

YOUR VACUUM GAUGE IS YOUR FRIEND

Two Essential Diagnostic Tools No Hot Rodder Should Be Without, and How to Use Them

✍️ 📷 Marlan Davis

➤ I've been answering readers' Pit Stop tech questions for decades, explaining how to improve performance, troubleshoot pesky problems, or recommend a better combination. Yet rarely do any of these problem-solving requests include information on the problem combo's vacuum reading. That's unfortunate, as vacuum can tell

you a heck of a lot about an engine's condition, without the need to invest in a bunch of high-tech diagnostic tools.

So what's the deal on vacuum? Consider an internal-combustion engine as basically a giant air pump that operates under the principles of pressure differential. The difference between normal atmospheric pressure (14.7 psi at sea level at standard temperature and pressure) and how hard this "pump" sucks under various operating conditions and states of tune creates vacuum (usually expressed in inches of mercury, or in-hg). The amount of vacuum in the induction tract at various operating points is used to properly meter fuel (through old analog devices like the carburetor, or via a MAP sensor, as part of a modern electronic

engine-management system).

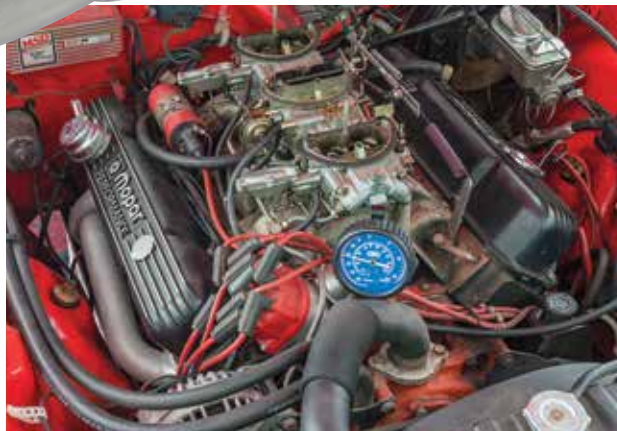
If present, the distributor vacuum advance system also depends on vacuum. Many emission-control devices—including the EGR valve, evaporative control system (ECS) canister purge, and PCV valve—likewise rely on consistent and correct engine vacuum.

Wait: There's even more stuff

that needs vacuum that—at least on the surface—seemingly doesn't tie directly into engine performance. These include vacuum consumers like the power-brake vacuum booster, automatic-transmission vacuum modulator, and classic-era HVAC (heating, ventilation, and air conditioning) controls. All need vacuum to operate, and

