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 3302-1:1996, Rubber -- Tolerances for products -- Part 1: Dimensional tolerances.

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

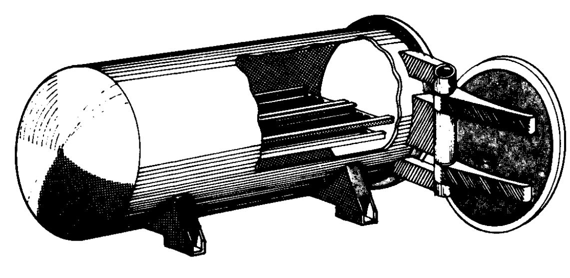
The extrudate is fed into the vulcanization process directly from the extruder permitting the extrusion to be vulcanized in a continuous length. Several media are employed in the continuous vulcanization of rubber, all of which must be operated at elevated temperatures: air, molten salts, oils, fluidized 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.

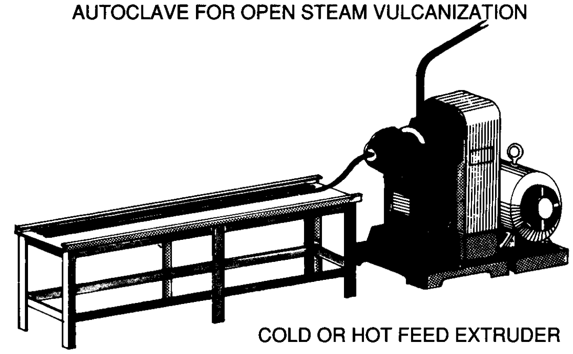
PROCESS ILLUSTRATIONS

RUBBER EXTRUDING SYSTEMS

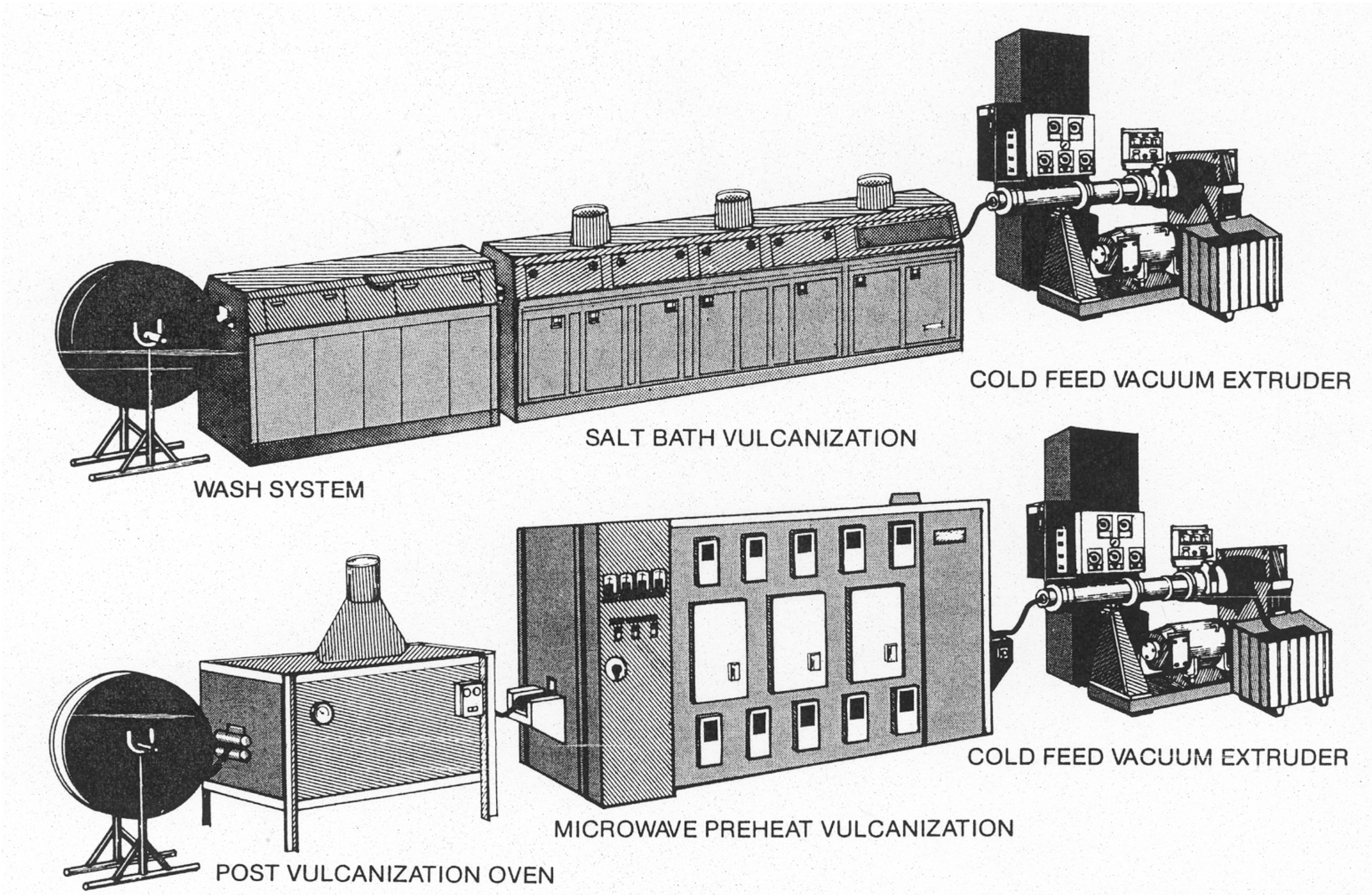
The systems shown below are a few variations of vulcanizing extruded rubber.



