Oxygen Sensor Performance

Oxygen sensors have been used in automobiles for over 30 years but are often taken for granted as part of the engine control system. They have progressed from single wire non-heated oxygen sensors to heated oxygen sensors and, in some vehicles, wide band oxygen sensors.

Proper oxygen sensor operation is critical for vehicle emissions, fuel economy and engine performance. However, technicians may misdiagnose the performance of an oxygen sensor if they are not familiar with how one works or are just reading a Diagnostic Trouble Code (DTC) from a scan tool without properly diagnosing the engine control system. Here’s a closer look at what an oxygen sensor does and how it works.

The switching Oxygen Sensor (O2S) is unique among the engine control system sensors because, when hot, it acts like a battery and is able to generate its own low voltage signal that is sent to the Engine Control Module (ECM) to monitor the amount of oxygen in the exhaust. The O2S provides feedback to the ECM, which uses the information to manage fuel delivery and maintain the stoichiometric air-fuel ratio of 14.7:1 (for gasoline engines).

The electrically heated oxygen sensor (HO2S) is used to reduce the amount of time it takes for the sensing element to become hot and active, allowing the fuel control system to go into closed loop more quickly, which helps reduce emissions. On some vehicles, it is also used to help keep the engine control system in closed loop when the engine is at idle and may have a low exhaust flow rate. On newer vehicles, the ECM determines the heater temperature by measuring the current flow through the heater and calculating the heater resistance, which correlates to sensing the element temperature, and then the control module can predict sensor element temperature based on heater resistance.

Measuring Oxygen

The switching O2S has a center element made of ceramic material, zirconia, and two platinum electrodes that make up the inner and outer surfaces of the center element. The inner surface of the sensor — exposed to outside air through its wire out to the harness connector — forms the positive terminal of the O2S circuit. The platinum coating on the outer surface of the center element provides feedback to the ECM, which uses the information to manage fuel delivery and maintain the stoichiometric air-fuel ratio of 14.7:1 (for gasoline engines).

continued on page 3
ACDelco Battery Warranty Changes

ACDelco is transitioning away from a pro-rated battery replacement warranty to a new, simpler, free replacement strategy for ACDelco batteries to help reduce customer confusion and dissatisfaction.

Here’s how it works: On a 30-month free replacement battery, for example, if the battery is up to 30 months old, it’s replaced for free. If it’s 31 months old, a new battery is sold to the customer. It’s that simple.

The new free replacement warranty batteries will have new part numbers, which began being rolled into inventories in March. Batteries purchased under the previous part numbers and warranty will still be warranted on the pro-rata basis. The warranty is what the battery has on it. Here’s a quick look at the batteries and their new part numbers:

- Professional 24-5YR (18-month free replacement warranty) – part number 24P (Professional)
- Professional 24-6YR (30-month free replacement warranty) – part number 24PS (Professional Silver)
- Professional 24-7YR (42-month free replacement warranty) – part number 24PG (Professional Gold)

The previous 60 Series battery is transitioning to the Advantage brand and will also carry a free replacement warranty; in the example above, it will be part number 24A and have an 18-month free replacement warranty.

In addition, non-automotive batteries have been moved to a simplified and improved free replacement warranty.

New point-of-sale materials have been developed to support these changes. For more information, contact your local ACDelco representative.

— Thanks to Dan Carter

Updated Wheel Alignment Specifications

Before performing a steering wheel angle/front toe set or wheel alignment check/adjustment, be sure to verify the wheel alignment specifications for the vehicle in order to avoid any complications from using the incorrect wheel alignment specs. This can occur if the wheel alignment rack specifications are not updated regularly. In addition, the vast variation in specifications, depending on the type of vehicle and tire, suspension and engine options, make it easier to use the wrong wheel alignment specs.

The only recommended source of current, accurate wheel alignment specifications (both targets and tolerances) is the Service Information for the particular vehicle make/model. The specifications indicated on the wheel alignment rack should always be verified with the appropriate Service Information.

In the first quarter of 2012, the following GM models had updated/changed wheel alignment specifications:

- 2007-2012 Acadia
- 2007-2012 Enclave
- 2009-2012 Traverse
- 2010-2012 Corvette
- 2010-2012 LaCrosse
- 2011-2012 Regal

Check the alignment specifications for these models in the appropriate Service Information against the alignment machine specifications before performing an alignment. Be sure to take into account all related option content on the vehicle, including optional tire and suspension packages. These updated specifications most likely will not be included in the latest specifications from alignment machine manufacturers.

