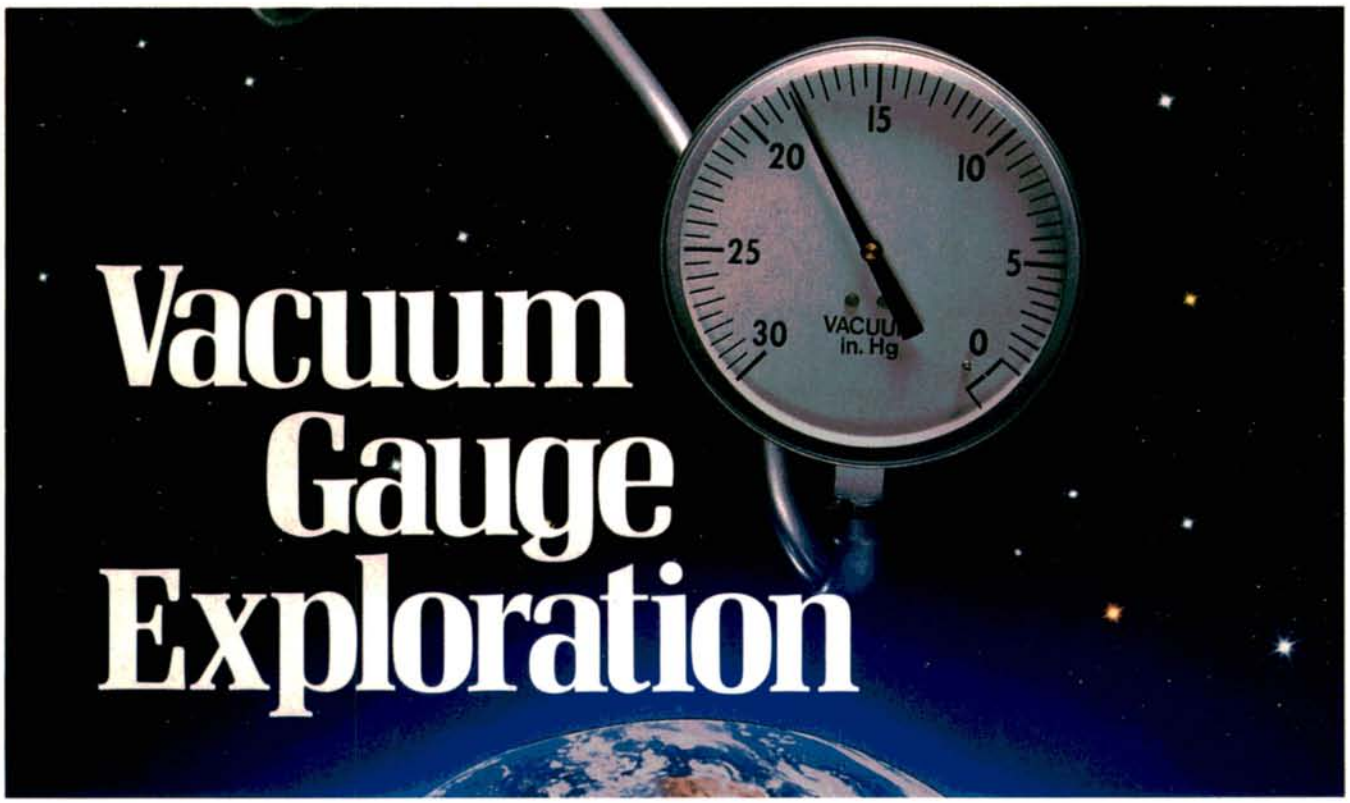


Vacuum Gauge Exploration

What do outer space and the intake manifold have in common? First, they both contain vacuum. Second, to most of us, they are mysterious, unexplored territory. To explore space's vacuum, you need billions of dollars in equipment. To explore intake vacuum, all you need is a pressure gauge!

What Is This Thing Called Vacuum?

For our purposes, vacuum is any pressure less than atmospheric pressure. Atmospheric pressure is what the air around us exerts on us. At sea level, atmospheric pressure is 14.7 PSI. Pressure greater than 14.7 PSI is *positive* pressure. Pressure less than 14.7 PSI is *negative* pressure or vacuum.

Whether you're studying automotive theory or diagnosing real world problems, think of positive pressure and negative pressure. Or, think of higher pressure and lower pressure. After all, every liquid and gas you deal with flows from a higher pressure point to a lower pressure point.

