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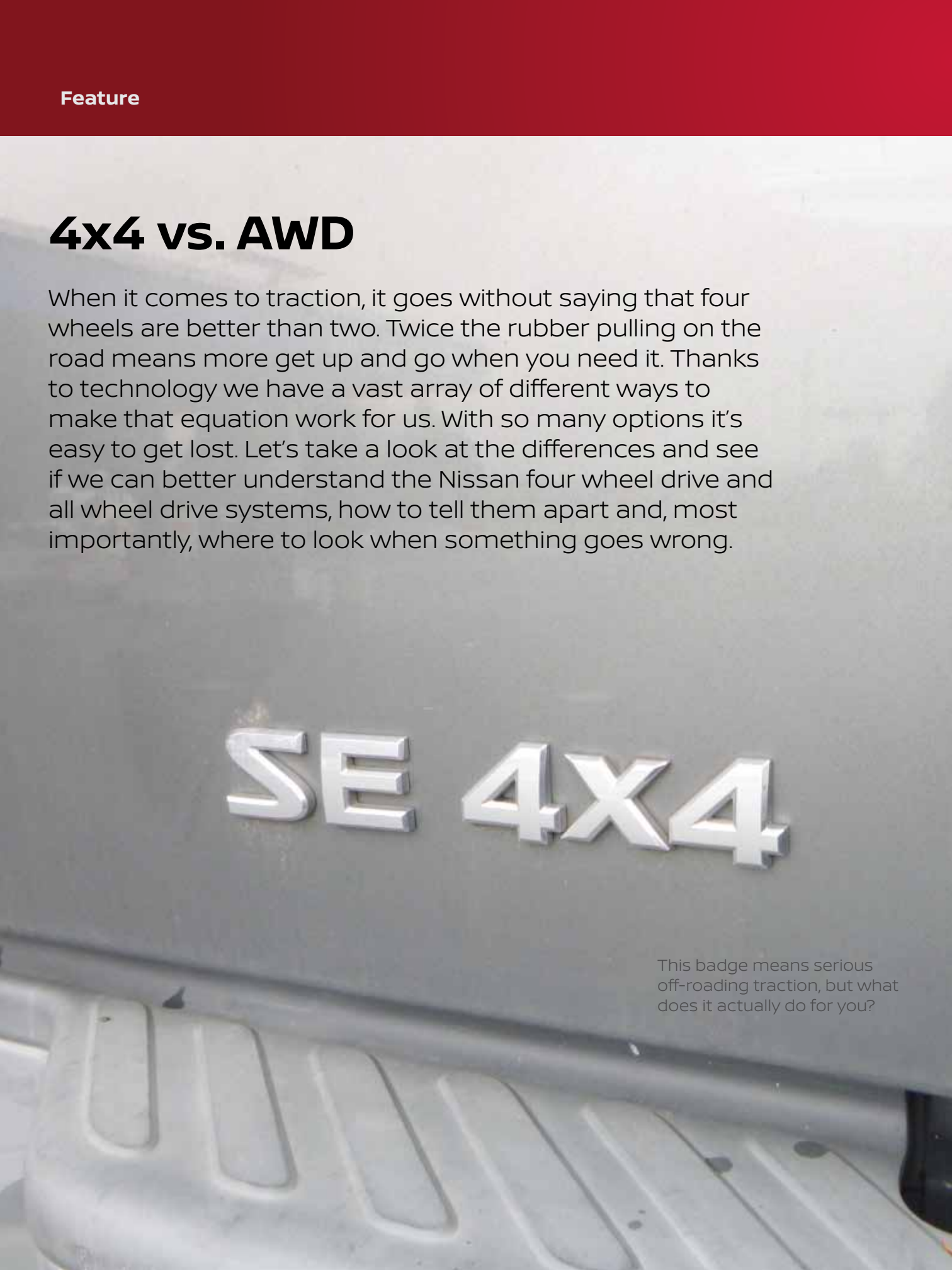
4x4 vs. AWD

When it comes to traction, it goes without saying that four wheels are better than two. Twice the rubber pulling on the road means more get up and go when you need it. Thanks to technology we have a vast array of different ways to make that equation work for us. With so many options it's easy to get lost. Let's take a look at the differences and see if we can better understand the Nissan four wheel drive and all wheel drive systems, how to tell them apart and, most importantly, where to look when something goes wrong.



This badge means serious off-roading traction, but what does it actually do for you?

As technology advances we have more opportunity to give the consumer so much more of what they want in a vehicle, and even provide some features they never knew they couldn't live without. Even if it is never used, the security of knowing a truck has four wheel drive is an excellent selling point — for safety, for the beefy appearance, or just for the potential of playing in the mud.

We have all seen the commercials where an all-terrain tire is slinging mud in slow motion as the truck bounces down a forest road or construction site. The driver is just grinning as he knows his truck is the toughest on the trail.

On the other side of the coin, we can't discount how all wheel drive gives the sense that the vehicle is secure and glued to the road, giving confidence to a driver in the storm with rocks falling on the road in their path as the small child sleeps in the back seat. There is no "fun" here, just a sophisticated car owner that made the right choice in the safety feature known as all wheel drive.

In replacing the old-fashioned transfer case shift lever, this on-dash switch makes changing to four wheel drive, and back again, very easy. The switch is accompanied by an electronic shift actuator on the transfer case.

Both systems seem to have the same meaning, that all four tires put power to the ground. In fact many of the same components make each system work. So why have different names?

It really isn't a big, complex secret, and there isn't any hard and fast rule in the actual wording. Generally speaking, four wheel drive is an aggressive locking of the drivetrain for maximum traction that can be applied by the driver at will through a gear shift, or electronically with a switch. This is the system you will have on trucks and SUVs that are intended to go off road.

All wheel drive, on the other hand, is a passive system that is either active all the time or is activated and deactivated by a sophisticated computer control system. It is flexible enough to provide the appropriate traction for any driving conditions and still keep fuel mileage as high as possible. This is the safety feature that will keep the car moving as the snow falls and makes it possible to get those cookies safely to grandma's house.

The big hurdle that has to be overcome in any system having all four tires tied to the drive train is that at some point the driver might want to turn the vehicle. When a car is going in a straight line, barring any difference in tire size, all four axles turn at the same speed. As soon as you turn the steering wheel, all four axles turn at different speeds.

In a turn the outside tires travel a longer distance and must rotate faster, while the inside tires rotate slower, the front tires slightly more so than the rear. 4x4 systems drive like a standard two wheel drive, usually rear wheel drive, until the driver decides extra traction is needed, such as in icy conditions. The driver then locks the vehicle into four wheel drive without worry of the tires binding due to the difference in speed while turning, since they can slip as needed to make up the difference.

When traction is restored by driving onto a solid, clean road surface, the driver is quickly reminded to shift back into two wheel drive by the binding in the system as all four tires gain traction once again. This binding action is often referred to wind-up. These are the systems you will find in the trucks and taller SUVs like the Frontier, Titan, Xterra, and older Pathfinders.

All wheel drive is either designed to be engaged all the time or is controlled by an on board computer and has no driver controls to turn the system on and off. The system has to automatically compensate for the difference in tire speed and, until recently, that made it necessary for the system to be less aggressive than the 4x4 version.

Different methods are used to introduce "slip" into the system, such as a viscous coupling, an extra differential in the transfer case and, more recently, electronically controlled clutch packs that can engage and disengage axles or even individual wheels as needed. The latest versions use computer controls that determine if a wheel is slipping and transfer power to the wheels that aren't. This gives the driver all the control they need and they never even realize it's happening. These are the systems you will find in shorter SUVs like the Juke, Murano, newer Pathfinder and Rogue as well as performance cars like the Infiniti G35x and GT-R.

It says AWD on the badging of this 2013 Juke, but what does that really mean, and how does this system differ from a regular 4x4?

This housing holds an electronically controlled clutch pack that is disengaged when the computer determines that the rear wheels don't need torque, improving fuel mileage.

Both of these are transfer cases. The AWD model is simply dividing power between the front and rear, whereas the 4x4 model has shifting capacity for front axle engagement, neutral, and even a lower gear set for particularly rough terrain.

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Although mix-ups should be rare, being precise about which system you're working on is a good idea. The main reason is in customer confidence. The four wheel drive and all wheel drive systems are different enough that actual diagnostics for any problem would be difficult to confuse. Ensure that your customer is confident that you know difference by using the correct terminology, especially if they ask you, out of curiosity, what the difference is. By necessity both systems will have certain components in common, although they will look wildly different. After the transmission there will be a transfer case, drive shaft, differentials and axle shafts for each wheel in both systems.

Take for example the transfer case on an AWD Murano and the transfer case on a 4x4 Frontier. The AWD transfer case, with a setup similar to that used in a front wheel drive vehicle, is in line with the right front axle shaft and has a small ring and pinion gear that converts the torque perpendicular to reach the rear axle with a long drive shaft. It's very small and only holds about half a pint of gear oil.

The 4x4 vehicle, with a setup similar to that of a rear wheel drive vehicle, has a transfer case bolted to the tailshaft of the transmission. It then has output yokes forward and rearward for short drive shafts to the front and rear axles respectively, as well as a built-in mechanism to engage the front axle drive shaft or reduce the transmission gear ratio for 4LO operation. This unit is much larger and holds over 2 quarts of transmission fluid. Both have the same basic function of torque distribution but will have different maintenance and diagnostic needs due to how they are used.

Extra maintenance for AWD and 4x4, as compared to two wheel drive, is required in that they have transfer cases and differentials that require fluid changes at regular intervals. The intervals are usually quite long and thus frequently neglected. It's a good idea, when doing these services, to use genuine Nissan fluids as many of these transfer cases have seals and clutches in them that require specific fluid properties. Problems caused by using incorrect fluids may take a lot longer to manifest than similar mistakes in an engine or transmission, but can still be quite costly to repair when they do. Ensuring you have the right fluid can save you in the long run.

Diagnostics for four wheel drive systems are typically pretty straightforward; verify

Simply looking at the transfer case we see the tell-tale blanket of rust indicating a failed Cardan joint. Catching these failures early can prevent further damage to the driveshaft yokes.

