Pipe formula 101

By Fidel J. Nabor
Special to Pipeline

In the June 1993 issue of *Pipeline* magazine I wrote an article called "Pipe formula 101".

The article walks you through the derivation of the formula for finding the weight per foot of a joint of steel pipe.

Why is this formula so important ? With so many sizes and walls that are not listed on scheduled pipe charts, or when pipe charts are not available, it becomes near impossible to buy, sell or even handle steel pipe without knowing it's weight. In most situtations it's essential that you know the weight per foot while doing your steel pipe calculations.

Since the weight of a cubic inch of steel has changed, and our readership has grown in both numbers and sophistication, I thought it appropriate in duplicating this article (for those who did not see it the first time) and adding a second derivation.

Here's the formula :

$$\boxed{(OD - Wall)\ (Wall)\ (10.69)}$$

Let's begin by looking at a solid round steel bar with radius R and a length of 12 inches (Figure 1A). From this round bar we will remove a second round bar from its center. This second, smaller round bar has a radius r and is also a 12" length (Figure 1B). As you can see, this leaves us with a hollow cylinder (a joint of steel pipe 12 inches long [L] (Figure 1C).

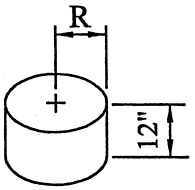


Fig. 1A

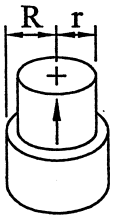


Fig. 1B

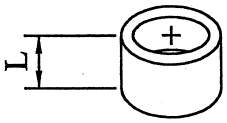


Fig. 1C

If the volume of both the larger bar and the smaller bar are known, then by simple subtraction, the volume of the remaining cylinder (our piece of pipe) is what's left. Since our volumes are expressed in cubic inches and the weight of a cubic inch of steel is .2836 lbs/cubic inch, then the weight per foot of a piece of pipe can now be calculated by multiplying its volume (in cubic inches) by .2836.

The formula for finding the volume of a solid steel cylinder is the area of the circle (πR^2) times the length. In our case L is 12 inches (1 foot). Hence,

Volume = (πR^2) (L)

(Area of Circle) (Length)

Since $V_G - V_S = V_P$

V_G = Volume Greater
V_S = Volume Smaller
V_P = Volume of remaining joint of pipe.

The Volume of the greater (V_G) minus the volume of the smaller (V_S) leaves us with the volume of the remaining cylinder which is our joint of steel pipe, V_P

Substituting $(\pi R^2 L) - (\pi r^2 L) = V_P$

where R is the radius of the larger circle and r is the radius of the smaller circle.

If we factor out L and π we get

$$L\ \pi\ (R^2 - r^2) = V_P$$

Replacing L and π with these known values.

$$(12)\ (3.1416)\ (R^2 - r^2) = V_P$$
$$37.70\ (R^2 - r^2) = V_P$$
$$37.70\ (R - r)\ (R + r) = V_P$$

Looking at Figure 2A, we see that (R + r) can be restated as "O.D. minus the wall" and figure 2B shows us that (R - r) is the wall.

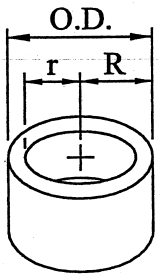


Fig. 2A

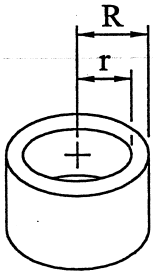


Fig. 2B

We can now say :

$$\frac{(OD - Wall)\ (Wall)\ (37.70)}{(R + r)\quad (R - r)} = V_P$$

The above gives us the formula for the volume (in cubic inches) of our piece of pipe 12 inches long.

Again, since the weight of a cubic inch of steel is .2836 lbs/cubic inch we can now factor this into the above equation to get the weight of our 12 inch joint of pipe.

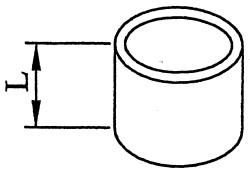
$$(OD - Wall)\ (Wall)\ (37.70)\ (.2836)$$

or

$$\boxed{(OD - Wall)\ (Wall)\ (10.69)}$$

Here's "Pipe formula 101" derivation II with yet another way to achieve the same result.

