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HOSE HANDBOOK

RMA
RUBBER MANUFACTURERS ASSOCIATION
1901 PENNSYLVANIA AVE., N. W. · WASHINGTON, D. C. 20006

THE RUBBER ASSOCIATION OF CANADA
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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.

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FOREWORD

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 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 so widely that 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 and approved jointly by the Rubber Manufacturers Association, representing producers in the United States, and the Rubber Association of Canada, representing Canadian producers. This is the fourth edition of a basic book on Hose, earlier editions of which had wide distribution and use in both the United States and Canada. The joint sponsorship of this "North American Standard" exemplifies the spirit of cooperation which has long existed between Canadian and U.S. producers, and between their respective trade associations.

The Rubber Manufacturers Association is a manufacturing trade association of more than 200 company members which produce finished rubber and plastic products. It works through industry-wide committees and also through product divisions. The Hose Industry is represented through a Subdivision of the Industrial Products Division.

The Rubber Association of Canada is the national trade association of the rubber manufacturing industry in Canada. Its membership includes most of the major Canadian manufacturers of all types of rubber products and specifically the major Canadian producers of hose.

OTHER PUBLICATIONS

Other publications . . .

Listed below are the titles of other publications issued by the Hose Subdivision, Industrial Products Division, of the RMA. Information concerning the latest edition, prices, etc., may be obtained on written request to:

Publications Desk
Rubber Manufacturers Association
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Publication No.	Title
IP-6	Rubber Lined Fire Hose, Specifications for
IP-7	Rubber Welding Hose, Specifications for
IP-8	Rubber Hose for Oil Suction and Discharge, Specifications for
IP-10	Liquefied Petroleum Gas Hose, Specifications for
IP-12	High Pressure Fire Engine Booster and Fire Extinguisher Hose, Specifications for
IP-14	Anhydrous Ammonia Hose, Specifications for
IP-11	HOSE TECHNICAL INFORMATION
IP-11-1	Steam Hose; Manual for Maintenance, Testing and Inspection
IP-11-2	Anhydrous Ammonia Hose; Manual for Maintenance, Testing and Inspection
IP-11-3	Liquefied Petroleum Gas 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 in the Use of
IP-11-6	Fire Hose; Manual for Maintenance, Testing and Inspection

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TYPICAL HOSE CONSTRUCTIONS

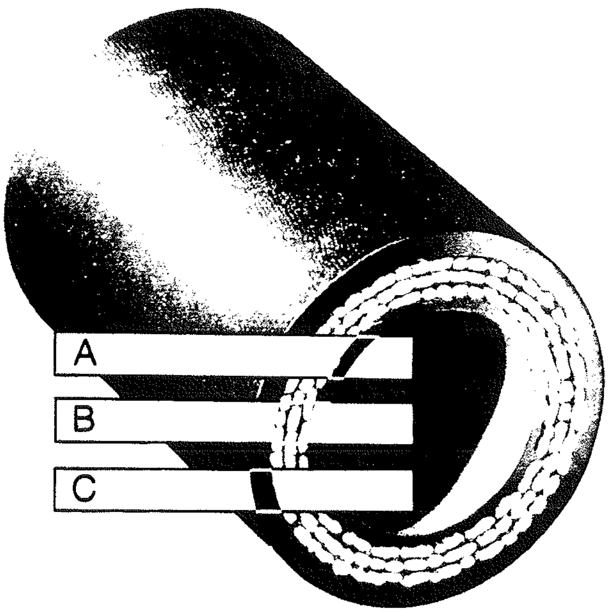
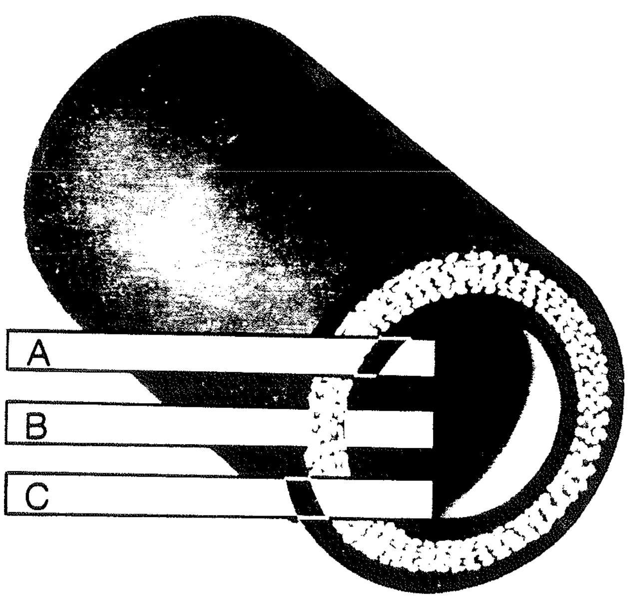


Figure 1 – 1



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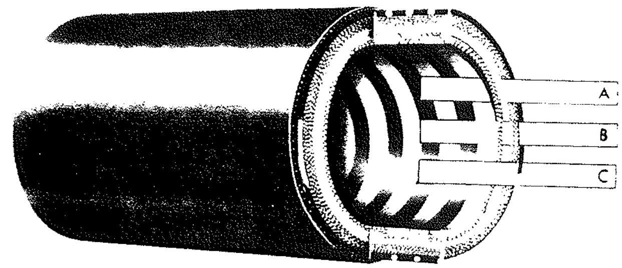

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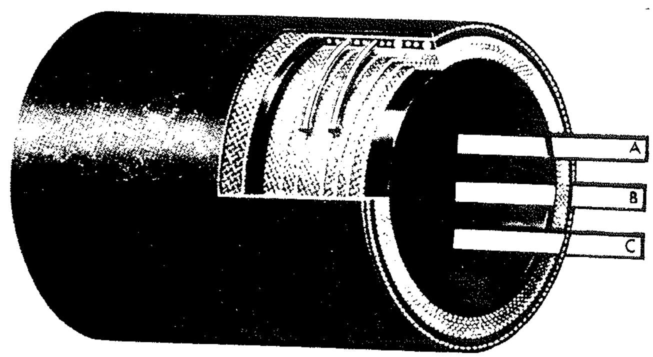

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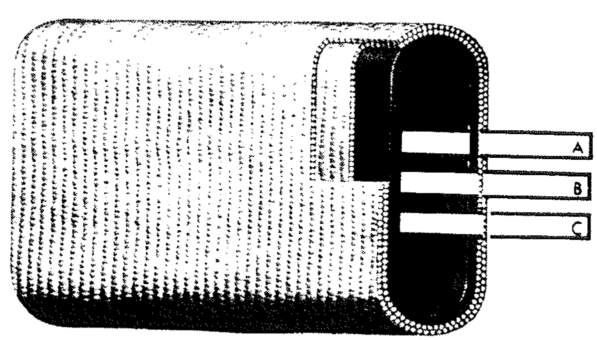


Figure 1 – 5

GENERAL

A hose is a reinforced, flexible conduit used to move materials — usually liquids, gases, or solids in suspension — from one point to another. 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. The tube should be resistant to the materials it is intended to carry. The characteristics of the rubber or plastic compound of which the tube is made and the thickness of the tube depend on the service in which the hose will be used.

Reinforcement

Reinforcement can be textile 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 of reinforcing material used depends on the method of manufacture and on the service requirements. Obviously, the drain hose on an electric clothes washer does not need the same reinforcement required for high-pressure air applications used in construction and mining. 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 of rubber, plastic or textile materials. Figure 1—5 shows how the reinforcement also serves as a cover for fire hose. Since the prime function of the cover is to protect the reinforcement from damage, many covers are made to be resistant to oils, acids, abrasion, flexing, temperature extremes, 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 or convoluted flexible tubing. Throughout this book, the term "rubber" will be used in its broadest sense. This will include all elastomeric materials which are compounds of natural or synthetic materials, or combinations of these materials.

The yarns and fabrics referred to include those made from natural and synthetic materials or combinations of these. Metals include copper, steel and aluminum.

Rubbers and Elastomers

To provide a wide range of physical properties for specific service needs, raw rubbers or 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.

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

Rubbers Most Commonly Used In Hose

ASTM Designation D1418	Common Name	Composition	General Properties
CR	Neoprene	Chloroprene	Good weathering resistance. Flame retarding. Moderate resistance to petroleum based fluids. Good physical properties.
NR	Natural	Isoprene, natural	Excellent physical properties including abrasion and low temperature resistance. Poor resistance to petroleum based fluids.
IR	Polyisoprene	Isoprene, synthetic	Same properties as natural rubber.
IIR	Butyl	Isobutene-isoprene	Very good weathering resistance. Low permeability to air. Good physical properties. Poor resistance to petroleum based fluids.
NBR	Buna N	Nitrile-butadiene	Excellent resistance to petroleum based fluids. Moderate resistance to aromatics. Good physical properties.
SBR	SBR	Styrene-butadiene	Good physical properties, including abrasion resistance. Poor resistance to petroleum based fluids.
CSM	Hypalon®	Chloro-sulfonyl-polyethylene	Excellent ozone, weathering and acid resistance. Good abrasion and heat resistance. Fair resistance to petroleum based fluids.
EPM	Ethylene Propylene Rubber	Ethylene-propylene	Excellent ozone, chemical and aging characteristics. Poor resistance to petroleum based fluids.
EPDM	Ethylene Propylene Rubber	Ethylene-propylene-diene-terpolymer	Excellent ozone, chemical and aging characteristics. Poor resistance to petroleum based fluids.

There a number of other materials used in hose, but used less commonly and for specialized applications. Some of these are shown below.

Specialized Polymers Used In Hose

ASTM Designation	Common Name	Composition	General Properties
T	Thiokol	Organic polysulfide	Outstanding solvent resistance and weathering resistance. Other properties poor.
FMQ	Silicone	Dimethyl-polysiloxane	Excellent high and low temperature resistance. Fair physical 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.
CIIR	Chlorinated Butyl	Chloro-isobutene isoprene	Same general properties as Butyl (see above).
BIIR	Brominated Butyl	Bromo-isobutene-isoprene	Same general properties as Butyl (see above).
AFMU	Teflon®	Fluorocarbon resin	Excellent high temperature properties, chemical resistance.
FPM	Viton® Fluorel®	Fluorocarbon rubber	Excellent high temperature resistance, particularly in air or oil. Very good chemical resistance.
BR	Butadiene Rubber	Butadiene	Excellent low temperature and abrasion properties. High resilience.
AU EU	Urethane Urethane	Polyester Polyether	Excellent abrasion, tear and solvent resistance, good aging. Poor high temperature properties.
CO	Epichlorohydrin Polymer	Polychloromethyl oxirane	Excellent oil and ozone resistance. Good flame resistance and low permeability to gases. Fair low temperature properties.
ECO	Epichlorohydrin Copolymer	Ethylene oxide and Chloromethyl oxirane	Excellent oil and ozone resistance. Fair flame resistance and low permeability to gases. Good low temperature properties.
CM	Chlorinated polyethylene	Chloro-polyethylene	Good long term resistance to UV and weathering. Good oil and chemical resistance. Excellent flame resistance. Good low temperature impact resistance.
	Cross-linked Polyethylene	Polyethylene and cross linking agent	Excellent chemical resistance with good heat and electrical properties.

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	Ethylene	Excellent dielectric properties. Excellent resistance to water, acids, alkalies and solvents. Good abrasion and weathering resistance.
PVC	Polyvinyl-chloride	Vinyl-chloride	Good weathering, moisture and flame resistance. General resistance to alkalies 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 blocked copolymers of styrene and butadiene	Good weather and aging resistance. Good for water and dilute acids and bases. Temperature range from -60°F (-50°C) to +250°F (+120°C).

Fibers Commonly Used In Hose

Common Name	Composition	General Properties
Cotton	Natural Celluiose	Natural vegetable fiber used in hose. Gains strength with increased moisture content. Requires protection against chemical and fungal activity.
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.
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 abrasion and fatigue resistance. Low moisture absorption and excellent moisture stability. High resistance to fungal activity.

Specialized Fibers Used In Hose

Kevlar*	Aramid	Exceptional strength with low elongation. High heat resistance.
Nomex*	Aramid	Exceptional heat resistance with low shrinkage.

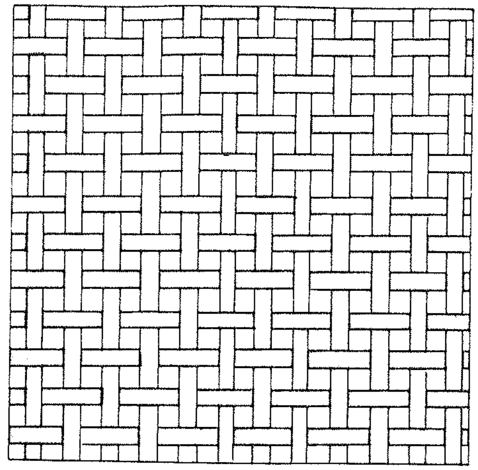
FABRICS

Textile fabrics used as reinforcement in hose construction provide strength or collapse resistance, or both. The method of building fabric into a hose is different from that when yarn is used.

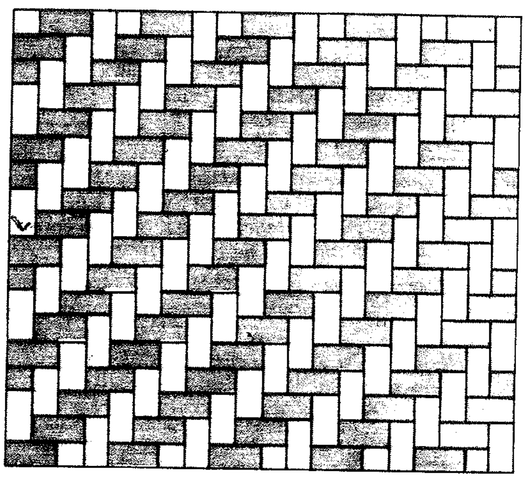
The properties of a fabric depend on the construction and the material from which the yarn is made and on the type of weave used.

Hose fabric is woven from warp yarns, which run lengthwise, and filling yarns, which run crosswise. 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.

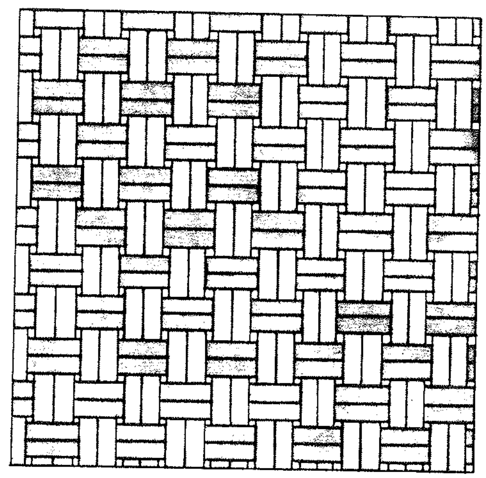
Woven Cord, Figure 1—10, is a special type of fabric. The warp cords are strong while the filling yarn is very fine and merely holds the cords in position. This is often called "tire cord" because this type of construction is commonly used in reinforcing tires. Woven cord provides strength in one direction only. When woven cord is used a minimum of two layers are applied in alternate directions. Layers in even multiples are required to provide a balanced construction.



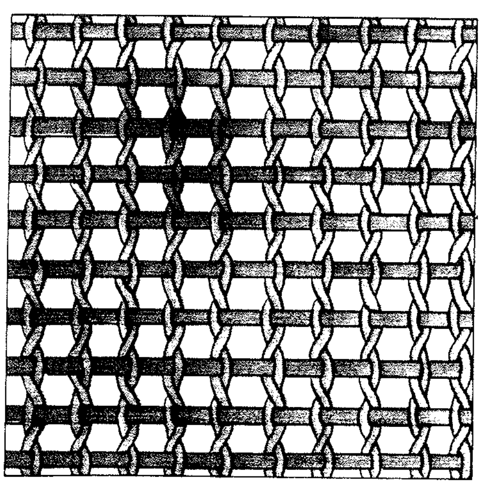
PLAIN WEAVE
Figure 1 — 6



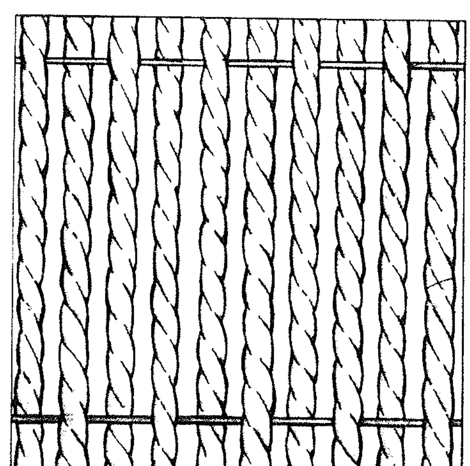
TWILL WEAVE
Figure 1 — 7



BASKET WEAVE
Figure 1 — 8



LENO WEAVE
Figure 1 — 9



WOVEN CORD
Figure 1 — 10

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.

YARNS

Textile yarns are used, as fabrics are, to provide strength and collapse resistance, or both. Various methods are used to incorporate the yarn into the hose during fabrication. Yarns for hose must have strength, good aging properties, dynamic fatigue resistance, and other special characteristics required by the hose application. Hose yarns are classified as either **staple** or **filament.**

Staple Yarns

A staple yarn is made by twisting relatively short lengths of fiber together in a random fashion to form a continuous yarn. The simplest type of yarn used is called **singles** yarn which is made of very small fibers twisted together into a strand. When two or more of these singles yarns are twisted together, the result is **plied** yarn. If two or more plied yarns are twisted together, the result is a **cable cord**. The tensile strength, elongation, and thickness of a yarn of any fiber type are determined by varying the twist and the number of "singles" used in the yarn. Staple yarns may be made from natural or synthetic fibers, or a combination of both. Yarn sizes are rated by the number of "hanks" of yarn it takes to weigh one pound.

Filament Yarns

Filament yarn is produced by extruding synthetic material through an orifice in a continuous process. A single filament is called a **monofilament**. Usually, a number of small filaments are combined to form a **multifilament** yarn. All filament yarns used in hose are synthetic and are generally stronger than an equal size of staple yarn.

Filament yarns are rated by a **denier** number — the weight in grams of 9000 meters of yarn. A universal system is now being adopted so that both staple and filament yarns can be rated on the same basis. This is called the **Tex System** and yarns are rated by the **Tex Number** — the weight in grams of one kilometer (1000 meters) of yarn.

WIRES

Reinforcing wire is used in a wide variety of industrial hose, primarily for hose where textiles alone do not satisfy special engineering designs or the service conditions for which the hose is destined.

Steel Wire

Steel wire has strength, fatigue resistance, and low cost, and is the major reinforcement used in high pressure hoses and in most suction hoses.

Fine Steel Wire

Fine 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 hoses, 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. Sometimes 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 tin-coated or galvanized finishes.

Wire Finishes

Wire finishes for steel wire can be either one of two types, (1) **drawn finish**, or (2) **coated finish**. The most commonly used finishes in the hose industry are copper or brass (drawn finish), or galvanized (coated finish). Other finishes include bronze, liquor, and tin. Round wires used 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 wire which offers exceptional resistance to corrosion and heat. Where light weight is essential, standard and special alloys of aluminum are used.

