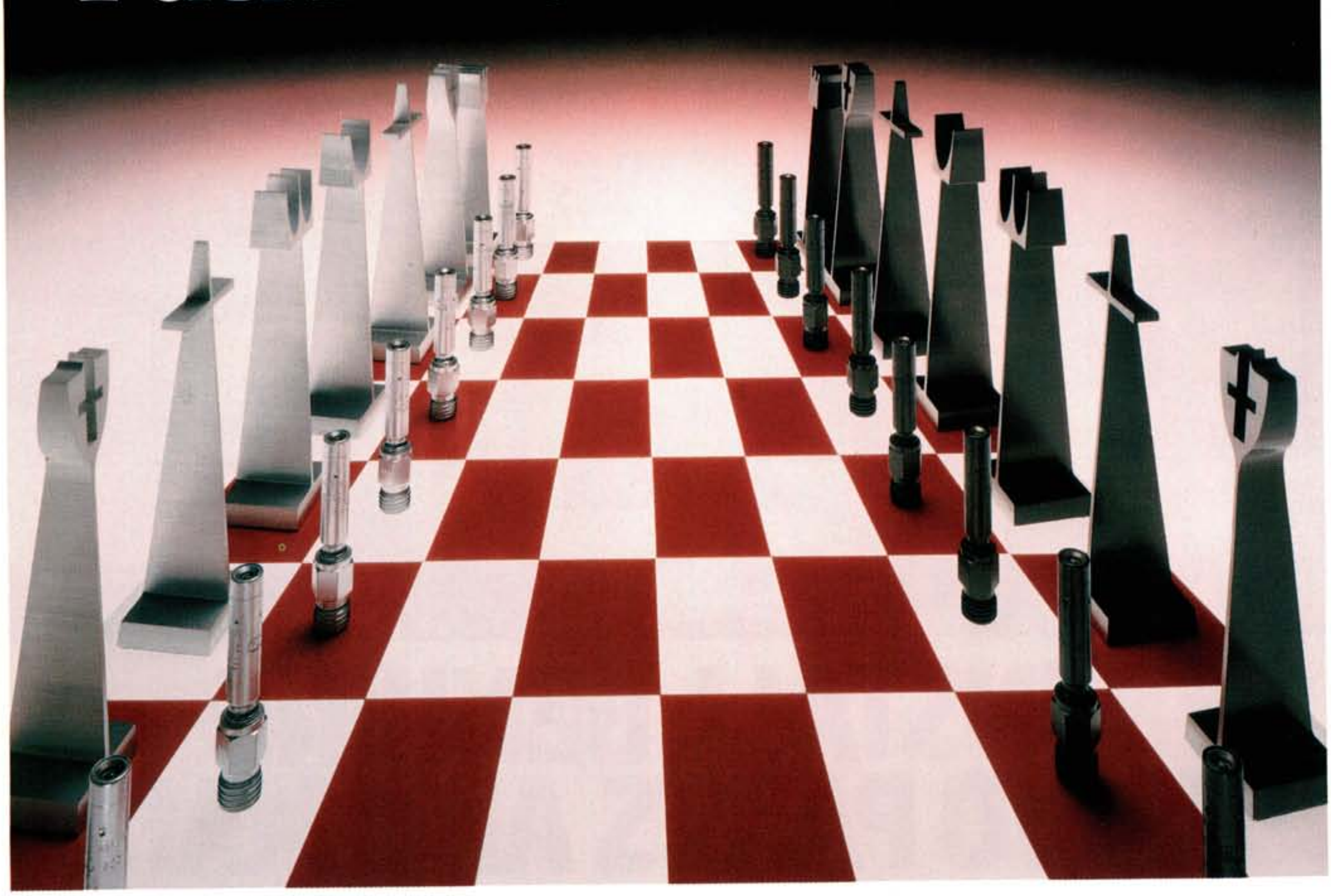
KE-Jetronic

Fuel Enrichment Modes



Enrichment Modes

There sure is a lot to know about KE-Jetronic. We hope that our first two articles on KE have been some help to you. But we're not through with this very precise system just yet.

