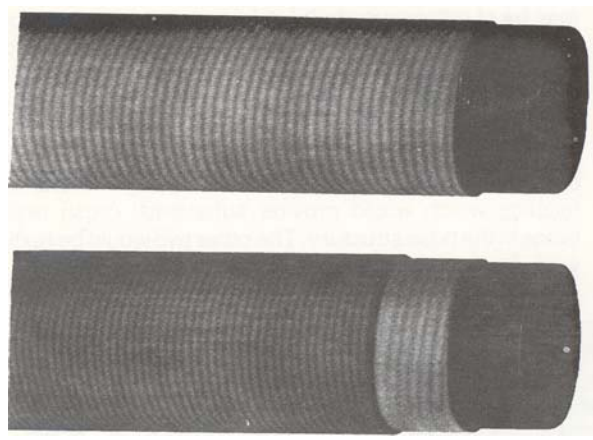


Figure 2-15

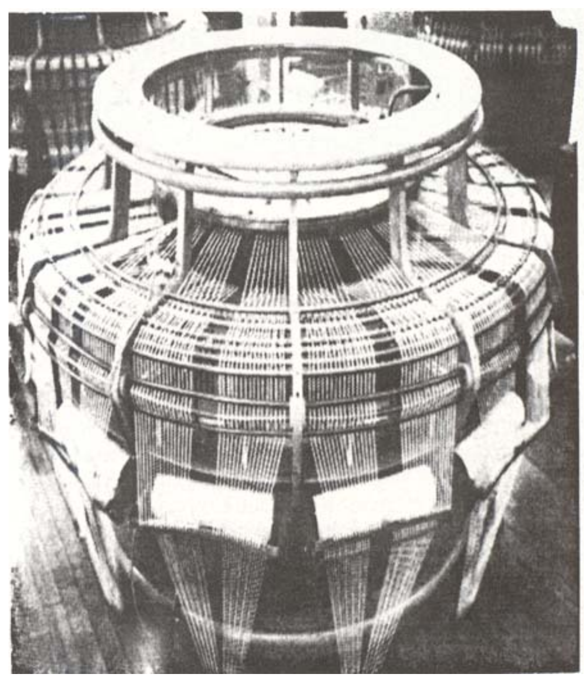


Figure 2-16

Figure 2-17

VULCANIZATION TECHNIQUES

Vulcanization (curing) changes the rubber product from a plastic to elastic material that is much stronger and rebounds to its original shape after load deformation. All rubber products need to go through the "curing" transformation, the final process, whereas with thermoplastic products, it is not required. Vulcanization is achieved by heating the rubber products to temperature generally between 280° F to 400°F. Although pressurized steam is the traditional method, techniques ranging from hot air, molten eutectic salts, hot glass beads, and high frequency microwaves have been used quite successfully for certain hose applications. Since the use of steam has become the most widely used method throughout the rubber industry, the techniques that will be described here will be lead sheath, wrap, open, and curved. All these methods utilize a steam vulcanizer for curing the rubber.

Lead Cure

Because of its low melting point and good ductility, lead has been used in the hose vulcanization process since early in the 20th century. After the hose is created, tubed, reinforced, and covered, if lead curing is utilized, a lead sheath is applied over the hose, rolled onto a reel and cured in a steam vulcanizer.

The lead sheath is applied as a hot extrusion through a set of dies. Its purpose is to compress the hose components thereby providing good bonding or homogeneous structure with adequate concentric dimensions. This method can be used for non-mandrel or flexible mandrel constructions. For non-mandrel styles, air or water is charged inside the hose for support during vulcanization. Figure 2-18 shows the lead extrusion equipment. After curing, the lead is stripped from the hose with a series of knives and melted for recycling. Although old fashioned and energy consuming, this method is still commonly used for multiple pIy hoses 1-1/2" and smaller. However with environmental concerns of the lead, this process is becoming obsolete.

Alternate material approaches to lead that still utilize an extruded sheath include a variety of heat stabilized thermoplastics. Although the compressive characteristics are not nearly as good as lead, for lighter weight products, especially single ply, a thermoplastic sheath cure might be a good alternative to lead.

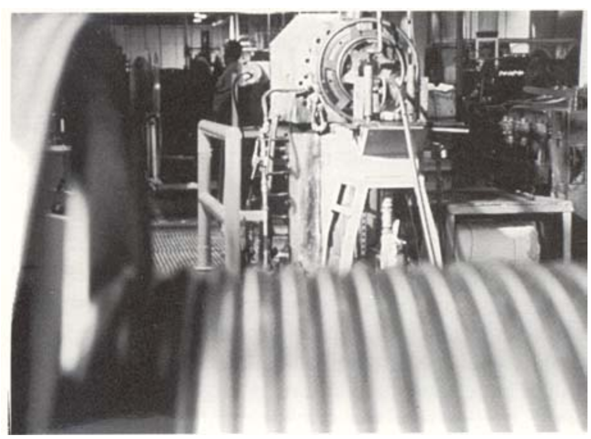


Figure 2-18

Wrap Cure

The wrap cure process uses a closely woven textile fabric tape generally 2" to 4" in width, wrapped spirally around the uncured hose and steam vulcanized. This fabric tape, generally nylon, is overlapped sufficiently that along with the shrinkage properties of the textile, provide compaction forces to the hose bonding the components during cure. The tape is removed and recycled after cure. The rough surface of the tape creates a similar rough finish on the hose. Wrap curing is used for flexible or rigid mandrel constructions in virtually all sizes. Figure 2-19 shows a late model wrapper.

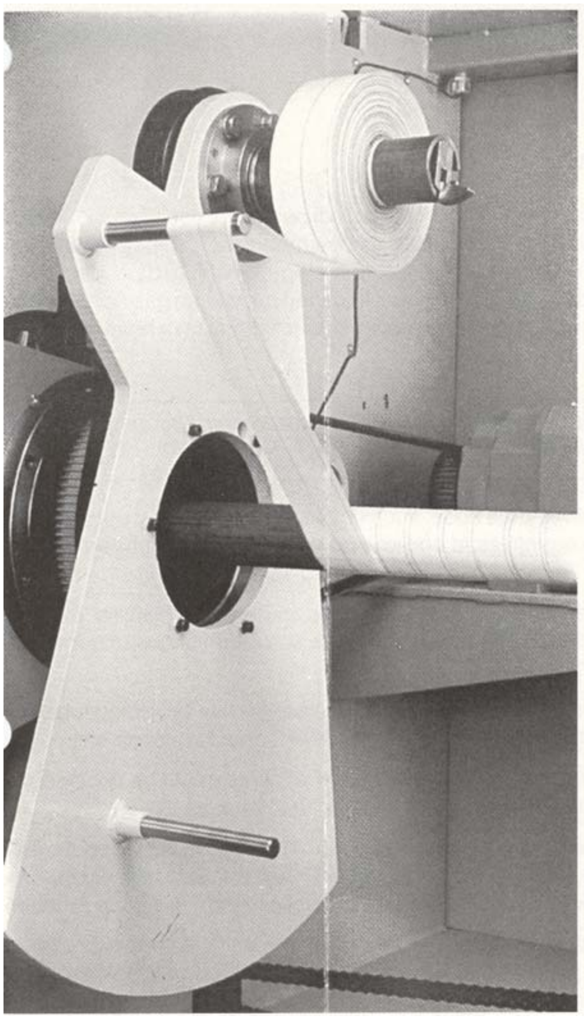


Figure 2-19

Open Cure

Open or pan cure is the simplest of rubber hose vulcanization techniques. Essentially, the hose is taken from the covering operation, coiled either on reels or horizontal pans and placed directly into the vulcanizer. Obviously, without any protective or compressive sheath during cure, this process is limited to products of one or two ply and 1" ID or less, either non-mandrel or flexible mandrel. If non-mandrel, a water or air charge may be used inside the hose for support during cure.

Curved Hose

For certain applications, such as automotive coolant hose, a curved or shaped configuration is required for the hose. In these cases, the uncured hose is cut to the specified length, installed on a metal mandrel that is the same shape as the finished part, open steam vulcanized, and then removed from the mandrel. Because the hose is cured in this configuration, it retains the shape of the mandrel. Figure 2-20 shows a typical curved hose/mandrel process.

Figure 2-20

HOSE IDENTIFICATION
Chapter 3

GENERAL

Hose is usually designed for use in specific operations although some applications will permit the use of multipurpose hose, e.g., for use with air, oil or water. In cases where safety demands caution, a hose manufacturer may specify the application for which a hose is designed in order that the hose might not be applied to a usage for which it is not intended or suitable. Examples of these kinds of applications include acid hose, steam hose, liquefied petroleum gas (LPG) hose, and anhydrous ammonia hose. In addition, a hose buyer may wish to specify a certain identification on a hose to ensure that it is used and handled safely.

SAFETY WARNING: Applications of hose to uses not intended by the manufacturer might be dangerous and might result in damage to property and serious bodily injury.

No specific rules apply to the identification markings on general trade hose; such details must be worked out between the manufacturer and the user. For economic reasons, large quantities of non-critical hose are manufactured without any identification markings.

On the other hand, many hose products, especially hydraulic hoses that are built to industry standards such as SAE, ISO, DIN, EN, JIS, etc., do have specific marking requirements. These may include the hose specification number, the hose dash number and size, the maximum working pressure of the hose and the date of manufacture. Additional marking is permissible, however, no mention of the burst pressure or the design factor is allowed on the hose as this information could be misinterpreted by the user and result in a hose being used above its rated maximum working pressure.

Questions concerning permanent identification markings often arise. It should be understood that no exterior identification marking used on hose can be characterized as truly permanent. There are some conditions under which any type of identification might be obliterated.

The most durable markings, molded (embossed and impression) brands, can be classified as providing legibility characteristics which one might expect to persist for a long time, even under abrasive or corrosive conditions.

Moderately durable types of markings, rubber labels/decals and pre-vulcanization imprinting, might be expected to remain legible for a long time if abrasive conditions and hostile environments are not encountered.

The least durable type of marking, printed identification, is done after vulcanization. This type is least resistant to obliteration by abrasive conditions or environmental exposure. Identification of this kind will last at least to the point when the hose is first placed into service, thereby giving the user knowledge of the proper application of the hose product.

A number of methods exist for applying identification markings on hose — there is no one universal method. Some methods are applicable only to certain products or to certain production methods. General methods will be described in the following paragraphs. If identification is required, the manufacturer and user should consult on the most suitable method to be used.

Brands (Molded)

Brands may be affixed along the length of the exterior surface of a hose at designated points. Such brands should be of a size and shape adequate to embrace the legend desired; however, the circumference of the hose and the means for applying the brand at the specified location (s) may act to restrict the size of the brand.

The most durable types of brands are those embossed or die formed from a metal sheet. These brands are applied to the surface at the designated place (s) along the hose length prior to vulcanization. The formed metal die acts to mold the brand in relief on the surface of the hose. The metal die is usually removed following vulcanization.

A variation of the embossed or molded brand system calls for the use of a brand in a color contrasting with that of the hose. To achieve this, a coating of unvulcanized colored rubber is applied to the back surface of the metal sheet from which the die is produced. During vulcanization, the colored rubber layer adheres to the hose cover and when the metallic die is removed following vulcanization, a distinctive brand remains in relief on the exterior surface. The colored brand acts to highlight the identifying information. Use of such brands is more costly and may not be necessary for most applications.

Another variation of the embossed or molded brand, employed to a significant extent in long length hose manufacturing, is continuous strip branding. This method requires that the legend be embossed at repeated intervals on long, narrow metallic or plastic strips. The strips are applied to the exterior surface of the uncured hose usually when it enters the sheathing device or the cure tape applicator. After vulcanization, the strip is removed leaving the hose with a continuous legend in relief along its entire length. Such a brand provides greater visibility than does the individual brand and will likely remain visible longer during the service life of the hose.

Impression Brands

An impression brand is the exact opposite of the molded (relief) brand described above. In this method, the legend is impressed into the surface of the hose. Such branding may be done at specific locations on a hose length or in a continuous line. It is accomplished by using a heated branding device either of specific configuration or on a heated wheel for continuous line branding. When used on vulcanized hose, the heated branding device compresses the hose cover material beneath the surface and either literally distorts it or destroys minute areas by charring. Some concern must be shown for the depth of the impression, particularly as it relates to the thickness of the hose cover and the heat transmitted by the branding device. If misused, it could affect the life expectancy of the cover or the reinforcement beneath.

Impression branding is not as widely practiced as is molded branding. Continuous impression brands have been employed on unvulcanized hose by use of an unheated wheel. This method is not applicable to hose which has exterior mold pressure applied to consolidate the hose wall since the impressed area would be filled in and obliterated.

Labels/Decals

Rubber labels are produced in several ways. A rubber sheet is either printed or has deposited upon one surface a coating of latex or other liquid rubber composition having the desired legend in a contrasting color. An adhesive backing may be applied to the opposite side of the label sheet stock. The individual labels are then die cut to the prescribed size and shape.

Rubber labels can be applied to hose prior to vulcanization and adhered to the outer hose surface by the pressures applied during vulcanization. They can also be pre-vulcanized and applied to the outer surface after vulcanization by use of an adhesive.

In either circumstance, labels are not considered as permanent or as durable an identification as are the brands described above. A label, if imbedded in the cover, may remain serviceable throughout the life of the hose; however, a label which is applied to a hose after vulcanization is much more vulnerable to early obliteration.

Another type of identification encountered can best be described as a decal. Decals are usually applied to a hose after vulcanization and are attached to the outer surface by means of pressure sensitive adhesive system. As with rubber labels, a decal cannot be considered a permanent or durable means of identification.

Printed Identification

Printed Identification has come into wide use because of its economy, particularly in long-length production methods. In this process, the identification legend is continuously printed on the outer surface of a hose either before or after vulcanization. The length of the legend to be repeated at intervals is restricted to the circumference of the continuous printing device used. Usually, the circumference will permit the legend to be repeated more than once per revolution. Another consideration used in determining the length of the legend is the shortest length of hose to be cut and used in service.

Printed identification is not considered as permanent or as durable as is a branded identification, however, prudent choice of inks and method of printing provide a reasonable means of identification. Printing before vulcanization is preferable for providing moderate durability. Printed identification provides the most convenient means of providing date coding where such information is required or desirable to assure that the product is being used within a specific period of time after production. Such printing may also provide a means of tracing a hose to its source and time of production.

Printed identification at specific locations along the length of a hose is practiced only on a small scale. The required legend may be applied by various printing methods, by hot stamping transfer from colored foil, or by stenciling.

The ability to use these methods is controlled by the size, length and weight of the hose in question and where the identification must appear on the hose length.

Stencil identification is widely used in identifying woven-jacketed hoses such as fire hose; such labeling is reasonably permanent due to ink penetration of the jacket yarns.

Exterior Surface Identification (Ribs, Plateaus, Grooves)

It is possible to manufacture hose having an exterior patterned surface of ribs or plateaus projecting from the surface, or having grooves below the hose surface, which extend along the entire hose length. Efforts have been made to adopt specific patterns to identify certain types of hose and to use these patterns in place of brands, labels or printed identification. There has been no effective industry or national standard established for this kind of identification system and use of the method is discouraged.

One established standard that has been particularly effective is a code which uses patterns of ribs and plateaus to identify the manufacturer. The pattern of ribs and plateaus to be used by a manufacturer is assigned by the Rubber Manufacturers Association (RMA), General Products Group, primarily for the identification of extruded products. Many hose manufacturers have obtained a pattern assignment and may be equipped to provide hose with their assigned identification code.

Colored Yarn or Cord Identification

In some methods of hose manufacture, it is possible and convenient to incorporate one or more yarns or cords having distinctive color (s) contrasting with the basic color of the reinforcement. Such a yarn or cord could be of the same size and composition as the basic reinforcement and be used in one or more locations in the reinforcement con-figuration. It could be different in size and composition and inserted in an alternate but compatible manner, e.g., spiraled and/or laid in longitudinally, in the reinforcement.

The General Products Group of the RMA, in response to a request from the Society of Automotive Engineers, has established and administered a system of using colored yarns to identify hose manufacturers. Initially, the colored yarn system was applicable to only brake hose manufacturers but, in response to worldwide requests for colored yarn code assignments, the restriction was removed.

Most U.S. hose manufacturers have been assigned codes. The use of hose identified by colored yarns incorporated into their structure is more reliable in identifying the manufacturer than hose marked on the exterior surface since the interior colored yarn is more likely to be retained and remain identifiable throughout the entire life of the hose.

TOLERANCES
Chapter 4

Dimensional tolerances attainable in hose are determined by the method of manufacturing. The tolerances given in this handbook are those which have been found practical in commercial usage and are satisfactory for the installation on hose of fittings and couplings and for security of attachment in service under normal circumstances.

Customers requiring use of zero defects acceptance sampling plans should understand that this will necessitate special handling and sorting procedures to attain the desired level of acceptance. Likewise, the requirement of tolerances tighter than those given will necessitate special handling and sorting procedures.

Most hose produced by conventional methods has good length stability and falls within the length tolerances shown in this chapter. However, some types of hose have a tendency to shrink or shorten more than normal during shipment or storage. This is especially true of hoses made with a helical wire embedded in the carcass. Consequently, the actual length should be determined by measuring under 10 psi (0.07 MPa) hydrostatic pressure. When these hoses are subjected to a nominal pressure, they generally will elongate to their original shipping length.

Class Identification

In order to provide for a quick and easy means of identifying the proper tolerances as set up by manufacturing methods, a code of three numbers with a letter has been devised. The first digit identifies the product by the broad general description of its method of manufacture. These numbers and their descriptions are as follows:

First Digit	Description
1	Textile — Braided, knitted or spiral wound
2	Wire — Braided or spiral wound
3	Machine made — Wrapped or spiralled ply
4	Hand built — Non-wire reinforced
5	Hand built — Wire reinforced
6	Circular woven — Fire hose
7	Circular woven — Chernack Loom
8	Dredging Sleeves

The second digit identifies the product by subdivisions of its method of manufacture. These numbers and their descriptions are as follows:

Second Digit	Description
1	Steel Mandrel
2	Flexible Mandrel
3	Non-Mandrel- Mold cured
4	Non-Mandrel- Non-Mold cured

The third digit distinguishes, where necessary, between tolerances on hose made with rubber cover as opposed to hose which is made without a rubber cover but with a cement protection. These numbers and their descriptions are as follows:

Third Digit	Description
1	No distinction between hose
2	Applies to rubber covered only
3	Applies to non-rubber covered only

The letter “A” designates that these are commercial tolerances.

Table 4-1
TEXTILE-BRAIDED, KNITTED, OR SPIRAL WOUND

Inside and Outside Diameter Tolerances

Hose Size		Steel-Mandrel Class 111-A				Flexible Mandrel Class 121-A				Non-Mandrel Mold Cure Class 131-A				Non-Mandrel Non-Mold Class 141-A			
		I.D.		O.D.		I.D.		O.D.		I.D.		O.D.		I.D.		O.D.	
Inch	mm	±inch	±mm	±inch	±mm	±inch	±mm	±inch	±mm	±inch	±mm	±inch	±mm	±inch	±mm	±inch	±mm
1/8	3.18	0.010	0.25	0.023	0.60	+0.023 -0.020	+0.60 -0.51	0.023	0.60	Not Made		Not Made		0.023	0.60	0.023	0.60
3/16	4.8	0.016	0.40	0.031	0.79	+0.023 -0.020	+0.60 -0.51	0.031	0.79	0.031	0.79	0.031	0.79	0.023	0.60	0.031	0.79
1/4	6.4	0.016	0.40	0.031	0.79	0.023	0.60	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79
5/16	7.9	0.016	0.40	0.031	0.79	0.023	0.60	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79
3/8	9.5	0.016	0.40	0.031	0.79	0.023	0.60	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79
7/16	11.1	0.023	0.60	0.031	0.79	+0.031 -0.023	+0.79 -0.60	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79
1/2	12.7	0.023	0.60	0.031	0.79	+0.031 -0.023	+0.79 -0.60	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79
5/8	15.9	0.023	0.60	0.031	0.79	+0.031 -0.023	+0.79 -0.60	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79
3/4	19.1	0.023	0.60	0.031	0.79	+0.031 -0.023	+0.79 -0.60	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79	0.031	0.79
7/8	22.2	0.023	0.60	0.031	0.79	+0.047 -0.031	+1.19 -0.79	0.031	0.79	0.047	1.19	0.047	1.19	0.047	1.19	0.047	1.19
1	25.4	0.031	0.79	0.031	0.79	+0.047 -0.031	+1.19 -0.79	0.031	0.79	0.063	1.59	0.063	1.59	0.063	1.59	0.063	1.59
1-1/4	31.8	0.039	1.00	0.047	1.19	+0.063 -0.031	+1.59 -0.79	0.047	1.19	0.063	1.59	0.063	1.59	0.063	1.59	0.063	1.59
1-1/2	38	0.039	1.00	0.047	1.19	+0.063 -0.031	+1.59 -0.79	0.063	1.59	0.063	1.59	0.063	1.59	0.063	1.59	0.063	1.59
2	51	0.039	1.00	0.063	1.59	Not Made		Not Made		0.063	1.59	0.063	1.59	0.063	1.59	0.063	1.59
2-1/2	64	0.047	1.19	0.063	1.59	Not Made		Not Made		Not Made		Not Made		Not Made		Not Made	
3	76	0.047	1.19	0.063	1.59	Not Made		Not Made		Not Made		Not Made		Not Made		Not Made	
3-1/2	89	0.063	1.59	0.063	1.59	Not Made		Not Made		Not Made		Not Made		Not Made		Not Made	
4	102	0.063	1.59	0.063	1.59	Not Made		Not Made		Not Made		Not Made		Not Made		Not Made	

NOTE: For Non-Mandrel Hose, if tapered plug is used, cut one inch ring from hose and use for determining inside diameter.

Table 4-2
WIRE-BRAIDED OR SPIRAL WOUND
Inside and Outside Diameter Tolerances
Rubber Covered and Non-Rubber Covered

		Mandrel Types							
		Rubber Cover Class 212-A and 222-A				Textile Cover* Class 213-A and 223-A			
Hose Size		I.D.		O.D.		I.D.		O.D.	
Inch	Millimeter	Inch	Millimeter	Inch	Millimeter	Inch	Millimeter	Inch	Millimeter
1/8	3.18	+0.031 -0.008	+0.79 -0.20	±0.031	±0.79	+0.023 -0.008	+0.60 -0.20	+0.031 -0.023	+0.79 -0.60
3/16	4.8	+0.031 -0.016	+0.79 -0.40	±0.031	±0.79	+0.031 -0.008	+0.79 -0.20	+0.031 -0.023	+0.79 -0.60
1/4	6.4	+0.031 -0.016	+0.79 -0.40	±0.031	±0.79	+0.035 -0.010	+0.89 -0.25	+0.031 -0.023	+0.79 -0.60
5/16	7.9	+0.031 -0.016	+0.79 -0.40	±0.031	±0.79	+0.035 -0.010	+0.89 -0.25	+0.031 -0.023	+0.79 -0.60
3/8	9.5	+0.031 -0.016	+0.79 -0.40	±0.031	±0.79	+0.035 -0.010	+0.89 -0.25	+0.031 -0.023	+0.79 -0.60
13/32	10.3	+0.039 -0.016	+1.00 -0.40	±0.031	±0.79	+0.039 -0.016	+1.00 -0.40	±0.031	+0.79
7/16	11.1	+0.039 -0.016	+1.00 -0.40	±0.031	±0.79	+0.039 -0.016	+1.00 -0.40	±0.031	±0.79
1/2	12.7	+0.039 -0.016	+1.00 -0.40	±0.031	±0.79	+0.047 -0.016	+1.19 -0.40	±0.031	±0.79
5/8	15.9	+0.039 -0.016	+1.00 -0.40	±0.031	±0.79	+0.047 -0.016	+1.19 -0.40	±0.031	±0.79
3/4	19.1	+0.039 -0.016	+1.00 -0.40	±0.031	±0.79	+0.047 -0.016	+1.19 -0.40	±0.031	±0.79
7/8	22.2	+0.047 -0.016	+1.19 -0.40	±0.047	±1.19	+0.047 -0.016	+1.19 -0.40	±0.031	±0.79
1	25.4	+0.047 -0.016	+1.19 -0.40	±0.047	±1.19	+0.047 -0.016	+1.19 -0.40	±0.047	±1.19
1-1/8	28.6	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59	+0.063 -0.016	+1.59 -0.40	+0.047	±1.19
1-1/4	31.8	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59	+0.063 -0.016	+1.59 -0.40	±0.047	±1.19
1-3/8	34.9	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59	+0.063 -0.016	+1.59 -0.40	±0.047	±1.19
1-1/2	38	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59	+0.063 -0.016	+1.59 -0.40	+0.047	±1.19
1-13/16	46	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59	+0.063 -0.016	+1.59 -0.40	±0.047	±1.19
2	51	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59	+0.063 -0.016	+1.59 -0.40	±0.047	±1.19
2-3/8	60	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59	+0.063 -0.016	+1.59 -0.40	±0.047	±1.19
2-1/2	64	+0.078 -0.016	+1.98 -0.40	±0.078	±1.98	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59
3	76	+0.078 -0.016	+1.98 -0.40	±0.078	±1.98	+0.063 -0.016	+1.59 -0.40	±0.063	±1.59
3-1/2	89	+0.078 -0.016	+1.98 -0.40	+0.078	±1.98	+0.078 -0.016	+1.98 -0.40	±0.078	±1.98
4	102	+0.078 -0.016	+1.98 -0.40	±0.078	±1.98	+0.078 -0.016	+1.98 -0.40	±0.078	±1.98

Note: Inside diameter measurements to be taken at least one inch from end of hose.
*Includes Textile- Wire-Textile style with thin rubber cover.

