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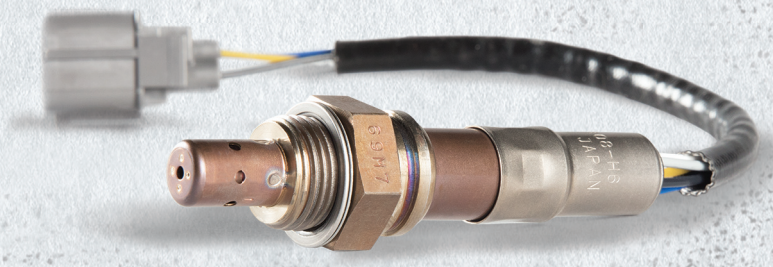

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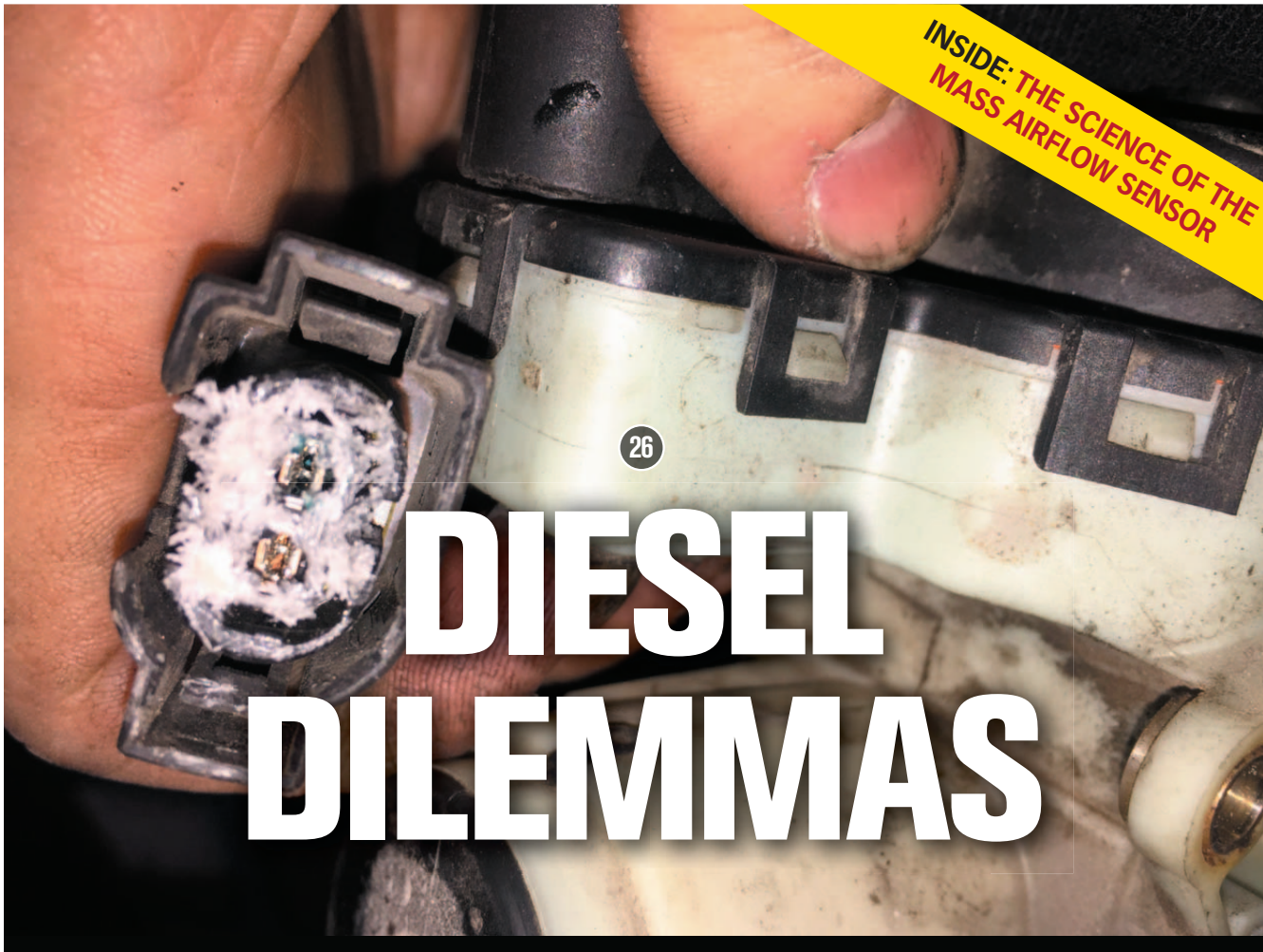

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TURNING OUR ATTENTION TO WINTER

With fall upon us and winter not far behind, it's time to help our customers prepare for the cold

THE TRAINER:
VOLTAGE DROP IS NOT ALWAYS A BAD THING

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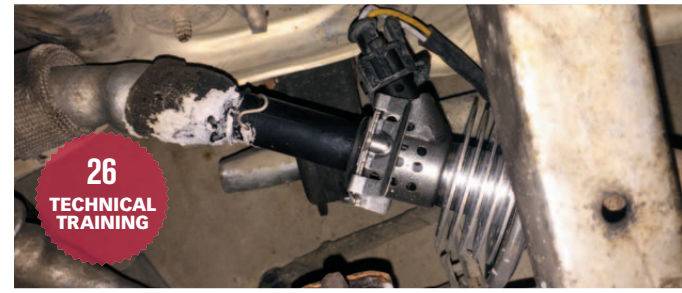

TECHNICAL

IN EVERY ISSUE

SPECIAL SUPPLEMENT

KIA QUALITY CONNECTION

The latest issue of the Kia Quality Connection is now available online at: *MotorAge.com/KQCSummer18*

WEB EXCLUSIVES // MOTORAGE.COM

5 TIPS TO CREATE GREAT ESTIMATES

Estimates are how shops ensure the repair process starts off right. But with a variety of information out there, it's time to cut through the unknowns and get right to it. Gary Hixson, senior product marketing manager with Mitchell 1, highlights the 5 most commonly asked questions of the Mitchell 1 Labor Department.

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ONLINE SHOPPING: A NEW WAY TO AFFECT CHANGE IN THE SHOP

In one minute, you will learn three key ways shopping for parts online can change processes in your business. With three real-world examples, online shopping gives service advisors options to build out their services and improve the bottom line.

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THE AUTOMOTIVE SERVICE ASSOCIATION'S Bob Redding, left, hosts panel discussion entitled "Repairs of the Future" at NACE Automechanika in Atlanta.

TECHNOLOGY TOPICS

TECHNOLOGY & TELEMATICS FORUM COVERS ADAS, AUTONOMY

PETE MEIER // Technical Editor

ATLANTA — The Automotive Service Association once again hosted its Technology and Telematics Forum at the 2018 NACE Automechanika show, held Aug. 8-10, in Atlanta. The six sessions held shared a common theme — the impact Advanced Driver Assist Systems (ADAS) are having on both the collision and mechanical repair industry segments and the path these systems were paving on the road to full autonomy.

Presenters included representatives from Ford, General Motors, VW and Audi, as well as leading aftermarket representatives like NASTF Executive Director Donny Seyfer, former ASA Chair Darrell Amberson and Carquest's Randy Briggs and Chris Chesney. The sessions were a split between individual presentations and panel discussions that focused on pressing issues facing both collision and mechanical repair business owners, as well as offering observations on what the future may hold for us all.

Here are just a few of the takeaways:

>> **FORUM** CONTINUES ON PAGE 5

BREAKING NEWS

STUDENT OPPORTUNITY

PANEL PRESENTS OPPORTUNITIES TO ATLANTA STUDENTS

ATLANTA — Nearly 700 students from the metro Atlanta area were the guests of NACE Automechanika as the event entered its last day on Friday, Aug. 10.

Dennis Smith, President and CEO of Messe Frankfurt, Inc., the show organizer, welcomed the students on their arrival at the Georgia World Congress Center. Before they were set free to explore the show floor, though, the students were introduced to the opportunities the automotive industry has to offer by a panel of experts, under the umbrella of the show's Career Connection.

Jason Rainey, General Manager of NAPA AutoCare kicked off the event, and was followed by speakers representing Automotive Training Institute, AkzoNobel, Metro Atlanta Automotive Dealers

>> **PANEL** CONTINUES ON PAGE 5

AROUND THE INDUSTRY

IMR INSIGHT SHOWS SHOP'S BIGGEST COMPETITORS

The latest IMR Insight report, "Independent Repair Shops' Biggest Competitors," is now available and shows who shops perceive as their strongest competition.

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AAPEX 2018 MOBILITY GARAGE TO PROVIDE TRAINING

Attendees of the AAPEX 2018 Mobility Garage can experience demos of scan tools, underhood training and the latest innovations in electric and alternative fuel vehicles.

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POWER TOOL INSTITUTE PROMOTES SAFE BATTERY USAGE

The Power Tool Institute encourages all to "take charge of their battery" in education and awareness campaign that promotes the safe use of lithium-ion batteries in power tools.

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SHOP MANAGEMENT SYSTEM USES AI

Shop4D, created by the founders of Auto Profit Masters and the RPM ToolKit, has launched a new cloud-based shop management system that integrates every aspect of the repair into a single tool.

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FORD EXPANDS INVESTMENT IN TELEMATICS

Ford is expanding its investment in telematics solutions with new connected vehicle products for the fleet market that give access to OEM-grade data.

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>> FORUM CONTINUED FROM PAGE 4

Update on federal autonomous vehicle and new vehicle technology policies

The Auto Alliance's Jeff Beck shared two numbers with the audience: 37,461 — the number of people who died on American roads in 2016; and 94 percent — the percentage of those accidents caused by human error. ADAS is already having an impact on preserving lives once lost to drivers more interested in their phones than to the task of driving.

Autonomous cars are another. And they are not that far away from reality, according to Beck, who estimates that SAE Level 3, 4 and 5 cars will be in production within the next five years. (In fact, GM announced earlier this year their intent to put a Level 5 fully autonomous Chevy Bolt into production in 2019. The new car will have no steering wheel or pedals and will be deployed as "ride hailing" vehicles in a number of U.S. cities.)

Beck also shared that it is increasingly important that the Fed sets up legislation and regulatory guidelines for autonomous vehicles before individual states. If left unchecked, the resulting patchwork of regulations would make it difficult for OEMs to meet the varying standards.

Repairs of the future

ASA Washington D.C. representative Bob Redding hosted a discussion featuring a cross-generation panel. Participating in the panel were Darrell Amberson (LaMettry's Collision Centers), Fred Hules (Tech 1 Auto), Brin Kline (Assured Auto Works), and Jake Rodenroth (asTech).

When the panel was asked about the future of the industry, some believed the number of vehicles would decline as autonomous transportation became more widely accepted, with consumers electing to use "ride share" services rather than own their own. But with that would come even greater needs for maintenance and service as they expected to see these vehicles in use for longer periods of time. Conversely, some of the older panel members felt that, while this may occur in the more congested areas of the country, consumers in general will want to maintain that sense of personal freedom that owning a car provides.

ADAS and vehicle calibration

After two short presentations from VW and Audi on their new technologies, NASTF Executive Director Donny Seyfer hosted a panel discussion on the real-world challenges ADAS was presenting to collision and mechanical repair shops. The panel was quick to share that following the OEM procedures, especially when it comes to target placement, was critical to ensure that the system(s) calibrated properly. Even placing the target a few inches off of the centerline, while possibly allowing the recalibration to be successful, could result in an unwanted ADAS activation. And the only way to know for sure was to perform a test drive and verify proper operation. DTCs will not necessarily be detected or recorded by the system(s).

CTI's Randy Briggs pointed out another important fact that techs should note. With the integration of other system inputs within ADAS, even routine services and repairs could impact the operation of the system(s). It is more critical than ever to understand how these systems work on the vehicle in your bay, and what needs to be done (if anything) after the service.

Today's car — front and center

The last presentation of the day was made by Chris Chesney, Senior Director of Customer Training for Advance Auto. He began by assuring the crowd not to fear the oncoming onslaught of new technology, saying, "We've been here before and got through it." But he did caution attendees, echoing a comment made by GM's CEO Mary Barra when she observed that we are going to see more technological advances in the automotive industry over the next five years than we've seen in the last 50.

The key, Chesney says, is education.

Education is a passion of Chesney's, and he continued to share his involvement with leading industry groups to revamp our approach to training the next generation. Chesney suggested that "we expect a '70s education to serve the technology of today." He went on to state that it was time for the industry to shift to a competency-based education model instead of the current outcome-based model. "The pace of technology change is growing faster than our current education model allows," Chesney told attendees, and described a new look for training that would include both oral and practical exams to actually certify a student's ability to perform a task or process.

>> PANEL CONTINUED FROM PAGE 4

Association (MAADA), Standard Motor Products, and was wrapped up by Shawn Collins, founder and CEO of the Technician Academy.

All the speakers echoed common themes — that there is more to our industry than just becoming a technician, that there are numerous opportunities to grow, and there is as much potential for success in the trades as there is in fields requiring more formal — and costly — education.

After the event, students were invited to explore the show floor and talk to the exhibiting companies about the individual opportunities their firms offered.

A NEW HIRE PROCESS

Properly acclimate new employees to your business to help ensure their success

JOHN BURKHAUSER //
Contributing Editor

Recently writing articles on raising and hiring your "home-grown" techs ("How to grow your own technicians," May 2018 and "How to onboard new hires in your repair shop," June 2018), I discovered that many shops have no process for bringing a new employee on board. Many individuals who I did reach out to see what their process was didn't even understand my question. Mind you, I only had a small sample of shops I approached with these questions, but the lack of having a process in place leaves you and your shop open to liabilities and possibly the loss of a new employee, making this a topic one we should all know.

The disclaimer: I don't have all the answers or even offer a complete onboarding process, because every shop is different and the labor laws in your local area may have their own requirements. I suggest that you investigate your local laws and requirements first, then put together your process based on what I offer here and what you determine is important for your business.

The process

When you get a phone call about your help-wanted posting, get some basic information about the individual, such as name, phone number and where they live. Then search online using their name and location of where they live. With the online "tracks" that most people have these days, you can do a quick evaluation of the caller while they are on the phone. If their online behavior is questionable, you can end the process here. For candidates who look great online, invite them in for the interview.

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On arrival, give the applicant a job application to fill out even if they have a resume. Matter of fact, you can send them a copy of the application via email, ask them to fill it out and bring it in when they agree to come in for an interview. (An application that suits your needs can be found online, downloaded and used.)

Read over the submission for a few minutes to see what the candidate has shared so that you can use this for some of your interview questions with them. Don't be afraid to mark up the application as you interview the individual for later consideration.

If the interview goes well, I suggest gathering some of the information that you will need to bring them on board. Give a copy of your state's Department of Transportation driver's license report to the individual and have them fill it out and sign it while you make a copy of their license. It would be good to also have the applicant fill out any tax and federal paperwork that is required at this time. But give the drug test before sending these items in to save money if they fail. Taking care of this paperwork now will help make the first day at your shop easier.

When the applicant has passed the drug tests and license checks, you can either have them come in or talk on the phone about the following:

- Finalize the compensation plan. Agree on the rate at which they'll start. Explain to the new employee the process of bringing them into your shop and that they are going to be in a 90-day period of observation. At the end of this time they will be evaluated and possibly given a raise and benefits.
- Arrange for their tool box delivery, if needed.
- Confirm the employee start date and time, dress code and any other information if need be.
- Have a plan for your new employee's first day. Don't just wing it. When you make the plan, make sure that you set aside some time with your new employee. Here are some things to consider for the first day of employment:

Introduce your new person to all the staff in the shop pointing out who the employee should go to when they have questions and/or assigning them a shop "buddy." This is done to start building the social connection that they will need to work as part of your team. They have enough to learn. Get them to the people who will teach them right.

Give the new employee a copy of your Employee Manual to read and sign. Don't have an Employee Manual or document? Today you need one to provide the new hire with all the details of how your shop runs, including sick days, medical coverage, information on harassment in the work place, how to handle a medical emergency and so on. Your shop's philosophy and beliefs in its mission should also be part of this manual.

There are many resources online that you can use to find or build an Employee Manual or document to use in your shop. Lay out all the basics of how your shop is run and what is expected of every employee each day. Clearly explaining the employee's compensation that they will get in pay, vacation and other benefits puts everyone on an even playing field. Having your new employee read the employee handbook and sign it leaves no doubt about what goes on in your shop, so they can focus on doing the job you hired them for. Additionally, this signed document can also help you if any issues or misunderstandings come up in the future.

Shop safety should be part of the Employee Manual, but is important enough to speak about separately. Implementing a safety orientation using video, an online source or other method is best and should be done as soon as possible. To find one that works for you, check with your insurance company first to see if they recommend one and possibly give you a discount on your rates. You will also find other sources online to help you in this situation. Whatever method you choose, be sure that it has a test or some other indicator that proves the employee has viewed and completed the training for your records.

Orienting the new employee

The first day of a new job can be overwhelming for even a seasoned technician. I suggest that the majority of the new employee's day should be spent just watching how your shop operates rather than diving into repairing vehicles. Let the new employee get an overview of your systems.

You can use this to your advantage, too. Have the individual walk around your shop and note what they see. Fresh eyes will see what you can no longer see because you've grown accustomed to it. They may notice that the building needs some work, the shop is dirty and so on. They will see your shop as a customer would. Tell them to be honest and have them write down what they find on a tablet. Take a good look at the results and make the necessary changes.

Shadowing

I suggest that a newer, less experienced tech shadow one of your better techs for a day or so. The new tech should be informed that they just watch and ask questions, but not do any work at all. As the newbie becomes more acclimated to how your shop works, then the guiding tech can start them on some smaller jobs or assist in what they are already working on.

The advantages of shadowing are many. You can prevent bad habits from forming, limit the damage that inexperience can cause and monitor their prog-

ress closely while better seeing what you need to focus on for this individual to grow into a top-tier tech.

Checking in

At the end of the day, check in with your new tech and their guide to see how the day went. Have a discussion between the three of you and offer any observations and answers that are needed.

In the beginning, check in more often; over time, less often, unless there are behaviors or concerns that you have with the new tech that need to be addressed. You will find this is the most effective way to keep them on the right path.

90-day review

After 90 days, I recommend having a good one-on-one sit-down session with your new hires. Go over everything, including what concerns you may have, if any, and how well they have done in learning how your shop works and the quality of the work they have done. Reinforce your shop's beliefs and rules. Give them a chance to ask questions and tell you how they think they are doing. If you have a keeper, I recommend a raise and giving the person any benefits your shop might give to your employees at this time.

Another advantage of the last three steps of this process is that you will be able to weed out any individual who shouldn't be working for you rather quickly and before they have a chance to do any real damage.

At this point you might be thinking that this is too much to do, that you don't have the time. Of course you can pick and choose what will work for your shop and use it to your benefit, but with today's issues of finding good help, any time you get a good individual, you want to do your best to keep them and train them to work like you want them to. You also want to protect yourself from any person who may not fit with your shop, eliminating them before they cause damage or cost money. Quality time spent up front with new employees will pay off in the long run, so put an onboarding process in place today for lots of better tomorrows.

JOHN BURKHAUSER is an auto repair specialist with more than 30 years of experience. As the Director of Education at BOLT ON TECHNOLOGY, John coaches independent and franchise repair facilities on how to grow their business using simple best practices and everyday technology, resulting in increased car count, repair order revenue and customer trust.
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Avoiding the black hole that is "what if..."

Keep a firm balance between your dreams and reality to avoid disaster

Most of us have had these thoughts. What if I won the lottery? What if my business got better and I could take some time off? What if it grew so successful that I didn't have to be there at all? What would happen if I lost my key people? What if they treated the customers so bad they didn't come back? What if I had to go back to turning a wrench again?

There are the good "what ifs" that turn bad and the bad "what ifs" that turn even worse. It's part of human nature, but how do we defend ourselves? Let's listen to ATI Head Coach George Zeeks explain how to prepare yourself.

What are what ifs?

"What if" is the key behind every invention, every new idea and every success story. This can only happen when you balance the "what is" right alongside of it.

I graduated from high school at 17. I had no real intention of going to college, but my mom demanded otherwise. She was in the process of fighting the cancer that would eventually kill her and she made me promise that I would go to college and finish. It didn't really sound that bad, at first. The problem was that there was no money in the family. I had envisioned a great summer. I worked three jobs that summer, caught up in the "what if." I saved every dime I could. The amount of money that I would need to pay, just for the fall semester, would take that much. I had to adjust to the reality of "what is."

