



HANNA RUBBER COMPANY

Tolerance Molded Rubber

Address:

908 West 25th Street
Kansas City, Mo. 64108

Phone Number:

816-221-9600

Email Address:

sales@hannarubber.com

Website:

www.hannarubber.com

America's First Choice for Rubber & Plastic Products

Hanna Rubber Company has been providing products and service to its construction, automotive, military and government customer base since 1925.

Purpose and Scope

The purpose of this section is to provide a method for standardizing drawing designations for specific design requirements of molded rubber products. Information set forth on the pages that follow should be helpful to the design engineer in setting up realistic specifications for molded rubber products.

The use of proper drawing designations by designers in specifying on drawings exactly what is required is a matter of paramount importance. Proper use of these drawing designations by both product designer and rubber manufacturers will result in a common understanding of the design requirements which must be engineered into molded rubber products. To assure a uniform method for use on drawings and in specifications, the drawing designations on the following pages have been standardized by the Rubber Manufacturers Association for use in the molded rubber field.

Although rubber manufacturers can produce products to high standards of precision, they welcome the opportunity to suggest modifications which would reduce costs. The purchasers of molded rubber products can assist to this end by furnishing the manufacturers with details covering the application of their parts.

The scope of this section presents to the user the tolerances and standards the rubber manufacturers are normally able to maintain. These tolerances may be described as shown in this manual or by geometric tolerancing as shown in the ASME Y14.5M standard.

Note: Where the term “**Rubber**” is used in this section, it is intended to include synthetic thermosetting elastomers as well as natural rubber. This information may also be suitable for products made from thermoplastic elastomers.

SUMMARY AND EXAMPLES OF RMA DRAWING DESIGNATIONS MOLDED RUBBER PRODUCTS

DRAWING DESIGNATIONS

The design engineer should select and designate on the drawing a separate RMA designation for each characteristic noted. Relative dimensions, bonding, spring rate or load-deflection characteristic are to be used only when applicable. (See examples below.) If no designation is specified, the rubber manufacturer will assume that commercial tolerances apply.

Table 1 - Summary of RMA Drawing Designations

Dimensional Tolerances (Tables 2-5)	Relative Dimensions	Finish (Table 6)	Flash Extension (Table 7)	Bonding (Specify Grade and Method on B1 and B2) (Tables 8 & 9)	Load-Deflection Characteristic (Specify only when needed) (Table 10)	Packaging (Table 11)
A1	No designation, see text and/or your rubber supplier. Specify only when needed.	F1	T.00mm T.000	B1	D1	P1
A2		F2	T.08mm T.003	B2	D2	P2
A3		F3	T.40mm T.016	B3	D3	P3
A4		F4	T.80mm T.032	B4	--	--
--		--	T1.60mm T.063	B5	--	--
--		--	T2.35mm T.093	--	--	--
--		--	T∞ T∞	--	--	--
--		--	--	--	--	--

Example 1:

Commercial tolerances; commercial finish; flash extension .80mm (.032 in.) would be designated on the drawing as follows: RMA A3-F3-T.80mm (.032 in.).

Example 2:

Precision tolerances; commercial finish; flash extension .80mm (.032 in.) and special agreement on bonding to metal would be designated on the drawing as follows: RMA A2-F3-T.80mm (.032 in.) - B5.

Example 3:

Basic tolerances; commercial finish; flash extension .80mm (.032 in.) would be designated on the drawing as follows: RMA A4-F3-T.80mm (.032 in.).

Example 4:

Precision tolerances; good finish; flash very close; (bond samples tested to 16kN/m (90 lbs./in.) width to destruction) would be designated on the drawing as follows: RMA A2-F2-T.40mm (.016 in.) - B2 Grade 1 Method B.

FACTORS AFFECTING TOLERANCES

Introduction

The purpose of this section is to list some of the factors affecting tolerances. In general, the degree of reproducibility of dimensions depends upon the type of tooling and rubber used, and the state of the art.

DISCUSSION OF FACTORS AFFECTING TOLERANCES

There are many factors involved in the manufacturing of molded rubber products which affect tolerances. Since these may be peculiar to the rubber industry, they are listed here.

Shrinkage

Shrinkage is defined as the difference between corresponding linear dimensions of the mold and of the molded part, both measurements being made at room temperature. All rubber materials exhibit some amount of shrinkage after molding when the part cools. However, shrinkage of the compound is also a variable in itself and is affected by such things as material specification, cure time, temperature, pressure, inserts, and post cure. The mold designer and the compounder must determine the amount of shrinkage for the selected compound and incorporate this allowance into the mold cavity size. Even though the mold is built to anticipate shrinkage, there remains an inherent variability which must be covered by adequate dimensional tolerance. Shrinkage of rubber is a volume effect. Complex shapes in the molded product or the presence of inserts may restrict the lineal shrinkage in one direction and increase it in another. The skill of the rubber manufacturer is always aimed at minimizing these variables, but they cannot be eliminated entirely.

Mold Design

Molds can be designed and built to varying degrees of precision, but not at the same cost. With any type of mold, the mold builder must have some tolerance, and therefore, each cavity will have some variance from the others. Dimensional tolerances on the product must include allowances for this fact. The accuracy of the mold register must also be considered. This is the matching of the various plates of the mold that form the mold cavity. Register is usually controlled by dowel pins and bushings or by self-registering cavities. For molds requiring high precision in dimensions and register, the design work and machining must be more precise and the cost of the molds will be greater than one with commercial requirements.

Trim and Finish

The objectives of trimming and finishing operations are to remove rubber material -- such as flash, which is not a part of the finished product. Often this is possible without affecting important dimensions, but in other instances, some material is removed from the part itself. Where thin lips or projections occur at a mold parting line, mechanical trimming may actually control the finished dimension.

Inserts

Most insert materials (metal, plastic, fabric, etc.) have their own standard tolerances. When designing inserts for molding to rubber, other factors must be considered, such as fit in the mold cavities, location of the inserts with respect to other dimensions, proper hole spacing to match with mold pins, and the fact that inserts at room temperature must fit into a heated mold. In these matters, the rubber manufacturer can be of service in advising on design features.

