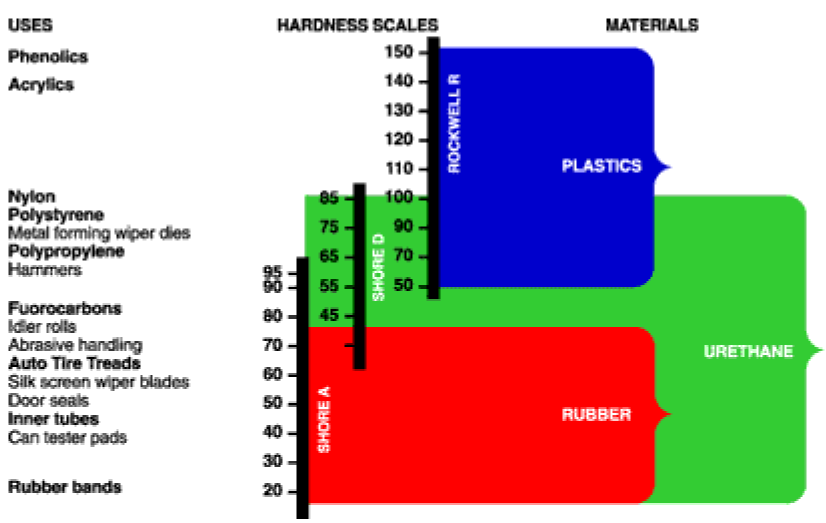
Anderson Development Company

Urethane 101: All you want to know about polyurethane elastomers and more!

A polyurethane elastomer is comprised to two necessary components: the prepolymer (usually called the "A-side") and the curative (usually called the "B-side"). The prepolymer consists of isocyanate groups (NCO) that react with either hydroxyl (OH) groups or amine (NH2) groups in the curative. There are also typically other crosslinking reactions involved, but these are the major two. The name urethane comes from the reaction of the NCO and OH to form a urethane linkage. Since many of these linkages are formed, it is called a polyurethane. The reaction of the NCO and NH2 form a urea linkage and many react to form a polyurea.

Prepolymers. There are numerous prepolymers available, but only a handful of different types in terms of chemical backbone structure. There are two main ingredients controlling the type of prepolymer are the type of isocyanate and the polyol type. For urethane prepolymers, MDI and TDI are the two that are most common. There are some others that are used, such as PPDI, IPDI, and hydrogenated-MDI, but these are more costly and typically used when special properties are needed. The polyol will be usually one of four types: polyester, PTMEG polyether, PPG polyether, or polycaprolactone. Each has their strengths and weaknesses. Polyesters are known for superior physical properties, such as tensile and tear strength, and are also solvent resistant. However, they are not resistant to aqueous applications where there are acids or bases involved. The PTMEG polyethers are well known for their dynamic performance and good physical properties, but they also are more expensive. They do well in application involving water, as do PPG polyethers. The PPG ethers are a lower cost ether alternative having properties not as good as the PTMEGs typically. Polycaprolactone prepolymers are really just a type of polyester, with the benefit of lower viscosity, but cost is higher.

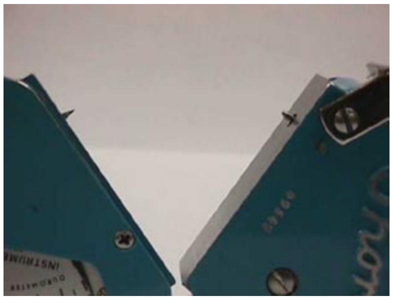
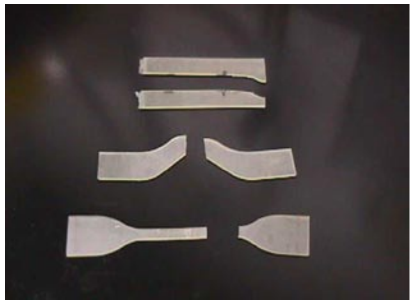
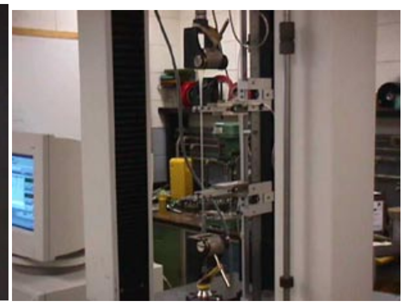
Curatives. As mentioned above, two principle reactions take place when the prepolymer and curative are mixed to form a solid. So, it makes sense that there are two basic types of curatives: amine functional and hydroxyl functional. The standard amine curative is a diamine called MBOCA. MBOCA is normally used with TDI prepolymers. The standard curative for MDI prepolymers is 1,4 butanediol, which is a hydroxyl functional curative. The are numerous other curatives out there (too many to mention), and many can be mixed with others to make custom blends. This is why urethane has such versatility and the ability to have a wide range of hardness as shown below in the chart.