I tried to work while going to school but found that I couldn't work enough and study enough to get it all done. It looked like a choice between flunking out or not having enough money for the spring. I thought college was supposed to be fun. What if I failed? What if I broke my promise? Would it affect her health? The black hole of "what if" had full control of me now. Everything started to slide downhill in a self-fulfilling prophecy. I was 17, and I was already a failure.

When you balance "what if" with "what is," things begin to change. I saw some people at my neighbor's house who were cleaning the carpets inside. I stopped and talked to the two guys. The conversation led me to ask my neighbor, Mrs. Baker, if I could watch the men clean her carpet. As I watched, I learned that the work wasn't that hard. It didn't take that long. Then I asked Mrs. Baker how much it cost to do those carpets. Then I got interested. I did some quick research on what I would need. I took all of my money out of the bank and bought the equipment and the chemicals. Now I just needed some customers.

TOO MUCH WORRYING AND YOUR ABILITY TO DRIVE ON DIES. THE KEY IS TO BALANCE THE "WHAT IF" VS. "WHAT IS." KEEP YOURSELF BALANCED AND UNDER CONTROL.

I took the change I had left and went to the library to photocopy phone numbers out of a crisscross reverse telephone directory. Now I had pages of phone numbers to call and get appointments, so I could clean the carpets in their house. I was on cloud nine! I was going to make a ton of money. I was stuck, once again in the land of "what if."

The reality of what is

The reality of "what is" crashed down again. It took ridiculous amounts of work

to call the people, get the appointment, sell the job and finally do the work. At first, I made far less money than I had working for someone else. Don't forget I still had a full load at school and was trying to help take care of my mom. Things got better, then they got worse. I hadn't counted on having almost no work after the holidays. It seemed that after the New Year's parties had been cleaned up, no one needed my services. What if I failed?

I understand the roller coaster that many of you are on. I have been there many times. The key is to balance the "what if" vs. "what is" and to keep yourself grounded and under control. Too much dreaming and the dream dies. Too much worrying and your ability to drive on dies. In case you're wondering, I did graduate from the University of Maryland, with a degree in marketing. It took five years, but I did it. The business did well enough that by the time I had graduated in spring of 1982, I was making between $800 and $1,000 a week in net profit. I gave my business, contained in my Atari 800 home computer, to my father. I kept the promise and I was off to do what I wanted to do. By the way, I still hate carpet to this very day.

The technician shop capacity calculator

Some of you may be going through similar times. You may be stuck, wrapped up too tight in one of the black holes. Some of you may have hit a ceiling that you can't break through. Some of you may be wondering what is the answer to the what if/what is that YOU may be going through. If it has to do with your shop, a great place to start is with a solid "what is." How about answering the question: what is possible in my shop? What is my shop built to do? How much can my technicians produce? How close to the best practices are we? If you are curious, simply go to ***www.ationlinetraining.com/2018-09*** and receive the Technician Shop Capacity Calculator to find out what is possible for your business.

CHRIS "CHUBBY" FREDERICK is the CEO and founder of the Automotive Training Institute. ATI's 130 full-time associates train and coach more than 1,500 shop owners every week across North America to drive profits and dreams home to their families. Our full-time coaches have helped our members earn over 1 BILLION DOLLARS in a return on their coaching investment since ATI was founded. This month's article was written with the help of ATI Head Coach George Zeeks.
chubby@autotraining.net

Your parts supplier questions answered

The industry needs to better educate itself on its partners' business

Today the aftermarket is a different industry than it was five years ago. Let's ask and answer some questions to bring clarity to the new reality.

Part suppliers are an essential part of the execution process for shops. How can a shop receive the best technical support and buy the right product at the right cost?

The shop owner and part supplier must learn to develop a win/win relationship by having discussions as to where and how the shop is going to move forward and what the supplier needs as well.

How can you get suppliers the information they need so they can process orders and deliver faster?

This, again, is a conversation as to what kind of parts the supplier should be stocking for the shop. Does the supplier truly understand their customers' business? It is also a technology question. The supplier and shop owner should engage in the conversation as to "how" they can embrace the right technology that serves both of them efficiently.

How can a repair shop improve its efficiency, knowledge and be more profitable on listening to the advice of part suppliers?

The first concern is: "Does the supplier truly understand the shop side of the business?" In most cases, part sales reps go into a shop and ask the question, "Are you busy?" That is the wrong question. A shop makes money when they are steady, as they are maximizing efficiencies. Site efficiencies only improve with increased billed hours. Billed hours improve with proper vehicle inspections. When billed hours improve, parts purchases are needed. Too many suppliers look at "sell a part and you should get some labor." That is out of touch today. A successful shop is in the knowledge business and understands the importance of the correct billed hours to ensure their client's vehicle is safe, reliable and efficient.

What will be the main challenge for both of them in the future?

The challenge will be a total change in mindset. Due to the dramatic increase in vehicle technology, the shop business and the technician are no longer in a trade. This truly is a profession, as all within the shop are in the knowledge business. Diagnostics is growing at a very rapid pace and that requires highly skilled people to successfully execute it by understanding the vehicles' software platform. The shop owner must understand the suppliers' business now as well and how tough it is when dealing with stocking issues and inventory management. A business relationship must be embraced and trust between the two must be developed. This is an incredible challenge when you have differing mindsets and ideals. Those who want to develop the right relationships can still struggle if others do not share the same thought process.

WHEN RELATIONSHIPS ARE IN A WIN/WIN SITUATION COMPARED TO A WIN/LOSE SITUATION, PROGRESS IS MADE AND PROFITABILITY FOR EACH BUSINESS IMPROVES.

What is your best advice for a better supplier/repair shop service?

The aftermarket industry must come together and educate themselves better about each other's business. When relationships are in a win/win situation, progress is made and profitability for each business improves. Imagine how many shops will close over the next 5 years because these owners did not want to make the necessary investments and adjust their business to the new reality to ensure growth and prosperity of their business. Imagine how many suppliers will sell out because they don't want to adjust their business to get the top shops in their marketplace with 85 percent purchase loyalty paid in full each month by understanding what value they can bring to their customers. Both businesses must develop and maintain a learning culture. When that is achieved and sustained, both enterprises will have an extremely positive effect on the future aftermarket.

Welcome to the new aftermarket.

BOB GREENWOOD, AMAM, is president and CEO of Automotive Aftermarket E-Learning Centre Ltd. (AAEC), which provides business management resources for the automotive aftermarket. Bob has more than 36 years of business management experience and is one of 150 worldwide AMi-approved instructors.
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a shift to a new look

You may have noticed. We're shifting from red to blue – saying goodbye to the red oval, and hello to a common brand for both OE and Aftermarket. With this change, you can expect the same quality parts, tools, training and support you've come to know and love. From brakes to steering, air conditioning to ignition, engine management to fuel systems — whether it's diesel, gasoline, hybrid or electric. We're still the OE experts. We're still delivering quality you can trust. But now, we are Delphi Technologies.

From Prussia with love

German engineer teaches his sons the value of always doing the right thing

ROBERT BRAVENDER // Contributing Editor

Ever since Karl Benz invented the modern car in 1885, German engineering has played a prominent role in automotive history, but it wasn't until the early 1950s that Germany cracked the U.S. market with the original Volkswagen Beetle. And as the Federal Republic's products grew in reputation, America would fall in love with some of their top-notch marques: Porsche, Audi, BMW and Mercedes-Benz.

And with German engineering came German engineers, among them Hans Wittler, who with his wife Christel, immigrated to Albuquerque, NM in 1958. There he worked as a factory-trained dealership technician before opening his own shop in 1975.

"Of course the Bug was reallly big back then, Audi was just coming along and Porsche was pretty big too — it was a pretty decent market," recalls Hans' younger son Andreas. "He had experience in all of those, for the simple reason that he had come out of (those) dealerships, so the buzz was huge at that point."

Besides Hans' detailed knowledge of German cars, "his own ideals shape[d] a quality service experience," notes the shop's website. "Christel and Hans worked together for 24 years to make their small business a success with help from their sons Roger and Andreas. With their father's standards of hard work, dedication and integrity, Roger and Andreas took control of the business in 1999," when their father passed away.

"My dad taught us to do the right thing no matter what," Andreas states. "He used to say 'just fix the car, whether you make money or not, and it will all work itself out in the end.' Those are the kind of things he instilled in us."

However, when the Wittler brothers took over the company, they had to do a bit of retooling to incorporate newer high-tech cars rather than the older, less sophisticated classics their father had specialized in. Just over the last six years they've had to evolve and upgrade with the market, even including their own roles in the shop.

"I was mainly the service writer," Andreas reports. "My brother did more behind-the-scenes management. But now I'm doing some management stuff with him, and right now my main role is more HR, dealing with the technicians and the service writers, making sure everything goes smoothly with the crew.

"Every once in a while we have to pinch hit for each other, but Roger still does more of the management stuff than I do." Andreas continues. "For example, he's getting it to where we can program Porsche keys — something I have absolutely no patience for. I'd rather deal with the people while he'd rather deal with the logistics, like setting up our scan tools. He's the go-to guy for fixing something or to improve our business in some way, shape or form."

For his own part, Andreas found there were several groups devoted to the German marques and their markets. "One in particular was BIMRS [pronounced 'Bimmers'], and they really helped get us into the BMW market," he explains. "You have to go through an application process to be able to join, and they vet you through different questionnaires, etc. I believe there are about 300 members in the country, and it's just an amazing group."

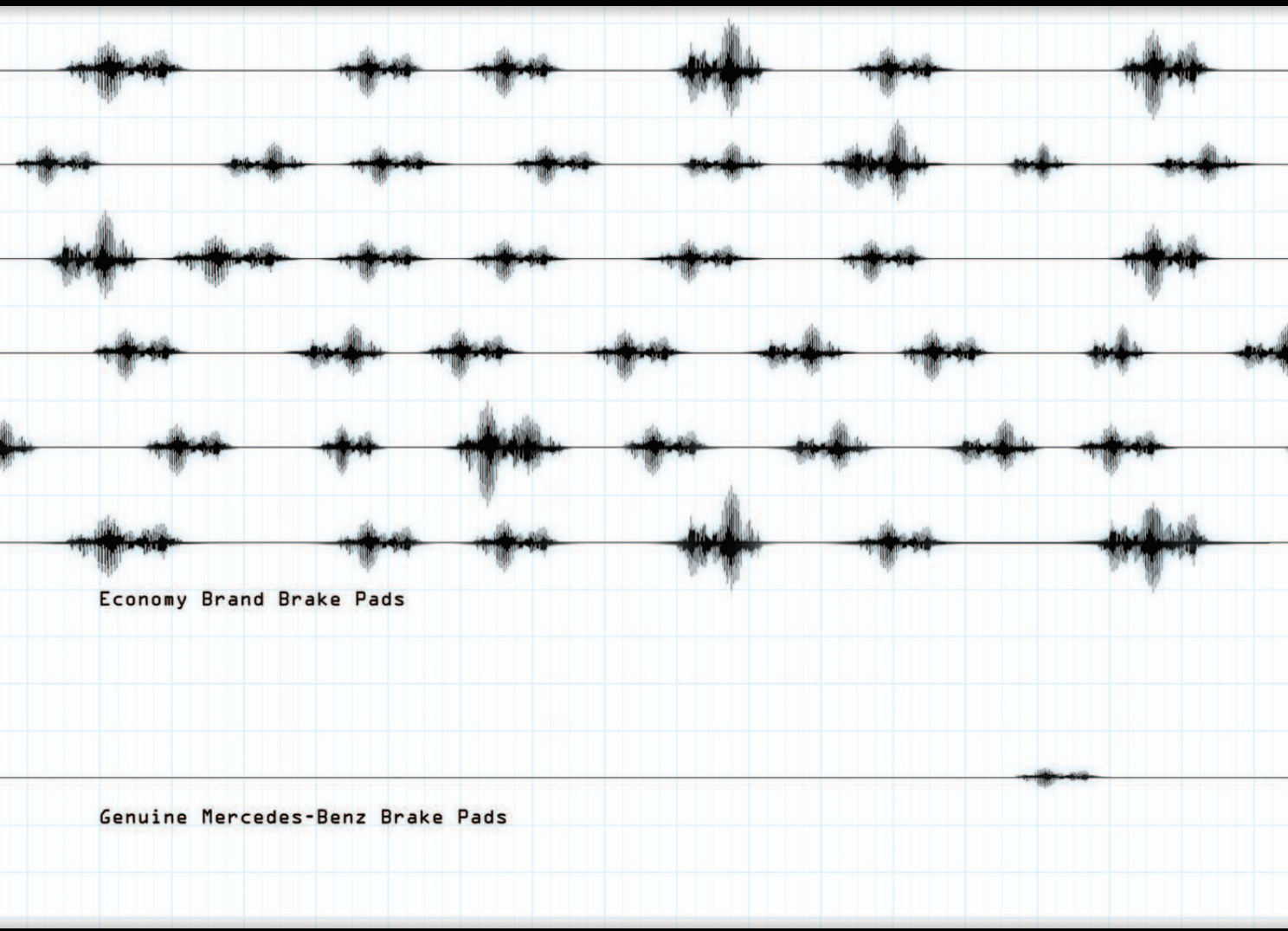
According to Andreas, BIMRS is similar to a 20 group, but more informal. "Their resources are what really got me moti-

HANS WITTLER'S AUTOMOTIVE

Albuquerque, New Mexico // www.hanswittlerauto.com

Andreas and Roger Wittler Owners	**10** No. of bays
1 No. of shops	**$550** Average repair order
43 Years in business	**65** No. of customer vehicles per week
10 No. of employees	**$1.9 million** Annual gross revenue
5,500 Total square footage of shops	

PHOTOS: HANS WITTLER'S AUTOMOTIVE



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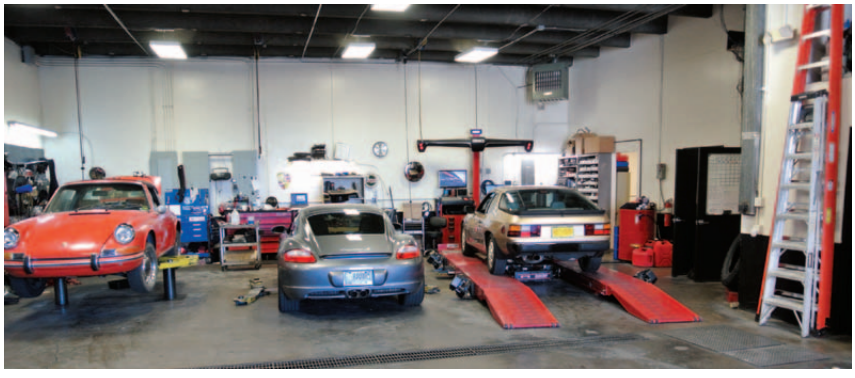

vated about 15 years ago. On the technical side, the training sessions have helped us, and they connected me with LMVIND, a tech support service." They also provided him with business and management advice, which helped the brothers expand beyond their primary market. "In percentage of business, BMW is now our biggest car line, the second being Audi/VW."

BIMRS was also helpful when it came to investing in new diagnostics. Before joining the group the Wittlers were arbitrarily trying systems with mixed results. "But these guys have 'been there, done that,'" says Andreas. "Being from huge cities like in Southern California, they see cars out of warranty earlier than we do; they know what to get and what to use and how to be cost efficient with their investment. We ourselves have invested $100,000 over the last 20 years in scan tools and scopes."

Working on German cars — let alone specializing in them — is clearly a challenge, one which most shops simply elect not to do. "And I totally understand," laughs Andreas. "They're tough, finicky cars. You can't cut corners on them. We go to great lengths to not do this, maybe even going a bit overboard on trying to make things as right as possible."

And key to this is a robust maintenance schedule, a fact hindered by a common misconception that these high-tech brands are low-maintenance cars. According to Andreas, back in the late 90s/early 2000s some German automakers promoted the idea that their cars could go for longer intervals without servicing. "And to a certain extent I think this has come around and bit them in the butt because they didn't tell you that this was under ideal driving conditions," he comments.

"Before this, every 30,000 miles you would change every fluid, every filter on the car, adjust the valves — you'd do like a major service. [The carmakers] had been getting away from that. We try to push maintenance a little bit more than that, so hopefully it will keep the customer from buying a big ticket item."

But as Andreas points out, "it's harder to explain to the customer why their owner's manual says not to worry about it while we're telling them otherwise. Do we know better than BMW? But we don't give up; we wade through a problem so we learn what to do better, and be able to walk up to a customer and say we know what it is, it's going to cost this much; what do you want to do? If you fix the car, you look like a hero, and they'll probably come back for the easy stuff." MM

ROBERT BRAVENDER graduated from the University of Memphis with a bachelor's degree in film and video production. He has edited magazines and produced shows for numerous channels, including "Motorhead Garage" with longtime how-to guys Sam Memmolo and Dave Bowman.
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OEM repair issues have no place in public policy arena

Pre- and post-repair scans should always be the industry norm

The 2018 state legislative season saw several states consider mandating the use of OEM repair procedures.

Why isn't following OEM repair procedures a common practice by collision repairers? Why don't all insurers require it as part of their DRPs? The question arises as to why policymakers are being brought in to referee what should be the accepted practice by all parties involved in collision repair. First, let's take a look at what we saw in the 2018 state legislatures:

Indiana – The Indiana Legislature considered OEM repair procedure legislation that allowed a work-around by recommending adherence to "industry standards" as an alternative to the vehicle manufacturer's repair procedures.

Rhode Island – Legislature sent the governor a bill that prohibits insurance companies from mandating the use of aftermarket parts without consent of the vehicle owner under certain timelines. Important for this discussion is language that required the use of OEM repair procedures but for OEM parts only.

Illinois – Legislation was introduced that required estimates to include OEM repair specifications for those parts, and no repair facility may use repair specifications or procedures that are not in compliance with the OEM for those parts authorized by the customer in writing.

Common to all of these bills was an interest by grassroots shops in those states to see reform relative to OEM repair procedures. Indiana's bill died in a conference committee. Including an "industry standards" baseline of repair versus OEM standards provided the path to the bill's end.

Although Rhode Island's legislation became law, it was rendered less effective by restricting the OEM standards requirement to OEM parts only. The Illinois bill did not gain significant traction.

Mechanical repairers find the lack of scanning in the collision industry confusing. Some collision shops are now, at times, without insurer reimbursement, pre- and post-repair scanning vehicles. Recently at the Collision Industry Conference (CIC) during the Automotive Service Association's (ASA) NACE Automechanika in Atlanta, Ga., CIC's Governmental Committee addressed OEM repair procedure legislation. Led by ASA Past Chairman Darrell Amberson, panelists discussed the importance of using OEM repair procedures in a collision repair. In addition, panelists Janet Chaney of Cave Creek Business Development, John Eck of General Motors and Wayne Weikel of the Alliance of Automobile Manufacturers (Alliance) highlighted the importance of scanning.

Questions and comments that followed the CIC presentation supported the use of OEM repair procedures and legislation mandating such practices if necessary.

ASA and the Alliance recently held a press conference to announce a joint effort in 2019 to establish public policy assuring collision repairs follow OEM repair procedures. These policies should also include pre-and post-scans. ASA and the Alliance will be working together to assure policymakers are educated about the importance for the safety of vehicle owners, passengers and the motoring public that OEM repair procedures are adhered to and scanning is a common collision repair practice.

Unfortunately, the lack of an industry solution was obvious during the 2018 legislative session when we saw the aforementioned bills introduced. Many consumers assume that these practices are followed and the vehicle has been scanned.

During the press conference, ASA noted that many consumers do not understand that there could be vehicle problem not necessarily indicated by a light or other vehicle information process. Until insurers and repairers find common ground on these repair procedures and scanning, the all for government intervention will only get louder.

