ESP, Inc.

CUSTOM RUBBER EXTRUSIONS

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Extruded Rubber Products

Among the items contained in this manual are copies of the following:

--**RMA Handbook** recommendation for tolerances to be used;

--**Precision Rubbers' Digest of Military and Aeronautical Numbers**, and miscellaneous information about rubber, its descriptions and terminology generally used.

The subject of this narrative is to try and reduce some of my acquired background to a format that is understandable and of some use to others. This information is a sum total of my experiences at Goodyear Tire, Hewitt Robbins, Mantaline and ESP.

EXTRUDED SILICONE PRODUCTS ("ESP") is a custom organic rubber and silicone manufacturer producing through extrusion and continuous curing methods. Raw material is purchased from major mixing facilities such as Dyna Mix, Poly One and Sil Mix.

A). The job of the raw material providers is to formulate and mix the feed stocks to our specifications and deliver it in a form that is conducive to feeding the extrusion systems;

B). The extruder, through a combination of temperature and rotating action of the screw, plasticizes (breaks down) the material and forces it through a shape die that is mounted on the exit side of the extruder. When the reshaped material exits the die, it is immediately tensioned through the **HAV** (Hot Air Vulcanizer) or the liquid care medium (Salt Bath) commonly known as a continuous cure system;

C). After tensioning through the cure phase, the cured rubber enters the wash and cool down phase to clean the cure medium and cool the extrusion back to room temperature so that proper packaging can be achieved;

D). After this stage, the extrusion is either shipped or staged for value added secondary operations. Coiling, cut to length, taping end joining (splicing), hole drilling and injection splicing are the normal secondary operations we perform. Die cutting is available, generally at sub contractors.

In summary, a more technically correct description of this process is that the action of the extruder changes the molecular structure of the feed stocks; the die reconfigures it; and, the cure system captures it in this altered state. Secondary operations further change the physical make up of this content.

As mentioned previously, **ESP** is a custom rubber, silicone, and gasket manufacturer. We are <u>not</u> in the design or engineering phase of the product. We typically do not have enough information about the total overall environment to which a gasket is being subjected to be involved in that phase of product development. Where we do fit is after design, engineering and testing is complete.

We typically get a finished print or sample that is identified as to material and hardness or an ASTM line callout so that material identification is possible. This is the INITIAL CONTACT PHASE. We then make a decision as to whether we can manufacture the product and if so, we initiate the QUOTING PHASE. If we are fortunate enough to get an order, we proceed with the TOOLING AND SAMPLE SUBMISSION PHASE.

Sample approval initiates the following sequence of events:

1. Removal from quarantine
2. Entry in Master Log and floor specifications
3. Scheduling and raw material procurement
4. Extrusion and secondary operations if necessary
5. QC and auditing
6. Shipment
7. Billing
8. Collection
9. Repeat orders (hopefully)

We typically operate in a 4 to 6 week window after approval from the customer.

Materials typically manufactured by ESP are as follows:

1. EPDM Black 40-50-60-70 and 80-85 Durometer
2. EPDM Colors Gray, White, Red and Yellow 60-70 Duro Gray & White EPDM (FDA)
3. Butyl – Black 65-70 Durometer
4. Neoprenes Black 40-50-60-70-80 Durometer
5. Nitriles Black 50-60-70-90 Durometer
6. Nitrile 70 White FDA Only
7. SBR's Black 60 & 70 Durometer
8. Polyisoprenes Black 40-50-60-70-75 Durometer (Synthetic natural Rubber)
9. Solid Silicones (FDA) 35-40-50-60-70-80
10. Silicone Sponge – Medium to firm density, Dark Gray, Lite Gray, Red, White, Green Note – Silicone Sponge not FDA.
11. EPDM/CPE Sponges 2A2, 2A3, 2A4 Black, White, Gray & Tan
12. Neoprene Sponge 2C3 Black only
13. FDA EPDM Sponge White & Black only 2A3 Density
14. Special Compounds Platinum Cure Silicone Low smell and taste
15. Florosilicone Blue Oil resistant $37.50/lb.
16. Tan Polyisoprene 40 & 50 Durometer

<u>POLYMER RECOMMENDATIONS</u>:

A). **<u>EPDM's</u>** are most commonly used in exterior applications where weathering (UV) temperature +300 F – 55 F are the prime elements the gasket is exposed to. Examples: Window gaskets, weather stripping, tarp straps, door gaskets, roofing membrane, appliance gaskets (when no oil is present). **EPDM** is now the most commonly used polymer.

B). **SBR's** – Applications where high abrasion resistance is necessary.
Examples: Motor mounts, belt covers, screen clothes.

C). **Synthetic Natural Rubber (Polyisoprene)** – Applications where flexing abrasion resistance and good recovery, stretch or rebound are necessary.

D). **Neoprenes** – UV, Contact with oil, fire retardant, water resistance, good resilience and tensile strength.

E). **Nitriles** – Where oil resistance is critical.
Examples: O rings, seal for fuel and hydraulic hoses and seals.

F). **Silicones** – FDA ingredients, low temp – 100 F high temp + 450 F, UV, color applications.
Examples: Automotive, aircraft, appliance, oven door gaskets, Refrigeration gaskets, color window gaskets.

An excellent way to determine what materials are used in what application is to survey your existing customers and find out what products they are currently buying and what the end uses are.

All rubber must be heat vulcanized to capture it in its finished form from the raw material state. If the rubber is formed and not heat vulcanized, it will eventually return to its' original state or cold flow. Vulcanization (heat curing) prevents this from happening

There are basically three (3) methods of curing rubber:

A). **Molding** – A metal mold configured to the exact finished shape of the part is manufactured. Raw feed stock is either pre-formed or injected into the cavity of the mold. The mold is placed in a press that supplies heat and exterior pressure. The material is cured for a period of time, cooled down, and part is removed. This method is time consuming, tooling intensive, but very accurate. The tire is an example of this type of curing method.