Basically, vacuum gauge readings tell you how well a pump creates negative pressure. The pump we test most often is an air pump called an engine. The better the engine's rings and valves are sealing—and the more accurately they're timed to each other—the more negative pressure the engine pumps.

The engine's intake stroke creates a lower pressure area inside the cylinder. In a normally aspirated engine, atmospheric pressure then pushes air into this bureted engine, atmospheric pressure also pushes fuel lower pressure area and fills the cylinder. On a car- from the fuel bowl into the engine.

Interpreting Vacuum Readings

Remember these three basic guidelines:

- a fluctuating reading usually means that all cylinders are not pumping equally;
- a low-but-steady reading usually means the problem is affecting all cylinders;
- the range and the frequency of the fluctuation usually tells you how severe the problem is.

The sample gauge readings shown in this story are manifold vacuum readings.

When you expose a manifold vacuum port, the engine should speed up and/or idle roughly. Always check the fitting or port for carbon deposits before you connect your gauge to it. A restricted port reduces the gauge's sensitivity and accuracy.

Pay attention to the location of the vacuum port too. Usually, connecting the gauge to the most centrally located vacuum port will give you the most accurate and most sensitive reading. Say you're testing a straight six. Say the problem is in number one cylinder but your vacuum gauge is connected near number six. Because the gauge is connected so far from number one, its reading could appear to be normal or almost normal in spite of the problem in number one!

Back Up Your Findings!

The vacuum gauge is like any other piece of diag-

nostic equipment. The more often you use it, the better you understand it. But although the vacuum gauge is a great barometer for the engine's mechanical condition, you cannot live by it alone.

Suppose an engine's suffering from several marginal and/or major problems at the same time. This *combination* of problems can alter the accuracy of your vacuum gauge diagnosis. Before you commit yourself, always complete the rest of the steps in your engine analysis—the ignition tests, timing checks, power balance test, etc.

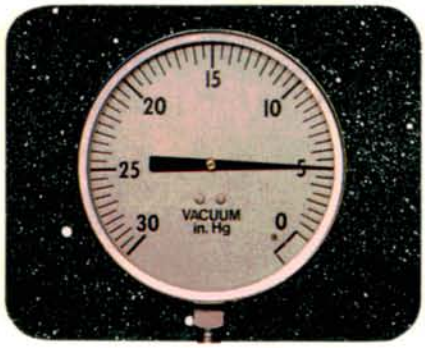
You can also supplement a vacuum test with logical follow-up tests. For example, a low and steady reading could be a big air leak or late ignition/valve timing. All other things being equal, an engine with an air leak should respond to artificial enrichment (choke the air intake or feed it propane). But engines with timing problems alone don't speed up and smooth out when you richen them!

Be careful here. On a feedback fuel system, the control computer may have already compensated for air leaks by richening the mixture. Unless you put the system into open loop, it will continue compensating for whatever rich or lean conditions it senses—including artificial enrichment!

The More Things Change . . .

The typical computer-controlled fuel system depends heavily on a sound engine and strong reliable vacuum signals. Therefore, vacuum readings are as valuable today as they've ever been. Ask the technician who uses them. He'll say he can't work without them. Truth is, you can't either!

—By Dan Marinucci



Normal Cranking Vacuum

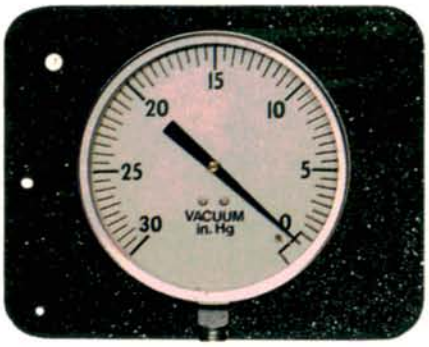
In order to start, an engine usually has to pump at least one inch of vacuum. When cranking, a healthy engine will pump a fairly steady 3-6 inches. The more vacuum the engine pumps, the quicker it'll start. The more cylinders the engine has, the stronger and steadier cranking vacuum tends to be.

Abnormal Cranking Vacuum

Cranking vacuum is healthy but it drops regularly and rhythmically. There's a compression problem here. Every time the weak cylinder tries to fire, two things happen momentarily: the cranking speed increases and the vacuum decreases. A burned valve can make the needle drop regularly to zero vacuum.