ROBERT REDDING is the Automotive Service Association's Washington, D.C. representative. He has served as a member of several federal and state advisory committees involved in the automotive industry. *rlredding@reddingfirm.com*

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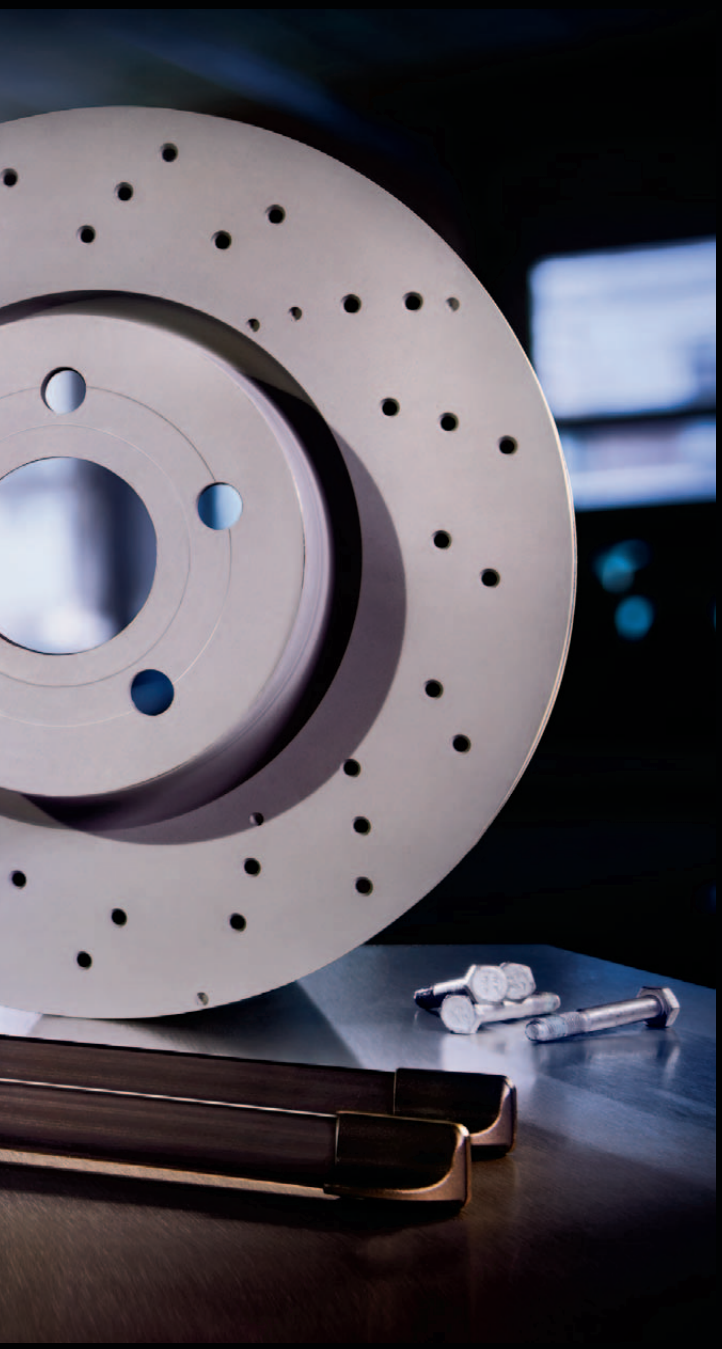

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Teach service advisors to continue selling even at delivery

KEEP THE BENEFITS OF THE NEXT SERVICE TOP OF MIND FOR YOUR CUSTOMERS

BOB COOPER // Contributing Editor

If you want to generate more repeat business, then there are a number of things you will need to do. You'll need to deliver an extraordinary value, exceed your customers' expectations at every touch point and stay in touch with your customers after the sale. Over the years I have discovered that most service advisors have the right intent, and make their best effort to do all of these things. They want to do a good job, and they know that a part of their job is to help their customers see the value in their services. This is why they work hard at building value in their company and services when speaking with first-time callers. It's also why they'll build interest and value in their service recommendations, with the hope that their customers will agree with their recommendations, authorize the services and then ultimately return.

The top advisors in America not only understand this, but they'll always put a strong focus on the benefits of their recommended services, rather than on the parts and labor. For example, when discussing the benefits of a brake service, they'll tell their customers that they'll have smoother and more responsive pedal operation, quieter braking, faster stopping and the peace of mind that they'll have good, safe and dependable transportation.

Yet where almost all advisors fail is at the point of car delivery. We have discovered that this is where they'll do a good job of reselling the customer on the services that were performed, and they'll certainly schedule the customer's next visit, but what they fail to do is this: They don't discuss the benefits of the next service.

Here's an example we can all relate to. You go to the dentist for a toothache, and they discover that you need a crown. The dentist then tells you that you have two options and explains the benefits of each. You like what you hear, and you make your choice based on the benefits that were shared with you. Then before you leave, the dentist tells you that you'll be due for a checkup and cleaning in six months, and they schedule you in. Will you return in six months? Well, you might, especially if the dentist met all of your expectations. But when that reminder card finally shows up in your mailbox, you may hesitate for one simple reason: None of us enjoy going to the dentist, and the dentist didn't explain the benefits of the checkup and cleaning during your last visit. If they had told you how this visit could save you money, help prevent other painful problems, and reduce the amount of time you'll ultimately spend with your dentist, you would more than likely be more willing to return. I can only hope you agree that it's no different with your business. If you want to see more return business, then do this:

At the time of car delivery, take just a minute or two to explain the benefits of the customer's next service. For example, rather than just telling your customers that they'll be due for their next scheduled service in six months, say something like this… "As I mentioned to you earlier, Doris, your next service is going to be a maintenance service, and it'll be due in six months. Now the good news is that service is going to help you squeeze every mile out of every gallon of gasoline, it's going to help you maintain your warranty and protect the value of your vehicle, and it's going to help you save time and money by preventing costly breakdowns."

Although I can't guarantee that your customers are going to return if you do what I am recommending at the time of car delivery, there is one guarantee that I can make you: If you take just a minute to explain the benefits of the next service to your customers, there is a strong probability that they'll want to come back. On the other hand, if the only reason for them to return is because you sent them a reminder card telling them that they need to come in for nothing more than to spend money with you and to be without their vehicles for a day, then you've given them a really good reason to toss the reminder card… and not come in.

BOB COOPER is the president of Elite, a company that offers coaching and training from the industry's top shop owners.
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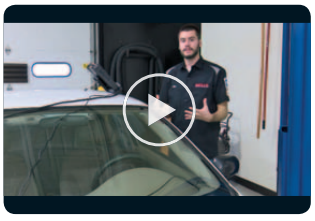

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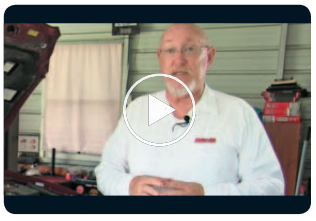

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MECHANICAL MOMENT

SERVICE REPAIR PROBLEMS AND SOLUTIONS THAT JUST MIGHT BENEFIT YOUR SHOP TECHNICIANS

LAND ROVER REAR SUSPENSION SAGS AFTER REPLACING BATTERY

VEHICLE:
2007 Land Rover LR3 (LA) V8-4.4L
Automatic Transmission/Transaxle

MILEAGE:
112,003

PROBLEM:
After replacing the battery, the customer noticed the rear suspension was lower than normal. The tech retrieved a DTC C1131 — an Air Spring Supply code from the Suspension Module.

DETAILS:
The tech visually inspected the system for air leaks and checked the reservoir valve block pipes for correct routing and installation. He did not find any issues.

CONFIRMED REPAIR:
The ALLDATA Tech-Assist consultant recommended performing a steering angle sensor relearn procedure. The procedure was simple — turn the steering wheel from lock to lock. After performing the relearn procedure, the tech cleared the DTC. The ride height went back to normal and the problem was resolved.

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TRAINING EVENTS

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Messe Frankfurt
Frankfurt, Germany

SEPTEMBER 13
TST Live Simulcast: Domestic/Asian Immobilizer System Diagnosis with Bob Augustine
www.TSTseminars.org
Mahopac, New York

SEPTEMBER 29
ASA Illinois: Hands-On Tech Training
College of DuPage
Addison, Illinois

OCTOBER 13
ASA-Midwest Des Moines: Hands-on Hybrid Training
Williamson's Repair & Tire
Bondurant, Iowa

OCTOBER 30-NOVEMBER 1
APPEX 2018
Sands Expo
Las Vegas, Nevada

FEBRUARY 21-23
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MARCH 30
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ANDREW LIBERT // Contributing Editor

The story begins in the early 2000s, when the government laid down the law on a new generation of emissions standards, requiring manufacturers to make drastic improvements in fuel economy and emissions. Manufacturers responded by looking at a wide range of new technologies, including Gasoline Direct Injection, electric cars, hybrids, fuel cell vehicles and Advanced Electronic Common Rail Diesels. Over half of the vehicles in Europe are diesels, which have excellent fuel economy and low HC/CO emissions, so German manufacturers chose to refine them and bring them to the U.S.

There was just one problem with that plan: diesel engines tend to produce very high levels of NOx emissions. NOx limits in the U.S. were always stricter than those in Europe, but the new laws slashed the limit by 90 percent! Engineers at Mercedes, BMW, Volkswagen and Bosch put their heads together and began searching for the ideal NOx solution that would revolutionize modern diesels.

Research focused on three different types of solutions. The first was to decrease the amount of NOx coming out of the engine; the second: use a NOx Storage Catalytic Converter to filter it out; and the third: Selective Catalytic Reduction (SCR). SCR injects a liquid urea solution (called Diesel Exhaust Fluid or "DEF") into the exhaust where it breaks the NOx down into nitrogen and water. Each technology has different tradeoffs. Reducing the engine's NOx production is less effective and decreases power. Using a NOx Storage Catalytic Converter is more effective but requires extra fuel to be injected to burn the stored NOx off, which reduces fuel economy. SCR is extremely effective and doesn't reduce fuel economy, but it requires many expensive parts and space for a large storage tank for the DEF. Another disadvantage of the SCR system is the requirement for maintenance; periodically, the DEF must be refilled or the system will stop functioning.


1

Mercedes-Benz and BMW ultimately decided SCR was the way to go. At the time, though, the government didn't like SCR — they preferred the NOx Storage Catalytic Converter technology VW was promoting because it was maintenance-free. U.S. officials were concerned that SCR systems would not be maintained and that the cars would run wild with untreated NOx emissions. The EPA made sure that the Ultra Low Sulfur Diesel (ULSD) needed for these new emissions technologies would be available everywhere by the time the new laws phased in, but there was concern that the supply and distribution infrastructure for DEF wouldn't be ready.

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Manufacturers were required to disable the vehicles if the SCR system is not working. Ordinarily, the driver doesn't even know the system is there, but if the DEF level runs low, warnings appear in the cluster in stages and ultimately the vehicle goes into limited starts mode and counts down. When the count hits zero, most vehicles will not start again. Make sure to refill the tank as part of your regular service on all SCR-equipped diesel vehicles!

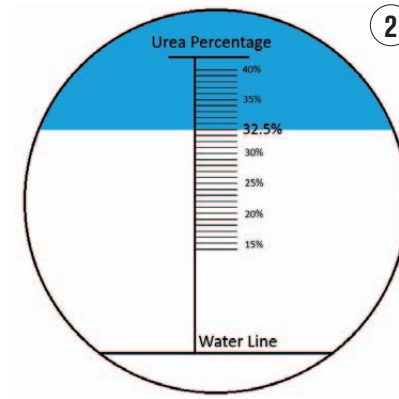
System overview

Diesel Exhaust Fluid is 62.5 percent deionized water and 32.5 percent urea by definition, and the industry standard for its quality is ISO 22241. You can buy DEF from any manufacturer and use it in a Mercedes system if it meets the ISO standard, which should be on the product label. AdBlue® is a German Auto Industry brand name for DEF, and I will use the term "AdBlue" when referring to DEF going forward.

Although you don't have to buy it from Mercedes, they sell a special bottle I really like. You screw it onto the fill port, push it down and the fluid will flow into the tank until it is full. Then you release and unscrew it for a drip-free job. It also makes it perfectly clear the tank is full without accidentally overfilling it and making a mess. AdBlue is corrosive, so always use gloves and safety glasses and keep it away from painted surfaces. Clean up is easy — just wash it away with water.

An important first step is to make sure that the fluid is good quality. AdBlue has a limited shelf life (at least one year when stored properly) and it is also vulnerable to contamination. On Sprinters, the AdBlue fill port is under the hood and commonly gets water or washer fluid in it instead. On the 166 chassis, it is right next to the diesel fill port, so sometimes it is contaminated with diesel, and vice versa (Figure 1).

Mercedes recommends using a refractometer to measure the quality of AdBlue. Refractometers work by measuring the way light bends as it passes through a liquid. When the chemicals or their concentrations change, the way they affect light changes as well. You want a refractometer made specifically for DEF testing because it will show a scale corresponding to the percentage of urea; an OTC 5025, for example. Regardless of which one you use, be sure to follow the instructions for proper calibration and testing. Mercedes simply specifies the exact standard of 32.5 percent, but good fluid generally tests within 32 percent to 33 percent (Figure 2). If the urea percentage is incorrect, the fluid is low quality or it was contaminated. In either case, it will be necessary to flush the system and replace the fluid. It's also not a bad idea to verify the quality of your own shop supply to avoid creating unnecessary contamination problems for yourself and your customer.



2

The AdBlue tank is designed to store enough to make it to the next service, but with aggressive driving it may have to be topped off before then. AdBlue's freezing point is 12° Fahrenheit and unlike windshield washer fluid, there are no compatible anti-freezing additives. As a result, the entire storage and supply system is heated and there are no moving parts in the tank. Instead of a float to measure the level, an electronic sensor uses three switches to indicate Full, Reserve and Empty. There are three

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heaters as well — one in the tank, one inside the pump, and one on the pressure line to the metering valve. The pump is mounted on top of the tank but it has to pull from the bottom, so it has a hard time priming, unlike a fuel pump, which is submerged. When the engine is shut off, the metering valve is held open, the pump switches into reverse and empties the line so that it doesn't freeze.

The exhaust portion of the SCR system includes the SCR catalyst, the AdBlue metering valve, a temperature sensor, and upstream and downstream NOx sensors. The SCR module monitors the storage, supply and heating systems and the CDI module controls the metering valve and monitors the emissions performance via the NOx sensors.


3

Troubleshooting

Start diagnosis by checking with the customer about service history and any previous diagnostic or repair attempts. It's common for these vehicles to make their way around the block and take some bruises before arriving at your doorstep. Where you go next depends on whether the vehicle was towed in or driven in. Diagnosis will require a few road tests, so you need to deal with any countdown or limited starts condition first.

Hook up the Autologic (or equivalent scan tool), do a complete vehicle scan, and record the results.

Do not clear the codes

Clearing DTCs on some models will cause the system to go into a "Tampering Mode" and get stuck in the start countdown even after repairs are completed. If you have zero remaining starts, you will need to reset the data that resulted in the system shutdown. Check the fill level of the AdBlue — if it is empty you will need to completely fill it and perform the tank reset adaptation. In order for the tank adaptation to succeed, all of the level sensors need to read WET and there cannot be any ambient temperature sensor faults. If the tank is full but does not read WET across the board you need to disconnect the SCR module and check resistance across each level switch. They should be within approximately 3.8 – 4.2 kOhms. After successful adaptation of the tank, try again to reset the start countdown. If it works, go straight to diagnosis. If not, perform the metering valve adaptation reset in the CDI module and try again. If you are still stuck, reset the adaptations of the AdBlue Quality, both NOx sensors and the SCR catalyst.

Due to the large number of variations/revisions of the CDI, SCR and NOx sensor module software and hardware, each vehicle performs a little differently. Sometimes reprogramming and SCN coding the CDI and SCR modules is necessary to get everyone on the same page, or even to escape limited starts. The NOx sensors have a Q code printed

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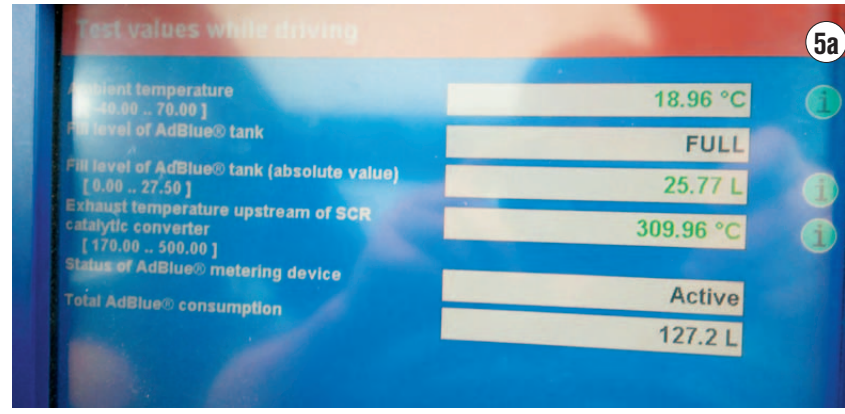
on the back, which indicates their version, with the latest being Q5. Q1 and Q2 sensors are not compatible with newer ones so if you have to replace one, you must do them both. Q3 and on is supposed to be compatible with later versions, but as a support specialist with Autologic, I have sometimes seen issues when only one is replaced. The sensors are very expensive, so it may be best to advise the customer that you will start with the faulty sensor and replace the other as needed, but ideally you would replace them in sets.

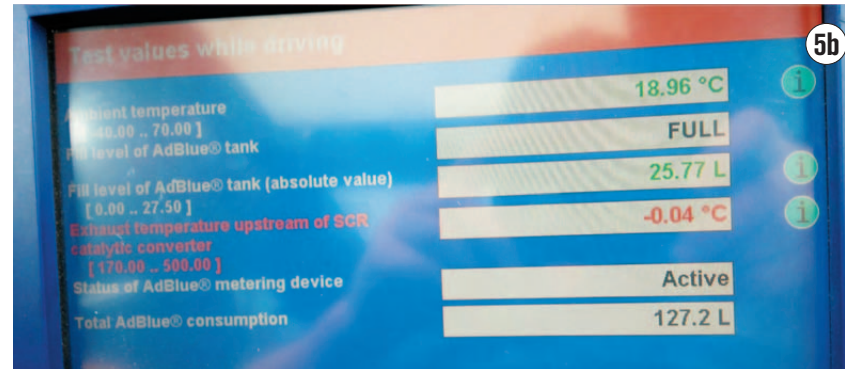
Aside from codes for NOx performance and adaptations, diagnose any and all engine performance faults first, then diagnose SCR faults. Diagnosing NOx performance requires a solid foundation — everything from the tank to the injection must be verified first.

Use the Autologic to test each heater with actuations. It's not necessary for NOx diagnosis, but it only takes five minutes and will help you to build familiarity with typical values, find failed heaters and find borderline heaters that could result in a comeback. Usually the heaters will fail with high resistance or as an open circuit; generally the tank heater tends to read a little lower. If you have to drop the tank for repairs, check the harness for AdBlue contamination and replace it as necessary. Also, make sure to fill the pot all the way to the top, or the pump may fail to prime and in the worst case scenario the motor can burn up (Figure 3).

Next, use the Autologic to perform the leak test. The pump will run automatically and hold the pressure at 5 bar (about 72 psi). Look for leaks, especially at the pressure line and metering valve. Remove the metering valve and check the nozzle for leakage and clogging, keeping in mind that some crusty white deposits are normal.

Perform the metering valve test; watch the spray and look for a finely atomized three-cone pattern. Collect

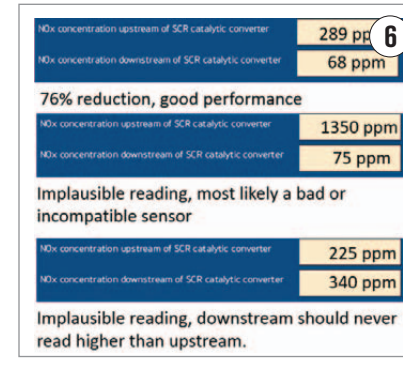




the AdBlue and weigh it. The Autologic will provide the specification — it is normally around 15 grams. Suitable electronic scales can be found online for $10-15; and just like the refractometer, it's best not to wait until you need it to buy one. Even if the spray is bad or the valve seems clogged you should not clean it yet but simply reinstall it because we want to see exactly what the control module saw when it decided that the system had failed before we change anything. Take that fluid sample and put it on your refractometer and check the quality. If your AdBlue is just reading marginally off, it's good enough for some test driving, but if it is contaminated, flush it out, refill it properly and reset the tank adaptation. You can also pull a sample from the tank's fill port.

Evaluating the SCR system performance

Now that the storage and supply system is verified, it's time to test the NOx sensors and NOx reduction performance. NOx sensors need to be heated to about 800° Celsius (1472° Fahrenheit) to operate, but at this temperature they can easily be damaged by a thermal shock if moisture or condensation hits them. Therefore, the NOx sensors are not turned on until the CDI module calculates that the exhaust temperature is high enough to vaporize the water. It's typical for this to take 5-15 minutes from a cold start depending on ambient conditions and drive cycle. It seems to occur around an SCR temp of about 300° Cel-



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sius (572° Fahrenheit).