Distortion

Because rubber is a flexible material, its shape can be affected by temperature. Distortion can occur when the part is removed from the mold 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 part as unstressed as possible for 24 hours at room temperature. Some rubber will crystallize (stiffen) when stored at low temperature and must be heated to above room temperature to overcome this condition.

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.

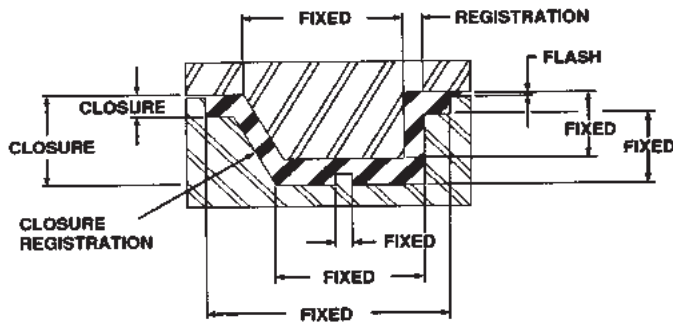
Dimension Terminology

The following will provide a common terminology for use in discussing dimensions of molded rubber products, and for distinguishing various tolerance groupings:

Fixed Dimension: Dimensions not affected by flash thickness variation. (Mold Closure) See Figure #1.

Closure Dimensions: Dimensions affected by flash thickness variation. (Mold Closure) See Figure #1.

Figure 1



In addition to the shrinkage, mold maker's tolerance, trim and finish, a number of other factors affect closure dimensions. Among these are flow characteristics of the raw stock, weight, shape of preform and molding process.

While closure dimensions are affected by flash thickness variation, they are not necessarily related to basic flash thickness. If a manufacturer plans to machine or die trim a product, the mold will have a built-in flash, which will be thicker than if hand deflashing or tumble trim were to be employed. Thus products purchased from two sources could have different basic flash thickness at the parting line and yet meet drawing dimensions.

There is usually a logical place for the mold designer to locate the parting line for best dimensional control and part removal. If the product design limits this location, an alternate mold construction will be required, which may affect the tolerance control on the product, and may, in some cases, increase the cost of the mold.

Registration Dimension: Dimensions affected by the matching of the various plates of the mold that form the mold cavity. Register is usually controlled by dowel pins and bushings or by self-registering cavities.

TOLERANCE TABLES

There are four levels of dimensional tolerances that are used for molded rubber products.

"A1"	High Precision
"A2"	Precision
"A3"	Commercial
"A4"	Basic

The level selected should be based upon the need with the following guidelines.

"A1" is the tightest tolerance classification and indicates a high precision rubber product. Such products require expensive molds, fewer cavities per mold, costly in-process controls and inspection procedures. It is desirable that the exact method of measurement be agreed upon between rubber manufacturer and customer, as errors in measurement may be large in relation to the tolerance. Some materials, particularly those requiring post curing, do not lend themselves to Drawing Designation "A1" tolerances.

"A2" tolerances indicate a precision product. Molds must be precision machined and kept in good repair. While measurement methods may be simpler than the Drawing Designation "A1", careful inspection will usually be required.

"A3" tolerances indicate a "commercial" product and will normally be used for most products.

"A4" tolerances apply to products where some dimensional control is required but is secondary to cost.

When applying tolerances the following rules should be kept in mind.

1. Fixed dimension tolerances apply individually to each fixed dimension by its own size.
2. Closure dimension tolerances are determined by the largest closure dimension and this single tolerance is used for all other closure dimensions.
3. Fixed and closure dimensions for a given table do not necessarily go together, and can be split between tables.
4. Tolerances not shown should be determined in consultation with the rubber manufacturer.
5. Care should be taken in applying standard tolerances to products having wide sectional variations.

**Table 2 - Standard Dimensional Tolerance Table
Molded Rubber Products Drawing Designation "A1" High Precision**

Size (mm)		Fixed	Closure	Size (inches)		Fixed	Closure
Above	Incl.			Above	Incl.		
0	10	±.10	±.13	0	.40	±.004	±.005
10	16	.13	.16	.40	.63	.005	.006
16	25	.16	.20	.63	1.00	.006	.008
25	40	.20	.25	1.00	1.60	.008	.010
40	63	.25	.32	1.60	2.50	.010	.013
63	100	.32	.40	2.50	4.00	.013	.016
100	160	.40	.50	4.00	6.30	.016	.020

**Table 3 - Standard Dimensional Tolerance Table
Molded Rubber Products Drawing Designation "A2" Precision**

Size (mm)		Fixed	Closure	Size (inches)		Fixed	Closure
Above	Incl.			Above	Incl.		
0	10	±.16	±.20	0	.40	±.006	±.008
10	16	.20	.25	.40	.63	.008	.010
16	25	.25	.32	.63	1.00	.010	.013
25	40	.32	.40	1.00	1.60	.013	.016
40	63	.40	.50	1.60	2.50	.016	.020
63	100	.50	.63	2.50	4.00	.020	.025
100	160	.63	.80	4.00	6.30	.025	.032
160	& over multiply by	.004	.005	6.30	& over multiply by	.004	.005

**Table 4 - Standard Dimensional Tolerance Table
Molded Rubber Products Drawing Designation "A3" Commercial**

Size (mm)		Fixed	Closure	Size (inches)		Fixed	Closure
Above	Incl.			Above	Incl.		
0	10	±.20	±.32	0	.40	±.008	±.013
10	16	.25	.40	.40	.63	.010	.016
16	25	.32	.50	.63	1.00	.013	.020
25	40	.40	.63	1.00	1.60	.016	.025
40	63	.50	.80	1.60	2.50	.020	.032
63	100	.63	1.00	2.50	4.00	.025	.040
100	160	.80	1.25	4.00	6.30	.032	.050
160	& over multiply by	.005	.008	6.30	& over multiply by	.005	.008

**Table 5 - Standard Dimensional Tolerance Table
Molded Rubber Products Drawing Designation "A4" Basic**

Size (mm)		Fixed	Closure	Size (inches)		Fixed	Closure
Above	Incl.			Above	Incl.		
0	10	±.32	±.80	0	.40	±.013	±.032
10	16	.40	.90	.40	.63	.016	.036
16	25	.50	1.00	.63	1.00	.020	.040
25	40	.63	1.12	1.00	1.60	.025	.045
40	63	.80	1.25	1.60	2.50	.032	.050
63	100	1.00	1.40	2.50	4.00	.040	.056
100	160	1.25	1.60	4.00	6.30	.050	.063
160	& over multiply by	.008	.010	6.30	& over multiply by	.008	.010

Measurement of Dimensions

Conditioning of Parts: Measurements of dimensions shall be made on parts conditioned at least 24 hours after the molding operation. Measurements shall be completed within 60 days after shipment or before the part is put into use, whichever is the shorter time. Care shall be taken to ensure that the parts are not subjected to adverse storage conditions.

