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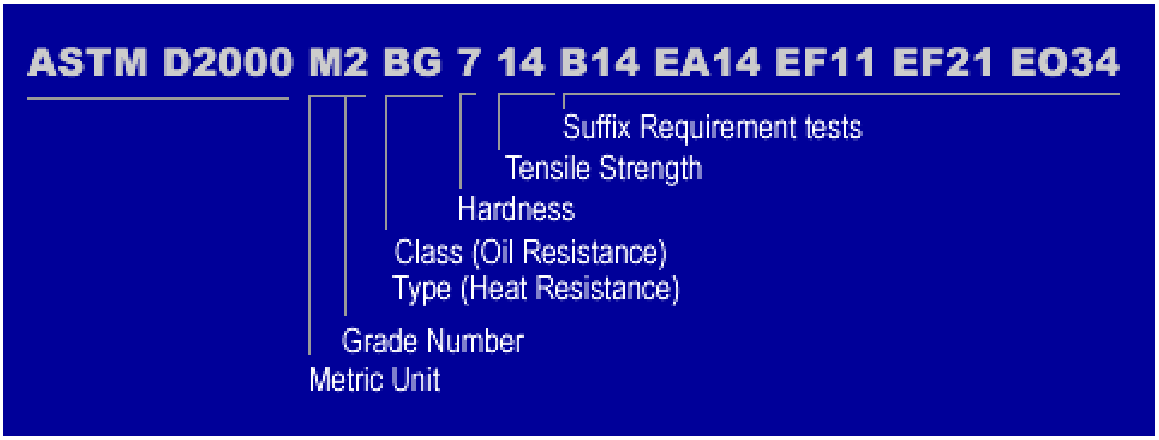
American Society of Testing & Materials (ASTM) provide a standardized method of calling out the required physical properties of a rubber product, based primarily on its Type and Class.



Specifications for physical properties of elasomeric seals can be very general or extremely specific in nature. Probably the most common general classification system is ASTM D 2000 Standard Classification System for Rubber Products in Automotive Applications. The purpose of this classification system is to aid in the selection of practical rubber products for specific environments. It also provides a line call out designation for the specification of materials.

Rubber materials are designated by Type (Heat Resistance) and Class (Oil Resistance). The heat resistance of an elastomer is based on changes in tensile strength of not more than ± 30%, elongation of not more than 50%, and hardness of not more than ± 15 points after 70 hours of aging at the specified temperature. The oil resistance is based on the volume swell of an elastomer after a 70 hour immersion in ASTM Oil No. 3.

ASTM D2000 Material Designation (Type & Class)

AA	Butyl, SBR, Natural Rubber	DA	Ethylene Propylene
AK	Polysulphide	DF	Polyacrylate
BA	Butyl, Ethylene Propylent	DH	Polyacrylate, HNBR
BC	Neoprene® (Chloroprene)	EE	Vamac® (Ethylene Acrylic)
BE	Neoprene® (Chloroprene)	EH	Polyacrylate
BF	Nitrile	FE	Silicone
BG	Nitrile, Urethanes	FK	Fluorosilicone
BK	Nitrile	GE	Silicone
CA	Ethylene Propylene	HK	Viton® (Fluoroelastomers)
CE	Hypalon	KK	Perfluoroelastomers
CH	Nitrile, Hydrin		

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ASTM D2000 Suffix Letter and Numbers

The suffix letter denotes the test method, the numbers indicate the temperature and parameters of the test

		Suffix Letter A, B, C, E, G, K, & L	
A	Heat Resistance	1	73F
B	Compression Set	2	100F
C	Ozone or Weather Resistance	3	158F
EA	Fluid Resistance (Aqueous)	4	212F
EF	Fluid Resistance (Fuels)	5	257F
EO	Fluid Resistance (Oils and Lubricants)	6	302F
F	Low Temperature Resistance		
G	Tear Resistance	For Suffix Letter F	
J	Abrasion Resistance	4	0F
M	Flammability Resistance	5	-13F
P	Staining Resistance	6	-31F
Z	Special Requirements	7	-40F
		8	-58F
		9	-67F
		10	-85F
		11	-103F

Suffix Requirement tests
These indicate the additional testing requirements needed to satisfy this specification callout. Each requirement is comprised of a suffix letter, calling out the property being tested, and the suffix numbers, which call out the the test method and test temperature. Z (if added at the end) suffix tests denote a customer added or specific test that is not necessarily covered by the D2000 document.

