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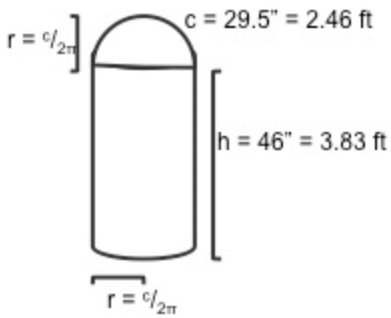
Abstract: The purpose of this document is to calculate the thickness of the walls of a HC-4500 Taylor-Wharton DOT Cylinder from American Airworks. Because each cylinder has a different height varying around 46”, 46” will be used as the approximate height up to the point at which the cylinder turns into a hemisphere. We find that the thickness of the wall of the cylinder to be 0.44 inches and weight to be 183.9 lbs.

Measures



r = 0.391 ft (4.7 in)

We assume a similar r for the hemisphere and the cylinder to simplify the hemisphere calculations. The radius difference with the measured height of the hemisphere is 4 inches, which means a difference of 0.7 in, creating a small amount of error.

The Cylinder in question is rated at 153 lbs.

Calculations

The total inner volume of the yellow cylinder is given by the equation

$$V_{Total} = V_{cylinder} + V_{hemisphere}$$

$$V_{cylinder} = 2\pi r^2 h \qquad V_{hemisphere} = \frac{4}{6}\pi r\text{^}3$$

We start by calculating the total volume of the yellow cylinders

$$V_{Total} = 2\pi r^2 h + \frac{4}{6}\pi r\text{^}3$$

We find a total volume to be 55.6 Liters, or 1.96 ft^3. However, we are looking for the inner volume, which is given by removing some thickness of walls

$$V_{inner} = \pi(r-t)^2(h-t) + \frac{4}{6}\pi(r-t)^3 \quad (1)$$

V_{inner} is the total inner volume, r is the outer radius of the cylinder and the hemisphere, h is the height of the yellow cylinder without the hemisphere cap, and t is the thickness of the containers.

V_{inner} is assumed to be 45 Liters, 1.589 ft^3 . Substituting values in for the knowns, and solving for t, t could equal 0.0368 ft, 0.822 ft, or 2.379 ft. Realistically, the wall of the yellow cylinder will not exceed the diameter, ruling out all but the first solution in a real physical system.

Thus we find the thickness of the walls to be 0.0368140 ft =0.44 in.

A second calculation we did to verify our findings was to calculate the mass of the steel used to see how it compares to the given mass, 153 lbs.

$$V_{Steel} = \pi r^2 h + \frac{4}{6}\pi r^3 - V_{inner} \quad (2)$$

$$V_{Steel} = 0.37698\, ft^3$$

V_{steel} is the volume of steel in the yellow cylinder and all other variables are as described above.

We can find the mass of the volume of steel by multiplying the density by the volume

$$m = d * V_{Steel} \quad (3)$$

d = 488 lbs/ft^3

Equation 3 is used to determine the mass of steel in each yellow cylinder, where m is mass, d is density, and V_{steel} is as described above.

Solving for the above equation we find the mass of our bottle to be 183.9 lbs, 20% greater than the reported 153 lbs. This can be attributed to several errors in the method we approximated it. First we approximated the top section as a hemisphere, which it not exactly. Rounding was employed in calculations. Another source of error would be in the measuring of the bottles. Each bottle seems to be a different height, indicating a different weight. There is also the possibility that the bottles are heavier than quoted.

Comparisons to Reported Values

American Airworks reports the HC-4500 cylinders at 153 lbs, while Taylor-Wharton reports them at 144 lbs, with a steel thickness of 0.28 inches. When we calculate the mass of the bottle using their specifications and our equation we come up 122 lbs. The specifications also do not account for variable height values.

Conclusions

In the end, this calculation was initiated to check the width of the walls, and how close it actually was to 1.5 inches. Though we find a weight over the given 153 lbs, we find a width of 0.44 inches. This implies that the walls are perhaps even thinner than our calculation to compensate for the lower volume of steel.

Additional information about these cylinders can be found at
http://www.americanairworks.com/cas-dot.html

And in the document database
http://lartpc-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=598