B). **Autoclave curing** – Typically an extruder is used to pre-form the feed stock. The pre-form comes out of an extrusion die and is placed on a metal tray or pan in an uncured state. The pan containing the uncured by shaped material is put on metal racks. The entire rack is moved into an autoclave cure unit. The door to the autoclave is closed and locked tight. Steam from a boiler is generally used to create the heat and air pressure from a compressor is purged in with the steam to about 300 PSI to exert a force on the extrusion in an attempt to hold shape and eliminate porosity. This method of manufacture is slow, and somewhat inaccurate due to the time span between extruding and curing. The main disadvantage is short pieces due to the size of the pans or holding trays on the racks. The advantage is that low price materials can be used. Tolerancing is very difficult because of distortion and cold flow before curing.

C). **Continuous Cure** – This is a system where forming of the rubber and curing are combined in a dedicated continuous system. Combinations for curing through this method are:

1. Microwave – Hot air
2. Microwave - Salt
3. Hot air vulcanizers
4. Salt baths
5. Glass beads (Balletini)
6. Hot oil

Microwave typically has to have a supporting cure system. Microwave only introduces energy. Temperature is very difficult to control using microwave alone. Curing as defined is a function of temperature for a given amount of time or dwell. This is generally not attainable in microwave.

The advantages of continuous curing are long continuous lengths possible, speed of manufacture, low labor content, energy usage, space economy, and dimensional tolerancing attainable.

The disadvantages are higher raw material set up costs, higher overall raw material costs due to the compounding necessary to run through these systems, size limitations due to the tensioning necessary to get the product pulled through the entire system, and certain shapes and radius' that cannot be attained through this method of curing. Closed cell expanded rubber is a classic example of a material that needs to be run through continuous cure systems.

The greatest advantage over molded is tooling cost and production attainable in a set period of time. The continuous cure method is the best choice when extrusions are smaller than 1 1/2” OD, require long lengths, have a hollowed out section (core hold), are sponge, need to be produced in great quantity, or have string insertion.

Closing:

There is a wealth of information in this manual, but this alone will not permit you to hand all situations.

The best information, is your ability to interface with your customers and extract from him or her what it is that they need to purchase and to describe to them what we can manufacture. Some purchasing agents are not very knowledgeable about rubber products. It is our job to enlighten them. That is your challenge and opportunity. If we can get them to depend on us for their rubber needs, we will prosper. Read, study, and ask questions.

David L. Ullom, President
ESP, Inc.
March 2009

Chapter 2 EXTRUDED RUBBER PRODUCTS

PURPOSE AND SCOPE

The purpose of this section is to outline in usable and easily understood form the methods used in the manufacture of a dense extruded rubber product, the problems that can arise from these methods and how they affect the finished product. By presenting this side of the process to the user he will be more adequately prepared to convey to the rubber supplier his needs and requirements. He will also be better able to understand the limits and tolerances that can normally be expected of this type product.

It is also the purpose of this section to improve the relationship of supplier and user through the use of common and meaningful terms and symbols (RMA Designations). Through this better understanding and the proper use of RMA Designations by the user, the manufacturer should be better able to supply the needs of the user thereby giving him better economy and satisfaction.

Certain statements and tables in this chapter have been changed to reflect current industry practices and to agree with International Standard ISO 3302-1988, RUBBER–DIMENSIONAL TOLERANCES FOR USE WITH PRODUCTS.

The information in this chapter is not intended to apply to thermoplastic elastomers.

PRINCIPLES OF EXTRUSION

An extruded rubber product differs from a molded rubber product in that the rubber is forced through a die of the desired cross-section under pressure from an extruder. The extruded product leaves the extruder in a soft pliable unvulcanized state. The extruded product normally must be vulcanized before it is usable.

Unvulcanized rubber compound is fed into the extruder. The flutes of the revolving screw carry the rubber forward to the die, building up pressure and temperature as it advances toward the die. The rubber is forced through the die by this pressure and swells in varying amounts depending on the type and hardness of the compound. Due to the many variables such as temperature, pressure, etc., the extrusion varies in size as it leaves the die, thus requiring plus or minus tolerances on the cross-section. During the vulcanization, the extrusion will swell or shrink in the cross-section and length depending on the compound used. After vulcanization, a length of extrusion has a tendency to be reduced in dimension more in the center of the length than the ends.

The extruded product is vulcanized either in a heated pressure vessel (static vulcanization) or by the continuous vulcanization process. A brief description of each follows:

STATIC VULCANIZATION

The extrusion is conveyed from the extrusion machine to a station where it is cut to varying lengths depending on the finished length and placed on a metal pan in a free state; that is, it is not contained in a cavity as in molding. The part is then vulcanized in a heated pressure vessel known as an autoclave. Generally the autoclave is heated by steam which is allowed to fill the autoclave, building up the required temperature, which then vulcanizes the rubber into its usable form. This is known as open steam vulcanizing. The pressure surrounding the extrusion during open steam curing minimizes porosity in the extrusion.