In the case of referee measurement, particularly on Drawing Designation "A1" tolerances or for materials known to be sensitive to variations in temperature or relative humidity, the parts in question should be conditioned for a minimum of 24 hours at $23^{\circ} \pm 2^{\circ} \text{ C}$ ($73.4^{\circ} \pm 3.6^{\circ} \text{ F}$) and at $50\% \pm 5\%$ relative humidity.

Methods of Measurement: Depending upon the characteristics of the dimension to be measured, one or more of the following methods of measurement may be used.

- (A) A coordinate measuring machine (CMM) with a stylus size appropriate for the smallest feature or dimension to be measured.
- (B) A dial micrometer with a plunger size and loading as agreed upon by the customer and the rubber manufacturer.
- (C) A suitable optical measuring device.
- (D) Fixed gauges appropriate to the dimensions being measured.
- (E) Other methods agreed on between customer and supplier.

Under no circumstances should the part be distorted during measurement. On dimensions which are difficult to measure or which have unusually close tolerances, the exact method of measurement should be agreed upon in advance by the rubber manufacturer and the customer.

Relative Dimensions

General Information: Relative dimensions such as concentricity, squareness, flatness, parallelism, or location of one or more inserts in the product are dimensions described in relation to some other dimension. Since it is impossible to foresee the many potential designs of all molded products in which relative dimensions will be specified, it is impractical to assign standard drawing tolerance designations to these dimensions. The design engineer should recognize that the more precise the requirement, the more expensive the product. He must allow the rubber manufacturer to use support pins, lugs, chaplet pins, or ledges in the mold to provide positive location and registration of the insert or inserts in the mold cavity. With this in mind, it is suggested that the design engineer discuss relative dimensional tolerances on all products directly with the rubber manufacturer.

Other factors do affect tolerances to some minor degree. Our attempt has been to acquaint the design engineer with background information on the major factors which result in the need for tolerances on molded rubber products.

Examples of Relative Dimensions: Several examples of relative dimensions the design engineer may be required to consider are shown:

- (A) Concentricity
- (B) Squareness
- (C) Flatness
- (D) Parallelism

In all cases the tolerances should be considered only as a very general guide.

CONCENTRICITY

Concentricity is the relationship of two or more circles or circular surfaces having a common center. It is 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.

All diameters formed in the same mold plate will be concentric within 0.25mm TIR (.010 in. TIR).

Example:

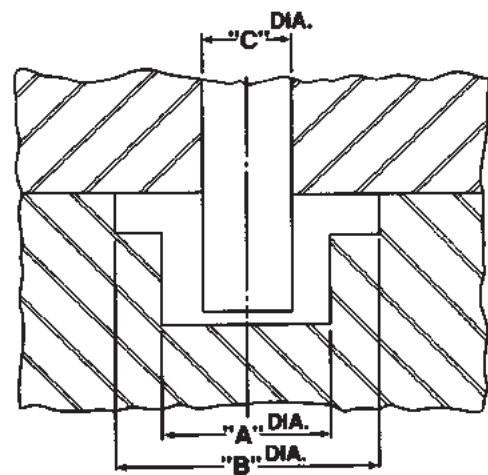
In Fig. #2 diameter "A" will be concentric with diameter "B" within 0.25mm TIR (.010 in. TIR)

Other diameters will be concentric within 0.75mm TIR (.030 in. TIR).

Example:

In Fig. #2 diameter "A" or "B" will be concentric with diameter "C" within 0.75mm TIR (.030 in. TIR).

Figure 2



DIA. "B" NOT OVER 50mm (2 in.).

Example:

Fig. #3 Outside surface will be concentric with shaft within 0.75mm TIR (.030 in. TIR) plus metal tolerance if unground.

Note: Parts may be ground to closer tolerances.

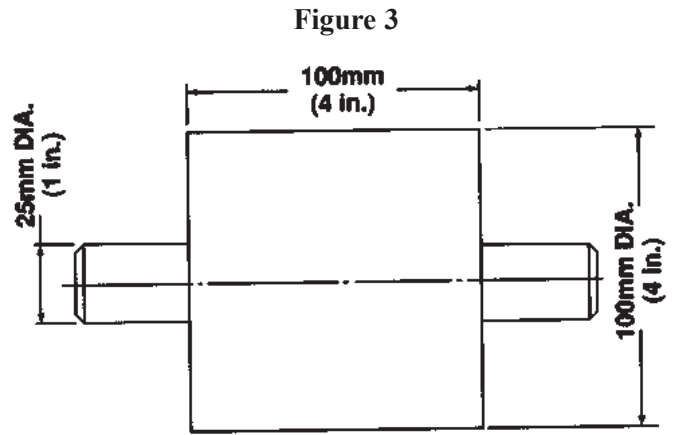


Figure 4

Example:

Fig. #4 Outside surface will be concentric with shaft within 2mm TIR (.085 in. TIR) plus metal tolerance if unground.

Note: Parts may also be ground to closer tolerances.

