



**COOPER STANDARD
INDUSTRIAL & SPECIALTY GROUP
SEALING DESIGN GUIDE**

OUR INNOVATION. YOUR ADVANTAGE.

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ABOUT COOPER STANDARD ISG

Cooper Standard Industrial and Specialty Group (ISG) supplies a wide range of industries with sealing systems, fluid transfer systems and fuel and brake delivery systems.

We are a single-source supplier of rubber, plastic and innovative material platforms with the ability to produce custom extruded and molded sealing products.

Cooper Standard ISG works with our customers to solve problems, providing custom engineered solutions and standard parts that will meet our customers' toughest challenges.

www.cooperstandard-isg.com

HOW TO USE THIS GUIDE

Polymer products may be shaped into their final form by either an extrusion or molding process.

This guide is intended to give design engineers the basic facts needed to begin designing effective extruded and molded polymer seals.

It is not intended to provide every piece of information available on the processes of extrusion and molding; the amount of information available is simply too great.

However, we hope that this guide will serve as a starting point and provide engineers with the necessary information to better understand what they need to consider during the design process.



EXTRUSION PROCESSES

Rubber Extrusion

In the extrusion process, the rubber compound, which includes the polymer, fillers and additives such as pigments, curing agents, antioxidants and processing aids, is fed into an extruder.

The extruder consists of a rotating screw inside a close-fitting heated barrel. The purpose of the extruder is to soften and pressurize the rubber as it is continuously transported to a die head containing a specific part profile at the extruder exit.

Typical extruded rubber products include continuous sheets, tubing, specific part-profiles for seals/gaskets and weatherstripping.

The die is a metal head that is attached to the end of the extruder. Each die consists of an individually machined part-profile opening specific to every seal or gasket. Pressure, built up by heat and the rotating screw, forces the rubber through the die opening—forming it into one continuous profile that has been previously machined into the die.

When the rubber shape (extrudate) exits the die, the material swells so that the part cross-section is larger than the die cross-section. This phenomenon is called “die swell” and depending on the rubber formulation and the extrusion conditions, the dimensions of the extrudate may be increased by several percent to several hundred percent beyond those of the die. For circular cross-sections (i.e. circular cords), the rubber does not swell uniformly in all directions.

After exiting the die, the rubber extrudate passes through a cure media (e.g. salt bath, hot air, microwave IR), causing the rubber’s chemical structure to cross-link and giving the rubber its elastic properties. This process is known as vulcanization. Upon emerging from the vulcanization chamber, the extrudate is cooled, giving the rubber its final shape.

Sponge Rubber

Sponge rubber, also called “expanded” or “cellular” rubber, is extruded by including a gas-forming ingredient (blowing agent) in the rubber formulation.



During the cure process, the extrudate reaches a temperature at which the blowing agent decomposes and gas bubbles form, creating individual cell structures in the rubber. The rubber is then continuously cured until it is vulcanized.

The vulcanization process preserves the cell structure formed by the gas in the interior of the extruded part. However, the surface of the extruded part is smooth, without exposed cells and is referred to as a “skin.”

Sponge rubber may have an “open cell” structure in which each cell is connected to other cells, providing a continuous gas pathway throughout the part. The sponge may also have a “closed cell” structure in which each gas cell is completely surrounded by rubber, thus isolated from all other cells. (See pages 21–22 for more information).

Co-extrusion

Variations of the basic extrusion process exist. In co-extrusion, softened rubber streams from two (or more) extruders that are connected by a single die, permitting features such as two colors, a sponge/dense combination or a dense/dense combination. Rubber can also be co-extruded with a metal carrier.

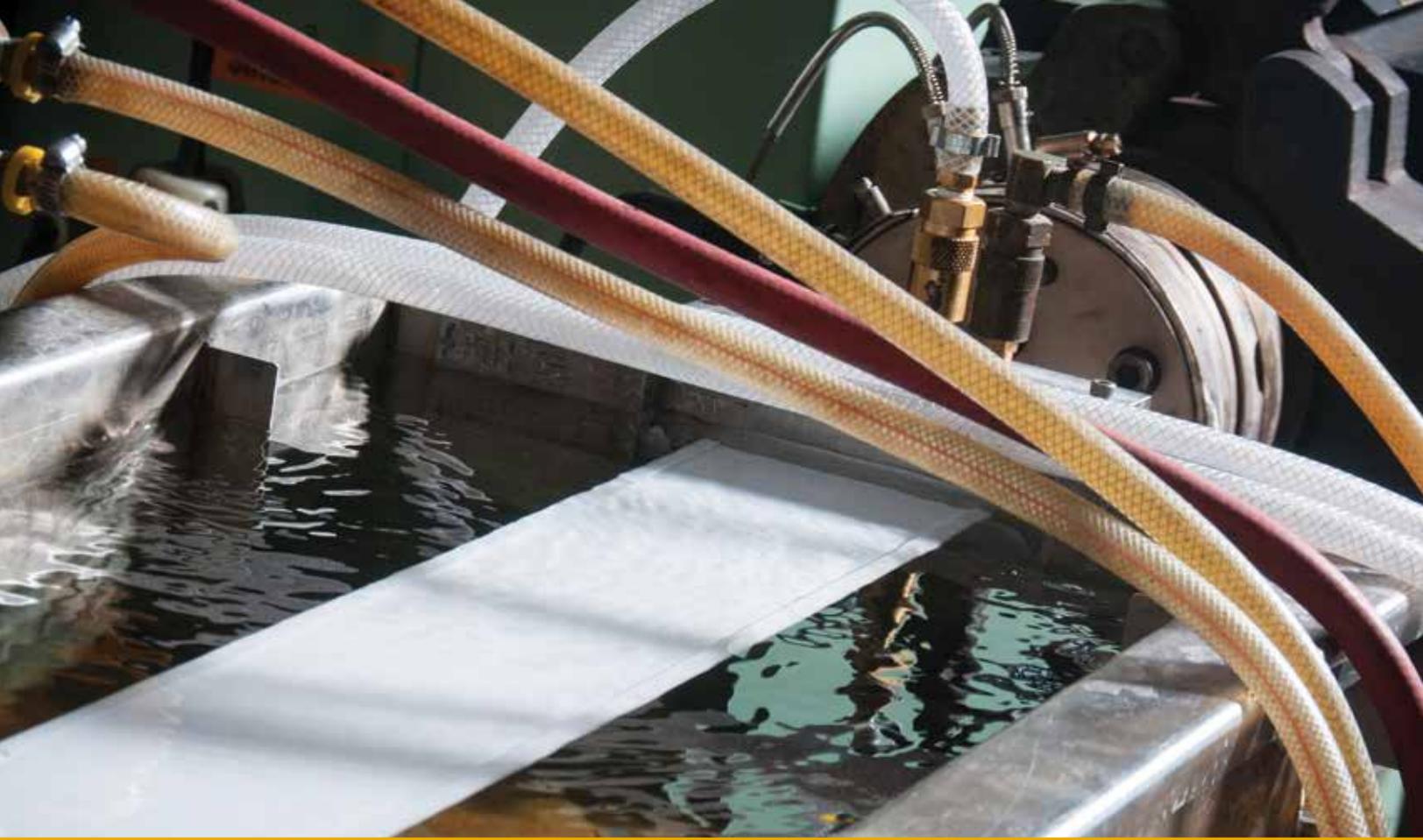


(a) Open Cell



(b) Closed Cell

Schematic views of the gas structural elements of a typical sponge: (a) open gas structural element; (b) closed gas structural element.



Plastic Extrusion

Similar to the rubber extrusion process, plastic extrusion involves forcing a resin through a die to form a consistent cross-section. Prior to reaching the die, the plastic material is melted by the heat generated from the rotating screw within the extruder.

The plastic profile is immediately cooled using a cooling bath or air rack upon exiting the die, giving the profile its final shape. It then may undergo a wide range of additional processes such as drilling, die-cutting or assembly. Compatible materials may be co-extruded to create dual- or tri-durometer extrusions that offer dynamic performance properties.

Resins can be designed to produce profiles that are extremely rigid or have physical properties that resemble rubber.



MOLDING PROCESSES

Polymer products may also be shaped into their final form through a molding process. In this process, the final shape of the end product, such as a ball, is determined by the shape and contour of a mold cavity.

Molding is used when the final product needs to be conjoined and transitional between planes, as opposed to the continuous, non-transitional profile of an extruded product.

Mold Types

There are three basic rubber molding processes used to shape polymer products: compression, transfer and injection. Other forms of molding, such as bladder molding, are variations of the three basic types.