Try to think of KE-Jetronic as the luxury car of the constant injection family. It's the fully loaded model, and comes equipped with a long list of options. And like any top of the line model, as it does more, it gets more complicated.

The original K-Jetronic system was almost purely mechanical. There was more wiring in the headlight circuit than there was in the injection system.

With K-Lambda, things got a bit more complicated, electrically speaking, as closed loop operation was included. But even with closed loop operation, K-Lambda was basically a mechanical system.

Finally, we saw some real fine tuning going on with the KE-Jetronic system. Switches, sensors, and computer control found their way to get into the act. There were modifications to the fuel distributor, the control pressure regulator was eliminated, and a Differential Pressure Regulator was installed. Many of us bought our first multimeters equipped to measure milliamps so we could decode messages sent back and forth between the computer and the DPR.

Block by Block

Now that you're familiar with the basic concepts behind KE, we'd like to start showing you some specific test, adjustment, and repair procedures for various components. If you understand the operating concept behind K-Jetronic, and refresh yourself with our two earlier articles, you can build your understanding of KE-Jetronic block by block.

This month we'll concentrate on the various enrichment modes built into the system to provide richer mixtures under the following circumstances:

- **Cold Cranking**
- **After-Start Enrichment**
- **Warm-Up Enrichment**
- **Cold Acceleration Enrichment**
- **Wide-Open-Throttle Enrichment**

Mixture Enrichment Modes

For cold starts, we still have the faithful cold start injector. The cold start injector squirts fuel into the intake plenum. It's activated when the key is in the start position, and the thermo-time switch is cold enough to provide ground. It's the same setup used on the old K-Jetronic.

But we no longer have control pressure regulation, so the ECU has to fatten the mixture coming from the injectors to provide after-start enrichment. A cranking voltage signal is sent to terminal number 24 of the control unit whenever the starter cranks.

To test for cranking voltage at terminal 24, ground the coil wire so the engine won't start. Then turn the ignition key to the start position. You should have cranking voltage at terminal 24 of the ECU plug-in connector. If you're using your logic probe to backprobe the connector, and the red light comes on, you know you have a minimum of 10 volts which is acceptable.

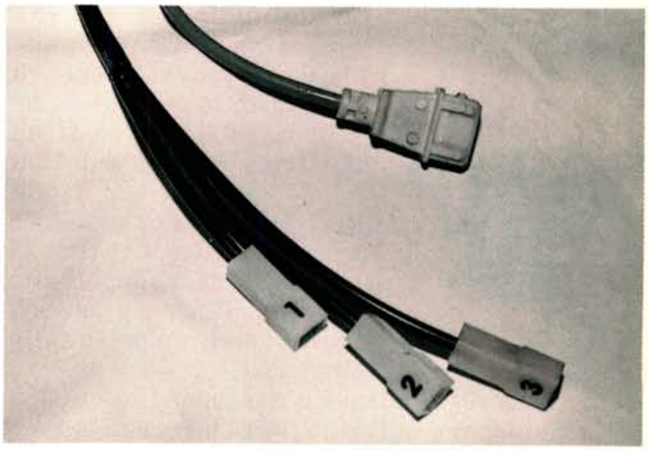
But the computer needs one more message from the Coolant Temperature Sensor before it'll instruct the Differential Pressure Regulator to richen the mixture. After all, it needs to know if the engine being started is cold—or already warmed up.

Fooling The Computer

You can simulate a cold engine signal by plugging a 15K ohm resistor at the Coolant Temperature Sensor (CTS) harness. Then connect your milliammeter in series with the DPR harness.

Crank the engine for a second and a half. You should get a 70 mA reading. If not, double check to be sure you have the starter crank signal at terminal 24. Also check between terminal 21 at the ECU connector and ground to be sure you have your 15K ohm signal signaling a cold engine.

