JETS Challenge 110

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Jack up the Basement!

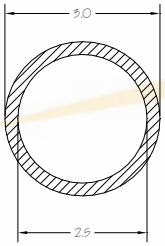
A building will collapse if the building columns are overloaded beyond their design limits. One formula for sizing the maximum load on a short steel pipe column is given by $P_{critical} = \frac{\pi E k^2 A}{L^2}$

where P is the critical load (psi), E is the modulus of elasticity (psi), A is the area of the cross section (in^2) of the column; L is the height of the column (inches); and K is the radius of gyration, (a geometric property of the shape of a pipe column) given by:

$$k = \sqrt{\frac{\pi(D^2 - d^2)}{4}}$$

where D and d are the outside and inside diameters of the pipe column, respectively. The moduls of elasticity for steel is 30 x 10^6 psi and it's yield strentght is 60,000 psi.

The Challenge: What is the critical load for a 90" high basement floor jack made from steel pipe with an outside diameter of 3 in and a wall thickness of 0.25 in?



$E = 30 \times 10^6$ psi

D = 3 in

D = 3-2(0.25) = 2.5 in

L = 90 in

A = area of metal in cross section = $\pi(\frac{D}{2})^2 - \pi(\frac{d}{2})^2 = \pi(\frac{3}{2})^2 - \pi(\frac{2.5}{2})^2 = 0.6875\pi$

$$k = \sqrt{\frac{\pi(D^2 - d^2)}{4}} = k = \sqrt{\frac{\pi(3^2 - 2.5^2)}{4}} = \sqrt{0.6875\pi}$$

so....

$$P_{critical} = \frac{\pi E k^2 A}{L^2} = \frac{\pi(30x10^6)(\sqrt{0.6875\pi})^2(0.6875\pi)}{(90)^2} = 54{,}300 \text{ psi}$$

ANSWER: **54,300 psi**

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JETS Challenge problems are generously provided by Dave Meredith, Associate Professor, Penn State University-Fayette