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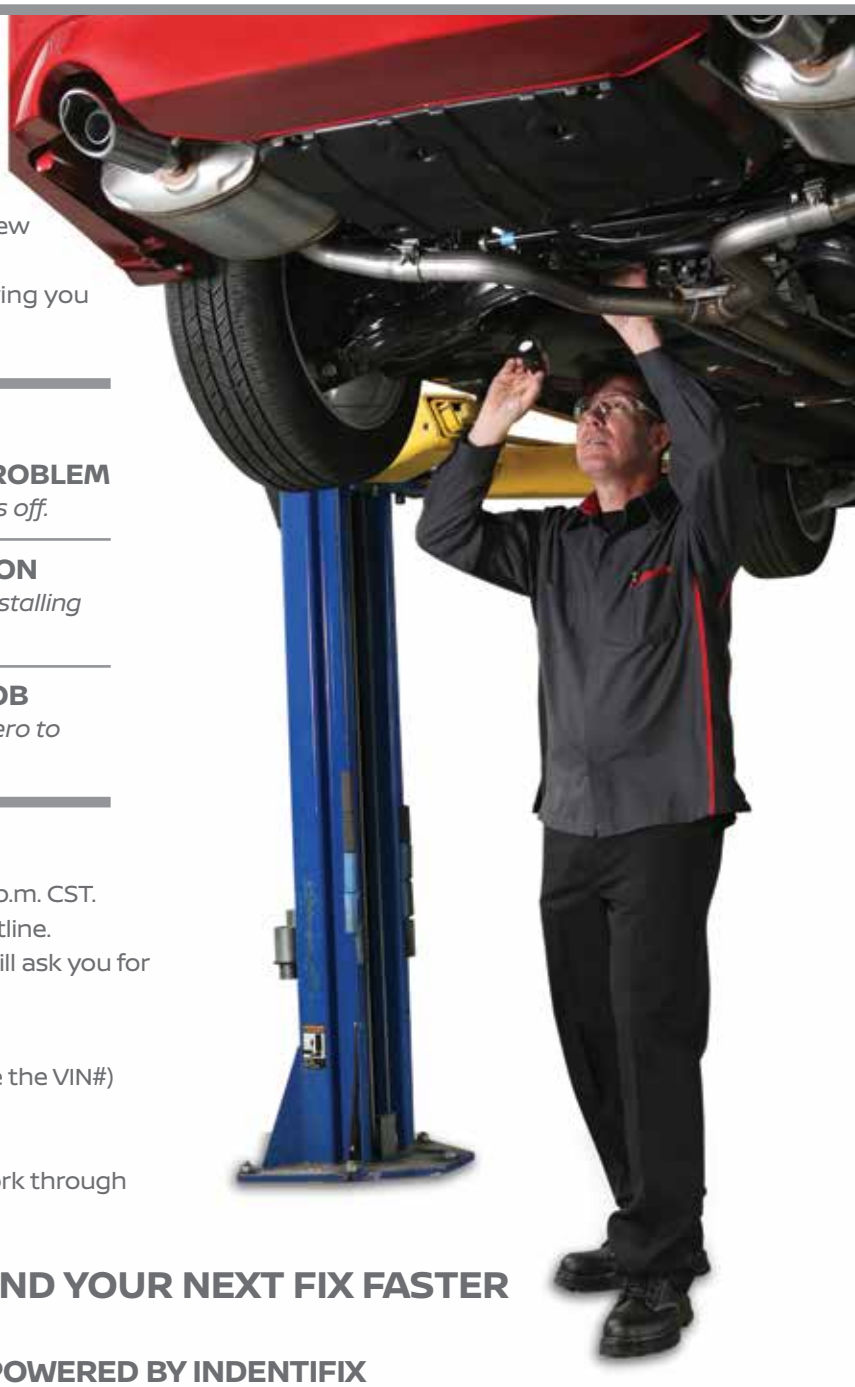

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proper function without strange noises. Before searching for any fault, tactfully make sure the customer isn't simply misunderstanding how and when to use four wheel drive.

Accidentally having the front axle engaged will feel like a serious problem when maneuvering in a parking lot. Likewise, having bumped the transfer case gear shift into neutral might have a driver thinking their truck has a serious transmission fault. Listen carefully to the customer's description of the problem then verify the concern.

Even though it seems relatively simple, the four wheel drive transfer case is not a system you want to guess as to what's wrong by the description of the problem. Clunking noises are very common as Cardan joints (C-V joints) frequently wear out, but it could be a worn gear in a differential or even a broken spring mounting allowing a rear axle housing to shift under tension.

A quick test to verify the 4x4 function is to place the truck in drive in 2HI, turn the steering wheel hard to one side and coast about 10 feet. Then repeat these steps in 4HI. The truck should coast smoothly in 2HI and come to a halt after a couple feet in 4HI as the drivetrain "winds up," meaning the gears bind up because the tires are turning at different rates. If the vehicle coasts the same both times you know there is a problem to further diagnose as the front axles are not engaging.

The next step is identifying if the problem lies in the front differential or in the transfer case. With the truck in Park (or first gear with a manual transmission) and in 4HI, lift the wheels off the ground and try to turn the front driveshaft. If the shaft doesn't turn you should be looking at the front axle and hubs for a problem. If it does turn, you'll be looking at the transfer case and possible control side problems. This is basically a divide and conquer method. Since the system is basically two separate components linked with drive shafts it's easy to isolate the fault to a particular component.

All wheel drive systems can't be verified as simply as the 4x4 systems can. Typically, faults will be noticed as noise or fault indicators on the instrument panel like an amber AWD light and stored codes in the computer. Since the computer monitors wheel speed, transmission and engine sensors will likely turn on more than one fault indicator. Issues that will turn on the light might range from simply having low tire pressure at one wheel to having a failed magnetic clutch pack.

This amber AWD light is the AWD drive version of a check engine light. It should come on when the key is turned on then turn off after a short time. If it remains on or flashes there is a problem that needs to be diagnosed.

The customer didn't notice that the green AWD light was now amber in this Murano. A failed wheel bearing physically damaged the wheel speed sensor, causing a fault in the AWD system.

A fault code isn't always the only thing that can indicate a problem in an AWD system. Many systems use electrically actuated clutch packs at the axle or differential as a means of applying torque to the specific axle. These clutches can wear out or become contaminated with fluid from a leaking rear differential pinion seal. Sometimes they will make strange clunking noises as they engage, or even moaning, grinding noises as torque is applied by turning in tight corners.

It should be noted that not all AWD systems are designed solely as a safety feature for grocery-getting crossovers. The strongest system is the Advanced Total Traction Engineering System for All-terrain with Electronic Torque Split, or ATTESA E-TS. This is used in the sports cars like the Infiniti G35x and the Nissan GT-R. The system has been credited with keeping the GT-R ahead of many seemingly better equipped supercars. ATTESA E-TS basically applies the torque of the seriously over-powered engine firmly to the ground in an almost magical way. By sensing for slip it can vary the torque applied from front to back and even side to side, keeping the power on the ground.

On some modern AWD vehicles, like this 2013 Juke, each axle has its own clutch pack to apply torque where it's needed and remove it from where it isn't. New technology also means more parts that can fail in new ways.

When servicing vehicles with AWD there are certain precautions you have to keep in mind. Obviously jacking up the front end and putting it in gear to listen for a bad wheel bearing will end poorly with an AWD vehicle. There are other things to consider as well. Tire pressures must be kept at the manufacturer's recommended pressure. This is usually found on a sticker on the driver's door jamb. Having incorrect tire pressure changes the effective diameter of the tire and can affect the AWD performance. In extreme cases it may even set a code.

Care must also be taken in selecting replacement tires. The tires must be the same size both side to side and front to rear. Even having badly worn tires on the front and new tires on the rear can cause issues, as the thickness of the tread affects the diameter of the tire and the axle rotation speed. It may sound like a sales pitch to sell more tires but it is valid in that all four tires need to be as close as practical to the same rolling diameter. If a flat is replaced with a poorly sized spare, it may trigger a fault code and deactivate the AWD.

As technology continues to evolve we are seeing the differences between these two types of drive trains diminish. Many AWD vehicles now have a button to push that will activate all four wheels at lower speeds, much like a 4x4. This allows the driver to be proactive if they know a slick spot is coming. In a system that's otherwise automatic, would this not make it a 4x4 vehicle? In this case, since the system will activate automatically and the vehicle is still safe to operate on standard roads, AWD is still appropriate. As long as adventurers will leave the road in search of mud, sand, and really steep boat ramps, locking transfer cases and low range four wheel drive will continue to be popular.

The Mysterious Misfire

A smooth running engine is an efficient engine. Thanks to the advancements in computer controlled engine management, keeping today's Nissans running great is easier than ever. The flip side of that coin is that, when things do go wrong, the knowledge required to repair a problem is more advanced than ever. Whether it's a rough running engine or a simple loss of fuel efficiency, let's take a look at those hard to find run-ability problems.

The days of actually tuning an engine are quickly coming to an end. In the not too distant past a mechanic would have to turn screws on a carburetor, adjust the timing, set the choke, test drive and do it all over again if something wasn't quite right. It wasn't just a science, it was also an art getting the engine to run its best through the entire rpm range.

Times have changed. What once was controlled by a metered orifice that was prone to clogging has been replaced with an impressively complex algorithm in the ECM. Today's vehicles don't just have control of the ignition timing, they control the timing of the valves in ways that boggle the mind. With the aid of scan tools, data systems, and an internet-connected community of technicians that are always willing to help, even the most mysterious engine run-ability problems don't stand a chance against you, the educated diagnostic technician.

At the core of modern engine management are computers that are constantly monitoring the performance of the engine. This is partly because they are required by the laws that brought us OBD II and partly because it's good old fashioned common sense. Many values that are critical to a smooth running engine are monitored by the computer to allow perfect adjustment on the fly.