Lets look at a joint of steel pipe 12" long (fig 3A) and "open it up" (fig. 3B). We are starting with a steel cylinder and finishing with a rectangular steel sheet (fig. 3C).



Steel Pipe
Fig. 3A

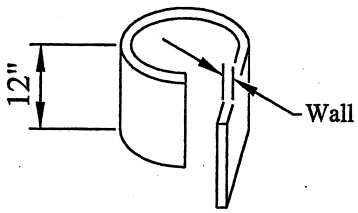
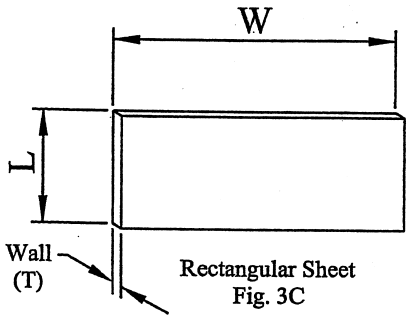


Fig. 3B



Rectangular Sheet
Fig. 3C

The length (L) and the wall thickness (T) remain the same. Now, if you use your imagination, after the joint of pipe is unraveled, you can see that the circumference on the original joint of pipe becomes the width (W) of the rectangular sheet (fig. 3C).

Since the formula for the circumference of a circle is πD, the question is : which diameter do we use ? The OD or the ID ? The answer is : both ! The large surface of the rectangular sheet in fig 3C is either the ID or the OD of the original unraveled joint of pipe. If it's the ID then the other side must be the OD and vise versa. Since there are two diameters involved we use their average, or the "mean" diameter. $\frac{OD + ID}{2}$

If we know the length (L) the width (W) and the wall thickness (T), we can calculate the volume and arrive at the number of cubic inches in the sheet. Knowing the weight of a cubic inch of steel (.2836 lbs/cubic inch) we can now calculate the weight of our rectangular sheet -- which also equals the weight of our joint of steel pipe.

Looking at the math -- here's the second derivation :

$L = 12"$

$W = \pi \frac{(OD + ID)}{2}$

$T = Wall$

$.2836 =$ Weight of a cubic inch of steel

$(L)\ (W)\ (T)\ (.2836) =$ Weight of the rectangular steel sheet

Substituting we get :

$$(12)\ [\pi \frac{(OD + ID)}{2}]\ (Wall)\ (.2836)$$

The value of multiplying out all the constants is :

$$\frac{(12)\ 3.1416 \times .2836}{2} = \frac{10.69}{2}$$

Now lets see what the original formula looks like :

$$\frac{10.69}{2}\ (OD + ID)\ (Wall)$$

The outside diameter equals 2R (two large radii)
The inside diameter equals 2r (two small radii)
Substituting :

$$\frac{10.69}{2}\ (2R + 2r)\ (Wall)$$

First we factor out the 2 then cancel it with the 2 in the denominator :

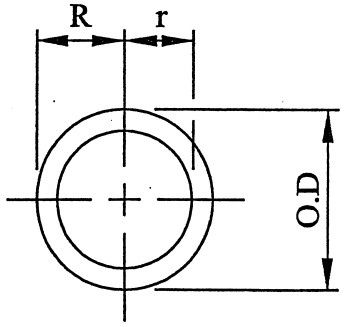
$$\frac{10.69\ (2)}{2}\ (R + r)\ (Wall)$$

Moving the 10.69 to the other side of the expression

$$(R + r)\ (Wall)\ (10.69)$$

As in the first derivation we have to clearly see that $(R + r)$ is equivalent to the "OD minus the wall" fig. 3D.

Fig. 3D



Substituting, again we get the weight of a 12" joint of steel pipe.

$$\boxed{(OD - Wall)\ (Wall)\ (10.69)}$$

Editors note: Thank you, Fidel J. Nabor, Chairman of the Board, President & CEO of 101 Pipe & Casing, 30300 Agoura Road. Suite 240, Agoura Hills, CA 91301