CONTINUOUS VULCANIZATION

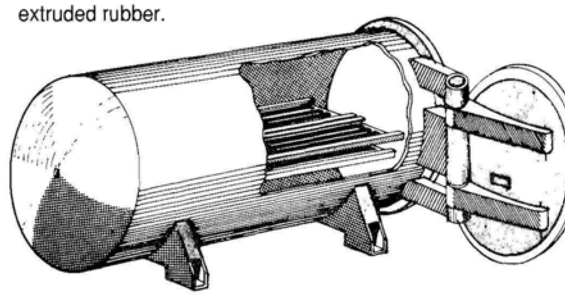
The extrudate is fed into the vulcanizing process directly from the extruder permitting the extrusion to be vulcanized in a continuous length. Several media are employed in the continuous vulcanization of rubber, all of which must be operated at elevated temperatures: air, molten salts, oils, fluidized beads, and microwave. Microwave is a method whereby the extrudate is subjected to high frequency electro magnetic waves which raises the temperature of the extrusion to near curing state, uniformly throughout. The lack of pressure in most continuous vulcanization processes makes porosity in the extrusion difficult to control. For most rubber compounds the open cure process is most practical.

A great many variables are encountered in the extrusion process which make it necessary to require tolerances more liberal than molded parts. A design engineer should have a general knowledge of the extrusion process and its variables to enable him to design parts that can be extruded at reasonable cost.

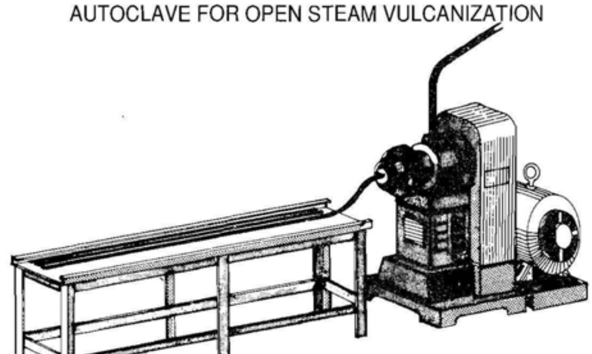
PROCESS ILLUSTRATIONS

RUBBER EXTRUDING SYSTEMS

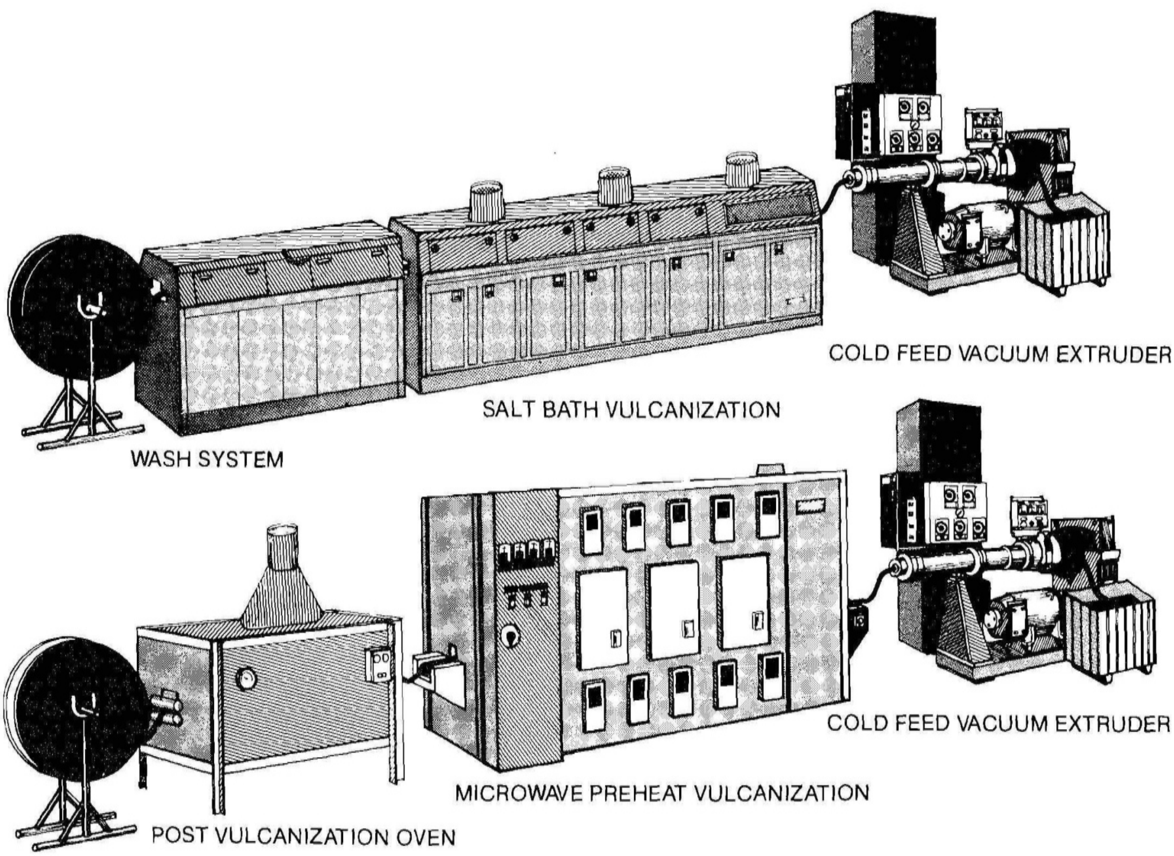
The systems shown below are a few variations of vulcanizing extruded rubber.



AUTOCLAVE FOR OPEN STEAM VULCANIZATION

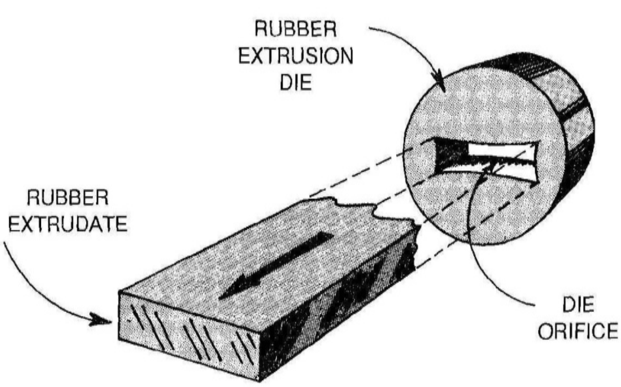


COLD OR HOT FEED EXTRUDER



EXTRUSION DIE

The extrusion die is a precise tool which is made by cutting an opening through a blank of steel; the opening is shaped to form the rubber into the desired cross-section as it is forced through the die by the pressure from the revolving screw of the extruder. Most rubber compounds swell and increase in dimension coming through the die orifice. The die, by necessity, is made for a particular extruder and a particular compound.