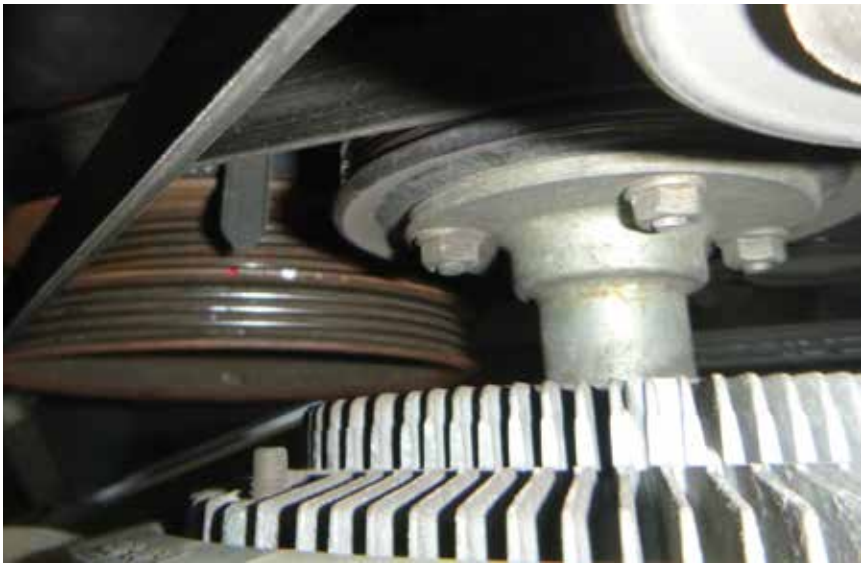
Air/fuel ratio is monitored by the oxygen sensors for fuel control. Detonation or pinging are monitored by the knock sensor for timing control. Intake air temperature, manifold vacuum, and a dozen other readings all come together for the ECM to adjust the engine "tuning" as you drive. On top of that the ECM will also monitor for other signs that the engine is running the best it can, like catalytic converter and misfire monitoring.

Notice the mounting at the base of the distributor has an elongated hole. This indicates the ignition timing can and should be adjusted. In the case of a random misfire, check the timing.

Opposite Page: It's easy to blame a tired spark plug for a rough running engine. The rounded edges of the electrodes let you know it's not new, but is it causing your problem? With a complete lack of deposits and a gap within a few thousandths of specification, you can change them for maintenance, but this isn't likely your underlying cause.

There are a few examples of Nissan engines that fill the gap between "needing to be tuned" and "computer controlled," like the late 1990s 3.3L and 2.4L you would find in a Pathfinder or Frontier. On the 3.3L the distributor sits on the left cylinder head and is driven by the left camshaft. Looking at the mounting bolt you may notice it has a slot. Whenever you see this slot it means the timing is adjustable. As little as 5 degrees out of base timing can make it difficult for the ECM to keep the engine running smoothly.

Although the procedures may be slightly different for some models, the basic principles are the same. Let's adjust the timing on a 1998 Pathfinder that uses this engine. First warm the engine up to operating temperature. Next turn off the key, unplug the TPS, and start the engine again. This disables the ECM timing control and allows you to adjust base timing.



The red mark is at top dead center (TDC). This is where you want to be for a leak-down test. The white mark is 10 degrees BTDC which is typical for base timing. Each mark to the right is 5 degrees more advanced.

Connect a timing light to the spark plug wire at cylinder number 1, that's the first cylinder on the right-hand bank. Aiming the timing light at the crankshaft pulley, loosen and rotate the distributor until the pointer lines up with 10 degree BTDC mark, or use your dial-back timing light as directed. Re-torque the distributor mounting bolt and double check that your pointer is still at the right mark.

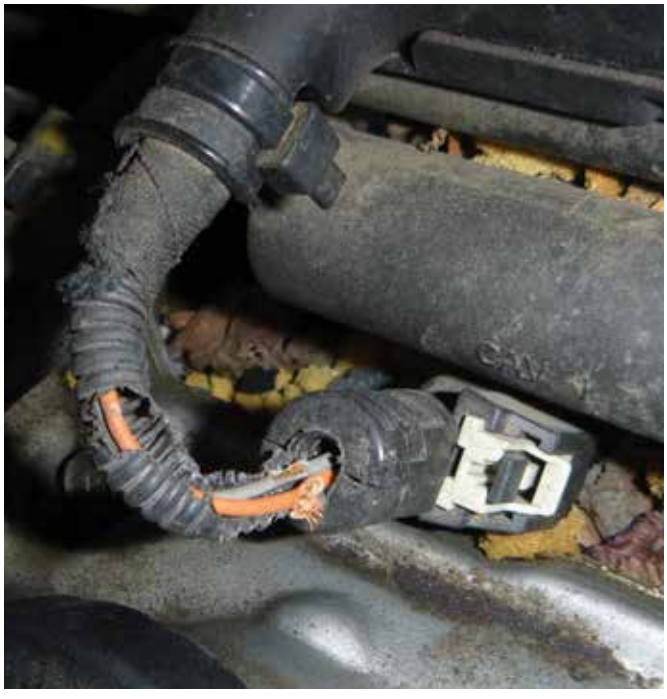
As the ECM discovers something not quite right with the engine it will indicate to the operator with an all too familiar MIL. Most of the time the code stored will lead you straight to the system at fault, and in a lot of cases will directly tell you which sensor or solenoid has failed. Just follow the OEM diagnostic tree in the OEM service manual and you will have a solid diagnosis with time to spare.

There are, however, times when the code stored isn't so straightforward and, worse, there are times when no code is stored at all. Where do you start when the engine just isn't running right?

Making sure the ECM is actually functioning can save a lot of headaches. Using a scan tool, check that the OBD II monitors have cleared. Ground points at the transmission and chassis can become loose, corroded, or even break from vibration stress.

With poor grounding the ECM cannot function properly. You may find it will lose its memory each time the engine is started, preventing any codes from being stored. On top of that the loose ground can also cause misfires by affecting the coils and fuel injectors. Although not common, a poor ground has even been known to cause coil failures. If you find multiple melted coils, or repeated coil failures, double check your grounding with a wiggle and voltage drop test.

Fuel left to sit in the gas tank will eventually go bad and cause many problems, not the least of which is rough idle. The gas in the bottle on the left has spoiled and smells like furniture varnish. The difference is clearly visible compared to a bottle of good gas on the right.



` More than just a broken wire can cause a break in the connection. A rodent chew leaves the wires bare and presents the possibility of a short to power at the injector driver in the ECM or a short to ground, disrupting power to the injectors. Either way it means a poor running engine, or worse.

When a misfire is indicated with codes P0301-P0308, it is primarily in a single cylinder, making it fairly easy to nail down what's wrong. By isolating the spark plug, coil, compression, and fuel delivery for the cylinder indicated, the diagnosis is straightforward.

What about the code P0300? This code indicates a random misfire. This is the ECM's way of saying "the engine is running rough." The diagnostic procedure is different in that you have to look at the entire engine as a whole machine and focus less on the individual cylinders.

Start by observing the way the engine actually runs. Is it rough at an idle? Does it lose power under acceleration? Does it have trouble keeping a steady rpm? Is it the same with the engine hot or cold? Is it the same with the weather wet or dry? All of these could be considered different symptoms. Using a solid knowledge of how the engine works and understanding some basic engine management strategies the ECM uses, you can isolate the issue down to a general system (like fuel delivery, air intake, core mechanical, etc.) and further isolate to a specific system and the problem.

The ECM monitors EGR flow with this heat sensor. You can measure for flow when it shouldn't be flowing by checking for heat.

Take the example of a couple's third car that has been parked in the driveway for the last three years without moving. It may start with a booster battery but will not likely run very well. Bad fuel, critters in the intake, and corroded electrical connections can all cause poor engine performance. The 3.5L often found in Quests and Altimas has an intake valley that is a perfect nesting place for small rodents, for example. Perhaps the vehicle was parked due to a poor running engine or poor fuel economy. Asking your customer may jog their memory and let you know there may be more than simply time to consider.

Typically, a vehicle parked for extended periods will have had a dead battery at some point so

stored codes are not likely going to be of any help. After draining any bad gas and checking the oil and coolant, fill the tank with new gas. Is the fuel filter serviceable? Can you perform a fuel rail cleaning? Any spoiled fuel that may have run though the engine can cause sticky deposits in the injectors and affect performance.

Once the engine is running you can listen for unusual lifter or timing chain noise as well as feeling if the engine is running smoothly. Being cautious when first starting a car out of storage may let you catch a serious problem before it gets worse. Identifying misfires is part of that caution.

A very important step in diagnosing a misfire code is verifying when the engine is actually misfiring. A misfire at idle for example may indicate a fuel control issue like a vacuum leak or faulty MAF sensor. A frequently overlooked possibility is a clogged EGR valve. If the EGR valve were completely clogged it would not cause a misfire, just a MIL for insufficient flow.

What can happen is, soot will build up and cause the valve to not fully seat; this allows exhaust into the fresh air stream. At cruising rpm this will cause no problems, as the percentage of exhaust in intake is low. At idle, however, the amount of air flow is much lower, and the exhaust displaces a much higher percentage of the fuel/air charge.

Many engines like the 3.5L in Altimas and Quests use a valve in a tube between the exhaust manifold and the intake manifold. These engines have a temperature sensor on the intake side of the EGR valve that can be monitored. If you are starting with a cold engine, an even easier way is to simply feel for heat from the EGR tube (careful, a bad failure can get really hot). If the tube is getting warmer at idle, exhaust is flowing through it, causing an imbalance in the fuel trim and ultimately a misfire.

Intermittent run-ability issues can be very frustrating. Checking TSBs for common failures and even picking the brains of the more experienced techs in the shop can save you a lot of time. As vehicles age, the same parts will typically fail with the same results.

It's important to realize, in diagnostics, that improbable doesn't mean impossible. When you are following the diagnostic trail, skipping steps can cost you time. One not so obvious example would be assuming spark plugs aren't the cause of a P0300 code.

If you look at most Nissan V-6s, the intake manifold covers half of the spark plugs, making them very difficult to check. To save time a technician might pull a plug or two from the front bank and assume, since they are new, that the rear plugs are OK too. No one would change

Even without an automated injector kill test, you can still disable each injector to watch for an rpm drop. While you're at it, check the resistance too.

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just the front plugs, right? With a 3.5L in a mid-2000s Nissan Quest, getting to the rear plugs is going to take up most of your day. It's not unheard of for a DIY mechanic to just change the three easy plugs and not finish the job.