Static Wires

Static wires are used in hose to prevent static electricity build-up and discharge as a spark. Electrical engineers differ in opinion on static electricity and the means of dissipating it. In handling gasoline and other petroleum-based liquids, recognized national associations and companies using hose to convey these liquids have conflicting opinions on the need for static wires in hoses.

Until a consensus is reached among all associations, laboratories and users and a standard practice is agreed to, 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 his company's Safety Division, (c) his insurer, and (d) the laws of the States in which the hose will be used. Requirements for a static wire follow:

1. It must be in positive contact with the couplings at each end of the hose, since it is through the couplings that connections to the ground are made. A continuous circuit must be provided throughout the length of the hose.
2. The wire must be resistant to atmospheric and operating conditions in instances where the wire may be exposed. It must also be resistant to rubber compounds in the hose with which it may be in contact.
3. Static wires must withstand the stresses imposed by flexing and the normal conditions of service.

Some types of hose include a body reinforcing wire. This wire can be used to dissipate static electricity provided that proper contact can be 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, the static wire can be spiralled between the reinforcing fabric plies. In a braided construction, the wire can be braided into the reinforcement or spiralled between the plies. In some rare instances, the static wire is run through the bore of the hose and attached to springs which, in turn, are attached to the couplings. This spring arrangement lets the hose accommodate to bending and coiling without undue strain.

Static wires can be made from many metals including copper, steel, stainless 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 thereby shortened.

Adequate flexibility means 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. This 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 withstand severe bends without flattening or kinking.

Generally, the preferred hose is the more flexible hose, provided all other properties are essentially equivalent. However, there are some applications which do not fall into the general pattern. Sandblast hose, for instance, is sometimes made with a wrapped-ply reinforcement instead of a braided one to take advantage of the less flexible wrapped-ply construction. Sand or grit traveling at high velocity strikes the tube wall wherever the hose changes direction. When this occurs at a small-radius bend, even the most abrasion-resistant hose tube can be completely destroyed in a few hours.

Some indication of relative hose flexibility can be determined from the manufacturer's minimum bend radius recommendations. Normal flexibility for ordinary hose is 12 inches (305 mm) of radius for each inch (25.4 mm) of hose I.D. The most flexible rating for standard types of hose is 6 inches (152 mm) for each inch (25.4 mm) of hose I.D. Hose that can be used in even tighter bends is classified as "extremely flexible" and calls for special design.

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 stiffened 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 intensity of the internal vacuum to be applied. 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 considered.

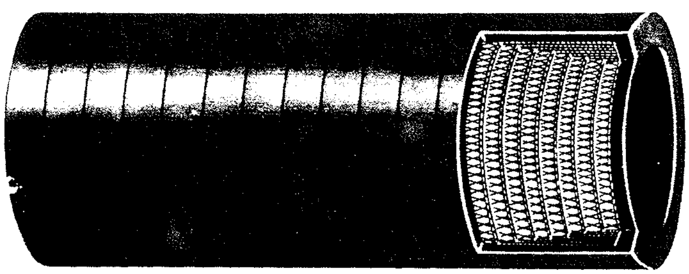
While suction hose is generally used to convey liquids, vacuum hose carries air under a partial vacuum. Vacuum hose is reinforced to resist collapse and maintain its shape under rough handling and/or mechancial abuse. It does not require the rigid construction of suction hose because the dry materials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

Chapter 2 MANUFACTURING METHODS

The principal methods used to manufacture hose are described and illustrated in this section. Such factors as service, size, production volume and cost usually determine the method by which hose is to be made.

New hose making processes and variations on old processes are constantly being evolved in a continuing effort by producers to provide the best hose at the lowest cost for each specific service. Most hose made today is produced by highly mechanized equipment specially designed for the purpose.

MACHINE WRAPPED PLY HOSE



8 PLY MACHINE WRAPPED PLY HOSE
Figure 2—1

Wrapped hose consists of a fabric reinforcement wrapped around a rubber tube over which is applied a protective rubber cover. This type of hose is most commonly made in approximate 50 foot (15 m) lengths and with an inside diameter (bore) ranging from 0.188 to 4.0 inches (4.8 to 102 mm).

A seamless rubber tube is formed to the desired diameter and wall thickness by a continuous extrusion process where the rubber stock is forced through the annulus of a pin (rod) and a die (ring) combination by the pressure generated by a helical worm rotating in a cylinder. Lubricants are generally injected into the bore of the tube as it is being formed to prevent the inner surface from sticking to itself (and later in the process to keep the tube from adhering to the mandrel). The tube is then mounted on a mandrel for the hose making operations either by drawing the tube over the mandrel or by pushing the mandrel through the tube, using air pressure to enlarge the tube temporarily.

The fabric used for reinforcing hose is received from the textile mill in large rolls. The roll of fabric is first thoroughly impregnated with a low plasticity rubber compound or "friction" by passing the fabric through the lower nip of a three roll calender, an operation called "frictioning." The surface speed of the middle roll, which carries the rubber friction, is faster than the speed of the fabric so that the rubber is driven into the interstices of the fabric. If necessary, the fabric is passed through the calender a second time so that the other side of the fabric can be frictioned.

When a hose construction requires a skin or layer of rubber between fabric plies, a thin coating of rubber compound is laid on one side of the frictioned fabric as it passes through a coating calender. The fabric is thus "skim coated."

The frictioned fabric is generally cut on the bias either by machine or by hand or, for special types of hose only, laid straight on the tube. Bias cut duck, which has the shape of a parallelogram, is pieced together with lapped seams to form a long strip just wide enough to make the required number of plies with an overlap when wrapped around the tube. The warp and filling threads of the fabric lay at an angle to the longitudinal axis of the hose.

The hose cover is prepared by calendering or forming a thin sheet of one or more plies to the required thickness on a rubber calender. The calendered cover stock is cut to a width which will wrap around the hose carcass with a slight overlap.

The actual making of the hose is done on a special purpose machine known as a "making machine." The 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 mounted on lever arms so that it can be raised and lowered. One or more of the rolls is power driven. A mandrel supported hose tube is placed in the trough formed by the two bottom rolls of the making machine. One lengthwise edge of the cut fabric is adhered to the tube. The pressure exerted by the top roll when it is brought down in contact with the tube forces the tube and mandrel to rotate as the machine rolls rotate. The fabric is drawn into the machine and wrapped around the tube as the tube rotates. The pressure from the top roll helps to form a compact carcass. The machine operation is repeated for the application of the sheet of cover stock around the hose carcass. Figure 2—2 shows the end view of a section of a making machine with the top roll in its raised position. Hose resting on the two lower horizontal rolls is ready to have the calendered cover applied.

Figure 2—2

Wrapped ply hose must be vulcanized under pressure to produce a solid, homogeneous construction. The necessary pressure is obtained by means of cotton or nylon wraps. The wraps may be in tape form and applied with an overlapping spiral or may be in wide sheeting, which is wrapped around the hose for a number of turns. The former is known as "cross-wrap," and the latter as a "straight-wrap." The straight-wrap may be supplemented with the cross-wrap where extra pressure is needed.

The wrapped hose is loaded into an open steam autoclave and is vulcanized under controlled conditions of temperature, pressure and time. The cloth-wrap is stripped from the vulcanized hose after cool down.

The final operation is the removal of the hose from the mandrel, which is accomplished with the aid of compressed air or water under pressure injected between the hose tube and mandrel at one end.

HAND-BUILT HOSE

The term "hand-built hose" applies to two general types of hose, i.e., non-wire reinforced and wire reinforced, which are made by hand on a steel mandrel. The mandrel is mounted on a series of double roller stands; one end of the mandrel is held in the jaws of a power-driven chuck in order to rotate the mandrel during the making operations.

Non-wire reinforced hand-built hose has the same components as machine wrapped ply hose, namely, a rubber tube, plies of fabric reinforcement wrapped around the tube, and a rubber cover. The hose is made by hand when it is too large in diameter, or too long to fit in the three-roll making machine, or when the hose is made with special ends. The hand method is also used frequently when the fabric reinforcement must be applied one ply at a time.

The tube for hose up to 4.0 inch (102 mm) inside diameter is usually extruded and mounted on a mandrel by methods already described above. The tube for larger hose is formed by wrapping calendered tube stock around a mandrel with an overlapping seam running the length of the tube. The frictioned and cut fabric is applied to the tube by hand and rolled down progressively as the mandrel is turned.

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

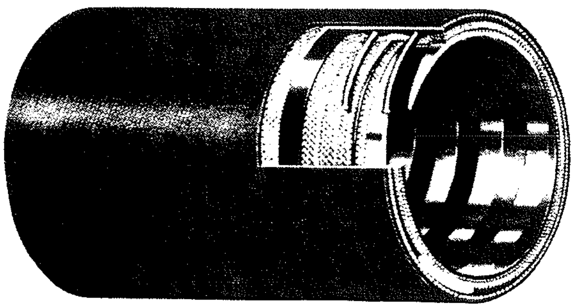
A calendered sheet of cover stock is applied to the carcass to complete the construction of the hose. The hose is cross-wrapped with one or more layers of nylon or cotton tape in a power chuck before vulcanization. The wrapping tape is removed after vulcanization and the hose removed from the mandrel.

Wire reinforced hand-built hose, as the name indicates, has wire added to the reinforcement component of most constructions. The wire may be present to prevent the hose from collapsing in suction service, to prevent kinking of pressure hose which must be curved in a small radius loop, or to obtain the strength necessary for high pressure service. In some constructions, layers of wire constitute the whole reinforcement.

Wire in most wire reinforced hose is present in the form of a closely spaced helix or spring which opposes inward or outward radial stresses but which does not add any significant strength to the hose in the axial direction. When high strength is needed in both axial and radial directions, the hose is built with two or more even numbers of layers of wire. Each layer is composed of many strands of solid round wire or wire cable applied over the fabric reinforcement. The wire lays on the hose in a spiral forming an angle greater than 45° with the axis of the hose. The direction of the wire spiral is reversed with each layer of wire for balanced strength.

LOCATION OF WIRE REINFORCEMENT

The wire in suction hose is located underneath the main plies of fabric reinforcement to provide rib support against external pressure. In fact, rough bore suction hose, Figure 2—3, is made with one helix of flat wire forming the bore of the hose and thus is located underneath the tube member of the construction.

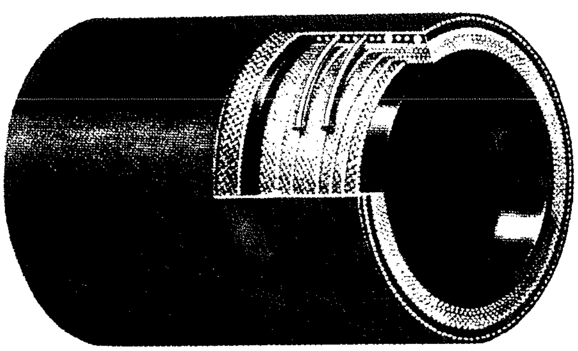


ROUGH BORE
Figure 2–3

Combination pressure and suction hose is made with the wire placed approximately midway in the plies of the fabric, Figure 2—4.

In pressure hose, the wire is positioned over the main plies of fabric to provide hoop strength against high internal pressure.

Flat wire is used for the inner wire of rough bore hose and round or flat wire may be used in the body of pressure or suction hose.



SMOOTH BORE
Figure 2–4

HOSE ENDS

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

Straight Ends — Hose where the inside diameter at the ends is the same as that of the main body of the hose.

Enlarged Ends — Hose ends having a bore diameter greater than that of the main body of the hose in order to accommodate a larger fitting.

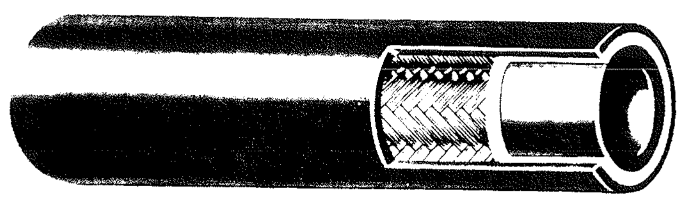
Soft Ends — These are generally restricted to suction hose that contains a helical wire reinforcement. To facilitate coupling, the wire helix is terminated before the ends of the hose and the ends are completed with fabric reinforcement to provide the desired strength and wall thickness.

Flanged Ends — Many installations are best suited for hose with flanged connections. Certain styles of hose can be made with rubber flanges molded as an integral part of the hose. These flanges can be drilled to match standard ratings. Metal inserts are sometimes used to provide the necessary rigidity and bolting strength. Another style of flanged end utilizes a partial flange molded as an integral part of the hose which is used in conjunction with metal backup rings for bolting purposes. This permits alignment of bolt holes without rotating the hose.

Built-In Nipples — Built-in nipples are used for high pressure service or for hose used for handling hazardous liquids.

BRAIDED HOSE

The term "braided hose" identifies a type of hose construction and the method by which its reinforcement is applied, either vertically or horizontally. By definition, the braid is a continuous sleeve of interwoven single or multiple strands of yarn or wire. The strands of reinforcement spiral around the inner hose structure in both directions in addition to being interlaced as shown in Figure 2—5.



BRAIDED HOSE
Figure 2–5

It may be shown mathematically that if the strands of reinforcing material are laid at an angle of 54° 44′ to the longitudinal axis, the hose will not change in diameter or length under internal pressure. As the braid angle decreases and the strand pitch increases, the hose will expand in diameter and contract in length under pressure. Conversely, as the braid angle increases and the strand pitch decreases, the hose will increase in length under pressure.

In actual practice, some change in diameter and length does take place under pressure but it can be kept within allowable limits. The movement is due to the fact that most reinforcing materials have some degree of stretch under stress which cannot be controlled precisely. In addition, the braid angle cannot be maintained at exactly 54° 44′ due to variations in tube diameter, the limitations of the braiders and the effect of subsequent production operations on the braid angle.

Braided hose is produced in a size range extending from 0.125 through 8.0 inches (3.18 to 203 mm) internal diameter. Various manufacturing methods are available for the operations preceding and following braiding. However, the combination of requirements associated with a particular service application such as internal diameter, length, tolerances on dimensions, burst strength, production rate and cost, will dictate to a large extent how the hose should be made from start to finish.

Vertical Braided Hose

Manufacturing of Vertical Braided Hose commences with the extrusion of an unsupported or a flexible mandrel supported tube in continuous lengths up to 500 feet (150 m) or more. An unsupported tube is formed using a straight delivery extruder of the type shown in Figure 2—6.

Figure 2–6

The tube must be firm enough in the unvulcanized state to resist deformation and stretch under normal processing conditions. A very high percentage of vertical braided hose is made with an unsupported tube. When the tube is too thin or too soft to withstand subsequent processing, or when the internal diameter must be kept within a narrow range, it is supported on a flexible mandrel. The flexible mandrel is at least as long as the hose to be made, has a round cross-section, and can be coiled to a small diameter. The flexible mandrel is made of a rubber or plastic material and may have a wire core to prevent stretching. A supported tube is obtained by passing the flexible mandrel through a crosshead extruder, Figure 2—7, thereby forming a tube over the flexible mandrel.

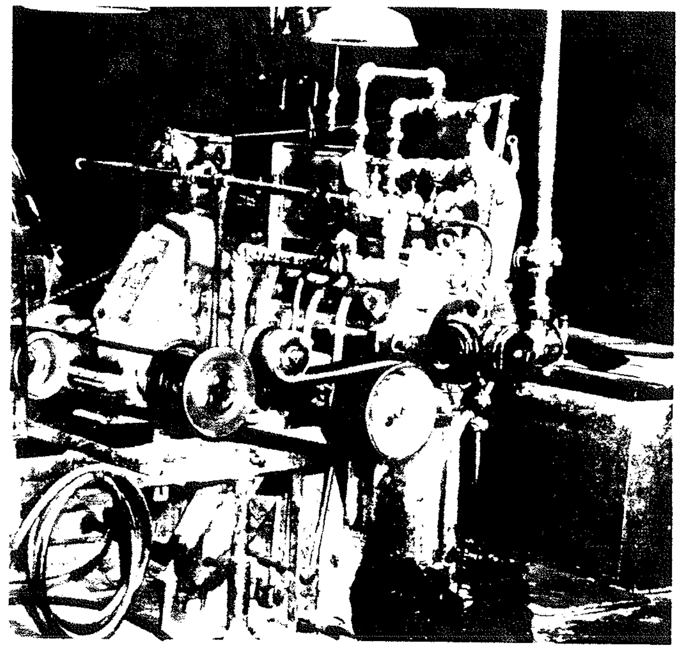


Figure 2–7

The tube, stored on a circular tray or a reel after extrusion, is moved to the braider where reinforcement is applied. The tube is drawn vertically up through the center of the machine, Figure 2—8, while the braid is forming on the tube surface. The braid formation is brought about by vertically disposed yarn or wire carriers weaving in and out on a horizontal circular track not unlike the movements and result of the Maypole dance. The movement of the carriers on the circular track is kept at maximum speed. The braid angle can be adjusted by changing the surface speed of the overhead take-off drum or capstan. Vertical braiders are rated in size according to the number of carriers on the deck. Machines with 16, 20, 24, 36, 48 or 64 carriers are used. Two layers of braid can be applied to a tube in one pass through a double deck vertical braider equip-

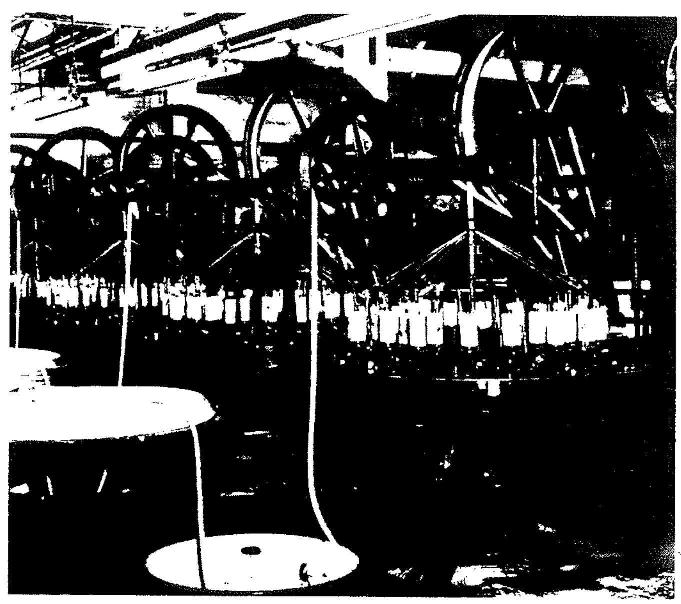


Figure 2–8

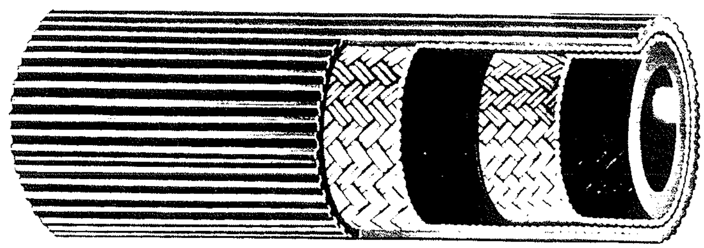
ped to coat the inner braid with cement or to insert a layer of rubber between the braids for adhesion between braids in the finished hose. Multiple braid hose is also produced by making multiple passes through a single deck vertical braider with a suitable bonding between the braids. The largest practical size in which vertical braided hose can be made is generally considered to be 1.50 inch (38 mm) internal diameter. Beyond this size, the problems related to the stretching and collapsing of unsupported tubes and to the use of a drum to draw either type of tube through a braider are almost insurmountable.