AUTOCLAVE FOR OPEN STEAM VULCANIZATION

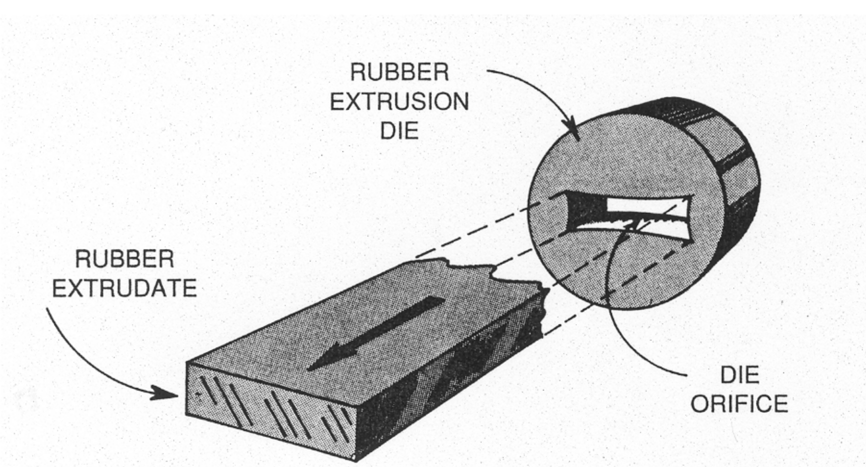


COLD OR HOT FEED EXTRUDER



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.



SUMMARY OF RMA DRAWING DESIGNATIONS FOR EXTRUDED RUBBER PRODUCTS

Drawing Designations

In those cases where the design engineer can specify and accept one RMA Class on extruded products for the applicable qualifications on dimensional tolerances, ground surface, mandrel vulcanization, cut length, contour, forming, finish, T.I.R. and packaging, then the drawing need only carry the symbol for the acceptable class as RMA Class 1-2-3 or 4 as the case may be.

Normally, however, there will be exceptions to an RMA Class. By using the following chart, these exceptions can be noted.

