

MotorAge

February 2015

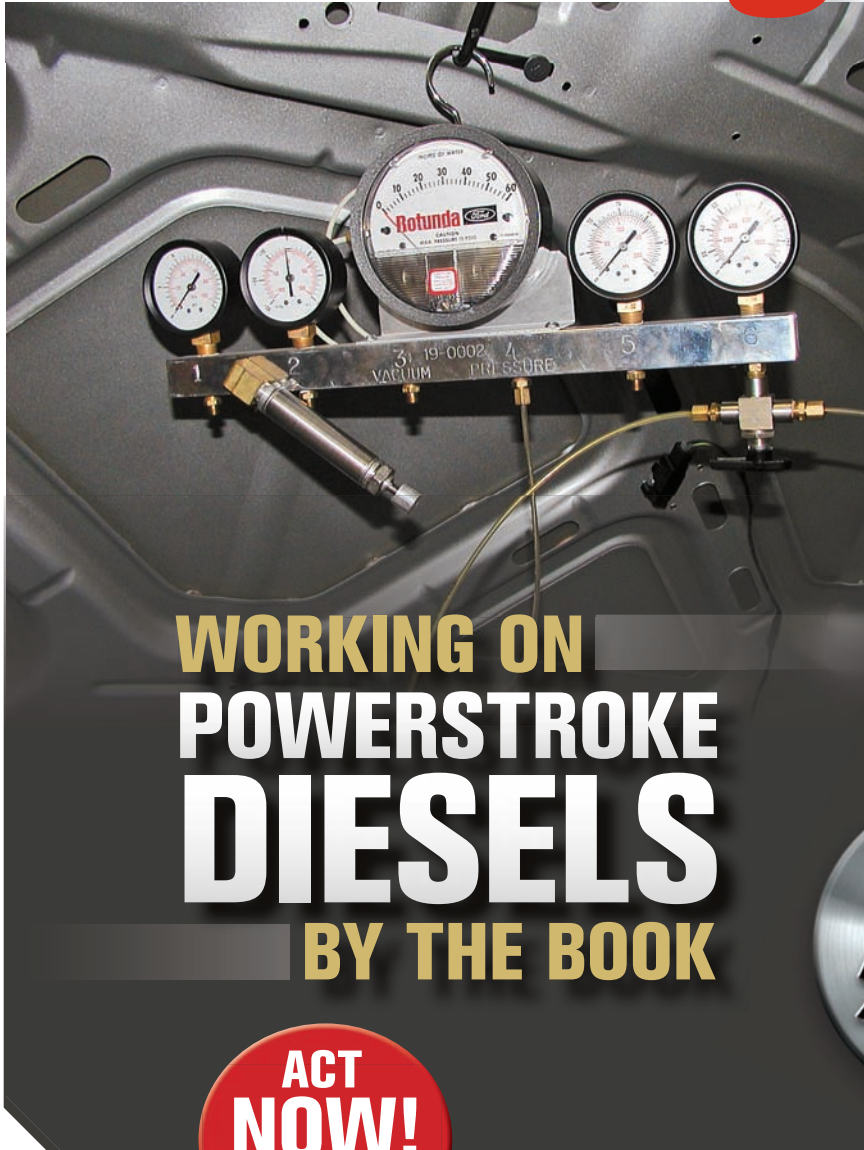
Talk Shop Anytime



AUTOPRO WORKSHOP

Vol. 134, No. 2

Advancing the Automotive Service Professional Since 1899



WORKING ON POWERSTROKE DIESELS BY THE BOOK

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COMMUNITY

IS A LACK OF KNOWLEDGE HURTING YOUR SHOP?

While what you don't know can hurt you, there are ways to educate yourself.

POWERTRAIN PRO

DEALING WITH DURAMAX

It's time to review this primer on the diagnosis and repair of GM diesels.

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While what you don't know can hurt
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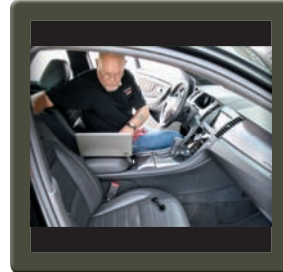


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What do you do when you have diagnostics to
perform? Creating a routine is the best start.

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ACCESS TO REPAIR INFO

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Workshop: Peter, CarGirl, BWrench, jatonymartin and more!



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POWERTRAIN PRO



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Don't lose sight of or neglect your responsibilities as a shop owner, and like on a motorcycle, know where your business is going.

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The forwardlift.com updates include modern graphics, new product pages and better organization for easy navigation.

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FEDERATED, PRONTO RELEASE MERGER DETAILS

The details of the companies' merger include answers to some frequently asked questions.

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GAS MODEL VEHICLE SALES TO DECREASE BY 2017

Conventional gasoline-powered vehicles are expected to make up less than half of new vehicles sold worldwide by 2017.

»» AFTERMARKETBUSINESS.COM/GAS

WHAT'S AHEAD IN 2015

See what ABRN anticipates for the collision repair industry in 2015.

»» ABRN.COM/ABRN2015

SPRAY GUN ADJUSTMENTS IMPACT PRODUCT QUALITY

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»» ABRN.COM/SPRAYGUN

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Pete Meier, director of training, has a personal invitation for you to Automechanika Chicago at MotorAge.com/AMCinvite.

AUTOMECHANIKA CHICAGO

Sign up now for top training in Chicago

There still is time to register for Automechanika Chicago, including securing a scholarship that will cover your training costs for the three days.

Scholarships for "Automechanika Chicago presents Motor Age Training Live" are available at MotorAge.com/AMCscholarships. You can sign up for any scholarship; it does not mean you have to attend a class presented by that sponsor. Scholarships are dependent on you attending all three days' of training.

Speaking of training, the course list, details and instructor information now is available at MotorAge.com/AMCschedule.

Trainers include Greg Sands, Bernie Thompson, Albin Moore, Donny Seyfer, Dean Mason, Vin Waterhouse, G. Jerry Truglia, Wayne Colonna, Peter Coll, Mary Koban, Jaime Lazarus, Tony Martin, Kris Lewis, Greg Moyers, Scott Brown, Skip Potter, Dave Hobbs and many more.

Eric The Car Guy conduct a Q&A on Sunday, and there will be an Industry Town Hall forum led by Motor Age's Pete Meier, director of training.

Book your room today. See a list of designated hotels at MotorAge.com/AMChotels while rooms are still available. Also, while at many events you might not get an invite to a top evening event, we are taking care of you with a kick-off party with food, drinks and music included at no cost for you. In addition to the training and fun, you will be able to experience hundreds of exhibitors and new products on display, see product demonstrations right on the show floor and network with other shop owners and technicians.

Go online at MotorAge.com/AMCinvite and see your own invitation from Meier.

BREAKING NEWS

TRAINING

MACS ROLLS OUT SECTION 609 TRAINING

The Mobile Air Conditioning Society (MACS) Worldwide rolled out a new Refrigerant Recovery and Recycling Technician Certification Training Program on Jan. 1, 2015. MACS also initiated proctored training, self-study training and online training simultaneously on that date.

Periodically, the U.S. EPA requires all Section 609 Technician Certification Programs to update their training materials, this year to "incorporate information on three new alternatives found acceptable subject to use conditions in motor vehicle air conditioning under the Significant New Alternatives Policy (SNAP) program, HFO-1234yf, R-744 (CO₂) and HFC-152a."

Since its beginning, MACS has regularly developed and expanded its Section 609 program to reflect industry changes in technology, service equipment and procedures, tools, alternative refrigerants and regulatory requirements.

MACS submitted the requested training materials for review, and on Nov. 13, 2014, received notification from the U.S. EPA that "Mobile Air Conditioning

[MACS] CONTINUES / PAGE 4

Discussion is on-going in [MotorAge.com forums](http://MotorAge.com/forums)

Photo: Pete Meier



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[MACS]

CONTINUED FROM PAGE 4

Society (MACS) Worldwide has met the requirements of the update and satisfactorily submitted revised Section 609 training and certification materials. With this letter EPA confirms MACS Worldwide's Section 609 Technician Training and Certification Program approval. MACS Worldwide will remain on EPA's list of approved programs."

"What this means," explains Elvis L. Hoffpaur, MACS Worldwide president

and chief operating officer, "is that in response to the introduction of the new refrigerant

R-1234yf and its unique service procedures MACS has met the new training standards for mobile A/C technicians as required by the EPA. In addition to meeting the requirements for Section 609 programs set by the U.S. EPA, MACS also is the first (and as of this writing the only organization) to certify its program to SAE International Standard J2845, "R-1234yf (HFO-1234yf) and R-744 Technician Training for Service and Containment of Refrigerants Used in

Mobile A/C Systems." The scope of this SAE standard states, "The technician shall be trained to recognize which refrigerant is being handled, how to handle it safely and be equipped with the essential information, proper equipment and tools, which are unique to these refrigerants."

EPA is not requiring a new Section 609 certification for handling R-1234yf, however if technicians want their Section 609 certification card to read that they are certified to recover R-1234yf, MACS will require they review the new training material and take a new test.

CONTINENTAL OPENS FREE APP FOR ATE, VDO PRODUCT LOOKUP

Continental Commercial Vehicles & Aftermarket, manufacturer and supplier of ATE and VDO replacement parts, now offers a free mobile app, which allows easy parts lookup on the ATE-VDO Auto Parts Catalog.

Continental developed the application for multiple mobile platforms in partnership with Vertical Development and ShowMeTheParts.

Vehicle specific VIN scan feature: The new app, which is compatible with Apple iOS and Android mobile devices, allows the user to scan the vehicle's VIN barcode through either the windshield VIN tag or the drivers' side door-frame sticker. The VIN scan will identify all of the parts in

the ATE-VDO Auto Parts Catalog that are related to that vehicle.

The new mobile app can be downloaded for free from the Apple Store for iOS devices and Google Play for Android devices. It allows users to quickly and easily search for compatible parts on any car or light truck on the market.

The catalog's comprehensive database also contains product information, specifications, instruction sheets, photos, vehicle relearn procedures for TPMS and other details for VDO brand electric motors, door systems, engine management, fuel supply, TPMS replacement parts, REDI-Sensor Multi-Application TPMS sensors and ATE brand brake pads and rotors.

In addition to the VIN scan, the new app also allows users to search based on vehicle make and model and cross-reference with the touch of a button.

MAKING YOUR SACRIFICES PAY OFF

BY LARRY SILVEY |
PUBLISHER OF CUSTOM CONTENT

Having interviewed countless repair shop owners and their technicians over the years, I know that what you accomplish every day is impressive by anyone's standards.

Those of you who you have been in business for a while have developed long-term customers by taking the time to get to know them and their vehicles. You know their driving habits and know what their interests are. You might even know their kids and what their interests are. Along the way, you have updated your approach to serving your customers, otherwise, you wouldn't be reading this now.

To retain your customers, you learned that you had to be honest with

your customers. You wouldn't think of doing any unnecessary work; in fact, you advise your customers on what work is needed now and what can wait. You also learned that you didn't have to be the cheapest repair facility in your area but you do have to charge fair prices for your work and the parts you install. And if you are one of the best shops out there, you have learned that if you install anything less than the very best parts, you are inviting comebacks, which is the first step to losing customers.

But in the last few years, you have found that the technology age has challenged you. Not new car technology. The technology that has challenged you — even threatened you — is an OEM-inspired and dealership-induced game called shop management. The dealerships are a savvy bunch and the more you can be like them when it comes to shop management, the fewer worries and more customers you'll have.

They threw out the paper R.O.s years ago. Have you? At the same time, they threw out the file cabinets in which to keep the quotes, R.O.s and invoices. Did you? They have automated all of their promotional and internal communications. Have you? They can provide customer quotes instantly. Can you? They can order the right parts quickly. Can you? Their parts ordering, pricing and labor are integrated. Are yours? They have access to educational videos that make a difference in doing things right or doing them wrong. Do you? They can track the progress of work orders at all times. They have access to and can track their customers' vehicle histories in moments. Can you?

More than likely you have answered yes to some of my questions. If you didn't answer yes to all of them, then you owe it to yourself to review the shop management system you have in place, as well as look at some other solutions for comparison.

The Building Blocks of Our Success



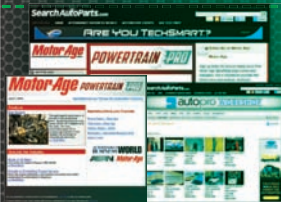
At Federated Auto Parts, you know you will always get great service and support from the most knowledgeable people in the business. You also know that you will get the best brand name, premium quality auto parts available. Parts that you can trust will help you get the job done right.



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ASE GUIDES

QUESTION OF THE MONTH



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☑ **SURVEY:** February's *Motor Age* is all about diesel service and repair, and so is the ASE A9 certification. Only makes sense that we open the A9 *Motor Age* study guide and pull this month's question from it. On a cold winter morning, a diesel engine vehicle will not start. All of the following are possible causes EXCEPT:

- A. Using Number 1 grade diesel fuel
- B. Using the wrong viscosity engine oil
- C. Weak battery
- D. Excessive starter current draw

Go to MotorAge.com/feb15survey to answer and enter our monthly contest from Federated Auto Parts.



Is a lack of knowledge hurting your business?

While what you don't know can hurt you, there are ways to educate yourself.

BY ROBERT SPITZ | WORKSHOP MEMBER

In the past, it was enough to have good mechanical skills, some common sense and a dose of good luck to be successful in the auto repair business. But there have been a lot of changes since that time. The increase in extended warranties, environmental demands, government regulations, more competition, less qualified help and an economical environment that has changed significantly since 9/11, all have contributed to making it tougher to make a profit.

Is Business Growth Tied to Management Knowledge & Skill? In

looking at the growth of thousands of shops, there is a definite pattern which is directly tied to the owner's business skill and knowledge. Often the growth and success of the business can be tied to the owner's background and experience.

Small to Mid Size Shops: In most small shops, those that have been in business for longer than five years and are doing somewhere between \$5,000 to \$25,000 in sales a month, the owners have come from the technical side of the business. Their time is spent primarily fixing cars.

Other shop owners have pushed their monthly sales up into the \$25,000 to \$45,000 range. In those

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BEST OF THE BLOGS are articles written by bloggers on Motor Age's community pages

Pete Meier

The causes of 'chatter'

One of the most difficult clutch related problems is chatter. Chatter is sometimes difficult to diagnose because it has many root causes, and some of them may not seem related at first.

Chatter can be detected as a pulsing or a grabbing sensation originating from the driveline or chassis / suspension and resonating into the vehicle cabin.

The driver may complain that the vehicle is hard to maneuver because the entire vehicle is "bucking or jumping". This will be especially evident while parking in tight spots, leaving from a traffic light or while trying to back up a trailer. Chatter is most evident when engaging the clutch or launching the vehicle. The driver will sense this at any contact point they have

with the vehicle, such as; seat, steering wheel, or floor of the vehicle.

Chatter has two primary origins: within the bell housing or the suspension and/or driveline.

