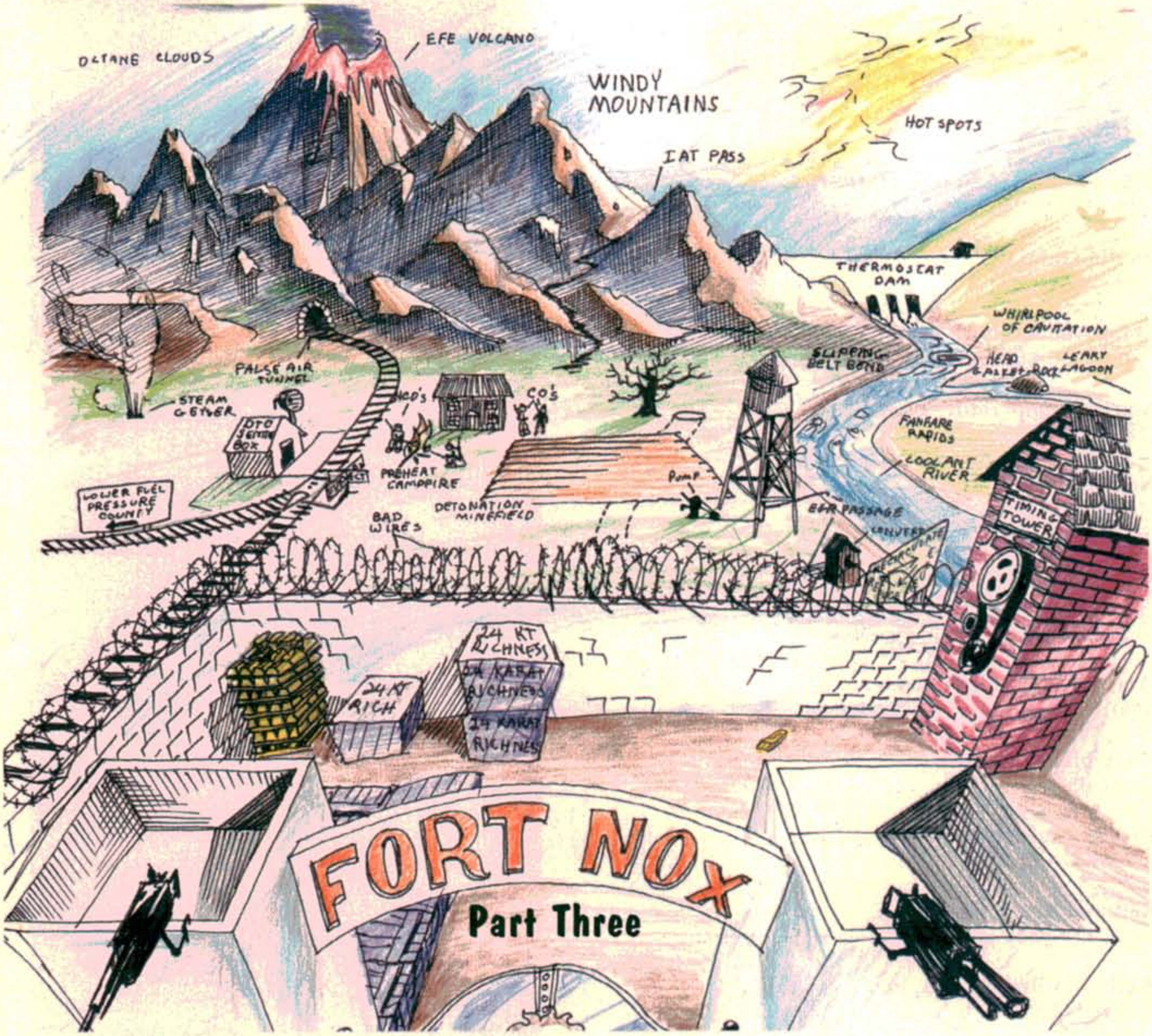


Illustration by Ken Johnson

Welcome back inside the friendly confines of Fort NO_x! As you may recall, last month's issue featured a Honda which had failed the I/M 240 test for excessive NO_x. This month's car, a 1988 Volvo 240, was also an I/M 240 NO_x failure. While the owner of last month's car had insisted there were no driveability problems, and had blissfully ignored the car's persistent pinging, the Volvo's owner readily acknowledged a lack of power. He also told us that his car pinged badly under all conditions unless he used high octane fuel. Even on high-test, the Volvo still pinged mildly on acceleration.

