6.20 (a) This part of the problem asks that we ascertain which of the metals in Table 6.1 experience an elongation of less than 0.072 mm when subjected to a tensile stress of 50 MPa. The maximum strain that may be sustained, (using Equation 6.2) is just

$$\varepsilon = \frac{\Delta l}{l_0} = \frac{0.072 \text{ mm}}{150 \text{ mm}} = 4.8 \text{ x } 10^{-4}$$

Since the stress level is given (50 MPa), using Equation 6.5 it is possible to compute the minimum modulus of elasticity which is required to yield this minimum strain. Hence

$$E = \frac{\sigma}{\varepsilon} = \frac{50 \text{ MPa}}{4.8 \text{ x } 10^{-4}} = 104.2 \text{ GPa}$$

Which means that those metals with moduli of elasticity greater than this value are acceptable candidates--namely, Cu, Ni, steel, Ti and W.

(b) This portion of the problem further stipulates that the maximum permissible diameter decrease is 2.3 x 10^{-3} mm when the tensile stress of 50 MPa is applied. This translates into a maximum lateral strain ε_x (max) as

$$\varepsilon_x(\text{max}) = \frac{\Delta d}{d_0} = \frac{-2.3 \text{ x } 10^{-3} \text{ mm}}{15.0 \text{ mm}} = -1.53 \text{ x } 10^{-4}$$

But, since the specimen contracts in this lateral direction, and we are concerned that this strain be less than 1.53 x 10^{-4}, then the criterion for this part of the problem may be stipulated as $-\frac{\Delta d}{d_0} < 1.53 \text{ x } 10^{-4}$.

Now, Poisson's ratio is defined by Equation 6.8 as

$$\nu = -\frac{\varepsilon_x}{\varepsilon_z}$$

For each of the metal alloys let us consider a possible lateral strain, $\varepsilon_x = \frac{\Delta d}{d_0}$. Furthermore, since the deformation is elastic, then, from Equation 6.5, the longitudinal strain, ε_z is equal to

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

Substituting these expressions for ε_x and ε_z into the definition of Poisson's ratio we have