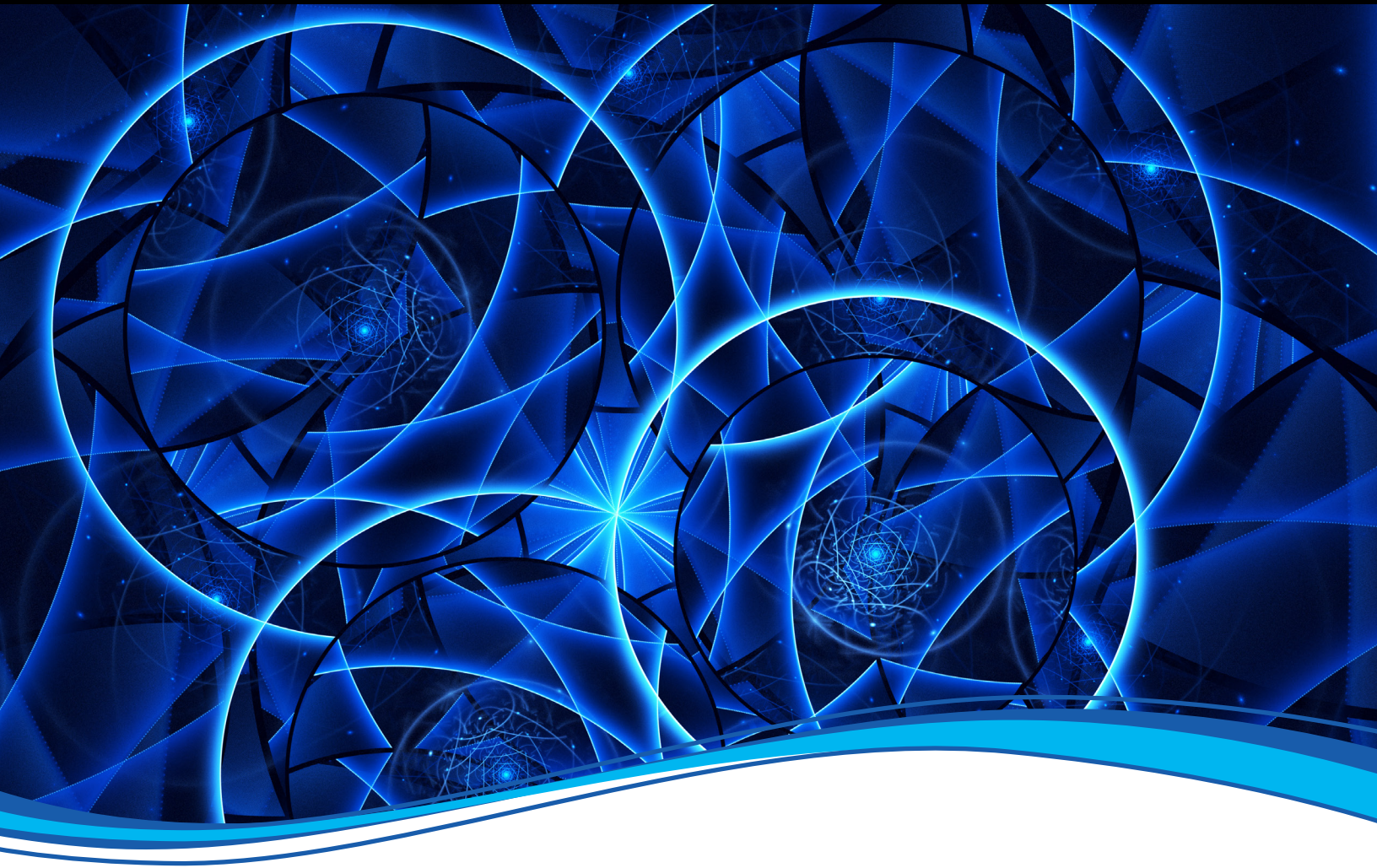


Elastomers for Waterworks: Pipes, Valves, and Fittings



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Elastomers for Waterworks: Pipes, Valves, and Fittings

First Edition



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Manual of Water Supply Practices—M75, First Edition

Elastomers for Waterworks: Pipes, Valves, and Fittings

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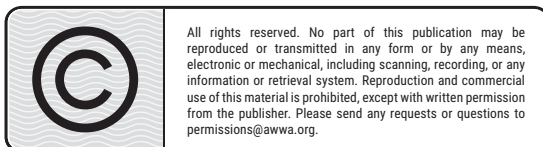
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Preface

This manual presents the history and general application of elastomers in waterworks pipes, valves, and fittings. The principles used for evaluating, selecting, testing, and maintaining various seals will be presented. It is a discussion of recommended practice, not an American Water Works Association (AWWA) standard. This document provides guidance on generally available elastomers and products and their application. Questions about specific situations or applicability to specific valves or fittings should be directed to the manufacturer or supplier.

Information contained in this manual is useful for operators, technicians, and engineers for gaining a basic understanding of the use and selection of elastomers. There are many special materials that are beyond the scope of this manual and require special consultations with suppliers and manufacturers. The elastomer properties and resistance data are generic, and actual data from the intended valve and fitting manufacturer should be obtained before making the final selection of an elastomer. This manual provides information on elastomers used in many AWWA Standards, including the following:

- [AWWA C110](#), Ductile-Iron and Gray-Iron Fittings
- [AWWA C111](#), Rubber-Gasket Joints for Ductile-Iron Pressure and Fittings
- [AWWA C115](#), Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
- [AWWA C151](#), Ductile Iron Pipe, Centrifugally Cast
- [AWWA C153](#), Ductile Iron Compact Fittings
- [AWWA C200](#), Steel Water Pipe, 6 In. (150 mm) and Larger
- [AWWA C207](#), Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm)
- [AWWA C221](#), Fabricated Steel Mechanical Slip-Type Expansion Joints
- [AWWA C223](#), Fabricated Steel and Stainless-Steel Tapping Sleeves
- [AWWA C227](#), Bolted, Split-Sleeve Couplings
- [AWWA C228](#), Stainless-Steel Pipe Flange Joints for Water Service – Sizes 2 In. Through 72 In. (50 mm Through 1,800 mm)
- [AWWA C230](#), Stainless-Steel Full-Encirclement Repair and Service Connection Clamps for 2-in. Through 12-in. (50-mm Through 300-mm) Pipe
- [AWWA C300](#), Reinforced Concrete Pressure Pipe, Steel-Cylinder Type
- [AWWA C301](#), Prestressed Concrete Pressure Pipe, Steel-Cylinder Type
- [AWWA C302](#), Reinforced Concrete Pressure Pipe, Non-Cylinder Type
- [AWWA C303](#), Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
- [AWWA C502](#), Dry-Barrel Fire Hydrants
- [AWWA C503](#), Wet-Barrel Fire Hydrants
- [AWWA C504](#), Rubber Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm)
- [AWWA C507](#), Ball Valves, 6 In. Through 60 In. (150 mm Through 1,500 mm)
- [AWWA C508](#), Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS

- [AWWA C509](#), Resilient-Seated Gate Valves for Water Supply Service
- [AWWA C510](#), Double Check-Valve Backflow Prevention Assembly
- [AWWA C511](#), Reduce Pressure Principle Backflow Prevention Assembly
- [AWWA C512](#), Air-Release, Air/Vacuum, and Combination Air Valves for Water and Wastewater Service
- [AWWA C515](#), Reduced Wall, Resilient-Seated Gate Valves for Water Supply Service
- [AWWA C516](#), Large-Diameter Rubber-Seated Butterfly Valves, Sizes 78 In. (2,000 mm) and Larger
- [AWWA C517](#), Resilient-Seated Cast-Iron Eccentric Plug Valves
- [AWWA C518](#), Double-Disc Swing Check Valves for Waterworks Service, 2-In. Through 48-In. (50-mm Through 1200-mm) NPS
- [AWWA C519](#), High Performance Waterworks Butterfly Valves – 3 In. (75 mm) Through 60 In. (1,500 mm)
- [AWWA C520](#), Knife Gate Valves, Sizes 2 In. (50 mm) Through 96 In. (2,400 mm)
- [AWWA C606](#), Grooved and Shouldered Joints
- [AWWA C900](#), Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)

This manual refers to AWWA standards, which are available for purchase from the AWWA Bookstore by calling (800) 926-7337 or online at www.awwa.org/bookstore.

Manufacturers graciously provided illustrations and other documentation. AWWA does not endorse any manufacturer's products, and the names of the manufacturers have been removed from the material provided.

Metrification Note: Valve and fitting sizes are listed in their current US designation— inches. To obtain an approximate metric equivalent, use a conversion factor of 25.4 mm per inch.

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Chapter **1**

Introduction

Elastomeric linings, gaskets, diaphragms, and seals play an essential role in the operation of water distribution systems. They are used in pipes, valves, and fittings to provide tight seals for joints and valve closure members under various operating parameters including pressure, temperature, and chemical environments. There are no defining industry or AWWA material standards for specific elastomers used in the waterworks industry. Therefore, it is important to understand the chemistry, properties, and test methods associated with elastomers when selecting and specifying their use.

All materials can degrade while in service. The physical changes due to the environment, ultraviolet light exposure, wear, corrosion, chemical compatibility, fatigue, and temperature are understood for most metallic components. For elastomers, these changes are not as well cataloged and understood and can be substantially different for various and combined service conditions. Degradation and other property changes can impact expected service life and preventive maintenance frequencies. Because elastomers have different rates of degradation, the intended service life and operational compatibility are always important for proper elastomer selection.

A marked change occurred in the US waterworks industry in the 1980s when many water utilities changed from chlorine to chloramine disinfection to meet new trihalomethane (THM) standards for drinking water. Within a few months of the conversion, Ft. Lauderdale, Fla., reported rubber flappers in toilet tanks breaking down; Topeka, Kans., reported gaskets and diaphragms on backflow prevention assemblies beginning to deteriorate; and in Ingleside, Tex., the seating materials of filter backwash valves failed prematurely. These events led to several studies in the industry to better understand commonly used elastomers and their applications in the waterworks industry (Reiber 1993).

Product application and service history are important factors for elastomer selection. The selection of an elastomer for use as a dynamic seal in a safety-related valve for a nuclear power plant is much more critical than the elastomer used for a residential water heater relief valve. However, components of water systems are expected to perform as designed

for many decades. Operating service experience with elastomers over long periods of time is one predictor of equipment functionality and longevity.

Many natural and synthetic elastomers are available to the designer. Some of the generic classifications of elastomers used in waterworks service include the following:

- AU, EU – Polyester and Polyether Urethane (Polyurethane)
- CR – Chloroprene (Neoprene)
- CSM – Chlorosulfonated Polyethylene (Hypalon^{®*})
- EPDM – Ethylene Propylene Diene Monomer
- FKM – Fluorocarbon (Viton^{®†})
- IIR – Isobutene Isoprene (Butyl)
- NBR – Acrylonitrile Butadiene (Nitrile, Buna-N)
- NR, IR – Polyisoprene (Natural Rubber, Synthetic Rubber)
- SBR – Styrene Butadiene
- VMQ – Polysiloxane (Silicone)

Elastomer chemistries continue to change, and many elastomer applications should be analyzed before installation. The intent of this manual is to provide a basic understanding of elastomers for the waterworks service industry.