After the hose has been braided, it is normally passed through a cross-head extruder, where an outer seamless rubber cover is applied. At this stage, the hose is still in the long length and consists of an unconsolidated construction of a tube, braid or braids and a cover either coiled on a circular tray or wound on a reel. It then passes to the final production operation of vulcanization.

Vulcanization Methods — Vertical Braided Hose

The lead sheath process is so eminently suited for the vulcanization of vertical braided hose that most hose of this kind is vulcanized by this method. The lead casing may be formed by means of a lead press, Figure 2—9, with a hydraulic ram forcing a column of solidified lead through a ring-like orifice to obtain a continuous sheath in which the hose is enclosed. The lead enters the die forming stage in this condition and emerges from the press as a continuous lead casing. The casing is actually formed around the hose as it passes through the lead press. A casing can also be formed by an extruder using molten lead.

The pin used in a lead press or a lead extruder to form the inside surface of the casing may be smooth or corrugated, depending on the desired surface of the finished hose. The corrugated cover on the hose in Figure



TWO BRAID CORRUGATED COVER

Figure 2–10

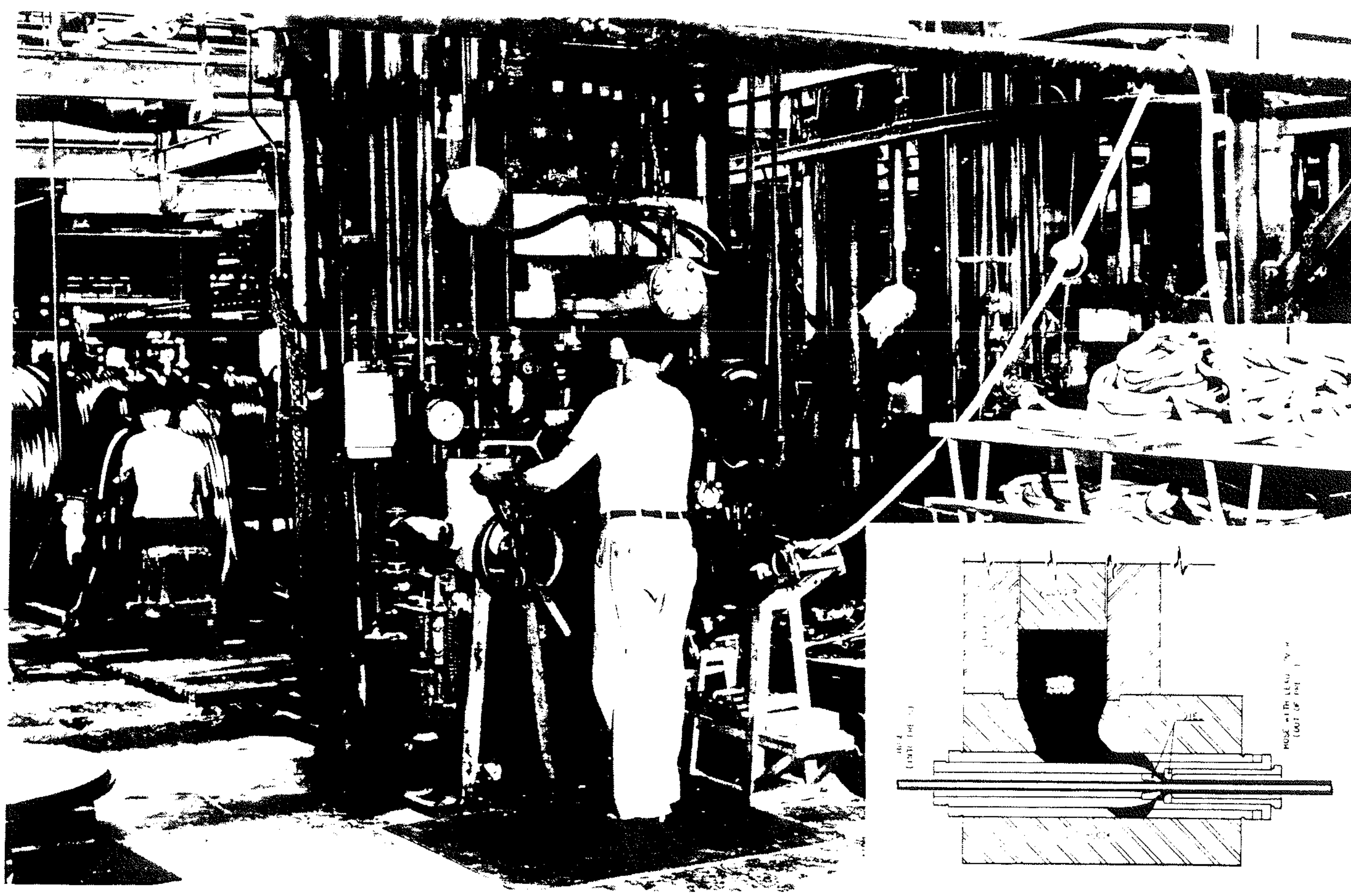


Figure 2–9

2—10 is the result of using a pin having the corrugated pattern in the press or extruder.

Prior to vulcanization, the lead sheathed unsupported tube hose is filled with water under pressure and the hose, wound on reels, is loaded into an open steam pressure vessel. The internal pressure is maintained during the vulcanization cycle to force the hose against the lead casing. Pressure and heat are the prime requisites for achieving vulcanization free of blisters and porosity and having the best possible adhesions and physical properties. Water is drained from the hose after vulcanization and the lead casing is stripped from the hose as shown in Figure 2—11. The lead is returned to the melting pot for re-use.

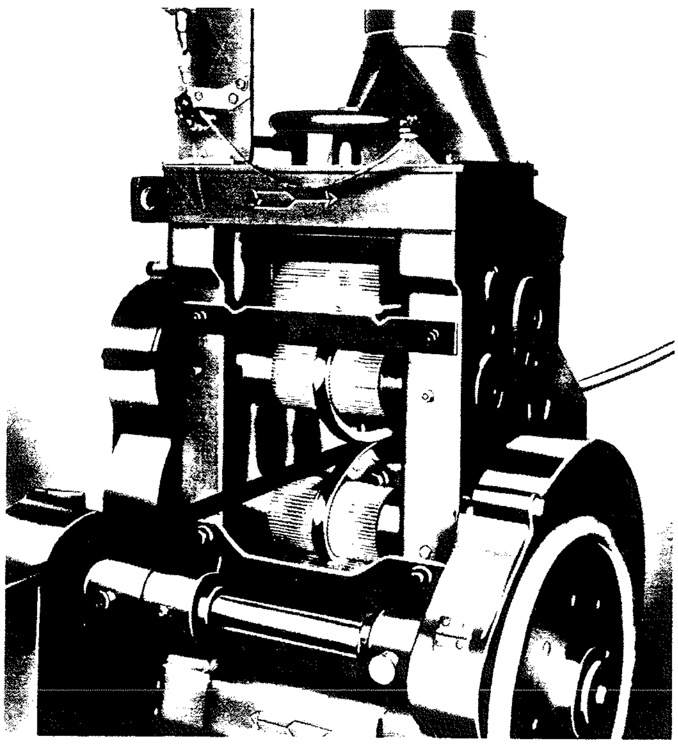


Figure 2—11

The application of a lead sheath squeezes the hose down onto the flexible mandrel and places the hose under slight initial pressure. However, most of the internal pressure comes from the mandrel and hose trying to expand as temperature is increased during vulcanization while closely confined within the lead casing. After vulcanization, the lead casing is removed in the same manner as for unsupported hose. One end of the hose is connected to a high pressure hydraulic system and the flexible mandrel is forced out of the hose.

Vertical braided unsupported tube hose can be vulcanized in two part steel molds as well. However, this method is only used for specialized hose which cannot, for various reasons, be put through the lead casing process. The steel mold is either straight and up to 50 feet (15.0 m) long with multiple mold cavities or circular with one spiral cavity which will take up to 500 feet (150 m) of hose. Each mold part has one half the cavity with a diameter corresponding to the nominal outside diameter of the hose to be vulcanized. The surface of the mold cavities is either smooth or machined with a corrugated design depending on the cover treatment required for the hose. The unvulcanized hose is laid in the bottom half of the cavity and the mold closed. The hose is subjected to internal air pressure causing it to expand against the wall of the cavity while the mold is steam heated to bring about vulcanization. In the straight mold, a long length of hose is vulcanized progressively, a section at a time with a short overlap in each cure. The spiral mold will vulcanize a long length in one cycle.

A third method of vulcanizing vertical braided hose is known as non-mold or open steam cure. The hose, coiled one or more layers deep in a metal pan, is exposed to open steam under pressure in an autoclave. The hose may be supported for cure by coiling in a bed of talc or other mediums and rounded out with internal air or water pressure.

Horizontal Braided Hose

The basic production machines and methods for vertical braided hose are used also, with a few exceptions and additions, for the production of horizontal braided hose. Horizontal braiding has the inherent capabilities of:

1. maintaining close control of inside diameter;
2. producing hose up to 8.0 inches (203 mm) internal diameter;
3. controlling the braid angle with precision, thereby limiting the reaction of the hose under pressure; and
4. making high pressure hose with tightly braided reinforcement.

All of the above are features not generally attainable with vertical braided hose.

The tube for horizontal braiding must be supported through all stages of production with the support provided by a steel mandrel 50, 60, or even 100 feet (15.0, 18.0, 30 m) long or by a long length flexible mandrel. Tubes intended for steel mandrels may be extruded separately and then mounted on the mandrel afterwards or the tube may be extruded directly on the steel mandrel. When a flexible mandrel is used there is no alternative but to extrude the tube onto the mandrel.

The braid is applied to the supported tube as it is pulled through the braider on a horizontal plane. The carriers are in a horizontal position and travel in both directions around a circular track mounted on a vertical plane. Again the braider size is determined by the number of carriers on the track. Horizontal braider sizes used are 20, 24, 36, 48, 60, and 64 carriers. Braiding production lines are set up with at least two and frequently three braiders working as a unit so that up to three layers of braid can be applied during one pass through the line, Figure 2—12. The braiders in a production line do not necessarily have to be all of the same size. Horizontal braiders have a very important advantage over vertical machines in that the horizontal line can be equipped with a powerful and positive takeaway or haul-off unit. The takeaway pulls the mandrel and hose through the braiders at a steady rate without slippage in spite of the higher tensions used with horizontal braiders. The speed of the carriers and the takeaway can be adjusted independently so that a broad range of braid angles and hose sizes can be accommodated.

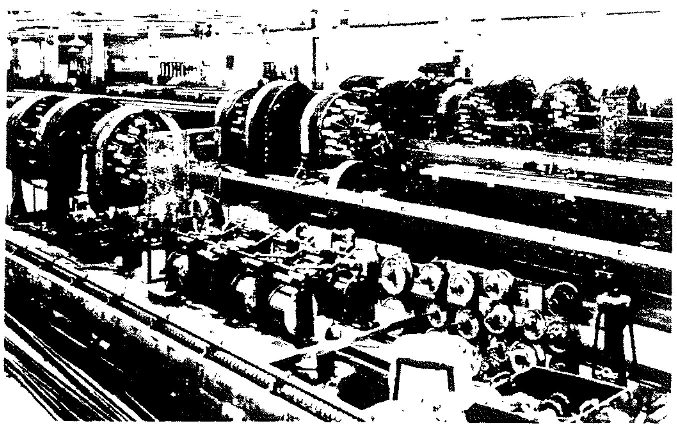


Figure 2—12

The bulk of vertical braided hose is reinforced with cotton, rayon, or other synthetic fiber yarns for what might be termed low and medium pressure service. In contrast, wire braided hose has been the more important product of the horizontal braided field even though very substantial quantities of yarn braided hose are made on the same equipment. The reinforcing material may be selected from any of the textile yarns listed in Chapter 1 or a wire of suitable size. The choice of the reinforcing material will be governed by the requirements of the service condition. In some instances a combination of textile and wire reinforcement is used.

Vulcanization Methods — Horizontal Braided Hose

The lead sheath process has been the preferred method of curing horizontal braided hose, and most is cured by this process. For vulcanization, horizontal braided hose on rigid or flexible mandrels may be encased in lead by either of the methods described above under Vertical Braided Hose. The rigid mandrel hose remains in straight lengths and is vulcanized in a long pressure vessel of relatively small diameter. Long length flexible mandrel hose is wound on metal reels and loaded into an autoclave for vulcanization. The lead process cannot be used for large diameter horizontal braided hose because of the size limitations of the lead presses and lead extruders now available. The required restraint and internal pressure for vulcanization for the full range of sizes is developed by temporarily cross-wrapping the hose with a woven nylon tape. The tape is removed after vulcanization, leaving a characteristic fabric impression on the outer surface of the hose.

Other methods of curing horizontal braided hose have been developed but are used on a relatively small proportion of the total production of these hoses.

One method uses a long metal tube attached to the cross-head of the extruder which applies the cover. The tube is filled with high pressure steam furnishing heat and external pressure, while the flexible mandrel used in the process furnishes internal pressure by expanding when heated, to effect the necessary consolidation. This process is suitable only for very long runs of a single style and size hose.

An open steam cure method can be used with some styles of horizontal braided hose, with either a rigid or flexible mandrel furnishing the internal pressure by expanding when heated, and steam pressure in the autoclave supplying external pressure and heat.

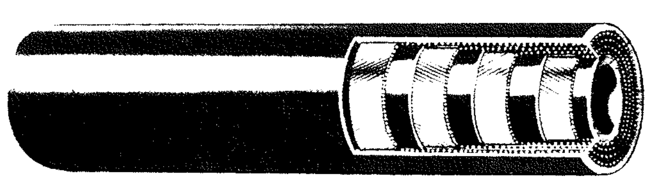
Suction Hose

Textile hose in sizes over 1.000 inch (25.4 mm) internal diameter may flatten or collapse under vacuum and consequently cannot be used for suction service. The insertion of a closely spaced wire helix buried in a rubber layer between textile braids has made possible a braided suction hose. The hose is made on a steel mandrel with a wire applicator situated between the decks of a horizontal braider line. One or more spools of wire are mounted on the rotating applicator and the wire is wound around the hose carcass as it passes through the line.

The cover can be applied to both the rigid and flexible mandrel supported hose by means of a cross-head extruder (described above under Vertical Braided Hose). Other methods of cover application are also used for steel mandrel hose such as spiral winding of a calendered strip of cover or machine wrapping a sheet of cover stock around the carcass.

SPIRALLED HOSE

The term "spiralled hose" identifies a type of hose construction in which the reinforcement in the form of strands of textiles or wire is applied by machine in a spiral pattern. In "spiralled hose" all of the wire or textile strands in one layer are laid parallel on the hose in one direction. Layers of reinforcement in multiples of



SPIRALLED HOSE
Figure 2—13

two are required with the layers spiralled in alternating directions in order to form a balanced construction. (See Figure 2—13.)

The reaction of spiralled hose to internal pressure is exactly the same as that of braided hose. "Spiralled hose" elongates under pressure when the angle of lay is larger than the optimum of 54° 44'. If the angle of lay is smaller than the optimum angle, the hose contracts in length and expands in diameter under pressure.

The separate layers of reinforcement are normally separated from each other by a layer of rubber or cement. The cover is formed by wrapping calendered sheet or spiralling a calendered strip over the carcass by machine, or by passing the uncovered hose through a cross-head extruder.

Wire spiralling machines have been set up in the same production line with a horizontal braider to produce a combined spiral and braid reinforcement.

Wire spiralled hose is made with the tube supported on a rigid or flexible mandrel. The tube is formed by the extrusion process, or by spiralling or wrapping calendered sheet stock over the mandrel.

Wire spiralled plies are applied either by a machine with rotating spools or packages, a rotating mandrel passing through fixed wire let-offs, or by a source of wire supply moving longitudinally along a rotating fixed mandrel. (See Figure 2—14.)

Wire spiralled hose is vulcanized by the lead casing process or cross-wrapped with a fabric tape and vulcanized in an autoclave.

Textile spiralled reinforced hose is made by spiralling textile yarns over an extruded tube. The tube can be non-supported or be supported by flexible or rigid mandrels.

Textile yarns can be spirally applied by any of the machines using the principles used for wire spiralling. The most common types are those with the spools or packages rotating around the tube. (See Figure 2—15.)

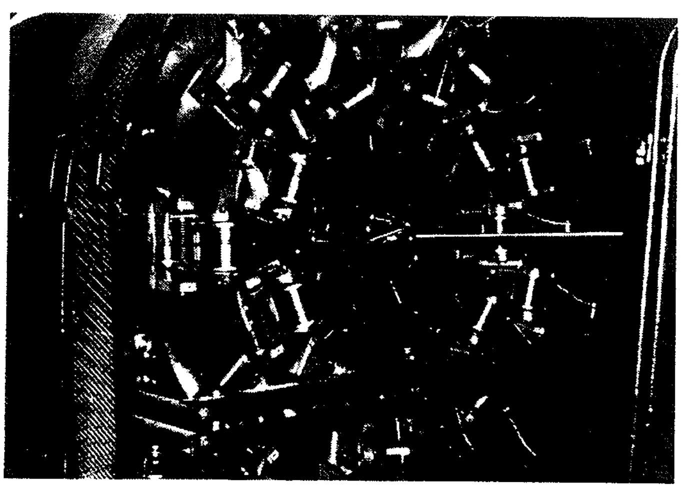


Figure 2—14

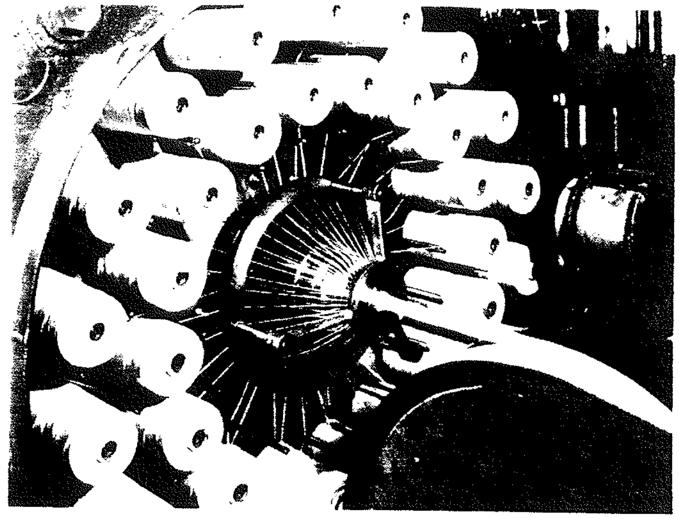


Figure 2—15

Textile spiralled hose has the cover applied by any of the means used for wire spiralled hose. The normal method, however, is to use a cross-head extruder to extrude the cover onto the carcass.

Textile spiralled hose is usually processed in long lengths and can be vulcanized by the lead casing method, or by non-mold and steel mold methods.

