# Driveability Corner



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Evaporative system leak-detection tools and techniques for finding larger leaks are well established. As vehicle self-testing capabilities get more sophisticated, you'll need to be more creative to find smaller leaks.

was wondering how much smoke machine smoke would escape from a .040-in. evaporative system leak. This would be useful to know for evap system testing. And how much smoke comes out of .020-, .015-, .010-, .007-, .005-, .004-, .003-, .002- and .001-in. leaks? To find out, I ordered some precision orifices and proceeded with testing.

Having had good success finding small evap leaks with a gas analyzer, we also tested the hydrocarbon (HC) plume with the orifices and a gas analyzer. We also tested the effectiveness of indentifying all leaks with the flow gauge on the smoke tester. Finally, we tested small leak location using an ultrasonic tester.

Fig. 1 below shows our setup. The precision orifices have a <sup>1</sup>/<sub>8</sub>-in. pipe thread, and we screwed them into a union held in a vise. The union was then connected to the smoke machine hose.

Fig. 1 shows smoke coming out of a .040-in. (1mm) orifice. We had near per-

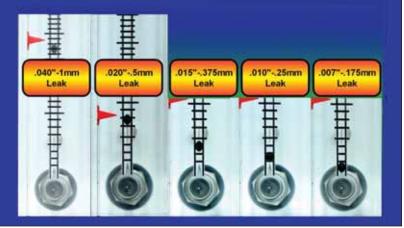
fect illumination, with two high-powered lights from two different angles. The smoke plume from this leak is about the size of a man's forearm. The smoke plume from the .020-in. (.5mm) orifice is about 2 in. wide and 15 in. long. These two leaks are pretty easy to locate with smoke. At .015 in., things get a little trickier. The smoke plume out of an orifice this size is about the size of two fingers, and difficult to see without perfect lighting.

Okay, let's drop back for some review. You might want to reference my June 2009 evap-leak-testing article to complement this one. The first things we need to know are, do I have a leak now and, if so, how big is it? As I stated in that 2009 column, you use the flow gauge on the smoke machine to make this determination.

Take a look at Fig. 2 on page 18. There are a couple of important points to be made here. The images are zoomed in as the leaks get smaller, so the relative heights of the balls in the image are not relevant; refer to the gauge scales instead. continued on page 18

Fig. 1 Smoke machine-produced smoke passing through a .040-in. (1mm) orifice produces a plume that's about the size of a man's forearm. Evap system leaks of this size should be relatively easy to find.





**Fig. 2** The smoke machine's flow gauge can be used to determine the relative size of an evap system leak. Our tests with precision orifices revealed the practical limits of this technique.

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Also, when using the flow gauge for precision testing, it's best to use the TEST mode and not the SMOKE mode (see the photo on page 16). In SMOKE mode, the machine heats the smoke chamber and the ball tends to bounce quite a bit from the boiling action. In TEST mode, no smoke is being produced and the flow is much smoother, which affords more accurate low-flow testing.

At .007 in., the ball is darn near seated; this is at or near the limit of the flow gauge's test capability. Remember, if you think the leak is intermittent, watch the flow gauge and wiggle-test the system.

The most important point to be made is this: When looking for

Most smoke machines time out after five minutes, so keep an eye on it during testing.

small leaks, you *must* be in a dead calm environment! This means all shop doors closed and a/c and fans off—zero air circulation.

The smoke machine's flow gauge will identify if you have a leak down to a pretty small size. Smoke works great for .040- and .020-in. leaks. But how are you going to find the really tiny ones? Use a gas analyzer when looking for HCs or carbon dioxide ( $CO_2$ ) if you're using  $CO_2$  as the charge gas. Shop air is not a safe option as a charge gas.

Fig. 3 on page 19 shows our setup for HC testing. Here we're testing a .040-in. orifice. The grid in the background is sectioned off in 1-in. squares and is 48 in. wide and 30 in. high. Note that we have a tube-style adapter on the gas analyzer probe. I usually use a stan-

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dard brake line for this testing, with a brass coupler connecting the brake line and gas analyzer handle. The brake line can be bent to get at the top of a gas tank or almost anywhere deemed necessary for testing.

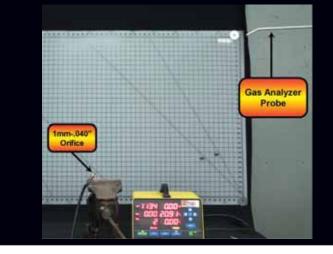
The cone-shaped HC plume for this .040-in. leak is about 48 in. long and 36 in. wide at the outer edge. You can see in this test that the HCs are 1134 a good 36 in. from the orifice.

Typically, HC plumes are four to five times the size of smoke plumes. When you've determined that you're looking for a small leak (less than .020 in., or .5mm), then secure a dead calm environment. Raise the vehicle on a lift. Pressurize the system with the smoke machine to drive HCs out through the leak. Walk around under the vehicle and sniff for fuel. Can you smell a car with 500ppm HC at the tailpipe? Most people can smell HCs down to 100ppm. If you can locate the leak by smell, then use the gas analyzer to follow the HC plume to locate the max HC concentration near the leak.

Some final points: The HCs in the tank may run out during your test. Make sure the fuel is good and hot before testing, and some sloshing wouldn't hurt. If you're using  $CO_2$  as the pressure gas, it will always be present during your test. Some systems leak only when cold and kept overnight. There should be an initial HC load in the tank. But if it's cold, it may not last too long. Also, most smoke machines time out after five minutes as a safety feature, so watch your machine while testing to make sure it doesn't time out.

The ultrasonic testing for evap leaks did not work well. The smoke machine pressurizes to 14 in./ $H_2O$ , or .5 psi. This low pressure does not create much ultrasound at the leak location.

Good luck with your evap leak testing. With the right equipment, the proper procedures and some patience you'll be successful. Fig. 3 An exhaust gas analyzer can be an effective tool to locate smaller evap leaks. In still-air conditions, our test revealed that HC was detected some distance away from a .040in. orifice.



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