Pete Meier

Give that battery a new life

Up to 99 percent of a car battery can be recycled. Electrolytes can be made into detergents and the plastics and metals are reused to make new batteries. This means you could be driving a car that's powered by the same materials that were in a battery from your grandparent's vehicle.

"Most people think about cans, paper or glass when they recycle, but the materials in automotive batteries are the most recycled materials in the world," said Ray Shemanski, vice president and general manager, Johnson Controls, Power Solutions.

Last year, Johnson Controls, a global multi-industrial company recycled 8,000 batteries per hour across its recycling system, making the company the world's largest automotive battery recycler.

In the U.S. and Europe, more than 95 percent of conventional batteries are recycled, but Johnson Controls' vision is a world where 100 percent of vehicle batteries are recycled.

According to a recent consumer survey, seven out of 10 Americans don't know their options for recycling used car batteries- which means two million end up sitting in garages or landfills.

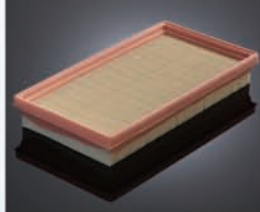
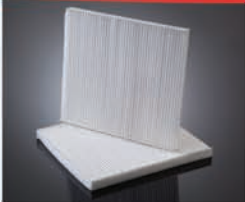
To find out where to go to recycle your battery, Johnson Controls has created www.recyclingmybattery.com.



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AN AUTOMECHANIKA CHICAGO PREVIEW

A LOOK AHEAD

A look at how to get involved in April.

THE TRAINER VIDEO

PETE MEIER

Beginning the diagnosis

shops, the owner tends to be the service writer and oversees the rest of the business. Their technicians fix most of the cars. In a small percentage of shops the owner hires a service writer, while continuing to work on cars himself. Sometimes owners bring in their wives or girlfriends to help out

and eventually handle customers.

What all the shops in this range have in common is that their business grew to a certain level of monthly sales and then ran into a barrier that seemed to stop the business from growing and expanding.

Read more at motorage.com/lack

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APRIL 24, 8:30-11:35 A.M.
Understanding Diagnosing and Repairing Fuel Trim Problems
Presented by Bernie Thompson.

APRIL 24, 2-5:15 P.M.
Servicing R-1234yf Vehicle A/C Systems: What You Need to Know
Presented Peter Coll of Neutronics and Mary Koban from DuPont.

APRIL 24, 2-5:15 P.M.
Financial Management for the Auto Repair Business
Presented by Vin Waterhouse.

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CHICAGO APRIL 24 TRAINING

APRIL 25, 8:30-11:45 A.M.
A Framework for Complex Testing and Diagnostics: Wiring Diagrams and Waveforms
Presented by Jorge Menchu.

APRIL 25, 8:30-11:45 A.M.
Electrical Troubleshooting - Making the Complex Simple
Presented by Tony Martin.

APRIL 25, 2-5:15 P.M.
Leveraging Your PC for the Automotive Service Professional
Presented by Scott Brown of iATN.

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APRIL 26, 8:30-10 A.M.
Transmission and Drivability Diagnostics
Presented by Wayne Colonna of ATSG.

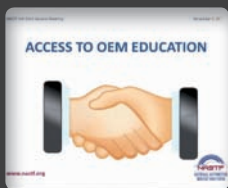
APRIL 26, 8:30-11:45 A.M.
Reflashing Electronic Modules In The Real World
Presented Greg Moyers of Delphi.

APRIL 26, 8:30-11:45 A.M.
Mastering the Six Financial Keys to Build A Multi-Million Dollar Shop
Presented by Scott Wheeler.

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comments from MotorAge's online communities

The best of what you're saying on [Facebook.com/MotorAgeMagazine](https://www.facebook.com/MotorAgeMagazine), [@Motor_Age](https://twitter.com/Motor_Age) and [@PeteMeier](https://twitter.com/PeteMeier) and the AutoPro Network.

Jim Bob via Facebook:
Took my first (ASE certification) in 1974, my last in 2012. Always ASE Master.

Stephen Ginoulias via Facebook:
Technicians of yesterday, if still in the business, bring much to the table, keeping all the basics many today skip over at times as the tech today has so much more to deal with as the technology advances every day. The basics will and are still there! In the 40 plus years since an automotive H.S. vocation and retired from it professionally, I can

still hear my teachers as they past as much on as we could absorb, still with the years ahead for the experience needed to succeed in the ever developing and challenging field. I'll always appreciate the classics and the history as the technology will always be amazingly interesting! Tinkering till my fingers and mind give up!

Mark Babbitt via LinkedIn:
Following logic based diagnostic paths (flow charts) is the best way to quickly trace your problem. When you skip steps based

on guesses, you will usually begin down the path of wasted time.

Nick Kilpatrick via LinkedIn:
I generally approach a vehicle with something in mind as a failure. Then I prove that assumption wrong. It is easy to get overwhelmed by computer lights and messages with crazy codes. Sometimes, you have to clear the slate and restart from page one, ignoring all previous diagnostics. Is there oil in the engine? Is the battery OK? Are the tires flat?



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- 12** Financial Figures
- 17** Going Social
- 20** Shop Profile

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PUT PEN TO PAPER

WORKING ON YOUR BUSINESS MEANS NOTHING IF YOU ARE NOT IMPLEMENTING WHAT YOU ARE LEARNING.

BY **BOB GREENWOOD** | CONTRIBUTOR



WITH the holidays now truly behind us, February is an excellent month to reflect upon from where you have come in the past three years. How many seminars and business development courses have you been to during this time period? How many times have you gone, gotten the message, taken it away and either cherry picked it to death or really did nothing with it?

This is the challenge for many within our industry; they have the desire to grow, but never take the steps to allow the true growth to happen. They end up living in a world of good intentions, where they talk a good story, but refuse to bring the story alive with behavior.

Oh, what are those three magical words? Behavior never lies!

The fact is most people find it very difficult to embrace an entire message, as they don't feel comfortable with the change they will have to go through to see the message to fruition. This is the real reason why it didn't work for them. The industry's biggest enemy is the lack of self-discipline to execute.

In our complicated business in which you are dealing with changing technology, a "fluid" economy and a nervous consumer, business change is now a constant. It also means we as individuals must accept and be willing to change in order to make it work.

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You most likely are a shop that has been exposed to a tremendous amount of knowledge to the point where it seemingly can be overwhelming. Slow down and ask this question when making a decision about implementing change: Will this feed my confusion or strengthen my clarity? You are maturing in so many ways of not only understanding your business so much better but also understanding your own entrepreneurial fears and insecurities.

Your business development is a journey and not a trip. There is no silver bullet in this industry, and it always will be a minimum of a two- to five-year time frame to experience the rewards. Stay focused, take your time and keep your eye on the ball, remembering to take one transaction at a time. It is a process.

“Now is the time to take inventory of your team’s competencies as well as management competencies and seek out the required additional training and development to ensure 2015 is a positive development year for your business.”

January and February a couple of those months where one can fall into a negative pattern of thinking. Don’t allow this to happen to you. Take the time and review all the material you have been exposed to over the last three years and make a detail list as to where improvement is still required. Now draw up a plan to tackle only two changes at a time with a firm dateline for completion.

The reason for only two changes at a time is that too many changes will overwhelm the staff. Remember, they are employees, not business owners so they do think differently. The reason for a firm dateline for completion is to keep you focused on the task at hand instead of using the words “I’m

going to do this or going to do that without a firm timeline.” The thick forest and noise of the industry starts to distract you and before you know it, another year has gone by without the changes really required being implemented.

Working on two important tasks will help to keep you focused on the detailed required for implementation. Go for it.

Now the rewards for your discipline to implement the changes required are very measureable. Consider that any important change within a shop business will likely reflect with an increase in total billed hours. The shop is becoming more efficient and professional. Measure daily, weekly and monthly your average billed hours per RO. This measurement is where the meat is when increasing the net income of your business. Billed hours are your life in the vehicle service business. Walk, talk, breath and dream billed hours and watch what happens to the profitability of your business.

Times have changed and so must management routines. One item that should also be on your immediate list is looking forward into the balance of the 2015 year to determine what technical and management training still is required within your shop.

Too many shops today have a tough time looking and planning ahead. They are not implementing what they are learning. They’re reactive instead of being proactive. When a shop “vision” is in the process of being executed, development of the “team” is also mandatory, so on-going training must be evaluated properly each year.

This is a proactive approach. Competent technicians now require 100 hours of training per year to stay level in their knowledge. Management requires six to eight days per year now. Times have changed and so must your processes as to how you look at and plan your business as well as training within your shop.

Now is the time to take inventory of your team’s competencies as well as management competencies and seek out the required additional training and development to ensure 2015 is a positive development year

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for your business that builds on to the last three years. Be prepared to travel — not all training will be in your back yard, so proper budgeting is also part of this process.

Don’t procrastinate on this topic, because the amount of change coming in the next three years will be more than the past five years, which, when one is not prepared for, creates tremendous stress personally and financially; stress that can definitely be controlled with the right planning.

Finally, discipline yourself to take a minimum of two hours a day to spend in your office totally undisturbed to allow you to think with clarity as to how you will approach the tasks required and how you will measure the results. This truly is working on your business, and now you are implementing what you have learned.

BOB GREENWOOD
CONTRIBUTOR

Bob Greenwood, AAM, is president and CEO of Automotive Aftermarket E-Learning Centre Ltd. (AAEC), a company focused on providing business management resources and development for the independent sector of the automotive aftermarket industry utilizing the Internet environment. Bob has more than 36 years of business management experience within the independent aftermarket industry, consulting independent retail shops on all facets of their business operations. Bob is one of 150 worldwide AAM approved instructors.

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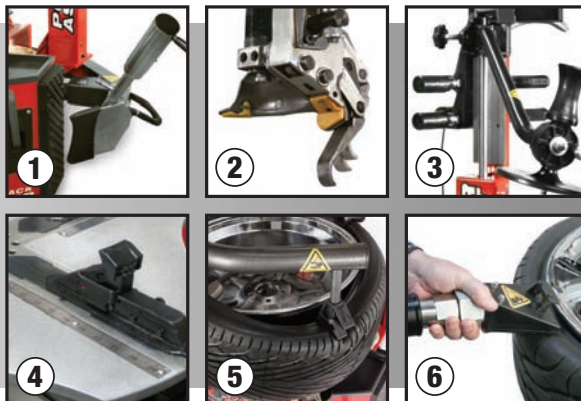


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SHINING A LIGHT ON SOCIAL MEDIA

ARE YOU IN THE DARK WHEN IT COMES TO OPTIMIZING YOUR ONLINE PRESENCE?

BY MICHELLE BIZON | CONTRIBUTOR

LET'S say you've been delaying attending to your online presence. It's uncharted territory for you, so it's natural to be weary and even doubt whether you'll be successful there. Still, with a larger and larger percentage of your customer base being glued to mobile devices, you know you can't afford to not be active online. So, what do you do when learning to navigate the social media landscape feels like a full-time job?

Sure, it's tempting to hop on the bandwagon of the newest flashy trend, but putting all of your proverbial eggs in one basket can hurt your bottom line over the long haul. With so much competition, that's not a risk you can afford.

The platforms might ebb and flow in popularity, but you'll notice your activity here will revolve around two main functions: publishing content and managing your reputation.

Content Sites

Gone are the days when just having a Facebook page would put you ahead of your competition. Quality is now the name of the game, and it's a do-or-die struggle. Remember, you're not just competing with the repair shop around the corner. Your messaging is up against posts from your customers' family members and friends, as well as from businesses of all sizes in other industries.

Social media is about your audience. Content sites, especially Facebook, tailor home feeds in response to user behavior, so you need to cater to their preferences. Essentially, you're playing in someone else's sandbox. So, what's a business owner to post?



Your foundational content should be entertaining or educational — or, better yet, both. Create and curate content your customers would thank you for. Then, get fans talking by asking questions and running contests with valuable prizes up for grabs. Keep the selling to a minimum.

With organic reach growing more dif-

ficult to earn, you also might want to consider investing in social ads, particularly on Facebook. You'll increasingly need to pay to play in the social media world, but that investment also gives you options. By allotting some of your budget to ads, you can target your ideal customers where they're already hanging out online.

The Other Players

Beyond the behemoth that is Facebook, you'll also want to take a look at Twitter, Google+ and, perhaps, Instagram. As you expand your social presence, keep in mind that it's better to do a few things well than a hundred things poorly. Take the time to get to know the platforms you're adopting, so you can follow each one's best practices to engage with your audience sincerely and successfully.

Twitter lends itself to casual conversation, customer service and news distribution. It's not about what you ate for lunch (unless you're really dying to share how much you enjoyed that tuna salad). If you're always on the lookout for the latest trend or hot topic, you'll find yourself in good company on Twitter. By networking here, you can position yourself as an industry expert and connect with your customers online in real time. As you acclimate, you'll find your sweet spot for posting frequency, but you'll want to Tweet more than you post on any other network to remain in your followers' constantly refreshing feeds.

Google+ is growing in importance to automotive repair shops, in particular, for localized search engine exposure. By posting content to your Google+ site (and taking care of reviews properly, as we'll discuss later on), you're building a robust history for yourself online to show Google you're a trusted source and an active member of its community. Especially if you don't have an active blog or intense SEO initiatives, Google+ is a must-have. You'll find your posts might not receive as much interaction as on other networks, but your ultimate goal here to create a body of high-quality, searchable content for Google to crawl.

With about 300 million users, Instagram is an up-and-comer to keep an eye on. Instagram is all about sharing real-time moments and has, perhaps, the most simple engagement options: Hit the heart icon to "like" and the speech bubble icon to comment on the photo or video. Worried about your sub-par photography skills? Instagram offers filters and editing tools to help you make your photos stand out. Auto shops still are learning how to define their success here using business metrics, so, if forced to choose, prioritize other networks with a stronger tie to your bottom line.

Reputation Management Sites

Customers see Google+, Yelp and other review sites as a direct customer service line to you. You wouldn't ignore feedback delivered in person or over the phone, and you no longer have the luxury of doing so online. Extend the personal touch you're dedicated to in-store to your online reputation sites.

The first step is to claim your business pages. You'll want to claim your Google+ and Yelp listings, as well as any other sites that are popular in your particular region. (Not sure which sites these are? Do a Google search for your business and take note of what shows up on the first page of results.) Most of these sites verify your ownership via an automated phone call to your main business line, so you'll want to be at your shop to streamline this process.


Once you claim your listings, update your business information. At best, they'll likely be incomplete. The more complete your listings are, the more likely you are to show up in search, both internally and via search engines. A prospective customer might be looking for

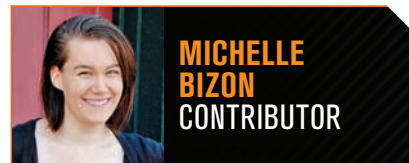
a shop that offers a shuttle service, so, if you neglect to include it in your profile, they might never find you.

At worst, your listing could be disseminating incorrect information about your business. (Never assume that the vetting processes for user-submitted information are thorough.) Many prospective customers look to these sites to find your hours, and arriving to a locked door on a Sunday morning when your Yelp listing says you're open will put an end to that customer relationship before it can begin.