Textile spiralled hose is also made by a continuous process and vulcanized in line. In this process, the tube

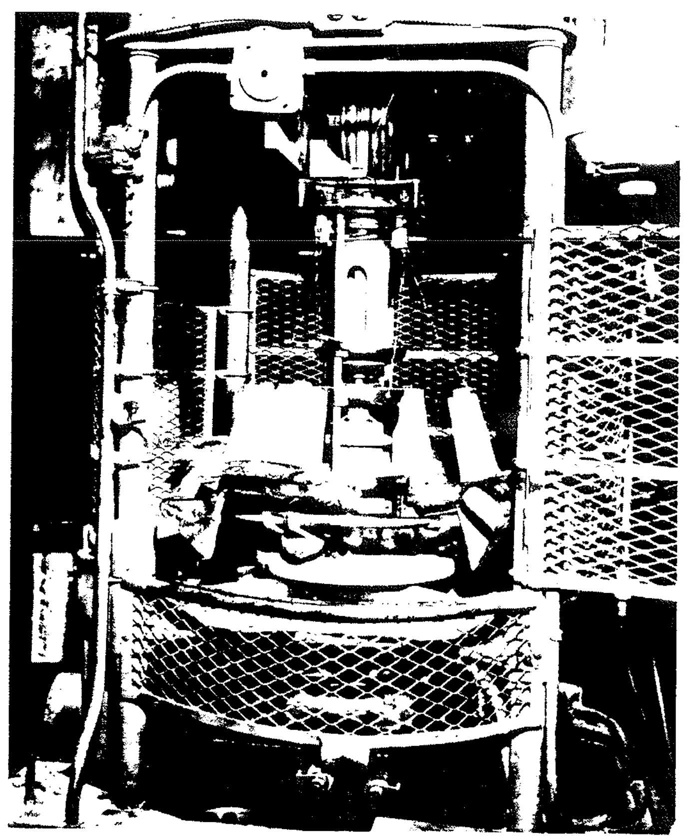


Figure 2—16

is extruded (unsupported) and passed directly through the spiral reinforcing machines, into a cross-head extruder to apply the cover, and then through a high temperature curing medium.

VERTICAL KNITTED HOSE

Vertical knitted hose is made by knitting yarns over a tube, Figure 2—16. The yarn may be cotton, rayon or other synthetic fibers. The knit may be plain, locked stitch, or wrap knit. The yarn spacing may be varied by adjusting the speed of the tube through the knitter relative to the rotational speed of the knitting head.

The wale or needle space is obtained by the number of needles used in relation to the diameter of the tube.

The knitters may have single or double heads.

Vertical knitted hose is made by the unsupported tube process described under Vertical Braided and Spiralled hose and, except for the knitter in place of a braider or spiral winder, follows the same procedure.

Knitted hose in long continuous lengths is cured by either the lead casing process or by the non-mold method described under Vertical Braided or Spiralled hose.

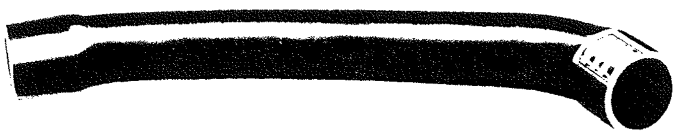


Figure 2—17

Knitted hose in curved-to-shape form, such as automotive radiator hose, is cut to the developed length required, placed over a metal mandrel of the correct diameter and shape, and then placed in an autocalve for final curing. After cure, the hose is removed from the mandrel and the ends trimmed, Figure 2—17.

REINFORCED PLASTIC HOSE

When hose is made with a thermoplastic tube and cover, it is manufactured by a method similar to the unsupported extruded tube process outlined under Vertical Braided or Spiralled hose. The reinforcement may be applied by means of horizontal or vertical braiders, spiral winders or knitters.

Since the tube and cover are thermoplastic, the cure methods outlined under Vertical Braided and Spiralled hose are not required. Adherence of the tube and cover may be obtained as it emerges from the extruder which applies the plastic cover.

NON-MANDREL LONG LENGTH WRAPPED HOSE

This type of hose is made usually in sizes smaller than 0.438 inch I.D. (11.1 mm) and is ordinarily limited to a maximum of five plies of lightweight square woven fabric reinforcement. It is often referred to as C.I. (cloth insert) tubing. Although the finished product is quite similar to mandrel made wrapped hose, the method of manufacture is quite different in that it is not built on a solid mandrel and therefore may be produced in long continuous lengths.

The tube is extruded in long lengths similar to the method used for Vertical Braided hose and is coiled on trays. It is then inflated with a slight amount of air pressure. This may be thought of as an air mandrel.

The tube is then fed longitudinally while at the same time a strip of bias cut square woven fabric is fed obliquely onto this tube at an acute angle. At the same time the tube is rotated through its entire length to such a degree as to wrap the fabric onto the tube to form one or more plies. This operation is performed by rolling the tube between two flat belts which are preset at an angle such that they will rotate any object which might be lying between them and in contact with both. The tube is rotated while on the pan at the let-off; the fabric wrapped tube is also rotated on a receiving pan at the end of the wrapping operation.

The cover is applied by conventional side head extruding machine as is used in covering Vertical Braided hose.

The hose is then cured, either by open steam pan cure or by the conventional Vertical Braided hose lead sheath method.

NON-REINFORCED "HOSE" (TUBING)

Rubber "hose" which consists of all rubber with no fabric or other non-rubber reinforcement is usually referred to as "rubber tubing."

Such tubing may be made of a variety of the materials described in Chapter 1. The tubing may be compounded to have many special characteristics or combinations of characteristics such as oil resistance, water resistance, food handling purity, acid resistance, weather resistance, etc.

The rubber compound is extruded using a die and pin to give the desired I.D., O.D. and wall thickness.

The extruded tubing may then be handled in a variety of ways depending on requirements, size, type and formulation, etc.

The tubing may be dusted with soapstone or passed through a lubricant solution such as soapy water and then coiled in long lengths on round pans. These pans are then stacked, using spacers, and placed in a steam autoclave for vulcanization. In special cases, the tubing may be extruded and vulcanized continuously. The tubing is then packed in coils or reels of desired lengths.

If the tubing is required to be perfectly round it is extruded in suitable lengths of 12 to 50 feet (3.6 to 15.0 m) and then blown over mandrels of the proper diameter. The mandrels are suspended at the ends and the assembly placed in a steam autoclave for vulcanization.

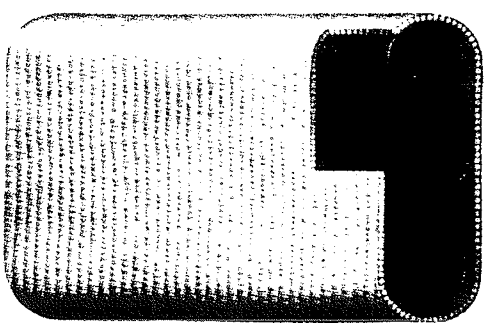
Mandrel cured tubing may or may not be wrapped with a fabric before vulcanization.

FIRE HOSE

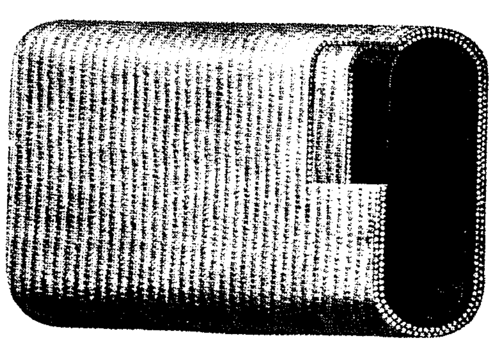
Fire hose consists generally of a tube and seamless circular woven jacket or jackets either separate or interwoven. See Figure 2—18 and 2—19 for single and double jacket hose. One of the types of looms used for the weaving of the fire hose jackets is shown in Figure 2—20. The tube may consist of a rubber or plastic compound. The rubber tube may be made in the following manner:

1. From a layer of stock plied together on a calender, where it is cut to the proper width. The plied stock is rolled out on a table, cut to length and made into a tube by joining together the two edges of the calendered strip; or
2. By extruding a tube to proper gauges; or
3. By the deposition of multiple layers of natural or synthetic latex or rubber on a suitable, finely woven fabric of synthetic or cotton fibers; or
4. By extruding a homogenous tube and cover with the jacket embedded in the hose wall.

CIRCULAR WOVEN



SINGLE JACKET
Figure 2—18



DOUBLE JACKET
Figure 2—19

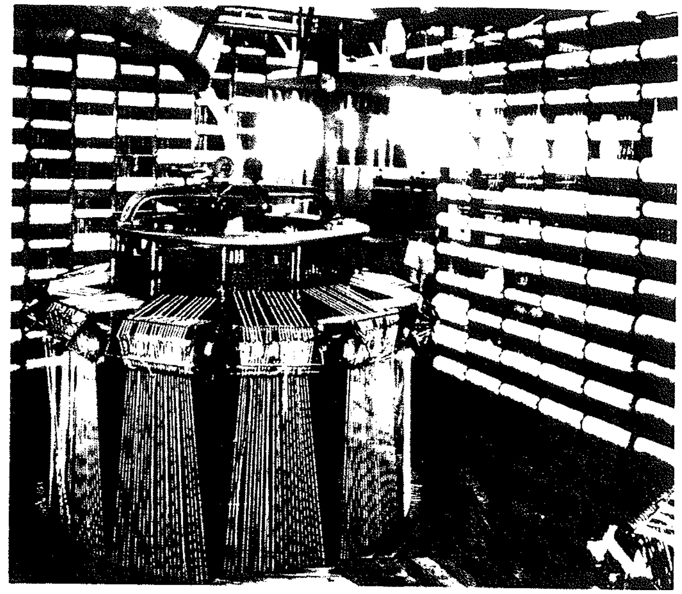


Figure 2—20

After the preparation of the tube in 1. and 2. if compounded rubber has been used as a tube, it may be semi-cured and then backed with a supplemental layer of rubber or the semi-cure and the supplemental layer may be eliminated as 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 becoming the pressure container.

Hose made with a plastic tube may also be built by a method which utilizes a high viscosity plastic compound placed on the inside and formed into a tube of the desired gauge.

Fire hose is normally made without an outer rubber cover or protection to the outer jacket. However, for certain users, especially in the chemical industry and at refineries where damage to the jacket would occur from deteriorating fumes or 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.

Where a rubber protective coating is used, the outer jacket is impregnated by dipping the jacket in the proper type of cement.

Where a rubber cover is used, the hose, after being cured as stated above, is placed on a rigid mandrel and calendered rubber covers are applied, after which the hose is wrapped with fabric tape under tension and cured and stripped in the same manner as described under Machine Made hose.

CHERNACK LOOM HOSE

A Chernack loom is a four shuttle circular loom in which the helical fill members may be of similar material or 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. A vertical loom uses an unsupported tube while a horizontal loom has the tube over a mandrel as it passes through for weaving the jacket. Depending upon the specific structure and use of Chernack loom hose, the outer surface may be left uncovered or it could have conventional rubber type outer protection or, particularly for smaller sizes a multiple lacquer dip. Vulcanizing sequence would depend on which particular variation of the hose structure is involved.

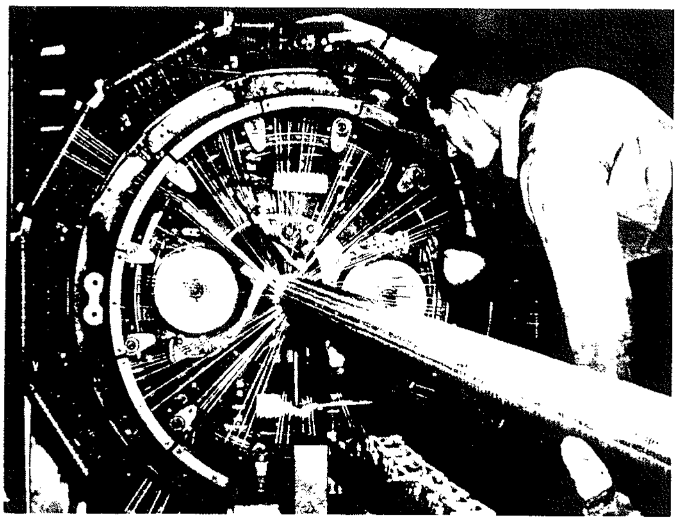
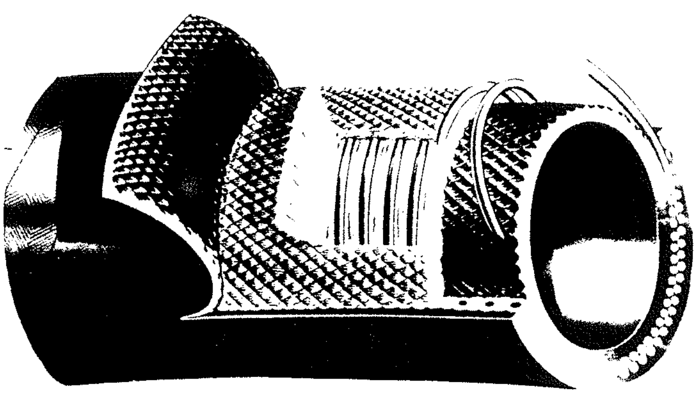


Figure 2—21

Non-wire — A Chernack loom non-wire construction may contain such helical filling members as cotton, rayon, nylon, etc., yarn, paper strand, plastic core or like material. All fill material would be similar but preferably two alternate fill members would have substantially more rigid characteristics than the other members.

Wire Stiffened — A Chernack loom hose wire filler construction would normally have two alternate members of round wire having physical characteristics which would provide substantial crush resistance in the hose structure. The other two would be textile yarn. A Chernack wire filler loom is shown in Figure 2—21 and an illustration of the Chernack loom construction is shown in Figure 2—22.



WIRE STIFFENED — ALTERNATE WIRE AND TEXTILE FILL MEMBERS
Figure 2—22

HOMOGENOUS LOOMED HOSE

Some hose made with a loomed carcass, either non-wire or wire stiffened, is produced with an homogenous tube and cover. The loomed jacket is put through a specially designed extruder cross-head where a compound is forced through the jacket and the tube and cover formed simultaneously.

VACUUM FORMED HOSE

Hose formed by the vacuum method is usually confined to special shapes, particularly those similar to corrugated gas mask tubes or tubes requiring great flexibility, collapse resistance, and extensibility. Basically, such tubes are made by placing them on a mandrel having the desired finished shape for the vulcanized tube. The mandrels are provided with bleeder holes so that the mandrels, when placed in the autoclave, have their interior exhausted to atmosphere or vacuum. Then steam pressure in the autoclave exerts a differential force which causes the tube to take the form of the mandrel while at the same time providing the temperature to vulcanize the tube to the prescribed configuration.

MOLD BLOWN HOSE

Hose made by this method requires placing a hose body or tube in a split half mold and suitably sealing the ends so that steam, air or other medium under pressure can be introduced to the interior of the tube causing the hose or tube to take the configuration of the mold. The presence of sufficient heat throughout the mold and interior of the hose or tube then vulcanizes it to the prescribed shape.

PLASTIC SUCTION AND DISCHARGE HOSE

Thermoplastic hose for suction and discharge service is produced by several proprietary processes.

The body of the hose consists of flexible plastic supported by a rigid helix. The flexible plastic member serves as the tube and cover as well as reinforcement. The rigid helix may be plastic, steel wire, or rigid plastic with a steel wire core; it provides reinforcing support against pressure or suction. The helical reinforcement can be completely embedded in the hose body or it can be adhered to the outside surface for discharge service, or adhered to the inside surface for suction service.

HOSE IDENTIFICATION

GENERAL

Hose is usually designed for use in specific applications although some applications will permit the use of multipurpose hose, e.g., for use with air, oil, or water. However, 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.

Questions concerning permanent identification markings inevitably 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 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 and printed legends, might be expected to remain legible for a long time if abrasive conditions and particularly 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 in identifying a specific hose product.

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 the 'long length hose manufacturing process', is continuous strip branding. This method requires that the legend be pre-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 lead sheathing device or the cure wrapper 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. Recently, 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

Rubber labels or brands 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 durable an identification as are the brands described above. A label, if imbedded in the cover, may well 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 label 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 a 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 method, 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, the prudent choice of inks and method of printing will 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 labelling 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), Molded and Extruded Products Division, primarily for the identification of extruded products.

However, many hose manufacturers have obtained a pattern assignment and are generally 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 a yarn or cord 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 configuration. 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 Industrial Products Division 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 and use them. The use of hose identified by colored yarns incorporated into their structure is far more preferable 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.

Chapter 4 TOLERANCES

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 have good length stability and fall 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 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.

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	0.031	0.79	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		Not Made		Not Made		Not Made		Not Made	
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.

WIRE-BRAIDED OR SPIRAL WOUND

Inside and Outside Diameter Tolerances
Rubber Covered and Non-Rubber Covered

Hose Size		Mandrel Types: Rubber Cover Class 212-A and 222-A				Textile Cover* Class 213-A and 223-A			
		I.D.		O.D.		I.D.		O.D.	
Inch	mm	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.

MACHINE MADE WRAPPED PLY

Inside and Outside Diameter Tolerances

Hose Size		Steel Mandrel Class 311-A				Non-Mandrel Class 331-A and 341-A			
		I.D.		O.D.		I.D.		O.D.	
Inch	mm	±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				

HAND-BUILT HOSE

Non-Wire Reinforced
Wire Reinforced
Class 411-A and 511-A

Size I.D.	I.D. ±Inch	I.D. ±Millimeter	O.D. ±Inch	O.D. ±Millimeter
3/4 inch (19 mm) and smaller	0.031	0.79	0.031	0.79
Over 3/4 through 2 inch (19-51 mm)	0.031	0.79	0.063	1.59
Over 2 through 4 inch (51-102 mm)	0.063	1.59	0.063	1.59
Over 4 through 12 inch (102-305 mm)	+0.063 −0.250	+1.59 −6.4	+0.125 −0.250	+3.18 −6.4
Over 12 inch (305 mm)	+0.125 −0.250	−3.18 −6.4	+0.125 −0.250	+3.18 −6.4
Enlarged Ends (All Sizes)	0.063	1.59	0.125	3.18

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	7.6	25	7.6	24**	7.3**
50	15.2	50	15.2	48***	14.6***
75	22.9	75	22.9	72	21.9
100	30.5	100	30.5	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.

CIRCULAR WOVEN CHERNACK LOOM

Class 711-A; 721-A; and 731-A

Size — I.D.	I.D. ±Inch	I.D. ±Millimeter	O.D. ±Inch	O.D. ±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. (25.4 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

DREDGING SLEEVES

Class 811-A

Size — I.D.	I.D. ±Inch	I.D. ±Millimeter	O.D. ±Inch	O.D. ±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

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

Note: These tolerances should not be applied to curved-to-shape hose.

Tolerances for Hose Built to Length

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

Length Feet	Length Meters	Tolerances ±Inch	Tolerances ±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 curved-to-shape, corrugated, or convoluted hose.

Squareness of Ends

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

Size Inch	Size Millimeter	Maximum Variation Inch	Maximum Variation Millimeter
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.

Chapter 5 COUPLINGS

Care should be taken in each instance cited below to follow properly the specific instructions of hose and coupling manufacturers regarding the match of hose and fittings and regarding assembly procedures. Such matching of hose and fittings and assembling of couplings should be performed only by trained personnel using proper tools and procedures. Failure to follow manufacturer's instructions or failure to use trained personnel might be dangerious and might result in damage to property and serious bodily injury.

