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NISSAN TechNews INFINITI

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Group Publisher
Christopher M. Ayers Jr.
cayers@automotivedatamedia.com

Editorial Director
Bob Freudenberger
bfreud@automotivedatamedia.com

Managing Editor
Tom Nash
tnash@automotivedatamedia.com

Contributing Editors

Bob Chabot
bchabot@automotivedatamedia.com

Paul Cortes
pcortes@automotivedatamedia.com

Phil Fournier
ffournier@automotivedatamedia.com

Christian Strohm
cstrohm@automotivedatamedia.com

Art Director
Jef Sturm
jsturm@automotivedatamedia.com

Nissan North America Project Manager
Don Meier
don.meier@nissan-usa.com

Nissan North America Technical Content Advisors

Edwin J. Hibma
ed.hibma@nissan-usa.com

James Von Ehr
james.vonehr@nissan-usa.com

Editorial and Circulation Offices:
134B River Road
Montague, NJ 07827
Phone: 330.620.3929
Website: www.mastertechmag.com

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High Voltage Air Conditioning

Let's explore the technical workings of the electrically-driven air conditioning systems found on Nissan Hybrids and the all-electric LEAF, system diagnosis, and why leak detection using dye must be avoided to prevent costly additional repairs.

It isn't news that hybrid and electric vehicles are on the road to stay. Nissan has released plans to develop the luxury Infiniti M35 Hybrid, and has started manufacturing the all-electric LEAF. What were once familiar air conditioning repairs have evolved with the hybrid electric or all-electric drivetrain, and a system you might think is unrelated to hybrid components is actually inextricably woven together with them. Instead of merely being unsuccessful at the repair, you now risk extremely expensive collateral damage. Do it right the first time, and read up on the factory service procedures!

First things First: Precautions

Before you begin work on the electrical A/C systems of any Nissan hybrid, consult the service manual. Take note of two important warnings:

1. DISCONNECT THE HV SERVICE PLUG. GRIP USING LINEMAN'S GLOVES AND DO NOT TOUCH THE HV CONNECTORS OR TERMINALS FOR 10 MINUTES AFTER THE PLUG IS REMOVED WHEN WORKING WITH THE ELECTRIC COMPRESSOR UNIT.
2. DO NOT USE A/C EQUIPMENT THAT HAS NOT BEEN DEDICATED TO ELECTRIC COMPRESSORS USING ONLY ND-OIL 11, OR HAS NOT BEEN PROPERLY PREPARED FOR USE WITH ELECTRICAL A/C (DISCUSSED BELOW).

Failure to disconnect the service plug risks your life and the lives of others who may be unaware of the repair you're performing. Remember to carry the service plug with you until the repair is completed to prevent another worker from accidentally restoring high voltage to the system.

We will discuss the second precaution in more detail later, but for now, know that the electric compressor uses an insulating oil to prevent high voltage leaks within the system. If you contaminate this oil by using standard PAG oil and dye, it can not only damage the compressor, but it could possibly infiltrate the entirety of the electrical A/C system and require total component replacement! Not cheap!

System differences and similarities

Don't be too intimidated by the electric compressor A/C system, because it is not at all conceptually different from your typical belt-driven air conditioning. If you follow the aforementioned precautions, and read

Locate and remove the high-voltage service plug to disconnect the battery from the electric compressor. This plug is on the LEAF.

the service manual, electrical A/C work can be profitable and rewarding.

Let's take a quick look at everything that functions identically between normal and electric A/C systems:

1. Refrigerant is the same (HFC-R134a).
2. The HI and LO side pressures are similar. Consult the repair manual chart.
3. Condenser is the same.
4. Receiver/Drier is the same (Nissan calls it the Liquid Tank).
5. Evaporator is the same.
6. Thermal Expansion valve is the same.

Let's make a short list of what's different:

1. The A/C oil is different. The electrical systems use ND-OIL 11, which is a non-conductive oil that CANNOT be interchanged with standard PAG.
2. The electric compressor is driven by an electric motor, rather than a drive belt.
3. Multiple computers control the electric compressor and other A/C systems.

Nissan also uses a refrigerant pressure sensor, which reports the high pressure liquid refrigerant pressure to the ECU. Some modern belt-driven A/C systems may also employ this sensor separately from the HI/LO pressure cut off switch or relief valve. It is located on the liquid tank.

The heart of the electric A/C system: the compressor

The electric compressor deserves its own section. First, we will discuss why hybrid systems utilize this design; then, we will outline the detailed workings of the device and its benefits.

The internal combustion engine of a hybrid vehicle shuts down intermittently when not required. Therefore, there is no guaranteed source of power from a crank pulley to drive a standard compressor. If the internal combustion engine shuts down to conserve power under light load or while sitting in traffic, a standard compressor would not spin. Therefore, the engineers at Nissan have bypassed the need to keep the engine idling for A/C by introducing the electric compressor. Due to the large demand for power from the A/C system, the electric compressor is directly linked to high voltage via the inverter.

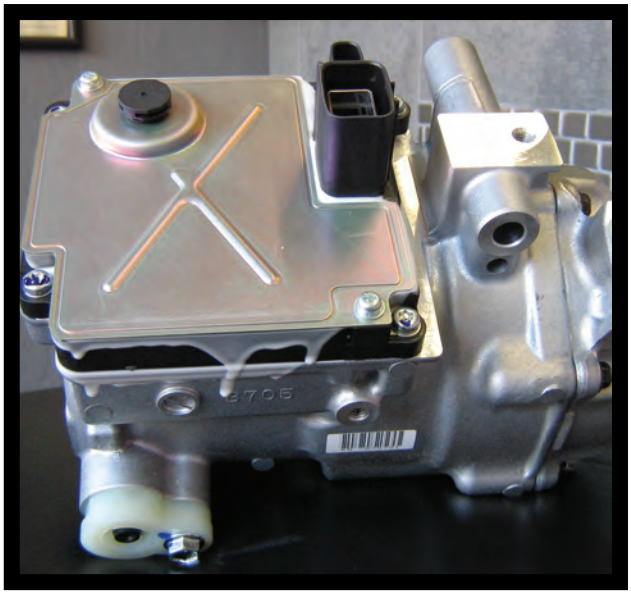
Running the electric A/C compressor requires a large amount of power. If the battery becomes drained, the HV ECU may request that the internal combustion engine restart and begin charging. This causes a reduction in mileage and fuel economy. Yet, it is no different from the increased load from a standard compressor.

Additionally, in an electrical air conditioning system, the A/C control unit (Auto Amp) has the ability to constantly request a change in the RPM of the electric compressor for maximum efficiency. As a result, the electric compressor will not be cycling FULL ON or OFF as a typical belt-driven compressor with a clutch would. Instead, the RPM range will vary between 0 and 12,000, based on calculated need. This may change system pressures, but it allows the Auto Amp to more effectively match the driver's requested temperature as efficiently as possible.

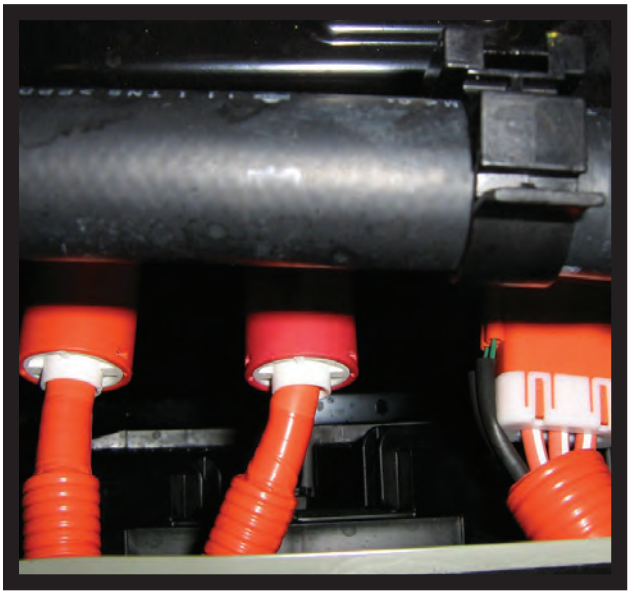
The three-phase power aspect of the electric compressor

Because an electric compressor can be controlled with more accuracy, and does not require a spinning crank pulley, it is inherently more efficient. It can perform the same duty as a standard compressor with more consistency, and is therefore ideal for a high miles-per-gallon hybrid. However, this new system requires re-education about its design and control. Let's investigate the electrical compressor's physical design.

When inspecting the electric compressor, you will immediately see three high voltage lines attached.



The electric compressor for a 2009 Altima Hybrid. Take note of the on-board inverter and control module. The insulating resin has leaked a bit from this unit, not a problem.



On the right, the three-wire connector attaches inverter to the electric compressor. System shown is the LEAF.

Three-phase power is provided from the hybrid inverter. Unlike standard 12V systems, power does not flow through chassis ground. Instead, the power flows from phase to phase, constantly changing as necessary. The compressor is also connected to the HV ECU in order to report its RPM, and to receive the command for the Auto Amp's desired RPM. Like the hybrid motor/generator, the A/C compressor consecutively energizes three sets of windings to create sequential electromagnetic fields. In the electric compressor, a permanent magnet attached to the compressor input shaft will "chase" the ever-moving electric fields generated from the energized windings. The chase causes the compressor to spin.

In a three-phase motor of this kind, if a short-to-ground occurs, high voltage would be detected by the ECU. This highlights the importance of ND-OIL 11: insulation. Since this special oil is non-conductive, it prevents the windings from shorting to the metal housing of the compressor, which is grounded to the chassis. Using the wrong kind of oil or dye will create a potential for voltage to go to ground, creating a serious safety hazard. If someone were to come in contact with another high-voltage line, he could be electrocuted.

Furthermore, there is a possibility for a phase-to-phase short to occur when the insulation is compromised. For this reason, it is not recommended to ignore or otherwise avoid any high voltage leak detected fault even though it's "just the A/C." A shorted winding could result in high temperatures and possibly smoke from under the hood!