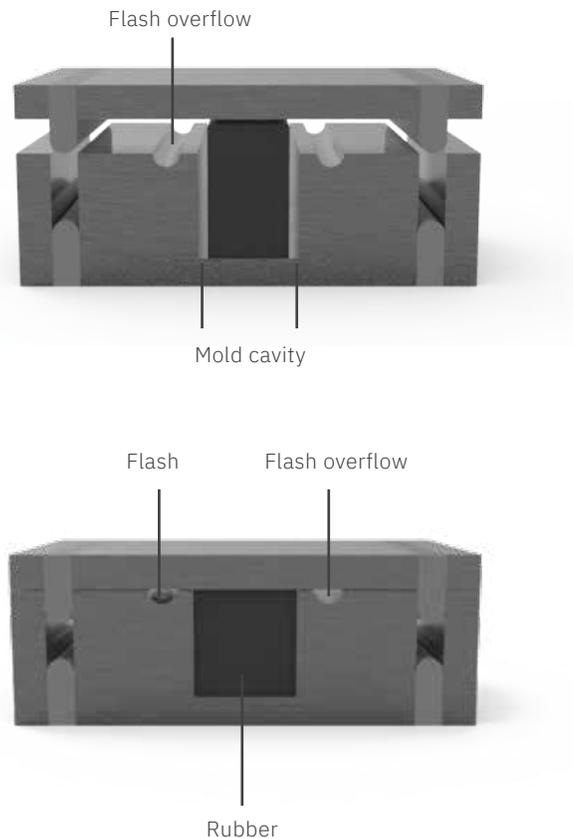
On the following pages are examples of common molding processes.

Compression Molding (Rubber)

Compression molding takes place as two plates of a mold are forced together. A slightly oversized rubber preform (raw compound) is shaped to approximately fit into the mold cavity. When the plates are squeezed together, the preform is compressed and forced to conform to the mold cavity.

A molding press is used to provide the necessary force to close the mold. Excess material, or flash, that squeezes out is pushed into overflows and/or tear trims and later trimmed off. Once the curing or vulcanizing process is complete, the mold is opened and the molded product can be removed.

Compression molds come in a variety of shapes and sizes. The cavities can range from very simple to very complex, and a single mold may contain up to 360 cavities, depending on the size of the press and part.



Injection Molding (Rubber and Plastic)

Injection molding is similar to transfer molding in that the material is forced into a cavity through sprues.

The most significant difference is that the mold is not forced together, rather the mold halves begin the process clamped together. Once the mold is clamped, preheated material is forced into runners that then flow to the sprues and into the mold cavity.

Depending upon the complexity of the injection molding machine and the number of cavities, the mechanism used to inject the material can be a ram device or a screw-type device. As with other molding processes,

once the curing process is finished, the mold can be opened and the part removed. Injection molds must be able to withstand very high pressure—as much as 10 times that of compression or transfer molds—without distorting.

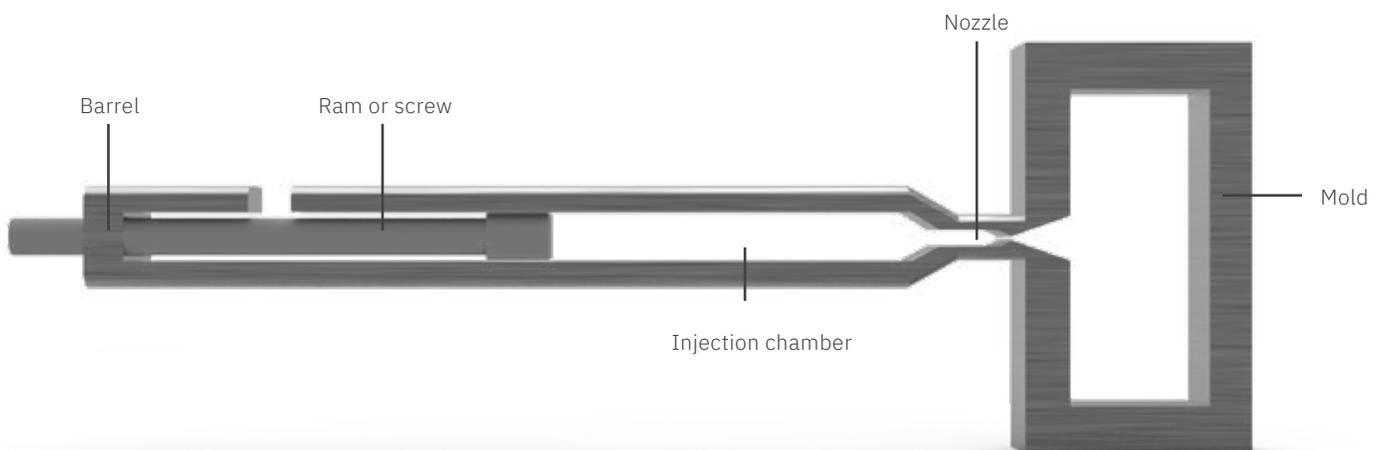
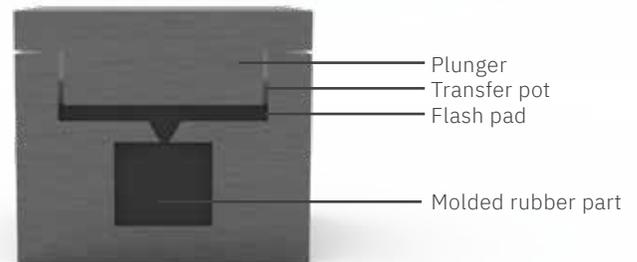
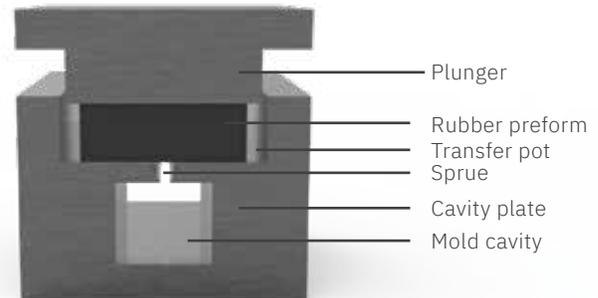
Injection molding can be combined with compression or transfer molding. Both injection/compression and injection/transfer molding processes deliver shorter cycle times than regular compression or transfer molding due to the fact that material entering the mold is preheated and therefore vulcanizes more quickly.

Transfer Molding (Rubber)

A unique attribute of transfer molding is that a rubber preform is heated and forced by a plunger through a funnel-shaped opening, or sprue, into the mold cavity.

As with any rubber molding operations, molds can vary greatly in shape, size and complexity and can be multi-cavity. However, transfer molding helps keep direct flash (the excess rubber that is forced out of the mold itself) to a minimum.

Most of the excess rubber is contained in the flash pad, on the far side of the sprue, away from the finished part. Once the vulcanizing process is completed, the mold can be opened and the part removed.







Additional Molding Applications

Molded End Details

(a) are an advanced process of molding rubber or plastic material around or conjoined to a polymer extrusion, metal or other component. Proper tooling enables this complex process to work for tight tolerance requirements. This procedure requires the selection of compatible materials in order to achieve superior physical and chemical bonding.



Molded Corners

(b) yield the ultimate protection against leaks. Rubber is injected under high pressure to bond the two pieces into a complete corner. This creates a strong bond and superior seal performance.



Overmolding

(c) is a process in which an elastomer is vulcanized and bonded directly to the metal or plastic substrate creating a robust bond. Many of the rubber/metal bonded products are used to isolate noise and vibration in applications such as medical, electronics, industrial and aerospace.



Pictured Left: Rubber Part Before Molded End Detail is Added via Compression Mold

Pictured Right: Rubber Part After Molded End Detail is Added





DESIGN CONSIDERATIONS

There are three items that should be considered when selecting a material:

1) Sealing Environment

Typically, the first consideration in the material selection process is the sealing environment.

- Will there be high or low temperatures present?
- Does the application require fluid resistance?
- Is the sealing application static or dynamic?
- Will the material be required to stand up against UV and ozone exposure?

Once these questions are answered, it becomes easier to match the right material to the application.

2) Material Characteristics

While there are significant differences between plastic and rubber, these materials have many overlapping performance properties. Therefore, it's important to consider which characteristics are needed in a given application.

If rigidity or impact resistant properties are required, plastic may be the better option. In dynamic applications where compression set properties are important, rubber is often preferred.

If a plastic material is desired, engineers should evaluate whether the seal needs to be flexible or rigid. Flexible plastics are better suited for dynamic applications, while rigid plastics perform better in static applications.

For rubber materials, another design consideration to determine is whether an application calls for sponge or dense material. If the application requires a low closing force or reduction in weight, then sponge is most likely best suited. If a seal must adhere to strict tolerances, dense rubber is generally the better choice.

Cooper Standard ISG's design team can provide expertise to optimize material performance properties while meeting material cost requirements.



3) Value-added Operations

What needs to be done to the product to make sure it is properly situated for the next stage of manufacturing?

Is it more efficient to perform these operations now or later?

Some of these value-added services include:

ADHESIVE SYSTEMS

In many cases, the use of an adhesive system can provide a fast, efficient way of attaching seals and gaskets to the end product and improve aesthetics, cost, weight and productivity during final assembly. (See pages 27–32.)

SPLICING / WELDING

Designed for applications that require a continuous seal—from a multi-sided frame to an o-ring. (See page 33).

CUTTING

Cutting processes include linear and angle cutting as well as die-cutting.

LOW-FRICTION COATING

Slip-coating or flocking for friction reduction can help avoid creaking, rattling, breaking and deicing of the final product and improve aesthetic appeal.

MOLDED DETAILS

These design features provide a way of transitioning around corners, joining dissimilar cross-sections/ profiles or allowing complex 3-dimensional shapes to be molded onto the end of an extrusion. (See page 10).

