Everything You Wanted to Know About Vacuum Advance and Ignition Timing

Timing is Everything

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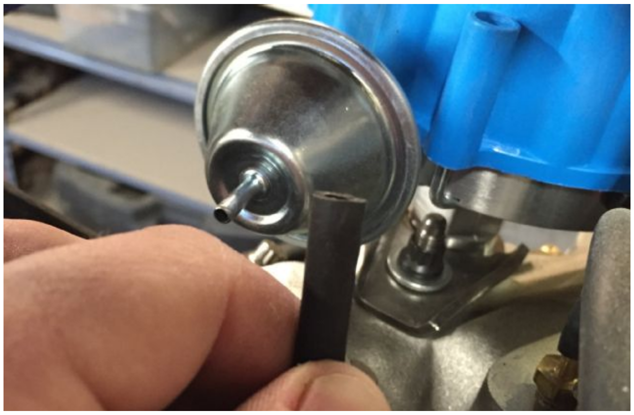

There's a tiny silver can on the side of most distributors that is easily the most misunderstood component of any distributor-based ignition system. Feared by many, and ignored by many more, the vacuum advance can is an important component of your ignition platform that offers both performance and economy. Leaving it unplugged is akin to throwing free engine efficiency straight down the drain.

To fully understand why the vacuum advance can is a necessity in any street-going car, we need to dive into spark timing as a whole and cover some ignition basics.

Why do I need ignition advance at all?

In a theoretical world, air and fuel in a combustion chamber burn instantaneously as the spark plug ignites them, sending the piston downward in the bore and producing horsepower. While that is a pretty easy visualization to conjure up, in the real world, that isn't quite how things work.

What actually happens is that the air and fuel mixture take time to burn. In fact, every aspect of the ignition process takes time; the ignition signal to travel from points or a magnetic pickup, the spark energy to travel from the distributor's rotor, to the terminal, through the wire and finally to the plug. If the spark plug were fired at true top dead center (0 degrees in crank revolution), the piston could be well on its way to bottom dead center – maybe even past it and onto the exhaust stroke – before combustion of the air and fuel was completed. That would make for an engine that was horribly inefficient and made terrible power. So, in order to give the fuel mixture adequate time to burn, we start the fire early, before top dead center (TDC) occurs. You know this process as ignition advance. Most engines have between 5-20 degrees of ignition advance at idle. This is referred to as initial timing.

What's the difference between mechanical and centrifugal advance?

As an engine revs up, we need to allow even more of a head start for the spark plug in order for complete combustion to occur. For this reason, a mechanical advance is built into most distributors. As the distributor spins faster and faster with engine RPM, centrifugal forces fling out weights inside the distributor housing, moving a cam mechanism and advancing the timing. This mechanical (also known as a centrifugal) advance is an extremely reliable and simplistic approach to controlling engine timing at given engine speeds. It can be adjusted by changing the stiffness of the springs on the distributor's weights, and the amount of mechanical advance can be increased or decreased based on stop-bushings in the mechanism. We make mechanical advance sound pretty great– and in theory, it is – but there is a major problem with it as the only source of ignition timing compensation. Mechanical advance relies on one input, and one input alone: RPM. It cannot take into account engine load, fuel mixture or any of the many other variables that dictate ideal ignition timing. For that reason, it is best paired with another form of ignition advance: you guessed it, the vacuum canister.

If you were to put a timing light on a car going down the highway with the vacuum advance properly connected, you would be extremely surprised to see somewhere around 40-50 degrees of ignition timing. Ping city? Detonation central? Nope. Not on a flat stretch of highway. In that situation, what many might deem a radical amount of timing is actually quite beneficial to engine performance.

Timing that could potentially damage an engine at wide-open throttle (WOT) can actually help it achieve significant mile per gallon improvements on the highway. You see, lean fuel mixtures burn very slowly and, at cruise, the engine should be approaching a stoichiometric ratio of right around 14.7:1 (about the leanest it will ever operate). The added ignition timing from the vacuum advance allows the lean cruise mixture to achieve as complete a burn as possible during the power stroke and maximize engine efficiency.

But how does the vacuum advance know when to engage? Simple. As a car cruises down a flat stretch of highway, the throttle plates in the throttle body, or carburetor, are barely cracked open as it takes very little horsepower to move a vehicle down a flat stretch of road in high gear.

