TECHNICAL BULLETIN

QUALITY STANDARDS GUIDELINES

DIA·COM CORPORATION

The Diaphragm Company

Online Guidebook: www.diacom.com

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The manufacturing of fabric reinforced diaphragms is a unique part of the rubber industry. The rubber industry has been around for many years, and has well-defined industry standards for rubber products that cover design and quality issues. These can be found in the Rubber Manufacturers' Association RMA Handbook, as well as many other industry publications. The rubber industry also has terminology that is commonly understood throughout the industry.

Fabric reinforced diaphragm manufacturing, however, in addition to those shared with the general rubber industry, also has its own terminology, design concepts, quality standards, and expectations.

This guideline identifies various issues associated with the manufacturing of fabric reinforced diaphragms. It provides an overview of typical issues found in rolling diaphragms, as well as definitions of common terms used to describe the various conditions associated with rolling diaphragms. It is intended to give our customers and ourselves a common frame of reference when discussing quality standards as they apply to fabric reinforced, rolling diaphragms and to avoid unnecessary confusion on new or existing production programs.

This technical bulletin augments the DiaCom Diaphragm Design Guidebook, which is available on our website, www.diacom.com, or by request. For more information, please contact us at:

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Measuring Diaphragms

Because of the inherent flexibility of rubber, measuring techniques, measuring equipment used, fixtures, and other variables all have an impact on the accuracy of measurements. Because rolling diaphragms are constructed with fabric reinforcement, and by design they have thin cross sections, the measurement techniques, equipment, and other variables become more critical in assuring the accuracy of any dimensional layouts.

Depending on the design of the diaphragm, DiaCom uses various measuring equipment such as optical comparators, Vision System, specialized thickness gauges, tool maker's microscopes, and mylar gauges. Measuring techniques used include: fixturing, sectioning diagrams for microscopic measurements, and other methods.

It is important to remember two key factors in measuring diaphragms: First, all diaphragms are flexible, and second, fabric is manufactured in a two dimensional matrix, length and width. These two factors may seem self-evident, but they must be kept in mind when measuring diaphragms. The flexibility factor means that a diaphragm may deform slightly when placed on a measurement surface. Also, some measuring equipment can deform the part while the measurement is being taken. For example, a snap-gauge used to check part thickness can squeeze the rubber - giving a false measurement. The second, or "fabric" factor, means that the diaphragm diameters, when unsupported, will have a slightly square condition as the fabric tries to revert to its original square condition. When measuring fabric-reinforced diaphragm diameters, it is a common practice to take two measurements 45 degrees apart. The actual diameter is the average of these two measurements.

In all cases, it is important that the measurement techniques, equipment, fixtures, & etc. are duplicated at DiaCom and customer locations to avoid unnecessary confusion. For questions regarding measurements, please contact DiaCom's Quality Manager.

FLASH

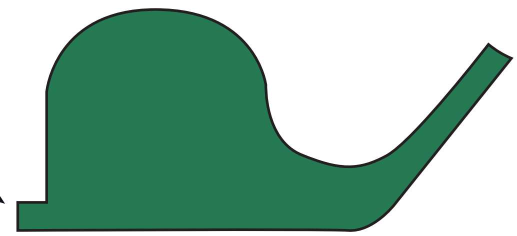
Definition: **Flash** is excess material (rubber, fabric or other material used in the part construction) on a molded diaphragm. It results from cavity overflow and is common to most molding operations. Flash has two dimensions: Extension and Thickness (0.015" x 0.020"). Flash extension is the material projection from the part along the parting line, or "trim edge", of the mold (0.015" in the example). Flash thickness is measured perpendicular to the mold parting line (.0.020" in the example). The fabric in the diaphragm will be exposed at all trim lines and may exhibit a slight fuzz at the trim line.

Flash exists on virtually all diaphragms and must be accommodated in the design of the mating hardware. Considerations include flash location, thickness and extension. When defining flash tolerances, it must be noted that tighter tolerances (less flash) require more sophisticated tooling and more stringent inspection criteria, both of which result in higher cost. Requiring "No Flash", is the most expensive tolerance and, in most cases, is impractical.

Flash Adjacent to a Molded Feature

When the diaphragm design has a bead, or change in thickness requiring the part to be trimmed adjacent to that feature, the resulting flash will be along the parting line of the mold. The sketch to the right shows the resulting flash.