COLOR MATCHING

Colors are often used for cosmetic purposes of the end product. They also can be used for color coding or for placement indication into a final assembly.

Depending on the material and the pigment required, color matching can require additional development time and costs.



DESIGN CRITERIA

There are several things to know about the application to properly determine a good cross-sectional design.

1) How will the seal be attached to the substrate or used in the application?

COMPRESSION FIT APPLICATION DESIGN

When designing compression fit applications, it is necessary to have a 30–40 percent compression in the channel for sponge sections to hold the seal in place. By the same token, for dense sections, up to 10 percent compression is necessary to hold the seal in the channel. As before, this is somewhat dependent upon the application, such as the size of the channel itself and the direction from which the load is applied.

ADHESIVE ATTACHMENT APPLICATION

The attachment surface should always be wider than 0.2 inches to ensure secure attachment. For dynamic sealing situations, the minimum strip of adhesive should be at least two-thirds (0.667) of the width of the cross-section for seals up to 1-inch wide. For static situations, all that is needed is enough adhesive to hold the seal in

place until the mating substrates are joined.

In addition, the adhesive placement should be on flat surfaces on both the seal and substrate. Transfer adhesives generally perform better than supported adhesives (adhesives that use a carrier) when it comes to bending around radii.

On the other hand, supported adhesives help prevent stretching of the seal during application better than transfer adhesives. The thickness of the adhesive itself should be taken into consideration when determining the overall height of the profile.

MECHANICAL SEAL ATTACHMENT APPLICATION

When designing seals that will be attached mechanically, accommodations must be made for the insertion of the attachment device (clip, nail, staple) to the seal. The attachment device either has to fit into the seal itself, or holes must be drilled in the seal to allow the insertion of the device. The seal design has to be such that the mechanical attachment device does not interfere with the compression of the seal.



2) What is the gap or opening that the seal is going to fit into and be expected to seal?

This includes both the minimum and maximum gap widths that exist in the application, taking into account tolerances of the enclosure and sealing material. In most cases, the amount of designed seal compression for sponge seals to be effective is 25–40 percent.

For dense materials, the general effective compression range is up to 10 percent. It is important to remember that the end-use always needs to be considered.

For example, there is significant difference between sealing a box to keep out dust and sealing a box to keep out moisture when it is submerged in 10 feet of water.

3) What is the closing force required for the application?

A seal requiring 50 pounds of force to seal will not work in an application where only 20 pounds of force is applied. The required force, the amount of surface area to be sealed, the type of material that is used and the size of the cross-section all need to be considered.

1) The direction in which the load is applied to the seal is also a critical factor. Very different results will occur if a 60° load is applied as opposed to a 90° load.

2) There are also ways to help reduce or control the total amount of load required to get a good seal:

- The shape of the cross-section can be changed, depending on how the load is applied.
- Holes or hollow sections can be introduced into the cross-section to help reduce the load required to compress the seal. For example, a dense “D” section will have a higher mechanical load deflection than one that has been “hollowed” out.

THE RIGHT MATERIAL

When selecting the best elastomer for an application, an engineer or manufacturer must be prepared to answer a series of questions about the physical, mechanical and chemical resistance properties required for the seal.

Unless the material specifications have been predesignated, gathering this information about the material's end use and the functional requirement of the seal in the application will help to ensure the material sustains its physical properties through temperature, environmental factors and time.

The best place to start gathering information is by taking a close look at what the application will require from the material. For replacement products, examine the properties and service conditions of the original material.

This information can provide the foundation for what properties are desired and what are not, in the new material. For new products, the properties of materials used in similar applications can provide valuable information.

Plastic vs. Rubber

For many applications, both plastic and rubber can be viable options for engineers. Considering both types of materials ensures you achieve the best performance for your project's needs.

A polymer expert or application engineer can help identify a material that will provide a balance of the desired properties for the end-use application.



The following checklist provides several characteristics that need to be taken into consideration when specifying a material.

PHYSICAL/MECHANICAL PROPERTIES:

- Tensile Strength and Elongation*
- Hardness Range (Dense) or Compression Deflection Requirements (Sponge)
- Compression Set at Room and Operating Temperatures
- UV, Ozone, Heat, Storage Requirements
- Color (If Color Matching is Desired or Necessary)
- Aesthetics
- Speed of Recovery from Deflection
- Flexibility
- Permeability to Gases and Liquids
- Flame or Temperature Extremes
- Tear
- Abrasion
- Density
- Impact Resistance (Plastics)

CHEMICAL RESISTANCE PROPERTIES:

- Acids or Caustics
- Hydrocarbon Solvents
- Oxygenated Solvents
- Fuels and Oils

* Primarily for dense material only



RUBBER MATERIAL SELECTION

The range of properties that can be developed for any given polymer is limited by the material itself and will vary within that range based on material formulation. All properties in a particular class are not found in a single material. However, it is often possible to raise or lower some ratings to acceptable levels through creative material design.

Selecting the best elastomer for an application is not always easy or clear cut, as temperature and other environmental factors can affect the long-term physical properties of a material. The best course is to seek a balance of properties desired for an application.

Information about the original material and service conditions can help when seeking a replacement material for an existing product. For new products, our experience with similar applications can be helpful.

The following pages include brief descriptions of rubber and plastic polymers and their respective performance properties. These materials can meet the majority of sealing needs. For polymers not listed here, including specialty and high-tech materials, please contact

a Cooper Standard ISG sales representative at www.cooperstandard-isg.com/contact.

Silicone (Polysiloxane) features excellent resistance to ozone, sunlight and oxidation and is very color stable. It maintains excellent flexibility at low temperatures, has outstanding resistance to high heat, low compression set and is a very good electrical insulator.

Silicone is not recommended for applications that require abrasion, tear and cut growth resistance, or high tensile strength. It is also not recommended for resistance to oil, gasoline, solvents, alkalis and acids.

EPDM (Ethylene-Propylene-Diene-Monomer) is found in a wide range of applications and is excellent for outdoor use. It is well known for its excellent ozone, weathering and aging resistance. It also has excellent water and steam resistance, maintains its flexibility at low temperatures, features excellent resistance to alkalis, acids and oxygenated solvents and is very color stable. EPDM is not recommended for resistance to oil, gasoline and hydrocarbon solvents.



Nitrile (Acrylonitrile-Butadiene) has very good oil, gasoline and abrasion resistance. Resistance to alkalis and acids increases as the nitrile content of the compound increases. Nitrile must be specially compounded for resistance to ozone, sunlight and natural aging. It has poor resistance to oxygenated solvents. Nitrile is superior to neoprene in oil and solvent resistance, but is not recommended for exposure to severe weathering.

Neoprene (Polychloroprene) is generally considered an excellent all-purpose elastomer with a solid balance of properties and few limitations. The polymer has moderate resistance to oils and gasoline. It features good flame resistance, weathers well and has very good resistance to abrasion, flex cracking, alkalis and acids. However, neoprene provides poor resistance to aromatic and oxygenated solvents and has limited flexibility at low temperatures.

SBR (Styrene-Butadiene-Rubber) has excellent impact strength, good resilience, tensile strength, abrasion resistance and maintains its flexibility at lower

temperatures. However, it is not recommended for resistance to oil, gasoline and hydrocarbon solvents. SBR materials are also not suitable for exposure to the outside elements, such as UV and ozone. Typical uses of SBR have been in tire treads, conveyor belt covers, mats and even shoe soles.

Fluoroelastomers provide premium performance and long-term reliability in very harsh and corrosive environments. Their exceptional resistance to heat, aging and a broad range of fuels, solvents and chemicals makes them ideal for many demanding aerospace, automotive and industrial applications.

Fluoroelastomers also offer excellent resistance to weather, ozone, oxygen and sunlight and are inherently more flame retardant than hydrocarbon rubbers. Fluoroelastomers have poor resistance to ketones, esters, ethers, amines and aqueous bases (i.e. ammonia and sodium hydroxide).

