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"Diaphragms: Design For Manufacturing"

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When developing original component designs the opportunity presents itself to put as much forethought into what can be done to optimize items such as the part's cost or life expectancy. However, an engineer can achieve both goals by designing for manufacturability. This achieves the most competitive part price for several reasons: improved scrap rates, lower capital tooling costs and the use of the most suitable materials. Bringing all of these concepts together will ultimately produce a superior diaphragm having the greatest life-cycle potential.

Several areas of importance would need to be discussed to offer a comprehensive guide to diaphragm design (for this refer to the Precision Industries Corporation: Diaphragm Engineering & DesignManual). Here, we will focus on those areas most important to manufacturability: flange design, bead geometry, height-to-bore ratio and proper material selection.

Flange design determines the success of the seal between diaphragm and hardware with two basic design options. With a flat/gasketed flange it is more difficult to control the compression of the material when compared to a beaded flange. Often, proper compression of flat-flanged parts can only be determined through trial and error while hardware design for beaded flanges is a quantifiable value; to maintain a good seal that hardware should produce 20-30% volumetric compression of the diaphragm's bead – higher compression will likely damage the part.

Although it does not incorporate the use of a bead, a flat flange may include a series of small, concentric V-ribs (either on the hardware or on the diaphragm) to increase seal success. Molding V-ribs on a flat flange typically does not affect the part's manufacturability and eliminates many of the quality issues related to beaded diaphragms.

Bead geometry is very important not only in the functionality it provides as a seal, but also in how complex the manufacturing process becomes. During molding, a poorly designed bead increases the potential for quality problems such as trapped air or flow/knit lines that affect seal compression and increase the scrap percentage. Some designs also make the parts more difficult to trim increasing scrap or tooling costs. Refer to the graphic below for several bead geometries and reasons for their successfulness.

Tear Drop - Under
- Better resistance to trapping air
- Better flow for less knit lines
- Better flash location for trimming

Tear Drop - Over
- Better resistance to trapping air
- Better flow for less knit lines
- Worse flash location for trimming

"D" Bead - Over
- Worse resistance to trapping air
- Worse flow for less knit lines
- Better flash location for trimming

"D" Bead - Under
- Worse resistance to trapping air
- Worse flow for less knit lines
- Worse flash location for trimming

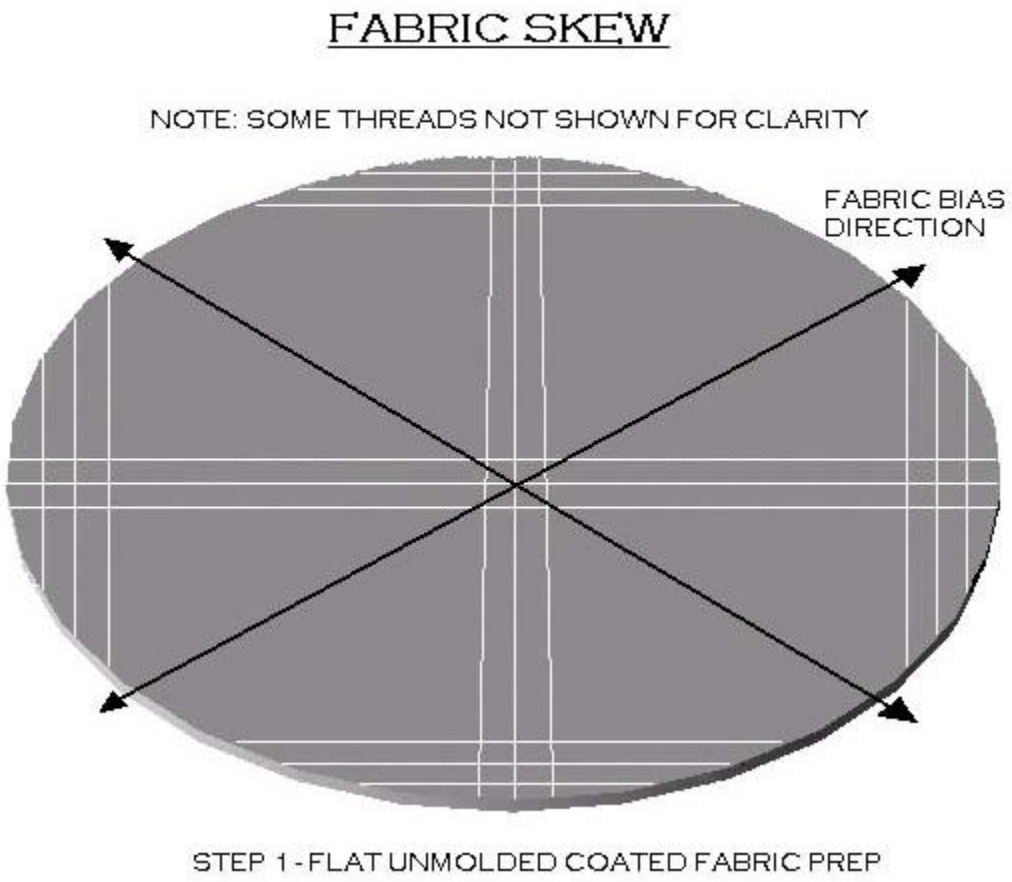
Height-to-Bore Ratio describes the relationship between the diameters of the convolution base to the overall convolution height. Typically, this ratio is set at a maximum of 1:1. Although larger ratios have been achieved before, it becomes much more difficult and relies heavily on a specific fabric style (more on this point will be discussed with material selection).

