Volvo TechTips

Information for the Independent Volvo Specialist

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Summer 2022

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Beyond the Bulb

Also Inside:

- Resealing Front Engine Cover
- Valvetrain
- Catalytic Converters

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Head of Volvo Car USA Parts Operations
Michael Lohfink
Director, Parts Operations

Head of Volvo Car USA Wholesale Parts Programs
Richard King
Senior Analyst, Parts Business

Head of Volvo Car USA Customer Service Strategy & Communications
Roman Grudinin
Senior Specialist, Customer Service Strategy & Communications

Publisher
Tamra Ayers Banz
tbanz@AutomotiveDataMedia.com

Editorial Director
Dick Moritz
dmoritz@AutomotiveDataMedia.com

Contributing Writers
Kevin Parkhurst, Gary Smith, Sean Stephens, Wayne Riley, Frank Walker

Art Director
Christopher M. Ayers III
ayersc3@AutomotiveDataMedia.com

Group Publisher
Christopher M. Ayers, Jr.
cayers@AutomotiveDataMedia.com

Editorial and Circulation Office:
134B River Rd., Montague, NJ 07827

Features

Resealing Volvo XC90 V8 Front Engine Cover

An oil leak or burning smell might indicate a leak from the front engine cover. Here's the procedure for resealing front engine covers.

Volvo V8 engine

You might have a customer that comes in complaining about an oil leak or maybe a burning smell. On the Volvo XC90 V8, the front engine cover might be leaking and oil could be all over the under chassis. In this article, we will go through the procedure of resealing the front engine cover.

First thing you might want to do is steam clean the engine to help clean it up for the procedure. This is a big job, so make sure to organize all of the parts during disassembly. The vehicle will need to go onto a hoist when doing this job. Disconnect the battery in the back of the vehicle.

Remove the four bolts, two on each side, near the strut towers, for the top mount cross bar. Remove the bolt at the engine mount, and set the cross bar out of the way.

Remove the cover over the ECM and the air filter housing by pulling straight up. Disconnect the ECM electrical connectors, being careful not to break the connectors when removing them. Disconnect the air mass meter connector. Remove the two bolts that hold down the fresh air intake to air filter housing and remove.

Loosen the hose clamp at the hose that connects the air mass meter to the throttle housing and remove air filter housing by pulling up. Set the filter housing out

Top cross bar for engine mount

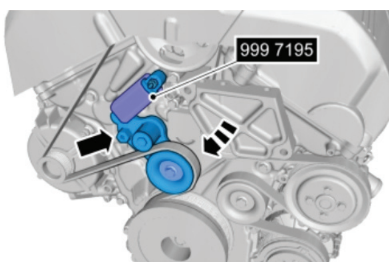
ECM connectors that need to be disconnected of the way. Remove the upper engine cover and both covers over valve covers. Pull out the dipstick so not to damage it.

Remove the four bolts that hold down the top mount and set aside. Raise the vehicle up and drain the oil and coolant. While the the vehicle is up, remove the protective cover and the six bolts that hold it in place. Once bolts are removed, lift up and pull out.

Lower vehicle and, on the front side of the engine, you will want to remove the expansion tank and power steering reservoir. If possible, remove all the fluid from the power steering reservoir so as not to make a mess.

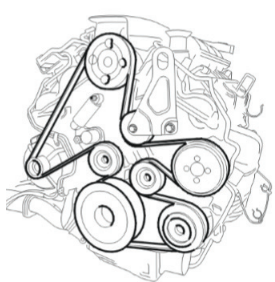
Remove the cover over the power steering pump, two bolts. Lift the cover from the top of the pump. Disconnect the ground cable between the engine block and chassis. Remove the oil line to the steering pump and plug the pump to prevent leakage.

Now you will be able to expose the auxiliary belt tensioner. Using a long ½ inch breaker bar and socket, pull from front of the vehicle, clockwise to 230 Nm. Pulling back should take about 20 seconds before inserting tool number 9997195 to lock in place. Now you will be able to remove the auxiliary drive belt.



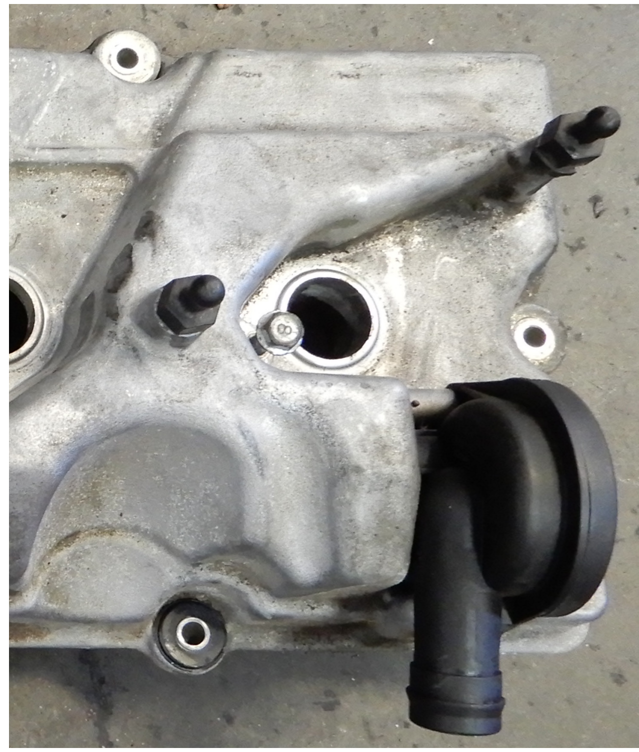
Auxiliary belt tensioner with tool in place

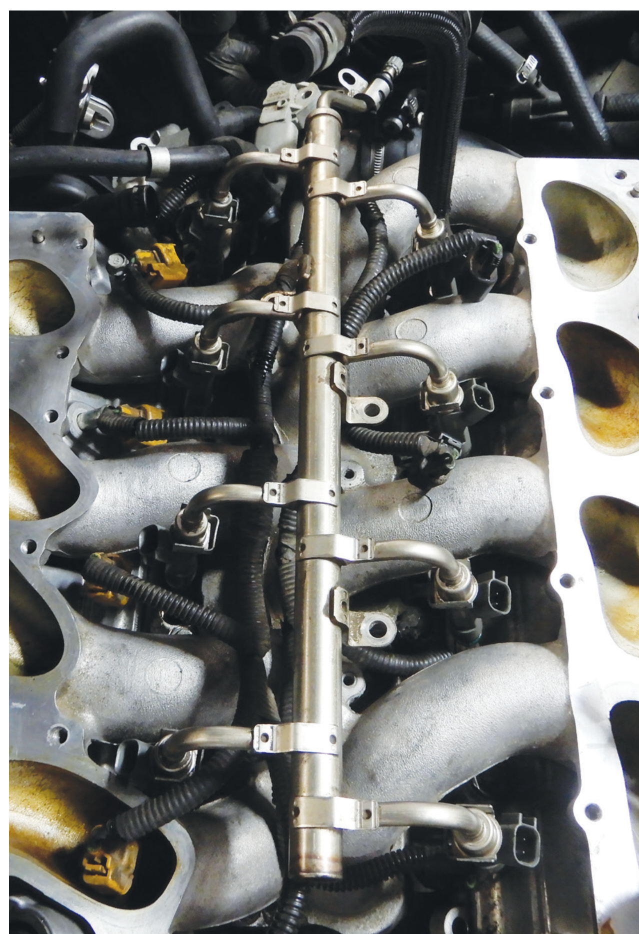
Before removing the drive belt, it's a good idea to take a photo of the belt routing.


Auxiliary drive belt routing

Now that the belt is removed, remove the connector at the top of the engine at the intake manifold for the pressure and temperature sensor, and also remove the two vacuum hoses to the check valve and distribution damper.

Remove the brake vacuum hose near throttle housing. Remove the hose at the throttle body from air mass meter. Remove the two nuts and screws that hold the throttle housing to the manifold. Now you will be able to disconnect the hose to the coolant pipe and throttle body. Remove the two bolts that connect the non-return valve for crankcase ventilation to the valve cover near the firewall. Disconnect the vacuum hose at the manifold.


Crankcase ventilation non-return valve connected to valve cover


Fuel rail in place that will need to be removed

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Remove the 21 bolts that hold the top intake manifold in place, lift up manifold and remove the two bolts that hold the coolant manifold to the bottom of the intake manifold. This will make the job a little bit easier, instead of disconnecting the coolant hose. If the coolant hoses are damaged, be sure to replace them when reassembling. Now you can remove the fuel rail, making sure to release the pressure. Remove the ventilation hose between the two valve covers, two hose clamps. There are three bolts that secure the fuel rail that need to come out, and the two at the fuel pressure sensor. Disconnect the main supply and return hose from the rail. Lift up and remove the fuel rail.

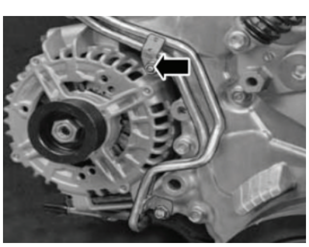
Now for the lower intake manifold; remove the 12 bolts that hold it in place. Remove it from vehicle. Remove the hose from the power steering pump to the reservoir cap at pump. Remove the three bolts that hold pump in place; looking through the pulley you will see the three bolts.

Next will be to remove the valve covers. First disconnect the electrical connectors at the coils. On the valve cover near the firewall, remove the fuel lines and remove the bolts at the bracket. Set the lines out of the way. Remove the bolts that hold down the ignition coils and remove the coils.

The valve cover is close to the radiator, so remove the cam sensor electrical connector and harness and push it down out of the way. Remove the seven bolts that hold the valve cover on and remove the valve cover.

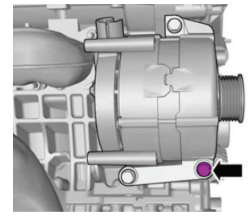
At the valve cover, near the firewall, you will need to remove the bolt near the alternator that holds the fuel lines in place. Disconnect the cam sensor and ignition coils and set the harness out of the way. Remove the bolts from the valve cover and remove from engine.

Now for the front engine cover, you will need to remove the two idler pulleys for the drive belt.



Bolt that needs to be removed from fuel lines near the alternator. Once the bolt is removed, move the lines out of the way.

Also remove the front pulley at the water pump, four bolts, and set aside. Remove the front bolt at the bottom of alternator that is connected to the front cover.



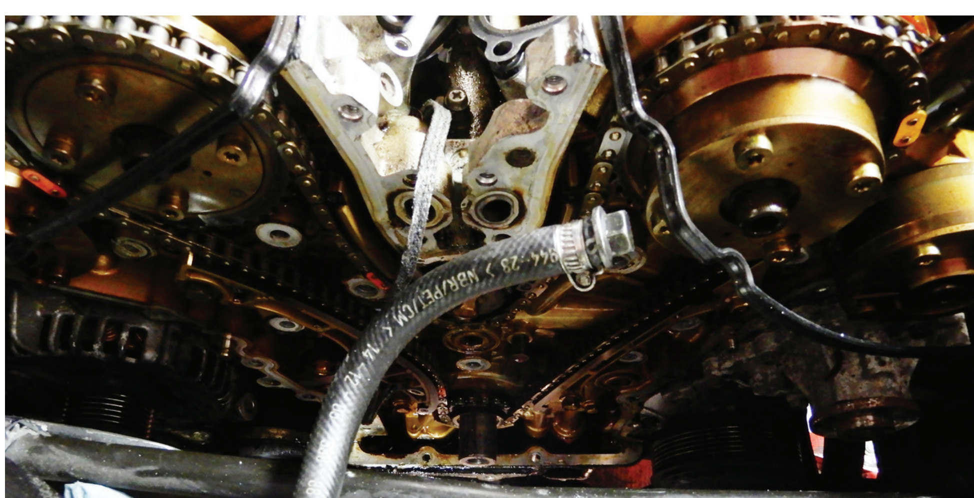
Bolt at alternator that will need to come out

Raise vehicle up on a hoist and remove the right front tire. Remove the inner plastic fender; this will help to get to front cover. Now you will want to remove the front crank pulley. Using tool number 9997196, secure it into place and remove the front bolt from the pulley. Use puller 9997198 to remove the pulley from the crankshaft. Now the front engine cover is exposed and ready to remove.

