

Carburetor Vacuum Ports: Manifold, Ported and Venturi Vacuum Explained

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This tech paper will discuss the concepts of 3 different types of vacuum sources, and will briefly discuss their potential uses and applications in tuning GM V8 engines.

Overview

The airflow through a carburetor and through an engine's intake system creates various pressure regions due to a variety of effects. The low pressure regions are sources for "vacuum" used for signal sources and power sources for operating accessories.

"Vacuum" in an engine is not truly a "vacuum." Rather it defines a lower-than-atmospheric-pressure area in the engine or in the carburetor. Lower-than-atmospheric pressure is measured in "inches of Mercury." Mercury has the chemical symbol "Hg," so the terminology for the measurement becomes "in. Hg." To visualize how this measurement works, imagine a U-shaped glass tube partially filled with Mercury. The one end of the tube is exposed to the atmosphere. The other end of the tube is attached to your low pressure source. The low pressure on the one end of the tube will cause the Mercury to rise up the tube. The amount that it rises is "in. Hg."

A funny terminology issue arises with this: Most people would describe that the low pressure area is "sucking" the Mercury up the U-shaped tube. To be technically correct, there is no such thing as "suction." What is actually happening is that the low-pressure area is allowing the high pressure on the other end to "push" the Mercury up the tube. Thus, when you "suck" on a straw in a milkshake, you are not sucking: You are creating a low pressure region in your mouth, and atmospheric pressure is "pushing" the milkshake up the straw and into your mouth.

How Vacuum is Produced

In an engine and carburetor there are two different mechanisms (processes) for producing vacuum. The two are interesting in their differences.

The most commonly recognized vacuum source in an engine is "manifold vacuum." Manifold vacuum is created in the intake manifold of an engine due to the pistons' intake downstroke on one end, and the restriction created by the partially open carburetor throttle plates on the other end. If the throttle plates are closed tightly and the pistons are moving quickly, a very high vacuum is created. If the throttle plates are opened more, creating a larger "leak path," less vacuum is created. If the pistons are moving slowly and the throttle plates are wide open, the pressure in the manifold will be very close to atmospheric pressure – no intake vacuum. Thus, intake vacuum can be used as a signal source to determine how hard an engine is working.

Less recognized, and more frequently misunderstood, is the term "venturi vacuum." Venturi vacuum is produced in an entirely different manner, and it behaves completely independently of manifold vacuum. To understand venturi vacuum, you have to think back to your high school physics class and the Bernoulli Effect: As a fluid (liquid or gas) moves through a tube, the areas of low velocity produce high pressure, and the areas of high velocity produce low pressure. Thus, as the tube necks down and becomes narrow,

the fluid flowing through the narrow section has to move faster, and pressure in the narrow section is lower than the pressure in the larger section. Venturi vacuum, and the Bernoulli Effect, occurs in the venturi of the carburetor: As air enters the carb, it passes through the “necked-down” area of the venturi. As it passes through the venturi, the air accelerates. This fast-moving air creates a low pressure area right in the middle of the venturi, and this low pressure area is used to discharge fuel from the float bowl of the carb into the air stream. Remembering our discussing in the Overview of this article, the fuel is not “sucked” out into the venturi: The low pressure area in the venturi allows atmospheric pressure on top of the fuel in the float bowl to “push” the fuel up and out of the venturi discharge nozzles. The venturi vacuum varies only by the total amount (“mass”) of airflow passing through the venturi and its velocity: The faster the air is passing through (more air), the higher the venturi vacuum will be. This is completely independent of the manifold vacuum.

How Vacuum is Used

Manifold vacuum is very easy to tap and utilize: Simply drill a hole in the intake manifold and stick a hose in it. This vacuum can then be used to power accessories (headlight doors and heater controls), or it can be used as a signal source based on how hard the engine is working. One such signal source application is distributor vacuum advance: When the engine is working lightly (high vacuum produced), the ignition is advanced, and as the engine loses vacuum due to the throttle being mashed to the floor, vacuum is lost and ignition is retarded. Pretty simple.

But what if you want to “switch” the vacuum on and off based on whether the engine is just idling or in cruise mode? Enter the term “Ported Vacuum.”

When emissions became a priority to vehicle manufacturers, a method had to be found to reduce emissions at idle. The amount of Hydrocarbons emitted out of the tailpipe can be drastically altered by changing the timing: Retarding the timing reduces Hydrocarbon emissions. But retarded timing adversely affects gas mileage at cruise. So a method was needed to retard timing at idle, yet maintain it at normal levels for cruise. The solution was seen to “turn off” the vacuum advance at idle, yet have it operate normally under all other operating conditions. To do this, a small hole was drilled in the carburetor throttle body just above the position of the throttle plate at idle (NOT in the venturi area), and this hole was connected to a vacuum nipple on the carb. When the throttle plates are closed at idle, they act as an “off” switch to block the drilled hole from manifold vacuum. As the throttle plates are opened up, the hole becomes fully exposed to manifold vacuum, and normal manifold vacuum is realized at the nipple. Thus, you have a manifold vacuum “on-off” switch, turning manifold vacuum “off” at idle, and restoring it to normal operation once the throttle plate is cracked open. Vacuum advance can be eliminated at idle for good emissions, and instantly restored to normal operation at cruise. At both cruise and Wide Open Throttle (WOT), manifold vacuum and ported vacuum are exactly the same: There is high vacuum at cruise, and virtually no vacuum at WOT. The difference in vacuum occurs only at idle.

