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February 2016
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Vol. 135, No. 2

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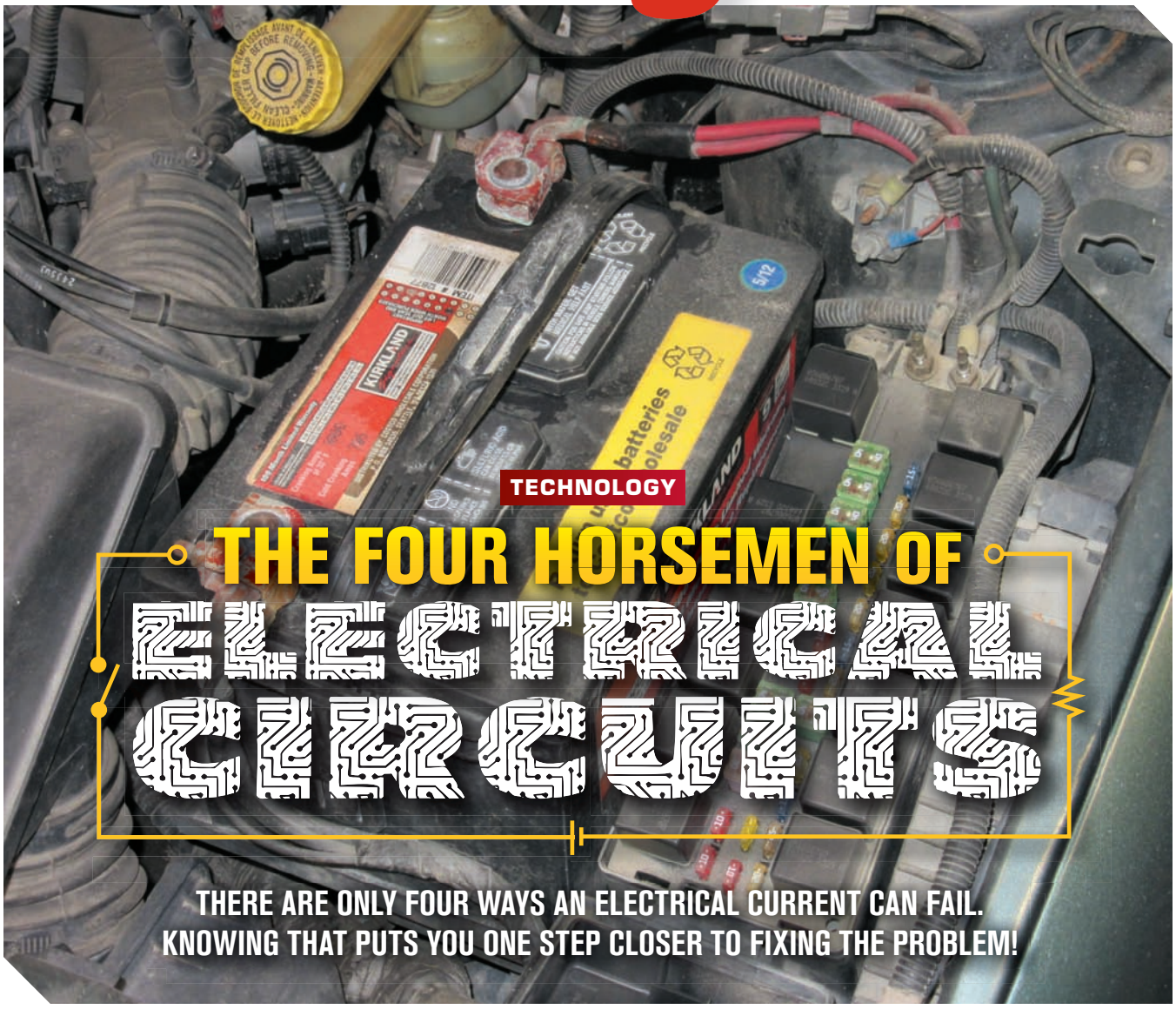

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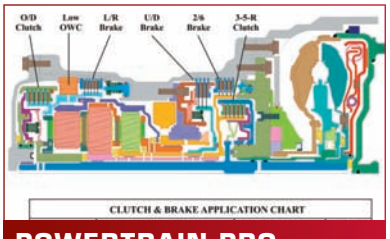

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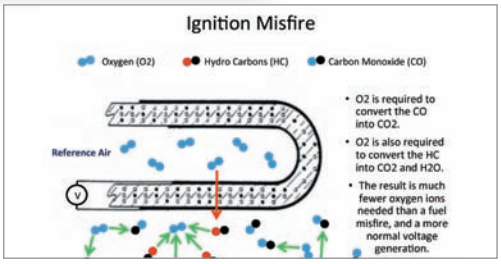

DRIVABILITY

DON'T MISS THE MISFIRE

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TECH CORNER

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MOTOR AGE GARAGE

LIFE ON THE FRONT LINES

BY **G. JERRY TRUGLIA** | CONTRIBUTING EDITOR

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MORE ABOUT THE 6-SPEED FROM KOREA

BY **WAYNE COLONNA** | POWERTRAIN PRO PUBLISHER

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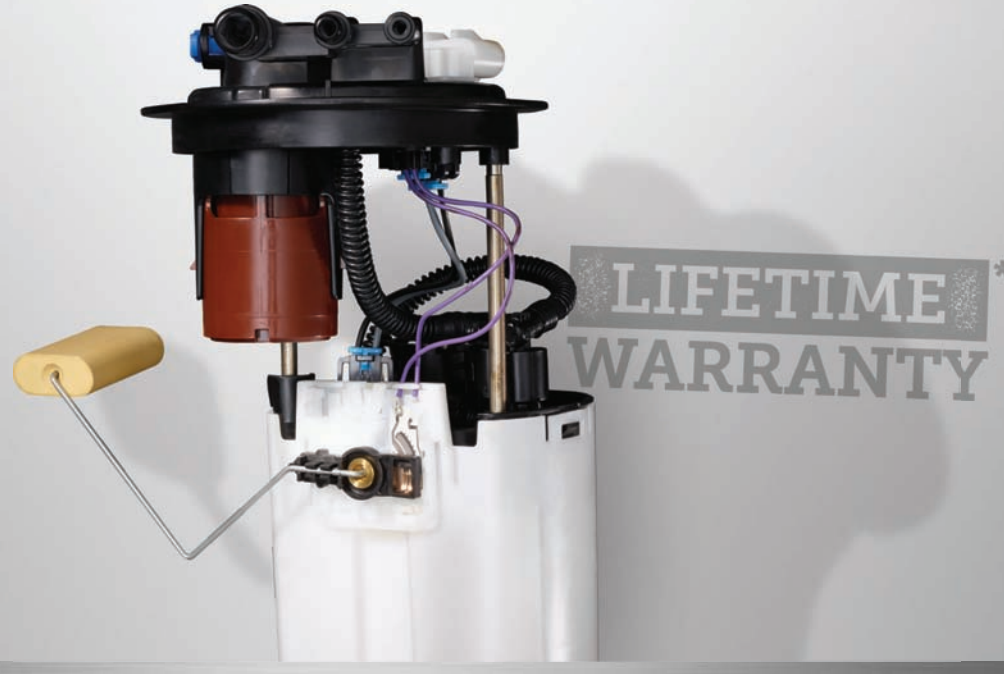

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The three finalists, Tyler Carroll, All Pro Service Center in Des Moines, Iowa; John Kessler, Tires Plus in Maple Shade, NJ; and Mike Emo, Captin's Repair in Wells, Maine, will be flown to Detroit to attend the 2016 North American International Auto Show — happening at press time — where one finalist will be drawn to win the grand prize.

»» *MOTORAGE.COM/DELPHIDREAM*

GARAGE GURUS ADDING ASE TEST PREP, EVENING WORKSHOPS AND MORE IN 2016

Garage Gurus, Federal-Mogul Motorparts' comprehensive technical education platform for service professionals, will offer expanded curriculum, additional training center locations, attractive technician incentives and several other program enhancements, all kicking off in early 2016.

»» *MOTORAGE.COM/GURUSENHANCED*

REPAIRPAL, ASE BEGIN NEW PARTNERSHIP

RepairPal and the National Institute for Automotive Service Excellence are working together to highlight excellence and quality in the auto repair industry through several joint initiatives.

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NASTF Board of Directors made OEM and independent co-chair appointments to each of six NASTF committees for 2016.

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SHOP TRAINING

TST training event sponsors lower cost

BY **KRISTA MCNAMARA** | CONTENT CHANNEL DIRECTOR

The cost to attend the 13th annual TST Technician Training Big Event in March just got a lot more affordable, thanks to event sponsors.

The TST (Technicians Service Training) 2016 Big Event previously cost $335 for non-members and $260 for members. With the help of sponsors including Automotive Test Solutions, Drew Tech, Neutronics, Smoke Pro and *Motor Age*, the cost has been dropped to just $75. At press time, more sponsors were being finalized, so the list is expected to grow.

"If technicians don't update, they will evaporate. Technology is moving fast and we all need training to stay up on the best diagnostic procedures and repairs," said G. Jerry Truglia, TST owner, on the importance of training events.

The sponsored training model is similar to that used at Automechanika Chicago 2015, which offered free training to all attendees, thanks to industry sponsorships. "Automechanika Chicago was a big test of this, as well as other events," said Truglia, who led some training courses at the Chicago event in April 2015. "Since technicians and shop owners don't have the money to spend on training, this template is the way to go."

In addition to making the training more affordable for the industry, it also offers manufacturers a new opportunity to reach potential customers. "We now have sponsors thinking about a different way to get their message right to the people who buy their products," Truglia said.

The Big Event features four industry speakers who aim to "keep our fellow technicians up to date with the latest technology," said Truglia, who, along with the event speakers, are all Motor Age contributors.

Truglia will be the event's keynote speaker, with Bernie Thompson covering Advanced Leak Detection; Dave Hobbs speaking on Telematics and Advanced Body Electronics Diagnostics; and Ed Hazzard offering Real World Tips from a Mobile Tech.

The full-day event will be held Saturday, March 19 at the Ramada Conference Center in Fishkill, NY. Also included in the training are two manuals, breakfast, snacks during breaks, a hot lunch and beverages available all day.

Truglia said there is more than just attending training events that technicians should be doing to stay on top of the industry and its changes. "Read all technical magazines and watch videos on YouTube and in webcasts," he said.

Photo: G. Jerry Truglia

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MANAGEMENT

PROTECT YOUR ASSETS

AVOID SHOP CATASTROPHES AND ENSURE BUSINESS SUCCESS WITH HAZARD-PREVENTION MEASURES AND PLANNING

BY **JOEY KAYLOR** | CONTRIBUTING EDITOR

ON NOV. 20, 2014, I watched my entire life go up in flames. In less than an hour everything I had built over 15 years, including my home (my wife and two-year-old daughter lived in an apartment above the office at the shop), was gone after a truck caught fire, burning the entire shop and 12 customer vehicles to the ground. Thankfully, no one was injured, but it was a devastating blow after I had recovered from a broken back and neck the year before.

Catastrophic event handling

A person's true skillset and character shows when a tragedy occurs. In an instant a business someone spent most of his or her life building can disappear, and there is nothing he or she can do about it. How you respond to a tragedy directly relates to how things progress. It's a highly emotional time, but you cannot let emotions affect your decisions. Step back, look at the situation as a whole, and then analyze what can be done; only then do you act.

Preplanning

People do not spend their days planning for catastrophes, and let's face it — most people think it will never happen. Then again, if we spent our days worrying over what could happen, we would die young of ulcers and stress, getting nowhere.

Have you ever thought about the potentials for fire, explosion or death in an auto repair shop? A quick tally of what was in my shop when it burned yielded over 300 gallons of diesel fuel, 1,000 gallons of new motor oil, 1,500 gallons used, 125 gallons of gas and more than 300 tires. Do you know how hot those combined combustible materials get? Hot enough to vaporize copper and melt steel beams.

Technicians are typically organized and clean, but inevitably, things get spilled, parts get piled up and workbenches become catchalls. Keeping piles of things from getting too big helps prevent disasters from happening. If nothing else, try to keep potential fire loads from getting too big.

In the months after the fire at the shop, I went to dozens of other shops just to look around during normal operations at the request of the owners. You would be amazed at all the fire hazards shops could potentially face every day. For example, scrap tires might be piled

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up next to waste oil tanks, cutting and welding might be executed without appropriate precautions, extinguishers might be hidden or not functional, there could be extreme carelessness with spills, etc.

Insurance prep

The very first shop I ever worked for is still going strong today, and I stay in touch with the owner and consider him a friend and mentor. One thing I always heard from him as I was wrenching was how expensive insurance was, and I asked him one day if it was worth it. He told me, "You cannot afford to not be insured," and I still hear that conversation 15 years later. Just like a good CPA, a good insurance agent is a worthwhile partnership. It stings writing that premium check, but at the end of the day, it's a cost of doing business that is factored into your overhead.

Policy needs and coverage areas are another article altogether. Just remember that employees' tools are typically NOT covered by the shop's contents policy. I've seen way too many techs lose their livelihoods after a shop burns and their tools were not covered. Discuss options with your carrier.

And for the love of Burt Reynold's moustache, document your inventory and assets! There is no reason you cannot have a short video on a smartphone of you walking through your shop. Just pan slow and don't narrate. Use HD if possible. Save the video and pictures and any other backups, records and files to a cloud server or rotate thumb drives out offsite. Remember, if you save backups and important files to a computer or drive at the site, it will be useless if something happens to your shop.

Site securing

Even before the smoke clears, you need to get the site secured. You do not have to post armed guards and razor wire, but you need to have a way to keep everything secure until adjusters and investigators are there. My fire was right before Thanksgiving on a Thursday. Saturday morning there were footprints in the mud and ashes from people walking around and drag marks from burned wire and scrap that were taken. It's sad to have to protect a fire loss site, but it has to be done to protect yourself from liabilities, additional losses and to be able to get compensated for the loss.

Persevere through

There comes a time when you will be hit hard with reality. It is going to be awful, and you can either wallow in self pity or you can dust off your shoulders and move forward. There isn't much you can do to change what has already happened, but there is a lot you can do about what happens moving forward.

What you decide to do is up to you, and believe me, it is not easy. Take your time and analyze it carefully, but listen to your gut. That's what got you into the business, isn't it?