High-voltage leak detected

A breakdown in insulation will result in DTC P0AA6 with info code 611. You may be unable to command the A/C compressor to engage. If it operates, A/C performance may be degraded. If you put the wrong type of oil in, cycling the compressor will increase the exposure of the rest of the system, which may result in more expensive additional repairs. Nissan states that even if a small amount of oil is used or accidentally enters the refrigerant recharge cycle, the DTC can be set. Confirmation of a high voltage leak can be performed with a "megger" (megaohmmeter). Check resistance between any one of the high voltage cables on the compressor and ground; Nissan's specification is at least two million ohms (2 MOhm). Less than that indicates an internal short that would cause high voltage leakage.

This special oil may take some time to receive, so be sure to have some on hand so you don't cause a delay for your customer.

If you suspect the P0AA6 DTC is from contamination due to dye, moisture, or conductive oil, Nissan says to replace all of the main components – evaporator, condenser and compressor – then flush the lines. Obviously, total component replacement is not a cost-effective or realistic method for A/C repair.

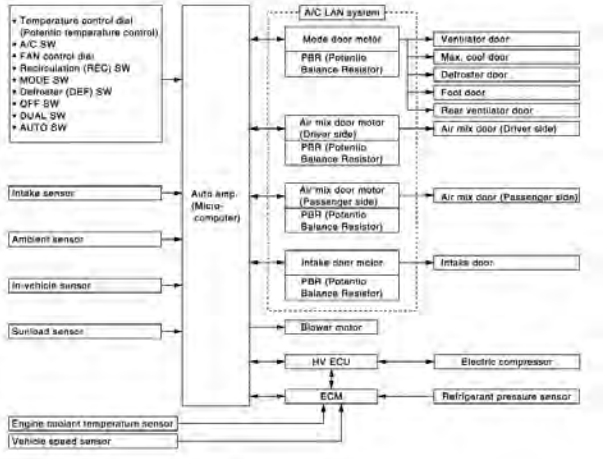
Don't use standard compressor oil, despite what the bottle may advertise. You can cause a huge headache!

It is required that you prepare your A/C equipment for electrical A/C work first to avoid contamination of the ND-OIL 11. The easiest method is to obtain dedicated equipment for electric A/C work; however, this is not always practical. It is possible to flush some A/C machines with R134a, eliminating all traces of traditional oil. Other machines have oil strippers that can remove oil before it enters the car's A/C system. The A/C machine should be SAE J2788 standard-compliant, or it should not be used for electrical air conditioning repair. Once your machine is ready, DO NOT add UV dye to aid in leak detection. The dye is conductive, and it only takes a small amount to negate the insulating properties of ND-OIL 11. At this time, there are no Nissan-approved dyes.

The Altima hybrid's electric compressor has a sticker indicating the required refrigerant R134a and special oil, ND-OIL 11.

Understanding electrical A/C controllers

The automatic air conditioning is primarily controlled by a dedicated computer that Nissan calls the Auto Amp. The customer provides direct commands to the Auto Amp unit by manipulating the dash controls.



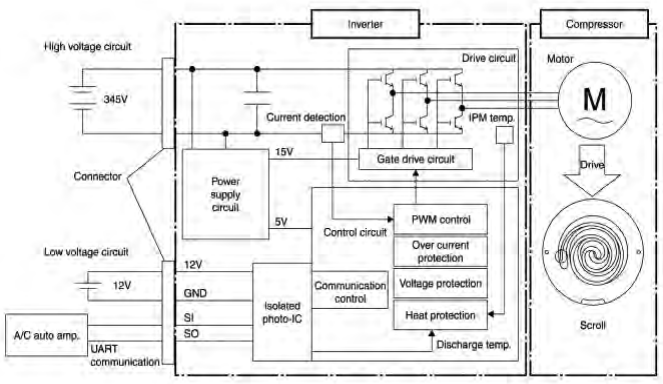
Nissan provides a system diagram to explain the flow of information among all the components. Altima Hybrid shown.

Understanding the relationship the Auto Amp has with the other computers, the under-dash A/C unit, and the various A/C-related sensors is crucial.

The Auto Amp communicates with multiple ECUs to control the various electronic A/C components as necessary, based on information it receives from the inlet temperature sensor, ambient temperature sensor, in-vehicle cabin temperature sensor, the sun load sensor, as well as engine coolant temperature, vehicle speed, and refrigerant pressure information from the main ECU. Using the A/C LAN system, the Auto Amp will automatically control the vent door and blower motors that reside within the A/C plenum beneath the dash.

The ICE ECU shares useful information about vehicle speed and engine coolant temperature with the Auto Amp that then can prohibit compressor operation in the event of vehicle overheating, or stop the condenser fan from cycling above a certain vehicle speed. The compressor RPM is controlled by the HV ECU once the Auto Amp has calculated and requested the ideal speed from sensor input.

The under-dash A/C unit contains blend and vent door motors, a communications bridge to the Auto Amp, the evaporator and heater core, blower motor, and the evaporator inlet temperature sensor. The Auto Amp controls this unit via the CAN bus, so any failure along the CAN may result in A/C malfunction. The Auto Amp controls driver/passenger comfort zones by manipulating the vent and blend door motors within the under-dash A/C unit. It is important to remember for diagnosis that all electrical controls and motors must be checked before assuming there is a refrigerant charge issue.



The electric compressor uses PWM (Pulse Width Modulation) within the inverter to control the three-phase motor based on input commands from the Auto Amp via the HV ECU. Nissan LEAF shown.

Operation	MODE 1	MODE 2	MODE 3	MODE 4	MODE 5	MODE 6	MODE 7
Mode door position	VENT	B/L1	B\L2	FOOT	D/F	DEF	—
Intake door position	FRE	20% FRE	20% FRE	FRE	FRE	FRE	—
Air mix door (driver side) pos.	FULL COOL	FULL COOL	FULL HOT	FULL HOT	FULL HOT	FULL HOT	—
Air mix door (passenger side) pos.	FULL COOL	FULL COOL	FULL HOT	FULL HOT	FULL HOT	FULL HOT	—
Blower motor duty ratio	47%	59%	59%	87%	87%	59%	OFF
Compressor	2,000 rpm	4,500 rpm	OFF	OFF	OFF	4,500 rpm	OFF
Heater pump	OFF	OFF	ON	ON	ON	ON	ON
Engine ON request	OFF	OFF	OFF	OFF	ON	OFF	OFF

Checks must be made visually, by listening to the sound, or by touching air outlets with hand, etc. for improper operation.

Using the CONSULT, choose from one of seven self-tests to verify compressor speeds, blend and vent positions, and blower motor operation.

Electrical A/C diagnosis

When working on modern hybrids, your first diagnostic tool should be the CONSULT. The electrical A/C system will have DTC information stored about any detected faults. The information gained from a DTC call will be invaluable for properly repairing the air conditioning. Furthermore, the CONSULT provides a self-check for air conditioning that will test various compressor speeds and vent/blend door positions. The CONSULT can also evaluate CAN-related errors, and illustrate a break in communication between two nodes. Why waste time and energy charging and recharging the A/C system when the problem is not the refrigerant, but the electrical control of some component?

The majority of the physical components within an electrical A/C system are identical to standard air conditioning: high-pressure hoses connect the compressor to the condenser to the expansion valve and the evaporator. Use some common-sense checks: If the low-pressure hose is cold to the touch, the A/C is operational. Check the high- and low-side pressures with gauges at the service ports; this information is still relevant to electrical A/C diagnosis. Use the pressure charts available in the repair manual to assist in diagnosis.

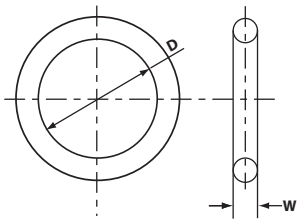
Use the CONSULT to gather DTC information directly from the A/C control units. Many A/C control malfunctions will store fault information, and the repair manual will include diagnostic trees to figure out the problems. Electrically-powered A/C systems require a slightly different approach than normal A/C, but don't be intimidated. Just think about the CONSULT as your first tool available to gather information about the behavior of the controls and the various sensors necessary for normal A/C operation. Reference the System Diagram in the service manual to understand the interaction among all the players in this different A/C game.

You can also utilize the bi-directional controls within the CONSULT's active test section to aid in diagnosis. Access the work-support section within CONSULT, then select the system you wish to command. For example, if a DTC is set about target compressor RPM not being met, you can determine at what load this occurs by commanding the compressor to incrementally increase RPM.

The CONSULT will also provide multiple PIDs (Parameter Identifiers) within the live data for all the A/C controls. From this section, you can monitor the sensor outputs and identify, at a glance, anything that seems out of specification. The repair manual details the PIDs available, including the units and "plain English" descriptions.

Some PIDs like HEATER NUP or NE HEATER might shed some light on strange A/C problems. HEATER NUP indicates a command has been made from the HV ECU to the CAN bus for the internal combustion engine to turn on. NE HEATER is the requested RPM of the engine necessary to provide the desired heater temperature, as interpreted and calculated by the Auto Amp. Maybe the customer complains that the engine is working hard with the heater on, but that's because the NE HEATER PID shows that the A/C is requesting an unusually high engine RPM. The problem lies with the A/C system, not the engine!

O-Ring Specifications*



Connection type	O-Ring size	D mm (in)	W mm (in)
New	8	6.8 (0.268)	1.85 (0.0728)
Former	10	9.25 (0.3642)	1.78 (0.0701)
New	12	10.9 (0.429)	2.43 (0.0957)
Former		11.0 (0.433)	2.4 (0.094)
New	16	13.6 (0.535)	2.43 (0.0957)
Former		14.3 (0.563)	2.3 (0.091)
New	19	16.5 (0.650)	2.43 (0.0957)
Former		17.12 (0.6740)	1.78 (0.0701)
New	24	21.8 (0.858)	2.4 (0.094)

Always check with the Parts Department for the latest parts information.

Refer to the chart to determine what the replacement O-ring should be used for your new component.

Electronic refrigerant detectors like this unit must be used in place of UV dye when searching for leaks.