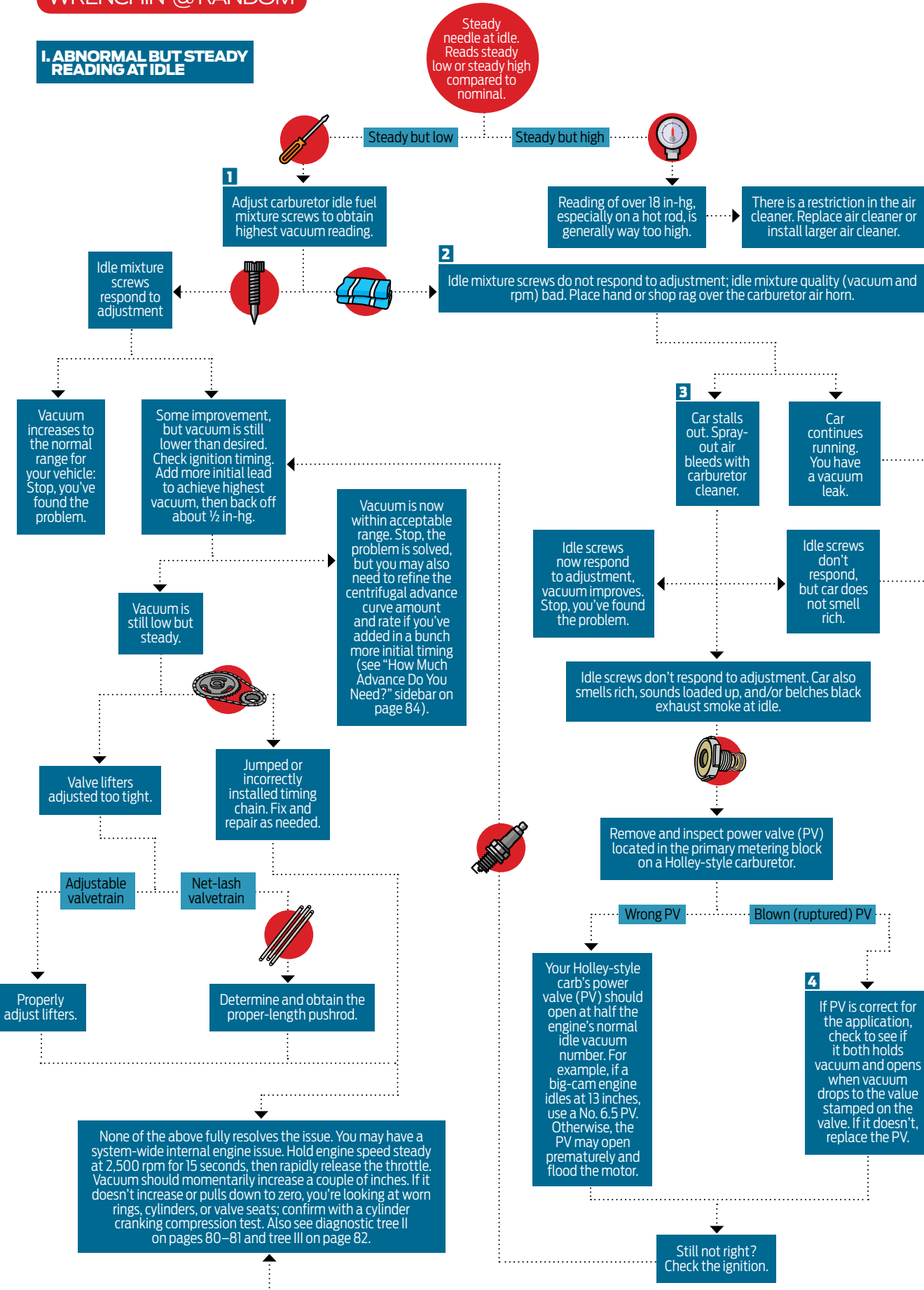
[Above: Two essential diagnostic tools no hot rodder should be without, from left: a Mityvac handheld vacuum pump for testing vacuum consumers (some models will even aid in brake bleeding), and a large, easy-to-read vacuum gauge like this one by OTC (this model also includes a pressure gauge for even more test possibilities).

[Left: Knowing how to use a vacuum gauge is the key to diagnosing many performance problems. It aids in tuning your motor to the tip of the pyramid. It even helps diagnose problems not seemingly engine-related, such as a weak power-brake system. Add one to your toolbox today.



“Vacuum is everything from a tuner’s standpoint. It’s the key to virtually every component.” — Norm Rollings

