1-3. The lever is attached to the shaft *A* using a key that has a width *d* and length of 20 mm. If the shaft is fixed and a vertical force $P \sim N(260, 20^2)$ N is applied perpendicular to the handle, find the dimension *d* that makes the probability of failure of the key less than 10^{-4}, given that the allowable shear stress for the key is $\tau_a = 25\,\text{MPa}$.

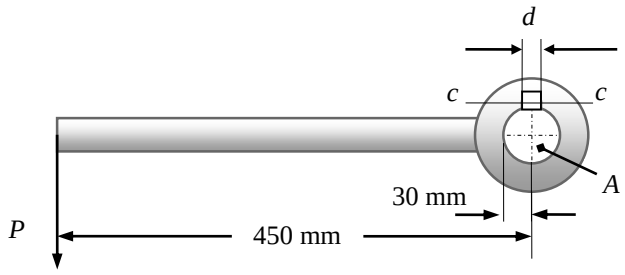

Fig. 1.3.1

Solution

$$\circlearrowleft + \Sigma M_A = 0\ ; \quad -F_{c-c}(30) + P(450) = 0; \quad F_{c-c} = 15P;$$

$$\tau = \frac{F_{c-c}}{A_{c-c}} = \frac{15P}{d(0.02)} = \frac{750P}{d};$$

Then

$$\mu_\tau = \frac{750}{d}\mu_P = \frac{750}{d}(260) = \frac{1.95\times10^5}{d}$$
$$\sigma_\tau = \frac{750}{d}\sigma_P = \frac{750}{d}(20) = \frac{1.5\times10^4}{d}$$

$$p_f = \Pr(\tau > \tau_a) = \Pr\left(\frac{\tau-\mu_\tau}{\sigma_\tau} > \frac{35\times10^6 - \frac{1.95\times10^5}{d}}{\frac{1.5\times10^4}{d}}\right) = 1-\Phi\left(\frac{35\times10^6 d - 1.95\times10^5}{1.5\times10^4}\right) < 10^{-4}$$

We can obtain $d \geq 10.03\,\text{mm}$. **Ans.**