If your codes indicate P0301, P0303, and P0305 indicating cylinders 1, 3, and 5 are misfiring, pulling the intake and checking those plugs, coils and fuel injectors is the next step. If you only have a P0300, indicating a random misfire, you may still have specific cylinders causing the problem, just more than one. It can still be a spark plug, coil or fuel injector issue on more than one cylinder.

With any luck your scan tool will have a power balance graphic or misfire counter that can give you an idea which cylinders are missing. Another possibility is an "injector kill" test. Often you can use your scan tool to individually turn off injectors while monitoring the engine rpm. The more the rpm drops when you kill the injector, the better that cylinder is running. No change at all would indicate a dead cylinder.

If neither one of those options will work in your situation you may be able to at least isolate which bank is having a problem. Simply run the engine at idle and monitor the performance of the catalytic converters via the post cat oxygen sensors. If the bank 2 catalytic converter is smoothing the oxygen sensor signal and the bank 1 catalytic converter isn't, it may be an indication you have a problem with cylinders 1,3, and 5. It seems like a lot of steps, but these tests are quick, they may identify individual cylinder failures, and help simplify your diagnosis.

Not all misfires originate from engine control systems. With today's quality metals engines seem to last forever. It's easy to forget, but on occasion an engine will run poorly simply due to mechanical failure. A blown head gasket, worn piston rings or improper valve timing can all manifest in a rough running engine. With any luck you will have other signs like a plume of white smoke out the tail pipe, or a loud ticking under the timing cover. It is possible to simply have worn piston rings that can't keep compression high enough to run properly.

With one simple test you can quickly identify if you have a core engine problem. Connect an accurate vacuum gauge to direct intake manifold vacuum. Be certain the connection doesn't have a check valve in-line. If manifold vacuum is fluctuating wildly, further mechanical engine testing is in order.

If compression is smooth and consistent in all cylinders, the vacuum will be steady and you can rule out most internal engine problems. The exception would be certain head gasket failures. If a head gasket failure is suspected, test for combustion gases in the coolant with "block check" tool.

With experience you will be able to recognize common symptoms quicker each time you see the same failure. Another often-forgotten learning tool is looking at data from a good running engine. Much like a banker spotting counterfeit bills, the more you are familiar with good data the easier you will spot bad data. This would also include paying attention to the way an engine feels on your test drive for a brake job, so that when the same model comes in for performance issues you'll be ready. It's tough to diagnose "running bad" if you don't know what "running good" feels like.

This tool is old and worn, designed for another era. Yet, this vacuum gauge can give you surprising insight into an engine's internal integrity.

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Ins and Outs of Oxygen Sensors

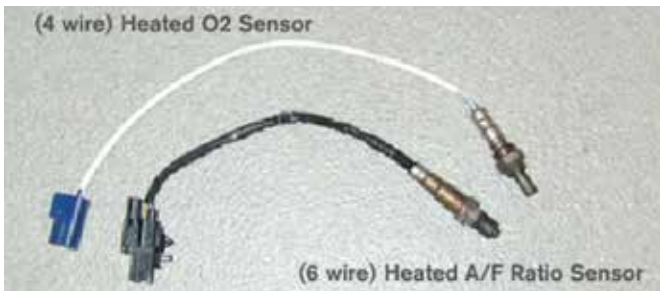
These clever devices come in a variety of flavors, all in the interest of optimizing engine performance, fuel economy, and emission control. Understanding how they work and how they wear out will assure that they report accurate information to the ECM.

O2 images courtesy of Robert Bosch, LLC

A gasoline engine requires 14.7 kilograms of air for each kilogram of gasoline in order to burn the fuel completely. This 14.7:1 air/fuel mixture is called a stoichiometric ratio and is the holy grail of engine management software and control modules. A tendency to operate on either side of that target number results in lower volumetric efficiency, which leads to reduced engine performance. If there is less air, the mixture is too rich, and some of the fuel cannot be burned. If there is less fuel, the mixture is lean, and the engine does not develop as much power as intended from each piston stroke.

In addition to performance problems, lower volumetric efficiency results in increased potential for emission of harmful substances, including carbon monoxide (CO), unburned hydrocarbons (HC), and oxides of nitrogen (NO_x). The catalytic converter takes these three major byproducts of incomplete or unbalanced combustion and converts them into substances that do not contribute to air pollution.

The catalytic converter is most efficient at reducing HC, CO, and NO_x when the air/fuel mixture is at or near the stoichiometric ratio of 14.7:1. However, different operating conditions require variations from the stoichiometric ratio. During cold start and engine warm-up, fuel condenses on cool cylinder surfaces, creating a lean condition. The engine control module (ECM) adds extra fuel to enrich the mixture. Similarly, the ECM enriches the mixture under full throttle conditions to provide more power.



Most modern oxygen sensors have at least four wires and some have as many as six.

Under idling conditions, the engine operates at the stoichiometric ratio. At part throttle, where the engine operates most often, a slightly lean mixture provides good fuel economy.

While transitioning from closed to open throttle, a lean condition occurs naturally. To avoid hesitation or lean surge during that transition, the ECM quickly richens the mixture.

Once the ECM issues commands to adjust the air/fuel mixture, it looks for feedback from oxygen sensors to confirm that its instructions had the intended result. Sensors before the catalytic converter measure and report to the ECM the content of the exhaust gases coming out of the combustion chambers. Post-cat oxygen sensors send data on whether or not the converter was able to successfully bring the three harmful gases – CO, HC, and NO_x – within limits mandated by the Environmental Protection Agency (EPA) and by local/state regulatory bodies.

Three major categories of oxygen sensors

Air/fuel mixture data comes to the ECM in the form of voltage or current, depending on the type of oxygen sensor. There are many different types of oxygen sensors, from the earliest unheated, single wire, chassis-grounded sensor to modern multi-wire wideband sensors with built-in ground and heater technologies. Most fall into one of three major categories of oxygen sensors.

The original oxygen sensor design features a zirconium dioxide ceramic element in a thimble-shaped construction. Exhaust gas flows along the outside of the thimble, while the interior is filled with air from the atmosphere. Atmospheric air contains about 21 percent oxygen. It serves as a reference against which the concentration of oxygen ions in the exhaust gas (approximately 0.3-3.0 percent) can be compared.

The ceramic element (called a "Nernst" cell) separates the exhaust gases from atmospheric (reference) air. But when heated to at least 350 degrees C (660 degrees F), the ceramic element becomes permeable to oxygen ions. As oxygen ions travel through the ceramic barrier, the change in oxygen content from one side to the other generates a voltage. If oxygen content in the exhaust gas is close to 3 percent (lean mixture), a voltage of 0.1 V is produced. An oxygen content of closer to or under 1 percent (rich mixture) produces a voltage of 0.9 V.

When the oxygen content in the exhaust is at the ideal stoichiometric ratio, the standard oxygen sensor produces 4.5 volts, in the middle of the range. Outside of a narrow band around that 4.5 V mid range, the standard oxygen sensor is not accurate in its measurements. For this reason, it is called a "narrow band" sensor. Instead of reporting an exact voltage when the mixture deviates from stoichiometric, the narrow band oxygen sensor is considered accurate only as a directional high or low indication. It switches back and forth approximately once per second from the low of 0.1 V to the high of 0.9 volts. A change as small as from 0.1 percent to 2.0 percent oxygen entering the exhaust stream causes the voltage signal to the ECM to switch from rich (more voltage) to lean (less voltage).

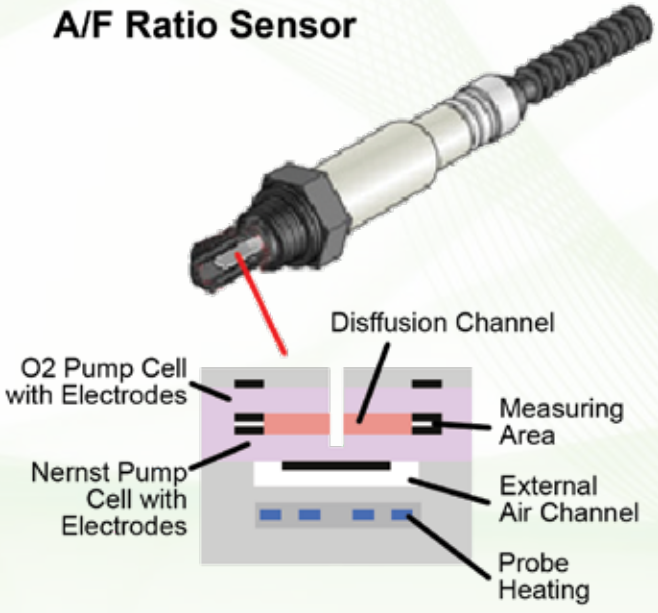
A second type of oxygen sensor features a titania rather than zirconia element. Unlike the traditional zirconia oxygen sensor which generates voltage as the air/fuel mixture goes from rich to lean and vice versa, a titania sensor cannot create its own voltage. Instead of the sensor using reference (atmospheric) air, the ECM supplies a base reference voltage to the titania sensor, then monitors the voltage changes in the sensor as the air/fuel ratio in the exhaust stream changes.

Like conventional narrow band sensors, titania oxygen sensors switch between high and low voltages. When the mixture is rich, resistance in a titania sensor will be low and the voltage signal will be close to 1.0 V. When the mixture is lean, resistance increases and the voltage signal falls to about 0.1 V.

Because they did not need reference air, titania sensors had no outside air ports in their housing to worry about becoming clogged with road debris. They offered a faster warm-up time than traditional zirconia sensors. Titania sensors could work at lower temperatures, allowing them to be located further downstream from the engine. They also would not cool down at idle and stop sending a voltage signal to the ECM, as would an unheated zirconia sensor.

Nissan used titania sensors from the mid-1980s to the mid-1990s on Maxima, Sentra, 300ZX, Stanza 4WD wagons, and Nissan D21 trucks. On newer models, the company no longer uses titania sensors.

Both the traditional zirconia and titania oxygen sensors are called "narrow band" because, while they tell the ECM whether the mixture is rich or lean, they cannot give enough detail to report how rich or lean.