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STANDARDS FOR ANGLE CUT TOLERANCES FOR EXTRUSIONS

Many methods are employed to cut extruded sections to length: circular knife, rotating knife, guillotine, shear, saw and hand knife.

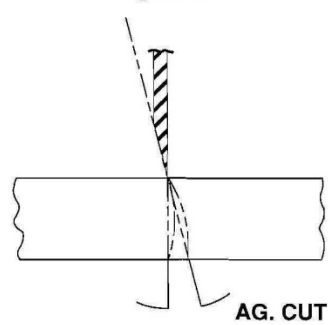
The angle and curve on cut face of extrusion will differ in degree depending upon the method used to cut the extrusion as well as the hardness of the compound, design or cross section and thickness of the extrusion.

Table 17

Angle (AG) Tolerances		
Drawing Designation		Cut (Max)
Precision	AG1	4°
Commercial	AG2	6°
Non Critical	AG3	10°

(The force of the knife upon the extrusion at the line of penetration deforms the extrusion resulting in a curved surface and an angle cut.)

Figure 20

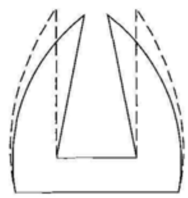


STANDARDS FOR SPLICED EXTRUSIONS

Testing Procedure

The manufacture of extrusions in circular or rectangular shaped gaskets, or a combination of both, can be accomplished by means of butt or corner vulcanized splices. The splice is usually never as strong as the original material from which the gasket is made. The stronger the splice is required to be, the more difficult the labor operations. A pressure mark will appear at the splice area due to required holding pressure in the mold. Glass and metal channels will be open at the corners 50mm (2 in.) to 75mm (3 in.) from the corner as a result of the forming plates of the mold. These will generally be open from 50% to 75% of the base of the channel. (See Figure 21.)

Figure 21



Open as indicated by Dotted Lines

The method of testing splices should be given serious consideration. The doubling over, pinching and the twisting of a splice or bending back on a corner splice are not proper methods of testing. Because of the wide variety in the types of cross sections, splice strength is very difficult to define.

Splice strength varies due to configuration of the cross section.

Transfer and injection splices are stronger than butt splice joints.

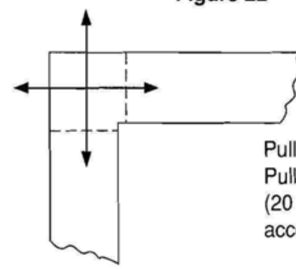
Pulling perpendicular to the plane of the splice is a sufficient test in the testing of a corner splice. The gasket should be clamped in such a way that the pull is evenly distributed over the splice and not have most of the stress on the inside corner. For injection splice, see Figure 22 and for 45° corner splice, see Figure 23.

Table 18

SPLICED LENGTH TOLERANCES

RMA Class	1 Precision	2 Commercial	3 Non-Critical
Drawing Designations	S1	S2	S3
Millimeters			
Above – Up to			
0 – 250	±3.2	±6.3	±7.1
250 – 400	4.0	7.1	8.0
400 – 630	5.0	8.0	9.0
630 – 1000	6.3	9.0	10.0
1000 – 1600	8.0	10.0	11.2
1600 – 2500	10.0	11.2	12.3
2500 – over	12.5	12.5	16.0
Inches			
Above – Up to			
0 – 10	±.13	±.25	±.28
10 – 16	.16	.28	.32
16 – 25	.20	.32	.36
25 – 40	.25	.36	.40
40 – 63	.32	.40	.45
63 – 100	.40	.45	.50
100 – over	.50	.50	.53

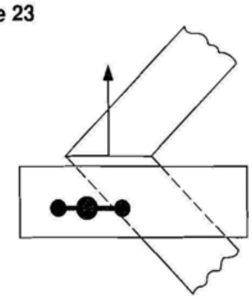
Figure 22



Pull test in Direction of Arrows. Pull rate of 500mm/min. (20 in./min.) is generally acceptable.

Figure 23

Pull test for 45° corners. Pull in direction of arrow.



In some applications, the splice is required only to position a gasket into place in assembly. This can be accomplished by staples or by using room temperature vulcanizing cements. These are more economical than vulcanized splices.

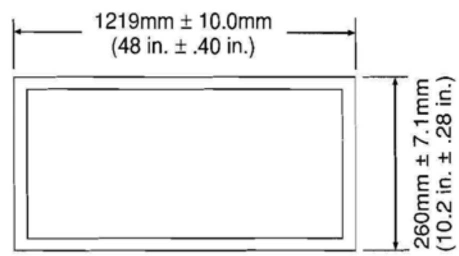
Tolerances must be allowed in the length of spliced parts. These tolerances must be varied according to length between splices and due to the method of making the splice. The following tables show classes which include both conventional splice requirements and injection splice requirements. Class 1 and 2 are acceptable for conventional splices and Class 2 and 3 are acceptable for injection splices. Discussion between manufacturer and customer should determine the class acceptable and the method of manufacture most acceptable.

