Motor Age®

ADVANCING THE AUTOMOTIVE SERVICE PROFESSIONAL SINCE 1899

COMMITMENT TO TRAINING

REGISTRATION NOW OPEN FOR MACS 2020 EVENT, TRADESHOW 26

informa markets

OCTOBER 2019

VOL. 138, NO. 10 // **MOTORAGE.COM**

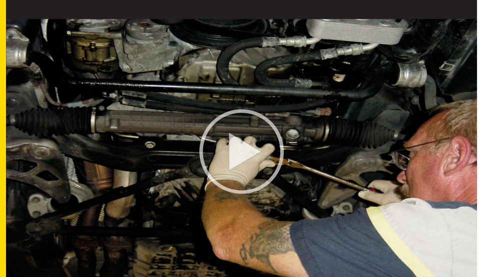
44 **EXHAUST RESTRICTIONS**

Learn how to make sure the path out of the pipe is "all clear!"

60 **A PID-O-FULL DIAGNOSIS**

Gas or diesel? It doesn't matter if you apply a diagnostic process and follow it!

72 **THE ONE TECHNOLOGY YOU NEED TO KNOW**



Motor Age®

ADVANCING THE AUTOMOTIVE SERVICE PROFESSIONAL SINCE 1899

COMMITMENT TO TRAINING

REGISTRATION NOW OPEN FOR MACS 2020 EVENT, TRADESHOW 26

informa markets

OCTOBER 2019

VOL. 138, NO. 10 // **MOTORAGE.COM**

INSIDE: 2019 INDUSTRY ROUNDTABLE 12

54

UNIVERSAL JOINT DIFFERENCES

Learn the right way to service these important driveline components

44 EXHAUST RESTRICTIONS

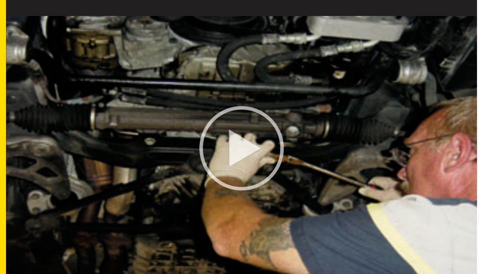
Learn how to make sure the path out of the pipe is "all clear!"

60 A PID-O-FULL DIAGNOSIS

Gas or diesel? It doesn't matter if you apply a diagnostic process and follow it!

72

THE ONE TECHNOLOGY YOU NEED TO KNOW



Motor Age

ADVANCING THE AUTOMOTIVE SERVICE PROFESSIONAL SINCE 1899

Talk Shop Anytime

OCTOBER 2019

VOL. 138, NO. 10 // **MOTORAGE.COM**

OPERATIONS

Commitment to **TRAINING**

TECHNICAL

IN EVERY ISSUE

EXCLUSIVE ONLINE TRAINING

SIGN UP TODAY!

Motor Age Training CONNECT is your online source for the training you need, and it's available when you are.

MotorAge.com/MATCONNECT

Motor Age TRAINING CONNECT Powered by AutoMate®

WEB EXCLUSIVES // MOTORAGE.COM

MONEY-SAVING TIPS FOR PURCHASING PARTS ONLINE

The Buyer Exemption Program is a new way collision and repair shops can save money when buying parts from eBay Motors. Launched this year, shops that register their reseller IDs can qualify to make sales tax exempt purchases.

MOTORAGE.COM/EBAYTIPS

HOW TO SURVIVE THE AMAZON AGE — AND BEYOND

Consumers now expect easy, convenient and transparent interactions with their service providers. It's sometimes referred to as the Amazon effect, and it is affecting automotive repair shops. Read on to hear from BOLT ON Technology's John Burkhauser how to make retirement a reality, stay relevant in the Amazon age and more.

MOTORAGE.COM/AMAZONAGE

Motor Age

MOTORAGE.COM

1100 Superior Ave. Suite 800 // Cleveland, OH 44114

Phone: (216) 696-7000

Motor Age (Print ISSN: 1520-9385, Digital ISSN: 1558-2892) is published monthly, by UBM LLC, 325 W. 1st Street, STE 300 Duluth, MN 55802. Periodicals postage paid at Duluth, MN 55806 and additional mailing offices. POSTMASTER: Send address changes to Motor Age, P.O. Box 6019, Duluth, MN 55806-6019. Please address subscription mail to Motor Age, P.O. Box 6019, Duluth, MN 55806-6019. Canadian G.T.S. number: R-124213133RT001. One-year rates for non-qualified subscriptions: U.S. $70.00; Canada/Mexico $106.00; International surface $106.00.

INDUSTRY NEWS

TECHNOLOGY FORUM

UNDERSTANDING, ANALZYING TECHNOLOGY VITAL FOR FUTURE

KRISTA MCNAMARA //
Content Channel Director

TROY, Mich. — The future of continuing to perform successful repairs in your shop for vehicles of the future lies in one phrase — sensors, sensors, sensors.

Debra Bezzina, managing director at the Center for Connected and Automated Transportation, University of Michigan Transportation Research Institute, presented during the "What's Now, What's New and What's Next" at the 2019 Technology & Telematics Forum, presented by the Automotive Service Association (ASA) and the Alliance of Automobile Manufacturers in Troy, Mich., on Sept. 12.

During a discussion with Bob Redding, ASA Washington, D.C. representative, Bezzina discussed the industry impact on stalled federal legislation regarding autonomous vehicles, what repairers need to know to handle advanced technologies and those to come and future technology in the works.

Stalled legislation

While industry guidelines have spurred

a lot of activity regarding autonomous vehicles, the lack of federal legislation is being felt.

In 2016, rather than push regulation, the Obama Administration opted for policy guidelines and published the "Federal Automated Vehicles Policy, Accelerating the Next Revolution in Roadway Safety." These "best practices" and model state policy guidelines provided no regulatory teeth to AV implementation. The current administration has issued two additional broad policies, "Automated Driving Sys-

>> **BEZZINA** CONTINUES ON PAGE **6**

BREAKING NEWS

VEHICLE SHARING

PEER-TO-PEER VEHICLE SHARING GAINING TRACTION

TROY, Mich. — There is a new model challenging the need for vehicle ownership — and it could be very profitable for you.

Ethan Wilson, senior government relations manager and legal counsel for Turo, presented about the company's peer-to-peer vehicle sharing model at the 2019 Technology & Telematics Forum, presented by the Automotive Service Association and the Alliance of Automobile Manufacturers in Troy, Mich.

Turo's mission is to put the world's 1.5 billion cars to better use and to help vehicle owners to create an economic engine out of items that are most likely the most expensive depreciating asset a person buys, Wilson said.

Founded in 2010, Turo is a community of vehicle owners, also known as "hosts," and

>> **SHARE** CONTINUES ON PAGE **6**

TRENDING

ARKANSAS LAUNCHES "BE PRO BE PROUD"

The Arkansas Chamber of Commerce and Associated Industries of Arkansas announced a Be Pro Be Proud mobile workshop to encourage technical training and careers in the industry.

MOTORAGE.COM/BEPRO

AAPEX SUMMIT TO ADDRESS INDUSTRY CHALLENGES

The Service Professionals Summit during AAPEX in Las Vegas will present "Aftermarket 2030: Consolidation Trends,, Opportunities and Challenges."

MOTORAGE.COM/2030

ICAHN AWARDS $50,000 IN SCHOLARSHIPS

Icahn Automotive has awarded 20 students each with a $2,500 scholarship for the 2019-2020 school year as part of its inaugural scholarship program, established as a multi-year commitment.

MOTORAGE.COM/ICAHN

AAPEX ADAS FORUM TO HELP TECHS PREPARE

AAPEX 2019 is hosting a three-hour ADAS Forum to help prepare auto repair shops for the opportunities and challenges of servicing ADAS-equipped vehicles on Nov. 7 in Las Vegas.

MOTORAGE.COM/NOV7

ENGINEERING THE NEXT GEN OF COATINGS

New hydrogen-free Diamond-Like Carbon coating technology provides unmatched protection for components in super cars, motor bikes and professional motorsports.

MOTORAGE.COM/DLC

>> BEZZINA CONTINUED FROM PAGE 4

tems: A Vision for Safety 2.0" and "Preparing for the Future of Transportation: Automated Vehicle 3.0."

AV legislation, the Self-Drive ACT — or AV START Act — passed the U.S. House of Representatives earlier this year, but stalled after Senate Commerce Committee passage. This leaves the U.S. Department of Transportation or state governments to move forward with AV research and implementation policies on their own.

Bezzina said the guidelines have helped the industry but are not enough. "The guidelines published spurred a lot of activities. People are focusing on it, and you can see it in the industry in terms of who is buying who and getting involved in what. There is so much that it spurns, so it is great for research. But it is hard for deployment — production, commercialized product. There are some gaps. And that can only be resolved with an industry-wide mandate," she said.

Legislators didn't want to dictate in terms of forcing the industry to use certain technology; they wanted the industry to determine that. But this creates a problem, Bezzina said.

"Connected vehicles only work when everyone uses the same standards. A patchwork (state by state) solution is really bad for an OEM," she said. But on the other hand, Bezzina said, "I don't think dictating everything down to a T is in the best interest of every state."

The future of repairs

The leap to autonomous vehicles will not be so sudden, but rather fairly gradual, Bezzina said.

"Currently there is some Level 2, Level 3 automation. We are going to see more sensors, more sensors, more sensors. Repairers need to understand what those sensors are and how they impact the system. Repairers need to learn what these sensors do, analyze the information given and use that information to fix the vehicle," she said.

Data access will also remain a challenge. Currently shops get data from many different sources — the vehicle, online, from OEMs, etc. "These channels are not going to change; there is just going to be more of it. The challenge is being able to analyze it for a proper repair," Bezzina said.

Future technologies

Bezzina mentioned two technologies that she is seeing being tested in her day-to-day roles that have her excited. The first is remote control. She used the example that if all cars are connected to each other, a traffic signal at an intersection could in theory control all the vehicles approaching it to prevent accidents, rather than relying on the vehicle's system. "This is currently being tested at (the University of Michigan's) MCity, and it is very impactful," Bezzina said.