Note that it's very unlikely the exhaust will get hot enough for the sensors to work if the engine is only idling; you must drive the vehicle!

Before they've come online, the sensors could read 0, 1000, 2000, or even "NOT OPERATIONAL" (Figure 4).

The SCR catalyst also needs to heat up and light off in order for the NOx reduction reaction to work properly, so you will need to drive the vehicle. Find someone to drive you for an SCR System Performance Road Test; I'm personally aware of a couple of technicians who have crashed doing it alone. Before you take off, check the exhaust temperature sensors for rationality — if the vehicle is cold there should be no more than 20°C (68° Fahrenheit) between the lowest and highest readings. During the drive, while you're waiting for the NOx sensors to come online, monitor your exhaust temperatures again. A bad temperature sensor can upset both engine and SCR systems. Look for a sensor that suddenly jumps to an implausible value (Figure 5).

When the NOx sensors come online you want to drive at about 55-60 miles per hour (85-95 kilometers per hour) with a very steady engine load. Do your best to avoid braking, hills, acceleration and coasting. NOx production increases when accelerating and decreases when slowing down, so for this performance test you need a stable NOx feed to the SCR catalyst and the catalyst temperature needs to be stable. Monitor the upstream and downstream values. Readings vary by application but the reduction on a working system will be 30 percent to 50 percent.

For the 906 Sprinter, 251 R-Class, 164 ML-Class, 164 GL-Class with the OM642 engine, the upstream will usually read anywhere from 200-300 ppm and the downstream will usually read from 75-100 ppm.

The 221 S-Class, 166 ML-Class, and 166 GL-Class use an updated version of the OM642 engine, so for these vehicles and for any vehicle with the OM651 engine (166, 204, 205, 253, 212, 906, 907), the ppm readings should be 50-150 upstream and 0-50 downstream.

METERING VALVE - PRESSURE LINE LEAKAGE

Diagnosing a malfunctioning system

What you do next depends on what you found in the earlier tests. If the metering valve was leaking, you need to replace it and see if it corrects the problem, but you also need to explain you can't diagnose the SCR cat or the NOx sensors with a metering valve that is leaking into the system. It's common to have to replace more than the metering valve to fix the vehicle, so set expectations appropriately. The downstream sensor, for example, can be skewed by the excessive AdBlue leaking onto it. If you had some marginally poor quality AdBlue, go ahead and replace it now.

If the metering valve was just a bit clogged or not spraying well, you can wash it off with warm water, put it back in and re-run the performance test. If you see a substantial improvement, you should still recommend replacing the metering valve to ensure a lasting repair. Metering valves often clog up because they are slowly leaking and while cleaning it may restore its function temporarily, in the long run this may result in a comeback. All parts of this system are very expensive, so when repairs seem like they might or might not be necessary, it's best to make the complete repair or let the customer make an informed decision. Don't forget to reset the metering valve adaptation after replacement and before quality check road testing.

Bad readings (Figure 6) could be caused by bad sensors or by a system malfunction. Here, the next step is to verify the NOx sensors are reading correctly and compatibly with each other. Disconnect the metering valve and go drive the vehicle hard for 20-30 minutes. The SCR catalyst is like a sponge and it stores a lot of ammonia, so there is always some available even if the metering valve is not spraying or there is a sudden increase in NOx (hard acceleration). You need to drive it and heat the exhaust up to burn off all of that stored ammonia. Once that happens, the upstream and downstream sensors should match pretty closely. We know the engine out NOx on a steady cruise is around 200-300 ppm (or 50-150 ppm), a bad sensor reading will generally contrast pretty sharply.

The last piece of the puzzle (and the least likely to fail) is the SCR catalyst. The job of the SCR catalyst is to absorb and store ammonia and to help it react with

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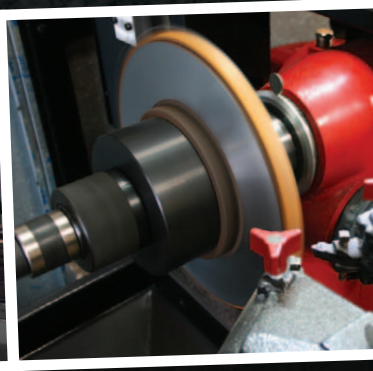

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the NOx to produce nitrogen and water.

What it needs most of all is a good amount of real estate — that is, a lot of surface area. Adblue deposits can build up on the SCR catalyst, causing it to "deactivate," or they can collect on the mixing element after the metering valve and restrict exhaust flow. The top three things that can ruin the SCR cat are 1) poor quality diesel fuel, especially with excessive sulfur; 2) AdBlue contamination/deposits; and 3) failures of the DPF (Diesel Particulate Filter) allowing soot leakage into the SCR cat.

Normally when the DPF is regenerated, the SCR cat is also heated up and burned clean, starting anew. If DPF regeneration stops because of a malfunction, the SCR catalyst is not regenerated either. Sometimes the SCR cat melts due to engine malfunctions, sometimes it breaks apart due to the harsh operating conditions. You can try to do a visual inspection with a bore scope or you can check the exhaust back pressure reading with and without the SCR temp sensor removed, but ultimately it is a matter of probability and process of elimination. Look for evidence of DPF leakage by checking the SCR temp sensor for soot stains, checking inside the exhaust pipe when removing the metering valve, or checking the tail pipe with a clean white cloth. When DPF failure is suspected to have damaged the SCR catalyst, Mercedes replaces the DPF and SCR together.

Late-model Mercedes diesels can be very challenging to diagnose, but with the right information, tooling and training, that service can be very profitable for your shop. Sprinter vehicles in particular are working vehicles, keeping businesses running every day, and their owners are often quick to open the wallet but even faster to ask for the keys. Don't be afraid to jump into the electronic diesel market, after all, this discussion of AdBlue has already got your feet wet.

P.S. Stay tuned for more developments on Diesel Emissions Technology, "clean diesel" isn't dead yet, as Bosch has recently announced dramatic breakthroughs in the NOx management technology.

ANDREW LIBERT attended Palm Beach State College's vocational automotive program, worked for GM at Chevrolet and then at Cadillac where he began specializing in diagnostic work. He moved to Continental Imports of Gainesville, where he fell in love with Mercedes-Benz and continued a full-time specialization in diagnostics. In January 2018, he joined Autologic doing programming, diagnostics and training.
andrew.libert@autologic.com

THE SCIENCE OF THE MAF

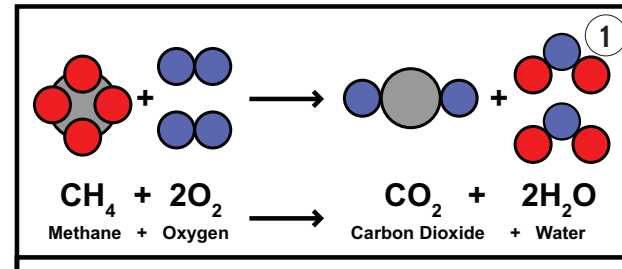
MANY OEMS ARE STILL USING THE MAF (MASS AIRFLOW) SENSOR AS THEIR PRIMARY MEANS OF MEASURING THE AIR ENTERING THE ENGINE. KNOWING HOW IT DOES ITS JOB MAKES IT EASIER TO KNOW WHEN IT ISN'T DOING ITS JOB.

BERNIE THOMPSON // Contributing Editor

We are all living at the bottom of an ocean — an ocean made of air instead of salt water. The earth has a vast ocean of nitrogen and oxygen encompassing it. This ocean of air is being pulled toward the earth by gravity. Gravity is the force that is created between two objects with mass that are attracted to one another. This force is proportional to the product of their masses and inversely proportional to the square of the distance between them. On earth, gravity is what gives weight to physical objects. This vast ocean of air surrounding the earth has mass and therefore has weight. The weight of this ocean of air will change depending on the depth of it. Just like an ocean of water, the deeper the water the more pressure is created. This ocean of air exerts 14.7 Pounds Per Square Inch (PSI) at sea level and at 18,000 feet this ocean of air exerts 7.34 PSI, which is only half of the pressure that is created at sea level.

How that impacts us

The internal combustion engine uses this air weight or air pressure in order to operate. When the piston moves downward, away from the head, the volume increases, thus creating a low-pressure area within the cylinder. This low-pressure area within the cylinder sets up a pressure differential. A pressure differential is the difference in energy between a higher pressure (atmospheric air) and a lower pressure (cylinder air). High pressure, having more force, always moves to a low pressure having less force, thus the surrounding air moves into the cylinder. This inrush of air into the cylinder will be used to operate the engine in several ways. The first is the volume of air (78 percent nitrogen, 21 percent oxygen, 1 percent other) will be compressed, creating heat within the cylinder. The second is the air within the cylinder, being comprised of 21 percent oxygen, will provide an oxidant for the chemical reaction with the hydrocarbon fuel stock. Third, the 78 percent nitrogen and 1 percent other will be heated by the burning fuel, which creates the expansion of the nitrogen, thus forcing the piston downward. This, in turn, produces torque on the crankshaft.



A stoichiometric diagram of the combustion reaction of methane

The burning of the hydrocarbon fuel stock within the internal combustion engine is essential. This is what powers the engine so that the pumping losses of the engine and the energy needed to move the vehicle can be produced. In order to properly burn the hydrocarbon fuel stock, the weight ratio of the air and fuel will be important. The proper air/fuel ratio to completely burn the fuel stock is referred to as stoichiometric. The stoichiometric ratio between the fuel and air is one where the hydrocarbons and oxygen are at a weight ratio that once they react with one another neither chemical will be present. This means that the hydrocarbons break apart, becoming hydrogen and carbon. In the presence of oxygen, the hydrogen combines with the oxygen forming a new chemical: dihydrogen monoxide (H_2O — water). The carbon attaches to the oxygen, forming a new chemical: carbon dioxide (CO_2). If the hydrocarbons and oxygen are at a stoichiometric ratio and react with one another, then neither of these chemicals will remain present within the combustion gases (Figure 1). The chemical weight will be the same but the new chemicals formed during a complete reac-

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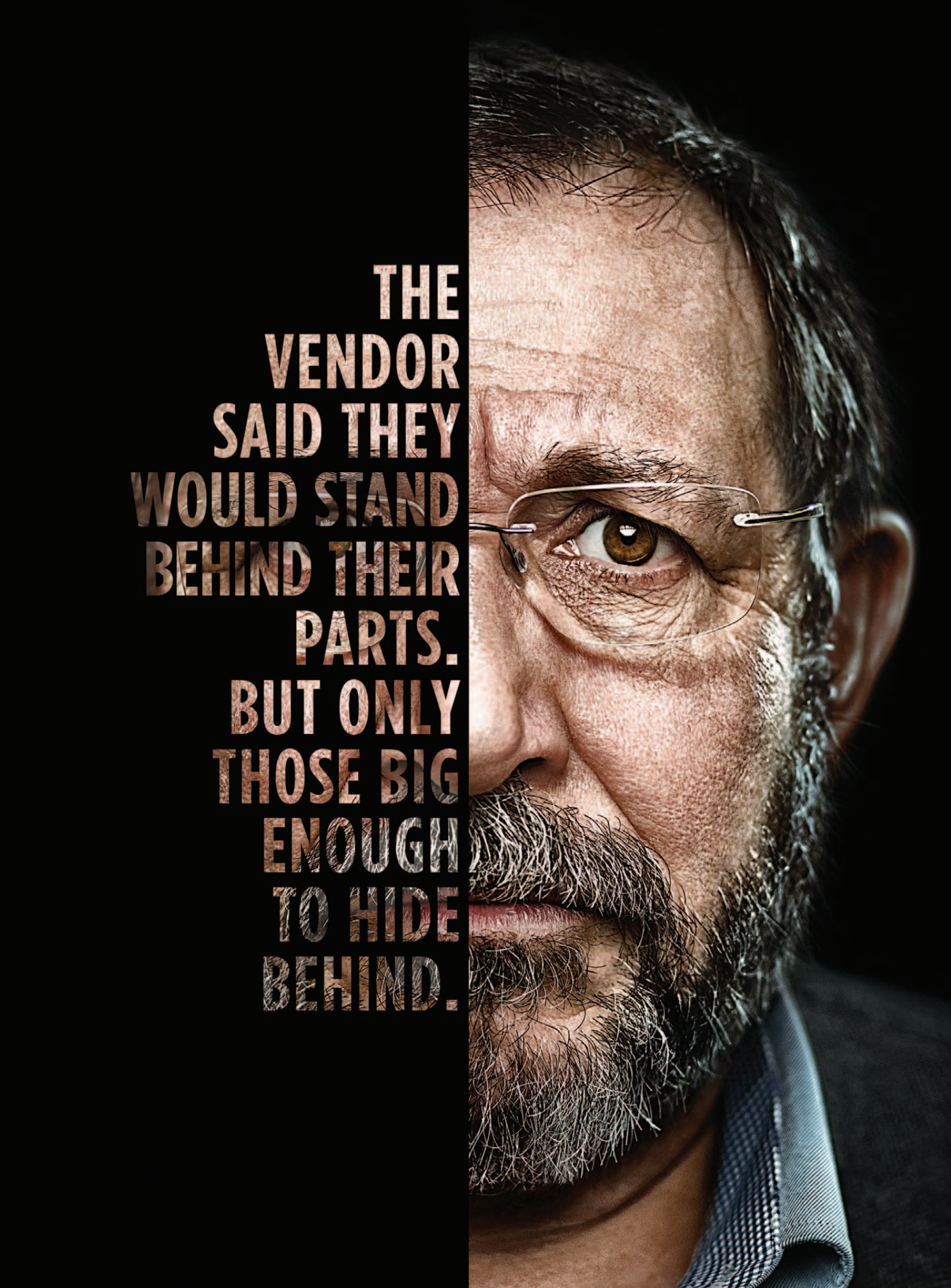
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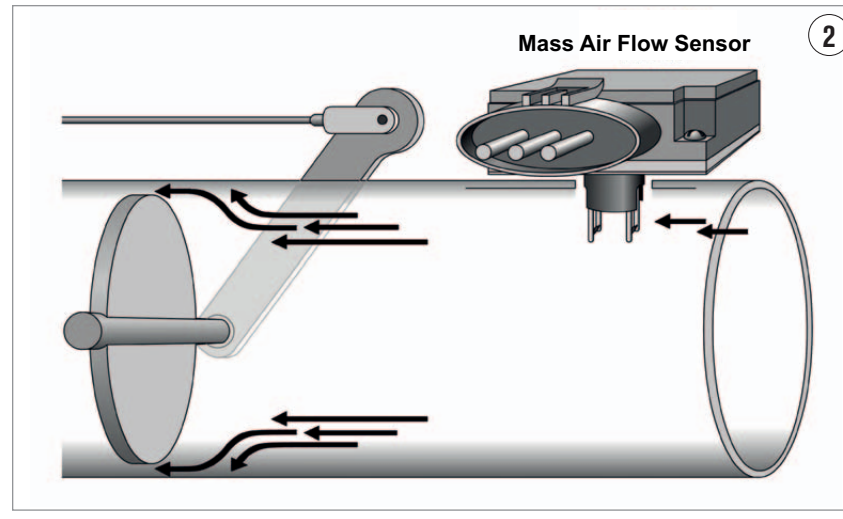
tion will be water and carbon dioxide.

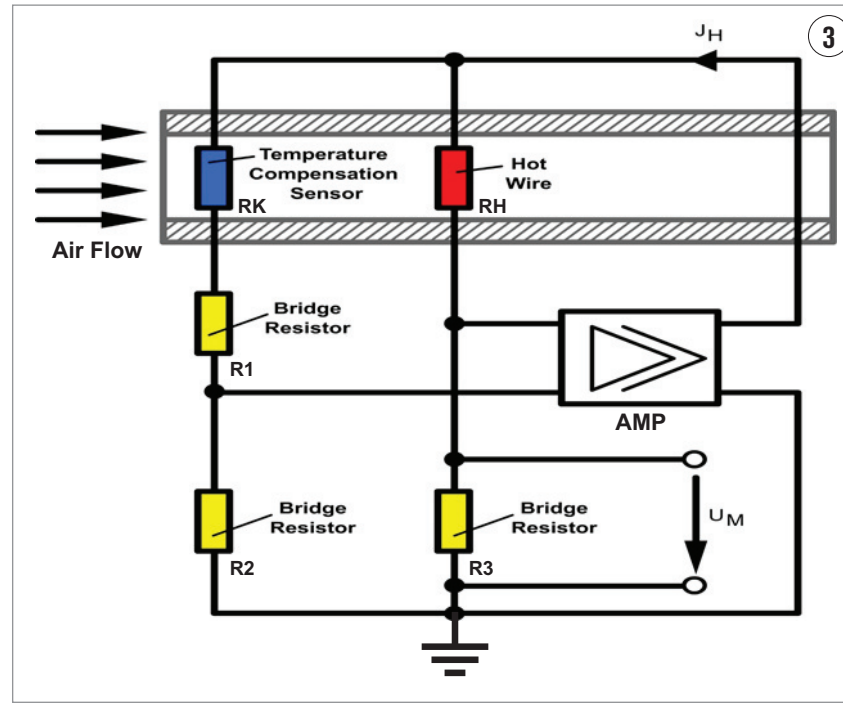
In order to obtain a stoichiometric ratio between the fuel and air, the weight of the air must be known. Since the fuel stock to be combusted is known, the fuel weight will also be known. However, due to the load of the engine constantly changing, the air weight is an unknown factor; therefore, there must be a method to properly weigh the air. With the fuel-injected gasoline-based engine there will be three basic methods used.

The first method is the Alpha-n method in which the Throttle Position Sensor (TPS) is the main sensor used. This is where a look-up table for the throttle-affected area is used to calculate the air weight entering the engine.

The second method is the Speed Density method in which the Manifold Absolute Pressure (MAP) sensor is the main sensor used. This is where a look-up table for the absolute pressure within the intake manifold is used to calculate the air weight entering the engine.

The third method is the Mass Air Flow Measurement method in which the Mass Air Flow (MAF) sensor is the main sensor used. This is where a look-up table for the air entering the induction system is used to calculate the air weight entering the engine.





Why MAF?

In each of these methods an accurate air weight can be calculated. Each of these methods have advantages and disadvantages, but perhaps the MAF method has the greatest advantages. When a thermal measurement air flow device is used, there is no altitude error, no significant moisture influence, no pulsation error, fast response time, and no moving parts. The fast response time from these thermal measurement devices will still have significant delay or latency. Additionally, it is hard to measure air flow in unsteady conditions, such as during a transitional event. Therefore, during an acceleration, the engine control program will not use the signal from these thermal measurement devices.

When using these thermal measurement devices, air weight is directly measured by the sensor. This is accomplished using a sensor that is located before the throttle plate (Figure 2). This sensor must be located in front of the throttle plate. If the sensor were located after the throttle plate, the turbulent air flow would have a negative effect on the sensor's output voltage, causing an erratic output voltage that cannot be used. Turbulent air is such a problem that these sensors are equipped with an inlet screen to allow the air moving through the sensor to be straightened before being measured. Some manufacturers show an MAF sensor located behind the throttle plate. These sensors are called out as MAF sensors in the wiring diagrams and scan tool data streams, but these are really MAP sensors, because when the sensor is located

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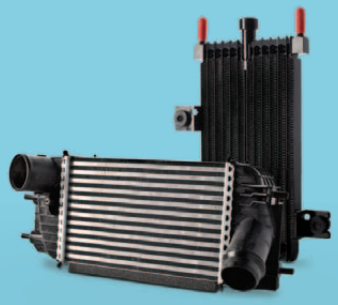

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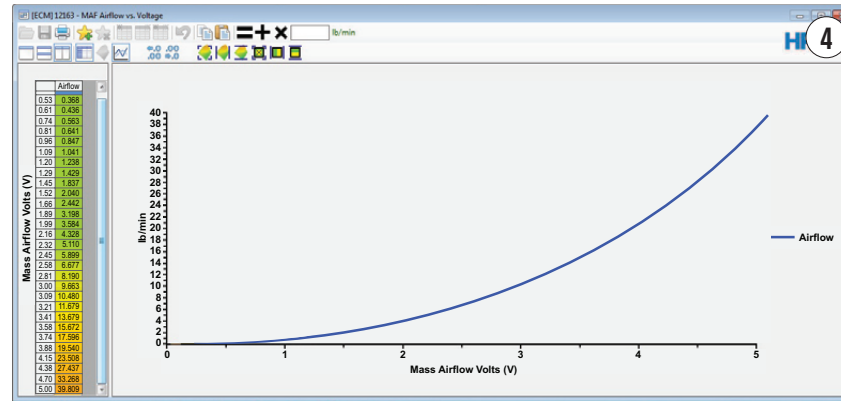
behind the throttle plate the sensor is based on the speed density method.