I. ABNORMAL BUT STEADY READING AT IDLE

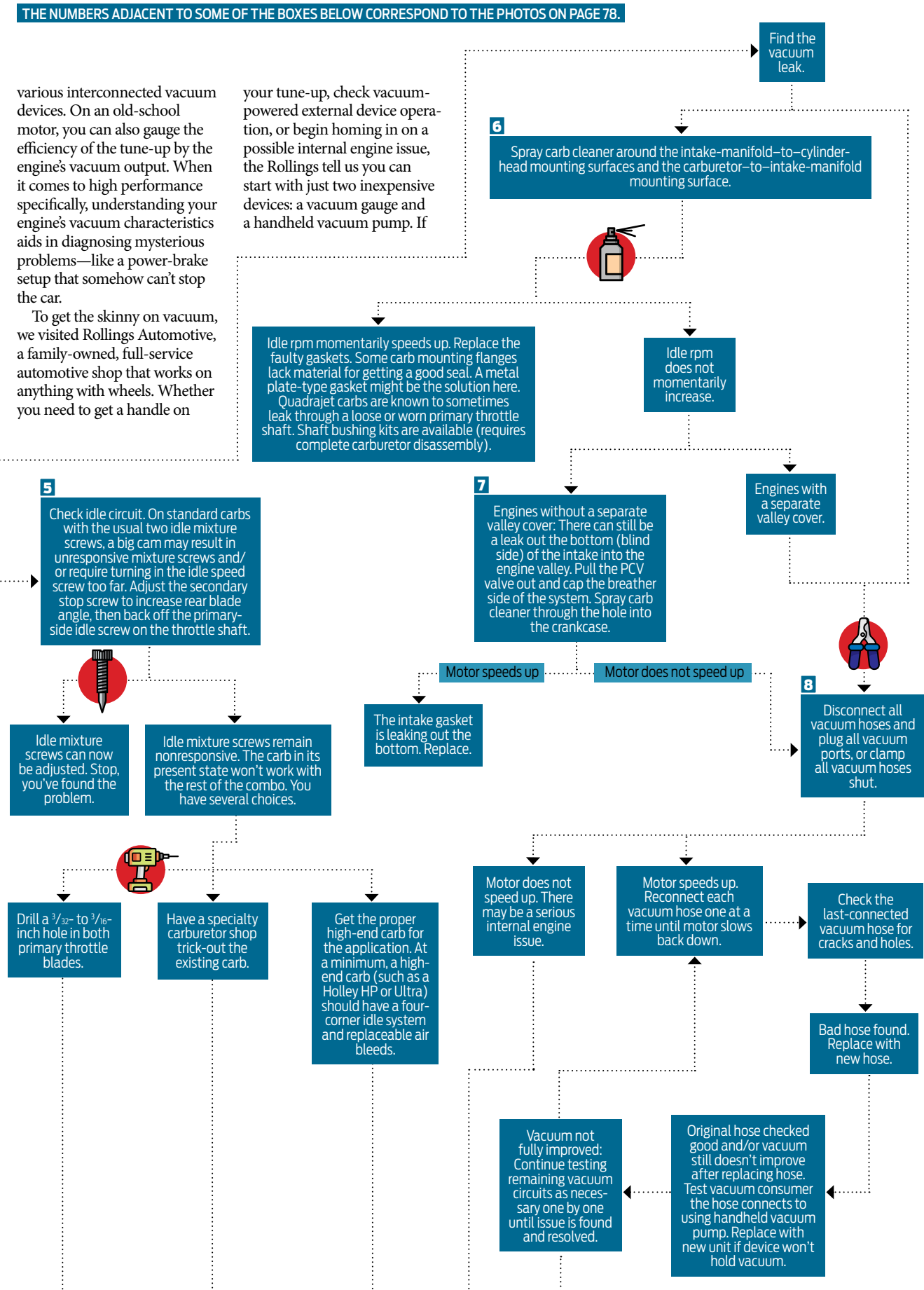


THE NUMBERS ADJACENT TO SOME OF THE BOXES BELOW CORRESPOND TO THE PHOTOS ON PAGE 78.

various interconnected vacuum devices. On an old-school motor, you can also gauge the efficiency of the tune-up by the engine's vacuum output. When it comes to high performance specifically, understanding your engine's vacuum characteristics aids in diagnosing mysterious problems—like a power-brake setup that somehow can't stop the car.

To get the skinny on vacuum, we visited Rollings Automotive, a family-owned, full-service automotive shop that works on anything with wheels. Whether you need to get a handle on

your tune-up, check vacuum-powered external device operation, or begin homing in on a possible internal engine issue, the Rollings tell us you can start with just two inexpensive devices: a vacuum gauge and a handheld vacuum pump. If



THE BOX NUMBERS ABOVE THE PHOTOS CORRESPOND TO THE DIAGNOSTIC TREE | BOXES ON PAGES 76-77.

See box 1



[Adjust the idle mixture screws to obtain the highest possible vacuum reading. Turn the curb idle speed screw slightly clockwise only as necessary to prevent the car from stalling out while doing this. A 15 in-hg gauge reading here isn't too bad for a hot rod, but be sure the power-brake vacuum booster can get the job done at that level. (Hint: don't rely on a minibooster.)