To obtain maximum efficiency and safety in using hose, hose couplings and other fittings must be of the proper type and be installed in the manner recommended by the manufacturer.

Hose couplings can be divided into three general classifications, (1) reusable with clamps, (2) reusable without clamps, and (3) non-reusable, described below.

Ordinary hose service applications do not require that special attention be paid to the base metal used in making the coupling. In some cases, however, corrosion or chemical attack pose special problems in which case Table I (page 45) should be consulted for proper coupling materials.

The following descriptions and recommendations are general in nature. In every case, specific instructions of the coupling manufacturer must be followed.

TYPES OF REUSABLE COUPLINGS AND FITTINGS

Short Shank Couplings — (Fig. 5—1) These couplings are suitable for service in suction and water hose in low pressure applications; they are not recommended for pressures exceeding 50 psi (0.35 MPa) in hose diameters of two (2) inches (51 mm) or larger. The hose is anchored to the shank of the coupling with banding devices, bent wire clamps, strap clamps secured by bolts, or with some other clamp arrangement. There is a limit to the diameter of the shank which can be inserted into a length of hose without damage to the hose. In general, the following dimensions should not be exceeded:

Nominal Inside Diameter of Hose	Maximum Outside Diameter of Shank Fitting
0.375 in. (9.5 mm) and smaller	Nominal I.D. of nose plus 0.063 in (1.59 mm)
Larger than 0.375 in. (9.5 mm) and through 2 in (51 mm)	Nominal I.D. of hose plus 0.094 in (2.38 mm)
Larger than 2 in. (51 mm)	Nominal I.D. of hose plus 0.125 in. (3.18 mm)

Construction:

A. Brass-bolted clamp or boltless band (E) (one per end) as specified.

B. Female swivel attached to serrated shank.

C. Waterway gasket to fit female (B).

D. Male serrated shank.

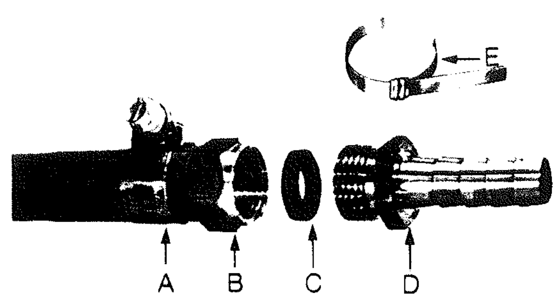


Figure 5 – 1

Installation Procedure:

1. Follow the general hose coupling procedure, page 44, below.
2. Place open clamp (A) or band (E) on hose. The clamp, when open, should fit snugly.

3. Screw male and female couplings together.
4. Slide hose on female shank to 0.125 in. (3.18 mm) clearance between swivel (B) and hose end.
5. Locate the clamp midway on the shank length. (Do not clamp close to the end of the shank or a damaged tube will result.) Tighten the clamp. When drawn tightly, 0.250 in. (6.4 mm) minimum clearance between the ears of the clamp is essential — otherwise, a smaller clamp is necessary. If band (E) is used, apply per the instructions furnished with the band.
6. Repeat steps 1 to 5 to attach the male coupling (D).
7. A waterway gasket should be properly inserted into the female swivel (B) before placing the hose in service.

Long Shank Couplings — (Fig. 5—2) Suitable for air and water in medium to low pressure range; not recommended for pressures exceeding 100 psi (0.69 MPa) on line diameters four (4) inches (102 mm) and over. The serrated shanks are long enough to permit the use of two clamps on each end. Some of the ridges on the coupling shank may be made larger than the rest to provide shoulders for improving clamping action.

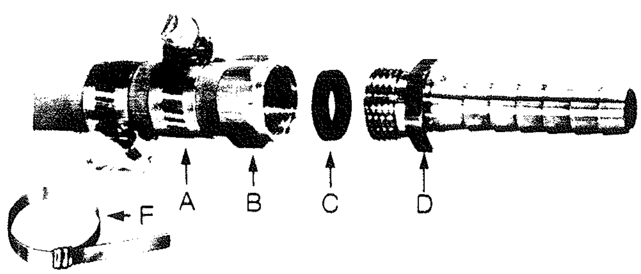


Figure 5—2

Construction:

A. Bolted clamps or permanent boltless bands (F) as specified (two per end);
B. Female swivel attached to long serrated shank. Hex nuts on female swivel and male end;
C. Waterway gasket to fit female;
D. Male serrated shank (NPSH* thread);
E. Male serrated shank with quick connect, nondirectional ends instead of threads (Figure 5—3).

Quick Connect Couplings — (Figure 5—3 & 5—4)

1. Figure 5—3 shows one type of quick connect coupling used for air.
2. Figure 5—4 shows a type of quick connect coupling made of brass or aluminum, used for gasoline and oil hose. "A" is the adapter applied to one end and "B" the coupler added to other end. If only one hose

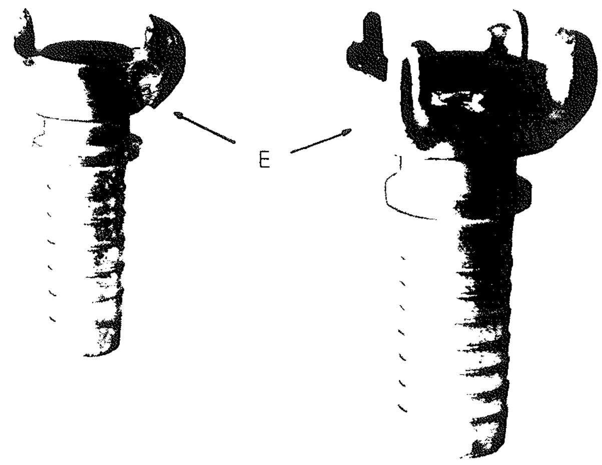


Figure 5—3

Figure 5—4

length is used and if joined to a threaded connection, the threaded connection should be equipped with an adapter so that the "coupler" on the hose may be joined to the adapted connection.

Installation Procedure:

1. Follow the general hose coupling procedure, page 44 below;
2. Place open clamps (A) or bands (F) on hose; clamps, when open, should fit snugly; it is important that the ears of the clamps be on opposite sides of the hose, as illustrated;
3. Screw male and female couplings together (where applicable);
4. Slide hose onto female shank to 0.125 in. (3.18 mm) clearance between swivel (B) and hose end;
5. Place clamps as follows: one clamp 0.500 in. (12.7 mm) from female swivel and other clamp 0.500 in. (12.7 mm) from end of shank; draw up tightly using vise jaws; when drawn tightly a minimum clearance of 0.250 in. (6.4 mm) between ears of clamps is essential—otherwise, a smaller clamp is necessary; if bands (F) are used, apply as per instructions furnished with bands;
6. Repeat steps 1 to 5 to attach male coupling (D);
7. Waterway gasket (C) should be properly inserted into female swivel (B) before placing hose in service.

*American National Hose Coupling Thread

High Pressure Couplings

> ***SAFETY WARNING***
>
> ***For maximum safety when handling high pressure air, water, or steam, special high pressure couplings must be employed. The clamps that encircle the hose ends must be attached to the nipples in such a way that it is nearly impossible for a nipple to blow out of the hose as long as the clamp remains intact. Failure to properly attach such clamps might result in damage to property and serious bodily injury.***

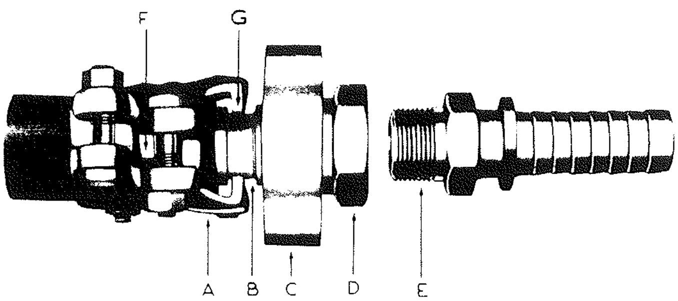


Figure 5—5

Construction:

A. Interlocking malleable iron clamp. In general, sizes 0.750 in. (19.1 mm) and smaller are two section, two bolts; sizes 1.000 in. (25.4 mm) to 3.00 in. (76 mm) are two section, four bolts; the 4.00 in. (102 mm) size is three section, six bolts;

B. Steel serrated female shank;

C. Malleable iron female wing nut; This nut may be either washer or ground joint type;

D. Steel spud;

E. Nipple, the steel serrated male shank (NPT* thread);

F. Interlocking finger;

G. Clamp finger.

Installation Procedure:

1. Follow general hose coupling procedure, page 44, below.
2. Screw male and female couplings together;
3. Insert shank of female coupling (B, C, and D — as a complete assembly) into a prepared hose end;
4. Place open clamp (A) on hose; engage interlocking clamp (A); place clamp fingers (G) in space provided on coupling shank collar;
5. Tighten coupling clamp causing it to conform to outside contour of hose;
6. When drawn tightly, interlocking fingers (F) of clamps should have 0.250 in. (6.4 mm) minimum clearance to allow for retightening;
7. Repeat steps 1 through 7 to attach male coupling shank (E).

*American Standard Taper Pipe Threads for General Use

NOTE: Select a clamp which has an inside dimension (measured finger to finger) (F) that is equivalent to hose O.D. Interlocking clamps have an exclusive advantage. Instead of being placed in alignment, the bolt lugs and interlocking fingers (F) are set in a staggered, or offset, relation to each other. This causes the clamp to grip the entire circumference of the hose evenly and securely. The opposing clamp sections dovetail together so that pinching of hose and straight line leaks are eliminated.

Compression Ring Type Couplings — The recess over the shank of the body of the coupling is tapered. The tapered compression sleeve which 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 gasoline and oil tank truck hose and for tank car hose.

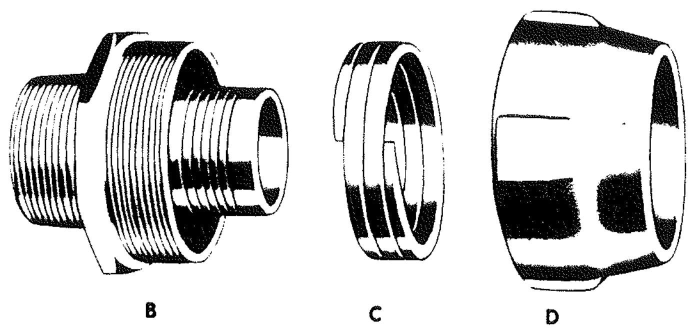


Figure 5—6

Construction:

A. Body with wrench flats and female swivel (not illustrated in Figure 5—6);

B. Male body with wrench flats;

C. Flat steel wire grip ring;

D. Compression sleeve;

E. Protective wire cuff (not illustrated) recommended for all hose except tank car hose to prevent flexing of hose at coupling.

Installation Procedure:

1. Secure male body (B) in vise at hexagonal nut;
2. Slide sleeve (D) and then steel grip ring (C) over hose end;
3. Thoroughly coat the hose end seat of male body (B) with sealant;
4. Slide hose end onto male body shank (B); butt hose end squarely against seat of coupling body;
5. Slide ring (C) up until it butts solidly against threaded part of body (B);

6. Move sleeve (D) over ring (C) to engage threads on body (B);
7. Using spanner wrench, screw threaded compression sleeve (D) onto threaded portion of coupling body (B) until tight;
8. For opposite coupling, repeat 1—7;
9. If female couplings are used, fluidway gasket should be properly inserted into recess of swivel before placing hose in service;
10. If wire cuffs (spring guards) are used, assemble wire cuff (spring guard) and compression sleeve (D) (requires special sleeve D);
11. If static wire is used, see page 44 below.

REUSABLE COUPLINGS WITHOUT CLAMPS

Gasoline Pump Hose Couplings — Another type of reusable coupling, used primarily in gasoline pump hose service, is shown in Figure 5—7.

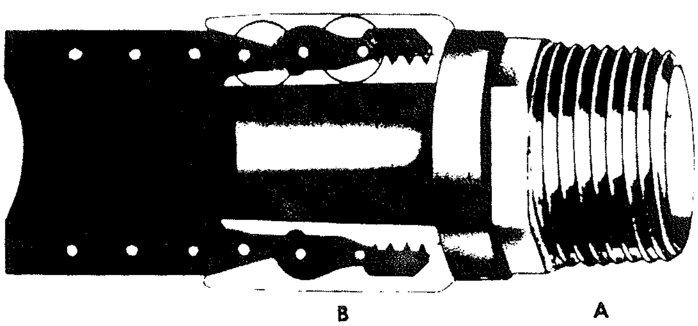


Figure 5 – 7

Construction:

A. Body (stem) with male NPT threads;

B. Sleeve

Installation Procedure:

1. Turn static wire out and back over hose cover, making sure at least 0.500 in. (12.7 mm) of wire is available for contact with sleeve (B) (see page 44, below);
2. Slide sleeve (B) over end of hose until hose is properly seated;
3. Place coupling sleeve (B) containing hose in bench vise, being careful not to distort sleeve; mark hose at tail of sleeve;
4. Coat shank of male body insert (A) with a light coat of neoprene cement or suitable lubricant;
5. Insert shank of body (A) into hose;
6. Using wrench, screw threaded insert portion of body (A) into threaded portion of sleeve (B) until hex nut on body is seated against shoulder of sleeve; inspect to insure mark on hose is within 0.125 in. (3.18 mm) of sleeve;
7. After sleeve assembly, inspect hose fluidway and remove excess cement or lubricant.

Hydraulic Hose Couplings — Also in the reusable couplings category is a hydraulic hose coupling for medium and high pressure applications. Figure 5—8.

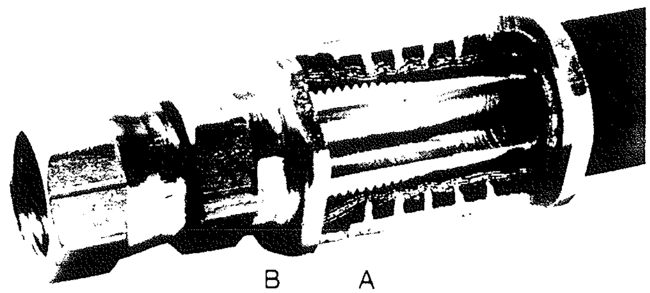


Figure 5 – 8

Construction:

A. Sleeve or socket;

B. Threaded insert or body.

Installation Procedure:

A. For Rubber Covered Hose

1. Obtain the correct length of hose required, measure in accordance with the instructions issued by the manufacturer;

   (Steps 2-5 are not necessary on certain thin cover hose — check manufacturers recommendations.)
2. After the correct length has been determined, make circumferential knife cut through the top cover; exercise caution in cutting so that hose reinforcement is not damaged;
3. Cut cover lengthwise from the circular cut to the end of the hose;
4. Pry up cover at the intersection of the two cuts;
5. Strip the cover from the end of the hose; this may be accomplished by grasping the loosened rubber section in a vise and turning the hose — or may be hand-pulled using nippers;
6. Screw sleeve onto hose until hose barely bottoms, then back off one-half turn if recommended by manufacturer; hold hose in vise if necessary;

7. Lubricate the threaded insert and hose I.D. with a suitable lubricant; place hose and sleeve assembly in vise vertically with sleeve up; insert is then threaded into the sleeve by means of a wrench until the hex of the insert seats on the sleeve.

B. For Braided Cover Hose (over the Cover Fitting)

1. Obtain the correct length of hose required, measure in accordance with the instructions issued by the manufacturer;
2. Screw the hose into the sleeve until hose barely bottoms in the end of the coupling; back off one-half turn;
3. Place threaded insert in vise and work hose and sleeve assembly onto insert; a mandrel-tool as supplied by the manufacturer may be used to assist in this operation (see manufacturers recommendation); lubrication of the mandrel, insert, and inside diameter of the hose with a suitable lubricant is necessary;
4. After insert has been threaded into the sleeve two or three threads, place assembly upright in vise; turn by means of a wrench until insert seats on sleeve.

Push-On Shank Couplings — These are available for use on specially constructed hose designed to function with this clampless or bandless coupling. The couplings are available in sizes 0.250 in. (6.4 mm) through 0.750 in. (19.1 mm) and are generally satisfactory for working pressures to 250 psi (1.75 MPa).

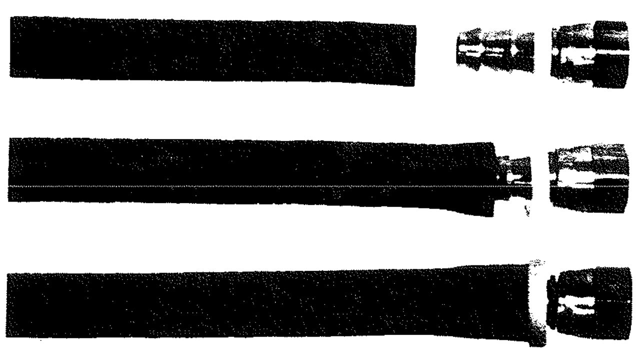


Figure 5—9

Construction — Figure 5—9

Male serrated shanks; no clamps or bands on outside required.

Installation Procedure:

1. Cut hose to desired length, being certain that ends are square;
2. Lubricate hose and shank for maximum ease in assembling;
3. Push hose on shank, as shown in Figure 5—9B, until the end of the hose is seated under the protective cap of fittings, Figure 5—9C.

MISCELLANEOUS SHANK AND CLAMP COUPLINGS

Special Couplings and Fittings — There are several variations of reusable shanks on the market which have been adapted for special applications. Detailed instructions for application may be obtained from the manufacturer.

Example — Grooved, Scored, Serrated (Fig. 5—10), and Ring Type Nipples — for suction and low pressure discharge service — use with wire clamps or other type clamps.

Figure 5—10

Sand Blast Sleeve Fitting — 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 Placing hose. Figure 5—11.

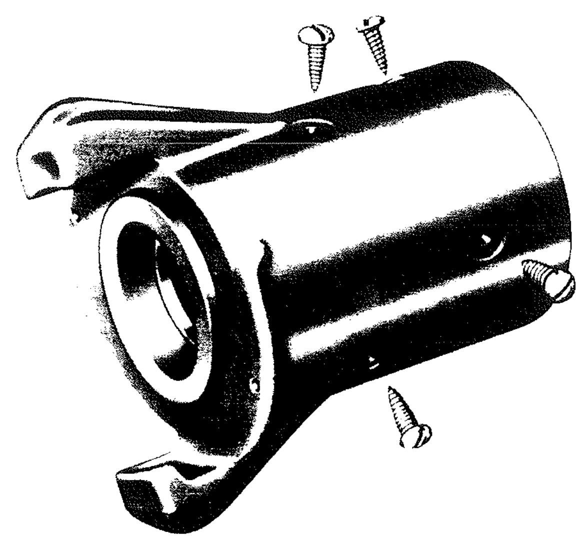


Figure 5—11

Construction:

A. One piece metal sleeve with four (4) or eight (8) holes drilled through the body spaced at 90° intervals (two (2) holes spaced apart lengthwise if eight

(8) holes are used); holes are tapered inward to accomodate standard flat head screws;

B. Screws are of sufficient length to end only in the carcass of the hose but not to pierce the tube;

C. Rubber gasket inserted in ends extending beyond the end of the sleeve to insure seal:

D. Ends shown are quick acting, but sleeves are also available with male and female sections with swivel connector which do not have the rubber gasket at the end; the hose extends to the end of the fitting.