Proper follow-up checking without using dye

After component replacement is completed, doing follow-up leak detection may be difficult without dye. However, Nissan recommends using an electronic refrigerant leak detector, or sniffer. Prior to leak detection, Nissan notes that the A/C static pressure should be at least 50 psi of pressure above 16 degrees Celsius. Consult the appropriate chart in the repair manual. Clean the areas to be checked, and begin with the high-pressure side. Move the sniffer around the compressor, hose fittings, relief valve, service ports, condenser, and liquid tank. Do not stop to repair a single leak if detected! Continue checking the entire system making notes about potential leaks. Use compressed air to clear the areas and revisit the previously noted leaks to verify there is active seepage.

To check for leaks at the evaporator, turn the ignition ON, but not READY. Run the blower motor for at least 15 seconds to clear out any trace refrigerant. Wait about 10 minutes for enough refrigerant to accumulate, then insert the nose of the sniffer into the A/C unit drain tube to check for leaks.

The last step is to ready the vehicle. Run the A/C on MAX COLD with the vents set to RECIRC for at least two minutes. Shut off the A/C and check for leaks as outlined above immediately. Start at the high-pressure side of the compressor. The pressure will steadily decline when the system is shut off.

Because O-rings are common leak points, Nissan has issued a chart to aid in proper O-ring replacement. Any new component will utilize a new O-ring, so do not attempt to compare the O-ring removed from the old component, even if you have a stash of various sizes of A/C O-rings. If the wrong O-ring is installed, refrigerant will leak at or around the connection.

Nissan will always strive to create the most efficient systems for it's cars. The hybrid and electric vehicles have the benefit of a direct, high-voltage source that can power an electric compressor. The future of auto repair will not be in basic removal and replacement, but rather in the knowledge of interconnectivity among advanced systems and their electronic controls. Keeping up with the technology takes training and awareness, but it will continue to be necessary for working with all future automobiles.

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- Lower harmful emissions

*Restores lost fuel economy by removing harmful fuel injector deposits

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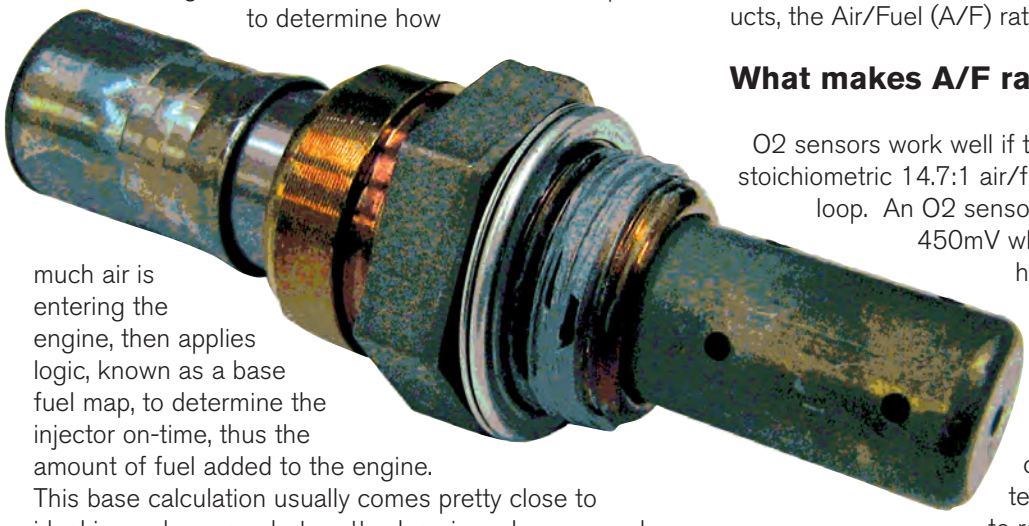
Fast Air/Fuel Ratio Sensor Diagnosis

Efficient troubleshooting of one of the most common causes of an illuminated MIL, plus how it's different from an O2 sensor, and replacement tips.

A quick review of the basics

The proper air/fuel ratio is one of the key aspects of engine performance, and is very important for reducing emissions. The ECM uses sensor input to determine how much air is entering the engine, then applies logic, known as a base fuel map, to determine the injector on-time, thus the amount of fuel added to the engine. This base calculation usually comes pretty close to ideal in modern cars, but pretty close is no longer good enough to deliver the fuel economy and low emissions expected and required in today's vehicles. Also, there are a number of variables such as manufacturing variances, engine wear, unmetered air leaks, injector condition, and fuel blends that will affect the accuracy of the base calculation.



A feedback system is employed to determine how close the base calculation came to providing the ideal air/fuel ratio, and allows the ECM to modify the ratio based on exhaust gas measurements. The feedback cycle starts when the ECM injects a pre-mapped amount of fuel based on sensor input. The exhaust sensor reports back, the ECM adjusts, the exhaust sensor reports, the ECM adjusts, and the cycle continues for as long as the engine is running in closed loop. Adjustments to the fuel map are known as fuel trim.

Feedback systems have been used on Nissan products since the late 1970s, even on some carbureted cars, so most technicians are familiar with the basics. However, until recently oxygen (O2) sensors were most often used to provide feedback. This article will cover differences, diagnosis, and service of the type of exhaust sensor used on almost all new Nissan products, the Air/Fuel (A/F) ratio sensor.

What makes A/F ratio sensors special

O2 sensors work well if the strategy is to provide the stoichiometric 14.7:1 air/fuel ratio while in closed loop. An O2 sensor will output less than 450mV when the mixture is 14.8:1 or higher, or more than 450mV when the mixture is 14.6:1 or lower. But what if you were a Nissan engineer and you wanted to run 15.5:1 to save fuel under certain driving conditions, or temporarily enrich the mixture to reduce NOx emissions? The O2 sensor is like a switch: it will read higher than lambda or lower than lambda, on or off, black or white, but no shades of gray. This is not good enough for the fuel control strategies used in modern cars.

The air fuel (A/F) sensor solves this dilemma. It measures the air/fuel ratio instead of providing rich/lean output. Some A/F sensors are capable of accurately reporting mixtures between 10:1 and 30:1, allowing the engineers a lot more freedom in fuel mapping.

The inner workings and construction of A/F sensors are an interesting study if the goal is a better understanding of how things work. However, since we will not be required to design or rebuild an A/F sensor during the course of our daily responsibilities, and an understanding of its fundamental workings is irrelevant to diagnosis and repair, our time is better spent seeking to understand what observable characteristics separate a "good" A/F sensor from a "bad" A/F sensor.

Diagnosis of AF sensor failure

The most common A/F failure is the heater. Why? Ever heard the expression "the candle that burns twice as bright burns half as long?" Well, the A/F sensor heater is one seriously bright burning candle! An O2 sensor heating element runs at about 600 deg. F., which is pretty hot. But that's nothing compared to an A/F sensor. Its heating element runs at almost 1,500 deg. F., hot enough to melt aluminum and make steel glow bright red and bend like a noodle. Combine this very-high operating temperature with corrosive gasses and incessant vibration and it's actually pretty amazing they last as long as they do.

Without a functional heater, the A/F sensor cannot work properly. Therefore, if you find a heater code and a performance code, always diagnose the heater code first. Many vehicles will not run the A/F performance tests if the heater test fails, but sometimes the results from a previous performance test will remain in memory, so it is possible to have both heater and performance codes stored.

Fused power is supplied to the A/F sensor heater whenever the key is in the ON position, and a ground pulse is supplied by the ECM based on MAF and RPM inputs. If engine load and calculated exhaust temperature are high enough to maintain A/F sensor operating temperature, the ECM will stop cycling the sensor.

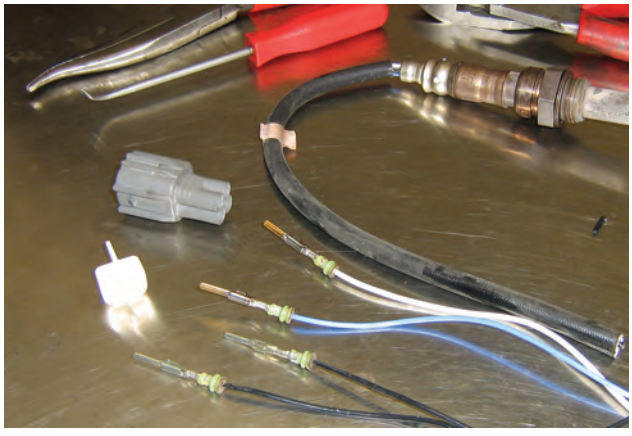
A common diagnostic blunder is to assume the A/F sensor heater is bad based only on the trouble code. The odds are certainly stacked in favor of a bad sensor, but fuse, wiring, and even ECM-driver problems do come up from time to time, so it's wise to check the whole heater circuit. Playing the odds may damage your shop's reputation with your customer, or your reputation with your boss.

Before checking the heater circuit, verify that the problem that caused the trouble code is current by running a DTC confirmation. Check the manual for the vehicle-specific procedure, but typically the DTC confirmation involves cycling the key on, then off for at least 10 seconds, starting the car, and letting it idle, or idle followed by revving, then returning to idle. The heater monitor can usually be run with the car in the bay in just a few minutes. When trying to duplicate a trouble code, it's best to use the CONSULT to monitor live data, as this will enable a check-mode that will decrease the time it takes to set a code.

If a heater code resets, check the circuit. A complete heater circuit check is quick and easy. You'll need a wiring diagram to decode the wire colors on the harness side, but the wires on the AF sensor side are often universal. Usually, the two heater wires are the same color, most often black. Which is power and which is ground/control can be easily deduced once you take measurements, as follows:

Many A/F sensors use the same wire color scheme.

Check the heater element resistance with an ohmmeter.



TIP: Disassemble and scavenge terminals from the O2 and A/F sensor sensors you replace. Some are male and some are female. They come in handy to make a solid DMM connection for future testing.

1. Disconnect the sensor connector and check resistance across the heater wires on the sensor side connector. Compare the resistance to the specification, typically between 2-5 ohms at 77F deg. F. Be sure to allow the sensor to cool before testing

Check for power while the heater is operating.

2. Reconnect the sensor connector and check for power at the sensor connector while the circuit is loaded. To do this, just hook up a voltmeter to the 12V+ wire at the sensor with the sensor plugged in and start the car. If you find battery voltage at the connector while the heater is on, it's good. A poor connection or faulty relay can easily be missed if the connector is unplugged or the heater is not loading the circuit while testing.