Table 12 - Summary of RMA Drawing Designations - Extruded Rubber Products

RMA Class	Dimensional Tolerance* Table 13	Finish Table 14	Formed Tubing Table 15	Cut Length Tolerance* Table 16	Angle Cut Tolerance Table 17	Spliced Length Tolerance Table 18
1	E1	F1	H1	L1	AG1	S1
2	E2	F2	H2	L2	AG2	S2
3	E3	F3	H3	L3	AG3	S3
4	--	F4	H4	--	--	--

RMA Class	Ground Surface* Table 19	Mandrel Cured* Table 20	T.I.R. Table 21	Ground Tubing Tolerance* Table 22	Packaging Table 23
1	EG1	EN1	K1	EW1	P1
2	EG2	EN2	K2	EW2	P2
3	--	EN3	--	--	P3
4	--	--	--	--	--

*As noted in the purpose and scope, certain statements and tables in this chapter have been changed to reflect current industry practices and to agree with International Standard ISO 3302-1:1996, Rubber -- Tolerances for products -- Part 1: Dimensional tolerances.

Distortion

Because rubber is a flexible material affected by temperature, distortion can occur when the part is stored or when it is packed for shipment. This distortion makes it difficult to measure the parts properly. Some of the distortion can be minimized by storing the parts as unstressed as possible for 24 hours at room temperature.

Environmental Storage Conditions

Temperature

Rubber, like other materials, changes in dimension with changes in temperature. Compared to other materials the coefficient of expansion of rubber is high. To have agreement in the measurement of products that are critical or precise in dimension, it is necessary to specify a temperature at which the parts are to be measured and the time required to stabilize the part at that temperature.

Humidity

Some rubber materials absorb moisture. Hence the dimensions are affected by the amount of moisture in the product. For those products which have this property, additional tolerance must be provided in the dimensions. The effect may be minimized by stabilizing the product in an area of controlled humidity and temperature for a period not less than 24 hours.

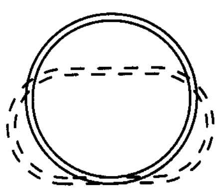
STANDARDS FOR CROSS SECTIONAL TOLERANCES

The following illustrations should be taken into consideration when designing rubber parts and when describing what is needed and expected from the manufacturer.

Extrusion Contour (Shape) Variation

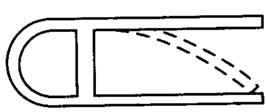
Contour designates the degree of rigidity and conformity to the cross sectional drawing. During vulcanization the tendency of the extrusion is to sag and flatten. The degree of change in shape is largely dependent upon the hardness or softness of the compound, the tensile strength or quality of the compound, the thickness or thinness of the cross sectional wall, the inner openings of the extrusion and the rate of vulcanization. This tendency to distort during vulcanization can best be eliminated by the use of forms or mandrels which generally add to the cost of manufacture. This cost can sometimes be eliminated if contour conformity is not necessary to the finished extrusion. The degree of allowable collapse or sag in a cross section should be indicated on the blueprint as shown in illustrations below.

Figure 12



Tube may collapse as indicated by dotted line.

Figure 13



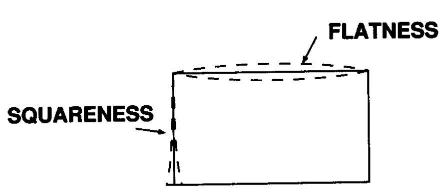
Lip may collapse as indicated by dotted line.

Squareness & Flatness of Rectangular Cross Sections

Tolerances for squareness and flatness of extruded sections are not included in these tables. Due to the difficulty of establishing meaningful limits to satisfy the wide area of needs, purchaser and manufacturer should discuss and agree on these limits.

Illustration is for enlightenment only.

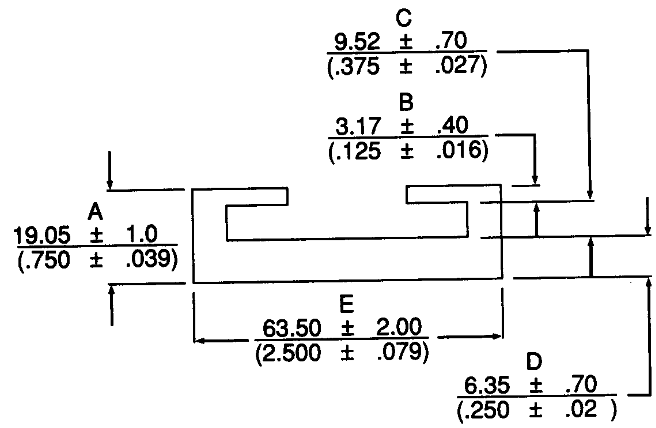
Figure 14



Cross Sectional Dimension Illustration.