With the engine turning highway rpms of between 2000-3000 rpm and the throttle cracked ever so slightly, manifold vacuum shoots way up. This negative pressure exerts a pulling force on the diaphragm inside the vacuum advance can which has a mechanism linked to it to advance timing.

Lets say you encounter a hill or go to pass another car while cruising down the highway. As you apply more throttle, air rushes through the carb, into the intake manifold increasing pressure and pushing the diaphragm in the vacuum can right back out, retarding timing back to wherever it would normally be, given engine RPM and mechanical advance.

Where should the vacuum canister be routed?

There's been a lot of debate whether or not the vacuum canister should be plugged into a ported or direct vacuum source. Internet forums are rife with opinions on both sides of the argument. However, there is a right and wrong way. And it's not an opinion; it's just a fact.

Plugging your vacuum advance into a direct source will allow it to engage at idle, which is good for a number of reasons. Much like cruise conditions, engines run leaner at idle than they do under load. Again, this means the mixture burns slower and needs an earlier spark to optimize the burn. Ensuring that the mixture has a complete burn before leaving through the exhaust port also helps the engine to run cooler at idle. All carbureted cars were set up with direct vacuum to the distributor before more stringent emissions requirements reared their heads.

Ported vacuum sources are a result of emissions laws and manufacturers doing whatever they could to get big V8 engines to pass smog before the incorporation of the catalytic converter. The idea was that by using little to no spark advance at idle, the exhaust gas would leave the cylinder still-on-fire and help maximize the efficiency of antiquated air injection systems. Engines from this era often ran very, very hot, were prone to warped exhaust valves, cracked cylinder heads and all other manner of issues. Using a ported spark advance will still allow the vacuum advance to do its job at steady cruising, but all of the benefits of idle cooling will be lost.

Here's a quick experiment you can try on your car. Plug the vacuum advance into a ported vacuum source and check the idle rpm. Now, switch the vacuum advance to a direct source of vacuum and again check the idle rpm? We'll bet money the RPM increased. Why? Because the additional ignition timing provided by the vacuum canister and full manifold vacuum source allowed the engine to more effectively burn the air/fuel mixture. It therefore produces more power (even at idle) and rpm rises as a result.

Where to route the vacuum canister for boosted application?

If your car is equipped with a blower or turbo, it is still perfectly OK to connect your vacuum advance. The vacuum advance does not know the different between positive pressure and zero pressure. In fact, it responds to them the same way. When your turbo/supercharger beings to produce positive manifold pressure (boost) the vacuum advance immediately goes away, exactly as it would in a naturally aspirated car that just had its throttle opened. Now, here is where things can get a little muddy. In a situation with a roots blower, the vacuum feed to the distributor should be routed underneath the blower. In certain instances, there can be a slight vacuum between the carb and the top of the blower and the last thing you want is for the distributor to get a false vacuum signal and advance timing under boost.

Racecars don't run vacuum advance systems, why should I?

It's true. If you headed down to your local drag strip and looked at most of the distributors delivering spark to their hopped-up engine hosts, you would notice a distinct lack of vacuum canisters. The reason for this is simple: racecars operate primarily at full throttle conditions – as one might expect of a "race" car. Unlike streetcars that need to start cold, get acceptable fuel economy, and idle in traffic without overheating, racecars don't experience as much of a variance in operating conditions. And, like we covered earlier, vacuum advance is nonexistent at low manifold vacuum, the system would bring nothing to the table on a car that is driven at wide-open throttle. Would a vacuum canister cause problems on a racecar? No, it would not, but in the name of simplicity, most billet, race-oriented distributors leave them out of the mix.

This Performance Distributors Street/Strip DUI unit will be used on our Blown Budget project engine in an upcoming story. It features a high-output coil and a vacuum advance canister for street use.

In a supercharged application, make sure the vacuum feed to the distributor is located underneath the blower. Plugging it into the carb could create a false vacuum signal under boost that could cause excess ignition advance and detonation. The photo to the left is a close up of the mechanical advance system. As RPM increases, the weights swing out, moving the location of the reluctor tabs relative to the magnetic pickup. The rate of advance is controlled by the stiffness of the springs and the amount the shaft is allowed to rotate, which is typically limited by a "stop" bushing.

Here is the backside of the vacuum advance mechanism. Inside the can is a diaphragm that, when exposed to high manifold vacuum, pulls on a linkage to rotate the position of the reluctor tabs. When the source of vacuum dissipates, such as at WOT conditions, the advance returns to wherever it would normally be at that RPM.