(Please see the trim methods in this section for more information on the various trim methods.)



Minimizing Flash

One effective method to used to minimize flash, is to trim "through" the diaphragm. This method is used when the area to be trimmed is flat, with no beads or other molded features near the trim area. This is effective only when using the Die Trim method for trimming the diaphragms. This is not "Flash Free", however, as there will be some minor irregularities at the trim area.

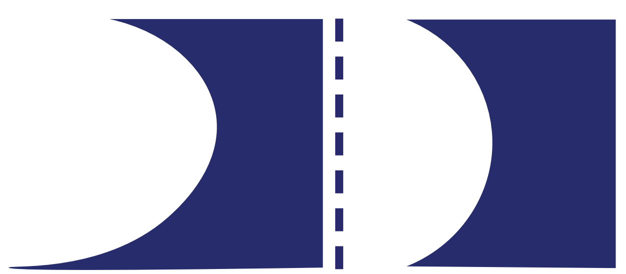
When using this method, the trim cross-section will yield a condition called "hourglass" or "snow plow" (Please see below).

Hourglass and Snow Plow

Due to the flexible nature of fabric-reinforced diaphragms and the mechanical nature of trim operations, the rubber material will deflect during the trimming operation. Although this deflection is minimal, it does have an impact on the cross-section shape of the finished part. This condition is usually more apparent on thicker cross-sectional areas and must be considered when measuring parts.

The sketch to the right shows exaggerated examples of the two most prevalent conditions resulting from the trim operations called *"snow plow"* and *"hourglass"*.

Diaphragm Trim Cross-Section:



"Snow Plow" *"Hourglass"*

TRIM METHODS

Virtually all compression molded rubber product require trimming of the outer diameter as well as trimming of any holes or irregular shapes. This is also true of most diaphragms. This section discusses the most common methods used at DiaCom to trim parts to their final configuration. If the part design demands it, other methods are available. The trimmed edges of the diaphragm are enclosed in the application's hardware and have no effect on the diaphragm performance. Diaphragms having beads or other molded features requiring the trim to be along that beaded feature will result in flash remaining on the finished part (See the Flash section of this technical bulletin). Unless other wise stated on the part drawings, DiaCom uses the "typical" dimensions shown below. Diaphragms that are trimmed through flat sections, will have less flash on the finished part. Any flash from trimming through the flat sections of the diaphragm is the result of the trimming operation and not part of the diaphragm design.

Die Trim

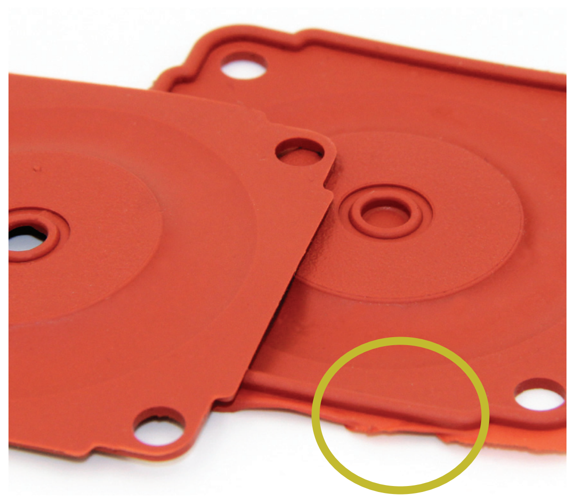
Die Trim refers to a trim method that uses steel blades for trimming the part to the final shape. This is the most accurate trim method that leaves the minimum flash on the diaphragm. As this method uses hardened steel tooling, the variation in flash is limited to the variation seen in the molding operation.

Tightened Flash Thickness & Extension:	*0.010 x 0.010" (max)*
Typical Flash Thickness & Extension:	*0.015 x 0.015" (max)*
Relaxed Flash Thickness & Extension:	*0.020 x 0.025" (max)*

Tear Trim

Tear Trim is a trim method where 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. The flash is then pulled from the part by hand, failing at the thinnest flash section adjacent to the molded part. This method can only be used in all-rubber designs.

This method may result in a saw-tooth or irregular appearance. This is available only in certain designs and with certain compounds. The advantage of tear trim is that it is inexpensive and no trim tool is required.



Typical Flash Thickness & Extension:	*0.010" x 0.032" (max)*

Hand Trim

Hand Trim refers to the trim method where the flash is removed by any expedient method using hand tools such as knives, scissors, razor blades or skiving knives. Hand trimming will yield the largest amount of flash and will have an irregular appearance. This method is usually appropriate for prototypes and usually does not require the purchase of any tooling or equipment.