Be sure to subscribe to email notifications for reviews. (Check the "Account Settings" section of your account to subscribe to them.) Take the time to post thoughtful, individualized responses to all reviews you receive. By responding to positive reviews, you strengthen customer loyalty and show your appreciation for them putting in the time and effort to help your business. By responding to questions and concerns in negative reviews, you have the opportunity to salvage the relationship and assure the prospective customers who are researching you that they'll be treated well at your shop. If you find yourself with a major snafu on your hands, take the conversation offline as soon as possible and communicate with the reviewer privately.

Measuring Success

The bottom line is that your social media presence is an investment in your business — just like your other marketing and advertising initiatives. Treat it as such. It quickly can become just an expense if you don't set clear, measurable goals. Set aside time each month to review your progress and tweak your strategy to help you reach your milestones. 



**MICHELLE
BIZON**
CONTRIBUTOR


Michelle Bizon is the Social Media Manager at Moving Targets. Her team helps hundreds of businesses engage their community, protect their online reputation and define their competitive advantage. Moving Targets is a print and digital marketing firm with more than 20 years of automotive industry experience. They help businesses build trust through campaigns that seamlessly blend print and digital messaging to reach customers at home, at work and on the go.

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OPERATIONS

SHOP PROFILE

A snapshot of one of the industry's leading shops

BRADHAM AUTOMOTIVE / ALEXANDRIA, VA.



Rebranded Bradham

A second-generation owner added a logo and so much more to his family's shop.

BY **ROBERT BRAVENDER** | CONTRIBUTOR

John Crowder has a tendency to dive into things; he certainly took the bull by the horns upon entering the auto repair industry. One caveat — he had a background in that in 1970 his father bought out Bradham Automotive, and Crowder was raised around this institution of Alexandria, Va.

"Our shop has been around for a long time," he notes. "We were known as the place where if no one else could fix it, you brought it to Bradham."

But by college Crowder wasn't sure what he wanted to do with his life, until Dad suggested giving the shop a try. Despite majoring in business administration, he started learning the trade from the ground up as a technician.

"My intention when I came onboard was to look into the future," Crowder explains. "I really needed to know this industry, because if I was going to do it, it would be at 100 percent."

That look quickly clarified to him that things had to change; what worked well in the 1970s and '80s no longer made them competitive.

"I ran it for a little bit just using what I'd learned from my dad," says Crowder. "But I knew I needed help, and I wasn't afraid to ask for it. So three years ago we

signed up with ATI (Automotive Training Institute)."

True to form, Crowder began absorbing everything ATI had to offer. "I didn't have any excuses as to why something (ATI recommended) wouldn't work," he reports, "I just implemented it. It made sense to me, and we saw immediate results."

At the end of those three years, Bradham Automotive is approaching triple the revenue it had at the start. "It's about building your business the correct way, making sure you're hiring the right people that fit the model you want, developing the business culture so it all becomes self-sustaining," he says.

Soon Crowder began rebuilding and rebranding Bradham inside and out, beginning with the actual brand.

"I had a friend design a logo for us; how does a place that's been in business this long not have one?" he laughs. "We

BRADHAM AUTOMOTIVE

George, Shirley & John Crowder

Owners

Alexandria, Va.

Location

1

Number of locations

67

Years in business

7 / 4

Total number of employees/techs

3,000 square feet

Shop size

9

Number of bays

\$1.4 million

Annual gross revenue combined

ASA, BBB, AAA, ATI

Shop affiliations

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needed an identity, so we came up with a vintage look. Now we make sure that all of our branding is consistent, universal. Every sign looks the same, every card looks the same, every piece of material that comes out of here all looks the same.

He approached the Internet with the same resolve. "One thing that I think is extremely important — and there are still quite a few shops that aren't em-

Photos: Bradham Automotive



A mural is dominant decoration in the bays at Bradham Automotive.



From left, service writer Erik Gunther, owner John Crowder, general manager Josh Sadr.

bracing it — web marketing and social media,” says Crowder. “ATI has a whole marketing class for it: Google, Google+, Facebook, shooting videos for YouTube, things like that. It’s extremely important nowadays for shop owners to do these kinds of things. That’s what is driving the market, that’s what people are looking for: reviews, content. They’re gauging you off of what they see, and they’ve made up their mind before they even call.”

As profits began to increase, Crowder immediately reinvested it back into the business.

“We looked at it logically,” he explains. “What’s the most important thing to do right now and what can we afford? What are we saying to customers as they come in the door? I didn’t like our message; we completely gutted the waiting room area. After that we started working our way toward the back.” That work extended to the staff as well.



ROBERT BRAVENDER
CONTRIBUTOR

Robert Bravender graduated from the University of Memphis with a bachelor’s degree in film and video production. He has edited magazines and produced shows for numerous channels, including “Motorhead Garage” with longtime how-to guys Sam Memmolo and Dave Bowman.

Email Robert at rbravender@comcast.net

“Fixing the car is expected; that’s the business we’re in,” Crowder points out. “So every week we go over a core value, and this week it’s on the fact that we’re in the customer service business. How can we make it more convenient for them--do we offer solutions? How do we treat them when they come in; what’s available to them here?”

Crowder has been finalizing his team for that vision of the future. “We took some things rapidly,” he admits, “but other things slow. For employees, we

weren’t looking for warm bodies, we were looking for the right person for the position. We just hired a new service writer, picked because he’s not from the automotive industry. And we have another technician coming onboard. Right now we’re focusing on that and a succession plan. I’m going to take a step back and have my general manager, Josh, take over. He and I basically have a conversation once a week to see where things are at and letting him run with it.”

Run, perhaps even dive? **ZZ**

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2-4 BRAKE ISSUE

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Bullet-point Issues in Your Shop Today

HAVE CERTAIN TRANSMISSIONS GIVEN YOU TROUBLE? CHECK THIS LIST TO SEE IF WE ADDRESS IT IN A LISTING OF CURRENT PROBLEMS WE'RE SEEING.

BY **WAYNE COLONNA** | POWERTRAIN PRO PUBLISHER

THERE is a lot of ground to cover this month, so let's jump in right away with a series of bullet points for a variety of transmissions. Chances are good that some issues I address this month will appear in your bays in the coming year, if they haven't already.

- Many 2014 and earlier GM vehicles might exhibit a slight rocking motion forward or backward while in Park at start up after cold soak. A clunking noise might be heard as well. GM notes

that this slight movement more often is seen visually, rather than felt, when viewed from the outside and using the auto-start feature, if equipped. This slight movement is due to the residual transmission fluid in the clutch packs that creates a partial apply on start up. The parking pawl and/or transmission fluid exhausting completely from the clutch packs stops this movement. This condition is normal and no repairs should be attempted. This can be verified by comparing with another identi-

cally built vehicle under the same cold conditions.

- GM vehicles using the 4L60-E series transmission might exhibit a 2-3 upshift or 3-2 downshift clunking noise. This is a synchronous shift transition between the application and release of the 2-4 band and the 3-4 clutch assembly. GM stipulates that the timing of this shift can cause a momentary torque reversal of the output shaft that results in a clunking noise. This same torque reversal also can occur on a 3-2 downshift when the 3-4 clutch is released and the 2-4 band applied. This condition might be more pronounced on 4-wheel drive vehicles because of the additional tolerances in the transfer case. This is a normal condition; no repairs should be attempted.

- A variety of GM vehicles (as early as 2006 to as late as 2015) might have owners commenting on a hesitation problem when they accelerate the vehicle from a rolling stop.

GM describes the event as starting when a driver coasts at low speeds of less than 15 mph with a closed throttle and then aggressively applies the throttle. Examples of this maneuver include a rolling stop or a lane change maneuver. In this type of maneuver, even though the accelerator is applied aggressively, the throttle blade is opened slowly for up to 0.7 second to help minimize driveline lash and clunking.



Figure 1



WAYNE COLONNA

is President of the Automatic Transmission Service Group (ATSG) in Cutler Bay, Fla., and a frequent speaker/instructor for transmission training around the globe.

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Also in a vehicle equipped with a 6 speed automatic transmission when making a hard, complete stop with a closed throttle immediately followed by an aggressive throttle opening, the transmission down-shifts might not be completed by the time the throttle is opened. As a result, approximately 0.5 second of zero torque might be commanded to allow the shift to first gear to occur.

Both of the above conditions are a result of torque management, and both of these conditions should be considered normal. No repairs should be attempted.

▪ Customers who own vehicles with the 6L and 6T series transmissions might comment on an illuminated Malfunctioning Indicator Light (MIL). Technicians might find Transmission Control Module (TCM) related codes P0601, P0603, P0604, P062F or P1621 stored in the TCM as an active code or as history codes.

GM states that some of these DTCs also can be set in the Engine Control Module (ECM) or Fuel Pump Control Module (FPCM). Make sure that you

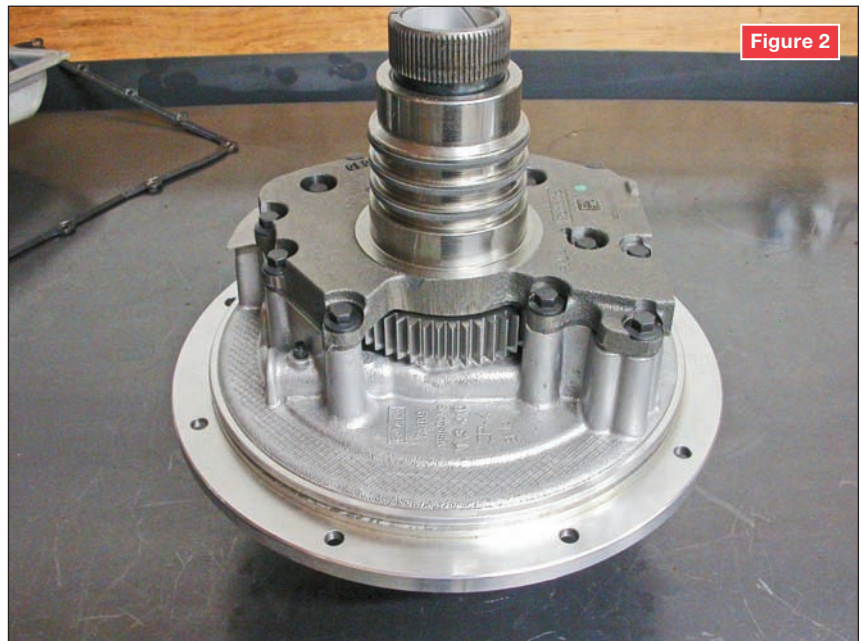


Figure 2

know which module set the DTC before attempting to diagnose and repair this condition. If the DTC is set in a module other than the TCM, those codes will require the appro-

appropriate diagnostics. In other words, if these codes are stored in the ECM or the FPCM, the codes are related to the module that is storing them.

If these codes are store in the TCM

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only, diagnostics for these DTCs instructs the technician to reprogram the TCM and then recheck to see if the DTC(s) have cleared. The Tech 2 can be used for most programming but certain 2010 thru 2015 models will require the use of Global Diagnostic System 2 (GLDS2) to accomplish the task.

- 2012 Buick LaCrosse and Regal equipped with the 6T40 transmission exhibits a coast downshift bump or jerking sensation from 40 to 30 mph. GM says that this condition is a normal operating characteristic of their vehicle. It will not impact the designed performance or reliability of the vehicle.

- Vehicles equipped with the 6T30/40/45 transmission might develop a TCM communication code U0101. The TCM is mounted on the internal valve and solenoid body assembly referred to as the Transmission Electro Hydraulic Control Module (TEHCM). This condition usually indicates a problem with the internal TEHCM assembly, specifically the TCM itself. According to GM, investigations made with several vehicles setting the U0101 code have shown that this condition is caused frequently by issues in areas other than the TEHCM assembly. Due to the elements of weather, temperature extremes and vibration, it is suggested to first inspect the TEHCM connector pins for damage or poor fitting terminals with the external harness connector.

Another area to look at is the underhood fuse block for damaged terminals or poor fitting terminals as well. Look for mispositioned fuses in fuse block. There have been issues related to the integrity of the TCM ground circuits G106 and G107.

- Ford and GM might experience noise that sounds like an engine or transmission knock or a hard rattling sound (6T70/6F50). The noise can be heard in Neutral and in gear, but not in Park. Some have been misled to inspecting the crankshaft to determine the source of the noise. A loose fitting park gear on the spline of the pinion drive gear shaft causes the noise. This loose fitment on the spline is because of the clearance between differential pinion bearing and the park gear. To resolve the concern, install special shims between the bearing and Park gear. Superior Transmission Parts provides a kit to service these repairs, part No. ST1005.

- Ford Fiesta (2011-2014) and Ford Focus (2012-2014) might display a Transmission Overheating Stop Safely message in the Base Message Center. Codes related to the Transmission Range Sensor, TCM Power Input and Communication Error Codes between the PCM and the RFA Module (Remote Function Actuator/Keyless Vehicle Module) will accompany the condition. Ford states that these codes might cause the overheat message to be displayed without the transmission overheating. It is suggested by Ford to diagnose the codes set prior to diagnosing the overheat message.

Codes that may be stored are TRS Related Codes P0706, P0707, P0708, P2801, P2802, P2805. TCM Power Related Codes: P0702 and P0882. Communication Codes: U0100 and U0294.

- Some 2008-2010 F-Super Duty 250/350 vehicles with single rear wheels and F-350 dual rear wheels might exhibit an excessive drive-away shudder or vibration under moderate to heavy acceleration from a stop, especially when heavily loaded. This might be due to driveline angle. The shudder or vibration might be more evident while towing a trailer or if vehicle is overloaded. Refer to Ford's TSB 09-20-5 for detailed angle measuring procedures followed by correctional shim adjustments to eliminate the vibration.

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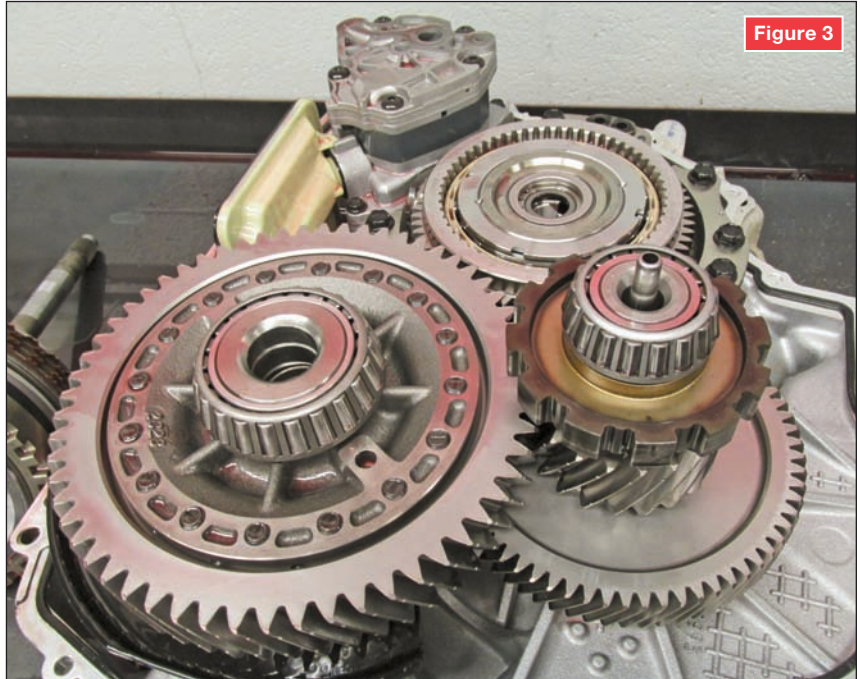
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▪ A number of 2013 F-Super Duty vehicles using the 6R140 transmissions equipped with a Power Take Off assembly (PTO) might exhibit a rattling or chattering type noise when not in operation but dissipates with increased engine speed. This is normal; no action is required. The engine's firing pulse is being transmitted through the PTO assembly. The noise will vary between the various driveline and chassis packages as well as the different PTO manufacturers being used.