Rebuilding and claims

Get ready for extreme frustration, stress and hassles. Or get ready for smooth sailing. A lot of things are out of your hands at this point, but the key is to remain as calm as possible and document everything. I filled a composition book of notes as I called, emailed, and wrote during the claim. It is a headache but can be managed. One thing to discuss with your insurance agent is if the carrier you have does claims themselves or contracts it. It is definitely more of a hassle if the claim is handled through outside contractors instead of being done in house, especially on a complex claim which usually involves multiple property owners. Most of your larger carriers do their claim processing in house. Discuss this and find the best option for you with your agent.

JOE'S GARAGE FIRE UPDATE: ONE YEAR LATER

Nov. 20, 2014 was a day I will never forget. It was the day my entire life went up in flames (literally) and changed my world forever. It is now one year later, and things have changed significantly.

First and foremost, all customers who had a destroyed vehicle have been taken care of by insurance.

Tooling and equipment is in process of replacement, and decisions are being made for any forward progress for reopening of Joe's Garage, Inc. After some major thought, I decided to make a shift in business model to focus more on the fabrication side of the business we were doing, which has kept me busy since the fire doing structural and architectural metal works, truck and trailer equipment and fabrication, and machine repair.

My community has been very supportive, and other shops in the area have worked with the customers we had to take care of their needs during the down time. There is still a long way to go, but everyone has worked very well together getting the customers taken care of during this time, which is a testament to being in business for a common goal of customer service.

Differences in coverage

Coverage has changed a lot in the last 15 years and one thing is for sure — policies are very confusing. My suggestion is to avoid the dreaded acronym of ACV (actual cash value) and to try to find coverage that does replacement cost. Again, this is a complex discussion that you need to have with your agent, but the gist is this: you lose tools, and you need to replace them. ACV coverage gives you a (often deeply) prorated amount to replace your tools up to the limit. Replacement coverage gets you the coverage to replace with like items — it makes a huge difference.

Prevention

An ounce of prevention is worth a pound of cure, eh? This is the same case. Simple things like keeping scrap tires outside and away from the building, keeping flammables away from ignition sources, utilizing safe disposal techniques, and even just keeping the shop clean can make all the difference in the world.

JOEY KAYLOR
CONTRIBUTING EDITOR

Joey Kaylor is an ASE Certified L1 Master Auto Technician, ASE Certified L2 Master Truck Technician, Service Writer, Collision Repair Technician, and Truck Equipment Technician. He owns Joe's Garage in Floyd, Va., where he also lives with his wife and daughter.

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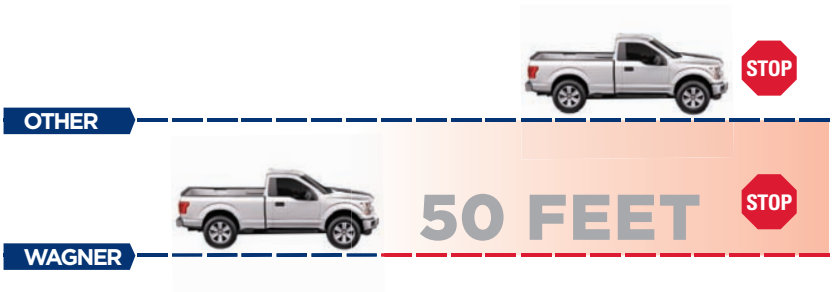

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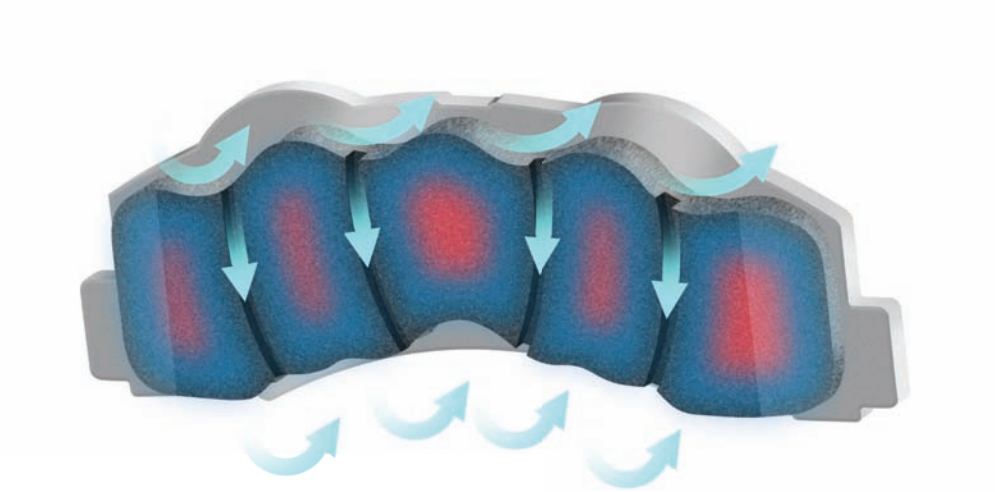

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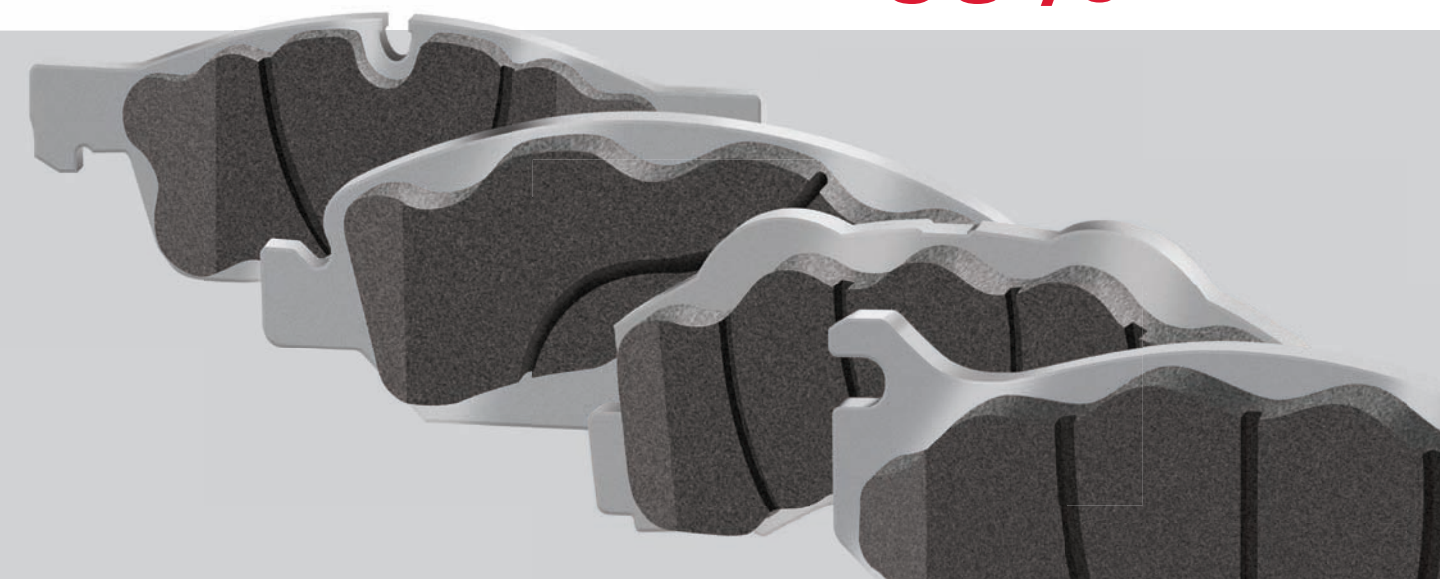

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FEDERAL-MOGUL MOTORPARTS

TECHNOLOGY CAN'T FIX EVERYTHING

DON'T EXPECT ELECTRONIC COURTESY CHECKS TO SOLVE THE HUMAN PROBLEM

BY **CHRIS "CHUBBY" FREDERICK** | CONTRIBUTOR

WE ALL have witnessed the benefits and sometimes disadvantages of new technology in our careers as shop owners. I spent almost 35 years helping shop owners invest in new technology, so I believe I know a thing or two about it. I was in one of our classrooms last month and overheard our coaching team leader, George Zeeks, teach a class on how to get the most out of electronic tablets currently used in the shops. I was thinking, "I wish I had had George when I was in the automotive equipment business." Here is George's story:

It was dark by the time I arrived at Columbus, Ga., otherwise known as Fort Benning, the home of the infantry. My grandson had been training there, and after working a full day, I had caught a late flight. Everything is going smooth. All I want to do at this point is get to my hotel. I collect my keys. I go to the car. I load my luggage. I sit in the driver's seat. I can't start the car. I drive a car that has keys, and they go into an ignition. I couldn't find a place to put the key.

Keep in mind that I have spent a large part of my life in the automotive field. I know that the new cars don't have ignition switches, but my older truck does. The problem is that at 10 o'clock at night, tired after a very long day, I just plain forgot. I felt silly 15 minutes later when I saw the button that said "Push to Start." Technology is a great thing, and it exists to help make our lives easier. We have a ton of new technology coming out to help us run our shops better. The real question is, are we ready enough for it to help us?

Electronic courtesy checks done right

Electronic courtesy checks are all the rage with the new technology available to us. The problem is, are we doing a good job with the courtesy checks now? First, you have to have two different checks: one for waiters and one for the drop offs. The biggest issue for a waiting customer is time. If it takes you longer than 15 minutes to start your presentation, you're probably out of luck. I want you to keep in mind that this customer has not been seen by anyone for at least three to five thousand miles. It is our job to let them know what they need for current, pending or maintenance issues. If we take so long that we can't or don't let them know what the car will need, in a clear and logical fashion, then we are not doing a proper service. The fact that you now have a tablet system to help expedite the process doesn't fix a broken process. A crew that doesn't do good courtesy checks in a timely manner, with a paper checklist, will not do them with a tablet. That is just the reality that we face.

Photos: Thinkstock/ VLADGRIN

"WHAT ARE THE EASIEST WAYS TO INCREASE PRODUCTIVITY IN A SHOP? WORK ON THE 40 MOST POPULAR PRODUCTIVITY ROBBERS, THEN CROSS OFF THE ONES YOU HAVE ACCOMPLISHED,"

-CHRIS "CHUBBY" FREDERICK [ATI]

Throwing some new gadgets at a problem does not make the problem go away. The one big advantage is that when an owner spends the money to install a tablet system, they usually invest some time in training to make sure it pays some dividends. Time spent training is still time spent training. Whether it's on paper or electronic, both will pay off. The customers, technicians and the owners all end up better off.

A good manual system first

Don't confuse yourself thinking that electronic shop systems will make you more productive. The big claim is that the new system will make your shop more productive and they will, providing that you have solid expectations of your staff in place before the system goes in. Technology can make good producers become better. They cannot, however, replace the need for a solid basis of expectations for each and every person on the staff. It's basic math, but too many owners don't know it or don't pay attention to it. How much are you paying the person? How much do your benefits, holidays, vacations, sick days, training, FICA, FUTA and workman's compensation multiply the wages you are paying your staff? Then how much do you need to make off of that investment in order to make a profit? Once you have done all the math, then you have a solid expectation that you can pass on to the staff member.

Everyone wants to feel like they are doing a good job. Have you defined what that is and made it clear to each staff member? If you don't have this basic foundation in place, then all the technology available cannot save you. At worst, it will give you a false sense that everything will be OK now. It is the worst kind of false promise for you and your staff. They trust you and depend on you to help provide birthdays, vacations, etc., for their family. The technology can certainly take you to the next level, but you must have a solid grounding first.

Work flow productivity system

The last, but not least, thing that you must keep in mind is how your work flows. Managers know that this is one of the most important parts of their job. Productivity and profitability depend on it. The problem is that if we do not have a firm grip on the work flow without the technology, we are doomed with it. Expectations for job completion, handling the courtesy check in a timely manner and the timing of the sale or part delivery are just some of the issues that come up in many shops. These issues can only get worse with a tablet system if you are not prepared for it. One of the main selling points for these systems is the ability to stay on top of issues, but only if you have processes in place to handle them. You should have the solutions in place regardless of how you handle your information flow. If not, you're going to have problems, no matter what.

One great thing that we have seen is that the investment in a tablet work flow system does help to drive additional training. The training and the effort put into creating systems to make this new technology work the way it is designed can help shops reach a new level of productivity. Some of that increase could have happened if the shop simply worked on the problems they were already having. All shops have "productivity robbers." Some have a few and some have more. The key is the ability to identify them and develop solutions. This drives more productivity for the technicians, resulting in better customer experience and more money for everyone. Technology is great, but it can't solve the human problems — only you can do that.

Productivity robbers

If you would like a checklist of the productivity robbers most commonly found in shops, please click on the link below. We would be happy to share them with you. Check off the ones that apply to your shop and you will have a starting point to help increase your shop's productivity. Simply go to www.ationlinetraining.com/2016-02 for a limited time.

CHRIS "CHUBBY" FREDERICK
CONTRIBUTOR

Chris "Chubby" Frederick is the CEO and founder of the Automotive Training Institute. ATI's 115 associates train and coach more than 1,400 shop owners every week across North America to drive profits and dreams home to their families. Our associates love helping shop owners who are having the same struggle as many of them have had, and who are looking for the same answers — and in some cases looking for a lifeline. This month's article was written with the help of Coach George Zeeks.

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GETTING TO KNOW THE NEW AMI

The next generation of AMi seeks to foster the learning culture, more opportunities

BY **CHELSEA FREY** | SENIOR ASSOCIATE EDITOR

With the onslaught of technological advances and new information in automotive repair, shops are struggling to stay ahead of the curve. Jeff Peevy, the new president of the Automotive Management Institute (AMi), is using his experience and passion for education to lead AMi to provide more opportunities for learning and education for the collision and service repair industries.

AMi's mission

Since AMi's inception in 1989, the organization has reviewed and approved management and leadership training programs, providing credit hours toward the AMi professional designation known as the Accredited Automotive Manager (AAM). AMi has also developed a series of specialty degrees for the service and collision repair segments.

The overall goal for AMi has been to recognize those who have taken personal initiative to improve their knowledge, specifically in terms of management and leadership.