Tolerances for illustration are taken from Class 2, Table 13, page 23.

Figure 15

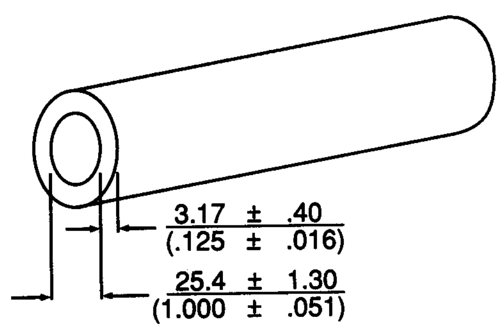


Dimension "C" in above illustration is affected by shape variation.

I.D. - O.D. Tube Tolerances

Tolerances should be established on the I.D. (or O.D.) and wall thickness only. To include a tolerance on both I.D. and O.D. generally conflicts with the other tolerances.

Figure 16



Tolerances for I.D. - O.D. tubing are found in Table 13, page 23.

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 general 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	0.40	0.70	1.00
10.0	16.0	0.50	0.80	1.30
16.0	25.0	0.70	1.00	1.60
25.0	40.0	0.80	1.30	2.00
40.0	63.0	1.00	1.60	2.50
63.0	100.0	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**			
0.00	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 in.) should be agreed on 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.

STANDARDS FOR EXTRUDED FINISH AND APPEARANCE

In the process of producing extruded parts, it is necessary to use various lubricants, release agents, dusting agents, and other solutions. It may be necessary to remove these materials from the extrusion after vulcanization because of an appearance requirement. The cost of cleaning may be eliminated from those products which are concealed or do not hinder assembly. The purchaser's intent and desire in this area should be conveyed to the rubber manufacturer by use of the proper RMA class of finish designation. Full consideration of finish requirements may result in considerable cost savings on the product.

Table 14 - Drawing Designation for Extrusion Finish

RMA Class	Drawing Designation	
1	**F1**	Product shall have surface finish smooth, clean and free from any foreign matter.
2	**F2**	Product shall have surface finish cleaned of dust and foreign matter but slight streaks or spots acceptable.
3	**F3**	Product shall have loose dust and foreign matter removed but natural finish (not washed) acceptable.
4	**F4**	Product shall be acceptable with no cleaning necessary. Dust or solution deposits acceptable. Coarse or grainy surface acceptable.

STANDARDS FOR FORMED TUBING (FOR SPECIAL SHAPES)

The type of product discussed in this section is formed by forcing unvulcanized tubing over a mandrel or flexible core bent to the required radii or shape.

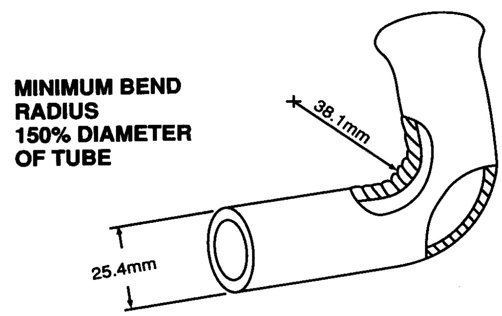
In forcing the unvulcanized tubing over the mandrel or flexible core and around a bend, the wall thickness will be stretched on the outside of the bend and compressed on the inside of the bend. If the bend or radius is too severe, folds or wrinkles will form on the inside of the bend and severe stretching will occur on the outside of the bend.

The minimum bending radius at which tubing may be formed will depend upon the outside diameter and wall thickness and should never be less than 150% of the outside diameter (O.D.).

If a small radius or a specific angle is required, the part should be molded. This is necessary because, in addition to folds and wrinkles on the inside of the radius, it may be impossible to force the tubing over the bend or to strip it from the mandrel during the manufacturing process.