ASTM International publishes a classification system for elastomers, which will also be explained in Chapter 3. Detailed descriptions, common uses, and temperature ratings for each of the listed elastomers will also be presented. Elastomers are enhanced with additives to improve performance and manufacturability. Unfortunately, formulations of elastomers and their additives are considered proprietary and are not published. When selecting elastomers, resistance to certain chemicals should be considered, and a chemical resistance guide is furnished in Chapter 5.

Elastomers can be mixed, molded, and extruded through various manufacturing processes to create elastomeric components or valves with integral elastomeric seals. During the manufacturing process, the properties of the elastomer can be verified with specialized quality control equipment such as a durometer and a rheometer. Finally, finished elastomer batches can be checked for many mechanical properties including hardness, tensile strength, resilience, and temperature resistance in accordance with ASTM test protocols described in Chapter 4 and Appendix B.

HISTORY

For more than 100 years, elastomeric materials have been used ubiquitously in drinking water distribution systems. Elastomeric materials have successfully been used in a variety of applications ranging from gaskets to equipment seals and have been equally suitable for a wide variety of piping gasket materials, including concrete, cast iron, ductile iron, steel, copper, and polyvinyl chloride (PVC). In general, elastomers have usually performed well in water distribution systems.

While rubber may seem like an old material, its use is actually quite recent as compared to the use, knowledge, and understanding of the basic metallic materials used in the waterworks industry. Just as there are various types of metals such as iron, carbon steel, stainless steel, lead, and bronze, there are many different elastomers like natural rubber, nitrile, styrene butadiene, ethylene propylene diene monomer, fluorocarbon, silicon, neoprene, butyl, and polyurethane. And just as there are many different alloys of the

* Hypalon[®] is a registered trademark of DuPont.

† Viton[®] is a registered trademark of The Chemours Company.

metals, there are many different chemistries and vulcanization procedures for elastomers. While the chemistries of metal alloys are well documented in published standards and are generally nonproprietary, elastomeric compounds are not. They vary widely and, in most cases, are considered proprietary.

The water industry has benefited from many of the advancements and achievements of elastomer research supported by the automotive industry. Once the water-sealing capabilities of vulcanized rubber were identified, the water industry slowly replaced lead and oakum with rubber seals and gaskets in pipe joints and other applications. While many new synthetic elastomer materials were made available, the water industry primarily focused on the “water sealing” properties of the elastomers and did not typically differentiate between materials. As such, vulcanized natural rubber was used in water system construction into the 1950s and 1960s. After that time, however, United States drinking water regulations forced a change from natural rubber to synthetic elastomer products because natural rubber appeared to promote the growth of bacteria (Leefflang 1968).

To date, elastomers and thermoplastics are revolutionizing the manufacturing industry; they appear as gaskets, coatings, membranes, hinges, structural materials, shock absorbers, and rigid bodies. They have become indispensable to the manufacturing industry and, in particular, to the portion of the industry producing valves, pipes, fittings, and the host of appurtenances required by the waterworks field (see Figure 1-1).

PURPOSE

The purpose of this manual is to explain the generic elastomer types, including their properties, characteristics, and compatibilities with waterworks systems, to assist in the selection of and application in waterworks products. Users will be able to evaluate various elastomeric materials for specific applications through a better understanding of how elastomeric parts are manufactured and tested, and a clearer understanding of their physical and mechanical properties such as strength, resilience, and hardness. Finally, the proper storage and maintenance of elastomeric parts and products are presented to help users effectively maintain inventories.



Figure 1-1 Various elastomeric seals for the waterworks industry

GENERAL DEFINITIONS

Adhesion	The state in which two surfaces are held together by interfacial forces that may consist of molecular forces, interlocking action, or both.
Age resistance	The ability of a rubber material to resist degradation of its properties caused by long-term exposure to various water environments, oxygen, heat, light, and ozone during storage or use.
Antidegradant	A compounding material used to retard degradation caused by oxidation, ozone, light, and a combination of these (ASTM D1566).
Autoclave	A pressure vessel used for the curing or vulcanization of elastomeric parts using steam under pressure.
Carbon black	A black pigment and reinforcement filler used in many rubber compounds.
Checking or crazing	A series of fine, shallow cracks appearing on a surface, resulting from aging or degradation from environmental conditions.
Chemical resistance	The ability of a material to maintain its properties while exposed to a chemical environment.
Cracking	Presence of visually noticeable deep cracks or fissures extending into the interior of a structure.
Compound	A term applied to a mixture of polymers, fillers, curing agents, and additives to produce an elastomeric material.
Compression set	The permanent deformation of a material that remains when an applied force is removed.
Copolymer	A polymer formed from two or more types of monomers, e.g., butadiene and acrylonitrile (NBR).
Degradation	The change in the physical properties of an elastomer through environmental exposure over time.
Disinfectant	Chemicals, such as chlorine and chloramines, added to drinking water to destroy microorganisms, control tastes and odors, oxidize inorganics and organics, and suppress microbiological growth in distribution systems.
Durometer	An instrument that measures a material's hardness. A material's hardness can be defined as its resistance to permanent deformation. It is also used to measure the viscous and elastic characteristics of a material when undergoing deformation. Most elastomers used in the waterworks industry are measured based on the ASTM D2240 Shore Type A and Type D scales.
Elastomer	A polymeric material with viscoelasticity (having both viscosity and elasticity) and very weak inter molecular forces, generally having low Young's modulus and high failure strain compared to other materials.
Flashing	Thin film of excess rubber formed at mold mating lines or venting gaps.
Formulation	Ingredients and their proportions in a compound; also called a recipe.
Mill	A machine used for the mechanical mixing or working of rubber consisting of two adjacent, heavy, hardened-steel, counter-rotating horizontal rolls.
Oakum	Loose fiber obtained by untwisting old rope, tarred, and used to seal gaps.
Permeation	The passage of contaminants external to the pipe, through porous, nonmetallic materials, into drinking water (USEPA 2002).
Plastic	A polymeric material that, during its manufacture or processing, can be extruded, molded, cast, drawn, or laminated into objects of all sizes and shapes by the application of heat and pressure. A thermoplastic (e.g., acrylic) can be softened and reshaped by heating and hardened by cooling. A thermoset plastic (e.g., epoxy) is irreversibly cured or hardened into a permanent shape (McTigue 2010).
Polymer	A synthetic organic compound with high molecular weight and composed of repeating chemical monomers (McTigue 2010).
Resilience	A measurement of a compound's ability to return quickly to its original shape after a temporary deformation.
Rubber	An elastomer capable of high elongation before fracture and returning quickly to its original shape after removal of the force causing deformation.