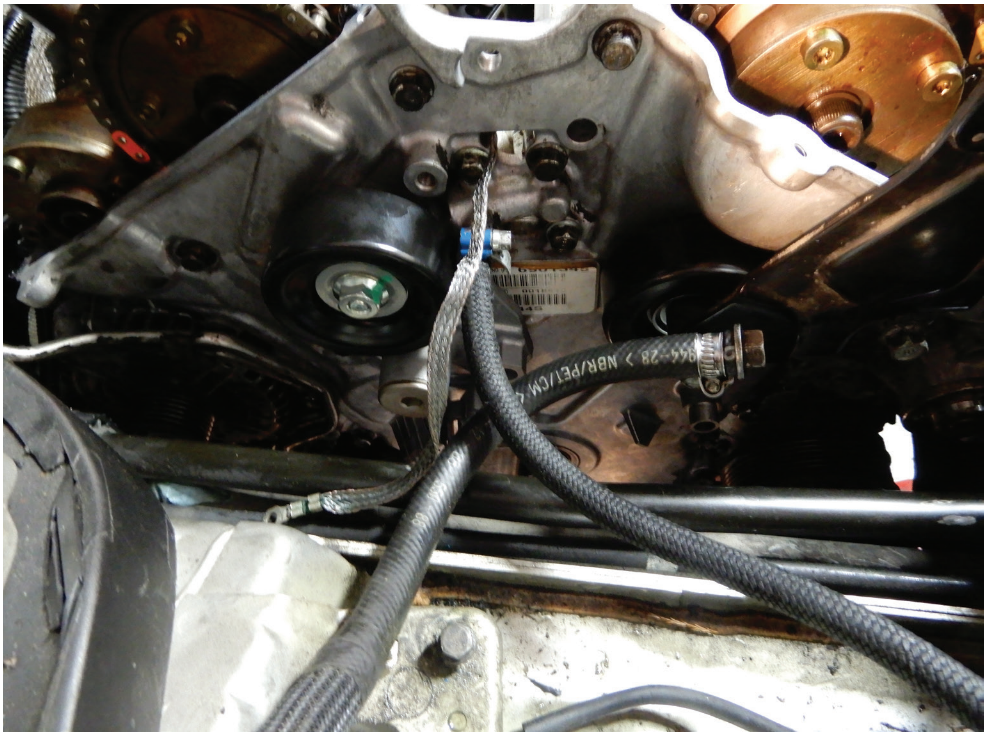
You will need to remove engine mount that is connected near front engine pulley. Using a jack and a block of wood, set it under the oil pan and jack up. Remove bolts at the front mount and remove the engine mount. Now remove the 24 bolts that hold the front engine cover on. Once all the bolts are out, remove front engine cover from engine. Check timing chain, guides and tensioner to make sure all are in good working condition.

Clean the front cover and engine block, making sure not to damage the surface. Once the cover and engine block are completely clean, you can now install the cover back onto the engine block. Using sealant part number 30757050, add sealant to the cover. Do not leave sealant on the cover for longer than five minutes. Install the front cover onto the engine block. Insert the 24 bolts into the cover and torque down to 24 Nm.

Install the new idler pulleys for the drive belt and tighten down. Do the same with the water pump pulley.



Front engine cover removed from engine



Front engine cover installed with idler pulleys

Install the bolt you took out of the alternator to front engine cover and tighten. Install a new seal at the crankshaft; use tool number 9997197 with the front crankshaft bolt and tighten down until the tool bottoms out. Remove the bolt and tool, and install the front crankshaft pulley; using special tool number 9997198 screw into crankshaft. Use the counter hold tool number 9997196 that connects to the front pulley, now screw in the center bolt at tool 9997197 until the pulley is completely installed. Remove the tools and tighten down the center bolt for the crankshaft pulley.

Both valve covers secured onto engine

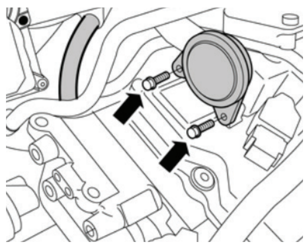
Now for the valve covers, first make sure all surfaces are clean and free of debris. Install a new valve cover gasket onto the valve cover. Install the valve cover onto the engine starting with valve cover closest to the firewall. Make sure nothing is in between the valve cover and engine. Install the seven bolts and torque down to 10 Nm. Install the other valve cover and secure in the same manner. Secure the bracket for the wire harness that connects to the bolt for the valve cover.

Install the ignition coils and tighten down. Run the ignition coil electrical harness to each coil and connect each electrical connector to its coil. If the connector is broken, this would be the time to replace it and the terminal. On the valve cover near the firewall, add the bracket and fuel lines, connect the fuel lines and secure them to the valve cover. Install the bolt at the front engine cover that holds down the hard fuel lines.

Install the electrical connectors for the vacuum valves at the front side of the valve cover near the firewall, and connect the camshaft sensor electrical connector on both sides.

Install new lower intake manifold gaskets and set the lower intake manifold into place. Install the 12 bolts that secure the manifold into place and torque down. Install fuel rail with injectors, lubricate the o-rings at the injectors and fit the fuel rail into place. Install the three bolts that hold down the fuel rail and tighten. Tighten the two screws that hold the fuel pressure sensor in place. Connect the fuel pressure hose to the fuel rail and tighten.

Add the hose between the top intake manifold and the crankcase ventilation non-return valve and tighten down the hose clamp. This makes it much easier to install the return valve into the valve cover after the top manifold is in place.



Hose from top intake manifold to ventilation return valve connected and ready to fit into valve cover

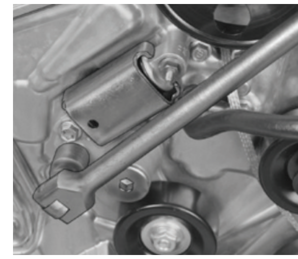
Set the power steering pump into place and tighten down the three bolts that secure it. Connect the power steering pressure line to the pump, and use a new o-ring.

With new gaskets in place, install the top intake manifold, install two bolts that hold the coolant manifold to bottom of the intake manifold, be sure to use a new rubber gasket. Make sure to connect the vacuum hoses. Install the 21 bolts that hold the intake manifold in place and torque down. Now slide the return valve into the valve cover and secure the two bolts that hold it in place. Connect the pressure sensor and temperature sensor electrical connectors at the intake manifold.

Install the top engine mount. Install the throttle housing with a new gasket and install the two nuts and the two bolts and tighten down. Connect the two coolant hoses and tighten the clamps. Connect the throttle housing electrical connector.

Set the air filter housing into place, and connect the hose from the throttle housing to the air mass meter at the filter housing and tighten the clamps. Connect electrical connectors to the ECM and air mass meter.

On the front of the engine, you will need to add the auxiliary belt tensioner. Install the center bolt and the top nut for the tensioning and damping element and tighten. Connect the ground strap from the body to engine and also connect the expansion tank hose to the engine. Route the auxiliary drive belt around the pulleys accordingly. Use tool number 9997279 at the center bolt of the tensioner. Using a breaker bar, turn clockwise to 230 Nm and remove tool number 9997195 from the tensioner and release the breaker bar. Make sure the belt is riding correctly on each pulley and tension is good.



Breaker bar with tool number 9997279 on belt tensioner for installing drive belt

Set the expansion tank and power steering reservoir in place. Connect the power steering delivery hose to the power steering pump and to the reservoir and tighten the two clamps. Secure the bracket at the front of the engine for the power steering pressure hose. Connect the coolant hoses at the expansion tank and tighten the clamps.

Install the cover over the power steering pump and covers over the valve covers. Raise the vehicle up and install the inner plastic fender, along with the front tire. Raise the vehicle completely up and install the skid plate, six bolts hold it in place. Install the protective cover on the subframe, six bolts hold it in place.

Lower the vehicle down, install the fresh air duct for the air filter housing and secure the two bolts that hold it down. Set the top cover over the engine into place and push down to secure. Put the cover over the ECM and snap into place.

Add power steering fluid, raise the vehicle up just so the front tires are off the ground and turn the steering wheel back and forth, without starting the vehicle, to remove all air from the system. Continue to do so until bubbles are completely gone. Fill with coolant and top off as needed. Check the engine oil and top off if needed.

Connect the battery and start the vehicle. Check the power steering fluid and add if needed. You might get a few air bubbles in the power steering. If so, shut the vehicle off and turn the steering wheel back and forth until air bubbles are gone again. Repeat if necessary.

Check the vehicle for any leaks, test drive and check again. ●

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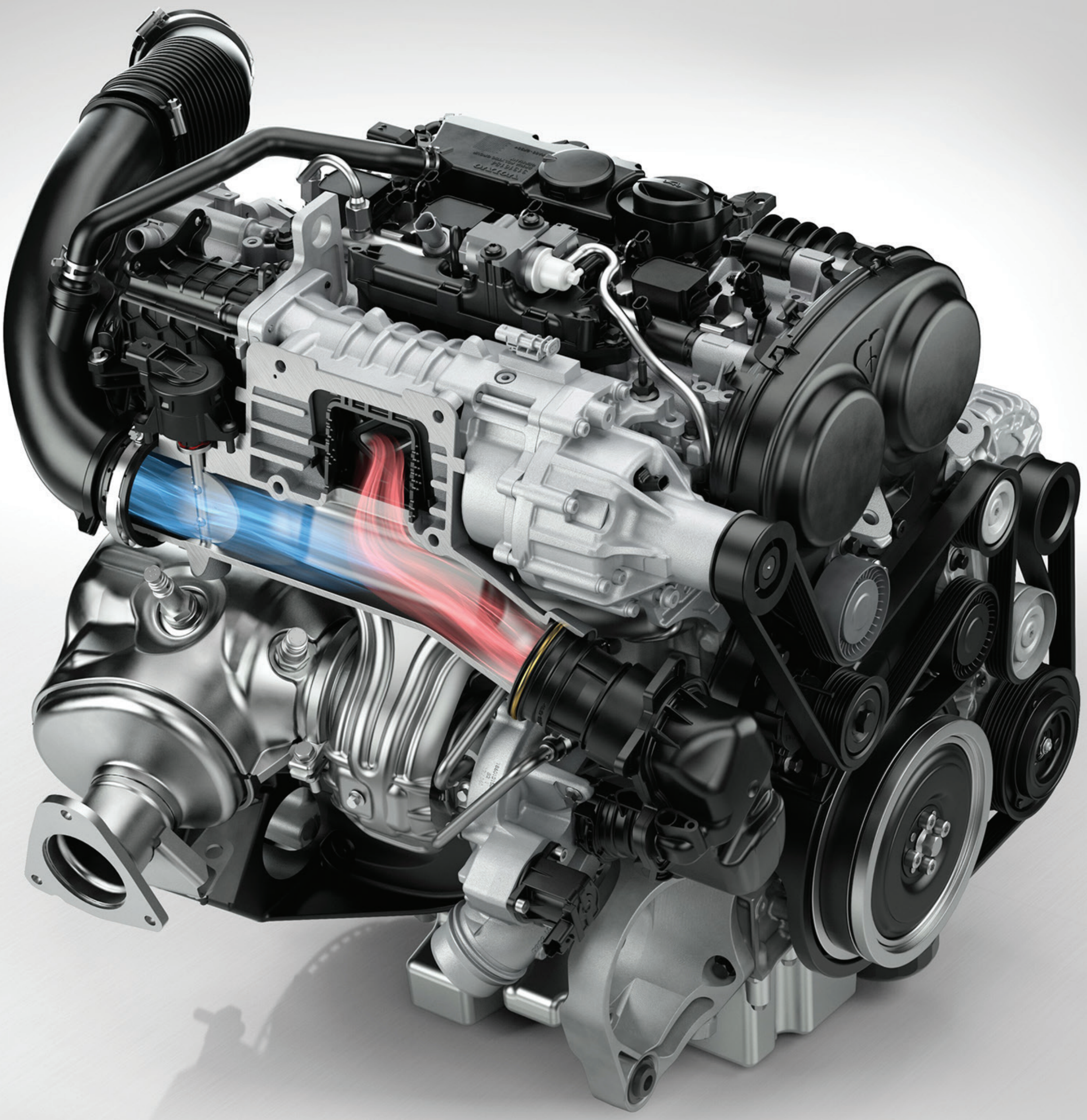
Two Vexing Volvos Violate Validated Valvetrain Viewpoints



Wow.

