Strain Hardening

7.27 (a) We are asked to show, for a tensile test, that

$$\%CW = \left(\frac{\varepsilon}{\varepsilon + 1} \right) \text{ x } 100$$

From Equation 7.8

$$\%CW = \left[\frac{A_0 - A_d}{A_0} \right] \text{ x } 100 = \left[1 - \frac{A_d}{A_0} \right] \text{ x } 100$$

Which is also equal to

$$\left[1 - \frac{l_0}{l_d} \right] \text{ x } 100$$

since $A_d/A_0 = l_0/l_d$, the conservation of volume stipulation given in the problem statement. Now, from the definition of engineering strain (Equation 6.2)

$$\varepsilon = \frac{l_d - l_0}{l_0} = \frac{l_d}{l_0} - 1$$

Or,

$$\frac{l_0}{l_d} = \frac{1}{\varepsilon + 1}$$

Substitution for l_0/ l_d into the %CW expression above gives

$$\%CW = \left[1 - \frac{l_0}{l_d} \right] \text{ x } 100 = \left[1 - \frac{1}{\varepsilon + 1} \right] \text{ x } 100 = \left[\frac{\varepsilon}{\varepsilon + 1} \right] \text{ x } 100$$

(b) From Figure 6.12, a stress of 415 MPa (60,000 psi) corresponds to a strain of 0.16. Using the above expression

$$\%CW = \left[\frac{\varepsilon}{\varepsilon + 1} \right] \text{ x } 100 = \left[\frac{0.16}{0.16 + 1.00} \right] \text{ x } 100 = 13.8\%CW$$