3. Check for the ECM ground pulse at the sensor connector (still plugged in). An oscilloscope is the best tool for this test, but a DMM with duty cycle, Hz, or pulse width can also be used.

An oscilloscope will provide more information, but a DMM that can measure Hz, duty cycle, or pulse width can also be used for a quick check of ECM heater control.

Sometimes a heater code does not reset following a DTC confirmation, and a check with a generic scan tool will reveal the heater monitor has passed. Intermittent faults can be frustrating for both shops and customers. Sometimes wiggle and tap testing will flush out the fault, especially if the problem is not with the A/F sensor, but other times the problem will need to "get worse" before it can be conclusively diagnosed.

The diagnosis of A/F sensor heater codes is not much different from that of O2 sensor heater codes,

other than the lower resistance of the heater element and differences in ECM control of the heater, so many technicians find no problem in making the switch from diagnosing O2 heater codes to A/F heater codes.

However, diagnosis of the sensor output is a whole different animal, and has created a fair amount of confusion, as well as some inventive but time consuming diagnostic techniques involving jumpers, ammeters, and oscilloscopes. The truth is that other than an inspection for exhaust leaks, there is no reason to leave the comfort of the cabin. The CONSULT is your friend.

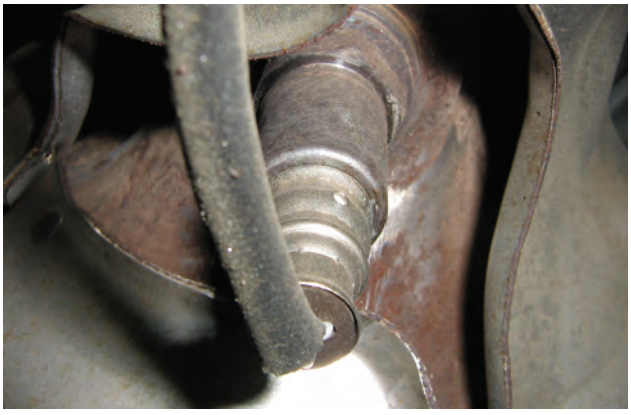
It would be foolish to diagnose an O2 sensor output from the driver's seat. An oscilloscope is still the best way to gauge O2 sensor health. Rise time, maximum voltage, minimum voltage, and cycle frequency are still the best diagnostic tests. It would be equally foolish to attempt to diagnose the A/F sensor from under the hood. The CONSULT has all the information you'll need.

There is a variety of A/F sensor designs, and sensor output varies depending on the vehicle. Some sensors will output 1.5V with a 14.7:1 ratio, others will output 2.2V at 14.7:1, and then there are those that will output 3.3V at 14.7:1. However, they all share something in common: they should respond rapidly and dramatically to sudden changes in the A/F mixture. The manual will have a ratio/voltage graph, so it's easy enough to find out what the voltage should be at 14.7:1. However, to truly know what normal response should be for a particular car, you'll need to check sensor output on known good cars.

The next time you have the CONSULT hooked up to a Nissan, take a peek at the A/F sensor voltage and snap the throttle a few times while watching the response. Depending on the car, it may be necessary to limit the number of PIDs to get good update speeds. The TPS and A/F sensor are all you'll need. You should notice that when you snap the throttle, the sudden rush of air creates a momentary lean condition and high A/F sensor voltage. The ECM will respond quickly with a burst of extra fuel, which will arrive just as the throttle is closing, creating a rich condition and low A/F sensor voltage.

As A/F sensors age, the amplitude of their response will decrease. An A/F sensor that is setting a code will have low amplitude, maybe 0.5V peak-to-peak or less. An A/F sensor that is good will have a larger swing, maybe 2.0V or more peak-to-peak. After you've built your database, you'll be able to hop in the car, snap the throttle a few times while watching live data, and then break for lunch.

If the vehicle has throttle-by-wire (and most newer Nissan vehicles do), you'll need to drive the car to force



Will it come out without a fight?

rapid changes in air/fuel ratio. If it's not easy to leave the bay for a quick spin, you could also use propane or large vacuum leaks to force the mixture rich or lean while monitoring A/F sensor response. Many of the newer vehicles with throttle-by-wire also have a CONSULT-guided DTC confirmation test, which makes testing even easier, because you will not need a known-good sample to compare against, nor will you need to guess at the good/bad threshold.

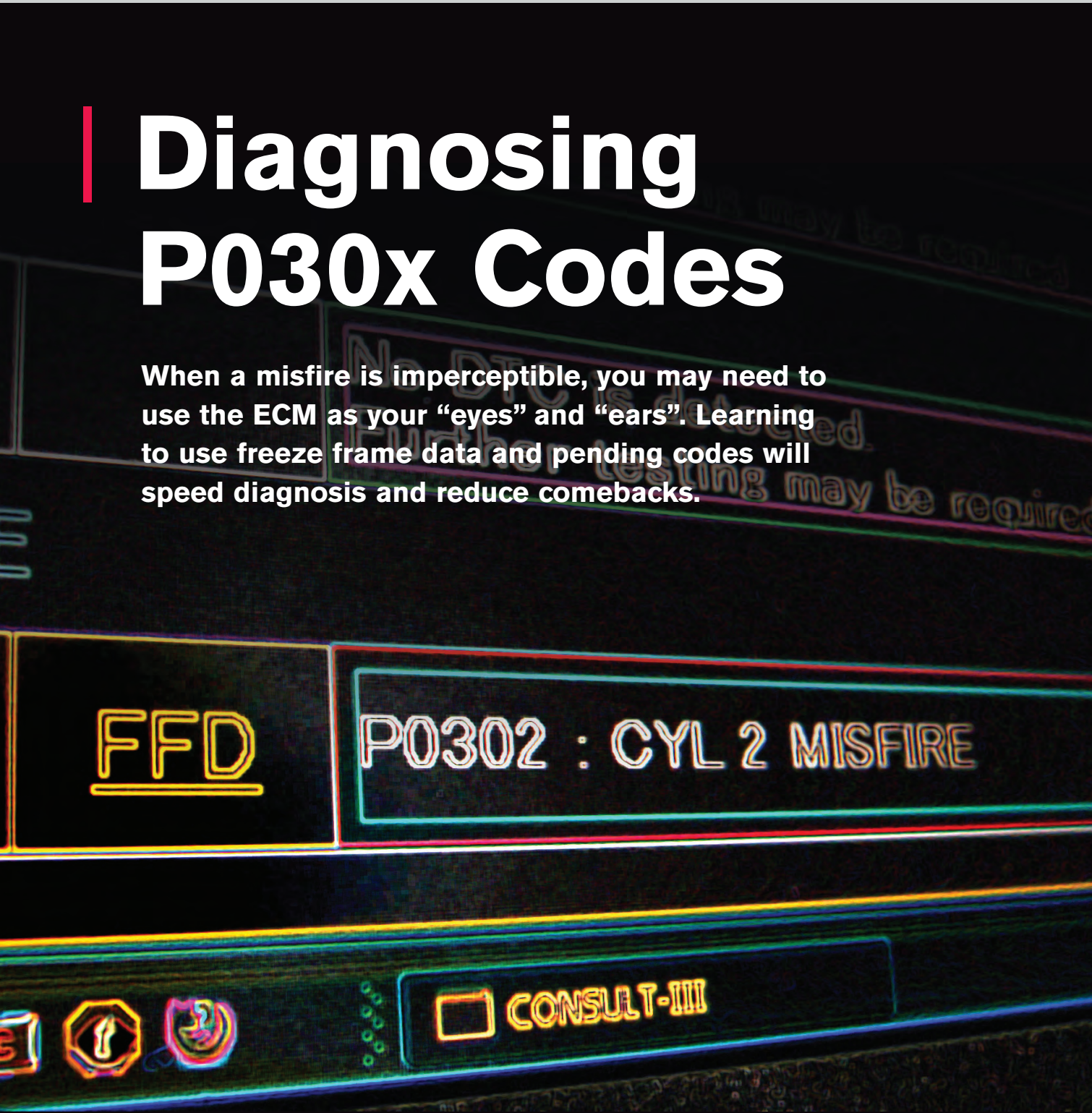
Replacing A/F sensors

A/F sensors are pretty easy to replace when all goes well. Unfortunately, sometimes all does not go well. First, exhaust sensors can get stuck. It's best to treat every sensor as if it's going to be stuck. Spray it with plenty of penetrating lubricant and let it soak a bit. Use a solid sensor socket and break the sensor free with a sharp rapping motion. If the sensor does not spin by hand after it is loosened, spray it with additional penetrating oil before continuing to remove. If the threads are galled, don't install the new sensor until they've been repaired. An inexpensive tool, the 18mm Oxygen Sensor Thread Cleaner (J-43897-18) can purchased from http://tools.nissantechmate.com to clean the threads and condition the gasket mating surface.

Lastly, A/F sensors are a bit delicate, despite their ability to survive in a very hostile environment. Nissan says to discard any A/F sensor that has been dropped from a height of 19.7" inches or greater. Wipe the oil off your hands before installing an A/F sensor so you don't fumble. Either that or keep the car close to the floor during the installation. When installing the new A/F sensor, use the provided anti-seize lubricant on the threads. This will help the next guy who removes the A/F sensor (maybe you!)

Diagnosing P030x Codes

When a misfire is imperceptible, you may need to use the ECM as your "eyes" and "ears". Learning to use freeze frame data and pending codes will speed diagnosis and reduce comebacks.



The misfire detection monitor, found on all 1996 and newer Nissan and Infiniti vehicles, will detect misfires long before they become noticeable from the driver's seat. This was a great advance for those who like to keep their cars running at peak efficiency with minimal emissions (and who wouldn't?). But, the sensitivity of misfire detection can make diagnosis frustrating, because a car that seems to be running fine may repeatedly set a misfire code. When diagnosing an imperceptible misfire, a technician must rely on the ECM for help with confirmation and diagnosis. Before jumping into a discussion of diagnostic techniques, let's talk a bit about the reasons for misfire detection and how it works.