— Thanks to David MacGillis

ACDelco TechConnect

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ACDelco TechConnect is published bi-monthly and online for technicians of Total Service Support (TSS) and Key Fleet accounts to provide timely service information, increase knowledge and improve the performance of the service center.

ACDelco 360 represents our mission to look at our businesses at every possible angle to provide value and assistance to our distributors and their customers as well as offer a full circle of support with programs, tools, training and marketing focused on enhancing and growing our partnership successfully.

Publisher:
Rick Balabon
ACDelco
E-mail ➔ richard.balabon@gm.com

Editor:
Greg St. Aubin
ACDelco
E-mail ➔ gregory.staubin@gm.com

Technical Editor:
Mark Spencer
E-mail ➔ mspencer@gpworldwide.com

Production Manager:
Marie Meredith

Desktop Publishing:
5by5 Design LLC
E-mail ➔ dkelly@5by5dzign.com

Write to:
ACDelco TechConnect
P.O. Box 500
Troy, MI 48007-0500

On the Web:
To read and search recent issues of TechConnect online:
- www.acdelcotechconnect.com, click the TechConnect Magazine link, or
- Log in to the ACDelco LMS, click the Resources link

ACDelco service tips are intended for use by professional technicians, not a “do-it-yourselfer.” They are written to inform those technicians of conditions that may occur on some vehicles, or to provide information that could assist in the proper service of a vehicle. Properly trained technicians have the equipment, tools, safety instructions and know-how to do a job properly and safely. If a condition is described, it cannot be assumed that the information applies to all vehicles or that all vehicles will have that condition.

All materials and programs described in this magazine are subject to change. Submission of materials implies the right to edit and publish. Inclusion in the publication is not necessarily an endorsement of the individual or the company.

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the sensor element — exposed to the exhaust gases — forms the negative terminal of the sensor circuit.

This oxygen-sensing cell becomes a galvanic device (battery) when heated, (the exhaust gases keep the sensor at about 600° F/315.5° C) and it generates an electrical signal as the result of the interaction of outside air, the inner surface of the element, the exhaust gases, and the outer surface of the element. The amount of voltage the O2S generates is proportional to the difference between the amount of oxygen in the outside air and the amount of oxygen in the exhaust gases.

**Using the Data**

The ECM typically applies a reference voltage, also known as bias voltage, to the sensor of 450 millivolts (some new ECMs use 1.9 volts as its bias voltage). The ECM uses this reference voltage with the voltage generated by the O2S. A normal oxygen sensor reading varies above and below the bias voltage; in a normally operating engine, the pre-catalyst O2S output voltage fluctuates rapidly between 100 millivolts and 900 millivolts. This rapidly changing voltage reflects the changes in the air-fuel ratio. The ECM adjusts injector pulse width in response to the changing O2S signals to try to keep the correct air-fuel ratio. This data also is used by the ECM to determine short-term and long-term fuel trim. Here are a couple of examples:

**Rich:**

The Earth’s atmosphere contains about 78% nitrogen and 21% oxygen. The exhaust from a rich air-fuel ratio will contain almost no oxygen. With a large difference between the amounts of oxygen contacting the two surfaces of the sensor, the sensor is able to generate more voltage. When the exhaust gas indicates it is rich, the voltage output is high (above 450 millivolts) and the ECM will try to lean the mixture out.

**Lean:**

The exhaust from a lean air-fuel ratio has about 2% oxygen. With a smaller difference between the amounts of oxygen contacting the two surfaces of the sensor, the sensor generates less voltage. When the exhaust gas is lean, the sensor’s voltage output is low (below 450 millivolts) and the ECM will try to enrich the mixture.

This is where having a good understanding of engine controls and oxygen sensor operation is particularly important. For example, when a misfire occurs, incomplete combustion leaves an abundance of oxygen in the exhaust, which passes the O2S and is interpreted by the ECM as a lean (lots of oxygen vs. fuel) condition. The ECM responds by increasing the fuel delivery. This condition is very hazardous to the catalytic converter.