Although he couldn't remember all of the painful details, he also told us about an incident that had occurred about two years earlier. It seems the engine had progressively lost power, before finally dying on the side of the road. It had been necessary to replace the entire exhaust system "and some other kind of complicated stuff in the engine" before the car could be brought back to life. A bit more questioning and a peek under the hood confirmed the presence of a new mass airflow meter.

Various hypotheses immediately presented themselves:

- A rich-running condition might have carboned up the engine so thoroughly that the compression still remained high, even a couple of years later.
- An inoperative O_2 sensor might have caused a rich running condition, but might have been misdiagnosed as a mass airflow meter failure.
- Or....well, you get the idea. In any event, it was time, once again, to start with the basics.

—By Sam Bell

NO_x Checklist

We've checked the boxes that apply to our vehicle.

Preliminary Checks

____ Fluid levels (especially oil and coolant).
__X_ Possible DTCs at MIL lamp: EVP, **low O_2S volts**, lean exhaust, ECT or IAT out of range.

NO_x Prevention

____ EGR: stalls engine if added at idle, engine runs rough if EGR added at 2000 RPM, check vacuum supply at cruise. Check EGR valve temperature.
____ Intake air temperature. Are the EFE and intake air preheat systems functioning properly?
____ Cooling System: Check head temperature, circulation, hot spots, plugged passages, air pockets, antifreeze quantity and concentration, thermostat, belts, hoses, radiator flow, cooling fan and controls.
____ Timing: Check base timing, timing advance (check for sticking), timing control system, knock sensor, TCSA system.
__**X**_ EGO: verify O_2 sensor function (cross counts), check for false air/vacuum leaks, fuel pressure and volume tests, other lean of condition causes.
____ Engine Mechanical: valve timing, hot spots, excessive compression, spark plug heat range.
____ Load Factors: Proper tire size, differential final drive ratios, payload exceeded?
____ Fuel: Correct octane level?

Treatment

____ Check catalytic converter reduction bed efficiency, measure external temperature difference before and after catalytic converter.

Symptoms:

__**X**_ Ping
____ Dieseling
__**X**_ Lean exhaust
_____Backfires through exhaust
__**X**_ I/M 240 failure
____ Low EGR temperature
____ Stalling, rough idle, high HC, low CO_2, possibly high O_2 and CO, high EGR temperature

Converter Chemistry

We mentioned the 24-karat goal of "richness" in our first installment, but we need to explain how a high-CO condition helps our NO_x control strategy. Our first goal is to prevent or minimize the production of NO_x, but we can see that some NO_x will be produced under almost all circumstances. So the next question becomes what to do about it after it has been formed in the combustion chamber. The task of NO_x reduction falls to "pre-cats" or to the appropriately named reducing bed of the two- or three-way catalytic converter. The basic chemical reduction reactions are:

$$CO + 2NO \rightarrow 2CO_2 + N_2;$$

$$4HC + 10\ NO \rightarrow 4CO2 + 2H_2O + 5N_2;$$

$$2NO_2 \rightarrow N_2 + 2O_2;$$

$$\text{and } NO \rightarrow N_2 + O_2$$

All of these reactions are expedited by the rhodium-based catalyst in the catalytic converter.

As you can see, one of the ingredients that is needed for cleaning up NO_x is CO! It is for this reason that we do not actually want to hold our mixture at a constant 14.7:1 ratio, but instead want it to vary between slightly rich (to facilitate this NO_x reduction reaction) and slightly lean (to supply enough O_2 to allow oxidation of HC into H_2O and CO_2 and of CO into CO_2 in the later beds of the converter.)

Like other catalytic converter reactions, there is a minimum "light off" temperature of about 260 degrees C (500 degrees F). Look for converter operating temperatures in the 765 degrees C (1400 degrees F) range in a normally operating car. As with other converters, the outlet should be hotter than the inlet.