Sometimes in the world of diagnostics, we run into some extremely hard to solve technical problems. Most of the time these days, the issues we are pursuing relate to the electrical and electronic control side of things. Sensors, Engine Control Modules (ECMs) and Central Electronics Modules (CEMs), ignition and fuel, driveability—all of these areas concentrate heavily on the electrical side of things. In fact, most of the automotive training found around the nation these days revolves around electronic control theory, chasing DTCs, electrical diagnostic techniques, lab scopes and related subjects like communication networks.

It is true, many of our driveability and electrical faults can be directly traced back to the electronics realm; however, there are vehicles that remind us from time to time that there is quite a bit more involved than just the electrons. Because we have nearly all of the mechanical systems today being either monitored, directly controlled, or both, by computer electronics, we encourage technicians to begin to learn and apply a new twist or concept in diagnostic thought and embrace the fact that in a modern computer-controlled vehicle environment, the mechanical units actually become the modulator for the electronics, and not the other way around.

Think about everything we've learned related to this thought. We have a Check Engine light, we use a scanner to pull codes, then we search service information for schematics and DTC charts, and we begin. Some more experienced techs have learned a rhythm to this process and can nail down many driveability and electronics problems quickly and effectively, but every so often, we get a doozy or two.

When we have a driveability issue, a misfire for example, or a surging throttle, conventional diagnostics has us going down the path (depending on DTCs, of course) of checking voltages, grounds, sensor and input signals, and output control signals as well as output device testing. But this is where we can get lost very quickly if we are not savvy to the fact that the engine is the actual modulator for the computer controlling it. Think deeply about this as you read forward, because the two vehicles we discuss here were some of the most twisted up and challenging cars we've had to solve back-to-back recently.

In these two cases, we had very similar Volvo vehicles with the same engines and almost exactly the same customer complaints. The problem at hand with the first Volvo, a 2017 S60 T5, with a B4204T11 engine that presented with P0301 and P0302 misfire DTCs occurring, along with a very frustrated technician and an equally exasperated shop owner and vehicle owner.

The back story here is that even though the vehicle was presenting with misfire DTCs, there was no perceptible misfire at all. The engine in this case was running "glassy smooth," as the technician said. Not even a hint of a misfire on this car, yet fairly quickly after startup, cylinders 1 and 2 would start rapidly counting misfires on the scanner, followed by the ECM disabling said cylinders via its engine protection strategy, Limp Mode. You're thinking cold-start carbon issue here, right? We wish.

All manner of repairs had been done to this car. Then, even more repairs after the repairs in chasing these ghostly misfires. What repairs, you might ask? Let's start with the original complaint, which was a hard misfire in cylinder 3. The engine was originally diagnosed with burned exhaust valves, and the cylinder head was removed and sent to a local machine shop (name withheld to protect the guilty).

The cylinder head was reinstalled and the engine misfired badly, only to be removed once again and sent back to the machine shop. (Repeat this process 2 more times, in the interest of saving space for the good part of the story.)

The usual suspects, spark plugs, fuel injectors, coil, MAF and a few other goodies were all thrown at this Volvo, but to no avail. As we interviewed and worked with this technician through his previous diagnosis to where we were now, we decided to cut to the chase and do some mechanical waveform analysis, as it didn't seem they were getting to the answer with the scan tool and the machine shop. We decided to hook up the scope and overlay the cam sensor, crank sensor, and in-cylinder pressure waveforms to see if we could determine quickly what was going on with this car.

What was the issue? Electrical or mechanical? We needed to narrow this down first.

ECM-P030100 Cylinder 1 Misfire Detected. General Failure Information. No subtype information, B4204T9

Diagnostic trouble code (DTC) information
Condition

The engine control module (ECM) checks the engine's combustion regarding misfires by registering speed deviations in the flywheel's rotation. A high number of misfires is deemed to affect emissions or be damaging to the catalytic converter. The diagnostic trouble code (DTC) is stored if the control module detects that:

- An excessive number of misfires registered for several cylinders during a number of crankshaft revolutions.

The control module's test for the diagnostic trouble code (DTC) starts in the event of:

- Engine running.

Note
The control module can only detect the fault conce the test has been started and the diagnostic trouble code (DTC) is stored when the conditions are met.

Substitution

- None.

Possible source

- Low fuel level.
- Repeated cold starting where the engine coolant temperature (ECT) has not reached normal operating temperature between starts.
- Damaged spark plug.
- Contaminated or incorrect fuel.

Figure 1: The P0301-00 misfire DTC chart describes the condition and Set Enable Criteria.

Fault symptoms[s]

- 1Q, Driving/Poor performance/lacks power/At take off
- AB, Starting/Engine hard to start/cranks slowly/ Unsure when/at all times
- AE, Idling/Uneven idle
- AJ, Driving/Poor performance/lacks power
- AK, Driving/Hesitates/surges/Unsure when/at all times
- AL, Driving/Hesitates/surges/During acceleration
- AM, Driving/Hesitates/surges/During deceleration
- BV, Driving/Hesitates/surges/At steady speed
- DL, Warning lights and chimes/Malfunction Indicator Light ("Check engine" light) indication/no indication
- IV, Text window and warning symbol/ Text message

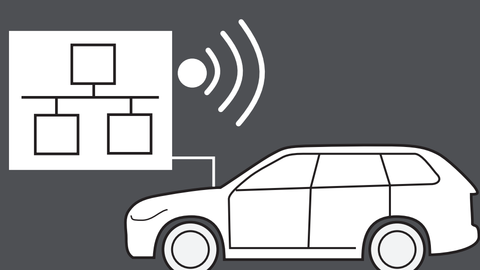
Fault-tracing
Checking other diagnostic trouble codes (DTCs)
Check that there are no faults in Engine control module (ECM) that have generated trouble codes for functions that may lead to misfiring.

- Fuel-related fault for fuel pressure or too low fuel level.
- Heated oxygen sensor-related (lambda) faults for fuel adaptation.
- Camshaft failure or defective camshaft adjustment.
- Electric failure of ignition coils and injectors.

Read diagnostic trouble codes by clicking the vehicle communication symbol.

If there is a trouble code set for above described function areas, stop the troubleshooting and troubleshoot acc. to relevant trouble code.

Fault-tracing
Check the counter values to see the fault's frequency and reproducibility.



If the frequency is at least medium, the OTC is considered possible to reproduce.

A fault that may be perceived as intermittent may be permanent at special driving conditions, e.g ., certain load ranges, rpm and temperature intervals.

Therefore it is important to look at the frozen values to be able to recreate the driving conditions when the fault was detected.

By reading off the average value of misfiring from the 10 latest operating cycles, a good picture can be built up of the chances of reproducing the fault.

Figure 1A: The P0301-00 Fault-tracing from the DTC chart. There are many possibilities, both electrical and mechanical that can cause the fault code. So, which is it? That is the question.

Once we scoped the car and gathered and saved some different files of the engine and sensor characteristics, we realized that there were really no indications in the ECM signaling versus the mechanical cam and crank timings that would cause this misfire issue in cylinders 1 and 2. After some further quick data checks to the air and fuel sides of the engine, our support crew decided that whatever this was, the computer was not happy with what it was seeing going on with cylinders 1 and 2. So what now, when everything checks out okay?

The Engine IS the Modulator for the Electronic Control System

Remember earlier we mentioned the engine is the modulator for the electronic control system? This case and the next 2015 Volvo right behind it (in the same week, believe it or not), proved this beyond a shadow of a doubt.

Think about this; a set of crankshaft sensors and camshaft sensors are reading the rotating shafts via toothed wheels or reluctors, calibrated to the camshaft and crankshaft's true position, and the ECM's misfire algorithm essentially analyzes crankshaft speed variations to determine misfire (see Figure 1A). What happens when twice or three times (at the cost of many arduous hours), we test over and over to find that, beyond a shadow of a doubt, these mechanical timing marks and sensors are indeed lined up properly, synchronized, and functioning perfectly, yet we still have the issue?

Could it be ECM programming? Possibly, but in this case, there were no posted TSB bulletins nor ECM software updates found specifically for our problem. Plus, the vehicle also has a new and freshly programmed ECM anyway, so there's that.

And there's the fact that the cylinder head has been off three times and back to the machine shop for so-called valve adjustments; there's that too.

Figure 3 shows the next test, which was an individual cylinder overlay of cylinders 1, 2, 3 and 4 for comparison.

We decided to ask the technician to record and save in-cylinder pressure waveforms under very strict setup conditions for each of

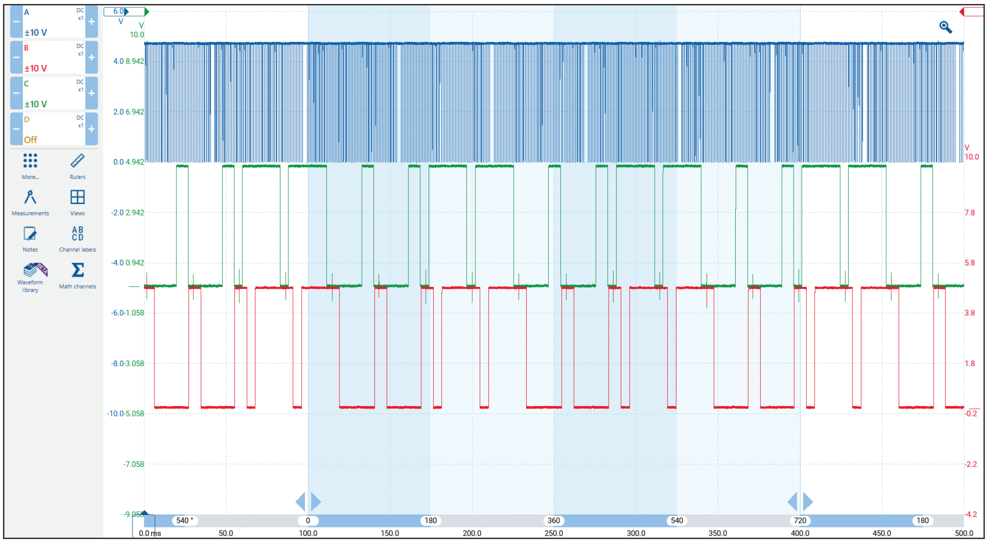


Figure 2: A typical camshaft-crankshaft sensor modulation signals with the mechanical engine running. The engine itself is the modulator for the ECM's control of the engine.