Figure 24

BUTT SPLICE **TRANSFER OR INJECTION SPLICE**

Figure 25

Tolerance on Illustration are Class 2



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Rubber Materials Available from ESP

Polymer	ESP No.	Color	Durometer	Special Property
Neoprene	CR415	Black	40	
Neoprene	CR415FR	Black	40	Fire Retardant
Neoprene	CR515	Black	50	
Neoprene	CR515FR	Black	50	Fire Retardant
Neoprene	CR615	Black	60	
Neoprene	CR615FR	Black	60	Fire Retardant
Neoprene	CR715	Black	70	
Neoprene	CR715FR	Black	70	Fire Retardant
Neoprene	CR815	Black	80	
Neoprene	CR815FR	Black	80	Fire Retardant
Neoprene	CR65White	White	60	White
Neoprene	CR60C	Black	60	Conductive
Neoprene	CR615	Black	60	-65 degrees F
Neo/SBR	17140	Black	70	Commercial
Natural	IR40	Black	40	
or	IR50	Black	50	
Synthetic	IR60	Black	60	
Natural	IR70	Black	70	
Rubber	IR75	Black	75	
Compound	IR70R	Black	70	
Compound	IR515T	Tan	50	

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Rubber Materials Available from ESP

Polymer	ESP No.	Color	Durometer	Special Property
EPDM	E-40	Black	40	
EPDM	E-50	Black	50	
EPDM	E-50P	Black	50	Peroxide Cure
EPDM	E-50FDA	Black	50	FDA
EPDM	E-60	Black	60	
EPDM	E-65	Black	65	
EPDM	E-70	Black	70	
EPDM	E-70P	Black	70	Peroxide Cure
EPDM	E-70NC	Black	70	Non Conductive
EPDM	E-70NM	Black	70	Non Marking
EPDM	E-70R	Red	70	Red
EPDM	E-70G	Gray	70	FDA
EPDM	E-70W	White	70	FDA
EPDM	E-70Y	Yellow	70	Yellow
EPDM	E-70T	Tan	70	Tan
EPDM	E-70B	Blue	70	Blue
EPDM	E-70FDA	Black	70	FDA
EPDM	E-71	Black	75	
EPDM	E-85	Black	85	
EPDM	E-90	Black	90	
EPDM	WJT5636	Black	55	Peroxide Cure
EPDM	EP217	Black	70	Peroxide Cure

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Polymer	ESP No.	Color	Durometer	Special Property
Neoprene	CR415	Black	40	
Neoprene	CR415FR	Black	40	Fire Retardant
Neoprene	CR515	Black	50	
Neoprene	CR515FR	Black	50	Fire Retardant
Neoprene	CR615	Black	60	
Neoprene	CR615FR	Black	60	Fire Retardant
Neoprene	CR715	Black	70	
Neoprene	CR715FR	Black	70	Fire Retardant
Neoprene	CR815	Black	80	
Neoprene	CR815FR	Black	80	Fire Retardant
Neoprene	CR65White	White	60	White
Neoprene	CR60C	Black	60	Conductive
Neoprene	CR615	Black	60	-65 degrees F
Neo/SBR	17140	Black	70	Commercial
Natural	IR40	Black	40	
or	IR50	Black	50	
Synthetic	IR60	Black	60	
Natural	IR70	Black	70	
Rubber	IR75	Black	75	
Compound	IR70R	Black	70	
Compound	IR515T	Tan	50	

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Rubber Materials Available from ESP

Polymer	ESP No.	Color	Durometer	Special Property
Nitrile	NBR50	Black	50	
Nitrile	NBR60	Black	60	
Nitrile	NBR70	Black	70	
Nitrile	DM471800R	Black	70	Ozone Resistant
Nitrile	NBR80	Black	80	
Nitrile	NBR90	Black	90	
Nitrile	4703FDA	White	70	FDA
N/PVC	47200	Black	70	Nitrile/PVC
Butyl	EX57150	Black	70	Butyl
SBR	27152	Black	70	
SBR	26152	Black	60	
SBR	25152	Black	50	
SBR	ST/ST	Black	70	Conductive

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Silicone Available from ESP

Polymer	ESP No.	Color	Durometer	Special Property
Silicone	37110	White	35	
Silicone	37310	Red	35	
Silicone	44312	Red	40	
Silicone	44512	Black	40	
Silicone	49749	Green	40	
Silicone	49410	Gray	40	
Silicone	48310	Red	50	
Silicone	48510	Black	50	
Silicone	48610	Blue	50	
Silicone	48410	Gray	50	
Silicone	58010	Translucent	50	
Silicone	58110	White	50	
Silicone	210-55TR	Red	55	
Silicone	210-55TLG	Lite Gray	55	
Silicone	210-55TG	Gray	55	
Silicone	210-55TDGAG	Gray	55	Heat Stabilizers
Silicone	210-55TB	Black	55	
Silicone	210-55TW	White	55	
Silicone	210-55TAG	Red	55	Heat Stabilizers
Silicone	210-55TT	Tan	55	
Silicone	68010	Translucent	60	
Silicone	68040	Red	60	
Silicone	69311	Red	60	Heat Stabilizers
Silicone	69111	White	60	Heat Stabilizers

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Silicones Available from ESP

Polymer	ESP No.	Color	Durometer	Special Property
Silicone	73000	Opaque	70	
	70113	White	70	Platinum Cure
	78443	Gray	70	Platinum Cure
	71619	Blue	70	Florosilicone
	78340	Red	70	
	75429	Lite Gray	70	
	76429	Dark Gray	70	
	79010	White	70	
	78040	Translucent	70	
	78540	Black	70	
	86140	White	80	
	89340	Red	80	
	89510	Gray	80	
	86240	Tan	80	

Note: In the majority of Silicone compounds all ingredients are on FDA white list and most compounds meet or exceed requirements of ZZR765 class 2A+2B.