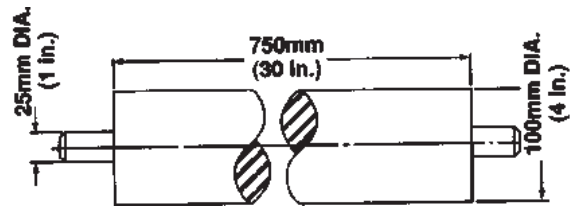
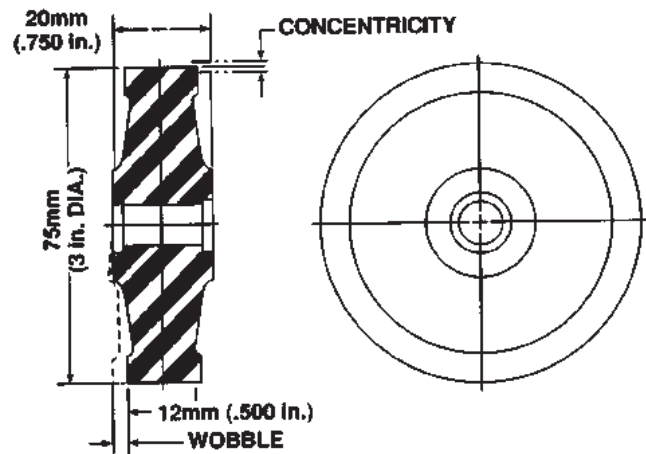


Figure 5

Example:

On products similar to that described in Fig. #5 having an outside diameter of 75mm (3 in.) concentricity within 0.75mm TIR (.030 in. TIR) and wobble within 0.75mm TIR (.030 in. TIR) can be expected.

Note: Wobble is a term used to identify movement of a surface that is not intended to be parallel to the TIR axis of rotation.



SQUARENESS

Squareness is the quality of being at an angle of 90° such as “surface must be square with axis”. A tolerance of 2° should be allowed for rubber surfaces that are not ground.

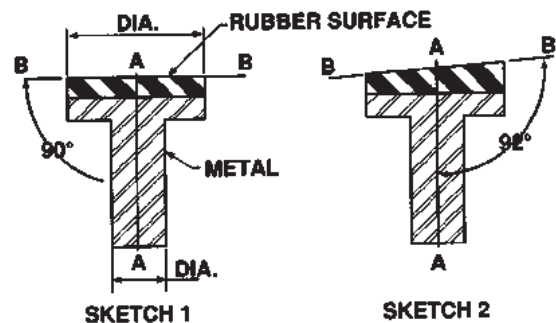
Rubber Product with Metal Insert

Example:

Rubber-to-metal product in Sketch 1 Fig. #6. Rubber surface B-B is square with axis A-A as the angle is true 90°. Sketch 2 indicates the same example with 2° tolerances exaggerated.

Note: This type of product requires closer control than is usually normal with commercial products.

Figure 6



FLATNESS

Flatness of a surface on a part is the deviation from a true plane or straight edge.

Rubber Product (Unground).

Molded Surfaces (unground) will be flat within 0.25mm (.010 in.).

Example:

Fig. #7 On a cup as illustrated, the bottom can be concaved or convexed by no more than 0.25mm (.010 in.).

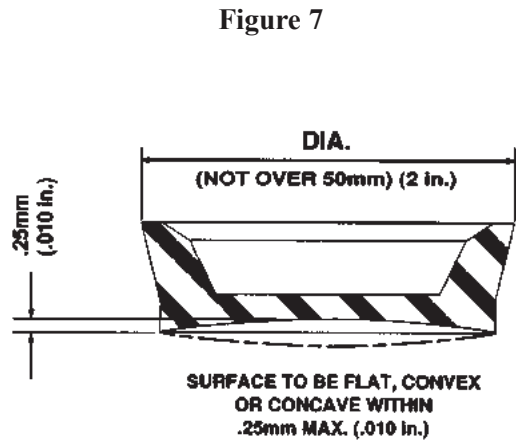


Figure 8

Rubber Product with Metal Insert

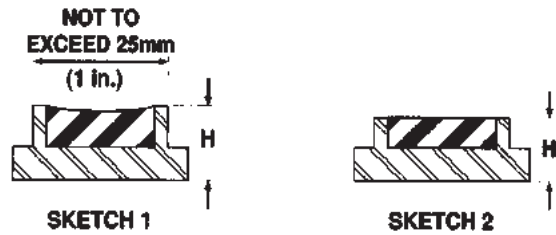
Surfaces that are ground after molding will be flat within 0.12mm (.005 in.). (Allowance must be made for removal of stock during grinding operation.)

Example:

In Sketch 1 Fig. #8 after molding, deviation from the true plane can be held to 0.25mm (.010 in.).

Example:

In Sketch 2 Fig. #8 after grinding, deviation can be held to 0.12mm (.005 in.) but dimension "H" will necessarily be affected.



PARALLELISM

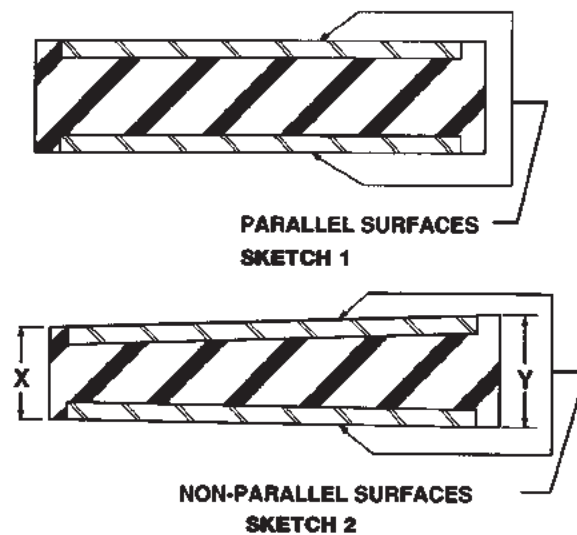
Parallelism is the relationship of surfaces in different planes. To be parallel the planes passing through the surfaces must be equidistant from each other at all points when measured at 90° to the planes.

Rubber Product with Metal Inserts.

Example:

In Sketch 1 Fig. #9 the plates of the sandwich mount are parallel. In Sketch 2 Fig. #9 they are not. On such a part approximately 200mm (8 in.) square, parallelism to within 0.75mm (.030 in.) can be expected.