Installation Procedure:

1. Hose ends must be square and capped or sealed with cement to prohibit air penetration of hose carcass;
2. Hold coupling tight against end of hose and install screws; center hose in coupling; use screws supplied with coupling which will penetrate the carcass but not the tube.

Clamps — There are numerous outside diameter hose clamps on the market, all of which will perform satisfactorily if recommended application procedures are followed. Some of these clamps, listed below, are shown in Figure 5—12.

1. Bands made from brass, stainless steel, or other metals having ends pulled together by bolt or worm drive thread;
2. Single or double bolt malleable iron clamps;
3. Wire type hose clamp (hairpin) made by wrapping the wire around the hose and anchoring the ends with a special tool;
4. Boltless band type — a tightened and locked band without bolts; the band is wrapped around the hose or otherwise secured to a sleeve or buckle by various methods.

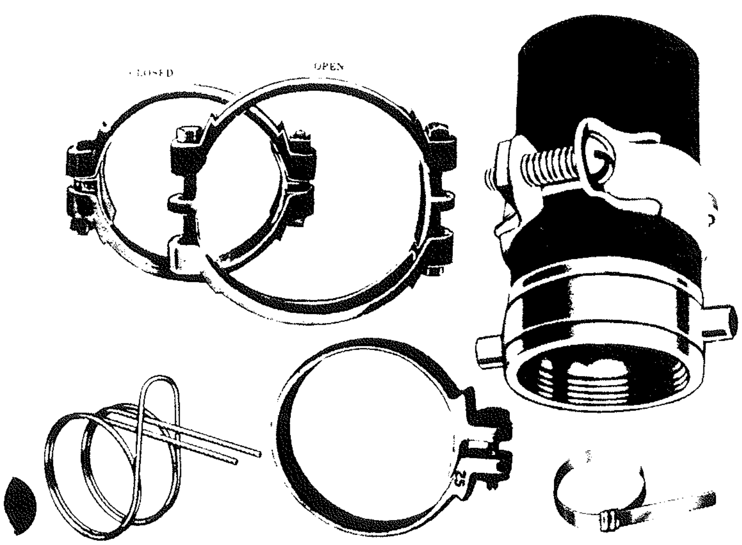


Figure 5—12

Fire Hose Couplings — For cotton-jacketed or rubber-covered fire hose. (Expansion ring type — Fig. 5—13). 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 requires a new expansion ring.

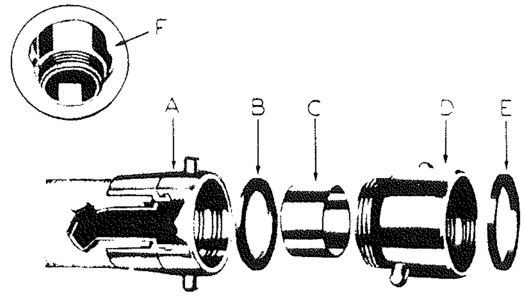


Figure 5—13

Construction:

A. Cast, or forged brass, or extruded aluminum alloy, female swivel attached to hose bowl by still thread or piston ring. Available with rocker lug (rounded ear) "F" and with pin lug as illustrated (A and D);

B. Waterway gasket;

C. Brass expansion ring;

D. Cast brass male coupling;

E. Hose cap gasket.

NPSH or NH* thread. If any other thread is desired, a sample coupling should be furnished for thread record. If this is not available, specify outside diameter of male thread and number of threads per inch. Correct thread data is especially important.

Installation Procedure:

1. Cut hose end squarely;
2. Insert cap gasket (E) into recess of coupling (D);
3. Slide coupling (D) over hose until hose end butts squarely against hose cap gasket;
4. Place expansion ring (C) on expander tool;
5. Slide hose and coupling (D) over ring on expander tool;
6. Operate expander tool as follows:
   (a) Expand ring until snug, then release pressure;
   (b) Turn coupling on expander tool 0.500 in. (12.7 mm) to 0.750 in. (19.1 mm) clockwise;
   (c) Apply pressure again for further expansion, then release;
   (d) Again turn coupling 0.500 in. (12.7 mm) to 0.750 in. (19.1 mm) clockwise on expander tool;
   (e) Make final expansion.

*American National Fire-Hose Coupling Threads

7. Repeat steps 1 to 6 to attach opposite coupling.
8. Place gasket (B) into recess of female coupling (A) before placing hose in service.

TYPES OF NON-REUSABLE COUPLINGS AND FITTINGS

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

Crimped-On and Swaged-On Couplings — Non-reattachable couplings (Figure 5—14) are applied with special equipment to either swage or crimp the outer sleeve or ferrule on the hose. While they are generally used for high pressure applications they may also be used on low pressure garden hoses.

Figure 5—14

Internally Expanded Full Flow Couplings — For gasoline and oil tank truck or tank car hose application. (Figure 5—15).

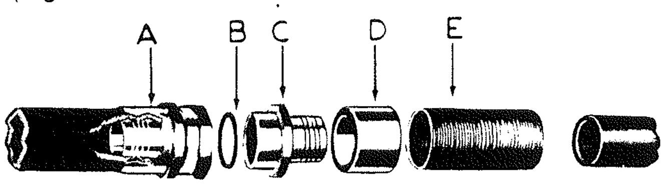


Figure 5—15

Construction:

A. Forged brass body with wrench flats and brass female swivel;

B. Fluidway gasket;

C. Forged brass or steel male body with wrench flats;

D. Brass or aluminum ferrule;

E. Protective wire cuff (spring guard), recommended for all hose except tank car hose. It prevents acute flexing of hose at coupling. This special cuff (spring guard) is held in position between cover of hose and brass ferrule. NPT threaded male; NPSH threaded female or as ordered.

Installation Procedure:

1. Follow special directions for making static bond connection shown on Page 44 below.
2. Insert wire cuff (E) into brass ferrule (D); make sure the wire cuff butts solidly against inside the shoulder of the ferrule;
3. Slide the wire cuff and ferrule over the hose end;
4. Place the male coupling body (C) on the expander, in accordance with instructions supplied with the expander tool;
5. Slide the hose, ferrule (D), and wire cuff (E), over the male body (C), making static bond connection;
6. Operate the expander until the punch is drawn completely through the fluidway;
7. For opposite coupling, repeat 1—6;
8. The fluidway gasket (B) should be properly inserted into the recess of the female swivel (A) before the hose is placed in use;
9. If wire cuffs (spring guards) are not used, select the correct size ferrule (D) to fit the O.D. of the hose; proceed as above.

NOTE: Selection of the proper sleeve (ferrule) size is most important. With wire cuffs, it is necessary to use a ferrule that fits over the wire cuff. Without wire cuffs (spring guards) the ferrule (D) should fit snugly the O.D. of the hose.

Gasoline Pump Hose Couplings — A similar type of internally expanded full flow coupling, used primarily for gasoline pump hose, is shown in Figure 5—16.

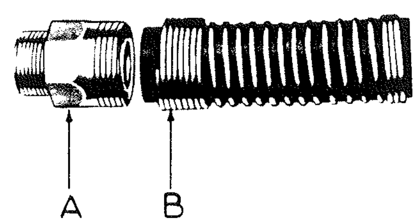


Figure 5—16

Construction:

A. One-piece tapered NPT* male body; machined for wire cuff (spring guard) when cuff is used;

B. Protective wire cuff (spring guard) if desired; an internal type spring guard is frequently used to prevent kinking the hose.

Installation Procedure:

1. Follow instructions on Page 44 (below), item 10, for static bond;
2. Place male body (A) on expander, per instructions with the expander tool;
3. Slide hose into shell of male body (A); make certain hose end butts solidly against seat of male body;
4. Operate expander until expanding punch has been drawn completely through the fluidway;
5. If wire cuff is used, first slide cuff (B) over hose end and, after coupling is expanded, screw cuff onto the machined part of the coupling; if internal type

*American Standard Taper Pipe Thread for General Use spring guard is used, press it into the bore of the coupling after expanding.

Built-In Fittings — Large size hose for oil suction and discharge and other similar services are commonly fitted with metal nipples. The nipples are in most cases fabricated from short lengths of steel pipe, threaded on the outer end, Figure 5—17.

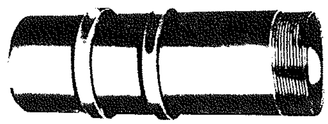


Figure 5 – 17
Two Band Nipple

Aluminum nipples and flanges are used when lightweight fittings are essential to the application (Figure 5—18). The nipples are first positioned on the mandrel so that the hose is built is over the nipples. The nipples are locked into the hose by means of the circumferential grooves or raised metal bands on the outside of the nipple.

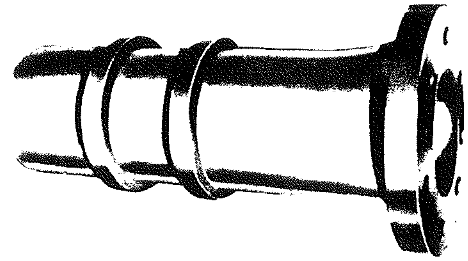


Figure 5 – 18

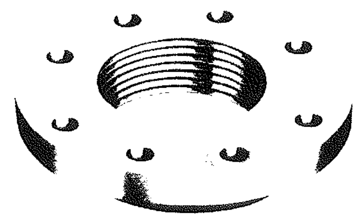


Figure 5 – 19

The exposed threaded nipple end is fitted with a pipe flange having bolt holes according to the standard specified, Figure 5—19.

GENERAL HOSE COUPLING PROCEDURE

1. Do not try to cut hose held in the hands; place the hose on a bench or other support. Wet the knife blade for easier cutting; some types of hose will cut more easily if flexed slightly.
2. Cut hose ends squarely; square ends are necessary to insure the proper alignment and depth of the hose on the coupling shank.
3. Lubricate the hose and coupling shank for easier insertion; rubber cement, soap and water, or even water alone, are recommended lubricants although with high-pressure, oil-resistant, or hydraulic hoses, heavy petroleum oils may be required.
4. Do not cut or burn out any of the inner tube to accommodate a coupling shank that is too large; however, countersinking the end of the tube 45° may help to insert the coupling.
5. Do not alter the shank of the coupling; doing so may either reduce some of the holding power or create sharp edges which could puncture the hose tube.
6. Keep hose and coupling shank aligned as they are being pressed together to avoid damaging the hose tube and to assure that they reach full insertion depth; place the coupling in a vise so it can be held securely.
7. Locate clamp(s) over shank, usually about midway of the shank length.
8. Do not remove any part of the hose cover (except in accordance with manufacturer's specific coupling instruction). Doing so can expose the reinforcement and shorten the life of the hose.
9. Seal the end of the hose with shellac or rubber cement to prevent absorption of water or oil into the reinforcement.
10. Static bonding. Certain types of hose have a wire built into their carcass for establishing positive electrical continuity between the two ends, thus grounding any static charges which could develop. This continuity can be assured with either of the following methods of couplings:

    A. **Method 1** — Cut end of hose flat and seal with cement or shellac. Insert a flat brass pin into center of static wire for about 0.250 in. to 0.375 in. (6.4 mm to 9.5 mm), remembering that the wire travels on an angle due to its spiral. Bend remaining end of pin inside of hose so it will be in direct contact with the coupling shank. If two wires are present, use two pins on each end.

    B. **Method 2** — Cut off end of hose about 0.500 in. (12.7 mm), being careful not to cut or damage the wire. Bend the projecting end of the wire inside the bore of hose and seal the end of the hose with shellac or cement. Insert coupling into the hose making positive contact with the wire. **Note:** On couplings which are designed with **positive contact** between the outer shell or ferrule and the coupling stem or shank, it may be easier to bend the wire outside the hose instead of inside before installing the coupling. Never attempt to make contact with the clamp only. If an exact length of hose is required, the hose must be ordered with an extra inch of length to allow for this cutting.
11. After assembly of couplings, inspect the inside of the hose at the end of the coupling for cuts, tears, folds, or bulges resulting from improper assembly.

TABLE I
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	Mall. Iron Steel	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 303, 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
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	2
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

*3 to X at high temperatures.

TABLE I (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	Mall. Iron Steel	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 303, 304, 308	Stainless 316	Monel
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
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
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%	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

TABLE I (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	Mall. Iron Steel	Brass	Bronze	Aluminum	Glass	Stainless 410, 416, 430	Stainless 302, 303, 304, 308	Stainless 316	Monel
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
Sodium Phosphate									
(Alkaline)		3				1	1	1	1
(Neutral)		2				1	1	1	1
(Acid)		2				X	2	1	1
Sodium Silicate	1	3		X		1	1	1	1
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				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

Chapter 6 HOSE TEST METHODS

***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 serious bodily injury.*

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

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

HYDROSTATIC TESTS

The reinforcement material and method of fabrication determines the bursting strength of a hose and the way a hose will react when internal pressure is applied.

Pressure characteristics may be measured by one or more methods of testing. Hydrostatic pressure tests are classified as follows:

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

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. Average burst is the mean value at which a large number of actual burst tests occur on hoses of the same size, construction and grade. The mean or average burst pressure is commonly used by a manufacturer as the basis for determining the working pressure of a hose. In hose specifications, it is normal to specify the minimum burst pressure required. Thus, the minimum burst pressure is a predetermined characteristic based on a knowledge of the actual working pressure to which the hose will be subjected, multiplied by a safety factor. The minimum burst pressure is calculated from the actual burst pressures of a large number of samples by determining a standard deviation and then subtracting three times the standard deviation from the average of the actual bursts. Normally, the minimum burst pressure will be approximately 85% of the average for textile type reinforced hoses and 90% for wire reinforced hoses.

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, usually 2 minutes or 10 minutes. The specified pressure is approximately 75% of the minimum burst pressure for a 2 minute hold and approximately 66% of the minimum burst pressure for a 10 minute hold. After a hold test is completed, it may be further required that the pressure be increased until burst occurs.

Non-Destructive Tests

Non-destructive tests are conducted on a full length of a hose or hose assembly and 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 or test pressure test is normally a pressure 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 test pressure is 60% of the specified minimum burst for single jacket and 66.7% for double jacket hose. 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 (0.07 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 (0.07 MPa) (except wire braided or wire spiralled) and that at the proof pressure times 100 divided by the length at 10 psi (0.07 MPa). Elongation occurs if the length of the hose under the proof pressure is greater than at a pressure of 10 psi (0.07 MPa). Contraction occurs if the length at the proof pressure is less than at 10 psi (0.07 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 (0.07 MPa) and that obtained under the proof pressure times 100 divided by the outside diameter or circumference at 10 psi (0.07 MPa). Expansion occurs if the measurement at the proof pressure is greater than at 10 psi (0.07 MPa). Contraction occurs if the measurement at the proof pressure is less than at 10 psi (0.07 MPa).

d. Warp is the deviation from a straight line drawn from fitting to fitting; the maximum deviation from this line is the warp. First, a measurement is taken at 10 psi (0.07 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. Twist is a rotation of the free end of the hose while under pressure. A first reading is taken at 10 psi (0.07 MPa) and a second reading at proof pressure. The difference, in degrees, between the 10 psi (0.07 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.

f. 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 (0.07 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.

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.

   Working pressure is established by the manufacturer and is based on a number of factors. The abuse or other conditions of service to which a hose will be subjected, whether it is handling hazardous materials such as gasoline, steam, ammonia, or inflammable gases, the diameter of the hose, and the type of reinforcement are all considered in establishing the safety factor applied to the average burst strength which, as has been noted, results in the working pressure assigned by the manufacturer.

The ratio of minimum bursting pressure to design working pressure for various hose applications is as follows:

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

METHOD FOR MEASURING ELECTRICAL RESISTANCE OF HOSE

Sample Preparation

1. Cut a 24 inch (610 mm) sample from the length of hose to be tested unless the size and length of the hose is such that it is necessary to test the entire length.
2. Buff both the tube and cover for 1.5 inch (38 mm) on each end with 120 grit emery paper.
3. Insert either polished steel or copper plugs having diameters equal to the I.D. of the hose into each end for a distance of one (1) inch (25 mm).
4. Clamp the plugs in the hose with a polished 0.500 inch (12.7 mm) reusable band clamp. Place the bands 0.250 inch (6.4 mm) from the end of the hose and tighten firmly.
5. After the clamps are applied, allow the hose to rest for at least ten minutes before the test is made.

Test Procedure

To measure the resistivity of the hose, lay the entire assembly out straight on a non-conducting surface. Place the ohmmeter electrodes on the plugs in the hose to record the tube resistivity.

If the cover resistivity is desired, place the electrodes on the clamps. This method tends to eliminate the greatest number of variables, yet it is simple to set up and make the test.

The resistance between the plugs or clamps shall be measured with a megohm meter (having a range of 0.08 to 10^6 megohms, utilizing a measuring voltage of 500 volts across the unknown resistance) which has previously been standardized against a known resistance.

The resistance of any hose shall be reported as ohms per foot of hose, as determined by dividing the total resistance by number of feet of hose between clamps.

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.