DENSE ELASTOMER PROPERTIES

	NATURAL RUBBER	SBR	EPDM	NEOPRENE	NITRILE	SILICONE	FKM	TPE*
CHEMICAL NAME	Polyisoprene	Styrene Butadiene	Ethylene Propylene Diene Monomer	Polychloroprene	Acrylonitrile Butadiene	Polysiloxane	Fluoroelastomers	Thermoplastic Elastomer

PHYSICAL PROPERTIES

SPECIFIC GRAVITY	0.93 to 1.15	0.94 to 1.20	1.00 to 1.20	1.10 to 1.40	1.00 to 1.30	0.95 to 1.20	1.40 to 1.95	0.20 to 0.98
DUROMETER, RANGE (A)	30-90	30-90	30-90	30-90	30-90	25-90	55-90	25-90
TENSILE STRENGTH	E	G	VG	VG	VG	F-G	VG	G
ELONGATION	VG-E	G	G	G	G	VG-E	F-G	G
COMPRESSION SET	G	G	G	F-G	G	G-E	G-E	F-G
HEAT RESISTANCE	F	F-G	VG-E	G	F-G	E	E	F
RESILIENCE OR REBOUND	E	F-G	G	VG	F-G	G	F	G
IMPACT RESISTANCE	E	E	G	G	F	P-G	E	VG
ABRASION RESISTANCE	E	G-E	G-E	G-E	G-E	P-F	F-G	F-G
TEAR RESISTANCE	E	F-G	F-G	F-G	F-G	P-F	F	VG
CUT GROWTH	E	G	G	G	G	P-F	P-F	P
FLAME RESISTANCE	P	P	P	G	P	F-G	VG-E	G
IMPERMEABILITY, GAS	F	F	F-G	F-G	G	F-G	E	G
WEATHERING RESISTANCE	P-F	F-G	E	VG	F-G	E	E	E
LOW TEMPERATURE LIMIT	-10° to -50°F	0° to -50°F	-20° to -60°F	-10° to -50°F	-10° to -30°F	-65° to -100°F	+10° to -40°F	-30° to -70°F
HIGH TEMPERATURE LIMIT	200°F	200°F	250° to 275°F	250°F	250°F	400° to 450°F	450°F	275°F

CHEMICAL RESISTANCE PROPERTIES

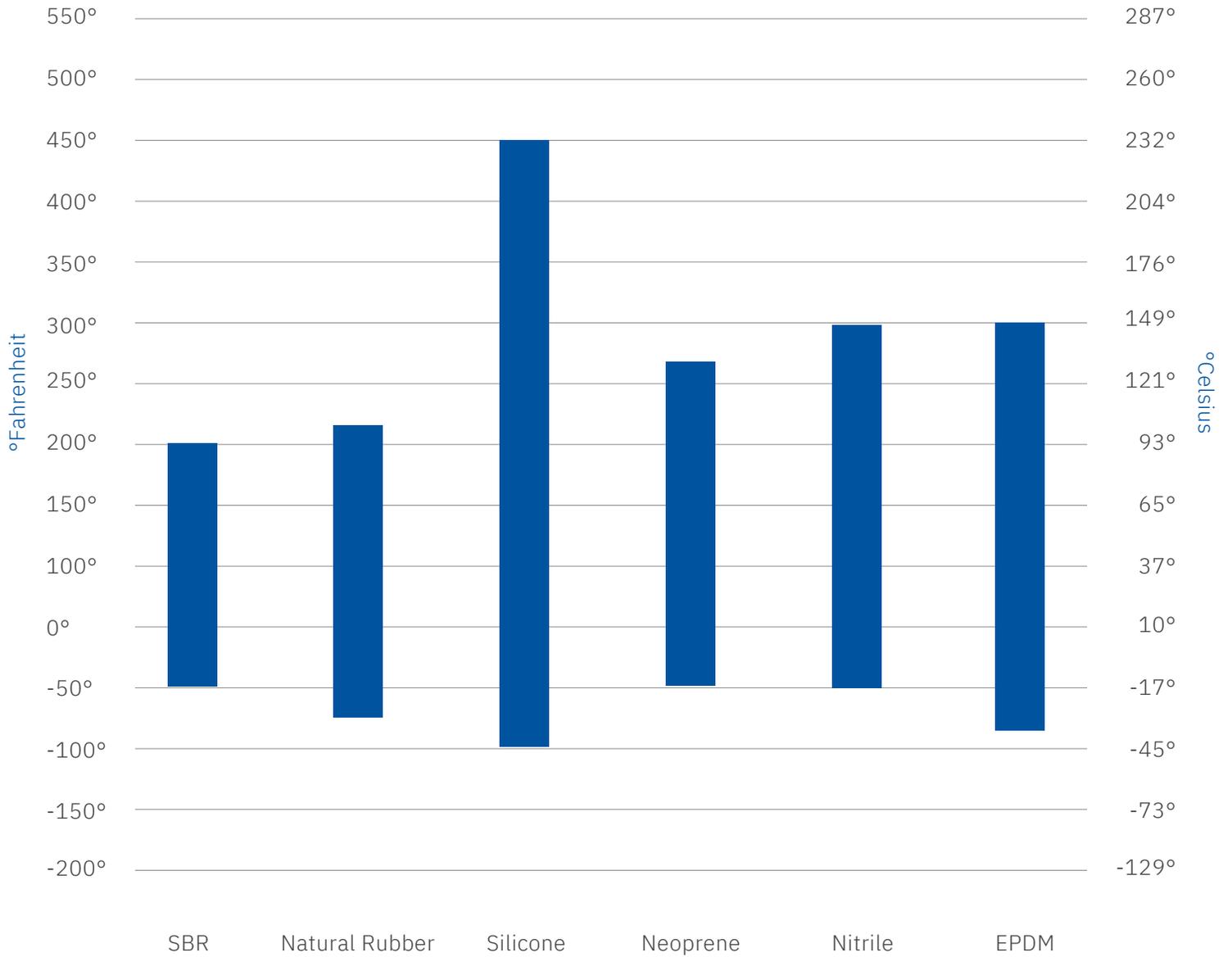
ACID	F-G	F-G	G	G	G	F	G	G
ALCOHOLS	G	G	F-G	VG	F-G	G	F-E	E
ALIPHATIC HYDROCARBON SOLVENTS	P	P	P	G	E	P-F	E	G
ALKALI	F	F	VG	E	VG	P	F-G	G
ANIMAL & VEGETABLE OILS	F	F	G	G	VG	G	E	G
AROMATIC HYDROCARBON SOLVENTS	P	P	P	P-F	F-G	P-F	E	P
OIL & GASOLINE	P	P	P	F-G	G-E	P-F	E	G
OXYGENATED SOLVENTS	G	G	VG	P-F	P	F	P	F
WATER	E	G-E	E	G	G-E	G-E	G	VG

Key: E=Excellent; VG=Very Good; G=Good; F=Fair; P=Poor

Product performance can vary based on compound formulation, product design and exposure to harsh conditions such as extreme temperatures or harmful fluids.

*TPE (thermoplastic elastomers) are materials that have comparable properties and performance to their rubber counterparts, but are processed like other thermoplastic materials. For more information, see page 25.

SERVICE TEMPERATURE OF ELASTOMERS





THE RIGHT SPONGE PRODUCT

Sponge vs. Dense Rubber

Sponge rubber is similar to dense rubber in many ways. It is made of basic polymers and can be affected by ozone, heat, sunlight, excessive cold, acids and oils. The difference is apparent in its construction and abilities.

A general sponge rubber consists of a base polymer, fillers, plasticizers and compounding agents.

As with all elastomer products, the specific abilities of each sponge rubber product depend on material design.

The addition of blowing or foaming agents create the sponge-like characteristics. Once activated, the blowing agent creates a gas that forms cells within the rubber. There are two different types of cells: open cell and closed cell.

Open Cell Sponge

Open cells are air pockets that do not contain cell walls, and in raw format offer little resistance to the passage of fluids. They are ideal for sound dampening and possess

strong cushioning characteristics.

Open cell sponge rubber is manufactured in sheets, molded strips and custom profiles. Open cell sponge sheets will frequently have a surface impression, since they are usually molded against a fabric surface that allows air to be vented during the expansion of the sponge.

Trapped air, which may affect the finish, is a universal problem of sponge manufacturing due to the fact that sponge molds are only partially filled with uncured rubber, allowing for expansion to fill the mold.

For this reason, long and/or complicated cross sections may require vents or multiple splices to reduce rejections. Open cell sponges are also available with skins through an extrusion process.

Molded strips will have open cells exposed at the ends unless otherwise specified. Die-cut parts will have open cells on all edges.



Closed Cell Sponge

Closed cell sponge rubber differs from open cell sponge in that the cells are individual and non-interconnecting. Expanded rubbers are manufactured in sheets, molded strips/custom profiles and profiles by molding or extruding.

Closed cell sponge is made by incorporating gas-forming ingredients in the rubber compound or by subjecting the compound to high-pressure gas such as nitrogen.

Sheets are generally made rectangular and of sufficient thickness for die-cutting. Typical applications for closed cell sponge include automotive, weatherstripping and architectural gaskets.



CLASSIFICATION OF FLEXIBLE CELLULAR MATERIALS

Cooper Standard Industrial and Specialty Group's sealing sponge products are identified by a three character classification (Example: 2A2). The three characters represent type, class and grade, and are defined as follows: Type, Grade, Suffix.