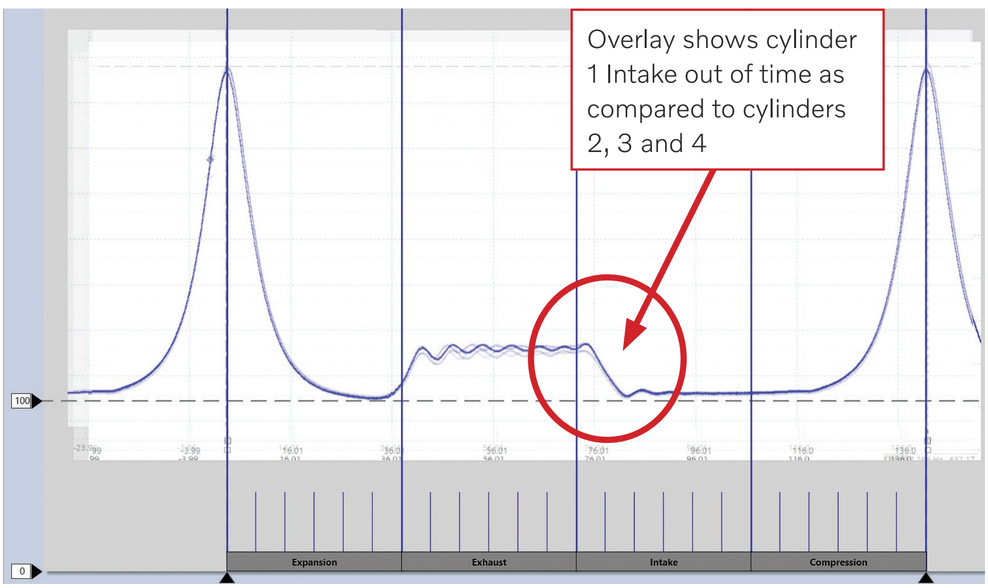


Figure 3: This overlay shows cylinder 1 with a valve timing problem caused by incorrect valve adjustment procedures.

the Volvo's four cylinders, so that a comparison could be made across the entire engine. This test is what we often use to determine several engine characteristics that can definitively diagnose things like broken or worn valve springs, valve leakage, and tough-to-find conditions too, like a worn camshaft lobe on one cylinder. But in this case, we were using the overlay test to check the gas exchange section (where the valves are opening and closing to exchange air) and making sure all four cylinders had exactly perfect overlays as compared to the others. Here, we saw our problem relatively quickly, but solving it would be the challenge. Figure 4 shows the variance of the exhaust valve opening on cylinder 1.

Once we performed the in-cylinder pressure waveform overlay and identified the issue, we advised the shop owner to remove the cylinder head once again, to see what the trouble was. This time, we had the shop disassemble it themselves, and purchase the Volvo special tools setup jig for the cylinder head valve adjustment. See Figures 6 and 6A for tool callout.

An Overhead Cam Machine Shop Trick is Uncovered

Upon disassembly of the head for the umpteenth time, it was discovered that the machine shop, in rebuilding the head, had used a technique called "Tipping the Valves," which allows the machine shop to quickly set valve lash when setting up the head. Tipping the valves involves grinding down the tip of the valve stem itself so as to adjust the valves to the lifter buckets in the head. This of course, is a risky way to adjust valves in most production engines, but yet, we find this is becoming a more common practice, as we untangle some of these gnarly diagnostics.

If we grind the valve stem instead of using the camshaft tools for measuring and setting up the lifter buckets properly to adjust lash, we necessarily change the valve installed height. Doing the valve adjustment this way led directly to the problem on our S60 T5; the machine shop, thinking only in terms of valve lash adjustment, and lacking the Volvo camshaft jig for valve clearance adjustment, actually ended up changing the camshaft's timing on the opening and closing of the valve in that one cylinder, as shown in Figures 3 and 4.

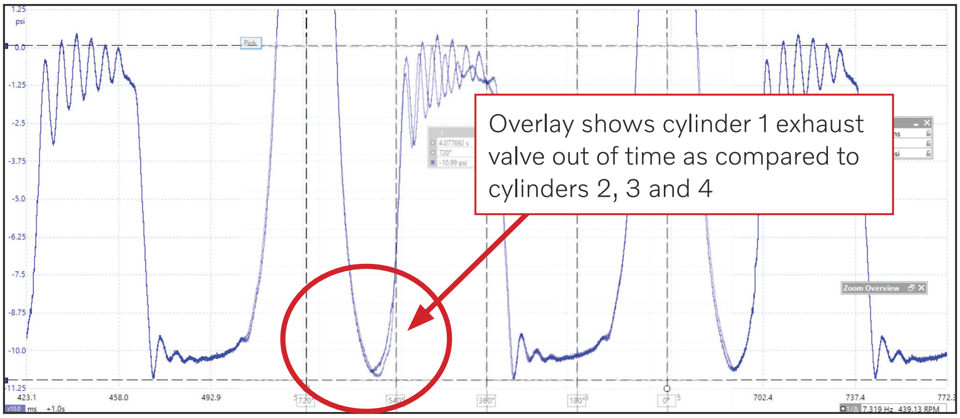


Figure 4: In this overlay zoomed view, we can see the difference in exhaust valve timing in this one cylinder contributing to the crankshaft speed imbalance. This was a direct result of tipping the valves. Had the tappet adjustment procedure been done using Volvo special tools and tappet swaps, this failure would likely not have been installed in the vehicle.

This is exactly what the ECM was seeing in the form of a slight difference in crankshaft speed due to the difference in valve opening times, which triggered a misfire DTC in cylinder 1 and the cylinder next to it while the engine was running.

To the humans—the driver, the technician and the shop owner—this misfire was entirely imperceptible while operating the vehicle. However, once the dreaded misfire code set and the drive cycle criteria were met, of course the ECM knocked out the injectors on cylinders 1 and 2 on which it saw the problem occurring. So, no matter whether or not you could feel a misfire before the codes set, you certainly couldn't drive it once injection was disabled in cylinders 1 and 2.

The fix for this vehicle was to replace the valves and set the valve lash properly using Volvo special tools.

The instructions show that once the cam jigs are set up, the cams are rotated clockwise, and valve lash is to be obtained by using the tappet (out of the set) that provides the proper lash. This procedure was clearly not done this way and as a result, the valves were ruined and had to be replaced.

The second case, a 2015 Volvo S60 T5 (same engine) was even more confusing. We had essentially the exact same codes, cylinders 1 and 2 misfire, and this car was also experiencing no perceptible misfires. Strangely, the cylinder head had also been off this car twice and at the machine shop for the same reasons.

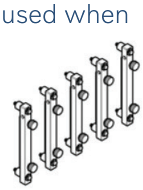
When this vehicle showed up on the support line two days after the first, we thought we would find the exact same problem. After a basic discussion with the technician about the external misfire-causing possibilities, plugs, coils, injection, etc., we decided to run the same tests as we did on the first vehicle above. Strange thing here was, we did not see any of the valve opening variance we saw in the other engine. So what gives?

What we did notice was that the intake cam was advanced by about 13 degrees (subject to cursor placement on the waveform), so we advised the technician to correct this. Indeed, once this was corrected, we all felt confident that the issue was solved. But not so much. Upon startup, this car had the exact same condition as before, the misfires set and the cylinders went dead.

After a fair amount of scan data analysis and a retest of the engine mechanical waveforms, we determined that we still could not detect any mechanical cylinder

Figure 5: A valve grinding jig for valve stem tips. This procedure must be done properly, or all manner of problems can result.

Figure 6: Part number 999 7578 Cam Cradle Tool is used for proper valve clearance adjustment on this B4204 T11 engine. These tools were not used when machine shop tipped the valves.



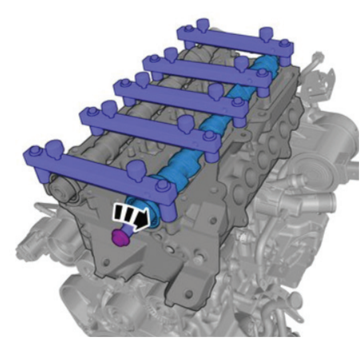


Figure 6A: Volvo Service Info graphic shows the tool jig installed, and also indicates proper clockwise (ONLY!) rotation of camshaft.

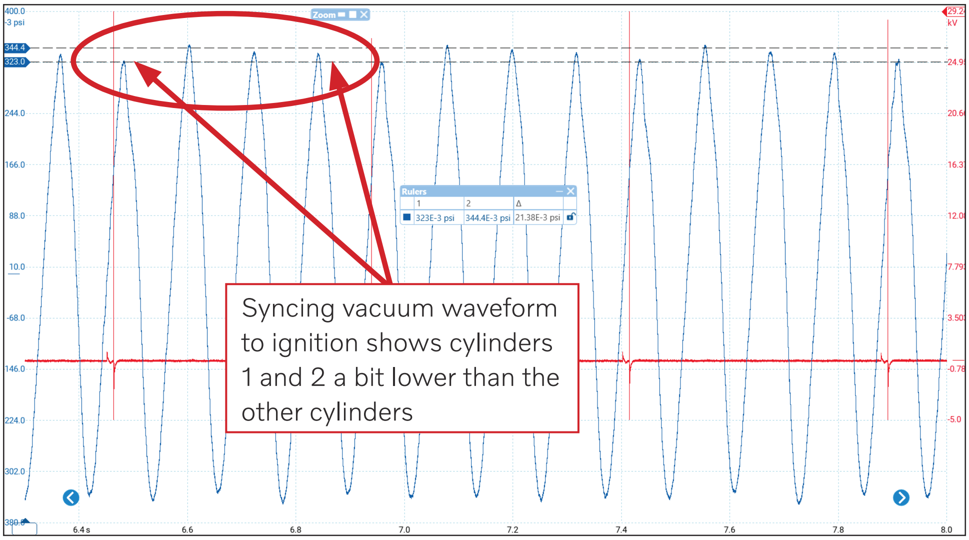


Figure 7: The cranking intake vacuum waveform showed the imbalance in vacuum pulls on this engine.

variance whatsoever upon rescoping the engine and performing the overlay. This vehicle, unlike our first S60, had something external causing the fault. The problem here was that, between the engine repair and first and second valve adjustment attempts by the machine shop, everyone involved, us included, suspected something mechanical for obvious reasons. This focus temporarily derailed all of us by focusing on that engine repair.

As the diagnosis continued, a quick look at the MAF sensor with the scope gave us a slight clue that led us to the eventual fix. Most normal analog MAF sensors, when idling, will read approximately 1.2 to 1.4 volts on the signal wire. When the throttle is snapped to WOT, the MAF signal should make about 4.0 volts at wide open throttle and then fall back to idle voltage as seen in Figure 8. On this car, we were only seeing about 0.8 volts at idle on the MAF. Hmmm...

We snapped the throttle twice as prescribed and measured about 3.6 volts at WOT. Looking at the fuel adaptations, we noticed that the long-term fuel trim was adding about 8% at idle, which corrected itself to about 3% off idle. At this point, we disconnected the support session and decided to reconnect in the morning. We decided before disconnecting to look at the cranking intake vacuum waveform to confirm whether this was an air-side problem. The support session ended until the next morning.