The learning culture

AMi's emphasis on the importance of personal growth partners with what Peevy garnered from his almost 17 years with I-CAR, which provides technical training for the collision repair industry. While with I-CAR, Peevy noticed a connection between shop management culture and the willingness of the shop's technicians to participate in training. Peevy explains, "Management tends to be the greatest hurdle a repair operation has to get over in order to change the attitude toward training and education." For Peevy, the transition to management-focused AMi was a great way to help both sides of the shop.

Changing the outlook on training partly involves altering terminology. Peevy says "to speak more in terms of 'learning' as opposed to 'classes' or 'training.'" Training is often viewed as a benefit, whereas learning is thought of as improving and developing the person. "Training is seen as a requirement and often isn't culturally connected to learning. Many will question the need to attend a class, but few question the need to learn," he states.

AMi's goals

Looking ahead for AMi, Peevy stresses the importance of spreading awareness about the learning culture. "Learning is truly the only source for a sustainable competitive advantage," Peevy explains.

AMi will offer various tools at no charge to help owners and managers better understand how they and their staff learn best as well as tips on how to get the most out of the various learning delivery methods, such as online, virtual and live instructor-led training.

AMi has multiple initiatives to implement the maximization of the learning culture, and it will carry them out by continuing to make industry connections. Peevy continues, "We will grow our collaboration with anyone offering high quality management and leadership learning opportunities, and through our new business model we will be able to do more to serve the student and the training providers. We plan to support consultants who often find individuals within an operation needing specific training in an area by providing training organized in structured competencies." The next generation of AMi will offer professional recognition and designations for roles specific to service repair and collision repair in customer service, office management and general management, including a masters-level general management program.

AMi will begin collecting Training Provider information through a survey on AMionline.org. The information will then be available free to the industry in a searchable database that will locate technical or management training in both service repair and collision repair, how the training is delivered and registration.

Finally, AMi will be launching the Leadership Foundation Program, enabling companies and individuals to support the relevant work of the new AMi. This program will recognize donations from those interested in the future success of their customers by enabling low-cost quality management and leadership training and professional recognition programs.

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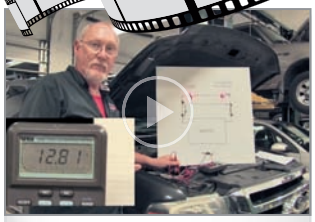

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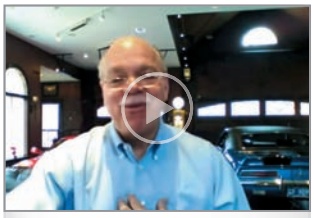

How to attract Millennials to your shop

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SOCIAL INSIGHTS

• Focus on employees

"Clients do not come first. Employees come first. If you take care of your employees, they will take care of your clients," said Richard Branson, as posted on the Facebook page of the Automotive Service Association of the Midwest.

MotorAge.com/ASAMidwestFB

• 5 misperceptions of marketing and the realities

"We're working on a proposal right now where the prospect stated they wanted to 'move quick.' Most salespeople would salivate with the opportunity to get a quick signature, but I view it now as a warning sign. Moving quickly typically leads to an expectation of getting leads quickly. While that may be possible, until we thoroughly analyze the client, the competition and the opportunity, we're not sure how quickly we can get the results," writes Douglas Karr on the Marketing Tech blog, www.marketingtechblog.com.

"Is it misperception? Misconception? Or perhaps it's missed expectations. Perhaps it's a combination of all of the above, but marketing does have incredible challenges."

Take a look at five key misperceptions, the realities and tips to improve the success of each.

MotorAge.com/MarketMyths

• Does your ZF5HP-19 go bump and clunk?

ATSG (Automatic Transmission Service Group) posted an article on its blog helping guide readers on how to tackle a transmission problem. "Audi or BMW vehicles, equipped with the ZF5HP-19/FL/FLA may exhibit a condition of a firm engagement in the drive position accompanied with a harsh coast-downshift. This condition will typically get more pronounced when hot. This condition seems to be more prevalent in vehicles 2003 and newer."

MotorAge.com/ZF5HP19

• How to wow your customers every time

Mitchell 1 shares some great stories and ideas, contributed by their readers, that will help you wow your customers every time they visit your shop.

"We hope that maybe you can start the new year by implementing some of these, or perhaps they will inspire you to come up with your own special ways to WOW your customer in your auto repair shop," wrote Mitchell 1 blogger Chris Bonneau.

Some ideas include: ice cream treats, free oil changes and free loaners. Take a read of the other suggestions to keep your customers coming back again and again.

MotorAge.com/customerwow

• Garage Gurus adds new enhancements in 2016

Garage Gurus wil offer an expanded curriculum, additional training center locations, attractive technician incentives and several other program enhancements in 2016, reported *Motor Age* on its Facebook page. Take a look at what else is to come in 2016.

MotorAge.com/Gurusadds

• ASE A-Series Car & Light Trucks

These nine Motor Age ASE study guides cover the passenger car and light trucks series of ASE certification, tests A1 through A9. They provide valuable information to help prepare for the ASE Certification Tests. Included in all of our ASE Study Guides is the ASE Task List for that particular exam, detailing exactly what type of knowledge and experience is necessary for the individual specialty. The easy-to-read text and illustrations provide important background information, as well as details of each area to fill in any gaps that may exist in your technical knowledge.

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MARCH 18-20
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MARCH 19
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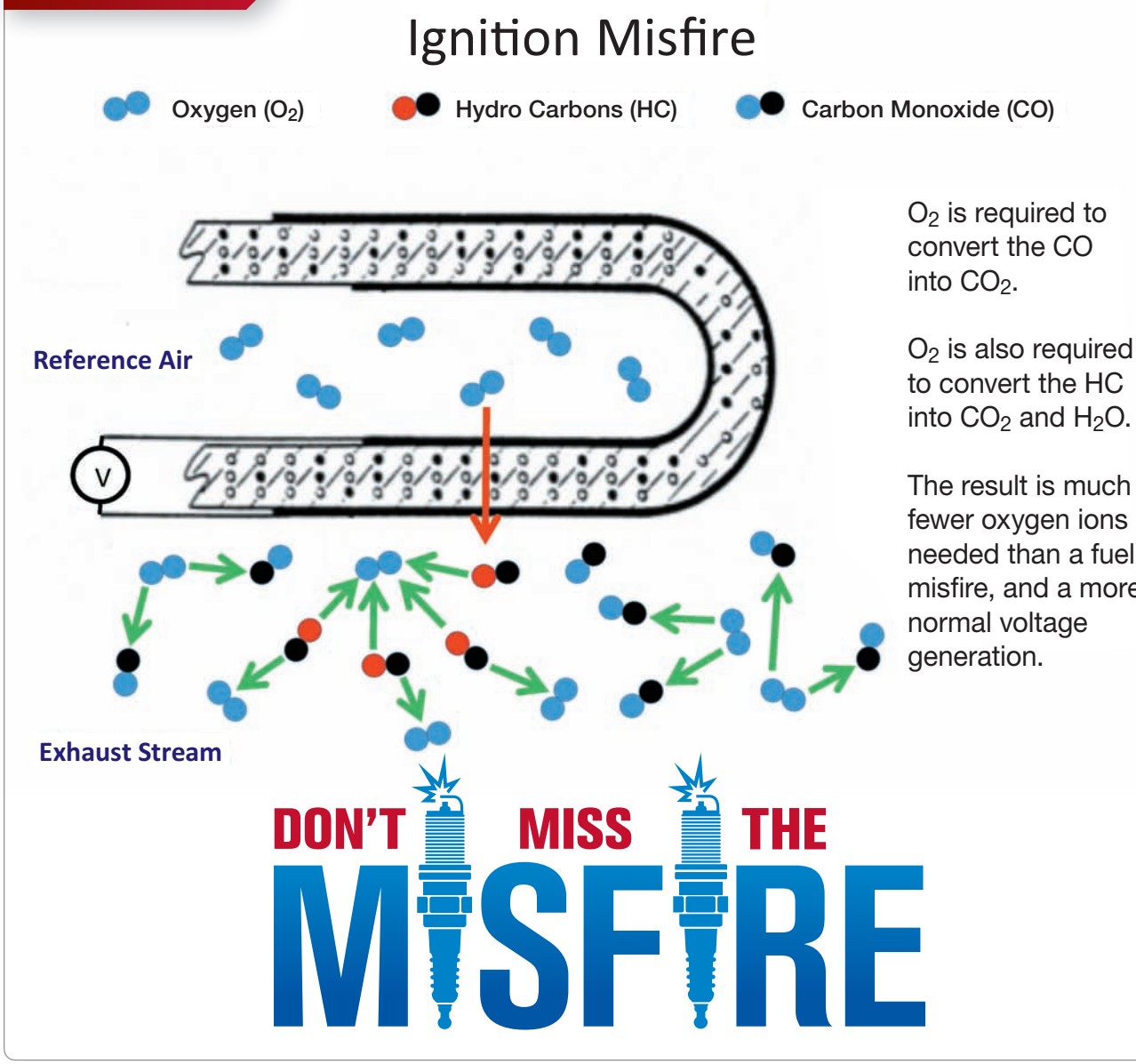

A PROFESSIONAL APPROACH TO MISFIRE TROUBLESHOOTING

BY **ERIC ZIEGLER** | CONTRIBUTING EDITOR

A friend once asked me about the difference between a mechanic and an automotive technician. After giving it some thought, the simplest explanation I could come up with was that a mechanic might spend 10 percent of the repair time diagnosing the problem and 90 percent of the time repairing the issue. Conversely, an automotive technician might spend 90 percent of the repair time diagnosing and 10 percent of the time actually repairing something. Most shops are a combination of both types of this work, and each tech/mechanic uses whichever description they self-identify with. My friend asked for an example of each. I provided that a brake noise caused by worn-out brake pads would be my impression of "mechanic" work and that misfire diagnostics would be more of a "technician" type job. After giving it some additional thought, I came to the conclusion that chasing down a misfire could be a little of both.

Misfire diagnosis can be fairly straightforward, but far too often one misses (pun intended) a crucial piece of information and ends up down the rabbit hole. This article's purpose is to look at the different causes of misfires and how to identify or eliminate the potential causes to come to an accurate diagnosis. I believe a solid plan of action (POA) is required to stay on task and avoid wasting time and money by missing the misfire.

There are some things we need to

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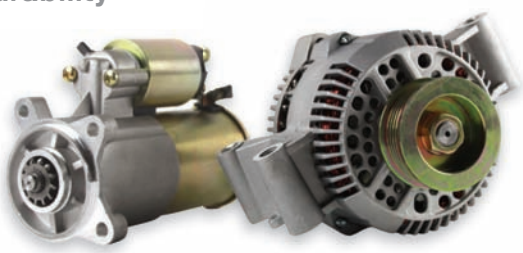

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take into account: pattern failures, Technical Service Bulletins (TSBs), vehicle history and customer descriptions. We need to examine the misfire conditions like load, humidity, ambient temperature and engine temperature. Is the misfire a single cylinder or multiple cylinder problem? Is the misfire on the same bank, on adjacent cylinders or on sister cylinders? All these are critical pieces of the misfire diagnostic process. The who, what, when, where and how questions need to start at the service counter. The "why" is our job as techs to identify.

Chasing down the "why"

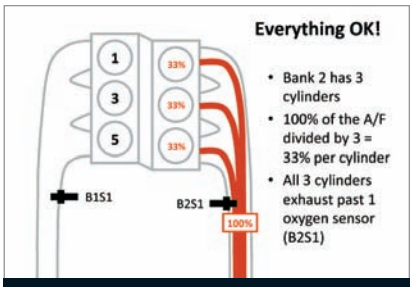
Misfires occur when combustion does not happen or is incomplete. Combustion requires three things: compression, fuel (or correct air to fuel ratio) and ignition. Where do we test first?

The best POA involves gathering as much information with the least amount of effort. I believe this always starts with a scan tool. Modern scan tools have gotten so much better at aiding in the diagnosis of misfires. OBD II codes, freeze frames, mode $06, cylinder contribution and relative compression tests are all great improvements to modern scan tools, not to mention the ability to graph data and fuel trims.

The scan tool approach begins with checking for codes and freeze frames to hopefully identify the cylinder(s) and the conditions when the misfire occurred. Next, fuel trims, O_2 sensors and other data Parameter Identifiers (PIDs) should be examined to help identify the root of the problem. From here, our goal is to form a hypothesis and design an experiment to test our theory. One of the major hairs to split with misfire is whether we are dealing with a fuel or ignition misfire issue. O_2 sensor readings and fuel trims (FTs) give us some direction and help to differentiate between these two. An important note to remember about using FTs is that we should be in closed loop and should always check our loop status PID.

What can fuel trim tell you?

Let's start with looking at a single cylinder fuel-related misfire. In this example, we had a bad poppet-style injector assembly on a 1996 Trailblazer with a



Each bank has a single oxygen sensor. The PCM computes fuel based on the total amount of air being fed to the engine, not per cylinder.

4.3 Liter V6 that coded P0300. The scan tool indicated a misfire on cylinder 6 and the FTs were +35 percent on Bank 2. Is this an ignition-related misfire or a fuel-related one?

What happens if we have a single cylinder ignition misfire? We know that if a cylinder misfires because a fuel injector does not open, the cylinder still pumps oxygen. The same could be said if a cylinder misfires because of an ignition misfire, correct? So shouldn't the oxygen sensor report the same for an ignition misfire as it does for a fuel misfire? Let's think about this a little more. When combustion occurs, are the HC (raw fuel) and O_2 being consumed? Molecularly, what is really happening?

We know that the engine takes in $HC + O_2 + N_2$. Heat causes the atoms to disassociate and reform new molecules after combustion/oxidation occurs. With combustion taking place we ideally would expect to see the output of $CO_2 + H_2O + N_2$. In all actuality, it would be more like $CO + CO_2 + O_2 + HC + H_20 + N_2 + NOx$. Regardless, the same number of atoms came out that went in — HC, O_2 and N_2. Or better yet: H, C, O and N. All of the atoms involved separated from one molecule and became a new molecule. The quantities of the individual hydrogen, carbon, oxygen and nitrogen atoms, however, stayed the same.

The amount of oxygen remains the same. The ignition misfire still produced the same exhaust output of 20 percent oxygen and 6 percent fuel. The fuel misfire produced different results – 20 percent oxygen and 4.5 percent fuel. Therefore, with the fuel misfire, the A/F ratio was lacking 25 percent of the fuel it should have had (or had 25 percent too much oxygen.) This would result in the oxygen sensor detecting

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a lean condition and would cause the fuel trims to go positive.