When troubleshooting fuel management faults, it is important to identify which air weight method is being used. Each of these methods have different effects on the fuel injection system. For example, if you have a single exhaust with a restriction, these systems would correct for this problem differently. The speed density system reads the pressure (vacuum) within the intake manifold. The exhaust restriction would cause the pressure to rise toward atmospheric pressure under load. This is interpreted by the Engine Control Module (ECM) that the air weight entering the engine is higher than what is actually entering. Thus, the fuel trim would move to a negative factor (taking away fuel). Using the MAF system with this same problem would cause the air flow to drop under load, which, since the MAF sensor reads the direct air flow into the engine, would read this drop in air flow correctly. Thus, no fuel trim factor would be utilized.

Now let's change the problem to one of an air leak. If the speed density method were used, the air actually entered the engine dropping the intake pressure. Since the air volume actually entered the engine there would be no fuel trim correction factor. If the MAF method were used and an air leak were to let air into the engine, this air would not be read by the MAF sensor so the unmetered air would have to be compensated for with a positive fuel trim factor (adding fuel). As you can see, these systems operate differently from one another making it imperative that you identify the system correctly in order to accurately diagnose the fuel injection system.

MAF construction and operation

The MAF sensor can be constructed in several different ways. The first MAF sensors were vane air flow sensors in which a mechanical door was pushed open by the air flow entering the engine. The vane air flow sensor is based on the equation for orifice flow, where the kinetic energy of the air flow is converted to pressure energy at the vane. The vane air door is connected to a potentiometer, which sends an output voltage to the ECM that is proportional to the door movement, and the door movement is proportional to the amount of air entering the engine, thus the air weight can be correctly calculated. The problem with this type sensor is that they are prone to damage from high pressure waves such as backfires.



4

Newer MAF sensors use an electrical circuit based on a wind speed anemometer (Figure 3). This is where a hot wire or hot film device works on the basic principle that the amount of electrical power required to maintain the heated element in a moving fluid stream at a fixed temperature above the fluid temperature is a direct function of the mass air rate past the element. This principle is based on convection. Convective heat transfer is a mechanism of heat transfer occurring due to the movement of fluids, in this case the fluid is air. The heated element is hotter than the surrounding air so when cooler air moves past the hot element, the heat is transferred into the cooler air, being carried and dispersed by the air flow.

This may sound complicated but you already understand this principal in the effect of wind chill. Your body temperature is hotter than the surrounding air temperature. If the air is not moving, there are not as many air molecules coming in contact with your body. Each air molecule that is colder and comes in contact with your body will take heat on. The more molecules that come into contact with your body, the greater the heat transfer. If the air flow has a higher velocity, then more air molecules will come into contact with your body, allowing more heat energy to be removed from your body.

Now in place of your body put the electric heating element. If the heating element is hotter than the surrounding air, the heat will be transferred into the air molecules. Each air molecule that comes in contact with the heated element removes heat from it. If the velocity of the air is increased, then more molecules come in contact with the heated element, which will remove more heat from the element. In the engine compartment the air temperature can be greater than 250°F. This means the heating element or hot wire will need to be hotter than its surroundings so the transfer of heat can be made from the hot wire to the air flow.

These heated elements will be kept at a constant temperature that, depending on the heating element type used,

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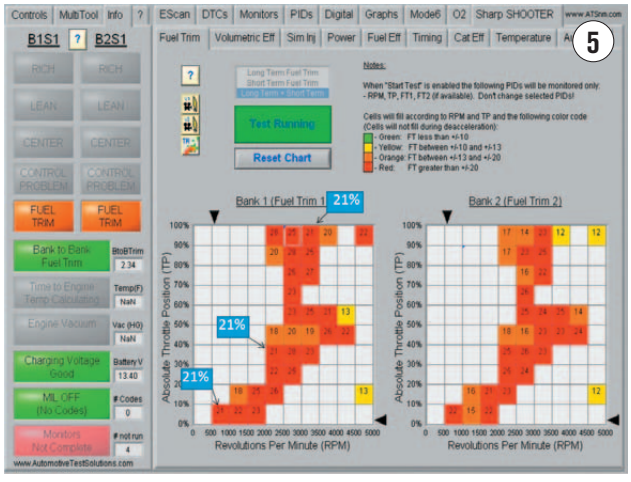
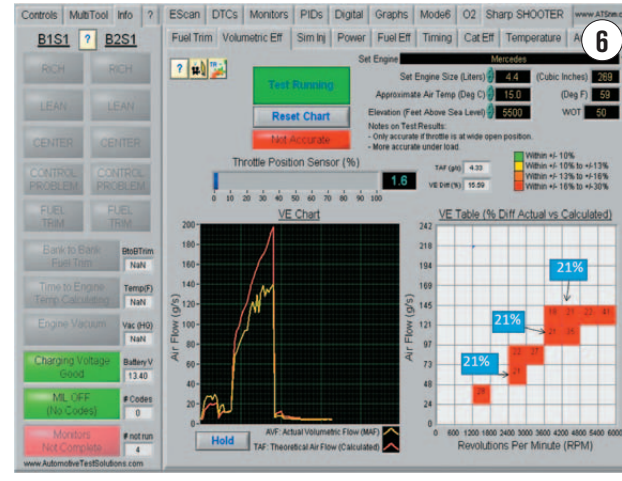




will be approximately 425°F to 450°F. This is accomplished with a bridge circuit from a platinum hot wire-type element as shown in Figure 3. The platinum hot wire is very thin (approximately .0027 inch in diameter) so it can obtain a rapid heat transfer that will help limit the transient delay from the sensor. The bridge circuit is designed so that the heating element is kept at a constant temperature regardless of the air flow across it. When the air flow is increased, removing more heat from the heating element, the resistance of the wire drops. This causes the bridge circuit to become out of balance where the amplifier supplies more current to the circuit in order to keep the temperature consistent. Depending on the air flow, the bridge circuit supplies 500 mA to 1500 mA to the heating circuit. Since the air flow is responsible for removing the heat from the heating element, the current will be proportional to the air flowing across it. This current will be read as a voltage drop across precision resistor R3. This voltage drop across R3 will be read by the ECU and converted from voltage to air weight in a transfer function table (Figure 4). When this table is calibrated by the manufacturer, the engine head and complete induction system, including the air filter, is used. This assembly is then put on a flow bench where air is allowed to flow through the induction system at different flow rates. The voltage output from the MAF sensor is written into a lookup table and then matched with the air flow weight that was present through the MAF sensor and induction system. When the engine is running, the ECU looks up the voltage that is being produced from the MAF sensor and converts it to actual air weight. This method allows an accurate way to normalize the voltage reading to an actual air weight reading.

The density of air changes with temperature change, thus the temperature must be compensated for. This is accomplished with a temperature compensation resistor (Rk). The temperature compensation resistor has a resistance of 500 ohms, so very little current will flow through this bridge leg as compared to the heating element bridge leg. The temperature compensation resistor will be made out of the same material as the hot wire: platinum. However, the temperature compensation resistor will be configured out of platinum-film and will be located close to the heating element. During production there are variances within the bridge circuit that will require calibration. Resistor R1 will be used to compensate for the temperature compensation circuit and is laser trimmed to provide means to calibrate the temperature circuit. Resistor R2 will be used to compensate the bridge circuit and is laser trimmed to provide means to calibrate the bridge circuit.

Since this sensor is basically a velocity sensor, the air speed is critical and is controlled by the sensor housing bore diameter. This bore diameter is engineered for the liter size of the engine that will be used. This is why a manufacturer can use the same electronic sensor on a 4, 6, 8, and 10-cylinder engine. All that will be needed is to change the sensor housing bore diameter so that the air velocity is the same on each engine. For example, on a 4-cylinder engine the bore diameter will be smaller than that on an 8-cylinder engine.

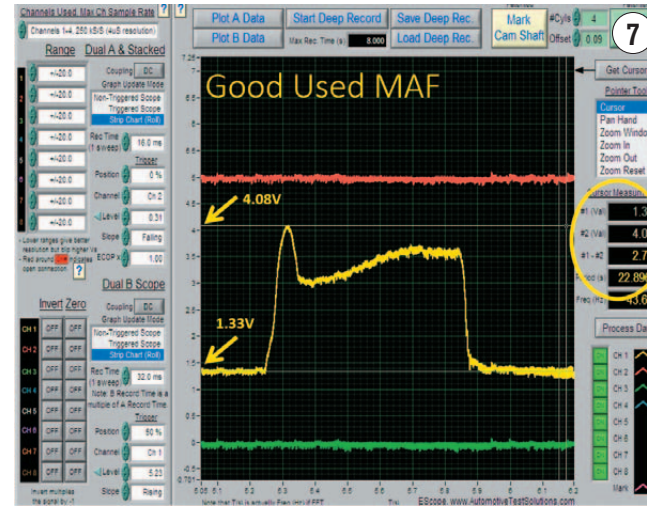
This method saves the manufacturer from having to produce a different electronic sensor for each different engine type. Beware that someone can put the wrong sensor on the engine. For example, an 8-cylinder MAF can be installed on a 6-cylinder engine. Now the air flow velocity will be slower, allowing the MAF sensor to produce less output voltage. Thus the voltage read from the MAF sensor and used to convert the air flow weight on the transfer function table will be incorrect. When this happens the fuel trim will compensate with a positive fuel trim factor that will be linear from idle, to light load, to full throttle (Figure 5). (Note: the positive fuel trim factor is 21 percent across the engine loads). To verify this problem a Volumetric Efficiency (V.E.) test will need to be run.

Volumetric Efficiency

A volumetric efficiency test is the best way to test the MAF sensor. The ECM takes the voltage produced from the MAF sensor and then normalizes it to an air flow weight that is used to run the engine. This MAF air weight is available on the scan tool data stream. If the Engine Liter Size, Revolution Per Minute (RPM), Barometric Pressure (BARO), Air Temperature (AT) and MAF air weight are known, then a calculation can be made to estimate the correct air flow to the engine. For example, if a 4.4-liter engine turned two revolutions and pumped 100 percent of the volume, it would move 4.4 liters of air. However, other factors come into play such as the BARO, AT, RPM and the actual engine flow efficiency. These factors will reduce the V.E. from the naturally aspirated engine where (at sea level, at 70°F AT) they are only about 89 percent efficient. Once these factors are known, a very accurate engine model calculation can be made.

A V.E. test is then run (Figure 6) on the same engine that is shown in Figure 5. This V.E. test shows the actual MAF reading in yellow and an engine model (V.E.) shown in red. This shows the actual air weight is low by 21 percent, and this is the same amount as the fuel trim correction factor. Remember the ECU reads the air weight first and then bases its fuel ratio calculation on this air reading. If the air weight is incorrect, then the fuel delivery rate will be incorrect as well. The fuel trim factor will need to make up for the incorrect air reading that was made by the MAF sensor. This is why the V.E. test shows 21 percent low, and a fuel trim correction factor of 21 percent corrects the air weight. This is accomplished by the fuel trim correction factor multiplying the actual air weight reading, and thus corrects for the incorrect air weight.

The output voltage from the sensor can be produced in an analog format (Figure 7) or that of a digital format (Note: when a digital frequency is used, the transfer function table is built using frequency instead of voltage). In Figure 5, a snap throttle event from a voltage output MAF sensor has been recorded on an oscilloscope. During a snap throttle event, a high air flow rate can be obtained due to the pressure differential that is created from a closed throttle plate at idle. When the throttle plate is snapped open, the inrush of air into the engine can be measured as shown in Figure 7 (Note: if a Drive By Wire system is used, this may not open the throttle plate to Wide Open Throttle (WOT). This inrush can be seen as point B, this is the maximum voltage output from the MAF sensor during the snap throttle event. Use the scope's cursors and make a measurement on the voltage waveform from the idle (point A) to WOT (point B). This is the voltage difference produced from the MAF sensor. This voltage change should be greater than 2.5 volts, which is half of the 5-volt supply to the sensor.



When the engineering team produces the MAF sensor they want enough voltage change with which to calibrate the engine. This voltage output from the sensor is broken down into increments that will represent the air flow from the engine. Depending on the engine type, if the engine went from idle to full load, the air flow may change 250 Grams Per Second (GPS). The greater the MAF voltage change the more points can be used to calibrate this air flow. If a 5-volt power supply is used, the calibration team will want at least half of the power supplied to the MAF sensor for calibration purposes. This means the minimum voltage change during this snap throttle event should be greater than 2.5 volts. We can change the MAF sensor on the engine from Figure 7 so the minimum voltage change is now 2.75 volts, instead of the 2.33 volts. This new MAF sensor's higher voltage output now matches the transfer function table in the ECM, thus fixing the fuel trim DTC's. During your day, take known good vehicles and snap test the MAF sensor on your scope. Keep the recording of this voltage change for future diagnostics. Just a little knowledge on how these MAF sensors operate will provide you with an easy diagnosis on your next MAF sensor engine problem.

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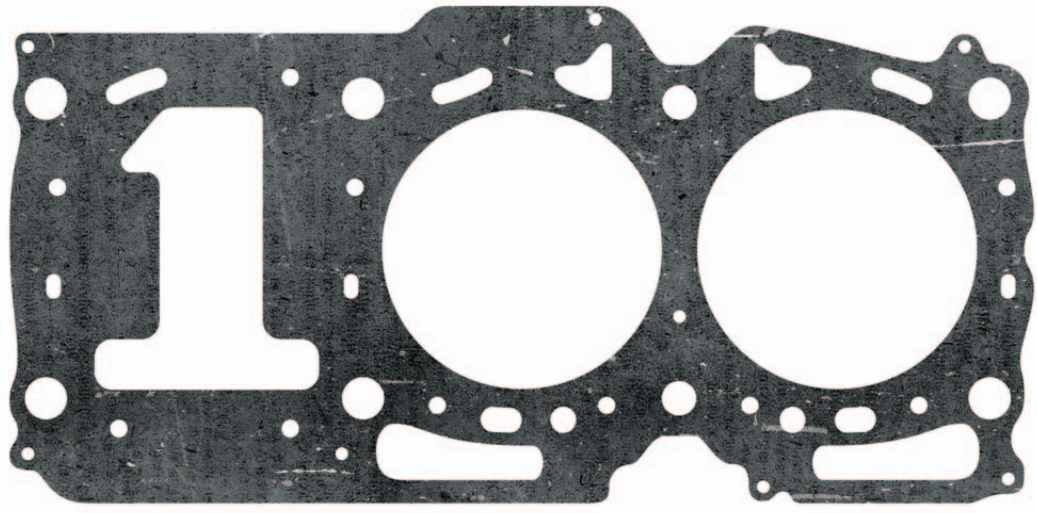

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TIRE SERVICE WITH A TWIST

INSTALLING TIRES USED TO BE A PHYSICAL AND TIME-CONSUMING TASK. BUT ADVANCEMENTS IN THE SERVICE EQUIPMENT USED FOR THIS AND RELATED "BREAD AND BUTTER" OFFERINGS MAKE THE WORK FASTER AND EASIER THAN EVER.

DAVE MACHCOLZ // Contributing Editor

Undercar service, diagnostics and repair have become more complex with advancements in vehicle weight reduction. Technicians will need to be aware of industry standard equipment and best practices in order to correctly perform these services. Understanding how to build this equipment into a shop's business model could also provide a new revenue stream for shop owners. Tire, wheel and brake service as well as noise vibration and harshness (NVH) diagnostics are great starting points when considering an upgrade to your current undercar service offerings.

If you haven't already noticed, every vehicle manufacturer is working to make their vehicles lighter in order to improve overall fuel economy and emissions. With the move towards light weighting, every possible method for weight reduction is in play. The effect this has had on undercar service

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is that every vibration is now amplified through the lighter-weight components that have an inherent ability to carry vibration frequencies from the road to the driver. Today's undercar service technician has to be aware of all areas of noise, vibration and harshness (NVH). Jobs such as tire replacement, wheel balancing, alignment and rotor machining have all become complex due to vibration concerns and require technicians and shop owners to raise their level of awareness, understanding and tooling to stay current. Additionally, vibrations that can't be easily pinpointed will require the technician to have a fundamental understanding of NVH diagnostics.

NON-CONTACT TIRE CHANGERS such as the Hunter Revolution provide an automated, efficient mounting process.

Tire mounting

In an effort to make wheel assemblies lighter, many manufacturers have moved to plastic cladded wheels to decrease overall wheel assembly weight. Wheel designs have also added expense with some European varieties priced at over $2,000. What this means for you is that the old center clamp tire machine is ready for the scrap pile or a sale or donation to a restoration shop. It also means that a job that was relatively straightforward in the past now comes with additional complications. How many scratched or damaged Audi wheels can your shop support? I think you get the idea.

In order to perform tire mounting, shops now have several choices. The first is to send tire work to the tire shop down the street. The second is to be the shop down the street. While new, non-contact tire machines may appear expensive, forward-thinking shops have realized that this new equipment can help to establish them as a go-to for tire replacement and ultimately turn tire service into a profit center for their business. As an example, the Hunter Revolution tire changer is claimed to be a fully-automatic tire machine designed for its ease of use and built-in efficiency. Once the technician sets the first tire up on the machine, a task that requires no lifting, the technician can walk away from the subsequent tire dismounts and let the machine do the work. While this is happening, the technician can spend his or her time at the wheel balancer. Hunter.com claims that this machine can save the technician 25 percent or more time as compared to traditional tire machines. Additionally, the leverless design of this machine allows for mounting and dismounting without tool contact with the wheel, preventing costly wheel repairs.

Wheel balancing

Growing up in auto shops we were all familiar with the concepts of static and dynamic balancing. However, balancing does not always ensure that a vehicle's tire will roll smoothly over the road. With the vibration concerns on today's vehicles, NVH from the force the road applies to a tire needs to be examined. This can only be accomplished by applying a force to the tire during the overall wheel balancing process. This process will inform the technician as to the overall ability of the tire to roll smoothly over the road and ensure the car will ride like it was intended to from the factory. To perform this function, a shop will need to possess a balancer with a road force drum. In many instances, the road force process will instruct the

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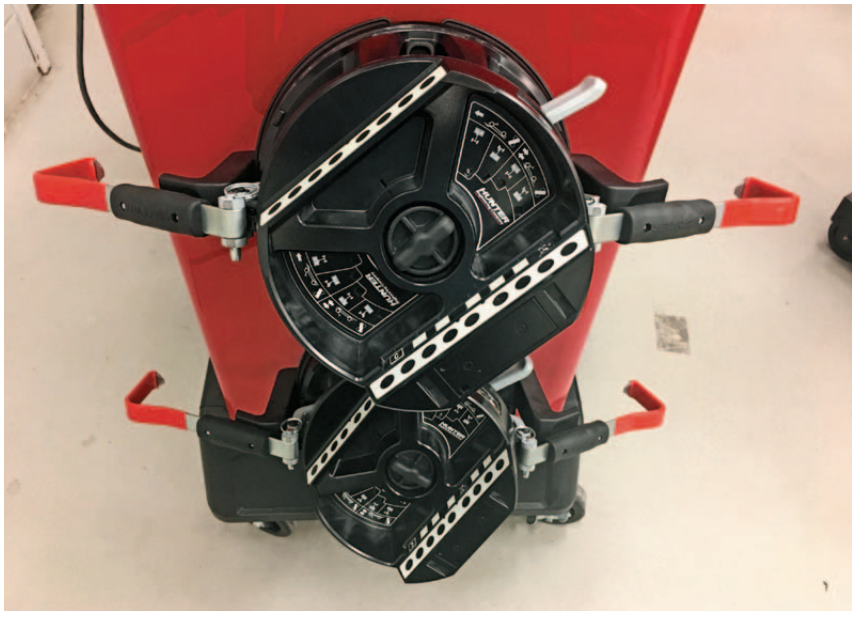

NEW ALIGNERS WILL NEED to have limited contact with the wheel, which also speeds up mounting sensors.

HUNTER'S CODELINK INTERFACE provides support for new aligner features that address ADAS issues.

technician to reposition the tire on the wheel assembly, provide suggested locations for weight placement to compensate for imperfect tires and in some cases may inform the technician that a tire is severely out of spec and will need replacement. If your shop is performing an extensive amount of tire and wheel service, this machine may soon become a necessity if it has not already.