Like a narrow band sensor, an A/F oxygen sensor includes a channel for exhaust gases, a channel that brings in external (atmospheric) air, and a zirconium ceramic element (Nernst cell) that separates them. It also contains a diffusion channel and a second permeable element which, when supplied with current, "pumps" oxygen ions into the diffusion channel at just the right rate to maintain the air/fuel mixture in the diffusion channel at 14.7:1.

The third major type of oxygen sensor is the modern zirconia-based air/fuel (A/F) ratio sensor. It outputs a continuous voltage signal that varies directly with oxygen content in the exhaust. The A/F sensor reports the exhaust proportions of fuel and air throughout the entire range, from almost no leftover oxygen to near zero remaining unburned hydrocarbons. It accurately measures a much wider range of fuel mixtures than the conventional narrow band sensor – from as low as 12.5:1 up to 19:1, and so has earned the nickname "wideband" sensor.

How does it accomplish its magic? The A/F sensor "pumps" oxygen ions through the zirconia element from its positive to its negative electrode and back at just the right rate of flow to maintain a Lambda of 1, or 450 mV, on the electrode that interacts with incoming exhaust. The polarity and level of current required to pump enough O_2 ions to restore Lambda inside the A/F sensor is then reported to the ECM, which translates it to fuel injector pulse width commands to achieve the 14.7:1 ratio in the actual air/fuel mixture.

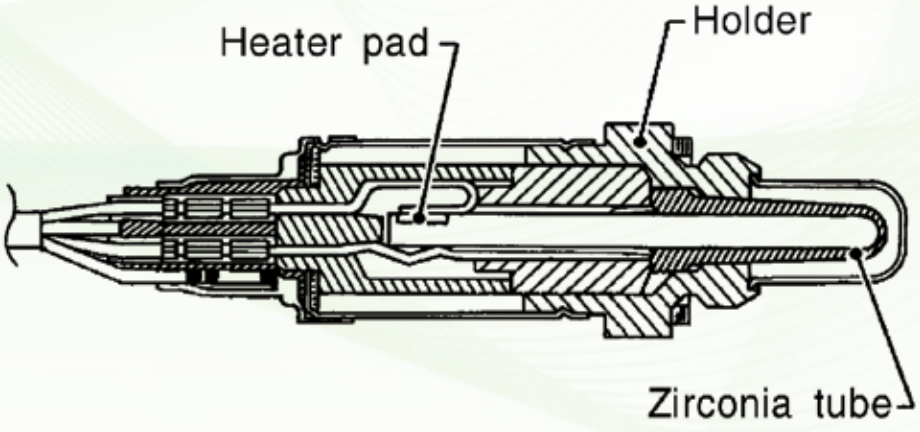
Note that the A/F sensor outputs a current, not a voltage. The current is converted to voltage inside the ECM. Algorithms in the ECM use the voltage number to determine the exact amount of injector pulse width adjustment needed to bring the air/fuel mixture back to stoichiometric. The A/F oxygen sensor effectively contains an internal small scale model of the vehicle's real-world closed loop air/fuel mixture control system.

A wideband sensor also updates faster (less than 100 milliseconds, or ten times per second) than narrow band zirconia and titania oxygen sensors. This leads to better fuel economy by allowing more mixture adjustments to be handled quickly by short term fuel trim (STFT) rather than needing to make long term fuel trim (LTFT) changes. Due both to its wider accuracy range and its faster response time, the wideband A/F oxygen sensor allows the ECM to make adjustments to the air/fuel mixture with greater precision and efficiency.

A/F sensors are typically located before the catalytic converter, while traditional narrow band oxygen sensors are positioned after the cat. The A/F sensor provides input that the ECM uses to make fuel trim adjustment decisions. The ECM uses measurements from the narrow band oxygen sensors in their post-cat locations to determine whether its fuel trim adjustments have brought the mixture back to or near stoichiometric. Nissan began transitioning from narrow band oxygen sensors to A/F (wideband) sensors with selected model year 2000 vehicles. All 2005 and newer Nissan models use A/F sensors for pre-cat measurements.

Not swappable

Because they look similar in construction from the outside, you have to be careful not to install a narrow band oxygen sensor in a vehicle that calls for a wideband unit. At minimum, this mistake will immediately reduce the information reported to the ECM to simply whether the exhaust gas coming into the catalytic converter is rich or lean. The ECM will not know the precise fuel injector pulse width adjustment needed to return the air/fuel mixture to stoichiometric in the shortest amount of time.



Oxygen sensors with built-in heating elements warm up to operating temperature quickly without needing to be located near the high-heat combustion chamber, which improves their functionality versus unheated sensors. The heating element requires its own power and ground.

Conventional versus A/F sensor heater operation

The earliest versions of zirconium oxygen sensors were unheated. That required them to be located close to the combustion chambers so they could warm up quickly during cold starts. Proximity to high engine heat led to the early demise of many unheated oxygen sensors, so manufacturers developed new versions with a built-in heating element.

The heater is activated by the ECM based on engine speed, engine coolant temperature, and intake air volume inputs. The heaters in conventional zirconia oxygen sensors are commanded on at startup and at engine speeds below 3,600 rpm, and off at speeds above 3,600 rpm.

The heating element in an A/F sensor is handled differently. Unlike the voltage signal from conventional oxygen sensors, the A/F sensor outputs current to the ECM. Because current is affected by resistance and resistance is sensitive to temperature, the A/F sensor's temperature must be kept constant in order to generate a consistently accurate signal.

The A/F sensor must be heated to approximately 650 degrees C (1,200 degrees F), twice the temperature of conventional narrow band sensors, to operate effectively. Battery voltage is supplied through a relay and fuse combination. The heater's ground circuit is controlled by the ECM. The A/F sensor's heater ground circuit is pulse width-modulated to keep sensor temperature constant in spite of rapidly fluctuating exhaust gas temperatures.

Nissan's oxygen sensor heater trouble code detection logic is pretty robust. It will set trouble codes if the heater circuit voltage signal is too low (P0031 for A/F sensor 1, P0037 for HO_2S2) or too high (P0032 for A/F R sensor 1, P0038 for HO_2S2). It will set P0043 or P0044, respectively, if a third post-cat oxygen sensor (HO_2S3) is installed and experiencing the same conditions.

The cause of a heater circuit problem could be an open circuit, short to power or short to ground, depending on whether the circuit is positively or negatively controlled. A less likely cause could be a faulty ECM not commanding the heater on. It may be complicated to find because, if an A/F heater is running very high voltage, the ECM may shut it down to prevent damage to the computer's electronics.

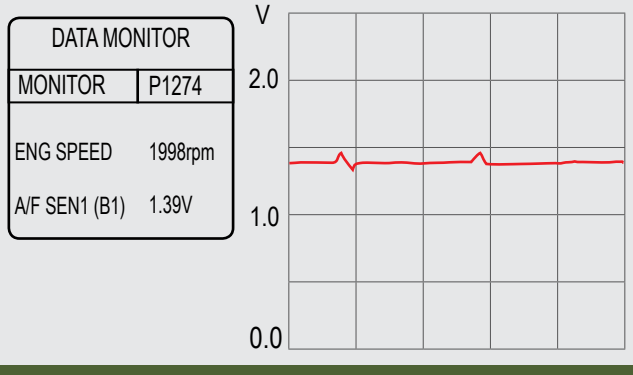
Checking the amperage of the sensor's heater circuit may confirm that there is a problem, but it cannot tell you the source of the fault. One effective quick and dirty test to confirm whether or not the ECM is functioning properly to send activation commands to the heater involves use of a small light bulb. Unplug the sensor's heater harness and connect a bulb and socket in place of the sensor. Clear the codes and turn off the MIL, then turn on the ignition switch. If the circuit has power and the ECM is sending commands to the heater, the bulb will light up or blink.

A/F sensor shifts rich or lean

The A/F sensor readings should fluctuate around 1.5 V when operating normally. Even a slight shift below or above the specified voltage could represent a shift to a richer or leaner mixture than desired. If the A/F signal shifts to the rich (<1.5 V) or the lean (>1.5 V) side, it could be caused by a malfunction in the sensor or its heater circuit. Before condemning the sensor, always check that the circuit indicated by any trouble code is receiving power and is properly grounded.

A/F SENSOR MONITORING RESULTS

Condition	Typical DTC
Shifted Rich	P1274 (Bank 1) P1284 (Bank 2) A/F Sensor 1



The ECM will set trouble codes if the A/F sensor shifts rich.

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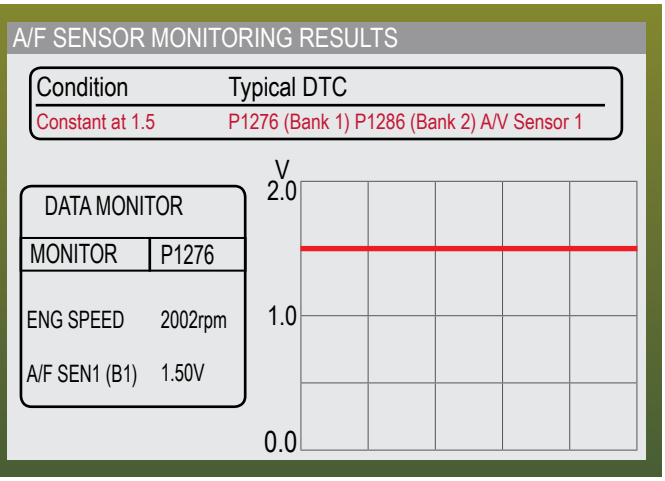
A/F sensor not fluctuating

If the A/F sensor is not fluctuating, even if it is constant at 1.5 V, there is likely an open or shorted circuit. Check the sensor's harness or connector. Do the same if the sensor is constant high at 5 V or straight-line low at 0 V.

Right: An open or shorted circuit in an A/F sensor harness or connector can cause an unresponsive (not fluctuating) voltage output. The ECM will set a trouble code pointing to the offending sensor.

