6.45 (a) We are asked to determine both the elastic and plastic strain values when a tensile force of 110,000 N (25,000 $lb_f$) is applied to the steel specimen and then released. First it becomes necessary to determine the applied stress using Equation 6.1; thus

$$\sigma = \frac{F}{A_0} = \frac{F}{b_0 d_0}$$

where $b_0$ and $d_0$ are cross-sectional width and depth (19 mm and 3.2 mm, respectively). Thus

$$\sigma = \frac{110{,}000 \text{ N}}{(19 \text{ x } 10^{-3} \text{ m})(3.2 \text{ x } 10^{-3} \text{ m})} = 1.810 \text{ x } 10^9 \text{ N/m}^2 = 1810 \text{ MPa} \ \ (265{,}000 \text{ psi})$$

From Figure 6.21, this point is in the plastic region so the specimen will be both elastic and plastic strains. The total strain at this point, $\varepsilon_t$, is about 0.020. We are able to estimate the amount of permanent strain recovery $\varepsilon_e$ from Hooke's law, Equation 6.5 as

$$\varepsilon_e = \frac{\sigma}{E}$$

And, since $E$ = 207 GPa for steel (Table 6.1)

$$\varepsilon_e = \frac{1810 \text{ MPa}}{207 \text{ x } 10^3 \text{ MPa}} = 0.0087$$

The value of the plastic strain, $\varepsilon_p$ is just the difference between the total and elastic strains; that is

$$\varepsilon_p = \varepsilon_t - \varepsilon_e = 0.020 - 0.0087 = 0.0113$$

(b) If the initial length is 610 mm (24.0 in.) then the final specimen length $l_i$ may be determined from a rearranged form of Equation 6.2 using the plastic strain value as

$$l_i = l_0(1 + \varepsilon_p) = (610 \text{ mm})(1 + 0.0113) = 616.7 \text{ mm (24.26 in.)}$$