Tightened Flash Thickness & Extension:	*0.015" x 0.032" (max)*
Typical Flash Thickness & Extension:	*0.015" x 0.064" (max)*

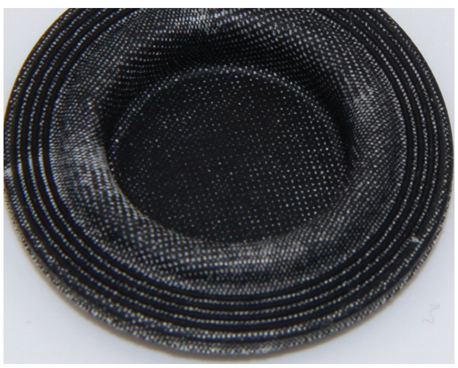
Definition: **Strike-through** is the amount of rubber that comes through the fabric to either fully or partially encapsulate the fabric during manufacturing.

The amount of strike-through, referred to as "light", "moderate", or "dark strike", is the result of several factors. The fabric and elastomer selected, the geometry of the finished part and the molding process parameters all have an impact on strike-through. Each of the factors mentioned, however, are also significant contributors to several other diaphragm design issues. For example, material selection is driven by the functional parameters of the diaphragm application. Although a different fabric may yield a better strike-through, it may not be able to meet the application's pressure requirements. An approach that balances all these concerns will yield the optimum strike-through for each diaphragm design. As thickness of each diaphragm is limited by the design, more strike-through means less rubber coating on the high-pressure side of the diaphragm and may actually be undesirable.

Optimum strike-through, therefore, is unique to each product design and will vary from part to part, yielding an effective bond. Optimum strike-through ensures proper adhesion of the fabric and rubber selected for the specific application.

Light Strike

The fabric pattern is readily visible as shown below. Note that the strike-through will vary across the part. As the square fabric pattern forms to the round shape of the diaphragm there will be a "four-cornering" effect. The resulting open areas of the fabric allow slightly more rubber through during the molding operation.

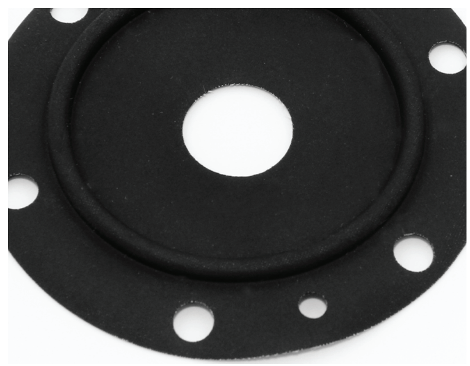


Moderate Strike

Pattern in the fabric is visible as in the photograph below, however, more rubber has migrated through the fabric. The "four-cornering" effect is less visually apparent although all diaphragms will experience this effect to some degree.

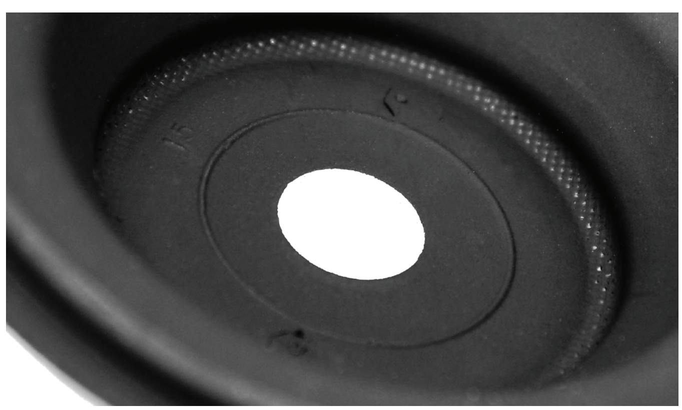
Dark Strike

In some applications, usually products that use black rubber, the fabric can only be seen upon very close inspection. Again, the fabric pattern is visible and most, BUT NOT ALL, the fabric is embedded in the rubber. This gives a visually pleasing appearance but does not imply better performance in the application.