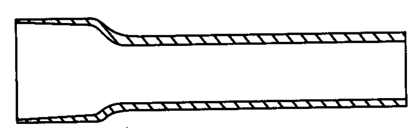
If a minimum wall thickness is specified, it will mean this minimum thickness must be furnished at the outside bend or stretched section, and depending on the severity of the bend or bends, it will require an oversize wall thickness on the rest of the tubing from 0.40mm (0.016 in.) to 0.80mm (0.032 in.) to ensure the minimum thickness on the stretched area. If tubing is specified, it must be understood that, depending on the severity of the bend or bends, wall thickness will be from 0.40mm (0.016 in.) to 0.80mm (0.032 in.) undersize in the stretched areas.

Figure 17



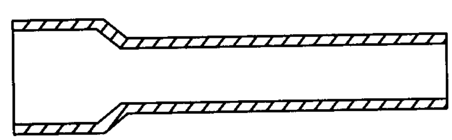
EXAMPLE OF RADIUS, STRAIGHT END, FLARED END, WRINKLES, BUCKLES AND WALL THICKNESS. MINIMUM BEND RADIUS.

Figure 18



EXAMPLE OF BLENDED CONTOUR

Figure 19



EXAMPLE OF DEFINITE CONTOUR

The leading end of the tubing will stretch and enlarge as it is forced over the mandrel or flexible core, according to the severity of the bend or bends, and will not fully recover to original size during vulcanization. If both ends of the formed tubing must meet specification set forth for the original cross section, the product should either be molded or the lead end should be designed to fit a 1.6mm (0.063 in.) oversize fixture. If the straight section adjacent to any sharp bend is to be shorter than 300% of the O.D. of the tube, it must be understood that the tube must be made long enough to eliminate the flare and cut back to desired length after removal from mandrel. When forming tubing all bends and radii must be approximate, as natural spring-back of tubing formed under tension precludes the possibility of holding to an exact radius or shape. The tubing being flexible will adjust itself on assembly to compensate for these small variations. Measurement from beginning of bends or radii to other bends and radii are also approximate and subject to small variations for the same reasons.

Where expanded ends are required, the inside and outside of the tubing should blend from the regular cross section to the expanded cross section and not with a definite contour and radius as formed on a molded part. The walls of the enlarged section will be thinner than the regular section by 0.40mm (0.016 in.) to 0.80mm (0.032 in.), depending on the severity of enlargement. Expansion beyond 100% of I.D. of tubing is not practical. Any requirements beyond 100% must be molded.

Table 15 - Drawing Designation for Formed Tubing

RMA Class	Drawing Designation	
1	**H1**	Product to be furnished to minimum wall thickness specified and maintained throughout. Ends to be trimmed true and even.
2	**H2**	Product to be furnished to general cross section with stretched or thinner wall acceptable at bends or radii. Otherwise, same as Class 1.
3	**H3**	Product may be furnished partially out of round in straight or bent sections. Ends may not necessarily be straight and true. Minor flat spots permissible.
4	**H4**	Product may be furnished partially out of round in straight or bent sections. Flat spots and slight wrinkles or buckles permissible. Product may be cut to length in unvulcanized state. (Allow 12.3mm (.500 in.) for every 750mm (30 in.) of length.) Special tolerance to be established between supplier and purchaser.

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 Table 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 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.

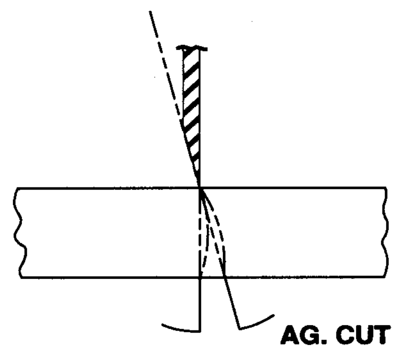
The angle and curve on cut face of extrusion will differ in degree depending upon the method used to cut the extrusion as well as the hardness of the compound, design or cross section and thickness of the extrusion.

(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.)

