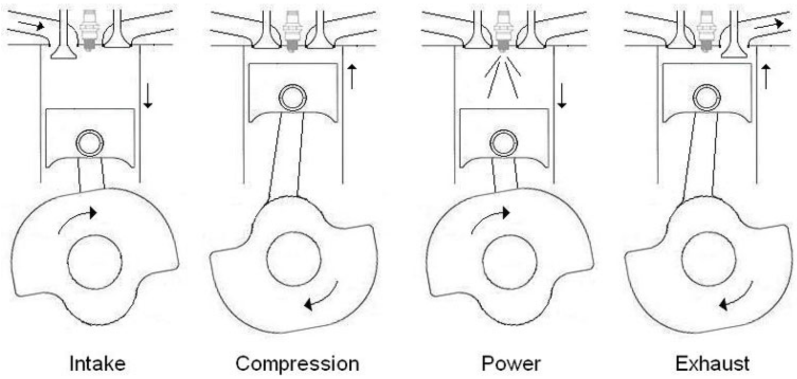
Compression and Vacuum

For an engine to run, it must have enough compression to raise the temperature of the air fuel mixture high enough so that a spark can easily start an efficient combustion process. If there is not enough compression, the engine will fail to start.



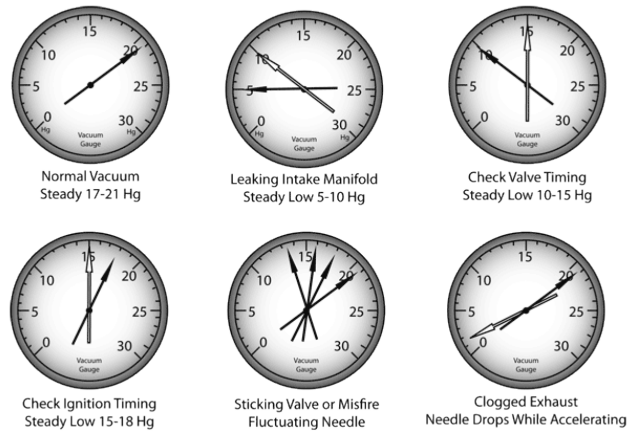
Engine compression is most accurately checked with a compression gauge. This test can take considerable time, especially when the spark plugs are difficult to remove. With this test you will know beyond doubt if there is low compression in one or more cylinders.

Relative Compression testing is useful to diagnose a rough running, or misfiring engine is to see if the compression in any one cylinder is substantially lower than compression in the other cylinders. It is much quicker to perform than by using a compression gauge. Relative compression is tested by monitoring small changes in battery voltage or amp flow while cranking the engine. To perform this test you need a lab scope. If all cylinders have low compression, such as in a badly worn engine, or one where the cam timing is incorrect, the relative compression test will not show a problem as all cylinders will have relatively the same amount of low compression.

A quick test that can eliminate compression as the cause of a non-starting engine is to check the manifold vacuum while cranking the engine. If you have over 3" of cranking vacuum, the engine will have enough compression to start and run.

Manifold and Ported are the two main types of engine vacuum in gasoline engines. Manifold vacuum is used to show engine compression and is created between the throttle plate and the intake valves. Normal manifold vacuum on an engine running at idle speed is around 18 to 20 inches. If you have an engine at idle and your vacuum gauge reads very low, or no vacuum, you are probably connected to ported vacuum.

As you gain experience working with engines you will be able to quickly identify vacuum lines and vacuum ports that will allow you to hook up a gauge to manifold vacuum.



When you test manifold vacuum you must be able to easily read small changes in vacuum. The larger the vacuum gauge, the more accurate your vacuum testing will be. I recommend using a vacuum gauge that is at least 2" in diameter. An inexpensive gauge will work fine as long as it is large enough to easily read small changes in vacuum.

The length and condition of your vacuum hose will affect the accuracy of your vacuum gauge. Old - used vacuum hose can easily collapse and provide a false reading to the vacuum gauge. Longer lengths of vacuum hose will slow down or eliminate quick changes in vacuum. It is important to be able to see quick changes in vacuum as they indicate problems like burned or sticking valves.