Bleed-through

Definition: **Bleed-through** is when the fabric migrates through the rubber and becomes partially exposed on the rubber, or high-pressure, side of the diaphragm. Some product designs are more prone to this condition. The photo to the right shows the typical pattern seen when Bleed-through occurs. (Note the exposed white threads.) No diaphragm application will work properly with this condition. A diaphragm exhibiting *any* amount of Bleed-through is considered a reject.



BEADS

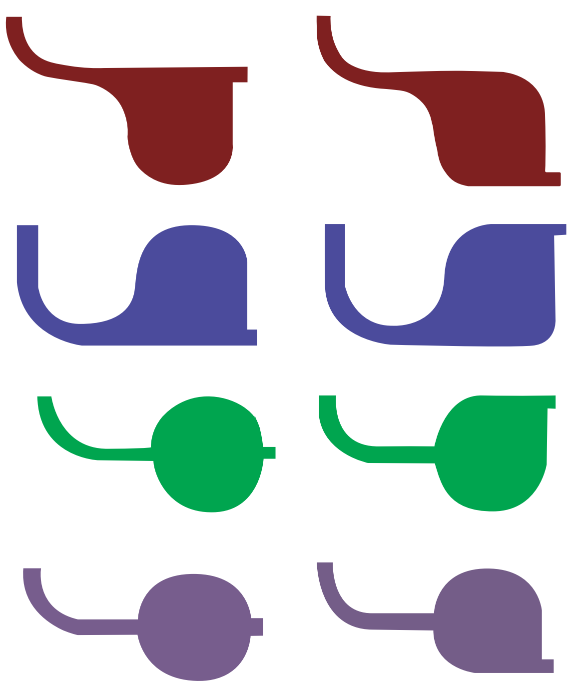
Beads can be added to the diaphragm in an almost infinite variety of shapes and sizes (some examples shown below). However, there are many things to consider before adding beads to the diaphragm design, not the least of which is the impact on the cost of the diaphragm. Most beads are added to a diaphragm to be used as the sealing mechanism in the final application. Beads are also used to improve ease of assembly, to aid in alignment of other components in the hardware or to provide a surface for the diaphragm to use to “bump” other components in the hardware during operation.

Beads are formed during the molding operation by flowing rubber into the mold cavity, filling the bead area while driving out the air. There are several limitations on bead design that must be considered due to this rubber flow. Bead location, shape, size, mold parting line, & etc. must be carefully considered. For instance, a bead with a square cross-section will have a strong tendency to “trap” air during the molding operation and should be avoided if possible. Also the design must properly fit into the application hardware. DiaCom’s design team would be glad to help in designing the proper bead for your application.

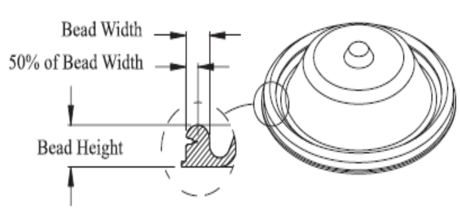
Bead Design Examples

Typical Bead Designs:

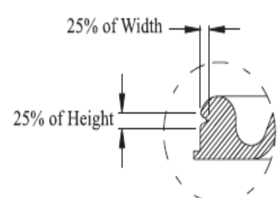
As Drawn: *Preferred:*



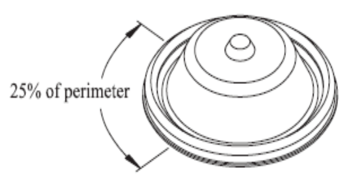
Standard Inspection Criteria Sealing Bead Non-fills/Bead Voids



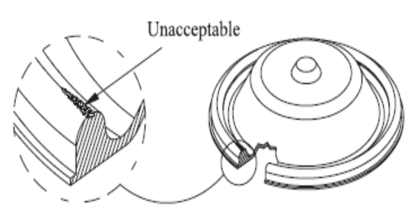
1. Void not to exceed 50% of the bead depth.



2. Void not to exceed 25% of the height and 25% of the width, simultaneously.



3. Length of void shall not exceed 25% of the perimeter of the part.



4. Any voids at the top of the bead, which may effect bead height when viewed from side, are unacceptable.

SERRATIONS

Serrations are small, typically less than 0.015" tall, concentric rings of rubber that can be on either side of the diaphragm. They are typically molded on the flange or on the head of the diaphragm to help seal the assembly. Usually, three or more serrations are designed on the part, but space limitation on some parts allow for only one serration.