Alignment

Wheel alignment has also evolved with the light-weighting trend as new wheel assemblies require equipment that cannot make contact with the rim. In addition to the wheel alignments we are all familiar with, Hunter has patented a second alignment: Safety System Alignment. This addition to Hunter's alignment software was designed to address the need for additional procedures following a wheel alignment, including calibration of steering angle sensors, camera-based lane detection systems, radar-based object detection and other future technologies. Utilizing their patented CodeLink technology previously utilized to reset steering angle sensors and a set of proprietary aids and targets, Hunter has created the ability to perform advanced functions on Ford, Lincoln, Chrysler, Dodge, Jeep, Nissan and Infiniti vehicles with more in development. While not directly an alignment function, these tasks are becoming a part of the job for many vehicles.

TRAINING AND CERTIFICATIONS ARE AVAILABLE through organizations such as the National Coalition of Certification Centers.

Brake service

The days of the off-car brake lathe are behind us. In order to address vibration concerns caused by excessive rotor runout, the stacked tolerances of the hub and rotor have to be taken into consideration. This has brought companies such as Pro-Cut International

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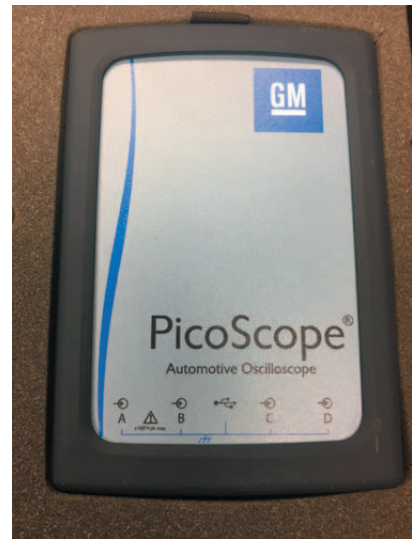
to the forefront of brake service within the dealership arena and they are starting to make their way into independent shops. The on-car brake lathe has evolved drastically from the early versions we all remember. Set up and use is very simple and will allow a technician to cut four rotors in approximately 20 minutes or less. Consider the math: If you were to perform a brake service and are charging a customer for a rotor, a large part of the money paid to you by the customer will be going to the parts warehouse and not to your bottom line. On-car machining offers a way of offering a brake service that is potentially more profitable than replacing rotors. The knock on the on-car machining process is that many rotors are already too thin to machine. While this can at times be true, the on-car process is also suggested when installing new rotors on a vehicle to ensure a machined surface that will reduce the frequency of vibration comeback complaints after brake service.

NVH diagnostics

Oftentimes a vibration cannot be easily located. You may be familiar with the "Chassis Ear" system that has been around for decades. Perhaps you remember the reed tachometer or the EVA? This equipment was taught for quite some time by the domestic OE manufacturers and oftentimes the independent shops were on the outside looking in when it came to this type of diagnostics. Additionally, the technician had to know the science behind matching a vibration frequency to a given system, which provided a steep learning curve, especially without access to some of the proprietary curriculum.

Recently, vibration software and hardware that interfaces with PC based oscilloscopes has been introduced as a factory tool by OEs such as General Motors. PICO Diagnostics



OE MANUFACTURERS HAVE LED THE WAY in NVH diagnostics – pictured here is a Pico developed for GM for NVH Diagnostics.

now offers a scope diagnostic solution that is available to the public for purchase. This hardware and software works with your existing four-channel PICO scope model 4425 and contains a microphone and accelerometer for monitoring noise and vibration levels and frequencies. Advanced kits are also available and contain additional microphones and accelerometers. The beauty of this system is that the diagnostic software helps the technician to identify the source of the vibration without a tremendous amount of experience and/or prior knowledge of NVH diagnostics. According to Pico, the NVH kit can be used to diagnose cabin vibrations at speed, engine vibrations throughout the entire RPM range, clutch judder or vibration, transmission and bearing whine, transfer case noise, brake judder and steering vibrations. If you are a Pico 4425 owner, the NVH add-on kit starts at around $1,700, which includes the basic kit to get you started with diagnosing difficult vibration and noise concerns.

If you have ever encountered a driveline vibration caused by a an out-of-balance driveshaft, you may

PICO OFFERS an interface and software for NVH diagnostics.

PICO OFFERS AN OPTIONAL OPTICAL SENSOR for diagnosing and balancing out-of-balance driveshafts.

have had to pull the driveshaft and send it to a driveshaft shop to have it balanced — or in some cases charge your customer a small fortune to replace it. Pico has a solution for this type of diagnostics and repair in the form of an optional NVH kit add-on in the form of an optical sensor. In this kit, the optical sensor is attached to a robust magnet that will help to keep the sensor in place while diagnosing a driveshaft vibration. A technician can

then diagnose and balance the driveshaft in place and view before and after graphs of the optical signal. This is considerably cheaper and more cost effective in many cases than replacing or sending out a driveshaft for balancing. This kit is available starting around $400.

Certifications

The learning curve in our industry for both seasoned and new technicians is immense. Fortunately, training is available and in the case of some of the pieces of equipment we have covered here, certifications are available as well. For example, Hunter.com features a variety of training options, including e-learning and videos for those getting started with Hunter's equipment. For those who prefer a live classroom environment, Hunter offers certification classes across the country in alignment and road force balancing. High school and college automotive programs can now offer certifications on Hunter equipment usage providing a recognizable credential.

Meaningful certification has become a topic that has not gone unnoticed by industry. The National Coalition of Certification Centers, known as "NC3," has established partnerships with Snap-on, Pro-Cut International and Starrett to offer a variety of certifications for the automotive sector. These certifications include precision measurement, torque, multimeter, diagnostics, wheel service and alignment and master rotor machining. These certifications are available through secondary and post-secondary NC3 affiliate schools, which offer the certification as either a part of a full-time program or through continuing education events for the local automotive community. In order to gain certification, the student must participate in the course and demonstrate an understanding and competency in using the equipment and performing related tasks. For more information on how to gain these certifications please visit www.nc3.net for a list of member schools.

Training on Pico scopes and NVH are not as readily available. However, picoauto.com provides a wealth of information and resources for the dedicated learner including some fantastic case study videos of the NVH product in use.

As with any new technology, be prepared to spend some time doing your homework. Be informed, get training and gain the knowledge you need to perform these services while adding a new revenue stream to your business.

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 New York State teaching certification in vehicle repair. *liautotraining@gmail.com*

ENGINE MECHANICAL TESTING USING AN IN-CYLINDER PRESSURE TRANSDUCER

LET'S EXPLORE THE BENEFITS OF PERFORMING IN-CYLINDER PRESSURE TESTING ANALYSIS USING A PRESSURE TRANSDUCER

SCOT MANNA // Contributing Editor

In "Engine mechanical testing: Good, better and best," June 2018, I shared two fundamental engine mechanical tests performed with a scope: cranking relative compression and cranking intake vacuum. So today, let's take it one step further.

Please keep in mind that the goal of all of these engine mechanical tests is to determine not only whether or not there is a mechanical problem present but to also determine what the problem is without engine teardown for visual inspection, which is very time consuming and may yield a situation where the car owner may bail out on the repair — but now the vehicle can no longer be operated unless the engine is reassembled. I'm sure many of us have been down this road, and it is one I like to avoid.

First let me categorize the types of problems that may be present before testing begins and the problems that will be uncovered with these tests. Modern engines can suffer from any of the following problems: cylinder sealing issues causing compression loss, incorrect valve timing from failed cam drive systems, incorrect ignition timing, shifted or out-of-sync engine rotation sensor signals, intake path restrictions, exhaust path restrictions and bank-to-bank breathing issues — all of which can be traced down using these tests. While I have documentation on all of these issues and I could fill a small textbook with all this information, it is beyond the scope of this article to discuss each problem in detail. It is my intention to whet your appetite so you'll invest in the tools needed to perform these tests and begin using them in your diagnostic routine. There are many excellent training classes on this subject and further research will be required to become proficient with this testing, but we must start somewhere so let's get started now.

A FOUR-CYLINDER HONDA ENGINE set up to perform in-cylinder pressure transducer testing. A Pico WPS500 transducer is connected to cylinder #4. Many various transducers are available from different companies, but this transducer does not require power supplied by the scope so it can be used with any scope and will produce very good waveforms.

Start at the beginning

To begin, you must have a scope and pressure transducer along with an assortment of compression test hoses for the different spark plugs used in the many engines found in the marketplace. The first item to be aware of is there cannot be a Schrader valve

PHOTOS: SCOT MANNA

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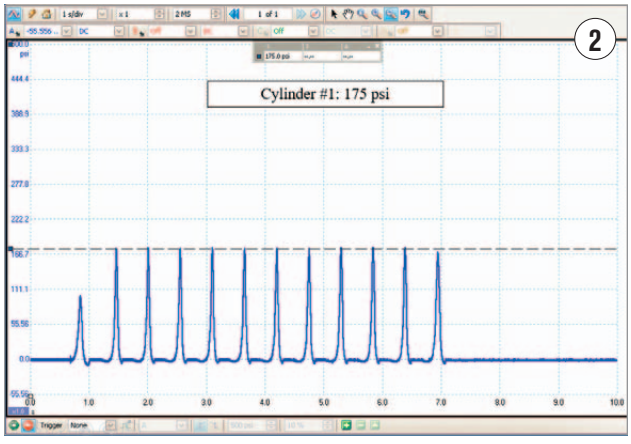
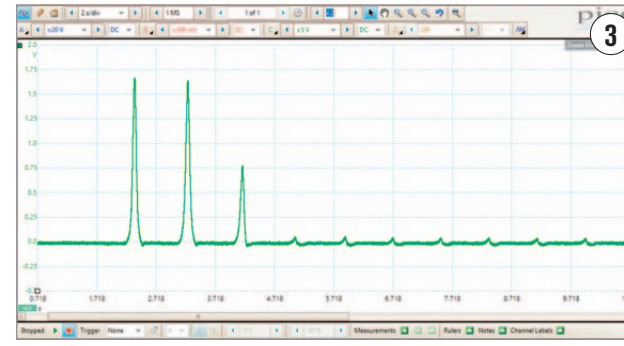


NORMAL CRANKING COMPRESSION WAVEFORM FROM A 4-CYL HONDA ENGINE. Remember to disregard the first and last pulse. The Pico scope can scale to pressure when you select a pressure transducer, but keep in mind the pressure transducer outputs a voltage and this transducer would output 1 volt per 100psi so another scope would display 1.75 volts. The range is 0-500 psi for this transducer.

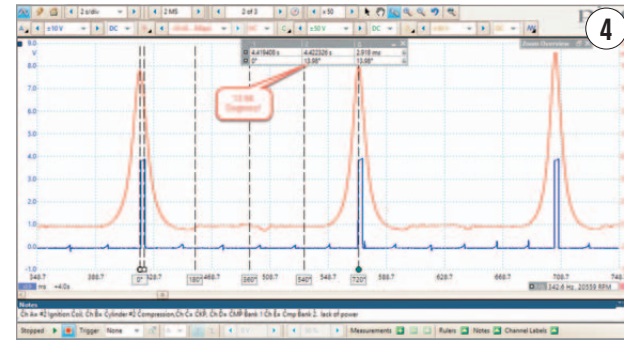
in the test hose when using a transducer! If you have a gauge-style compression test kit with a hose assortment, you can use these hoses, but be sure to remove the Schrader valve when using a transducer. The Schrader valve is the reason a mechanical gauge builds pressure and shows compression puffs or pulses, but this is not how pressure builds in the cylinder and you will see that the pressure pulses shown on a scope are all the same on a normal engine during cranking.

We will not pay too much attention to the first or last pulse in a transducer generated compression waveform because you don't know where the piston was when the engine began to crank or stops turning. If cranking pressure peaks are varying during the test we have already uncovered a problem and one that a conventional gauge will never be able to show us! The sequence of in-cylinder pressure testing should be a cranking test first, then a running test with a snap throttle event to allow analysis of the various problems mentioned above. You must prevent the engine from starting during your cranking tests, preferably by removing fuel. Scoping the ignition event will also be needed during certain tests.

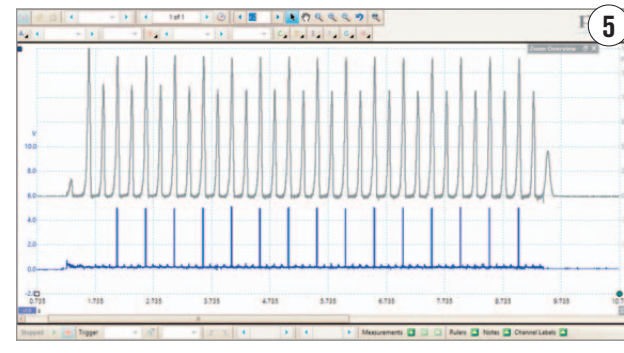
Two cranking pressure waveforms will be shown to illustrate a normal waveform and a problem vehicle. The first waveform shows normal compression pressure from the 4-cyl Honda engine shown in Figure 1. Notice the first compression event is low due to the piston being somewhere above bottom dead center when the engine began to crank, but all of the subsequent compression events are at the same pressure of 175psi (Figure 2). This engine had a leaking exhaust valve in cylinder #2 and when tested, the cranking compression was only 149psi — below the 15 percent variance that would be considered a max variance on an OBDII vehicle with misfire detection.



THIS CRANKING COMPRESSION WAVEFORM SHOWS the first two pulses at 165psi, the third pulse at 75psi and all remaining pulses at 4psi. A broken valve spring is the culprit. Because a gauge-style compression tester uses a hose with a Schrader valve, which traps pressure, the gauge showed about the same value as the other cylinders.

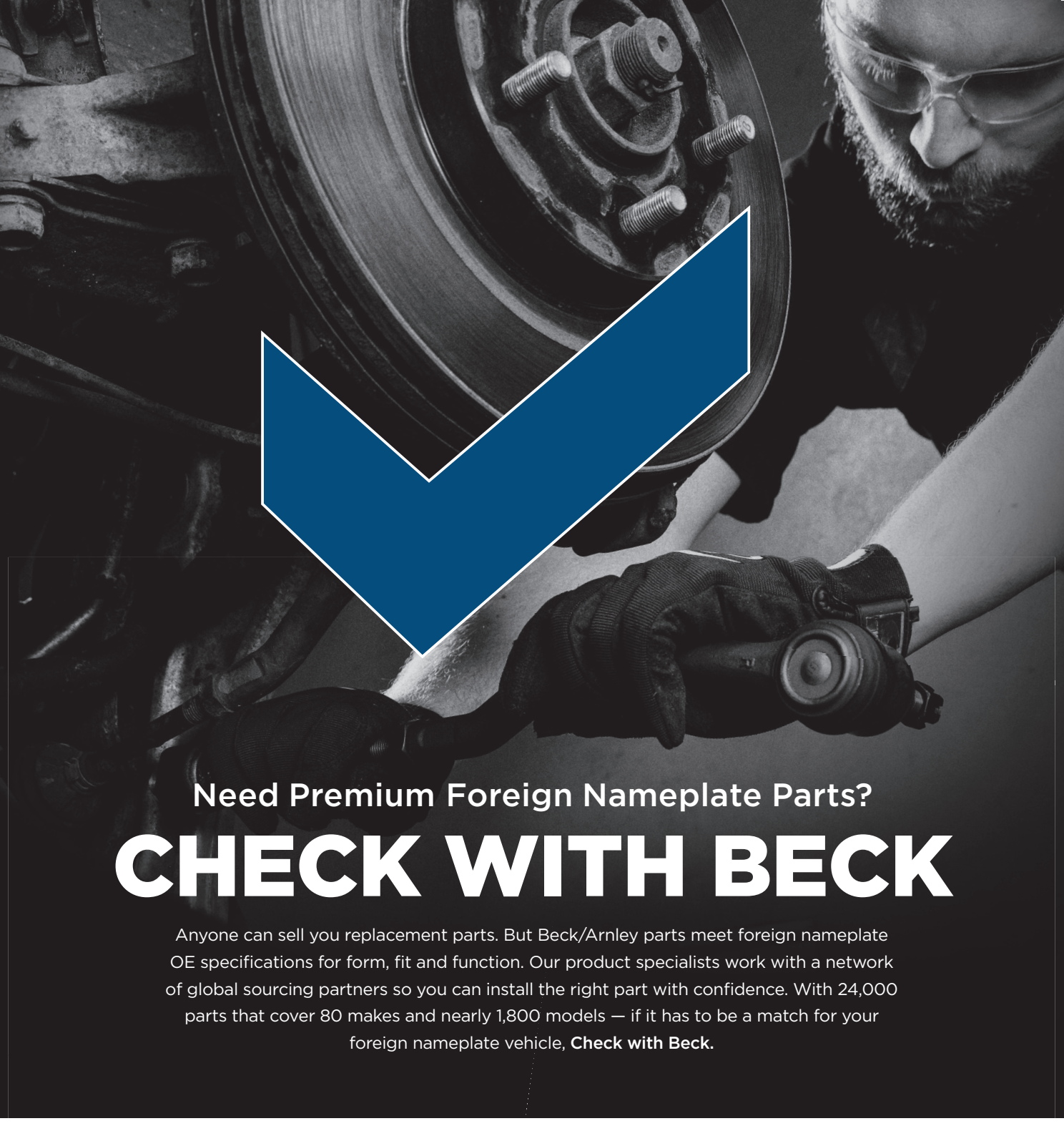


THIS IGNITION TIMING RELATIONSHIP WAVEFORM WAS CAPTURED on a 3.3 V6 Toyota during a mild brake torque. The scope rotational rulers are used to measure the ignition signal and show the ignition pulse in blue occurring 14 ATDC. This means the timing is retarded about 22 degrees because the scan tool timing PID was reading 8 degrees BTDC.



THIS CRANKING COMPRESSION TEST from a 2.0 VW engine looks odd with what looks like a double compression event. The waveform will be zoomed in for a closer look.

The next waveform shows several good compression pulses and then a complete loss of cylinder compression (Figure 3). This 5.3 V8 GM truck engine had a cylinder #3 misfire. A compression test was performed with a gauge, and the tech said the compression was the same on all cylinders on that bank. This is the same truck discussed in my June article and



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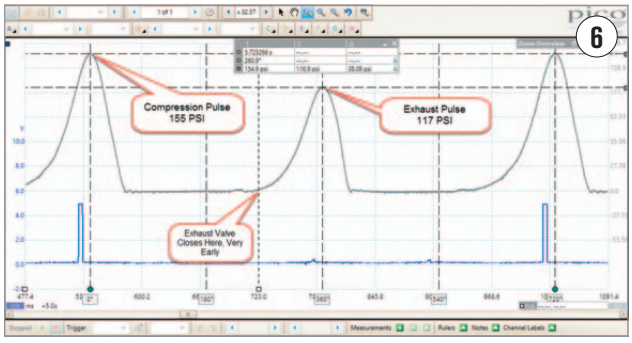


THIS IS THE CLASSIC WAVEFORM for what should be called an exhaust path restriction. Pressure on the exhaust stroke should be the same as atmospheric pressure, which would be the zero point on the waveform scale. This was caused by an advanced exhaust cam and it prevented the engine from starting.

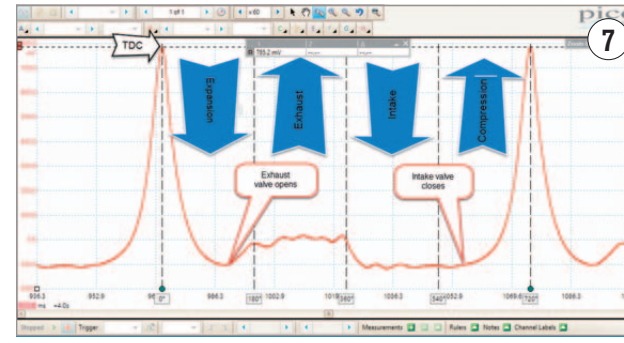
the problem was a broken valve spring. This problem would not escape the cranking compression test done with a transducer! If the engine is cranked over for at least 10 seconds and the compression peaks are varying more than a few psi, then valve sealing issues are likely present.