Augmented reality is also being utilized to better prepare vehicles for situations on the road. "We don't often talk about how to get automated vehicles ready for reality. But we have to do due diligence for verification, and no one agrees on how best to do that. But we all agree there needs to be more testing," said Bezzina, who supports a combination of testing — simulations, road testing, engineer analysis, among others — to prepare vehicles. Bezzina explains that MCity uses an "augmented reality" with one vehicle on a closed track that has to interact with other virtual vehicles to test reactions and results. She also pointed out that this testing can help save millions of dollars when creating test vehicles. MA

>> SHARE CONTINUED FROM PAGE 4

consumers looking to share these vehicles, or "guests." Guests can choose from a unique selection of nearby and locally-sourced cars. The company serves more than 5,500 cities across the U.S., Canada, Germany and the UK.

The model is driven by the ever-rising cost of vehicle loans — with $504 being the average monthly loan payment for vehicle ownership. Turo looks to help change the economies of vehicle ownership and boasts that the average host will earn $625 per month with just 11 monthly booked days.

According to Turo research, 75 percent of hosts use the income to pay down car loans or cover primary vehicle expenses.

The five most popular models that guests seek are the Jeep Wrangler, Toyota Prius, BMW 3-Series, Tesla Model S and Mustang.

Wilson also shared that Turo has been working proactively with legislators and regulators on creating peer sharing legislation that protects all parties.

The company offers 24-hour roadside assistance, and has partnered with Liberty Mutual on insurance plans for all hosts and guests.

"We want everyone on the platform to feel safe. A big part of that is the dynamic of peer-to-peer review. You know the vehicle being reviewed is the one you are going to be driving," Wilson said. And while Turo checks every vehicle for open safety recalls, Wilson said state-to-state laws dictates if the vehicle needs to have a safety inspection.

Those in the audience challenged the company to partner with the automotive industry on performing vehicle inspections and repairs to ensure the cars are safe to drive and repaired correctly. MA

YOUR SHOP. OUR SOLUTIONS.

Castrol ePODS™

Castrol® ePODS™ offer faster and more efficient oil changes

Castrol ePODS are an exciting technology that help make your shop's oil changes run smoother. Gravity-fed design ensures use of every drop of oil with zero spills. The MAXFLOW™ pitchers provide 2X faster flow rate than traditional pitchers and reduce oil dispensing time by up to 50%. ePODS bottles are 100% recyclable.

Learn more at **www.AdvancePro.com**.

SPECIAL OFFER! Professional Customers who buy 6 or more ePODS bottles will earn a FREE Dispensing Kit.*

*ePODS Dispensing Kit includes one rack, one dispenser and 4 MAXFLOW pitchers.

CARQUEST AUTO PARTS | Advance Professional

The reason your shop meetings aren't working

The biggest problem with communication is the illusion that it has taken place

Most of us have learned valuable lessons from our mentors that have made a huge difference in our lives. Today's lesson once changed my life. Let's listen to veteran ATI coach Eric Twiggs explain how it affected his life:

As a new district manager of automotive service, I had just returned from a national meeting where our president clearly communicated the company direction. What he said was good for the car, the customer and the corporation. My next step was to have a meeting with my managers to get their buy-in.

I told them that the courtesy checks were a non-negotiable aspect of the business that had to be done on every car.

I expected every service advisor to make a quality visit to the car with every customer as they were checking in.

I also expected all customers in the waiting room to be updated on their vehicle status at ten o'clock, two o'clock and four o'clock, every day without fail.

To seal the deal, I created a flip chart containing these three items, and had all 17 of my managers sign it, saying that they would get their teams to comply.

Several weeks later, Gary, my regional manager, called to let me know that he would be visiting my shops with me and asked if my team was executing the three main items discussed at the national meeting.

"Gary, we are on it!" I was looking forward to our upcoming visits.

Gary and I visited five of my locations, and we saw some interesting things. The employees at my shops were doing everything, except the courtesy checks, the quality visit and the customer updates! Here was my feeble response, "But Gary, I told them!"

Where did I go wrong? I'll bet it's the same place you went wrong when you came back from the SuperConference, your 20 Group or ATI class, filled with great ideas. I was unaware of the 70 percent rule!

Have you ever been all in and onboard with an idea you heard, but failed to achieve implementation at your shop? Keep reading to uncover why this happened and what you can do about it.

The 70 percent rule

Based on 26 years in the business and thousands of coaching sessions with shop owners, I have become aware of the 70 percent Rule.

When communicating a significant change, I've found that 10 percent of employees will refuse to buy in no matter what, 20 percent will execute with or without leadership oversight, and 70 percent of the group can go either way depending on how the leader follows up. (Disclaimer: These are merely averages and the results may vary depending on shop culture and the specific idea in question!)

Let's say you have a shop of 10 employees, and you come back from the SuperConference and tell them that everyone must do a goal poster.

Based on the math, one employee will refuse, two will comply just because you told them to, and the rest can go either way depending on how you follow up.

Since I was unaware of the 70 percent rule, I just "told them" and was surprised when it didn't happen! So, the key to implementing change at your shop is to always inspect what you expect.

Inspect what you expect

Here's the question: How do YOU respond when your employee isn't doing what was mentioned at the meeting?

If there isn't a response, it's like the meeting never happened. At least 70 percent of your team will go back to business as usual.

You can't respond to what you don't see, so the key is to create systems that allow you to inspect what you expect.

When you can see what's going on, you are positioned to respond accordingly. The following are my favorite follow-up systems:

- **Daily RO Audits** — This is the daily habit of reviewing a random selection of work orders, invoices and courtesy checks and providing the appropriate feedback. If you discussed courtesy check compliance at your meeting, the RO audit gives you an opportunity to provide positive recognition for those who are executing and constructive feedback to those who aren't.
- **Weekly One-on-Ones** — The most effective one-on-ones are those that are scheduled on the same day and at the same time every week. If I work for you and I know that every Tuesday at 2 p.m., you will be reviewing the digital inspection report with me, I will be more likely to follow through with sending my customers the digital photos, as we spoke about at your meeting.
- **Regular Review of Recordings** — In years past, I would conduct phone shops and send the owner the feedback based on what I heard. Sometimes, the advisor would claim that I was wrong or deny even getting the call. The beauty of the recordings is that everyone can hear what happened at the same time. The most effective coaching method is to play the recording and have them tell you how the call went based on the standards you shared at the meeting.

Don't expect what you don't inspect

The reason my shop meeting didn't work is because I failed to inspect what I expected.

Not sure where to start? A great place could be a review of the last quarter! You could always go over last week, but to give some real perspective to your crew, a longer time frame does the trick. If you are still not sure where to start, download our Quarterly Review Checklist by going to *www.ationlinetraining.com/2019-10* for a limited time. This Checklist will give you all of the most important items you may want to cover. The Checklist gives you a great start to improving your shop.

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 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 Coach Eric Twiggs.
chubby@autotraining.net

BRAKES THAT WON'T
STOP
YOUR

A GAME OF PICK UP STICKS

Panelists sift through intertwining challenges, opportunities in the annual roundtable

CHELSEA FREY //
Senior Associate Editor

This year, *Motor Age* gathered four industry experts (See sidebar: "Who was at the table?", page 16) for the annual roundtable. Panelists discussed challenges, opportunities and the future of the industry through topics such as licensure, ADAS and the importance of connecting with techs around the world.

Here are some of the highlights of this year's *Motor Age* Roundtable. (Responses were edited for length and clarity.)

Do you think the liability and dangers of improper ADAS repairs will push licensure of service repair technicians?

Ray Fisher: I think we need to have some sort of credential, whether it's government-related or whether it's our own internal mechanism. There's a lot

PHOTO: VLADGRIN / GETTYIMAGES.COM


driving
the FUTURE
of STOPPING

at stake in these ADAS systems. As an industry we need to be identified as professionals. I think it's an opportunity for us to step up and show our professionalism.


Ray Fisher

Matt Fanslow: I find this question difficult to answer because there are a lot of shops that are not addressing ADAS at all. The whole liability conversation is "we don't know." Nobody knows. The only thing we have to go on is the John Eagle court case on what could happen. There's a lot of cars out there that haven't been aimed properly, that aren't calibrated properly driving around that could've been in accidents. But I haven't heard of anyone who's been taken to task for it.


Matt Fanslow

Pete Meier: Most of the shop owners, technicians and teachers who might be reading this, who watch our videos are on the higher end of the scale. They're the techs who do care about doing things right. But there are so many that are kind of living in comfortable ignorance of what the modern automobile has become. ADAS itself is not overly complicated; any decent technician is going to be able to adapt and use technology just fine. I think as far as liability goes, that's kind of an unknown quantity that we have yet to see.


Pete Meier

Randy Briggs: I have to agree with Matt. There is a glaring unawareness of not only how ADAS systems operate but how the services that both aftermarket and dealer shops are doing now that are not directly ADAS-related but still affect it — something as simple as alignments or changes in ride height, body repairs, brackets that aren't put back exactly the way they should be. In our research, just about every time there's an ADAS failure there's a simple reason behind it — bent bracket, a networking issue, an initialization of a module that wasn't done properly. Awareness of your current services and how they affect ADAS have to be industry-wide.


Randy Briggs

Pete: Personally, I think it is time for some type of licensure or credentials that the consumer can rely on in knowing that the repairs are going to be performed properly. With the different technologies that are in place and those on the horizon, these repairs are not as forgiving as they used to be. They have to be done correctly. You could impact the vehicle's drivability and operational safety.

Randy: I don't think licensure is necessarily the answer. I think certifications are, and I think they need to be driven by industry practices. In other words, I think these certifications need to come from the inside out, not the outside in.

Pete: I won't disagree with that, Randy. I think we kind of have a foundational element with the ASE certification program. I know there's been a lot of discussion among folks in the industry about building on that and adding some type of real-world proof of their book knowledge. I'll admit, I can take the book test pretty well. I have my ASE Master certification, but I'm not tearing apart a 10-speed automatic transmission. If we're going to be working on these systems, coupling that book and classroom knowledge along with a practical hands-on experience is essential. It would add much more meat to that credential.

Could you speak to the importance of connecting and collaborating with other professionals at industry events, training events, in organizations, and online?

Randy: That is an absolute necessity in my mind. In particular, online specialized groups out there are invaluable. Whether it's ADAS calibrations or reprogramming or just general diagnostics and repair, I don't know how an independent technician could survive without that type of resource right now, especially when you get into the higher levels of technology that involve such a myriad of little stumbling blocks that you can rarely find in service information.

Pete: There's also the groups like iATN and Diagnostic Network that have added to the resources and capabilities. With the challenges today and the number of system variations and technologies, no one tech is going to be able to do and know it all.