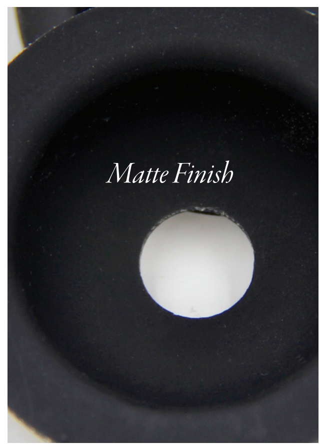
Often, in a design using several serrations, an under-fill (an area that does not completely fill with rubber) in one or more serration is acceptable as long as the minimum number of serrations have full dimensional integrity. The minimum number is defined on the print and is determined by an evaluation of the design that considers the pressures, hardware design, past experience, etc.

Four serrations on the flange of the diaphragm

Surface Finish

The surface finish on the rubber side of the diaphragm is directly due to the surface finish of the mold used in the manufacturing process. The surface finish can vary from a high-gloss to a dull, or matte finish.

In many cases, a matte finish aids in the molding process and is intentionally added to the mold. If not, the tooling surface is specified as 32 finish which will yield a high-gloss finish but due to cleaning, the surface will eventually become dull. In fact, it is more costly to maintain a high-gloss finish on your diaphragms



Matte Finish

Shiny Finish

(Please note: The surface finish has NO EFFECT on the performance or life-cycle of the diaphragm!)

Part Marking

DiaCom has capability to ink-jet print directly on parts, or mold-in markings like part numbers and date codes directly on the surface of our diaphragms.

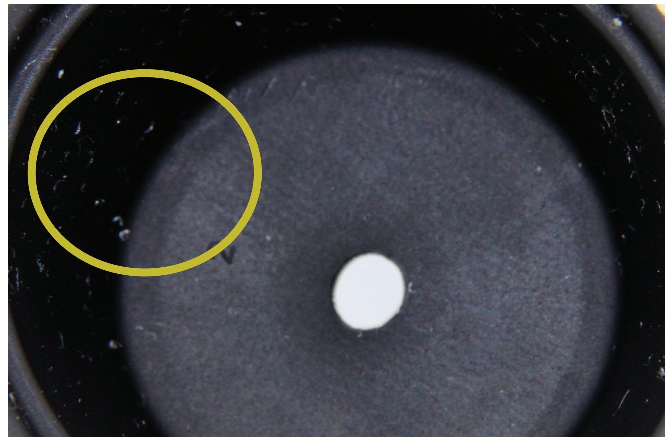
Ink-Jet Printing

MISCELLANEOUS

Loose Fibers on Parts

In a manufacturing environment that deals with cutting fabric and rubber, and as parts are shipped in bulk, it is to be expected that parts may arrive with small amounts of loose fibers on the diaphragms. This is normal and in most applications is perfectly acceptable.

If the application is sensitive to this type of debris, the parts will need special handling and/or cleaning to eliminate the debris. This issue must be clearly understood before production shipments begin in order to avoid unnecessary confusion.



Contamination

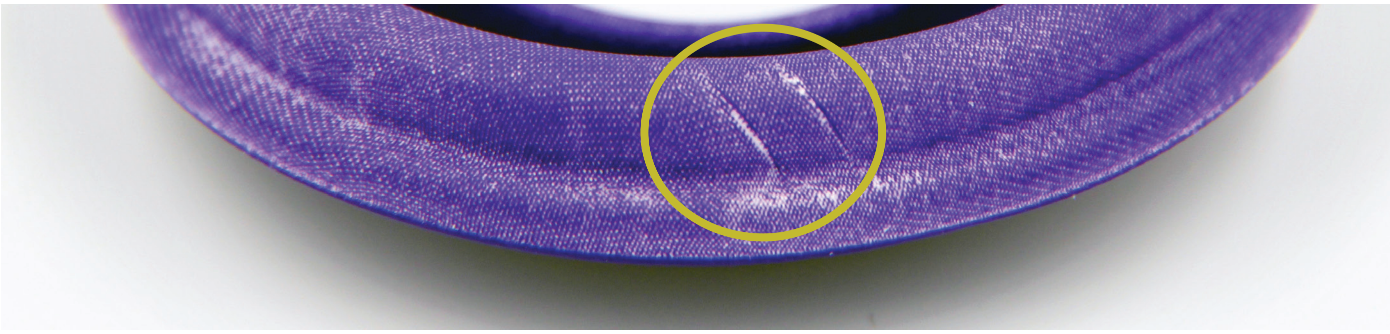
Contamination, as opposed to debris as seen on the part above, is defined as foreign material molded into the diaphragm. In virtually all applications, any amount of contamination on the rubber side is unacceptable, and cause for rejection (scrap) of the parts. Care must be taken with colored materials as small particles of dust can be smeared on the surface of the rubber. This "trace contamination" is usually acceptable. Some contaminates on the fabric side of the diaphragm not on the working area of the diaphragm do not affect the performance or life of the diaphragm and are not normally considered cause for rejection (scrap).