Timing is everything

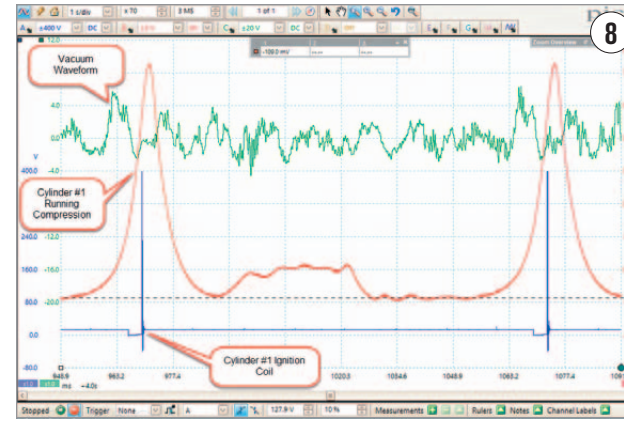
The next item I'd like to mention is timing — both ignition and valve timing. Many technicians today do not have a quick and reliable way to verify timing on most engines. Ignition timing marks are mostly a thing of the past and few techs have a working timing light. If a car comes in as a cranking no-start or lack of power, how does one eliminate a timing problem as the issue and do it quickly? The answer is to compare the ignition event to an in-cylinder pressure event of the same cylinder using two scope channels and a pressure transducer (Figure 4).

I recently looked at a 2004 Toyota Highlander 3.3 V6 that another shop was struggling with diagnosing a lack of power complaint. When test driven, the vehicle seemed like it was starting off in third gear, but the transmission had no codes and was shifting through the gears. Wondering about a possible torque converter problem, I decided to make sure that the timing was correct on the engine and found the problem. The timing was severely retarded due to a grooved-out crankshaft timing belt sprocket, which also has the crank sensor trigger wheel cast into the sprocket. This technique has uncovered many similar problems and is a simple test to verify a very important relationship that is all too often taken for granted because timing is no longer adjustable.

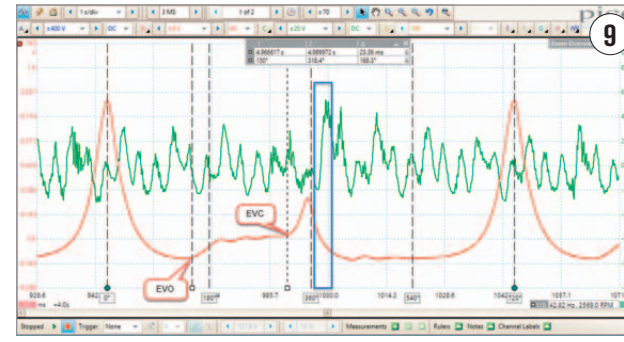
Some readers may think this is advanced diagnostic testing and would only be used in rare cases, but nothing could be further from the truth. A nearby shop towed over a 2010 VW CC they were stuck on. Considerable time had been spent trying to diagnose a cranking no-start on this 2.0, GDI turbo engine with



NORMAL RUNNING COMPRESSION WAVEFORM WITH CALLOUTS. The blue arrows represent the direction of piston travel through the 4-stroke cycle. Valve overlap occurs in the area of the 360-degree ruler on the screen.



RUNNING COMPRESSION WAVEFORM FROM CYLINDER #1 on a 2010 Dodge Challenger 5.7 Hemi engine. This is a normal pattern from a good cylinder comparing in-cylinder compression to running vacuum from a Sen-X Technologies First Look transducer.



RUNNING COMPRESSION AND VACUUM WAVEFORM FROM THE MISFIRING CYLINDER # 3 on the 2010 Dodge Challenger. Note the exhaust pressure pulse and vertical rise in the vacuum waveform and their relationship to each other as highlighted.

no answers. After verifying a few basics, a cranking in-cylinder waveform was captured and analyzed. The waveform quickly pointed out what I will call an exhaust path restriction (Figure 5). The scope rulers are showing the 4-stroke cycle and there is a high-pressure pulse at the point where the exhaust stroke is ending and the intake stroke is beginning that measures 117 PSI

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(Figure 6). This is caused by the exhaust cam being advanced nearly 90 degrees due to a jumped timing chain. I will point out that older engines that jumped time usually resulted in retarded camshafts, but today's engine with their complex camshaft drive mechanisms can have cams that jump and end up advanced or retarded. Exhaust cams that are out of time have very little effect on cylinder compression. When an intake cam is out of time there will be a large effect on compression; retarded cams will lower compression and advanced cams will raise compression. When checking any V-style or opposed engine with two banks, if one bank has different compression than the other you should immediately suspect camshaft timing. Advanced intake cams are why an engine can have too much compression, if the measured compression is above specifications suspect an advanced intake cam possibly from incorrect installation, a jumped chain or frozen cam phaser assembly.

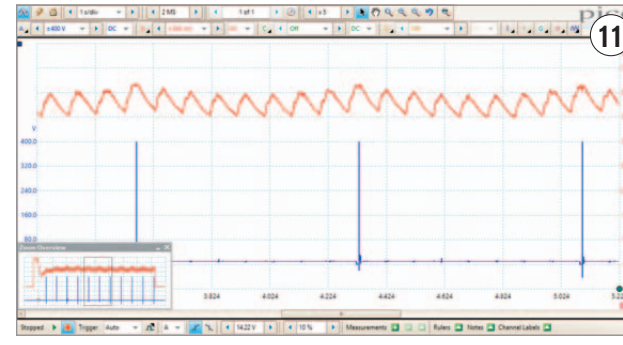
If this exhaust pressure pulse was seen on only one cylinder expect a worn-down cam lobe or plugged exhaust manifold runner. A clogged catalytic converter could produce a similar waveform, but expect the pressure rise to begin earlier due to the transducer seeing the pressure in the manifold as soon as the exhaust valve opens. I will mention here that some late-model DOHC engines that phase both camshafts may have no valve overlap when the cams are not phased and can produce a pressure pulse at the end of the exhaust stroke and this can be normal. It should be clear that an in-cylinder pressure test is an excellent way to measure exhaust backpressure! It is almost always easier to remove a spark plug than to take out an oxygen sensor to measure exhaust backpressure.

On to running compression

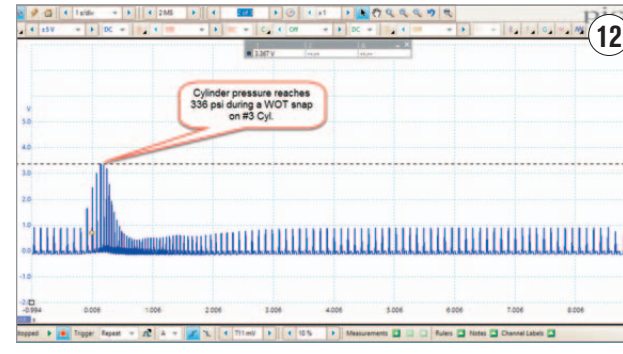
Everything to this point has been cranking tests, but once we start the engine there is quite a bit more information presented. Let's take a look at a running compression waveform and point out what it is showing us. We will look at the basic 4-stroke cycle (Figure 7) starting with the power stroke and continuing from there. Remember that we are viewing the change in cylinder pressure as the piston is pulled up and down in the cylinder by the crankshaft, there is no combustion in the cylinder so we call the first event the expansion stroke, not a power stroke. There are two basic reasons the pressure changes in the displayed waveform: the piston changes direction or a valve event occurred (valve opens or closes). Once you understand the basic 4-stroke cycle and what the waveform represents some pretty powerful diagnostics can be generated.

The next waveform was captured on a 2010 Dodge Challenger with a misfire code complaint and a slight tick from the engine. The scan tool would show some misfire counts on cylinder #3 and sometimes there were none. Relative com-

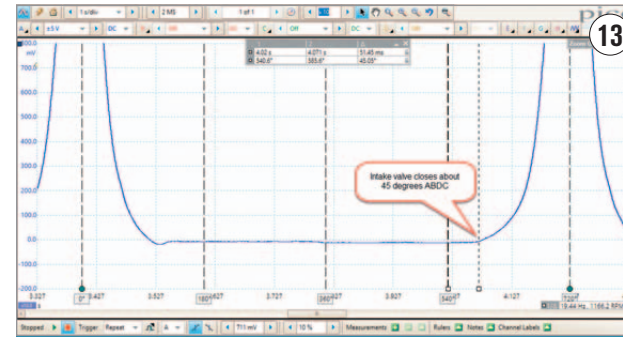
THE WORN EXHAUST CAM LOBE IS THE SECOND FROM THE LEFT IN THIS PICTURE.



RELATIVE COMPRESSION TEST FROM THE 2011 DODGE RAM 5.7 HEMI ENGINE. Cylinder #1 has the highest peak. Compression is not the problem, right?



RUNNING COMPRESSION TEST FROM CYLINDER #3 with a throttle snap is shown. This is a known good cylinder.



THIS ZOOMED CAPTURE OF A CRANKING COMPRESSION TEST FROM CYLINDER #3 is measuring the point of intake valve closing, which occurs on the compression stroke.

pression and cranking vacuum tests looked normal. There was very little fuel trim correction so it did not appear to be injector related. It was decided to do an in-cylinder test after noticing an abnormality in the running vacuum waveform. It is always a good idea to capture a waveform from a known good cylinder to compare to a problem cylinder. After testing cylinder #1 (Figure 8) the transducer was moved to the problem cylinder.

The cylinder #1 waveform shows a pressure rise in the vacuum waveform that is just in front of the compression peak; this would be the vacuum event for cylinder #3. When the transducer is connected to cylinder #3 the problem is obvious (Figure 9). The waveform shows the vacuum pressure rise lines up with where the intake valve opens. The in-cylinder waveform shows a 23psi pressure pulse at the end of the exhaust stroke, which is not normal. When the intake valve opens, this trapped pressure is released into the intake manifold and can be seen with the intake pressure transducer. The waveform cursors are measuring the difference between exhaust valve opening and closing at 168 degrees, way below what normal duration would be on a cam lobe in a Hemi! This engine has a worn-out exhaust cam lobe on cylinder #3 and needs a cam and lifters. You can see the damage from the picture (Figure 10) of the camshaft after removal.

Another Hemi misfire resolved

The next problem vehicle is a 2011 Dodge Ram pick-up with another 5.7 Hemi engine. This truck idles fine but misfires under hard acceleration. Normal parts replacement has failed to rectify the problem — spark plug, ignition coil and fuel injector were all tried to no avail. The truck is driven and only cylinder #1 misfires under load. A relative compression test shows cylinder #1 has slightly higher compression (Figure 11).

After seeing a higher compression event for cylinder #1 and knowing this is the problem cylinder a running compression test is performed. The result is quite revealing. A good cylinder (Figure 12) will be compared to the problem cylinder.

The good cylinder shows a compression peak during a snap throttle application reaching over 330 PSI and the intake valve closing at 45 degrees after bottom dead center (Figure 13). Comparing the same test from cylinder #1 shows peak compression during a snap at only 287 PSI (Figure 14) and the intake valve closing at 20 degrees after bottom dead center.

The early intake valve closing and reduced peak cylinder pressure during a snap throttle illustrate a worn intake camshaft lobe causing an intake path restriction. Cylinder pressure is a function of airflow and the effective compression ratio, which is determined by the point at which the intake valve closes so that pressure can be built. When an intake valve closes earlier than normal, the effective compression ratio increases and will cause higher compression values. It must be clear at this point that engine mechanical problems cannot escape detection when using the tests performed in this article. Once these tests are mastered your accuracy in determining engine mechanical problems will be spot on without requiring engine disassembly.

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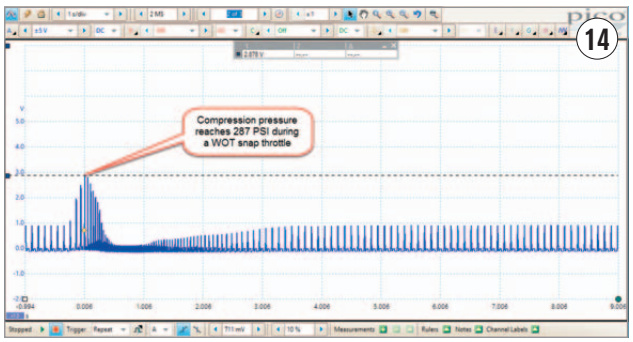
scotmanna@sbcglobal.net



RUNNING COMPRESSION TEST FROM THE PROBLEM CYLINDER showing lower peak compression during a throttle snap.

TURNING OUR ATTENTION TO WINTER

WITH FALL UPON US AND WINTER NOT FAR BEHIND, IT'S TIME TO HELP OUR CUSTOMERS PREPARE FOR THE COLD!

PETE MEIER // Technical Editor

Just as the heat of summer brings us unique service opportunities, so does the approach of Old Man Winter — especially if you live in the Snow Belt! Even if you live in a part of the country where the difference between summer and winter is hardly noticeable, you can still use this time of year to market important maintenance services to your customer. And while I think that these system inspections are something we should all be doing year-round, they tend to lend themselves to special attention in the minds of our customers when the mercury in the thermometer begins to dip.

THE "PK" NUMBER (CIRCLED) IS A STANDARD METRIC DESIGNATION FOR BELTS that can help you select the correct replacement when you're stuck. The first number (6) is the number of ribs, "PK" means metric, and the last number (1256) is the "effective" length (not the actual outside circumference).

Cooling system check — belts and hoses

The cooling system is one that seems to be more on the mind of consumers in the winter than the summer. It's easy to understand why — the first time the cabin won't warm up is almost as bad as the first time it won't cool down when it's hot outside! Interesting how our customers are so keen on cabin comfort, even when we recommend much needed work on their vehicle's safety systems, isn't it?

Begin by performing an overall inspection of the cooling system components. Inspect the level of coolant in the recovery bottle and note its condition. If the level is low, inspect for signs of leakage. Even small leaks can lead to air in the system, and that can lead to premature depletion of the coolant's additives and system component damage. Keep in mind, too, that the leak may be internal, so no signs on the outside doesn't mean a leak doesn't exist!

Let's inspect the accessory drive belt next, since in many cases it drives the all-important water pump. Since nearly every belt today is made with EPDM and can be worn out well before you see any visual indications, you'll need a belt wear gauge to perform this check.

The tools vary depending on who makes them, but the objective is the same. As an EPDM belt wears, the ribs become narrower and the grooves wider. This wear pattern allows the belt to fit more closely to the pulley and that's not a good thing. As the belt moves in, the gap between the belt and the pulley that allows a path for water to escape decreases to the point that the belt can actually hydroplane when operated in wet weather. Additionally, the wider spacing in the grooves reduces the interference friction that keeps the belt from slipping. A slipping belt may not make noise but will operate hotter than normal. This extra heat is passed on to the components that the belt drives, leading to accelerated wear and premature failure in their own pulley bearings.

If you don't already have one of these wear gauges in your toolbox, check with your parts suppliers. If that fails, you can always reach out directly to any of the major belt manufacturers for one. For more tips on checking and servicing belt issues, check out our Trainer video on the subject at https://youtu.be/71toy_rpUbA.

On to the hoses. The biggest cause of cooling system hose wear is electro-

PHOTOS: PETE MEIER

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chemical degradation, or ECD, and it's not easy to detect. ECD attacks the rubber from within and is caused by the acids developed in coolant over time. Check the hoses by squeezing them between your thumb and forefinger. The hoses should feel soft and pliable. If they feel tight or crunchy, they may require replacement. Take a close look at the hose connections, looking for signs of softness, bulging (especially when the system is under pressure), or cracks that could be signs of damage caused by ECD or age.

Even if the hose appears to be OK, a good rule of thumb is to recommend hose replacement when a hose is over five years old.

Cooling system check — coolants

Coolant can last a long time if maintained. Look at our HD cousins as an example. Class 8 trucks routinely go 400,000 miles or more on a single coolant service. The difference? The health of the additives included in the coolant is checked and maintained regularly!

These additives play important roles. Some work hard to delay the degradation of the coolant, preventing acidic decomposition by-products from entering the system. Others provide lubrication for cooling system components and seals, while others protect against corrosion. In the automotive sector, we don't test for these additives specifically but we can perform a few simple tests that will allow us to gauge the condition of the coolant overall so that it can be replaced if these additives are depleted prematurely.

And that happens more than you may think. A small leak that slowly depletes the coolant recovery tank may be refilled with tap water, diluting the mix and introducing contaminants in the system. A cylinder head gasket leak, even though it isn't causing a drivability issue, may be present and allowing exhaust gasses into the system and that will lead to acidic build up, leading to ECD. A bad electrical ground can cause underhood circuits to seek a path back to the battery via the coolant, also leading to ECD. So even if you personally serviced the cooling system last season, inspect it again just in case!

TO ACCURATELY MEASURE the mixture ratio of the coolant, use a refractometer. Test strips are also available to help you gauge the coolant ratio.

USE A TEST STRIP TO MEASURE the pH and reserve alkalinity of the coolant. If reserve alkalinity is low, but pH is correct, advise your customer that the coolant will be needing service in the near future.

Start with inspecting the mixture ratio of the coolant. Take your sample from the radiator rather than the recovery tank in case someone has added straight water or coolant to the system. That will throw off your test results. I prefer to use a refractometer myself but there are test strips that you can use for this purpose. Don't use the old hydrometer your dad used back in the '70s!

The mixture should be between 40 percent and 60 percent. Too much water will lead to corrosion problems and too little will interfere with heat transfer. If the next test passes, you can

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adjust the mixture by adding water or the proper coolant as needed.

The second test is to measure the pH of the coolant. This is a great indication of the coolant's condition and typically will become more acidic as the additives are depleted and the coolant degrades. This is the root cause of ECD. As the coolant becomes acidic, the cooling system component metals start reacting, turning the system into a battery cell that you can actually measure the voltage in! In fact, I'm betting many of you were taught this as a method for inspecting coolant condition. There's a little more to it than that but I don't have the space to dive into that topic today!

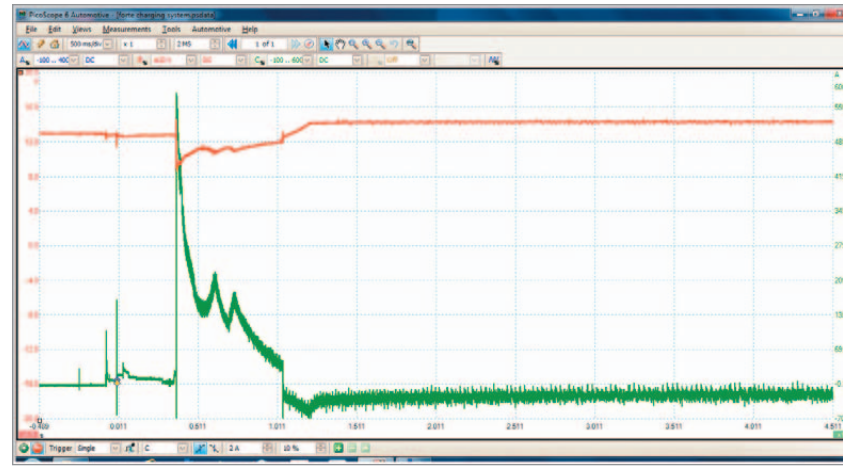
If the coolant pH is out of range, you'll need to do two things. First, you'll need to service the cooling system and replace the degraded coolant. Second, you'll need to be sure you've identified why the coolant degraded, especially if the coolant has failed well before its normal service life. For more info on testing coolant, check out this Trainer at https://youtu.be/zY4YDncoYoI.

Don't forget the battery!

The battery's state of health is increasingly important with the growth of electronics used on the vehicle. And we all know that a dip in temperature can quickly point out the weaknesses in a battery that tested fine the day before.

My personal preference for battery testing is the scope method. I've found weak batteries that tested fine otherwise with this method, and it's a great excuse to set up your scope as part of your regular morning routine. Because the scope captures data so much faster than conventional testing equipment, expect to see some strange things the first time you try this!

For example, we all know that normal starter draw is somewhere around 150 amps, depending on the size of the engine and its compression. But that's after the starter has the engine turning. In the few microseconds before that, the amount of current needed to get that mass moving is significantly higher — and you'll see that on the scope. Over 500 amps is not unusual and is referred to as "in rush" current.



IT TAKES ONLY A FEW MINUTES to test a battery and the charging system using a scope. The resulting capture can provide so much more information than conventional testing methods.

Along with high current for a few microseconds, you'll notice a larger battery voltage drop occurring at the same time. We've been taught to look for loaded voltage levels no lower than 9.5 volts when testing conventionally, but that "norm" drops to 8.5 volts when using a scope.

In addition to the battery performance, you can visually see current passing through the starter solenoid contacts, failed diodes in the alternator (both in the voltage and current patterns) and other system problems. You also have a "picture" you can share with your customer when recommending any needed repairs. Add an ignition reference, and you can also do a quick check of the engine's timing and mechanical health using the relative compression test. The scope connections are the same.