Cleanup Duty

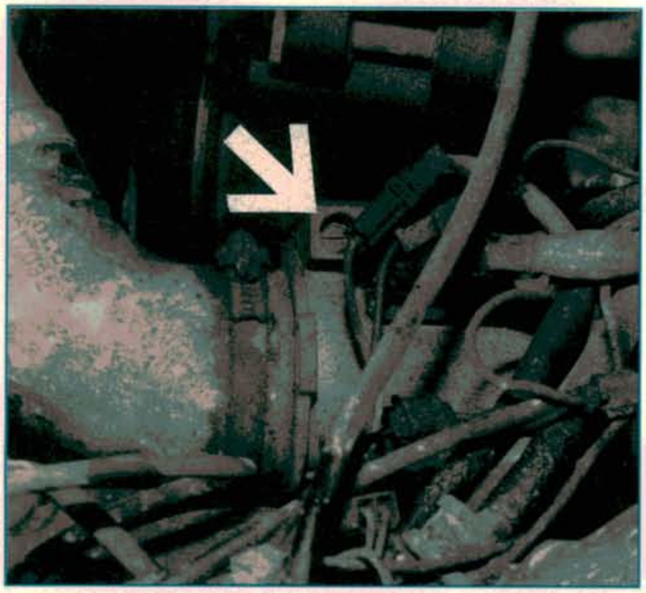
Most of the NO_x failures you will see will be caused by lean mixtures or inoperative EGR valves. But you're also likely to see other types of failures as well. If you're working on a car that has failed an I/M 240 test for high CO emissions, there is one step that is easy to overlook after you've finished fixing the root cause of the rich running condition.

A carbon cleaning treatment should always be performed to remove the combustion chamber deposits the rich mixture may have left behind. If this step is overlooked, the now leaner-running engine could turn into a NO_x failure when the vehicle is retested.

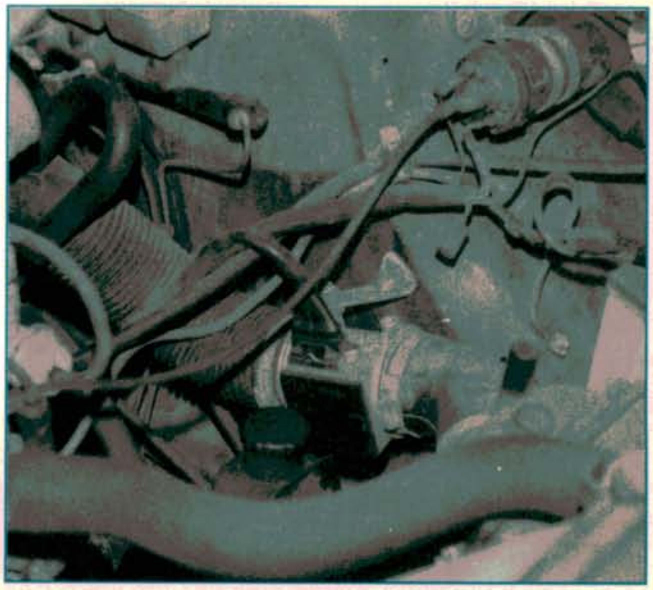
The lean mixture produces extra combustion chamber heat. The heat in the combustion chamber causes the leftover combustion chamber deposits to warm up and glow, which can cause preignition and additional NO_x formation. Suddenly you've got a whole different kind of emissions problem.

It's awfully hard to explain to your customers how their car, which previously failed for CO and HC, now passes for CO and HC and fails for the one thing it was previously able to pass for (NO_x). Remove the carbon before retesting the car.