Tear strength	The force necessary to rip a material and to make the crack continue until it fails.
Tensile strength	A measurement of the stress required to rupture a standard test piece of elastomeric material.
Ultimate elongation	The percentage of distance a specimen can be strained to the point of failure or rupture.
Vulcanization	The process of treating polymers chemically to give them useful properties (such as elasticity and strength) by introducing cross-links.

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Chapter 2

Use of Elastomers

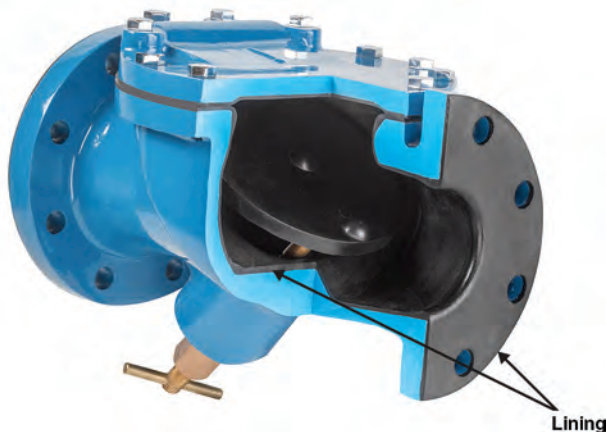
Elastomeric gaskets, linings, and seals play an essential role in the operation of water distribution system components. They are used in pipes, valves, and fittings to provide tight seals for joints and valve closure members under various operating parameters, including pressures, temperatures, and chemical environments. They are also used as diaphragms, linings, and coatings. Because there are no defining AWWA standards for specific elastomers used in the waterworks industry, it is important to understand the chemistry, properties, and test methods associated with elastomers when selecting and specifying their use.

The uses of elastomers fall into four basic functional groups as follows:

- Linings and coatings
- Static seals, such as O-rings, flange gaskets, push-on gaskets, mechanical joint gaskets, and O-ring gaskets
- Dynamic seals, such as valve seats and shaft or stem packing or O-ring seals
- Diaphragms, such as valve position controllers and flexible sheets that separate adjacent expanding and contracting chambers, as in control valves

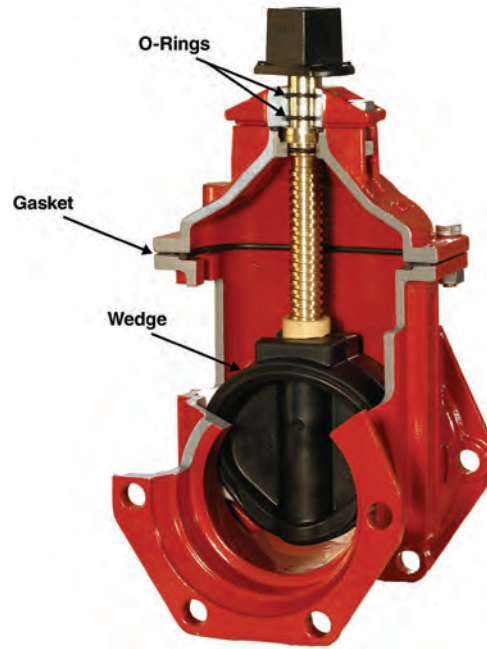
LININGS AND COATINGS

Linings and coatings provide a barrier to protect the base material from the operating fluid or environment. Elastomeric coatings also serve to form a sealing surface typically by encapsulating a wedge, disc, or plug. The interior lining can also extend over the adjoining flange face and serve as the flange gasket. In these applications, the elastomer must be compatible with the structural properties of the base metal material and function. As a lining, the elastomer primarily provides protection from corrosion, chemical attack, wear, or impact resistance. Valves, pipes, and fittings may be lined with elastomers such as NR, IR (natural rubber) or elastomers such as CR (chloroprene) (see Figure 2-1).



Courtesy of DeZURIK APCO HILTON.

Figure 2-1 Check valve with rubber-lined interior and flange facing



Courtesy of American Flow Control.

Figure 2-2 Resilient wedge gate valve with O-ring seal and rubber encapsulated wedge

As an encapsulating coating, elastomers can provide a sealing mechanism in various valve configurations, such as the gate valve wedge shown in Figure 2-2. Lining applications traditionally require low material strength; however, because a significant amount of surface area is exposed to the fluid and internal environment, linings and coatings are highly susceptible to fluid compatibility with the elastomer. Linings are also used for protection against abrasive media, which require a high-strength, wear-resistant elastomer.

When used as a lining or coating, the more important elastomeric properties are the long-term permeability, wear, tear resistance, and the chemical compatibility with the operating fluid.

STATIC SEALS

Static seals are installed between adjacent parts that are stationary. These include flange O-rings, flat flange gaskets, mechanical joint (MJ) gaskets, push-on gaskets, and restrained joint gaskets. In static seal applications, the elastomer is mechanically placed under compression. The seal experiences little tension, shear, or bending loads. In most water applications, thermal, pressure, and mechanical cyclic loads are generally low. Gaskets generally exhibit a low surface area exposure to the system fluid.