Various 6R80 transmissions between vehicle build dates May 23, 2012, to June 3, 2013, in Ford F-150 3.5L 4X4s might develop a transmission leak requiring the case to be replaced. Fluid might be seen coming out of the case in the bell housing ribs at the 4 and 6 o'clock positions.

▪ The 2009 to 2010 Escape or Mariner as well as a 2010 Fusion or Milan might have a complaint of fifth gear only and stored diagnostic trouble codes P072F – Stuck In Fourth Gear, P073A – Stuck In Fifth Gear, P073B – Stuck In Sixth Gear, P07A8 – Transmission Friction Element



D Stuck Off, P07A9 – Transmission Friction Element D Stuck On, P07AA – Transmission Friction Element E Stuck Off, P0731 - Gear Ratio Error In

First Gear or P0732 – Gear Ratio Error In Second Gear after using the Grade Assist feature on a steep downgrade. The Malfunction Indicator Lamp will be

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illuminated. This is a Powertrain Control Module Software Malfunction which can be remedied by reprogram the PCM to the latest calibration.

Pressing the Transmission Control Switch on the side of the gearshift lever activates Grade Assist and cancels Overdrive. This provides additional engine braking and extends lower gear operation on uphill climbs for hilly terrain or mountainous areas. It provides additional engine braking through the automatic shift strategy that reacts to vehicle inputs such as acceleration, accelerator pedal, brake pedal and vehicle speed. It allows the transmission to select gears that will provide the desired engine braking based on the vehicle inputs mentioned above. This will increase engine rpm during engine braking.

Next, the Grade Assist lamp in the instrument cluster will be illuminated. Grade Assist is designed to aid the driver with optimal gear selection in hilly terrain or mountainous areas, but is not intended for normal operation. It is recommended to return to overdrive operation on flat surfaces for optimum



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To return to overdrive operation, press the transmission control switch once after which the Grade Assist lamp in the instrument cluster will turn OFF and the transmission will operate in gears one through six. Overdrive opera-

tion is automatically returned each time the engine is turned off and restarted.

The 2012-2013 Dodge Ram 4.7L or 5.7L engine vehicles equipped with automatic transmissions might experience a whine, howl and/or humming noise at speeds below 30 mph (48 kph) with engine speeds between 1,200 to 1,500 rpms. The noise emanates from the transmission cooling lines going to the transmission cooler. Dodge provides a foam sleeve kit (part No. 68217310AA) to be installed on each line reducing the noise considerably.

Also, 5.7L Jeep vehicles (09-12 Grand Cherokee (WK), 09-10 Commander (XK) and 11-12 Durango (WD)) might develop the an erratic or inconsistent initial 2-3 upshift (3-4 upshift on 2012 MY vehicles) and/or sluggish performance during low speed/rolling stop maneuvers (2012 MY vehicles only). There is a Transmission Enhancement programming fix for this concern part No. 0427506AB, which also includes enhanced torque converter lock-up schedule to reduce transmission operating temperatures for 2009 model year vehicles only. *WZ*

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DEALING WITH DURAMAX

With the growth of light duty diesels, every tech needs to develop their diesel diagnostic skills.

A PRIMER FOR THE DIAGNOSIS AND REPAIR OF GM DIESELS.

BY DAVE HOBBS | CONTRIBUTING EDITOR

As a trainer, I sometimes pose the question, “Who here feels comfortable diagnosing late model diesel engines such as the GM Duramax?” I’m surprised at how many techs specializing in diesels don’t hold up their hands confidently. It almost always turns out that the techs know a lot more than they realize.

Duramax Beginnings

When the 6600 Duramax came on the scene in 2001, the world changed for both gas and diesel techs. Diesel techs now found themselves up to their necks in the world of OBDII computerized engine management systems along with the common rail system. Starting out as the Regular Production Option (RPO), LB7 the engine had 300 hp and 520 foot-pounds of torque. The extra power resulted in GM coupling the engine to a new 5-speed 1000 series automatic transmission from Allison.

The engine has seen some fairly radical changes in its 6600 format. From the LB7 in 2001-2004 came the 2004-2005 LLY replacement that advertised more

power and 90 percent fewer HC and NO_x emissions. Injector fuel feed lines were exposed, and it featured a new Garret variable displacement turbo, an electronic linear EGR valve with cooler and a host of other technical details such as new fast light off glow plugs and a new closed PCV system. The 2007-2011 LMM engines included an oxidizing catalyst and diesel particulate filter (DPF) to reduce soot and particulate matter.

An electronically controlled throttle aids in EGR operation and the DPF regeneration process. The 2011 to present LML engines use 29,000 psi piezo injectors with a complete fuel system-hardening to handle up to 20 percent biodiesel mixtures and urea injection. Urea helps with NO_x reduction, so trucks were equipped with a 5.3 gallon urea tank.

Technical Foundations

The Duramax is a 6.6 liter, 90-degree V8, direct-injection, overhead valve, four-valve-per-cylinder turbocharged engine with aluminum heads and a cast iron block. The electrically controlled common rail fuel system allows for full control of

fuel injection timing and quantity. Just the right piston dome design coupled with a technique of starting just a little bit of injection first before shooting the full dose of fuel is the combination credited for the smooth and quiet idle factor.

The engine is not exactly a stealth model, however. One GM Preliminary Information (PI) bulletin regarding Duramax engine noise is one of those, “It’s not broken, so don’t try to fix it” bulletins. The PI basically reads that if your customer concern is a fuel knock type noise heard either at 2,500 to 2,600 rpm or when the vehicle is accelerated with a throttle angle above 80 percent, there is nothing wrong, so no repairs should be attempted.

Because diesels time their combustion events with fuel spray (as opposed to ignition timing on gas engines) you will see the “main injection event” following the pilot injection used at idle. As a general statement, it is important to note that not only will you see at least one pilot injection event prior to the main injection, you also might see an early post injection (for added

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torque) and even a late post injection on Selective Catalyst Reduction (SCR) equipped vehicles to aid in regeneration of the particulate filter.

Lowdown on Low Pressure

Duramax begins the high-pressure process with fuel from the tank the old fashioned way – suction from a pump up at the engine. In the gear-driven, high-pressure pump that creates the pressure for the common rail is a section of the pump that pulls fuel from the tank. If there is a problem getting that fuel, you'll have low fuel pressure from the high-pressure pump and hard starts/no starts often will be the result. You can install a diesel low pressure/vacuum gage to determine which type of problem you have.

KD makes a gauge that has quick disconnect fittings to make testing easier. If air is being pulled into the low pressure side of the fuel supply system, you'll see insufficient vacuum. If you see excessive vacuum, you have a restriction. Possible points for air are the lines from the tank to the Fuel Injection Control Module (FICM) fuel filter, water separator assembly and

the pump itself. The place for possible restriction most likely is the filter.

The filter/water separator features a hand pump and bleeder screw to assist with priming the system and purging air for restarts in the event your customer runs out of fuel. Air getting in the system can cause misfires, stalling and hesitations on any common rail diesel engine.

- Cranking Speed Vacuum – 1 - 5 in. Hg
- Idle Speed Vacuum – 1 - 3 in. Hg
- Hard Acceleration – 6 - 10 in. Hg
- 3,000 rpms No Load – 3 - 5 in. Hg

Really High Pressure

The same engine gear-driven pump that pulled fuel up from the tank next pressurizes the fuel to the common rail at pressures required for direct injection. Unlike earlier non-common rail diesels, this pump is not timed to the engine. The Duramax engine's higher fuel pressure leads to a valuable point of caution.

The fuel supply systems in diesel engines with common rail technology, including GM Duramax engines, can range from operating pressures of 5,000 psi at idle to as high as 29,000

psi under off idle conditions. For this reason, extreme caution must be used when working on or near the fuel system. Safety glasses must be worn when working around the high-pressure system. Never crack open a high-pressure line when the engine is running or check for underhood fuel leaks using your hands, because personal injury might result. The pressure from just the right type of leak source could spray high-pressure diesel fuel in the same manner as a cutting tip on a pressure washer. Lacerations to hands and fingers and subsequent blood poisoning can be the result of a mishap involving a high-pressure diesel injection system. In addition to this hazard, the fuel injectors operate at as high as 93 VDC, well within the range of some hybrid electric vehicle voltages we've been taught to handle with caution. Refer to OE service information whenever servicing engine.


All the Duramax variations use a fuel return system between each injector, the high-pressure pump and the fuel tank. Early LB7 models were known for injector problem, and GM had to release

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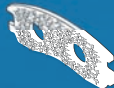




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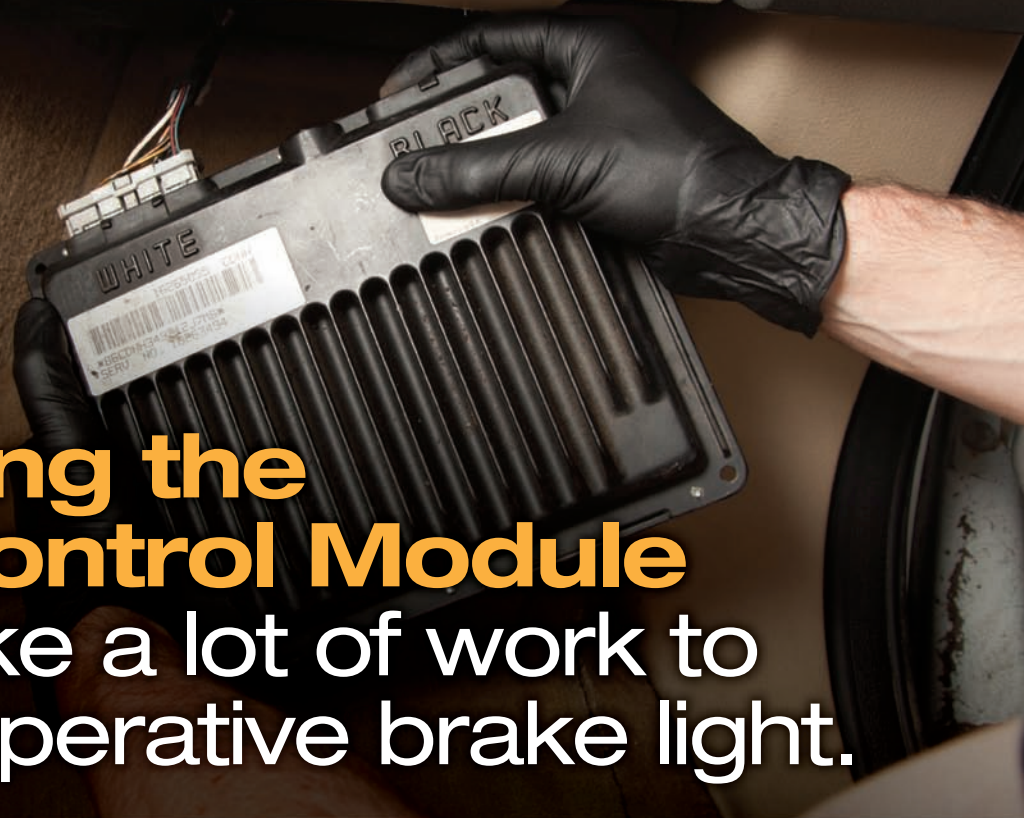


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a special policy No. 04039B extending free replacement out to seven years and 200,000 miles. Fuel injector body cracks, ball seat erosion and high pressure seal extrusion were experienced with these trucks. Hard starts, no starts, DTCs, fuel smells and diluted crankcases were the common complaints because of too great of return volume at the injectors or internal leakage at the injectors.

The FICM

Duramax injectors receive their 90-plus volts of DC courtesy of the FICM on earlier models and directly from the ECM on 2007 and up. The FICM (or ECM) captures the first event of an injector coil's inductive kick back when the injector has 12 volts applied. The kick back voltage from the injector coil collapsing its magnetic field is used to charge capacitors in the FICM. Higher voltages stored in the FICM can be applied back to the injectors to accomplish the injection.

If an injector experiences an open or short circuit internally or within the wiring harness, the ECM shuts down an entire group of injectors that are related. When that happens, the FICM raises the injection volume for the other group of injectors to keep the engine running. Injector group pairings are the inner cylinders on one bank and the outer cylinders on the opposite bank. Injector electrical DTCs along with this grouping strategy means you are doubly sure that four cylinders on the same injector group circuit not firing means injector solenoid winding or injector wiring issues.

Injector Balancing Rates

The Duramax has misfire detection within the ECM via CKP and CMP inputs at idle. You can view on your scan tool the basic misfire counts or view injector balancing rates. The ECM detects if a cylinder needs more or less fuel to be balanced with the other injectors to provide smooth power contribution. Your target is zero, and that's what you'll see on a new set of injectors installed in a mechanically sound engine.

After the injectors have been in that engine a while, those numbers will vary. If an injector exceeds specs, there is a problem. View balancing rates for each injector with the engine idling above 180°F for at least 30 seconds. Maximum specs are ± 4 in park and ± 6 in drive. One other important thing to remember

is that misfire diagnostics may be suspended when the fuel level is very low.

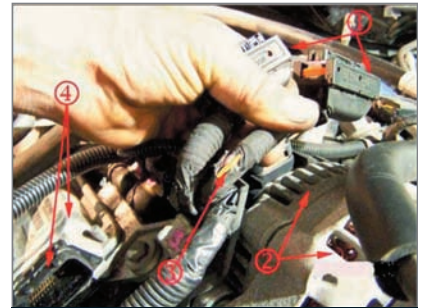
The high-pressure pump houses an important player called the Fuel Rail Pressure Regulator (FRPR), which normally is open, meaning it allows full pressure from the pump to the rail. The FRPR opens and closes on the ECM's commanded duty cycle. Unplugging the regulator allows for full high-pressure to the rail, and is an effective way to determine if a starting/drivability issue is due to low pressure.

Running maximum pressure is 23,000 psi for the earlier Duramax models, then 26,000 psi for the 2006 model years forward to 2010.5 and 29,000 psi going forward after that. Any common rail diesel should lope and run rich at idle when the regulator is unplugged due to an overly high pressures/rich mixture if the engine is not starving for fuel. When checking for leaky injectors, you can disconnect the FICM and the rail pressure regulator to run the high pressure to the closed injectors while cranking the engine to spot injector leakage. The FRPR often is a victim of water and contamination due to lack of fuel filter replacement/maintenance mentioned earlier.