M
If the M is present, the unit of measure is expressed in Metric units. If the letter M is not present however, the unit of measure is in English units (as in psi for the tensile strength). Prior to 1980, all ASTM specifications were in English units. Beginning in 1980, the Metric unit callouts became the standard.

Grade Number
The Grade Number designates instances where more extensive tests are required. Any grade other than 1 mandates additional requirements that are spelled out in Table 6 of the D2000 document.

Type
Indicates the Heat Resistance properties of the elastomer.
A 70C 158F
B 100C 212F
C 125C 257F
D 150C 302F
E 175C 347F
F 200C 392F
G 225C 437F

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H 250C   482F
J 275C   527F

Class
Indicates the Oil Resistance properties of the elastomer as measured by volume swell under test procedures

Volume Swell, Max. %
A No Requirement
B 140
C 120
D 100
E   80
F   60
G   40
H   30
J   20
K   10

Hardness
The Shore A Durometer hardness requirement of the elastomer. In this case the 7 calls out 70 +/- 5 Durometer.

Tensile Strength
This indicates the minimum tensile strength of the elastomer. If the designation has an M after the Revision Year, then this callout is stated in Metric units, megapascals (MPa). If no M is present, then the callout is specifying the English unit, pounds-per-square inch (psi). In this example, the 14 is calling-out 14 MPa. The conversion to psi is: MPa x 145 = psi. Therefore, the psi Tensile Strength requirement of this designation is 14 x 145 = 2030 psi.
Tensile strength is the maximum tensile stress reached in stretching a test piece (either an O-ring or dumbbell).

Tensile tests are used for controlling product quality and for determining the effect of chemical or thermal exposure or an elastomer. In the latter case, it is the retention of these physical properties, rather than the absolute values of the tensile stress, elongation or modulus, that is significant.

Elongation:
The strain, or ultimate elongation, is the amount of stretch at the moment of break.

Modulus:
Also called "Mod 100" This is the stress required to produce a given elongation. In the case of "Mod 100", the modulus would be the stress required to elongate the sample 100%. In elastomers, the stress is not linear with strain. Therefore the modulus is neither a ratio nor a constant slope, but rather denotes a point on the stress-strain curve.

Test Methods:
ISO 37
ASTM D412
Elastomers are often treated as incompressible materials for analytical convience. However, in many instances the compressive response of elastomers is very important.

Bulk or Static Modulus.
The bulk modulus is a property of a material which defines its resistance to volume change when compressed. It can be expressed as:

K = p/ev

Here p is the hydrostatic pressure, ev is the volumetric strain and K is the bulk modulus. In practice, a positive volumetric strain is defined as a decrease in volume. Measuring a material's strain response to an applied pressure is a simple test for bulk modulus. The bulk modulus can be expressed as the derivative (slope) of the pressure-strain curve.

Relationships between Young's modulus E, the shear modulus G, and Poisson's ratio v are related by:

E = 3 K (1 - 2v)

E = 2 G (1 + v)

Test Methods:

ISO 7743

ASTM D575

Rebound Resilience. When a pendulum hammer impacts a rubber specimen from a certain distance or angle, the degree or distance that the pendulum does not return is an indication of the energy lost during the deformation.

Test Methods:

ISO 4662

ASTM D1054, D2632

Compression Set:

Elastomer compression set is a measurement of the ratio of elastic to viscous components of an elastomer's response to a given deformation. Longer polymer chains tend to give better "set resistance" because of the improved ability to store energy (elasticity).

Elastomer compression set measurement standards call for a 25% compression for a given time and temperature. The cross-section is measured after the load is removed. Elastomer compression set is the percentage of the original compression (25%) that is not recovered. This test may be conducted on cylindrical disks or O-rings. At the end of the test, the samples are removed and allowed to cool at room temperature for 30 minutes before measuring. After a load is released from an elastomer, the difference between the final dimensions and the original dimensions is considered the compression set.

The use of elastomer compression set measurements is most beneficial for production quality control, indicating the degree of curing. Elastomers with high compression set values may require special considerations for gland design and handling. Elastomer compression set is a relatively simple test to perform, and as such, may not yield the type of predictive information desired for custom sealing applications.

When a constant load is placed on an elastomer, the deformation is not constant, but rather it increases gradually with time. Terms used to describe this behavior are relaxation or creep. These properties, including compression set, are a result of physical (viscoelastic) and chemical (molecular structure) changes in an elastomer.