One of the most important reasons for misfire detection is to protect the catalytic converter. When a cylinder misfires, it sends all or part of its air/fuel charge into the converter, causing the temperature to rise. If too many misfire events take place, the catalyst will overheat and suffer permanently damage. The amount of acceptable degradation on modern catalysts is very low, due to ever-tightening emissions standards. Catalytic converters are quite expensive, so rapidly detecting and correcting a misfire is very important!

If the air/fuel charge does not ignite fully, its potential energy is not converted into motive force. If fuel is being used, but is not pushing the car down the road, the MPG will decrease. With current fuel prices, a typical driver with a typical car might spend $3,000 per year on gasoline assuming it's running properly. This is a pretty compelling reason to ensure a car runs as well as possible.

Another reason for early detection and elimination of misfires is engine wear. The unburned fuel in a cylinder with an ignition misfire or excessive fuel delivery may wash the oil film from the cylinder wall, causing the piston ring to contact the cylinder wall and result in accelerated compression loss, as well as oil dilution, further increasing wear on bearing surfaces.

Early detection

So how does the ECM detect misfires that go unnoticed by the driver? Simply, it monitors crankshaft speed. With each power stroke, the crankshaft will accelerate as the piston is forced down in the cylinder. The ECM monitors this acceleration using a crankshaft position sensor. If the acceleration is slower in one cylinder than the others, it stands to reason there was less power being generated on that cycle (a misfire). Thus, the ECM is able to detect a single misfire, even at 3,000 RPM. For us, this is too fast to detect. For example, on a four cylinder, that would mean picking one irregular power stoke out of 100 that had just occurred in a single second.

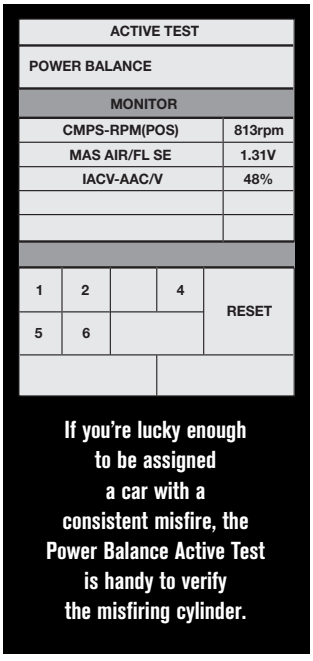
A severe misfire will provoke a different ECM response than a mild misfire. A severe misfire will trigger One Trip Detection Logic. A less severe misfire will trigger Two Trip Detection Logic. "Trips" are measured in key cycles for the misfire monitor. As long as the car is warmed up and has adequate fuel, the misfire monitor will run continuously while the engine is running. There is not a drive pattern that must be followed to get the monitor to run, although a specific drive pattern may be necessary to duplicate the misfire. It's important to note that the key must be cycled off for at least 10 seconds to complete a trip.

If a misfire is severe enough to cause rapid damage to the catalytic converter, the ECM will blink the MIL as soon as the problem is discovered. This is called One Trip Detection Logic. If the misfire condition subsequently becomes less severe, the MIL will be turned off provided a misfire has not been detected on a previous trip.

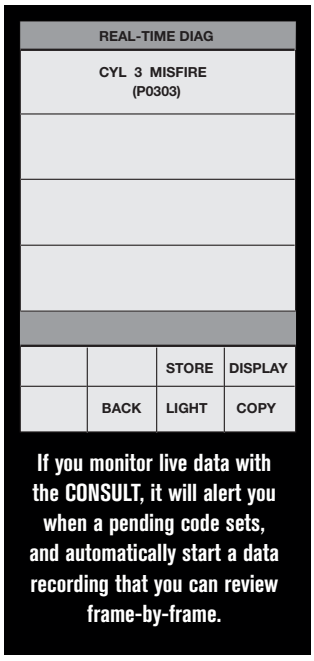
If the misfire won't cause rapid damage to the catalytic converter, the ECM will "remember" the misfire on the 1st trip, but will not turn the MIL on. Then, if a misfire is detected on a 2nd trip, the MIL is illuminated steadily. A Pending Code will be set after the 1st, so even though the MIL will not come on, you'll have access to the pending code with the CONSULT or a generic scan tool.

Analyzing codes and freeze-frame data

The key to quick diagnosis lies in planning a logical attack based on available information. When faced with a MIL, the first step is to talk to the ECM and find out what it knows. The trouble codes and freeze frame data don't hold the answers, but they do hold important clues. At the start of a diagnosis, they contain the information you'll need to plan your next steps. So instead



If you're lucky enough to be assigned a car with a consistent misfire, the Power Balance Active Test is handy to verify the misfiring cylinder.



If you monitor live data with the CONSULT, it will alert you when a pending code sets, and automatically start a data recording that you can review frame-by-frame.

of rushing to start "checking stuff," or blindly following a flow chart, take a few moments to look at the codes and the freeze frame data and see if you can think like an ECM, applying what you read in the manual about the DTC detection logic, and combining it with your unique human intelligence and knowledge of internal combustion engine operation. A diagnostic flow chart, no matter how well thought out, will never provide the fastest path to the right conclusion; in fact it may lead to no conclusion, or even worse, the wrong conclusion. Step one: put on your "thinking cap".

Seeing patterns

Sometimes, misfire codes come in bunches. Looking for patterns in the cylinder numbers can sometimes lead you to a more fruitful diagnostic path. Nissan cylinders are numbered as they are laid out on the crankshaft. On a V6, the cylinder closest to the crank pulley is #1, and the farthest from the pulley is # 6.

If codes P0301, P0303, and P0305 were stored, it would be a clue that there is a problem common to all of the cylinders on Bank #1. Perhaps this is caused by a stuck VVT sprocket, or a clogged B1 converter, or a bad B1 A/F sensor, or a wiring problem particular to the injectors or coils on Bank #1.

If codes P0302 and P0304 were stored, you'd want to think about problems that would affect only those two cylinders, such as a head gasket blown between cylinders, or a leaking injector on cylinder #6 (driving cylinders #2 and #4 lean).

Like a flow chart, these few examples do not cover all possibilities, and there are many different engine designs and control strategies, so a pattern that might have possible meaning on one car may not on another. The point is that by looking for patterns and thinking about what might be causing them on your particular vehicle, you can eliminate unnecessary testing and jump straight to the tests that are most likely to yield useful results.

Freeze-frame data

Freeze frame data (FFD) is very important when diagnosing the cause of a misfire code. A cursory glance and printout will not do. Really examine the FFD. Read each PID and try to imagine what the car was doing when the code set, then verify your imagined operating scenario by driving the car and watching the same PIDs in live data.

Knowing the operating conditions that cause the misfire is not only important for trying to duplicate the conditions when the codes set, it's also important for determining the likely cause of the codes. If a code was set at idle, you might lean towards checking for vacuum leaks or compression. If a code was set at light cruise, you might want to look at injectors or EGR. If a code was set at high load, the secondary ignition or fuel delivery become prime suspects.

It should be noted that the FFD is sometimes a bit delayed, especially on older models, so the FFD captured may be a second or so behind the event that resulted in the code setting. For instance, if the driver was at wide open when the misfire counter reached the threshold, then suddenly decelerated, the FFD may be misleading. It's not a perfect world; it's better to have access to information that is usually right than to have no access at all. If diagnosis were always easy, our paychecks would be a lot smaller.

Driving by the numbers

The other important use of freeze frame data is to duplicate the conditions that caused the misfire. There are three reasons you'll need to do this.

First, you'll need to confirm that the misfire can be duplicated now. If the misfire was caused by a transient condition, water trapped in a spark plug tube for instance, then you will not be able to confirm the cause

or any repair. You may be able to find the cause and fix it without current symptoms through inspection and guessing, but you'll never know for sure without a before and after confirmation.

Secondly, once the misfire is confirmed, swap testing is an excellent technique for isolating the cause. Swapping parts from cylinder to cylinder, and applying logic, can lead to a rapid diagnosis and a confirmation that you have come to the correct conclusion. Many engines have limited access to coils, plugs and injectors. When working with engines like this, it makes sense to reposition multiple parts at the same time.

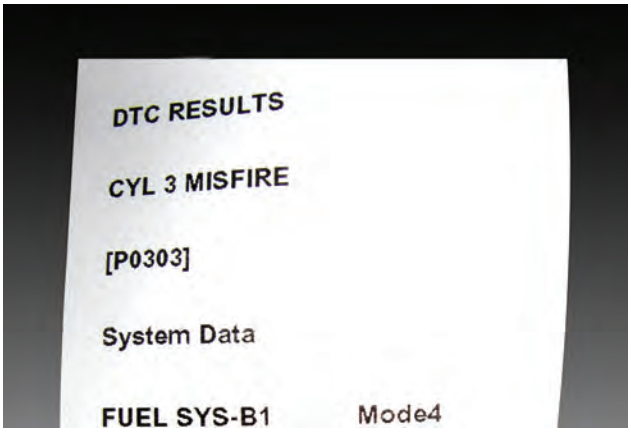
For example, let's say a V6 engine has a P0303, and the coil and injector are buried under an intake plenum. Once you've confirmed the misfire is still present on cylinder #3, you'll want to get maximum value for the time you spend removing the plenum. If you swap coil #3 to cylinder #1 and vice versa, injector #3 to cylinder #5, and plug #3 to cylinder #2, the misfire will follow the bad part. (It also makes sense to check compression on cylinder #3 while the plug is out). After the swap, confirm the misfire again. If it moved to cylinder #1, the coil is bad. If it moved to cylinder #5, the injector is bad. If it moved cylinder #2, the plug is bad. If it stays with cylinder #3, it's not the coil, plug or injector, so focus on engine mechanical problems like vacuum leaks, valve sealing, etc.

The final reason to use FFD in misfire diagnosis is confirmation of the repair. Once customers have paid the bill, they aren't likely to want to spend any more money fixing the same code. Running a DTC confirmation procedure takes some time, but it's time that can be billed. Time spent ensuring the car is indeed fixed is always time well spent. It protects your reputation, time, and avoids inconveniencing your customer.