Static Seal – O-rings

Many valves use O-rings to seal body sections or cover plates. In Figure 2-2, the stem is sealed with O-rings. An O-ring is a molded torus or donut-shaped resilient ring typically housed in a precision gland or groove specially designed to compress the elastomeric



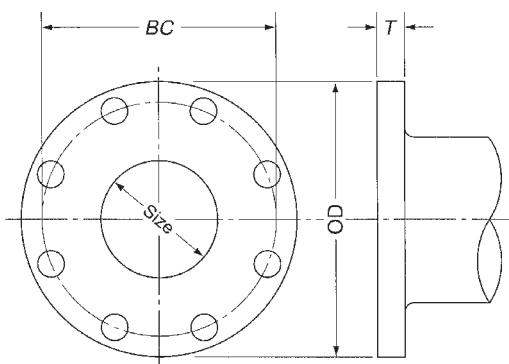
Figure 2-3 O-ring installation without and with pressure (P)

element and provide a seal. The seal is highly reliable because the groove and mating surface hold the O-ring in place, which prevents the O-ring from dislodging and leakage from occurring. The groove and mating surfaces are typically bolted together, creating metal-to-metal contact with low bolt torque to provide the necessary compression on the O-ring. As shown in Figure 2-3, the O-ring gland and groove are designed to compress the O-ring in one direction, provide volume for compression and thermal expansion, and allow the O-ring to move to one side of the groove when pressure is exerted. Because of the imposed compression, an O-ring can seal from zero to very high pressures (i.e., 0–5,000 psig or 0–34.5 MPa). While O-rings are typically static seals, they can also be used on moving parts, such as rotating shafts and oscillating cylinders, to contain the line fluid within the pressure boundary. When used in dynamic applications, the mating metal surfaces must be very smooth to prevent wear. O-rings are available in many standard circular cross sections and diameters but can also be custom-molded to suit a particular valve application. The standard sizes used by O-ring manufacturers in the United States are defined by standards such as Aerospace Standard AS-568. Typical cross-sectional diameters range from 0.040 to 0.275 in. (1.02–6.98 mm). Typical inside diameters range from 0.029 to 25.940 in. (0.74–658.9 mm). There are more than 300 standard sizes. O-rings are typically molded from high-tensile elastomers to a hardness of 70 Shore A, which is similar to that of automobile tires. O-rings are readily available in many different compounds to be compatible with hundreds of chemicals and fluids.

Static Seal – Flange Gaskets

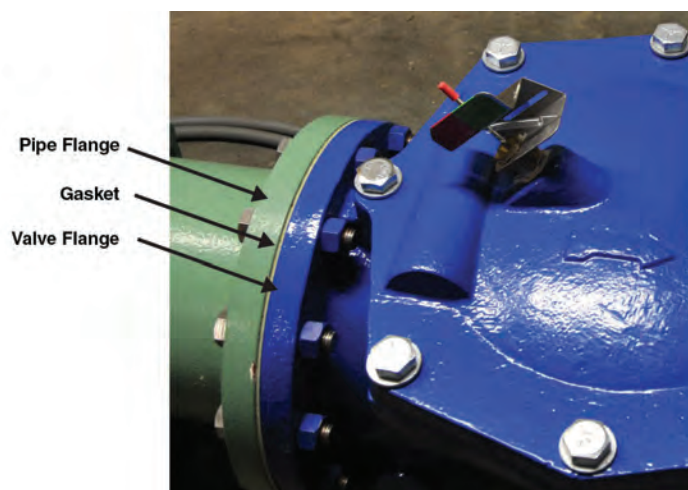
Pipelines are often assembled using sections of pipe, fittings, and valves joined together with standardized bolted flange connections. In general, the flange connection consists of two circular flat rings of a specified thickness (T) integrally cast, welded, or threaded to the ends of the pipe with a series of bolt holes around a bolt circle (BC) with a specific diameter to compress the seal and withstand the hydrostatic and pipe loads during service (see Figure 2-4). Flanged connections are commonly used for aboveground water and wastewater service requiring a fixed restrained joint but are also used below ground in buried applications (with corrosion protection where required) and nonburied applications such as vaults. They are popular in treatment plants and industrial piping systems, in both interior and exterior applications, as well as bridge and other elevated crossings. Flanged joints allow for easier access to the piping system and associated pipeline equipment, such as valves and pumps (see Figure 2-5).

There are numerous standards for flange connections around the world with varying dimensions and pressure ratings. While there are special adapting devices available, various flange standards are not necessarily compatible either by virtue of diametrical dimensions, seal designs, bolt hole diameters, and/or bolt circle diameters. The common standards for waterworks flanges are shown in Table 2-1. Iron flanges finished in accordance with MSS SP-6 may include a flat or raised sealing surface with a serrated face (i.e., containing spiral or concentric grooves). In cases where flanges are provided with a protective coating, the



Courtesy of Val-Matic Valve & Mfg. Corp.

Figure 2-4 Typical waterworks flange



Courtesy of Val-Matic Valve & Mfg. Corp.

Figure 2-5 Waterworks check valve flange connection with full-face gasket

Table 2-1 Waterworks flange and fittings standards

Flange Standard	Materials	Classes	Size Range
ASME B16.1	Gray and ductile iron	25, 125, 250	NPS 1 to 96
ASME B16.5	Steel, stainless steel	150, 300, 400, 600, 900, 1500, 2500	NPS ½ to 24
ASME B16.42	Ductile iron	150, 300	NPS 1 to 24
ASME B16.47*	Steel, stainless steel	75A, 150A, 300A, 400A, 600A, 900A, 75B, 150B, 300B, 400B, 600B, 900B	NPS 26 to 60
AWWA C110	Gray and ductile iron	125	NPS 3 to 48
AWWA C111	Rubber gaskets	125	NPS 3 to 48
AWWA C115	Gray and ductile iron	125	NPS 3 to 64
AWWA C153	Ductile iron	125	NPS 3 to 64
AWWA C207	Steel	B (86 psi), D (175 psi), E (275 psi), F (300 psi)	NPS 4 to 144
AWWA C228	Stainless steel	SA (50 psi), SB (86 psi), SD (175 or 150 psi), SE (275 psi)	NPS 2 to 72
MSS SP-44*	Steel	150, 300, 400, 600, 900	NPS 12 to 60

Courtesy of Val-Matic Valve & Mfg. Corp.

