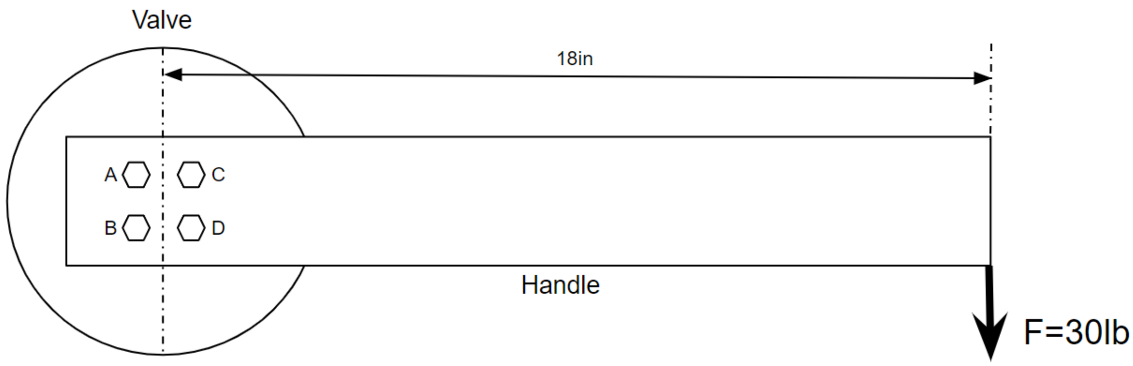
45.10 The handle of a large manual valve is secured with a square bolt pattern, as shown. The handle is $18in$ long and the force applied to the end of the handle during valve opration is $30lb_f$. The bolts have a nominal diameter of $1/4in$ and a cross-sectional area of $0.03in^2$. When the valve is being closed, which statement can be made about the shear stress experienced by the bolts?



A. Bolts A and B experience higher shear stress than bolts C and D.

B. Bolts C and D experience higher shear stress than bolts A and B.

C. Bolts A and C experience higher shear stress than bolts B and D.

D. Bolts B and D experience higher shear stress than bolts A and C.

This is a qualitative problem, so there is no need to quantify the loads applied to the bolts. Since all bolts have the same diameter and cross-sectional area, the maximum shear stress will be a direct outcome of the resultant force experienced due to the applied load and moment.

Since the applied load is downward, the reaction forces on the bolts from the applied load are all upward.

Since the load is applied a distance away from the bolts, it produces a clockwise moment, generating reaction forces perpendicular to lines drawn through each bolt and the center of the bolt pattern. In othwer words, the forces resulting from the moment are tangent to a circle drawn through all four bolts.

Adding the vectors for the reaction forces from the applied load and the moment, notice the directions of the reaction forces partially offset for bolts A and B. However, the forces are partially additive for bolts C and D. Therefore, bolts C and D have larger resultant reaction forces and more shear stress than bolts A and B.

Answer B

45.11 A nominal $2in$ chilled water pipe ($D_o = 2.375in$, $D_i = 2.067in$) is filled with water and simply supported with pipe hangers located $18ft$ apart. Steel has a specific weight of $0.284\frac{lb_f}{in^3}$ and a modulus of elasticity of $29 \times 10^6 \frac{lb_f}{in^2}$. What is the maximum deflection of the pipe?

A. $0.03in$

B. $0.26in$

C. $0.43in$

D. $0.63in$

Search for the table for Deflection of Beams of Uniform Cross Section, Under Various Conditions of Loading. The pipe can be modeled as a Simple Beam with a Uniform Load. The maxmum deflection occurs at the center of the span and is given by the formula below where W is the uniform load per unit length, l is the length of the span, E is the modulus of elasticity for the pipe, and I is the moment of inertia.

$$y = \frac{5Wl^4}{384EI}$$

The span and modulus of elasticity are given.

$$l = 18ft$$

$$E = 29 \times 10^6 \frac{lb_f}{in^2}$$

The uniform load can be determined by finding the weight of the pipe and the water contained within it and dividing by the span. However, it is more convenient and faster to use the table Schedule 40 Steel Pipe which provides the total weight per linear foot for various pipe sizes. Convert to weight per inch for ease of use in the deflection formula.

$$W = \left(5.11\frac{lb_f}{ft}\right)\left(\frac{1ft}{12in}\right) = 0.426\frac{lb_f}{in}$$

The moment of inertia can be determined using the geometry of the pipe cross section and a formula found in the table Properties of Various Shapes under the column Area Moment of Inertia. However, again the Schedule 40 Steel Pipe table saves time by providing the moment of inertia directly. Note the moment of inertia is a function of the cross sectional area only, so there is no need to consider the length. The value from the table should be taken and used directly.

$$I = 0.666in^4$$