Figure 9



Standards for Mold Cavity Finish and Molded Product Appearance

Introduction

The purpose of this section is to list and discuss some of the factors that have an effect on the finish and appearance of molded products and to present standards covering four classes of finish to be applied to the mold cavity surface.

FACTORS AFFECTING FINISH AND APPEARANCE

Machined Finish of Mold

The machined finish of the mold has considerable effect on the surface finish or appearance of a rubber product.

The best finish can be obtained from a highly polished steel mold, free from all tool marks or other imperfections. Naturally, this type of mold is quite expensive to construct and maintain and is not generally required unless surface finish is of paramount importance from either an appearance or functional standpoint. In addition, it may be desirable in some cases to chrome plate the mold in order to maintain the required surface finish under production conditions.

The commercial type mold is a machined steel mold made to conform to good machine shop practice. Machine tool marks will not ordinarily be polished out of this type mold. It should be noted that regardless of how highly the mold itself is polished, the appearance of the rubber surface will depend to a large extent upon the factors outlined in the following paragraphs.

Type of Rubber Material Used

The type of rubber material used can greatly affect the appearance of the rubber product. Some compounds lend themselves to a bright glossy surface while others may be dull as molded or become dulled very easily during handling or storage. Also, there are some rubber compounds to which antiozonants are added to impede attack from ozone. As these compounds age, the antiozonants “bleed out”, giving the product a colored or waxy surface, often referred to as “bloom”. This is a common practice and the product should not be considered imperfect or defective in any way. This or other specification requirements may make it impossible to produce a product with a glossy surface.

Mold Release Used

There are certain rubber compounds that can be removed from the mold with the use of little or no mold release lubricant, while others require the use of a considerable quantity of mold release lubricant. The latter may have the appearance of being oily.

If the surface of the rubber product is to be bonded to other materials in its application or is to be painted, the designer should designate this on the drawing so that the manufacturer may use a mold release lubricant that will not impair adhesion quality.

Flash Removal Method

Some of the many methods used to remove flash from rubber parts may affect the appearance of the finished product. As an example, hand trimming will ordinarily have no effect, while tumbling may result in a dull surface.

Method of Designation of Finish

The symbol “F” followed by an appropriate number selected from Table 6 shall be used to designate the type of finish required.

An arc enclosing the actual area included by this designation and a leader to the finish number designates the type of finish desired. The use of a finish symbol on the surface does not preclude the possibility that other surfaces may require different finishes. However, the use of a standard notation is desirable wherever possible to eliminate the repetition of finish symbols and maintain simplicity. SEE FIG. #10.

Always permit “Commercial Finish” (F-3) whenever possible.

Figure 10

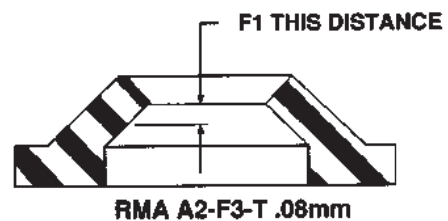


Table 6 - RMA Drawing Designation for Finish

Drawing Designation	
F1	A smooth, polished and uniform finish completely free of tool marks, dents, nicks and scratches, as produced from a highly polished steel mold. In areas where F1 is specified, the mold will be polished to a surface finish of 10 microinches (250nm) or better.
F2	A uniform finish as produced from a polished steel mold. In areas where F2 is specified, the mold will be polished to a surface finish of 32 micro-inches (800nm) or better but with very small tool marks not polished out.
F3	Surfaces of the mold will conform to good machine shop practice and no micro-inch finish will be specified. This is “Commercial Finish”.
F4	Satin finish.

Introduction

It is the purpose of this section to list and discuss many of the factors that have an effect on the amount of flash, to describe the basic methods by which flash can be removed, and furnish the means by which the designer can designate on the product drawing the flash location and flash variation permissible.

Definition

(A) Flash.

Flash is excess rubber on a molded product. It results from cavity overflow and is common to most molding operations. Flash has two dimensions -- Extension and Thickness.

(B) Flash Extension.

Flash extension is the film of rubber projecting from the part along the parting line of the mold.

(C) Flash Thickness.

Flash thickness is measured perpendicular to the mold parting line. Variations in flash thickness are normally included in closure tolerances.

General Information

A method for designating permissible flash extension and thickness on a molded product will result in better understanding between rubber manufacturer and consumer and benefit both. This method must permit the designation of a surface where no parting line is permissible. It must also designate areas where a parting line is permissible and define the amount of flash extension tolerable in such areas. The designer, without specific rubber processing knowledge, should be able to specify flash extension limits in any given area on this drawing. Use of RMA Drawing Designations provided in this section will provide this capability; however, the designer should not specify how flash is to be removed. He should specify the amount of flash extension which can be tolerated without impairing product function or appearance. A method designating areas permitting flash and describing flash extension tolerance will result in the following benefits:

- (A) Avoid errors in mold design concerning parting line location.
- (B) Uniformity in appearance and function of molded products supplied by more than one source.
- (C) Simplification of inspection procedures.
- (D) Reduce over-finishing or under-finishing products.

Molding techniques have been developed to produce "flashless" products. The mold parting line, depending on location on the product, is barely discernible with no measurable thickness or extension. Initial cost and maintenance of this tooling and equipment is high and very close manufacturing control is required.

In instances where flash extension is not a problem or where it is otherwise advantageous, parts are shipped as molded with no flash removal necessary.

Methods for removing flash from products with metal or other inserts are approximately the same as for non-inserted rubber products. Rubber flash adhering tightly to inserts is generally acceptable. If it must be removed, it is done by mechanical means such as wire brushing, abrasive belts or spot facing. If adhered rubber flash is not permissible, it should be so specified on the drawing.

Flash removal is an important cost factor in producing finished molded rubber products. Cost conscious designers will permit the widest possible latitude in flash thickness, flash extension, and in location of flash consistent with adequate function and appearance of the product.

FACTORS AFFECTING FLASH

Flash Location

Parting lines (flash lines) must be located to facilitate part removal from the mold cavity after curing.