Vacuum is a unit used to measure changes in pressure. The standard unit for measuring Vacuum is inches of mercury. Manifold vacuum measures the difference in air pressure from the inside of the intake manifold, to the air pressure on the outside of the engine.
A difference of 1 Pound per Square Inch in pressure will move a column of mercury 2.036254 inches. If your engine is reading 20 inches of vacuum it is measuring a difference of about 10 pounds per square inch between the inside of the intake manifold and outside air pressure. A common sensor used to calculate air flow into an engine is the Manifold Absolute Pressure (MAP) sensor. MAP sensors measure the pressure difference between outside air pressure and intake manifold air pressure.

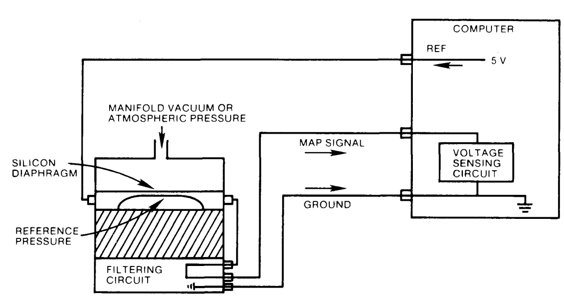
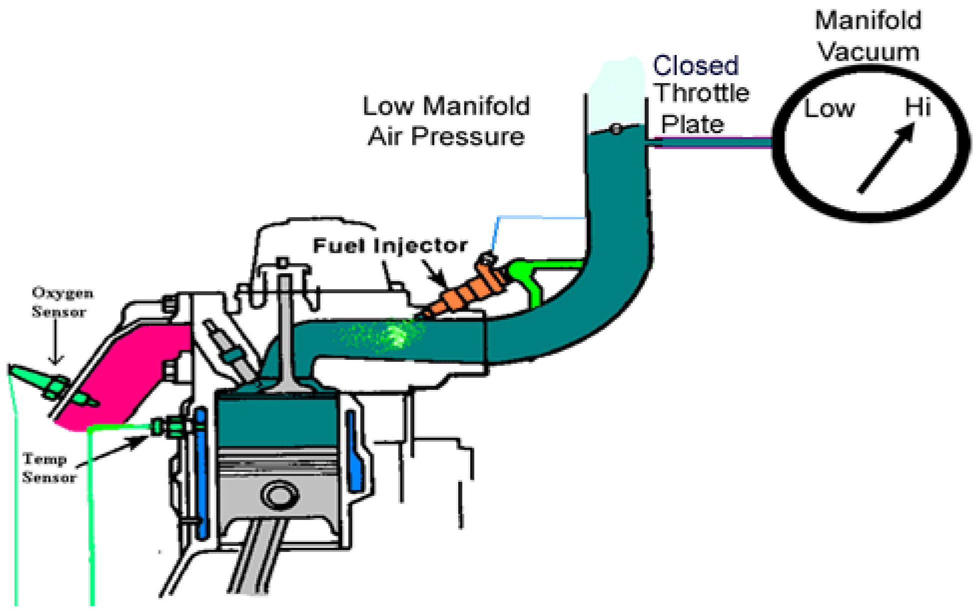
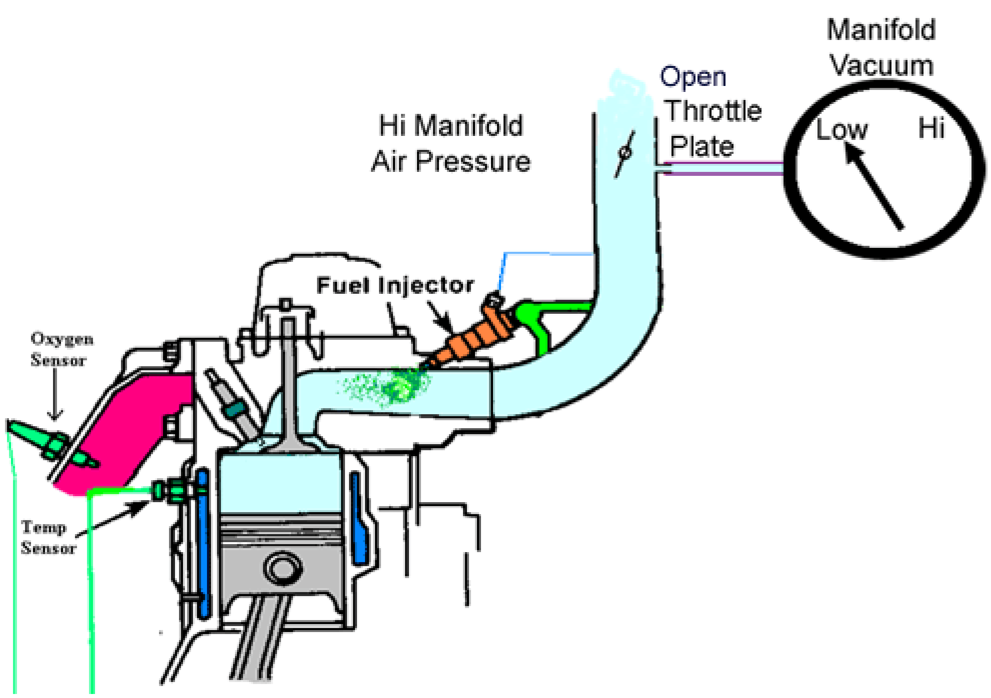