Table 17

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

Figure 20

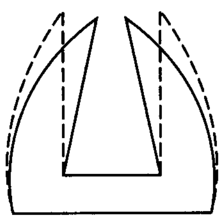


STANDARDS FOR SPLICED EXTRUSIONS

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



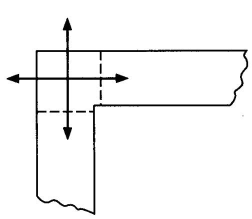
Open as indicated by Dotted Lines

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.

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.

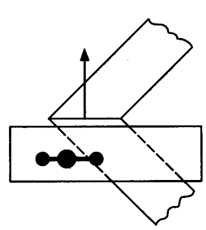
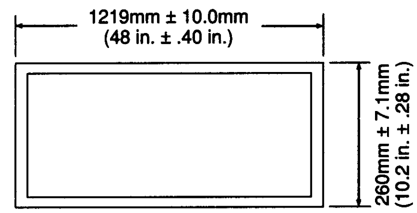


Figure 24

Figure 25

Tolerance on Illustration are Class 2.



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.

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

DESIGN OF EXTRUDED ENDLESS SPLICES

When designing endless splices for extruded profiles, several factors must be considered: durometer of compound, cut length, size of cross section and in the case of tubing, wall thickness.

Mold cavities are normally designed to the nominal dimension. If the extrudate cross section is at the top of the extruded tolerance, mold pressure marks will be visible on the surface and more so with the use of lower durometer compounds. If the extrudate cross section is at the low end of the extruded tolerance, the mold cavity would have to be shimmed in order to attain splicing pressure creating some surface marking. The longer the cut length, the greater the difference in size at each end. (One end may be on high tolerance and the other end on low tolerance.) Generally, this gives the appearance of a step or mismatch. See Figure 26.

Tubing is subject to the same considerations but in addition, thin wall tubing may require internal support in order to achieve sufficient molding pressure. The type of insert used and whether or not it should be removed would have to be resolved between manufacturer and purchaser.

It is to the advantage of both customer and rubber manufacturer to discuss design and application of extruded endless splices. See Figure 27.

Figure 26

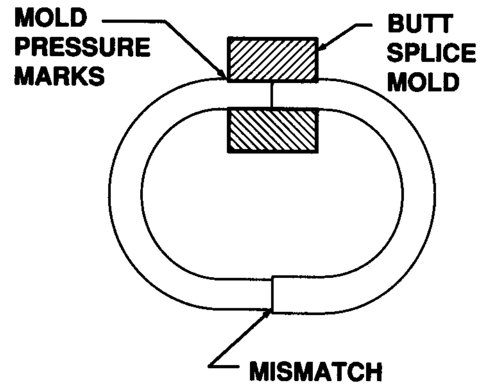
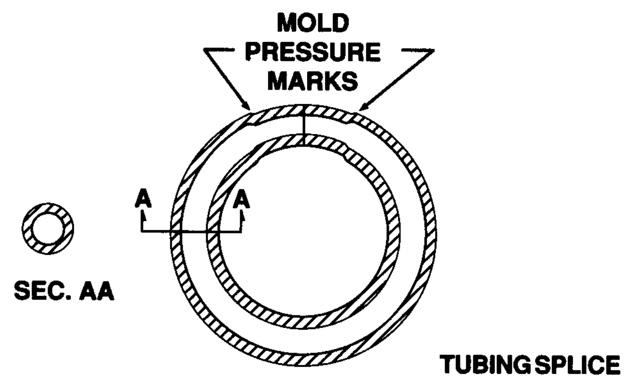


Figure 27



STANDARDS FOR OUTSIDE DIMENSIONS OF SURFACE GROUND EXTRUSIONS

If it becomes necessary to hold the outside diameter of extruded mandrel cured tubing to closer tolerances than normal manufacturing methods will permit, this can be accomplished by surface grinding the part if the part has an inside diameter of 5.0mm (0.20 in.) or more.

A drawing of this type of part should specify inside diameter or outside diameter, wall thickness, and outside finish. If ground finish is desired, it should be classified as one of the following : rough, smooth, or fine.