* Caution: These standards do not match B16.1 drilling in the larger diameters. The "A" designation under "Classes" indicates MSS SP-44 compatibility; the "B" designation indicates API-605 compatibility (ASME B16.47).

surface finish requirements should only pertain to the machined surface under the coating. The machined grooves in the sealing surface help restrain the gasket from being radially forced out of the pipeline joint under the force from the internal pipeline pressure. The purpose of the gasket is to prevent leakage through the joint despite the flange's varying flatness, pressure, pipeline loads, and deflection in service.

The gasket is usually cut from sheet material to match the dimensions of the flange face or to a set of specified standard gasket dimensions. Other gasket dimensions and materials may be found in ASME B16.21 for Nonmetallic Gaskets for Pipe Flanges. Flange gaskets are available as full face, ring type, or full face with a dual-sealing element, which

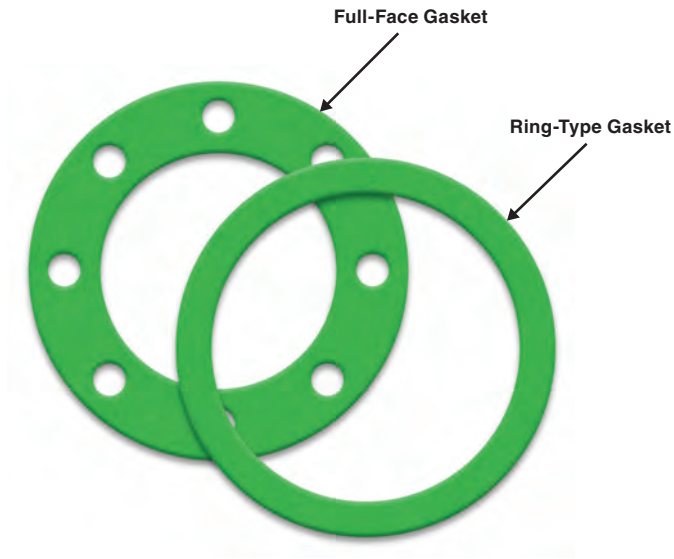


Figure 2-6 Sample full-face and ring-type gaskets

may either incorporate an integral O-ring, bulb, or seal on the inner diameter portion of the gasket (see gasket in Figure 2-2). A full-face gasket will cover the entire face of the flange and encompass the bolt holes. A ring gasket fits between the inside diameter of the flange and the inside diameter tangent edge of the bolt holes (see Figure 2-6). Ring gaskets are used for higher pressures and often require lower bolting torques given the smaller surface area of the gasket, which results in a higher gasket compression when the bolt torques are identical to full-face gaskets.

[AWWA C207](#) describes the elastomer (rubber) gasket for steel flanged piping to be hardness (Shore A) 70–85, suitable for water service temperature of up to 200°F (93.3°C) with gasket seating stress of 200 psi (1,379 kPa) minimum. The specified hardness is similar to that of a shoe heel (Figure 4-6) and assures that the gasket maintains its dimensional shape when compressed by the flange bolts. If assembly seating stress recommendations are unavailable, elastomeric gaskets are rated for a minimum of 175 psi (1,206 kPa) internal working pressure by the manufacturer. Compressed fiber gaskets are a blend of synthetic fibers, fillers, and elastomeric binders suitable for potable water service. Gaskets that are polytetrafluoroethylene (PTFE) based are also acceptable. Gasket seating stress should be no greater than 4,800 psi (33 MPa). The specified seating stress provides the necessary strength to prevent the blowout of the gasket or damaging plastic deformation during pipeline operation.

For sealing harsh chemicals or high pressures or temperatures, the gasket material is usually a fiber gasket with a rubber binder material. Depending on the fiber and rubber binder, fiber gaskets are rated to pressures over 500 psi (3,450 kPa) and temperatures over 300°F (149°C). Some types are also meant for electrical isolation purposes, such as between differing pipe materials for corrosion prevention or cathodic protection. The gasket manufacturer should be consulted for specific temperature and chemical exposure limits.

ASME PCC-1 Guidelines for Pressure Boundary Bolted Flange Joint Assembly provides recommendations for the use and installation of ring-type gaskets for general pressure service, including recommended flange bolt tightening patterns and target torque values. The leak tightness of a bolted flanged joint assembly is related to many factors in addition to the selection of the gasket material. AWWA provides an online, interactive tool for members to evaluate steel flange connections based on [AWWA C207](#)

requirements, [AWWA M11](#) guidelines, various gaskets materials, and bolt torques (AWWA Flange Torque Calculator).

When used as a static seal, the important elastomeric properties of the gasket are the compressive and tensile strength, compression set, permeability, and hardness. Depending on application, temperature limitations may also be important.

Static Seal – Push-On Gaskets and Pipe Connections

Pipelines are also assembled with various elastomeric seal designs depending on the pipe material (e.g., plastic, concrete, and iron) and type of joint (e.g., push-on, flanged, and mechanical joint). The performance requirements for the elastomeric gaskets are contained in either the pipe standard or a standard specific to the type of joint. A summary of the physical/mechanical properties of gaskets for the various pipe material standards are presented in Appendix A.

