Manufacturing processes can demand different things from an elastomeric or rubber covering. In order to understand what can be done to help the process, one needs to understand what options they have available to them in regards to an elastomeric roll cover. One needs to understand what rubber is and how it can be customized to help meet the process needs.

**What is Rubber?**

Rubber is used in many industries to fulfill a variety of needs. But in its simplest form, rubber is a spring. How it performs is governed by the same laws of vibration, physics, and dynamics as any other spring material would be.

\[ F = k \times x \]

where:

- \( F \) = force
- \( x \) = displacement
- \( k \) = spring constant

Durometer is a term and device developed in the 1920’s to define an elastomers resistance to deformation. Essentially a force required to deform a material a set distance. Therefore, the “\( k \)” value for an elastomer is analogous the durometer.

There are a variety of spring types, but in a roll application one is using the elastomeric cover like a compression spring. In the category of compression springs there are many types and some of the more common are as follows: linear/constant, progressive, progressive with knee, degressive, and dual rate. Some of these can be seen in many of the current and common rubber
covered roll. In the roller industry, one could think of these as a single durometer, dual durometer, and a hybrid.

**Single Durometer Rubber**

Single durometer rubbers would be best related to a linear spring, which is by far the most common compression spring found in use. While there is a lot of things that can be done through compounding to improve their performance in a process, they still have a fairly linear force/displacement relationship. If one where to graph the results of a force displacement curve it would be seen that as the durometer changes only the slope of the line really changes (Graph 1).

![Graph 1 – Durometer Comparison](image)

As seen in the graph, the higher the durometer the steeper the slope of the curve. These results are based upon testing on a roll therefore as the rubber physically moves the nip area is increasing effecting the shape of the curve. One may notice that the slopes are not quite straight but the variation is not great enough to be considered truly progressive. The only variation from
these slopes occurs when the loads increase to the point where the core starts to influence the results.

A single durometer rubber is the most common material used on rubber coated rolls. Most processes will work well using a simple rubber formulation. Applications include those where the desired effect is the force not increasing too quickly with variation in displacement or processes that tend to not have much variation in web thickness.

But what if the process requires something else? What if one is not looking for a linear response? What if one has a process with web thickness variation and needs the cover to stiffen quickly with changes in the deflection?

**Dual Durometer Rubber**

A dual durometer cover is another type of rubber cover that can be used when a single durometer will not provide the proper response. This is just as it sounds, two different durometers on top of each other. Typically the roll is built with a harder durometer rubber as the base layer. The roll is cured and ground and then a second layer of a softer durometer is built on top of that. The roll then has to be cured and ground again. This process means that the roll is essentially processed twice for one cover. This process will mimic what you would see in a dual rate spring and is often used in the PCB industry.

There are a multitude of ways that one can customize the slope of the force/displacement curve on a dual durometer roll. Most typically one will change either the durometers of the two different materials or one will change the ratio of the inner to outer thickness. Graph 2 shows the relationship of commonly used durometers with different thickness ratios.
Graph 2 – Various Cover Thickness Ratios of a Dual Durometer Cover

As seen on the graph, the shape of the curve is essentially the same. One is limited to using two linear spring materials on top of each other so the result will be a linear slope with a transition to another linear slope. Also seen from the graph is the fact that the ratio of thicknesses does not change where the transition happens but only the slope after the transition. As the outer layer becomes thinner, the inner material has more influence on the spring rate and the resultant slope is steeper.

This rapid transition between slopes can be useful in certain processes. On a single durometer cover, as the displacement changes there is a linear relationship to the force generated and applied to the web. If the process requires a quicker change, the covers thicknesses and durometers can be adjusted to put the process around that described transition (Graph 3).
This type of cover does however have limitations. The shape and size of the transition window in a process will vary. Many times it has been seen that the ratio of inner to outer covers is important to processes that require a dual durometer characteristic. Therefore, as the roll starts to wear the slope after the transition starts to increase, which can affect the process. Second, there are times when it is advantageous to be able to perform a regrind on a roll to save cost and time. Many processes will impart small cuts or blemishes that could be fixed with a simple regrind. However this removes material from the outer layer only and, again, changes that ratio.

**Hybrid Rubber**

There is yet another option emerging for rubber covers. That is a hybrid, or engineered, rubber. This rubber is exactly what it sounds like, it is a combination of different materials. It is compounded to take into account all parameters of a process. It is a completely customizable material. Everything from internal hysteresis, abrasion resistance, elongation, compression set, exposure limits, and force/displacement response can be adjusted to meet the process needs.
The main advantage of a hybrid material is that the characteristics are homogeneous throughout the rubber. Unlike a dual durometer, who’s response is constrained to the initial build condition, a hybrid can be reground as wear or abuse occurs and the material acts the same. Graph 4 shows a sample of a material that was compounded to mimic the response of a dual durometer.

![Graph 4 – Hybrid Material Test](image)

This sample compound has the same linear response followed by a quicker transition to a second linear section. The shape and slopes of each section can be customized and changed to match what the process needs.

Again, all the properties of the material are homogeneous within the material. This can help reduce cost in the long run as the cover can be reground instead of recovered every time. Also, this material is customized for each process. This means that it can be not only be dialed in but also adjusted as the process or needs change.
Summary

There are a variety of needs for a rubber cover and there are a lot of options available. While many processes will be satisfied with a simple single durometer rubber cover, others will require more elaborate solutions. Dual durometers and available to help with processes that need a modified force/displacement response. If a truly customized solution is needed, then a hybrid can be formulated to meet the needs of virtually all processes. Whether it’s response issues, internal heating through hysteresis, compression set, elongation, or exposure limitations help can be provided through proper selection and engineering of the elastomeric materials.