That evening, the shop owner and technician went over all of the work and steps done putting the engine back together, just to see if anything was awry. The next morning, we received a call from the shop saying that they had located a line and grommet near the front of the engine that was not seated correctly and was leaking vacuum slightly. Upon correcting this mechanical issue, the vehicle was cleared of codes and road tested and returned no misfire codes.

In going through these two Volvos this week, we all learned a few lessons. First, the practice of “tipping the valves” for adjustment of lash can return some ugly results, in the form of tight valves that measure fine while cold on the bench, but not so much in the heat-expanded, warmed up engine. This practice had created problems on both of these cars.

Secondly, if ground down too far, tipping the valves can change the camshaft’s timing of the valve opening and closing significantly. It can be argued that for race engines and other applications, tipping the valves often produces a good result when done with skill and precision. But for adjusting lash on a passenger car cylinder head, rather than taking the time to use the factory tools and valve lash procedure, we’re often asking for trouble, as was the case with the two vexing Volvos we tangled with this week. Third, mistakes can be made on reassembly!

The lesson we learned is to never let the back story drive our diagnostic direction. In this second case, because the engine had just been apart twice, the technician was insisting that the basics had been well covered (along with the seemingly exact condition on the previous Volvo we had just solved). Our internal lesson is that we probably should have insisted that we spend more time asking the technician going back to the basic checks first rather than jumping straight into the mechanical measurements.

It just goes to show you that any and all of us can easily out-tech ourselves when approaching these modern-day driveability issues. Sometimes the issue is mechanical and not electrical. We need to always have in the back of our minds that the engine is the modulator and can cause all manner of DTCs that would seem on the surface to be electrical in nature. This was the case in both of our Volvo cars this week. But because of persistence and some good old targeted physical testing, we have two victorious Volvo owners happily driving their cars home again, and two techs and shop owners breathing a sigh of relief. ●

Some Thoughts on Physical Testing for Volvo Diagnostics

No matter what vehicle system we technicians tangle with today when servicing Volvo vehicles, we can be sure that electrical circuits, electronic controls and communications networks will be an integral part of whatever it is we are trying to solve.

Even during maintenance and light repair operations, we often need to reset, relearn, recode or reprogram components or modules. It is a tangled-up world of ones and zeros we live in. The advances in technology, multiple chip modules, stacked systems, gateways, and advancements in line coding, network language (protocols) as well as the sheer depth of complexity built into these vehicles is sometimes overwhelming.

And then, there's ADAS systems, Radar Adaptive Cruise Control, X-By-Wire controls, hybrid and EV vehicle systems… wow, it is an incredible handful for the modern automotive technician to study, read, internalize and apply all of these variant technologies in order to be a productive, effective and profitable diagnostician.

These days, finding high-level diagnostic technicians can be a real challenge, as most well-studied technicians with 20,000 plus hours of practicing diagnostics are getting older, while newer generation technicians teach us old dogs a few new tricks regarding the more recent programming and "I.T." side of the automotive repair sphere.

We get calls daily from shops stuck on a vehicle that they, quite frankly, had no business working on; let me carefully qualify that statement, lest I raise the ire of shops that try hard to do it right.

Many of our calls involve driveability complaints or electrical/electronics issues that were actually induced by the repair facility itself. The vehicle came in for a timing problem, for example. Or maybe an electrical issue with the Start button, immobilizer or keyless entry system…

The trouble comes when the shop's team decided to try to diagnose or repair the vehicle without the required special tools; in the case of the engine timing problem, this would be the camshaft and crankshaft lock tool sets, holding jigs etc. In the case of the electrical issue with the Start button, maybe we have been banging our heads against the wall with a keyless entry fob and Immobilizer system, but we do not have the proper RF signal testers, or a lab scope required to "see" and verify the function or presence of those critical signals.

This was a big issue last week for a technician working on a XC90. He had no way to see if the RF signals were working, so parts cannon diagnostics were applied. Yikes.

The big miss, however, the critical one that costs the consumer many dollars and provides the service advisor and shop owners lots of expensive headaches, is the dreaded "parts cannon" diagnostic procedure. This is where a serious lack of actual physical testing may take place, as the desperation, guesswork and panic ensue during a diagnosis on a multi-module networked vehicle doing weird things, especially when the right diagnostic equipment and information systems are not available at the shop.

You see, when it all comes down to brass tacks, we techs do not really work on electronics at all, we work in the analog electrical realm. The electronics, per se, happen inside the modules, not outside the box, so to speak. Most everything we do in our diagnostic work comes down to basic electrical testing of voltage potential, voltage drops, currents, and resistances in (wired) analog electrical circuits.

This basic practice is where most technicians of any era fall short, once the technology of the vehicle system(s) we are chasing takes over to create a condition we call “out-teching” ourselves. Meaning, we get so wrapped up in the hi-tech operational theory, the unknowns, in the form of the electronics and software coding, the data networks carrying requests from one system module to another... these distractions can really trip up even the most astute diagnostic technician.

What this rapid-fire look at problematic cases day over day has taught our support team, is that basic, and yes, even some advanced physical testing, is almost always the answer and was almost always what was missed or wasn’t done, or it wasn’t done thoroughly or correctly before the call was made on a parts replacement.

This is true in so many of our cases; we just wanted to identify the simple lack of physical testing as the cause of misdiagnosis in an overwhelming majority of current day diagnostic disasters.

How do we address this as an industry?

First, realize that all modulized computers, networks, and electronic systems require good clean power and ground sources. Without all the powers and grounds verified, including circuit 15 (key-on) and wakeup circuits as well as grounds must be tested and verified, (preferably by the voltage drop method, while the circuit or network is connected and working), prior to replacing a module. I’d bet that over 60 percent of our “really tough” diagnostic hotline cases where a module was replaced needlessly was a lack of basic power and ground testing.

Second, realize that technicians without suitable diagnostic equipment, programming equipment (or resource) and information systems are lost from the start. The days of scan tool-only testing and diagnostics are over. When all of the scanner and software magic fails, the lab scope, transducers, an RF tester and a good information system, maybe even with the help of a good diagnostic support hotline, will always get the job done.

And lastly, as easy as it is for all of us to get out-teched these days, stay humble, go back to understanding and perfecting your basic electrical testing methods. You can even go back and study, with a more advanced outlook, the principles and fundamentals of electricity and apply this to your testing of analog voltage, current, and resistance.

You are just guessing, without physical testing. ●

Volvo Lights
Beyond the Bulb

Advanced materials and technology play a leading role in Volvo lighting systems.

Shown Here: Bi-Xenon bulb D2R used in the GDL (Gas Discharged Lamps)

Through the years Volvo's lighting systems have changed significantly. From the basic bulb lights, front and rear, to halogen, xenon, and now LED. In this article we will go over the different lights, how they work, and the different functions in the system.


S70 Headlight assembly with glass lenses

Here we have an S70 with halogen front lights with glass lenses. This system of lighting was a pretty simple system. The bulbs were pretty easy to get to and did not experience frequent failures. The biggest problem with this model was the connector at the headlight becoming very hot and melting, burning the connector and harness. Cutting the wires back and replacing wires and connectors is a common repair with this model.

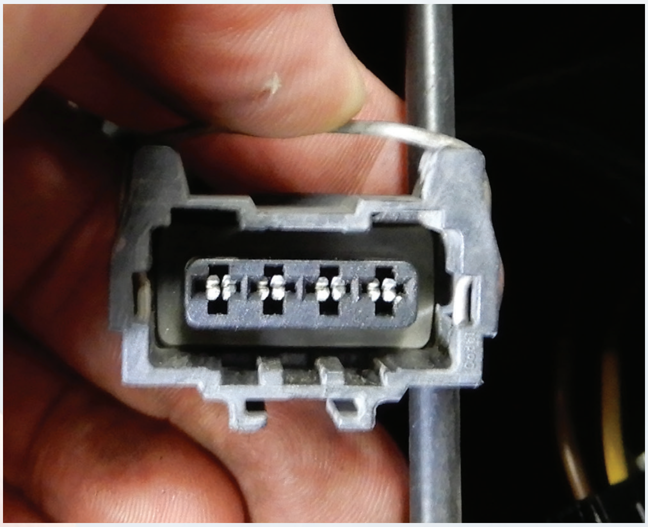
Headlight switch with adjustment to shut off daytime running lights

The headlight switch on the S70 has an adjustment so you can turn off daytime running lights. This way the lights only work when you turn the switch to the On position.

Another common problem on these S70s was corrosion at the electrical plug at the headlight assembly. Cleaning the plug and headlight receptacle with electric spray cleaner and adding dielectric grease and plugging it back in would usually take care of this problem.

Leveling and adjusting the headlight and beam is pretty straightforward on this model. There are two adjustments for moving the beam up and down and also side to side. There is also a small bubble level on top of these headlights to help with adjustment.

In early 2003, Volvo introduced Gas Discharged Lamps (GDLs). These lamps were brighter and made nighttime driving a little easier. The Bi-Xenon or GDL designs use a gas discharge technology and the


Electrical plug in for front headlight


Small bubble adjustment on top of headlight assembly

headlight system has moving reflectors for more ability to see at night.

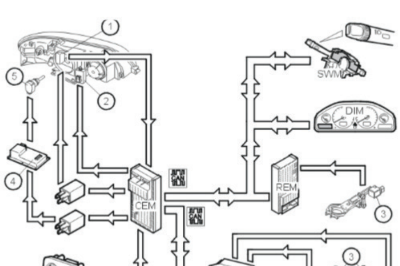
The high and low beam lights are intergraded into one bulb. When using a signal bulb for both high and low beams, the headlights are equipped with an automatic leveling system.

The bulb itself consists of a discharge pipe surrounded by glass which filters out damaging UV radiation. There are a number of chemical compounds in the glass tube, including xenon gas.

An electric discharge between two tungsten electrodes creates the arc in the light itself. The D2R bulb is designed for the special reflector system. The power consumption is 35 watts, and the bulb is less susceptible to bumps and vibration.

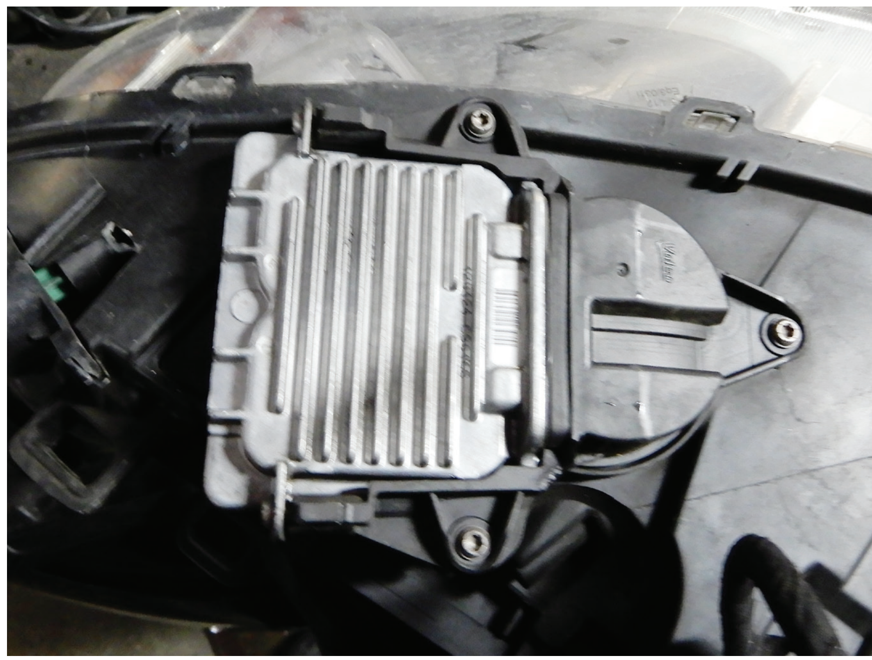
The difference between halogen and xenon is that xenon has a higher color temperature which gives a whiter light. This helps with the reflection of road signs and has a lower power consumption. The high and low beam bulb having the same color light is an advantage in the Bi-Xenon system. The human eye finds this easier to react to between changes.