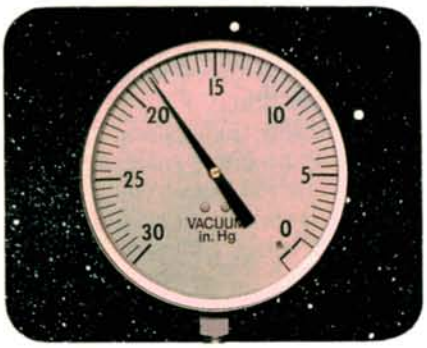
Abnormal Cranking Vacuum

When the engine cranks erratically, the cranking vacuum will also fluctuate erratically. Valve timing problems (a belt or chain) are the most common cause of erratic cranking vacuum and cranking speed. However, the engine could also be so hot it's actually dieseling during cranking!



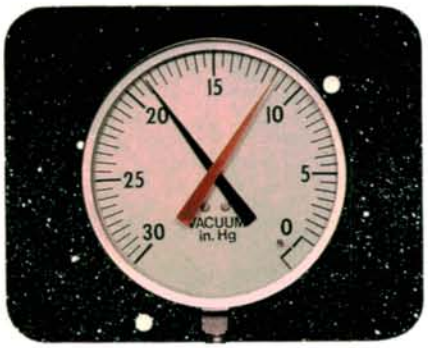
Abnormal Cranking Vacuum

Zero cranking vacuum? Before you go crazy looking for monstrous air leaks, see if the throttle blade(s) are sticking open. If they are, close them and retest. Unless the throttle blade(s) are closed or nearly closed, some vacuum gauges may not respond very well to a cranking vacuum test.



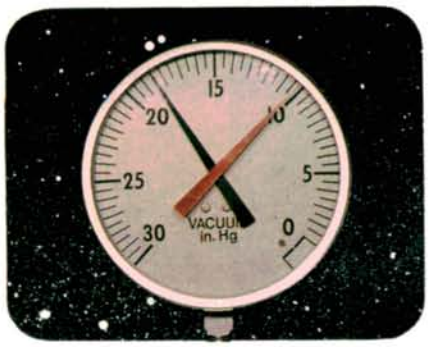
Normal Idle Vacuum

On a normal engine, the idle vacuum should be a steady reading between 17-21 in/Hg. Larger displacement engines tend to produce stronger idle vacuum than smaller engines do. The better the rings and valves are sealing, the more vacuum the engine will pump.



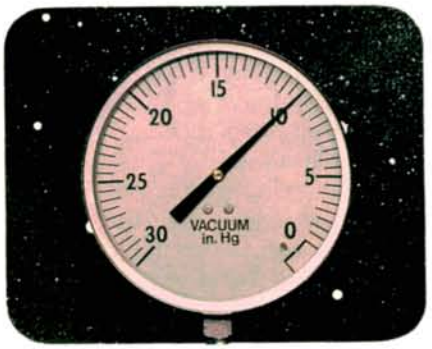
Abnormal Idle and High-Speed Vacuum

When the needle drops regularly and predictably at idle, one or more valves are leaking. During compression stroke, a burned intake valve allows positive pressure pulses to enter the intake manifold. When you rev the engine, the reading doesn't stabilize.



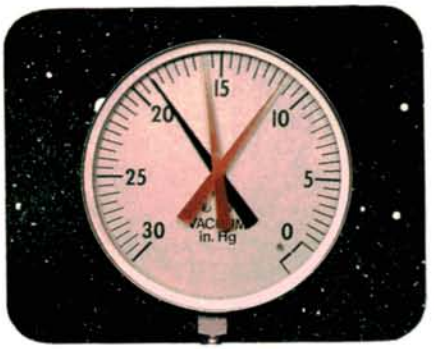
Abnormal Idle and High-Speed Vacuum

When the reading fluctuates sharply between a normal and a very low reading, there may be a compression leak between adjacent cylinders. If so, these two cylinders will both show up weak on a cylinder balance test.



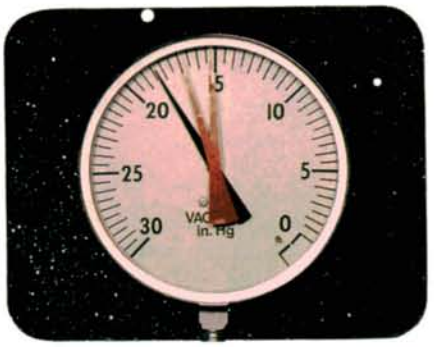
Abnormal Idle Vacuum

A steady, lower-than-normal reading can be a vacuum leak, an EGR leak, or an ignition/valve timing problem. If it is a vacuum leak, artifically richening the mixture will improve idle quality. Richening the mixture does't help? Look elsewhere—continue following your diagnostic procedure.