If these signals are good, check for an open between the ECU and the DPR connector. That's good too? Then you'd better try another ECU.



If you do any amount of work on KE systems, you should purchase the correct connectors and fabricate a patch harness, or simply buy one that's already made, like this Zelenda harness, P/N VW 1501. A harness saves a lot of time during hookups, and keeps you from damaging terminal ends.

After-Start and Warm-Up Enrichment

The Coolant Temperature Sensor signal continues to play a very important role after the engine springs to life. Back when cars had carburetors, a choke break or choke unloader was used to open the choke blade just enough to keep the car running after start up. The choke stayed on part way, however, and opened slowly to provide after-start enrichment.

A similar thing happens in the KE system. Milliamp signals of 120 mA or more will richen the mixture from 20 to 50 seconds after start up, depending on engine temperature. (You begin to see just how important the engine's coolant thermostat is to proper fuel system operation—both cold and hot.)

Milliamp signals will decrease to the 80 to 110 milliamp range after the initial after-start enrichment period. The milliamp signals will gradually decrease as the engine warms and CTS resistance falls. This warm-up enrichment mode allows for smooth, stumble-free warm ups.

Remember that lower means leaner when you think of milliamp readings on KE-Jetronic.

Test procedures and milliamp values are slightly different for Mercedes-Benz cars. First disconnect the oxygen sensor and substitute a 2.5K ohm resistor for the CTS. Ground the coil wire and then crank the engine for three seconds. Leave the ignition key in the "on" position. DPR current should go to 24 mA and then drop back to the 9-14 mA range.

Cold Acceleration Enrichment

Okay, so you have enough enrichment to keep the engine running when it's cold and the throttle is closed. But what happens when you step on the gas to accelerate with a cold engine? How is the fuel system supposed to know the difference between closed and open throttle operation while the engine's cold?

Just because the mixture is rich enough to keep the engine idling, doesn't mean it's rich enough to keep the engine from stumbling and sagging during cold engine acceleration. We need more gas in a hurry.

In our first KE-Jetronic article, we mentioned the Airflow Position Sensor, or APS. Voltage signals from the APS inform the ECU about the position of the sensor plate. As the sensor plate moves in response to an opened throttle, the message from the APS calls for more gas. (Maybe we should rename the APS the Acceleration Performance Signal as a memory aid!)

APS Tests With Engine Running

Follow these procedures to check the APS:

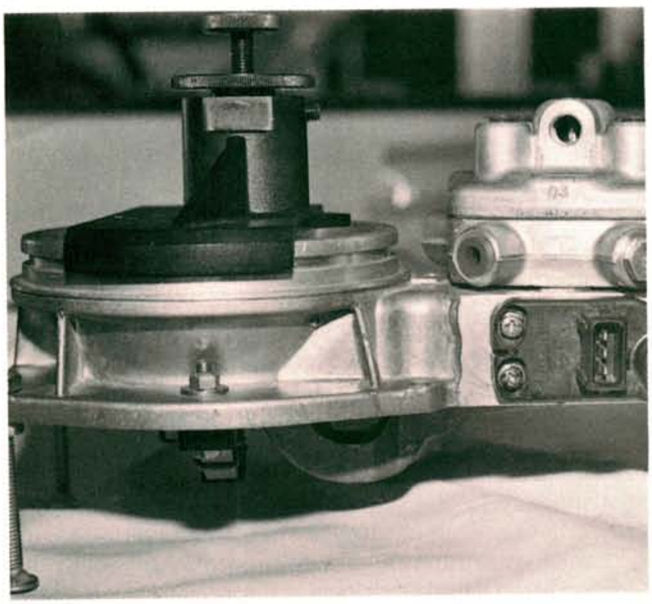
- Remove the rubber intake boot above the air flow sensor plate.
- Disconnect the wiring harness connector at the CTS to simulate a cold engine.
- Use your phone-tap patch harness and connect your milliammeter in series with the Differential Pressure Regulator and the ECU.
- Connect your pressure gauges and set them to read differential pressure (valve closed).
- Turn on the ignition. The milliammeter should read 80-110 milliamps.
- Lift the sensor plate to its full height. Milliamp readings should increase briefly and then settle back to the 80-110 milliamp range.
- Replace the intake boot and start the engine.
- Rev the engine to 2500 RPM. Lower chamber pressure should drop briefly each time you rev the engine, giving us that richer mixture we need for cold acceleration.