Randy: We've gone from "I know a guy" to "I know 100 guys."

Matt: Something that was very important to me as a young tech when I came into the industry was iATN — the dominant online resource for technicians and managers at the time. It was a brutal wakeup call to find out just how far I had to go, because I thought I was pretty good, even as a young tech, figuring out cars that others were struggling with. I started to kind of get a big head. But iATN beat me down to realize just how much there was to learn. I've learned from iATN, and now you're getting a similar experience on Facebook and Diagnostic Network. You might think you're pretty good and then you see someone who is *really* good and how far you have to go. It gives you

something to strive for.

Ray: One of the great things we're seeing in relation to that is that we're getting rid of our egos once we understand that there is a lot we don't know and have yet to learn. I think this a great time for our industry to move forward in a professional way.

What is the biggest challenge you're facing now that you didn't have to face 10 or 15 years ago? Do those challenges provide any opportunities for you or techs entering the field?

Matt: One big challenge is the technology — the technology in the vehicle itself as well as the technology required to service the vehicles. Years and years ago a scan tool or two was all you needed to pretty much do everything. Now, if you're serious about fully servicing a vehicle, you're probably going to have a minimum of two or three aftermarket scan tools and an OEM scan tool for the cars that dominate your bays. If a shop sees the technology as an opportunity and is willing to make the investment to purchase calibration equipment, targets, OE tooling, etc. to do ADAS service, you might corner the market in your area for everyone — all the repair shops and all the collision shops. Same with the OE tools — you will start cornering a market of techs and shops giving up on cars and sending them your way. That offers a lot of opportunity.

Ray: It also brings the technicians there, too, because they start thinking, "Oh, why is everything going to that specific shop?" and they want to be a part of that entity. It's self-fulfilling. Not only are you marketing your equipment and your values as a repair facility, but eventually technicians are going to be interested, too, because they see the shop owner as someone who will invest in technicians as well. It becomes full circle.

Randy: There's a huge, great future for talented technicians who are passionate about their work and are ready to attend training, to make the investment. It's the same discussion we've had for years. How do we attract these people? Is it the fault of the school counselors? Is it the fault of the parents? Is it the poor public image? Is it the fact that the industry isn't paying technicians commensurate with their skill levels? Or is it the consumer who doesn't want to pay that cost? It's a vicious circle, and it always has been. We've had these discussions for years and years and years. And they don't sound that different than they did 10-15 years ago. The question becomes, when are we as an industry going to get out of our silos, each of the individual groups trying to find an answer and come to the table and create a solution? Somebody needs to make that first step. When that first step is made, the rest will follow.

Ray: When I've spoken at conferences, I've sometimes started with "I'm a commodity in which you can order something that can be delivered right to your doorstep." And I go on with a few more details and then I say, "Who am I?" And everyone responds, "Amazon." Well, actually it's Sears Roebuck back in the 1890s; they had a catalog system. You look at where Sears is today — they lost sight of that vision. Amazon reinvented it with new technology with essentially the same model. I think that it's time for us to put our heads together — like Randy said — and start getting our think tanks going in the right direction together, collaboratively. To add to that, the big threat to this industry is ourselves. We always see the same people online, and I'd like to see a lot more different faces — no offense to anyone on this panel, including myself. It's going to take more than us. Together we can get this done.

Matt: I've said this before in other venues — blissful ignorance is a big problem. A lot of shop owners, managers and technicians who aren't investing in training and equipment, who aren't looking for solutions to these problems don't realize they're on a race to the bottom — and they're standing on the gas.

Randy: How many times have we heard, "Well, I've done it this way for 20 years." My response typically is, "It's a good thing that cars never change."

Pete: I used to say that the issues that are facing us all are like that old game of Pick Up Sticks in which you spread out the sticks on a table and had to pull one out without disturbing the others. You can't do that. The issues in our industry are so intertwined and so interlinked that you can't just address one without addressing them all. These are challenges — or similar challenges — that we've always faced, and we've always found a way to overcome. The greatest advantage to our industry is that independent mindset: I'm going to do this and I'm going to find a way to overcome it and succeed. And that's what continues to move us forward. We'll find the solutions; I'm not overly worried. If anything, I'm more optimistic about our industry now than I've ever been. MA

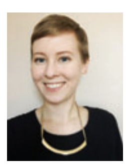
WHO WAS AT THE TABLE?

Matt Fanslow, Diagnostic Technician and Shop Manager at Riverside Automotive

Pete Meier, *Motor Age* Director of Training

Randy Briggs, Research and Development Center Manager at CARQUEST Technical Institute

Ray Fisher, Executive Director of ASA



CHELSEA FREY is the Senior Associate Editor for *Motor Age* and for its sister publication, *ABRN*, in the collision repair segment.
chelsea.frey@ubm.com

Review your service advisor job description

The role is vital to ensuring positive client communication and expectations

With the dramatic change taking place within the aftermarket service shop business, it is time to clearly define the roles of each position within the business. One critical position that must be reviewed is that of the service advisor. Consider this description and compare it to your current service advisor position.

The service advisor is the person in charge of all communications when clients come in for their appointments. The main function of the service advisor is to show leadership and take control of the process at the client's arrival in a professional way. The service advisor must inform and update the client on the shop process at each step, solve primary concerns and set realistic expectations. The client must know what is going to happen before it happens. The goal is to reduce tension, earn and increase trust and bring value to the client to build a relationship. The service advisor must educate the client on the service intervals recommended for their vehicle for safety, reliability and efficiency to secure repeat business on an on-going basis.

Here is a breakdown of expected duties:

1. Review all folders from the previous day to ensure:

- All pertinent information has been collected
- That miles are matched to the maintenance schedule
- Areas of opportunity from last visit have been addressed
- Parts are ordered if booking is for parts installation and not in stock
- You are familiarized with the client and the vehicle
- The pre-repair order is accurate

2. At the time of client arrival, smile, tune the world out, take control and introduce yourself. Ask for their name — first and last — confirm the vehicle and listen actively to concerns and additional information about the vehicle. Check off the appointment on the appointment board and inform them of your intention to go out to the vehicle.

THE GOAL IS TO REDUCE TENSION, EARN AND INCREASE TRUST AND BRING VALUE TO THE CLIENT TO BUILD A RELATIONSHIP.

3. Perform the walk-around with the client. Explain what you are doing and involve them. Note the following: if the vehicle is clean or dirty; its condition and age; any malfunction indicator lamps, confirm mileage, etc.

4. Inform clients on our process: Go through the diagnostic, courtesy inspections and complaint inspection steps. Inform the client on our professional responsibility for safety and reliability. Suggest maintenance by outlining the client's need, vehicle history, intervals and OE recommendations.

5. Build a professional repair order and get a signature on every repair order.

6. Dispatch the job.

7. Assume all communications with client. Confirm how the client wants you to communicate – email, text, telephone — and document it to the file.

8. Communicate to the client the results and findings of the inspection and diagnostics. Primary concern(s) should be addressed first with a full estimate before additional service can be discussed. Review inspections and make sure to point out positives.

9. Get approval for work with exact pricing, parts availability, options and a time frame to complete the work with reasonable expectations. Separate the services to be done and those to be deferred. Re-schedule work if needed. Determine who will complete the work and get parts ordered. Keep everyone informed of any change in schedule.

10. Assure that all promises have been kept: primary and other concerns, road test by technician and any special requests by the client.

11. Make sure the repair order is completed and ready.

12. Call the client to inform them that the vehicle is completed. Start active delivery over the phone by scheduling time of pick up, determine the next appointment and log the next appointment electronically. Inform client of the bottom-line price, which should be the same as the approval.

13. Perform active delivery: speak slower than normal, review primary concern(s) first, advise of any special-order parts, when they will arrive and the process to have them installed. Discuss work not completed, explain the investment in vehicle, warranties and

SERVICE ADVISOR PAY PROGRAM TIPS THAT WORK

If you are looking to drive up your profits, you need to ensure you have service advisors who have the right attitude, aptitude and ethics. They will need to have the natural talent to sell, they will need to be well trained, and they will need to have the proper support systems in place. And lastly, you will need to have the right compensation and incentive plan in place to help your advisors excel.

Here are three tips you can use to drive up your sales, profits and customer satisfaction scores, all at the same time.

1. Identify what you want to accomplish
2. Create a shared commission for your advisors
3. Implement daily sales goals

Continue reading for the details on these suggestions at ABRN.com/paytips.

supply educational material.

14. Schedule next appointments for deferred work and set intervals for follow-up.

15. Create a memo for deferred work and contact clients for deferred work on safety, reliability and vehicle efficiency issues.

As you can see, the service advisor has a very key role in engaging the client today. The detail is enormous, and that is why the recommended staffing level is one service advisor to every two technicians. There is so much communication required between the techs and the client that when a service advisor has to work with four technicians, he or she is overwhelmed and cannot execute effectively. Therefore, net profit is being missed.

Is your business up to date with the required new description?

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.
greenwood@aaec.ca

AV conversation should not exclude safety inspection

With social and technological trends, who's responsible?

During the discussions of autonomous vehicle (AV) legislation in the last Congress, several members of Congress raised concerns about who would be responsible for assuring that these vehicles would be maintained and safe for America's roads. Currently, only 15 states have vehicle safety inspection programs. With the 115th Congress' failure to move AV legislation, the issue has arisen again.

U.S. House and Senate policymakers asked that organizations interested in new vehicle technologies submit comments about what AV legislation should include. The Automotive Service Association emphasized the importance of vehicle safety inspection in a letter to the committees:

"As vehicles become increasingly sophisticated and the owner less attached and knowledgeable about their vehicle, ASA believes that vehicle safety inspection and maintenance will be less of a priority. Autonomous vehicles raise numerous issues related to vehicle safety including the day-to-day responsibility for monitoring important safety items on the vehicle, i.e. tires, lights, brakes, condition of the windshield, etc. States that allow AVs on their roads should also be required to have a state periodic motor vehicle safety inspection program in place."

In a recent study, the Boston Consulting Group (BCG) noted three important trends for the automotive industry: technological; social; and regulatory.

Technological includes autonomous driving, electrification, connectivity. Social includes urbanization, new way of working and sharing. Finally, the regulatory trend would involve city regulation and emissions standards. These trends should impact how federal, state and local policymakers view vehicle safety.

With increased ride-sharing, who's responsible for the maintenance and safety inspection of the vehicle? The majority of jurisdictions have no inspection or maintenance requirement. For anyone traveling around the country, ride share vehicles vary greatly in their condition for clients. What assurance will web-based consumer comments or less stars provide that the vehicle will be repaired?