Table 4-3
MACHINE MADE WRAPPED OR SPIRALLED PLY
Inside and Outside Diameter Tolerances

Hose Size		Steel Mandrel Class 311-A				Non-Mandral Class 331-A and 341-A			
		I.D.		O.D.		I.D.		O.D.	
Inch	Millimeter	±Inch	±Millimeter	±Inch	±Millimeter	±Inch	±Millimeter	±Inch	±Millimeter
1/8	3.18	0.016	0.40	0.031	0.79	0.016	0.40	+0.031 −0.016	+0.79 −0.40
3/16	4.8	0.016	0.40	0.031	0.79	0.016	0.40	0.031	0.79
1/4	6.4	0.016	0.40	0.031	0.79	0.016	0.40	0.031	0.79
5/16	7.9	0.016	0.40	0.031	0.79	0.023	0.60	0.031	0.79
3/8	9.5	0.016	0.40	0.031	0.79	0.031	0.79	0.031	0.79
7/16	11.1	0.031	0.79	0.031	0.79				
1/2	12.7	0.031	0.79	0.031	0.79				
5/8	15.9	0.031	0.79	0.031	0.79				
3/4	19.1	0.031	0.79	0.031	0.79				
7/8	22.2	0.031	0.79	0.031	0.79				
1	25.4	0.031	0.79	0.063	1.59				
1-1/4	31.8	0.031	0.79	0.063	1.59				
1-1/2	38	0.031	0.79	0.063	1.59				
2	51	0.063	1.59	0.063	1.59				
2-1/2	64	0.063	1.59	0.063	1.59				
3	76	0.063	1.59	0.063	1.59				
3-1/2	89	0.063	1.59	0.063	1.59				
4	102	0.063	1.59	0.063	1.59				
4-1/2	114	0.063	1.59	0.094	2.38				
5	127	0.063	1.59	0.094	2.38				
6	152	0.063	1.59	0.094	2.38				

Table 4-4
HAND-BUILT HOSE
Non-Wire Reinforced
Wire Reinforced
Class 411-A and 511-A

Size I.D.	I.D. ±Inch	O.D. ±Millimeter	±Inch	±Millimeter
3/4 inch (19mm) and smaller	0.031	0.79	0.031	0.79
Over 3/4 through 2 inch (19-51 mm)	0.031	0.79	0.094	2.38
Over 2 through 3 inch (51-76mm)	0.063	1.59	0.125	3.18
Over 3 through 8 inch (76-203)	+0.063 −0.250	+1.59 −6.4	0.188	4.8
Over 8 inch (203 mm)	+0.125 −0.250	+3.18 −6.4	0.250	6.4
Enlarged Ends (All Sizes)	Same as Hose Sizes		Same as Hose Sizes	

Note: The OD tolerances do not apply to corrugated or convoluted hose.

Table 4-5
CIRCULAR WOVEN - FIRE HOSE TOLERANCES
Class 643-A

Inside diameter tolerances are based on the necessity of obtaining the maximum volume of water possible for a given size of hose. Consequently, minus tolerances are not acceptable.

The length tolerances are:

Length Ordered		Minimum Average(*) Length of Shipment		Minimum Length(*) of individual pcs.	
Feet	**Meters**	**Feet**	**Meters**	**Feet**	**Meters**
25	7.5	25	7.5	24**	7.3**
50	15.0	50	15.0	48***	14.6***
75	22.5	75	22.5	72	21.9
100	30.0	100	30.0	97	29.6

* Length to be measured back of coupling to back of coupling under 10 psi (0.07 MPa).
** Except length from which burst test sample has been taken may be 22 feet (6.7 m).
*** Except length from which burst test sample has been taken may be 47 feet (14.3 m).

The I.D. tolerances are:

(a) On all sizes except 2-1/2 in. (64 mm)I.D., no minus tolerance is permissible. No plus tolerance is set.
(b) On the 2-1/2 in. (64 mm) I.D. size, the minimum inside diameters shall be not less than 2.56 inches (65 mm). No plus tolerance is set.

Table 4-6
CIRCULAR WOVEN CHERNACK LOOM
Class 711-A: 721-A; and 731-A

Size —- I.D.	I.D.		O.D.	
	±Inch	**±Millimeter**	**±Inch**	**±Millimeter**
Up to 1 inch (25.4 mm)	+0.047 −0.031	+1.19 −0.79	0.031	0.79
1 in. thru 3 in. (25 mm thru 76 mm)	0.063	1.59	0.063	1.59
Over 3 in. (76 mm)	0.094	2.38	0.094	2.38

Table 4-7
DREDGING SLEEVES
Class 811-A

Size —- I.D.	I.D.		O.D.	
	±Inch	**±Millimeter**	**±Inch**	**±Millimeter**
Under 12 inch (305 mm)	0.125	3.18	0.125	3.18
12 Inch (305 mm) and over	0.250	6.4	0.250	6.4

Table 4-8
LENGTH TOLERANCES
Tolerances for Specific Cut Lengths of Hose

These tolerances apply to hose which is made in conventional lengths and then cut to specified shorter pieces.

Length		Tolerances	
Inch	**Metric**	**±Inch**	**±Millimeters**
12 and under	305 mm and under	0.125	3.18mm
Over 12 through 24	305 mm through 610 mm	0.188	4.8mm
Over 24 through 36	610 mm through 915 mm	0.250	6.4mm
Over 36 through 48	915 mm through 1.22 m	0.375	9.5mm
Over 48 through 72	1.22 m through 1.83 m	0.500	12.7mm
Over 72	1.83 m	1%	1%

Note: For tolerances of curved-to-shape hose, see SAE J20 or J30.

Tolerances for Hose Built to Length

When fittings or special ends are built-in the hose at the time of manufacture, tolerance is applied to overall length.

Length		Tolerances	
Feet	**Meters**	**±Inch**	**±Millimeters**
5 and under	1.5 and under	1	25.4
Over 5 through 10	1.5 through 3.0	1.5	38
Over 10 through 20	3.0 through 6.0	2.5	64
Over 20	6.0	1%	1%

Note: These tolerances should not be applied to corrugated or convoluted hose.

Squareness of Ends

Ends must be cut square within the tolerance limits shown below:

Size		Maximum Variation	
Inch	**Millimeters**	**±Inch**	**±Millimeters**
3/4 and under	19.1 and under	0.063	1.59 mm
Over 3/4 through 2	19.1 through 51	0.125	3.18 mm
Over 2 through 6	51 through 152	0.250	6.4 mm

Note: These tolerances should not be applied to hose containing helical reinforcing wire where wire will protrude from the end when cut.

COUPLINGS
Chapter 5

CAUTION! Because the hose/coupling interface is critical to hose assembly performance, always follow the specific instructions of hose and couplings manufacturers regarding the match of hose/fittings and assembly procedures. Trained personnel using proper tools and procedures should make hose assemblies. Failure to follow manufacturer's instructions or failure to use trained personnel might be dangerous and could result in damage to property and serious bodily injury.

The value of a hose is enhanced by the proper selection of couplings. Couplings attach to the end of hose in order to facilitate connection to a pressure source. In order to make this transition successful, the coupling termination must provide a leak proof seal and the hose/coupling interface must be properly matched.

The three basic methods for making leak proof terminations are:

1. Washer seal
2. Mechanical seal
3. Thread seal

Examples of each connection type are shown in Figure 5-1.

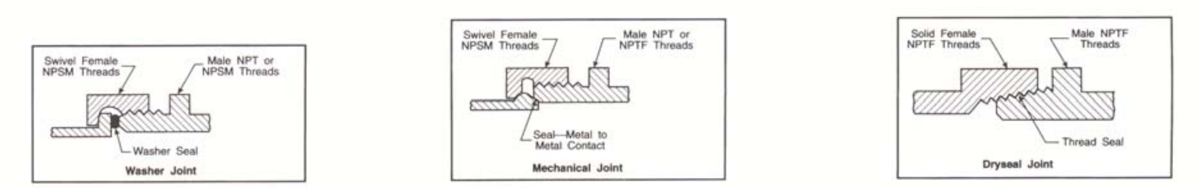


Figure 5-1
Methods for Leakproof Terminations

Common North American tread types are:

Abbreviation	Thread Name	Seal Method	Thread Compatibility
GHT	Garden Hose Thread	Washer Seal	GHT - - GHT
JIC 37° Flare	Joint Industrial Committee	Mechanical Seal	JIC Male - - JIC Female
NH or NST	American Standard Fire Hose Thread National Hose or National Standard Thread	Washer Seal	NH or NST -- NH or NST
NPT	American Standard Taper Pipe Thread National Pipe Thread	Thread Seal Or Washer Seal	NPT - - NPT or NPTF
NPTF	American Standard Taper Pipe Fuel Dryseal Thread National Pipe Tapered Fuel	Thread Seal Or Washer Seal	NPTF - - NPTF or NPT

NPSH	American Standard Straight Pipe for Hose Couplings National Pipe Straight Hose	Washer Seal	NPSH - - NPSH or NPT
NPSM	American Standard Straight Mechanical Joints National Pipe Straight Mechanical	Washer Seal Or Mechanical Seal	NPSM - - NPSM, NPT or NPTF
SAE 45° Flare	Society of Automotive Engineers	Mechanical Seal	SAE Male – SAE Female

Note – Thread sealant is required for Thread Seal connections except for NPTF during initial use.

Note – Compatibility of thread types does not insure compatibility of fittings. Always use mating fittings of the same type.

For detail drawings of various thread types, see ANSI B.2.

The hose/coupling interface is not as straightforward as coupling terminations. Because of the difficulty in making the transition between rigid or high modulus materials such as metal to flexible or low modulus materials such as rubber, numerous coupling configurations have evolved. In an attempt to generally describe common coupling configurations, the coupling types will be broken down into the following categories:

1. Reusable shanks with clamps
2. Reusable couplings without clamps
3. Non-reusable couplings
4. Special Purpose fittings and clamps

REUSABLE SHANKS WITH CLAMPS

This category of coupling consists of a shank, that can often be reused, and banding clamps. To simplify the category, it can be divided into short shank, long shank, interlocking type, and compression ring type couplings.

A. Short Shank - The definition of a short shank coupling is the shank is only long enough to accommodate a single banding clamp. This type coupling is suitable for low-pressure service in air, water, and suction applications. This type coupling is not recommended for pressures exceeding 50 psi (0.35 MPa) when used in hoses with diameters (I.D.) 2 inches (50 mm) or larger. Examples of a short shank coupling are shown in Figures 5-2a & 5-2b.

Figure 5-2a.

Figure 5-2b.

Short shank couplings

Figure 5-3. Long shank coupling for water applications.

B. Long Shank - The serrated shank on this type coupling is long enough to permit the use of two or more banding clamps. The additional shank length and banding clamp allows the coupling to be used in medium pressure applications such as air, water, oil, gasoline, and chemical discharge. This type coupling is not recommended for pressures exceeding 100 psi (0.69 MPa) when used in hoses with diameters (I.D.) 4 inches (100 mm) or larger. Examples of long shank couplings are shown in Figures 5-3, 5-4, 5-5 and 5-6.

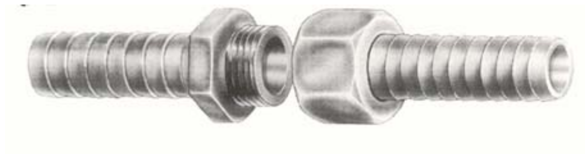


Figure 5-4. **Long shank coupling for small I.D. air applications.**

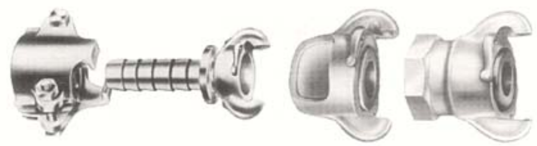


Figure 5-5. **Long shank coupling with quick connect termination for air applications.**

Figure 5-6. **Long shank coupling made of brass or aluminum for oil, gasoline, chemical delivery applications.**

C. Interlocking type - For higher-pressure applications, such as steam, it is important to use clamps that interlock with the shank such that the shank is held firmly in place. Two, four, and six bolt clamps offer a further advantage of being able to be tightened during service to compensate for rubber set or flow. An example of a four-bolt steam hose coupling is shown in Figure 5-7.

Interlocking, Ground Joint Interlocking, Washer Joint

Figure 5-7. **Four bolt interlocking joint**

D. Compression Ring Type - Compression ring couplings have a recess over the shank that is tapered. A compression sleeve that encircles the hose has a matching internal taper. When the collar is tightened, the ring is compressed into the hose cover. This type of coupling is generally used for oil and gasoline delivery applications. See Figure 5-8 for an example of a compression ring type coupling.

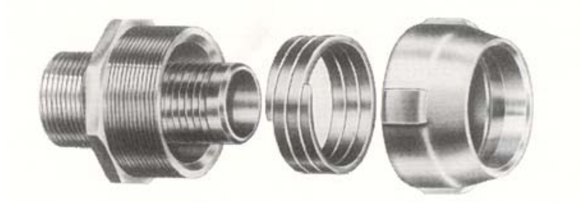


Figure 5-8. **Compression Ring Type Coupling**

REUSABLE COUPLINGS WITHOUT CLAMPS

The reusable couplings without clamps category can be broken down into two main types, screw type and push-on type.

A. Screw type - This type of reusable coupling consists of a threaded socket and shank. The socket is placed on the hose end and then the shank is screwed into the threaded portion of the socket until the shank is seated against the socket. The hose wall is compressed between the socket and shank to provide the coupling hold. Applications for screw type reusable couplings are gasoline pump hose and hydraulic hose. See Figure 5-9 and 5-10.

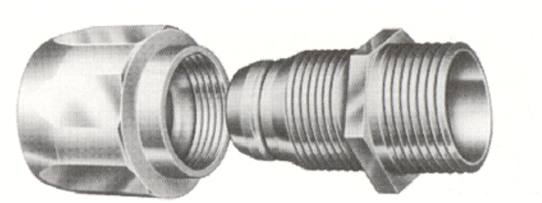


Figure 5-9. **Gasoline pump hose coupling is made of chromed brass in order to provide a non-sparking feature.**

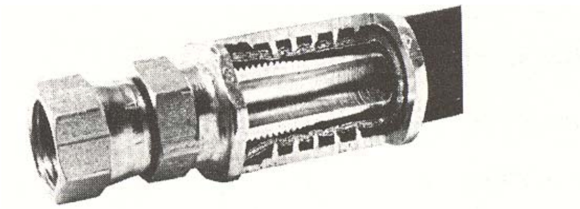


Figure 5-10. Reusable hydraulic hose couplings.

B. Push-on Couplings - This type of coupling functions without the use of bands or sockets; however, it does require the use of specially designed hose. The coupling consists of a male serrated shank. The couplings are available in sizes 0.250 inches (6.4 mm) through 0.750 inches (19 mm) and are generally satisfactory for working pressures to 250 psi (1.75 MPa). See Figure 5-11.

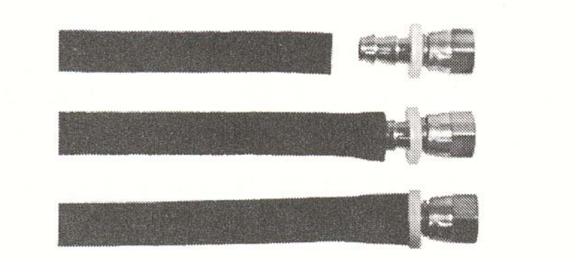


Figure 5-11. Installation of push-on type couplings.

NON-REUSABLE COUPLINGS

Generally, there are four types of non-reusable couplings: swaged-on, crimped-on, internally expanded, and built-in fittings.

A. Swaged-on Couplings - This type of coupling is applied by using special equipment to "swage" a ferule on to the outside of the hose. "Swaging" is defined as squeezing the ferule by passing it lengthwise into a split die. This type of coupling is often used with thermoplastic hose. See Figure 5-12.

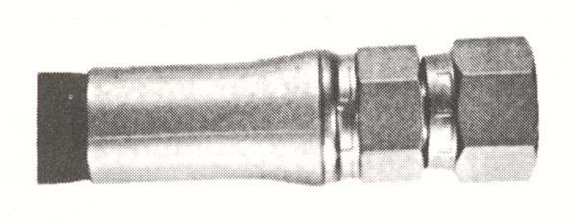


Figure 5-12. Swaged-on Coupling

B. Crimped-on Couplings - This type of coupling is applied by crimping or compressing it radially by a number of fingers moving toward the hose axis. This coupling attachment method is versatile since crimped assemblies can be made with low-pressure hose, as well as high-pressure hydraulic hose. See Figure 5-13.

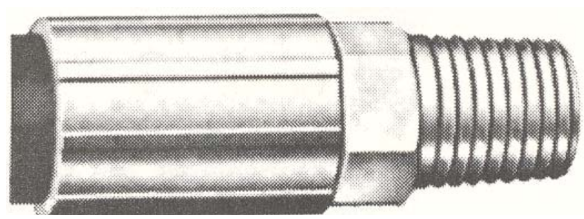


Figure 5-13. Crimped-on Coupling

C. Internally Expanded Full Flow Couplings - This type of coupling is used in applications where full flow is required such as oil, gasoline, chemical, and food transfer hose. The coupling is attached by passing an expander through the I.D. of the shank. This expands the shank, thus providing compression of the hose wall to aid in coupling retention while achieving full flow characteristics. See Figure 5-14.

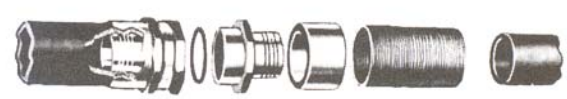


Figure 5-14. Internally Expanded Full

D. Built-in Fittings - Large bore hose is commonly manufactured with built-in fittings. The primary reason is that the fittings need to be attached to the hose body in order to withstand the end thrust pressures. Common types are built-in nipples (BIN), built-in nipple flange (BINF), built-in rubber covered flange (BIRF), and beaded ends with split ring flanges (BE). Examples of each are shown in Figures 5-15 through 5-18.

Figure 5-15. BIN

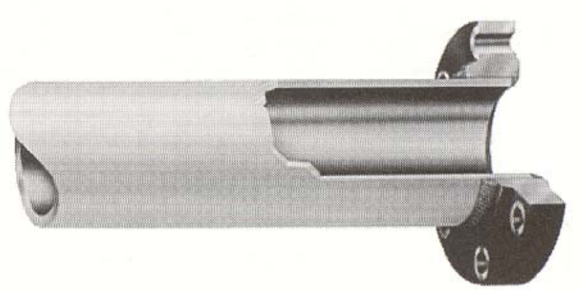


Figure 5-16. BINF

Figure 5-17. BIRF

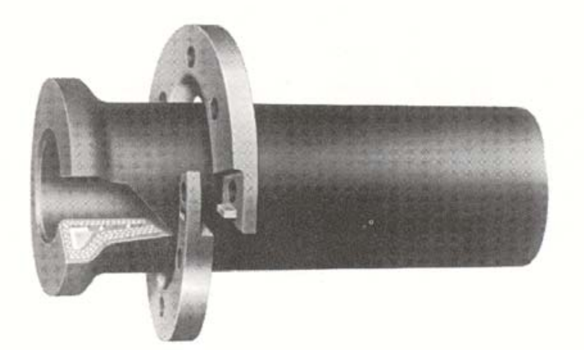


Figure 5-18. BE

SPECIAL COUPLINGS AND CLAMPS

There are many coupling and clamp variations on the market which have been adapted for special applications. Some of these special couplings and clamps are:

A. Sand Blast Sleeve Fittings - This fitting is designed so that the material carried through the hose does not contact the metal. It is used for sand blast and cement placement hose. See Figure 5-19.

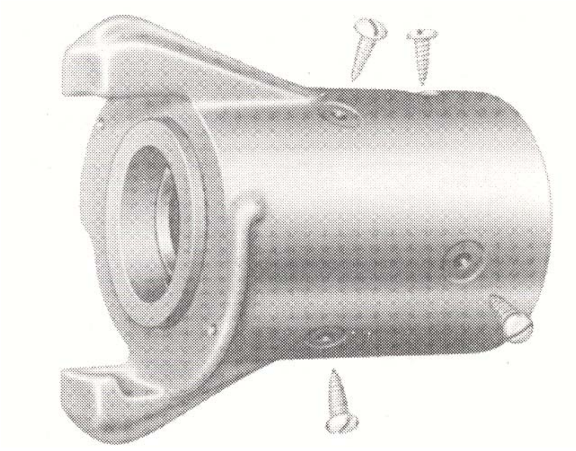


Figure 5-19. Sand Blast Sleeve Fitting

B. Radiator and Heater Clamps - Automotive coolant hose applications often use reusable clamps to attach the hose to the radiator, heater, or engine. These clamps can also be used for low-pressure water discharge applications. Examples of these clamps are shown in Figure 5-20.

Figure 5-20. Low pressure clamps.

Another low-pressure clamp is referred to as a “constant tension” type clamp. This clamp has the ability to provide constant sealing force over a narrow range of OD’ s, thus accommodating changes in hose and stem OD’ s due to thermal expansion and contraction along with compression set of the hose. See Figure 5-21.

Figure 5-21. Constant Tension Clamp

C. Gasoline Pump Hose Couplings - Similar to an internally expanded full flow coupling, this type is primarily used for gasoline pump hose.

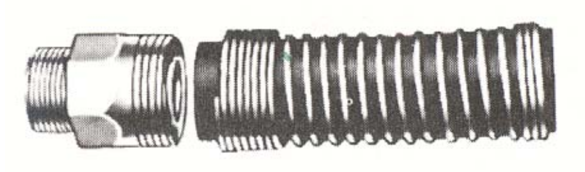


Figure 5-22. Gasoline Pump Hose Full Flow Coupling

D. Coaxial Gasoline Pump Couplings - This type of coupling accommodates a hose within a hose such that gasoline is delivered through the inner hose and vapors are

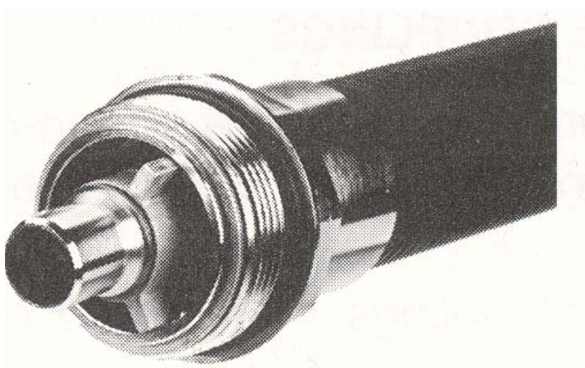


Figure 5-23. Coaxial Gasoline Coupling

E. Welding Hose Couplings - These couplings have machined brass shanks with right and left-handed threads to prevent mixing up the acetylene and oxygen lines.

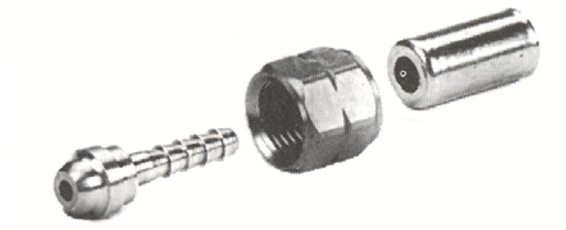


Figure 5-24. Welding Hose Couplings

F. Fire Hose Couplings - For fire hose, expansion ring type couplings are used. The bowl of the coupling fits over the hose end and the hose is forced against the inner surface of the bowl by an expansion ring. This type of coupling is reusable, but

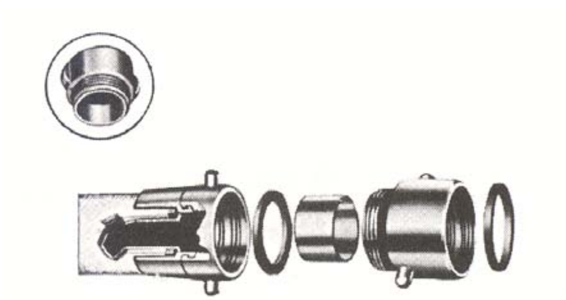


Figure 5-25. Fire Hose Coupling

COUPLING PROCEDURE

Proper coupling selection and installation are critical for hose assembly performance. Consult the hose and/or coupling manufacturer for coupling recommendations and proper installation instructions. Trained personnel using the recommended tools and procedures should make hose assemblies.

Additional guidance for NAHAD members can be obtained using the Hose Assembly Guidelines for Industrial, Composite, PTFE, Hydraulic and Flexible Metal hose assemblies. The guidelines are available at www.nahad.org.

TABLE 5-1
CORROSION RESISTANCE OF COUPLING MATERIALS

CAUTION: The following data has been compiled from generally available sources and should not be relied upon without consulting and following the specific recommendations of the manufacturer regarding particular coupling materials.

RATINGS:
1. Excellent
2. Good
3. Fair or conditional
X. Not Satisfactory

NOTE: No rating indicates no data available

AGENT	Steel/Iron	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 202, 304, 308	Stainless 316	Monel
Acetate, Solvents, Crude		3				2	1	1	2
Acetate, Solvents, Pure		1	1	1		1	1	1	1
Acetic Acid	X	X	X	2	1	X	2	2	2
Acetic Acid Vapors	X	X		3		X	2	2	3
Acetic Anhydride	X	X		2		X	2	2	2
Acetone	1	1	1	1	1	1	1	1	1
Acetylene	1	2		1		1	1	1	2
Alcohols	1	2		1		1	1	1	1
Aluminum Sulfate	X	3	3	3	1	X	3	2	2
Alums	X	3	2	3	1	X	3	2	2
Ammonia Gas	1	X	3	1	3	1	1	1	X
Ammonium Chloride	1	3		1*		3	3	1	1
Ammonium Hydroxide	2	X		2		1	1	1	3
Ammonium Nitrate	1	X		2		1	1	1	3
Ammonium Phosphate (Ammoniacal)		X				1	1	1	2
Ammonium Phosphate (Neutral)		3				1	1	1	2
Ammonium Phosphate (Acid)		3				3	2	1	2
Ammonium Sulfate	1	3				2	1	1	2
Asphalt	1	2				2	1	1	1
Beer	2	2	1	1		X	1	1	1
Beet Sugar Liquors	1	2		1		2	1	1	1
Benzene, Benzol	1	1	1	1	1	1	1	1	1
Benzine (petroleum-naphtha)	1	1		1		1	1	1	1
Borax	2	2				1	1	1	1
Boric Acid	X	3		1		3	2	1	1
Butane, Butylene	1	1	1	1		1	1	1	1
Butadiene		1				1	1	1	1

*3 to X at high temperatures

TABLE 5-1 (Continued)
CORROSION RESISTANCE OF COUPLING MATERIALS

CAUTION: The following data has been compiled from generally available sources and should not be relied upon without consulting and following the specific recommendations of the manufacturer regarding particular coupling materials.