A fuel rail pressure sensor measures the constantly fluctuating high pressure and is a scan tool PID giving you some very good information in your diagnostic routines. Another scan tool PID — desired fuel rail pressure — always should be very close to what the actual rail pressure reads via the rail pressure sensor, both during running and cranking conditions. A handy feature on most scan tools is live data plotting. Plotting Desired Fuel Pressure along with Actual Fuel Pressure is an excellent way of determining if a drivability problem is fuel related. If you have a no start/hard start complaint, always go to these two scan tool PIDs first.

HP Fuel Lines/Fittings

The "plumbing" of the high-pressure systems on any high-pressure common rail diesel including the Duramax is picky about torque. Do not skip the proper torque spec and procedure thinking you'll just get it as tight as possible without breaking fasteners or stripping threads. Before and after those "seat of the pants" torque methods are leaks from being just slightly too loose and damaged fittings from being just slight-



A TSB on 2001-2005 models states that there may be MIL illumination along with a significant reduction in engine power, as well as DTCs for problems with injector driver circuit DTCs P0201 - P0208 and/or Cylinder Bank Shut Down DTCs P2146 or P2149 all caused by some injector wires rubbing a spot through their insulation right on top of the alternator housing.



Depending on the model year, Delphi made the PCM to control the Isuzu engine, Bosch made the FICM to control the fuel injectors while Motorola made the controller for the Allison transmission. If you run into a P0700 TCM failure and can't find the Freeze Frame, experience your scan tool locking up when you are reviewing monitor status or a host of other crazy scan tool related issues, GM TSB 02-06-04-002 addresses them. A re-flash of the PCM fixes it.

ly too tight. Also, for safety's sake do not try to snug a fitting while the engine is running.

Piezo Injectors

The 2010.5 model Duramax engines began using this new style of injector that uses several hundred piezo wafers (stacked) that expand in an applied electric field. The ECM grounds the control circuit and supplies up to 250 volts at 20 amps, creating the movement in the piezoelectric actuator module. In less than 1 microsecond, the actuator module acts directly on the amplifier module through a hydraulic connection, which in turn controls the valve group inside the injector. This gives more injection control than ever before.

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valve and EGR cooler issues. Soot is an age-old problem with diesels causing carbon buildup throughout the induction and exhaust systems. Without a throttle body) and all things equal, a diesel is a better breather than a gas engine.

All things equal starts to change when the intake and exhaust passages are not flowing like they once were. Crankcase vapors do contribute to this problem in addition to EGR. Blending exhaust gas back into the intake for the purpose of quenching combustion temperatures (courtesy the inert nature of exhaust) makes sense for a limiting NO_x emissions, but can exasperate the issue of soot and carbon buildup. The turbocharger also can be a victim of carbon and soot deposits causing vanes to stick.

Fortunately on Duramax engines there is pair of scan tool PIDs to compare desired and actual turbo vane positions so you can diagnose sticking turbo vanes. Regarding EGR carbon plugging, information and misinformation abounds on the Internet from Duramax owners and aftermarket suppliers regarding various forms of EGR delete kits. Some are blocking plates, some bypass and shut off the ECM software and some owners report success while others experience problems. One thing is certain, they are advertised as "Off Road Use Only."

Getting Glow Plugs Right

Glow plugs on the Duramax, or any other diesel for that matter, draw a lot of current making good electrical connections essential. On the 2006 models, dealers performed recall to reprogram the soft-

ware in Glow Plug Control Modules (GPCM) that were over working the glow plugs to death. A diagnostic tip TSB on the same model year Duramax simply states if any of the glow plugs are above 1 ohm to replace them all.


There are two different failure modes of a glow plug: fast and slow. Fast failures involve an open circuit internal to the glow plug and no visible evidence of a problem. Slow failures involve an obvious missing or damaged tip of the plug along with an open circuit. Obviously, the head is going to have to come off if you've spotted a missing tip, because it went somewhere into the cylinder. Always check for issues with the alternator output connection, battery cable connections, bussed electrical center connections and, of course, grounds. They all need to be in tip-top condition.

There are other electrical problems that can create an electrical noise issue that also can damage glow plugs. The damaging electrical noise might be induced by jump starting, disconnecting the batteries with the ignition in the ON position, or a battery charger being used during a module reprogramming event. Finally, you must ensure you have the correct glow plugs for the truck's RPO code. Early LB7 models used a gold tipped glow plug while later models transitioned to a silver tipped glow plug that has a fast heat up characteristic to help with reduced emissions.

To meet 2001 California emissions, a solid-state glow plug controller operated by the ECM had dominion over heating each cylinder separately. During a typical glow plug cycle, 110 amps of current is applied for 1.8 seconds, dropping to the 30 amps needed to maintain a tip temperature of 1,832°F. Later model years using silver and earlier gold tipped glow plugs can't be interchanged. Popping in the older gold tips in a truck that requires the silver plugs will result in hard starting due to a lack of heat. Vice versa might result in glow plug failure and engine damage from glow plug shrapnel.

Hot Air and Calibration Updates

The Duramax 6600 uses a heating element in the intake manifold inlet for heating the air during cold starts. It supplements glow plugs, which all Duramax engines use. If your cus-



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tomers Duramax is equipped with a heater that doesn't work, cold starting and drivability issues are possible. The purpose of the heater is to reduce the amount of white smoke on startup and after long downhill decelerations.

Speaking of white smoke on startup, there are calibration updates available for the ECM that address a multitude of Duramax issues including the white smoke symptom. Due to the mid-year RPO changeovers, you could have more than one choice of Duramax engine in a GM truck. A telltale tip for which engine you have is sometimes the shape of the air cleaner. Round or square air cleaner choices are listed in the GM calibration tables.

For some unknown reason, many techs report this actually can have a reverse effect – causing white smoke that wasn't present before. Keep in mind in addition to a thorough search for TSBs, always Google "GM CAL ID" early on in your diagnostic path even if you don't personally do flashing at your shop. *ZZ*



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Dave Hobbs is a field trainer and training product developer for Delphi Product & Service Solutions. He holds ASE CMAT/L1 and EPA 609 certifications and is an experienced hybrid instructor. Dave has been featured as an instructor in more than 15 automotive training videos.

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EGR issues plague diesels and the Duramax is not exception. Later Duramax models transitioned to a linear electronic EGR valve to pass more stringent Nox emissions requirements.

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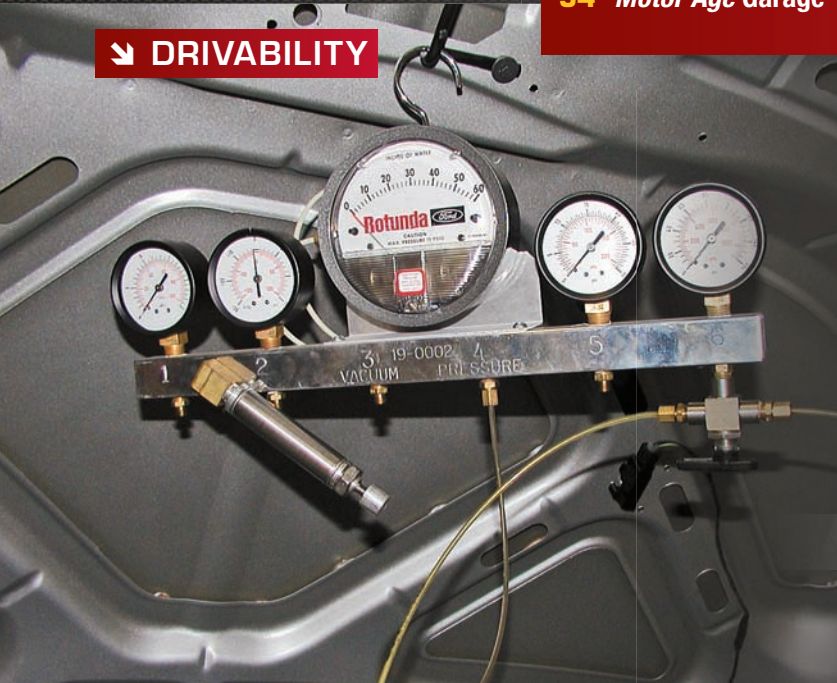
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WORKING ON POWERSTROKE DIESELS BY THE BOOK

The correct way to connect a fuel pressure gauge on a 7.3L is to check each head for fuel pressure and have one gauge with a T handle to switch between heads. The spec is 45psi minimum, and typical pressure is 60psi. If you see more than a 3psi difference in look for a leak.

DIAGNOSTIC FLOW CHARTS CAN BE THE RIGHT TOOL FOR THE JOB – IF USED PROPERLY!

BY MARK DEKOSTER | CONTRIBUTING EDITOR

In February 2014's *Motor Age* (also dedicated to diesels), I did an article on the analysis of hard start/no start concerns on the 7.3/6.0L PowerStroke engines. In that article, I only got through Step 1 of the 10-, 11- and 12-step procedure sheets that Ford required its technicians to fill out for trucks that were under warranty.

Ford also had a similar procedure sheet for these engines when they had performance concerns, and the technicians had to fill them in for warranty as well. These sheets worked well to find concerns in a timely manner. Experienced technicians sometimes could skip steps or jump to a certain step based on product knowledge and experience, but even they typically followed the procedure as each test step builds on the last. Jumping too far ahead might find the concern, but that is luck as opposed to skill.

The idea behind this system is that you keep going until you find the concern and fix it. Also, accessing Ford service information is important. Each one of the following test steps has detailed procedures and specifications in the service manual.

Step 1 – Visual Inspection

In the last article I did, this is all the farther I got, and you may wish to retrieve and review that article. Make sure the engine is mechanically sound — that the batteries, cables, starter and alternator are working correctly. If the vehicle is a true no start, then at least make sure the batteries and cables are good.

Step 2 – Check Oil

The 7.3/6.0 PowerStroke uses a HEUI (Hydraulic Electric Unit Injection) injection system. The injectors use engine oil to operate, and bad oil equals bad operation.

We all know that the wrong viscosity oil can cause cold weather cranking concerns, and that doesn't change just because you have a diesel. In fact, diesels are even more susceptible to this than gas engines. I've known many Ford diesel technicians who change oil as part of their analysis process. You might even need to consider having an oil analysis done.

Viscosity, contamination and level all are important. When I was with Ford, I took a 2002 Excursion with a 7.3L to an offsite training session. The vehicle developed an oil leak and lost two quarts before I knew it had a leak. I figured it out as the truck started doing a buck-jerk at low speed cruise and took longer to start. I checked the oil and found it was down just two quarts. That was enough to begin to cause concerns. The 6.0L has a different oiling system and is not as susceptible to low oil levels causing running concerns like

Photos: Mark DeKoster

the 7.3L, but still will have similar low/contaminated oil issues.

Recommended oil for both engines is 15W-40 above 32°F and 10W-30 below 32°F. Make sure that the oil also meets the Ford WSS specifications and API service classifications.

Step Three – Intake and Exhaust Restrictions

The 7.3 engines have an exhaust backpressure control on the turbo. This system is designed to close the exhaust outlet down to keep as much warm exhaust in the engine during warmup and extended idle during cold weather conditions. This is a flap that is opened and closed by the PCM directing oil pressure to one side of a piston. If this flap is stuck closed or if the flap has broken off the shaft so it opens and closes by itself, you will have an engine that can't breathe well enough to start easily. It will also have very poor performance.

The 6.0 engines have a variable rate turbo, and when it malfunctions the concern typically is performance related, but can also effect crank times. Most of these engines have filter minders on the air box, which is a way to check for intake restrictions.

Because of the age of these trucks you also might be dealing with a Charge Air Cooler concern. Any turbo system is susceptible to some oil seepage as well as blow by gases. This oil mist can condense out in the CAC and over time begin to plug off the passages. Poorly filtered air can allow dirt to enter and combine with any oil that may be in that cooler and cause blockage.

Step Four – Sufficient Clean Fuel

In step one you were asked about fuel and fuel quality. This step is a more formal look at the fuel that is in the truck. Is it actual diesel fuel? Is it road use rated? Is it a summer or winter blend? A "quick" test is when the truck won't start in cold weather, but once it warms up in your shop starts fine. This might be related to the glow plug system as well but summer fuel in the winter will want to gel. Is the customer playing with bio or waste something? When was the fuel filter replaced? Is there water in the fuel? Of course the real kicker: Is it out of fuel?



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Step Five on the 7.3L

Testing the fuel system on each engine is looking for the same things. It is the same in that we are looking for a specific pressure at the injectors (as close as we can get a gauge) and we back track through the system to find our concern.

For those of you who use a scope as a primary analysis tool, you might wish to do some quick tests on the electrical side of the system. Using a low amp probe, check to see if the pump is powered up by the PCM. What is the current draw and pump rpm? If these are suspicious, check for power and ground at the pump.

Tech Tip: These testing procedures might drain even good batteries. Make sure that you use a quality battery charger that can maintain at least 12.5 volts during testing and will never exceed 15 volts.

You should have confirmed that the batteries are good and if not replaced them back in step one. If you could not start the truck, you don't know whether the charging system works, but you will have confirmed the engine is mechanically sound so you can justify the new batteries.

On the 7.3L, you will check for fuel pressure at each cylinder head. Pressure should be within specifications and within 3 psi on each head. You will use a single gauge with a tee handle valve to switch between left and right heads.

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On the 6.0L you can check at the filter housing. If the pressure is low here you are asked to check pressure into the filter housing on each engine, then pressure at the pump outlet and finally on the suction side of the pump.

The 6.0L circulates fuel between the filter housing on the top of the engine and the Fuel Pump Module assembly located on the frame below the driver's seat. Ford will ask for a clear line to be spliced into this return to check to see if the system has air in it. If you have put a new filter in the truck, it might take the equivalent of driving for several miles to bleed the air out. If you have not touched the system, you might be pulling air into the system from somewhere.

Step 6 – 6.0L Fuel System Inlet Restriction

Running these tests also is where the extra step comes from in the procedure sheet on the 6.0L engine. On the 6.0L, the fuel pump suction test for tank inlet restrictions is step six, while on the 7.3L it is part of step five.

Next Steps

For this part, steps six, seven and eight are for the 7.3L KOEO continuous injector self-test and KOEO injector test. Also, steps seven, eight and nine are for the 6.0L KOEO continuous injector self-test and KOEO injector test.

The 7.3L has two modules that control the injection system, the PCM and the IDM. Communication with these modules is very limited with the IDM and more robust with the PCM. Because of this, checking for codes is done out of order from what we have done on Fords for many years.

You're probably in the habit of checking continuous first and clearing and then doing KOEO and KOER. On the 7.3L, if you do that, you will clear any IDM codes without ever seeing them.

IDM codes are read during KOEO but are cleared in continuous codes. So you do a KOEO (step five) and record all codes. Then without clearing the codes go right into checking Continuous Memory Codes (step six). Record those and now clear codes.