The lack of federal AV legislation, and nothing set to move in the foreseeable future, puts much responsibility on the states and communities. Are cities equipped to assure ride share vehicle safety? States have a modest history of support for vehicle safety inspection unless it's tied to a significant funding source, i.e. highway funds. The National Highway Traffic Administration (NHTSA) has already noted the importance of vehicle safety inspection in various initiatives.

In NHTSA's "Automated Driving Systems 2.0," federal regulators offered guidance to state and local jurisdictions for AVs. "Post-Crash ADS Behavior Entities engaging in testing or deployment should consider methods of returning ADSs to a safe state immediately after being involved in a crash… Additionally, entities are encouraged to have documentation available that facilitates the maintenance and repair of ADSs before they can be put back in service."

NHTSA's "Automated Vehicles 3.0" continued its boundaries of federal and state responsibilities. NHTSA publishes the "Uniform Guidelines for State Highway Safety Programs" and highlights that "Each state should have a program for periodic inspection of all registered vehicles to reduce the number of vehicles with existing or potential conditions that may contribute to crashes or increase the severity of crashes that do occur, and should require the owner to correct such conditions." NHTSA is describing what we have today in only 15 state vehicle inspection programs. As ownership continues to shift to ride share and other programs, more responsibility will likely fall on local and state governments for vehicle safety post-manufacture. Any federal legislation that ignores this important responsibility is not fulfilling its duty to protect the motoring public. MA

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*


I GOT FOUR ALTERNATORS. BOX ONE WAS MISLABELED. TWO WAS DEFECTIVE. THREE DIDN'T FIT. CAN'T WAIT TO OPEN BOX NUMBER FOUR.
OMNICRAFT™ GETS IT. FORD BACKS IT.
Get what you expect, not surprises, right out of the box. Choose premium Omnicraft parts for your non-Ford vehicle repairs. OmnicraftAutoParts.com
Omnicraft™
Backed by Ford Motor Company
Omnicraft™ is a trademark of Ford Motor Company.

Dedicated to ADAS

Shop stands out with location solely for ADAS service and calibration

ROBERT BRAVENDER // Contributing Editor

Whether reading *ABRN* or *Motor Age*, ADAS shows up in a lot of articles. While some Advanced Driver-Assistance Systems have actually been around quite a while — anti-lock brakes, airbags, traction control, collision mitigation — they're now being integrated with increasingly intricate sensor systems as the technology evolves toward self-driving cars. And with repair costs and complexity going up, the shop sector watches and wonders about the future.

Some, however, are taking a more proactive approach. For instance, Advanced Tire & Auto Centers recently changed their name to Advanced ADAS Calibration Centers (AACC) to reflect their new business model. Founded in 1995 by Jason and Janet Bigelow, the original shop in Keyport, NJ, still handles traditional services along with ADAS calibration, while their second facility in nearby Old Bridge is strictly calibration, filling a growing void in the market.

"We're unique in New Jersey because we're the first one," says Jason Bigelow. "The next closest dedicated ADAS calibration center is in North Carolina."

As the Bigelows noted in a press release, "today's cameras, radar and other sensors require careful calibration to keep them working properly, and demand continues to grow for the specialized ADAS training, expertise and diagnostic technology…"

"For example," offers Bigelow, "if I'm off one millimeter calibrating a radar unit on a Honda, it will affect that vehicle's emergency braking by up to 75 feet. That's why it's important to stay on factory tools and have certified people who specialize in this to do the job."

With demand for these skills and technology primarily coming from local insurance companies and body shops, the Bigelows have essentially switched from one industry to another.

"We ended up migrating more toward the collision industry from about 2012 on," Bigelow explains. "Last year there was a 44 percent increase in what we were doing; by the end of that year it was up to 68 percent in ADAS assistance. We opened a second location to just service our collision industry. We're expecting by this time next year to experience another 40-45 percent increase in calibration.

"Probably the most defining moment was when we started taking lifts out of the building," he recalls. "That just goes against all logic of the repair business. But because of what's involved with these 360-degree camera systems and the ADAS calibrations, I need a very strict environment: non-reflective paint, non-reflective walls, special LED lighting placed in various locations. I also need 30 feet on each side of the car and up to 60 feet front and back to calibrate the camera systems correctly."

ADVANCED ADAS CALIBRATION CENTERS
Keyport, New Jersey // www.advancedadas.com

Jason & Janet Bigelow
Owners

2
No. of shops

14
Years in business

This impetus for precision was present from the very start. "When we opened in 1995, our primary focus was to diagnose vehicles correctly," Bigelow states. "Back then the average car had two computers; today most cars have up to 200. Through different techniques, whether oscilloscopes or lab scopes, we approached the cars analytically like we were repairing computers, so we had to change our focus and turn more into IT professionals."

To that end, they accumulated 21 factory scan tools, an "exorbitant investment…in the industry," he notes. "To help offset the cost of what we were spending, upwards of a million dollars to purchase just the software and equipment, it was just a natural transition to what we were already doing. Once we

PHOTOS: ADVANCED ADAS CALIBRATION CENTERS

partnered with the collision industry, we became the front of the ADAS revolution. We're now seeing cars with 30 miles on them, 200 miles; we're solving problems at an engineering level that even the manufacturers haven't seen.

"If you've ever (parallel) parked in a city, other cars tap your bumpers getting in and out," says Bigelow. "[Some] systems get uncalibrated just by minor impacts, and the customers are getting collision mitigation warnings on the dashboard. This requires recalibrating the radar; there's a targeting system that checks it at different distances."

At the other end of the spectrum, AACC also provides body shops and insurance companies collision analytics. "If a vehicle's involved in a crash or a loss, we go in with our factory equipment and do a pre-repair analysis to determine what the car needs to be put back to a pre-loss condition," he outlines.

"Then there's a post-repair analysis to make sure none of the systems were affected during the repair process," Bigelow continues. "For instance, if a car is put into a heated paint booth, (some ADAS) systems can only go to a certain temperature before they're affected. Or were any systems disturbed while the car was being welded on? Was the battery ever disconnected so the camera lost its calibration?

"Once repairs are made, we then calibrate the radars, the blind spot, collision mitigation, eyesight, lane departure, infrared and night vision systems. An average calibration is two hours, and they can go up to four hours. Between the ADAS calibrations and the collision analytics, in one month we did 132 vehicles."

The name change also heralded a push to build awareness. "We have customers who have brand new cars with ADAS problems," notes Bigelow. "Unfortunately, what happens is they turn these systems off because their dash will beep or buzz, which becomes very annoying. I have vehicles with 50 miles, 100 miles on them involved in heavy collisions, heavy losses, and the ADAS were never given the opportunity to do what they were designed to do.

"In many cases it's as simple as someone placing a bumper sticker over a blind spot module. So we're trying to educate customers that ADAS does work. While we're still quite a ways from the fully autonomous vehicle, the manufacturers need these consumers to make this work."

They've certainly got their work cut out for them, although Bigelow contends "that this is ultimately what we've always done. As cars became more advanced, so did we. We've always made our living staying five years ahead of the curve. The motto that's painted on all of the shop walls and printed on our shirts is 'continued education in the pursuit of excellence.' And we hold true to that today." MA

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.
rbravender@comcast.net

LAUNCH TECH USA

SCAN OUR LAUNCHTECH QR CODE

INTRODUCING THE THROTTLE & ADD-ON TRUCK MODULE

THROTTLE WORKS WITH HD ADD-ON MODULE

Each item sold separately

ULTIMATE POWER! MAXIMUM PERFORMANCE!

X-431 Throttle is the newly developed high-end comprehensive diagnostic equipment with charging base based on the Android 7.1 system, supports dual 5GHZ WIFI communication, has a wide coverage of models, strong diagnostic capabilities, accurate detection data and other characteristics.

HD ADD-ON TRUCK MODULE

Available for purchase for Full Heavy Duty Coverage. Works with Throttle to expand the diagnosis coverage for HD truck vehicles. The Launch Heavy Duty Truck Add-On Module is perfect for a shop that works on both heavy-duty (Class 4 through 8) and medium-duty trucks. This add-on Module turns existing Pro line tools, into full function Heavy Duty Truck Scan Tools.

Find us on Social Media

PRODUCT FEATURES

- Easy to use Interface
- Military Tough Design
- Android 7.1 Processor
- Dual Band WIFI
- 2 hour Quick Charge Tech
- Bluetooth Technology
- 13 MP Rear Camera
- OBD 1 Kit Included

LAUNCH 1820 S. Milliken Ave. Ontario, CA 91761 1-877-528-6249 www.launchtechusa.com

Registration is now open for MACS 2020 event, tradeshow

GAIN ACCESS TO MOBILE A/C AND ENGINE COOLING SERVICE AND INFORMATION

MOTOR AGE WIRE REPORTS //

Registration is now open for ACcess, the MACS 40th anniversary Training Event and Trade Show to be held February 19-22, 2020 at the Gaylord Opryland Resort and Convention Center in Nashville, Tenn.

Attendees will gain ACcess to mobile A/C and engine cooling service and repair information needed to make accurate diagnoses and reliable repairs, while attending training sessions with the experts in the field for in-depth A/C training for passenger car and light truck, HD truck and off-road vehicles. They will also enjoy ACcess to network with other mobile A/C professionals. In addition to 35 hours of blockbuster training classes with 36 of the industry's top trainers, the MACS 2020 Training Event includes a trade show featuring the designers and manufactures of A/C systems, components, tools and equipment. A golf tournament at Gaylord Springs and multiple networking opportunities in entertaining social settings like Nashville's Wildhorse Saloon round out the event.

NASCAR driver David Starr will be the keynote speaker at the 2020 Training Event keynote luncheon sponsored by MAHLE Service Solutions. Competitive, determined and passionate with over 20 years of racing experience under his belt, Starr has proven himself as one of the top racers in the United States.

Starting out at his local Houston dirt tracks, Starr climbed the ladder gaining championships and victories under his belt. He learned the skills and mechanics behind racing on dirt and pavement, vaulted to success, and entered the then-named NASCAR Craftsman Truck Series in 1998. Throughout a decade of racing, Starr has racked up wins in the Truck Series and competed for championships.