See box 4



[Most Holley carbs made after 1992 have built-in power valve (PV) blowout protection, but those on older Holley models sometimes rupture from an engine backfire. This results in a super-rich, blubbery engine at idle and off idle—as well as low vacuum. Test with the handheld vacuum pump. If you're careful, its cup adapter sort of works (A); better is the pump connected to Moroso's PV tester (PN 62295, B), about \$45 through Amazon.com.

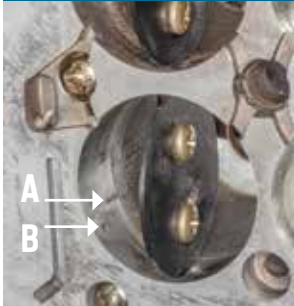
you really get into it, you might want to invest a little more on a cylinder-compression tester and maybe an electrical multimeter, but we'll leave those tools for another time.

See box 2



[If the idle mixture screws don't respond, place a shop towel or your hand over the carb's air horn. Normally, this action should cause the engine to immediately stall out. If it keeps running, there's a vacuum leak somewhere.

See box 5



[At idle, a Holley primary-side idle transfer slot (A) should be exposed just 0.020 to 0.030 inch. If a big cam requires turning the idle screw on the throttle linkage too far "in" to achieve stable idle, too much of the slot is exposed, deactivating fuel flow through the idle discharge hole (B) and prematurely activating the main circuit. Result: An over-rich, low-vacuum condition.

See box 6

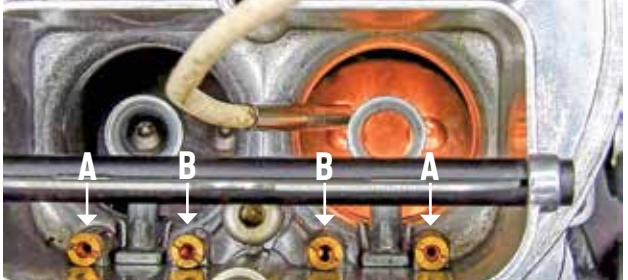


[To check for vacuum leaks, Rollings sprays the intake-manifold and carb-gasket surfaces with carb cleaner (he says it's slightly safer and less volatile than brake cleaner). If rpm momentarily increases, you've found the vacuum-leak source.

REALISTIC VACUUM FOR HOT RODS

"People need to use a vacuum gauge on just about anything,"

See box 3



[Sometimes just spraying the air bleeds with carb cleaner helps free up idle system response. High-end Holley-style carbs like this Quick Fuel unit have replaceable air bleeds (idle, A; high-speed, B) plus a "four-corner" idle system that facilitates tuning for big cams in radical engines compared to old-school "two-corner"-idle systems with fixed bleeds.

See box 5



[Cure for excessive Holley carb primary idle-transfer slot exposure: Turn in the secondary idle stop screw located on the bottom-right side of the baseplate about 0.015 inch in from its lightly bottomed position. This cracks open the secondary blades slightly farther at idle, which permits backing off the primary curb-idle screw to reduce slot exposure and restore idle mixture screw authority.

See box 7



[There can be a hard-to-find vacuum leak out the bottom of the intake into the valley area. Rollings' solution: Pull out the PCV valve and cap off the system's breather side. Spray carb cleaner down the open PCV hole. If rpm momentarily increases, you've found the leak.

See box 8



[Not leaking through the gaskets? Plug or pinch off all vacuum ports and hoses; rpm should speed up. Reconnect the hoses one at a time until the engine slows back down—you've found the leak. If the motor didn't speed up, there may be a serious internal engine issue.