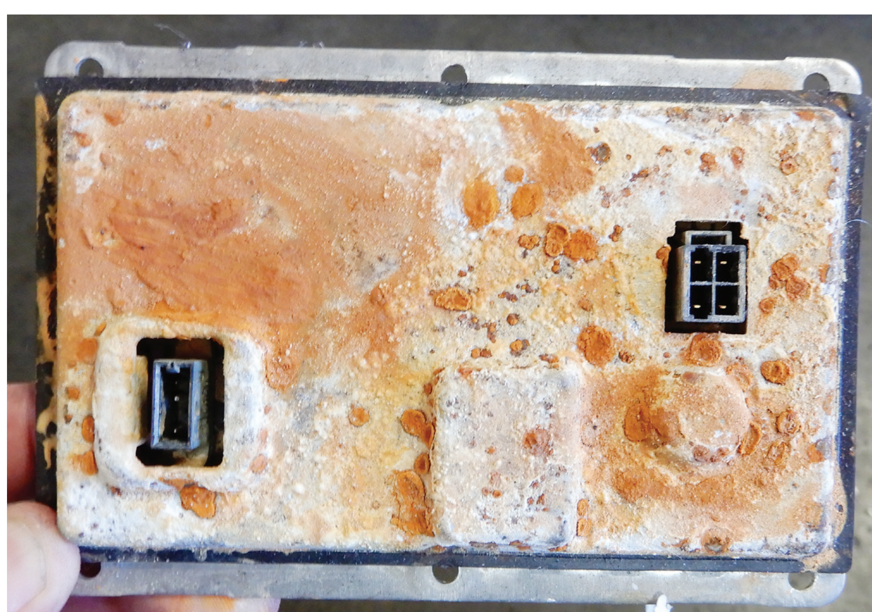
Each headlight in the Bi-Xenon setup also has a ballast that is positioned on the bottom side of the headlight assembly. The ballast works as a voltage regulator and generates alternating current. The ballast basically lights the bulb and controls the light during operation.



The early Bi-Xenon headlight system

Here we have a customer with a headlight that doesn't work. The place to start is by checking the bulb and fuse just to make sure one or the other is not bad; if so, replace either bulb or fuse. In this case both were fine. We removed the headlight to find that the headlight lens seal had failed and water was getting inside. On the bottom side of the headlight assembly, we found that the ballast was rusty and was damaged from water getting into the unit. The ballast was replaced and the headlight worked fine. Make sure to replace the seal or headlight assembly so this won't happen again.

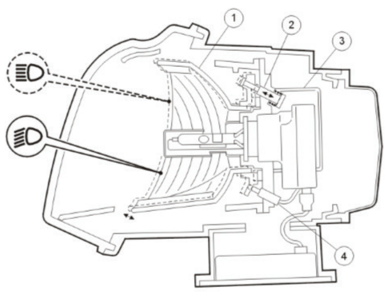

The basic ballast that is positioned on the bottom of the headlight assembly


Ballast at bottom of headlight assembly that has water damage

The voltage from the ballast transforms 12 volts DC to 1000 volts AC. High voltage is necessary to get the lamp lit. Once the headlamp is lit, the voltage is reduced to 100 volts to keep the headlamp lit.

The headlamp will not light if the voltage is 9.5 volts or less within a time span of 200 ms. If the voltage is too low during a cold startup and the headlamp does not come on, the alternator will charge the system and you will have to turn the light switch off and then on again to restart the headlamp. With the ignition on, it usually takes three seconds for the headlamp to activate.

The moving reflector inside the headlight plays a key role; there are three different segments inside the headlamp. The reflectors are adjustable and can move depending on whether the position of the light is on high or low beam. The bulb never moves and the headlight lens is clear. The movement of the reflectors determines the position of the headlamp, high or low.

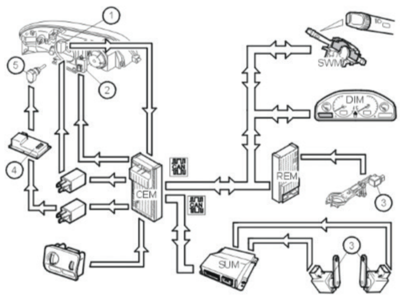


The general function of the Bi-Xenon headlamp

The Four-C system (Continuously Controlled Chassis Concept) automatic level control is different, using sensors to control the angle of the vehicle relative to the surface it rides on. The angle is measured from the vehicle leaning and is dependent on weight distribution.

The sensors are mounted on the control arms and are mounted differently depending on whether vehicle is AWD or just FWD. The CEM (Central Electronic Module) controls the motors for the headlamp range adjustment. The REM (Rear Electronic Module) reads an analog signal (0.5-4.5 volts) from the position sensor and converts it to an angle value (plus or minus 35 degrees). Then this information is transmitted to the CEM.

The two sensors on the rear control arms read off the angle of the vehicle relative to the position it is sitting on the pavement. The angle is a measurement of how much the vehicle is leaning and is dependent on the weight distribution. The SUM (SUspension Module) reads the signals from the sensors and converts them to an angle value.



Bi-Xenon system overview with numbered components

The value is transmitted through the CAN (Control Area Network) to the CEM (Central Electronic Module), and then the CEM uses the information to control the motors for the headlamp's adjustment.

Under about 2 1/2 mph with ignition on, the position sensor is read off and the headlamp range is adjusted in the headlamps. Over that speed, during driving, the headlamps change depending on the angle of the vehicle. Control is dependent on the time for the system not to react to short term changes such as uneven road surfaces.

When replacing rear suspension parts such as sensors, bushings, shock absorbers, springs or axles, the system must be calibrated through VIDA. Calibration can be done through VIDA, Diagnostics/Vehicle Communication, REM (Rear Electronic Module).

Automatic Headlamp Leveling and Active Headlamps 2012 S60

On the 2012 S60 Volvo, the functions of the automatic leveling and active headlamps are controlled by the CEM (Central Electronic Module). There is a separate control module that controls the automatic headlamp leveling and active headlamp functions.

Here are the input signals to, and the output signals from, the CEM. Here we will divide the signals from input signals to output signals, serial communication and CAN communication. We will also show the Volvo component designation number.

Input Signals:

Directly Connected

- **Position Sensor (7/119,7/121)**

via serial communication:

- **Left Headlight Control Unit (LHCU)**
- **Right Headlight Control Unit (RHCU)**

via Controller Area Network (CAN) Communication:

- **Suspension Module (SUM) (4/84)**
- **Transmission Control Module (TCM) (4/28)**
- **Brake Control Module (BCM) (4/16)**

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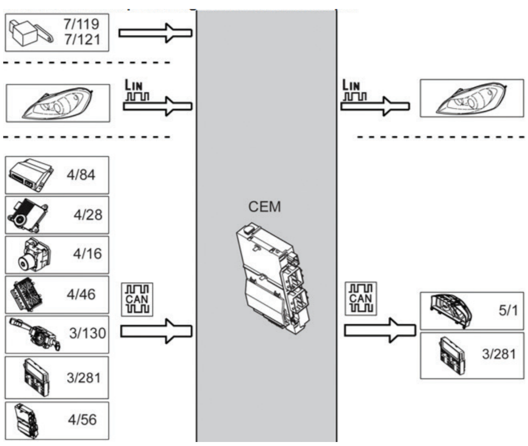
- **Engine Control Module (ECM) (4/46)**
- **Steering wheel Angle Sensor Module (SAS) (3/130)**
- **Infotainment Control Module (ICM) (3/281)**

Output signals:

Directly connected via serial communication:
- **Left Headlamp Control Unit (LHCU)**
- **Right Headlamp Control Unit (RHCU)**

via Controller Area Network (CAN) communication:
- **Driver Information Module (DIM) (5/1)**
- **Infotainment Control Module (ICM) (3/281)**



Input and output signals from CEM (Central Control Module)

Headlight System Bi-Xenon Model 2012

The Bi-Xenon headlight system is based on gas discharge technology with reflectors that are moveable inside the headlamps. Like the earlier models, the Bi-Xenon lights are quite alike, as far as bulbs, position sensors and leveling systems go.

The position sensors have three wires and are directly connected to the CEM. Two wire connectors are ground and power supply and the other is used for signals for vehicle angle. When the ignition is switched on, the level control becomes active and the position sensors are used to calculate the average vehicle angle. At about 2.5 mph, the dynamic level control is activated. As speed increases or decreases, the system will make its corrections. Darkness is required in addition to speed controlled and angle of the vehicle.

Like the earlier models, calibration is needed and saved in the CEM when replacing position sensors or a control module. Calibrating the system can be done through VIDA, Diagnostics/Vehicle Communication.

Four-C (Continuously Controlled Chassis Concept) uses the signal from the suspension module. Diagnosing the position sensors can be done through VIDA.

2010 XC 90 Headlight Control Module

The headlight control module on this Volvo model communicates with directly connected components and other control modules via CAN. The control module is located under the driver's seat, so if you need to replace the control module, the seat will need to be removed.

The control module checks input and output signals, as well as activation for components using an integrated diagnostic system. If a fault occurs, the control module will set a diagnostic trouble code. If a diagnostic trouble code does register, a number of values that were frozen when the fault occurred are stored.

Depending on how severe the fault is, some functions might not work correctly. The driver's information module will display information text, and the LED in the active headlight button will flash. The faults and frozen values can be read through VIDA for diagnosing the fault.

The headlight control module (HCM) (4/118) needs information from the vehicle's speed, the current gear the vehicle is in, and light conditions to activate the active headlight functions.

The headlight control module receives information from the following control modules:

- Brake Control Module (BCM) (4/16) for vehicle speed
- Transmission Control Module (TCM) (4/28) for current gear the vehicle is in with automatic transmission
- Central Electronic Module (CEM) (4/56) from the reversing light switch with manual transmission and also information from the twilight sensor (7/12)

When the ignition switch is turned on, the headlight control module is activated. To turn the light beam off, the following conditions must be met.

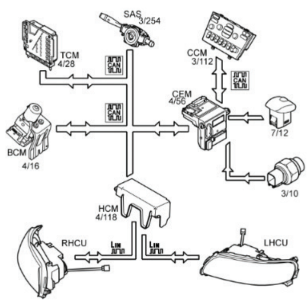
- The vehicle must be moving at a greater speed than 2.2 mph.
- The vehicle must not engage reverse gear.
- And no daylight conditions.

The switch on the Climate Control Module (CCM) (3/112) for the active headlight function can be used to disable or enable the function.

When the active headlight function is turned on, the headlight control module receives continuous information on speed and steering angle. The brake control module sends the message for the speed of the vehicle, and the steering angle sensor (3/254) sends information on the steering angle of the vehicle. This information then enables headlight control module to calculate the current turnout of the light beam.

Software can be added to headlight control module to change the active headlight function to adapt to either driving on the right side of the road or left side of the road, depending on the country you drive in. To change the settings, hold the active headlight switch on the climate control module down for five seconds. When the settings have been changed, a message will appear in the driver's information module to let you know if it's for right-hand or left-hand traffic.

