Helpful hints by John Robison

Diagnosis of Code 44 and 45 in 1990-1995 Land Rovers with 14CUX engine management

This is the motorhead column. The Robison on Rovers article is for the general Land Rover enthusiast. If you're not a motorhead, I suggest you return to the Robison on Rovers article and continue from there.

OK, you're still here. Even though the title spells it out, I'll repeat here that this article is mostly for people with 14CUX Land Rover engines, but the theory applies to all modern fuel injected motors. 14CUX motors came in 3.9 and 4.2 litre sizes, and utilize distributors vs coil pack. They were made between 1990 and 1995 for the US market. I'll make the assumption that all of you reading this article know you have a box under the passenger seat, and the box has a 2-digit display that shows faults codes, and the reason you are here is that your box is showing code 44 or code 45. Or maybe you just had a beer-induced vision that your box is going to show 44 or 45 soon, and you want to be ready. Or maybe it showed 44 or 45 last week and you just paid $1,000 to fix it, and you want to know what they did. Or maybe you're just curious.

So, you've got a code and you'd like to know what to do next. Penicillin, anyone? You've read that these codes mean oxygen sensor left bank (code 44), or oxygen sensor right bank (code 45). Do you replace the sensors? I've stated many times on the bulletin boards that these codes do not usually signify a bad o2 sensor. So what do they mean? To understand, we'll have to look at what o2 sensors are and how they work.

The job of oxygen sensors, commonly called o2 sensors and occasionally called lambda sensors, is to sniff the outgoing exhaust and provide an electrical signal corresponding to the oxygen content of your exhaust. The sensors tell the engine management computer - the ECU - if your motor is running rich or lean. Oxygen sensors contain elements that react with oxygen when heated to produce an electrical signal. Because heat is required, the o2 sensors do not function until the motor has warmed up.

Once they are warm, the o2 sensors produce a voltage that varies between about 0.1 volt and 0.8 volt to indicate a rich or lean engine condition. Rich or lean, you say? What if it's running just right? Well, there is no such thing. The ECU in a modern catalyst equipped engine switches it between a rich state and a lean state at a rate of one to three times per second. They don't ever run "in the middle." They do this because catalytic converters function much better when switched in this way. This need for switching is the principal reason carburetor's vanished from catalyst-equipped cars in the 1980s as catalytic converter technology evolved.

The engine is trimmed toward a rich or lean average by adjusting the ratio of time spent in each state; for example, by running in a lean state 40% of the time and a rich state 60% or vice versa. When the engine is switching back and forth in this mode the ECU is said to be running in closed loop mode. In this mode the engine ECU constantly adjusts the firing time of the fuel injectors to keep switching from rich to lean in the desired ratio.

From a cold start, the ECU can't get into closed loop mode until the o2 sensors warm up and begin responding. So it has a program called warm up or open loop that uses values from memory to set the mixture while the engine heats up. Land Rovers usually get into closed loop mode within 5 minutes of cold start, or even faster. To speed up this process the sensors in your Land Rover have heating elements that get them hot quicker. As soon as the sensors start responding the ECU switches from warm up mode to closed loop mode, where it evaluates all the other sensor inputs in view of their effect as seen in the o2 sensors.

The ECU takes in a number of inputs to decide what this rich/lean ratio should be. Engine temperature is monitored, because a colder motor needs a richer mixture. Throttle position is monitored and compared to the signal from the air flow meter to determine if the engine needs to be sped up or slowed down. Obviously, speeding up the motor will call for more fuel. These and other parameters are collected by the ECU through the various sensors on your motor.

Through all the changes that take place in normal driving, the engine should remain in closed loop mode. If you were to connect an oscilloscope to the o2 signal lead, you'd see a roughly square wave as it transitioned back and forth - rich to lean. Switching cycles speed up as the motor runs faster and they slow down as the motor slows. If the switching cycle comes to a halt - meaning the o2 sensor signals rich or lean all the time- a fault code 44 or 45 is set. The engine has to stick for over a minute for a code to set, so the system is not "hair triggered" as some people believe.

So once a code 44 or 45 has set what do we do to find the problem?

First, we use a scope to see if either o2 sensor is switching. If one is switching and the other is not, we have a problem that is confined to one side of the motor. If neither are switching the problem affects both sides of the motor. So, let's hook up the scope . . . but wait! Where do we connect it?