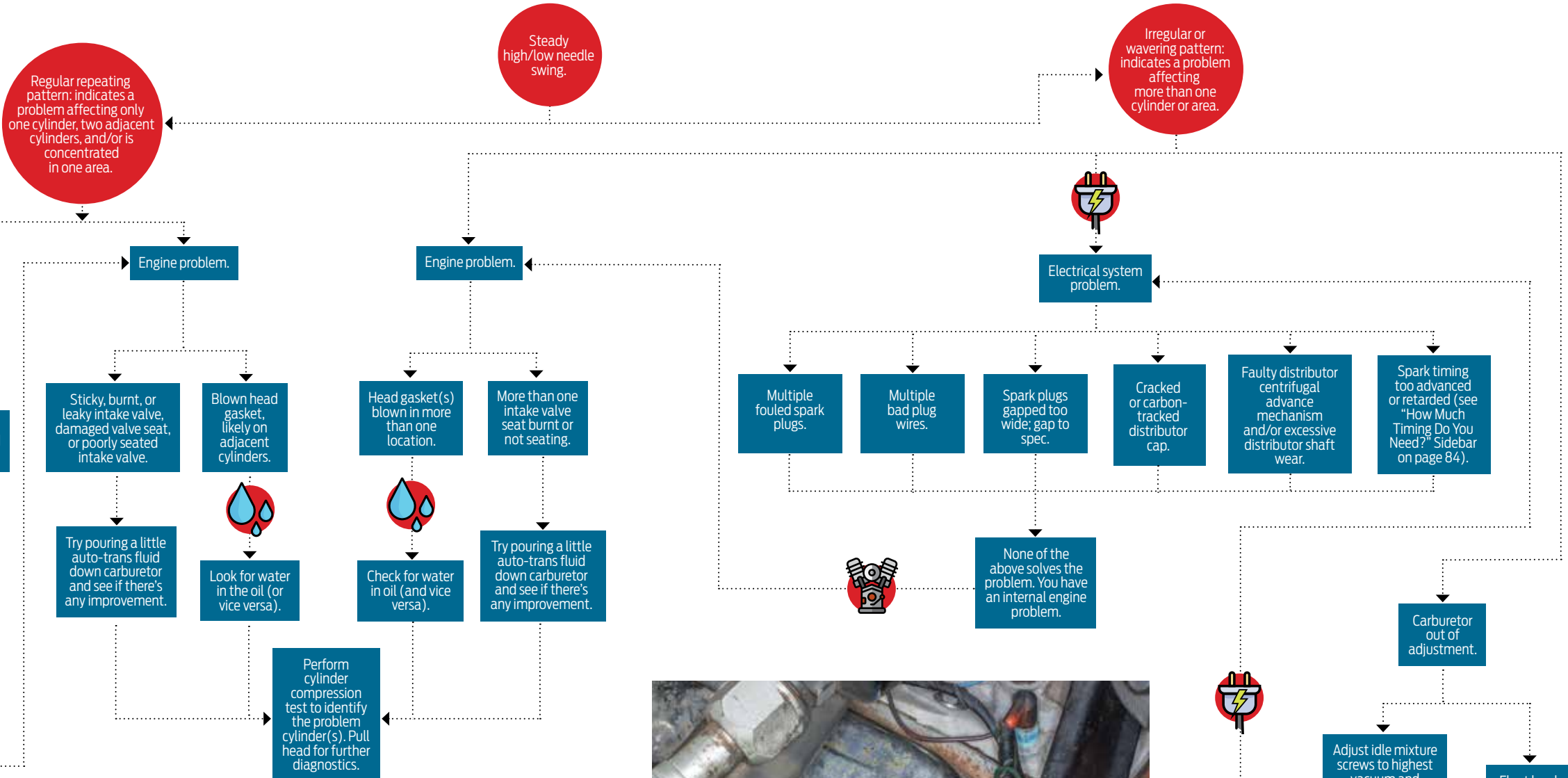
Rollings says. "It's the first basic step for us when a car comes in with an issue. It tells us a story. If vacuum is low, we need to find out why and fix the problem."

Begin diagnostics by connect-

ing your vacuum gauge to a full-time vacuum port on the intake manifold. Traditionally, with the car warmed up, at idle you want to see vacuum readings of 18 to 22 in-hg from sea

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II. FLUCTUATING POINTER AT IDLE



level to 1,000 feet. But that's with a stocker and a mild cam. Realistically, hot rods with a performance cam will be lower, sometimes as low as 10 to 11 in-hg (not great if you want to drive your car daily or go on Power Tour®).