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Closed Cell Sponges Available from ESP

Polymer	ESP No.	Color	Durometer	Special Property
EPDM	600-0004	Black	Soft	Automotive
EPDM	610-0004	Black	Medium	Automotive
EPDM	630-0004	Black	Medium/Firm	Automotive
EPDM	640-0004	Black	Firm	
EPDM	650-0004	Black	Very Firm	
EPDM	9065 Gray	Gray	Medium	NSF
EPDM	9065 White	White	Medium	NSF
EPDM	9065 Red	Red	Medium	
Neoprene	WJT6009	Black	Medium	UL

Closed Cell Silicone Sponges Available from ESP

Polymer	ESP No.	Color	Durometer	Special Property
	40519AW	Gray	Medium	Fire Retardant
	40319R	Red	Medium	
	58443	Lite Gray	Soft	
	51443	White	Medium	
	52443	Yellow	Medium	
	40333	Red	Firm	
	20519	Gray	Medium	Fire Retardant
	40502	Gray	Firm	
	40412	Lite Gray	Medium	

Note: All Medium Density Closed Cell Silicone Sponges Meet or Exceed AMS3195 E

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E.S.P. Cord Tolerances

60 Durometer and Over

Size	Range	Tolerance
0 -	0.130	0.005
0.131 -	0.300	0.007
0.301 -	0.550	0.010
0.551 -	0.750	0.015
0.751 -	1.000	0.025

50 Durometer and Under

Size	Range	Tolerance
0 -	0.100	0.008
0.101 -	0.160	0.010
0.161 -	0.250	0.013
0.251 -	0.400	0.016
0.401 -	0.630	0.020
0.631 -	1.000	0.025

Note: Use +/- 2.25% For Over 1 Inch

STANDARDS FOR CROSS SECTIONAL TOLERANCE TABLE

The closer tolerance classes outlined below should not be specified unless required by the final application and they should be restricted to critical dimensions. The closer tolerances demanded, the tighter the control which must be exercised during manufacture and hence higher costs.

When particular physical properties are required in the product, it is not always possible to provide them in a combination which is capable of fabrication to close tolerances. It is necessary, in these circumstances, that consultation take place between the customer and supplier. In general, softer materials need greater tolerances than harder ones. Where close tolerances are required, a specific technique of measurement should be agreed upon between purchaser and manufacturer.

Table 13

Tolerances for outside (O.D.) diameters, inside (I.D.) diameters, wall thickness, width, height, and genaral cross sectional dimensions or extrusions . . . see Figures 15 and 16, Page 22.

RMA Class		1 High Precision	2 Precision	3 Commercial
Drawing Designation		**E1**	**E2**	**E3**
Dimensions (In Millimeters)				
Above	Up to			
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

RMA Class		1 High Precision	2 Precision	3 Commercial
Drawing Designation		**E1**	**E2**	**E3**
Dimensions (In Inches)				
Above	Up to			
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

Note: Tolerances on dimensions above 100mm (3.94) should be agreed on by supplier and user. General cross sectional dimensions below 1mm (0.04) are impractical.

In general, softer materials and those requiring a post cure need greater tolerances.

STANDARDS FOR CUT LENGTH TOLERANCES FOR UNSPLICED EXTRUSIONS

Unspliced extrusions are classified as those that generally require only extruding, vulcanizing and cutting to length. They are of various cross sectional designs and do not include lathe cut parts, formed tubing, or precision ground and cut parts. They are generally packed in a straight or coiled condition after being measured and cut to length.

The following tables are to be used to convey to the manufacturer the limits that are desired by the purchaser.

It should be understood by the design engineers that due to the stretch factor in rubber, a period of conditioning at room temperature must be allowed before measurements for length are taken. Accurate measurement of long lengths is difficult because they 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.

Table 16

CUT LENGTH TOLERANCE TABLES FOR UNSPLICED EXTRUSION

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

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

STANDARDS FOR CUT LENGTH TOLERANCES FOR UNSPLICED EXTRUSIONS

Unspliced extrusions are classified as those that generally require only extruding, vulcanizing and cutting to length. They are of various cross sectional designs and do not include lathe cut parts, formed tubing, or precision ground and cut parts. They are generally packed in a straight or coiled condition after being measured and cut to length.

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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%

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

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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%

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

EXTRUDED SILICONE PRODUCTS, INC.

