



## Density

One Dura-Bar is lighter than steel. It is approximately 10% lighter because of the graphite. Ductile iron has higher carbon additions than gray iron and has a lower density. Steel does not have any graphite causing it to be denser than either gray or ductile iron.

Density is expressed in weight per unit of volume and in the US system of measurement, the most common units are pounds per cubic inch, or C. The density in metric units is expressed as grams per cubic centimeter. To convert to gms/cc, multiply lbs/in<sup>3</sup> by 27.68. To convert to lbs/in<sup>3</sup>, multiply gms/cc by .0361.

To calculate the weight of a bar, you have to know two things:

- 1) The volume of the bar in cubic inches or cubic centimeters
- 2) The density in lbs/in<sup>3</sup> or gms/cc.

To find the volume of the bar, multiply the surface area by the length. Be sure to keep all units constant; do not multiply the surface area in square inches by the length in feet. The area depends on the dimensions of the cross section...the diameter of a round bar or the height and width dimensions of a rectangle or square.

The area of a round bar is  $\pi$  ( $\Pi$ ) divided by 4 multiplied by the diameter squared. Pi is the ratio of the circumference to the diameter which is always a constant: 3.1415 and there are no units on Pi., therefore 3.1415 works whether the calculations are in metric or US units. It is a good idea to remember that Pi divided by 4 = .7854.

*(Hint: The digits 7, 8, 5 and 4 are closely grouped together on a calculator. Get used to hitting those numbers, and remembering that  $\pi/4 = .7854$  will seem natural!)*

The cross sectional area of a 3.00" round bar (assume 3.00" actual size, not nominal) is:

$$.7854 * (3.00)^2 = 7.07\text{in}^2$$

Multiplying the area by the length equals the volume. Suppose the 3.00" bar is 10" long. The volume is:

$$7.07\text{in}^2 * 10 \text{ in} = 70.7 \text{ in}^3$$

Always remember to keep units constant! If the bar is 3.00" in diameter and 5 feet long, the length first has to be converted to inches.



Suppose the bar is ductile iron. The density is expressed in pounds *per* unit of volume, and the density of ductile iron is .255 lbs per cubic inch. In the above example, the volume is 70.7 cubic inches, therefore; the bar weighs:

$$0.255 \times 70.7 = 18.028 \text{ lbs.}$$

If the bar were made out of steel having a density of 0.284 pounds per cubic inch, the bar would weigh:

$$0.284 \times 70.7 = 20.08 \text{ lbs.}$$

The area of a rectangle is calculated by multiplying the dimensions of the perpendicular sides together. A 3.00" x 5.00" rectangle has an area of:

$$3.00" \times 5.00" = 15 \text{ in}^2$$

To calculate the volume, multiply the area by the length. If the above rectangle is 10" long, the volume is:

$$15 \text{ in}^2 \times 10.0 \text{ in} = 150 \text{ in}^3$$

Suppose the bar is gray iron. The density of gray iron is slightly higher than ductile because there is a little less graphite by volume in gray iron. The density is .26 lbs/ in<sup>3</sup> and the weight is:

$$150 \text{ in}^3 \times .26 \text{ lbs/ in}^3 = 39 \text{ lbs.}$$

The weight difference between Dura-Bar and steel can mean cost savings in shipping as well as weight reduction of the part being converted from steel to Dura-Bar. Using the densities calculated for gray and ductile iron along with the density given for steel, the weight of a bundle of 3.00" diameter bars (26 bars at 72" per bundle) of ductile iron, gray iron and steel is:

$$\text{Volume} = .7854 \times 3^2 \times 72 = 509 \text{ in}^3 \text{ (volume of each bar)}$$

$$509 \times 26 = 13,234 \text{ in}^3 \text{ (volume of the entire bundle)}$$

The weight of each bar is calculated by multiplying the volume by the density:

$$\text{Steel:} \quad 509 \text{ in}^3 \times .284 \text{ lbs/in}^3 = 145 \text{ pounds}$$

$$\text{Ductile Iron:} \quad 509 \text{ in}^3 \times .255 \text{ lbs/in}^3 = 130 \text{ pounds}$$

$$\text{Gray Iron:} \quad 509 \text{ in}^3 \times .260 \text{ lbs/in}^3 = 132 \text{ pounds}$$



The weight of each bundle is:

Steel:  $13,234 \text{ in}^3 \times .284 \text{ lbs/in}^3 = 3,758 \text{ pounds}$

Ductile Iron:  $13,234 \text{ in}^3 \times .255 \text{ lbs/in}^3 = 3,374 \text{ pounds}$

Gray Iron:  $13,234 \text{ in}^3 \times .260 \text{ lbs/in}^3 = 3,441 \text{ pounds}$

By rearranging the numbers to calculate the number of bars that can be transported on a truck that carries 40,000 lbs shows that truck can carry:

275 steel bars

307 ductile iron bars

The following table lists the densities of common (and some not-so-common) engineering materials:

Material	Density (lbs/in <sup>3</sup> )	Density (gms/cc)
Osmium (very uncommon but is the worlds heaviest solid)	.813	22.50
Gold	.697	19.30
Bronze	.320	8.86
Brass	.306	8.47
Steel	.284	7.86
Gray Iron	.260	7.20
Ductile Iron	.255	7.06
Aluminum	.100	2.77
Titanium	.161	4.46
Molded Nylon	.040	1.11