In 2014, Starr moved to the NASCAR Xfinity Series where he drove the No. 66 Toyota for Carl Long, as well as others such as AJ Foyt and NFL player Randy Moss. Starr currently competes full-time in the NASCAR Xfinity Series, driving the No. 52 Chevrolet Camaro for Jimmy Means Racing and part-time in the Monster Energy NASCAR Cup Series, driving the No. 51 Chevrolet Camaro ZL1 for Rick Ware Racing and the No. 97 Toyota Camry for Obaika Racing.

"David has been involved in racing since he was 14 years old and knows the business of racing inside and out. After spending time with him, we are convinced our attendees will be fascinated by a life-long driver's perspective on the sport," remarked Elvis L. Hoffpauir, MACS president and chief operating officer.

A complete list of events for the MACS 2019 Training Event and Trade Show is available on the MACS website at www.macsw.org and at this link: http://read.nxtbook.com/macs/action_magazine/2020_training_event_trade_sho/_2020_training_event_trade_sh.html

Registration for the training event can be completed at the MACS website, or by phone at 215-631-7020 x 0 or by fax at 215-631-7017. Email inquiries can be sent to info@macsw.org.

MACS Host hotel reservations for the Gaylord Opryland Resort can be made by phone at 877- 491-7397 or on the hotel page of the MACS website. The MACS hotel room rate is $199 plus tax, single or double per night. Be aware: Neither MACS nor the Gaylord Opryland Resort will ever call you to book a hotel room.

Since 1981, the Mobile Air Conditioning Society (MACS) Worldwide has been the advocate for service and repair owners, distributors, manufacturers and educators making their living in the total vehicle climate and thermal management industry.

MACS Worldwide empowers members to grow their businesses and delivers tangible member benefits through industry advocacy with government regulators and by providing accurate, unbiased training information, training products, training curriculum, and money-saving affinity member services. MACS has assisted more than 1.2 million technicians to comply with the 1990 Clean Air Act requirements for certification in refrigerant recovery and recycling to protect the environment.


TYC®
Expect More. Expect TYC.
WIRING HARNESS
Included to replace old existing, worn out vehicle harness, for better connection and power delivery.*
RESERVOIR
Secondary fuel outlet straight from the pump to quickly and reliably fill the reservoir and prevent fuel shortage and overheating.*
SENDING UNIT
Features an enhanced "fingered" contact design for maximum contact surface regardless of dirty fuel, sharp turns, or bumpy roads.*
MULTI-LAYER STRAINER
Multi- layer strainer designed to allow fuel through while holding more dirt (prevents overheating and premature failure due to clogs).*
FUEL PUMP
Increased flow rate and efficiency from enhanced internal components.*
NOVITAS FOUNDATION
International Relief • Innovation • Sustainable Development
TYC is a Proud Supporter of Novitas Foundation
Your gift can save lives, bring hope, and build a future for a world in need. Go to NovitasFoundation.org.
*Available for select applications
For more information about TYC™ replacement automotive parts, consult your local TYC™ parts distributor, or look up parts online at www.TYCUSA.com

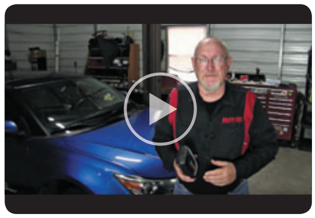
WATCH + LEARN

The fight for vehicle data access

MOTORAGE.COM/AccessToData

The value of soft skills training

MOTORAGE.COM/SoftSkills



TPMS essentials

MOTORAGE.COM/Essentials

The importance of marketing, relationship building

MOTORAGE.COM/Relationship

MECHANICAL MOMENT

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

TOYOTA RAV4 DTC P0171 FIX

VEHICLE: 2003 Toyota RAV4, 2WD, 2.0L, Automatic Transmission

MILEAGE: 220,336

PROBLEM: The vehicle came from another shop. They had installed a new Mass Airflow (MAF) sensor, but the MIL/DTC would not clear.

DETAILS: The technician pulled DTC P0171. The fuel trims verified that the fuel system was lean. The technician introduced propane into the intake manifold. The oxygen sensors and fuel trims responded correctly.

CONFIRMED REPAIR: Since the fuel management system appeared to be working correctly, the technician decided to replace the aftermarket MAF sensor with an OEM (Denso) MAF sensor. He cleared the Keep Alive Memory and performed the appropriate dive cycle to insure the repair was complete. The MIL did not come back on. Problem solved by an OEM part.

This tech tip and others come from ALLDATA Tech-Assist, a diagnostic hotline of ASE-certified Master Technicians. Learn more at: ALLDATA.com.

Not an ALLDATA customer? For access to this valuable experience-based repair data and reliable OEM information, go to: MotorAge.com/trialnow to start a free trial.

TRAINING EVENTS

NOVEMBER 5-7
AAPEX 2019
Sands Expo
Las Vegas, Nevada

DECEMBER 2-3
AUTOVATE 2019
Kimpton Van Zandt
Austin, Texas

DECEMBER 3-6
Automechanika Shanghai
National Exhibition & Convention Center
Shanghai, China

JANUARY 9-11
Mobile Tech Expo 2020
Orange County Convention Center
Orlando, Florida

FEBRUARY 19-22, 2020
MACS 2020 Training Event and Trade Show
Gaylord Opryland Resort
Nashville, Tennessee

MARCH 6-7, 2020
Vision Hi-Tech Training and Expo
Overland Park Convention Center
Overland Park, Kansas

MAY 3-6, 2020
ACPN Knowledge Exchange Conference
Hyatt Regency Seattle
Seattle, Washington

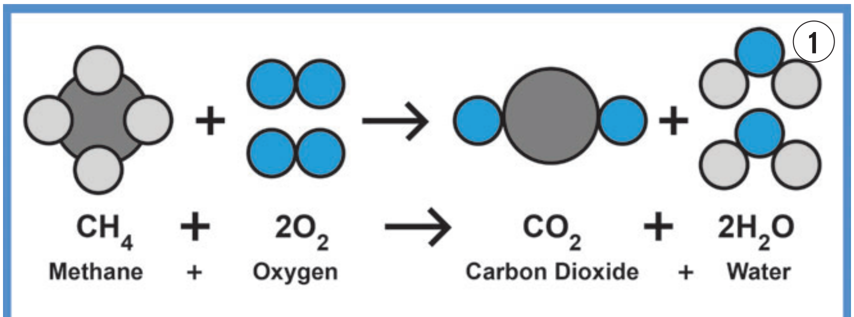
MAY 13-15, 2020
Auto Care Association Spring Leadership Days
Denver, Colorado

ADVANCED DIAGNOSTICS USING THE FIVE GAS ANALYZER

THERE'S MUCH TO LEARN BY SAMPLING WHAT EXITS THE TAILPIPE!

BERNIE THOMPSON //
Contributing Editor

The internal combustion engine has been around for more than 200 years. In this time, there have been many changes to the engine, the fuel and the automobile. We attribute the modern engine to Nikolaus Otto. Nikolaus was a German engineer who developed the compression charge internal combustion engine that ran on liquid petroleum gas. Nikolaus' engineering marvel is still used to power the modern vehicle.



A stoichiometric diagram of the combustion reaction of methane

First, some theory

The fuel stock and the internal combustion engine have undergone some changes in the past years, but the basics are still the same. The fuel stock that we will cover is a liquid petroleum product that we refer to as gasoline. Modern gasoline is a mixture of different chemical components with varying vapor points and varying auto-ignition temperatures. Basically, when these components are mixed together and form gasoline, they have an approximate flash point of -45°F and an approximate auto-ignition point of 536°F.

It will be necessary to understand that liquid gasoline cannot burn in this state (liquids do not burn). In order to burn gasoline it must be heated so that it makes a phase transition and turns into a vapor (vapors can be burned). The compression within the cylinder accomplishes the heating of the fuel. When air is compressed rapidly, the molecules are accelerated off of the moving piston where they hit one another. The kinetic energy from the piston is turned into thermal energy in the air charge. This occurs from the atoms hitting one another, which in turn starts the atoms vibrating, causing a heating effect. This process is called Adiabatic Compression. The Adiabatic processes are characterized by zero heat transfer with the surroundings, such as the piston, cylinder and cylinder head. In the case of rapid compression, the process occurs too quickly for any heat transfer to occur to these components. Heat transfer is a slow process. This rapid compression of the air creates a rapid heat increase within the air charge. Thus, this heat increase is put into the fuel that is suspended within the air. When this air/fuel charge is heated, it turns the fuel into a vapor that can be burned.

Now that the fuel is in a vapor format and is ready to burn, a spark takes place across the sparkplug electrode. The spark ionizes the spark plug electrodes, producing a state of plasma that takes the fuel well past the auto-ignition temperature of the fuel, setting up the ignition phase of the fuel. This is where the temperature in a localized area around the sparkplug starts to burn. The next stage is the combustion phase. This is where the charge changes from chemical energy to thermal energy. The heat released is then driven into the next layer of the charge, thus igniting it. This

PHOTOS: BERNIE THOMPSON


IT'S GOOD TO BE
GENUINE

is referred to as deflagration. Deflagration is the combustion that propagates at subsonic speeds through the gas that is driven by the transfer of heat. This heat transfer heats the working fluid (nitrogen), which in turn puts pressure on the piston, thus pushing the piston down the cylinder.