For a street-driven hot rod with power brakes and other vacuum consumers, Rollings

wants to see at least 16 in-hg at sea level, or he says, "We'll have to compensate in some way." Other sources maintain power brakes work OK with as little as 14 in-hg, but you better know how to tune the entire combo to the peak of the pyramid.

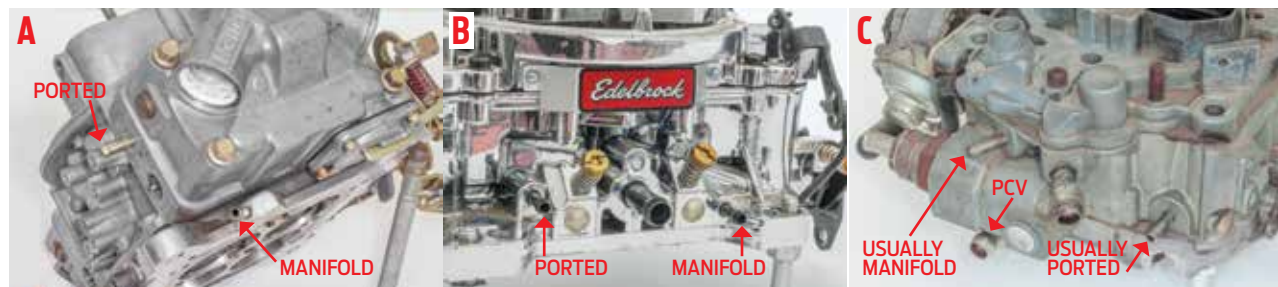
Engine vacuum is established relative to atmospheric pressure, so as altitude increases,

"normal" readings will decrease about 1 in-hg for every 1,000 feet of elevation gain above 1,000 feet. For example, at 5,000 feet, normal vacuum for a given combo will be down about 4 in-hg. But that still doesn't change that threshold for proper vacuum device operation. Living in mile-high Denver, for instance, makes it more likely

your hot rod requires an auxiliary vacuum-assist device to ensure reliable and repeatable power-brake operation.

ABNORMAL VACUUM AT IDLE

Under an initial hot-idle vacuum test, the vacuum-gauge needle should hold steady



