Engineering Property - Urethanes in Compression

Urethane elastomers have higher load bearing capacity than do conventional elastomers of comparable hardness. This permits design of smaller parts, with possible savings in weight and materials cost. Compression-deflection curves for 1 – Thane and natural rubber vulcanization of equivalent hardness (80 durometer A) are compared in Figure 1. This figure illustrates that urethanes can be loaded beyond conventional limits for rubber. Die-Thane DT-25 has sustained short-term loadings of greater than 20,000 psi and Die-Thane DT-15 has been loaded to 68,000 psi without fracturing.

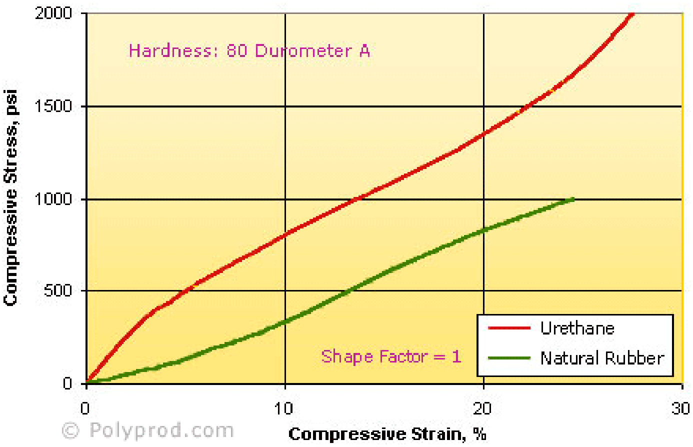

FIGURE 1 COMPRESION OF DIE-THANE DT-25 NATURAL RUBBER IN COMPRESSION

Effect of Load Surface Conditions

When an elastomeric piece is compressed between parallel plates, the surfaces in contact with the plates tend to spread laterally, increasing the effective load bearing area. If this lateral movement of the surface is restricted, the compression deflection behavior of the piece is changed. Restriction of lateral movement greatly stiffens the part.

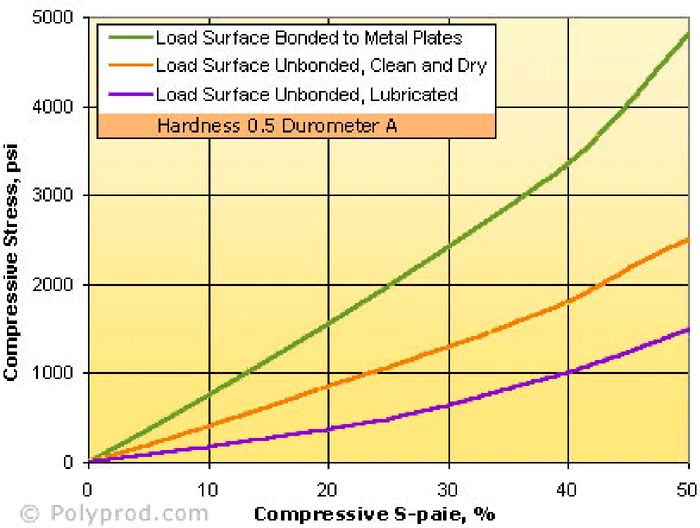

FIGURE 2 SURFACE CONDITION EFFECTS ON COMPRESSION

Figure 2 illustrates this effect quite clearly. A lubricated surface offers essentially no resistance to lateral movement. Lubrication at the metal-rubber surface may excessively strain the part because extreme deformation may occur. A clean, dry loading surface offers some resistance due to friction; if the surface is bonded to the metal plates, no lateral movement is possible and insures reproducible compression values. These differences in contact surface result in three distinct compressive stress-strain relationships for the same piece of rubber. The loading bearing capability of Die-Thane can be altered by a factor of 5 to 1 by changing the surface conditions.

Effect of Shape

Shape factor is defined as the ratio of the area of one loaded surface to the total area of the unloaded surfaces which are free to bulge. Parts made from the same compound and having the same shape factor behave identically in compression, regardless of actual size or shape.

Effective use of compression-deflection data is dependent on knowledge of test conditions under which the data were taken. The values presented are for normal room temperature and static or slow speed operation. Other temperatures and dynamic loadings would change these values completely. Shape factors below 0.25 may permit buckling; therefore, higher shape factors should be used.