ENGINEERED CUSTOM RUBBER EXTRUSIONS

(330) 733-0101 Fax (330) 733-0104

Elastomer Characteristics

Rubber	Advantages	Applications
Natural (natural polyisoprene)	High resilience, good strength, resists wear and tear; low permanent set characteristics; excellent flexing qualities or low temperature; bonds well to most metals and fabrics.	For products requiring unusual flexing, resilience, abrasion resistance, or water exposure, such as boots, bumpers, belts, tubing.
Synthetic (synthetic polyisoprene)	Outstanding resilience; better resistance to extreme temperatures, aging and weathering; more uniform quality and usually lower in cost than natural rubber	For products requiring unusual flexing, resilience, abrasion resistance, or water exposure, such as boots, bumpers, belts, tubing.
SBR (styrene butadiene)	Low Price, very fine abrasion, wear and tensile qualities; can be readily substituted for natural rubber in many applications; bonds easily to many materials	Widely used for washers, gaskets, grommets and many other mechanical rubber goods applications requiring high tensile strength and abrasion resistance.
Butyl (isobutylene isoprene)	Excellent impermeability; outstanding resistance to ozone, oxidation, weathering, acids and many chemicals; superior resistance to abrasion; ideal flexing and damping characteristics	Rubber parts include weather stripping, bumpers, shock absorbers, lining for bowling pits, chemical tubing, as well as tubing handling hot fluids.
Polybutadiene	Offers unusually good performance at low temperatures (-100°F), lower heat build-up plus high resistance, to wear and abrasion; cost less per pound than natural rubber	Its most popular use is for building ties; recommended for a wide range of general mechanical goods applications similar to those for natural rubber.
EPDM (ethylene propylene)	Provides excellent resistance to ozone, oxidants and severe weather conditions;outstanding color stability, odor-free characteristics, high heat resistance and dielectric qualities.	Used for a wide range of molded and extruded parts in the appliance and automotive industries: weather stripping, boots, seals, dust covers, sleeves, mounts.
Neoprene (chloroprene)	Resists ozone, sunlight, oxidation and many petroleum derivatives; resistant to combustion; provides good resistance to water, many chemicals; has good resilience and tensile strength properties.	Typical uses include gaskets, impellers, instruments mounts, seals, weather stripping.
NBR (butadiene acrylonitrile)	Highly resistant to petroleum oils, aromatic hydrocarbons, mineral oils, vegetable oils and many acids; has good elongation properties, as well as adequate resilience, tensile and compression set.	For products where oil resistance is of critical importance, including diaphragms, hose gaskets, tubing, cups and seals for fuel and hydraulic components.
Polyurethane (polyurethane diisocyanate)	Good elongation and high tensile strength at high durometer readings; excellent abrasion and tear strength; good resistance to ozone and oxygen; low coefficient of friction.	Bumpers, drive wheels, impellers and shock pads are currently the most popular applications.
Silicone (polysiloxane)	Temperature resistance ranges from-160°F to +600°F and as high as 700°F for short periods of time; tensile strengths as high as 1,800 psi are attainable; elongation characteristics up to 800% can be achieved; offers good resistance to weathering and compression set as well as fatigue and flexing; has unusual cut-growth plus excellent bonding and fusing qualities.	Ideal for automotive, aircraft and appliance components; also for certain surgical and food processing applications because it is odorless and tasteless.
Hypalon (chlorosulfonated polyethylene)	Affords outstanding resistance to most chemicals, heat and oil; is flame resistant, offers excellent color stability, weather and abrasion resistance; also low moisture absorption and good dielectric qualities.	Popular for weather stripping, gaskets, seals, insulator boots and special heat application.
Acrylics (polyacrylic)	Furnishes outstanding heat and oil resistance; provides excellent protection against oxygen and ozone; good heat aging and flex life.	Automotive transmission seals, O-rings and allied applications are its chief uses.
Fluoroelastomers (fluorinated hydrocarbon)	High resistance to solvents, acids, basesfuels, oils and hydraulic fluids; unusual performance at elevated temperatures. Outstanding resistance to weathering, ozone, oxygen and flame. Good tensile strength, resilience, low compression set, low temperature range is approximately -60°F.	Precision seals, O-rings, tubing, valve seats, linings and coated fabrics are a partial listing of the products now being produced from fluoroelastomer stocks.

EXTRUDED SILICONE PRODUCTS, INC.

ENGINEERED CUSTOM RUBBER EXTRUSIONS

(330) 733-0101 Fax (330) 733-0104

THE CHEMICAL RESISTANCE OF VARIOUS ELASTOMERS
GENERAL SUMMARY

	GENERAL PURPOSE NON-OIL RESISTANT				GENERAL PURPOSE - OIL RESISTANT					SPECIALTY ELASTOMERS				
TABLE KEY	NR, IR	SBR, BR	IIR	EPM, EPDM,	NBR	CO, ECO	CR	CSM	AU, EU	T	SI	FSI	FPM	ACM
MATERIAL	Natural Rubber, Isoprene	Butadiene Styrene, Butadiene	Butyl	Ethylene Propylene	Nitrile	Epichlorohydrin	Neoprene	Hypalon	Urethane	Polysulfide	Silicone	Fluoro Silicone	Fluoro Elastomer	Poly Acrylate
CHEMICAL GROUP	Poly Isoprene	Styrene Butadiene Copolymer Poly Butadiene	Isobutylene Isoprene Polymer	Ethylene Propylene Copolymer and Terpolymer	Butadiene Acrylonitrile Copolymer	Epichlorohydrin Polymer and Copolymer	Chloroprene Polymer	Chlorosulfonated Polyethylene	Urethane Polymer	Organic Polysulfide Polymer	Organic Silicone Polymer	Fluorinated Organic Silicone Polymer	Fluorocarbon Polymer	Copolymer of Acrylic Ester and Acrylic Halide
GENERALLY RESISTANT TO	Most Moderate Chemicals Wet or Dry, Organic Acids, Alcohols, Ketones, Aldehydes	Similar to Natural Rubber	Animal and Vegetable Fats, Oils, Greases, Ozone, Strong and Oxidizing Chemicals	Animal and Vegetable Oils, Ozone, Strong and Oxidizing Chemicals	Many Hydrocarbons, Fats, Oils, Greases, Hydraulic Fluids, Chemicals	Similar to Nitrile with Ozone Resistance	Moderate Chemicals and Acids, Ozone, Oils, Fats, Greases, Many Oils, and Solvents	Similar to Neoprene with Improved Acid Resistance	Ozone, Hydrocarbons, Moderate Chemicals, Fats, Oils, Greases	Ozone, Oils, Solvents, Thinners, Ketones, Esters, Aromatic Hydrocarbons	Moderate or Oxidizing Chemicals, Ozone, Concentrated Sodium Hydroxide	Moderate or Oxidizing Chemicals, Ozone, Aromatic Chlorinated Solvents, Bases	All Aliphatic, Aromatic and Halogenated Hydrocarbons, Acids, Animal and Vegetable Oils	Ozone, Extreme Pressure, Lubricants, Hot Oils, Petroleum Solvents Animal and Vegetable Fats
GENERALLY ATTACKED BY	Ozone, Strong Acids, Fats, Oils, Greases, Most Hydrocarbons	Similar to Natural Rubber	Petroleum Solvents, Coal Tar Solvents Aromatic Hydrocarbons	Mineral Oils and Solvents, Aromatic Hydrocarbons	Ozone*, Ketones, Esters, Aldehydes, Chlorinated and Nitro Hydrocarbons *except PVC blends	Ketones, Esters, Aldehydes, Chlorinated and Nitro Hydrocarbons	Strong Oxidizing Acids, Esters, Ketones Chlorinated, Aromatic and Nitro Hydrocarbons	Concentrated Oxidizing Acids, Esters, Ketones, Chlorinated, Aromatic and Nitro Hydrocarbons	Concentrated Acids, Ketones, Esters, Chlorinated and Nitro Hydrocarbons	Mercaptans, Chlorinated Hydrocarbons, Nitro Hydrocarbons, Ethers, Amines, Heterocyclics	Many Solvents, Oils, Concentrated Acids, Dilute Sodium Hydroxide	Brake Fluids, Hydrazine, Ketones	Ketones, Low Molecular Weight Esters and Nitro Containing Compounds	Water Alcohols, Glycols Alkali, Esters, Aromatic Hydrocarbons, Halogenated Hydrocarbons, Phenol