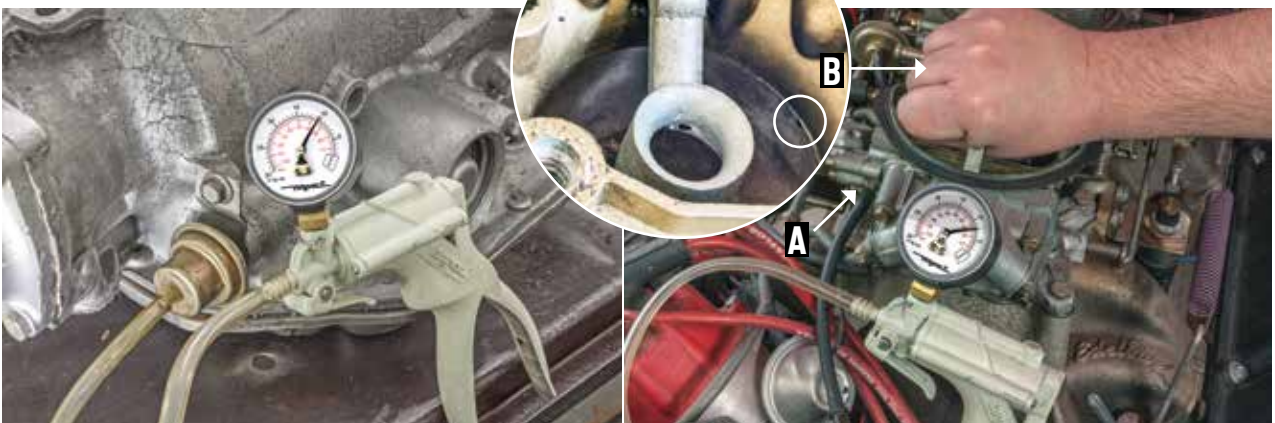
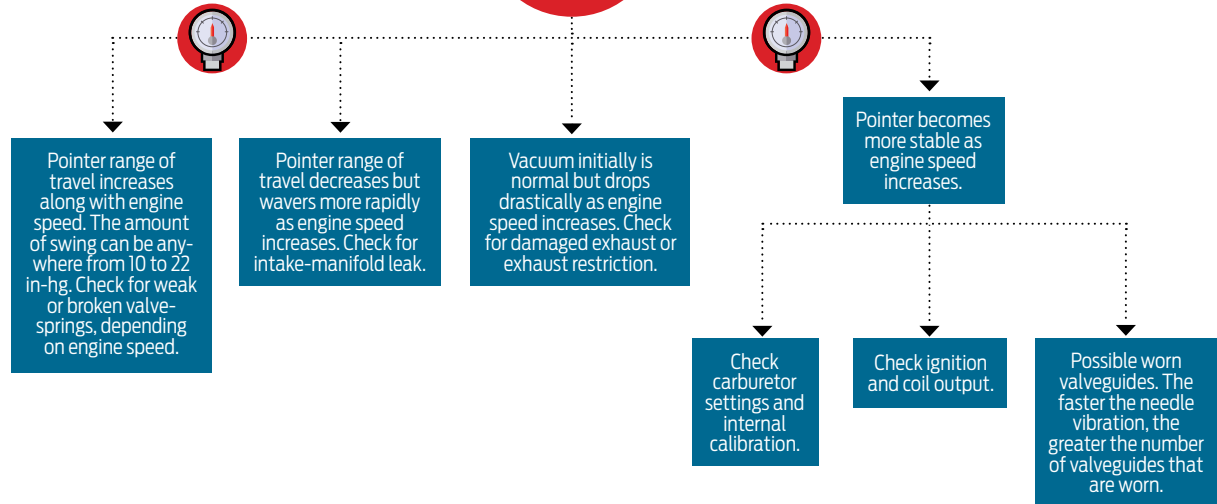
[Connect your vacuum gauge to a full-time manifold vacuum port on the intake or at the carburetor. A carb's multiple vacuum ports may reference either manifold (full-time) or ported vacuum. Ported will have zero or near-zero vacuum at idle, which you don't want for a basic vacuum test; confirm if in doubt. These photos show common vacuum port locations on a typical Holley (A), Edelbrock (B), or Quadrajets (C). Be careful on the Q-jet; GM switched ported/manifold vacuum functionality, depending on model or year.



[If you've checked everything else and the engine still doesn't respond properly, it's finally time to get out the big gun: perform a cylinder compression check.

III. IRREGULAR WAVERING POINTER AT SPEED

Progressively increase amount of throttle opening and observe results.



[One often overlooked vacuum consumer is the auto-trans vacuum modulator. When a good modulator goes bad, trans fluid gets sucked into the motor, displaying symptoms like bad rings or valves. Late, firm shifts are one sign it's gone bad, but the surest clue is trans fluid in the modulator hose. Test the modulator with the vacuum pump.]

[Vacuum secondary Holley four-barrels, as well as end carbs on its 3x2 setups, require vacuum to work. A malfunction won't affect idle, but will come into play in the midrange and top end. Before messing with different-tension secondary springs, see if the diaphragm holds vacuum (isn't leaking). On Holley 3x2 end carbs, connect the pump to the diaphragm's external vacuum reference port (A). Hold your thumb over the small D-shaped kill bleed near the casting seam above the passenger side (inset, circle, B). You should see steady vacuum when the test pump is engaged.]

within the preceding parameters. A fluctuating needle, abnormally high, or abnormally low readings indicate a potential problem that calls for further investigation and diagnosis. That's one reason why it pays to establish a decent baseline "normal" vacuum reading for your combo, as what's normal for your hot rod may not be the

same as your buddy's. When vacuum is not what it should be, pay particular attention to not just the raw vacuum numbers but also the range of gauge-needle fluctuation (and the pattern). Broadly speaking, abnormal at-idle vacuum readings can be broken down into several categories:

- Low but steady: a condition affecting all cylinders.
- High but steady (over 20 in-hg): although rare, could indicate a restricted air filter.
- Fluctuating with a steady rhythm in a regular pattern: The trouble is concentrated in one area or cylinder.
- Fluctuating with an

irregular or wavering pattern: Conditions exist in more than one cylinder.

