Chapter 6
Rubber and Elastomer Piping Systems

6-1. General

The diverse nature of the chemical and physical characteristics of rubber and elastomeric materials makes these material suited for many chemical handling and waste treatment applications. The most common elastomeric piping systems are comprised of hoses. These hoses are constructed of three components: the tube, the reinforcement, and the cover. The tube is most commonly an elastomer and must be suitable for the chemical, temperature, and pressure conditions that a particular application involves. Table 6-1 lists several elastomers used in piping systems and the chemical identifications of the polymers. Physical and chemical characteristics of elastomers used in hose manufacturing are specified in ASTM D 2000. Hose reinforcement is designed to provide protection from internal forces, external forces, or both. Reinforcement usually consists of a layer of textile, plastic, metal, or a combination of these materials. Hose covers are designed to provide hoses with protection from negative impacts resulting from the environment in which the hose is used. Covers are also typically composed of textile, plastic, metal, or a combination of these materials.

6-2. Design Factors

In selecting and sizing a rubber or elastomeric piping system, four factors must be considered: service conditions, (pressure and temperature); operating conditions (indoor/outdoor use, vibration resistance, intermittent of continuous service, etc.); end connections; and environment requirements (flame resistance, material conductivity, labeling requirements, etc.).

a. Service Conditions

For applications requiring pressure or vacuum service reinforcement can improve the mechanical properties of the hose. The maximum recommended operating pressure in industrial applications utilizing Society of Automotive Engineers (SAE) standards hose designations is approximately 25% of the rated bursting pressure of the specific hose. Table 6-2 lists common SAE hose standards.

In determining the maximum operating conditions, special consideration must be given to the operating temperatures. Rubber and elastomer materials are temperature sensitive, and both the mechanical qualities and chemical resistance properties of the materials are effected by temperature. Appendix B provides information regarding the effects of temperature on chemical resistance, and Table 6-1 provides information

Table 6-1
Common Materials Used in Rubber/Elastomer Piping Systems

Elastomer	ASTM D 1418 Class	Common or Trade Name	Minimum Service Temperature - Continuous Operations	Maximum Service Temperature - Continuous Operations
Fluoroelastomer	FKM	FKM, Viton, Fluorel	-23°C (-10°F)	260°C (500°F)
Isobutylene Isoprene	IIR	Butyl	-46°C (-50°F)	148°C (300°F)
Acrylonitrile Butadiene	NBR	Buna-N, Nitrile	-51°C (-60°F)	148°C (300°F)
Polychloroprene	CR	Neoprene	-40°C (-40°F)	115°C (240°F)
Natural Rubber or Styrene Butadiene	NR or SBR	Gum Rubber; Buna-S	-51°C (-60°F)	82°C (180°F)

Source: Compiled by SAIC, 1998.

Table 6-2
Rubber and Elastomer Hose Standards

SAE Designation	Tube	Reinforcement	Cover
100R1A		one-wire-braid	synthetic-rubber
100RIT		one-wire-braid	thin, nonskive
100R2A		two-wire-braid	synthetic rubber
100R2B		two spiral wire plus one wire-braid	synthetic rubber
100R2AT		two-wire-braid	thin, nonskive
100R2BT		two spiral wire plus one wire-braid	thin, nonskive
100R3		two rayon-braided	synthetic rubber
100R5		one textile braid plus one wire-braid	textile braid
100R7	thermoplastic	synthetic-fiber	thermoplastic
100R8	thermoplastic	synthetic-fiber	thermoplastic
100R9		four-ply, light-spiral-wire	synthetic-rubber
100R9T		four-ply, light-spiral-wire	thin, nonskive

Source: Compiled by SAIC, 1998.

on the temperature limitations of the mechanical properties of rubber and elastomeric materials. As the operating temperature increases, the use of jacketed or reinforced hose should be considered to accommodate lower pressure ratings of the elastomeric materials.

Like plastic piping systems, rubber and elastomer systems do not display corrosion rates, as corrosion is totally dependent on the material's resistance to environmental factors rather than on the formation of an oxide layer. The corrosion of rubbers and elastomers is indicated by material softening, discoloring, charring, embrittlement, stress cracking (also referred to as crazing), blistering, swelling, and dissolving. Corrosion of rubber and elastomers occurs through one or more of the following mechanisms: absorption, solvation, chemical reactions, thermal degradation, and environmental stress cracking.

General compatibility information for common elastomer is listed in Table 6-3. Information regarding the compatibility of various elastomers with specific chemicals can be found in Appendix B. In addition, standards for resistance to oil and gasoline exposure have been developed by the Rubber Manufacturer's Association (RMA). These standards are related to the effects of oil or gasoline exposure for 70 hours at 100°C (ASTM D 471) on the physical/mechanical properties of the material. Table 6-4 summarizes the requirements of the RMA oil and gasoline resistance classes.

b. Operating Conditions

In most cases, the flexible nature of elastomers will compensate for vibration and thermal expansion and contraction in extreme cases. However, designs should incorporate a sufficient length of hose to compensate for the mechanical effects of vibration and temperature.

Table 6-3
General Chemical Compatibility Characteristics of Common Elastomers

Material	Good Resistance	Poor Resistance
Fluoroelastomer	Oxidizing acids and oxidizers, fuels containing <30% aromatics	Aromatics; fuels containing >30% aromatics
Isobutylene Isoprene	Dilute mineral acids, alkalies, some concentrated acids, oxygenated solvents	Hydrocarbons and oils, most solvents, concentrated nitric and sulfuric acids
Acrylonitrile Butadiene	Oils, water, and solvents	Strong oxidizing agents, polar solvents, chlorinated hydrocarbons
Polychloroprene	Aliphatic solvents, dilute mineral acids, salts, alkalies	Strong oxidizing acids, chlorinated and aromatic hydrocarbons
Natural Rubber or Styrene Butadiene	Non-oxidizing acids, alkalies, and salts	Hydrocarbons, oils, and oxidizing agents

Notes: See Appendix B for more chemical resistance information.
Source: Compiled by SAIC, 1998.