Table 19 - Tolerances on Outside Dimensions of Surface-Ground Extrusions

RMA Class		1 (Precision)	2 (Commercial)
Drawing Designation		EG1	EG2
Dimensions (In Millimeters)			
Above	Up to		
5	10	±0.15	±0.25
10	16	0.20	0.35
16	25	0.20	0.40
25	40	0.25	0.50
40	63	0.35	0.70
63	100	0.40	0.80
100	160	0.50	1.00
160		0.3%	0.6%
Dimensions (In Inches)			
Above	Up to		
0.20	0.40	±0.006	±0.010
0.40	0.63	0.008	0.014
0.63	1.00	0.008	0.016
1.00	1.60	0.010	0.020
1.60	2.50	0.014	0.028
2.50	4.00	0.016	0.032
4.00	6.30	0.020	0.040
6.30		0.3%	0.6%

STANDARDS FOR INTERNAL DIMENSIONS OF MANDREL-SUPPORTED EXTRUSIONS

When it becomes necessary to hold the tubing round and to close tolerances, a mandrel of the proper size must be inserted in the I.D. of the tubing before vulcanizing. This limits the length of the tubes. Shrinkage usually occurs when the product is removed from the mandrel so that the resulting size of the mandrel-supported dimension is smaller than the mandrel size. The dimension may, however, be larger should the positive tolerance for the mandrel exceed the shrinkage of the extrudate and in this case both positive and negative tolerances will need to be applied.

The designer should indicate what type of surface would be required on the O.D. of the tubing such as ground surface, cloth wrapped surface or as extruded. Any tube that has to have close tolerances on the O.D. generally will have a ground finish. A cloth wrap is used usually to help maintain a round I.D. and O.D. when the stock is soft and may sag in curing. The cloth wrapping of a tube (the tube is placed on a mandrel and wrapped tightly in cloth before vulcanizing and then removed after vulcanizing) leaves the imprint of the cloth weave in the rubber.

If type of surface is not indicated, it would then be assumed that the surface is to be as extruded.

Table 20 - Tolerances on Internal Dimensions of Mandrel-Supported Extrusions

RMA Class		1 (Precision)	2 (Commercial)	3 (Non-Critical)
Drawing Designation		EN1	EN2	EN3
Dimensions (in Millimeters)				
Above	Up to			
0	4	±0.20	±0.20	±0.35
4	6.3	0.20	0.25	0.40
6.3	10	0.25	0.35	0.50
10	16	0.35	0.40	0.70
16	25	0.40	0.50	0.80
25	40	0.50	0.70	1.00
40	63	0.70	0.80	1.30
63	100	0.80	1.00	1.60
100	160	1.00	1.30	2.00
160		0.6%	0.8%	1.2%
Dimensions (in Inches)				
Above	Up to			
0	0.16	±0.008	±0.008	±0.014
0.16	0.25	0.008	0.010	0.016
0.25	0.40	0.010	0.014	0.020
0.40	0.63	0.014	0.016	0.028
0.63	1.00	0.016	0.020	0.032
1.00	1.60	0.020	0.028	0.040
1.60	2.50	0.028	0.032	0.051
2.50	4.00	0.032	0.040	0.063
4.00	6.30	0.040	0.051	0.079
6.30		0.6%	0.8%	1.2%