Run the KOEO Injector buzz test and see if any IDM codes appear. If they do, these are hard faults. If there were IDM codes before and none comes back, then they were memory codes. Repair and then clear codes before moving on.

The 6.0L has a FICM controlling the injectors and it is a more powerful module with bi-directional control with certain scan tools. The procedure for this engine is the same and repairs need to be done and codes cleared before moving on.

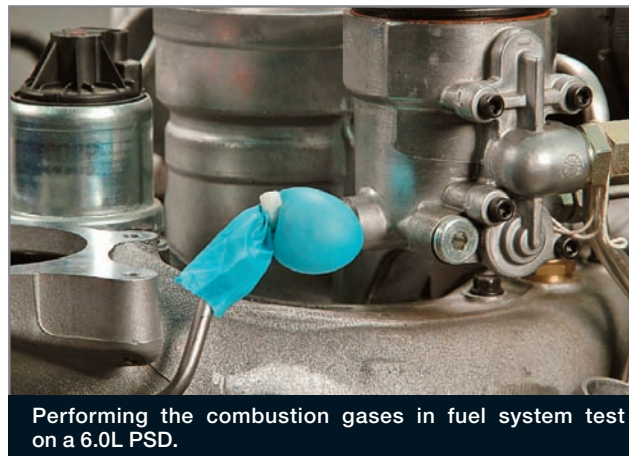
Step 9 (7.3L) and Step 10 (6.0L) – Scan Tool Checks

The 7.3L worksheet calls out four PIDs to monitor during cranking: VPWR, RPM, ICP and FUEL_PW. VPWR is the main power into the PCM you may wish to monitor this with a scope as well. The book calls for at least 8V during crank. I personally think the spec should be 9V minimum, as many modules are prone to shut down at 8V and definitely will as voltage drops lower than this. It is important to stress the need for good batteries again. At 7-plus volts, the engine might be cranking at a speed that sounds fast enough and might actually be fast enough if the system voltage was higher.

RPM checks to see if the crank sensor, but wait as there is only a cam sensor on the 7.3L engine. This test is to see if the PCM sees the cam sensor and that it is actually turning at a 100 rpm minimum cranking speed.

Injection Control Pressure (ICP) during normal operation means this PID will vary between 750 and 3500 psi. The default is 500, and if it never goes higher, then the PCM is not controlling injection pressure or there is a massive oil leak keeping pressure from being able to be built up.

Tech Tip: Monitor the IPR PID, Injection Pressure Regulator as well. This is the PCM command to the High Pressure Oil system. The default value is 14 percent, and if it does not change, then the ICP won't either. The maximum value you will see on this PID is 65 percent, which is



Performing the combustion gases in fuel system test on a 6.0L PSD.

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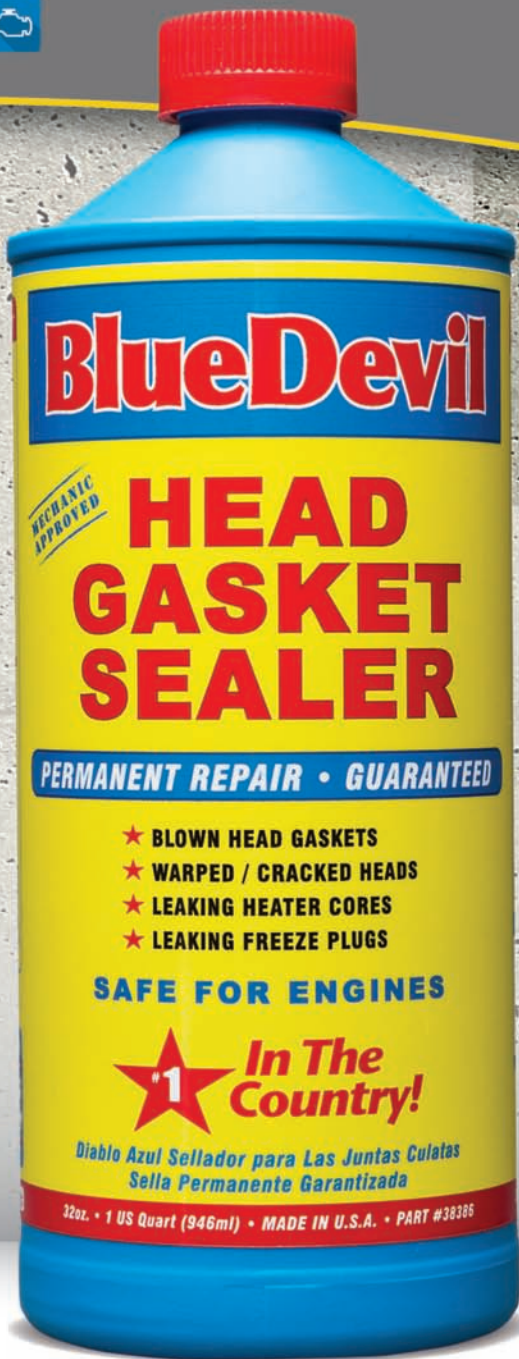
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This is an early model air cleaner on a 7.3L with the Filter Minder gauge.



This is a late model 7.3L with the glow pug module. It is the silver box with the light green and black connectors.

calling for maximum oil pressure. The PCM must see the rpm signal before it will control this system.

For FUEL_PW Fuel Pulse Width, injector on time, both of these engines use a variable pressure fixed pulse width fuel control. Therefore the on time will usually be approximately 3 milliseconds except during crank, acceleration and deceleration. The amount of fuel sprayed into the engine is controlled by varying the oil pressure to the injector. If the value does not change, then the PCM is not controlling the system.

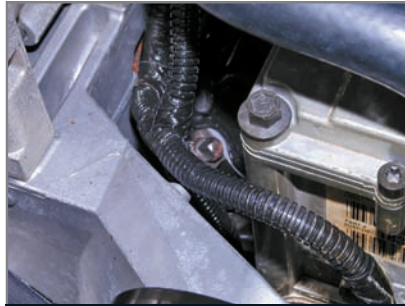
If the value is changing it is possible that the PCM is trying to control the system but the request is not received by the IDM due to wiring faults, corrosion or faulty box issues.

The 6.0L has additional PIDs to monitor during what is step 10 for this engine. They are B+, FICMPWR, FICMVPWR, FICMMPWR, RPM, ICP_DES, ICP, IPR, ICP, FUEL_PW and FICMSYNC.

B+, FICMPWR, FICMVPWR are checks to see that the modules are getting power, like the 7.3 8.0v minimum, more is better.

FICMMPWR is the available voltage to operate the HEUI injectors. These run at a voltage less than the 7.3L, but still enough to be cautious when electrically testing injectors.

ICP_DES, ICP, IPR, ICP, FUEL_PW are checks to see if the PCM is getting information from the sensors and attempting



The quarter-inch square head bolt is removed to access the fuel rail on the 7.3L. Connect an adaptor and tube to your pressure gauge; this is the right head and is just behind and below the alternator bracket. Heads are the same on this engine, so the port for the left head is at the back of the engine under the Intake and Turbo tubes.

to control the fuel delivery system.

FICMSYNC the 6.0L has a cam and crank sensor. The 7.3: only had a cam sensor. On the 6.0L, the PCM is looking for both signals and comparing when they occur. If the PCM loses either signal the engine may stall if running and may also be a no start.

Step 12 (6.0L only) – Combustion Gas in the Fuel Rail

This last test is checking for leaking gaskets allowing combustion gasses into the fuel rail. The test first checks to see if there is a leak. If there is you are then directed on how to determine cylinder head and then actual cylinder(s) that are at fault.

As you gain experience on these engines, you might be able to skip to certain tests or combine several of them to perform those at once. This overview of the process is designed to assist you in learning how to effectively work on these engines and becoming the go-to tech for PowerStroke diesels in your shop and town. **TM**



MARK DEKOSTER
CONTRIBUTING
EDITOR

Mark DeKoster has been fixing or teaching people how to fix cars for over 30 years. He has been a tech, trainer for Snap-on and Ford Motor Company, and currently is an associate professor at Ferris State University. He is the lead instructor in The Automotive Management Degree Program.

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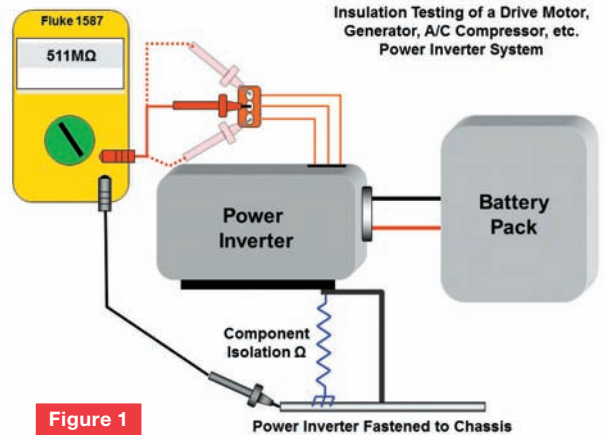
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WE CONTINUE A LOOK AT ON-BOARD DIAGNOSTIC SYSTEM AND OFF-BOARD TESTING.

BY **MARK QUARTO** | CONTRIBUTING EDITOR

Editor's note: This is the second part of a two-part feature from Mark Quarto. The first part ran in January 2015, and can be found at MotorAge.com/janelectrical.

For the technician, the anatomy of how they can receive an electrical shock is very easy, if proper safety precautions are not observed.

When servicing the HV system, the technician should be wearing Class 0 Electrical Gloves and disable the HV system to mitigate the possibility of electrocution. This is standard within all OEM service procedures to ensure safety. Because the vehicle chassis is always an element of the HV circuit, if an LOI exists and the technician is not wearing HV electrical gloves and has not disabled the vehicle, if the technician contacts the chassis they now become a possible parallel path element of the circuit.

In fact, HV current always is being injected onto the chassis by the HV system. It is the amount of electrical current that is the key variable. If the HV current on the chassis is in the microamp range the technician will never “feel” its presence and is safe. If the electrical current is greater than or equal to 2mA (assuming voltages are greater than or equal to 60) the technician will begin to feel the effects, although the level may not be near a fatal level. Therefore, if: 1) the HV system has not been disabled, 2) Class 0 Electrical Gloves are not being used, 3) an LOI is present, 4) the technician is touching the chassis and 5) the technician then touches any open connection

that is connected to the HV Positive or Negative bus circuit, there is a possibility of being electrically shocked (e.g., electrocuted) and it could be fatal.

The chassis merely serves as a point for HV current to enter/exit from the Positive or Negative HV bus rail. It should be mentioned here that, depending on where the LOI failure has occurred, the technician may electrically be more positive or negative, with respect to the chassis. Therefore, either the Positive or Negative bus could electrocute the tech.

HV Chassis Current Sensing Circuits

The HV system uses two types of circuits to monitor the chassis for LOI. The two circuits use direct current (DC) and alternating current (AC) to monitor for LOI. The DC circuit monitors the chassis continually for LOI, as mandated by FMVSS-305. The AC circuit functions only when the vehicle has been powered OFF. Each of these circuits will be discussed in detail within this section of the article. The DC circuit monitoring is typically performed by either the Battery System Controller or the Power Inverter System and Controller. The AC circuit monitoring is typically performed by the Battery System Controller. Each system will communicate with the Hybrid Controller (master controller of

the hybrid system) via Controller Area Network (CAN) messaging so that the Hybrid Controller can safely manage data and functions of the hybrid system.

Chassis LOI Monitoring Using DC Sensing

Monitoring the chassis with a DC circuit is a simple method to determine if there is an LOI and a simple circuit to understand. To simplify the DC LOI detection circuit, it typically resides in the battery or power inverter control system, uses a simple series circuit that connects the positive and negative HV bus rails by using two resistors. Each resistor is typically valued in the 1MΩ range to significantly reduce the current flow between the positive and negative HV bus for safety while providing excellent voltage fidelity for accurate measurements.

Notice in Figure 2 that the controller is monitoring the chassis at the circuit mid-point (center-tapped). This means the controller mid-point is used as the reference point for measuring LOI on the positive or negative rails of the HV bus. This doesn't mean the point the controller is measuring is electrically zero volts, but rather it's a point of a reference (or half) of the circuit voltage at the point of measurement). The other resistors in this circuit are to illustrate the isolation resistance between the HV components.

Photos: Mark Quarto

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Although we consider the isolation barrier to be resistive, it should actually be considered an impedance barrier. Although we will not include a background section on electrical impedance, it is important for a technician to know the difference between resistance and impedance. Impedance is an AC electrical term that defines the effective resistance (or opposition) to oscillating currents in a circuit and circuit components, due to the inductive and capacitive properties of circuit components with respect to the vehicle chassis.

Because most materials contain capacitive and inductive properties, impedance is always considered when analyzing an electronic circuit. The inductive and capacitive properties are added with the pure resistive properties of the circuit and its components to determine the overall effective resistance. Inductance, capacitance, and resistance are added mathematically in a complex (square-root) mathematic function to determine the overall impedance (effective resistance) of the circuit. For purposes of clarity and thoroughness, the impedance equation (formula) includes where Z = Impedance, R = Resistance, X_C = Capacitive Reactance and X_L = Inductive Reactance.

The symbol for the units for the Impedance measurement is the letter Z . Therefore, the reference to Z in the circuit encompasses all properties of the circuit that must be measured as part of the DC continual resistance measurement.

Applying DC LOI Sensing Circuit to the Vehicle

Sensing Z with DC to locate an LOI is very similar to diagnosing an injector with a Digital Volt-Ohmmeter (DVOM). Although a standard DVOM can provide basic information about the circuit whether the injector is operating or not, it really doesn't provide the diagnostic fidelity of an oscilloscope. The standard DVOM does provide data to detect a gross (general) circuit information but, it does not provide live data and visual waveform representation provided by an oscilloscope that results in data with a much higher fidelity (precision and accuracy). When analyzing the DC LOI sensing circuit (Figure 3) the analysis indicates that the circuit is functional only when the HV circuit is operational.

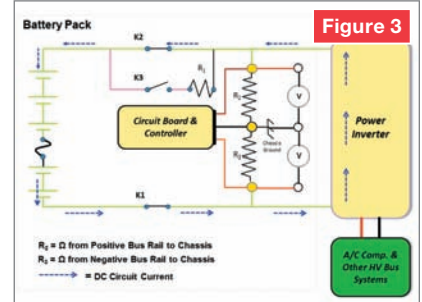
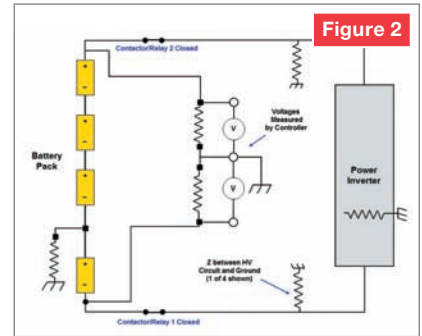
Note that the HV battery pack K1 & K2 contactors (relays) are closed and

all of the other HV system components are connected to the battery pack and the circuits are operational. Note that the controller circuit board is connected between R2 and R3. This mid-point serves as a reference point for the controller to measure voltage across R2 and R3. If the HV circuit has very low current leakage on either the positive or negative rails, the voltage drop across R2 and R3 will be virtually identical. However, if either the positive or negative rails develop a more aggressive leak to ground, then the voltage drops across the resistors will become unbalanced, and the voltage will be shifted to be more positive or negative with respect to the mid-point. When there is a voltage imbalance (whether on the positive or negative rail), and it finally equals (increases/decreases) the calibrated voltage threshold value in the software, the MIL will illuminate and a DTC will be stored in the controller to alert the technician that there is an LOI failure.