Stuck Rubber

If extra material is trapped in the mold, or is not cleaned out properly, additional rubber can adhere itself to the diaphragm while it is being molded causing irregularities in the final product. Additionally, if a diaphragm does not release completely from the mold, gaps can be created which will cause performance failure and are unacceptable. Tacky flash can also adhere to the parts when pulling the parts when pulling them out of the mold

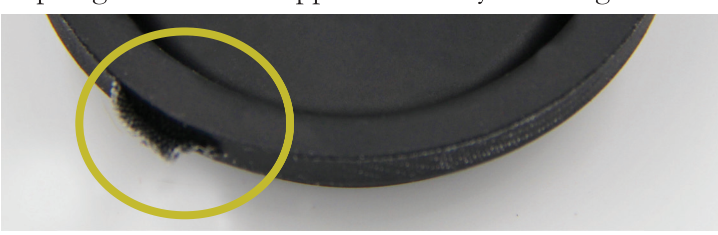
Pleating

Pleating is a defect in a diaphragm caused by the fabric folding on itself. When pressure is applied to the diaphragm, the pleat will open, creating a weak area of the diaphragm to fail prematurely. Radial Pleats, or **R-Pleats**, are those pleats that occur along the diaphragm radius. Circumferential Pleats, or **C-Pleats**, are those pleats that occur across the radii of the diaphragm.



Poor Adhesion

When the bonding process between fabric and rubber is incomplete during the molding process, it causes the fabric side to pull away from the rubber in the diaphragm leaving an undesirable gap between the two. Adhesion between rubber and fabric is critical to the proper functioning of diaphragms within the applications they are being used for.

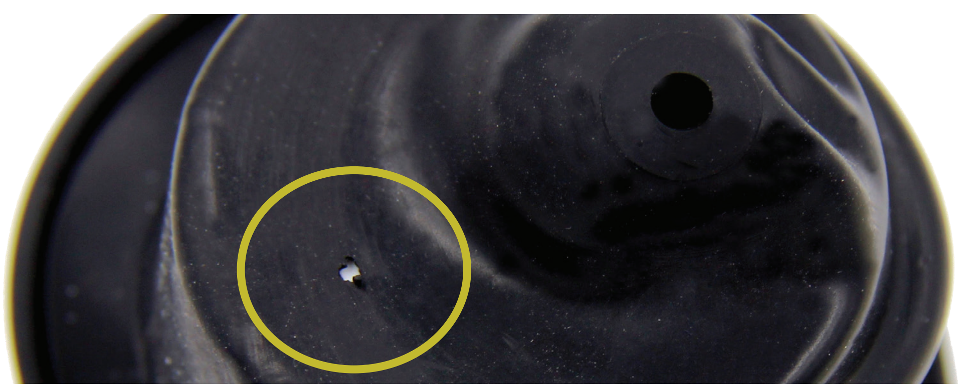


Threads

Threads can occur in finished diaphragms when the trimming process does not completely cut through the fabric leaving a clean edge. Cutting tools must be kept sharp in order to prevent this condition from developing.

Pinholes

If contaminants (or clumps of unmixed ingredients) find their way into the rubber used to create diaphragms, "pinholes" can occur. Pinholes are actual gaps in the diaphragm material which most often occur in thin-walled and homogeneous type diaphragms. Another cause of pinholes are molds that are dirty or not cleaned properly, which leave a contaminant stuck to the mold. A contaminant can cause a pinhole in the diaphragm as the rubber will not fill in the area on the mold where it is located. When the finished diaphragm is stretched, these pinholes can be seen as light comes through. Any diaphragms exhibiting pinholes are immediately considered defective.