And yes, we have a video you can watch on how to perform this test! https://youtu.be/dZSyshg0GfE

Certainly, the fall provides additional opportunities to check the overall condition of your customers' cars with a focus on these traditional areas. But helping your customer maintain their vehicles in peak condition is not a seasonal thing — it's a year-round thing!

USING YOUR MIN/MAX FUNCTION, you can perform a quick "down and dirty" battery test that will give you Open Circuit Voltage (OCV), loaded voltage and charging system voltage in about three minutes.

PETE MEIER is an ASE certified Master Technician with over 35 years of practical experience as a technician and educator, covering a wide variety of makes and models. He began writing for *Motor Age* as a contributor in 2006 and joined the magazine fulltime as Technical Editor in 2010. Pete believes in the mission of the magazine to "advance the automotive professional" and provides resources to working techs around the country through print, social media and YouTube.
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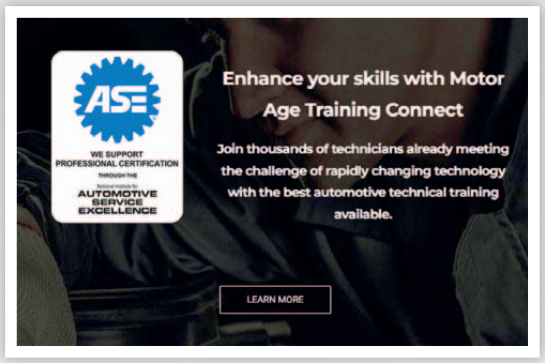

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MANY DRIVABILITY CONCERNS ARE RELATED TO ENGINE MECHANICAL CONDITIONS. CHECK FOR THESE FIRST BEFORE YOU SPEND TOO MUCH TIME PLAYING WITH IGNITION OR FUEL ISSUES!

ERIC OBROCHTA // Contributing Editor

This diagnosis begins like many others have in the past. The local guy from the used car lot drags in a "great deal" he picked up at the auction. You know the vehicles — clean, southern, low mileage, and (oh yeah!) it doesn't run! This time it happened to be a 2008 Jeep Liberty 3.7 brought in on the trailer. It would crank and attempt to start, smelt heavily of gas when it did run, accompanied with a heck of a lot of mechanical noise from under the hood. Prior to dropping it off, the throttle body was replaced as well as the intake manifold gaskets and spark plugs. However, now that it is at our shop it is time to see how much of a "great deal" this vehicle really was.

Now that the vehicle is in the bay it is time to get to work. Where to begin? I initially scanned the vehicle for codes to see if there was anything that might help give some direction. There were approximately 12 codes stored in the ECM, but at first glance none of them seemed to be of any

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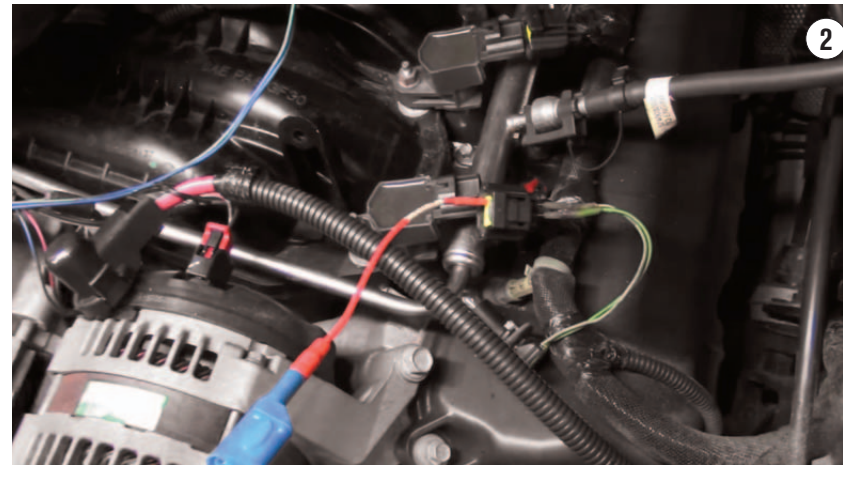
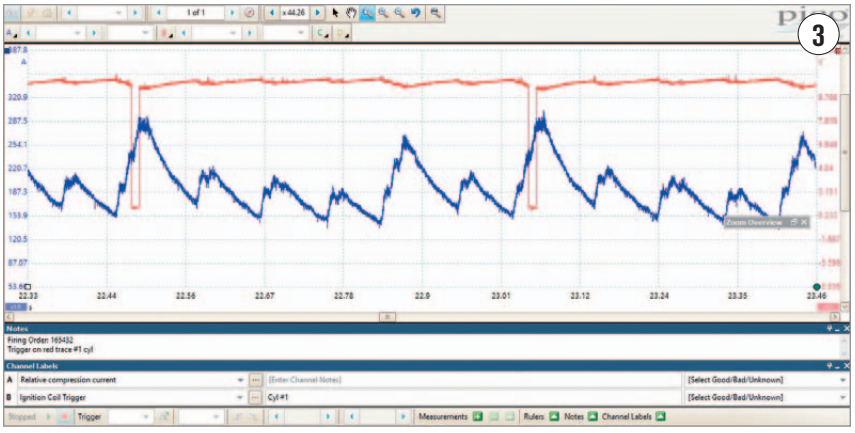

2

PHOTOS: ERIC OBROCHTA

value for the current situation (Figure 1). It was obvious when I pulled the vehicle in there was a hard misfire on one or more cylinders, along with a fair amount of popping and mechanical engine noise, so I made an attempt to use scan data to see which cylinder(s) were having a hard time, but at this point I was not able to get the vehicle to run long enough to gather any useful data. Seeing that gathering scan data was not going to be an option, it was time to move on.

The next step in my diagnostic routine was to set up my Pico scope and run a relative compression test on the engine to gather a "general health check" of the engine. With the heavy amount of mechanical noise, you could hear when the engine did run, so I figured this would be the best next step. Oftentimes the relative compression test can give us an insight to the cylinders' ability to seal and show us how they are in comparison to each other. I am sure if you have used this approach you are familiar with the classic waveform and the benefits it can hold. After disabling the fuel pump and unplugging the ignition coils, I clamped my high-amp clamp around the battery cable and set up a trigger on the #1 ignition coil (Figure 2). Now we are ready to crank the engine!



This is where we gather our first bit of usable data and direction. Have a look at the waveform we gathered and tell me what you see (Figure 3). The blue trace is our starter current

PERFORMING A RELATIVE COMPRESSION TEST WITHOUT AN AMP CLAMP

Even an inexpensive single channel scope can be used to perform this simple test!

PETE MEIER // Technical editor

Now, we've written and discussed the process for relative compression testing many times in the pages of this magazine so I'm not going to rehash it all here. Typically, though, the contributors who have demonstrated this test method always use a high amp clamp to capture the starter current pattern – one basis for this test method.

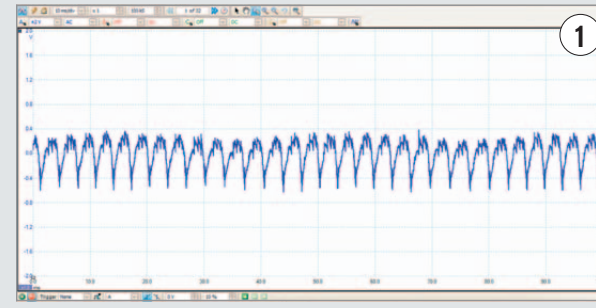
But it's not the only one, and owning an amp clamp is not a prerequisite to performing the test. All you need is a single channel of any scope that allows you to select "AC Coupling" as an input for the voltage scale. What does that do? It eliminates the DC component from the waveform and allows you to see just the AC component of the voltage signal you're attached to. This comes in handy, for example, when inspecting the alternator diodes for failure by measuring the amount of AC voltage present in the DC output. Figure 1 is an example of AC ripple. The leads are attached directly to the battery and if the normal DC signal were present, we would see a somewhat fuzzy line across the scope at around the 13.5v level. But to zoom in and see the reason for the "fuzz" would be nearly impossible for most scopes. Notice, too, how the AC signal remaining is passing over the "0" line, providing us with a measurement of just how much AC ripple there is. Anything over 0.50 VAC is too much and indicates a failed diode.

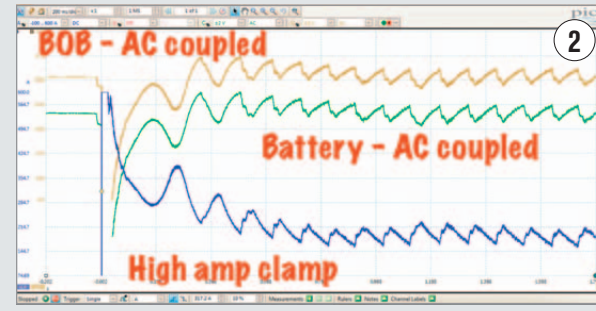
But I'm getting off track a bit. There is some AC ripple present even on healthy charging systems and since the alternator is being turned by the engine, we can use that signal the same way we use the starter current. And we can track the signal from a variety of sources to make our lives even easier!

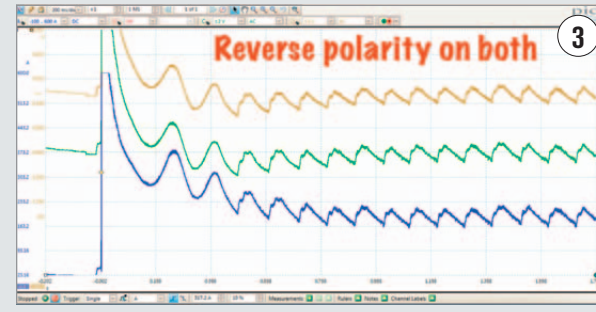
Take a look at Figure 2. The blue trace is a conventional starter cranking current test using a high-amp current clamp at the battery. The green trace is also directly at the battery but is a voltage reading that is AC coupled, showing the AC ripple produced by the alternator. The third trace, the gold one, is at the Diagnostic Link Connector by way of a breakout box (or "BOB"), and the leads are connected to pin #5 for ground and pin #16 for B+.

Notice how similar they are? Wait, we're not done yet.

When most of us perform any kind of current test using our scopes, we tend to orient the pattern so any current "draw" appears as a positive reading up from the "0" line. Actually, it's a negative number, isn't it? But that would be harder to relate to, for me anyway, and I hate making anything harder than I have to. I have enough trouble as it is!







Rather than get used to a whole new way of viewing a relative compression pattern, let's cheat and simply reverse the leads for the two AC Coupled channels and see what happens. That's what you see in Figure 3.

Note now that all three patterns are nearly identical.

So next time you do a relative compression test, try this method. And if you have never performed a relative compression test because you don't own a high amp clamp – you're welcome!

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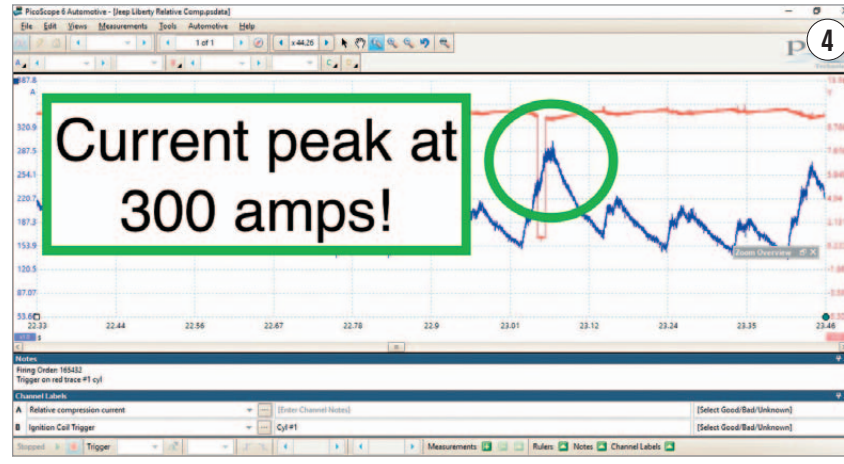
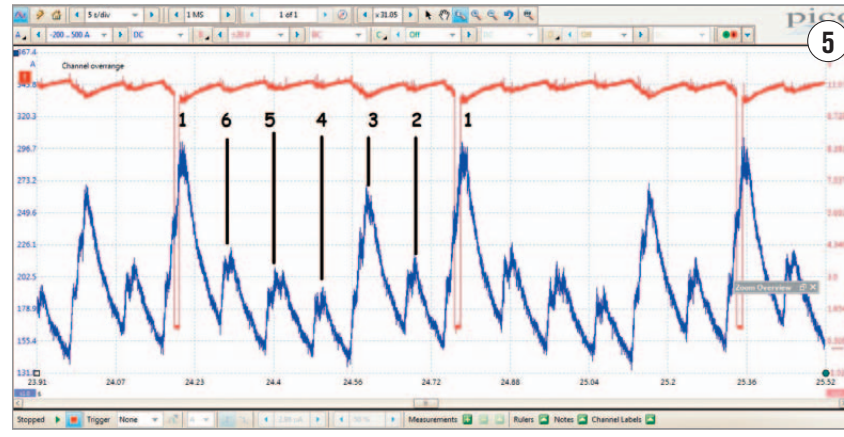
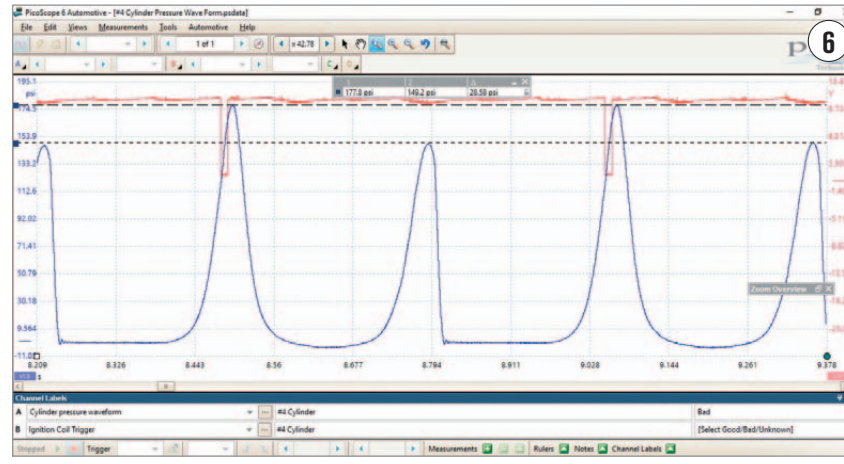
and the red trace is our #1 ignition coil trigger. Quickly we can see that the ignition timing seems to be about right occurring just before TDC. Ok, we can put that in our memory bank. Let's focus on the starter current now. At first glance on the starter current waveform, we might think there are two "good" cylinders (the higher humps) and perhaps three other cylinders that are not contributing as much (the lower humps). But before we draw any types of conclusions based on this let's have a close look at the amperage scale (Figure 4). We can see that the amperage draw of the higher humps is near 300 amps! Experience will kick in at this point and tell us that "normal" starter current draw is around 150 to 200 amps on these engines. After observing this the big question becomes how can the starter draw too much current? Can a cylinder have too much compression?

After some pondering and knowing that these 3.7s along with the 4.7 liters are notorious for the cam followers (rocker arms) falling off, can we make a hypothesis based on this data as to what might be going on in this engine? After all, we are trying to gather as much data as we can before we open it up. Knowing the firing order 1,6,5,4,3,2 and knowing the companion cylinders 1 and 4, 6 and 3 and 5 and 2, could this help us (Figure 5)?

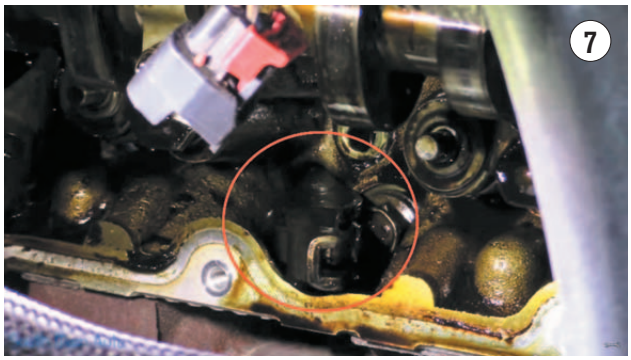
After a few moments, a cup of coffee and some pondering, I came up with the conclusion that if #4 and #6 exhaust valves were not opening then it would appear on the relative compression test that the #1 and #3 were doing extra work on their compression stroke. Make sense? So let's say the #1 cylinder is traveling up on its compression stroke and starting to draw current from the starter. At this same time, the #4 cylinder is on its way up on the exhaust stroke. TECHNICALLY this should not affect the starter current because the exhaust valve is open. But what if it wasn't? In that case, it would be building compression in #1 AND #4 drawing near twice the current as normal from the starter. Same goes for cylinders 6 and 3.







Now that we have a pretty darn good idea what could be happening and we know what two cylinders are the potential culprits, can we prove this 100 percent before pulling out the wrench set? The easiest way I figured would be to use the Pico and an in-cylinder pressure test to prove or disprove



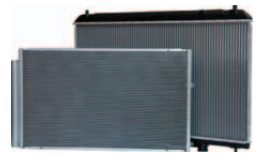
our theory. It should be pretty easy to identify a nonfunctioning exhaust valve with the pressure test. I started on cylinder #4 and there it was (Figure 6) — 180psi compression and 150psi compression on the exhaust stroke of the engine! It did not take long to move the transducer down one hole and see the same exact waveform on the #6 cylinder. This made the diagnosis 100 percent complete. The #4 and #6 exhaust valves were not opening. On a side note, what would you have seen if you were using a regular compression gauge? 180psi? Would you perhaps have moved on at that point, assuming the cylinder was good? Always keep in mind that the standard compression test only shows the cylinder's ability to seal, not breathe. This is where a pressure transducer and a scope can really shine over a compression gauge.

Data has been gathered, pondered and proved, so now it is time to get dirty. Fortunately for us, both 4 and 6 are on the same bank, so we only had to pull one valve cover. As soon as the passenger valve cover was removed, both exhaust rocker arms were found laying on top of the head (Figure 7). Ahh, the sweet feeling of victory! I discussed with the used car lot as to my thoughts on what causes this and what the corrective action should be and you may know how this ends. The rocker arms were snapped back on, valve cover reinstalled and it was off to the sale! The customer was happy that he really did get a "good deal."

If you take anything away from this, I would hope it would be that sometimes we need to slow down to go fast. Gather as much data as you can before tearing into an engine and take the time to look at the scales on your relative compression test and not just the overall picture, because as we proved, sometimes an engine can have too much compression!

ERIC OBROCHTA is the owner of South Main Auto Repair LLC, a Napa Auto Care Center, in Avoca, NY since 2005. In addition to taking care of customer cars, Eric also provides mobile diagnostics and programming to other area shops. Born to shop-owning parents in 1980, Eric now shares his experiences with others as the owner of the popular South Main Auto YouTube channel. *ericobrochta@hotmail.com*

RADIATORS AND CONDENSERS



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AD INDEX

PRODUCTS

VOLTAGE DROP IS NOT ALWAYS A BAD THING!

VOLTAGE DROP, USED AS A TESTING TOOL, IS A GREAT WAY FOR FINDING PROBLEMS IN ELECTRICAL CIRCUITS. BUT VOLTAGE DROP IS ALSO USED AS A NORMAL PART OF SOME SYSTEMS. THIS MONTH, WE'LL LOOK AT A FEW EXAMPLES OF "GOOD" VOLTAGE DROP.

PETE MEIER // Technical Editor

If you know me even a little bit, you know that I am a big proponent of learning how to test electrical circuits using the voltage drop testing method. My very first webinar (co-hosted by TST's G. Truglia) was on this very topic and I've written, taught and produced videos on this invaluable testing tool ever since.

But I've never taken a good look at when voltage drop in a circuit is a good thing! There are many examples of how engineers use voltage drop to their advantage. If you think about it for a minute, the first example that pops into your mind may be the same one that popped into mine — the blower motor resistor!

This simple circuit uses resistors to "drop" the available voltage allowed to feed the blower motor. A lower voltage supply across an equal resistance results in a lower current flow, doesn't it? That's basic Ohm's Law stuff. Of course, the lower current flow results in a slower motor! This allows the engineer to offer the driver various blower motor speeds simply by adding or subtracting the number of resistors the source voltage has to feed.

And there are others that you troubleshoot every day. In this edition of The Trainer, we'll take a look at a few common examples as well as analyze a cooling fan circuit that uses voltage drop in a way you may find unique!

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