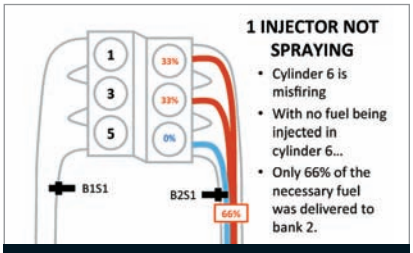
As a generalization, a single cylinder misfire caused by fuel usually manifests itself with high positive fuel trims. Conversely, a single cylinder misfire caused by ignition will generally have minimal positive fuel trim corrections. To prove this to yourself, design an experiment and record the results using the same vehicle while creating a single cylinder misfire by disabling ignition to a single cylinder and then by disabling fuel to a single cylinder.

What about mechanical causes?

Up to this point we have discussed the two more common causes of misfire: fuel and ignition. However, the mechanical misfire is another type of misfire that troubles techs and drives service advisors and owners crazy after ignition or fuel-related parts/procedures have been recommended and an issue still persists. Obviously compression and cylinder Volumetric Efficiency (VE) have an effect on combustion in the cylinder and can result in a misfire issue as well. A colleague once told me that he trains his techs that driveability diagnostics is oftentimes more of proving what something isn't as much as it is proving what something is.

Mechanical misfire is a perfect example of this. I want to figure out very early in the diagnostic process that I can eliminate engine mechanical as a cause of the misfire rather than after ignition or fuel-related parts/procedures have been recommended. I was taught a great technique to do this with a lab scope by John Thornton. It is called the "Relative Compression with Sync" test, and I use it every time I pull out a scope for a drivability issue and most certainly for misfire diagnostics. I also couple it with a cranking vacuum test with a transducer in the intake manifold to quickly eliminate engine mechanical as a cause of a misfire or a drivability problem. Let's look at how to perform this quick, efficient and essential diagnostic test.

The test requires a lab scope and a couple of peripherals to complete it. A high current inductive probe is needed, as is the ability to capture an ignition sync of some sort. This could be an inductive sync probe if plug wires are present, a low-current inductive probe, a scope lead and attenuator (if required) for a single cylinder's primary voltage or to a scope lead attached to a COP trigger signal. The fuel system is disabled and a steady RPM crank/no start condition is required. The high current inductive probe is attached to the starter, the battery



If fuel is lost to one cylinder, it's seen in the exhaust as a loss in relation to the number of cylinders in the bank. In this example, one could expect to see a positive fuel trim correction on Bank 2 of roughly 30 percent positive.

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positive or the negative battery cable. This test uses the principle that the compression stroke in a cylinder is the stroke that requires the starter to work the hardest to overcome the pressure being built in each cylinder. It also recognizes that there are compression strokes occurring at different times. As the starter has to work harder to overcome each cylinder coming up on its compression stroke, the starter current raises and then falls as the piston passes Top Dead Center (TDC) of the compression stroke in each individual cylinder.

Next, an ignition sync should be added. The ignition sync can be secondary voltage, primary voltage, primary current or ignition trigger. The purpose of the ignition sync is two-fold — to identify a specific cylinder in order to apply the firing order correctly and to determine if the ignition firing event is timed properly to piston position. If the ignition sync signal fires to the right of the TDC portion of the starter current on the relative compression waveform, it can be an indication that the plug is being fired after TDC compression in the synced cylinder. This can be caused by the reluctor mechanically shifting. Examples of this could be a broken flywheel or a worn balancer key.

Adding a vacuum transducer to the intake manifold will enhance our engine mechanical testing by showing whether each cylinder has a distinct vacuum "pull" and whether they are relative to one another. Transducer testing is a whole other article in itself, but what I want to know quickly and early on is whether or not I can take engine mechanical off my list of possible suspects in my misfire investigation.

Here's an example

The following vehicle is a 2000 Honda S2000 with 2.2 liter 4 cylinder with 156,000 miles. It had set PCM codes for P0300, P0301, P0302, P0303 and P0304. It had been recently tuned up and had the fuel injectors and upper intake tract cleaned. The shop also replaced a couple of ignition coils. The vehicle didn't seem to run profoundly bad, however, the idle was slightly shaky. The FTs were slightly negative and the MAP voltage seemed a little high at 1.4 volts at idle. A scope was used to gain better diagnostic direction.

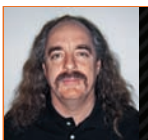
The relative compression with sync test will be used first and then the cranking vacuum test will be added. The cranking vacuum test reveals that each individual cylinder's vacuum "pulls" are not relative to one another either. Both of these results are indicative that the misfire is most likely mechanical in nature and that further engine mechanical testing will be required to complete the diagnostic. The one thing we do know is that there is a mechanical issue that needs to be corrected.

A compression test is performed and the results are compared. Cylinder 1 has 171 psi of compression and cylinder 3 has 141 psi.

With the results of the misfire codes in multiple cylinders, the relative compression with sync test, the cranking vacuum test and the compression imbalance between cylinders, it appears that the issue lies in the valve train. Since the Honda uses a mechanically adjusted valve clearance (screw and tappet), the first logical place to look was the valve clearance. The valve adjustment is checked and the clearances are too tight.

Once the adjustment is completed, the compression is now equal in the cylinders; the cylinders in the relative compression test and cranking vacuum waveform are now "relative" to one another, the idle smooths out and the misfire codes no longer set. If the above scope testing had been performed earlier in the diagnostic, the technician wouldn't have "missed the misfire."

In summary, having a good POA, starting simple with a scan tool, using fuel trims and using the scope tests to eliminate mechanical issues will serve you well in misfire diagnostics.



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COMPACT TRANSMISSION OFFERS DIAGNOSTIC BENEFITS

BY **WAYNE COLONNA** | POWERTRAIN PRO PUBLISHER

KIA and Hyundai manufacturers use a front-wheel drive 6-speed transmission in many of their vehicles. The name for this transmission is determined by the size of the engine it's paired to. From as small as a 1.2L engine to as big as a 4.0L, the names begin with A6GF1, increasing to A6MF1 and 2, and then to A6LF1, 2 and 3. Similarly, as engine size increases, so does the size of the transmission, due to the necessary increase in torque capacity. The general application of these transmissions is as follows and is not limited to:

- The A6GF1 is fitted with a 1.2L, 1.6L, 1.8L or a 2.0L engine. Most are behind the 1.6L.
- The A6MF1 is fitted with a 2.0L/2.4L engine with a maximum torque capacity of 230 Nm (376.4mm length).
- The A6MF2 is fitted with a 2.4L engine with a maximum torque capacity of 280 Nm (386.4 mm length).
- The A6LF1 is fitted with a 3.3L engine with a maximum torque capacity of 329 Nm (386 mm length).
- The A6LF2 is fitted with a 3.5L/3.8L engine with a maximum torque capacity of 358 Nm (389 mm length).
- The A6LF3 is fitted with a 4.0L engine with a maximum torque capacity of 392 Nm (402 mm length).

A variation of this little 6-speed can also be found in late-model Dodge Dart 2.0L and 2.4L vehicles (2012 and up), which in this application is called the 6F24. In Hyundai and Kia vehicles, this would be the A6MF1 transmission.

In some instances, on the transmission there is a tag riveted to the case with the vehicle identification number on it. Alongside this tag, etched into the case is a transmission number. If the identification number begins with the letters NA, it is the A6GF1; BA, it is the A6LFx transmission. EA or FA will be the A6MFx. When it comes to Hyundai and Kia, this transmission is simply referred to as the A6 transmission.

A component application chart is provided in **Figure 1** for this compacted transmission. Three brake clutches, two driving clutches and a one-way roller clutch are used to operate three planetary gear sets to obtain six forward ratios (speeds) and one reverse ratio (speed).

One nice aspect to this transmission from a diagnostic standpoint is that there is a pressure tap for each clutch assembly. Converter clutch apply and release taps are also available between the side pan and the converter housing. These can be easily identified with the typical case embossments next to the taps with letters DR and DA for Damper Release and Damper Apply.

Two reducing pressure taps are also available by the back cover. The pressures observed on these taps are pressure supplied to the solenoids and pressure switch valves (PSV) in the valve body. RED 1 is solenoid supply pressure to shift solenoids A and B and the PSVs while RED 2 provides supply pressure to all remaining solenoids.

What makes these taps nice to have is that the valves that provide these pressures are prone to elongating their bore. This will cause unstable supply pressure to the solenoids and PSVs producing either solenoid performance codes or gear ratio codes. Dodge offers up pressure specifications for these two valves with their 6F24 transmission. RED 1 is 73-75 psi max and RED 2 is 79-81 psi max. Making a quick pressure check on these taps can give you your valve body's state of health before pulling the unit or the valve body.

Another nice aspect to this transmission is the ability to perform TCM re-learn procedures. Other than the first to second shift, all other shifts are synchronized. This makes TCM re-learn critical towards having quality clutch to clutch shifting. When shift shock or flare occurs, or parts related with the transaxle are replaced, TCM learning should be performed.

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.

Photos: Wayne Colonna

TCM learning is required during Transaxle assembly replacement, TCM replacement and TCM upgrading.

TCM Re-learn steps:

ATF temperatures must be between 60 - 115°C (140 - 239°F) during all relearn procedures

1. The stop or stationary learning procedure re-learns garage shifts into gear.

With foot on the brake and 0 percent throttle opening, shift into neutral for three seconds. Then place the selector lever into drive and hold for three seconds.

Repeat this shift pattern four times or more all the while keeping your foot on the brake.

2. The drive learning procedure is as follows:

Drive the vehicle through all gears in the D range.

Drive from stop to 1st to 2nd to 3rd to 4th to 5th to 6th with keeping upshift throttle opening fixed at 15 percent - 30 percent.

Downshift from 6th to 5th, 5th to 4th, 4th to 3rd, 3rd to 2nd, 2nd to 1st.

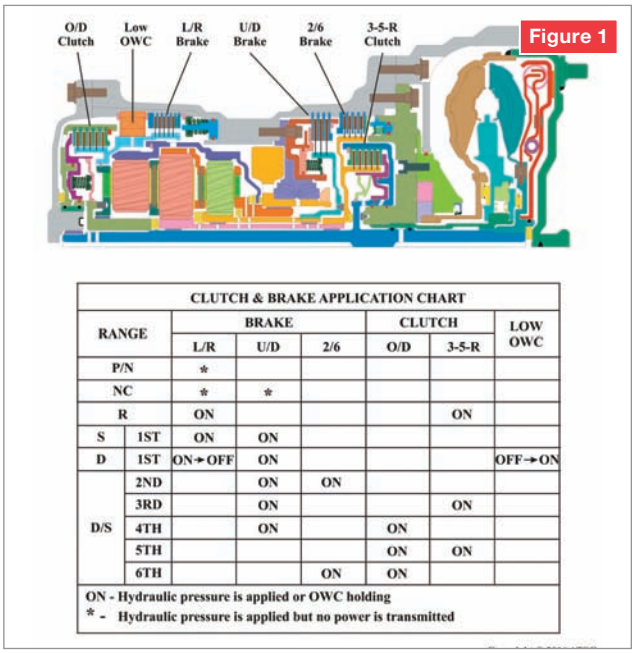
Repeat the above driving pattern four times or more.

In the lower left corner of the side pan is a fill and check lever plug. If the transmission has been drained, the following is the factory ATF Level Inspection procedure:

1. Add approximately 5 qts of Kia Type-4 ATF.

2. Using the GDS (or scanner), select vehicle; then A/T menu; then Current Data, and then Oil Temperature Sensor.

3. Run the vehicle long enough to warm up ATF to approximately 122-140°F (50-60°C).



CLUTCH & BRAKE APPLICATION CHART

RANGE		BRAKE			CLUTCH		LOW OWC
		L/R	U/D	2/6	O/D	3-5-R	
P/N		*					
NC		*	*				
R		ON				ON	
S	1ST	ON	ON				
D	1ST	ON→OFF	ON				OFF→ON
D/S	2ND		ON	ON			
	3RD		ON			ON	
	4TH		ON		ON		
	5TH				ON	ON	
	6TH			ON	ON		

ON - Hydraulic pressure is applied or OWC holding

* - Hydraulic pressure is applied but no power is transmitted

4. Depress the brake pedal and move the shift lever into reverse, neutral and drive and then back, pausing 2 to 3 seconds in each gear range.

Repeat this procedure two times.

5. Shift to park" leave the engine running, and then lift up

vehicle on hoist.

6. Remove the splash shield under the automatic transaxle.

7. Remove the oil level plug. ATF level is correct if the ATF flows out in a thin, steady stream. If no ATF flows out, go to step 8.

8. If ATF flow does not occur, add Kia Type-4 ATF via the oil level hole until ATF flows out in a thin, steady stream.

9. Reinstall the oil level plug and torque to 25-32 lb-ft (34-43 Nm).

Alternate ATF filling procedure:

If a suction gun or equivalent tool is not readily available, locate the Vent Eyebolt on the top of the automatic transaxle oil pan near the battery. Remove the Vent Eyebolt and add Kia Type-4 ATF via the opening. Reinstall the Vent Eyebolt. Full fill typically is 8.24 qts (7.8L).

Transmission fluid temperature plays a major role in checking both fluid level and with re-learning the TCM. Should the temperature sensor be defective providing incorrect data, this will negatively affect both procedures.

There is an OE TSB (#043 [Rev 2] 02/25/2013) that speaks about defective oil temperature sensors producing TFT codes P0711 (Rationality), P0712 (Circuit Low) and/or P0713 (Circuit High).

Be sure the TFT sensor is working properly before performing any procedure that is dependant upon it. It may be helpful to own a laser temperature gun to compare what it says to the parameter displayed in the scan tool. If the TFT sensor needs to be replaced, it is located on the valve body.

Another issue is a Torque Converter Clutch Circuit Performance or Stuck Off code P0741 code setting in memory. This typically is a bad solenoid. To avoid any confusion, some literature and/or scan tools will refer to this solenoid as the DC solenoid for Damper Clutch. It is the solenoid to the very right.