To use the scope, you need to understand what the various wires do. Each o2 sensor has either three or four wires. In early trucks, the white wire is ground, the red wire is the heater, and the black wire is the o2 sensor signal. One confusing thing here is that the colors change on the vehicle side of the o2 sensor connector. On the vehicle side the colors are blue for the o2 signal and white/orange for the heater. On a newer truck with four wire sensors the fourth wire is a second ground for the heater, so you have red/black and blue for the signal circuit wires and white/orange and white for the heater circuit wires. We'll test the heater circuit first. Whenever the truck is running, you should measure 12 volts between the heater wires. A reading of zero usually means the truck is not really running (thought you'd fool me, eh?) but if the truck is really running, it means you have identified your wires wrong (likely) or you have a wiring problem in the harness (unlikely).

Assuming you measured 12 volts, the next step will be to shut the truck off and unplug the sensor. Use a multimeter to measure the resistance between the two heater leads. Measuring between the heater wires you should get a reading of between 6 and 30 ohms. A much higher reading (hundreds or thousands) means the heater has opened up and failed, and you need a new sensor. A near-zero reading (under 2 ohm) indicates the heater has shorted, and again you need a new sensor. But make sure you did the measurement right, because a shorted heater circuit will generally blow the fuel pump fuse and the truck won't run.

Made it past this test okay? Next we'll look at the signal wires.

Reconnect the o2 sensors and get the vehicle running. You're going to need to measure the signals between the o2 signal and ground wires. You may do this with slick insulation piercing probes or you may use straightened paper clips in the connector. However you do it, connect your scope ground to the ground wire and the signal to the signal wire. Set your vertical sensitivity to .2 volts per division, your sweep speed to .1 second per division, and

your input to DC coupling. Don't understand this? Get a book on scope operation and read it. It's more than I can go into here, but the ability to use a scope and understand the settings is key to successfully diagnosing modern cars. Usually this is done one sensor at a time, unless you have a slick 2-channel scope that allows you to see both sensors at once. Check to see if the sensor is switching or if it's a flat line. A line that is flat at zero means a dead o2 sensor or broken wiring. If that's your situation, the testing stops till a new sensor is fitted, at which time normal operation should resume. A voltage line that is flat at some voltage level between .1 and .9 volt means the motor is stuck somewhere in the rich/lean continuum. If that's your situation check the other sensor and see if it's the same and read on - you'll follow different paths depending upon whether one or both sensors are stuck.

Let's start with diagnosis of a motor where neither sensor switches. We begin with our scope connected to the signal lead and a can of choke cleaner or the new flammable brake parts cleaner in our hand. Spray the choke cleaner into the air intake while the motor is idling. You should hear the engine stagger as it gets overfed on fuel and goes way rich. Did your o2 signal move? If yes, your engine is stuck lean. You should look for causes of lean running - vacuum leaks, weak fuel pumps, bad fuel pressure regulators, etc. If there is no response to the choke cleaner, move on to the next test.

Pull off a vacuum line and see what happens. Does the line move or cycling begin? If so you've got a motor that is stuck rich. Common causes are ignition misfires, incorrectly connected plugs wires, injector problems, or a burnt or stuck valve or piston.

Neither test caused the line to move? You did something wrong. Either a bigger shot of choke cleaner, or a bigger vacuum leak, or the correct connection of the scope is going to get a result. Go back and do it again.

What if only one side is stuck? The test procedure is the same but the causes are different. Look for misfires of one cylinder, a sticking valve in one cylinder, a single stuck or bad injector, etc. Look for faults that are specific to one cylinder. It often helps to pull the plugs - you will often see one plug that looks different from the rest.

If you complete these tests, you'll find the answer to why your code was set. In most cases, it will be some fault that made the truck run rich or lean, and fixing it cleared up the problem. If, after all this, you still cannot see what's wrong, your next stop should be a shop with the specialized Land Rover test gear. They can plug into the ECU test connector and see the actual readings from the o2 sensors alongside all the other sensor readings. That final bit of information may make the difference in solving a tough problem.

Next issue, we'll cover another aspect of Land Rover testing. Two Robison articles per issue you say? What a treat. I agree. Send money, ten dollar bills or postal money orders will be fine. See you in the summer.