All combustion engines utilize air and fuel to generate power. Simply stating, increasing the amount of air entering the engine will result in an increase in power output. There are two ways to increase the amount (mass) of air consumed by the engine: increase the volumetric airflow, or increase the air density. Modifying the engine to increase the displacement, or swapping out camshafts, are a couple ways to increase the volumetric airflow (CFM) that the engine consumes. The other way to increase engine power, by increasing air density, is what we will discuss in this article. (There is a relationship between air pressure and volumetric airflow involving volumetric efficiency, but that is outside the scope of this article). Air density is predominantly controlled by temperature and pressure. (Humidity has a small effect on air density as well with humid air being less dense than dry air).

Air Density and Temperature
One can determine how a reduction in temperature increases air density by using a simple formula that takes the absolute air pressure and divides it by the temperature and specific gas constant. We used the standard sea-level pressure of 14.7 psi, and a specific gas constant of 53.35 to give us the graph (on right). You can see that air density decreases as temperature increases.

When it comes to intake design, you simply want to pull in the coldest air possible for maximum air density. If the intake is pulling in warm air from inside the engine bay, the loss in air density will result in a loss of engine power. Many modern stock OEM intakes do a pretty good job of drawing cool ambient air from places such as the fender well or the front of the vehicle. It’s important for an aftermarket performance intake to pull cool ambient air from these same sources and to have a proper seal to prevent hotter air from the engine bay from leaking in.

Should I remove the lid of an S&B Intake?
Side Note: We are often asked if removing the lid of our intake will improve performance. While removing the lid can reduce restriction, the air being pulled in from the engine bay will be much hotter resulting in less engine power. We only suggest removing the lid in special circumstances such as dyno pulls with the hood up.

Air Density and Pressure
If the temperature of the air pulled in by the S&B intake is the same as stock, isn’t the air density the same? No, because air temperature is only one part of the equation. Assuming that the S&B intake and stock are pulling in the same temperature of air, the air density isn’t necessarily the same. Greater air density can be achieved when air pressure is increased. Most auto manufacturers are more concerned with noise reduction and serviceability with respect to their intake system than they are with maximizing the air pressure. Thus, by redesigning the intake to minimize airflow pressure loss, we can dramatically improve the air density fed to the engine.
Restriction is the measurement of pressure loss through the intake system. For example, when we say “the intake has 14 inches of restriction at 600 cfm,” the “inches” is referring to “inches of water,” which is a unit of measurement of pressure. Inches of water can also be expressed as pounds per square inch, or “psi.” For reference, 14 inches of water is roughly equivalent to 0.5 psi. It is just as correct to say “the intake has 0.5 psi of restriction at 600 cfm.” The conversion from inches of water to psi can be made simple by remembering that 1 psi is roughly equivalent to 28 inches of water.

2017 Ford Powerstroke 6.7L

Here is how it breaks down in the real world. From our airflow testing of the 2017 Powerstroke 6.7L, we found that the air flowing through the stock intake loses .45 psi of air pressure as the air travels through the stock intake (tested at 580 CFM). Standard atmospheric air pressure at sea-level is 14.7 psi. Thus at sea-level, air would enter the stock intake at 14.7 psi and exit at 14.25 psi. This loss in pressure is directly related to a loss in air density resulting in a loss of engine power. S&B cold air intakes minimize this pressure loss. For example, our 75-5085 intake, for the 2017 Powerstroke 6.7L, has a pressure loss of only .20 psi (air enters the S&B intake at 14.7 psi and exits at 14.50 psi). The pressure loss of the S&B intake is 56% less than stock. By comparing the exit pressures of the S&B intake and stock intake, 14.50 psi and 14.25 psi respectively, you can conclude that the air will be 1.75% more dense going through our intake.

If the engine was naturally aspirated, the 1.75% increase in air density would provide about a 1.75% increase in engine power, but with a turbocharger and intercooler the improvement in power isn’t as linear. If the air going into the turbocharger is less dense (due to less air pressure), the turbo must work harder to bring the air to the desired boost pressure. This increases the pressure ratio of the compressor (pressure of air coming out of the compressor outlet divided by the pressure of the air going into the compressor). The increased pressure ratio causes an increase in air temperature. In other words, less air pressure going into the turbo means hotter air coming out of the turbo. This hotter air will then travel to the intercooler and hotter air entering the intercooler means hotter air exiting the intercooler. It is important to note that the decreased air density caused by a restrictive intake system results in decreased air density even after the turbocharger and intercooler. In other words, a turbocharger and intercooler can only partially make up for the decreased air density caused by a restrictive intake system.

If the vehicle has other modifications, such as an upgraded turbocharger, exhaust, tuner, etc., the power gains from an S&B intake are even bigger. For example, let’s say that instead of pulling 580 CFM, the vehicle has been modified so that it can pull 870 CFM. By looking at the test results for our 75-5085 intake for the 2017 Powerstroke 6.7L, you can see that the stock intake suffers a pressure loss of 29.33 in H2O (or 1.06 psi) at 870 CFM. The S&B intake only has a pressure loss of 12.56 inH2O (or 0.45 psi) at 870 CFM. If we subtract these pressure loss numbers from the sea-level ambient pressure of 14.7 psi, we get 13.64 psi for the stock intake and 14.25 psi for the S&B intake. In this scenario with the engine pulling 870 CFM, the S&B intake results in air that is 4.5% more dense than stock. From this example, it is clear that if the vehicle is modified so that the engine pulls more air, having the S&B intake provides even more power increase.

In conclusion, an S&B intake doesn’t lose as much pressure as the stock air intake system while still pulling in the coldest air possible. The combination of cooler air and minimal pressure loss is what increases the power output of your engine.