Test Methods:

ISO 815 (Ambient & High Temp.)

ISO 1653 (Low Temp.)

ASTM D395 (Ambient & High Temp.)

D1229 (Low Temp.)

Stress Force Retention:
Elastomers are viscoelastic in nature. When deformed, energy storage is always accompanied by some energy dissipation. The entanglements of the long elastomer chains act as obstructions to the movement of the polymer chains. These obstructions enable the elastomer to store energyâ€"an elastic property. The rearrangements of the polymer chains are dependent on the specific chemical structure, time, temperature and deformation rate. Since elastomers are viscoelastic, the stored energy decreases over time. This decrease of the stored energy (seen as contact sealing force) over time is known as stress relaxation. In other words, stress relaxation is the change in stress with time when the elastomer is held under constant strain.

Common instruments for measuring stress relaxation are Lucas and Wykeham Farrance. There are three standard methods:

Method A - compression is applied at test temperature and all
force measurements are made at test temperature.
Method B - compression and force measurements are made at ambient temperature.
Method C - compression is applied at ambient temperature and all force measurements are made at test temperature.

The three methods do not give the same values of stress relaxation. The resulting force measurements in all methods can be normalized to the initial counterforce, and expressed as a Retained Sealing Force percent.

Test Methods:
ISO 8013 - Creep Strain Relaxation
ASTM D412 - Creep Strain Relaxationâ€"Tensile Properties
ISO 3384 - Stress Relaxation

Shear Modulus:
The shear modulus is an important property in design calculations for elastomers used in shear. The test methods typically require that the test sample be bonded to metal plates. The resulting ratio of the shear stress to shear strain is the shear modulus.

Test Methods:
ISO 1827

Tear Strength:
For considerations of removing a molded part from the production mold, or for determining the ease of which a tear can start and propagate in application, tear strength is an important property. Different test methods use different shapes and methods for applying a tearing force.

Test Methods:
ISO 34, 816
ASTM D624

Dynamic Stress-Strain:
In cyclic or dynamic applications, the viscoelastic properties of elastomers are very important. Lost energy, in the form of heat, arises from molecular friction as a result of an applied load. The percentage energy loss per cycle is known as hysteresis. When the loading and unloading cycle continues, the shape and position of the hysteresis curve changes.

The response of a specimen to a sinusoidal deformation can best exhibit the dynamic properties of an elastomer. The elastic component of the elastomer is responsible for the in-phase stress, while the viscous component is responsible for the out-of phase stress. The amount by which the strain response lags the resultant of the two stresses (in-phase and out-of-phase) is known as the phase or loss angle, °. The more viscous an elastomer, the greater the phase or loss angle. The

Bulk or Static Modulus.
The bulk modulus is a property of a material which defines its resistance to volume change when compressed. It can be expressed as: tangent of this angle "tan °" in the simplest terms, is the ratio of the viscous modulus to the elastic modulus.

Abrasion:
Resistance to wear may be a very important property in many applications. Standard test methods use a uniform abrading material and application. Abrasion is a measure of the amount of material lost in these tests.

Test Methods:

ISO 4649 (ISO), 5470 (Taber)
ASTM D394 (Du Pont), D1630 (NBS),
D2228 (Pico), D3389 (Taber)
Coefficient of Friction:
The coefficient of friction is the ratio of the frictional force between two bodies, parallel to the contact surface, to that of the force normal to the contact surface. Breakaway friction is the threshold friction coefficient as motion begins, and running friction is the steady-state friction coefficient as motion continues.

Volume Resistivity:
The measure of electrical resistance through a volume of elastomer. This property is useful in predicting conductive or antistatic behavior.

ASTM D991

Dielectric Constant (Permittivity):
The ratio of the capacitance of a capacitor filled with the elastomer to that of the same capacitor having only vacuum as the dielectric.

ASTM D150
Dielectric Strength:
The measure of the ability of an elastomer to resist current flow when a voltage is applied.

ASTM D149
Adhesion: The use of bonded elastomer-metal or elastomerplastic assemblies typically requires the use a bonding agent and surface preparation. Care must be taken in selecting a bonding agent which will be compatible with the process chemistry and/or temperature. Specific tests are available to determine the strength of the adhesive bond.

Radiation: Exposure to radiation may cause additional cross-linking or degradation. While the type of radiation and energy is very important, gamma radiation is considered typical exposure for most elastomer testing. At 10 Mrad dosages, moderate damage will occur to the physical properties (>40% change).

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