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Importance of creep data to the designer

Two of the most important types of long term viscoelastic behavior are creep and stress relaxation. The short-term stress/strain behavior usually occurs in less than an hour and is considered instantaneous. Creep and stress relaxation may continue to occur over the life of a part or structure on a time scale of 100,000 hours or more. When any thermoplastic material is subjected to a constant stress for an extended period of time, the strain will increase. This is known as creep.

Figure 1 shows an illustration of creep. Three identical bars have the same load (P) on them for a long period of time, giving a constant stress. Over time the strain increases.

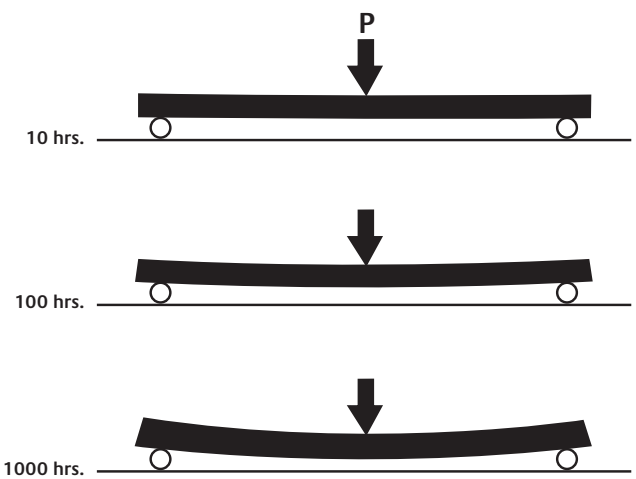

Figure 1 Creep

Figure 2 illustrates graphically what happens in figure 1. When the stress is removed (point A), some elastic recovery occurs followed by more viscous recovery. However some permanent deformation or deflection remains as a result of creep.

Creep

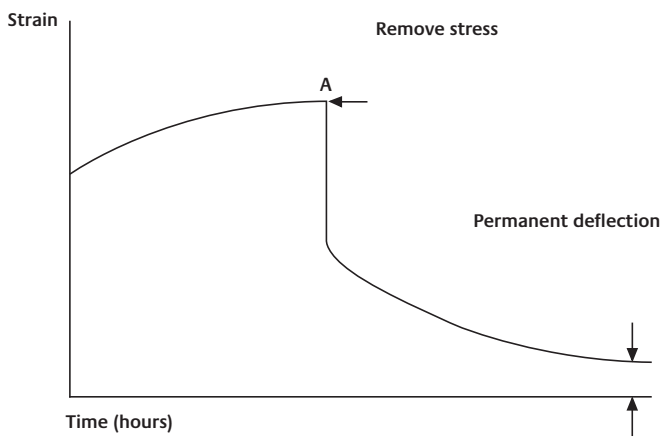

Figure 2

We know that elastic modulus is equal to stress/strain. When creep occurs extra strain is added to the denominator, which means that the modulus decreases. This decreasing modulus is known as the apparent modulus (EA). It is the apparent modulus that allows the designer to account for creep.

EA = Stress/Strain = Stress/(e1+ e2)

Apparent modulus versus time for Noryl* resin is plotted in figure 3. Note that the curve varies with temperatures. The effect of raising the temperature is to increase the molecular activity and increase the rate of creep.

Note that elastic modulus alone is not enough to design for long term loading of a part.

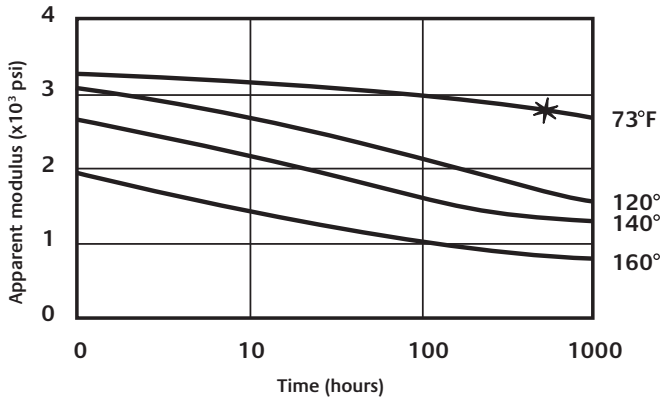

Figure 3

Creep need not be a problem for the designer using thermoplastics, if the apparent modulus at the appropriate time period and temperature is used in the design equations.