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A Reference Manual on Elastomers

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The history and general application of elastomers in pipes, valves and fittings is the subject of the recently published Manual of Practice developed by the American Water Works Association (AWWA).

Most water infrastructure piping and equipment contain seals, gaskets or packing made of synthetic elastomers that have been developed over the last 100 years. The AWWA Standards Committee on Gaskets studied elastomers and their application for over two decades and have published their knowledge and recommendations for elastomer selection and use in a new AWWA Manual of Practice, M75. It is hoped that this document will serve as a foundation of elastomer knowledge and guide other product standards committees in the drinking water industry to develop standard requirements for seals, diaphragms, gaskets and packing used in piping and valves. Figure 1 illustrates an elastomeric expansion joint, valves that have seals and piping with flange gaskets.

Figure 1. Pipe, valves and fittings in a treatment plant

TYPES OF ELASTOMERS

Elastomeric pipe gaskets, equipment linings, diaphragms and seals have played an essential role in water distribution and the operation of water and wastewater treatment system equipment, most of which are expected to last many decades. Elastomers are used in joining pipes and fittings, sealing valves and other equipment under a wide range of pressure, temperature and chemical environments. The wide array of elastomer types in use today are enhanced with additives to provide improved mechanical and environmental resistance to match the intended application and can be molded or extruded into the desired shape. Since there are no defining AWWA or ASTM standards for specific elastomers used in the waterworks industry, it is important for design engineers to understand the chemistry, properties and test methods associated with elastomers when selecting and specifying their use.

Some of the common elastomers identified for use in waterworks service include:

- Polyurethane
- Neoprene (Chloroprene)
- Chlorosulfonated Polyethylene
- Ethylene Propylene Diene Monomer (EPDM)
- Fluorcarbon (FKM)
- Butyl (Isobutene Isoprene)
- Nitrile (Acrylonitrile Butadiene)
- Synthetic Natural Rubber (Polyisoprene)
- Styrene Butadiene (SBR)
- Silicone (Polysiloxane)

ASTM International publishes a classification system of the properties of vulcanized elastomeric compounds in Standard ASTM D2000. The system is used to categorize rubber products based on their characteristics such as resistance to oil exposure. Basic requirements are established for each type and class along with additional requirements to reflect the intended purpose of the material. A "line call-out" is used to specify the properties of the material so that properties are easily understood. For example, a typical line call-out for a Nitrile compound can be:

M-4-B-G-7-14-A13-B13-C12-EA14

Where:

M	=	SI unit Designation
4	=	Suffix grade of material
B	=	Material Type based on heat resistance (B = 100°C)
G	=	Material Class based on oil resistance (G < 40% swell)
7	=	x 10 is Type A durometer hardness +/-5
14	=	Tensile strength (MPa) (2031 psi)
A13	=	Heat Resistance Test at 100°C
B13	=	Compression Set Test at 100°C
C12	=	Ozone Resistance Test
EA14	=	Water Resistance Test

Table 1. Common elastomers (adapted from the AWWA Manual of Practice, M75)

Elastomer	Common Uses	Normal Temp. Rating	ASTM D2000 Designation Type, Class
Polyurethane	Water, ozone, hydrocarbons, greases	175°F 80°C	BG
Neoprene	Water, salt water, wastewater, greasy waste, UV light	240°F 110°C	BC, BE
Polyethylene	Water, oil, grease, ozone and outdoor service, UV light	255°F 125°C	CE
EPDM	Water, salt water, wastewater, elevated temperatures, outdoor service, UV light, dilute acids, dilute alkalis, ketones, acetone, alcohol	300°F 150°C	BA, CA, DA
FKM	Water, salt water, wastewater, most chemicals and solvents, aromatic hydrocarbons and fuels, chlorinated hydrocarbons, high temperatures	390°F 200°C	HK
Butyl	Water, salt water, wastewater, low permeability, outdoor service	230°F 110°C	AA, BA
Nitrile	Water, salt water, wastewater, refined petroleum hydrocarbons, chlorinated solvents, fats, greases	250°F 120°C	BF, BG, BK, CH
Natural Rubber	Water, salt water; not for use with residual disinfectants or hydrocarbons and chlorinated solvents	212°F 100°C	AA
SBR	Water, salt water, wastewater; not for use with hydrocarbons and chlorinated solvents	212°F 100°C	AA, BA
Silicone	Water, salt water, wastewater, outdoor service, hot air, electrical insulation.	420°F 215°C	FC, FE, GE

By referencing the ASTM D2000 specification, an engineer can specify the test requirements and specifications for a particular elastomer type and class of rubber compound. Some of the typical properties of the listed elastomers are given in Table 1.