When driving straight forward, the light beam is turned so it does not blind oncoming traffic. The light beam will also be turned out in the direction when cornering, but not as much. The light beam is also aimed down slightly so as not to blind oncoming traffic.



2010 XC90 active headlight components on the CAN system

Diagnostic Functions

Volvo diagnostics are built into the control module to continuously monitor the functions of the system, in addition to monitoring the input and output signals.

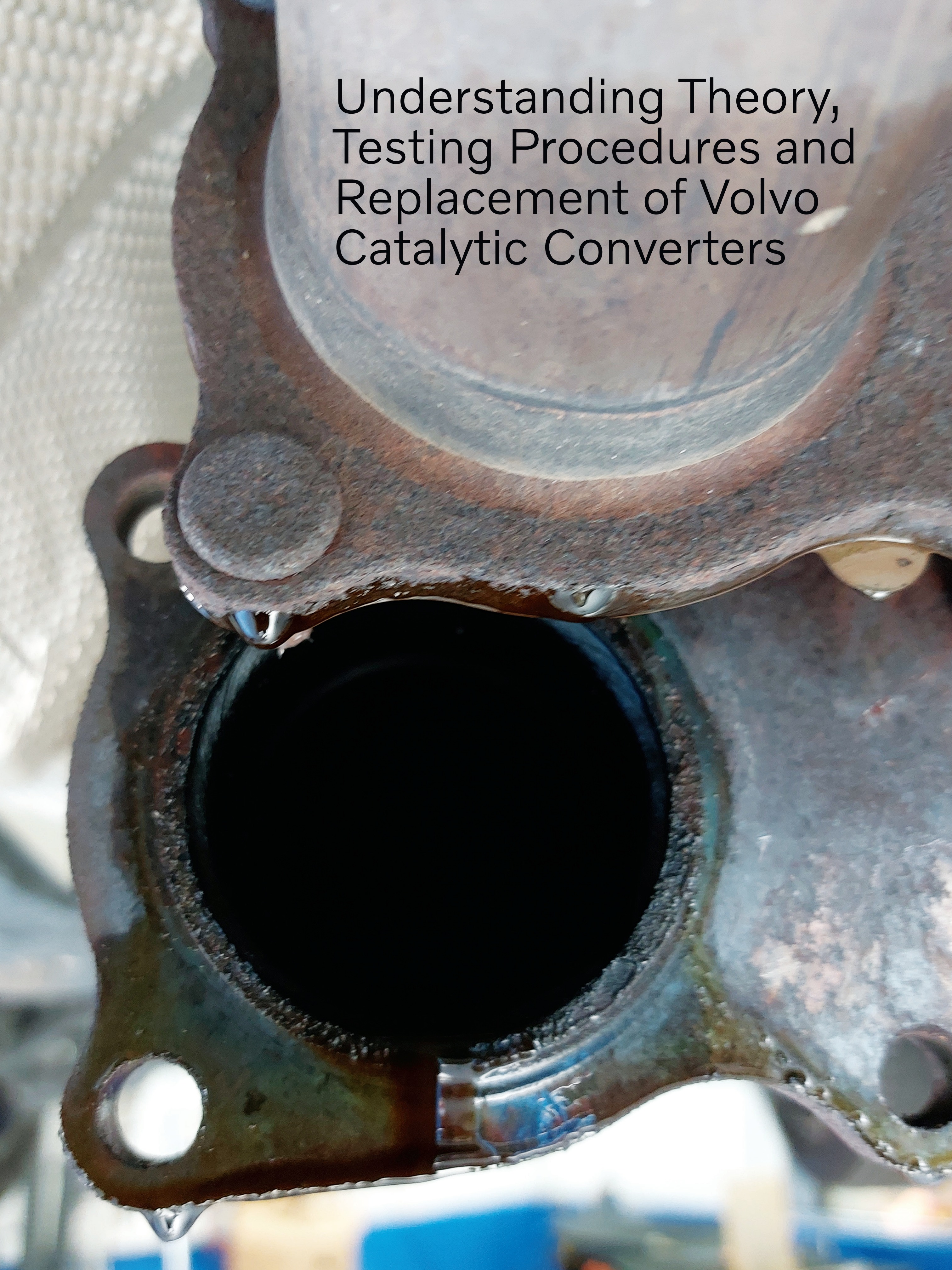
If a fault occurs, a diagnostic trouble code will be stored in the control module. A fault that occurs during a most recent driving cycle is a permanent fault. Other faults are intermittent faults and could be harder to locate.

Using VIDA, you can read all faults and erase using this function. VIDA can be used to monitor the input and output signals of the control module in Vehicle Communications. Also in VIDA, you can activate components to check if they are working correctly.

With VIDA, you can read off the control module hardware part number, hardware serial number, software part number and diagnostic software part number.

The Volvo lighting system can be very challenging at times; using VIDA can give you the information you need to diagnose, download software and understand the complete function of the system. ●

Understanding Theory, Testing Procedures and Replacement of Volvo Catalytic Converters



Catalytic converters have been all over the news lately, but not because of the fact that they are incredible devices that can literally change the molecules of the exhaust gases and convert toxins into less harmful byproducts, such as water vapor (steam) and carbon dioxide.

Catalytic converters have been in the news lately because all around the world they are getting stolen at an alarming rate.

The wave of thefts around the U.S. and in many countries around the world has increased, mainly because of the price of the precious metals that are used in the modern three-way catalyst.

Metals that are most commonly used in converters are platinum (Pt), palladium (Pd) and rhodium (Rh).

The current price of rhodium is the main reason that they are so sought after by thieves around the world.

Converter theft is not very common when it comes to Volvos, though, because later Volvos have most of their catalysts installed up near, or as part of, the exhaust manifold. This makes them very difficult to remove from the car without a lift and some special tools.

Testing

Accurate testing is very important when condemning a Volvo catalytic converter because it can be easy to misdiagnose and you could unnecessarily replace a very expensive part or parts. Just because the car stored a code P0420 or P0430 does not mean it's time to replace the cats.

There are a lot of different methods and schools of thought out there on converter testing; some testing methods are more accurate than others, depending on who you ask.

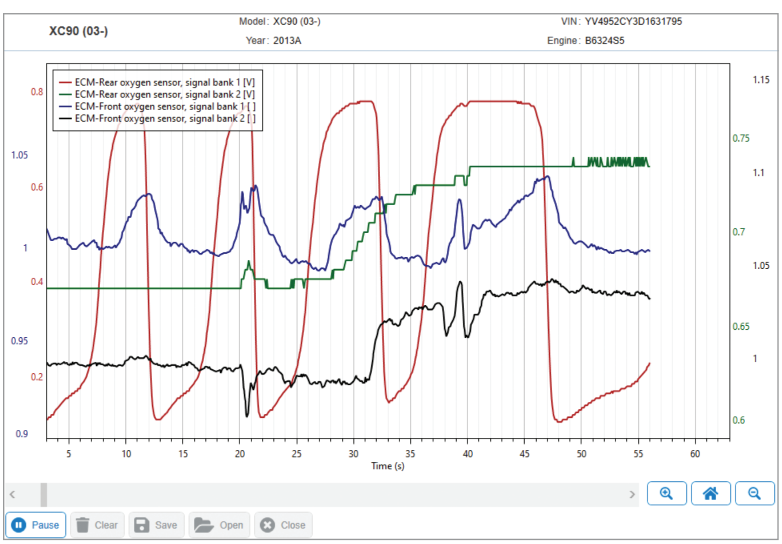
Here is how most Volvos perform self diagnostics on their catalytic converters...

Three-Way Catalytic Converter (TWC) Diagnosis

The three-way catalytic converter stores oxygen from the exhaust gases and uses it to make toxic gases more environmentally friendly. The catalytic converter is a three-way converter in which HC (hydrocarbons) and CO (carbon monoxide) are oxidized and NO_x (nitrous oxide) is reduced.

As the three-way catalytic converter ages, its ability to store oxygen is reduced. The conversion capacity of the three-way catalytic converter is reduced and unburned residue is released. To reduce the environmentally damaging emissions, the Engine Control Module (ECM) checks the efficiency of the three-way catalytic converter. In brief, this check is carried out as follows:

To be able to check the catalytic converter, two sensors are used.



VIDA software is still the best tool to use when you are performing diagnostics like cat failure testing.

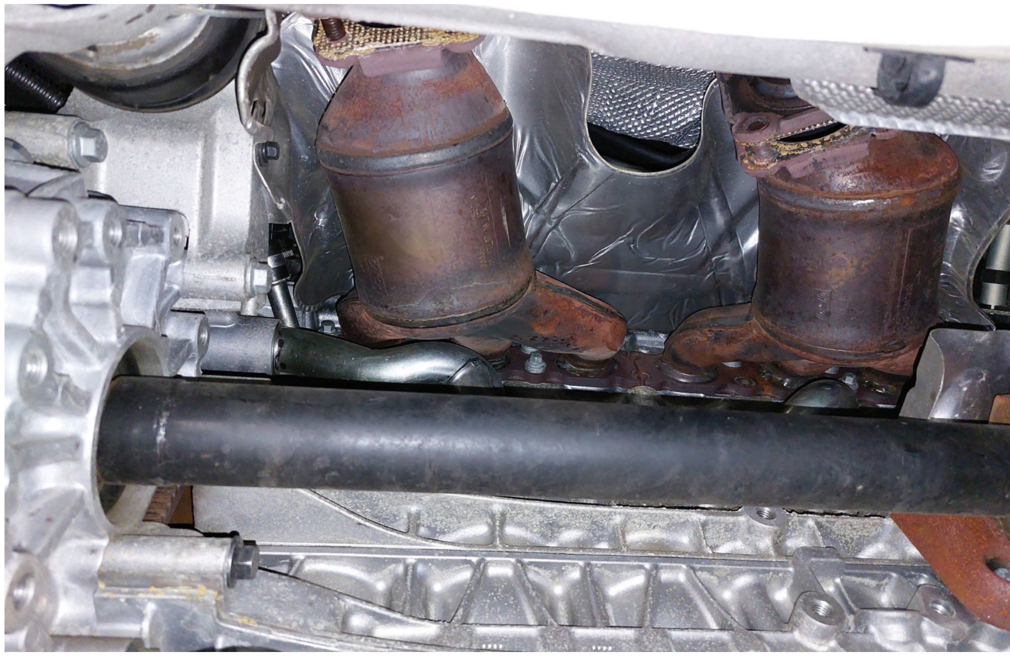
Opposite Page: Most premature catalytic converter failures can be traced to contamination such as unburned fuel, engine oil, and coolant being introduced onto a hot converter stratus during normal operation.

One heated oxygen sensor is located in front of the catalytic converter in the engine compartment (front heated oxygen sensor), and a heated oxygen sensor is located after the catalytic converter in the engine compartment (rear heated oxygen sensor).

After the rear heated oxygen sensor, there is another catalytic converter located at the front end of the propeller shaft tunnel under the vehicle's floor. However, this catalytic converter is not monitored.

The main function of the heated oxygen sensors is to measure the oxygen content in the exhaust so that the engine control module can maintain the fuel/air mixture at around lambda=1. This mixture allows for optimum catalytic conversion.

To evaluate the efficiency of the three-way catalytic converter, one uses a deviation added to the lambda signal.



Volvo catalytic converters should last for the life of the car, but that's not always the case. Accurate testing is critical when condemning a Volvo converter because it can be easy to misdiagnose and you could replace a very expensive part and not fix the problem.