The DC test cycle can be accomplished by the controller in seconds, typically less than 30 seconds and it is a continual testing function when the vehicle is powered ON. Fundamentally, the DC circuit cannot indicate where the failure has occurred because DC circuit properties are a gross measurement circuit and cannot provide targeted diagnostic data unless there are automatic diagnostic software routines or special functions as part of a scan tool that can be activated to help locate the LOI. More importantly, it is very difficult (if not impossible) for the DC circuit to determine if there are capacitive LOI faults because, capacitive failures will block DC current. This will actually hide the failure mode. Therefore, to provide fidelity for locating or confirming an LOI failure, it will be necessary for the vehicle safety system to utilize an additional diagnostic circuit. This circuit will use AC to help detect LOI.

Chassis LOI Monitoring Using AC Sensing

Sensing Z with AC to locate an LOI is a very different process when compared it to how the DC sensing circuit detects LOI. One of the primary differences between the DC and AC sensing circuits is the AC sensing is accomplished with the vehicle powered OFF. The primary reason that the AC sensing is performed with the vehicle powered OFF is to



ensure electrical noise created by components in the electric propulsion system is deactivated. This will provide an electrically "quiet" environment for the controller (typically the battery controller) to begin measuring Z between the HV system and the chassis.

Because the controller uses electrical signals (sine waves) to measure Z , all other components must be powered off so the electronic filtering can detect any problems with the isolation barrier. If the electric propulsion system were permitted to be activated during the AC measurement process it would be extremely difficult for the battery controller to filter all of the unwanted noise from the system to determine if there was a low Z measurement between the HV system and chassis. In fact, it is very difficult to determine if a battery pack system as an LOI using the DC method, due to high electrical noise activity. Furthermore, it is very difficult to sense battery pack LOI problems caused by capacitive failures when the HV system is operational, especially when batteries have capacitive electrical properties and the module construction can be of non-ferrous (metal) materials. This is also true for measuring the Z (capacitances) of HV components.

The simplest method to understand the AC LOI sensing circuit is to begin analyzing the circuit when the HV contactors in the open position. This is the natural state for the HV contactors after the elec-

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trical control system has de-energized the contactors when the vehicle HV system is powered OFF. The AC LOI method must be used for the battery pack because it is highly difficult for DC sensing to locate an LOI in systems or components with capacitive properties. Although, the battery pack is the component in that has received the most focus in this discussion, there are other components that need to be tested using the AC LOI method such as the Power Inverter, DC-DC Converter, A/C Power Inverter, etc.

In the AC LOI control circuit, the battery controller will generate a low amplitude, low frequency AC signal and inject it onto the chassis. This AC signal is approximately a 5 volt sine wave with a low frequency (Hz) of approximately 2-5 Hz. The controller 5 volt sine wave is then transmitted to an amplifier stage that utilizes a Resistor-Capacitor (RC) network that is electrically connected to the chassis. The amplifier stage has two outputs. The first output stage, Voltage In (Vin), is measured by the controller and will be used as the reference waveform to ultimately compare the output measurement of the second output stage, using Voltage Out (Vout). The second stage will be connected in series with the vehicle chassis to acquire the total Z measurement. Since the RC network is located between the first and second stage, and the second stage is measuring Z of the RC network and the battery pack/vehicle chassis, it will generate an output waveform that is less than the Vin stage one output measured by the controller. If stage two waveform drops below a calibrated software value (due to low Z), a DTC will be stored for the LOI fault.

The primary reason that AC is used with an RC network is because, unlike using a capacitor in a DC circuit where current will be blocked by the capacitor, in an AC circuit the capacitor will permit current to pass through it. What results from passing current through both the resistor and capacitor RC circuit and the battery pack is the battery controller will be able to measure the Z of only the battery pack circuit to determine if there is an LOI. This can be accomplished because there is no other electrical noise in the system and the AC sensing circuit can use the properties of AC current to measure the capacitive isolation barrier between the battery pack and chassis – a

test that could not be accomplished with the DC sensing circuit.

The capacitance being measured is the “Y” capacitance value. The “Y” capacitance is the capacitance measured between the HV system components and the chassis. Although there are other types of capacitances that can be measured, the “Y” capacitances in each of the HV components (connected in parallel) to the chassis will be the values effecting the total LOI Z value. When the capacitance values (one or more in parallel with the controller RC network) have reduced the Z value between the battery pack and the chassis, this will result in a lower overall Z value measured (with the RC network) by the battery pack controller and a corresponding DTC will be stored to alert the technician to the fault.

The vehicle service manual will provide additional information on any LOI special tests that the vehicle or scan tool will support.

The following sequence can provide an example of how sequencing battery pack, power inverter hardware, and A/C hardware components with software or scan tool special functions can provide additional testing methods and sequences to help a technician locate a HV LOI. All AC tests must be performed by the battery controller with the vehicle powered OFF.

1. Open K1 and K2 HV Contactors – inject/measure AC into battery pack to test it for LOI.

2. Close K1 Relay and Open K2 HV Contactors – inject/measure AC into negative bus rail to test the negative HV cable and power inverter circuit for LOI on the negative side of the HV circuit.

3. Open K1 and Close K2 HV Contactors – inject/measure AC into positive bus rail to test the positive HV cable and power inverter control circuit for LOI on the positive side of the HV circuit.

4. Close K1 or K2 HV Contactor and command either the positive or negative power inverter transistor motor drive network (one or the other at a time, not both at one time) circuit ON to test for any electric MGU winding LOI. This will test for gross electrical/electronic failures only, not intermittent failures caused by partial discharge energy that can only be generated at voltages greater than 300 volts.

5. The A/C circuit and the compressor motor windings can also be tested sepa-

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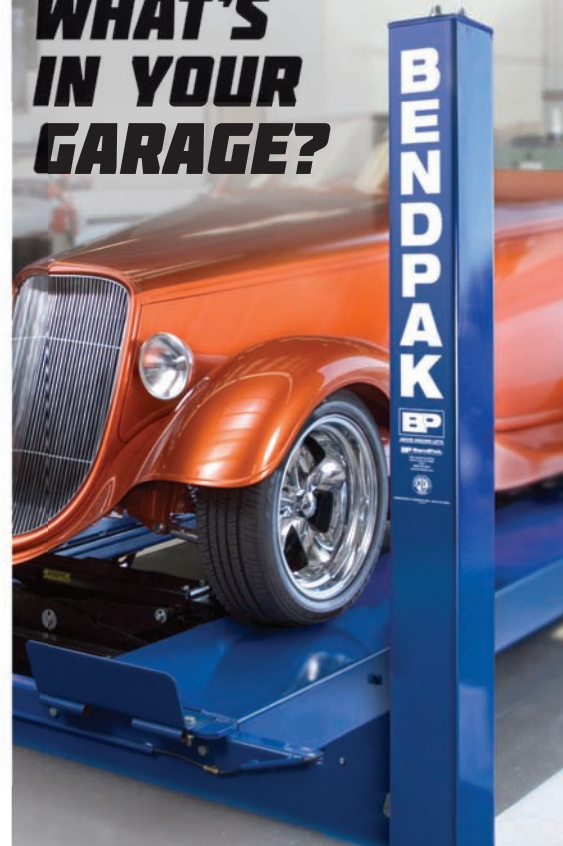
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rately for LOI, much the same manner as the power inverter, by virtue of being connected to the HV bus and using its power inverter transistor network (this will test for gross electrical/electronic failures only, not intermittent failures caused by partial discharge energy).

By controlling the K1 and K2 HV contactors, many HV components can be tested for LOI without disassembling the system. However, whether a system is able to automatically test or use special function tests with a scan tool to command the tests for LOI in a HV system, this functionality will be OEM dependent. However, if the vehicle is equipped with software that will automatically test the system for LOI (and provide the technician with some possible locations for the failure) or use scan tool commands to execute LOI systems tests, the technician will be required to confirm the LOI.

Confirmation means that the technician will be required to confirm an LOI DTC by using off-board testing and testers. Or, if the vehicle software is not designed execute automatic or scan tool commanded functions to help locate the LOI then, the technician must manually test each device in the HV system with an off-board tester to determine the fault origin. The OEM service information will provide the fundamental information on how to test individual components but, there are some "short cuts" that are technically very sound that can assist in reducing the amount of time in testing individual HV components for LOI. These

short cuts are taught in hybrid courses by reputable hybrid training companies.

Manual Testing for LOI

Although vehicle systems can utilize controller based DC and AC LOI testing, there will always come the time when manual testing of components will be necessary to either eliminate possible failures by process of elimination or confirm a failure. Although manual testing will be discussed in a more targeted focus in this article, each OEM will provide specific manual loss of isolation testing procedures for their system. The OEM procedures will typically write the procedures to test the insulation of a component for how well it isolates the circuits from the chassis by using the following process:

1. Wearing the proper personal protective equipment (e.g., Class 0 High Voltage electrical gloves) disable HV from the vehicle by using the proper disabling procedures.
2. Confirm the HV has been disabled.
3. Disconnect the HV cables that connect the HV components (if equipped with cables) to segregate them so that individual testing can be completed. The OEM service manual may provide a specific sequence in which to test the components. However, if a technician has received quality education and training and is familiar with HV hybrid/electric systems, they may elect to use quicker methods and procedures of testing the system.

4. Using a DVOM or Insulation Meter (e.g., Fluke 1587, Fluke 1507, etc.), select the proper insulation test voltage range to test the system. As an example, the Fluke 1507 will provide voltage ranges from 50, 100, 250, 500, 750, and 1000 volts.

The OEM will state a voltage range for the technician to use for insulation testing. If the OEM does not require the use of an insulation meter to test for LOI, and there is no insulation test voltage range recommendation in their service information, there is alternative method that can be used. The alternative method is to determine the highest typical operating voltage of the system and set the insulation meter at the next highest voltage range.

As an example: If the operating voltage range of the vehicle hybrid system is 120 – 170 volts then, use a range higher than 170 (e.g., use the 250 volt range). So,

why wouldn't a technician use 500, 750, or 1000 volts to test a 170 volt system? The reason is that a system with electronic and electrical components that are designed/rated to operate in a 170 volt system will get electrically stressed (and possibly damaged) if an excessive test voltage is used. Stressing a component means that a test voltage may exceed the operating maximum designed voltage specification of a device. If a capacitor is rated for 250 volts and 500 volts is used to test it, it will stress the capacitor and damage it immediately or reduce its operating life (e.g., it will fail at a later time but, much sooner than it's normal service life). This general rule holds true for an electronic device or electric machine (MGU stator winding) tests.

5. When the electronic or electrical device is tested, the test results indicated on the insulation meter will be provided in units of Ω resistance. This provides an indication of how much isolation barrier (insulation resistance) is present between the device being tested and the vehicle chassis.

Motor-Generator Unit Insulation Testing Example

To perform an insulation test on MGU 3-phase windings, the system must be properly prepared (see Steps 1 through 4 in previous section). Hybrid and electric vehicle MGUs are designed with 3-phase windings that share a common winding neutral connection. The insulation test for a 3-phase MGU is a very simple test. One of the insulation meter (black) leads is connected to chassis ground and the other lead to one of the three MGU cables/wires that is usually connected to the power inverter.

After connecting the insulation meter to chassis ground and one of the three MGU cables/wires, the tech will command the insulation meter to execute the test. When the test is executed, the insulation meter will inject a small current into the 3-phase windings to "excite" the chemical properties of the wire insulation and test the dielectric (isolation resistance) strength of the stator slot insulation and winding (enamel or varnish) coating properties. Though most insulation meters are capable of injecting a maximum of 2mA of current (at a voltage near or at the voltage range selected), the actual current being injected into the windings will be in the microamp range.

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This limitation of current injection into the three-phase windings is due to the isolation resistance barrier between the MGU and vehicle chassis. If there is a direct short between the windings and ground, the maximum current that can be injected is limited to 2mA by the tester control circuitry. This is a safety design feature to ensure that the user cannot receive an electrical shock that places them in danger of a fatal electrocution. The technician will execute the test until the maximum resistance value can be acquired by the insulation meter and will be displayed on the tester in units of Ohms resistance. There is no need to connect the insulation meter to the other two cables/wires of the 3-phase winding because, the windings are connected together at a common neutral point. Therefore, when the current is injected into one phase, it is electrically injected into all three phases for testing the isolation barrier between the MGU and the vehicle chassis.


Typically, an OEM will provide a minimum insulation resistance value for a component. There are additional insulation meter techniques that can be used to help determine the condition of a MGU. If a technician has interest in learning these techniques, they should seek out a course from a qualified hybrid and electric vehicle training organization to learn the additional techniques and skills.

Power Inverter Insulation Testing Example

As with testing MGUs, when performing an insulation test on a power inverter system it must be properly prepared (see Steps 1 through 4 in MGU testing section). Hybrid and electric vehicle power inverter systems are designed to provide 3-phase electrical current to the MGU windings. Unlike the MGU, the three power inverter circuits are separate circuits within the power inverter that must be tested separately (Figure 1). There is no neutral (common) connection. The insulation test for a three-phase power inverter system is a very simple test. One of the insulation meter (ground) leads is connected to chassis ground. The three power inverter cables/wires will be probed and tested individually with the other insulation meter lead. Using the same testing procedure that was used on the MGU (selecting the proper insulation meter voltage testing range – e.g.

500 volts, etc.) each of the power inverter circuits will be probed and tested.

Unlike the MGU, power inverter insulation resistance is not governed by the IEEE, due to the volume of different power inverter applications and designs. Therefore, there is no single industry specification metric that can be cited. The OEM will typically provide a specification in the service information for this device. However, in the event that the OEM does not provide a specification, the typical insulation resistance for a good power inverter has tested at 500kΩ – 1MΩ. Conversely, a failed power inverter will easily be identified with insulation resistances that have been measured from 25kΩ (or less) to 100kΩ. It should be restated here, it is the FMVSS-305 requirement of 500Ω/volt, and the associated calibration that, ultimately determines what resistance level will cause a MIL and DTC. Therefore, the FMVSS-305 requirement can (and should be) used as the governing baseline testing metric reference for all LOI testing because, it is electrically specific to all vehicle systems (irrespective of OEM). So, this is a wonderful metric to remember and use in your LOI testing.

Whether testing an MGU, power inverter, A/C compressor system, battery pack system, etc. using an insulation meter is a simple process of selecting the proper testing range and then, probing and testing each of the individual components for its insulation resistance (isolation barrier) value. Although a particular OEM and vehicle system may provide automated LOI testing or, a scan tool may also provide functions that will command the system to initiate special testing protocols, knowing how/where to test the system manually is an insulation meter is of utmost importance to a technician. 