PACKAGING

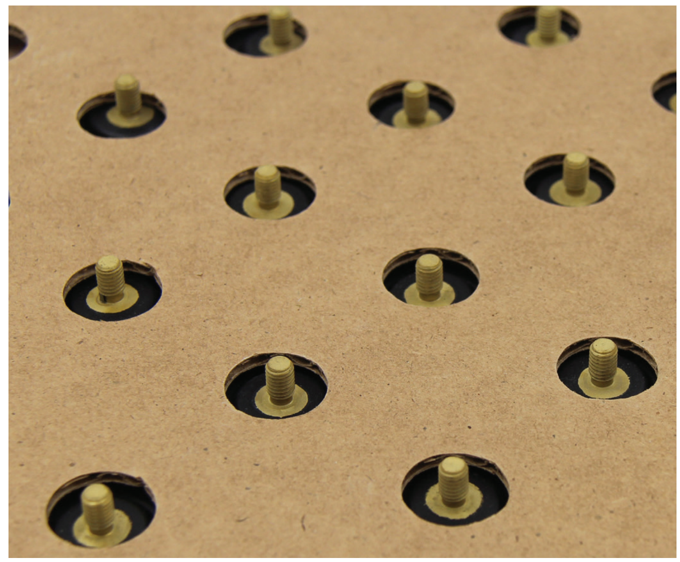
DiaCom Corporation can accommodate a variety of customer packaging requirements using different packing methods suited to the style, quantity and design of diaphragms being shipped. Our standard packaging includes Bulk Pack, Separators, Stack Packaging, and Rod Packaging.

Bulk Pack

Bulk packaging of diaphragms utilizes weight to determine quantity of units within the container(s) used for shipping.

Separators

Diaphragms needing to be kept apart from each other during shipping are packaged using Separators.



Stack Packaging

In Stack Packaging, diaphragms are placed one inside the next and then packaged for shipping.

Rod Pack

Rod Packaging is used when a wire rod can be inserted through the center of the diaphragms and they are bent at the ends prior to shipping.

Bleed-through: A defect in a diaphragm caused during manufacturing where the fabric is pulled through the rubber to the high pressure side of the diaphragm. When pressure is put on the diaphragm, the rubber will be blown away from the fabric and rupture.

Bloom: A coating on some rubber surfaces that develops due to the rubber formulations. In many cases, bloom is a desirable effect that can improve diaphragm performance. For example, resistance to ozone is often accomplished with bloom.

Blow-through: This occurs when the pressure on the diaphragm reaches a level high enough to blow a piece of the rubber through the threads of the fabric, causing a leak. This is the result of selecting a weave of fabric that is too open for the diaphragm's thickness.

Contamination: Material inclusions embedded in the diaphragm.

Debris: Trace material that is on the part and not embedded in the diaphragm. This includes dust, fabric fibers, & etc.

Dispersion: The amount of separation between the various compounding ingredients used in the milling of rubber.

Double Coat: This a type of diaphragm construction where the fabric is inserted between two layers of rubber.

Fabric Bias: All fabrics are manufactured with the weave in two major directions, warp and fill, which are 90° apart. Fabric Bias is the direction that is 45° to the weave of the fabric.

Fabric Interstices: This is the space between the threads in the fabric.

Four-Cornering: This refers to the result of the fabric deformation that occurs during the manufacturing process. The fabric in all rolling diaphragms deforms in such a way that there will be four radial directions where the square fabric thread pattern will change to a diamond shape. This means that the forces applied to a rolling diaphragm will have different effects on different parts of the diaphragm.

Over-stroke: Exceeding the designed stroke of the diaphragm causing it to come out of convolution. This will cause the premature failure as more pressure is applied to the fabric reinforcement in the diaphragm.

Pleat: A defect in the diaphragm caused by the fabric folding on itself. When pressure is applied to the diaphragm, the pleat will open, creating a weak area of the diaphragm to fail prematurely. Radial Pleats, or R-Pleats, are those pleats that occur along the diaphragm radius. Circumferential Pleats, or C-Pleats, are those pleats that occur across the radii of the diaphragm.

Single Coat: This is a type of diaphragm construction where there is rubber on the high-pressure side and fabric on the low-pressure side of the diaphragm.

Strike-through: Also referred to simply as Strike, refers to the amount of rubber that comes through the fabric to either fully or partially encapsulate the fabric during manufacturing.

Trace-Contamination: Material inclusions deemed to be of insignificant concern to the operation or life of the diaphragm.

Molded Diaphragms - Ideal solutions to tough sealing problems.

DIA·COM CORPORATION

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