Figure 2–10 Silicon diaphragm pressure sensor

Vacuum is created when each piston travels down the cylinder with the intake valve open and the throttle plate closed. It will change drastically as the engine is running at different RPM and load conditions. It will also change if the compression in a cylinder is lost, or there are air leaks between the throttle plate and the cylinders.



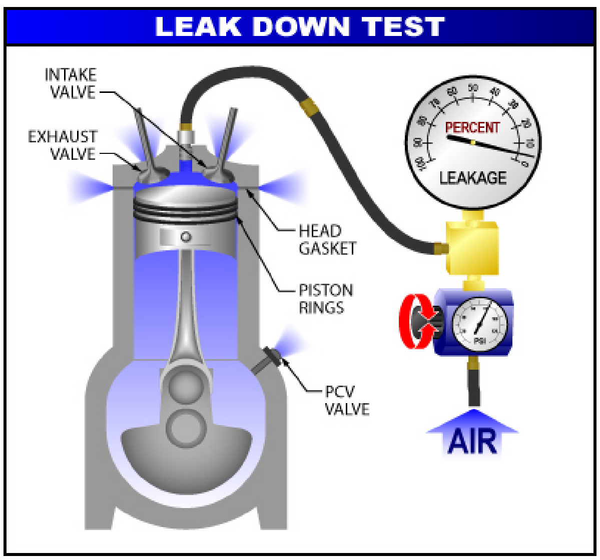
A primary factor in manifold vacuum is throttle plate position. When the throttle plate is closed, manifold vacuum should be higher than when the throttle plate is open. With an open throttle it is easy for the outside air to get into the engine and there will be less difference in pressure between the outside air and the air found in the intake manifold. As the throttle plate closes, a restriction in airflow is created and manifold vacuum increases.



A second factor in manifold vacuum is the RPM of the engine. A slow turning engine will produce less manifold vacuum than a fast turning engine. Manifold vacuum will be at its highest when the engine RPM is high, and the throttle plate is closed. This happens when the engine is decelerating. Manifold vacuum will be much lower when the engine is at starter motor cranking speeds than it will be at idle speeds.

A third factor in manifold vacuum is engine compression. If an engine has low compression in all cylinders, it creates a steady, but low, manifold vacuum. If an engine has low compression in one cylinder, manifold vacuum will be low only during that cylinders intake stroke. This will be observed as a gauge that fluctuates or quickly changes reading.

Any factor that keeps the cylinder from filling with air, or sealing during the compression stroke, will cause low compression. Common causes are defects in the opening or sealing of the intake or exhaust valve, worn or broken piston rings, or a blown head gasket. Watching quick changes in manifold vacuum is a type of relative compression test. Performing a cylinder leak test will help find the cause for low compression.



Engine compression is directly affected by how easily the engine can breathe. If a cylinder cannot pull in fresh air it will have low compression. An engine with a restricted exhaust will also lose compression. If the compressed gasses cannot exit the cylinder, fresh intake gasses cannot get in. Clogged catalytic converters or other restrictions in the exhaust system will cause intake manifold vacuum to be lower, especially as the engine load increases. A badly plugged catalytic converter, or collapsed and plugged exhaust system will cause a non starting engine with very low, or no manifold vacuum while cranking the engine.

A final factor affecting manifold vacuum are leaks in the air intake between the throttle plate, and the intake valves. Leaking or disconnected vacuum lines, leaks in vacuum operated devices, or intake manifold gaskets are common causes for low vacuum. When the throttle plate is wide open it will almost eliminate restrictions between the outside air pressure and the pressure inside the cylinder. An open throttle will always lower, or eliminate, manifold vacuum.