This is a Normally Low variable force solenoid. Without operating the solenoid, it does not send hydraulic pressure to its associated valves (TCC Pressure Control and Shift valve). As it is duty cycled, its controlled signal pressure works on these valves to smoothly apply the converter clutch. As it is being commanded to do, the computer is comparing engine rpm (ERPM) with the input shaft rpm (ISS) to control the rate in which the clutch is applied. Once it is fully applied, both rpm readings should be near the same. If these two rpm reading do not match when full apply is commanded, P0741 sets.

This also typically is due to a mechanically failed solenoid. It can also be stuck valves, bad rings or torque converter. Should a new converter clutch solenoid be needed, there are two different part numbers. If the transmission being worked on is using a steel side oil pan, it takes a 46313 3B673 solenoid. If it has a plastic oil pan, all A6LF transmissions will use this same solenoid. But the A6GF and the A6MF style transmissions with a plastic pan use solenoid part number 46313 3B073.

If P0743 sets for electrical problems, this solenoid measures approximately 5 ohms and ranges between 50 to 850 mA. **Figure 2** provides terminal identification for the transmission's pass through connector. Pin 10 is the power supply for the TCC solenoids and is ground controlled through pin 2.

If checks are to be made at the computer, refer to factory wiring diagrams. With the transmission being in a variety of platforms, the transmission is controlled by one of three different computers. As a result, the TCM/PCM makes can be Kefico (TCM), Delphi (PCM) or Continental/Siemens (PCM).

Figure 2

Pin Assignments

1. Not used	10. Power Supply (TCC, OD, 35R, SSA)
2. TCC Control Solenoid	11. 2/6 Variable Force Solenoid
3. OSS Power	12. Shift Solenoid B
4.OSS Signal	13. TFT +
5. Power Supply (LP, U/D, 2/6, SSB)	14. ISS Power
6. 3-5-R Variable Force Solenoid	15. Empty
7. OD Variable Force Solenoid	16. UD Variable Force Solenoid
8. ISS Signal	17. Line Pressure Solenoid
9. TFT -	18. Shift Solenoid A

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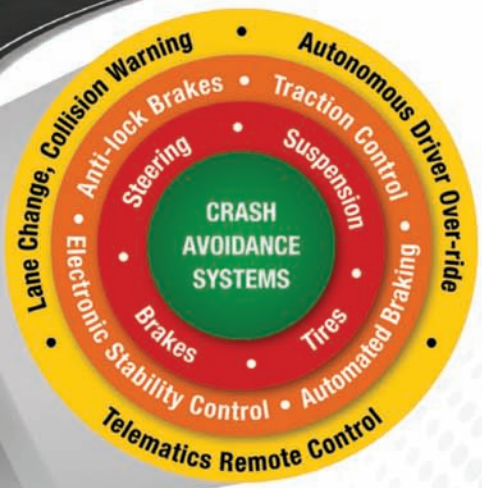

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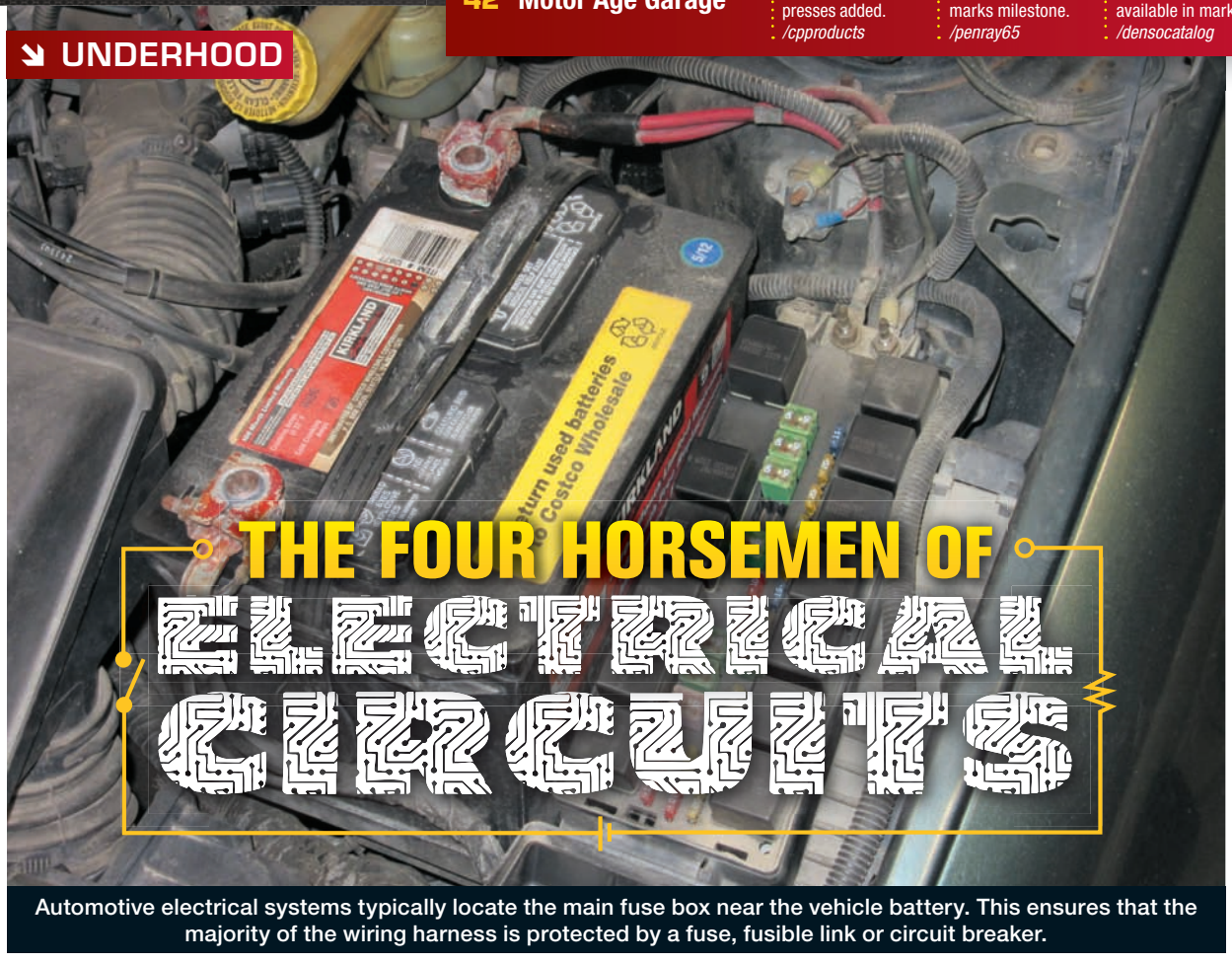

THE FOUR HORSEMEN OF ELECTRICAL CIRCUITS

Automotive electrical systems typically locate the main fuse box near the vehicle battery. This ensures that the majority of the wiring harness is protected by a fuse, fusible link or circuit breaker.

THERE ARE ONLY FOUR WAYS AN ELECTRICAL CIRCUIT CAN FAIL. KNOWING THAT PUTS YOU ONE STEP CLOSER TO FIXING THE PROBLEM!

BY **TONY MARTIN** | CONTRIBUTING EDITOR

It's easy to feel intimidated when you are tasked with solving an electrical problem on a late-model vehicle. Modern automotive electrical systems are complex and only getting more so with each new model year. To make matters worse, lots of technicians struggle with basic electrical theory and have not acquired diagnostic strategies to assist them in conquering these problems. Many would rather be doing brakes or engine work, but there aren't any systems left on the vehicle that don't have electrical components. You can run, but you can't hide!

If this is describing you, take heart. The electrically-challenged technician should always remember the following:

1. Electricity always works the same, no matter how complex the system.
2. There are only four possible failures that can take place in an electrical system. These are the open circuit, high resistance, short to ground and short to power.
3. Understanding the customer concern and simple visual inspection can often narrow down which of the four failures you are dealing with.

So, take a deep breath while we walk through the basics of what you need to know to become a top-notch electrical troubleshooter!

The basics

Let's do a quick review of electrical fundamentals. First off, what is electricity? Scientists are always coming up with new information on that, but we can assume that electricity is the flow of electrons through a conductor. Electrons are one of the basic building blocks of matter, and are an integral part of the atom. An atom is the smallest particle that an element can be broken into and still retain the properties of that element. An example of

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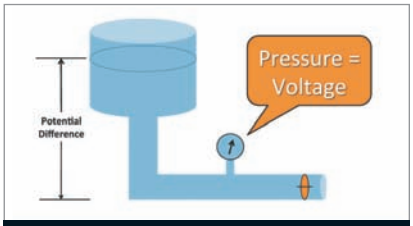
an element is copper, which has free electrons that can be moved from one atom to the next, much like a rock skipping across the water.

Electrical geniuses like Edison discovered long ago that if you could make electrons flow, you could do a lot of useful work. Electron flow is known as current, and is measured in amperes. Think of it like water flowing in a pipe. In order to increase the rate of flow, the pipe will have to get bigger in diameter. Electricity is no different. More electrical current can do more work, and the more current you want to move, the bigger the wire will have to be. All the biggest wires on your car are made to flow more current and do more work, the best example being the cable running from the battery to the starter motor.

What makes water flow through a pipe? There has to be a pressure difference; a higher pressure at one end and a lower pressure at the other. Water will naturally flow through the pipe away from the end with higher pressure and towards the area with lower pressure. If there is no difference in pressure, water will not flow. In the same manner, electrical current will not flow without a pressure difference. The "pressure" behind the electrical current is known as voltage, and is measured in volts. Voltage is also known as potential difference, or electromotive force (EMF). While it is possible to have voltage (pressure) with no current flow, it isn't possible to have current flow without voltage.

A partially closed valve or damage to a water pipe that reduces its diameter will increase the pipe's restriction to flow. Increased restriction to flow, in turn, will reduce water flow. Electrical resistance works the same; increased resistance results in reduced electrical current flow. Electrical resistance is measured in ohms and can be caused by loose connections, frayed wires or corroded terminals. An important principle to keep in mind concerning resistance is that the closer you get to zero ohms, the less the resistance in the circuit. In turn, an energized circuit that has zero amperes of current flow would have infinite resistance.



Voltage is electrical pressure — the force that causes current to flow in a circuit. You can have voltage with no current flow, but current flow will not happen without voltage.

You've likely heard of Ohm's Law, which is named after a German physicist and mathematician named Georg Simon Ohm. Ohm's Law is central to this discussion because it describes the relationship between voltage, current and resistance. In simple terms, Ohm's Law states, "one volt of electrical pressure will cause one ampere of current to flow through one ohm of resistance."

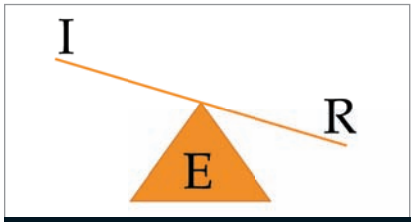
Ohm's most important contribution to a technician's understanding of electricity is that when circuit resistance rises, current flow decreases. The reverse is also true; if circuit resistance is reduced, current flow will increase. This explains a lot of what we see in the field everyday as technicians, helping us understand the why and how of many electrical failures. When failures take place, either current isn't flowing at all, current flow is reduced, or the current is flowing somewhere that we don't want it to.

What goes wrong

We all know armchair automotive technicians who attempt to diagnose electrical problems by hearing the story and then telling you that a "short" is causing it somewhere in the system. Not helpful! I don't do this personally, but if you were to ask them exactly what a "short" is or how to narrow down where it is taking place, they would be hard pressed to give you an answer.

Despite their good intentions, calling every electrical failure a "short" is misinformed. There are a total of four possible failures that can take place in an electrical circuit: an open circuit, high resistance, short to ground and short to power. So what are the symptoms of each of these failures, and how do we go about locating them?

The technician needs to start by getting a solid understanding of the



If voltage (E) stays the same but resistance (R) decreases, current (I) will increase. If resistance increases, on the other hand, current will decrease.

customer concern. Ask clarifying questions, including whether or not the problem is intermittent. This will give you some clue as to which of the four possible failures you are dealing with. Try to have the customer present as you verify the concern, and if necessary, go for a test drive with the customer at the wheel.

The next step is to perform a visual inspection and basic tests. This is the simple stuff like bulbs and fuses. Don't pull the fuse; instead, check both sides for battery power with your voltmeter. Is the fuse melted? If so, there has been excessive current flow caused by reduced resistance in the circuit. If the fuse is OK, circuit resistance is either normal or too high. A significant percentage of electrical problems are solved at this step, so be thorough.

1. Open circuits

When the customer states that a device is not working at all, you should start thinking open circuit. An open circuit is a broken connection that stops electric current from flowing. Because a connection is broken, circuit resistance is infinite. An open circuit is also known as a non-continuous circuit.

If the fuse is OK, this further reinforces the open circuit diagnosis. Your next step is to gain access to the malfunctioning device and turn the circuit on. With the negative lead of your voltmeter connected to a good ground, measure voltage on the power side of the device. You should see battery voltage on the meter; if not, you will need to measure voltage at points upstream from the device to narrow down the location of the open circuit. Keep working your way back towards the battery; when you suddenly find battery voltage, the problem is between there and the last place that you measured.

What if you measure voltage on the power side of the device, but it still isn't working? Your next step is to measure voltage on the ground side. If you happen to measure battery voltage on both sides of the device, the device is good and there is an open on the ground side of the circuit. Connect a jumper wire between the ground lead of the device and the vehicle frame to confirm your diagnosis.

If there is battery power and a good ground available at the device but it still doesn't work, it's pretty obvious that the device itself has failed.

2. High resistance

When the customer states that a device is working poorly, this immediately tells you that you are dealing with high resistance. This could be a dim lamp, a motor turning slowly, or an electric heater that isn't getting hot enough. There is a poor connection somewhere in the circuit, and increased resistance is reducing the voltage available to the device.

This is caused by a phenomenon called voltage drop, which takes place any time electrical current flows through a resistance. Low resistance connections allow current to flow unopposed and cause very little voltage drop. A poor (corroded or loose) connection, on the other hand, will actually consume voltage and leave less for the device to use. A voltmeter connected across a connection or wire will tell the story. If the connection is good, only a few millivolts of drop will show on the voltmeter. A poor connection will show more than just higher voltage drop numbers, it may also show signs of getting hot. This can melt plastic connectors and burn insulation over time, and is a sure visual sign that you've found the source of your high resistance!

No need to check the fuse on this one — it is good. Turn the circuit on and take a voltage measurement across the device. You should see close to battery voltage, but odds are good in this situation that it will be significantly less. If you are seeing more than 1 volt below battery voltage, it is time to go looking for a high resistance failure.