Flash Thickness

Flash thickness is determined in the molding operation and may vary with mold design, closing pressure, with weight and shape of preform, and type of compound used -- and many lesser factors. Normal variations in flash thickness have been taken into account in the tables set up for closure tolerances, and this will receive no further consideration.

The designer should be aware that heavy or thick flash is frequently designed to facilitate removal of parts from the mold and to facilitate subsequent handling. In this regard the maximum thickness that can be tolerated without impairing the product function or appearance should be specified.

Flash Extension

There are many methods by which flash extension on rubber products can be removed. The particular method selected will be determined by the degree of flash extension permitted as well as by flash location, flash thickness, and other factors. Some of the more common methods of flash removal are as follows:

(A) Buffing

A moving abrasive surface material is applied to the rubber part to remove excess rubber by abrasive action.

(B) Die Trim

A cutting tool, shaped to the contour of the molded product at the parting line, is applied with a force perpendicular to the flash extension and against either a flat plate or a fitted shape. This creates a shearing or pinching action removing the excess flash. Die trim can be done with a hand or machine mounted die. Machine mounted dies are often used for multiple trimming of small uniformly shaped products from multi-cavity molds.

(C) Machine Trim

Flash is removed by passing the rubber part through machine mounted rotating or reciprocating cutting tools. These devices are customarily adapted to a particular product and may shear, saw, or skive the flash away.

(D) Tumble Trim

There are two basic types of tumble trimming. Both utilize a rotating barrel or drum in which the heavier rubber sections strike the thinner and more fragile flash breaking it free. Dry tumbling at room temperature is most effective with the higher durometer "hard" compounds. The other type of tumbling utilizes carbon dioxide or nitrogen to freeze the molded parts, thus making the compound more brittle so the flash will break more readily. Any tumbling operation will have an effect on surface finish.

(E) Mechanical Deflashing

Modern deflashing machines utilize an abrasive medium, tumbling, and a refrigerant for quick freezing. The time and temperature are closely controlled while the parts are agitated in an enclosed barrel. Refrigerant (usually carbon dioxide or nitrogen) is metered into the deflashing chamber while the parts are being impinged with a mechanically agitated abrasive medium. The flash, being thin, freezes first and is broken away by the abrasive medium and the tumbling action before the heavier rubber part itself has lost its resiliency. Some loss of surface finish may be expected and some of the abrasive medium may adhere to the molded parts.

(F) Pull Trim or Tear Trim

A very thin flash extension is molded immediately adjacent to the part and a thicker flash is molded adjacent to the thin flash but farther from the part. When the flash is pulled from the molded part, it separates at its thinnest point adjacent to the molded part. This method may result in a sawtooth or irregular appearance and it is limited to certain compounds and product designs.

(G) Hand Trim

Flash is removed by an expedient method using hand tools such as knives, scissors, razor blades or skiving knives.

Method of Designation of Flash

Extension

The symbol "T" with a notation in hundredths of a millimeter for the maximum extension shall be used. Example: T .80mm. (.80mm maximum extension permitted.) IF ENGLISH DIMENSION THE DRAWING DESIGNATION WILL NOT BE FOLLOWED BY ANY LETTERS. EXAMPLE T .032.

Thickness

The flash thickness may be specified following the extension limit if it is critical to the function of the part. Closure tolerances will apply as in tables 2, 3, 4, and 5 on page 6.

Location

An arc enclosing the actual area included by this designation and a leader to the trim symbol designates the maximum allowable flash extension and thickness thus enclosed. If no flash can be tolerated in a given area, the symbol "T" .00mm is used. SEE FIG. #11.

Standards

The designer may indicate on his drawing any amount of maximum flash extension permissible. However, as a matter of simplicity, a progression of flash extension Drawing Designations is suggested in Table 7. Only those areas requiring such a designation should be specified. The use of a standard note can frequently be used with no further notation. SEE FIG. #11.

Figure 11

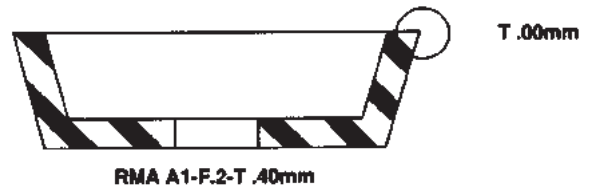


Table 7 - RMA Drawing Designation for Flash Extension

Drawing Designation	
T .00mm	(T .000) No flash permitted on area designated. (Standard notation regarding other surfaces must accompany this notation.)
T .08mm	(T .003) This tolerance will normally require buffing, facing, grinding or a similar operation.
T .40mm	(T .016) This tolerance will normally require precision die trimming, buffing or extremely accurate trimming.
T .80mm	(T .032) This tolerance will normally necessitate die trimming, machine trimming, tumbling, hand trimming, or tear trimming.
T 1.60mm	(T .063) This would be the normal tear trim tolerance.
T 2.35mm	(T .093) This tolerance will normally require die trimming, tear trimming, or hand trimming of some type.
T ∞	(T ∞) No flash limitation.

Standards for Rubber-To-Metal Adhesions

Introduction

The processes of adhering rubber to metal components are widespread techniques in the rubber industry. Generally the same considerations and procedures are applicable for rubber to rigid non-metallic components, but the adhesion values may be lower. Only the broad aspects of rubber-to-metal molding are covered here, and more precise information can be provided by the rubber manufacturer involved.

GENERAL INFORMATION

Application

Various adhesion levels can be obtained. For instance, to obtain adhesion on critical products, such as engine mounts, very close controls are required, both on metal and rubber preparation. Some products may require only enough adhesion for assembly.

The adhesion level (tear/tensile strength) is directly affected by type of metal, surface preparation, non-metallic inserts, compound composition, curing conditions, and type of adhesive.

Drawings should clearly state adhesion requirements and any other factors which can explain the degree of adhesion required and the method of testing. A clear understanding between customer and rubber manufacturer is essential.

Methods of Obtaining Adhesion

The method most commonly used to obtain adhesion between rubber and metallic or non-metallic components is the use of adhesive cements. Prior to the use of these special adhesives, the surface of the insert must be clean and free of contamination.