**Catalyst Efficiency**

In addition to fuel control, the ECM uses O2S information to perform diagnostics and monitor catalyst efficiency. A post-catalyst O2S will not vary the voltage reading as quickly as a pre-cat O2 sensor if the catalytic converter is operating properly. A leak in the exhaust system can lead to misdiagnosis of the pre- or post-cat O2 sensor if proper diagnosis is not followed. Anything that will allow extra oxygen into the exhaust stream can change the amount of oxygen the O2S measures and may set a DTC. Just because an O2S DTC is set does not mean it is caused by a bad sensor; it may just be that the sensor is seeing information outside of the expected range. This would be similar to blaming the engine coolant gauge because it indicates a hot engine. The coolant gauge is only an indicator of the condition. The engine is overheating, not the gauge.

**OEM Sensors**

If proper diagnosis leads to replacing a malfunctioning oxygen sensor, what are you going to replace it with? There are instances of aftermarket oxygen sensors that may fit but have questionable functionality; the sensor tip openings may have different configurations or the length of the sensor body may cause interference issues. ACDelco has learned of one aftermarket supplier that has consolidated several GM/ACDelco O2S part numbers and applications into a single aftermarket part number.

GM engineers spend a lot of time designing the OEM sensors to work properly, in both fit and function. In OEM and ACDelco sensors, the openings in the tip are specifically designed to monitor the oxygen content and the tips are designed to shield the sensor from thermal shock, which is caused by condensation in the exhaust system hitting a hot sensor. Plus, the wire lead lengths are designed to fit (not be too short and possibly pull wires out of the connector or too long and rub against a chassis component or melt against the exhaust system), and the O2 electrical heater resistance tolerances are set to properly maintain the correct temperature of the internal sensing element, all ensuring proper operation and performance.

Finally, be sure to follow the appropriate Service Information when replacing an O2 sensor or making repairs to the wire lead as there are specific repair instructions and torque specifications for this procedure.

– Thanks to Rick Balabon
ACDelco Online Specialty Catalogs

WISE Internet Parts (WIP) is an online parts catalog and ordering system that connects you to your ACDelco distributor’s inventory, pricing and parts information 24 hours a day, seven days a week. In addition to the regular ACDelco parts catalog, WIP offers several specialty catalogs.

Illustrated Catalog

ACDelco’s Illustrated Catalog provides a unique view and navigation style that makes it easy to find and order the parts you need. The online catalog features GM vehicle applications with aftermarket categories and sub-categories.

The easy-to-use navigation of the GM vehicle application catalog enables technicians and parts department personnel to instantly find the desired parts. It’s as easy as 1, 2, 3.

1. Click the part groups
2. Explore the view to navigate from part group down to the specific parts needed, without having to know or guess the correct categories
3. Order the part

Catalog features include:

- VIN filtering, application and system illustrations all on the SAME page.
- Aftermarket-friendly categories and sub-categories
- Notepad tool to view and compare application notes
- Exploded view of GM system illustrations with part number identification
- Zoom controls for accurate part identification
- Color coded to identify ACDelco parts
- Fast moving parts identified with a flame icon

- Vehicle search options
  - Year, Make, Model
  - Complete VIN filtering using vehicle options and build
- Part search options
  - Category/Sub-category
  - Part name/Part number
  - Key word
- Parts detail
  - Imaging
  - Supplier Part availability
  - Ordering capability

New 2nd quarter catalog enhancements include:

- Search by the last 8 digits of a VIN for easier look up
- Show/hide price so service center owners can remove their cost from the screen

A/C Catalog

The unique, horizontally-aligned online ACDelco Air Conditioning Catalog emulates the style of many paper catalogs. After identifying a vehicle, all the A/C parts are listed horizontally across the page, making it quick and easy to view all the A/C parts needed for a vehicle in one efficient catalog search.

Catalog enhancements include:

- A new layout to optimize the horizontal alignment
- Rear parts (where applicable)
- An order summary added to the main page
- Multi-view images and product information on a "smart" page that links from the part number
- Labor references

In addition to the A/C catalog on WIP, a stand-alone A/C catalog is available on acdelcotechconnect.com.

Chemical Catalog

The specialty ACDelco Chemical Catalog allows users to search by the GM and/or ACDelco part number as well as chemical type. In order to make it easier to find what you’re looking for, the catalog details 20 chemical types, such as air conditioning, power steering fluids, brake fluids and motor oil.
Competitive Parts Analysis Helps Ensure ACDelco Quality

ACDelco routinely performs testing and analysis of products with competitive parts to ensure that the highest quality products are delivered to ACDelco customers. Recently, an analysis of an ACDelco fuel pump and a competitor’s fuel pump for 2002-2003 GM full-size trucks and SUVs showed some striking differences that can impact durability and performance.