Looking through the ECM's "eyes"

If a tree falls in the woods, and there is no one there to hear it, does it make a sound? Likewise, if a cylinder misfires imperceptibly, is there really anything in need of repair?

If the misfire monitor is there to tell the tale, then yes, there is. Because the ECM is detecting what we cannot, we should let it guide us in our diagnosis. The FFD will tell us which road to take, and pending codes will tell us of our success or failure. When confronted with a P030x, we're working for the ECM. It both guides us and judges our success.

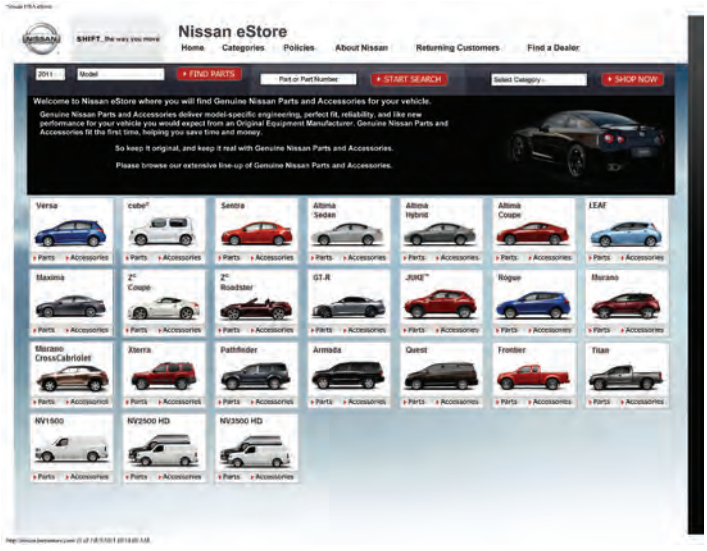


Print freeze-frame data. Keep it with your paperwork in case you need to refer to it later.

Sometimes you get lucky and can see the problem, but only if you take the time to look carefully.

Ignition and spark problems may be the most common cause of misfires, but don't neglect your compression and vacuum gauges.

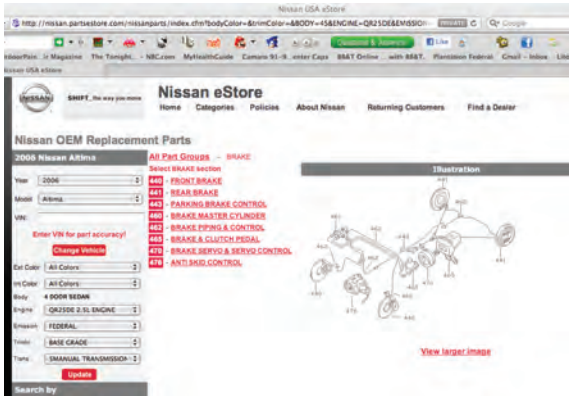
Wholesale Parts eStore Coming Soon!



Developed in conjunction with industry-leader TradeMotion, Nissan and Infiniti will be launching a new Wholesale Parts eStore. Through this exciting new e-commerce site, independent Nissan and Infiniti repair professionals will be able to purchase replacement parts, accessories, performance parts and NISMO directly from participating Nissan and Infiniti dealers. In addition, you will be able to access the most current electronic parts catalogue for easy search and selection.

The Wholesale Parts eStore will include:

- Full VIN decoding for proper part application
- Complete illustration with callouts
- Direct OE Parts Data from Nissan
- No cost for your use to look up or order parts
- Ability to attach pictures of your requirements
- One Stop Shop for Nissan Parts and Accessories
- Special pricing and promotion opportunities



Watch for additional Nissan and Infiniti Wholesale Parts eStore information.

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*Enrollment in Parts Rewards required. 60 Parts Reward Points can be used to receive gift cards with a value of up to $50 (Cabella's, Target, Amazon.com and more). Points have no actual cash value. Limited to one transaction per installer. To claim your reward visit AdvantageAwards.com/NNA. Enter code PR250 to receive your extra points.
Offer expires 9/15/2011.

**See your participating dealer for details and enrollment information.

Body Basics
Equipment & Tools

Every day, more and more independent body shops are forming relationships with Nissan and their local Nissan and Infiniti dealerships to avail themselves of Genuine Nissan and Infiniti parts, service information and special service tools. The benefits of such a relationship are procuring parts that make it possible to return the vehicle exactly to its pre-accident condition, that are manufactured in the same factories with the same materials and processes as those installed on the assembly line, and that are backed by the same company that engineered and made the car in the first place. Also, this gives the independent access to the best possible, up-to-date service information, and tools that work perfectly.

Independent shops that purchase parts from Nissan and Infiniti dealers have found the arrangement to be the most cost-effective course. That's not only because they are price-competitive (and the chance of getting the wrong part is almost nil), but more importantly because precision mounting holes save time, making the shop more profitable. Plus, the rapid delivery, ability to return parts, and local community attachment works out best for both parties. Add to all this the protection of Market Shield and the convenience of Collision Link, and you have an unbeatable combination.

Using the Nissan and Infiniti technical information websites

aking full use of www.nissan-techinfo.com or www.infinititechinfo.com ensures getting the proper information to get the job done right, the first time and quickly. There's no waiting for a call back from a third party information provider when time is of the essence.

Nissan also provides a way to obtain the special service tools that Nissan and Infiniti dealers use to service its vehicles. These special service tools can easily be procured via the TechMate website at www.nissantechmate.com.

Nissan and its dealers value these relationships with independent collision/body service shops and make it easy to obtain and use everything you need to properly service Nissan and Infiniti vehicles.

In this issue, we will look at the equipment and tools a modern body facility should have to function at optimum efficiency.

In this first of a series of body service articles, we will cover collision equipment and tools that Nissan suggests independent shops have and use to properly repair damage to Nissan and Infiniti vehicles.

Proper Equipment and Tools

Nissan has a list of recommendations for its dealer collision and body repair facilities. Perhaps the list can be used as a guideline for independent facilities that already have a profitable relationship with their local Nissan or Infiniti dealer, or for those wishing to establish such a mutually-beneficial relationship.

The following outline is merely a list of the best practices in creating a top-notch body service facility for repairing modern cars and trucks, including Nissan and Infiniti vehicles.

General Workshop

Nissan lists these general workshop items as being standards for optimum results when performing body service:

- A dedicated paint mixing room with exhaust fume extraction that complies with local legislation. The lighting in the paint mixing room should be set to a minimum of 750 lux.
- Appropriate storage for hazardous materials and liquid waste.
- Lighting with a minimum of 70 foot-candles in the metal working area (measured at 36" above the floor surface), a minimum of 90 foot-candles in the paint shop, paint preparation areas, and detail shop.
- Color matching areas should have color-correct lighting.
- A high-pressure, high-volume compressed air system providing oil-free and moisture-free compressed air.
- An electrical diagnostic system and capability of diagnostic analysis for Nissan vehicle electrical systems.
- Personal protective equipment must be available to all employees.

For the best results, always keep your spray guns in top condition.

Paint Shop Tools and Equipment

Here are guidelines for the painting & finishing areas:

A paint spray booth that will meet at a minimum these specifications:

- Lighting at a minimum 100 foot candles at the center of the booth with upper and corner color-corrected fluorescent lamps.

- Air handling and heating requirements:
Exhaust system to be capable of 125 ft/minute measured at the face of the vehicle shell and a minimum of 19,000 CFM.

- A heat supply system with direct-fired burners with a minimum of 1.5 MTBU capacity.

- Equipment designed, constructed and installed in accordance with the BOCA Building and Materials Codes, NFPA 33 and 70, OSHA and all applicable local, state, and federal codes.

An adequate number of electric buffers and polishers.

Painter suits and other protective safety gear suitable for use when mixing and applying the specified refinish materials.

An enclosed paint gun cleaner.

A solvent recycler that is compliant with local, state, and federal laws, and a compliant hazardous waste disposal system.

Metal Shop Tools and Equipment

The following is list of suggested metal shop equipment and tools:

A three-dimensional electronic measuring, and/or fixture system with an anchoring and straightening rack or bench to allow 360° pulling and access to Nissan body dimensions data for damage analysis and repair.

All the necessary anchoring and pulling accessories including clamps, fixtures, and chains.

A squeeze-type resistance spot welder (STRSW) capable of welding high and ultra-high strength steels. Machines in this category will generally produce a minimum of 9,000 amps with a minimum of 600 p.s.i. squeeze force at the electrodes and have manual or automatic settings for steel types and coatings. The facility wiring must be capable of supplying adequate power to the machine as specified to produce acceptable welds. Test welds using the same metal type and thickness of the vehicle being repaired can be produced and be destructively tested to verify the machine and facility wiring capability and performance.

A MIG welder capable of producing 140 amps output.

An induction heater to provide flameless heat when controlled heating is required. A heat monitoring system or a non-contact thermometer is also required.

Fire-retardant welding blankets (a minimum of two per each GMA and STRSW machine).

A masking paper and tape and welding spark paper dispenser.

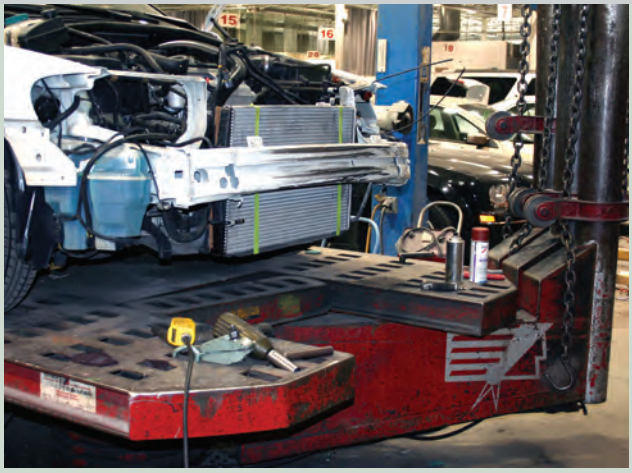
A mobile fuel retrieval system.

An R134a refrigerant recharging/recovery/recycling station and, at least one technician certified to operate this equipment.

An A/C leak detection tool (sniffer-type).