For polyvinyl chloride (PVC) pipe joints, a push-on gasket meeting [ASTM F477](#) is provided (ASTM 2014). As shown in Figure 2-7, sections of PVC pipe are joined using a push-on joint where a continuous elastomeric ring gasket is compressed into an annular space formed by the pipe bell and the spigot end of the pipe. The dimensions of the socket and gasket are in accordance with the manufacturer's standard design dimensions.

Similarly, ductile iron pipe can also be furnished with bell and spigot ends sealed with a push-on gasket meeting [ANSI/AWWA C111](#) as shown in Figure 2-8.

Steel pipe sections can be joined by welding, flanges, or grooved/shouldered joints (see Figure 2-9).

Polyethylene (PE) pipe is joined by butt fusion, electrofusion couplings, or with mechanical joining alternatives as shown in Figures 2-10, 2-11, and 2-12.

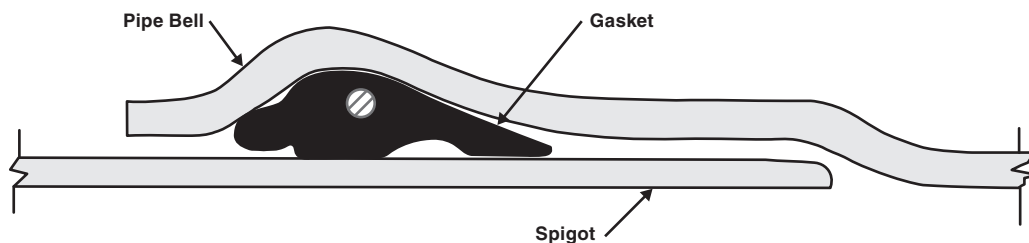
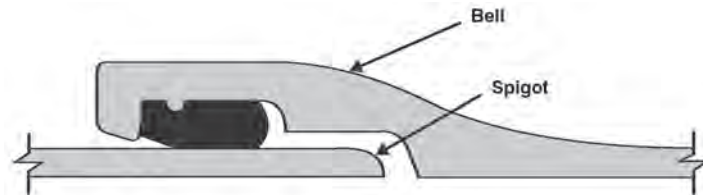


Figure 2-7 PVC pipe push-on joint



Courtesy of Ductile Iron Pipe Research Association.

Figure 2-8 Ductile iron pipe push-on joint

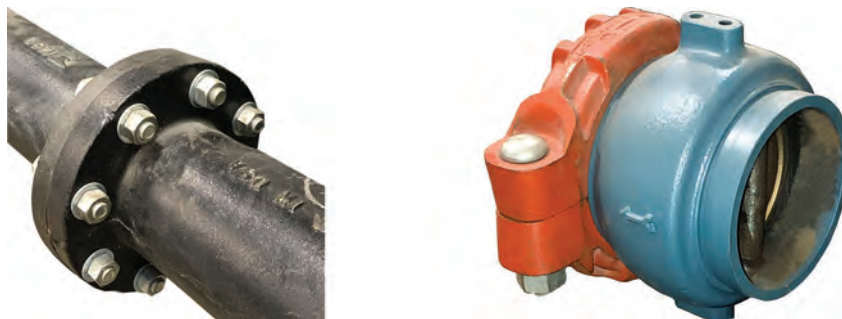


Figure 2-9 Steel pipe flanged and grooved joints

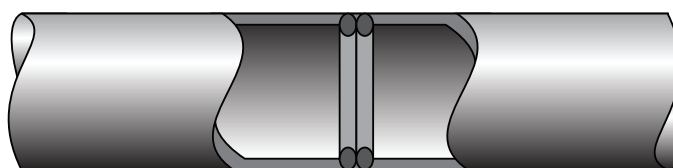


Figure 2-10 Butt fusion of PE pipe

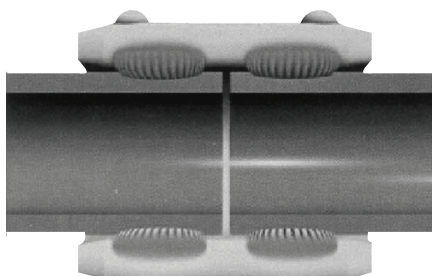
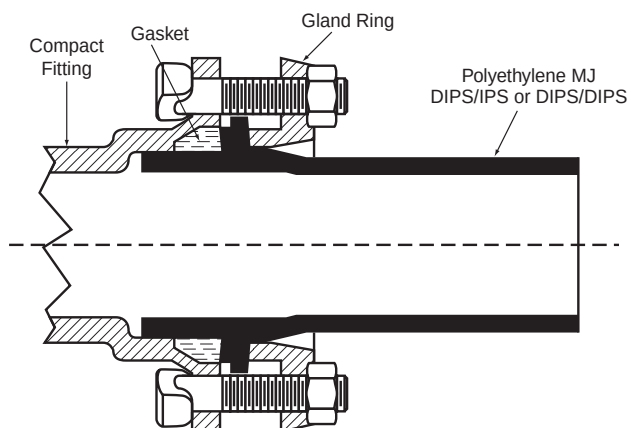
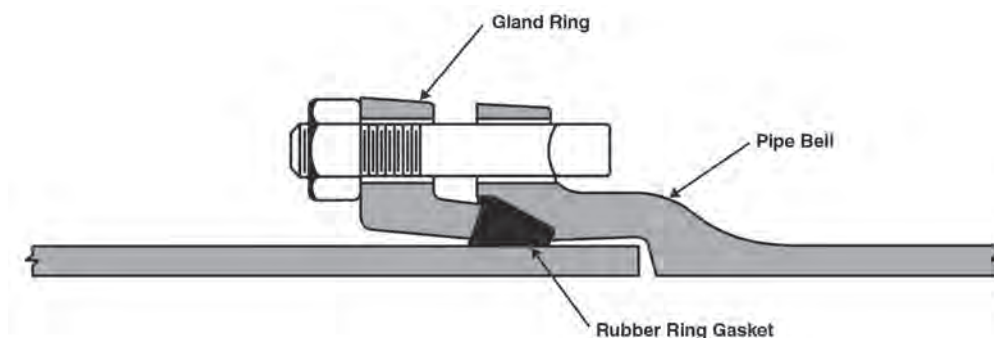


Figure 2-11 Electrofusion coupling for PE pipe



DIPS—ductile iron pipe size, IPS—iron pipe size, MJ—mechanical joint

Figure 2-12 Mechanical joint adapter for PE pipe



Courtesy of Ductile Iron Pipe Research Association.