Type

Type 1 = Open Cell

Type 2 = Closed Cell

Class A = Non-oil resistant
(Example: EPDM)

Class B = Oil resistant, low swell
(Example: Nitrile)

Class C = Oil resistant, medium swell
(Example: Neoprene)

Class D = Extreme temperature resistant
(Example: Silicone)

Grade

Grade ratings represent compression deflection, or the amount of force in pounds per square inch to deflect the sample 25 percent of its height. They are listed as follows:

Grade 1 = 2 to 5 psi

Grade 2 = 5 to 9 psi

Grade 3 = 9 to 13 psi

Grade 4 = 13 to 17 psi

Grade 5 = 17 to 25 psi

Example Line Call Out for Sponge

ASTM D-1056 2C2 A1 B2 E1 Z1

(Z = Material passes FMVSS 302)

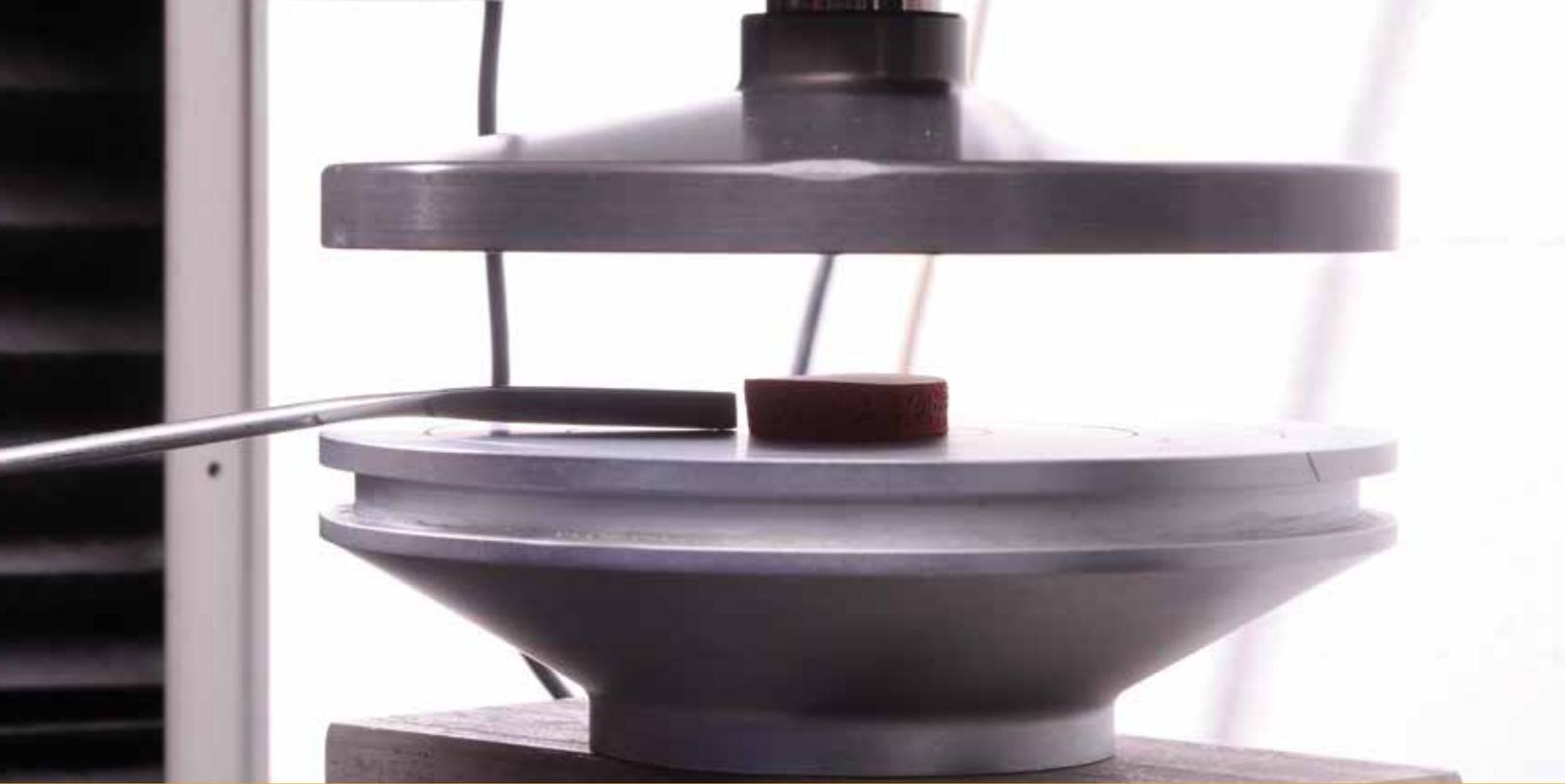
Suffix

Suffix numbers that follow the suffix letters denote different testing parameters or conditions for that suffix. Once testing is complete, a Line Call Out is assigned to the appropriate compound per specification requirements.

SUFFIX LETTER

TEST REQUIRED

A	Heat resistance
B	Compression set
C	Ozone or weather resistance
D	Load deflection
E	Fluid resistance
F	Low temperature resistance
G	Tear resistance
J	Abrasion resistance
K	Adhesion capability
L	Water absorption
M	Combustion characteristics
N	Impact resistance
P	Staining resistance
R	Resilience
T	Tensile elongation
W	Density
Z	Special requirements



UNDERSTANDING COMPRESSION TESTS

Compression Set

Compression set, as outlined in ASTM D-395 and D-1056, is the percentage by which a standard rubber test piece fails to return to its original thickness after being subjected to a standard deflection for a fixed period of time.

A compression set test is used to determine the quality of sponge and dense rubber compounds and their ability to perform in certain applications.

If the material has good compression set resistance, it will quickly recover when the load is released. It is not necessary for a material to have zero percent compression set to produce an effective, repeatable seal. If the seal is under constant compression, material recovery is not as important.

The compression set test has a different effect on closed cell materials versus open cell materials due to differences in cell structure.*

Compression Load Deflection

The Compression Load Deflection (CLD) test is a method that consists of gently compressing a sponge specimen at a controlled rate without impact, as outlined in ASTM D-1056. It measures the force required to compress a standardized test specimen to a deflection of 25 percent. The reported result is expressed in kilopascals or pounds per square inch.

Sponge compounds, whether open or closed cell, are classified by grades. Each grade is based on a specific range, as expressed by the CLD test. CLD provides engineers with standardization of load force for any given compound. They can then determine which grade of sponge will work best for a given application. Digits 1 through 5 on the previous page denote these grades.

*For more information, please contact Cooper Standard ISG at www.cooperstandard-isg.com/contact

PLASTIC MATERIALS

Plastic materials can be designed to meet many needs, including operating temperatures, UV resistance, coloration or opacity and flame resistance.

An important design consideration for plastics is whether the profile needs to be rigid or flexible. Rigid plastics work well for applications in which durability and impact resistance are important. Flexible plastics can be engineered to mimic the physical properties of rubber when those characteristics are desired.

PVC (Polyvinyl Chloride) ranges from rubbery soft to rigid. Flexible PVC is widely used for plastic profile extrusions because of its resistance to abrasion and ability to insulate. Flexible PVC is commonly used for impact resistant bumpers, weatherstripping, cushioning devices and flexible tubing. Tough and economical, rigid PVC is inherently flame retardant and resistant to most chemicals. Rigid PVC can be offered in clear, opaque, weather resistant, high-tensile-strength and impact-resistant formulations that are easily machined.

HIPS (High-Impact Polystyrene) is a rigid, economical, lightweight plastic which is used for rigid plastic profile extrusions and plastic tubing extrusions. High-impact polystyrene typically has a flat finish and is available in natural (translucent white), standard and custom colors.

ABS (Acrylonitrile Butadiene Styrene) is a versatile, rigid and high-impact plastic with good chemical resistance to most non-aromatic compounds. It is used primarily in plastic profile extrusion applications where material will be indoors. ABS has a satin finish and is available in standard or custom colors.

ASA (Acrylonitrile Styrene Acrylate) is produced by introducing acrylic elastomer during the reaction between styrene and acrylonitrile. ASA material has great toughness and rigidity, good chemical resistance and thermal stability, outstanding resistance to weather, aging, yellowing and high gloss.

EPP (Expanded Polypropylene) is an exceptionally eco-friendly, flexible and versatile plastic foam designed for lightweight, energy-management and cushioning applications. EPP can replace materials such as metals, wood and a variety of other plastics.

PP (Polypropylene) is a semi-rigid, lightweight, economical plastic with excellent chemical resistance and a fairly high service temperature. Polypropylene is available in natural (translucent white), standard and custom colors.

PE (Polyethylene) ranges from flexible (LDPE) to semi-rigid (HDPE). A very economical material, polyethylene is good for plastic profile extrusion applications requiring low surface resistance. It is available in both FDA and industrial grades. Polyethylene also has good chemical resistance and is available in natural (translucent white), standard and custom colors.

TPE (Thermoplastic Elastomers) is a collective name for several different families of elastomers that may contain differences in composition and molecular structure. Their performance properties are similar to conventional thermosets, such as EPDM or neoprene.

The important features of TPEs are their flame and ozone resistance, excellent flex fatigue and performance in alcohol. TPEs, however, are limited by their poor resistance to aliphatic and aromatic hydrocarbon solvents as well as oil and gasoline.

PA (Polyamide), also known as Nylon, is a resin of choice for numerous industrial and commercial applications. This thermoplastic material is resistant to wear and abrasion, exhibits good mechanical properties even at elevated temperatures, has low permeability to gases and demonstrates good chemical resistance. Polyamides are available in a wide variety of colors.