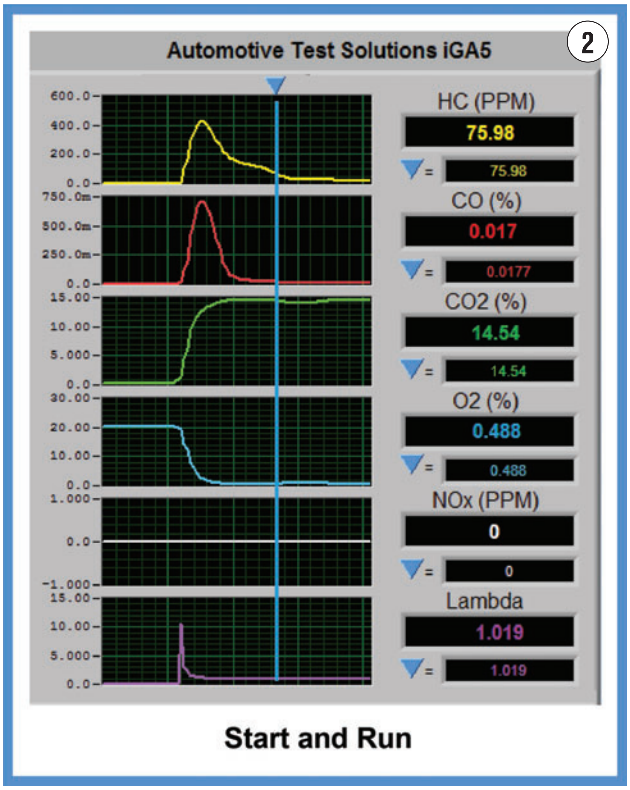
Stoichiometry

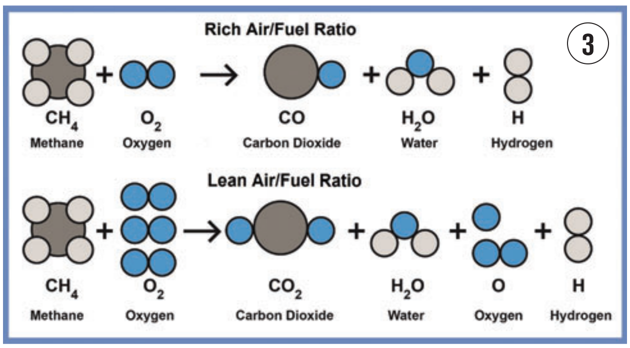
In the spark ignition method, the charge prior to ignition is that of a homogenous charge. This means that the air/fuel charge is evenly mixed throughout the cylinder volume. In order to completely burn an evenly distributed mixture within the cylinder, the air/fuel ratio must be very close to that of stoichiometry. Stoichiometry refers to the weights of the chemicals that will react. In an internal combustion engine the fuel is the reactant and the air is the oxidant. Air is comprised of approximately 78.09 percent nitrogen, which is used as the working fluid, and 20.95 percent oxygen, which is used as the oxidant. The reaction will occur between the fuel, which is hydrocarbon based, and the oxidant, which is the oxygen. 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, will no longer 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 (see **Figure 1**.) The chemical weight will be the same, but the new chemicals formed during a complete reaction will be water and carbon dioxide. Although the mixture is at a stoichiometric ratio, in the real world a complete reaction between all of the chemicals does not occur so there will always be some hydrocarbons and oxygen left after the combustion process. This is due to the flame front being unable to get into the crevasses around the spark plug, valve pockets, and piston rings.

If the cylinder compression is present, the fuel was vaporized, the air/fuel ratio was that of stoichiometric, the cylinder was homogeneous and the spark occurred correctly, the vast majority of fuel and air will react with one another. When this occurs the tailpipe gas charge will have high CO_2 (> 14 percent), low O_2 (< 1 percent), low CO (< 1 percent), and low HC [< 100 Parts Per Million (PPM)], as seen in **Figure 2.**

Analyzing that comes out

Figure 2 also shows an engine with no problems on start and run. Since the hydrocarbons react with the oxygen, the hydrocarbon level will drop, the oxygen level will start at atmospheric condition at about 21 percent and drop sharply, the carbon dioxide will rise sharply and the carbon monoxide will drop as well. At this point the catalyst (catalytic converter) is not hot enough to further the reaction of the fuel. There will be more on this later.





Carbon monoxide forms when the air/fuel mixture does not have enough oxygen to fully oxidize the carbon. The chemical reaction will always drive to that of carbon dioxide. Note the difference is that carbon dioxide has one carbon atom and two oxygen atoms, where carbon monoxide has one carbon atom and one oxygen atom. If there is oxygen present around the carbon during the combustion process, then two oxygen atoms will always stay together and will bond to a single carbon atom. Thus, when CO levels rise this is usually created by a rich condition as seen in **Figure 3**. CO and pico Technology

Introducing the new

PicoScope® 4823

8-channel diagnostic oscilloscope

More channels. More potential.

- Take multiple measurements simultaneously
- Fast enough for CAN, CAN FD and FlexRay
- Access to 150 guided tests and the waveform library

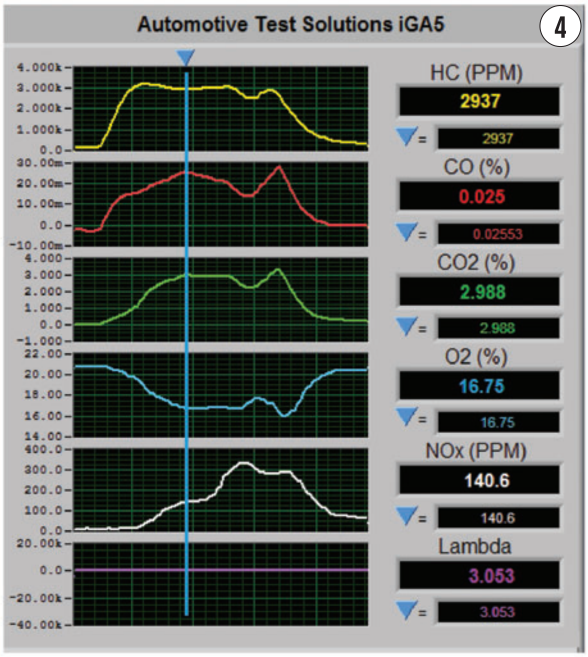
Find out more at:

www.picoauto.com/A407

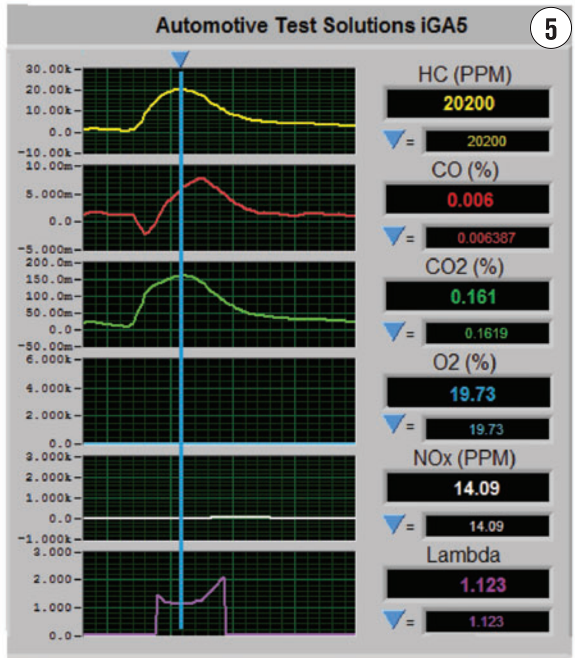
Email: sales@picoauto.com. Errors and omissions excepted.
Please contact Pico Technology for the latest prices before ordering.

YouTube

Visit our YouTube channel to watch guided test videos and more!
Search for **PicoScope Automotive**



No Start No Fuel



No Start No Spark

CO_2 are very good combustion indicators; CO is produced by incomplete combustion, whereas CO_2 is produced by complete combustion. Therefore, the presence of high CO_2 gases of 14 percent to 16 percent represents good combustion has occurred within the cylinders.

A rich mixture condition is one that has more hydrocarbons than oxygen. When this occurs there is not enough oxygen to oxidize the carbon and hydrocarbons. Thus, there are extra hydrocarbons left after the reaction and each carbon only has one oxygen atom bound to it making carbon monoxide, as seen in **Figure 3**.

A lean mixture condition is one that has more oxygen than hydrocarbons. When this occurs, there is not enough hydrocarbons for the amount of oxygen atoms, so the reaction leaves additional oxygen atoms as well as extra hydrogen, as seen in **Figure 3**. One may ask: why did the additional oxygen not oxidize the hydrogen during the reaction? This is due to the air/fuel charge not being that of a stoichiometric ratio. In this condition the air/fuel charge has too much space between the hydrocarbons. Therefore, as the flame front starts to propagate across the combustion chamber, these large areas between the hydrocarbons create impedance to the flame front movement. This in turn slows the flame front allowing only a partial burn of the gasoline. This will leave oxygen, hydrocarbons and hydrogen.

In order to have complete combustion in a spark ignition gasoline based engine, the air/fuel charge must be that of a homogeneous charge. A substance is homogeneous if its composition is identical wherever you sample it. This means that the charge mixture (air and fuel) has a uniform composition throughout the cylinder. Additionally, the air/fuel charge must be that of a stoichiometric ratio.

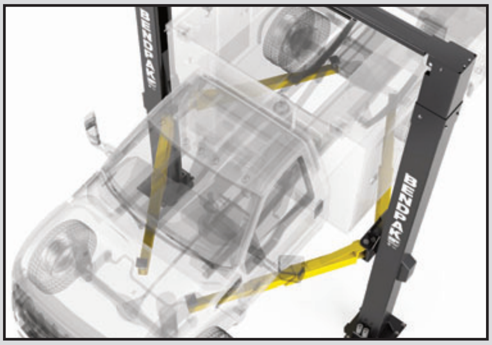
A stoichiometric ratio, as discussed above, is where the two reactants that started the reaction are no longer present at the end of the reaction. Different chemicals will have different chemical weights, so these chemical weights will change the stoichiometric ratio. For example, methanol has a stoichiometric ratio of 6.45:1. Ethanol has a stoichiometric ratio of 9:1, whereas gasoline, being comprised of various chemical components, has a stoichiometric ratio of 14.5:1 to 14.7:1. If ethanol is blended with the gasoline, the stoichiometric ratio will drop depending on how much ethanol is used in the blend.

Lambda and NOx

A reading given for stoichiometry on a gas analyzer is that of Lambda. Lambda is a calculation that is based on all of the gas traces that are read by the exhaust gas analyzer. This equation takes the gases that are coming out the tailpipe and calculates the amount of oxygen and fuel that went in. Make no mistake — what goes in must come out. The weight of the atoms does not change. The molecules are structured differently after the combustion process; however, the weight is the same. By taking the exhaust gas weights one can calculate what gases went in. It is extremely important that there are no exhaust leaks in the

D PRODUCTIVITY,

DISTANCE.



- 12,000-lb. lifting capacity
- Dual direct-drive hydraulic cylinders
- Oversized 53” tall carriage for superior strength and durability

*Always read and follow all safety warnings that accompanied your lifting equipment at the time of purchase. More information regarding vehicle lift safety is available directly from BendPak or from the Automotive Lift Institute.

exhaust system. This allows oxygen to enter into the exhaust system; however, this oxygen was not part of the combustion gases. This false oxygen will move the Lambda equation to the lean side when it is not really lean. If there is an exhaust leak, Lambda cannot be used.