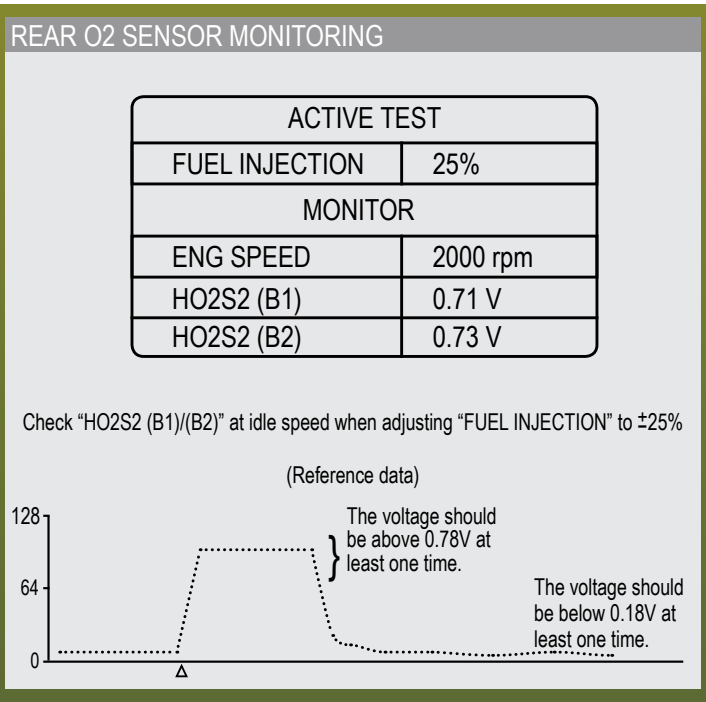


Rear oxygen sensor output

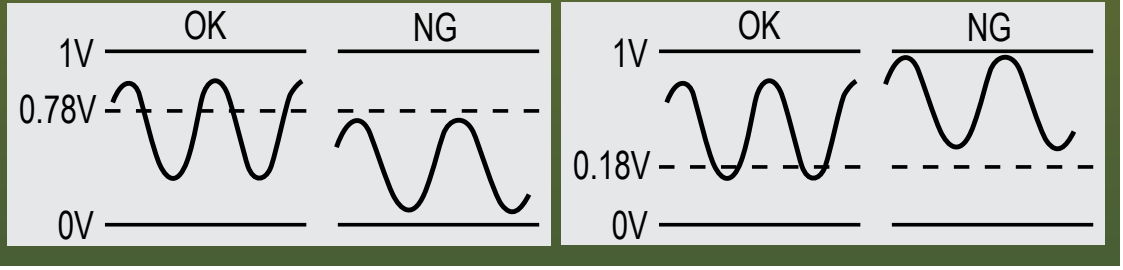
The rear heated oxygen sensor is used to check the effectiveness of the catalytic converter. If performing as intended, the sensor should output voltages that swing from below 0.18 V to above 0.78 V.

If the rear oxygen sensor does not swing above 0.78 V and below 0.18 V as it switches from rich to lean and back, you can use CONSULT III PLUS to command injector pulse width up 25 percent and down 25 percent. If the voltage output signal still does not hit its minimum and maximum targets, you can suspect a faulty sensor.

Top-Right: You can use your CONSULT III PLUS tool (Active Test screen from CONSULT II shown here) to test whether or not the rear oxygen sensor is accurately measuring changes in post-catalytic converter O2 content when fuel trim changes.



Bottom-right: The ECM will set trouble codes if the voltage signal from the rear oxygen sensor fails to reach its minimum and maximum specifications.



Is the O_2 sensor signal getting to the ECM?

Before condemning an O_2 sensor, you need to determine whether or not there are any opens or shorts preventing the sensor's voltage signal from reaching the ECM. You'll need to simulate rich and lean conditions at the O_2 sensor and watch to see if injector pulse width (short term fuel trim) and carbon monoxide (CO) level in the exhaust changes in the appropriate direction.

In newer O_2 sensors you should be able to simulate rich and lean conditions through commands in your Nissan CONSULT III or with a high level aftermarket scan tool. With older O_2 sensors you can add propane to the air/fuel mixture to force a working O_2 sensor to see a rich condition. If the system shortens the injector pulse width in response to the propane, that tells you to check for plugged injectors or other causes of a system not adjusting STFT lean when needed.

Reference air pathway restricted

Outside (non-exhaust) air enters the reference air chamber through vent holes in the housing of old style oxygen sensors. Newer oxygen sensor designs bring outside air in through a channel actually built into the wire. If these ports or channels are blocked or restricted, the oxygen sensor will not be able to "breathe" in outside air. The two chambers in the sensor will not accurately reflect the difference between atmospheric and exhaust levels of oxygen. The rich versus lean condition in the exhaust will be reported incorrectly to the ECM, leading to skewed fuel trim adjustments.

Inspect the sensor to make sure that dirt, airborne contaminants, and leaking oil and other under-hood fluids have not entered the ports in old style sensors and blocked the air pathway. On newer sensors, check that reference air channel openings in the wire connectors are not plugged with contaminants or crushed. Also, make sure that no sealant, dielectric grease, or other materials get into the connector, where they could restrict air flow into the air channel in the wire.

Higher A/F sensor ground voltages

When testing the ground side of the A/F sensor, you need to connect to the sensor's ground, not chassis ground. This is because the A/F sensor circuitry is very sensitive. It does not do well handling interference that could come through the chassis. So manufacturers design the A/F ratio sensor to be grounded through the sensor, or use a floating ground from another sensor on the vehicle. Expect to see a higher voltage for the A/F sensor ground than the 0 voltage value of the typical chassis ground.

Cracked ceramic

The zirconia in an O_2 sensor can last tens of thousands of miles. That is, unless you drop it or bang it around in the shop. If you drop or hit an oxygen sensor with a wrench, you may crack the ceramic element, which is what separates the reference air chamber from the exhaust gas. Once the ceramic is cracked, exhaust gas can flood into the reference air chamber. That will throw the reference comparison off balance and result in a biased voltage reading. You are unlikely to see the crack, as the ceramic is embedded in the sensor. If you dropped it or hit it hard, replace the sensor.

Mode $06

You can use Mode $06 test data to identify O_2 sensors and other components that haven't yet set trouble codes, but are close to the minimum or maximum limit of their factory-specified operating range. This is useful because an O_2 sensor that is close to failing but has not set a code may still cause damage to the catalytic converter.

Mode $06 also includes a subset of additional O_2 sensor data points, including a signal amplitude test, a switch point test, and a heater circuit amperage test. Each test has upper and lower limits that are set to ensure ideal emissions performance for the specific year and Nissan model. The additional tests may help you see that, even though the O_2 sensor has not set a code, it is losing effectiveness in one or more key functional areas and should be replaced.

There are 62 different oxygen sensor codes in the on-board diagnostic (OBD) system, not including manufacturer-specific codes. Nissan does a really good job of providing clear, detailed, step-by-step diagnostic and repair procedures for many oxygen sensor-related trouble codes. Refer to the Engine Controls (EC) section of the service manual for trouble code diagnosis procedures. Study the differences in oxygen sensor type, their control strategies, and any applicable technical service bulletins, and you'll be delivering perfect combustion to your customers.

REMOVAL PROCEDURE FOR SEIZED EXHAUST SENSOR

Reference: NTB10-009b
Date: 03.20.2018

APPLIED VEHICLES: All Nissan vehicles (except LEAF or Titan XD with Cummins 5.0L engine)

SERVICE INFORMATION

If an exhaust sensor is seized in the exhaust manifold/catalyst/front tube, perform the procedure described in this bulletin to remove the sensor. DO NOT replace the exhaust manifold/catalyst/front tube.

The threads of the exhaust sensors are made of a softer material than the part they thread into on the exhaust manifold/catalyst/front tube, so the sensor can be removed without replacing exhaust manifold/catalyst/front tube.

NOTE: The replacement of exhaust manifolds/catalysts/front tubes for stripped exhaust sensor threads may not be considered a warrantable expense.

This procedure can be performed by two methods:

Method One

If the Sensor Can Be Easily Accessed

- The procedure can be performed on the vehicle.
- The exhaust manifold/catalyst/front tube will not have to be removed.

Method Two

If the Sensor Cannot Be Easily Accessed

- The exhaust manifold/catalyst/front tube must be removed from the vehicle.
- The procedure will be performed with the part clamped in a vise.

Rust Penetrant

Recommended rust penetrants to be used in this procedure: WD-40 or Nissan Rust Penetrant P/N 999MP-A3020P.

NOTES:

- Rust penetrant is considered a shop supply.
- Nissan Rust Penetrant can be order through the Nissan Maintenance Advantage program: Phone: 877-NIS-NMA1 (877-647-6621). Website order via link on dealer portal www.NNAnet.com and click on the "Maintenance Advantage" link. The MSDS for this chemical will also be found on this site.
- WD-40 is available from various local sources.

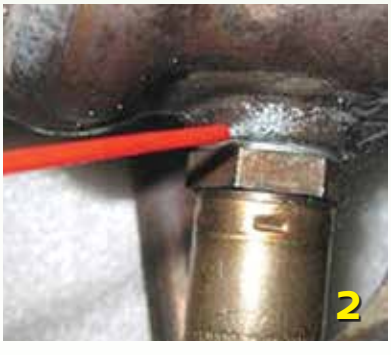
NOTE: This SERVICE PROCEDURE applies only to seized exhaust sensors.

Removal Tool

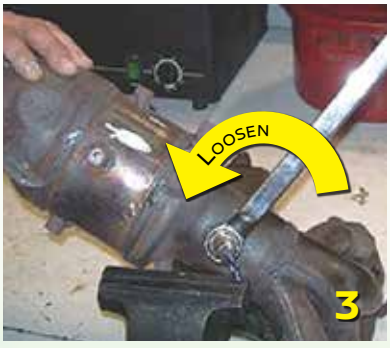
When removing a seized exhaust sensor with a specialty socket (which contains a slit to accommodate the wiring harness), it may spread open and strip the sensor.

Before this occurs, it is recommended to cut the wiring harness from the sensor and use a box end wrench or 6-point deep well socket.

1. Clamp the exhaust manifold/catalyst/front tube in a vise.



2. Spray the sensor with the rust penetrant for 2 to 3 seconds.

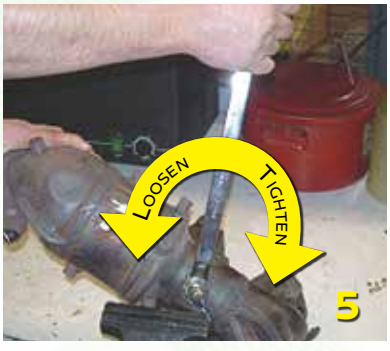


- It is important that the spray is directed at the base of the sensor to ensure it penetrates into the threads.