They 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. Improper use of hose or use of hose not designed for the service intended can result in possible serious consequences, i.e. 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 7)
  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) Delivery requirement: Quantity, Time

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
  4. Non-reusable
- (d) Material for Fittings
  1. ANSI (or SAE or ASTM) metal composition specifications
  2. See Chapter 5, Table 1, and Chapter 7

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 5, 6, 7.
  2. Treatment for specific services
  3. See Chapter 5, Table 1, and Chapter 7

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 APPLICATIONS

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 organizations

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

Other organizations

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BIA	Boating Industry Association
CGA	Compressed Gas Association
FM	Factory Mutual Research
ISO	International Organization for Standardization
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 kinds of 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 only 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 & 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 may result in possible damage to property and serious bodily injury.*

Resistance-Rating

- **A**—Good
- **F**—Fair
- **C**—Depends on Condition
- **X**—Unsuitable
- **T**—No Data-Normally likely to be satisfactory

Elastomers

NR	Isoprene, natural
IR	Isoprene, synthetic
SBR	Sytrene-butadiene
CR	Chloroprene
NBR	Nitrile-butadiene
IIR	Isobutene-isoprene
CSM	Chloro-sufonyl-polyethylene
EPDM	Ethylene-propylene-diene terpolymer
FMQ	Dimethyl-polysiloxane
FPM	Fluorocarbon rubber
CM	Chlorinated polyethylene
ECO/CO	Epichlorohydrin
XLPE	Cross-Linked polyethylene

(Maximum Temperature 100°F (38°C) Unless Otherwise Specified)

Material		Most Commonly Used Elastomers: NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	Special Elastomers: FMQ	FPM	CM	ECO CO	XLPE
Acetic Acid, Dilute, 10%		F	C	C	C	A	C	A	A	X	A	F	A
Glacial		C	X	X	X	F	C	F	F	X	A	X	A
Anhydride		C	C	F	F	F	A	T	C	X	A	X	A
Acetone		A	A	F	X	A	F	A	A	X	A	X	A
Acetylene		A	A	F	A	A	F	A	C	T	T	T	A
Air	150°F (65°C)	A	A	A	A	A	A	A	A		A	A	A
Aluminum Chloride	150°F (65°C)	A	A	A	A	A	A	A	A	A	A	A	A
Aluminum Fluoride	150°F (65°C)	A	A	A	A	A	A	A	F			A	A
Aluminum Sulfate	150°F (65°C)	A	A	A	A	A	A	A	A	T	A	T	A
Alums	150°F (65°C)	A	A	A	A	A	A	A	A		A	T	A
Ammonia Gas		A	A	A	A	A	A	A	A	X	A	T	A
Ammonium Chloride		A	A	A	A	A	A	A	C	T	A	A	A
Ammonium Hydroxide		C	F	F	F	A	A	A	A	A	A	T	A
Ammonium Nitrate		A	A	A	A	A	A	A	A		T	A	A

Material	NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	FMQ	FPM	CM	ECO CO	XLPE
	Most Commonly Used Elastomers								Special Elastomers			
	(Maximum Temperature 100°F (38°C) Unless Otherwise Specified											
Ammonium Phosphate, monobasic	A	A	A	A	A	A	A	A		A	T	A
dibasic	A	A	A	A	A	A	A	A		T	T	A
tribasic	A	A	A	A	A	A	A	A		T	T	A
Ammonium Sulfate	A	A	A	A	A	A	A	A	T	A	T	A
Amyl Acetate	F	X	X	X	F	X	A	A	X	C	X	A
Amyl Alcohol	A	A	A	A	A	A	A	A	A	A	A	A
Aniline, Aniline Oil	X	X	C	X	A	X	C	C	A	C	X	A
Aniline Dyes	F	F	F	F	A	F	C	C			T	T
Asphalt	X	X	F	F	X	F	X		A		A	X
Barium Chloride 150°C (65°C)	A	A	A	A	A	A	A	A		A	A	A
Barium Hydroxide 150°C (65°C)	A	A	A	A	A	A	A	A	T	A	A	A
Barium Sulfide 150°C (65°C)	A	A	A	A	A	A	A	A		T	A	A
Beer	A	A	A	A	A	A	A	A		T	A	A
Beet Sugar Liquors	A	A	A	A	A	A	A	A		T	T	A
Benzene, Benzol	X	X	X	C	X	X	X	C	A	C	X	A
Benzine, petroleum ether and Benzine, petroleum naphtha	X	X	C	F	X	F	X	C			T	A
Black Sulfate Liquor	A	A	A	A	A	A	A	A		T	T	A
Blast Furnace Gas	C	C	A	C	C	C	C	C		T	T	A
Borax	A	A	A	A	A	A	A	A	T	T	T	A
Boric Acid	A	A	A	A	A	A	A	A		T	A	A
Bromine	X	X	X	X	X	C	X	F	A	C		F
Butane	X	X	F	A	X	A	X	A	T	A	A	A
Butyl Acetate	C	X	X	X	F	X	F	A	X	F	X	A
Butyl alcohol, butanol	A	A	A	A	A	A	A	A	A	F	T	A
Calcium bisulfate	C	C	A	A	F	A	F	C	T	A	T	A
Calcium chloride	A	A	A	A	A	A	A	A	T	A	A	A
Calcium hydroxide	A	A	A	A	A	A	A	A	T	A	A	A
Calcium hypochlorite	X	X	X	X	A	F	A	C	T	A	F	F
Caliche liquors	A	A	A	A	A	A	A				T	A
Cane sugar liquors	A	A	A	A	A	A	A	A		A	A	A
Carbolic acid, phenol	C	C	C	C	C	C	A	A		A		A
Carbon dioxide, dry/wet	A	A	A	A	A	A	A	A		A	A	A
Carbon disulfide	X	X	X	X	X	X	X	C	A	C		C
Carbon monoxide 150°C (65°C)	C	C	C	C	C	F	C	A	T	T		A
Carbon tetrachloride	X	X	X	C	X	X	X	C	A	C	F	A
Castor oil	A	A	A	A	A	A	A	A	T	A	A	A
Cellosolve acetate	F	F	X	X	A		A	C	C			A
China wood oil, tung oil	X	X	F	A	A	F	A	A	C		T	A
Chlorine, dry/wet	X	X	X	X	X	X	X	X	A	X	X	F
Chlorinated solvents	X	X	X	X	X	X	X	C		C		A
Chloroacetic acid	X	C	C	C	X	A	T	C	X			A
Chlorosulfonic acid	X	X	C	C	X	X	X	C	X			F
Chromic acid	X	X	X	X	C	A	T	C	T	A		F
Citric acid	A	A	A	F	A	A	A	A	T	A	A	A
Coke oven gas	C	C	C	C	C	A		A	X	A	X	C
Copper chloride 150°F (65°C)	C	A	F	A	A	F	A	A	T	A	T	A
Copper sulfate 150°F (65°C)	C	A	A	A	F	A	A	A	T	A	A	A
Corn oil	X	C	F	A	A	F	C	A		A	A	A
Cottonseed oil	X	C	F	A	A	F	C	A	A	A	T	A
Creosote, coal tar	X	X	F	A	X	F	X	C	F		X	A
wood	X	X	F	A	X		X	C	F			A
Creosols, cresylic acid	C	X	X	C	C	F	X	C		F		A
Ethers	C	C	C	C	C	F	X	C	X	A		A
Ethyl acetate	F	X	X	X	F	X	F	F	X	F	X	A
Ethyl alcohol	A	A	A	A	A	A	A	A	A	A	A	A
Ethyl cellulose	F	F	F	F	F		F	C		F		A
Ethyl chloride	A	F	F	X	A	F	A	C	F	F	F	F
Ethylene gylcol	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	T	A	A	A

Most Commonly Used Elastomers — **Special Elastomers**

(Maximum Temperature 100°F (38°C) Unless Otherwise Specified

Material		NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	FMQ	FPM	CM	ECO CO	XLPE
Ferric sulfate	150°F (65°C)	A	A	A	A	A	A	A	A		A	A	A
Formaldehyde		A	A	C	A	A	A	A	A	A	A	F	A
Formic acid		A	A	C	F	A	A	A	A	X	A	F	F
Freon #12 (Liquid)		X	X	A	F	F		F	X	A		A	T
Fuel oil		X	X	F	A	X	F	X	C	T	F	A	A
Furfural		X	C	C	X	A	F	C	C	X	A	X	A
Gasoline, Non Leaded		X	X	X	A	X	X	X		A	C	A	F
Gasoline, Reg. Leaded		X	X	X	A	X	X	X	C	A	C	A	F
Hi Test-Leaded		X	X	X	A	X	X	X	C	A	C	A	F
Gelatin		A	A	A	A	A	A	A	A			A	A
Glucose		A	A	A	A	A	A	A	A			A	A
Glue		F	F	A	A	F	A	A	A	T		A	A
Glycerine, glycerol		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
Hydraulic fluids													
Petroleum		X	X	A	A	X	F	X			A	A	
Phosphate ester alkyl		X	X	C	X	A	X	A			A	X	
Phosphate ester aryl		X	X	X	X	C	X	C			C	X	
Phosphate ester blends		X	X	X	X	X	X	C			C	X	
Silicate ester		X	X	C	C	X	C	X			C	C	
Water-Glycol		A	A	A	A	A	A	A			A	A	
Hydrobromic acid		C	X	C	C	A	A	A	C		A		T
Hydrochloric acid		A	X	X	X	C	C	C	C	A	A	X	A
Hydrocyanic acid		F	F	C	F	C	A	C	A	T			A
Hydrofluoric acid		X	X	X	X	C	A	C	X	A	A		A
Hydrofluosilicic acid		A	F	F	F	A		A	A		A		T
Hydrogen gas		F	F	A	A	A		A	A	T		A	A
Hydrogen peroxide		X	X	C	C	C	C	C	A	A	A		T
Hydrogen sulfide, dry		C	C	F	C	A	A	A	C	T			A
wet		C	C	F	C	A	A	A	C			F	A
Kerosene		X	X	F	A	X	C	X	C	A	A	A	A
Lacquers		X	X	X	X	C	X	X				X	F
Lacquers solvents		X	X	X	X	C	X	X		X		X	F
Lactic acid		C	C	C	C	C	A	C	A	T			A
Linseed oil		C	X	F	A	A	A	A	A	A	A	A	A
Lubricating oil, crude		X	X	F	A	X	C	X	C	A		A	A
refined		X	X	F	A	X	C	X	C		A	A	A
Magnesium chloride	150°F (65°C)	A	A	A	A	A	A	A	A	T	A	A	A
Magnesium hydroxide	150°F (65°C)	A	F	F	F	A	A	A	F	T	A	A	A
Magnesium sulfate	150°F (65°C)	A	A	A	A	A	A	A	A		A	A	A
Mercuric chloride		F	F	C	F	A	A	A	A	T		A	A
Mercury		A	A	A	A	A	A	A	A	T		A	A
Methyl alcohol, methanol		A	A	A	A	A	A	A	A	C	A	F	A
Methyl chloride		C	C	C	C	C	X	C	X				F
Methyl ethyl ketone		X	X	X	X	F	C	A	C	X	C	X	A
Methyl isopropyl ketone		X	X	X	X	F	C	C	C	X	F	X	A
Milk		C	C	F	F	A	A	A	A		A	A	A
Mineral oils		X	C	F	A	X	F	X	A	T	A	A	A
Natural gas		C	C	A	A	C	A	X	C		A	A	A
Nickel chloride	150°F (65°C)	A	A	A	A	A	A	A	A		A	T	A
Nickel sulfate	150°F (65°C)	A	A	A	A	A	A	A	A		A	T	A
Nitric acid, crude		X	X	X	X	C	C	X	X		A	X	F
Diluted 10%		X	X	C	X	C	A	C	C	C	A	X	T
Concentrated 70%		X	X	X	X	C	C	X	X	C	X	X	F
Nitrobenzene		X	X	X	X	X	X	X	C	F	C	X	A
Oleic acid		X	F	C	F	F	F	F	A	T	A		A
Oleum spirits		X	C	C	C			T		C			T
Oxalic acid		F	C	F	F	A	A	A	A		A	F	A
Oxygen		F	C	A	C	A		A	A		A	F	A
Palmitic acid		X	F	A	A	F	F	F	C	T	A	F	A

Material	NR or IR	SBR	CR	NBR	IIR	CSM	EPDM	FMQ	FPM	CM	ECO CO	XLPE
	Most Commonly Used Elastomers								Special Elastomers			
	(Maximum Temperature 100°F (38°C) Unless Otherwise Specified											
Perchlorethylene	X	X	X	C	X	X	X	C	A	C	F	A
Petroleum oils and crude 200°F (95°C)	X	X	F	A	X	C	X	C		C	A	A
Phosphoric acid, crude	A	C	C	C	C	A	C	C		A		A
pure 45%	A	C	C	C	C	A	C	C	A	A		A
Picric acid, molten	C	C	C	C	C		T					T
water solution	A	C	F	F	A	A	T	A	T			T
Potassium chloride	A	A	A	A	A	A	A	A		A	A	A
Potassium cyanide	A	A	A	A	A	A	A	A		A	A	A
Potassium hydroxide	F	F	C	C	A	A	A	A	T	A	A	A
Potassium sulfate	A	A	A	A	A	A	A	A		A	A	A
Propane	X	X	F	A	X	F	X	A		A	A	A
Sewage	C	C	F	A	C	A	C	C			T	A
Soap solutions	A	A	F	A	A	A	A	A	T	A	A	A
Soda ash, sodium carbonate	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
Sodium bisulfate	A	A	A	A	A	A	A	A		A	A	A
Sodium chloride	A	A	A	A	A	A	A	A		A	A	A
Sodium cyanide	A	A	A	A	A	A	A	A		A	A	A
Sodium hydroxide	F	F	C	C	A	C	A	A	A	A	F	A
Sodium hypochlorite	X	X	X	X	A	F	A	C	T	A	F	F
Sodium metaphosphate	A	A	C	A	A	F	A	A		A	T	A
Sodium nitrate	C	C	C	C	A	A	A	C		A	A	A
Sodium perborate	C	C	C	C	A	A	A	A				A
Sodium peroxide	C	C	C	C	A	A	A	C	T			A
Sodium phosphate, monobasic	A	F	C	F	A	A	A	A		A		A
dibasic	A	F	C	F	A	A	A	A				A
tribasic	A	F	C	F	A	A	A	A				A
Sodium silicate	A	A	A	A	A	A	A	A		A	T	A
Sodium sulfate	A	A	A	A	A	A	A	A		A	A	A
Sodium sulfide	A	A	A	A	A	A	A	A		A	T	A
Sodium thiosulfate, "hypo"	A	A	A	A	A	A	A	A		A	T	A
Soybean oil	X	C	F	A	A	A	A	A	A	A	A	A
Stannic chloride	A	A	A	A	F	A	F	A	T	A	T	A
Steam 450°F (230°C)	C	C	C	C	C	C	F	C			X	X
Stearic acid	X	X	C	F	F	C	F	A	T		F	A
Sulfur	F	F	A	F	A	A	A	F			F	C
Sulfur chloride	X	X	C	C	X	A	X	C				A
Sulfur dioxide, dry	C	C	C	C	C	A	C	A	T		T	T
Sulfur trioxide, dry	X	C	C	C	C	F	C	A	T			T
Sulfuric acid, 10%	A	A	A	A	A	A	A	A	A	A	A	A
11%-75%	C	C	C	C	F	A	C	C	T	A	F	A
76%-95%	X	X	X	X	C	A	X	X	A	X	X	A
fuming	X	X	X	X	X	X	X	X	A	X	X	X
Sulfurous acid	C	C	C	C	C	A	C	C	T	A	C	A
Tannic acid	A	C	A	C	A	A	A	A	T	A	T	A
Tar	X	X	C	C	X	C	X	C			F	X
Tartaric acid	A	C	C	C	F	A	F	A	T	A	F	A
Toluene, toluol	X	X	X	C	X	X	X	C	A	C	X	A
Trichloroethylene	X	X	X	X	X	X	X	C	A	C	X	A
Turpentine	X	X	X	F	X	X	X	C	A	F	A	A
Vinegar	C	C	C	C	A	A	A	A		A		A
Water, acid mine	A	A	C	A	A	A	A	A	A	A	T	A
Water, fresh	A	A	C	A	A	A	A	A		A	A	A
distilled	A	A	C	A	A	A	A	A		A	A	A
Whiskey and wines	A	A	A	C	A	A	A	A		A	T	A
Xylene, xylol	X	X	X	C	X	X	X	C	A	X	X	A
Zinc chloride	C	C	C	C	A	A	A	A	T	A	T	A
Zinc sulfate	A	A	A	A	A	A	A	A		A	T	A

OIL AND GASOLINE RESISTANCE

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 hydro-carbons 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 ASTM No. 3 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 compound classes and a corresponding description are here listed.

Physical Properties After Exposure to Oil

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

* * *

Chapter 9 CARE, MAINTENANCE, AND STORAGE

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 follow properly 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 hose should a failure occur. Such a failure might result in possible damage to property and serious bodily injury.

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 a restrained by placing steel rods or straps close to each end and at approximate 10 foot (3m) 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.

*Woven jacketed fire hose should be tested in accordance with the service test provisions of National Fire Protection Association Bulletin No. 1962 (formerly 198) on Care, Maintenance and Use of Fire Hose. Actual service test pressure for fire hose is based on the trade size of hose, whether single or multiple jacketed, and the new hose rated acceptance test pressure.

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

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

The Rubber Manufacturers Association has published separately a series of Hose Techical Information bulletins describing hoses designed for different applications which detail Maintenance, Testing and Inspection recommendations. Reference should be made to the RMA Catalog of Publications, issued annually, to determine the availability of the latest edition. Bulletins published as of January 1979 include the following:

Publication No.

IP 11—1 — Steam Hose
IP 11—2 — Anhydrous Ammonia Hose
IP 11—3 — Liquefied Petroleum Gas Hose
IP 11—4 — Oil Suction and Discharge Hose
IP 11—5 — Welding Hose
IP 11—6 — Fire 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. 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.

Chapter 10 GLOSSARY OF TERMS USED BY THE HOSE INDUSTRY

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.

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.

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 or 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.

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 soft rubber layer between a hose tube and/or cover and carcass to provide adhesion.

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.

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.

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 piles of braid having no separating rubber layers.

brand: a mark or symbol indentifying 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.

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

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

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.

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 processing equipment without milling.

cold flex: see low temperature flexing.

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 device attached to the end of hose to facilitate connection to a suitable fitting and insure a passageway. A female coupling carries the internal thread. A male coupling carries the external thread.

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.

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 spiralled hose.

cross wrap: the overlapping layer or layers of narrow tensioned wrapper fabric spiralled 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.

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

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: an arbitrary numerical value which measures the resistance to indentation of the blunt indentor point of the durometer. Value may be taken immediately or after a short specified time.

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: a macromolecular material which, in the vulcanized state at room temperature, can be stretched repeatedly to at least twice its original length and which, upon release of the stress, will immediately return to approximately its original length.

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

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.

ferrule: a metallic collar placed over the hose end to anchor the coupling to the hose. The ferrule may be crimped, forcing the hose in against the shank of the coupling, or the shank may be expanded, forcing the hose out against the ferrule, or both.

filament: textile fiber or 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 or yarns running at right angle to the warp.

flange: 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 mandrel 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.

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.

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 calender 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 (calender 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 uni-directional orientation of rubber or filler particles resulting in antisotropy 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 slubbing, roving, or yarn. The length is specified by the yarn numbering system in use, e.g., cotton hanks have a length of 840 yards; (3) a term applied to slubbing or roving which indicates the yarn number (count), e.g., a 1.5 hank roving.

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 spiralling a wire or other reinforcement around the cylindrical body of a hose.

herringbone wrap: a narrow herringbone woven tape spiralled 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.

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 mildewing.

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 a product, induced by winding or doubling upon itself.

knitted 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.

knitted 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 or lead press hose caused by particles of lead flakes sloughing off the lead press 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 press hose caused by deformations in lead covering before vulcanization.

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

lead discoloration: a dark stain on the colored cover of lead press 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 press 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 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.

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 for 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 reabsorption 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.

N

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.

nip: the clearance between rolls of a mixing mill or calender

nipple: a cylindrical pipelike attachment one end of which is securely inserted and retained in the end of a hose, serving the same purpose as a hose coupling.

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.

overcure: a state of cure greater than the optimum.

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 test: see service test.

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

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 of 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 a 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.

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.

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

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.

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 it rests.

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

RMA: the abbreviation of The Rubber Manufacturers Association, Inc.

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

rubber: a material that is capable of recovering from large deformations quickly and forcibly and can be, or already is, modified to a state in which it is essentially insoluble (but can swell) in a boiling solvent such as benzene, methyl ethyl ketone, and ethanoltoluene azeotrope. A rubber in its modified state, free of diluents, retracts within one minute to less than 1.5 times its original length after being stretched at room temperature (18 to 29°C) to twice its length, and held for one minute before release.

rubber cement: see cement.

S

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

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.

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 coupling 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 measured 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.

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 weave. Normally laid on a frictioned 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 on an angle to the surface of a sheet of rubber to produce a tapered or feathered 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.

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 meterial 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.

staple: (1) textile fiber of relatively short length when spun and twisted forms of 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 press 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.