Table 6-4
RMA Oil and Gasoline Resistance Classifications

RMA Designation	Maximum Volume Change	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%

Source: RMA, "The 1996 Hose Handbook," IP-2, p. 52.

c. End Connections

Hose couplings are used to connect hoses to a process discharge or input point. Methods for joining elastomeric hose include banding/clamping, flanged joints, and threaded and mechanical coupling systems. These methods are typically divided into reusable and non-reusable couplings. Table 6-5 lists common types of couplings for hoses. Selection of the proper coupling should take into account the operating conditions and procedures that will be employed.

d. Environmental Requirements

Hose is also manufactured with conductive, non-conductive, and uncontrolled electrical properties. Critical applications such as transferring aircraft hose or transferring liquids around high-voltage lines, require the electrical properties of hose to be controlled. Unless the hose is designated as conducting or nonconducting, the electrical properties are uncontrolled. Standards do not currently exist for the prevention and safe dissipation of static charge from hoses. Methods used to control electrical properties include designing contact between a body reinforcing wire and a metal coupling to provide electrical continuity for the hose or using a conductive hose cover. ASTM D 380 describes standard test methods for the conductivity of elastomeric hoses. For a hose to be considered non-conductive, it should be tested using these methods.

6-3. Sizing

The primary considerations in determining the minimum acceptable diameter of any elastomeric hose are design flow rate and pressure drop. The design flow rate is based on system demands that are normally established in the process design phase of a project and which should be

Table 6-5
Typical Hose Couplings

Class	Description
Reusable with clamps	1. Short Shank Coupling 2. Long Shank Coupling 3. Interlocking Type 4. Compression Ring Type
Reusable without clamps	1. Screw Type 2. Push-on Type
Non-reusable couplings	1. Swaged-on 2. Crimped-on 3. Internally Expanded Full Flow Type 4. Built-in Fittings
Specialty couplings	1. Sand Blast Sleeves 2. Radiator and Heater Clamps 3. Gasoline Pump Hose Couplings 4. Coaxial Gasoline Pump Couplings 5. Welding Hose Couplings 6. Fire Hose Couplings

Source: Compiled by SAIC, 1998.

fully defined by this stage of the system design. Pressure drop through the elastomeric hose must be designed to provide an optimum balance between installed costs and operating costs. Primary factors that will impact these costs and system operating performance are internal diameter (and the resulting fluid velocity), materials of construction and length of hose.

6-4. Piping Support and Burial

Support for rubber and elastomer piping systems should follow similar principles as metallic and plastic pipe. However, continuous piping support is recommended for most applications due to the flexible nature of these materials. Also due to its flexible nature, elastomer piping is not used in buried service because the piping is unable to support the loads required for buried service.

When routing elastomer hose, change in piping direction can be achieved through bending the hose rather than using fittings. When designing a rubber or elastomer piping system, it is important to make sure that the bend radius used does not exceed the maximum bend radius for the hose used. If the maximum bend radius is exceeded, the hose may collapse and constricted flow or material failure could occur. As a rule of thumb, the bend radius should be six times the diameter of a hard wall hose or twelve times the diameter of a soft wall hose.

6-5. Fluoroelastomer

Fluoroelastomer (FKM) is a class of materials which includes several fluoropolymers used for hose products. Trade names of these materials include Viton and Fluorel. Fluoroelastomers provide excellent high temperature resistance, with the maximum allowable operating temperatures for fluoroelastomer varying from 232 to 315°C (450 to 600°F), depending upon the manufacturer. Fluoroelastomers also provide very good chemical resistance to a wide variety of chemical classes.

6-6. Isobutylene Isoprene

Isobutylene isoprene (Butyl or IIR) has excellent abrasion resistance and excellent flexing properties. These characteristics combine to give isobutylene isoprene very good weathering and aging resistance. Isobutylene isoprene is impermeable to most gases, but provides poor resistance to petroleum based fluids. Isobutylene isoprene is also not flame resistant.

6-7. Acrylonitrile Butadiene

Acrylonitrile butadiene (nitrile, Buna-N or NBR) offers excellent resistance to petroleum oils, aromatic hydrocarbons and many acids. NBR also has good elongation properties. However, NBR does not provide good resistance to weathering.

6-8. Polychloroprene

Polychloroprene (neoprene or CR) is one of the oldest synthetic rubbers. It is a good all-purpose elastomer that is resistant to ozone, ultraviolet radiation, and oxidation. Neoprene is also heat and flame resistant. These characteristics give neoprene excellent resistance to aging and weathering. Neoprene also provides good chemical resistance to many petroleum based products and aliphatic hydrocarbons. However, neoprene is vulnerable to chlorinated solvents, polar solvents, and strong mineral acids.

6-9. Natural Rubber

Natural rubber (styrene butadiene, gum rubber, Buna-S, NR, or SBR) has high resilience, good tear resistance, and good tensile strength. It also exhibits wear resistance and is flexible at low temperatures. These characteristics make natural rubber suitable for general service outdoor use. However, natural rubber is not flame resistant and does not provide resistance to petroleum based fluids.