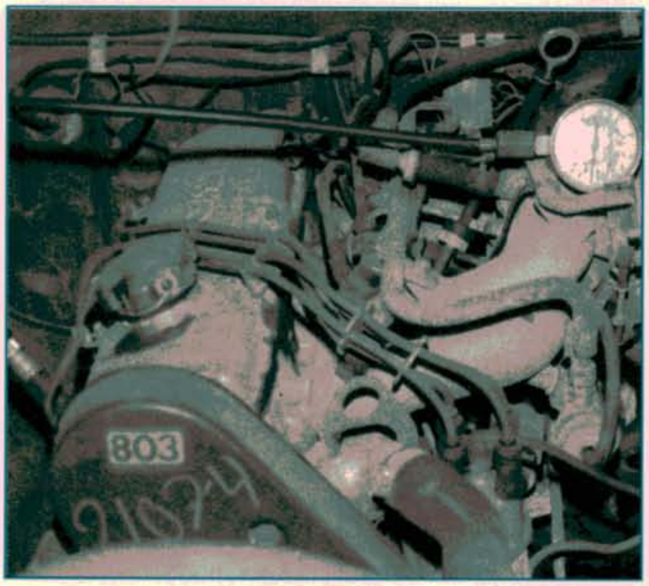
Fort No_x Part Three



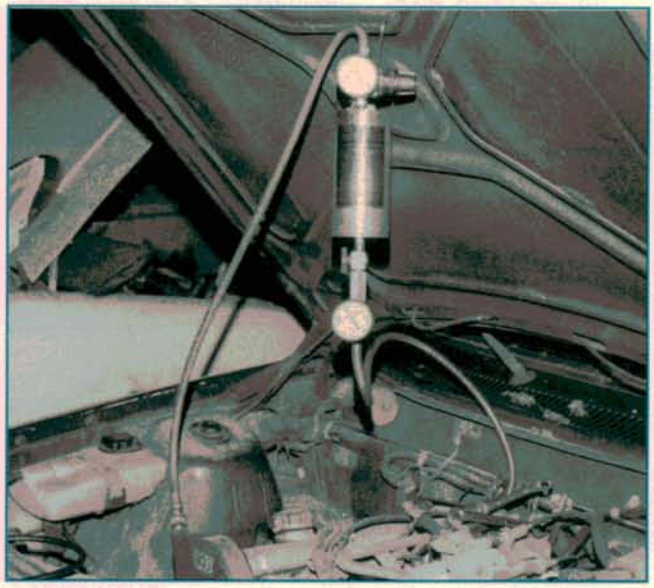
The CO section of the I/M 240 printout traces indicated a very lean condition. Most Volvos don't use EGR for NO_x control. Could it be something as simple as a mixture adjustment? It seemed unlikely, so we continued our step-by-step analytical routine. Refer to the subhead in last month's article for an explanation of I/M 240 trace analysis.



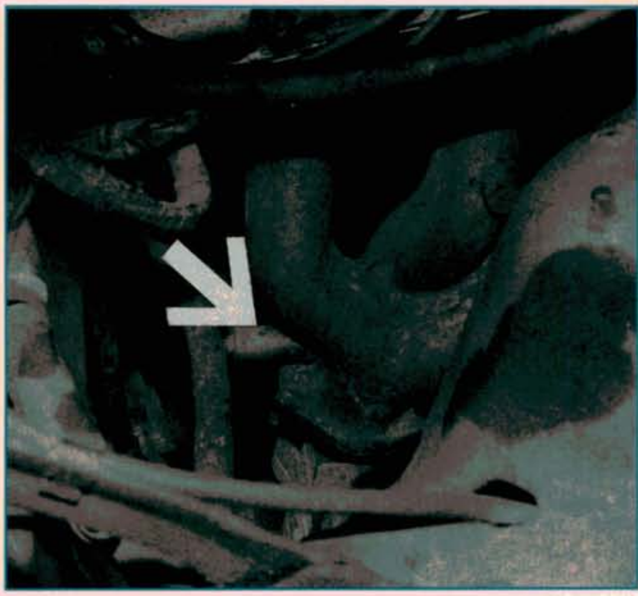
With last month's Honda still fresh in our minds, we took a few minutes to check the Volvo's preheat system. It uses a wax-pellet type system to control intake air switching. Our trusty heat gun confirmed that the preheat control door was cycling appropriately. Well, we really hadn't expected it to be that easy to find the problem.



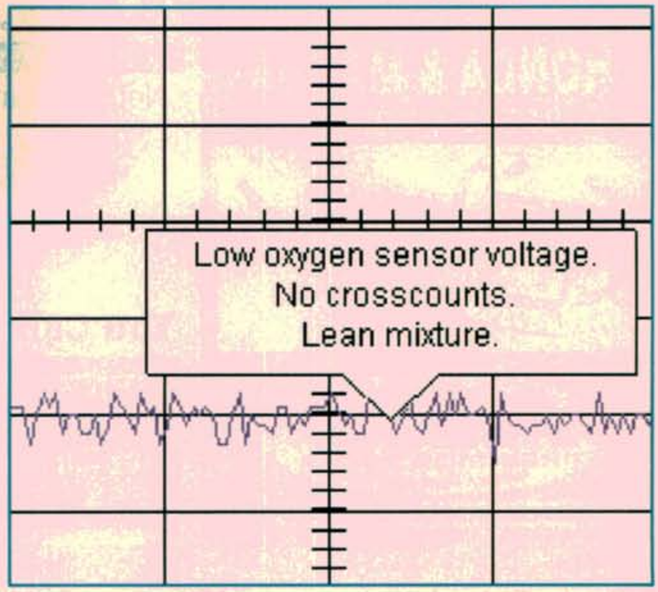
A road test confirmed the presence of a light ping under load and a lack of performance. The temperature gauge read normal. A compression check would rule out a valve timing or carbon buildup problem. A reading of 185 PSI on all cylinders seemed high for this engine. We rechecked ignition and valve timing. They were right on the money.