A Lambda reading of 1.0 is that of a stoichiometric ratio. A Lambda greater than 1 indicates a lean condition. So a Lambda of 1.2 indicates the air/fuel ratio is 20 percent lean of a stoichiometric ratio. A Lambda less than one indicates a rich condition. So a Lambda of .8 indicates the air/fuel ratio is 20 percent rich of a stoichiometric ratio.

Nitrogen Oxide (NOx) is a gas that is produced during the combustion process. This is where oxygen bonds to nitrogen. These chemicals do not want to bond with one another, so they will stay separated until they are force together. This force will be provided by temperatures greater than 2500°F during the combustion event or extreme pressure conditions during the combustion event.

Applying to drivability

Now that we have set the parameters to combust a gasoline-based fuel stock in the cylinder, let's analyze some data from different engine problems. The first engine problem is a no start condition as seen in **Figure 4**. The blue cursor at the top of the graph marks the position that all of the gases are measured at. The gases are then read as a digital number on the right-hand side of the graph next to the specific gas trace, such as HC, CO, CO_2, O_2, NOx, and the calculation of Lambda. We will discuss what the gas traces indicate and what is happening within the engine. First, we will take note that the HC is reading 2937 PPM, the CO is reading .025, the CO_2 is reading 2.98 percent, the oxygen is reading 16.75 percent, the NOx is reading 140.6 PPM, and the Lambda is at 3.05 percent.

The HC at 2937 PPM seems like a lot, but, when taken with the other gas data, really is not. Since there is CO_2 present at 2.98 percent and the oxygen fell from 21 percent to 16.75 percent, we know that some of the hydrocarbons reacted with oxygen. This would indicate that fuel and oxygen are in the cylinder and a spark has occurred. Since the engine is cold, the spark is present due to the CO_2 reading of 2.98 percent. If there was no spark present, then the reaction could not occur; therefore, there would not be any production of CO_2 gas. The CO is also very low at .025 percent. This indicates that there is more than enough oxygen in the cylinder for the combustion process. The NOx gas at 140.6 PPM also indicates that there was some combustion within the cylinder. The key here is the Lambda reading of 3.05 percent. This indicates that the air/fuel ratio is three times too lean. With a lean air/fuel ratio, the flame front is impeded and cannot propagate through the cylinder. So the spark starts the ignition event and creates enough heat for the point of ignition. This then starts the combustion event; however, the combustion event starts but is stopped due to the lean air/fuel ratio. This engine has a lack of gasoline causing the no start problem. This vehicle's problem was a bad fuel pump.

Now let's analyze **Figure 5**. This is also a no start condition. We will discuss what the gas traces indicate and what is happening within the engine. First, we will take note that the HC is reading 20200 PPM, the CO is reading .006 percent the CO_2 is reading .1619 percent, the oxygen is reading 19.73 percent, the NOx is reading 14.09 PPM, and the Lambda is at 1.14 percent.

The HC reading of 20200 PPM is the correct amount of gasoline to combust within the cylinder. The CO at .006 percent also shows there is not a lack of oxygen within the cylinder. The CO_2 at .1619 indicates that there is no, or very little, reaction between the hydrocarbons and the oxygen. The oxygen at 19.73 confirms no, or very little, reaction took place. The Lambda at 1.14 percent indicates that the air fuel ratio is 14 percent lean of stoichiometric. However, this is a combustible air/fuel mixture. The lack of a reaction is not based on the air/fuel ratio, but on the spark. If there is no spark event to bring

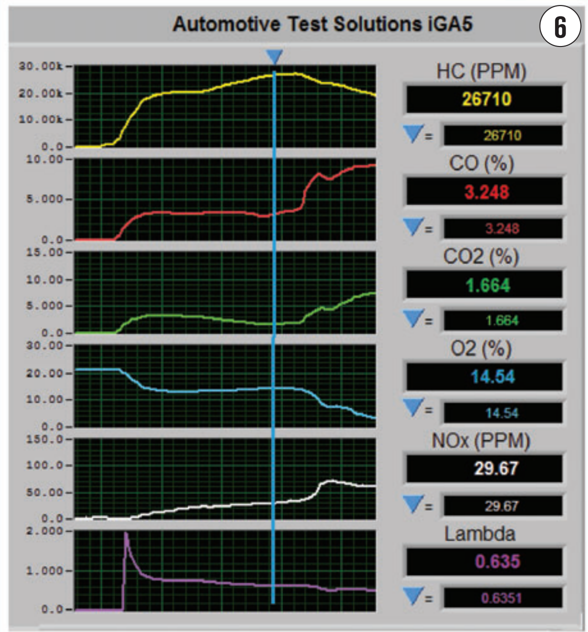
the temperature above the auto-ignition point of the gasoline, there will be no reaction between the hydrocarbons (fuel) and the oxidant (oxygen). It is important to understand that if the engine is hot and compression took place, then some of the hydrocarbons can react with some of the oxygen without a spark present. However, this will still represent a small amount of CO_2. If combustion is established, the CO_2 will rise sharply. This vehicle's problem was a bad ignition coil, causing a no spark condition.

Next, let's analyze **Figure 6**. This is a long hard start condition. We will discuss what the gas traces indicate and what is happening within the engine. First, we will take note that the HC is reading 26710 PPM, the CO is reading 3.24 percent, the CO_2 is reading 1.164 percent, the oxygen is reading 14.54 percent, the NOx is reading 29.67 PPM, and the Lambda is at .63 percent.

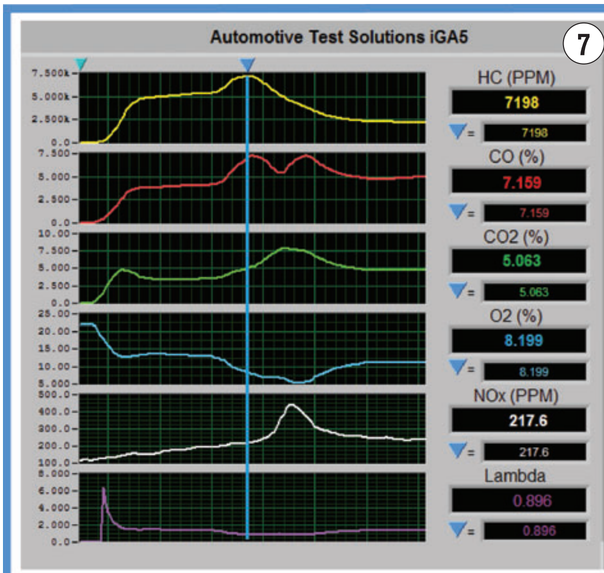
The HC reading of 26710 PPM indicates there is sufficient gasoline within the cylinder. The CO at 3.24 percent indicates that there is a lack of oxygen in the cylinder for the amount of hydrocarbons; additionally, a spark has started a reaction to occur. The CO_2 at 1.64 percent indicates that a reaction occurred but was incomplete. The oxygen starting at 21 percent and dropping to 14.54 percent indicates a reaction took place with the carbon producing high CO gas traces and low CO_2 gas traces. The NOx at 29.67 indicates that combustion occurred. The Lambda at .63 indicates the air/fuel mixture is 37 percent rich of stoichiometric. The air/fuel mixture at the beginning of the starting process is too rich for the starting conditions of the engine. Thus, a long hard start condition is present. This vehicle's problem was a misreading Engine Coolant Temperature (ECT) sensor, which allowed the cold start enrichment to be active, thus creating a rich start condition.

On to **Figure 7**. This is a hard start condition with poor engine running. We will discuss what the gas traces indicate and what is happening within the engine. First, we will take note that the HC is reading 7198 PPM, the CO is reading 7.159 percent, the CO_2 is reading 5.063 percent, the oxygen is reading 8.199 percent the NOx is reading 217.6 PPM, and the Lambda is at .89 percent .

The HC reading of 7163 PPM indicates that the hydrocarbons are not burning completely. The CO at 7.159 percent indicates a poor combustion process, but indicates that a spark event occurred. The CO_2 at 5.063 percent confirms poor combustion of the gasoline. The oxygen starting at 21 percent and falling to only 8.199 percent shows that the combustion event happened but is incomplete. There are leftover hydrocarbons and leftover oxygen that should have been combusted in the reaction. The NOx is at 217.6, showing a reaction occurred. The Lambda at .89 percent is 11 percent rich of stoichiometric. However, this should be a combustible mixture that is just slightly



Hard Start Rich Condition



Poor Start and Run, Timing off

rich. This is caused by either a weak spark or the ignition timing is off. This vehicle's problem is a late ignition timing event.

I'm going to walk you through **Figures 8 and 9**, though to see them, you need to go to MotorAge.com/5gas. **Figure 8** is a rough running idle condition. We will discuss what the gas traces indicate and what is happening within the engine. First, we will take note that the HC is reading 1663 PPM, the CO is reading 2.27 percent, the CO_2 is reading 12.52 percent, the oxygen is reading 2.71 percent, the NOx is reading 13.2

PPM, and the Lambda is at .99 percent.

The HC reading of 1663 PPM indicates that the hydrocarbons are not burning correctly. The CO at 2.27 percent indicates that there is poor combustion within the cylinders, but a spark event did occur. The CO_2 at 12.53 is a little low, indicating that the combustion is poor. The oxygen at 2.71 percent is a little high, indicating that the combustion event is incomplete. The NOx is quite low at 13.2 PPM. The Lambda is .99 percent, indicating that the engine is running at a stoichiometric ratio. Since the air/fuel ratio is correct at a Lambda of 1, the air/fuel charge is definitely combustible. However, the combustion event is incomplete. Additionally, just off idle the combustion gases are good. So the problem occurs just at idle. This vehicle's problem is the Exhaust Gas Recirculation (EGR) valve is intermediately sticking open at cruise and when it returns to idle, dilutes the air/fuel charge. This puts too much space between the hydrocarbons creating an impediment to the flame front and, thus, incomplete combustion.

Now let's analyze **Figure 9**, a vehicle with a DTC P0420 (Catalytic Converter Efficiency). We will discuss what the gas traces indicate and what is happening within the engine. First, we will take note that the HC is reading 166 PPM, the CO is reading 1.26 percent, the CO_2 is reading 13.81 percent, the oxygen is reading .426 percent, the NOx is reading 1183 PPM, and the Lambda is at .979 percent.