ACDelco electric fuel pumps are designed to provide outstanding fuel delivery, quick engine starts, long-lasting durability, and proper fit. Quality testing and tear-downs are part of ACDelco’s commitment to continuous improvement.

When comparing the fuel pumps, here are some of the built-in quality features that were evident on the ACDelco pump.

The ACDelco pump has 10 motor contact points, while the competitor’s pump has 8 contact points. More contact points makes the spinning of the fuel pump turbine more efficient and quieter.

The ACDelco fuel pump also has a shorter fuel reservoir, reducing the chance to pinch the fuel lines.

The fuel sender of the ACDelco pump has internal springs in the reservoir, which eliminates the potential for pinching wires or rubbing through the fuel line. The competitive fuel pump has external springs on the guide rods.

In addition, the ACDelco fuel sender has thicker, more robust fuel level sensor wiper contacts and wear pads for enhanced durability.

The ACDelco fuel pump also features a jet pump to prevent fuel pump starvation when the fuel level is low. The competitor’s pump doesn’t have a jet pump.

Finally, ACDelco uses 100% new parts, and the quality testing of those parts is evident when tearing down these fuel pumps. The wear marks on the armature of the motor, for example, indicates the end-of-the-line quality testing all ACDelco fuel pumps go through to ensure full functionality and proper performance. The competitive pump is clean with no marks, showing it has not completed the same extent of full-functionality testing as the ACDelco part.

– Thanks to Dan Carter

The motor oil category offers a search by weight or by type: conventional/mineral, synthetic blends, or full synthetics.

In addition to chemical type, specification information by application is offered with the ability to link to the desired product from the specification area.

In addition to the WIP chemical catalog, there also is a stand-alone chemical catalog on acdelcotechconnect.com.

GM Medium-Duty Applications

GM medium-duty applications will be released in all catalogs in June and will include:

- 40 Chevrolet and GMC medium-duty models
- Over 1,800 part numbers
- Over 280,000 applications
- Virtually all ACDelco product lines

For more information about WIP and the ACDelco specialty catalogs, go to acdelcotechconnect.com and click the eBusiness tab.

– Thanks to Kelli Abbott
Looking for a new GM vehicle? ACDelco Professional Service Center (PSC) Program member employees can save big on a new GM car or truck with the GM Supplier Discount.

All employees of ACDelco Professional Service Center accounts qualify for the GM Supplier Discount, which allows you to take advantage of savings on a wide range of eligible, new GM vehicles from Chevrolet, Buick, GMC, and Cadillac.

Your discount is just three easy steps away:

1. Visit gmsupplierdiscount.com and sign in using the ACDelco Company Code, which can be obtained from acdelcotechconnect.com under the PSC Program tab; click Program Benefits on the GM Vehicle Supplier Discount page.
2. Follow the prompts to get your personal Authorization Number.
3. Print it out and take it to a participating dealer to receive your discount.

For more information about the GM Supplier Discount and other ACDelco Professional Service Center Program benefits, visit acdelcotechconnect.com and click the PSC Program tab.

– Thanks to Laura Rollinger

Potential History DTCs after Servicing a Vehicle

When servicing a vehicle, any control module that wakes up with a circuit disconnected may set a current Diagnostic Trouble Code (DTC), which will go into history once the circuit is reconnected. This condition is related to how the vehicle power mode works with different control modules with the key On vs. the key Off. These DTCs often are set inadvertently by waking a control module when opening a door and will not clear until the proper self-test has been completed, which depends on operating conditions being met.

Here’s an example of how a history DTC could be set on 2010-2013 GM vehicles that require the Global Diagnostic System 2 (GDS 2) scan tool for vehicle communication (2010-2012 Buick LaCrosse; 2011-2012 Buick Regal; 2012 Buick Verano; 2010-2012 Cadillac SRX; 2010-2012 Chevrolet Camaro and Equinox; 2011-2012 Chevrolet Cruze and Volt; 2012 Chevrolet Sonic; 2013 Chevrolet Malibu, and 2010-2012 GMC Terrain). A history DTC P0113 (Intake Air Temperature Sensor Circuit High Voltage) may be stored immediately after vehicle service if the Engine Control Module (ECM) wakes up (activates) while a 5-volt reference sensor is unplugged and the ignition is Off.