ABNORMAL VACUUM AT SPEED

Another valuable diagnostic tool is closely studying the vacuum-

HOW MUCH TIMING DO YOU NEED?

You can't go too far wrong on a new build without a track record by starting out with a conservative baseline that takes into consideration the engine's cranking compression, which provides a substantially reliable indicator of an engine's pump-gas compatibility and baseline timing requirement.

For engines that crank over 150 psi, a good rule of thumb is to establish an initial base timing of 1 degree for every 100 rpm. For example, if the engine likes to idle at 700 rpm with the carburetor properly adjusted, you want to initially set the base



[Adding more initial timing can improve engine vacuum and idle quality, but if the engine likes a lot of initial lead, you may have to back down the advance curve to prevent top-end detonation.]

timing around 7 to 8 degrees BTDC on 91-octane or better street gas.

Engines that crank under 150 psi are lazy and need more time to complete a full mixture burn; 10 to 15 degrees initial at a 700-rpm idle speed is a good starting point. On the other hand, if an engine cranks over 200 psi, tuning expertise becomes critical if you have any chance (and that chance is slim) of reliably running on pump gas.

For total ignition advance, continue following the "1 degree of timing/per 1,000 rpm" rule until reaching maximum advance. For typical traditional engines, that's around 34 to 36 degrees total (base

plus mechanical, as read on the balancer) at 3,200 to 3,600 rpm. Efficient late-model engines or even old-school engines with the latest aftermarket quick-burn aluminum heads may require less total timing. Either way, if a given combo likes more initial timing to develop best idle vacuum and response (including, based on trial and error, going beyond the 1 degree/1,000 rpm rule at idle), total timing must be correspondingly reduced (the "curve" slowed or limited) on the top end to remain within the preceding total ignition advance parameters.



gauge needle's sweep under conditions of increased throttle opening. On a healthy, properly tuned engine, the normal response to suddenly opening and closing the throttle should be a wide, smooth sweep of the gauge needle. If this doesn't happen, at a minimum, you have a vacuum leak somewhere in the induction system. Otherwise, you could be looking at bad valve seats or poorly sealing piston rings.

If needle sweep is irregular and/or wavering as engine speed increases under normal cruising conditions, pay attention to how and when the amount of needle sweep and waver changes as engine speed changes. This, too, can help pinpoint where you need to investigate further.


We've included vacuum-gauge diagnostic "trees" to help you methodically sort these issues out. It'll get easier as you gain experience with the idio-



[Above: Does your distributor vacuum advance diaphragm actually hold vacuum? Pump it up and see with your vacuum pump. Also pop the cap to look inside the unit and see if the rod coming out of the diaphragm is actually pulling on the advance plate.]

[Left: Some carbs use a vacuum-actuated choke pull-off. The blade over the air horn is normally closed with the engine off. When the motor starts making vacuum under crank, a rod connected to the diaphragm pulls the blade open a set amount, allowing air to flow into the carb and the car to start. Exhaust heat or an electrical coil then opens the choke completely as the engine warms up. A bad hose or diaphragm here creates a hidden vacuum leak (and cold-start issues).]

syncracies of a particular engine combo. In other words, get to know, honor, and cherish your

vacuum gauge. It will help you understand how to really help your engine suck. 

Contacts

AMAZON.COM INC.; Seattle, WA; [Amazon.com](https://www.amazon.com)

MITYVAC, SKF LUBRICATION SYSTEMS USA INC.; St. Louis, MO; 314.679.4200 (customer service) or 844.772.1341 (tech service); [Mityvac.com](https://www.mityvac.com)

MOROSO PERFORMANCE PRODUCTS; Guilford, CT; 203.453.6571 (sales/customer support); 203.458.0542 or 203.458.0546 (tech); [Moroso.com](https://www.moroso.com)

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