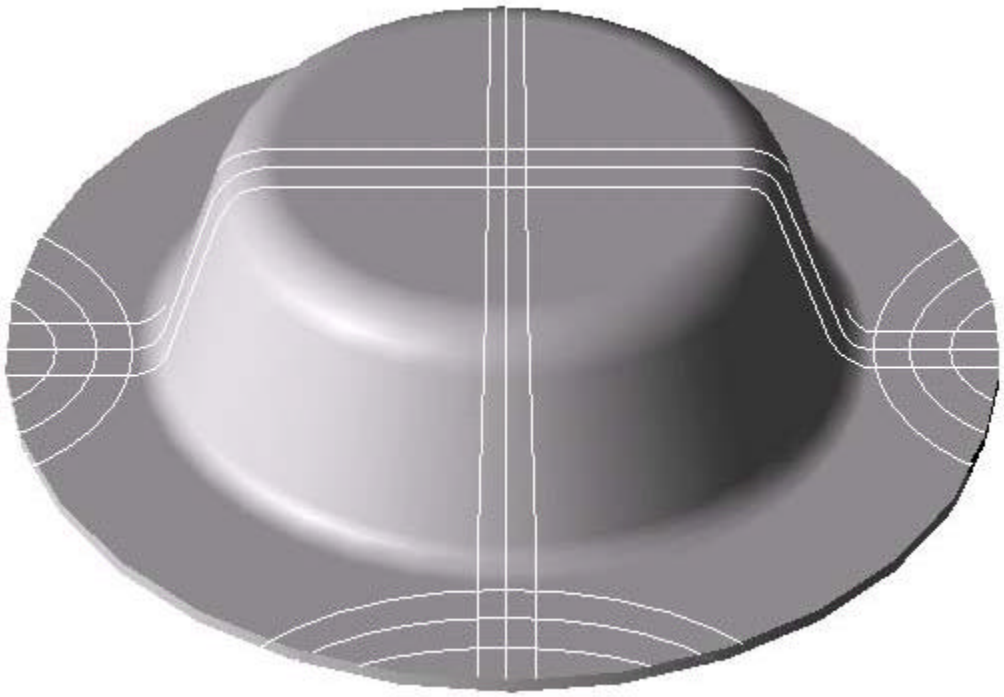
When determining the height-to-bore ratio, the engineer should also consider the resulting draft angle of the sidewall. Although there is no recommended minimum, the draft angle should be as large as the hardware will allow – this maximizes diaphragm life while minimizing manufacturing difficulty.

Material Selection often requires the knowledge and experience of the diaphragm supplier. Specifying the best choice of materials not only ensures the longest possible life of the diaphragm, but often unnecessary costs can be avoided by not over-designing for the application.

The elastomer choice is critical when considering the environment in which the part will operate, and will often override considerations taken for manufacturability. Relevant elements include: chemical contact, abrasive hardware or medium, applied loads and health or federal regulations. If conditions allow, the elastomer will be selected for manufacturability based on its flow characteristics, cure system/rate, gasket/fabric adhesion and the ease of cut (generally described by durometer).

Fabric choice can increase/decrease the difficulty involved in manufacturing the diaphragm. Knit fabrics are more difficult to predict because of the dissimilar stretch characteristics in each thread direction. For diaphragms with large height-to-bore ratios, a fabric with an open weave (larger thread spacing) must be used to allow the fabric threads to realign themselves when formed (see the picture below). The engineer should keep in mind that shaping fabric essentially forces an initially square structure into a round structure.





STEP 2 - MOLDED COATED FABRIC

The burst strength of the fabric, environmental compatibility and abrasion resistance will also help to define viable options. As can be imagined, materials with the most capability and highest quality fetch the highest prices – thus selected materials should be capable of meeting only the necessary requirements.

Taking advantage of the opportunity to properly design a diaphragm for manufacturability in the initial stages minimizes lead-time, decreases tooling costs, maximizes production efficiency and yields the highest quality product possible. Additional design background is explained in the Precision Industries Design Manual or for direct feedback contact the Precision Industries Engineering Department.