RATINGS:
1. **Excellent**
2. **Good**
3. **Fair or conditional**

X. Not Satisfactory

NOTE: No rating indicates no data available

AGENT	Steel/Iron	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 202, 304, 308	Stainless 316	Monel
Calcium Bisulfate		X				X	2	1	X
Calcium Hypochlorite	3	3	3	X	3	X	3	2	3
Cane Sugar Liquors	1	2		1		2	1	1	1
Carbon Dioxide (Dry)	1	1		1		1	1	1	1
Carbon Dioxide (Wet & Aqueous Sol)	2	3		2		2	1	1	1
Carbon Disulfide	2	3		2		2	1	1	3
Carbon Tetrachloride	3	1	2	3	1	1	1	1	1
Chlorine(Dry)	2	2	2	1	2	2	2	2	1
Chlorine (Wet)	X	X	3	X	2	X	X	3	3
Chromic Acid		X	X	X	1	3	2	2	3
Citric Acid	X	3		1		3	X	1	2
Coke Oven Gas	1	3		2		1	1	1	2
Copper Sulfate	X	X		X		1	1	1	3
Core Oils		1	1			1	1	1	1
Cottonseed Oil	1	1	1	1		1	1	1	1
Creosote	2	3		1		1	1	1	1
Ethers	2	1		1		1	1	1	1
Ethylene Glycol	2	2				1	1	1	1
Ferric Chloride	X	X	X	X	1	X	X	X	X
Ferric Sulfate	X	X		X		1	1	1	3
Formaldehyde	2	2		2		1	1	1	1
Formic Acid	X	2		X		X	2	1	2
Formic Acid	X	2		X		X	2	1	2
Freon	3	1	1	1		1	1	1	1
Furfural	1	2		1		1	1	1	1

TABLE 5-1 (Continued)
CORROSION RESISTANCE OF COUPLING MATERIALS

CAUTION: The following data has been compiled from generally available sources end should not be relied upon without consulting and following the specific recommendations of the manufacturer regarding particular coupling materials.

RATINGS:
1. Excellent
2. Good
3. Fair or conditional
X. Not Satisfactory

NOTE: No rating indicates no data available

AGENT	Steel/Iron	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 202, 304, 308	Stainless 316	Monel
Gasoline (Sour)	3	3		3		3	1	1	X
Gasoline (Refined)	1	1	1	1		1	1	1	1
Gelatin	1	3		1		1	1	1	1
Glucose	1	1		1		1	1	1	1
Glue	1	3		1		1	1	1	1
Glycerine or Glycerol	1	2		1		1	1	1	1
Hydrochloric Acid	X	X	X	X	1	X	X	X	X
Hydrocyanic Acid	3	X		1		3	1	1	2
Hydrofluoric Acid	X	3	3	X	X	X	X	X	1
Hydrogen Fluoride		3				X	X	3	1
Hydrogen	1	1		1		1	1	1	1
Hydrogen Peroxide	X	X		1		1	2	1	2
Hydrogen Sulfide (Dry)	3	3		2		3	2	1	3
Hydrogen Sulfide (Wet)	3	3		2		3	2	1	3
Lacquers and Lacquer Solvents	3	2		1		1	1	1	1
Lactic Acid	X			3			3	2	1
Lime-Sulfur	2	X		2		1	1	2	
Linseed Oil	1	1		1			1	1	1
Magnesium Chloride	3	3		X		3	2	1	1
Magnesium Hydroxide	1	2		X		1	1	1	1
Magnesium Sulfate	2	2		3		1	1	1	1
Mercuric Chloride	3	X		X		X	X	3	X
Mercury	1	X		X		1	1	1	2
Milk	3	3		1		2	1	1	3
Molasses	2	X		2		2	1	1	1
Natural Gas	1	2		1		1	1	1	1
Nickel Chloride		X		X		X	3	2	2
Nickel Sulfate		3		X		3	2	1	1
Nitric Acid	X	X	X	3	1	2	2	2	X

TABLE 5-1 (Continued)
CORROSION RESISTANCE OF COUPLING MATERIALS

CAUTION: The following data has been compiled from generally available sources and should not be relied upon without consulting and following the specific recommendations of the manufacturer regarding particular coupling materials.

RATINGS:
1. **Excellent**
2. **Good**
3. **Fair or conditional**

X. Not Satisfactory

NOTE: No rating indicates no data available

AGENT	Steel/Iron	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 202, 304, 308	Stainless 316	Monel
Oleic Acid	2	3		1		2	2	1	1
Oxalic Acid	3	3		2		3	2	1	1
Oxygen	1	1	1	1		1	1	1	1
Palmitic Acid	1	3		1		2	2	1	1
Petroleum Oils (Sour)		3				3	1	1	X
Petroleum Oils (Refined)	1	1	1	1		1	1	1	1
Phosphoric Acid - 25%	3	X		3	3	X	3	1	2
Phosphoric Acid - 25-50%	X	X		X	3	X	X	2	2
Phosphoric Acid - 50-85°/a	X	X		X	X	X	X	2	2
Picric Acid	3	X		3		2	1	1	X
Potassium Chloride	2	3		3		3	2	1	1
Potassium Hydroxide	3	X		X		1	1	1	1
Potassium Sulfate	2	2		1		1	1	1	1
Propane	1	1				1	1	1	1
Rosin (Dark)	1	2			1	1	1	1	1
Rosin (Light)		X		1		1	1	1	2
Shellac		2		2		1	1	1	1
Sludge Acid		X				X	X	3	2
Soda Ash (Sodium Carbonate)	1	2		X		1	1	1	1
Sodium Bicarbonate	3	1		X		1	1	1	1
Sodium Bisulfate	X	3		3		X	1	1	1
Sodium Chloride	2	3	2	X	1	3	2	1	1
Sodium Cyanide	2	X		X		1	1	1	2
Sodium Hydroxide	3	X	3	X	X	2	2	2	1
Sodium Hypochlorite	X	X		X		X	3	2	3
Sodium Metaphosphate	X	3		1		2	1	1	1
Sodium Nitrate	1	3		1		1	1	1	1
Sodium Perborate	3	3		1		1	1	1	1
Sodium Peroxide	3	3		1		1	1	1	1

TABLE 5-1 (Continued)
CORROSION RESISTANCE OF COUPLING MATERIALS

CAUTION: The following data has been compiled from generally available sources and should not be relied upon without consulting and following the specific recommendations of the manufacturer regarding particular coupling materials.

RATINGS:
1. Excellent
2. Good
3. Fair or conditional
X. Not Satisfactory

NOTE: No rating indicates no data available

AGENT	Steel/Iron	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 202, 304, 308	Stainless 316	Monel
Sodium Sulfate	1	2		3		1	1	1	1
Sodium Sulfide	1	X				1	1	1	2
Sodium Thiosulfate (Hypo)	3	X		X		1	1	1	2
Stearic Acid	3	3		3		2	2	1	1
Sulfate Liquors		X				1	1	1	2
Sulfur	2	X		2		2	2	1	3
Sulfur Chloride	X	X				X	3	2	2
Sulfur Dioxide (Dry)	2	1		1		1	1	1	1
Sulfur Dioxide (Wet)		X				X	2	1	X
Sulfuric Acid 10%	X	X	3	3		X	X	2	2
Sulfuric Acid 10-75%	X	X	X	X		X	X	X	2
Sulfuric Acid 75-95%	3	X	X	X		3	3	2	3
Sulfuric Acid 95%	2	X	X			2	2	2	X
Sulfurous Acid	X	X		X		X	3	2	X
Tannic Acid	3	3	1	X			1	1	1
Tar	1	2		1		2	1	1	1
Toluene, Toluol	1	1		1		1	1	1	1
Trichlorethylene	3	1		3		1	1	1	1
Turpentine		3		1		3	1	1	1
Varnish	2	2				1	1	1	1
Vegetable Oils	1	2		1		1	1	1	1
Vinegar	3	3		3		3	2	1	2
Water (Acid Mine Water)	3	X		3		2	1	1	3
Water (Fresh)	3	1		1		1	1	1	1
Water (Salt)	3	3	2	X		3	2	2	1
Whiskey	X	2				3	1	1	2
Wines	X	2		1		3	1	1	2
Xylene, Xylol	2	1		1		1	1	1	1
Zinc Chloride	X	X		X		3	2	1	1
Zinc Sulfate	3	3		3		3	2	1	1

HOSE TESTING
Chapter 6

SAFETY WARNING: Testing can be dangerous and should be done only by trained personnel using proper tools and procedures. Failure to follow such procedures might result in damage to property and/ or serious bodily injury.

The Rubber Manufacturers Association (RMA) recognizes, accepts and recommends the testing methods of the American Society for Testing and Materials (ASTM).

Unless otherwise specified, all hose tests are to be conducted in accordance with ASTM Method No. D-380 (latest revision). Where an ASTM D-380 test is not available, another test method should be selected and described in detail.

RMA participates with ASTM under the auspices of the American National Standards Institute (ANSI) in Technical Committee 45 (TC45) of The International Organization for Standardization (ISO) in developing both hose product and hose test method standards. Many of the hose test method standards published by ISO duplicate or closely parallel those shown in ASTM D-380. Many are unique and, in those cases, the RMA may be able to provide the necessary test standard references which may be purchased from the American National Standards Institute (ANSI).

HYDROSTATIC PRESSURE TESTS

Hydrostatic pressure tests are classified as follows:

1. DESTRUCTIVE TYPE
   a. Burst test
   b. Hold test
2. NON-DESTRUCTIVE TYPE
   a. Proof pressure test
   b. Change in length test (elongation or contraction)
   c. Change in outside diameter or circumference test
   d. Warp test
   e. Rise test
   f. Twist test
   g. Kink test
   h. Volumetric expansion test

Destructive Tests

Destructive tests are conducted on short specimens of hose, normally 18 inches (460 mm) to 36 inches (915 mm) in length and, as the name implies, the hose is destroyed in the performance of the test.

a. Burst pressure is recorded as the pressure at which actual rupture of a hose occurs.

b. A hold test, when required, is a means of determining whether weakness will develop under a given pressure for a specified period of time.

Non-Destructive Tests

Non-destructive tests are conducted on a full length of a hose or hose assembly. These test are for the purpose of eliminating hose with defects which cannot be seen by visual examination or in order to determine certain characteristics of the hose while it is under internal pressure.

a. A proof pressure test is normally applied to hose for a specified period of time. On new hose, the proof pressure is usually 50% of the minimum specified burst except for woven jacket fire hose where the proof pressure is twice the service test pressure marked on the hose (67% of specified minimum burst). Hydrostatic tests performed on fire hose in service should be no higher than the service test pressure referred to above. The regulation of these pressures is extremely important so that no deteriorating stresses will be applied, thus weakening a normal hose.

b. 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 spiralled hose, are made with original length measurements taken under a pressure of 10 psi (0.069 MPa). The specified pressure, which is normally the proof 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 (0.069 MPa) (except wire braided or wire spiralled) and that at the proof pressure times 100 divided by the length at 10 psi (0.069 MPa). Elongation occurs if the length of the hose under the proof pressure is greater than at a pressure of 10 psi (0.069 MPa). Contraction occurs if the length at the proof pressure is less than at 10 psi (0.069 MPa). In testing wire braided or spiralled hose, the proof pressure is applied and the length recorded. The pressure is then released and, at the end of 30 seconds, the length is measured; the measurement obtained is termed the "original length."

c. Percent change in outside diameter or circumference is the difference between the outside diameter or circumference at 10 psi (0.069 MPa) and that obtained under the proof pressure times 100 divided by the outside diameter or circumference at 10 psi (0.069 MPa).

   Expansion occurs if the measurement at the proof pressure is greater than at 10 psi (0.069 MPa). Contraction occurs if the measurement at the proof pressure is less than at 10 psi (0.069 MPa).

d. Warp is the deviation from a straight line drawn from fitting to fitting; the maximum deviation from this line is warp. First, a measurement is taken at 10 psi (0.069 MPa) and then again at the proof pressure. The difference between the two, in inches, is the warp. Normally this is a feature measured on woven jacket fire hose only.

e. Rise is a measure of the height a hose rises from the surface of the test table while under pressure. The difference between the rise at 10 psi (0.069 MPa) and at the proof pressure is reported to the nearest 0.25 inch (6.4 mm). Normally, this is a feature measured on woven jacket fire hose only.

f. Twist is a rotation of the free end of the hose while under pressure. A first reading is taken at 10 psi (0.069 MPa) and a second reading at proof pressure. The difference, in degrees, between the 10 psi (0.069 MPa) base and that at the proof pressure is the twist. Twist is reported as right twist (to tighten couplings) or left twist. Standing at the pressure inlet and looking toward the free end of a hose, a clockwise turning is right twist and counterclockwise is left twist.

g. Kink test is a measure of the ability of woven jacket hose to withstand a momentary pressure while the hose is bent back sharply on itself at a point approximately 18 inches (457 mm) from one end. Test is made at pressures ranging from 62% of the proof pressure on sizes 3 inches (76 mm) and 3.5 inches (89 mm) to 87% on sizes under 3 inches (76 mm). This is a test applied to woven jacket fire hose only.

h. Volumetric expansion test is applicable only to specific types of hose, such as hydraulic or power steering hose, and is a measure of its volumetric expansion under ranges of internal pressure.

DESIGN CONSIDERATIONS

In designing hose, it is customary to develop a design ratio, which is a ratio between the minimum burst and the maximum working pressure.

Burst test data is compiled and the minimum value is established by accepted statistical techniques. This is done as a check on theoretical calculations, based on the strength of reinforcing materials and on the characteristics of the method of fabrication.

Minimum burst values are used as one factor in the establishment of a reasonable and safe maximum working pressure.

MAXIMUM WORKING PRESSURE IS ONE OF THE ESSENTIAL OPERATING CHARACTERISTICS THAT A HOSE USER MUST KNOW AND RESPECT TO ASSURE SATISFACTORY SERVICE AND OPTIMUM LIFE.

It should be noted that design ratios are dependent on more than the minimum burst. The hose technologist must anticipate natural decay in strength of reinforcing materials, and the accelerated decay induced by the anticipated environments in which the hose will be used and the dynamic situations that a hose might likely encounter in service.

Including all considerations, the following recommended design ratios are given for newly manufactured hose:

1. Water Hose up to 150 psi WP: 3:1
2. Hose for all other liquids, solid materials suspended in liquids or air, and water hose over 150 psi WP: 4:1
3. Hose for compressed air and other gases: 4:1
4. Hose for liquid media that immediately changes into gas under standard atmospheric conditions: 5:1
5. Steam Hose: 10:1

ELECTRICAL RESISTANCE TESTS
FOR HOSE AND HOSE ASSEMBLIES

1.0 Purpose: This procedure specifies methods for performing electrical resistance tests on rubber and/or plastic hose and hose assemblies.

2.0 Scope: These procedures are intended to test electrical conductive, antistatic and non-conductive (insulating) hoses, along with electrical continuity or discontinuity between fittings.

Warning: Hydraulic hoses used on power and telephone mobile equipment should be tested to SAE 100R8 requirements.

3.0 Definitions:

3.1 Antistatic Hose - Antistatic hose constructions are those that are capable of dissipating the static electricity buildup that occurs during the high velocity flow of material through a hose.

3.2 Conductive Hose – Conductive hose constructions are those that are capable of conducting an electrical current.

3.3 Direct Current (DC): Flow of electrical current in one direction at a constant rate.

3.4 Electrical Conductivity: A measure of the ease with which a material is capable of conducting an electrical current. Conductivity = 1/Resistance.

3.5 Electrical Resistance: Property of an object to resist or oppose the flow of an electrical current.

3.6 Non-Conductive (Insulating) Hose: Non-conductive hose constructions are those that resist the flow of electrical current.

3.7 Ohm's Law: The electrical current, I, is equal to the applied voltage, V, divided by the resistance, R. In practical terms, the higher the electrical resistance at a constant voltage, the lower the electrical current flow through an object.

3.8 Ohm: The amount of resistance that limits the passage of current to one ampere when a voltage of one volt is applied to it.

4.0 Apparatus:

4.1 Test Instruments:

All test instruments shall have a gauge reliability and reproducibility (R&R) of less than 30%. Some instruments made to measure high electrical resistance may have an internal protection circuit built in which will cause test errors in the less than one megohm range.

During the test, no more than 3 watts (W) shall be dissipated in the specimen, to prevent erroneous results due to effects of temperature. The power dissipated shall be determined by the square of the open-circuit voltage divided by the measured resistance, see formula 1 (Power Dissipation).

1) Power Dissipation $= \dfrac{(\text{Voltage})^2}{\text{Resistance in ohms}}$

To determine the electrical resistance of non-conductive hose, the test should be made with an instrument designed specifically for measuring insulation resistance, having a nominal open-circuit voltage of 500 Volts D.C., or with any other instrument known to give comparable results. For measuring electrical discontinuity, a 1,000 Volt D.C. source may be used instead of a 500 Volt D.C. source.

For hoses with a conductive tube or cover, the resistance values obtained may vary with the applied voltage, and errors may occur at low-test voltages. As a starting point, an ohmmeter (9 volts) can be used.

For tests requiring measurement of electrical continuity between end fittings or through continuous internal or external bonded wires, the instrument used shall be an ohmmeter (9 volts).

4.2 Electrodes and Contacts:

When the test procedure calls for contact with the hose cover, electrodes shall be formed around the outer circumference of the hose as bands 25 mm +2 mm, 0 mm (1" +1/16", 0") wide by applying silver lacquer/conductive liquid and metallic copper foil tape (i.e. 3M Scotch Brand) as shown in Figure 1.

When a conductive silver lacquer (i.e. Colloidal Silver Liquid is available from Ted Pella, Inc. catalogue # 16031) is used, the surface resistance between any two points on a sample of the dried film shall not exceed 100 Ω.

When a conductive liquid is used the electrode contact area shall be completely wetted and shall remain so until the end of the test. The conductive liquid shall consist of:

- Anhydrous polyethylene glycol of relative molecular mass 600: 800 parts by mass
- Water: 200 parts by mass
- Wetting agent: 1 part by mass
- Potassium Chloride: 10 parts by mass

When the test procedure calls for contact with the hose tube, it is preferable to use a copper plug of external diameter equal to or slightly greater than the hose ID or a steel hose stem, coated with the conducting liquid, and pushed 25 mm (1") into the hose. An alternative for 50 mm (2") and above hose would be to apply the conductive silver lacquer onto the hose ID, then insert the plug or hose stem. The electrical leads from the test instrument shall be clean and they should make adequate contact with the metallic copper foil and/or copper plugs/hose stems.

5.0 Preparation and Cleaning for Test:

The surfaces of the hose shall be clean. If necessary, the hose surface may be cleaned by rubbing with Fuller's earth (magnesium aluminum silicate) and water, followed by a distilled water rinse, and allowing the hose to dry in a non-contaminating environment. Do not use organic materials that attack or swell the rubber, and do not buff or abrade the test surfaces.

The surface of the hose shall not be deformed either during the application of the contacts or during the test. When using test pieces, the supports shall be outside the test length. When using a long length of hose, the hose shall be uncoiled and laid out straight on polyethylene or other suitable insulating material. Care should be taken to ensure that the hose is insulated from any electrical leakage path along the length of the hose.

6.0 Test Conditions:

For lab testing, the hose or hose assemblies shall be conditioned for at least 16 hrs at +23° C ± 2°C (73.4°F ± 3.6°F) with a relative humidity not to exceed 70%. However, it is permissible, by agreement between the supplier and the customer, to use the conditions prevailing in the factory, warehouse, or laboratory, provided that the relative humidity does not exceed 70%.

7.0 Test Pieces:

Prepare three test pieces approximately 300 mm (12") long from samples taken at random from a production run or lot. Condition the test pieces per section 6.0.

Place the test piece on blocks of polyethylene, or other insulating material, to provide a resistance of greater than 10^{11} Ω between the test piece and the surface on which the blocks are supported. Ensure that the leads from the instrument do not touch each other, the hose, or any part except the terminal to which each is connected.

Avoid breathing on the test surfaces and thus creating condensation that may lead to inaccuracies.

8.0 Procedure for hoses with conducting tube:

Apply the electrodes as specified to the inside surface of the hose at each end of the hose. The edge of the electrode plug shall be coincident with the end of the hose. When using a conductive liquid, care shall be taken to avoid creating a leakage path between the tube and the reinforcement or cover of the hose.

Apply the metal contacts to the electrodes.

Apply the test voltage (9V) and measure the resistance 5 seconds ± 1 second after the voltage is applied.

Note: In previous editions of the Hose Handbook, this method was referred to as the Plug Method.

9.0 Procedure for hose with conducting cover:

Apply the electrodes as specified to the outer circumference of the hose at each hose end. See Figure 6-1.

Ensure that contact is maintained with the electrodes around the circumference and that the contact pieces are sufficiently long enough for the two free ends to be held securely by a tensioning clip (see Figure 6-1) such that the fit of the electrodes is as tight as possible.

Apply the metal contacts.

Apply the test voltage (9V) and measure the resistance 5 seconds ± 1 second after the voltage is applied.

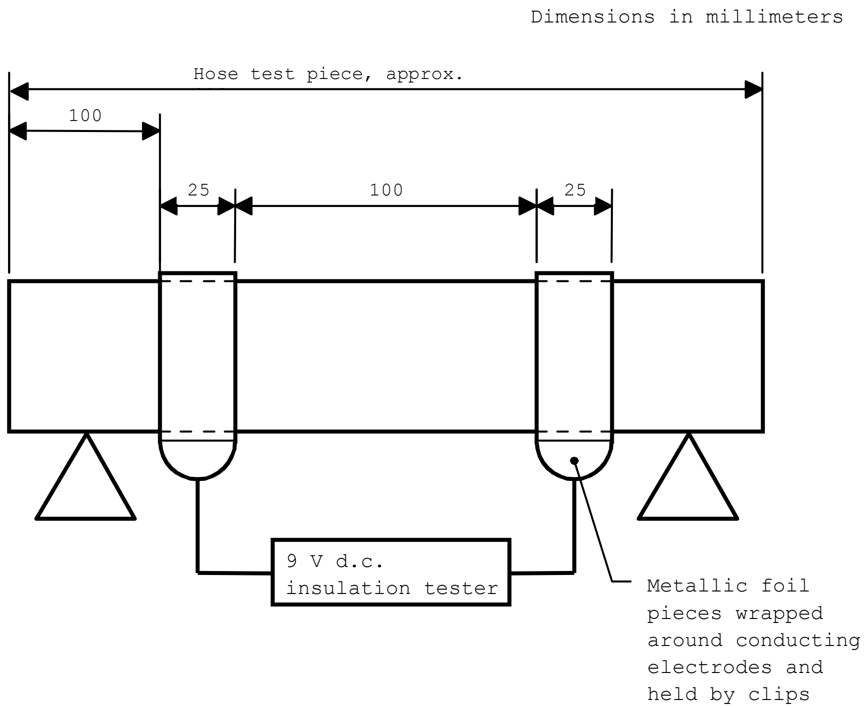


Figure 6-1 --- Electrodes and contacts for testing hose

10.0 Procedure for hose with conducting or non-conducting compounds throughout:

Apply the electrodes as specified on the inside surface at one end of the hose (end A) and on the outside surface at the other end of the hose (end B).

Apply the metal contacts to the electrodes.

Apply the test voltage (9V for conductive compounds and 500V for non-conductive compounds) and measure the resistance 5 seconds ± 1 second after the voltage is applied.

Alternative method for non-conductive hose– Nail or "Pot Room" Method

Conduct test as follows:

1. Cut sample hose, 24 inches long
2. Assure that both inside and outside of hose are free of oil, dirt, etc.
3. Pierce sample ends with clean nails, as shown in Fig. 6-2.
4. Connect nails to 1000-volt DC power source and megohm meter or 1000 volt "megger" as shown in Fig. 6-2.
5. Record total resistance, in megohms.
6. Measure "test length" as shown in Fig. 6-2.
7. Divide total resistance by test length to get megohms per inch.

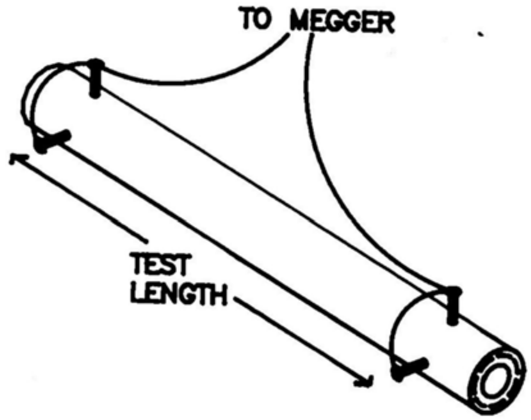


Fig. 6-2 – Nail or "Pot Room" Test

11.0 Procedure for hose assemblies fitted with metal end fittings:

When it is required that the resistance of a hose assembly be measured, the leads of the test instrument shall be attached directly to the metal hose shank (threaded end connection, fixed flange, stub end of a floating flange, etc.) of the metal end fittings.