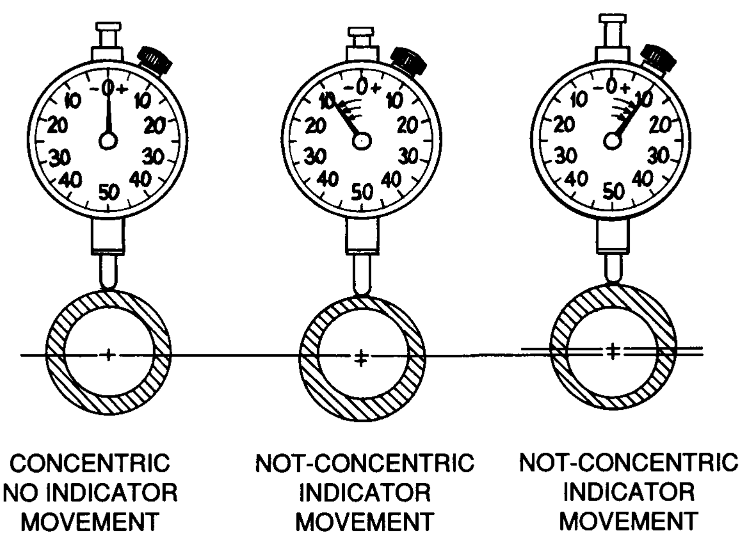
STANDARD FOR CONCENTRICITY OF MANDREL CURED AND GROUND EXTRUDED TUBING

CONCENTRICITY

Concentricity is the relationship of two or more circles or circular surfaces having a common center. It is usually designated as T.I.R. (Total Indicator Reading) and is the total movement of the hand of an indicator set to record the amount that a surface varies from being concentric.

Table 21 - T.I.R. Tolerances

RMA Class		1 (Precision)	2 (Commercial)
Drawing Designation		**K1**	**K2**
O.D. (In Millimeters)			
Above	**Up to**		
0	13	0.20	0.40
13	20	0.25	0.50
20	32	0.33	0.75
32	50	0.47	1.15
50	80	0.50	1.65
80	Over	0.64	2.30
O.D. (In Inches)			
Above	**Up to**		
0.0	0.5	0.008	0.015
0.5	0.8	0.010	0.020
0.8	1.25	0.013	0.030
1.25	2.00	0.016	0.045
2.00	3.15	0.020	0.065
3.15	Over	0.025	0.090



When the above specimen is rotated 360° about the center of the inside circle with a dial indicator in contact with the outside circle, the total sweep of the indicator hand or difference to right and left of zero in above example is referred to as "Total Indicator Reading" or T.I.R. The T.I.R. in this example is 20 units.

OPTIONAL METHOD OF TOLERANCING GROUND EXTRUDED TUBING

Table 22 - Tolerances on Wall Thickness of Surface-Ground Extrusions

RMA Class		1 (Precision)	2 (Commercial)
Drawing Designation		EW1	EW2
Nominal Dimension (In Millimeters)			
Above	Up to		
0.0	4.0	±0.10	±0.20
4.0	6.3	0.15	0.20
6.3	10.0	0.20	0.25
10.0	16.0	0.20	0.35
16.0	25.0	0.25	0.40
Nominal Dimension (In Inches)			
Above	Up to		
0.0	0.16	±0.004	±0.008
0.16	0.25	0.006	0.008
0.25	0.40	0.008	0.010
0.40	0.63	0.008	0.014
0.63	1.00	0.010	0.016

STANDARDS FOR PACKAGING

When a rubber part is packaged, it is for the sole purpose of transportation from the supplier to the user. Packaging usually causes some distortion of the rubber part which, if used in a reasonable length of time, does not permanently affect the part. However, when rubber parts are held in a distorted position for a prolonged period of time, permanent set may cause permanent distortion and result in unusable parts. Any product on which distortion may make the part unusable should be specified and packaged by such methods as will prevent distortion. However, such methods are expensive and should not be specified unless absolutely necessary. With extrusions in long lengths, where it is impractical to ship in straight lengths and coiling in boxes or cartons causes distortion of the product, the product should be removed from the container when received and stored in straight lengths on shelves to preserve usability. Packaging is a complex area and should be given serious consideration. The table at right is to be considered only as a guide. Special packaging problems should be considered between purchaser and supplier.

Table 23 - Extrusion Packaging

RMA Class	Drawing Designation	
1	**P1**	This class of product will be packaged to eliminate all possible distortion during transportation and storage. This may require special boxes, cartons, forms, cores, inner liners, or other special methods.
2	**P2**	This class of product will be packaged in corrugated containers or boxes. The quantity of the product packaged per container will be held to an amount which will not crush the lower layers from its own weight, but no forms, cores, inner liners, etc. are necessary.
3	**P3**	This class of product will be packaged in corrugated paper containers, boxes, crates, burlap bags or bundles, or on skids and pallets. This is the most economical method of packaging but may also produce the greatest distortion in the product.