In practice this means that catalytic converter diagnosis starts within 20 minutes after engine start (time varies depending on market).

The process is as follows:

A deviation is added to the lambda signal and the engine control module is allowed to correct this.

The deviation switches between positive and negative values so that the fuel/air mixture switches between rich and lean.

A counter registers the number of switches occurring while the diagnosis is taking place.

If the center and rear heated oxygen sensors register a large number of switches exceeding a parameter, a diagnostic trouble code for catalytic converter efficiency will be stored.

If the parameter is not exceeded, the three-way catalytic converter is deemed to be operating properly.

The costs of new catalytic converters these days are steep and getting steeper, so accurate testing is critical, because you don't want to be the technician that recommends cat replacement to "fix" a customer issue and a few weeks later and a few thousand dollars later, the customer comes back into the shop with the same problem.

Don't be "that guy," you know, the technician that gets out a generic scan tool to check for codes stored in the ECM and any time the infamous PO420 code comes up, they automatically sell their customer a new catalytic converter.

Volvo's Diagnostic Trouble Code Information For ECM-P042000

Condition: The ECM checks the efficiency of catalytic converter (bank 1) by switching between rich and lean fuel/air mixture. When the changeover is made, the signal from the rear heated oxygen sensor (HO_2S) is checked and the time taken for the probe to switch is noted.

The DTC is stored if the ECM registers that the rear heated oxygen sensor (HO_2S) switches too quickly, and this is interpreted as poor catalytic converter efficiency.

The diagnostic trouble code can be diagnosed with the engine at operating temperature, approximately 15 minutes after the engine has first been started if the vehicle is driven (normal road load) at about 45-55 mph for 30-40 seconds.

Substitute value

- Nothing

Possible source

- Air leak in the exhaust system
- Damaged front heated oxygen sensor (bank 1)
- Damaged front catalytic converter (bank 1)

In a perfect world, where your customers' cars are meticulously maintained and repairs are done as soon as they are needed, the catalytic converter should last for the life of the vehicle.

Of course, we don't live in a perfect world and a lot of customers are not the best at staying on top of their car's service needs.

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How many times has one of your customers come into the shop with an illuminated Check Engine light, and when asked how long it has been on, they say something like, "I don't know," or the ever popular "a few weeks," which often translates to "over a month."

The standard OBD II fault code setting parameters most ECM trouble codes are anything that can cause the car to emit 1 ½ times the acceptable tail pipe emissions for that car's year and engine size.

What can out of control fuel trim or unregulated emissions do to the average catalytic converter?

Well, it usually depend on how much and how long the problem is ignored by the driver.

Volvo catalytic converters are engineered to reduce exhaust emissions for the life of the vehicle and should perform well even when the car has passed the 100K mile mark.

The care and feeding of your customer's Volvo is very important to the lifespan of their car's catalytic converters.

How Many Miles Should a Catalytic Converter Last? 50K? 100K? 200K?

This is probably a very popular question among customers that are facing the cost of catalytic converter replacement at your shop.

The best way to answer this question is to say, "It depends." The failure of the catalyst has very little to do with mileage and more to do with the way the car was serviced and repaired, or not repaired, in a lot of cases.

The most common cause of premature cat failure is due to ignition misfires, poor fuel control, or fuel, oil, or coolant contamination.

Excess heat, unburned fuel, and excess oxygen all can damage the cat in a very short time.

Also, in rare cases, the cat's substrate can be damaged by impact from the customer going off road or the exhaust hitting something like a speed bump.

In the case of impact, you can usually hear the broken pieces of the converter's substrate rattling around inside.

Have You Ever Seen Early Volvo Catalytic Converter No Code Failure Diagnosis (1998-2000 Volvo S/V/C/XC 70 Series)?

Yes, there are more than a few of these cars left on the road today.

You may still run into one of these early Volvos with this problem, especially if your shop is in a state that requires enhanced emissions testing.

In states like California, the standard smog test includes checking the car's ECM to see if all or most of the emissions monitors have been completed .

As most technicians know, it can be difficult to perform the correct drive cycles to run all the monitors, especially in cities with a lot of traffic.

These early Volvos can be extremely difficult to clear all the emissions monitors in the ECM, unless you have access to a closed race track for two days straight.

But in some cases these 1998—2000 Volvo S/V/C 70 models can be almost impossible to set the monitors on.

Some early Volvos may have trouble completing all their emission monitors no matter how long they are driven, even with no stored trouble codes or freeze data in the ECM. These cars won't set the cat or O_2 sensor monitors because of the way Volvo set up the order and setting parameters on these early cars. In most cases, these Volvos have a worn out converter even though the ECM has no codes.

Most likely, when you get one of these cars in your shop and check to see what monitors have run after hundreds of miles driven by your customer and maybe you, you will see that all monitors have run, except for the one for the oxygen sensor and the one for the catalyst.

And guess what? There are no stored trouble codes and no pending codes stored for either the O_2 sensors or the cat.

The reason is the order in which this series of Volvo runs its emissions monitors and the setting criteria for the trouble codes for this car's catalytic converter.

Yes, you could drive one of these Volvos to the moon and back and probably never get that cat monitor to run.

So if you get a 1998—2000 Volvo S/V/C 70 in your shop that has no Check Engine light on, no stored pending codes or freeze data that just won't complete the monitors for the cat or the O_2 sensors, try the following:

Run the engine up to operating temp with a scan tool connected and monitor the front and rear oxygen sensors.

You can also use an oscilloscope to graph the sensor readings for a better comparison.

Hook up a scan tool like VIDA and bring up live data for the front and rear O_2 sensors.

Start the engine and run the engine until the car reaches operating temperature.

Rev the engine up to 2,500 rpm. You can do this in the shop with the transmission in Park.

In most cases, you will see that the front and rear O_2 sensors are mirroring each other even though the car will not set a cat efficiency code. Yes, this car needs a new catalytic converter.

Once the cat is replaced, guess what? This car that your customer or you have been spending way too much time driving to set monitors will easily complete all the emission monitors in two trips.

Case Study: Common Volvo Catalytic Converter Misdiagnosis (2007-2013 Volvos With 3.2L N/A Engines) XC90/S80/V70/XC70

Which came first, the chicken or the egg?

This age-old question is meant to make you think of the possibilities. Well, when it comes to Volvo catalytic converter diagnostics, keep this old question in mind.

There have been a lot of these Volvos that have had their cats replaced unnecessarily due to rushed diagnostic procedures along with the ever popular "jumping to conclusions."

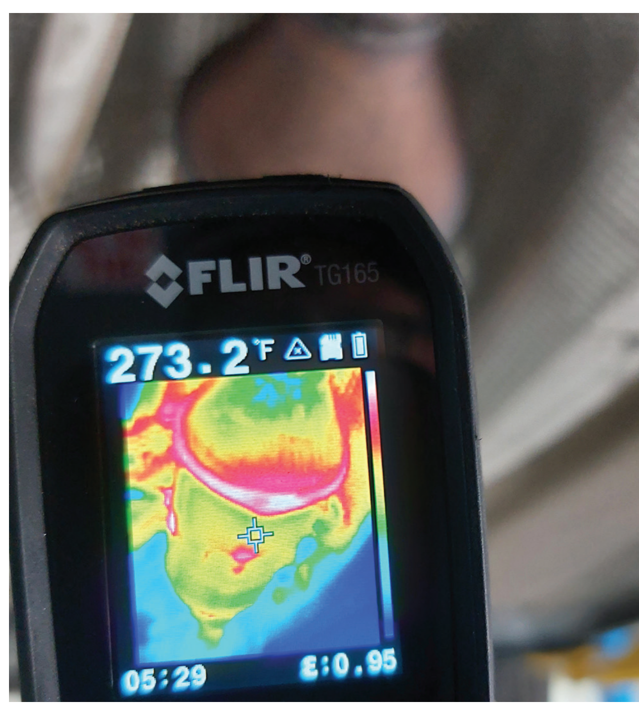
Volvos can be daunting for the technician that only works on Volvos once in a blue moon, especially if they only have access to generic scan tools and generic repair information.

You may have had one of these Volvos come through your shop, usually because the Check Engine light has come on.

These cars usually seem to not display any other issues for the customer other than the dash warning light being illuminated.

In the case of the Volvos in this case study, the ECM will usually store a Catalyst Efficiency code like P0420 or P0430.

Some shops will see a car with these codes that has over 100K on it and automatically assume that the catalytic converter or converters are "worn out."



One really cool way of checking out the internal temperature of a catalytic converter as it warms up is to use a FLIR gun or FLIR camera adapter for your cell phone; you will be able to "see" the cat working.

Possibly, but this is not always the case; testing is needed to determine the real cause of these codes.

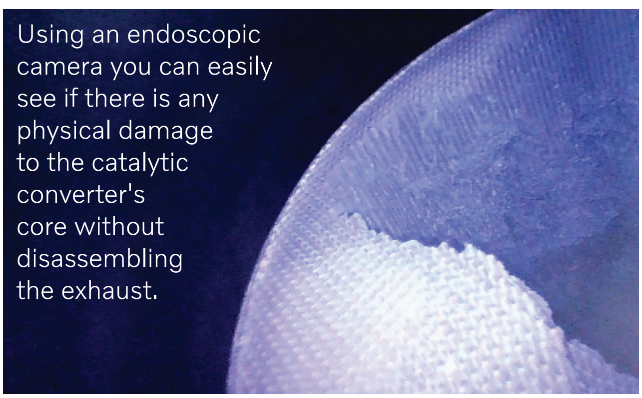
What tests do you prefer?

The old faithful test for most technicians is the standard comparison of the upstream and downstream oxygen sensor signals to see if the sensors are mirroring each other.

In most cases this test is effective, but could a damaged, shorted, contaminated sensor give a false reading? You bet!

False signals are a common cause of "jumping to conclusions."

Before condemning a cat, make sure to do the proper testing.



Using an endoscopic camera you can easily see if there is any physical damage to the catalytic converter's core without disassembling the exhaust.

Wi-Fi endoscopic camera

Think Outside the Box

Here are some examples of some newer tools that can be useful when diagnosing catalyst problems.

FLIR or Forward Imaging InfraRed

The use of thermal imagining is a relatively new tool in the modern technician's arsenal of testing equipment.

If you are one of those technicians that likes to test the temperature difference between the inlet and the outlet of a catalytic converter to see how it's performing using a direct or indirect thermometer, try using a FLIR gun or FLIR camera attachment for your phone.

Using FLIR you will be able to see the catalyst warm up and be able to capture the image of the cat to compare to other similar cars that are performing normally.

Using thermal imaging is not an exact science, but the more you use it, the better you will be able to easily spot potential problems.

In the old days, the only way to see if the inside of a catalytic converter was physically damaged was to unbolt it and use a flashlight to peek inside, and that’s not possible if the cat had a long pipe on one or both ends.

In some cases, you might be able to see part of the stratus of the cat by removing one of the oxygen sensors and peering through the hole.

Both of these methods take time and can have mixed results.

But luckily for the modern automobile technician, there is a better option.

Endoscopic cameras used to be only used in hospitals and they used to be very expensive. But today you can get a decent endoscopic inspection camera that uses your cell phone as the display for about $20.

Of course, you get what you pay for with tools, but you don’t have to spend a lot to get a good, clear look inside tight spaces like a combustion chamber or a catalytic converter housing.

You can usually remove an oxygen sensor and fish the camera probe all the way to the face of the catalytic converter's core to inspect it and capture images that you can show your customer to show the damage. ●

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