But What If It Doesn't Work Like That?

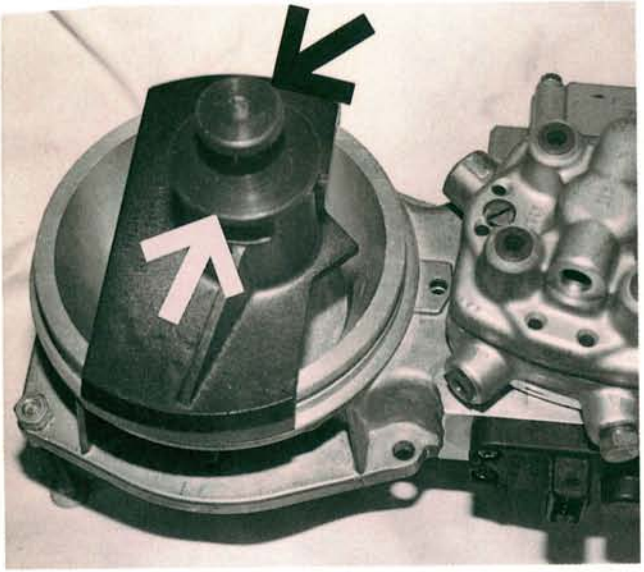
Now that you know how it's supposed to work, you probably want to know how to fix it if it doesn't.

Let's start by making some basic observations. First, the APS is adjusted at the factory. Unless someone has replaced it, something has gotten bent or broken, or the sensor plate is way out of adjustment, you shouldn't have to readjust the APS.

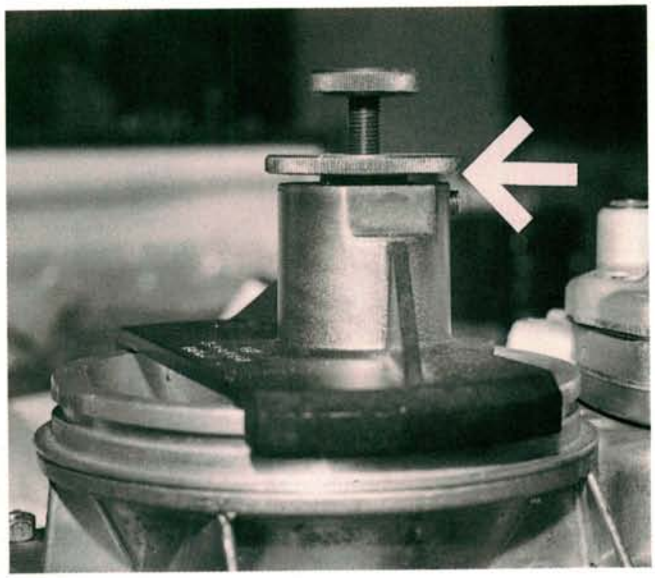
Things do happen, though. And sometimes people who shouldn't do so try to make adjustments they don't understand. Then you end up having to make things right.



One other special tool that takes the guesswork and hassle out of APS adjustment is this adjusting jig, Zelenda P/N VW 1348/1A (formerly 134811). It has a magnet at its tip to grab and hold the air sensor plate, and preset detents that hold the sensor plate in the proper position for checking APS values at idle position.



Position the jig on the mouth of the sensor cone, with the arrow on the jig facing the fuel distributor. Turn the adjusting screw until the magnet just touches the sensor plate. Then lift the larger, knurled collar to its first stop. The sensor plate is now positioned to do an APS adjustment.