Some hoses, especially thermoplastic hoses, have conductive layers within the hose construction. These hoses shall be tested as assemblies made with fittings and assembly techniques specified by the hose and fitting manufacturer.

Apply the metal contacts to the metal end fittings.

Apply the test voltage (9V) and measure the resistance 5 seconds ± 1 second after the voltage is applied.

12.0 Procedure for measurement of electrical continuity:

In certain types of hose constructions, electrical continuity is provided between the end fittings by means of a continuous wire or wires bonded to each coupling. When the construction is such that there are internal and external wires, the electrical continuity of both wires shall be established.

It is essential that contact resistance between the end fittings and the ohmmeter be minimized.

Apply the metal contacts to the metal end fittings.

Apply the test voltage (9V) and measure the resistance 5 seconds ± 1 second after the voltage is applied.

13.0 Procedure for measurement of electrical discontinuity:

In certain types of hose which contain wire in the hose carcass, it is required that such wire be insulated from the end fittings (rubber compounds should also be non-conductive). In these cases, condition the hose per lab testing or agreed upon factory environmental conditions. Measure the resistance between the fittings using a 500-volt insulation tester, or other suitable instrument known to give comparable results.

It is essential that contact resistance between the end fittings and the ohmmeter be minimized.

Apply the metal contacts to the metal end fittings.

Apply the test voltage and measure the resistance 5 seconds ± 1 second after the voltage is applied.

14.0 Test Report

The test report shall include items a) to e) and, as appropriate f) to k):

a) Hose type and inside diameter (ID).
b) Reference to this test procedure.
c) Conditioning and test atmosphere, i.e. temperature and relative humidity.
d) Distance between electrodes.
e) Electrode material used.
f) Resistance, in ohms per foot, of the hose tube detailing individual readings.
g) Resistance, in ohms per foot, of the hose cover detailing individual readings.
h) Resistance, in ohms per foot, of the hose tube to hose cover detailing individual readings.
i) Resistance, in ohms per foot, of the hose assembly between couplings detailing individual readings.
j) Whether electrical continuity has been established.
k) Resistance, in ohms/length, obtained when establishing electrical discontinuity.

HOSE AND COUPLING SELECITON GUIDE
Chapter 7

GENERAL

A number of hose specifications have been developed for specific applications in industrial, agricultural or public service. These specifications are based on successful performance of the hose in the field as reported by consumers, manufacturers and governmental agencies.

These may be used as procurement specifications or performance standards when the application agrees with the scope of the hose specification. The RMA has published a number of hose specifications which are recommended for use.

Often, additional or new requirements may be imposed on hose because of the severity of service conditions, a change in service conditions, a change in the materials handled or in the method of handling, or the development of new uses or procedures. Hose specifications must then be prepared with the supplier and be based on all conditions affecting the expected service and performance of the hose. Generally, a hose manufacturer may have types of hose or can devise new ones which may meet other requirements than those covered by published standards.

For best performance, a hose should be selected to meet the service conditions under which it is to be used. Before deciding on size, type, and quality of hose, complete information on the actual service requirements should be examined.

SERVICE CONSIDERATIONS FOR HOSE IN CRITICAL APPLICATIONS

Hose is often used in locations and/or to convey materials where property damage or human injury could occur if the hose and/or associate fittings failed while in service.

The user must insure that the service conditions are known to himself and to the hose supplier. The improper use of hose or the use of a hose for service applications for which it was not designed may result in serious consequences.

Some examples of improper uses of hoses include the following: water hose should not be used for chemicals or solvents; low pressure hose should not be used for high pressure service; only steam hose should be used for steam service; hose for conveying mild chemicals should not be used for strong or concentrated acids which require special types of hose. Temperatures in or around the hose should be known so as not to exceed supplier's recommendations, etc.

INFORMATION NEEDED

Hose Dimensions

(a) I.D.

(b) O.D.

(c) Length (state whether overall length or length excluding couplings)

(d) Tolerance limitations (if normal RMA tolerances as shown in Chapter 4 cannot be used)

Types of Service

(a) Material to be conveyed through hose

1. Chemical name (See Chapters 5 and 8)
2. Concentration
3. Temperature extremes (low and high)
4. Solids, description and size

(b) Working pressure (including surge)

(c) Suction or vacuum requirements

(d) Velocity

(e) Flow Rate

Operating Conditions

(a) Intermittent or continuous service

(b) Indoor and outdoor use

(c) Movement and geometry of use

(d) Flexibility- Minimum bend radius

(e) External conditions

1. Abrasion
2. Oil (Specify type)
3. Solvents (Specify type)
4. Acid (Specify type and concentration)
5. Temperature Range

    Normal

    Highest

    Lowest

6. Ozone

Uncoupled Hose

(a) Bulk or cut to length

(b) Ends

1. Straight or enlarged
2. Capped or raw (uncapped)
3. Soft ends or wire to end

Coupled Hose, Fittings

(a) Factory applied

(b) Field applied

(c) Type of Fitting

1. Type of thread
2. Male or female
3. Reusable/Field Attachable
4. Non-reusable

(d) Material for Fittings

1. ANSI (or SAE or ASTM) metal composition specifications
2. See Chapter 5, Table 1, and Chapter 8

Hose with Built-in Fittings

(a) Ends

1. Threaded (type of thread)
2. Grooved
3. Beveled for welding
4. Integral flange

(b) Flanges

1. Type (threaded, slip-on, welding neck, lap joint)
2. Pressure rating
3. Drilling

(c) Materials and Dimensions

1. ANSI (or SAE or ASTM) composition and specifications. See Chapter 11, Tables 6, 7, 8.
2. Treatment for specific services
3. See Chapter 5, Table 1, and Chapter 8

Hose Now in Use

(a) Type of hose

(b) Service life being obtained and description of failure

(c) Service life desired

Special Requirements or Properties

(a) Electrical and static conductive

(b) Flame resistant

(c) Sub-zero exposure

(d) Non-contaminating to material

ORGANIZATIONS HAVING REGULATIONS OR SPECIFICATIONS FOR HOSE

U.S. Government agencies

DOD	Department of Defense
DOT	Department of Transportation
FDA	Food and Drug Administration
MSHA	Mine Safety and Health Administration
NHTSA	National Highway Traffic Safety Administration
OSHA	Occupational Safety and Health Administration
PHA	Public Health Administration
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture

Canadian agencies and organization

CGA	Canadian Gas Association
CGSB	Canadian Government Specifications Board
RAC	Rubber Association of Canada

Other organizations

ABS	American Bureau of Shipping
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BIA	Boating Industry Association
BSI	British Standards Institute
CGA	Compressed Gas Association
DIN	Deutches Institut for Normung – German Standards
DNV	Det Norske Veritas
EN	European Norms
FM	Factory Mutual Research
FPS	Fluid Power Society
ISO	International Organization for Standardization
JIC	Joint Industrial Council (defunct)
JIS	Japanese Industrial Standards
NAHAD	National Association of Hose and Accessories Distributors
NFPA	National Fire Protection Association
	National Fluid Power Association
RMA	Rubber Manufacturers Association
SAE	Society of Automotive Engineers
TFI	The Fertilizer Institute
UL	Underwriters Laboratories

CHEMICAL RECOMMENDATIONS
Chapter 8

The materials being handled by flexible rubber hose are constantly increasing in number and diversity. To assist in the selection of the proper elastomer for the service conditions encountered, the following table has been prepared. The reader is cautioned that it is only a guide and should be used as such, as the degree of resistance of an elastomer with a particular fluid depends upon such variables as temperature, concentration, pressure, velocity of flow, duration of exposure, aeration, stability of the fluid, etc. Also variations in elastomer types and special compounding of stocks to meet specific service conditions have considerable influence on the results obtained. When in doubt, it is always advisable to test the tube compound under actual service conditions. If this is not practical, tests should be devised that simulate service conditions or the hose manufacturer contacted for recommendations.

The following table lists the more commonly used materials, chemicals, solvents, oils, etc. The recommendations are based on room temperature and pressure conditions normally recommended for the particular type of hose being used. Where conditions beyond this can be met readily, they have been so indicated; where conditions are not normal and cannot be readily met, the hose manufacturer should always be consulted. The table does not imply conformance to the Food and Drug Administration requirements or federal or state laws when handling food products.

TABLE OF CHEMICAL, OIL AND SOLVENT RESISTANCE OF HOSE

WARNING: The following data has been compiled from generally available sources and should not be relied upon without consulting and following the hose manufacturer's specific chemical recommendations. Neglecting to do so might result in failure of the hose to fulfill its intended purpose, and/or may result in possible damage to property and serious bodily injury.

Resistance Rating

A — Good Resistance, usually suitable for service.
F — Fair Resistance, the chemical has some deteriorative effects, but the elastomer is still adequate for moderate service,
C — Depends on Condition, moderate service may be possible if chemical exposure is limited or infrequent.
X — Not Recommended, unsuitable for service,
I — Insufficient Information, not enough data available at the time of publication to determine rating.

Elastomers/Plastics

NR	Natural Rubber
IR	Isoprene, synthetic
SBR	Styrene-butadiene
CR	Chloroprene
NBR	Nitrile-butadiene
IIR	Isobutene-isoprene
CSM	Chloro-sulfonyl-polyethylene
EPDM	Ethylene-propylene-dieneterpolymer
MQ	Dimethyl-polysiloxane
FKM	Fluorocarbon rubber
CM	Chloro-polyethylene
ECO/CO	Epichlorohydrin
XLPE	Cross-linked polyethylene
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride
PA	polyamide*
UHMWPE	Ultra high molecular weight polyethylene**

Material		NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Acetic acid, dilute, 10%		F	C	C	C	A	C	A	A	X	A	F	A	A	A	A	X
glacial		C	X	X	X	F	C	F	F	X	A	X	A	A	A	X	X
Acetic acid anhydride		C	C	F	F	F	A	I	C	X	A	X	A	A	A	X	X
Acetone		A	A	F	X	A	F	A	A	X	A	X	A	A	A	X	A
Acetylene		A	A	F	A	A	F	A	C	A	I	I	A	A	A	X	
Air	68°F (20°C)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Air	150°F (65°C)	A	A	A	A	A	A	A	A		A	A	A	A	A	F	A
Aluminum chloride	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	F	X
Aluminum fluoride	150°F (65°C)	A	A	A	A	A	A	A	F			A	A	A	A	X	F
Aluminum sulfate	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	F
Alums	150°F (65°C)	A	A	A	A	A	A	A	A		A	I	A	A	A	A	F
Ammonia gas, anhydrous		A	A	A	A	A	A	A	A	X	A	I	A	A	A	X	F
Ammonia, 10% water solution		F	F	F	A	A	A	A	A	A			A	A	A	A	A
30% water solution		F	F	F	A	A	F	A	A	A			A	A	A	F	F
Ammonium chloride		A	A	A	A	A	A	A	C	A	A	A	A	A	A	A	F
Ammonium hydroxide		C	F	F	F	A	A	A	A	A	A	I	A	A	A	F	A
Ammonium nitrate		A	A	A	A	A	A	A	A		I	A	A	A	A	F	F
Ammonium phosphate, monobasic		A	A	A	A	A	A	A	A		A	I	A	A	A	F	A
dibasic		A	A	A	A	A	A	A	A		I	I	A	A	A	F	A
tribasic		A	A	A	A	A	A	A	A		I	I	A	A	A		
Ammonium sulfate		A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	F
Amyl acetate		F	X	X	X	F	X	A	A	X	C	X	A	A	A	X	F
Amyl alcohol		A	A	A	A	A	A	A	A	A	A	A	A	A	A	X	F
Aniline, Aniline oil		X	X	C	X	A	X	C	C	A	C	X	A	A	A	X	X
Aniline dyes		F	F	F	F	A	F	C	C			I	I	A	A	X	X
Asphalt		X	X	F	F	X	F	X		A		A	X	A	A	X	A
Barium chloride	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Barium hydroxide	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	F
Barium sulfide	150°F (65°C)	A	A	A	A	A	A	A	A	A	I	A	A	A	A	A	X
Beer		A	A	A	A	A	A	A	A	A	I	A	A	A	A	A	A

Material	NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Beet sugar liquors	A	A	A	A	A	A	A	A	A	I	I	A	A	A	A	A
Benzene, Benzol	X	X	X	C	X	X	X	C	A	C	X	A	C	A	X	F
Benzine, petroleum ether and													F	A	X	A
Benzine, petroleum naphtha	X	X	C	F	X	F	X	C	A		I	A	F	A	X	A
Black sulfate liquor	A	A	A	A	A	A	A	A		I	I	A	A	A	C	X
Blast furnace gas	C	C	A	C	C	C	C	C	A	I	I	A	A	A	X	A
Borax	A	A	A	A	A	A	A	A	A	I	I	A	A	A	A	A
Boric acid	A	A	A	A	A	A	A	A	A	I	A	A	A	A	A	F
Bromine	X	X	X	X	X	C	X	F	A	C		F	X	A	X	X
Butane	X	X	F	A	X	A	X	A	A	A	A	A	A	A	X	A
Butyl acetate	C	X	X	X	F	X	F	A	X	F	X	A	A	A	X	A
Butyl alcohol, Butanol	A	A	A	A	A	A	A	A	A	F	I	A	A	A	X	C
Calcium bisulfate	C	C	A	A	F	A	F	C	A	A	I	A	A	A	A	
Calcium chloride	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Calcium hydroxide	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Calcium hypochlorite	X	X	X	X	A	F	A	C	A	A	F	F	A	A	A	X
Caliche liquors	A	A	A	A	A	A	A				I	A	A	A	A	A
Cane sugar liquors	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Carbolic acid, phenol	C	C	C	C	C	C	A	A	A	A		A	A	A	X	X
Carbon dioxide, dry/wet	A	A	A	A	A	A	A	A	A	A	A	A	A	A		A
Carbon disulfide	X	X	X	X	X	X	X	C	A	C		C	C	A	X	C
Carbon monoxide 150°F (65°C)	C	C	C	C	C	F	C	A	A	I		A	A	A	A	C
Carbon tetrachloride	X	X	X	C	X	X	X	C	A	C	F	A	C	A	X	X
Castor oil	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Cellosolve acetate	F	F	X	X	A		A	C	C			A	A	A	X	F
CFC-12	X	X	A	A	F		F	X	A		A	I		A	X	F
China wood oil, tung oil	X	X	F	A	A	F	A	A	C		I	A	A	A		F
Chlorine, dry/wet	X	X	X	X	X	X	X	X	C	X	X	F	X	A	X	X
Chlorinated solvents	X	X	X	X	X	X	X	C	C	C		A	F	A	X	C

Material		NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Chloroacetic acid		X	C	C	C	X	A	I	C	X			A	A	A	X	X
Chlorosulfonic acid		X	X	C	C	X	X	X	C	X			F	X	A	X	X
Chromic acid		X	X	X	X	C	A	I	C	C	A		F	C	A	C	C
Citric acid		A	A	A	F	A	A	A	A	A	A	A	A	A	A	A	F
Coke oven gas		C	C	C	C	C	A		A	X	A	X	C	X	A	X	A
Copper chloride	150°F (65°C)	C	A	F	A	A	F	A	A	A	A	I	A	A	A	A	X
Copper sulfate	150°F (65°C)	C	A	A	A	F	A	A	A	A	A	A	A	A	A	A	A
Corn oil		X	C	F	A	A	F	C	A	A	A	A	A	A	A	F	A
Cottonseed oil		X	C	F	A	A	F	C	A	A	A	I	A	A	A	F	A
Creosote, coal tar		X	X	F	A	X	F	X	C	F		X	A	A	A	X	X
wood		X	X	F	A	X		X	C	A			A	A	A	X	X
Creosols, cresylic acid		C	X	X	C	C	F	X	C		F		A	F	A	X	X
Dichlorobenzene		X	X	X	X	X	X	X	X	A		X	X	X	A	X	A
Dichloroethylene		X	X	X	X	X	X	X	X	A	X	X	C	C	A	X	C
Diesel fuel		X	X	X	A	X	F	X	X	A	A	A	F	F	A	X	A
Diethanolamine 20%		C	X			A	X	A	X	X			A	A	A		A
Diethylamine		F	F	F	C	F	X	F	F	X			A	A	A		
Diisopropylamine		F			F		C						A	A	A		
Dioctylphthalate		X	X	X	X	F	X	F	X	F		F	A	F	A	X	A
Ethers		C	C	C	C	C	F	X	C	X	A		A	F	A	X	A
Ethyl acetate		F	X	X	X	F	X	F	F	X	F	X	A	F	A	X	A
Ethyl alcohol		A	A	A	A	A	A	A	A	A	A	A	A	A	A	F	F
Ethyl cellulose		F	F	F	F	F		F	C	X	F		A	A	A	X	C
Ethyl chloride		A	F	F	X	A	F	A	C	F	F	F	F	C	A	X	A
Ethylene glycol		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ferric chloride	150°F (65°C)	A	A	A	A	A	A	A	A	I	A	A	A	A	A	A	C
Ferric sulfate	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Material	NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Formaldehyde	A	A	C	A	A	A	A	A	A	A	F	A	A	A	F	C
Formic acid	A	A	C	F	A	A	A	A	X	A	F	F	A	A	X	X
Fuel oil	X	X	A	A	X	F	X	C	A	F	A	A	F	A	F	A
Furfural	X	C	C	X	A	F	C	C	X	A	X	A		A	X	X
Gasoline, unleaded	X	X	X	A	X	X	X		A	C	A	A	F	A	X	A
Gasoline + MTBE	X	X	X	A	X	X	X	C	A	C	A	A	F	A	X	
Hi Test + MTBE	X	X	X	A	X	X	X	C	A	C	A	A	F	A	X	
Gelatin	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A
Glucose	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A
Glue	F	F	A	A	F	A	A	A	C		A	A	A	A		F
Glycerine, glycerol	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Green sulfate liquor	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	X
HFC-134A	F	X	A	A	A	F	A		X	F		A		A		
Hydraulic fluids:																
Petroleum	X	X	A	A	X	F	X			A	A		A	A		A
Phosphate ester alkyl	X	X	C	X	A	X	A			A	X			A	X	A
Phosphate ester aryl	X	X	X	X	C	X	C			C	X			A	X	A
Phosphate ester blends	X	X	X	X	X	X	C			C	X			A	X	A
Silicate ester	X	X	C	C	X	C	X			C	C			A	X	A
Water glycol	A	A	A	A	A	A	A		A	A	A		A	A	X	A
Hydrobromic acid	C	X	C	C	A	A	A	C	A	A		I	A	A	A	X
Hydrochloric acid	A	X	X	X	C	C	C	C	A	A	X	A	A	A	C	X
Hydrocyanic acid	F	F	C	F	C	A	C	A	A			A	A	A	F	X
Hydrofluoric acid	X	X	X	X	C	A	C	X	A	A		A	F	A	F	X

Material		NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Hydrofluosilicic acid		A	F	F	F	A		A	A	A	A		I	A	A	C	X
Hydrogen gas		F	F	A	A	A		A	A	A		A	A	A	A	A	A
Hydrogen peroxide		X	X	C	C	C	C	C	A	A	A		I	C	A	C	C
Hydrogen sulfide, dry		C	C	F	C	A	A	A	C	F			A	A	A	A	X
wet		C	C	F	C	A	A	A	C	C		F	A	A	A	A	X
Isobutyl alcohol		A	A	A	F	A	A	A	A	F			A	A	A	F	C
Isopropyl alcohol		A	A	A	F	A	A	A	A	F		A	A	A	A	F	C
Isooctane		X	X	F	A	X	A	X	X	A	A	A	A	A	A	A	A
Kerosene		X	X	F	A	X	C	X	C	A	A	A	A	F	A	X	A
Lacquers		X	X	X	X	C	X	X		X		X	F	F	A	X	A
Lacquers solvents		X	X	X	X	C	X	X		X		X	F	F	A	X	A
Lactic acid		C	C	C	C	C	A	C	A	A			A	A	A	A	C
Linseed oil		C	X	F	A	A	A	A	A	A	A	A	A	A	A	A	A
Lubricating oil, crude		X	X	F	A	X	C	X	C	A		A	A	A	A	A	A
refined		X	X	F	A	X	C	X	C		A	A	A	A	A	A	A
Magnesium chloride	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Magnesium hydroxide	150°F (65°C)	A	F	F	F	A	A	A	F	A	A	A	A	A	A	A	A
Magnesium sulfate	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Mercuric chloride		F	F	C	F	A	A	A	A	A		A	A	A	A	F	C
Mercury		A	A	A	A	A	A	A	A	A		A	A	A	A	F	A
Methyl alcohol, methanol		A	A	A	A	A	A	A	A	C	A	F	A	A	A	X	F
Methyl chloride		C	C	C	C	C	X	C	X	A			F	C	A	X	X
Methyl ethyl ketone		X	X	X	X	F	C	A	C	X	C	X	A	A	A	X	A
Methyl isopropyl ketone		X	X	X	X	F	C	C	C	X	F	X	A	A	A	X	A
MTBE													A		A		
Milk		C	C	F	F	A	A	A	A	A	A	A	A	A	A	A	A
Mineral oils		X	C	F	A	X	F	X	A	A	A	A	A	A	A	F	A

Material		NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Natural gas		C	C	A	A	C	A	X	C	A	A	A	A	A	A	A	A
Nickel chloride	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	A
Nickel sulfate	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	A
Nitric acid, crude		X	X	X	X	C	C	X	X	C	A	X	F		A	X	X
diluted 10%		X	X	C	X	C	A	C	C	C	A	X	I	A	A	F	X
concentrated 70%		X	X	X	X	C	C	X	X	C	X	X	F	X	A	X	X
Nitrobenzene		X	X	X	X	X	X	X	C	F	C	X	A	F	A	X	X
Oleic acid		X	F	C	F	F	F	F	A	C	A		A	A	A	X	A
Oleum		X	C	C	C			I		C			I	X	A	X	X
Oxalic acid		F	C	F	F	A	A	A	A	A	A	F	A	A	A	F	A
Oxygen		F	C	A	C	A		A	A	A	A	F	A	A	A	A	A
Palmitic acid		X	F	A	A	F	F	F	C	A	A	F	A	A	A	C	C
Perchlorethylene		X	X	X	C	X	X	X	C	A	C	F	A	C	A	X	X
Petroleum oils and crude	200°F (95°C)	X	X	F	A	X	C	X	C	A	C	A	A	X	A	X	X
Phosphoric acid, crude		A	C	C	C	C	A	C	C	A	A		A	A	A	F	
pure 45%		A	C	C	C	C	A	C	C	A	A		A	A	A	F	C
Picric acid, molten		C	C	C	C	C		I					I	X	A	X	X
water solution		A	C	F	F	A	A	I	A	A			I	A	A	X	X
Potassium chloride		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Potassium cyanide		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Potassium hydroxide		F	F	C	C	A	A	A	A	C	A	A	A	A	A		C
Potassium sulfate		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Propane		X	X	F	A	X	F	X	A	A	A	A	A	A	A	A	A

Material		NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Sewage		C	C	F	A	C	A	C	C	A		l	A	A	A		
Soap solutions		A	A	F	A	A	A	A	A	A	A	A	A	A	A		
Soda ash, sodium carbonate		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Sodium bicarbonate, baking soda		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Sodium bisulfate		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Sodium chloride		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Sodium cyanide		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Sodium hydroxide		F	F	C	C	A	C	A	A	C	A	F	A	A	A	C	C
Sodium hypochlorite		X	X	X	X	A	F	A	C	A	A	F	F	C	A	A	C
Sodium metaphosphate		A	A	C	A	A	F	A	A	A	A	I	A	A	A	F	A
Sodium nitrate		C	C	C	C	A	A	A	C		A	A	A	A	A	A	A
Sodium perborate		C	C	C	C	A	A	A	A	A			A	F	A		
Sodium peroxide		C	C	C	C	A	A	A	C	A			A	C	A	X	X
Sodium phosphate, monobasic		A	F	C	F	A	A	A	A	A	A		A	A	A		
dibasic		A	F	C	F	A	A	A	A				A	A	A		
tribasic		A	F	C	F	A	A	A	A				A	A	A	X	A
Sodium silicate		A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	A
Sodium sulfate		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Sodium sulfide		A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	C
Sodium thiosulfate, “hypo”		A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	
Soybean oil		X	C	F	A	A	A	A	A	A	A	A	A	A	A	X	A
Stannic chloride		A	A	A	A	F	A	F	A	A	A	I	A	A	A	A	C
Steam	450°F (230°C)	C	C	C	C	C	C	F	C	X		X	X	X	A	X	X
Stearic acid		X	X	C	F	F	C	F	A	I		F	A	A	A	F	A
Sulfur		F	F	A	F	A	A	A	F	A		F	C	A	A	F	A
Sulfur chloride		X	X	C	C	X	A	X	C	A			A		A	X	X
Sulfur dioxide, dry		C	C	C	C	C	A	C	A	A		I	I	A	A	X	X
Sulfur trioxide, dry		X	C	C	C	C	F	C	A	A			I	X	A	X	X

Material	NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	MQ	FKM	CM	ECO or CO	XLPE	UHMWPE**	PTFE	PVC	PA*
Sulfuric acid, 10%	A	A	A	A	A	A	A	A	A	A	A	A	A	A	F	X
11 %-75%	C	C	C	C	F	A	C	C	A	A	F	A	A	A	F	X
76%-95%	X	X	X	X	C	A	X	X	A	X	X	A	A	A	C	X
fuming	X	X	X	X	X	X	X	X	A	X	X	X	X	A	X	X
Sulfurous acid	C	C	C	C	C	A	C	C	A	A	C	A	A	A	C	X
Tannic acid	A	C	A	C	A	A	A	A	A	A	I	A	A	A	A	A
Tar	X	X	C	C	X	C	X	C	F		F	X		A		
Tartaric acid	A	C	C	C	F	A	F	A	A	A	F	A	A	A	A	A
Toluene, Toluol	X	X	X	C	X	X	X	C	A	C	X	A	C	A	X	C
Trichloroethylene	X	X	X	X	X	X	X	C	A	C	X	A	F	A	X	X
Turpentine	X	X	X	F	X	X	X	C	A	F	A	A	F	A	X	A
Urea, water solution	A		A	A	A	A	A	A				A	A	A	X	A
Vinegar	C	C	C	C	A	A	A	A	A	A		A	A	A	A	A
Vinyl acetate	X	X	X	X	A	X	F		A				A	A	X	
Water, acid mine	A	A	C	A	A	A	A	A	A	A	I	A	A	A	A	
Water, fresh	A	A	C	A	A	A	A	A	A	A	A	A	A	A	A	A
Water, distilled	A	A	C	A	A	A	A	A	A	A	A	A	A	A	A	A
Whiskey and wines	A	A	A	C	A	A	A	A	A	A	I	A	A	A	X	A
Xylene, xylol	X	X	X	C	X	X	X	C	A	X	X	A	C	A	X	A
Zinc chloride	C	C	C	C	A	A	A	A	A	A	I	A	A	A	A	A
Zinc sulfate	A	A	A	A	A	A	A	A	A	A	I	A	A	A	A	X

*A variety of PA types were included in this data. For the specific chemistry and performance characteristics, contact the individual manufacturer.
** UHMWPE molecular weight 4 million minimum

Rubber hose is used to convey petroleum products both in the crude and refined stages. The aromatic content of refined gasoline is often adjusted to control the octane rating. The presence of aromatic hydrocarbons in this fuel generally has a greater effect on rubber components than do aliphatic hydrocarbons. Aromatic materials in contact with rubber tend to soften it and reduce its physical properties. For long lasting service, the buyer of gasoline hose should inform the hose manufacturer of the aromatic content of the fuel to be handled so that the proper tube compound can be recommended for the specific application.