There could be high resistance on the power side, on the ground side, or both. Connect the negative lead of your voltmeter to a good ground and check the voltage at the power side of the device.

If the voltmeter is now showing close to battery voltage, the power side is good. However, if the voltage there is low, you will need to work your way upstream looking for voltage drop. If you see battery voltage at a point in the circuit, the high resistance is somewhere between there and the last point you checked.

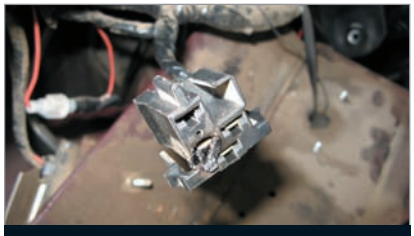
If the power side showed close to battery voltage, the failure is taking place on the ground side of the circuit. With the negative lead of your voltmeter connected to a good ground, check voltage at the ground wire of the device. The voltmeter should show just millivolts of drop if it is good. If the reading is higher, repair the poor ground connection and verify correct device operation.

3. Short to ground

Here is where it gets interesting. If the customer tells you that a device is not working at all and you find that the fuse is melted, a short to ground is a possible cause. A short to ground is a low-resistance path to ground, causing excessive current flow. This is often caused by a wire rubbing through its insulation and making contact with the frame of the vehicle (copper to steel). However, it can also be an internal failure of a device, which can only be repaired by component replacement.

If you happen upon a melted fuse, start by replacing it and then operate the circuit. It is possible for the fuse itself to be the root cause of the problem, but if the new fuse blows right away, you've got something else going on. Did the fuse blow the moment you replaced it, or after the circuit was switched on? That tells you right away if the problem is upstream or downstream from the switch.

Take a careful look at the wiring diagram to determine how many circuits are powered by the fuse that failed. Which circuits are most likely to cause a short to ground? Is it possible to disconnect circuits that you suspect may be causing the problem? If the fuse stops blowing when a certain component or section of the circuit is disconnected, you are that much closer to solving the problem.



A telltale sign of a high-resistance failure is a melted connector. Once this terminal started getting hot, it was game over for the pigtail and the switch connected to it.

In my experience, a short to ground can often be found where some kind of monkey business has taken place. A really good example of this is trailer wiring that has been spliced into the vehicle harness. Loose wires that rub against the frame can cause an intermittent short to ground that affects lighting circuits. Another possibility is an accessory that was installed in the vehicle recently. Is it possible that a mounting screw was driven into a wiring harness?

A more sophisticated method for locating a short to ground is to use a tone generator. This diagnostic tool has a transmitter that connects to the fuse holder (or another point on the wiring harness) and sends a signal through the problem circuit. The technician follows the circuit with a receiver that emits a tone when it senses the signal traveling through the wire. When you get close to where the short to ground is located, the sound from the receiver turns off. These tools can sometimes be used to assist the technician with finding open circuits as well.

4. Short to power

A short to power could be reported to you in a couple different ways. First, the customer could tell you that a certain device on their vehicle won't shut off. Another possibility is the customer saying that they have to get their vehicle jump started after it sits overnight. A short to power is a failure where a switch is being bypassed; either the switch itself has an internal short circuit, or a wire downstream from the switch is making contact with a wire from another circuit. In all likelihood, the fuse will be OK, but the circuit will be powered up when you don't want it to.

If the customer says that a device won't shut off, start by pulling the fuse for that circuit. If the device is now off, the problem is isolated to that one circuit. Reinstall the fuse and then disconnect the circuit switch; if the device turns off now, the switch has an internal short circuit. If the device stays on when the fuse is pulled, it is getting power from another circuit. Inspect the wiring harness carefully, looking for sections that may have rubbed through and caused a copper-to-copper failure.

Here's an example of a failure in a ground that affected more than one device. Voltage drop across this connection caused malfunctions in the rear wiper, rear washer and rear defrost circuits.

If the customer says that their battery is going dead overnight, you likely have a parasitic drain to deal with. Avoid pulling fuses if you can. Instead, use your DVOM to measure voltage drop across individual fuses with the ignition key off. Normal circuits will display very low millivolt readings. If you find a fuse that has a much higher millivolt reading than the others, you've likely found the circuit that is killing your customer's battery!

Get after it

We can talk all day about electrical troubleshooting, but the only way to really learn it is to get out there and start fixing cars. Get yourself a good quality DVOM, start looking at wiring schematics every time you diagnose a vehicle, and get some solid repairs under your belt. In good time, you will have customers asking for you by name to get their electrical problems taken care of.

TONY MARTIN
CONTRIBUTING EDITOR

Tony Martin is a mobile equipment maintenance trainer with Kinross Gold Corporation. He is a qualified Heavy Duty Equipment Mechanic and post-secondary level educator. He writes about automotive electronics, diesel technology, and alternative energy.

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Knowing how and when to use your electrical diagnostic tools such as a digital multimeter is a necessity for getting to the correct diagnosis quickly.

TO BE SUCCESSFUL IN ELECTRICAL DIAGNOSTICS, YOU HAVE TO BE SOLID IN YOUR FUNDAMENTALS.

BY **DAVID MACHOLZ** | CONTRIBUTING EDITOR

Experts in every field have something in common: They possess the ability to perform at a high level repeatedly. In our field, diagnostic technicians like John Thornton, Scott Manna and Bernie Thompson come to mind as top performers. While automotive is their craft, they share traits with the greats in other areas, such as sports and music. The secret to their success started early in each one of their careers with mastering the fundamentals. If you master electrical fundamentals, you will fix cars right the first time on a consistent basis. Here we will take a different look at some fundamental concepts that apply to your daily diagnostic routine, whether you are the newbie in the shop or the seasoned foreman. While principles of electricity work well in the classroom, the application to reality can sometimes be hard to see. Basic principles of electricity are used in a multitude of diagnostic applications whether you realize it or not. Let's look at some examples.

Voltage essentials

Whether you are fixing a simple circuit problem or an advanced computer input or output fault, knowledge of voltage and voltage testing is essential. Voltage is a unit of electrical pressure that is necessary for current to flow. Without voltage there is no flow, therefore testing available voltage is typically a good starting point in any electrical diagnostic routine. When using voltage testing, keep in mind that voltage is only the command, as the work in the circuit is done by electron flow, or current/amperage. Voltage can be measured digitally with your DVOM or graphically with a graphing meter or lab scope. Knowledge of your equipment is key.

When diagnosing ECU inputs and outputs, always remember that ECUs communicate only in voltage. Sensor inputs can be both analog and digital, but an ECU can only process a signal that is digital or on/off. For that reason, analog to digital (AD) converters are used. A common scenario when diagnosing input faults is that data will not always make sense. For example, if a two-wire analog wheel speed sensor reading jumps between speed values yet the scope waveform at the ECM

Photos: David Macholz

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looks normal, you may have a bad A to D converter.

Scoping inputs such as crank, cam, wheel speed, etc. is a great way of diagnosing input problems. While these sensors are outputting a voltage of some sort, it is important to remember that a repeatable pattern's frequency and signature is often used by the ECU to determine input speed and position. Also keep in mind that triggering and slope come in to play when an ECU is interpreting a signal. I remember a case study a few years back of a wiring repair on a two-wire crank sensor. The tech mixed up the polarity of the wires and wound up with an inverted slope, which led to all sorts of problems for the poor truck owner.

Dealing with voltage outputs on ECUs can also be thought about fundamentally. Output signals can really only be on or off voltage signals. It is a fairly simple concept. Where it gets tricky for most techs is understanding that pulse width modulation (on time), amplitude (height of the voltage pattern), frequency (speed at which the cycle is repeating) and duty cycle (the percentage of on time of a cycle) are all control mechanisms that utilize voltage for a specific outcome. One example is a fuel injector. We turn it on for a specified duration (PWM) to match fuel to incoming air. In another example, duty cycling controls your instrument cluster illumination dimming. A low percentage duty cycle results in dim lights, while a high percentage duty cycle will yield brighter illumination. You may ask: how does a signal that is duty cycled not blink on and off if it is on for only a portion of the cycle? The answer is simple: They are duty cycled at a frequency that is too quick for your eye to really see.

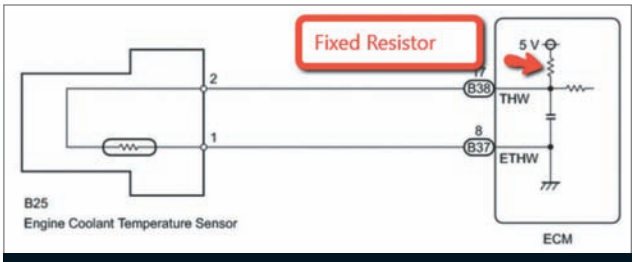
When we think of voltage testing, we all too often think about basic circuitry. Challenge your fundamental voltage testing skills by using a scope to view inputs and outputs to ECUs. If you have questions, ask them. Learn to take scope captures and screenshots and share them on forums and with other seasoned techs.

Kirchhoff's Law of voltage drop

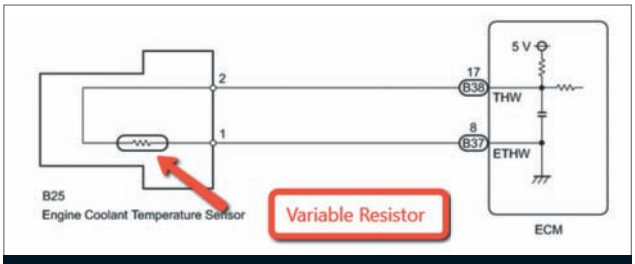
Kirchhoff's Law states that voltage drops across a load. A load is basically anything that has resistance and does work in a circuit and is typically a device such as a bulb, inductor, motor, etc. Resistance is also found in connections and other places that we may often overlook. The beauty of understanding voltage drop testing is that we can easily pinpoint the location of unwanted resistance in a circuit or connection. While this concept isn't new to most, applying it in other areas of diagnosis can provide some new insight on the subject. Let's look at a few.

MAF rationality testing

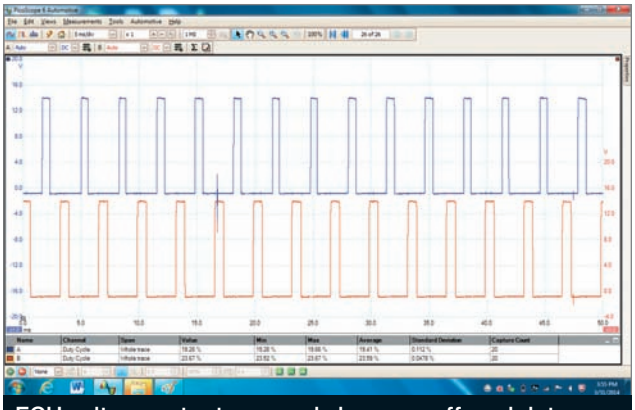
If you have ever tested an MAF sensor for rationality, you may have used a plug-the-numbers type formula or other methods to determine if the MAF sensor is performing properly. Scoping an MAF snap-throttle event is a method that can come in handy to identify MAF problems. Using this type of testing will require knowledge of known good waveforms; however, I like to use this method if I suspect a problem with resistance in an MAF connector or harness. Using this technique, you will scope the signal wire of the MAF circuit both at the sensor as well as at the ECM. For example, most Toyota MAF sensors will have a peak voltage



An ECU uses voltage drop by reading a voltage after a fixed resistor to determine the resistance and temperature at the coolant temperature sensor.



A variable resistor and fixed resistor are used by the ECM to determine voltage input.



ECU voltage outputs can only be on or off, and duty cycling is one way of accomplishing variable speed or position of an ECU output.

of around 4 volts on a WOT snap. Anything significantly less can be a great indicator of MAF problems. If the voltage on the WOT snap at the sensor is different from the voltage measured at the ECM, the problem is typically resistance somewhere in the harness or connections. This test is more or less a graphed voltage drop test and provides a visible confirmation of voltage drop problems.

Voltage drop as a representative of parasitic draw

Parasitic draw testing on late-model vehicles can be a time-consuming task. Waiting for modules to "go to sleep" and connecting and disconnecting circuits by removing fuses is a recipe for a time-suck of a job. My favorite technique for finding current flow in a circuit is using voltage drop across the top of a fuse. The reason that this concept works is simple as long as you remember one of the essentials of voltage drop. There will only be voltage drop in a circuit

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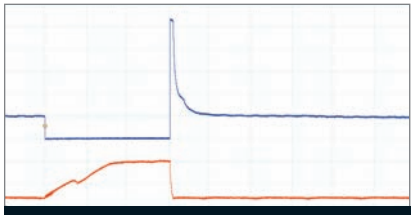
when the circuit is closed and flowing current. For that very reason, we can eliminate circuits with no voltage drop and narrow our search for the drain down to the fuse that is showing the highest amount of drop, typically only millivolts of drop.

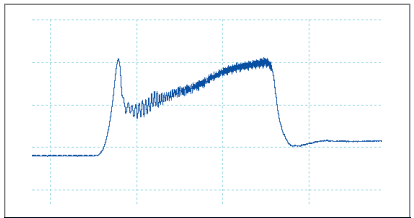
ECU voltage detection

Another important concept that utilizes voltage drop is the concept of ECU voltage detection. On circuits that utilize an analog voltage signal such as a coolant temperature or throttle position sensor circuit, the computer utilizes voltage drop to determine the temperature or position.

If you notice in the circuit pictured (page 36), there is a fixed value resistor inside of the ECU. The voltage supplied in the circuit is 5 volts; however, the important voltage reading is the one between the fixed resistor and the ECM. In this type of voltage detection circuit the ECM is reading the voltage drop after the fixed resistor. As the resistance value of the temperature sensor, or thermistor (temperature sensitive resistor) changes, so does the voltage value read by the ECU. The ECU then compares the voltage value to a programmed lookup table and determines a temperature to be output to a data PID or sent as a signal to the Instrument Cluster for the temperature gauge.



Scoping voltage and amperage provides a view of the command and the result of the command. Notice the opening of the injector pintle in the amperage waveform.



A MAF voltage signal throttle snap test is another great way of using voltage to create a picture on your scope.