Portable hydraulic rams with 4 and 10-ton kits.

Pressure-feed corrosion protection material application equipment that has wand attachments for applying anti-corrosion materials inside body cavities with a 360° spray pattern.



A modern fixture and measuring system is mandatory for precise repairs.

You should have all the pulling and anchoring accessories.

A spot welder and an assortment of tips ensures the strongest welds.

A dent-pulling stud welder for steel and aluminum panels.

A battery charger with start and boost capability.

An adequate number of hydraulic floor jacks, jack stands and ramps to allow vehicles with low ground clearance to be loaded onto lifting equipment without damaging the vehicle.

A caulking/sealer applicator gun kit.

A heat gun.

A coolant pressure tester, manual or electronic pressure test system.

A spot sand/media blaster hand-held tool for small area blasting.

Plastic welding and adhesive repair equipment for plastic/urethane parts.

A headlight alignment system.

Resources

The best source for obtaining many of these Nissan-Approved items is the Nissan Techmate website at www.nissantechmate.com.
The TechMate website can also be accessed through the Nissan and Infiniti Technical Information websites at www.nissan-techinfo.com and www.infiniti-techinfo.com, without having to purchase a subscription or logging on.

Here's a list of Nissan-approved suppliers. Many more companies also offer excellent equipment and tools for body service:

Bench Aligning Systems
Blackhawk Equipment www.blackhawkequipment.com
CAR-O-LINER Company www.car-o-liner.com
Chief Automotive Technologies Inc.
www.chiefautomotive.com

Paint Booths and Accessories
Global Finishing Solutions www.globalfinishing.com
Goff's Enterprises www.goffscurtainwalls.com

Vacuum Sanding Equipment
Eurovac Inc. www.eurovac.com

Air Compressor Systems, Air Dryers and Accessories
Champion www.championpneumatic.com
Curtis-Toledo www.curtis-toledo.com

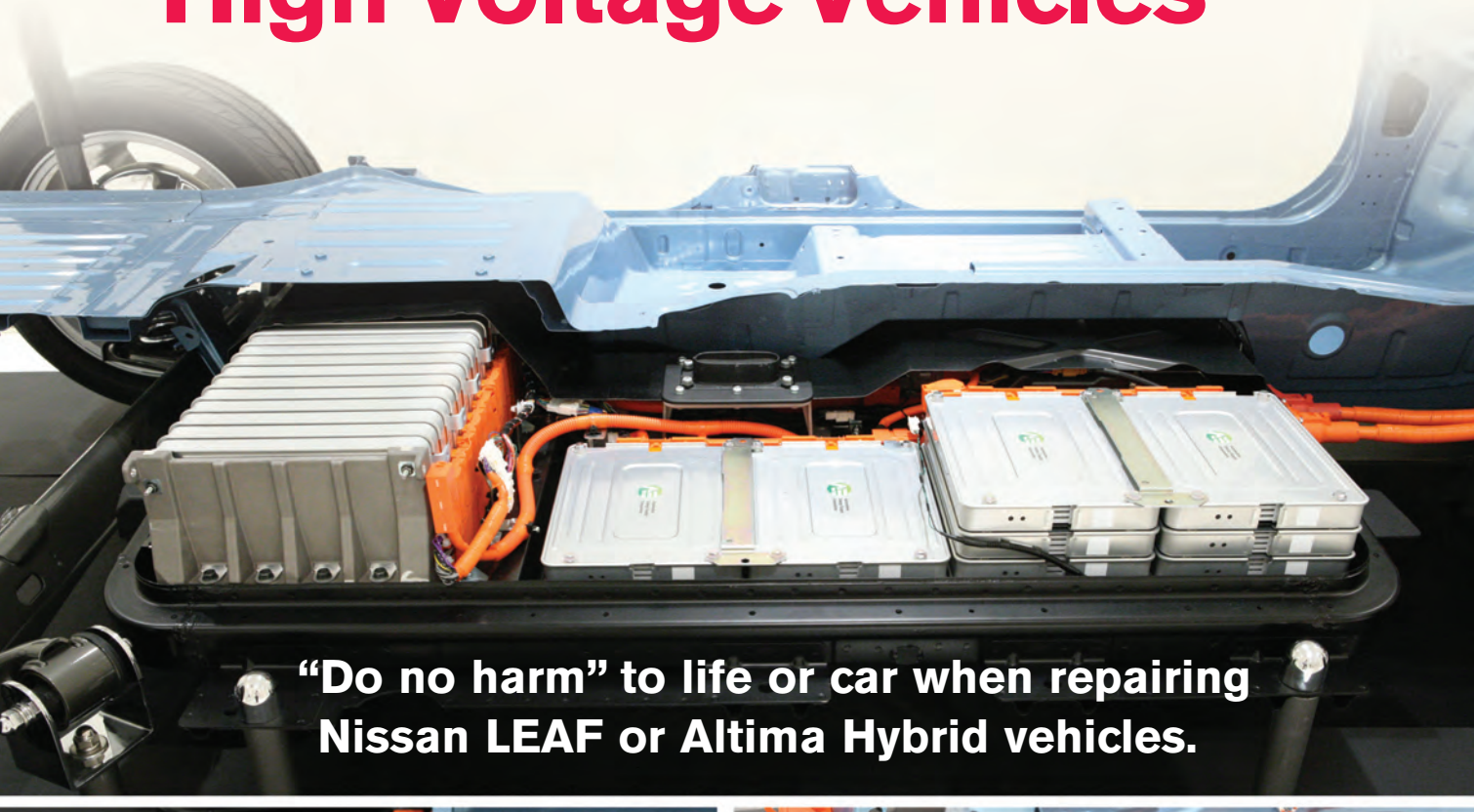
Welding Equipment
Blackhawk www.blackhawkequipment.com
Pro Spot www.prospot.com

A high-amp MIG welder is invaluable for body service.

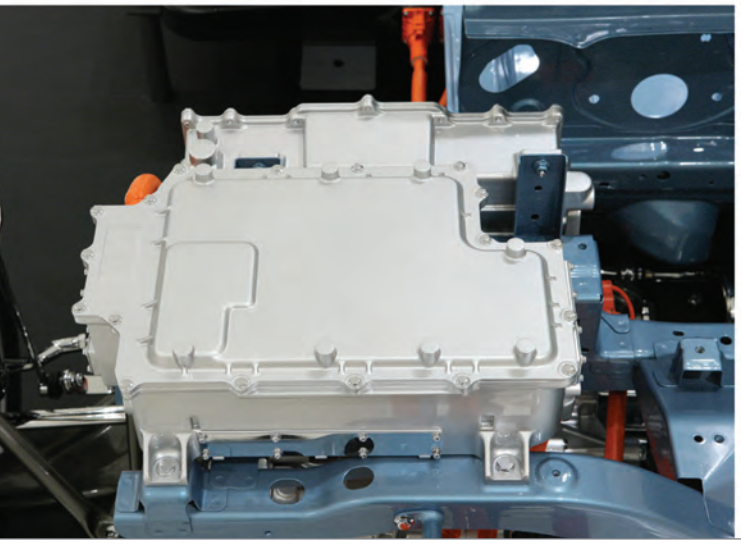
A masking paper and tape dispenser saves time and gets the job done right.

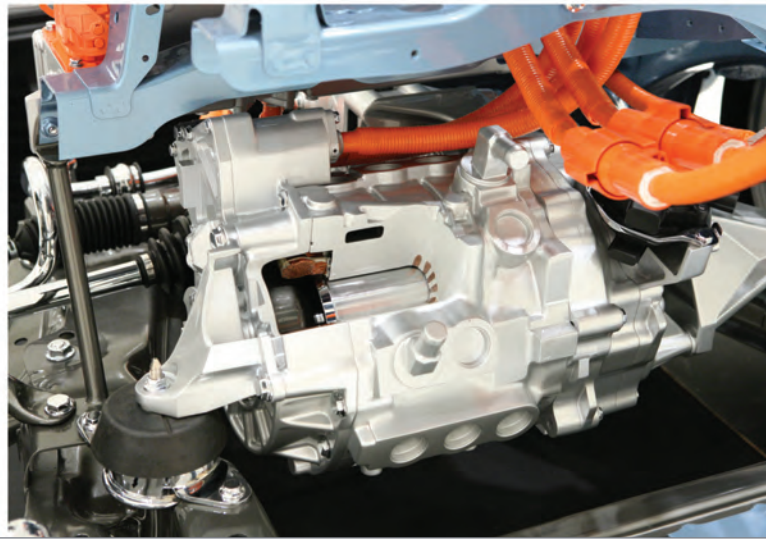
An R134 refrigerant recharging/recovery /recycling station helps you meet regulations, saves time and holds down costs.

Collision Service on Nissan High Voltage Vehicles



"Do no harm" to life or car when repairing Nissan LEAF or Altima Hybrid vehicles.





Technological change and rising complexity are constants in collision repair. Whether unibody design, advanced high-strength steels, exotic alloys, or carbon fiber, innovation has ratcheted up the service knowledge, equipment, training, and associated repair techniques required. Today, the electric vehicle (EV) challenge for collision repairers is at hand. Resistance is futile. Preparing, adapting, and training for the inbound change is not.

Nissan's EV portfolio is growing

At Nissan, the electric tide is evidenced by the Altima Hybrid and the all-electric Nissan LEAF – with more models on the way. Even conventional vehicles are incorporating electrified components such as start-stop technology or electric air conditioning. EVs will get into accidents, with many of the subsequent repairs being made at independent collision facilities.

The 2011 LEAF combines an air-cooled, 650-pound, lithium-ion battery pack and high-response 80kW AC synchronous motor to operate the vehicle's 400V components. LEAF batteries are warranted for 100,000 miles or eight years. At the end of 10 years, Nissan projects that the battery pack will still retain 70 to 80 percent of its capacity.

Nissan says the LEAF has a range of 100 miles in optimal driving conditions. Based on five-cycle tests that employed varying driving conditions and climate

The all-electric 2011 Nissan LEAF combines an air-cooled lithium-ion battery pack and a high-response 80kW AC synchronous motor to operate the vehicle's 440V components.