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 may be woven, as a woven cloth or yarn; (2) a fibrous material suitable for being spun and woven into cloth or yarn.

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 bi-lateral, 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, per unit of length, of a fiber, roving yarn, cord, etc. Twist is usually expressed as turns per inch; (2) the turn about the axis of a hose subjected to internal pressure.

U

ultimate strength: see tensile strength.

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

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 spiralled 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: see 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

GENERAL

This chapter covers tables of useful information as it particularly 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 Industrial Products Division, are based on average conditions and are not to be used as a minimum-maximum but merely as a guide.

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 always 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.

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

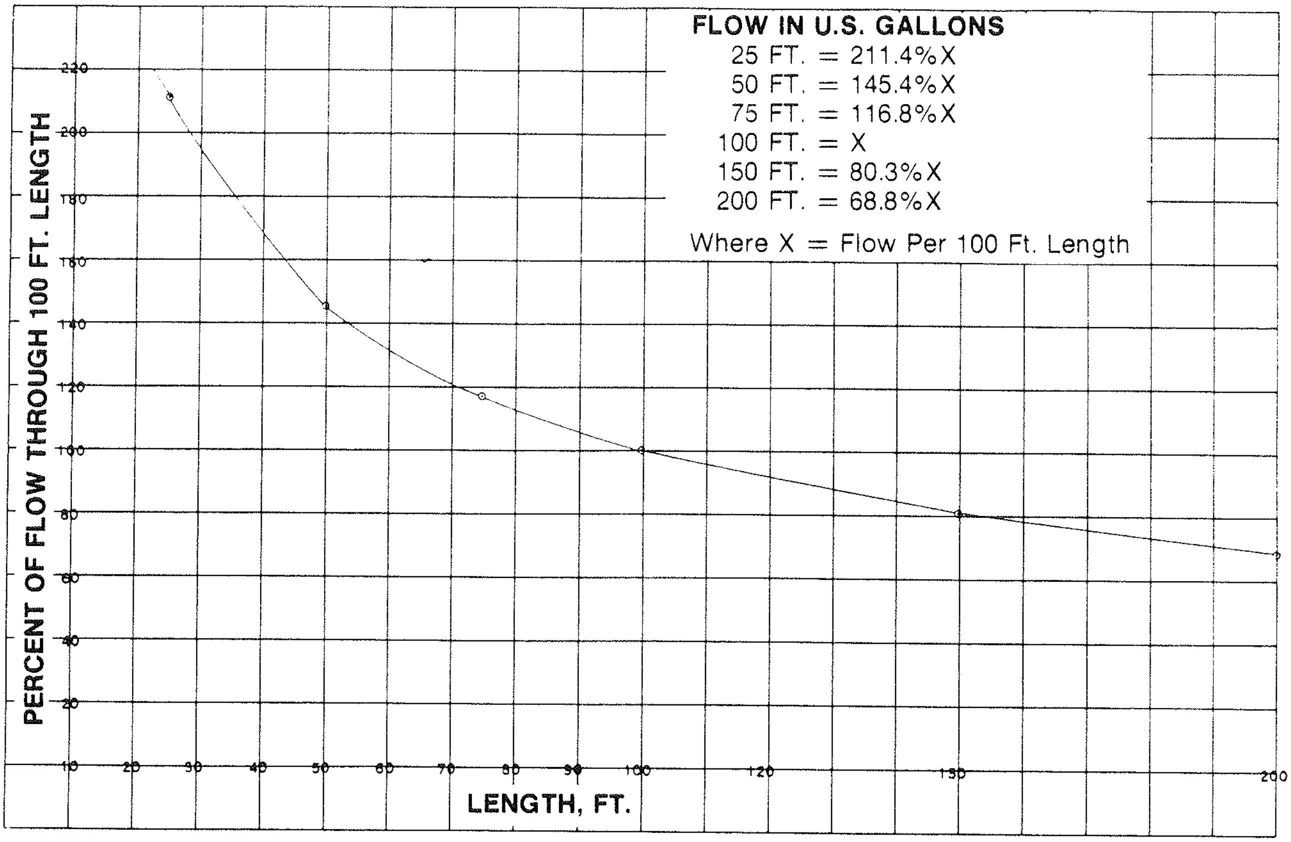


TABLE 11-3
FRICTION LOSS IN WATER HOSE
POUNDS PER SQUARE INCH PER 100 FOOT LENGTH
STRAIGHT-SMOOTH BORE

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 0.006895

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 6.309×10^{-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.

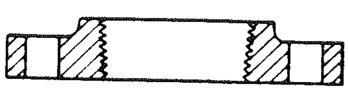
$$\Delta P = 4.51 \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{d^{4.87}} \quad \text{or} \quad \Delta P_{100} = \frac{(0.0483Q)^{1.85}}{d^{4.87}} \quad @\ 60^\circ F\ (15.6^\circ C)$$

where: ΔP = 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

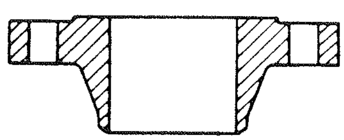
TABLE 11-4
FRICTION LOSS OF PRESSURE IN AIR HOSE (PULSATING PRESSURE FLOW)

I.D. of Hose	Gauge Pressure	CUBIC FEET AIR PER MINUTE THROUGH 100 FT. HOSE LINES 40	50	60	70	80	90	100	110	120	130	140	150
		LOSS OF PRESSURE IN LBS. PER SQ. INCH											
1/2″ Hose (Coupled)	50	20.2	36.2										
	60	16.8	29.6	46.8									
	70	14.0	24.8	40.0	56.8								
	80	12.0	21.6	34.8	50.4	69.2							
	90	10.8	19.0	29.6	44.0	61.0	82.0						
	100	9.6	16.8	26.6	38.6	54.4	73.3						
	110	8.6	15.2	24.0	35.2	49.2	66.6	89.0					
3/4″ Hose (Coupled)	50	3.0	4.8	7.0	8.8	13.0	17.0	22.8	28.4				
	60	2.4	3.8	5.6	7.6	10.4	13.6	17.2	22.4	28.2			
	70	1.8	3.0	4.6	6.4	8.4	11.0	14.0	17.6	22.0			
	80	1.6	2.6	3.8	5.6	7.2	9.4	11.6	14.4	17.6	21.2		
	90	1.4	2.2	3.2	4.6	6.2	8.0	10.0	12.4	15.0	18.0	21.6	
	100	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	1.0	1.8	2.6	3.6	4.8	6.2	7.8	9.8	11.8	14.2	16.8	19.8
1″ Hose (Coupled)	50	0.6	1.0	1.6	2.2	3.0	4.0	5.2	7.0	9.6	14.0		
	60	0.6	0.8	1.2	1.6	2.4	3.0	4.0	5.2	6.6	8.2	11.0	14.4
	70	0.4	0.8	1.0	1.4	2.0	2.6	3.2	4.0	5.0	6.2	7.6	9.4
	80	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	0.4	0.6	0.8	1.2	1.4	1.8	2.4	2.8	3.4	4.0	4.8	5.6
	100	0.4	0.4	0.8	1.0	1.2	1.6	2.0	2.4	3.0	3.6	4.2	4.8
	110	0.4	0.4	0.6	0.8	1.2	1.4	1.8	2.2	2.6	3.0	3.6	4.2
1 1/4″ Hose (Coupled)	50		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			0.4	0.4	0.6	0.8	0.8	1.2	1.4	1.6	2.0	2.6
	80			0.2	0.4	0.4	0.6	0.8	1.0	1.2	1.4	1.6	2.0
	90				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
1 1/2″ Hose (Coupled)	50					0.4	0.4	0.4	0.6	0.8	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	0.6	0.6	0.6	0.8
	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									0.4	0.4	0.4	0.4
	110									0.4	0.4	0.4	0.4

RAISED FACE AND FLAT FACE FLANGES



FLAT FACE



RAISED FACE

125 LB. FLANGES ARE FLAT FACE
150 LB. AND 300 LB. STEEL FLANGES FURNISHED WITH 1/16″ RAISED FACE U.O.S.
250 LB. CAST IRON FLANGES FURNISHED WITH 1/16″ RAISED FACE U.O.S.
FLANGE THICKNESS INCLUDES RAISED FACE

TABLE 11-5
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	11.00	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.

TABLE 11-6
PIPE FLANGE DIMENSIONS
250 LB. U.S.A. STANDARD CAST IRON USA ANSI B16.2
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	7/8	58
10	17.50	1.875	15.250	16	1	76
12	20.50	2.000	17.750	16	1 1/8	115
14	23.00	2.125	20.250	20	1 1/8	163
16	25.50	2.250	22.500	20	1 1/4	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 11-7
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 36.1

Wrought Steel and Wrought Iron Pipe — ANSI D 36.10

Standard Pipe Dimensions shown are the same as Schedule 40 pipe through 10 inch. Above this 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 1/2″

Wrought Iron Pipe has slightly greater wall thickness (0.001 to 0.020) resulting in correspondingly smaller internal diameter than tabulated above.

TABLE 11-8
TEMPERATURE-PRESSURE EQUIVALENTS OF SATURATED STEAM GAUGE PRESSURE AT SEA LEVEL

Temperature °F	Temperature °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	131.1	25.8	0.178
269	131.7	26.5	0.183
270	132.2	27.2	0.187

Temperature °F	Temperature °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 11-8 (Continued)
TEMPERATURE-PRESSURE EQUIVALENTS OF SATURATED STEAM
GAUGE PRESSURE AT SEA LEVEL

Temperature °F	°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	°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
Degree Celsius = 5/9 (Degrees F -32)

TABLE 11-9
LINEAL MEASUREMENT UNITS
DECIMAL AND MILLIMETER EQUIVALENTS OF FRACTIONAL INCHES

Fractional Inch				Decimal Part of an Inch	Millimeters
1/64	1/32	1/16	1/8		
1				0.016	0.40
2	1			0.031	0.79
3				0.047	1.19
4	2	1		0.063	1.59
5				0.078	1.98
6	3			0.094	2.38
7				0.109	2.78
8	4	2	1	0.125	3.18
9				0.141	3.57
10	5			0.156	4.0
11				0.172	4.4
12	6	3		0.188	4.8
13				0.203	5.2
14	7			0.219	5.6
15				0.234	6.0
16	8	4	2	0.250	6.4
17				0.266	6.7
18	9			0.281	7.1
19				0.297	7.5
20	10	5		0.313	7.9
21				0.328	8.3
22	11			0.344	8.7
23				0.359	9.1
24	12	6	3	0.375	9.5
25				0.391	9.9
26	13			0.406	10.3
27				0.422	10.7
28	14	7		0.438	11.1
29				0.453	11.5
30	15			0.469	11.9
31				0.484	12.3
32	16	8	4	0.500	12.7
33				0.516	13.1
34	17			0.531	13.5
35				0.547	13.9
36	18	9		0.563	14.3
37				0.578	14.7
38	19			0.594	15.1
39				0.609	15.5
40	20	10	5	0.625	15.9
41				0.641	16.3
42	21			0.656	16.7
43				0.672	17.1
44	22	11		0.688	17.5
45				0.703	17.9
46	23			0.719	18.3
47				0.734	18.7
48	24	12	6	0.750	19.1
49				0.766	19.5
50	25			0.781	19.8
51				0.797	20.2
52	26	13		0.813	20.6
53				0.828	21.0
54	27			0.844	21.4
55				0.859	21.8
56	28	14	7	0.875	22.2
57				0.891	22.6
58	29			0.906	23.0
59				0.922	23.4
60	30	15		0.938	23.8
61				0.953	24.2
62	31			0.969	24.6
63				0.984	25.0
64	32	16	8	1.000	25.4

1 inch = 25.40 Millimeters

1 Millimeter = 0.03937 Inches

TABLE 11-10
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 11-11
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	0.15240
7			2.1336	1000	—	304.80	0.30480
8			2.4384	3280.84	0.6214	1000.00	1.00000
9			2.7432	5280	1.000	1609.35	1.60935
10			3.0480				

1 Foot = 304.80 Millimeters
1 Mile = 1609.35 Meters
1 Meter = 3.28084 Feet
1 Kilometer = 0.62137 Miles

TABLE 11-12
SQUARE CENTIMETER EQUIVALENTS OF SQUARE INCHES
CENTIMETERS² TO INCHES²

1 cm² = 0.155 in²

cm²	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

INCHES² TO CENTIMETERS²

1 in.² = 6.4516 cm²

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	193.549	200.000	206.451	212.903	219.354	225.806	232.258	238.710	245.161	251.613
40	258.064	264.516	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.125
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 11-13
VOLUME UNITS
CUBIC CENTIMETER EQUIVALENTS OF CUBIC INCHES
CENTIMETERS^3 TO INCHES^3

1 cm^3 = 0.0610238 in.^{3}

cm^3	Units									
	0	1	2	3	4	5	6	7	8	9
0	—	0.06102	0.12205	0.18307	0.24409	0.30512	0.36614	0.42716	0.48819	0.54921
10	0.61023	0.67126	0.73228	0.79330	0.85433	0.91535	0.97637	1.03740	1.09842	1.15944
20	1.22047	1.28149	1.34251	1.40354	1.46456	1.52559	1.58661	1.64763	1.70866	1.76968
30	1.83070	1.89173	1.95275	2.01377	2.07480	2.13582	2.19684	2.25787	2.31889	2.37991
40	2.44094	2.50196	2.56298	2.62401	2.68503	2.74605	2.80708	2.86810	2.92912	2.99015
50	3.05117	3.11219	3.17322	3.23424	3.29526	3.35629	3.41731	3.47833	3.53936	3.60028
60	3.66140	3.72243	3.78345	3.84447	3.90550	3.96652	4.02754	4.08857	4.14959	4.21061
70	4.27164	4.33266	4.39368	4.45471	4.51573	4.57675	4.63778	4.69880	4.75983	4.82085
80	4.88187	4.94290	5.00392	5.06494	5.12597	5.18699	5.24801	5.30904	5.37006	5.43108
90	5.49211	5.55313	5.61415	5.67518	5.73620	5.79722	5.85825	5.91927	5.98029	6.04132

INCHES^3 TO CENTIMETERS^3

1 in.^{3} = 16.38706 cm^3

in.^{3}	Units									
	0	1	2	3	4	5	6	7	8	9
0	—	16.39	32.77	49.16	65.55	81.94	98.32	114.71	131.10	147.48
10	163.87	180.26	196.65	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	426.07	442.45	458.84	475.22
30	491.61	508.00	524.39	540.77	557.16	573.55	589.94	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	917.69	934.06	950.45	966.84
60	983.22	999.67	1016.00	1032.38	1048.77	1066.18	1081.55	1097.93	1114.32	1130.77
70	1147.09	1163.48	1179.87	1196.26	1212.64	1229.03	1245.42	1261.80	1278.19	1294.58
80	1310.98	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	1540.39	1556.77	1573.16	1589.54	1605.73	1622.32

TABLE 11-14
LITERS TO U.S. GALLONS

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	3.9628	4.2268	4.4909	4.7551	5.0192
20	5.2834	5.5476	5.8118	6.0760	6.3401	6.6043	6.8685	7.1326	7.3968	7.6610
30	7.9259	8.1893	8.4535	8.7177	8.9818	9.2450	9.5102	9.774	10.0385	10.3027
40	10.5660	10.8311	11.0951	11.3594	11.6235	11.8877	12.1514	12.416	12.6803	12.9444
50	12.2086	13.4728	13.7369	14.0011	14.2653	14.5295	14.7936	15.0578	15.3220	15.5862
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	19.8125	20.0771	20.3412	20.6055	20.8896
80	21.1338	21.3979	21.6621	21.9261	22.1905	22.4546	22.7188	22.9830	23.2471	23.5110
90	23.7755	24.0397	24.3038	24.5680	24.8322	25.0963	25.3605	25.6247	25.8889	26.1530

U.S. GALLONS TO LITERS

U.S. Gals.	0	1	2	3	4	5	6	7	8	9
0	—	3.7854	7.5708	11.3562	15.1416	18.9270	22.7125	26.4979	30.2833	34.0687
10	37.8541	41.6395	45.4249	49.2104	52.9958	56.7811	60.5666	64.3510	68.1374	71.9228
20	75.7082	79.4937	83.2791	87.0645	90.8499	94.6359	98.4207	102.2061	105.9915	109.7769
30	113.5624	117.3478	121.1332	124.9186	128.7040	132.4894	136.2748	140.0502	143.8457	147.6310
40	151.4165	155.2019	158.9873	162.7727	166.5581	170.3435	174.1210	177.9144	181.6998	185.4852
50	189.2706	193.0560	196.8414	200.6267	204.4122	208.1917	211.9831	215.7635	219.5534	223.3303
60	227.1247	230.9101	234.6955	238.4810	242.2664	246.0518	249.8372	253.6226	257-4080	261.1934
70	264.9788	268.7698	272.5497	276.3351	280.1205	283.9059	287.6913	291.4767	295.2621	299.0475
80	302.8330	306.6184	310.4038	314.1892	217.9746	321.7508	325.5454	329.3308	333.1163	336.9017
90	340.6871	344.4725	348.2579	352.0433	355.8287	359.6141	363.3996	367.1850	370.9704	374-7558

TABLE 11-15
VELOCITY UNITS
METER PER 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	4.064
		900	4.572

TABLE 11-16
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	111.21
2	907.18	0.9072	8.8964	50		22.68	222.41
3	1360.78	1.3608	13.3457	100		45.36	444.82
4	1814.37	1.8144	17.7929	500		226.80	2224.11
5	2267.95	2.2680	22.2411	1000		453.59	4448.22
6	2721.55	2.7215	26.6995	2000	1.0000 (Short)	907.10	8896.44
7	3175.15	3.1751	31.1376	2204.6	1.0000 (Metric)	1000.00	9806.65
8	3628.74	3.6287	35.5879	2240	1.0000 (Long)	1016.05	9964.02
9	4082.39	4.0823	40.0300				
10	4535.92	4.5359	44.4822				

1 kilogram (kg) = 2.2046 pounds (lbs)
1 kilogram force (kgf) = 9.8066 newtons (N)
1 pound (lb) = 0.4536 kilograms (kg)
1 pound-force (lb-f) = 4.4482 newtons (N)

TABLE 11-17
PRESSURE UNITS
MEGAPASCALS (MPa)
EQUIVALENTS OF POUNDS/SQ. IN.

Lbs./Sq. In.	MPa	Lbs./Sq. In.	MPa
1	0.007	200	1.4
5	0.034	500	3.4
10	0.069	1000	6.9
14.696	0.101	2000	13.8
(1 atmosphere)		3000	20.7
		5000	34.5
25	0.17		
50	0.34		
100	0.69		

1 MPa = 145.04 lbs./in.^{2}

TABLE 11-18
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/meter (kN/m)
1 pound-force/inch (lb-f/in) = 4.448 newtons/25.4 millimeters (N/25.4 mm)

TABLE 11-19
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	1.86532	3/16	7.9769	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	1/2	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	7/16	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	5/8	106.14	36.5210	5/8	243.98	55.3706	5/8	438.36	74.2201
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	74.6128
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	1/16	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	76.5783
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	47.173	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	24.5428	3/8	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	43.5896	7/8	310.24	62.4392	7/8	525.84	81.2887

One Square Inch = 645.16 Square Millimeters

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