The next time you have a free moment, unplug a coolant or air temperature sensor. When looking at the data PID it should read -40°F. The reason for this? The voltage detected after the fixed resistor is 5 volts because of the principle of voltage that tells us that there will be available voltage up to the point of an open in a circuit.

Once you have the sensor unplugged, install a jumper wire across the harness. The Temperature PID should now read 284°F. This is because the entirety of the 5 volts will be used up or "dropped" across the fixed resistor.

The ECM/PCM uses these numbers as set points for diagnostic trouble codes. It is really as simple as that. Remember computers are not smart; someone programmed them and told them how to respond. The bottom line here is that they are simply voltage in and voltage out devices. Wrapping your mind around this principle will make fixing even the most complex of input or output faults a lot easier.

Amperage

Amperage or current is the flow of electrons through a conductor. Amperage provides a better picture of the work being performed in a circuit and should be looked at when performing electrical diagnosis on electric motors, inductors or solenoids. The best tool for the job here is an inductive current probe. In the pictured scope capture of a fuel injector, the blue trace is voltage, or command, and the red trace is amperage. When looking at different outputs it is often a good idea to think command and response. As you can see in the image the voltage pattern looks textbook. The amperage pattern does as well. Pay particular attention to the incline or ramp as the coil of the solenoid builds towards saturation. You will notice the buildup is even and happens slowly. You will also notice the classic "seagull" effect in the middle of the ramp. This is the point in which the pintle is lifted off the seat.

Advice for beginners

So you are the new tech in the shop and are wondering where to begin. First, get your hands on as much info as you can whether it is printed materials, such as textbooks, or articles like this one. You can often pick up some older edition textbooks rather inexpensively online. Popular authors for automotive electrical and electronics include Barry Hollembeak, James Halderman and Jack Erjavec, for starters. To get an idea of all the topics that you will need to be fundamentally sound in start by having a look at NATEF.org. The National Automotive Technicians Education Foundation (NATEF) is the accrediting body that governs secondary (high school) and post-secondary (college) automotive programs. NATEF specifies task lists for each service area and the lists are available on their website. If you want to get good at something, practice the concept that you are the worst at and go from there. Another suggestion is to write down concepts, ideas and terms that you don't really understand. Then do some homework to find the answers you are looking for. Don't rely solely on someone else to teach you. Dig deep and do your homework.

Training events

Fantastic training opportunities are happening all over the country. Live training events will provide you with the opportunity to learn from some of the best in the business. If you didn't have a chance to make it to Automechanika Chicago, you best put it on your calendar for July 2017. Last year's event included some fantastic classes on electrical testing by some of the best trainers in the business. Make it a point to get to these events and most importantly, apply what you learned when you get back to the shop.

Become an expert in electrical principles and apply them to even your most complex of diagnostic scenarios. In the end you will be glad you did.

DAVE MACHOLZ
CONTRIBUTING EDITOR

Dave Macholz is an instructor for the Toyota T-TEN, Honda PACT and general automotive programs at Suffolk County Community College in Selden, N.Y. He is an ASE CMAT and L1 technician and holds a NY State teaching certification in vehicle repair.

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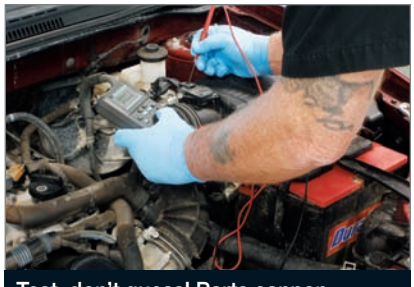
BY **PETE MEIER** | DIRECTOR OF TRAINING

It has been my great pleasure to travel across our country to a variety of trade and association events over the last several years, and I've had the opportunity to meet techs from all over the world in the process. There are many common bonds among us, not the least of which is the desire to stay educated and on top of the technology that is changing so fast around us.

Many of you that I've met are also highly skilled — probably the top 10 percent of our industry when it comes to efficiently and effectively diagnosing the root cause of failure in these complex systems. You've developed effective troubleshooting strategies, invented new ways of using old diagnostic equipment, and have even come up with brand new methods of your own!

Back in the old days, we willingly shared our own experiences and expertise with others in our shop and we all became the better for it. With the advent of the internet, that sharing now takes place on a global stage. Sadly, not all of what you find when you "Google" a problem is in keeping with standard industry practices and guidelines and some results could even cause more harm than good.

In this column, I intend to bring you new testing techniques, new repair procedures, a few war stories or just sage advice I learn from the collective whole as I continue my travels and interactions with you — our faithful readers. I am also inviting any one of you who have an interesting diagnostic story to share to submit it for inclusion in this column. If you think you have a good tale to tell and the talent to tell it, send me an email (pmeier@advanstar.com) with your submission!



Test, don't guess! Parts cannon ammunition is expensive and wasteful.

Let's start with a war story

I'll be the first one to say that I'm one of the luckiest guys in the world. I was fortunate enough to be in the right place at the right time when I was given the opportunity to join *Motor Age* fulltime. Up to that point, I was working in a shop as a technician and had been for nearly 35 years. Had it not been for the magazine, I'd still be sweating over a wrench until the day I couldn't do it anymore.

Because I've "been there, done that," I understand how tough this business is and how tough it can be to make a living doing what we do. We stay in it because we love the challenges of fixing what is broken! And I can personally say that this business always supplied me with a steady living, if not always a lucrative one.

Training was always an issue. Most of the shops I worked for didn't supply training, and if there was training available from a third-party source, I didn't know about it or I couldn't afford it. I'm sure many of you reading this are nodding your heads in agreement with me. That's why it is my primary objective each and every month to provide you with as many resources as I can, in as many ways as I can, all with the idea of trying to make your life in the shop a bit easier and to put a little more coin in your pocket each pay day.

Are you availing yourself of all these resources we've started for you? Do you get the Certified Technician newsletter? Have you attended one of our free technical webinars (hosted at least four times a year)? Are you subscribed to our YouTube channel? If you said "no" to any of the above, what are you waiting for?

On to business

Let's start off this new column with some tech tips (of a sort) you can put to use right away!

1. Training, training, training. The days of relying on what you know now to carry you into the future are long gone. There are vehicle safety systems in use today that require precise repair in order to work properly and anything less could result in someone getting seriously hurt or even killed. Quality training has been getting easier to find and access. I've already mentioned the resources we offer you each and every month and in addition to that, we'll be hosting single-day training events in select cities later this year, culminating in our second Automechanika Chicago training event scheduled for July 2017. Just like the first one held last year, the training event will be free to attend — you just have to get yourself there!

In addition to our efforts, many of the major aftermarket companies have stepped up their training offerings. Federal-Mogul's Garage Gurus program is one that comes to mind, as is the traveling training hosted by Bosch. Of course, they aren't the only ones. CARQUEST, NAPA, WORLDPAC, SMP, and many more have professional trainers on staff and on the road. Look for more listings of events and opportunities right here in our pages to find training sessions in your area. Set a personal goal of at least 40 hours of continuing education a year and if your boss isn't supportive, find one who is.

2. Use your resources. Believe it or not, I learned that tip in the Boy Scouts. No one can know everything there is to know about everything, and as I

Photos: Pete Meier

Vehicle systems on the market today require precise diagnosis and repair in order to function as designed. Anything less could result in injury to you or your customer.

mentioned earlier, relying on your own storehouse of knowledge to see you through every challenge you face will only cause you grief in the long run.

So unless you've performed a procedure or diagnostic process on a particular model car over and over again, you owe it to yourself to spend the first 10 minutes or so working on reading — reading the specifics on the vehicle system you are preparing to repair, reading the specifics on why a particular DTC is set on that particular model, and even researching tech resources to see if others have already done the hardest parts for you.

It may be hard to believe that using the wrong oil can lead to catastrophic engine failures, or that installing a new headlight can cause some vehicles to pull to one side or the other, or that you have to tell a computer that you replaced a battery, but all of these scenarios (and many more like them) are true. The majority of our self-inflicted headaches can be avoided if you just take the time to do a little reading before you open up your toolbox.

3. Think twice, repair once. Talk to most any mobile tech (the guys you call in for help when you can't fix the car yourself) and they'll tell you that the majority of the work they do is basic in nature, and that any reasonably competent technician should have been able to fix what they found.

Truth is, when we're under the pressure of flat rate and our boss is screaming at us to get this car done, it is very easy to forget the basics and start looking for the magic bullet. Rather than think about the repair we are going to make, we check the experts on Google to see what they're replacing and then we open fire with our own parts cannon.

The majority of the time, this process fails miserably. It costs you time and money, and may cause you to lose a good customer. Rather than rely on the magic bullets, rely on your skills and expertise. If they're lacking a bit, no worries — we all started somewhere. Use tips No. 1 and No. 2 to improve your skill sets and you'll find yourself firing the cannon less and less. And that means more money in your pocket!

PETE MEIER
DIRECTOR OF TRAINING

Pete Meier is an ASE certified Master Technician and sponsoring member of iATN. He has over 35 years practical experience as a technician and educator, covering a wide variety of makes and models. His primary goal is to bring working techs the information they need.

Email Pete at pmeier@advanstar.com

LIFE ON THE FRONT LINES

YOU NEVER KNOW WHAT A DAY IN THE SHOP WILL BRING

BY **G. JERRY TRUGLIA** | CONTRIBUTING EDITOR

Sometimes vehicle owners don't understand the importance of engine oil and only look at price when they need their oil changed. I am sure we have all come across a customer who has purchased or, worse yet, leased a vehicle that they really can't afford. This vehicle owner is always looking for a bargain that in the long run will get them into trouble. We recently had one such customer who gave his 2002 Lexus GS300 to his son.

He had changed the oil about every 7,000 miles at a tire shop that used the wrong oil grade and a cheap overseas oil filter. In fact, when the vehicle owner went to the tire shop with the Malfunction Indicator Lamp (MIL) illuminated, they told him they didn't repair engine drivability problems and just proceeded to clear the codes.

The father instructed his son to go to the auto parts store and see if they could read the codes and recommend a fix. The auto parts store usually reads codes for free and recommends replacement parts for the common problems, but this vehicle was another story. The problem with this 3.0L DOHC 6 cylinder Lexus was that it had a P1349 along with eight different ABS/VSV/TRAC DTCs, so they recommended him to us. The first thing after speaking to the vehicle owner that I did was to check the oil level to make sure it was correct, checked the DTCs for myself (**Figure 1**) and tested the Variable Valve Timing (VVT) using the Toyota Techstream's bi-directional control.

Using the VVT command with the Techstream on this vehicle is a simple on or off command that should cause the engine to run rough and stall. When the bi-directional command did not stall the engine, I disconnected the wire after turning the ignition off, followed by restarting the engine to check the VVT solenoid operation. The results were the same as the scan tool — VVT command that did not yield any results and confirmed the lack of operation of the VVT system.

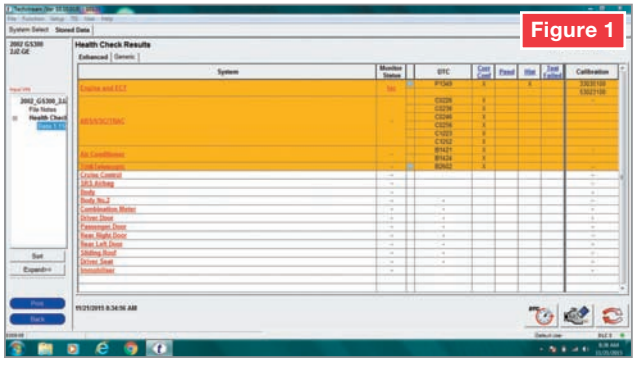


Figure 1

My next step was to remove the oil line (**Figure 2**) and check the screen to see if it was clogged. What I found were only pieces of the screen along with debris that I proceeded to clean out, followed by draining the oil and replacing the filter. With the correct 5W-30 GF5 ILIC rated oil, I retried the bi-directional VVT command, and now the engine was stalling out every time I selected the command. This confirmed that the circuit was now functioning properly. Our problem engine had over 138,000 miles and was neglected, since it did not even have the oil changed at the correct intervals. The engine was also way overdue for a tune up and timing belt.

While looking up the service information for the P1349 VVT DTC, I found that there were other problems that can set this DTC besides oil problems. MotoLogic listed a DTC diagnostic plan that included checking the mechanical condition of the timing belt and ECM as the possible causes. As I stated before, the timing belt was never replaced so I removed the front upper cover to confirm what I already suspected. The timing belt (**Figure 3**) was old and had never been replaced, but the timing marks were still properly aligned. Next I decided to check the most common problems as found on Identifix and found that techs had also reported issues with the VVT actuator sprocket, VVT solenoid, VVT oil control valve (OCV), timing belt, spark plugs, ignition coils and ECM. Other important information I found is an intermittently sticking VVT solenoid or a VVT actuator sprocket that leaks oil. I explained these potential problems to the vehicle owner who said his father would be making the decision on what repairs, if any, would be performed. After explaining and reviewing all the data along with the pictures of the vehicle, the father said his son will just drive the vehicle as is.

I told you so

A couple of days went by before I received a call from the owner's dad, mad that the MIL was back on and the vehicle was now bucking and stalling. After checking the vehicle out again, I found new codes stored in the ECM, namely; P0300, P0301, P0302, P0303, P0304, P0305, P0306, along with the same P1349. I explained that the spark plugs, coils and wires

Photos: G. Jerry Truglia

were original and in real bad shape, and that replacing them would be the next logical place to start. I also reminded him that there were still the other problems that I had already reported to him, such as the timing belt, VVT solenoid, VVT sprocket and ECM that may also need replacing. To rule the ECM/PCM out, I connected my labscope to check for a PCM command. As you can see by the waveform (**Figure 4**), a commanded signal square wave signal was present. But even though the square wave command changed with engine rpm, the timing never moved. These results led me to believe that the oil passages may still be clogged, so I recommended an engine flush along with changing the oil and filter. The engine flush helped remove a bunch of debris, but the solenoid still would not function properly, so I recommended replacing the solenoid to get the engine back running good (that is until the timing belt breaks). We can only lead the vehicle owner down the right path and suggest what needs to be repaired, but we cannot make them do it. You can't fix it cheap and since the owner did not want to spend the money, I could not repair his vehicle!