Figure 2-13 Mechanical joint connection

Static Seal – Mechanical Joint Gaskets

Another common gasket joint in the waterworks industry is the mechanical joint connection where the plain pipe end is inserted into a special hub with gasket and gland ring as shown in Figure 2-13. In this joint, a gland ring compresses a specially shaped rubber ring gasket between the outside diameter of the pipe and the inside diameter of the pipe bell.

Similar to the flange joint, the important elastomeric properties of the gasket are the compressive and tensile strength, compression set, permeability, and hardness. Chemical compatibility with the operating fluid is less important given the small surface area exposure to liquid versus material volume. Depending on application, temperature and other limits specific to the gasket material type may also be important.

Static Seal – Valve Face Seal

Many types of valves rely on a flat elastomeric seal that mates to a metal surface. These seals are common in check valves and air valves, for example. Figure 2-14 illustrates an air/vacuum valve, which can be mounted on the top of water or wastewater lines. The round stainless steel float presses against a flat resilient seal to prevent water from leaking out of the valve. Similar to other static seals, the important elastomeric properties of static valve seals are compressive strength, compression set, permeability, and hardness.

DYNAMIC SEALS

Dynamic seals perform a seal function between parts that move relative to each other during operation. In this application, the mechanical loads are associated primarily with valve closure seal mechanisms. These vary widely by valve type and design, and with the type of shaft or stem packing seal. These seals must withstand the stresses under seating, unseating, and operating loads. These loads usually include compression, tension, pressure, bending, and cyclic loads. In water applications, thermal and thermal cycling stresses are generally low. Thus, surface area exposure becomes a significant factor. Finally, any degradation caused by chemical exposure can also be detrimental to the valve's ability to seal.

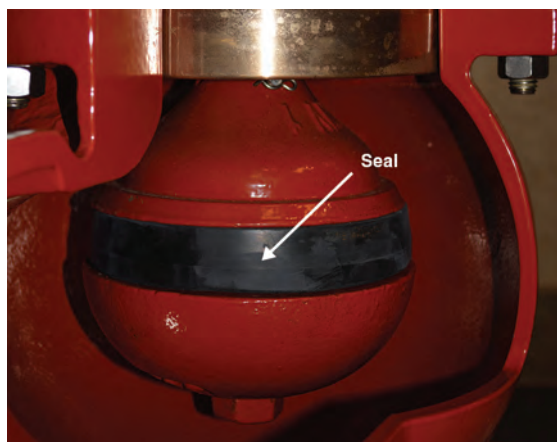
The important elastomeric properties of dynamic seals can vary widely given the design of the valve seal or gland but generally include most of the mechanical properties previously noted for static seals.

Valves often rely on resilient seals for tight shutoff. Figure 2-15 illustrates a common seal used in dry-barrel fire hydrants. Figures 2-16 and 2-17 illustrate typical butterfly



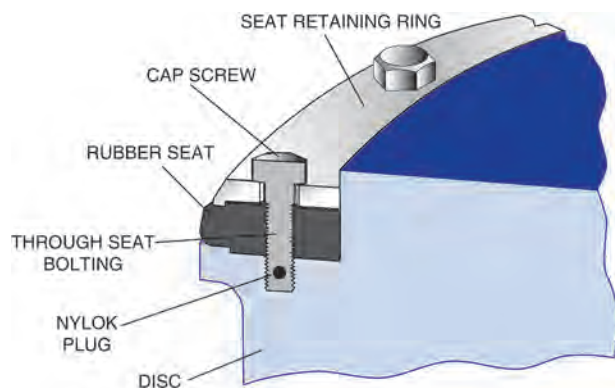
Courtesy of Val-Matic Valve & Mfg. Corp.

Figure 2-14 Air/vacuum valve



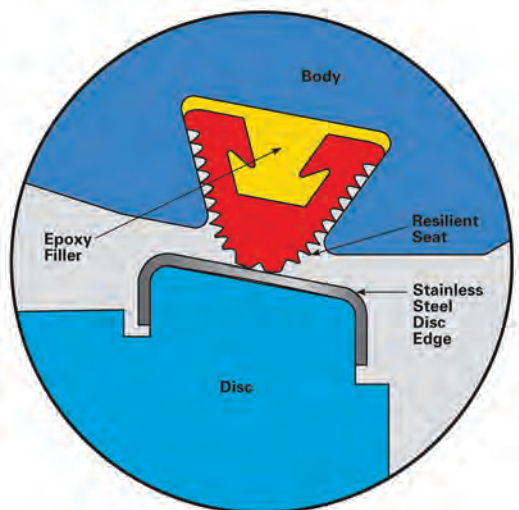
Courtesy of American Flow Control.

Figure 2-15 Typical dynamic seal in a dry-barrel fire hydrant



Courtesy of Val-Matic Valve & Mfg. Corp.

Figure 2-16 Typical bolted resilient seat in AWWA butterfly valve



Courtesy of DeZURIK APCO HILTON.

Figure 2-17 Typical epoxy-retained resilient seat in AWWA butterfly valve