So if there is no manifold vacuum or ported vacuum at WOT, how can vacuum open the secondaries on a vacuum secondary carb at WOT? Manifold or ported vacuum is not used to open the secondaries: The secondaries are opened by venturi vacuum. On a true vacuum secondary carb (Holley and BG are the only real vacuum secondary carbs – Q-Jets and AFBs are not vacuum secondary carbs), there is a small hole drilled right into the middle of the venturi wall on the passenger side primary venturi. This passage runs over to the vacuum diaphragm, and the low pressure created in the primary venturi from very high airflow through the venturi is used to open the secondary throttle shaft. The more air that passes through the primary side, the more the secondary diaphragm will open. It is strictly a function of airflow through the primary venturi and the low pressure that this creates in the venturi. Manifold vacuum can be non-existent, yet if the airflow through the carb is high, the secondaries will be pulled open by the venturi vacuum. Note, however, that there is no external nipple on any carb for venturi vacuum: The only source is the small drilled hole in the venturi, and this hole only runs to the secondary diaphragm through an internal passage.

Thus, we see that we have 3 types of vacuum in the engine: Manifold Vacuum, Ported Vacuum (simply a “switched” manifold vacuum source), and Venturi Vacuum. Of these, only Manifold Vacuum and Ported Vacuum can be utilized for tuning purposes.

Tuning with Vacuum

I see a lot of discussion and confusion regarding the use of Ported Vacuum versus Manifold Vacuum for distributor vacuum advance. Once understood, the tuner can effectively utilize one source or the other, depending on the tuning requirements of the vehicle. There is no right or wrong answer on which source to use, but using the correct source for the tuning requirements of a given engine can have a big effect on off-idle and near-idle performance characteristics.

First, be sure to locate and read my paper titled “Distributor Vacuum Advance Control Units.” This contains a lot of technical information related to this issue that I won’t be repeating under this paper heading.

The timing advance curve requirements for an engine will vary a bit from one engine to another depending on cam, compression ratio and other efficiency factors. But in general terms, most GM V8s will produce peak power at WOT with 36-38 degrees of ignition timing. Peak fuel economy and drivability at cruise is achieved with about 52-54 degrees of advance. Best idle quality has a much wider range depending on cam & engine, but tends to be in the 12-24 degree range. Lowest emissions usually occur with timing in the 4-8 degree range.

When tuning, it is important to realize that the upper limits on timing are determining factors for how to set things up: You want the total WOT timing (the maximum timing the engine will see with vac advance disconnected and with the centrifugal advance fully deployed) to be not over 38 degrees. 36 is the best setting for most applications. Once this has been set, it automatically determines what your initial advance ends up being unless you physically alter the length of the advance curve. In most cases, once total advance has been set to 36, the initial advance will end up being about 12 degrees-or-so. And, since most vacuum advance control units pull in about 16 degrees of vacuum advance at cruise speed (where the full centrifugal advance will also be deployed), the 36-degree setting will produce 52 degrees of total combined advance at cruise with the vac advance fully deployed.

But what if your engine/cam combination idles best at 26 degrees advance? Radical cams often require quite a bit of advance at idle. If you simply bump the initial timing up from 16 to 26, your total WOT advance will go from 36 to 46. The total combined timing at cruise will go from 52 to 62. This is not acceptable, and can result in severe engine damage from detonation at WOT, and the car will chug and jerk at cruise from the over-advanced condition. An appropriately selected vacuum advance unit, plugged into manifold vacuum, can provide the needed extra timing at idle to allow a fair idle, while maintaining maximum mechanical timing at 36. A tuning note on this: If you choose to run straight manifold vacuum to your vacuum advance in order to gain the additional timing advance at idle, you must select a vacuum advance control unit that pulls in all of the advance at a vacuum level 2 in. Hg below (numerically less than) the manifold vacuum present at idle. If the vacuum advance control unit is not fully pulled in at idle, it will be somewhere in its mid-range, and it will fluctuate and vary the timing while the engine is idling. This will cause erratic timing with associated unstable idle rpm. A second tuning note on this: Advancing the timing at idle can assist in lowering engine temperatures. If you have an overheating problem at idle, and you have verified proper operation of your cooling system components, you can try running manifold vacuum to an appropriately selected vacuum advance unit as noted above. This will lower engine temps, but it will also increase hydrocarbon emissions on emission-controlled vehicles.

If, however, your engine idles best in the 12-16 degree range due to a mild cam, plug the vacuum advance control unit to a ported vacuum source to eliminate the vacuum signal at idle. You will still obtain the 36-degree WOT total, and you’ll still have 52 at cruise. Also, if you need to pass an emissions test, use the ported source to reduce your hydrocarbons.

By playing with the total length of your centrifugal advance curve, selecting between ported or manifold vacuum, and carefully selecting a matched vacuum advance control unit that meets your specification requirements, you can achieve an optimum idle, excellent off-idle throttle response, and the best fuel economy possible.

Questions, Comments & Technical Assistance

If you have questions or comments regarding this article, or if you notice any errors that need to be corrected (which is quite possible since I'm writing this from memory...), please feel free to drop me an e-mail. Also, if you need any technical assistance or advice regarding this process, or other maintenance issues, feel free to contact me:

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