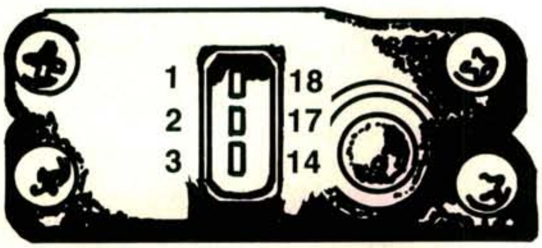
Make sure the jig fits flat and square. Lift it to its first stop. In this setting, the top of the sensor plate is even with the base of the cone. The jig can also be used to check injector fuel delivery rates at this first stop, or wide-open-throttle delivery rates when raised to its next, higher stop.

Testing APS Resistance Values-Key Off

If the cold acceleration enrichment mode isn't working, proceed as follows. We'll start with some resistance tests that are done with the ignition key off and the wiring harness disconnected from the APS. Take your readings right at the APS terminals.

• Check for free play between the sensor plate and the control plunger in the fuel distributor. You should have a minimum of SOME free play to a maximum of about 2 mm (the thickness of a nickel). If you don't have free play at the sensor plate, all other adjustments are useless.

• The terminals on the APS are numbered 1, 2, and 3, with terminal number 1 at the top. These terminal numbers correspond to the following terminal numbers at the ECU.



• Connect a high impedance ohmmeter between terminals 1 and 2 and check for a resistance of more than 4K ohms.

• Connect your ohmmeter between terminals 2 and 3. Resistance should be less than 1.2K ohms.

• Lift the sensor plate slowly and evenly. Resistance between terminals 2 and 3 should increase to more than 4K ohms.

• If readings are out of limits, you'll need to readjust the APS.

Testing Mercedes

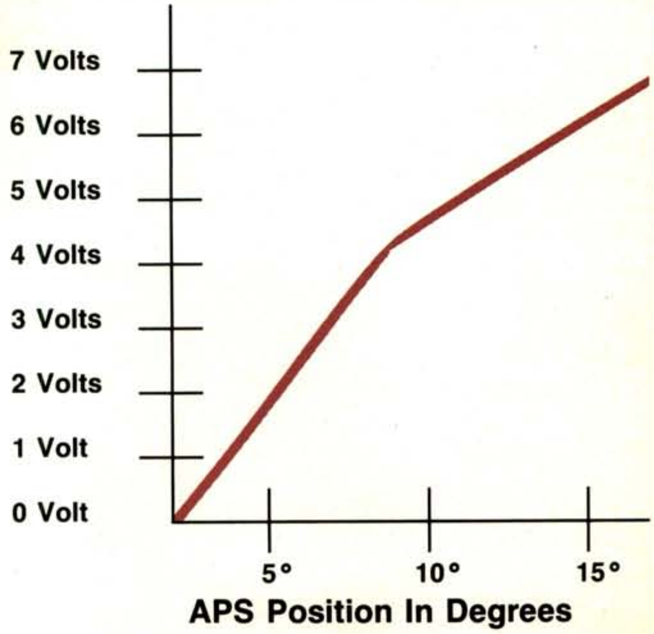
Test values and procedures for Mercedes vehicles are slightly different.

• Resistance between terminals 1 and 2 should be 3.2 to 4.8K ohms.

• Resistance between terminals 2 and 3 should be 560 to 1060 ohms with the sensor plate in the rest position. This should increase to 3.76-5.64K ohms as you raise the sensor plate to its full height.

The Mercedes air sensor must also be level with the base of the cone when adjusting the APS. If you leave the sensor in the rest position when making your adjustments, you can be off by 100 to 350 ohms.

Air Position Sensor Voltage Signal



The Air Position Sensor is a potentiometer. It can travel a total of 18 degrees. The signal it generates is not linear, however. As you can see, the most rapid change in its signal occurs during the first 5 degrees of movement, when it's needed most.

APS Voltage Values—Key On

Voltage tests are done with the APS harness connected and the ignition key in the on position. Our resistance tests told us whether or not the APS was good or bad, and whether or not it was properly adjusted.