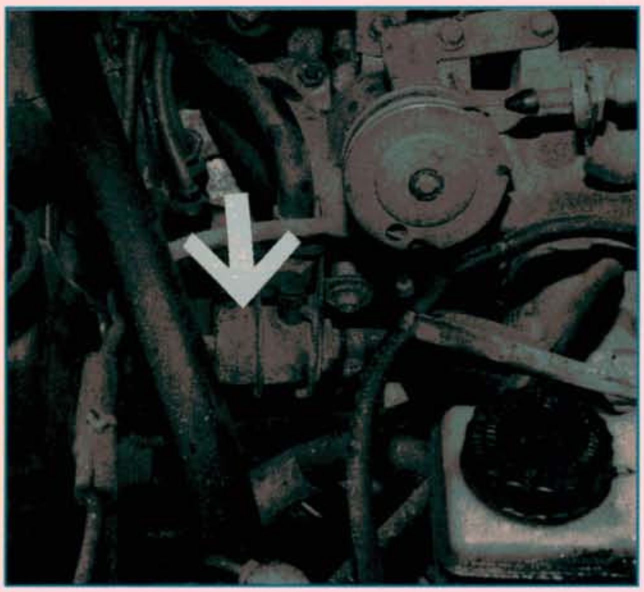
The next logical step was a thorough carbon cleaning. Clogged injectors could account for the lean running condition and the combustion chambers might be carboned up. We pulled off the fuel feed and return lines, looped them back onto one another, then started up the engine with our cleaning apparatus supplying the fuel.



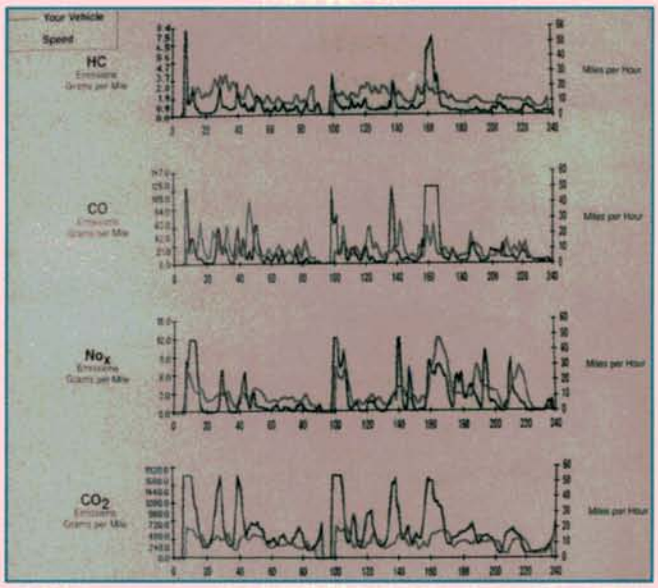
The engine sounded dramatically better soon after we started it up. This seemed like an opportune moment to check O_2 sensor function, so we pulled out our trusty lab scope, attached it to the sensor lead with a 10:1 probe and looked at the results. Not only did the motor sound fine, the O_2 traces were those of a good-running engine.



As soon as we restored the car to its own fuel system, O_2 sensor activity ground to a halt and the engine was running lean again. It looked like the Volvo wasn't getting an adequate fuel supply. We pulled the return line off the regulator and measured a flow of about 750 ml in 30 seconds—more than enough volume.



We quicky discovered that the fuel pressure was just 1.5 bar (20 PSI). With the gauge attached, we slowly clamped down on the return line until the pressure reached 2.5 bar (36 PSI). O_2 sensor activity also returned to normal as pressure increased. We ordered a new pressure regulator and kicked ourselves for neglecting to check fuel pressure first.



We hope you've enjoyed this series from Fort NO_x and that you have found the information to be useful. Even if I/M 240 testing hasn't gotten started in your area, an awareness of NO_x control can help you find and fix a number of slippery driveability problems. And who knows? You may just manage to smuggle a little of the gold out of Fort NO_x!