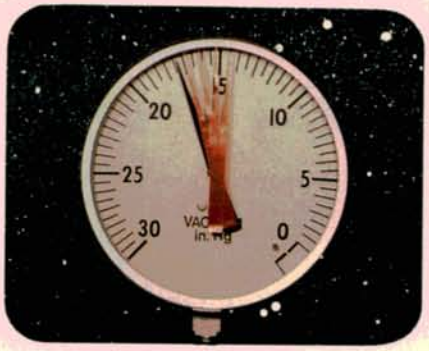
Abnormal Idle and High-Speed Vacuum

When the reading drops erratically and unpredictably at idle, a valve or valves are sticking. The needle may not drop as much as it does when the valve is burned. If the valves are sticking, cooling the engine down or using a valve-freeing oil additive may temporarily steady the vacuum reading.



Abnormal Idle/Normal High-Speed Vacuum

Here, the needle slowly wanders back and forth between a normal reading and a slightly lower-than-normal reading. This floating reading tells you the carburetor is out of adjustment.

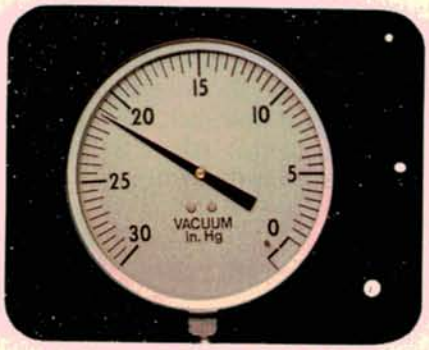


Abnormal Idle/Abnormal High-Speed Vacuum

Weak valve springs make the needle flutter rapidly—more rapidly when you rev the engine. Depending upon RPM and spring condition, the needle may flutter irregularly. When weak/broken springs can no longer close a valve, the reading will take on the pumping motion a burned valve creates.

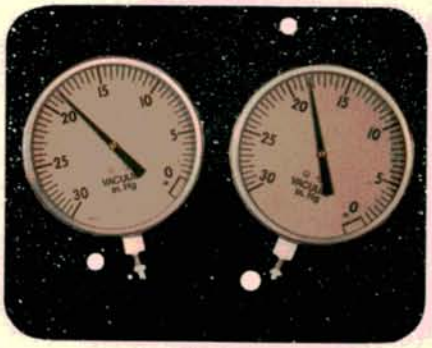
Abnormal Idle/Normal High-Speed Vacuum

At idle, the needle flutters rapidly over a wide area, but the reading steadies when you rev the engine. This indicates badly worn valve guides. When the guides are this worn, the engine has a serious oil consumption problem.



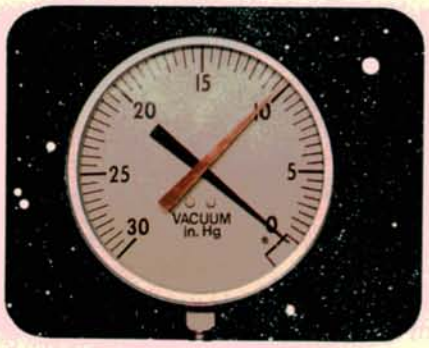
Normal High-Speed Vacuum

At 2500 RPM in neutral, the reading should at least equal idle vacuum. Usually, vacuum at 2500 will be greater than idle vacuum. If vacuum at 2500 is less than idle vacuum, disable the EGR system and retest. If the reading is still low, check for an exhaust restriction.



Comparing Vacuum Signals

You can monitor a vacuum device and its vacuum source simultaneously. For example, connect one gauge to manifold vacuum and tee the other one into the tranny's vacuum modulator hose. If both readings don't react the same way during a road test, inspect the modulator hose and its connections.



Road Testing With a Vacuum Gauge

Use your vacuum gauge on as many road tests as time allows. The more you use it, the quicker you'll learn what "normal" readings are. With an exhaust restriction, under-load readings will all be lower than normal and it will take very little throttle movement to drop the reading to zero.

Choosing the Best Vacuum Port

Whenever possible, connect the gauge to a large, centrally located vacuum port. Be sure the port isn't loaded with carbon deposits! Depending upon engine and intake design, where you connect the gauge can make a big difference in the accuracy and sensitivity of the readings you get!