If a technician were to leave the Intake Air Temperature/Mass Air Flow (IAT/MAF) sensor disconnected and open the driver’s door with the battery connected, ignition Off, and the ECM “asleep,” the Body Control Module (BCM) would wake up the ECM, causing the ECM to sense the open IAT sensor and set a current DTC P0113. After the IAT sensor is reconnected, the DTC status will clear as a current DTC, but it will still be in stored in history.

This is just one example. There are others that may occur when other sensors are disconnected and a control module wakes up.

If this condition occurs during unrelated vehicle repairs, do not replace any parts. Simply clear the DTCs and ensure that they do not reset.

If current DTCs are stored, this information does not apply and the appropriate Service Information diagnostics should be followed.

– Thanks to James Parkhurst

Take the TechConnect Reader Survey

TechConnect provides technicians with the latest technical news and information from ACDelco and the automotive industry. We cover a wide range of topics, including technical information and programs from ACDelco, GM, Professional Service Center Program partners, tool suppliers, and more.

To help in developing future issues of TechConnect, we’d like to hear from you. Go to the link below to take a short survey about what automotive-related service news and information you want most in TechConnect.

Your input is very important to us. Thanks for taking the time to complete the survey.

– Thanks to Rick Balabon

To take the survey, scan the QR code with your smartphone or go to www.onlineconsumersurveys.com/R.aspx?a=616
The following technical tips provide repair information about specific conditions on a variety of vehicles. If you have a tough or unusual service repair, the TSS Diagnostic Hotline can help. Call 1-800-825-5886, prompt #2, from 8 a.m. to 8 p.m. ET Monday-Friday, to speak with a technical expert with the latest OEM information.

Cooling System Performance


Diagnostic Trouble Code (DTC) P2181 (Cooling System Performance) may be set. Use a scan tool to determine that all engine systems are functioning as designed. Repair any other DTCs as necessary.

To address DTC P2181, reprogram the Powertrain Control Module (PCM) with the latest software.

After PCM programming, clear any DTCs that may have set in other modules due to reprogramming. On 62TE-equipped vehicles, clear the Variable Line Pressure Counters, and perform the Quick Learn function for the PCM.

Refer to Bulletin #18-032-11 for more details.

Duramax Diesel Exhaust Fluid Quality Poor Message

2012 Chevrolet Express and Silverado; 2012 GMC Savana and Sierra; equipped with the 6.6L Duramax diesel engine (RPOs LGH, LML)

An Exhaust Fluid Quality Poor message may be displayed on the Driver Information Center notifying the driver that the Engine Control Module (ECM) has detected a drop in the NOx reduction efficiency of the Selective Catalyst Reduction (SCR) system. The Exhaust Fluid Quality Poor message may be displayed without any set Diagnostic Trouble Codes (DTC).

An Exhaust Fluid Quality Poor message does not always mean the fluid is contaminated or needs to be changed. The J-26568 Coolant and Battery Fluid Tester can be used to test the fluid before deciding to discard it.

1. Collect a DEF sample of about 150 ml (5 oz.) from the DEF tank in a clear container. The DEF sample should be clear with no obvious coloration when held up to a light.

As clean DEF is clear, contamination by any common automotive fluids will cause the DEF to exhibit a trace of color associated with a specific contaminant.

- Windshield washer solvent – orange, purple or blue
- Engine coolant – orange or green
- Engine oil – brown
- Transmission fluid – red or brown
- Diesel fuel – clear, yellow, green, red or brown

2. Observe the DEF sample. It should have an ammonia smell. Clear fluid without the presence of an ammonia odor may indicate water or DEF diluted with water.

3. Measure the refractive index of the DEF sample using the J-26568 Tester. The refractive index of pure DEF should be between 1.310 – 1.3843 at 20° C (68° F). If not within the specified range, drain the remaining DEF and refill the tank with fresh DEF.

4. If the DEF tests normal, perform the DEF Quality test with a scan tool. The DEF Quality test should pass. If the test fails, replace the DEF.

If an Exhaust Fluid Quality Poor message is displayed without any set DTCs, diagnose the condition using the appropriate Service Information diagnostics for DTC P20EE (NOx Catalyst Efficiency Below Threshold) and P2BAD (Exhaust NOx Concentration High–Unknown Reason). After making repairs, use the DTC P20EE/P2BAD repair verification to evaluate and clear the Exhaust Fluid Quality Poor message.