The effects of oil on rubber depend on a number of factors that include the type of rubber compound, the composition of the oil, the temperature and time of exposure. Rubber compounds can be classified as to their degree of oil resistance based on their physical properties after exposure to a standard test fluid. In this RMA classification, the rubber samples are immersed in IRM 903 oil at 100°C for 70 hours. (See ASTM Method D-471 for a detailed description of the oil and the testing procedure.) As a guide to the user of hose in contact with oil, the oil resistance classes and a corresponding description are listed.

Physical Properties After Exposure to Oil

	Volume Change Maximum	Tensile Strength Retained
Class A (High oil resistance)	+25%	80%
Class B (Medium oil resistance)	+65%	50%
Class C (Limited oil resistance)	+100%	40%

CARE, MAINTENANCE, AND STORAGE
Chapter 9

Hose has a limited life and the user must be alert to signs of impending failure, particularly when the conditions of service include high working pressures and/or the conveyance or containment of hazardous materials. The periodic inspection and testing procedures described here provide a schedule of specific measures which constitute a minimum level of user action to detect signs indicating hose deterioration or loss of performance before conditions leading to malfunction or failure are reached.

SAFETY WARNING: Failure to properly follow the manufacturer's recommended procedures for the care, maintenance and storage of a particular hose might result in its failure to perform in the manner intended and might result in possible damage to property and serious bodily injury.

General instructions are also described for the proper storage of hose to minimize deterioration from exposure to elements or environments which are known to be deleterious to rubber products. Proper storage conditions can enhance and extend substantially the ultimate life of hose products.

General Care and Maintenance of Hose

Hose should not be subjected to any form of abuse in service. It should be handled with reasonable care. Hose should not be dragged over sharp or abrasive surfaces unless specifically designed for such service. Care should be taken to protect hose from severe end loads for which the hose or hose assembly were not designed. Hose should be used at or below its rated working pressure; any changes in pressure should be made gradually so as to not subject the hose to excessive surge pressures. Hose should not be kinked or be run over by equipment. In handling large size hose, dollies should be used whenever possible; slings or handling rigs, properly placed, should be used to support heavy hose used in oil suction and discharge service.

General Test and Inspection Procedures for Hose

An inspection and hydrostatic test should be made at periodic intervals to determine if a hose is suitable for continued service.

A visual inspection of the hose should be made for loose covers, kinks, bulges, or soft spots which might indicate broken or displaced reinforcement.

The couplings or fittings should be closely examined and, if there is any sign of movement of the hose from the couplings, the hose should be removed from service.

The periodic inspection should include a hydrostatic test for one minute at 150% of the recommended working pressure of the hose. An exception to this would be woven jacketed fire hose.* During the hydrostatic test, the hose should be straight, not coiled or in a kinked position.

Water is the usual test medium and, following the test, the hose may be flushed with alcohol to remove traces of moisture. A regular schedule for testing should be followed and inspection records maintained.

SAFETY WARNING: Before conducting any pressure tests on hose, provision must be made to ensure the safety of the personnel performing the tests and to prevent any possible damage to property. Only trained personnel using proper tools and procedures should conduct any pressure tests.

1. Air or any other compressible gas must never be used as the test media because of the explosive action of the gas should a failure occur. Such a failure might result in possible damage to property and serious bodily injury.

****Woven jacket fire hose should be tested in accordance with the service test provisions contained in the current edition of National Fire Protection Association Bulletin No. 1962 - Standard for the Care, Use and Service Testing of Fire Hose.***

2. Air should be removed from the hose by bleeding it through an outlet valve while the hose is being filled with the test medium.

3. Hose to be pressure tested must be restrained by placing steel rods or straps close to each end and at approximate 10 foot (3 m) intervals along its length to keep the hose from "whipping" if failure occurs; the steel rods or straps are to be anchored firmly to the test structure but in such a manner that they do not contact the hose which must be free to move.

4. The outlet end of hose is to be bulwarked so that a blown-out fitting will be stopped.

5. Provisions must be made to protect testing personnel from the forces of the pressure media if a failure occurs.

6. Testing personnel must never stand in front of or in back of the ends of a hose being pressure tested.

7. If liquids such as gasoline, oil, solvent, or other hazardous fluids are used as the test fluid, pre-cautions must be taken to protect against fire or other damage should a hose assembly fail and the test liquid be sprayed over the surrounding area.

The Rubber Manufacturers Association has published separately a series of Hose Technical Information bulletins describing hoses designed for different applications which detail Maintenance, Testing and Inspection recommendations. Reference should be made to the current RMA Catalog of Publications, to determine the availability of the latest edition. Bulletins published as of January 2003 include the following:

Publication No.

IP 11—1—Steam Hose

IP 11—2—Anhydrous Ammonia Hose

IP 11—4—Oil Suction and Discharge Hose

IP 11—5—Welding Hose

IP 11—7—Chemical Hose

IP 11—8—Fuel Dispensing Hose

Storage

Rubber hose products in storage can be affected adversely by temperature, humidity, ozone, sunlight, oils, solvents, corrosive liquids and fumes, insects, rodents and radioactive materials.

The appropriate method for storing hose depends to a great extent on its size (diameter and length), the quantity to be stored, and the way in which it is packaged. Hose should not be piled or stacked to such an extent that the weight of the stack creates distortions on the lengths stored at the bottom.

Since hose products vary considerably in size, weight, and length, it is not practical to establish definite recommendations on this point. Hose having a very light wall will not support as much load as could a hose having a heavier wall or hose having a wire reinforcement. Hose which is shipped in coils or bales should be stored so that the coils are in a horizontal plane.

Whenever feasible, rubber hose products should be stored in their original shipping containers, especially when such containers are wooden crates or cardboard cartons which provide some protection against the deteriorating effects of oils, solvents, and corrosive liquids; shipping containers also afford some protection against ozone and sunlight.

Certain rodents and insects will damage rubber hose products, and adequate protection from them should be provided.

Cotton jacketed hose should be protected against fungal growths if the hose is to be stored for prolonged periods in humidity conditions in excess of 70%.

The ideal temperature for the storage of rubber products ranges from 50° to 70°F (10-21°C) with a maximum limit of 100°F (38°C). If stored below 32°F (0°C), some rubber products become stiff and would require warming before being placed in service. Rubber products should not be stored near sources of heat, such as radiators, base heaters, etc., nor should they be stored under conditions of high or low humidity.

To avoid the adverse effects of high ozone concentration, rubber hose products should not be stored near electrical equipment that may generate ozone or be stored for any lengthy period in geographical areas of known high ozone concentration.

Hose should not be stored in locations where the ozone level exceeds the National Institute of Occupational Safety and Health's upper limit of 0.10 ppm. Exposure to direct or reflected sunlight- even through windows should also be avoided. Uncovered hose should not be stored under fluorescent or mercury lamps which generate light waves harmful to rubber.

Storage areas should be relatively cool and dark, and free of dampness and mildew. Items should be stored on a first-in, first-out basis, since even under the best of conditions, an unusually long shelf life could deteriorate certain rubber products.

GLOSSARY OF TERMS USED BY THE HOSE INDUSTRY
Chapter 10

The reader is cautioned that the following Glossary of Terms contains words and expressions as generally understood by persons familiar with hose industry terminology; however, such words and expressions should not be relied upon as the sole or precise meaning of any particular term under all circumstances.

A

abrasion: a wearing away by friction.

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

ABS: American Bureau of Shipping.

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

accelerator: a compounding ingredient used with a curing agent to increase the rate of vulcanization.

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

activator: a compounding ingredient used to increase the effectiveness of an accelerator.

adapter: the accessory part which can complete the connection between a hose fitting and another fluid system component. Often, a tube fitting connected to a hose assembly rather than a tube assembly.

adhesion: the strength of bond 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 owing to service conditions.

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

adhesive coating: a layer applied to any product surface to increase its adherence to an adjoining surface.

aftercure: a continuation of the process of vulcanization after the cure has been carried to the desired degree and the source of heat removed.

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

aging: changes in physical properties over a period of time.

air bomb: a chamber capable of holding compressed air heated to an elevated temperature.

air bomb aging: a means of accelerating changes in the physical properties of rubber compounds by exposing them to the action of air at an elevated temperature and pressure.

air checks: the surface markings and depressions which occur due to air trapped between the material being cured and the mold or press surface.

air cure: vulcanization without the application of heat. See also: hot air cure.

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.

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

angle of lay: the angle developed at the intersection of a structural element and a line parallel to its lineal axis.

ANSI: the abbreviation for the American National Standards Institute, Inc.

antioxidant: a compounding ingredient used to retard deterioration caused by oxygen.

antiozonant: a compounding ingredient used to retard deterioration caused by ozone.

anti-static: see static conductive.

armored hose: a hose with a protective covering, applied as a braid or helix, to protect from physical abuse.

API: American Petroleum Institute

assembly: see hose assembly.

ASTM: the abbreviation for the American Society for Testing and Materials.

autoclave: a pressure vessel used for vulcanizing rubber products by means of steam under pressure.

B

backing: a rubber layer between a hose tube and/or cover and carcass to provide adhesion (also known as adhesion gum, or friction).

banbury mixer: a specific type of internal mixer used to incorporate fillers and other ingredients into rubber or plastic.

band: (1) a metal ring which is welded, shrunk, or cast on the outer surface of a hose nipple; (2) a thin strip of metal used as a boltless clamp. See also: clamp, hose clamp.

bank: an accumulation of material at the opening between the rolls of a mill or calender.

barb and ferrule fitting: a two-piece hose fitting comprised of a barbed nipple and ferrule, normally with peripheral ridges or backward-slanted barbs, for inserting into a hose and a ferrule, usually crimped, outside.

bare duck: the duck surface of a hose wherein the exposed duck surface is free of any rubber coating.

batch: the product of one mixing operation.

bench marks (tensile test): 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: the curvature of a hose from a straight line.

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

bend radius: the radius of a bent section of hose measured to the innermost surface of the curved portion.

BIA: Boating Industry Association

bias angle: the smaller included angle between the warp threads of a cloth and a diagonal line cutting across the warp threads.

bias cut: a cut of a textile material made diagonally at an angle less than 90' to the longitudinal axis.

bias seam: a seam at which bias cut fabrics are joined together.

binding-in wire: a wire used to anchor a hose to a nipple, usually applied during the construction of the hose. Also called nipple wire.

bite: see nip.

bleeding: surface exudation. See also: 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.

block end: see end reinforcement.

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. Examples: sulfur bloom, wax bloom. Not to be confused with dust on the surface from external sources.

body wire: 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: the exterior shell of an expansion ring-type coupling.

braid: a continuous sleeve of interwoven single or multiple strands of yarn or wire.

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

braid smash: a defect in a braided reinforcement caused by one or more of the ends of reinforcing material breaking during the braiding operations. Colloquial.

braided hose: hose in which the reinforcing material has been applied as interlaced spiral strands.

braided ply: a layer of braided reinforcement.

braider: a machine which interweaves strands of yarn or wire to make a hose carcass.

braider deck: the base plate upon which the bobbin carriers of a braider machine travel.

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

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

breaker ply: an open mesh fabric used to anchor a hose tube or cover to its carcass and to spread impact.

BSI: British Standards Institute

buckled ply: a deformation in a ply which distorts its normal plane.

buffing: grinding a surface to obtain dimensional conformance or surface uniformity.

burst: a rupture caused by internal pressure.

burst pressure: the pressure at which rupture occurs.

C

calendar: a machine equipped with three or more heavy, internally heated or cooled rolls revolving in opposite directions, which is used for continuously sheeting, plying up rubber compound, frictioning or coating fabric with rubber compound.

Canadian agencies and organizations:

CGA-Canadian Gas Association, CGSB-Canadian Government Specifications Board, RAC- Rubber Association of Canada.

capped end: a hose end covered to protect its internal elements.

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

cement: unvulcanized raw or compounded rubber in a suitable solvent used as an adhesive or sealant.

cemented end: a hose end sealed with the application of a liquid coating.

CGA: Canadian Gas Association, and the abbreviation for U.S. organization, Compressed Gas Association

CGSB: Canadian Government Specifications Board

chafer duck: a duck of approximately square woven construction made with single or ply yarn warp and filling.

chalking: the formation of a powdery surface condition due to disintegration of surface binder or elastomer by weathering or other destructive environments.

charge mark: see lead stop.

checking: the short, shallow cracks on the surface of a rubber product resulting from damaging action of environmental conditions.

chernack loom: a four shuttle circular loom for the production of seamless hose reinforcement.

churn: a vessel used for making rubber cement, in which rubber compounds are stirred into solvents.

C I: in hose, an abbreviation for "cloth inserted," a term applied to low strength small diameter hose reinforced with a ply or plies of lightweight fabric.

C I tubing: a small diameter hose reinforced with a ply or plies of lightweight fabric. Colloquial.

circular woven jacket: a textile reinforcing member produced on a circular loom for such types of hose as fire hose.

clamp: in hose, a metal fitting or band used around the outside of a hose end to bind the hose to a coupling, fitting or nipple.

cloth impression: see fabric impression.

cold feed: the introduction of compounded rubber into extrusion processing equipment without milling.

cold flex: see low temperature flexibility.

cold flexibility: the relative ease of bending following exposure to specified low temperature conditioning.

cold flow: continued deformation under stress. See also: creep and drift.

commercially smooth: a degree of smoothness of an article which is acceptable in accordance with industry practice.

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.

compound ingredient: a material added to a rubber to form a mix.

compound material: a substance used as part of a rubber mix.

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 the purpose of evaluating creep and stress relaxation properties of rubber).

conditioning: the exposure of a specimen under specified conditions, e.g., temperature, humidity, for a specified period of time before testing.

concentricity: the uniformity of hose wall thickness as measured in a plane normal to the axis of the hose.

conductive: a rubber having qualities of conducting or transmitting heat or electricity. Most generally, applied to rubber products capable of conducting static electricity.

control: a product of known characteristics which is included in a series of tests to provide a basis for evaluation of other products.

copolymer: a polymer formed from two or more types of monomers.

cord breaker: an openly spaced cord fabric to spread impact or to improve cover adhesion or both.

corrugated cover: a longitudinally ribbed or grooved exterior.

corrugated hose: hose with a carcass fluted radially or helically to enhance its flexibility or reduce its weight.

count: in fabric, the number of warp ends, or the number of filling picks, or both, in a square inch of fabric.

coupled length: see hose assembly. coupling: a frequently used alternative term for fitting.

cover: the outer component usually intended to protect the carcass of a product.

cover seam: the spiral or longitudinal joint formed by the lapping of hose cover stock.

cover wear: the loss of material during use due to abrasion, cutting or gouging.

cracking: a sharp break or fissure in the surface. Generally caused by strain and environmental conditions.

crazing: a surface effect on rubber articles characterized by multitudinous minute cracks.

creep: the deformation, in either cured or uncured rubber under stress, which occurs with lapse of time after the immediate deformation. See also: cold flow, and drift.

crimp: in fabric, (1) the sinusoidal curvature impressed in the warp or filling during weaving; (2) the difference in distance between two points on a yarn as it lies in a fabric, and the same two points when the yarn has been removed from the fabric and straightened under tension.

crimping: the act of forming a hose fitting with a surrounding series of die segments to compress the hose within the fitting.

crosshead extruder: an extruder so constructed that the axis of the emerging extruded product is at right angles to the axis of the extruder screw. Commonly used for applying the cover to braided or spiraled hose.

cross-link: chemical bond bridging one polymer chain to another.

cross wrap: the overlapping layer or layers of narrow tensioned wrapper fabric spiraled circumferentially over the outside of a hose to obtain external pressure during vulcanization. See also: wrapped cure.

crystallization (polymer): an arrangement of previously disordered polymer segments of repeating patterns into a geometric symmetry (which results in a reversible hardening of a rubber compound).

cubical expansion: the volume increase of hose when subjected to internal pressure. It is generally reported in cubic centimeters per unit length of hose.

cure: the act of vulcanization. See also: vulcanization.

cure time: the time required to produce vulcanization at a given temperature.

cut resistant: having that characteristic of withstanding the cutting action of sharp objects.

D

date code: any combination of numbers, letters, symbols or other methods used by a manufacturer to identify the time of manufacture of a product.

denier: a yarn sizing system for continuous filament synthetic fibers. The denier of filament yarn is the weight in grams of a length of 9000 meters of that yarn.

density: the mass per unit of volume of a material.

design factor: a ratio used to establish the working pressure of the hose, based on the burst strength of the hose.

dielectric strength: the measure of a product's ability to resist passage of a disruptive discharge produced by an electric stress.

DIN: Deutsches Institut for Normung-German National Standards Organization.

DOD: Department of Defense (U.S.)

DOT: Department of Transportation (U.S.)

drift: a change in a given hardness value after a specified period of time.

dry: the absence of tack; no adhering properties.

duck: a term applied to a wide range of medium and heavy-weight woven fabrics.

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.

E

eccentricity: in hose, tubing or cylindrical articles, the condition resulting from the inside and outside diameters not having a common center. See also eccentric wall and off-center.

eccentric wall: in hose or tubing, a wall of varying thickness.

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.

elastomer: macromolecular material which returns rapidly to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress; an elastic polymer.

elongation: the increase in length expressed numerically as a fraction or percentage of the initial length.

EN: European Norms

end: a single strand or one of several parallel strands of a reinforcing material on a single package such as a braider spool.

end block: see end reinforcement.

end reinforcement: extra reinforcing material applied to the end of a hose product to provide additional strength or stiffening.

ends: see fabric count.

endurance test: a service or laboratory test, conducted to product failure, usually under normal use conditions.

enlarged end: in hose, an end having a bore diameter greater than that of the main body of the hose in order to accommodate a larger fitting.

extruded: forced through the shaping die of an extruder. The extrusion may be solid or hollow cross section.

extruder: a machine, generally with a driven screw, for continuous forming of rubber or plastic through a die. It is widely used for the production of hose tubes.

F

fabric: a planar structure produced by interlaced yarns, fibers or filaments.

fabric count: the number of warp ends per inch, and the number of filling picks per inch.

fabric finish: see fabric impression.

fabric impression: a pattern in the rubber surface formed by contact with fabric during vulcanization.

fabric picks/inch: the number of filling (weft) yarns per inch.

fatigue: the weakening or deterioration of a material occurring when a repetitious or continuous application of stress causes strain.

FDA: Food and Drug Administration (U.S.)

ferrule: a collar placed over a hose end to affix the fitting to the hose. The ferrule may be crimped or swaged, forcing the hose in against the shank of the fitting, or the shank maybe expanded, forcing the hose out against the ferrule, or both.

filament: textile fiber of indefinite or extreme length.

filler: (1) any compounding material, usually in powder form, added to rubber in a substantial volume to improve quality or lower cost; (2) the material added during hose fabrication to fill gaps or voids between turns of body wire; (3) improperly used in place of "filling" to denote the transverse strength member in a circular woven reinforcement.

filling threads: the threads of yarns running at right angle to the warp.

fitting: a device attached to the end of the hose to facilitate connection.

flange-fitting: a circular ring at the end of a hose or hose assembly for joining to another circular ring, generally by bolting; may be a rubber member integral with the hose or a metal ring attached to a pipe nipple.

flat cure: a method of curing fire hose in a flat form.

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

flat wire: the rectangular cross-section wire commonly used as the inner element of rough bore suction hose.

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

flexible mandrel: 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.)

flex life: the relative ability of a rubber article to withstand cyclical bending stresses.

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

flow crack: a surface imperfection caused by improper flow and failure of stock to knit or blend with itself during the molding operation.

flow line: see flow mark.

flow mark: a surface imperfection similar to a flow crack, but the depression is not quite as deep.

flow rate: a volume of fluid per unit of time passing a given cross-section of a flow passage in a given direction.

FM: Factory Mutual Reasearch

foreign material: any extraneous matter such as wood, paper, metal, sand, dirt or pigment that should not normally be present in the tube or cover of a hose.

formula: a list of ingredients and their amount, used in the preparation of a compound.

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

freeze resistant: see cold resistant.

friction: (1) a rubber adhesive compound impregnating a fabric, usually applied by means of a calendar with rolls running at different surface speeds (the process is called “frictioning"); (2) the resistance to motion due to the contact of surfaces; (3) erroneously used to denote adhesion, or degree of adhesion.

friction coating: a rubber covering applied to the weave of a fabric simultaneously with impregnation.

friction surface: the exposed portion of a hose formed by a layer of rubber impregnated fabric as distinguished from a product having the fabric completely covered with a layer of rubber.

frictioned fabric: a fabric impregnated with a rubber compound by friction motion (calendar rolls running at different surface speeds).

frosting: see chalking.

fungicide: a material that prevents or retards the growth of fungi.

G

grab test: a tensile test for woven fabric using specimens considerably wider than the jaws holding the ends of the test specimen.

grain: the unidirectional orientation of rubber or filler particles resulting in anisotropy of rubber compounds.

ground finish: a surface produced by grinding or buffing.

gum compound: a rubber compound containing only those ingredients necessary for vulcanization. Small amounts of other ingredients may be added for processability, coloring, and improving resistance to aging.

H

hand-built hose: a hose made by hand on a mandrel, reinforced by textile or wire or combination of both.

hank: (1) a skein of yarn; (2) a standard length of yarn. The length is specified by the yarn numbering system in use, e.g., cotton hanks have a length of 840 yards.

hardening: an increase in resistance to indentation.

hardness: resistance to indentation. See also durometer hardness.

hawser twist: a cord or rope construction in which the first and second twists are in the same direction while the third twist is in the opposite direction, i.e., S-S-Z.

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

helical cord: in hose, a reinforcement formed by a cord or cords wound spirally around the body of a hose.

helix: in hose, a shape formed by spiraling a wire or other reinforcement around the cylindrical body of a hose.

herringbone wrap: a narrow herringbone woven tape spiraled circumferentially over the outside of the product to apply external pressure during vulcanization. See also wrapped cure.

Higbee: the thread of a hose coupling, the outermost convolution of which has been removed to such an extent that a full cross section of the thread is exposed, this exposed end being beveled.

hold test: a hydrostatic pressure test in which the hose is subjected to a specified internal pressure for a specified period of time.

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

hose assembly: a length of hose with a coupling attached to one or each end.

hose clamp: a collar, band or wire used to hold hose on to a fitting, See also: clamp, ferrule.

hose duck: a woven fabric made from plied yarns with approximately equal strength in warp and filling directions.

hot air cure: vulcanization by using heated air, with or without pressure, See also: air cure, vulcanization.

hysteresis: a loss of energy due to successive deformation and relaxation. It is measured by the area between the deformation and relaxation stress-strain curves.

hysteresis loop: in general, the area between stress-strain curves of increasing and reducing stress; a measure of hysteresis.

I

ID: 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.

immediate set: the amount of deformation measured immediately after removal of the load causing the deformation,

impregnation: the act of filling the interstices of an article with a rubber compound. Generally applies to the treatment of textile fabrics and cords.

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

impression, fabric: impression formed on the rubber surface during vulcanization by contact with fabric jacket or wrapper,

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

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

inhibitor: an ingredient used to suppress a chemical reaction or a growing activity such as mildew.

insert: optional term for nipple (see nipple).

inspection block: a description on a drawing of the dimensional inspection to which a hose will be subjected.

instantaneous modulus: the slope of a stress-strain curve at a single point, employed when modulus varies from point to point.

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

intrinsic viscosity: the ratio of the difference of the viscosity of the solution, at the given concentration and the viscosity of the pure solvent to the product of the viscosity of the pure solvent and the volume concentration of the solution.

IPT: the abbreviation for standard iron pipe thread.

ISO: the abbreviation for the International Organization for Standardization.

J

jacket: (1) a seamless tubular braided or woven ply generally on the outside of a hose; (2) a woven fabric used during vulcanization by the wrapped cure method.

K

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

knit fabric: a flat or tubular structure made from one or more yarns or filaments whose direction is generally transverse to the fabric axis but whose successive passes are united by a series of interlocking loops.

knit ply: a layer of textile reinforcement in which the yarns are applied in an interlocking looped configuration in a continuous tubular structure.

knitter: a machine for forming a fabric by the action of needles engaging threads in such a manner as to cause a sequence of interlaced loops (Interlaced loops forming a continuous tubular structure are commonly used as hose reinforcement).