3. Loosen the sensor approximately 10 degrees.

4. Spray with rust penetrant again for 2 to 3 seconds.

5. Tighten the sensor 10 degrees, then loosen the sensor 10 degrees.



- Repeat this motion several times until the sensor begins to turn more easily.

6. Continue the tightening/loosening motion while gradually unscrewing the sensor. Stop when the sensor will not unscrew any further.

7. Spray with rust penetrant again for 2 to 3 seconds.

8. Repeat steps 6 and 7 until the sensor is removed.

9. Use compressed air to remove any metal debris from inside the boss threads.

CAUTION: DO NOT perform this step if the procedure is being done on the vehicle (Method #1). Doing so may cause metal debris to enter the engine cylinders.

10. If metal debris remains trapped in the boss threads, use a spiral nylon brush to remove it.

11. Spray the boss threads with rust penetrant for 2 to 3 seconds.

12. Run a thread chaser through the boss to clean the threads.

- Use Kent Moore part number J-43897-18 or J-43897-12A.
- These tools are available from TECH-MATE: 1-800-662-2001.

13. Use compressed air to remove any remaining debris. CAUTION: DO NOT perform this step if the procedure is being done on the vehicle (Method #1). Doing so may cause metal debris to enter the engine cylinders.

14. If metal debris remains trapped in the boss threads, use a spiral nylon brush to remove it.

14. If metal debris remains trapped in the boss threads, use a spiral nylon brush to remove it.

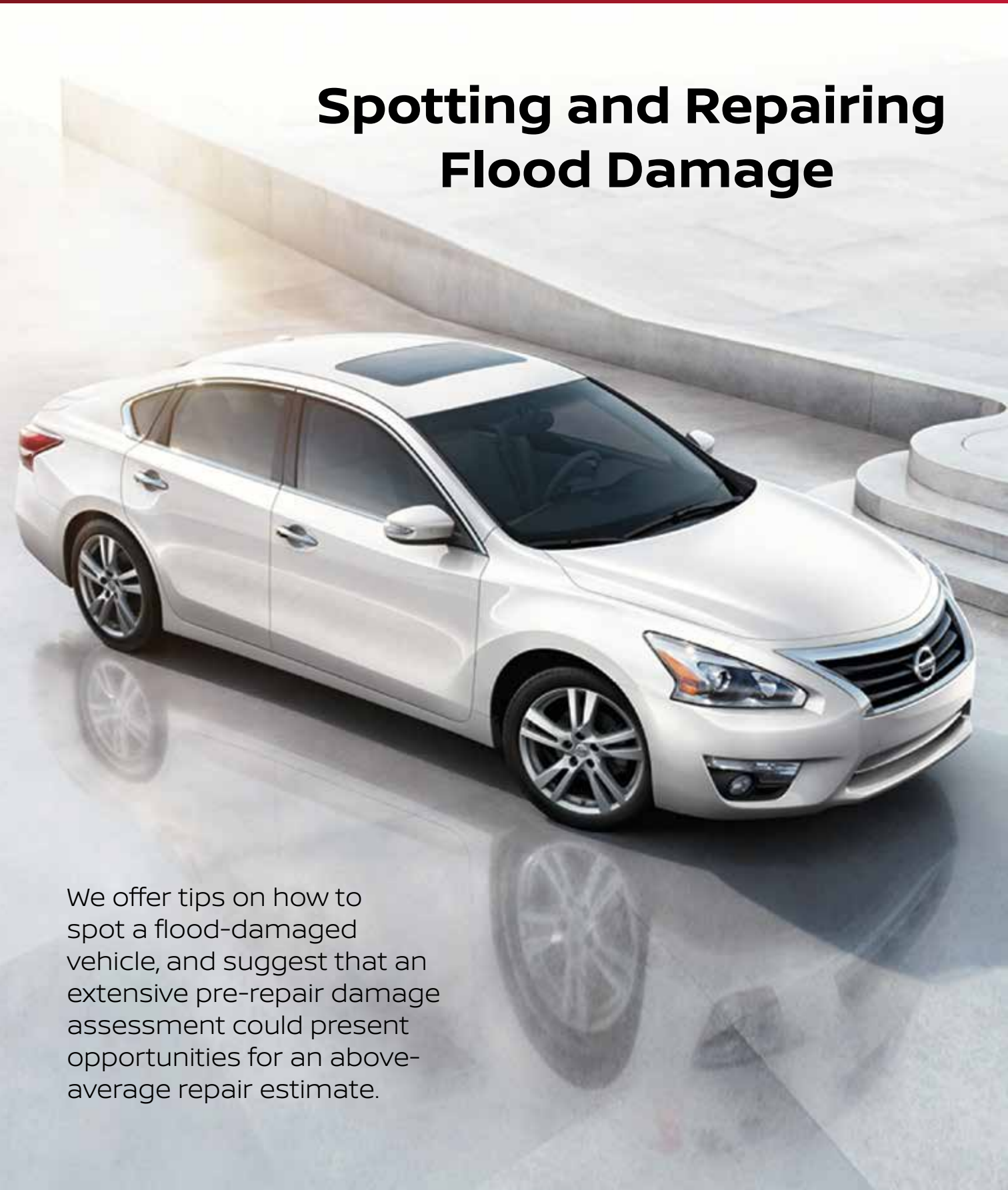
15. Tilt the manifold/catalyst/front tube so that the metal debris falls out of the part.

16. Apply compressed air through the boss to blow out any remaining debris.

CAUTION: DO NOT perform this step if the procedure is being done on the vehicle (Method #1). Doing so may cause metal debris to enter the engine cylinders.

17. Install the new sensor as described in the applicable Electronic Service Manual (ESM).

Spotting and Repairing Flood Damage



We offer tips on how to spot a flood-damaged vehicle, and suggest that an extensive pre-repair damage assessment could present opportunities for an above-average repair estimate.

Flood damage assessment is more like the diagnostic process for collision than mechanical repair. Rather than a single point of failure, there is the high probability of damage to multiple vehicle systems in many different areas. Your job as detective is much broader than of a mechanical problem diagnosis. And your shop should have strict guidelines to determine when the extent of damage indicates that you should declare the car not repairable and decline to service it.

The first thing you need before tackling the repair of a flood-damaged vehicle is an awareness of the fact that it has been up close and personal with water. You don't want to find out after you've sold a non-flood repair that the vehicle has significant water damage and requires a major increase in the estimate. Worse, you don't want a comeback (or series of comebacks) due to corrosion or other water-related damage that doesn't show up until a few months later. It can be difficult to convince even a good customer that this must be billed as a new repair.

Warning signs

Some flood damage is obvious. Water marks up the sides of interior door panels and trunk side wall linings, saturated carpet and backing, and leaves, debris, and water puddled in indentations on the top of the engine are but a few indications of flood damage that are easy to spot. A thorough inspection is your friend.

Help your customers prevent flood damage from harming the performance of Nissan's smooth 270 hp, 3.0 liter V-6, shown here in the 2013 Altima sedan.

It's easier to catch if the car comes in the day after a flood in your market area. Or the tow truck driver tells you that the customer tried to muscle through a two-foot deep wading pool created by flash flooding of a low bridge underpass.

The smell of desperation

Unscrupulous operators sell used cars without identifying them as having been flood-damaged. The customer that notices the phrase "sold as-is" on the purchase agreement only after he or she discovers flood damage may try to push some of their pain onto you as the repair service provider.

They may bluster their way through an argument that something must be defective on the vehicle, hoping that it can be covered by warranty. That may be a sign that you need to get the customer to tell you more about the vehicle's repair history. If you get a feeling that the vehicle has been shopped around to multiple service providers, dig deeper. The smell of desperation is a big red flag.

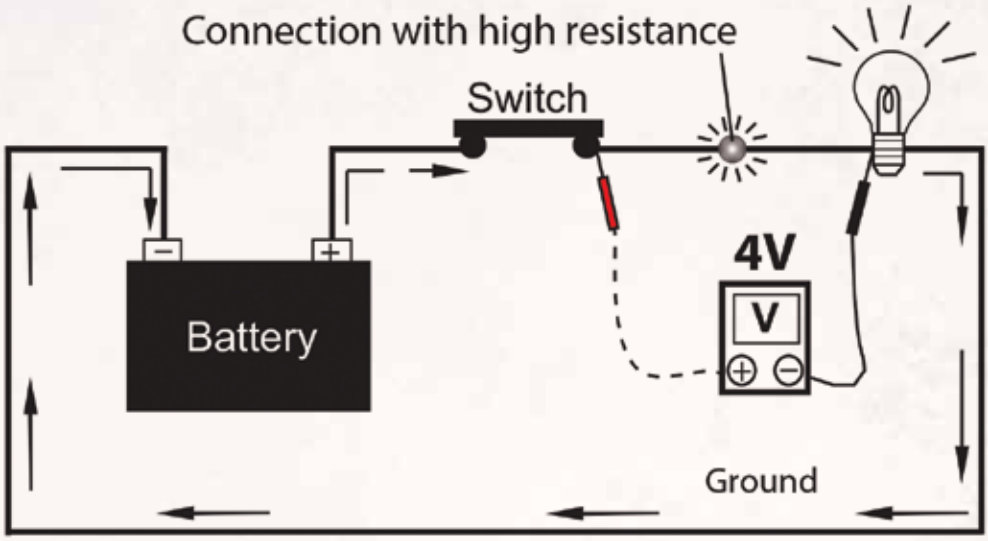
What is that new carpet hiding?

Even without intentional deception, some flood damage may be difficult to spot. Mold and mildew in the vehicle interior may not be visible, although the odor can be detected – and you won't need a trained dog. Look for a musty, dirty sock smell or rotten egg odor.

Another warning sign of flood damage is new carpeting or carpet backing (jute) that has been removed or recently replaced. The replacement may have been an attempt to eliminate a moldy smell.

The chemistry of corrosion

A battery moves current from its anode (negative terminal) to its cathode (positive terminal), and in this discharge process provides electrons to perform work in the attached device. The electrolyte in the battery connects the anode and cathode, allowing the flow of current between the two terminals.