Vacuum testing is quick, easy, and provides excellent diagnostic information IF you know what you are doing. The more often you use a vacuum gauge, the more valuable a tool it will become.

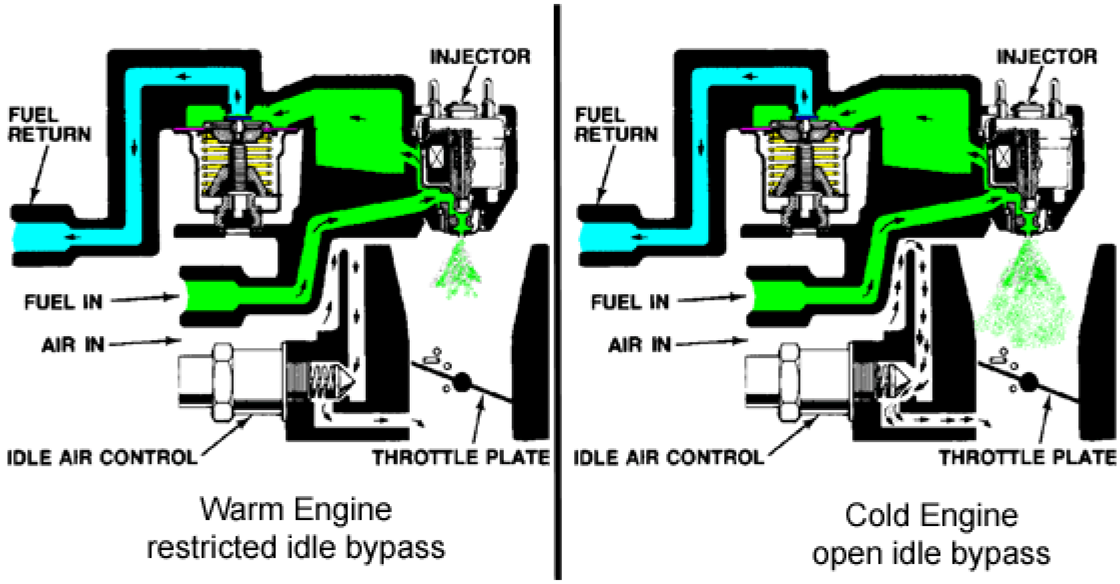
Remember these guidelines when using a vacuum gauge on gasoline engines.
1) At idle, the more vacuum the better.
2) The highest manifold vacuum will be on deceleration.
3) A closed throttle will create more vacuum than an open throttle.

As the engine load increases, the throttle will open wider. This will allow for more air and fuel, create more power, and lower the manifold vacuum reading. Caution! The only time you can safely run an engine with an open throttle is when the engine is under a load. This can be done using a dynamometer, or on a road test. If you attempt to leave the throttle wide open on a running engine that is in Park or Neutral, the engine RPM will quickly climb too high and damage the engine. For most engines that are running in neutral, the maximum safe engine speed is 2,500 RPM.

The “Throttle Snap Test” can allow a technician to quickly observe engine vacuum when the throttle is open and the vehicle is not under a load. This test must be done with care to avoid damage to the engine. We will practice the throttle snap test in the lab.

Any time you use a vacuum gauge, begin by paying attention to how much manifold vacuum is present while the engine is cranking. If you understand what “Good” cranking vacuum looks like, you will be able to quickly spot “Bad” cranking vacuum.

Cranking vacuum is a good indication there is enough compression to run the engine. Finding no cranking vacuum on a gasoline engine does NOT mean the engine has poor compression. Many vehicles will use an idle air control valve that opens wide during cranking. The idle air control valve opens an air passage that bypasses the throttle plate. This lets in more air and lowers the cranking vacuum.



Notice the idle air control valve opens during cranking, especially on cold engines. This allows more air in (while the injector stays on longer adding more fuel)

So how can you tell if a no-start engine has good compression?

A) Measure cranking compression with the throttle plate closed (foot off the gas pedal). If there are 3 or more inches of vacuum then compression is NOT the reason for your non starting engine.

B) If there is low, or no cranking vacuum, place your hand over the throttle body. An engine with good compression will have a strong suction at the throttle opening while cranking the engine.

C) Listen to the engine. An engine with no vacuum will crank over faster and sound different than an engine with normal compression. An engine with a broken timing belt will have no compression and an experienced technician will easily recognize that the engine "sounds like it has no compression".