Unfortunately, resistance values at the APS won't tell us a thing about reference voltage, or any possible problems in the wiring harness or the ECU circuit.

To adjust the APS, proceed as follows:

• Remove the rubber intake boot.

• Lift the sensor plate until the top of the plate is even with the base of the cone. (Some plates sit at an angle in the cone. Use the side of the sensor plate closest to the fuel distributor.)

• Hold the sensor plate steady in this position. Use a tool like VW 1348/1A or fabricate a tool to hold the plate in this position.

• Use a jumper harness like VW 1501 to tap into the APS circuit. Thexton harness kit number 392 will also work on these terminals. The harness plugs in line between the APS and the carside harness, but has three test leads that let you listen in. While we strongly urge you to make or purchase a test harness, it is also possible to backprobe the APS harness after gently rolling back the rubber boot at the APS connector.

• Use a 10 meg impedance DVOM set to the 20 volt scale. Connect the meter leads between terminal number 2 and a good ground.
• Turn the ignition on.
• Voltage should read 0.2 to 0.3 volts.
• If not, you'll have to loosen the four screws holding the APS so you can rotate and adjust it. The factory buried the screw heads beneath a wad of RTV. Dig out the RTV. Loosen the screws holding the APS and rotate it to get the correct voltage readings.

You saw this photo in an earlier article. To adjust the APS, loosen the four screws holding it to the fuel distributor. With the jig installed and raised to its first stop, rotate the APS and check for 0.2 to 0.3 volts. (Check between the center terminal and ground.) Retighten the screws and reseal them with RTV.

You also saw this photo before, but it's worth repeating. There has to be some free play between the sensor plate arm and the control plunger in the fuel distributor, up to a maximum of 2 mm. A nickel's worth is just fine, and when was the last time you accomplished anything with a nickel?

This is a very delicate adjustment. If you're not careful, retightening the APS mount screws is sometimes enough to throw off the adjustment you just made. Watch the voltmeter as you tighten the screws to be sure the adjustment isn't changing.
• When you're finished, reseal the screws with RTV.
• Now lift the air sensor to its full height. Voltage should increase gradually and peak out around 7 volts with the sensor fully raised. Watch for skips or opens as you raise the plate, indicating dirty or worn switch contacts.

Wide-Open-Throttle Enrichment

The wide-open-throttle switch is your normal maker-breaker, clicker-style continuity switch. It is a normally open switch. It closes when the throttle is fully opened. The fuel system then goes into open loop and the ECU adds about 3 mA to the signal sent to the DPR, richening the mixture even more.

A quick test of the WOT switch itself can be done with an ohmmeter. The switch should stay open-circuited until just before the throttle plate is fully open. One of the wires to the switch is battery hot, except on Mercedes-Benz cars where it's ground. The other wire goes to terminal number 5 at the ECU.

The WOT circuit is also fairly easy to test.

You can test WOT operation on a warm, running engine as follows:
• Connect your milliammeter to check DPR current.
• Disconnect the 0^2 sensor.
• Start the engine. Rev it over 2500 RPM.
• Manually close the WOT switch.
• Milliamp readings should increase by about 4 mA.
• If you have a CO machine hooked up, CO readings should also increase briefly.

If the engine is cold, you can also check the circuit with the engine off, as follows:
• Connect your milliammeter to check DPR current.
• Bridge the connections at the CTS connector. This simulates a warm engine signal.
• Open the throttle until it closes the WOT switch. You should get the same 4 mA increase in DPR current readings.

As you can see, a stuck or shorted WOT switch or grounded signal wire can put a real dent in fuel economy.

Summing Up

Now that you know the various enrichment modes of the KE system, you can match customer driveability complaints to specific components, tests, and adjustments within the system. Find out when the problem occurs during the starting and warm-up cycle. Match the problem to the enrichment mode that should be taking care of enrichment at that point. It'll help you zero in on the source of your problem.

—By Dré Brungardt