RIGID THERMOPLASTIC MATERIAL PROPERTIES

MATERIAL	LDPE	ABS	NYLON	PC	HDPE	PP	RPVC	HIPS
STRENGTH	Medium	Medium	Medium	Medium	Low	Low	Medium	High
TOUGHNESS	High	Medium	Medium	High	Low	Low	Medium	High
STIFFNESS	Low	High	Medium	High	Low	Medium	High	High
HIGH TEMP LIMIT (°C)	80°	80°-90°	120°-140°	110°-130°	80°-90°	90°-110°	100°-120°	60°
LOW TEMP TOUGHNESS	High	Medium	Low	High	Medium	Low	Medium	High
COST	Low	Medium	High	Medium	Low	Low	Low	Medium
CHEMICAL RESISTANCE	High	Low	High	Low	High	High	Medium	Low
WEAR RESISTANCE	High	Low	High	Low	Medium	Low	Low	Low
WEATHERABILITY	Medium	Low	Low	Medium	Medium	Low	High	Low
HARDNESS R	55	105	85	120	90	95	105	61

MATERIAL KEY: LDPE (Low-Density-Polyethylene); ABS (Acrylonitrile-Butadiene-Styrene); PC (Polycarbonate); HDPE (High-Density-Polyethylene); PP (Polypropylene); RPVC (Rigid-Polyvinyl-Chloride); HIPS (High-Impact Polystyrene)

FLEXIBLE THERMOPLASTIC MATERIAL PROPERTIES

MATERIAL	TPV	TPO	TPU	FPVC
DENSITY	Medium	Low	High	High
TENSILE STRENGTH	Medium	Medium	High	Medium
ELONGATION	High	High	High	Medium
HIGH TEMP LIMIT (°C)	125°	80°	150°	100°
LOW TEMP LIMIT (°C)	-60°	-60°	-40°	-30°
COST	Medium	Medium	High	Low
WEAR RESISTANCE	Medium	Medium	High	Medium
WEATHERABILITY	Medium	Medium	Medium	Medium
HARDNESS A	50-90	70-90	70-90	60-90

MATERIAL KEY: TPV (Thermoplastic Vulcanizate); TPO (Thermoplastic Polyolefin); TPU (Thermoplastic Polyurethane); FPVC (Flexible-Polyvinyl-Chloride)

THE RIGHT ADHESIVE

In most cases, the use of adhesive tapes can eliminate mechanical fastening systems (staples, nails or retaining clips) and the inherent problems associated with them, i.e. cost, weight and breakage.

Adhesive tapes can also be a superior alternative to liquid or spray adhesives, epoxies and other conventional joining methods.

Adhesive tapes can improve productivity during the final assembly process by providing a faster, more efficient way of attaching seals and gaskets to the end product. There are two predominant types of adhesive tapes: pressure-sensitive adhesive (PSA) and heat activated tape (HATS). Each will be discussed later in this section.



Key Questions

To begin the adhesive tape selection process, it is important to have the answers for several basic questions:

- To what type of substrate will the adhesive be attached?
- In what temperature range will the adhesive be expected to perform?
- With what chemicals will the adhesive come into contact?
- Will the adhesive come into contact with moisture or sunlight?
- Will the adhesive be functional after installation?
- Will the adhesive be in shear?
- What type of radius will the adhesive need to go around?

Achieving Maximum Adhesion

SURFACE PREPARATION: Although the type of bonding surface is important, it should be noted that one of the most critical and overriding factors in adhesion is the condition of the bonding surface.

The presence of surface contaminants, such as oils, grease, plasticizers, mold release or dirt in general, can cause adhesive failure regardless of the specific adhesive. Isopropyl alcohol can be used to remove most surface contaminants.

SUFFICIENT PRESSURE: Sufficient pressure must be applied to get full contact (wet-out) between the substrate and the adhesive to create the best bond.

PROPER STORAGE: Adhesives should be stored in a dry, dust-free environment and at room temperature.

ADHESION PROMOTER: Many low-surface energy materials may need an adhesion promoter for the adhesive to adhere as expected.*

*Ask a Cooper Standard ISG representative for more information on adhesion promoters for a particular substrate.

Pressure Sensitive Adhesives

There are three primary PSA joining systems used most widely today: double-coated paper and film tapes, double-coated foam tapes and adhesive transfer tapes. Each system offers specific benefits depending on the surfaces to be joined, the strength of the bond required and environmental factors, such as temperature, ozone/weathering and chemical resistance.

DOUBLE-COATED PAPER AND FILM TAPES are designed to join or bond two substrates and can be highly customized to meet end-use requirements. They can also be die-cut to match specific applications. Double-coated paper and film tapes are made up of a layer of adhesive, a paper or film carrier, another layer of adhesive and a release liner.

Carriers with adhesive on both sides give double-coated tapes additional body for greater dimensional stability and easier handling and dispensing. They also help avoid stretching the rubber extrusion during application to the substrate.

This system is ideal for high-volume assembly processes and can be configured for use on opposing carrier surfaces to join different materials. Commonly used carriers include paper, polyester film, cloth and synthetic constructions.

ADHESIVE TRANSFER TAPES provide the same basic bonding capability and purpose as a double-faced product, but they do not have a carrier reinforcing the adhesive.

The tapes consist of thin ribbons of pressure sensitive adhesive pre-applied on one release liner. Occasionally, there is a second protective release liner added. Without a reinforcing carrier, the adhesive is extremely pliable and can be used on substrates that are pliable and conformable without significantly altering that property.

Transfer tape systems allow the user to apply a precise, clean, dry adhesive to the surface of the seal or gasket.

DOUBLE-COATED FOAM TAPES consist of a layer of adhesive, a foam carrier, another layer of adhesive and a release liner. They are flexible, conformable and ideally suited for filling space and joining rough or irregular surfaces.

Double-coated foam tapes help cushion and dampen noise and vibration and provide excellent impact resistance. Depending upon the foam carrier selected, they can also offer sealing properties, temperature resistance and provide good insulating qualities.

Foam carrier options include open cell polyurethane, closed cell vinyl, polyethylene and elastomeric and neoprene foam formulations.

Heat-activated Tapes

Heat-activated tapes are constructed by layering materials together that include: an OEM-applied heat-activated adhesive, an acrylic foam core, a high-performance acrylic adhesive and a polyolefin release liner.

These tapes feature an adhesive layer that is activated by heat during the lamination process of the tape to the extruded profile. This creates a secure and durable bond.

Gaskets using these tapes provide excellent performance at both high and low temperatures.

The tapes are high-performance formulations designed to meet a variety of requirements, including holding power, UV light stability, moisture resistance, salt spray resistance and more.



DOUBLE-COATED PAPER AND FILM TAPES

- Adhesive
- Carrier
- Adhesive
- Liner



DOUBLE-COATED FOAM TAPES

- Adhesive
- Foam
- Adhesive
- Liner



ADHESIVE TRANSFER TAPES

- Adhesive
- Liner



HEAT ACTIVATED TAPES

- Heat-activated adhesive
- Acrylic foam core
- High-performance acrylic adhesive
- Polyolefin liner

Adhesive Selection

When specifying an adhesive tape, it is also important to know whether a rubber- or acrylic-based adhesive is more appropriate for the application.

Note: It is important to recognize that both types of adhesive, while they have different natural adhesion characteristics, can be made to bond to most surfaces through special formulating techniques.

RUBBER-BASED ADHESIVES

Rubber-based adhesives are comprised of a rubber structure and a variety of additives that impart special characteristics, such as oxidation resistance, color and stability. Rubber-based adhesives are also very thermoplastic.

The addition of heat will soften the adhesive and directly affect its function.

Advantages:

- High Initial Bond to Substrates
- Adhere to a Wide Range of Materials (Polar and Non-polar)
- Generally Very Economical
- Resistant to Polar Chemicals (Active Oxygen-Containing Solvents)

Disadvantages:

- Poor Cohesive Strength at Elevated Temperatures [150° F (66° C)]
- Fair to Poor Resistance to Non-polar Chemicals
- Generally Poor Resistance to Ultraviolet Light and Oxidation
- Susceptible to Plasticizer Migration

ACRYLIC-BASED ADHESIVES

As copolymers, acrylic-based adhesives do not require as many additives as rubber-based adhesives. In fact, the addition of other ingredients tends to detract from their strength.

Acrylics soften when exposed to heat and harden when cooled.

Advantages:

- Good Adhesion to Polar Substrates (Metal, Glass, Polyesters, Polycarbonates, etc.)
- Acrylic Adhesives are Cross-linkable
- Deliver Good Resistance to Varying Temperature Ranges [-50° F (-46° C) to 350 °F (176° C)]
- Good Resistance to Chemicals (Gasoline, Petroleum Naphthas, etc.)
- Good Adhesion to Irregular or Rough Surfaces
- Age Well in Presence of Ultraviolet Light, Corona and Oxidation
- Very Color Stable
- Can be Easily Removed and Reinstalled in the Application if Positioned Incorrectly
- Offer Excellent Oxidation and Plasticizer Resistance

Disadvantages:

- Generally Have Poor Adhesion to Non-polar Surfaces (Polyethylene, Polypropylene, etc.)
- Tend to be More Expensive
- Initial Bond or Tack Strength is Low (It Can Take 48 to 72 Hours to Achieve Ultimate Strength)



SPLICING / WELDING

Splicing is used when an application requires a continuous seal such as a multi-sided frame or an o-ring. When designing a spliced seal, key considerations include the physical integrity of the joint and actual sealing properties (i.e. leak resistance or load compression), cosmetics (how the seal will be fixed or attached to a substrate) and the overall cost.

