

In-Class Exercise Specific Strength SOLUTION

A small, uniaxial stress of 1 MPa is applied to a rod of high-density polyethylene.

- (a) What is the resulting strain?
- (b) Repeat for a rod of Kevlar®.
- (c) Calculate the specific strength of pure aluminum and compare it to the specific strength of Kevlar®. (**Specific strength is TS/density**)

(a) From Shackelford (5th Edition), the Young's modulus for high-density polyethylene is 830 MPa. Since the applied stress is low, we can assume that we are in the elastic deformation region and use the following equation:

$$\varepsilon = \frac{\sigma}{E} = \frac{1 \text{ MPa}}{830 \text{ MPa}} = 1.2 \times 10^{-3}$$

(b) From Shackelford (5th Edition), the Young's modulus for Kevlar® is 131 GPa. Again Hooke's law can be used to calculate the strain:

$$\varepsilon = \frac{\sigma}{E} = \frac{1 \text{ MPa}}{131 \times 10^3 \text{ MPa}} = 7.63 \times 10^{-6}$$

As can be seen, Kevlar® is much stronger and deforms little compared to the typical polyethylene.

(c) In order to calculate the specific strength, we must know the tensile strengths and densities of each material.

The tensile strength of pure aluminum is 175 MPa and the tensile strength of Kevlar® is 3800 MPa.

The density of pure aluminum is 2.70 Mg/m³ and the density of Kevlar® is 1.44 Mg/m³.

The specific strength of pure aluminum is:

$$\text{sp. str., Al} = \frac{T.S.}{\rho} = \frac{(175 \text{ MPa}) \times (1.02 \times 10^{-1} \text{ kg/mm}^2) \text{ MPa}}{(2.70 \text{ Mg/m}^3) (10^3 \text{ kg/Mg}) (1 \text{ m}^3 / 10^9 \text{ mm}^3)} = 6.61 \times 10^6 \text{ mm}$$