Inoperative Cruise Control

2007-2012 Chevrolet Avalanche, Silverado, Suburban, Tahoe; 2007-2012 GMC Sierra, Yukon, Yukon Denali, Yukon XL, Yukon Denali XL; equipped with a Trailer Brake Controller (RPO J11)

The cruise control may be inoperative and the Trailer Brake Control Module may set Diagnostic Trouble Code (DTC) B3894 (Stop Lamp Switch Circuit Plausibility Failure).

If normal diagnostics do not lead to a correction, check the Master Cylinder Pressure Sensor parameter listed in the Trailer Brake Control Module data list. If it is displaying pressure with no brake pedal input, there may be a concern with the master cylinder pressure sensor, wiring/terminals, or Electronic Brake Control Module (EBCM).

On models with Stabilitrak (RPO JL4), the master cylinder pressure sensor is internal to the Brake Pressure Modulator Valve (BPMV)/EBCM.

Power Steering Fluid Contamination


Severe damage to the steering system may result from the use of any fluids or supplements that contain Teflon, which will cause a restriction at the filter in the power steering fluid reservoir. Use only approved fluids in the power steering system. The addition of any unapproved fluids or supplements can interfere with the proper function of the fluid.

Refer to Bulletin #19-010-04 for additional information.

Product Information

For free technical assistance and product information regarding specific ACDelco products, contact these toll-free information hotlines staffed by ASE-certified technicians:

- Brakes – 1-888-701-6169 (prompt #1)
- Chassis – 1-888-701-6169 (prompt #2)
- Clutches – 1-888-725-8625
- Lift Supports – 1-800-790-5438
- Shocks – 1-877-466-7752
- Starters and Alternators – 1-888-725-8625
- Steering (Pumps, Rack and Pinion, Gears) – 1-888-833-5567
- Wiper Blades – 1-800-810-7096
How to Take AC Delco Training

Go to www.acdelcotechconnect.com and click the Training tab to log in to the AC Delco Learning Management System (LMS).

- To enroll in an Instructor-Led Training (ILT) course (ILT courses are full-day hands-on classroom courses), click Take Training > Instructor-Led Training to view the catalog and select a specific course.
- To enroll in a Virtual Classroom Training (VCT) course (VCTs are 1-2 hour live online courses), click Take Training > Virtual Classroom Training to view the catalog and select a specific course.
- To launch a Web-Based Training (WBT) course (WBTs are 1-4 hour self-guided online courses), click Take Training > Web-Based Training to view the catalog and select a specific course.
- To launch a TechAssist (TAS) course (TAS courses are 15-20 minute online presentations on a specific topic), click Take Training > TechAssist to view the catalog and select a specific course.

Training Spotlight

S-EP08-23.01WBT – Compressed Natural Gas (CNG) Fuel Systems

This course covers the laws and regulations, component function and operation, diagnosis, service, and inspection and maintenance procedures for CNG fuel systems.

S-EL06-28.01WBT – eAssist Battery Storage Systems

The GM eAssist battery storage system, including the components and function of the generator battery assembly, generator control module, and battery cooling system, are presented in this course.

S-EL06-27.01WBT – eAssist Introduction

The GM eAssist system and its impact on the drive cycle are covered in this course. Components of the system that are reviewed include the starter generator, liquid cooling system, accessory drive belt system, and high voltage battery assembly.

S-EL06-48.01TAS – eAssist Safety

GM eAssist safety practices, such as high voltage service precautions, personal safety, warning labels and the disabling procedure, are highlighted in this course.

S-FN00-20.02WBT – Multiple Diagnostic Interface (MDI) Familiarization

This course covers the operation of the MDI, required for diagnosis and programming of some GM vehicles. MDI Setup Software, on-vehicle operation and the Service Programming System procedure are reviewed.

Training Schedule

To search for currently scheduled courses in your area, view the Training in Your Area section on the Home page. Select search terms from the dropdown menus and click the Submit button.

Instructor-Led Training Courses

The following ILT courses are currently being scheduled:

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<td>S-BK05-01.01ILT</td>
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<td>Body Electrical Global Diagnostics</td>
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Virtual Classroom Training Courses

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<td>S-AC07-02.01VCT</td>
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<td>Electrical Circuit Cooling, Flushing, Recovery and Diagnostics</td>
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<td>6.6L Duramax LGH and LML Diesel Engines</td>
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– Thanks to Greg St. Aubin