L

laminated cover: a cover formed to desired thickness from thinner layers vulcanized together.

lap: a part that extends over itself or like part, usually by a desired and predetermined amount.

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 also: pitch, spiral lay.

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

lead burst: a leak in lead press hose during vulcanization caused by a rupture of the lead casing.

lead casing: the extruded lead tube or sheath which confines the hose during vulcanization.

lead chip mark: a minor nick or mark in the surface of the cover of lead finished hose caused by particles of lead flakes sloughing off the lead extrusion die during the process of lead covering.

lead cure finish: a type of exterior surface, either ribbed, smooth, or longitudinally corrugated, obtained by the lead pipe mold method of vulcanization.

lead dent: an indentation in the surface of lead finished hose caused by deformations in lead covering before vulcanization.

lead die mark: the longitudinal line or mark in the cover of lead finished hose caused by a damaged lead extrusion pin.

lead discoloration: a dark stain on the colored cover of lead finished hose caused by a chemical reaction of the lead with the rubber compound.

lead flake: a particle of lead which remains on the cover of lead finished hose after the lead covering has been stripped from the hose

lead pop: a surface protrusion, the result of a rupture of lead sheath during vulcanization.

lead press cure: a near-obsolete process wherein a lead sheath acts as a restraining member or mold during vulcanization.

lead press finish: the type of exterior surface obtained by the lead press method of vulcanization.

lead press joint: see lead stop.

lead stop: the mold mark in a lead press hose cover caused by stopping the lead press to add another lead billet.

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.

legs: tension filaments appearing when cemented or frictioned plies are pulled apart. Colloquial.

leno breaker: an open mesh fabric made from coarse ply yarns, with a leno weave. See also: breaker ply.

leno weave: a fabric structure in which the warp yarns are bound in by the filling, resulting in an open perforated fabric.

life test: a laboratory procedure used to determine the resistance of a hose to a specific set of destructive forces or conditions. See also: 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.

lined hose: term generally referring to fire hose having a seamless woven jacket or jackets and a tube.

liner: a separator, usually cloth, plastic film or paper, used to prevent adjacent layers of material from sticking together.

lining: see tube.

livering: a gelling in cement giving a liver-like consistency.

loop edge: a selvage formed by having the filling loop around a catch cord or wire which is later withdrawn, leaving small loops along the edge of the cloth.

loop-edge tape: a tape woven with a selvage edge formed by looping the filling threads to prevent raveling, allowing extensibility for even tensions.

loose cover: a separation of the cover from the carcass or reinforcements.

loose ply: a separation between adjacent plies.

loose tube: a tube separated from the carcass.

lot: a specified quantity of hose from which a sample is taken for inspection.

low temperature flexibility: the ability of a hose to be flexed, bent or bowed at low temperatures without loss of serviceability.

low temperature flexing: the act of bending or bowing a hose under conditions of cold environment.

LPG: the abbreviation for liquefied petroleum gas.

M

machine made: a mandrel-built reinforced hose made by machine as opposed to hose built by hand.

mandrel: a form, generally of elongated round section, used for size and to support hose during fabrication and/or vulcanization. It may be rigid or flexible.

mandrel built: a hose fabricated and/or vulcanized on a mandrel.

mandrel wrapped: a tubing, built up by wrapping a thick unvulcanized sheet around a mandrel.

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 a given cross-section of a flow passage in a given direction.

masterbatch: a preliminary mixture of rubber and one or more compound ingredients for such purposes as more thorough dispersion or better processing, and which will later become part of the final compound in a subsequent mixing operation.

migration: in a rubber compound, the movement of more or less rubber soluble materials from a point of high concentration to one of low or zero concentration. Migration is applied to the movement of accelerators, antioxidants, antiozonants, sulphur, softeners and organic colors. It is a form of diffusion.

migration stain: a discoloration of a surface by a hose which is adjacent to but not touching the discolored surface.

mildew inhibited: containing material to prevent or retard the propagation of a fungus growth.

mildew resistance: withstanding the action of mildew and its deteriorating effect.

mill: a machine with two horizontal rolls revolving in opposite directions used or the mastication or mixing of rubber.

minimum burst pressure: the lowest pressure at which rupture occurs under prescribed conditions.

mix: see compound.

modulus: in the physical testing of rubber, the load necessary to produce a stated percentage of elongation, compression or shear.

moisture absorption: the assimilation of water by a rubber or textile product.

moisture regain: the re absorption of water by textile.

monomer: a low molecular weight substance consisting of molecules capable of reacting with like or unlike molecules to form a polymer.

Mooney scorch: a measure of the incipient curing characteristics of a rubber compound using the Mooney viscometer.

Mooney viscosity: a measure of the plasticity of a rubber or rubber compound determined in a Mooney shearing disc viscometer.

MPa: megapascal a measure of pressure, one MPa equals 145 psi

MSHA: Mine Safety and Health Administration

N

NAHAD: National Association of Hose and Accessories Distributors

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

nerve: a measure of toughness or recovery from deformation in unvulcanized rubbers or compounds.

NFPA: National Fluid Power Association, also National Fire Protection Association

NHTSA: National Highway Traffic Safety Administration

nip: the clearance between rolls of a mixing mill or calendar.

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

nominal: a dimensional value assigned for the purpose of convenient designation; existing in name only.

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

O

OD: the abbreviation for outside diameter.

off-center: see eccentricity.

off gauge: not conforming to a specified thickness.

oil proof: not affected by exposure to oil.

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

open seam: a seam whose edges do not meet, creating a void.

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

operating pressure: see working pressure,

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

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

OSHA: Occupational Safety and Health Administration

overcure: a state of vulcanization beyond the optimum cure.

oxidation: the reaction of oxygen on a rubber product, usually evidenced by a change in the appearance or feel of the surface or by a change in physical properties. oxygen bomb: a chamber capable of holding oxygen at an elevated pressure which can be heated to an elevated temperature. Used for an accelerated aging test.

oxygen bomb aging: a means of accelerating a change in the physical properties of rubber compounds by exposing them to the action of oxygen at an elevated temperature and pressure.

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).

P

peptizer: a compounding ingredient used in small proportions to accelerate by chemical action the softening of rubber under the influence of mechanical action, heat, or both.

performance teat: see service test.

permanent fitting: the type of fitting which, once installed, may not be removed for use in another hose.

permanent set: the amount by which an elastic material fails to return to its original form after deformation.

PHA: Public Health Administration

photographing: a bas-relief or outline of a reinforcement which appears on the cover of a hose after vulcanization. Also called "profiling."

pick: an individual filling yarn of a fabric or woven jacket.

pitch: the distance from one point on a helix to the corresponding point on the next turn of the helix, measured parallel to the axis. See also: spacing.

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

plain ends: the uncapped, or otherwise unprotected, straight ends of a hose.

plasticity: (1) a measure of the resistance to shear of an unvulcanized elastomer; (2) a property of vulcanized rubber to retain a shape or form imparted to it by a deforming force.

plasticizer: a compounding ingredient which can change the hardness, flexibility, or plasticity of an elastomer.

plastometer: (1) an instrument for measuring the viscosity of raw or unvulcanized rubber; (2) an instrument for measuring the hardness of vulcanized rubber.

plied yarn: a yarn made by twisting together in one operation two or more single yarns,

ply: (1) a layer or rubberized fabric; (2) a layer formed by a single pass through a single deck of a yarn, cord, or wire braiding machine; (3) a layer formed by a single pass through a single head of yarn, cord, or wire knitting machine; (4) a seamless woven jacket consisting of warp and filler yarns and/or wire; (5) a layer consisting of multiple strands of cord or wire closely spaced; (6) a layer formed by winding a single strand of cord or wire closely spaced; (7) a single yarn in a composite yarn; (8) a layer of unvulcanized rubber.

ply adhesion: the force required to separate two adjoining reinforcing members of a hose.

ply separation: a loss of adhesion between plies.

pock marks: uneven blister-like elevations, depressions, or pimpled appearance.

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

popcorn: a term common to steam hose where small eruptions within the tube wall rip or tear material, leaving cavities in the tube.

porous tube: (1) the physical condition of a hose tube due to the presence of pores; (2) a hose tube that has low resistance to permeation.

pre-cure: see semi-cure and scorch.

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

pressure, burst: the pressure at which rupture occurs.

pressure, operating: see: working pressure.

pressure, proof: a specified pressure which exceeds the manufacturer's recommended working pressure applied to a hose to indicate its reliability at normal working pressure. Proof pressure is usually twice the working pressure.

pressure, service: see: working pressure.

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

pricker mark: a perforation of the cover of a hose performed before or after vulcanization.

printed brand: see brand.

processability: the relative ease with which raw or compounded rubber can be handled in or on rubber processing machinery.

pressure, operating: see: working pressure.

pressure, proof: a specified pressure which exceeds the manufacturer's recommended working pressure applied to a hose to indicate its reliability at normal working pressure. Proof pressure is usually twice the working pressure.

pressure, service: see: working pressure.

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

pricker mark: a perforation of the cover of a hose performed before or after vulcanization.

printed brand: see brand.

processability: the relative ease with which raw or compounded rubber can be handled in or on rubber processing machinery.

proof pressure: a specified pressure which exceeds the manufacturer's recommended working pressure applied to a hose to indicate its reliability at normal working pressure. Proof pressure is usually twice the working pressure.

proof pressure test: a non-destructive pressure test applied to a hose to determine its reliability at normal working pressures by applying pressures which exceed the manufacturer's rated working pressure.

psi: the abbreviation for pounds per square inch.

pulled-down tube: see loose tube.

pure gum: a rubber compound containing only those ingredients necessary for vulcanization; particularly applicable to natural rubber.

Q

qualification test: the examination of samples from a typical production run of hose to determine adherence to a given specification; performed for approval as a supplier.

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 run.

R

RAC: the abbreviation for the Rubber Association of Canada.

rag-wrap: see wrapped cure.

recovery: the degree to which a hose returns to its normal dimensions or shape after being distorted.

reinforcement: (1) the strengthening members, consisting of either fabric, cord, and/ or metal, of a hose; (2) the non-rubber elements of a hose. See also: carcass

reinforcing agent: an ingredient (not basic to the vulcanization process) used in a rubber compound to increase its resistance to mechanical forces.

resin: a compounding material, solid or liquid in form, used to modify the processing and/or vulcanized characteristics of a compound.

retarder: a compounding ingredient used to reduce the tendency of a rubber compound to vulcanize prematurely.

reusable coupling: see reusable fitting.

reusable fitting: the type of fitting which, by design, may be removed and reused.

reversion: the softening of vulcanized rubber when it is exposed to an elevated temperature; a deterioration in physical properties. (Extreme reversion may result in tackiness.)

rise test: a determination of the distance a fire hose, under a specified internal pressure, lifts from the surface on which is rests.

roll ratio: the ratio of the surface speeds of two adjacent mill or calendar rolls.

RMA: the abbreviation of The Rubber Manufacturers Association.

rough bore hose: a wire reinforced hose in which a wire is exposed in the bore.

rubber: elastomer which can be, or already is, modified to a state in which it is essentially insoluble (but can swell) in boiling solvent, such as benzene, methyl ethyl ketone and ethanol-toluene azeotrope, and which in its modified state cannot be easily remoulded to a permanent shape by the application of heat and moderate pressure.

rubber cement: see cement.

S

SAE: Society of Engineers

safety factor: see design factor.

sampling: a process of selecting a portion of a quantity of a hose for testing or inspection, selected without regard to quality,

scorch: premature vulcanization of a rubber compound.

screw-together resuable fitting: a type of hose fitting whose SOCKET and NIPPLE are threaded together in combination with the hose.

seam: a line formed by the joining of the edges of a material to form a single ply or layer.

seaming strip: a strip of material laid over a seam to act as a binder.

self cure: see air cure.

selvage: the lengthwise woven edge of a fabric. Also called selvedge.

semi-cure: a preliminary but incomplete cure applied to a tube or hose in the process of manufacture to cause the tube or hose to acquire a degree of stiffness or to maintain some desired shape, service pressure: see working pressure.

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

set: the amount of strain remaining after complete release of a load producing a deformation.

shank: that portion of a fitting, which is inserted into the bore of a hose.

shear modulus: the ratio of the shear stress to the resulting shear strain (the latter expressed as a fraction of the original thickness of the rubber measure, at right angles to the force) Shear modulus may be either static or dynamic.

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

shell: see ferrule.

shock load: a stress created by a sudden force.

simulated service test: see bench test

sink: a collapsed blister or bubble leaving a depression in a product.

skim coat: a layer of rubber material laid on a fabric but not forced into the eave Normally laid on a firictoned fabric, Sometimes called skim.

skimmed fabric: a fabric coated with rubber on a calender. The skim coat may or may not be applied over a friction coat

skive: (1) a cut made at an angle to the surface of a sheet of rubber to produce a tapered or leathered cut (2) the removal of a short length of cover to permit the attachment of a fitting directly over the hose reinforcement.

smooth bore hose: a wire reinforced hose in which the wire is not exposed on the inner surface of the tube.

smooth cover: a cover having an even and uninterrupted surface; a commercial finish.

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

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

spacing: the space between adjacent turns of helically wound wire. (Differs from "pitch" in that the diameter or width of wire is not included.)

specification: a document setting forth pertinent details of a product, such as performance, chemical composition, physical properties and dimensions, prepared for use in, or to form the basis for, an agreement between negotiating parties.

specific gravity: the ratio of the weight of a given substance to the weight of an equal volume of water at a specified temperature.

specimen: an appropriately shaped and prepared sample, ready for use in a test procedure.

spider mark: (1) a cleavage or weak spot caused by the failure of a compound to reunite after passing a spoke of the spider of an extrusion machine; (2) the grain produced at point of joining of stock after passing the spoke of the spider of an extrusion machine.

spiral: a method of applying reinforcement in which there is no interlacing between individual strands of the reinforcement.

spiral lay: the manner in which a spiral reinforcement is applied with respect to angularity and lead or pitch as in a hose or cylindrical article. See also angle of lay

splice: a joint or junction made by lapping or butting, straight or on a bias, and held together through vulcanization or mechanical means.

spread: a thin coat of material in solvent form applied on a fabric surface by means of knife, bar or doctor blade.

spread fabric: a fabric the surface of which is coated with a rubber solution and dried.

spring guard: a helically wound wire applied internally or externally to reinforce the end of a hose. stain: see migration stain.

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.

Standards Organizations: ABS-American Bureau of Shipping, ANSI-American National Standards Institute, API-American Petroleum Institute, ASTM-American Society for Testing and Materials, BIA-Boating Industry Association, BSI-British Standards Institute, CGA-Compressed Gas Association, DIN-Deutsches Institut for Normung-German Standards , EN-European Norms, FPS-Fluid Power Society, FM- Factory Mutual Research, ISO-International Organization for Standardization, JIS-Japanese Industrial Standards, NAHAD-National Association of Hose and Accessories Distributors, NFPA-National Fluid Power Association, RMA-Rubber Manufactures Association, SAE-Society of Automotive Engineers, TFI-The Fertilizer Institute, UL- Underwriters Laboratories

staple: (1) textile fiber of relatively short length when spun and twisted forms a yarn; (2) the length of such a textile fiber.

static bonding: use of a grounded conductive material to eliminate static electrical charges.

static conductive: having the capability of furnishing a path for a flow of static electricity. static wire: a wire incorporated in a hose to conduct static electricity.

stock: an uncured rubber compound of a definite composition from which a given article is manufactured.

straight end: a hose end with an inside diameter the same as that of the main body of the hose.

straight wrap: in a curing process, a wrap of lightweight fabric in which the warp threads of the fabric are parallel to the axis of the hose.

stress relaxation: the decrease in stress after a given time at constant strain.

stress-strain: the relationship of force and deformation of a unit area of a body during compression, extension or shear.

stretch: (1) an increase in dimension; an elongation; (2) the endload applied to fire hose during vulcanization to reduce hose elongation,

strike through: (1) in coated or frictioned fabric, a penetration of rubber compound through the fabric, (2) in woven fire hose, the penetration of the rubber backing through the jacket,

stripper cuts: the longitudinal cuts in the cover of lead finished hose caused by an improperly set stripper knife.

strip test: in fabric testing, tensile strength test made on a strip of fabric raveled down to a specified number of threads or width of fabric, all of which are firmly held in grips wider than the test piece.

sulfur, free: the sulfur in a rubber compound extractable by sodium sulfite after the normal vulcanization process.

sulfur, total: all the sulfur present in a rubber compound, including inorganic sulfides and sulfates.

sun checking: the surface cracks, checks, or crazing caused by exposure to direct or indirect sunlight.

surge: a rapid and transient rise in pressure.

swaging: the act of forming a hose fitting by passing it into a die, generally split, which is sized to yield the desired finished fitting diameter.

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

T

tabby: a section of cord fabric with closely woven pick yarns. enabling the woven cord to be cut without the individual cords in the rest of the roll becoming displaced.

tack: the ability to adhere to itself: a sticky or adhesive quality or condition

tack, rubber: a property of a rubber and rubber compounds that causes two layers of compounds that have been pressed together to adhere firmly at the area of contact.

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

teeth: the tension filaments which appear between two adhering plies of rubber as they are pulled apart

tensile strength: the maximum tensile stress applied while stretching a specimen to rupture.

tensile stress: a stress applied to stretch a test piece (specimen).

test pressure: see proof pressure test.

tex: a yarn size system defined as the weight in grams of 1000 meters of yarn.

textile: (1) the general term applied to that which is or maybe woven, as a woven cloth or yarn, (2) a fibrous material suitable for being spun and woven into cloth or yarn.

TFI: The Fertilizer Institute

thin cover: (1) a cover, the thickness of which is less than specified; (2) a wire braid hydraulic hose specifically made with a thin cover to eliminate the need for buffing when attaching couplings.

thin tube: a lining the thickness of which is less than specified.

tight braid: (1) an unevenness in a braid reinforcement caused by one or more ends of the reinforcement being applied at a greater tension than the remaining ends; (2) a localized necking down of the braided reinforcement caused by a stop in the braiding operation.

tolerance: (1) the upper and lower limits between which a dimension must be held; (2) the total range of variation, usually bilateral, permitted for a size, position or other required quantity.

trapped air: air trapped during cure (which usually causes a loose ply or cover, a surface mark, depression or void.)

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

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

tubing machine: see extruder

twist: (1) the turns about the axis, permit of length, of a fiber, roving yarn, card, etc. Twist is usually expressed as turns per inch; (2) the turn about the axis of a hose subjected to internal pressure.

U

UL: Underwriters Laboratories

ultimate strength: see tensile strength.

undercure: a less than optimal state of vulcanization, which may be evidenced by tackiness or inferior physical properties.

USCG: U.S. Coast Guard.

USDA: U.S. Department of Agriculture.

U.S. Government agencies

DOD- Department of Defense, DOT- Department of Transportation, FDA-Food and Drug Administration, MSHA-Mine Safety and Health Administration, OSHA- Occupational Safety and Health Administration, PHA- Public Health Administration, USCG- U.S. Coast Guard, USDA- U.S. Department of Agriculture.

V

viscosity: the resistance of a material to flow under stress.

void: the absence of material or an area devoid of materials where not intended. See also: blister, sink.

volume change: a change in linear dimensions of a specimen immersed in a liquid or exposed to a vapor.

volume swell: see swelling.

vulcanization: an irreversible process during which a rubber compound, through a change in its chemical structure (e.g. cross-linking), becomes less plastic and more resistant to swelling by organic liquids, and which confers, improves or extends elastic properties over a greater range of temperature.

W

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.

wavy tube: a tube or lining with an inner surface having surface ripples formed by the pattern of the reinforcement.

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

weft: a term used for filling. See filling.

weftless cord fabric: a cord fabric either without filling yarns or with a few small filling yarns widely spaced.

wire braid: see braid.

wire loop: in braided hose, a loop in the wire reinforcement caused by uneven tensions during bobbin winding or braiding.

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

wire throw-out: (1) in braided hose, a broken end or ends in the wire reinforcement protruding from the surface of the braid; (2) a displaced coil in rough bore hose.

wire wound: having a single wire or a plurality of wires spiraled in one or more layers as a protective or reinforcing member.

wire woven: woven with the wire reinforcement applied helically by means of a circular loom.

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

woven fabric: a flat structure composed of two series of interlacing yarns or filaments, one parallel to the axis of the fabric and the other transverse.

woven jacket: see jacket.

WP: the abbreviation for working pressure.

wrap: see straight wrap and cross wrap.

wrapped cure: a vulcanizing process using a tensioned wrapper (usually of fabric) to apply external pressure.

wrapper marks: the impressions left on the surface of a hose by a material used during vulcanization. Usually shows characteristics of a woven pattern and wrapper edge marks; see also: wrapped cure; wrinkled ply; buckled ply.

Y

yarn: a generic term for continuous strands of textile fibers or filaments in a form suitable for knitting, weaving, or otherwise interwining to form a textile fabric. It may comprise: (a) a number of fibers twisted together, (b) a number of filaments laid together without twist (a zero-twist yarn), (c) a number of filaments laid together with more or less twist, (d) a single filament with or without twist (a mono-filament), or (e) one or more strips made by the lengthwise division of a sheet of material, such as a natural or synthetic polymer, a paper or metal foil used with or without twist in a textile construction.

yarn number: the number of hanks in a pound, usually cotton.

USEFUL TABLES
Chapter 11

This chapter covers tables of useful information as it pertains to hose. Some of the data in these tables has been extracted from standard engineering texts; other tables, devised specifically by the Hose Technical Committee of the RMA General Products Group, are based on average conditions and are not to be used as a minimum-maximum but merely as a guide. Conversion to metric units have been rounded for convenience.

The reader is cautioned that the following tables are 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 reader should also refer to and follow manufacturers' specific instructions and recommendations with regard to such information, where they exist.

TABLE 11-1
WATER DISCHARGE
FLOW OF WATER THROUGH 100 FOOT LENGTHS HOSE, STRAIGHT-SMOOTH BORE
U.S. GALLONS PER MINUTE

PSI at Hose Inlet	Nominal Hose Diameters — Inches											
	1/2	5/8	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	6	8
20	4	8	12	26	47	76	161	290	468	997	2895	6169
30	5	9	15	32	58	94	200	360	582	1240	3603	7679
40	6	11	18	38	68	110	234	421	680	1449	4209	8970
50	7	12	20	43	77	124	264	475	767	1635	4748	10118
60	8	14	22	47	85	137	291	524	846	1804	5239	11165
75	9	15	25	53	95	154	329	591	955	2035	5910	12595
100	10	18	29	62	112	180	384	690	1115	2377	6904	14712
125	11	20	33	70	126	203	433	779	1258	2681	7788	16595
150	12	22	36	77	139	224	478	859	1388	2958	8593	18313
200	15	26	42	90	162	262	558	1004	1621	3455	10038	21390

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.

$$Q = 0.443Cd^{2.63}\left(\frac{P_1 - P_2}{L}\right)^{.54}$$

C value is the Hazen- Williams coefficient; smaller values must be used for rougher tube surfaces.