As shape factor increases, the unit load required to produce a given strain also increases. There is, however, no mathematical relationship between shape factor and compressive modulus; the relationship must be determined empirically. Figure 3 and 4 show compression-deflection curves for Die-Thane of hardnesses and shape factors. These curves were obtained with bonded surface. The compression-deflection characteristics of a fabricated item of a particular hardness may vary up to ? 10% from the curves shown. Deviations arise primarily from inaccuracies in measuring hardness of an elastomer compound.

Deformations are usually limited from 15% to 25%, which is the predictable straight line portion of the shape factor curves. Deformations above 25% impose higher stresses which induce much higher set and increase creep in the part.

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Use of Compression Stress-Strain Curves in Design

The following examples show how the compression stress-strain curves can be used in the design of urethane parts. Shape factor for blocks and cylinders is calculated as follows:

EXAMPLE 1

For rectangular shaped prisms

where l = length
W = width
T = thickness
D = diameter
H = height

$$\text{Shape factor} = \frac{lw}{2t(l + w)}$$

For discs and cylinders

$$\text{Shape factor} = \frac{d}{4h}$$

This relationship is limited to the following:

1. pieces which have parallel loading faces;
2. pieces whole thickness is not more than twice the smallest lateral dimensions; and
3. pieces whose loading surfaces are restrained from lateral movement.

(b) In Figure 3 we find that the compressive stress-strain curve of a 70 A durometer urethane part with a shape factor of 2 crosses the 1000 psi stress abscissa at 11% strain. Therefore, the pad will deflect 11% of one inch or 0.11 inch.