There are several typical ways to splice rubber gaskets:

Hot Splicing

Considered the industry standard, hot splicing is the most desirable in regard to cosmetics. Hot splicing uses a rubber-based adhesive (excluding products made from silicone).

The splice must be cured, or vulcanized, in place. The resulting splice retains many of the properties of the original seal while maintaining its aesthetic appearance.

Depending on the cross-section, additional time should be allowed for the hot splicing process because of curing. Tooling costs may be incurred due to splice molds being cut for specific cross-sections.

Cold Splicing

Cold splicing is simply a matter of adhering two or more pieces of a seal together using quick-setting glue, such as a cyano-acrylate. There are few, if any, tooling costs included with this technique, but the splice may become brittle and sometimes proves to be less effective than other options.

Transfer Splicing

Transfer splicing works in much the same way as transfer molding (see section on The Molding Process on page 8).

A mold is created so that two or more pieces of a seal can be inserted into the tooling. A polymer is transferred into the mold cavity, adhering the ends of the seal and creating a continuous o-ring or multi-sided gasket. The process allows for enhanced detail work on the seal and produces a splice that is very aesthetically pleasing.

Film Welding

Film welding uses a plastic film as media to bond EPDM materials. It is typically used for parts with pre-applied adhesive or that have complex cross-sections. The benefit to this method is that it has no adverse effects on the adhesive performance at or around the joint.

Heat Welding (Plastics)

Heat welding uses applied pressure and heat to create a bond between thermoplastics. This process provides better strength for plastic materials than mechanical connections (such as snap fits and screws) or adhesives.



REQUEST FOR QUOTATION

As mentioned earlier, selecting the right seal or gasket for a specific application involves answering many questions. The following checklist outlines information you may need to provide when requesting a quotation. In addition, it can be helpful to outline preliminary ideas you may have for gasket shape or profile cross-section.

On the following page is a Request For Quotation checklist. Contact ISG for help on your next project at www.cooperstandard-isg.com/contact.

1) What is the application?

2) To what is the seal/application being exposed?

- Oil, grease, fuels
- Water
- Weathering
 - Extreme temperature fluctuations
 - Ozone
- Will this application call for a dense or sponge compound?

3) What is important in the performance of your seal?

- Which mechanical properties are important?
 - Speed of recovery from deflection
 - Flexibility
 - Permeability to gases
- Which resistance properties are necessary?
 - Reaction to acids, hydrocarbons, oxygenated solvents, abrasion, flame, tearing
- How important is compression set?

4) Will the seal be under constant compression or will the load be released frequently?

5) Which physical properties are important?

- Tensile/elongation strength
- Hardness range or compression deflection
- Compression set at room temperature and operating temperatures
- Exposure to sunlight, ozone and temperature extremes
- Color (if color matching is desired)

6) How will the seal or gasket be applied?

- With adhesives
- Mechanically (clips, staples, nails)

7) If using adhesives, what are the specifications?

- Adhesive
 - Rubber- or acrylic-based
- Construction
 - Transfer tapes
 - Double-coated paper or film tapes
 - Double-coated foam tapes
- Adhesive width

8) Design considerations:

- High or low closing force for the seal
- Static or dynamic sealing application

9) What are the cost considerations?

- Estimated annual usage

10) Are secondary operations necessary?

- Cutting
- Splicing
- Custom packaging
- Laminating



ARPM RUBBER TOLERANCE TABLES

ARPM TABLE 3 - MOLDED A2 PRECISION

STANDARD DIMENSIONAL TOLERANCE TABLE—MOLDED RUBBER PRODUCTS
DRAWING DESIGNATION “A2” PRECISION

Size (Millimeters)	Fixed	Closure	Size (Inches)	Fixed	Closure
Above - Including			Above - Including		
0 - 10	±0.16	±0.20	0.0 - 0.40	±0.006	±0.008
10 - 16	0.20	0.25	0.40 - 0.63	0.008	0.010
16 - 25	0.25	0.32	0.63 - 1.00	0.010	0.013
25 - 40	0.32	0.40	1.00 - 1.60	0.013	0.016
40 - 63	0.40	0.50	1.60 - 2.50	0.016	0.020
63 - 100	0.50	0.63	2.50 - 4.00	0.020	0.025
100 - 160	0.63	0.80	4.00 - 6.30	0.025	0.032
160 & over			6.30 & over		
multiply by	0.004	0.005	multiply by	0.004	0.005

**ARPM TABLE 13 - DENSE CROSS-SECTION
ORGANIC/SILICONE CLASS 2 PRECISION**

STANDARDS FOR CROSS-SECTIONAL TOLERANCE TABLE

Note: Tolerances on dimensions above 100 mm (3.94 in.) should be agreed upon by supplier and user. General cross-sectional dimensions below 1mm (0.04 in.) are impractical. In general, softer materials and those requiring a post-cure need greater tolerances.

	1	2	3
ARPM Class	High Precision	Precision	Commercial
Drawing Designation	E1	E2	E3
Dimensions (in Millimeters)			

Above – Up to

	1	2	3
	High Precision	Precision	Commercial
	E1	E2	E3
0 - 1.5	±0.15	±0.25	±0.40
1.5 - 2.5	0.20	0.35	0.50
2.5 - 4.0	0.25	0.40	0.70
4.0 - 6.3	0.35	0.50	0.80
6.3 - 10	0.40	0.70	1.00
10 - 16	0.50	0.80	1.30
16 - 25	0.70	1.00	1.60
25 - 40	0.80	1.30	2.00
40 - 63	1.00	1.60	2.50
63 - 100	1.30	2.00	3.20

	1	2	3
ARPM Class	High Precision	Precision	Commercial
Drawing Designation	E1	E2	E3
Dimensions (in Inches)			

Above – Up to

	1	2	3
	High Precision	Precision	Commercial
	E1	E2	E3
0 - 0.06	±0.006	±0.010	±0.015
0.06 - 0.10	0.008	0.014	0.020
0.10 - 0.16	0.010	0.016	0.027
0.16 - 0.25	0.014	0.020	0.031
0.25 - 0.39	0.016	0.027	0.039
0.39 - 0.63	0.020	0.031	0.051
0.63 - 0.98	0.027	0.039	0.063
0.98 - 1.57	0.031	0.051	0.079
1.57 - 2.48	0.039	0.063	0.098
2.48 - 3.94	0.051	0.079	0.126

ARPM TABLE 16 - DENSE CUT LENGTH

L2 COMMERCIAL

CUT LENGTH TOLERANCE TABLES FOR UNSPLICED EXTRUSION

Note: Special consideration of tolerances will have to be given to both extremely soft and high tensile stocks.

RMA Class	1	2	3
Drawing Designation	Precision	Commercial	Non-Critical
Length (in Millimeters)	L1	L2	L3

Above – Up to

0 - 40	±0.7	±1.0	±1.6
40 - 63	0.8	1.3	2.0
63 - 100	1.0	1.6	2.5
100 - 160	1.3	2.0	3.2
160 - 250	1.6	2.5	4.0
250 - 400	2.0	3.2	5.0
400 - 630	2.5	4.0	6.3
630 - 1000	3.2	5.0	10.0
1000 - 1600	4.0	6.3	12.5
1600 - 2500	5.0	10.0	16.0
2500 - 4000	6.3	12.5	20.0
4000	0.16%	0.32%	0.50%

Length (in Inches)

Above – Up to

0 - 1.6	±0.03	±0.04	±0.06
1.6 - 2.5	0.03	0.05	0.08
2.5 - 4.0	0.04	0.06	0.10
4.0 - 6.3	0.05	0.08	0.13
6.3 - 10.0	0.06	0.10	0.16
10.0 - 16.0	0.08	0.13	0.20
16.0 - 25.0	0.10	0.16	0.25
25.0 - 40.0	0.13	0.20	0.40
40.0 - 63.0	0.16	0.25	0.50
63.0 - 100.0	0.20	0.40	0.63
100.0 - 160.0	0.25	0.50	0.80
160.0	0.16%	0.32%	0.50%

ARPM TABLE 37 - LENGTH AND WIDTH
DIE CUT SPONGE #2, BL2

Tolerances on length and width dimensions of die-cut sheet or strip, expanded, closed-cellular rubber.

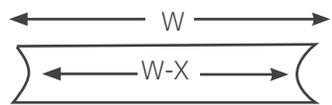
RMA Class	1	2	3
RMA Drawing Designation	BL1	BL2	BL3
Millimeters	Tolerance		
For thickness up to 6.3 mm*			
under 25	±0.63	±0.80	±1.0
25 to 160	0.80	1.0	1.25
over 160 multiply by	0.0063	0.01	0.016
For thickness over 6.3 to 12.5 mm*			
under 25	±0.81	±1.0	±1.25
25 to 160	1.0	1.25	1.6
over 160 multiply by	0.0063	0.01	0.016
For thickness over 12.5 mm*			
under 25	±1.0	±1.25	±1.6
25 to 160	1.25	1.6	2.0
over 160 multiply by	0.0063	0.01	0.016

Inches	Tolerance		
For thickness up to .25 in.*			
under 1.0	±0.025	±0.032	±0.040
1.0 to 6.3	0.032	0.040	0.050
over 6.3 multiply by	0.0063	0.010	0.016
For thickness over .25 to .50 in.*			
under 1.0	±0.032	±0.040	±0.050
1.0 to 6.3	0.040	0.050	0.063
over 6.3 multiply by	0.0063	0.010	0.016
For thickness over .50 in.*			
under 1.0	±0.040	±0.050	±0.063
1.0 to 6.3	0.050	0.063	0.080
over 6.3 multiply by	0.0063	0.010	0.016

*Separate schedules of length and width tolerances are listed for the different thicknesses of these materials because of the “dish” effect in die-cutting. This is more noticeable as the thickness increases. As shown in the drawing below, the “dish” effect is a concavity of die-cut edges (due to the squeezing of the material by the pressure of the cutting die).