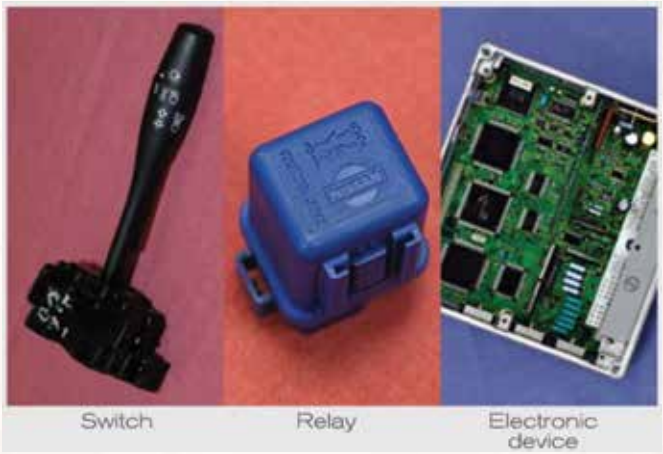
Corrosion in a wiring connection can increase resistance and voltage drop, leading to slower than normal electric motor speeds, dim or intermittently flickering bulbs, wire overheating, and other problems.

When moisture is in contact with exposed iron or steel, it creates an electrochemical pathway that encourages electrons to move from one place (anode) on the surface to another (cathode). Electrons transfer from iron or steel molecules to nearby oxygen molecules, changing the composition of the metal. We see the result as corrosion, rust, or a loss of surface material in the metal.

The process can begin within minutes of exposure of metal to moisture. Once begun, it doesn't take much moisture to keep corrosion progressing. As little as 60 percent relative humidity can create an electrolytic condition and continue corroding exposed metal surfaces. You probably know this from the surface rust that forms almost immediately after steel parts have been sand-blasted or stripped.

In automotive applications, corrosion aggressively weakens the structural integrity of metal panels and components and lessens the ability of paint and coatings to adhere to the metal surface. Look for surface corrosion on steel body panels, and weakened or deteriorated flanges and areas where metal layers overlap.

Inspect rocker panels, frame rails, exhaust systems, and other exposed underbody metals. Check support brackets, door and trunk hinges, and other areas where metal components are joined using bolts, rivets or other metallic fasteners.



Corrosion can cause glitches and failure of switches, relays and engine control modules.

Paint job

Corrosion under paint will eventually cause a bubble or irregular surface area. If you see imperfections or variation in surface height, a recent paint job could be hiding corrosion damage.

Sensitive modules and connectors

Corrosion also reduces the conductivity of electrical connections. Many electronically-controlled systems rely on low voltage signals

that are extremely sensitive to corrosion in connectors. Even if water reached only a little above the bottom of the vehicle, there is enough wiring under the seats and in the floor that exposure may have caused corrosion to affect many systems and multiple connections within those systems.

Wheel speed sensors and other ABS brake components, crash sensors, seat belt pre-tensioners and buckles, body control modules, yaw rate sensors, and other safety-critical components are often built into the floor or near it, depending on the Nissan model. Full of sensitive electronics and located by necessity near the exterior of the vehicle, these components are especially vulnerable to flood damage.

Are any exterior or interior lights not working? Are any warning lights lit on the dash? Do the ignition and starter motor circuits function erratically or not at all? Water helps create new paths to ground for secondary ignition parts. Are other systems not working? Water intrusion into connectors may prevent CAN communication between various control modules.

Perform visual checks for corrosion in wiring harnesses and connectors. Then do pre-repair scans for trouble codes indicating performance problems with sensors, actuators, and control modules. Although corrosion in connectors and wiring harnesses may not be readily visible, trouble codes can help point you to diagnostic procedures that will reveal corrosion-related shorts and intermittent faults. They will help focus your search to the most likely problem circuits, fuses, and wiring harnesses, saving you diagnostic time.

If the ABS light is on and you find a code for a wheel speed sensor (WSS), check the sensor wires for breaks or a loose/corroded connector. Broken wires are probably the leading cause of WSS failures. Water rising to the height of the wheel speed sensors may not occur as often as wiring harness damage, but once it happens, it is equally deadly. Flood water can corrode the teeth of the wheel speed sensor tone ring, even on vehicles in which the tone ring is built into the hub assembly. Hub assembly seals protect against rain and/or road water splashes, not wheels that are submerged for minutes or hours.

Check the threads of ground connections. Corroded grounds are a common cause of reduced power and intermittent failure of electrical devices.

Voltage drop testing can help you find corrosion-caused excess resistance in a connector or circuit.

In from the cold

If the customer comes in with a cold weather complaint of an intermittent problem that goes away after the car warms up, the cause may be water freezing in an electrical component or its wiring harness. If you think it could get cold enough overnight for the problem to repeat, you could keep the vehicle parked outdoors and in the morning have your technician diagnose those components you suspect may be affected.

Alternately, you could place the component you suspect is the cause in a freezer for a couple of hours. Once chilled

enough that any water inside has re-frozen, re-install the part on the vehicle and check whether or not the intermittent fault re-occurs. If it does, then you can determine whether to repair (dry out) or replace the component.

Salty dog

Reconditioning experts recommend that if you do tackle a flood repair, you should limit your efforts to only those vehicles that have been exposed to fresh water. Salt water accelerates the development of corrosion and electrical problems at a significantly higher rate than fresh water. The high concentration of salt makes the water function more like the electrolyte in a battery, encouraging the electrochemical reaction that produces movement of electrons in the metal.

Engine and transmission

If water rose halfway up the side of the engine or transmission, the potential for damage is greater. Engine and transmission seals and gaskets are potential entry points for water, especially if there was an oil leak from those areas before the flooding event. And water and dirt can get into bearings and accelerate wear.

Water in the engine

Before attempting to start an engine that you suspect has suffered flood damage, check all fluids for water. Cranking the starter motor could cause hydrostatic lock in an engine. If the engine has sat in moist or flooded conditions for a while, corroded pistons or bores could cause it to seize up. Attempting to start it could lead to a bent connecting rod or more extensive damage.

Remove the spark plugs or fuel injectors and rotate the engine by hand to ensure that it turns over freely. If water comes out of the ports, continue rotating the crankshaft manually until no more water exits. Then use compressed air or other technique to remove any water that may remain in the cylinders. Inspect the spark plugs and fuel injectors and replace as needed.

Water in the engine oil can cause oil foaming, loss of power and sludge formation. Drain a little oil from the oil pan. If you detect water or the oil has a milky discoloration, drain and replace it, change the oil filter, and refill the system with new oil.

Drain a small amount of fuel from the fuel tank and test it for water. If there is water in the fuel, drain and replace all of the fuel in the tank and hoses. Replace the fuel filter. Drain some fuel from the fuel pump and check for water. If you find water in the pump, drain the fuel and replace it with fresh gasoline.

Remember that water does not mix with gasoline or engine oil, so any water that's present will settle to the bottom of the sump or fuel tank. As such, it will be the first liquid to come out when you drain oil or fuel, so look closely right from the start.

Remove air filters and check for the presence of moisture. If the filters are or have been wet, replace them.

Fuses and circuit breakers are easily accessed and inexpensive to replace if flood-damaged.

Transmission (clutch, final drive and hydraulic systems)

An outwardly visible sign that a transmission has been submerged in water is the presence of a powdery white film on its exterior. This is due to oxidation of the aluminum case, and will be more severe than normal after a flooding event.

On the inside, transmission clutches are hygroscopic, meaning they absorb water. The water will displace transmission fluid, pushing it out of clutch linings. Once it's absorbed, you cannot remove water from the clutches. The only safe choice is to replace them.

Water in transmission fluid deteriorates the friction modification properties of the clutches and results in chatter and harsh shifts. Even a small amount of water can damage the clutches. It won't always be enough to create the milky appearance that is a warning sign of transmission fluid contamination.

There are test strips available that can simplify the task of determining whether the transmission fluid has been contaminated. There are different types, including one that tests for antifreeze contamination and another that identifies plain water in the ATF.

Using both reveals a lot of useful information. No reaction from either strip is the best news; that would show that the transmission fluid is not contaminated. If the coolant strip reacts, that is a sign of a cooling system leak. If both strips react it is also coolant contamination; the coolant has enough water in it to cause a reaction from each separate test strip. If only the water strip reacts, that rules out coolant contamination and confirms the presence of water in the ATF.

Rear differential

Water in the rear differential could eventually cause corrosion on the ring gear, leading at minimum to a noisy rear end. If the vent on the rear axle differential was submerged, water has likely mixed with the gear oil. And the vehicle does not have to be submerged long. Just driving through high water could allow water in if the axle seals were not in good shape.

Insurance considerations

State law and insurance company guidelines play a large part in whether repair is an option, or the car must be declared a total loss and sent to salvage. Vehicles are typically declared a total loss when the cost of repairs exceeds the vehicle's pre-accident actual cash value (ACV).

However, two other factors often come into play. First, many states have laws that specify when an insurer can total out a vehicle. The laws are based on a number called a total loss ratio, created by dividing the cost of repairs by the ACV. Some states set a lower limit for that ratio, below which an insurer cannot total out the vehicle.

This total loss ratio minimum is called a Total Loss Threshold (TLT). As of 2016, 29 states have set a TLT ratio.

The second factor affecting the total loss decision applies only in the 21 states that do not set a TLT. In those states, insurance companies typically add the cost of repair plus the salvage value of the damaged vehicle and compare that number to the ACV. If repair cost plus salvage value exceeds the ACV, the insurer will likely declare that vehicle a total loss. That calculation is called a Total Loss Formula (TLF), and the 21 states where there is no government-mandated TLT use it.

You can search online for the phrases "Total Loss Threshold" and "Total Loss Formula" to see which applies in your state.

Money and time

The solution to most vehicle problems is just a question of money and time. If you have done good detective work to identify the problems on a flood-damaged vehicle, you will earn more of that money from the customer that wants his or her vehicle restored to safe operating condition.

Thanks and a tip of the hat to Neal Barnes and David Edwards, both part of the Nissan Aftersales Division, for contributing real-world insights from market areas that have been heavily impacted by major floods in recent years.

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