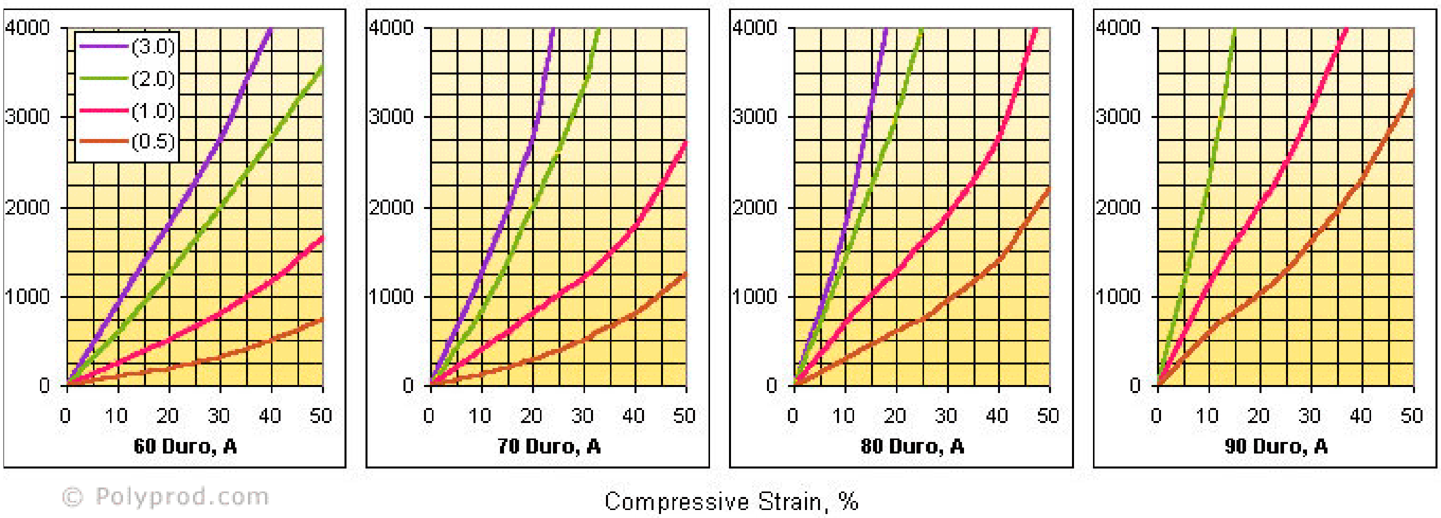

FIGURE 3 COMPRESSION-DEFLECTION CHARACTERISTICS OF SOFT URETHANES

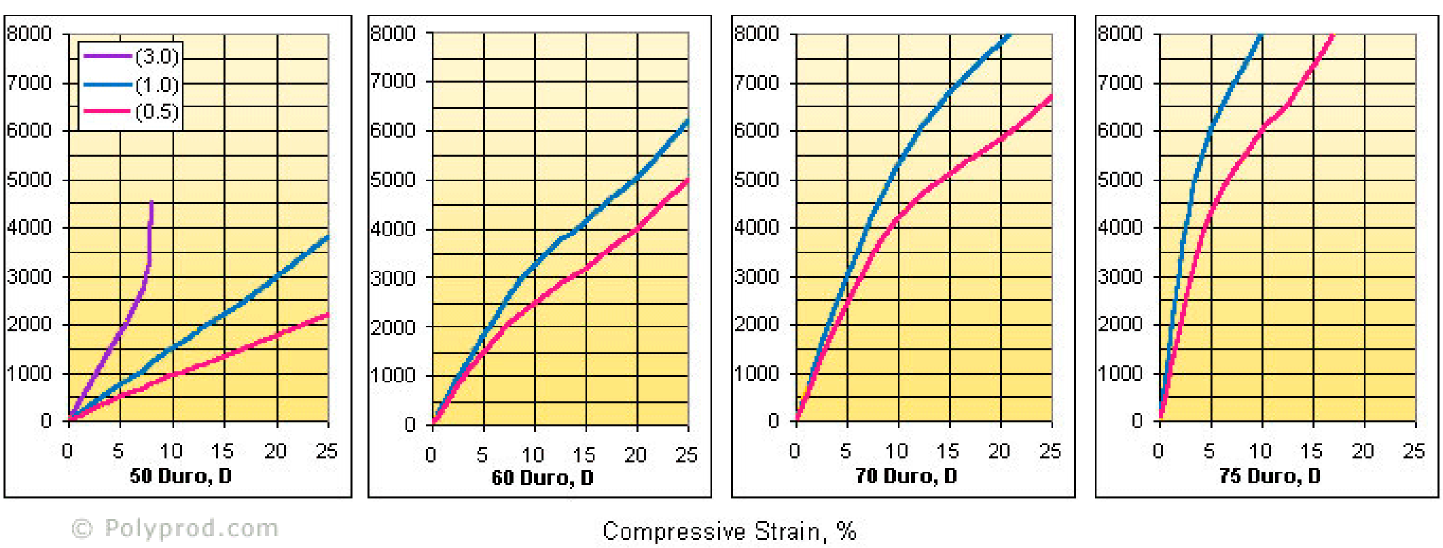

FIGURE 4 COMPRESSION-DEFLECTION CHARACTERISTICS OF HARD URETHANES

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EXAMPLE 2

Problem: What happens if the pad thickness is doubled in Example 1?

Solution:

(a) Shape factor of the piece is now:

$$\frac{(8)\ (8)}{(2)\ \ (2)\ \ (8+8)} = \frac{64}{64} = 1$$

(b) From Figure 3, the compressive strain at 1000 psi stress for a 70 durometer A part with a shape of 1 is 25%. In this case, the pad will deflect 25% of two inches, or 0.50 inch. (In practice, parts made of conventional elastomers are generally designed so that compressive strain does not exceed 15%).

As a general rule, the harder the elastomer, the greater its load-bearing capacity. The manner in which load-bearing properties Die-Thane change with hardness at various deformations is shown in Figures 5 through 7.