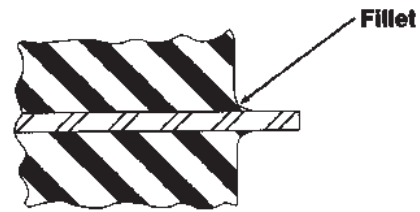
The inserts may be prepared by suitable methods such as degreasing, blasting, and/or a suitable chemical treatment. When any one of these preparatory processes is objectionable, it should be noted on the drawing. The rubber compound is then vulcanized to the prepared inserts to obtain the desired adhesion.

Design Factors and Limitations

- Avoid localized stress raising irregularities.
- Minimize edge effects. Break, coin, or otherwise eliminate sharp edges of all metallic members covered by the rubber.



Provide fillets in the rubber at junction line with inserts where possible.



Where fillets are not possible, extend the rubber beyond the edges of the inserts which would otherwise terminate line to line with the rubber.



c. Minimize surface roughness of metallic members in area adjacent to adhered rubber.

d. Avoid welding a molded rubber component to a machine or structure to prevent unnecessary heat deterioration. When welding is mandatory, design metallic member as a heat sink and provide for assembly techniques which will keep the adhered rubber area of the metallic member below 150° C (302° F).

Test Methods for Determining Adhesion Values

Adhesion testing is done in several ways, depending upon the application and the product design. The methods recognized for this testing are treated in full detail in ASTM Test Method D 429. These methods are:

- Method A. Rubber adhered between two parallel metal plates.
- Method B. Ninety degree stripping test, rubber adhered to one metal plate.

The above methods are used primarily for laboratory development and testing production parts. These methods may be modified and applied as described under RMA Production Test Methods section as follows.

RMA PRODUCTION TEST METHODS

Method A. Used where two metal surfaces, not necessarily parallel, can be separated until the specified adhesion value is obtained using the projected adhered area. The area to be considered should be the projected active adhered working area of the smallest metallic member, excluding fillets, overedge, and radii. Very irregular areas are to be given special consideration.

Method B. Used where the rubber can be stripped from the entire width of the part to obtain a specified adhesion value or where the rubber can be cut in 25.4mm (1.0 in.) wide strips. Specimen rubber thickness shall not exceed 9.5mm (.375 in.). In rubber sections over 9.5mm (.375 in.), values should be negotiated between customer and supplier.

Acceptance Criteria

Looseness contiguous to the adhered areas at corners, fillets, mold parting lines, and back-rinding will ordinarily be acceptable.

The adhesion strength is usually considered to be satisfactory if the failure causes permanent distortion of a metallic member.

If the deformation of the rubber section under test far exceeds the functional service requirements, this factor should be taken into consideration when establishing a reasonable adhesion value.

It is recognized that conditions for adhesion will exist where a quantitative value cannot be obtained. In these instances, it is customary to pull the rubber from the metallic member and examine the nature of the failure. The acceptable degree of adhesion must be agreed upon between the customer and the rubber manufacturer. Customer's test methods and fixtures should be identical with those of the rubber manufacturer and correlation procedures established.

METHODS OF DESIGNATING ADHESION VALUES

The design engineer when writing specifications should use a designation to obtain suitable adhesion for the purpose intended.

Methods of testing, such as tension pull or shear pull (RMA Production Method "A") or 90 degree stripping (RMA Production Method "B") and the minimum destruction values, as well as the design of special testing fixtures should be specified on the drawings. ASTM D2000 -- SAE J200 has two types of adhesion designations for adhesion of vulcanized rubber to metal:

1. Adhesion by vulcanization, designated by K11 or K21.
2. Adhesion by the use of cements or adhesives after vulcanization, designated by K31.

This section is concerned only with K11 and K21.

Table 8 - RMA Drawing Designation for Rubber-To-Metal Adhesion Classification

Drawing Designation	
B1 (Specify method and grade from Table 9.)	Production 100% tested to 70% of the minimum destruction values as noted in Table 9, Method A only. In addition, sample parts tested to destruction must exceed the minimum destruction values as noted in Table 9. (Specify Method A or Method B and Grade.)
B2 (Specify method and grade from Table 9.)	Sample parts tested to destruction must exceed the minimum destruction values as noted in Table 9.
B3	Rubber to be adhered to metal. This designation would ordinarily be used on products where adhesion is not critical to product function.
B4	Mechanical attachment only. Rubber is not adhered to metal.
B5	Products requiring special consideration.

As an illustration of the above drawing designation, see Example 4 in the Summary of RMA Drawing Designations on page 3.

Table 9 - RMA Drawing Designation for Minimum Adhesion Destruction Values

Method A

Drawing Designation	S.I. Metric Units		USA Customary Units
Grade 1	2.8 MPa		400 psi
Grade 2	1.75 MPa	For rubber compounds over 10.5 MPa (1500 psi) tensile strength and 50 or greater hardness (SHORE "A")	250 psi
	1.4 MPa	For rubber compounds under 10.5 MPa (1500 psi) tensile strength or under 50 hardness (SHORE "A")	200 psi
Grade 3	0.35 MPa		50 psi

Method B

Drawing Designation	S.I. Metric Units		USA Customary Units
Grade 1	16 KN/m width		90 lbs./in. width
Grade 2	9 KN/m width	For rubber compounds over 10.5 MPa (1500 psi) tensile strength and 50 or greater hardness (SHORE "A")	50 lbs./in. width
	7 KN/m width	For rubber compounds under 10.5 MPa (1500 psi) tensile strength or under 50 hardness (SHORE "A")	40 lbs./in. width
Grade 3	2.7 KN/m width		15 lbs./in. width

As an illustration of the above drawing designation, see Example 4 in Table 1 on page 3.

Table 9 is applicable only to RMA B1 and B2 levels shown in Table 8.

All grades of adhesion cannot be obtained with all compound classifications.

Grade 2 is similar to ASTM-SAE K11 and K21.