The Leaf 220/240V Level 2 (right) and 440/480V Level 3 (left) charging ports are located under a panel above the front bumper.

controls, the U.S. Environmental Protection Agency says the LEAF averages 73 miles. It found that using the LEAF's electric air conditioning system, heavy stop-and-go traffic, faster speeds, cold winter temperatures and hilly environments can all reduce range.

The battery pack frame sits underneath the LEAF and helps provide greater body rigidity than a conventional compact car has. The pack consists of 48 laminated modules, each containing four cells, for a total of 192 cells connected in series. Currently, an on-board 3.3-kilowatt battery charger recharges the battery pack. This will be upgraded to 6.6-kilowatts for 2012 for faster recharging, with retrofits available for 2011 models.

Owners have two recharging options. Each uses a SAE J1772 plug, which connects to the driver-side charge port located under a panel at the front of the LEAF. The other end of the cord connects to a power supply. Any standard 110V supply can be used to fully recharge the LEAF in 21 hours (Trickle). Alternately, home-based and public 220/240V (Normal) recharging stations, recommended by Nissan, will do so in seven hours. Should the U.S. adopt emerging 440/480V (Quick) chargers and plugs, the other charge port could be used to recharge the battery pack to 80 percent capacity in just 30 minutes. However, Nissan cautions that Level 3 recharging will cause 10 percent or greater loss in battery capacity over a 10-year period.

The 2007–2011 Altima Hybrid combines 244V technology and nickel metal hydride battery pack with a 2.5L Nissan internal combustion engine.

In comparison, the Altima Hybrid combines a smaller-sized nickel metal hydride (NiMH) battery pack supplemented by a 2.5L Nissan gasoline engine to power 244V high-voltage technology. The engine employs an Otto-based cycle to deliver higher power density, useful in hilly environments or situations where more range is needed. Unlike the LEAF, no home or public battery recharging is required. Both vehicles, however, have very expensive high-voltage components, including electric A/C compressors, inverters, liquid-cooled DC-DC inverters, electric drive motors, capacitors, air-cooled battery packs, service plugs and wiring that require both awareness and careful handling.

Consider this for a moment: A Nissan/Infiniti publication titled Body Shop Administrative Manual for Certified Electric Vehicles (EV) Dealers begins with this statement: "To ensure the safety of body shop personnel, EV battery and high-voltage (HV) parts located near the damaged portion of the vehicles shall be removed and installed by a certified EV dealer. Certified EV dealers have the facilities, equipment and exclusively-trained technicians to safely service your vehicle. The EV should only be delivered to a body shop after removing the battery pack, high-voltage parts and any related parts that may be an obstacle to the body repair and painting process."

That's fine should an Altima Hybrid or LEAF arrive at your collision repair facility from a certified EV dealership, but what if an EV arrives at your facility directly from an accident? Liaison with a Nissan-certified EV dealer is one solution. Becoming EV-ready is another. To do so, key resources such as information, tooling and training must be sourced and aligned to overcome resistance, apprehension and fear.

Nissan/Infiniti service technical information websites are a must-use resource

Service information is a dynamic, evolving database. The LEAF is brand-new and the Altima Hybrid is less than five years old. The Nissan (www.nissan-techinfo.com) and Infiniti (www.infiniti-techinfo.com) service information websites provide collision professionals with access to the most current and accurate Altima Hybrid and LEAF service/repair information, technical service bulletins, schematics, diagrams and useful publications. They should be your primary information source and be consulted before any collision technician ever touches an EV body.

For example, the websites provide year-specific LEAF and Altima Hybrid service manuals, body repair and painting manuals, dismantling guidelines, collision repair warnings, first responder information and more.

Details include:

- When and how to safely remove, store and install high-voltage battery packs.
- Diagrams that show the location of high-voltage components, cutting locations and instructions for the removal of certain high-voltage components for specific collision repair operations.

- Guidelines to safely disconnect the battery pack, then power down high-voltage systems and capacitors, and service plug removal.
- Precautions and procedures for performing welding, painting or other collision repair operations.
- Emergency procedures to follow in the event of a collision or shop accident.

Tech-Mate is the Nissan-approved source for EV tools, equipment and more

The high-voltage in battery packs, components and wiring can damage and kill. Frying a complex EV-rated multimeter or any of the high-voltage powertrain components can cost you four figures. The cost of cooking an NiMH or Li-ion battery pack in a paint booth, should the temperatures exceed 140°F, exceeds five figures. In addition, the safety of personnel is also critical. Just 40 to 60 volts at 0.50 amps for as little as 20 seconds can kill if it finds a path to the heart. In addition, the high-voltage components and magnetic drive motors can interfere with cardiac pacemakers, defibrillators or other implanted devices inside of personnel. Facilities should check with manufacturers of these medical devices before allowing anyone to work on EVs.

Proper tooling and equipment – from high-voltage safety gloves to battery removal equipment – is critical to preventing damage to expensive EV tools, equipment and vehicle components. To help, Nissan/Infiniti provides a valuable resource to collision facilities: the Tech-Mate Tool and Equipment Program (www.nissantechmate.com). Tech-mate is the only Nissan-approved source for a full range of EV service tools and equipment. Not only are products tested for performance before approval, Tech-Mate specialists will also provide assistance on product selection, application, service and facility planning.

Using the most functional diagnostic scan tool available is essential for the safe, complete collision repair of LEAF or Altima Hybrid vehicles. The Nissan CONSULT-III Plus is the only scan tool available today that can effect and verify complete repairs for both the Nissan LEAF and Altima Hybrid before returning vehicles to customers.

Collision professionals can also consider reputable aftermarket suppliers, such as Fluke Corp. or Midtronics Inc. Here are some examples of what those two companies can provide repair shops and technicians wishing to be fully competent (some of which are available through Tech-Mate):

- DMMs (Digital Multi Meters), such as Fluke's 88V, differential oscilloscopes, insulated leads and hand tools must be rated at CAT III 1,000V or better. Underrated, defective or damaged DMMs can explode, so technicians should not hold them during use. For eye and face safety, meter readings should always be taken from a side angle.

With EVs, just one-tenth of a volt can be the difference between driveability and a no-go. An inexpensive adapter, such as the 225SVE Stray Voltage Eliminator, inserted between an 88V DMM and its leads, can zero-out a multimeter and allow complete repair. (Courtesy Fluke Corp.)

The Midtronics HYB-1000 Hybrid Battery Tester determines if an Altima Hybrid battery pack or some of its individual cells are damaged or underperforming. (Courtesy Midtronics Inc.)

- As little as 0.10V can be the difference between an EV being driveable and a no-start. Yet many techni cians who use a CAT III, 1000V rated multimeter are not aware that these devices and attachments can harbor ghost voltage that exceeds 0.10V. An inexpensive adapter, such as the Fluke's 225SVE Stray Voltage Eliminator, can zero-out a multimeter to allow accurate diagnosis.

- The Midtronics HYB-1000 Hybrid Battery Tester enables a collision technician to determine if an Altima Hybrid battery pack or some of its individual cells are damaged or underperforming and need replacing, before beginning collision repair.

- Midtronics GRX-5000 EV Module Balancer tool, developed for Nissan, enables repair profes-sionals to check all of a LEAF's battery pack modules to determine which are defective and need replacement. In addition, similar to the way diesel injectors need to be balanced when one or more is replaced. The new tool will also "pre-con-dition" new replacement modules to fit the state of the rest of the battery pack.

Seek and maintain EV auto technician certification

Thorough EV training and continuing education is necessary to harness the service information and hardware to effect collision repair. It's essential to properly power down, remove, store or install an EV battery pack or other electrified component, as well as to perform any welding, painting or other repair procedure. And remember, it isn't enough to get current; staying current is also necessary.

The new GRX-5000 EV Module Balancer determines which, if any, of a LEAF battery pack's modules are defective, then precon-ditions new replacement modules to match the state of the battery pack.
(Courtesy Midtronics Inc.)

Would you know if and how to safely remove a LEAF or Altima Hybrid battery pack? Nissan/Infiniti service information, TechMate equipment and tools, and approved automaker and aftermarket training are essential.

For example, consider what is involved should the 650-pound battery pack need to be removed from underneath a LEAF. Not only does the pack need to be disconnected from the vehicle first, the remaining components must be disabled and discharged safely. The removal process also requires a special portable platform jack that supports the battery so that it can be lowered just enough to safely and properly remove bolts and disconnect high-voltage wiring cables. Once disconnected, the "live" battery pack must then be lowered and stored safely and securely out of harm's way, typically on this platform, with caution tape or warning signage.

The Nissan and Infinti websites provide training and education links for this and other collision repair operations for the LEAF and Altima Hybrid. Training is available in three formats – downloadable traditional classroom manuals, e-learning modules, and specialized training videos. Here's one example of each type:

- Downloadable electronic training includes the LEAF EV Technologies Course, a four-day, classroom-style, instructor-led, competency-based, technical learning experience. It provides a detailed look at the systems, operation, and safety procedures for the LEAF.

- Video training includes Volume 162: CONSULT-III Plus, and Volume 156: Replacing the Altima Hybrid Battery, which looks at the procedures for replacing the high-voltage (HV) battery. It covers a battery system overview, the training required, necessary safety precautions, and the procedures for disassem bling and removing the HV battery and the individual components of its subassembly.

- E-Module training includes the Introduction to EV Technologies and Introduction to EV Safety and Overview. Both are available to any person holding a valid Nissan/Infiniti website subscription.

Today, over three million hybrids have been sold worldwide, two million of them here in the America. More partial or full EVs are coming, as they help automakers meet tougher fuel economy and emission regulations. That commitment is going to impact your business. Don't let the opportunity to perform EV collision repairs pass you by.

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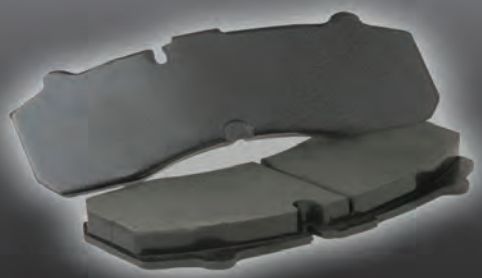

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