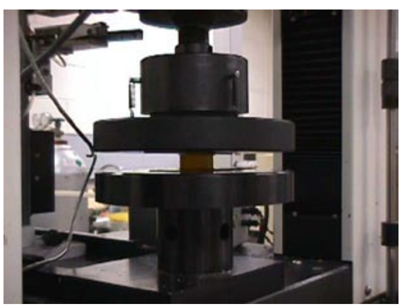
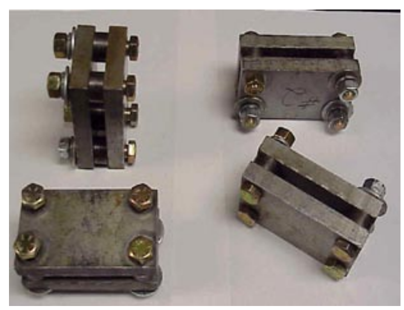
Additives. There many different additives for polyurethane elastomers that can enhance them in some way. The table below list common types of additives, their function, where and how to add them, and names of the most commonly used for polyurethanes. For a more complete list, check out our Supplier list.

Additive Type	Functions	How/Where to Add	Examples
Plasticizers	Lower viscosity (prepolymer or curative) and hardness	Add to prepolymer or curative before casting the part	Benzoflex® 9-88SG, DOA, DOP, DIOA, Santicizer® 160, TXIB
Fillers	lower system cost (sometimes), increase rigidity, enhance strength	Normally added to the prepolymer	silica, sand, fiberglass, glass
Catalysts	shorten potlife and demold time	Varies	dibutyltin dilaurate, tertiary amines (triethylamine - TEA), oleic acid, adipic acid, azelaic acid
Degassing aids	helps the prepolymer to degas quicker	Added to the prepolymer before degassing	X-Air®, silicones (anti-foamers)
Antioxidant/UV Stabilizers	Slows oxidation/photodegradation	Added to the prepolymer/curative before casting	Irganox®, BHT, Tinuvin®
Antistatic agents	Disspates static electricity buildup on the surface	Added to the curative before casting	Larostat®, Catafor®
Flame Retardants	Reduces flammability	Usually added to the curative before casting	Alumina trihydrate, antimony oxide, Fyrol®, Martinal®

Physical Testing Methods and Equipment

The picture on the left is of two durometers, used for measuring hardness. There is an indenter that sticks out from the bottom that is pushed into the urethane to give the hardness reading. The picture in the middle is of broken specimens that have already went through testing. The top specimen is from a split tear test. The specimen looks like a pair of pants and the object is to see how much force it takes to tear the "legs" apart. The middle piece is from another tear test called DieC. In this test, the part is again pulled apart, but at a 90 degree edge. The last part is in a dog bone shape and is for a tensile strength test. The picture on the right shows a tensile test being performed. Modulus and elongation is also measured during this test. These common physical tests give an idea of how strong or tough an elastomer might be.

The pictures just above are of tests done on urethane "buttons". The left is a picture of a compression-deflection test where the elastomer is compressed to predefined percents and the force used to do this is measured. The middle is a picture of a rebound gauge. Rebound is a measure of the energy an elastomer will give back, and can be a good measure of the elasticity of the urethane. A weight is dropped down a rod and hits the urethane, bouncing back up to the percent of the energy that is returned. For dynamic applications, high rebound is needed. The picture on the right show compression set jigs. Compression set is a measure of how much specimen will come back after being compressed for 22 hrs. at 70 degrees Celsius to a specific height (method B). A low compression set is most normally favored.