Standards for Static and Dynamic Load Deflection Characteristics

Introduction

Primarily, rubber is used in place of metallic, ceramic, and other rigid materials because it will provide a greater deflection for a given force than these other materials. Most uses of rubber are based upon this characteristic.

In many uses of rubber, stiffness variation is not critical to the rubber product function and in such cases the Shore A durometer hardness specification is sufficient.

Rubber is used as an engineering material in resilient mountings, vibration isolators, dampers, impact pads and many similar applications. Where static or dynamic stiffness characteristics become critical to the function of the product, appropriate test specifications must be established.

METHODS AND CONSIDERATIONS

Static Methods

When a static load-deflection specification is established for a product, in addition to a hardness requirement, the load-deflection specification shall supercede the hardness, should be stated on the product drawing, and agreed upon between the customer and the rubber manufacturer. A static test is only "static" in that the load application comes to rest before the measurement is taken or the rate of deflection does not normally exceed 0.8mm/s (2 in./min.). Such a test usually places the rubber in shear or compression. There are several ways of specifying static load-deflection characteristics.

- a. Specify spring rate in load per unit deflection, e.g., N/m (lb./in.) or torque per degree, e.g. N-m/deg. (lb.-in./deg.).
- b. Specify a load to deflect the product within a specified deflection range.
- c. Specify a deflection resulting in a load within a specified load range.

Dynamic Methods

Applications where rubber is used as vibration isolators are dependent upon the behavior of the rubber under dynamic operating conditions.

Rubber is stiffer dynamically than in a static mode; and, since the static to dynamic stiffness ratio varies with individual compounds, it may be advisable to specify the dynamic characteristics of the rubber for such applications.

When dynamic stiffness or spring rate is specified, and is critical to the rubber product performance, the complete conditions and methods of measurement must be established between customer and rubber manufacturer.

There are several methods of dynamic testing:

- a. Steady State Resonance
- b. Free Decay Resonance
- c. Steady State Non-Resonant
- d. Rebound Evaluation

FACTORS AFFECTING STATIC AND DYNAMIC LOAD DEFLECTION CHARACTERISTICS

Age

The aging of rubber compounds over a period of time is a complex process. The normal net effect of aging is an increase in modulus or stiffness. The magnitude of this change is dependent upon the specific material involved and the environmental conditions.

Short term age, in the sense of the minimum number of hours which should elapse between molding and evaluation, is also a significant factor. Depending upon the nature of the product, the minimum period will vary from 24 hours to 168 hours.

Dynamic History

The load-deflection characteristics of a rubber product are affected by the work history of that specific product. The initial loading cycle on a new part, or a part that has been in a static state for a period of time, indicates a stiffer load-deflection characteristic than do subsequent cycles. In static testing this effect becomes stabilized and the load-deflection characteristics normally become repeatable after two to four conditioning cycles.

In dynamic testing, the conditioning period is normally selected as the time required to obtain reproducible results.

Temperature

Temperature has an effect on spring rate -- the higher the temperature the lower the spring rate, and the lower the temperature the higher the spring rate of a rubber product not under continuous tension.

Test Conditions

The following details must be defined by the product drawing, or referenced specification, to ensure relevant and consistent product performance evaluation:

a. Mode of Test

1. Tension, Shear or Compression. A schematic diagram depicting product orientation is highly desirable. The spring rate in the compression mode is always higher than the spring rate in the shear mode.

2. Static or Dynamic

The dynamic spring rate is always higher than the static spring rate.

b. Test Level and Control Mode

1. Static testing load level or level of deformation, together with the appropriate limits on deflection or limits of loading in response to deformation, shall be stated.

2. Dynamic load levels shall be identified by a plus (+) value for downward forces and a negative (-) value for upward forces. Dynamic tests utilizing deformation control shall be specified by double amplitude (total amplitude) values.

c. The amount and direction of preload, if required.

d. The linear or angular rate of loading or cyclic frequency.

e. The nature and number, or duration, of conditioning cycles required prior to the test cycle or test period.

f. The ambient test temperature and the period of time the product is held at test temperature prior to evaluation.

g. When the requirements are stated as “Spring Rate” the location on the load-deflection chart at which the tangent is drawn, or the load levels between which an average is taken, must be indicated.

METHODS OF DESIGNATING STATIC & DYNAMIC TOLERANCES

When applicable, the design engineer must specify load-deflection, spring rate, method of test and load-deflection tolerances. Table 10 presents standards for the three drawing designations for load-deflection tolerances. If damping, characteristics are required as a part of a dynamic specification, commercial tolerances would be $\pm 25\%$ on parts up through 65 durometer hardness (SHORE A) and $\pm 30\%$ for above 65 durometer hardness (SHORE A).

Table 10 - RMA Drawing Designations for Load-Deflection Tolerance

Drawing Designation	Durometer Hardness	Tolerance Range Rubber Wall Thickness 6mm (0.25 in.) or over	Tolerance Range Rubber Wall Thickness under 6mm (0.25 in.)	
D1	65 Durometer Hardness (Shore A) or below	$\pm 10\%$	$\pm 15\%$	Very high precision. This close tolerance should only be requested in unusual circumstances.
	Above 65 Durometer Hardness (Shore A)	$\pm 15\%$	$\pm 20\%$	
D2	65 Durometer Hardness (Shore A) or below	$\pm 11\%$ to $\pm 14\%$	$\pm 16\%$ to $\pm 20\%$	
	Above 65 Durometer Hardness (Shore A)	$\pm 16\%$ to $\pm 19\%$	$\pm 21\%$ to $\pm 26\%$	Precision
D3	65 Durometer Hardness (Shore A) or below	$\pm 15\%$	$\pm 20\%$	
	Above 65 Durometer Hardness (Shore A)	$\pm 20\%$	$\pm 25\%$	Commercial

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 sometimes costly and should not be specified unless absolutely necessary. When distortion is a problem, the product should be removed from the container when received and stored on shelves or in a manner to preserve usability. Packaging is a complex area and should be given serious consideration. Table 11 at right is to be considered only as a guide. Special packaging problems should be considered between purchaser and supplier.

Table 11 - Packaging

Drawing Designation	
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.
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.
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.