SELECTION OF ELASTOMERS

When selecting an elastomer, consideration should be given to the cost, function of the elastomeric part and environmental conditions. Each elastomer will have a temperature rating at which point some mechanical properties of the elastomer will be degraded. The chemical environment is evaluated with knowledge of the chemical concentration, length of exposure and the surface area of the elastomeric part. Certain pipe gaskets may degrade with exposure to groundwater contaminants, but because of their design, only a small surface of the gasket may be directly affected. It is also important to understand the failure mode of the elastomeric part. A butterfly valve seat may be damaged if it is subject to significant swelling in service. A valve diaphragm must retain its strength and strain ability throughout its life. Chemical resistance guides for elastomers are readily available to evaluate elastomers in various chemical environments.

In addition to resistance to chemical and temperature effects, the designer must understand the physical properties of elastomers. On a mechanical basis, elastomers must resist excessive distortion, tear, aging and permanent set while subjected to various pressure, compression and shear load requirements. Once the seal designer quantifies the load and stress condition, the characteristics of various elastomers can be evaluated. Elastomers can be formulated with various additives and chemicals and cured to varying process parameters to achieve the desired strength requirements. The resultant mechanical strength, elasticity and chemical stability can vary widely between elastomers.

To assist the designer in selecting a compound, several standardized tests have been developed to specify and measure various strength properties of elastomers. For example, pipe gaskets are tested for tensile strength, ultimate elongation, compression set and hardness. Each of these properties are quantified using specific ASTM test methods. Elastomers can be produced in different hardness and tensile strength to work at low pressure or high pressure. Figure 2 illustrates some of the common hardness scales used to measure elastomers.

STORAGE OF ELASTOMERS

Elastomers in products undergo changes in their physical properties over time, including excessive hardening, softening, cracking, crazing or other surface degradations. These changes may be the result of a single factor or a combination of factors, such as the action of oxygen, ozone, sunlight, heat, humidity, oils, water or other solvents.

Proper storage methods can increase the life of elastomers in storage. New products should be stored indoors or covered before installation. Exposing elastomeric seals to outdoor conditions with ultra-violet sunlight or ozone and elevated temperatures can rapidly degrade the elastomers. The ideal storage temperature range is between 40°F (4°C) and 80°F (26°C). Lower or freezing temperatures are

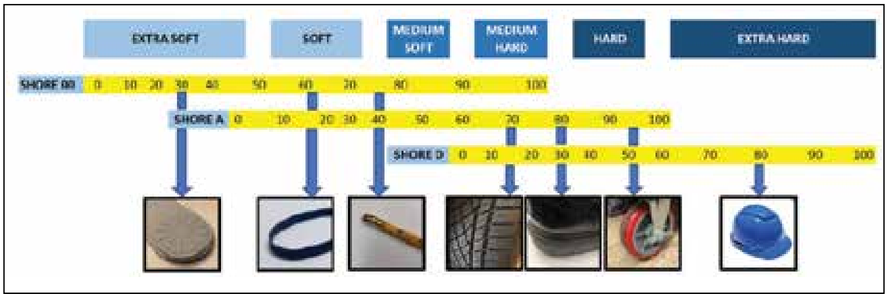

Figure 2. Shore Hardness Scales for elastomers

typically not deleterious to the elastomers. Similarly, humid environments are acceptable.

If products containing elastomeric seals must be stored outside, they should be secured with flange covers and dark-colored shrink wrap to minimize exposure to the elements and keep the parts free from debris. It is recommended to store elastomeric parts in the relaxed condition. Therefore, depending on the design, products containing elastomeric seals are typically shipped in the partially open position. Parts should not be stored near ozone generators, including electric motors, mercury vapor lamps and high-voltage equipment.

CONCLUSION

With the proper selection and care of equipment containing elastomers, you can expect decades of service for the products. M75 provides a basic understanding of elastomers for the waterworks service industry along with detailed descriptions, common uses and temperature ratings for each of the listed elastomers. When selecting elastomers, resistance to certain chemicals should be considered, and a chemical resistance guide is furnished. This manual provides the water industry the knowledge needed to safely advance the use of elastomers in the industry. VM

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