Running rough

Our next problem vehicle is a 2004 BMW 745i 4.4L with a complaint of engine misfire only when the engine was cold. Before coming to us, it was at a BMW dealer where the owner was told that the repair would be more than $5,000 because the engine needed a complete Valvetronic unit replacement. Since the owner did not trust the diagnosis from the dealer, he decided to call me (after watching a few of my webcasts on YouTube). I saw what most likely happened and why the dealer recommended the Valvetronic repair. There is a TSB on rough running that relates to the Valvetronic unit, along with another TSB for reprogramming the ECU (that the dealer performed but it did not fix the problem). The mistake in a proper diagnosis by the BMW dealer cost them a good customer because they overlooked the basics.

When one of these BMWs comes in with a complaint of rough running, it usually has the problem both cold and hot. That was not the case on this 745i, since it only happened when the engine was cold. To confirm the problem, we checked Freeze Frame data that indicated a cold temperature when the DTCs were set. After reviewing the Freeze Frame, we inspected the intake with our video scope for carbon build up, since it's a common problem on these engines. Our visual looksee did result in finding some carbon, but not an overabundance of it, but we still recommended the service to the vehicle owner since the engine had 140K on the clock. We checked the engine out hot both with our Autologic scan tool and with the ATS pressure transducer scope kit. The results with the scan tool showed very few misfires, while the ATS pressure transducer (**Figure 5**) found many. After performing the decarb, the engine still ran fine hot with no noticeable engine misfires.

We also noticed that the engine was leaking a large amount of oil so we suggested that the breather/PCV system be replaced since it was never replaced. We showed the owner the white oily debris that was in the breather hose ends and made him aware of the upgrade cold weather tube kit that has been available for years. We suggested that he leave the vehicle with us so we could check the engine when


Figure 2

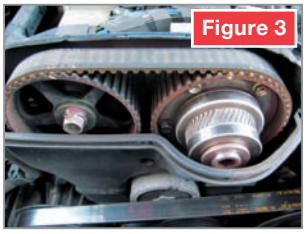
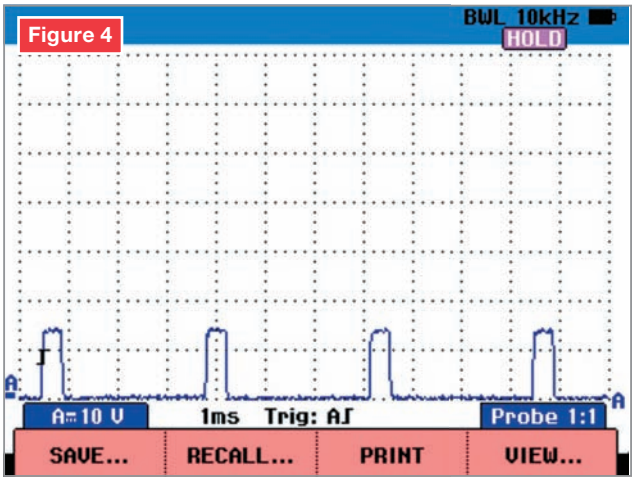


Figure 3



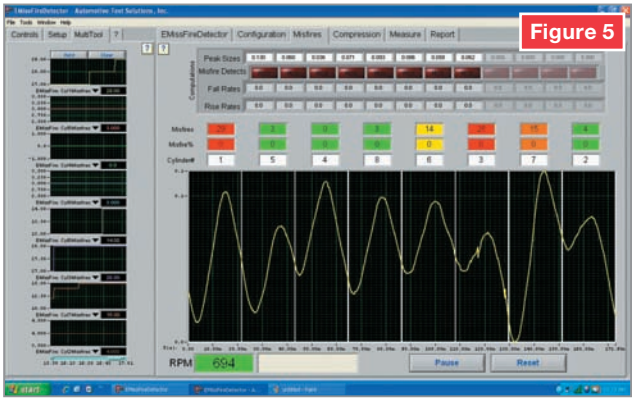


Figure 5

it was cold, since this was when the engine was misfiring and causing the check engine light to flash.

The next morning when the engine was cold, I started the vehicle up to drive it in the bay and noticed that the check engine light was flashing and the engine was running rough. Before the engine warmed up and reached operating temperature, we smoked the engine and found smoke coming out of the intake manifold at a high volume. Next we started the engine up so it could reach operating temperature then re-smoked the engine only to find no smoke coming out of the intake manifold. The results now confirmed why the engine only ran rough when it was cold and had no problem misfiring when it was hot. Now it was time to come up with a game plan by first performing a visual inspection followed by checking the battery. We found that the battery was original and needed to be replaced before moving on and performing the other repairs. With the starting and charging system components all passing the test, I now could perform a relative compression test using my labscope to make sure that there were no engine problems. With all the testing completed, I turned the job over to Bill, who had the fun job of taking

the intake manifold off and cleaning everything up. After waiting for all the parts to show up, I suggested to Bill to seal up the intake plenum while it was off the engine to make sure that the plenum was not leaking. It was a good move (**Figure 6**)! We found an intake plenum leak on the rear seam of the unit. We checked the torque on the bolts and added some RTV to the seam, since there are no gaskets available for the unit, only a complete replacement is available. After the repair was complete the real test would be if the vehicle would start up cold without flashing the MIL and running rough. The next morning with the temperature in the low 30s, I started the engine up and noticed the engine was running good and there was no flashing MIL or DTCs being set. I drove the vehicle for about an hour to make sure that there were no other problems before calling the vehicle owner and telling him it was ready to pick up.

Misfiring Ford

A 2008 Ford E350 van came in with a vehicle owner complaint of an illuminated MIL and a real bad misfire that the owner said just appeared suddenly. The engine was running so bad there was no doubt that the engine had a severe misfire. Our next step was to connect our scan tool to check for DTCs and see what was happening. A P0202 (cylinder number 2 circuit open) was the cause of the problem. This code should be an easy fix since there are only three different possibilities: an open circuit, defective fuel injector and/or a PCM problem.

The first place to start is by checking voltage at the fuel injector to make sure that system voltage is going to the injector on one side. Our test confirmed the injector was getting more than 13 volts at one side of the injector, but was the PCM supplying ground to the injector? To confirm if the injector would fire, we grounded the negative side of the injector momentarily to make sure the injector was working and spray fuel. Since the injector had the ability to open and close, we could rule out the injector and suspected that the wiring or the PCM injector driver for cylinder 2 had to be burned open.

Before jumping to replacing a PCM, we need to confirm what caused the PCM injector driver to burn out. If we just install a replacement PCM and the injector or the wiring has low electrical resistance, the high amperage would just take out the replacement PCM. To confirm what the amperage of this conventional saturated drive injector was, we installed our amp clamp around one of the wires going to the injector as we applied ground. What we found was that the injector was drawing about 1 amp — right in spec. If the injector was drawing more than 1.2 amps for more than 6 ms, the PCM drive would be damaged. Confirming that the injector was good led us to our next step: making sure the wiring to the injector was not shorted anywhere. To confirm if the wires are shorted, damaged or good, we disconnected the wire from the PCM and the injector while placing a volt meter (min/max selected) at one end and applying 12 volts from our Power Probe at the other end. If the wiring was good, the meter should read 12 volts without blowing the Power Probe fuse. As we were performing this test we wiggled, jerked and massaged the wires to make sure the voltage was stable while making sure not to pop the Power Probe circuit breaker. After confirming that the wiring to the PCM was good on both sides, we now felt confident in ordering a replacement PCM. We called around to the local parts store and dealers and were told that it would take a couple of days to get the PCM so we decided to call AutoPCMS.com, which could overnight the unit. The job looked like an easy PCM replacement followed by a test drive that would put this van back on the road.

Well, not so fast because after we replaced the PCM, the engine ran fine on the test drive until I went to park the van. The MIL illuminated and revealed a P0420 DTC that was most likely a result of the previous cylinder misfire. We suggested to the owner a fuel system cleaning to clear out the carbon and clean up the converter substrate. After the procedure was completed the P0420 was gone, but the engine had a network DTC along with P0201, 202, 203 and 204. The engine was running great with no power or misfire noticed during the test drive. We checked all the injectors


Figure 6

for power and ground, along with current ramping all the injectors only to find everything normal. It did not make any sense that the engine was running great while still having DTCs and the illuminated MIL. We called AutoPCMS.com and had them send another PCM only to find a similar problem where the engine was running great but the DTC and MIL were still a problem. At this point you start to second guess yourself and go back and recheck all your test results and do them over. All our test results were good, so I decided to install the original PCM to see if it had the same DTCs as the two replacement PCMs. What we found was that the original PCM had just the P0202 DTC that made the engine run rough. I even made sure that I programmed all three PCMS with the same Ford software from my IDS. With the same software on all three PCMs, the same problems existed on the two replacement PCMs while the original PCM just had the No. 2 cylinder problem. I called AutoPCMs.com back up and explained what was going on. They said all the PCMs that they send out are tested and that there were no problems, but they would overnight me the other one. The third PCM was good, and the vehicle ran great without an illuminated MIL or DTC and was ready to give back to the vehicle owner.

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CHECK TIMING BELT SYSTEMS TO AVOID PROBLEMS

Your customers are keeping their cars longer. As a result, their timing belts likely need to be replaced or run the risk of failure. If a timing belt fails, the vehicle can be stranded and the engine may potentially be ruined. That's why it's important to train yourself to be aware of the warning signs and understand why replacing all the components is most often the best course of action for keeping the engine running at peak performance. Warning signs and symptoms include:

Symptom: Noisy Drive

Causes:

- Tension too high or too low
- Defective bearings
- Pulley, tensioner or idler misalignment

Symptom: Shining Belt

Causes:

- Back idler of tensioner misalignment
- Tooth top – tension too high
- Tooth flank – mismeshing, tension too high or too low
- Belt edge – misalignment

Symptom: Dirty Drive

Causes:

- Leaking cam or crank seal
- Defective cover – oil, water or dust intrusion

Symptom: Wobbling Belt

Causes:

- Misalignment
- Defective bearings

Symptom: Noisy Drive

Causes:

- Backside temperature cooling problem
- Tooth root – bearing failure
- Incorrect tension

Change the belt. Change the system.

These days, many components are designed with a system approach. When there is damage to a timing belt, the root cause is always related to a failure of one of the other system components. So when you detect symptoms of belt damage or wear and are preparing to change the belt, remember, the best strategy is to replace the system as a whole for optimum performance.

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THE REASON CIRCUITS FAIL

UNDERSTAND THIS AND YOU'RE ON YOUR WAY TO ELECTRICAL TROUBLESHOOTING!

BY **PETE MEIER**
Director of Training

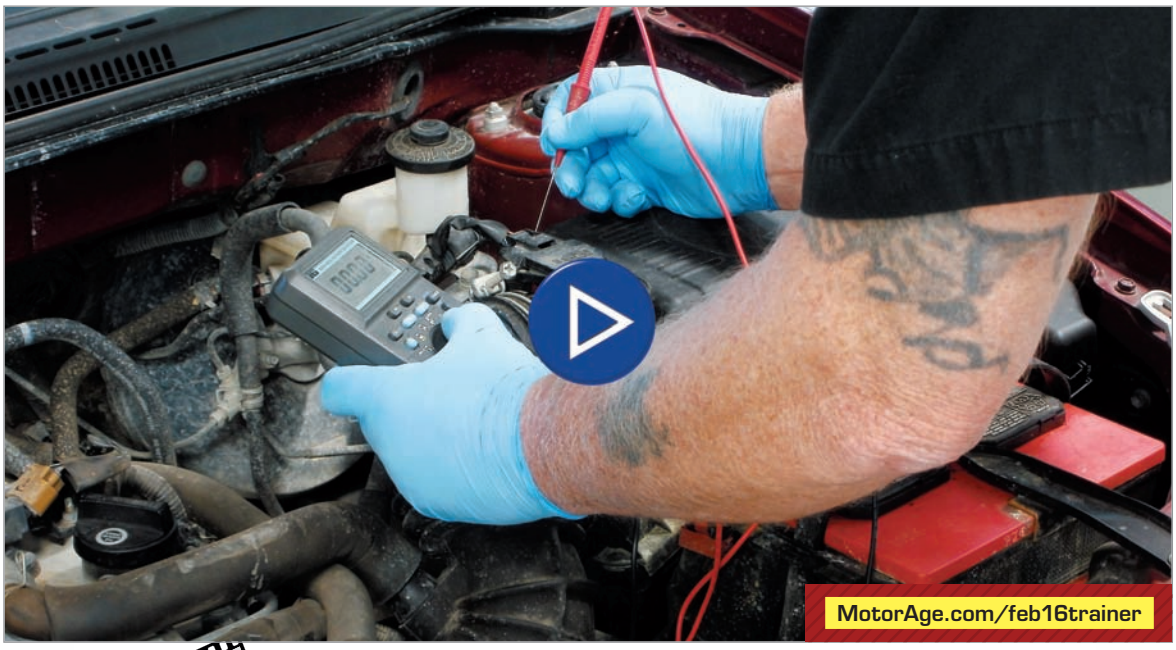
The last few editions of "The Trainer" have focused on the voltage drop electrical troubleshooting technique. In this month's edition, we're going to look at the most common faults you'll encounter when isolating the cause of an electrical concern.

What are those, you ask? Obviously, one of the first that comes to mind is an opening in the path anywhere in the circuit. Electrical 101 teaches us that an electrical circuit needs a complete path for current to flow. The result of an open circuit is kind of obvious, too. The circuit will not function.

Next is one of the more common issues you'll face — high resistance in the circuit. This can be on either side of the load or even in the load and takes many forms. Adding resistance under a given voltage reduces current flow (basic Ohm's Law) and the load will work sluggishly or not at all.

What about lower resistance in the circuit? There are a couple of scenarios for this situation. One that comes to mind is an internal short in a coil of some type; an ignition coil, injector winding, or window motor are some examples. When that happens, current will increase but the component will not function or function weakly. Another example is one you may or may not have already thought of yourself — the short circuit, or a short to ground in the positive side of the circuit. That certainly will cause current to rise!

Current can be a great tool in helping locate the cause of electrical concerns and mated with the voltage drop techniques you've learned to date, would go a long way in helping you master the art of electrical diagnosis. Watch this month's "Trainer" to see how!



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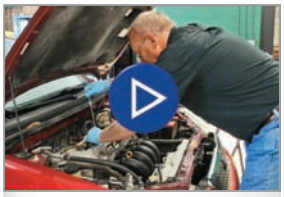

Remember this one important acronym

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Measuring voltage on the ground side

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Suspension dos and don'ts

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