Where: Q = quantity in U.S. gallons per minute
C = 140 for clean, extremely smooth bore and straight hose
d = inside diameter of hose in inches
$P_1 - P_2$ = pressure change in lbs. per square inch
L = length of hose in feet

TABLE 11-2
CONVERSION FACTOR
FLOW OF WATER THROUGH LENGTHS OTHER THAN 100 FEET
STRAIGHT-SMOOTH BOORE

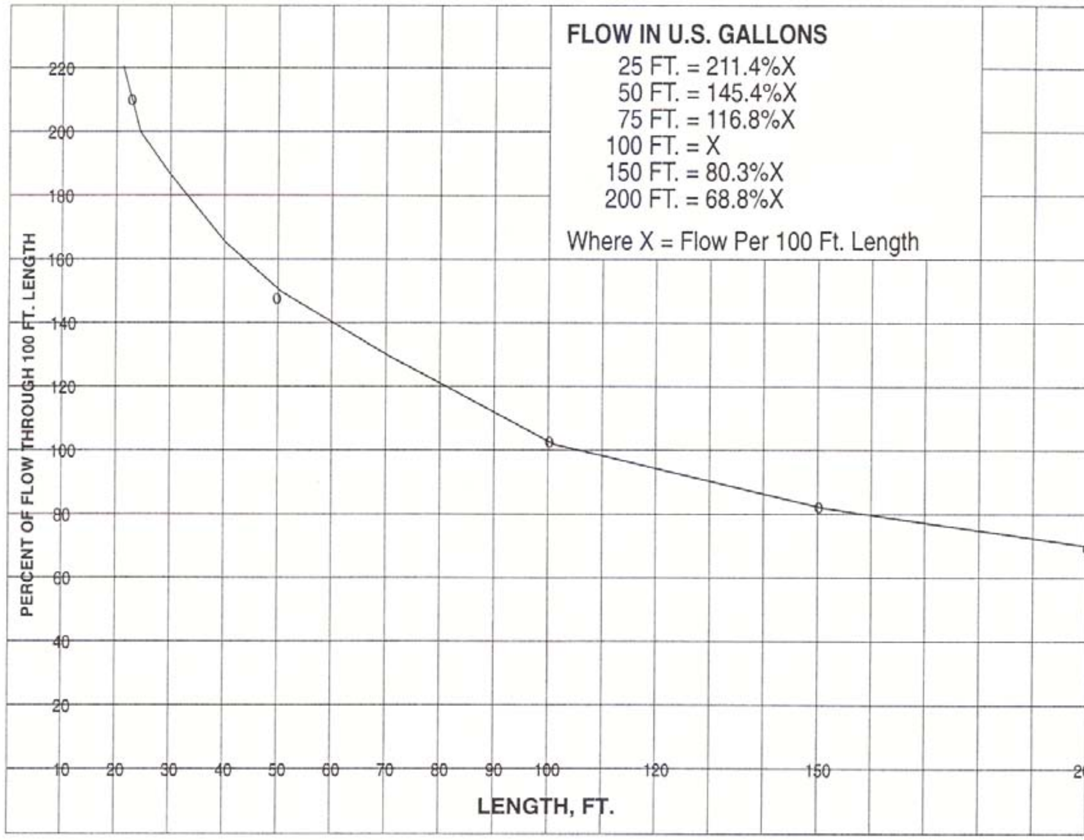


TABLE 11-3
FRICTION LOSS IN WATER HOSE
POUNDS PER SQUARE INCH PER 100 FOOT LENGTH STRAIGHT SMOOTH BORE

Flow of water in U.S. Gal Per Min	ACTUAL INTERNAL DIAMETER —— INCHES														
	1/2	5/8	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6	8	10	12
1	1.41														
2	5.09	1.72	0.71												
5	27.7	9.36	3.85	0.95	0.32	0.13									
10	100	33.7	13.9	3.42	1.15	0.47	0.12								
15		71.4	29.4	7.24	2.44	1.00	0.25	0.08							
20		122	50.0	12.3	4.16	1.71	0.42	0.14							
25			75.6	18.6	6.28	2.59	0.64	0.21							
30			106	26.1	8.80	3.62	0.89	0.30	0.12						
35			141	34.7	11.7	4.82	1.19	0.40	0.16						
40				44.4	15.0	6.17	1.52	0.51	0.21						
45				55.3	18.6	7.67	1.89	0.64	0.26						
50				67.1	22.7	9.32	2.30	0.77	0.32						
60				94.1	31.7	13.1	3.22	1.09	0.45						
70				125	42.2	17.4	4.28	1.44	0.59						
80					54.0	22.2	5.48	1.85	0.76						
90					67.2	27.7	6.81	2.30	0.95	0.23					
100					81.7	33.6	8.28	2.79	1.15	0.28					
125					123	50.8	12.5	4.22	1.74	0.43					
150						71.1	17.5	5.91	2.43	0.60	0.20				
175						94.6	23.3	7.86	3.24	0.80	0.27				
200						121	29.8	10.1	4.14	1.02	0.34				
225							37.1	12.5	5.15	1.27	0.43				
250							45.1	15.2	6.26	1.54	0.52				
275							53.8	18.1	7.47	1.84	0.62				
300							63.2	21.3	8.77	2.16	0.73	0.30			
350							84.0	28.3	11.7	2.87	0.97	0.40			
400							108	36.3	14.9	3.68	1.24	0.51			
450								45.1	18.6	4.57	1.54	0.64			
500								54.8	22.6	5.56	1.88	0.77	0.19		
600								76.8	31.6	7.79	2.63	1.08	0.27		
700								102	42.1	10.4	3.49	1.44	0.35	0.12	
800								131	53.8	13.3	4.47	1.84	0.45	0.15	
1000									81.4	20.0	6.76	2.78	0.69	0.23	0.10
1200									114	28.1	9.47	3.90	0.96	0.32	0.13
1400									152	37.3	12.6	5.18	1.28	0.43	0.18
1600										47.8	16.1	6.64	1.64	0.55	0.23
1800										59.5	20.0	8.25	2.03	0.69	0.28
2000										72.2	24.4	10.0	2.47	0.83	0.34
2500											36.8	15.2	3.73	1.26	0.52
3000											51.6	21.2	5.23	1.76	0.73

To convert PSI to Megapascals (MPa) multiply by 0.06895
To convert from PSI to feet of Hydraulic Head multiply by 2.309
To convert from U.S. gallons per minute to cubic feet per minute multiply by 0.1337
To convert from U.S. gallons per minute to cubic meters per second multiply by 6.309 x 10^{-5}.

NOTE: Friction loss can vary by 20% due to temperature. Bends can increase friction loss by 50%.

C value is the Hazen-Williams coefficient; smaller values must be used for rougher tube surfaces.

$$4.51\left(\frac{Q}{C}\right)^{1.85} X \frac{L}{d^{4.87}} \quad or \quad \Delta P = \frac{0.0483Q^{1.85}}{d^{4.87}} \quad @\,60°\ F\ (15.6°C)$$

where: △ P= pressure loss in lbs. Per square inch
Q= quantity in U.S. gallons per minute
C= 140 for clean, extremely smooth bore and straight hose
L= Length of hose in feet
d= inside diameter of hose in inches

The flow of air through hose can be treated similarly to the flow of liquids, the main difference being the consideration for compressibility of the air.

Table 11-4A and 11-4B show the relationship between rate of flow, hose size and pressure loss for various operating pressures. They can be used for general problems but are especially adapted to problems involving air compressors. Compressors are rated in cubic feet of free air at a certain discharge gauge pressure.

The pressure loss in the charts is listed for certain volumes of free air that have been compressed to one of several gauge pressures, then passed through the hose.

Example: What is the pressure loss through 100' of 1" I.D. hose connected to a compressor rated at 100 cubic feet per minute and 90 psi?

Solution: On Table 11-4B, find 100 cubic feet per minute in the top row of values. Read down that column until opposite 90 psi in the 1" I.D. group. The pressure loss value is 2.4 psi

TABLE 11-4A

***Frictional Loss of Air Pressure in Hose**

Hose I.D. (In.)	Gauge Pressure At Line (psi)	Cubic Feet Free Air ② Per Minute (SCFM)								
		.25	.50	.75	1.0	2.0	3.0	4.0	5.0	10.0
		③Loss of Pressure (psi) in ①100' Lengths of Hose								
	10	.12	.48	1.08						
	20	.09	.34	.77	1.37					
	30	.07	.27	.60	1.06					
	40	.05	.22	.49	.87	3.48				
	50	.05	.18	.41	.74	2.94				
	60	.04	.16	.36	.64	2.54				
	70	.04	.14	.32	.56	2.24	5.05			
1/4	80	.03	.13	.28	.50	2.01	4.52	8.03		
	90	.03	.11	.26	.45	1.82	4.09	7.26		
	100	.03	.10	.23	.41	1.66	3.73	6.63	10.36	
	110	.02	.10	.21	.38	1.52	3.43	6.10	9.53	
	125	.02	.08	.19	.34	1.36	3.06	5.44	8.51	
	150	.02	.07	.16	.29	1.15	2.60	4.62	7.21	
	200	.01	.06	.13	.22	.89	1.99	3.54	5.53	22.14
	10	.04	.15	.33	.60					
	20	.03	.11	.24	.42	1.70				
	30	.02	.08	.18	.33	1.32	2.96			
	40	.02	.07	.15	.27	1.08	2.42			
	50	.01	.06	.13	.23	.91	2.05	3.64		
	60		.05	.11	.20	.79	1.77	3.15	4.92	
5/16	70		.04	.10	.17	.69	1.56	2.78	4.34	
	80		.04	.09	.16	.62	1.40	2.48	3.88	
	90		.04	.08	.14	.56	1.26	2.25	3.51	
	100		.03	.07	.13	.51	1.15	2.05	3.21	
	110		.03	.07	.12	.47	1.06	1.89	2.95	11.79
	125		.03	.06	.11	.42	.95	1.68	2.63	10.53
	150		.02	.05	.09	.36	.80	1.43	2.23	8.93
	200		.02	.04	.07	.27	.62	1.10	1.71	6.85
	10	.01	.06	.13	.23	.91				
	20		.04	.09	.16	.65	1.46			
	30		.03	.07	.13	.50	1.14	2.02	3.15	
	40		.03	.06	.10	.41	.93	1.65	2.58	
	50		.02	.05	.09	.35	.78	1.39	2.18	
	60		.02	.04	.08	.30	.68	1.21	1.89	
3/8	70		.02	.04	.07	.27	.60	1.07	1.66	6.66
	80		.02	.03	.06	.24	.54	.95	1.49	5.95
	90		.01	.03	.05	.22	.48	.86	1.35	5.39
	100			.03	.05	.20	.44	.79	1.23	4.92
	110			.03	.05	.18	.41	.72	1.13	4.52
	125			.02	.04	.16	.36	.65	1.10	4.04
	150			.02	.03	.14	.31	.55	.86	3.42
	200			.01	.03	.11	.24	.42	.66	2.63

Note: Losses too high for efficient tool operation

*Tabulated Data based on $\Delta P_{100} = 6.25\times10^{-5}\times\frac{520}{P}\times\frac{(SCFM)^2}{d^{5.257}}$

ΔP_{100} = pressure drop/100' hose
P = absolute pressure, psia
SCFM = standard ft^2/min of air flow
d = I.D. of hose

① For longer or shorter lengths, the pressure drop is directly proportional to the given value here.
② Free Air — 14.7 psi and 80 F.
③ These pressure drop figures are accurate for hose with smooth I.D. tube and full-flow couplings. Greater pressure drops will occur when hose has a rough I.D. tube or restrictions at the fittings.

TABLE 11-4B
Frictional Loss of Pressure for Pulsating Flow of Air Through Hose For ① 100' Coupled Lengths

HOSE I.D. (In.)	Gauge Pressure (psi)	Flow of Free Air, Cubic Feet Per Minute												
		30	40	50	60	70	80	90	100	110	120	130	140	150
		②Loss of pressure, psi												
	50	10.0	20.2	36.2										
	60	8.0	16.4	29.6	46.8									
	70	6.8	14.0	24.8	40.0	56.8								
1/2	80	5.6	12.0	21.6	34.8	50.4	69.2							
	90	4.8	10.8	19.0	29.6	44.0	61.0	82.0						
	100	4.6	9.6	16.8	26.6	38.6	54.4	73.2						
	110	4.0	8.6	15.2	24.0	35.2	49.2	66.6	89.0					
	50	1.6	3.0	4.8	7.0	8.8	13.0	17.0	22.8	28.4				
	60	1.2	2.4	3.8	5.6	7.6	10.4	13.6	17.2	22.4				
	70	1.0	1.8	3.0	4.6	6.4	8.4	11.0	14.0	17.6	22.0			
3/4	80	1.0	1.6	2.6	3.8	5.6	7.2	9.4	11.6	14.4	17.6	21.2		
	90	0.8	1.4	2.2	3.2	4.6	6.2	8.0	10.0	12.4	15.0	18.0		
	100	0.8	1.2	2.0	2.8	4.0	5.4	7.0	8.8	10.8	13.2	15.8	18.8	22.2
	110	0.6	1.0	1.8	2.6	3.6	4.8	6.2	7.8	9.8	11.8	14.2	16.8	19.8
	50	0.4	0.6	1.0	1.6	2.2	3.0	4.0	5.2	7.0	9.6	14.0		
	60	0.4	0.6	0.8	1.2	1.6	2.4	3.0	4.0	5.2	6.6	8.4	11.0	14.4
	70	0.2	0.4	0.8	1.0	1.4	2.0	2.6	3.2	4.0	5.0	6.2	7.6	9.4
1	80	0.2	0.4	0.6	1.0	1.4	1.6	2.2	2.8	3.4	4.0	4.8	5.4	7.0
	90	0.2	0.4	0.6	0.8	1.2	1.4	1.8	2.4	2.8	3.4	4.0	4.8	5.6
	100	0.2	0.4	0.4	0.8	1.0	1.2	1.6	2.0	2.4	3.0	3.6	4.2	4.8
	110	0.2	0.4	0.4	0.6	0.8	1.2	1.4	1.8	2.2	2.6	3.0	3.6	4.2
	50		0.2	0.4	0.4	0.6	0.8	1.0	1.4	2.0				
	60			0.2	0.4	0.6	0.6	1.0	1.2	1.6	2.0	2.4	3.0	
	70			0.2	0.4	0.4	0.6	0.8	0.8	1.2	1.4	1.6	2.0	2.6
1-1/4	80				0.2	0.4	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.0
	90				0.2	0.4	0.4	0.6	0.6	0.8	1.0	1.2	1.4	1.6
	100					0.2	0.4	0.4	0.6	0.8	0.8	1.0	1.2	1.4
	110					0.2	0.4	0.4	0.6	0.6	0.8	1.0	1.0	1.2
	50					0.2	0.4	0.4	0.4	0.6	0.6	0.8	1.0	1.2
	60						0.2	0.4	0.4	0.4	0.6	0.6	0.8	1.0
	70							0.2	0.4	0.4	0.4	0.6	0.6	0.8
1-1/2	80								0.2	0.4	0.4	0.4	0.6	0.8
	90									0.2	0.4	0.4	0.4	0.6
	100										0.2	0.4	0.4	0.4
	110										0.2	0.4	0.4	0.4

① For longer or shorter lengths, the pressure drop is directly proportional to the value given here.
② These pressure drop figures are accurate for hose with smooth I.D. tube and full-flow couplings. Greater pressure drops will occur when hose has a rough I.D. tube, or restrictions at the fittings.

TABLE 11-5
CUBIC FEET PER MINUTE (CFM) AIR FLOW
THROUGH STRAIGHT, SMOOTH BORE HOSE

Hose Size Inlet Pressure (psi)	40	50	60	70	80
3/16” x 100 ft.	3.0	4.0	5.0	5.8	6.2
3/16” x 50 ft.	4.0	5.0	6.0	7.0	8.0
1/4” x 100 ft.	7.0	8.0	10.0	12.0	14.0
1/4” X 50 ft.	10.0	12.0	15.0	18.0	22.0
5/16” X 100 ft.	10.0	13.0	16.0	18.0	22.0
5/16” x 50 ft.	17.0	21.0	25.0	28.0	31.0
3/8” X 100 ft.	18.0	22.0	27.0	32.0	37.0
3/8” X 50 ft.	25.0	30.0	35.0	41.0	47.0
1/2” X 100 ft.	40.0	48.0	55.0	60.0	70.0
1/2” x 50 ft.	52.0	60.0	70.0	80.0	89.0

NOTE: Values are based on actual test data, however, they should be considered approximate due to variations in air supply source, volume and pressure. Data was obtained with a ¾” pipe supply line source connected to a standard ½” pressure regulator with pressure gauge. Larger sizes (5/8” and ¾”) cannot be determined because of air volumes.

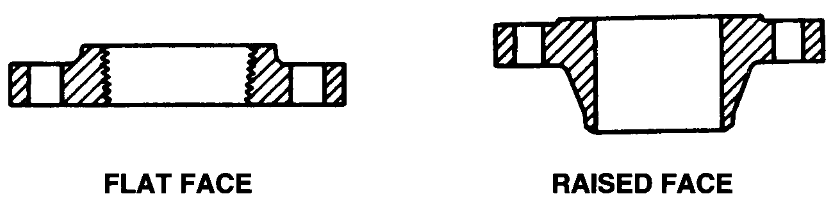
TABLE 11-6
PIPE FLANGE DIMENSIONS
125 LB. U.S.A. STANDARD CAST IRON — ANSI B16.1
150 LB. U.S.A. STANDARD STEEL — ANSI B16.5

Steel is generally used.

Designated Pipe Size Inches	O.D. of Flange Inches	Thickness Of Flange Inches	Bolt Circle Inches	No. of Bolts	Size of Bolt Inches	Approx. Wt.-Lbs. Forged Steel (Slip-on* * * or Threaded)
1	4.250	0.563*	3.125	4	1/2	2
1 1/4	4.625	0.625*	3.500	4	1/2	3
1 1/2	5.000	0.688*	3.875	4	1/2	3
2	6.000	0.750*	4.750	4	5/8	5
2 1/2	7.000	0.875* *	5.500	4	5/8	8
3	7.500	0.938* *	6.000	4	5/8	9
3 1/2	8.500	0.938*	7.000	8	5/8	12
4	9.000	0.938	7.500	8	5/8	13
5	10.000	0.938	8.500	8	3/4	14
6	11.0	1.000	9.500	8	3/4	18
8	13.50	1.125	11.75	8	3/4	27
10	16.00	1.188	14.25	12	7/8	37
12	19.00	1.250	17.00	12	7/8	59
14	21.00	1.375	18.75	12	1	79
16	23.50	1.438	21.25	16	1	101
18	25.00	1.563	22.75	16	1 1/8	112
20	27.50	1.688	25.00	20	1 1/8	146
24	32.00	1.875	29.50	20	1 1/4	210

*Cast Iron are 0.125” thinner. Figures above apply to Forged Steel.
** Cast Iron are 0.188” thinner. Figures above apply to Forged Steel.
***Cast Iron flanges are not available in slip-on style.

RAISED FACE AND FLAT FACE FLANGES



125 LB. FLANGES ARE FLAT FACE
150 LB. AND 300 LB. STEEL FLANGES FURNISHED WITH 1/16” RAISED FACE (UNLESS OTHERWISE SPECIFIED)
250 LB. CAST IRON FLANGES FURNISHED WITH 1/16” RAISED FACE (UNLESS OTHERWISE SPECIFIED) FLANGE THICKNESS INCLUDES RAISED FACE

TABLE 11-7
PIPE FLANGE DIMENSIONS
250 LB. U.S.A. STANDARD CAST IRON USE ANSI B16.1
300 LB. U.S.A. STANDARD STEEL ANSI B16.5
Steel is generally used.

Designated Pipe Size Inches	O.D. of Flange Inches	Thickness Of Flange Inches	Bolt Circle Inches	No. of Bolts	Size of Bolt Inches	Approx. Wt.-Lbs. (Slip-on* or Threaded)
1	4.875	0.688	3.500	4	5/8	3
1 1/4	5.250	0.750	3.875	4	5/8	4
1 1/2	6.125	0.813	4.500	4	3/4	6
2	6.50	0.875	5.000	8	5/8	7
2 1/2	7.50	1.000	5.875	8	3/4	10
3	8.25	1.125	6.625	8	3/4	13
3 1/2	9.00	1.188	7.250	8	3/4	17
4	10.00	1.250	7.875	8	3/4	22
5	11.00	1.375	9.250	8	3/4	28
6	12.50	1.438	10.625	12	3/4	37
8	15.00	1.625	13.000	12	3/4	58
10	17.50	1.875	15.250	16	7/8	76
12	20.50	2.000	17.750	16	1	115
14	23.00	2.125	20.250	20	1 1/8	163
16	25.50	2.250	22.500	20	1 1/8	220
18	28.00	2.375	24.750	24	1 1/4	280
20	30.50	2.500	27.000	24	1 1/4	325
24	36.00	2.750	32.000	24	1 1/2	492

*Cast Iron flange not available in slip-on style

TABLE 11-8
WROUGHT-IRON AND STEEL PIPE SIZES
All Dimensions in Inches

Standard and Extra Strong Pipe		Standard Schedule 40	Extra Strong — Schedule 80
Nominal Pipe Diameter	**Actual External Diameter**	**Approx. Internal Diameter**	**Approx. Internal Diameter**
1/8	0.405	0.27	0.21
1/4	0.540	0.36	0.29
3/8	0.675	0.49	0.42
1/2	0.840	0.62	0.54
3/4	1.050	0.82	0.74
1	1.315	1.05	0.95
1 1/4	1.660	1.38	1.27
1 1/2	1.900	1.61	1.49
2	2.375	2.07	1.93
2 1/2	2.875	2.47	2.32
3	3.500	3.07	2.89
3 1/2	4.000	3.55	3.36
4	4.500	4.03	3.82
5	5.563	5.05	4.81
6	6.625	6.07	5.75
8	8.625	7.98	7.63
10	10.750	10.02	9.75
12	12.750	12.00	11.75
14 O.D.	14.000	13.25	13.00
16 O.D.	16.000	15.25	15.00
18 O.D.	18.000	17.25	17.00
20 O.D.	20.000	19.25	19.00
22 O.D.	22.000	21.25	21.00
24 O.D.	24.000	23.25	23.00

Welded and Seamless Steel Pipe – ANSI B36.10

Wrought Steel and Wrought Iron Pipe – ANSI B36.10

Standard Pipe Dimensions shown are the same as Schedule 40 pipe through 10 inch. Above the size wall thickness is uniformly 3/8”.

Extra Strong Pipe Dimensions shown are the same as Schedule 80 pipe up to 8 inch. For 8 inch and above wall thickness is uniformly ½”.

Wrought Iron Pipe has slightly greater wall thickness (0.001 to 0.020) resulting in correspondingly smaller internal diameter than tabulated above.

TABLE 11-9
TEMPERATURE-PRESSURE EQUIVALENTS OF SATURATED STEAM
GAUGE PRESSURE AT SEA LEVEL

Temperature ˚ F	˚ C	Lbs. Per Sq. in.	MPa
212	100.0	0.0	
214	101.1	0.6	0.004
216	102.2	1.2	0.008
218	103.3	1.8	0.012
220	104.4	2.5	0.017
222	105.6	3.2	0.022
224	106.7	3.9	0.027
226	107.8	4.6	0.032
228	108.9	5.3	0.037
230	110.0	6.1	0.042
232	111.1	6.9	0.048
234	112.2	7.7	0.053
236	113.3	8.5	0.059
238	114.4	9.4	0.065
240	115.6	10.3	0.071
242	116.7	11.2	0.077
244	117.8	12.1	0.083
246	118.9	13.1	0.090
248	120.0	14.1	0.097
250	121.1	15.1	0.104
252	122.2	16.2	0.112
254	123.3	17.3	0.119
256	124.4	18.4	0.127
258	125.6	19.6	0.135
260	126.7	20.7	0.143
261	127.2	21.4	0.147
262	127.8	22.0	0.152
263	128.3	22.6	0.156
264	128.9	23.2	0.160
265	129.4	23.9	0.165
266	130.0	24.5	0.169
267	130.6	25.2	0.174
268	121.1	25.8	0.178
269	131.7	26.5	0.183
270	132.2	27.2	0.187

Temperature ˚ F	˚ C	Lbs. Per Sq. in.	MPa
271	132.8	27.9	0.192
272	133.3	28.6	0.197
273	133.9	29.3	0.202
274	134.4	30.0	0.207
275	135.0	30.8	0.212
276	135.6	31.5	0.217
277	136.1	32.3	0.223
278	136.7	33.0	0.227
279	137.2	33.8	0.233
280	137.8	34.5	0.238
281	138.3	35.3	0.243
282	138.9	36.1	0.249
283	139.4	36.9	0.254
284	140.0	37.7	0.260
285	140.6	38.6	0.266
286	141.1	39.4	0.272
287	141.7	40.3	0.278
288	142.2	41.1	0.283
289	142.8	42.0	0.289
290	143.3	42.9	0.296
291	143.9	43.8	0.302
292	144.4	44.7	0.308
293	145.0	45.6	0.314
294	145.6	46.5	0.321
295	146.1	47.5	0.328
296	146.7	48.4	0.334
297	147.2	49.4	0.341
298	147.8	50.3	0.347
299	148.3	51.3	0.354
300	148.9	52.3	0.361
301	149.4	53.4	0.368
302	150.0	54.4	0.376
303	150.6	55.4	0.382
304	151.1	56.4	0.389
305	151.7	57.5	0.396

PSI x .006895 = Megapascals (Mpa) = Meganewton/meter^2
Degrees Celsius = 5/9 (Degrees F –32)

TABLE 11-9 (Continued)
TEMPERATURE-PRESSURE EQUIVALENTS OF SATURATED STEAM
GAUGE PRESSURE AT SEA LEVEL

Temperature ° F	Temperature ° C	Lbs. Per Sq. in.	MPa
306	152.2	58.6	0.404
307	152.8	59.7	0.412
308	153.3	60.7	0.419
309	153.9	61.9	0.427
310	154.4	63.0	0.434
311	155.0	64.2	0.443
312	155.6	65.3	0.450
313	156.1	66.5	0.459
314	156.7	67.6	0.466
315	157.2	68.8	0.474
316	157.8	70.0	0.483
317	158.3	71.3	0.492
318	158.9	72.5	0.500
319	159.4	73.7	0.508
320	160.0	75.0	0.517
321	160.6	76.3	0.526
322	161.1	77.5	0.534
323	161.7	78.8	0.543
324	162.2	80.1	0.552
325	162.8	81.5	0.562
326	163.3	82.8	0.571
327	163.9	84.2	0.581
328	164.4	85.6	0.590
329	165.0	87.0	0.600
330	165.6	88.4	0.610
331	166.1	89.8	0.619
332	166.7	91.2	0.629
333	167.2	92.7	0.639
334	167.8	94.1	0.649
335	168.3	95.6	0.659
336	168.9	97.1	0.670
337	169.4	98.7	0.681
338	170.0	100.2	0.691
339	170.6	101.8	0.702
340	171.1	103.3	0.712
341	171.7	105.0	0.724
342	172.2	106.5	0.734
343	172.8	108.2	0.746
344	173.3	109.8	0.757
345	173.9	111.5	0.769

Temperature ° F	Temperature ° C	Lbs. Per Sq. in.	MPa
346	174.4	113.1	0.780
347	175.0	114.8	0.792
348	175.6	116.5	0.803
349	176.1	118.2	0.815
350	176.7	119.9	0.827
352	177.8	123.5	.852
354	178.9	127.1	.876
356	180.0	130.8	.902
358	181.1	134.5	.927
360	182.2	138.3	.954
362	183.3	142.3	.981
364	184.4	146.2	1.008
366	185.6	150.3	1.036
368	186.7	154.4	1.065
370	187.8	158.7	1.094
372	188.9	163.0	1.124
374	190.0	167.4	1.154
376	191.1	171.9	1.185
378	192.2	176.4	1.216
380	193.3	181.1	1.249
382	194.4	185.8	1.281
384	195.6	190.6	1.314
386	196.7	195.6	1.349
388	197.8	200.6	1.383
390	198.9	205.7	1.418
392	200.0	210.9	1.454
394	201.1	216.2	1.491
396	202.2	221.5	1.527
398	203.3	227.0	1.565
400	204.4	232.6	1.604
402	205.5	238	1.641
404	206.7	244	1.682
406	207.8	250	1.724
408	208.9	256	1.765
410	210	262	1.806
412	211.1	268	1.848
414	212.2	275	1.896
416	213.3	281	1.937
418	214.4	288	1.986
420	215.6	294	2.027