Elastomer Characteristics

Rubber	Advantages	Applications
Natural **(Natural polyisoprene)**	**High resilience, good strength, resists wear and tear, low permanent set characteristics. excellent flexing qualities *or* low temperature; Bonds well to most Metals and fabrics.**	**for products requiring unusual flexing, resilience, and abrasion resistance, or water exposure, such as boots, bumpers, belts, tubing.**
Synthetic **(synthetic pclyisoprene)**	**Outstanding resilience; better resistance to extreme temperatures, Aging and weathering; more uniform quality and usually lower in Cost than natural rubber**	**For products requiring unusual flexing, resilience, abrasion resistance, or water exposure, such as boots, bumpers, belts, tubing.**
SER **(styrene butadiene)**	**Low Price, very fine abrasion, wear and tensile qualities; can he readily substituted for natural rubber in many applications; bonds easily to many materials**	**Widely used for washers, gaskets, grommets and many other mechanical rubber goods applications requiring high tensile strength and abrasion resistance.**
Butyl **(isebutylene isoprene)**	**Excellent impermeability; outstanding resistance to ozone, oxidation, weathering, acids and many chemicals; superior resistence to abrasion, ideal flexing and damping characteristics**	**Rubber parts include weather stripping, bumpers, shock absorbers, lining for bowling pits, , as well as tubing handling hot fluids**
EPDM **(ethylene proylene)**	**Provides excellent resistance to ozone, oxididants and severe weather conditions: outstanding color stability, odor-free characteristics, high heat resistance and dielectric qualities.**	**Used for a wide range of molded and extruded parts in the appliance and automotive industries: weather stripping, boots, seals, dust covers, sleeves, mounts.**
Neoprene **(chloroprene)**	**Resists ozone, sunlight, oxidation and Marlypetrolsum derivatives; resistant to combustion; provides good resistance to water, many chemicals; has good resilience and tensile strength properties.**	**Typical uses include gaskets, impellers, instruments mounts, seals, weather stripping.**
NBR **(Butadiene; acrylonitrile)**	**Highly resistant to petroleum oils, aromatic hydrocarbons, mineral oils, vegetable oils and many acids; has good elongation properties, as well ea adequate resilience, tensile and compression set.**	**for products where oil resistance is of critical importance, including diaphragms, hose gaskets, tubing, cups and seals fuel and hydraulic components,**
Silicone **(polysiloxane)**	**Temperature resistance ranges km -160°F to +600°F and as high as 700 *F for short periods of time; tensile strengths as high as 1,800 psi are attainable; elongation characteristics up to 800% can be achieved; offers good r resistance to weathering and compression set as well as fatigue and flexing; has unusual cut-growth plus excellent bonding and timing qualities.**	**Ideal for Automotive, aircraft and applience components; also for certain surgical and food processing applications because it is oderless and tasteless.**

ESP Cord Tolerances

60 Durometer and Over

Size	Range	Tolerance
0-	0.130	0.005
0.131-	0.300	0.007
0.301-	0.550	0.010
0.551-	0.750	0.015
0.751-	1.000	0.025

50 Durometer and Under

Size	Range	Tolerance
0-	0.100	0.008
0.101-	0.160	0.010
0.161-	0.250	0.013
0.251-	0.400	0.016
0.401-	0.630	0.020
0.631-	1.000	0.025

Note: Use +/- 2.25 for Over 1 Inch

Thank you for reviewing ESP's website
Understanding the basics of rubber, materials and tolerancing can be very demanding.
Additional Information is available to you, at no Charge, upon request, via email or fax.
A list of information available is listed below.

•ASTM D 1566:

Standard Terminology Relating to Rubber

•ASTM D 2527:

Standard Specification for Rubber Seals- Splice Strength

•ASTM D 2000:

Flexible Cellular Materials- Sponge or Expanded Rubber

•Specifications for Elastomer Compounds for
Automotive Applications

•Chemical Resistance of Various Elastomers

•Architectural Gasket Specification Matrix

•Pipe Gasket Specification Matrix

•Compound Selection Guide of Certain Military and
Government Standards – A Reference Chart

•Mil C-3133C

Military Specification for Cellular Elastomeric Materials

•Mil-R-3065E

Military Specification for Rubber Fabricated Products

•Mil-R-6130C

•Military Specification for Rubber Cellular