Figure - 5

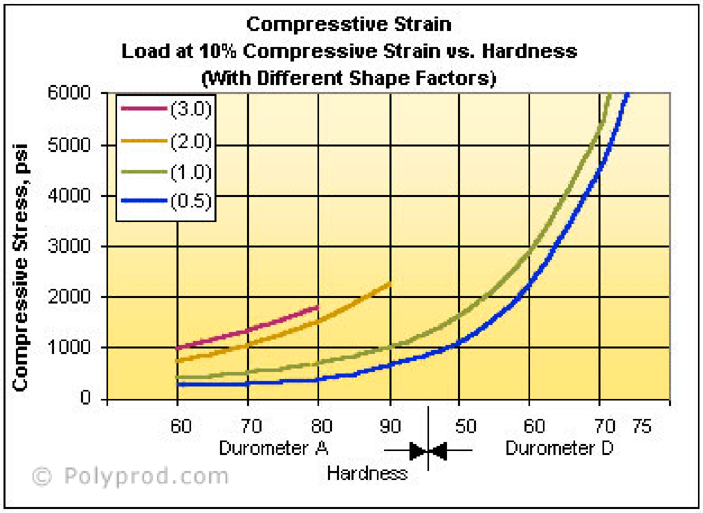


Figure - 6

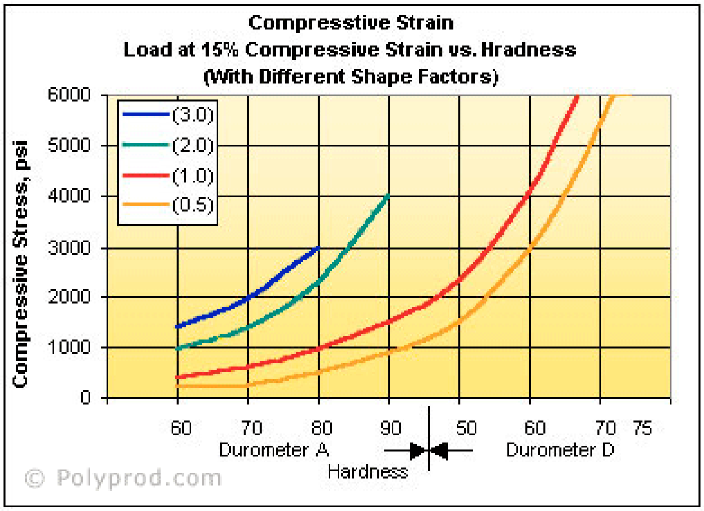
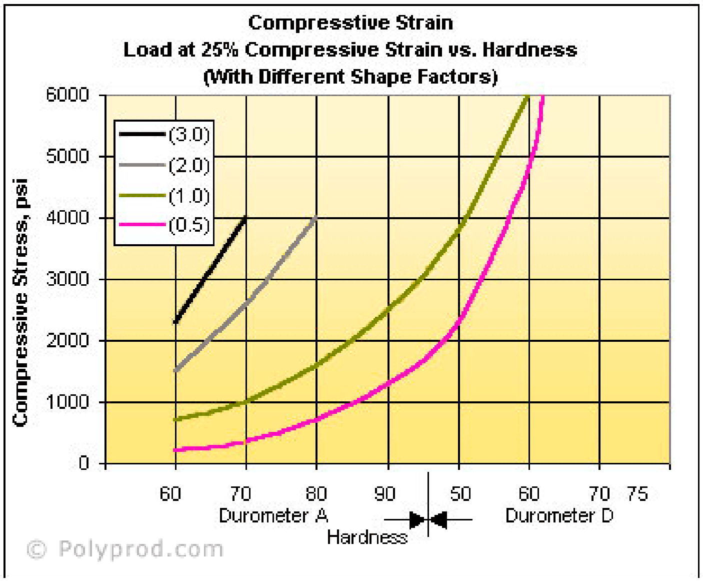


Figure - 7



EXAMPLE 3

Problem: Assume a pad which is one inch square by one-half inch thick and bears a 2500 lb. Compressive load. The pad may not deflect more than 0.05 deflect more than 0.05 inches because of space limitations. What hardness Die-Thane should be specified?

Solution:

(3) Shape factor of the piece is:

$$\frac{(1)\ (1)}{(2)\ (1/2)\ (1+1)} = \frac{1}{2} = 0.5$$

(b) Unit compressive stress is:

$$\frac{2500}{(1)\ (1)} = 2500\text{ psi}$$

(c) Compressive strain is:x

$$\frac{0.05}{0.5} \times 100 = 10\%$$

(d) On scanning the compressive stress-strain curves we find in Figure 4 that vulcanizates which are 60 D hard or harder will bear a compressive stress of 2500 psi with 10% or less deflection.