PSI x .006895 = Megapascals (Mpa) = Meganewton/meter^2
Degrees Celsius = 5/9 (Degrees F –32)

TABLE 11-10A
LINEAL MEASUREMENT UNITS
DECIMAL AND MILLIMETER EQUIVALENTS OF FRACTIONAL INCHES

Fractional Inch 1/64	1/32	1/16	1/8	Decimal Part of an inch	Millimeters	Fractional Inch 1/64	1/32	1/16	1/8	Decimal Part of an inch	Millimeters
1				0.016	0.40	33				0.516	13.1
2	1			0.031	0.79	34	17			0.531	13.5
3				0.047	1.19	35				0.547	13.9
4	2	1		0.063	1.59	36	18	9		0.563	14.3
5				0.078	1.98	37				0.578	14.7
6	3			0.094	2.38	38	19			0.594	15.1
7				0.109	2.78	39				0.609	15.5
8	4	2	1	0.125	3.18	40	20	10	5	0.625	15.9
9				0.141	3.57	41				0.641	16.3
10	5			0.156	4.0	42	21			0.656	16.7
11				0.172	4.4	43				0.672	17.1
12	6	3		0.188	4.8	44	22	11		0.688	17.5
13				0.203	5.2	45				0.703	17.9
14	7			0.219	5.6	46	23			0.719	18.3
15				0.234	6.0	47				0.734	18.7
16	8	4	2	0.250	6.4	48	24	12	6	0.750	19.1
17				0.266	6.7	49				0.766	19.5
18	9			0.281	7.1	50	25			0.781	19.8
19				0.297	7.5	51				0.797	20.2
20	10	5		0.313	7.9	52	26	13		0.813	20.6
21				0.328	8.3	53				0.828	21.0
22	11			0.344	8.7	54	27			0.844	21.4
23				0.359	9.1	55				0.859	21.8
24	12	6	3	0.375	9.5	56	28	14	7	0.875	22.2
25				0.391	9.9	57				0.891	22.6
26	13			0.406	10.3	58	29			0.906	23.0
27				0.422	10.7	59				0.922	23.4
28	14	7		0.438	11.1	60	30	15		0.938	23.8
29				0.453	11.5	61				0.953	24.2
30	15			0.469	11.9	62	31			0.969	24.6
31				0.484	12.3	63				0.984	25.0
32	16	8	4	0.500	12.7	64	32	16	8	1.000	25.4

1 inch = 25.40 Millimeters
1 Millimeter = 0.03937 Inches

TABLE 11-10B

HOSE SIZE IDENTIFICATION NUMBERS

NOMINAL HOSE I.D. INCHES		SAE DASH SIZE	METRIC SIZE
FRACTION	**DECIMAL**		
3/16	.188	-3	5
1/4	.250	-4	6.3
5/16	.312	-5	8
3/8	.375	-6	10
1/2	.500	-8	12.5
5/8	.625	-10	16
3/4	.750	-12	19
1	1.000	-16	25
1 1/4	1.250	-20	31.5
1 1/2	1.500	-24	38
2	2.000	-32	51
2 1/2	2.500	-40	63
3	3.000	-48	76
3 1/2	3.500	-56	89
4	4.000	-64	102

TABLE 11-11
INCH – MILLIMETER EQUIVALENTS

Inches	Millimeters
1	25.4
1 1/8	28.6
1 1/4	31.8
1 3/8	34.9
1 1/2	38
2	51
2 1/2	64
3	76
3 1/2	89
4	102
4 1/2	114
5	127
6	152
7	178
8	203
10	254
12	305
14	355
16	405
18	460
20	510
24	610
30	762
36	915

1 inch = 25.40 Millimeters 1 Millimeter = .03937 Inches

TABLE 11-12
LINEAL MEASUREMENT UNITS
MILLIMETER, METER AND KILOMETER EQUIVALENTS OF INCHES, FEET AND MILES

Feet	Inches	Millimeters	Meters	Feet	Miles	Meters	Kilometers
					-		
1/12	1	25.4	0.0254	25		7.62	-
1	12	304.8	0.3048	50	-	15.24	-
2		609.6	0.6096	75	-	22.86	-
3	36	914.4	0.9144	100	-	30.48	-
3.28	39.36	1000.0	1.0000	125	-	38.10	-
4			1.2192	150	-	45.72	-
5			1.5240	300	-	91.44	-
6			1.8288	500	-	152.40	0.15
7			2.1336	1000	-	304.80	0.30
8			2.4384	3280.84	0.6214	1000.00	1.00
9			2.7432	5280	1.000	1609.35	1.61
10			3.0480				

1 Foot = 304.80 Millimeters
1 Mile = 1609.35 Meters
1 Meter = 3.28084 Feet
1 Kilometer = 0.62137 Miles

TABLE 11-13
SQUARE CENTIMETER EQUIVALENTS OF SQUARE INCHES
CENTIMETERS^2 TO INCHES^2
1 cm^2 = 0.155 in^2

cm^2	Units									
	0	1	2	3	4	5	6	7	8	9
0	—	0.155	0.310	0.465	0.620	0.775	0.930	1.085	1.240	1.395
10	1.550	1.705	1.860	2.015	2.170	2.325	2.480	2.635	2.790	2.945
20	3.100	3.255	3.410	3.565	3.720	3.875	4.030	4.185	4.340	4.495
30	4.650	4.805	4.960	5.115	5.270	5.425	5.580	5.735	5.890	6.045
40	6.200	6.355	6.510	6.665	6.820	6.975	7.130	7.285	7.440	7.595
50	7.750	7.905	8.060	8.215	8.370	8.525	8.680	8.835	8.990	9.145
60	9.300	9.455	9.610	9.765	9.920	10.075	10.230	10.385	10.540	10.695
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345

INCHES^2 TO CENTIMETERS^2
1 in.^{2} = 6.4516 cm^2

in.^{2}	Units									
	0	1	2	3	4	5	6	7	8	9
0	—	6.452	12.903	19.355	25.806	32.258	38.710	45.161	51.613	58.064
10	64.516	70.968	77.419	83.871	90.322	96.774	103.226	109.677	116.129	122.580
20	129.032	135.484	141.935	148.387	154.838	161.290	167.742	174.193	180.645	187.096
30	193.548	200.000	206.451	212.903	219.354	225.806	232.258	238.709	245.161	251.612
40	258.064	264.516	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.128
50	322.580	329.032	335.483	341.935	348.386	354.838	361.290	367.741	374.193	380.644
60	387.096	393.548	399.999	406.451	412.902	419.354	425.806	432.257	438.709	445.160
70	451.612	458.064	464.515	470.967	477.418	483.870	490.322	496.773	503.225	509.676
80	516.128	522.580	529.031	535.483	541.934	548.386	554.838	561.289	567.741	574.192
90	580.644	587.096	593.547	599.999	606.450	612.902	619.354	625.805	632.257	638.708

TABLE 11-14
VOLUME UNITS
CUBIC CENTIMETER EQUIVALENTS OF CUBIC INCHES
CENTIMETERS^3 TO INCHES^3
1 cm^3 = 0.0610238 in.^{3}

Units										
cm^3	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	—	0.06102	0.12205	0.18307	0.22410	0.30512	0.36614	0.42717	0.48819	0.54921
10	0.61024	0.67126	0.73229	0.79331	0.85433	0.91536	0.97638	1.03740	1.09843	1.15945
20	1.22048	1.28150	1.34252	1.40355	1.46457	1.52560	1.58662	1.64764	1.70867	1.76969
30	1.83071	1.89174	1.95276	2.01379	2.07481	2.13583	2.19686	2.25788	2.31890	2.37993
40	2.44095	2.50198	2.56300	2.62402	2.68505	2.74607	2.80709	2.86812	2.92914	2.99017
50	3.05119	3.11221	3.17324	3.23426	3.29529	3.35631	3.41733	3.47836	3.53938	3.60040
60	3.66143	3.72245	3.78348	3.84450	3.90552	3.96655	4.02757	4.08859	4.14962	4.21064
70	4.27167	4.33269	4.39371	4.45474	4.51576	4.57679	4.63781	4.69883	4.75986	4.82088
80	4.88190	4.94293	5.00395	5.06498	5.12600	5.18702	5.24805	5.30907	5.37009	5.43112
90	5.49214	5.55317	5.61419	5.67521	5.73624	5.79726	5.85828	5.91931	5.98033	6.04136

INCHES^3 TO CENTIMETERS^3
1 in.^{3} = 16.38706 cm^3

Units										
in.^{3}	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	—	16.39	32.77	49.16	65.55	81.94	98.32	114.71	131.10	147.48
10	163.87	180.26	196.64	213.03	229.42	245.81	262.19	278.58	294.97	311.35
20	327.74	344.13	360.52	376.90	393.29	409.68	426.06	442.45	458.84	475.22
30	491.61	508.00	524.39	540.77	557.16	573.55	589.93	606.32	622.71	639.10
40	655.48	671.87	688.26	704.64	721.03	737.42	753.80	770.19	786.58	802.97
50	819.35	835.74	852.13	868.51	884.90	901.29	917.68	934.06	950.45	966.84
60	983.22	999.61	1016.00	1032.38	1048.77	1065.16	1081.55	1097.93	1114.32	1130.71
70	1147.09	1163.48	1179.87	1196.26	1212.64	1229.03	1245.42	1261.80	1278.19	1294.58
80	1310.96	1327.35	1343.74	1360.13	1376.51	1392.90	1409.29	1425.67	1442.06	1458.45
90	1474.84	1491.22	1507.61	1524.00	1540.38	1556.77	1573.16	1589.54	1605.93	1622.32

TABLE 11-15
LIQUID VOLUME LITERS TO U.S. GALLONS
1 liter = 0.264172 gal.

Liters	0	1	2	3	4	5	6	7	8	9
0	—	0.2642	0.5283	0.7925	1.0567	1.3209	1.5850	1.8492	2.1134	2.3775
10	2.6417	2.9059	3.1701	3.4342	3.6984	3.9626	4.2268	4.4909	4.7551	5.0193
20	5.2834	5.5476	5.8118	6.0760	6.3401	6.6043	6.8685	7.1326	7.3968	7.6610
30	7.9252	8.1893	8.4535	8.7177	8.9818	9.2460	9.5102	9.7744	10.0385	10.3027
40	10.5669	10.8311	11.0952	11.3594	11.6236	11.8877	12.1519	12.4161	12.6803	12.9444
50	13.2086	13.4728	13.7369	14.0011	14.2653	14.5295	14.7936	15.0578	15.3220	15.5861
60	15.8503	16.1145	16.3787	16.6428	16.9070	17.1712	17.4354	17.6995	17.9637	18.2279
70	18.4920	18.7562	19.0204	19.2846	19.5487	19.8129	20.0771	20.3412	20.6054	20.8697
80	21.1338	21.3979	21.6621	21.9263	22.1904	22.4546	22.7188	22.9830	23.2471	23.5113
90	23.7755	24.0397	24.3038	24.5680	24.8322	25.0963	25.3605	25.6247	25.8889	26.1530

LIQUID VOLUME U.S. GALLONS TO LITERS
1 gal. = 3.785412 liters

Gals.	0	1	2	3	4	5	6	7	8	9
0	—	3.7854	7.5708	11.3562	15.1416	18.9271	22.7125	26.4979	30.2833	34.0687
10	37.8541	41.6395	45.4249	49.2104	52.9958	56.7812	60.5666	64.3520	68.1374	71.9228
20	75.7082	79.4937	83.2791	87.0645	90.8499	94.6353	98.4207	102.2061	105.9915	109.7769
30	113.5624	117.3478	121.1332	124.9186	128.7040	132.4894	136.2748	140.0602	143.8457	147.6311
40	151.4165	115.2019	158.9873	162.7727	166.5581	170.3435	174.1290	177.9144	181.6998	185.4852
50	189.2706	193.0560	196.8414	200.6268	204.4123	208.1977	211.9831	215.7685	219.5539	223.3393
60	227.1247	230.9101	234.6955	238.4810	242.2664	246.0518	249.8372	253.6226	257.4080	261.1934
70	264.9788	268.7643	272.5497	276.3351	280.1205	283.9059	287.6913	291.4767	295.2621	299.0476
80	302.8330	306.6184	310.4038	314.1892	317.9746	321.7600	325.5454	329.3308	333.1163	336.9017
90	340.6871	344.4725	348.2579	352.0433	388.8287	359.6141	363.3996	367.1850	370.9704	374.7558

TABLE 11-16
VELOCITY UNITS
METER SECOND EQUIVALENTS OF FEET PER MINUTE AND SECOND

Ft./Second	Meters/Second	Ft./Minute	Meters/Second
1.0	0.30480	1.0	0.00508
3.28084	1.0	10	0.05080
10	3.048	100	0.508
20	6.096	196.8504	1.000
30	9.144	200	1.016
40	12.192	300	1.524
50	15.240	400	2.032
60	18.288	500	2.540
70	21.336	600	3.048
80	24.384	700	3.556
90	27.432	800	1.064
		900	4.572

TABLE 11-17
WEIGHT AND FORCE UNITS
GRAM, KILOGRAM, AND NEWTON EQUIVALENTS IN POUNDS AND TONS

Pounds (force or wt.)	Grams (wt.)	Kilograms (wt.)	Newtons (force)	Pounds (force or wt.)	Tons (wt.)	Kilograms (wt.)	Newtons (force)
1	453.59	0.4536	4.4482	25		11.34	1 11.21
2	907.18	0.9072	8.8964	50		22.68	2 22.41
3	1360.78	1.3608	13.3447	100		45.36	4 44.82
4	1814.37	1.8144	17.7929	500		226.80	2224.1 1
5	2267.96	2.2680	22.2411	1000		453.59	4448.2 2
6	2721.55	2.7216	26.6893	2000	1.0000 (Short)	907.10	8896.4 4
7	3175.15	3.1752	31.1375	2204.6	1.0000 (Metric)	1000.00	9806.65
8	3628.74	3.6287	35.5858	2240	1.0000 (Long)	1016.05	9964.02
9	4082.33	4.0824	40.0340				
10	4535.92	4.5359	44.4822				

1 kilogram (kg) = 2.2046 pounds (lbs)
1 kilogram force ((kgf) = 9.80665 newtons (N)
1 pound (lb) = 0.4536 kilograms (kg) or 453.59237 grams (g)
1 pound-force (lb-f) = 4.4822 newtons (N)

TABLE 11-18
PRESSURE UNITS
MEGAPASCALS (MPa), BARS
EQUIVALENTS OF POUNDS/SQ. IN.

Lbs./Sq. In.	MPa	Bars	Lbs./Sq. In.	MPa	Bars
1	0.007	0.07	200	1.4	14
5	0.034	0.34	500	3.4	34
10	0.069	0.69	1000	6.9	69
14.696 (1 atmosphere)	0.101	1.01	2000	13.8	138
			3000	20.7	207
			5000	34.5	345
25	0.17	1.7			
50	0.34	3.4			
100	0.69	6.9			

1 MPa = 145.04 lbs./in.^{2}
1 Bar = 14.5 lbs./in.^{2}

TABLE 11-19
ADHESION UNITS
EQUIVALENTS OF POUNDS-FORCE/INCH
KILONEWTONS/METER (kN/m)
NEWTONS/25.4 MILLIMETERS (N/25.4 mm)

Lb.-Force/In.	kN/m	N/25.4 mm	Lb.-Force/In.	KN/m	N/25.4 mm
1	0.175	4.45	9	1.575	40.03
2	0.350	8.90	10	1.750	44.48
3	0.525	13.34	12	2.100	53.38
4	0.700	17.79	15	2.625	66.72
5	0.875	22.24	18	3.150	80.06
6	1.050	26.69	20	3.500	88.96
7	1.225	31.14	25	4.375	111.20
8	1.400	35.58	30	5.250	133.44

1 pound-force/inch (lb-f/in) = 0.175 kilonewtons (kN/m)
1 pound-force/inch (lb-f/in) = 4.448 newtins/25.4 millimeters (N/25.4 mm)

TABLE 11-20
AREAS AND CIRCUMFERENCES OF CIRCLES FOR DIAMETERS IN UNITS AND FRACTIONS

Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum In.	Dia. In.	Area Sq. In.	Circum. In.
0			2	3.1416	6.28319	5	19.635	15.7080	8	50.265	25.1327	14	153.94	43.9823	20	314.16	62.8319
1/32	0.00077	0.098175	1/16	3.3410	6.47953	1/16	20.129	15.9043	1/8	51.849	25.5254	1/8	156.70	44.3750	1/8	318.10	63.2246
1/16	0.00307	0.196350	1/8	3.5466	6.67588	1/8	20.629	16.1007	1/4	53.456	25.918	1/4	159.48	44.7677	1/4	322.06	63.6173
3/32	0.00690	0.294524	3/16	3.7583	6.87223	3/16	21.135	16.2970	3/8	55.088	26.3108	3/8	162.30	45.1604	3/8	326.05	64.0100
1/8	0.01227	0.392699	1/4	3.9761	7.06858	1/4	21.648	16.4934	1/2	56.745	26.7035	1/2	165.13	45.5531	1/2	330.06	64.4026
5/32	0.01917	0.490874	5/16	4.2000	7.26493	5/16	22.166	16.6897	5/8	58.426	27.0962	5/8	167.99	45.9458	5/8	334.10	64.7953
3/16	0.02761	0.589049	3/8	4.4301	7.46128	3/8	22.691	16.8861	3/4	60.132	27.4889	3/4	170.87	46.3385	3/4	338.16	65.1880
7/32	0.03758	0.687223	7/16	4.6664	7.65763	7/16	23.221	17.0824	7/8	61.862	27.8816	7/8	173.78	46.7312	7/8	342.25	65.5807
1/4	0.04909	0.785398	1/2	4.9087	7.85398	1/2	23.758	17.2788	9	63.617	28.2743	15	176.71	47.1239	21	346.36	66.9734
9/32	0.06213	0.883573	9/16	5.1572	8.05033	9/16	24.301	17.4751	1/8	65.397	28.6670	1/8	179.67	47.5166	1/8	350.50	66.3661
5/16	0.07670	0.981748	5/8	5.4119	8.24668	5/8	24.850	17.6715	1/4	67.201	29.0597	1/4	182.65	47.9093	1/4	354.66	66.7588
11/32	0.09281	1.07992	11/16	5.6727	8.44303	11/16	25.406	17.8678	3/8	69.029	29.4524	3/8	185.66	48.3020	3/8	358.84	67.1515
3/8	0.11045	1.17810	3/4	5.9396	8.63938	3/4	25.967	18.0642	1/2	70.882	29.8451	1/2	188.69	48.6947	1/2	363.05	67.5442
13/32	0.12962	1.27627	13/16	6.2126	8.83573	13/16	26.535	18.2605	5/8	72.760	30.2378	5/8	191.75	49.0874	5/8	367.28	67.9369
7/16	0.15033	1.37445	7/8	6.4918	9.03208	7/8	27.109	18.4569	3/4	74.662	30.6305	3/4	194.83	49.4801	3/4	371.54	68.3296
15/32	0.17257	1.47262	15/16	6.7771	9.22843	15/16	27.688	18.6532	7/8	76.589	31.0232	7/8	197.93	49.8728	7/8	375.83	68.7223
1/2	0.19635	1.57080	3	7.0686	9.42478	6	28.274	18.8496	10	78.540	31.4159	16	201.06	50.2655	22	380.13	69.1150
17/32	0.22166	1.66897	1/16	7.3662	9.62113	1/16	28.867	19.0460	1/8	80.516	31.8086	1/8	204.22	50.6582	1/8	384.46	69.5077
9/16	0.24850	1.76715	1/8	7.6699	9.81748	1/8	29.465	19.2423	1/4	82.516	32.2013	1/4	207.39	51.0509	1/4	388.82	69.9004
19/32	0.27688	1.886532	3/16	7.9798	10.0138	3/16	30.069	19.4387	3/8	84.541	32.5940	3/8	210.60	51.4436	3/8	393.20	70.2931
5/8	0.30680	1.96350	1/4	8.2958	10.2102	1/4	30.680	19.6350	1/2	86.590	32.9867	1/2	213.82	51.8363	1/8	397.61	70.6858
21/32	0.33824	2.06167	5/16	8.6179	10.4065	5/16	31.296	19.8314	5/8	88.664	33.3794	5/8	217.08	52.2290	5/8	402.04	71.0785
11/16	0.37122	2.15984	3/8	8.9462	10.6029	3/8	31.919	20.0277	3/4	90.763	33.7721	3/4	220.35	52.6217	3/4	406.49	71.4712
23/32	0.40574	2.25802	7/8	9.2806	10.7992	7/16	32.548	20.2241	7/8	92.886	34.1648	7/8	223.65	53.0144	7/8	410.97	71.8639
3/4	0.44179	2.35619	1/2	9.6211	10.9956	1/2	33.183	20.4204	11	95.033	34.5575	17	226.98	53.4071	23	415.48	72.2566
25/32	0.47937	2.45437	9/16	9.9678	11.1919	9/16	33.824	20.6168	1/8	97.205	34.9502	1/8	230.33	53.7998	1/8	420.00	72.6493
13/16	0.51849	2.55254	5/8	10.321	11.3883	5/8	34.471	20.8131	1/4	99.402	35.3429	1/4	233.71	54.1925	1/4	424.56	73.0420
27/32	0.55914	2.65072	11/16	10.680	11.5846	11/16	35.125	21.0095	3/8	101.62	35.7356	3/8	237.10	54.5852	3/8	429.13	73.4347
7/8	0.60132	2.74889	3/4	11.045	11.7810	3/4	35.785	21.2058	1/2	103.87	36.1283	1/2	240.53	54.9779	1/2	433.74	73.8274
29/32	0.64504	2.84707	13/16	11.416	11.9773	13/16	36.451	21.4022	7/8	106.14	36.5210	5/8	243.98	55.3706	5/8	438.36	74.220
15/16	0.69029	2.94524	7/8	11.793	12.1737	7/8	37.122	21.5984	3/4	108.43	36.9137	3/4	247.45	55.7633	3/4	443.01	74.6182
31/32	0.73708	3.04342	15/16	12.177	12.3700	15/16	37.800	21.7949	7/8	110.75	37.3064	7/8	250.95	56.1560	7/8	447.69	75.0055
1	0.78540	3.14159	4	12.566	12.5664	7	38.485	21.9911	12	113.10	37.6991	18	254.47	56.5487	24	452.39	75.3982
1/16	0.88664	3.33794	1/16	12.962	12.7627	1/18	39.175	22.1876	1/8	115.47	38.0918	1/8	258.02	56.9414	1/8	457.11	75.7909
1/8	0.99402	3.53429	1/8	13.364	12.9591	1/8	39.871	22.3838	1/4	117.86	38.4845	1/4	261.59	57.3341	1/4	461.86	76.1836
3/16	1.1075	3.73064	3/16	13.772	13.1554	3/16	40.574	22.5803	3/8	120.28	38.8772	3/8	265.18	57.7268	3/8	466.64	76.5763

TABLE 11-20 (Continued)
AREAS AND CIRCUMFERENCES OF CIRCLES FOR DIAMETERS IN UNITS AND FRACTIONS

Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum. In.	Dia. In.	Area Sq. In.	Circum In.	Dia. In.	Area Sq. In.	Circum. In.
1/4	1.2272	3.92699	1/4	14.186	13.3518	1/4	41.282	22.7765	1/2	122.72	39.2699	1/2	268.80	58.1195	1/2	471.44	76.9690
5/16	1.3530	4.12334	5/16	14.607	13.5481	5/16	41.997	22.9730	5/8	125.19	39.6626	5/8	272.45	58.5122	5/8	476.26	77.3617
3/8	1.4849	4.31969	3/8	15.033	13.7445	3/8	42.718	23.1692	3/4	127.68	40.0553	3/4	276.12	58.9049	3/4	481.11	77.7544
7/16	1.6230	4.51604	7/16	15.466	13.9408	7/16	43.446	23.3657	7/8	130.19	40.4480	7/8	279.81	59.2976	7/8	485.98	78.1471
1/2	1.7671	4.71239	1/2	15.904	14.1372	1/2	44.179	23.5619	13	132.73	40.8407	19	283.53	59.6903	25	490.87	78.5398
9/16	1.9175	4.90874	9/16	16.349	14.3335	9/16	44.918	23.7584	1/8	135.30	41.2334	1/8	287.27	60.0830	1/8	495.79	78.9325
5/8	2.0739	5.10509	5/8	16.800	14.5299	5/8	45.664	23.9546	1/4	137.89	41.6261	1/4	291.04	60.4757	1/4	500.74	79.3252
11/16	2.2365	5.30144	11/16	17.257	14.7262	11/16	46.415	24.1511	3/8	140.50	42.0188	3/8	294.83	60.8684	3/8	505.71	79.7179
3/4	2.4053	5.49779	3/4	17.721	14.9226	3/4	4.173	24.3473	1/2	143.14	42.4115	1/2	298.65	61.2611	1/2	510.71	80.1106
13/16	2.5802	5.69414	13/16	18.190	15.1189	13/16	47.937	24.5437	5/8	145.80	42.8042	5/8	302.49	61.6538	5/8	515.72	80.5033
7/8	2.7612	5.89049	7/8	18.665	15.3153	7/8	48.707	24.7400	3/4	148.49	43.1969	3/4	306.35	62.0465	3/4	520.77	80.8960
15/16	2.9483	6.08684	15/16	19.147	15.5116	15/16	49.483	24.9364	7/8	151.20	43.5836	7/8	310.24	62.4392	7/8	525.84	81.2887

One Square Inch = 645.16 Square Millimeters
Area = 0.7854 x $(\text{diameter})^2$
Circumference = 3.14159 x diameter

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