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BY EDWIN HAZZARD | CONTRIBUTING EDITOR

As a mobile diagnostic tech, I receive numerous calls from many different shops asking me to program a module or diagnose a problem vehicle that's in their shop. Many times the information I'm given over the phone isn't quite the complete story. In this particular instance, a tech called to tell me they had a 2012 Mitsubishi that had an Antilock Braking System (ABS) light illuminated on the dash and they couldn't seem to find the problem. I arrived at the shop thinking that the vehicle in question was a car, but it turned out to be a medium duty truck, 2012 Mitsubishi Fuso FE160.



BIG BAD BRAKES

2012 MITSUBISHI FUSO FE160

Vehicle Year/Make/Model

60,511

Mileage

4M4T3 DIESEL

Engine

M036S5 AUTOMATIC

Transmission

ABS WARNING LIGHT ON

Complaint

Most car and light duty shops around my area are not geared and properly tooled to work on vehicles like this. As a mobile tech, I have to be able to cover just about every vehicle on the road. Not being able to service a vehicle is out of the question. When it comes to scanning these vehicles, they can be a little dicey, as most scan tools won't communicate with these trucks due to the communication network protocol they use. You might get lucky communicating with it using a Global OBDII scan tool, but the information you will see might not be accurate or there is just not a lot of it. The tool of choice on these vehicles is the factory Mitsubishi scan tool, called the Multi-Use Tester (MUT) III. Because this is an ABS problem, I hooked up my tool to the Diagnostic Link Connector (DLC) and tried to communicate with the vehicle.

Talk to Me

OK, that's strange; there isn't any communication with the ABS module. Is that why the ABS light is on? I wanted to make sure that the tool was working, so I tried communicating with the Engine Control Module (ECM), which it did. Before I located the ABS control module on this vehi-

cle to check its powers and grounds, I wanted to make sure that the scan tool was at least attempting to talk to this control module.

I installed a DLC breakout box between the connector and the scan tool. This is a great tool to use to check the circuits at the DLC connector for proper power and grounds. On this vehicle, pin 16 is power and pins 4 and 5 are grounds just like the cars and light duty trucks on which you normally work. Those circuits checked out just fine. The communication lines on this vehicle are pin 7 and pin 13.

As I tried to communicate with the scan tool, the pin 7 light illuminated on the breakout box. That told me that the scan tool was at least making an attempt to communicate with the ABS module. I also verified that I was receiving a signal of about 12 volts with my Digital Volt-Ohm Meter (DVOM). The next step I took was to locate the control module itself and with the help of a wiring schematic, I checked the powers and grounds to the module. Those, too, checked out to be working properly.

Why can't I communicate with this module? By all accounts I should be talking to it based on the testing I have done so far. My next step was to use

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one of the most powerful tools I have in my arsenal: networking. I contacted a friend at the Mitsubishi dealer and asked him about this problem. He told me that in 2011/2012, Mitsubishi started using a tool called the SD Connect, the same tool used on the Mercedes Benz vehicles. I plugged my SD Connect VCI (Vehicle Communications Interface) and finally was able to connect with the elusive ABS module.

Now That We're In

The generated code was for a right rear wheel speed sensor open circuit. When a sensor circuit code is reporting "open," there could be a couple of causes for the problem. The sensor could be disconnected, the wires from the control module to the sensor connector could be open or broken or the sensor itself could be internally open. I've already done a lot of testing so far just to see why I wasn't communicating with the ABS system, now it's time to get to some serious testing and find out just what is causing this truck to turn the ABS light on. I did a quick scan of the ABS data just to make sure everything looks ok, but I clearly can see a problem.

When I diagnose a problem on a vehicle, before I do any pinpoint testing I always like to perform a good visual check of the components in the system I'm working on. That would be the connections at the module, the wiring from the module to the sensor and the sensor itself. I like to start from where it all starts. In this case, I want to check the wiring from the module to the sensor connector so I can isolate the circuit point by point. When working on any vehicle today, you have to have an electrical schematic of the

system your working on. An electrical schematic is nothing more than a road-map. Without a roadmap in place, you won't know what path to take.

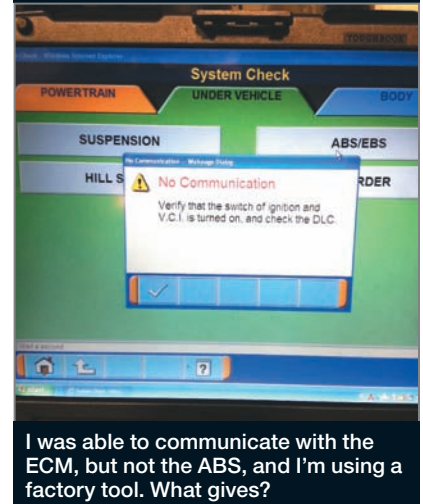
I go to my information system and pull up a wiring diagram of the ABS system for this vehicle. At the ABS module, I remove connector AH26A from the module and hook one of my test leads from my DVOM to terminal 17 of the connector. At the other end, I disconnect connector AB14B (which is the connector going to the right rear wheel speed sensor) and I connect the other lead connector terminal 1. I set my meter to the ohms setting and read my results. My meter read 0.01 ohms of resistance. I at least know that the path between the two connectors is complete.

I am always a little leery of wire testing using an Ohm meter, though. Sometimes the resistance can be inaccurate due to corrosion or, in some cases, broken strands of wire inside the wiring insulation. But an initial resistance reading is one way to find out something about a circuit's integrity pretty quick. Could a high resistance reading in this circuit cause a wheel speed sensor fault? Yes it could. Also, this particular vehicle is approximately 25 feet long, so the circuit that I am testing (from the front of the truck to the back) could have a better than even chance of having the wires becoming compromised due to the fact that this truck operates in a harsh environment and is in the Rust Belt.

That being said, I like to do a more thorough circuit integrity check. I take a headlight bulb and wire it in series so I can apply the headlight to the circuit being tested. The headlight now becomes the load in the circuit. If the



MUT III is a PC-based scan tool that uses a Vehicle Communications Interface (VCI), shown here.



I was able to communicate with the ECM, but not the ABS, and I'm using a factory tool. What gives?

headlight shines bright, it is a good indication that the wiring in this circuit is in good condition. If the headlight is dim, then that would tell you that there is a potential problem in

No.	Name	Actual value	Specified value
000	Supply voltage of component 'Electric motor'	14.16V	[9.00 .. 18.00]
001	Supply voltage of component 'Solenoid valve'	14.16V	[9.00 .. 18.00]
002	Supply voltage of component 'Solenoid valve Relays'	14.16V	[9.00 .. 18.00]
003	Stabilized supply voltage of control unit	14.16V	[9.00 .. 18.00]
004	Present supply voltage of control unit	14.16V	[9.00 .. 18.00]
005	Wheel speed at left rear axle	0.0mph	[0.0 .. 155.3]
006	Wheel speed at right rear axle	223.7mph	[0.0 .. 155.3]
007	Wheel speed at left front axle	0.0mph	[0.0 .. 155.3]
008	Wheel speed at right front axle	0.0mph	[0.0 .. 155.3]
013	Status of engine brake (Switching off)	OFF	

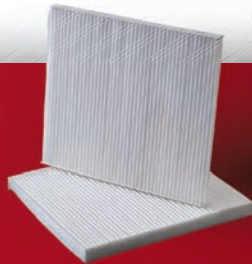
(Left) The ABS module is telling me the circuit has an "open," but not where that open is. (Right) ABS data confirms the problem is in the right rear. The truck certainly isn't going 223.7 mph.

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(Left) A phone call to a Mitsubishi tech friend answered my communications questions, and I found out that my MB scan tool VCI would do the trick. (Right) After verifying the circuit path between the sensor and the module was intact, the only thing left was the sensor itself. But I still want to confirm that's all it is.

that circuit. An ohms test might not pick up the problem on the circuit, but this test surely will.

I did the same from connector AH26A at the ABS module terminal 18 to connector AB14B terminal 2 at the wheel speed sensor. That too passed the ohms and circuit integrity test. Looking at the wiring schematic, there are a couple of junction connectors our wires pass through. These junction connectors are a great place for corrosion to build up and resistance to increase in the circuit. Remember, anytime you have a connection in a circuit it is a place for potential resistance to be and connection problems to reside.

If I didn't have a bright bulb or if I had high resistance in either test, then I would have broken the circuit down in sections and tested each section until I came upon the area that was causing the problem. But based on these test results, the wiring from the ABS control module to the wheel speed sensor connector is in good shape and not the cause of our ABS system trouble code.

Next up would be back by the wheel area itself. With the sensor disconnected, a visual inspection into the cavities of the connector is important as this is where a lot of road salt, grit and dirt build up could accumulate which can bring on corrosion. Next, I removed the sensor from the backing plate. With the sensor removed, I found a lot of particles on the sensor tip which is magnetic but not enough to create a potential problem reading the ABS tone ring. I used a video

scope and pointed the scope inside the hole where the sensor usually resides so I could get a good look at the toner ring. I could clearly see the teeth on the ring. I had a technician in the shop raise the rear of the truck off the ground and spin the wheel while I looked at the ring. I did not see any missing teeth, a loose wheel or any wobble in the ring as the wheel was being spun.

Last Step

This leaves only one item left unchecked. At this point, I could throw a sensor on this truck, but this sensor is priced at around \$500. For that price, I want to make absolutely sure that the sensor is indeed bad. I began my testing of the sensor by going to the information system and retrieving the specs.

I found that on this truck there are two types of sensors. The front wheels use a sensor that has a pole piece in the center and the rears do not have that pole piece. There are two types of tests on this sensor: a resistance test for measuring between the two terminals and one for measuring between the terminals and the sensor body itself. This latter test is a great test to check for excessive resistance in the sensor body caused by water intrusion that has made its way internally, leading to corrosion inside.

When I performed the first test on the type 1 sensor, I hooked up my meter to both terminals on the sensor harness and set my ohm meter to auto range. I came up with a reading

of 2.7K ohms. That reading is way out of spec. As I was testing this sensor, I went along the harness and wiggled the wires and watched my meter. The readings changed a little bit but they never went in spec. Now I can say its time for a new sensor but being the perfectionist that I am sometimes I still want to perform the second test as well.

I hooked my meter up between one terminal and the sensor housing. Terminal 1 read 1,100K ohms, which is, in fact, in spec. Next I hooked to terminal 2 and the sensor housing and my reading was 130,000 ohms. With that reading, I knew that this sensor was, in fact, bad. Now I am satisfied with my diagnosis and any and all doubts are now gone.

I reinstalled the connectors to the ABS control module and had the shop order a new sensor and install it. I came back to the shop the next day and was able to clear the diagnostic trouble code from the system. The light is off and the customer and shop owner are happy. *M*



Edwin Hazzard has more than 30 years experience in the automotive industry as a tech, service consultant and mobile diagnostic tech. He is the owner of a successful mobile auto and truck repair service in Newburgh, N.Y.

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FEDERATED OFFERS PREMIUM BRAKING PERFORMANCE FOR TODAY'S VEHICLES

Federated Auto Parts has developed an addition to its friction offering with a new co-label line developed and supplied by Wagner Brake. The new product line is a premium offering designed for professionals that was exclusively designed for Federated members and their customers.

The line uses the highest performing formulas specific to each application and includes System Synergy Technology (SST) which is an OE approach to brake design that ensures the interaction of all brake components to provide the ultimate performance.

Each set of Federated Professional Premium is engineered and designed to match the OE pad in fit, form and function and uses premium formulations and shims designed for ultimate performance on each application.

The System Synergy Technology focuses on managing the NVH (noise, vibration, and harshness) issues through testing and validation of the various components used in disc pad designs. While many consider a disc brake pad one component it actually consists of many different components including backing plates, shims, hardware, along with friction material, slots and chamfers that all must be designed to work together to deliver ultimate performance.

Working with Wagner Brake experts, Federated has developed a product line that uses OE designs, and improvements in materials and component integration, to deliver superior performance to other aftermarket lines. The Federated Professional Premium line provides superior braking performance, long life and quiet operation for customers who perform premium brake service and have a reputation for using high quality brand name parts.

Federated has a history of working closely with high-quality manufacturers to develop exclusive products designed specifically for use by quality technicians and professional service providers. The Federated Professional Premium line of disc brakes is designed to take all the mystery out of all the different materials and grades available in the market today by using System Synergy Technology to focus on the best solution for each vehicle.

"We spent countless hours working with Wagner Brake experts in designing this line," stated Phil Moore, senior vice president for Federated Auto Parts. "The results from both testing and customer feedback have been outstanding. This new



product line delivers premium performance in every area and we believe will be a major benefit to our professional customers.

"Working with Wagner and Federal Mogul made this project easier due to their commitment to quality and their outstanding manufacturing and R&D facility in Smithville, Tenn.," Moore continued. "We are proud to have a premium product line that is made in the USA."

Federated Professional Premium brake uses an OE approach to the design process that delivers the ultimate in overall performance for the professional service provider and is available exclusively from members and affiliates of Federated Auto Parts.

For more information, visit www.federatedautoparts.com.



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BEGINNING THE DIAGNOSIS

FOLLOWING A SET ROUTINE WILL INCREASE YOUR CHANCE OF DIAGNOSTIC SUCCESS.

BY **PETE MEIER**
Technical Editor

Most of the diagnostic challenges that entered my bay were met easily, as they were caused by pattern failures that I had seen often enough to recognize and repair quickly. Once in a while, though, the answers were more elusive and often caused my brain matter to knot up and lock up. I then would find myself assuming that some systems were OK when they were not, or overlooking component tests that I shouldn't have. Once you find yourself lost in the maze, it can take a lot of time and energy to find your way back out.

The best solution, of course, is to avoid the maze in the first place.

I was lucky during my time as a full-time technician working in a shop. I had the opportunity to meet diagnostic techs who were at the top of their game and tried to learn what habits they had that those who struggled didn't have. One habit that stood out was their commitment to educating themselves. Every one of them would tell me that was a key to their success, and that constant education was a must in order to stay at the top of their game.

And they all had a routine that they applied to their troubleshooting challenges, no matter what system (drivability, electrical, chassis – didn't matter) they were working on. They would stress to me that having a routine prevented wasted time and duplicated efforts.



MotorAge.com/feb15trainer

The troubleshooting routine that will improve your diagnostic success? That's the topic for this month's edition of The Trainer, our how-to video series for technicians of all skill levels

Also, if you're reading this column, then odds are you too are committed to your continued education. And we at *Motor Age* are committed to providing you with the resources you need to succeed in doing just that, in print and online. And if you haven't registered for Motor Age Training Live (part of Automechanika Chicago, April 24 to 26), I have one only question: Why not?

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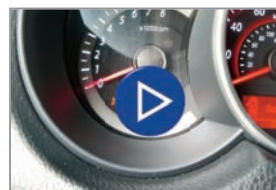
On being professional in today's shop

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