Figure 32

The width “W” (or length) at the top and bottom surface are slightly greater than the width “W-X” at the center.



Note: Class 1 tolerances should not be applied to the softer grades of material, below 63 kPa (9 psi).

**ARPM TABLE 38 - SPONGE CROSS SECTION
ORGANIC/SILICONE #1, BEC1**

Tolerances on cross-sectional dimensions of irregular and cored shapes of extruded, expanded, closed-cellular rubber. Class 1 tolerances in the table below are recommended for high volume, tight products for automotive applications.

ARPM Class	1*	2	3
ARPM Drawing Designation	BEC1	BEC2	BEC3
Millimeters	Tolerance		
Above – Including			
0 - 6.3	±0.4	±0.5	±0.63
6.3 - 12.5	0.63	1.0	1.25
12.5 - 25.0	1.25	2.0	2.5
25.0 - 40.0	2.0	3.2	4.0
40.0 & over multiply by	0.06	0.08	0.1

ARPM Class	1*	2	3
ARPM Drawing Designation	BEC1	BEC2	BEC3
Inches	Tolerance		
Above – Including			
0 - 0.25	±0.016	±0.020	±0.025
0.25 - 0.50	0.025	0.040	0.050
0.50 - 1.0	0.050	0.080	0.100
1.0 - 1.6	0.080	0.125	0.160
1.6 & over multiply by	0.060	0.080	0.100

*Class 1 tolerances should not be applied to the softer grades of material—below 63 kPa (9 psi) compression deflection.

ARPM TABLE 40 - SPONGE CUT LENGTH #1, BEL 1

Tolerances on cut lengths of all extruded, expanded, closed-cellular rubber products.

RMA Class	1*	2	3
RMA Drawing Designation	BEL1	BEL2	BEL3
Millimeters	Tolerance		
Above – Including			

0 - 80	±1.6	±1.6	±3.2
80 - 160	3.2	3.2	6.3
160 - 315	6.3	6.3	12.5
315 - 630**	multiply by .02	12.5	25.0
630 - 1250**	multiply by .02	25.0	50.0
1250 & over multiply by	0.02	0.03	0.04

RMA Class	1*	2	3
RMA Drawing Designation	BEL1	BEL2	BEL3
Inches	Tolerance		
Above – Including			

0 - 3.15	±0.063	±0.063	±0.125
3.15 - 6.3	0.125	0.125	0.250
6.3 - 12.5	0.250	0.250	0.500
12.5 - 24.0**	multiply by .02	.500	1.000
24.0 - 50**	multiply by .02	1.000	2.000
50.0 & over multiply by	0.02	0.030	0.040

*Class 1 tolerances should not be applied to the softer grades of material—below 63 kPa (9 psi) compression deflection.

**Accurate measurement of long lengths is difficult because these materials stretch or compress easily. Where close tolerances are required on long lengths, a specific technique of measurement should be agreed upon between purchaser and manufacturer.



GLOSSARY OF TERMS

ABRASION: The surface loss of a material due to frictional forces.

ABRASION RESISTANCE: The resistance of a material to loss of surface particles due to frictional forces.

ACCELERATORS: Increase the speed of vulcanization, and in many instances also improve the final product's physical properties.

ACCELERATION ACTIVATOR: Work with accelerators to reduce vulcanization time and improve a compound's final characteristics.

AGE RESISTERS: Materials such as antioxidants and antiozonants that serve to slow down the deterioration of rubber products that can occur as a result of exposure to light, heat, oxygen, radiation, ozone, etc.

BLISTER: A cavity or sac that deforms the surface of the material.

BLOWING AGENT: Any substance that alone, or in combination with other substances, is capable of producing a cellular structure in a plastic or rubber.

Blowing agents include compressed gases that expand when pressure is released, soluble solids that leave pores when leached out, liquids that develop cells when they change to gases and chemical agents that decompose or react under the influence of heat to form a gas. Chemical blowing agents range from simple salts such as ammonium or sodium bicarbonate to complex nitrogen releasing agents.

CARRIER: Metal that is co-extruded with a rubber profile in order to reinforce the structure so as to aid in retention on to the substrate it is being installed on.

CELL: A single, small cavity surrounded partially or completely by walls.

CELLULAR MATERIAL: A generic term for materials containing many cells (either open, closed or both) dispersed throughout the mass.

CELLULAR RUBBERS: A cellular material made of rubber. Cellular rubber products all contain cells or small hollow receptacles. The cells may either be open or interconnecting or closed and not interconnecting.



CLOSED CELL: A cell totally enclosed by its walls and hence not interconnecting with other cells.

CO-EXTRUSION: The process of extruding two or more materials through a single die with two or more cavities arranged so that the extrudates merge and weld together into one structure.

COLLAPSE: Inadvertent densification of a cellular material during its manufacture resulting from breakdown of cellular structure.

COMPOUND: An intimate mixture of a polymer with all the ingredients necessary for the finished article.

COMPRESSION DEFLECTION: The PSI required to compress a lab slab a specified percentage of overall height, normally 25 percent.

COMPRESSION MOLDING: A method of molding in which the rubber compound is molded between two plates that fit together to form the mold cavity. A molding press is used to provide the necessary force to close the mold.

COMPRESSION SET: The residual deformation after removal of the force that has subjected the specimen to compression.

CRAZING: A surface effect on rubber articles characterized by many minute cracks.

CURE: The act of vulcanization. See vulcanization.

DUROMETER: An instrument for measuring the hardness of vulcanized rubber or plastic. Shore 00 scale is used for sponge, Shore A is used for dense/solid.

DUROMETER HARDNESS: An arbitrary numbering scale that indicates the resistance to indenter point of the durometer. High values indicate harder materials.

ELASTOMER: An elastic, rubber-like substance, such as natural or synthetic rubber.

EXPANDED RUBBER: Cellular rubber having closed cells made from a solid rubber compound.



FLASH: Surplus material that is forced into crevices between mating mold surfaces during a molding operation and remains attached to the molded article at the parting line of a mold or die, or is extruded from a closed mold.

FLOCKING: Coating of surfaces with textile fibers using a suitable adhesive.

INJECTION MOLDING: A molding process in which the mold halves begin the process clamped together. Once the mold is clamped, preheated rubber is forced into the sprue of a hot mold.

OPEN CELL: A cell not totally enclosed by its walls and hence interconnecting with other cells.

OZONE CRACKING: The surface cracks, checks or crazing caused by exposure to an atmosphere containing ozone.

PREFORM: A partially completed part that will be subjected to subsequent forming operations.

PRESSURE SENSITIVE ADHESIVE: Adhesive, which in dry form, is aggressively and permanently tacky at room temperature and firmly adheres to substrates upon contact without activation by water, solvent or heat.

REBOUND: A measure of resilience, usually as the percentage of vertical return of an object that has fallen and bounced.

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 boiling solvent, such as benzene, methyl ethyl ketone and thanol-tulene azeotrope.

SHELF AGING: The time an unvulcanized rubber stock can be stored without losing any of its processing or curing properties.

SHORE HARDNESS: See durometer hardness.

SKIN: A dense layer at a cellular material's surface.

SPONGE RUBBER: Cellular rubber consisting predominantly of open cells made from a solid rubber compound.

SPRUE: In an injection or transfer mold, the main feed channel that connects the mold-filling orifice with the runners leading to each cavity gate.

SUBSTRATE: A material upon the surface of which an adhesive is applied for any purpose, such as bonding or coating.



TEAR STRENGTH: The resistance to growth of a nick or cut when tension is applied to the test specimen, commonly expressed as pounds per inch or newtons per meter.

TENSILE STRENGTH: The maximum tensile stress applied during stretching a specimen to rupture.

TRANSFER MOLDING: A molding process in which a rubber preform is heated and forced by a plunger through a funnel-shaped opening, or sprue, into the mold cavity. Often considered a form of compression molding.

VULCANIZATE: Used to denote the product of vulcanization, without reference to its shape or form.

VULCANIZATION: An irreversible process during which a rubber compound, through a change in its chemical structure (i.e. cross-linking), becomes less plastic and more resistant to swelling by organic liquids and elastic properties are conferred, improved or extended over a greater range of temperatures.

VULCANIZING AGENT: Can be added to a compound's composition and may affect its physical properties. They must be stable, free from bloom and possess the required building tack, all of which is dependent on compounding and processing.

WEATHERING: The surface deterioration of a rubber article during outdoor exposure, such as checking, cracking, crazing or chalking.

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