The HC reading of 166 PPM indicates that the hydrocarbons are slightly high. The CO at 2.27 percent indicates that there is poor combustion within the cylinders, but a spark event did occur. The CO_2 at 13.81 is a little low, indicating that the combustion is incomplete. The oxygen at 2.71 percent is slightly high, indicating that the combustion event is not complete. The NOx is quite high at 1183 PPM. The Lambda is .979 percent, indicating that the engine is running 2 percent rich of a stoichiometric. Since the air/fuel ratio is correct at a Lambda of close to 1, the air/fuel charge is definitely combustible; however, the combustion event seems incomplete. This exhaust gas data was taken while driving under load. These exhaust gas traces are correct for the condition that they were under. The problem is that the catalytic converter is not functioning properly and can no longer react the exhaust gases, further combusting these gases.

The catalytic converter is a device that further combusts the exhaust gases through catalysis. This is where heated metals drive a chemical reaction to a different chemical species. All metals will drive catalysis, but the chemical species at the end will vary depending on which metal was used. Automotive three-way catalytic converters use platinum, palladium and rhodium. These rare earth metals are used because they drive the catalysis to a desired chemical species. These metals will need to be hotter than 700°F in order to function correctly. This means on cold start the catalytic converter is not working for the first 20 seconds to one minute. Once the catalytic converter has obtained operational temperature it will further combust the exhaust gas through catalysis. So any exhaust gas analysis must take this into account. For example, if the engine is misfiring, one would expect to see incomplete combustion gases at the tailpipe, such as high HC readings with high oxygen readings. However, the modern catalytic converter, when at operating temperature, can continue to combust the gases where there are no signs of incomplete combustion.

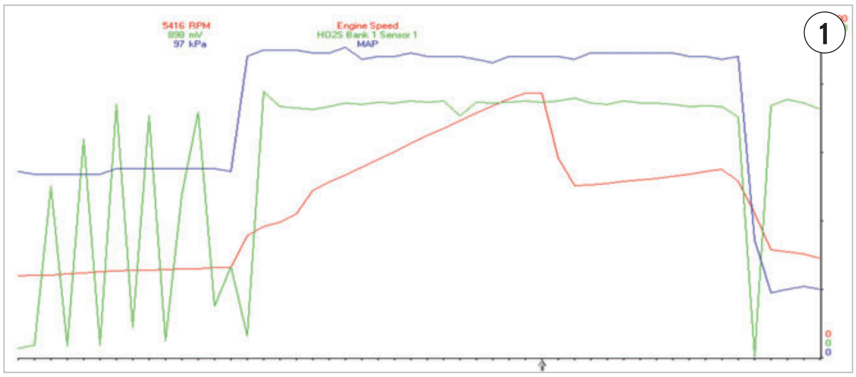
It is clear that the exhaust gases can be used for advanced engine diagnostics. We have seen just a few examples here. You can use these gases to do far more than what has been presented in this article. With a little knowledge and practice, you will be diagnosing engine problems that used to take hours, in just minutes.

BERNIE THOMPSON is an automotive diagnostician and trainer, and co-founder of Automotive Test Solutions in Albuquerque, N.M. He is an expert at diagnostics and repair strategy and designs award-winning diagnostic tools and software for the automotive industry.
sales@automotivetestsolutions.com

TROUBLESHOOTING EXHAUST RESTRICTIONS

ANY AIR THE ENGINE TAKES IN HAS TO GET BACK OUT AGAIN. HERE'S HOW TO MAKE SURE THE PATH OUT OF THE PIPE IS "ALL CLEAR!"

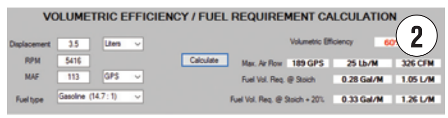
SCOTT SHOTTON // Contributing Editor



A few years back, I had a customer who parked their car in a barn for almost a year. This particular customer stored his vehicle because he was deployed to Afghanistan with the U.S. Army. Being an Army veteran myself, I felt the need to help this individual out. The Ford Focus that I had to deal with exhibited a crank no-start condition. It is not uncommon for a vehicle stored in a barn — for those of us who are used to rodent damage — to exhibit the complaint of chewed wires. Some initial checks were made including checking DTCs and a quick visual inspection. No obvious faults, including nesting material or damaged wires, were found. After pumping the last few gallons of old gasoline out of the fuel tank and adding some fresh gasoline, the engine started to sound like it was trying to fire. After some additional cranking and exercising the throttle, a weird "pop" was heard, and the engine roared to life. However, it still did not have the most desirable acceleration even in the shop. I found out what the "pop" was when I walked around the back of the vehicle and saw a shotgun blast of four or five mouse carcasses scattered about three feet behind the tail pipe. Who knows how many more mice, nesting material, feces and food stash still remained in the muffler? I really didn't want to run the vehicle for too long and smell what was left cooking in there. My guess is that would have been an unpleasant odor that might not leave the shop for a week. The decision was made to replace the muffler, which was quite heavy, by the way, and the car ran fine.

The Focus did not have a typical exhaust restriction. The most common cause of a restricted exhaust is a failed catalytic converter. However, the testing techniques covered in this article will identify the issue regardless of what the restriction is. In most exhaust restriction cases, the vehicle will still run but exhibit low power complaints, and if the restriction becomes bad enough, the vehicle may also exhibit misfires.

In order to diagnose a restricted exhaust, I follow a logical process that consists of basically two steps. The first step is to perform a test drive while recording some data for analysis. If a restriction is suspected, the second step is to confirm the restriction using one of a few possible physical testing methods. Let us attack these two steps individually.



The test drive

Before performing any intrusive testing, a scan tool (preferably one with good graphing capabilities) is connected and the vehicle is taken for a test drive that includes some normal driving and a wide-open-throttle portion. A handful of data PIDs are chosen and recorded. These PIDs include: RPM, MAF, O_2 sensors, short-term fuel trim and long-term fuel trim. If you are familiar with how the particular vehicle displays its Load PID, then it can be used as well. Upon return to the shop, the data that was recorded can now be analyzed.

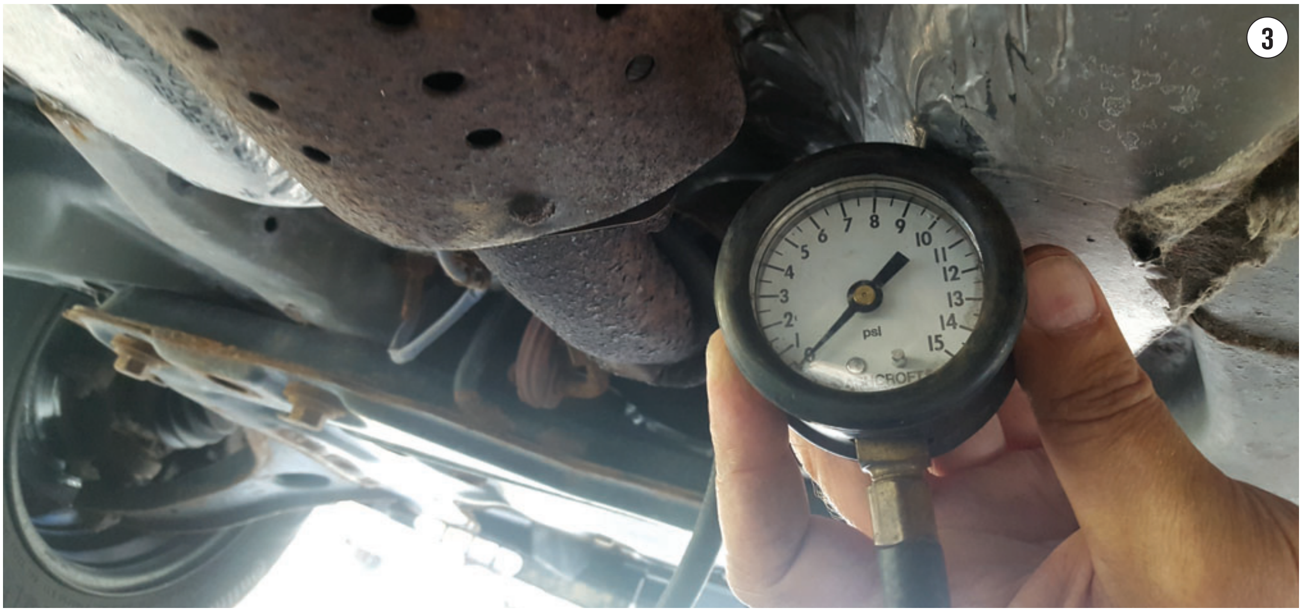
The first thing to check is the volumetric efficiency, or VE, of the engine. This is basically a measure of how well

PHOTOS: SCOTT SHOTTON


Expect More. Expect TYC.
TYC®
CHILLING AFTER A JOB WELL DONE
TYC's Transmission Oil Coolers and Charge Air Coolers are designed to be application-specific (non-universal) for drop-in fit
Designed, engineered, and manufactured to meet or exceed OE specifications
Consistently having the latest applications available for your repair needs
Transmission Oil Cooler
Charge Air Cooler
NOVITAS FOUNDATION
International Relief • Innovation • Sustainable Development
TYC is a Proud Supporter of Novitas Foundation
Your gift can save lives, bring hope, and build a future for a world in need. Go to NovitasFoundation.org.
For more information about TYC™ replacement automotive parts, consult your local TYC™ parts distributor or look up parts online at www.TYCUSA.com

an engine can breathe. This topic has been covered in previous *Motor Age* articles, but can be summarized as follows: MAF and RPM are noted near the peak of the wide-open-throttle portion of the test drive. These two numbers are entered into a VE calculator, along with engine displacement, and a VE number is calculated. For naturally aspirated applications, we would expect somewhere around 80 percent or higher if the engine can breathe efficiently. A VE number in this range indicates that the exhaust is not restricted because the engine can effectively "exhale." On the other hand, if our VE is low, then more of the recorded data PIDs need to be observed. Note: This is also where a LOAD PID can be used if you know what is known good for the vehicle being tested. If you don't know what a good LOAD number is for the specific vehicle, the VE will still work the same for almost all naturally aspirated applications equipped with an MAF sensor.

Next, provided we have a low VE number, the oxygen sensors are observed during the wide-open-throttle portion of the drive. With a restricted exhaust, the oxygen sensors go rich



3C Intelligent Induction Cleaner™

Patent Pending

Pictures below show a 1.6L Turbo Mini Cooper at 83,000 miles that was cleaned in just 17 minutes.


Before Cleaning


After Cleaning

Heavy Carbon GUARANTEED Deposits Removed

When major chemical companies products were tested* on GDI engines; one stood above all others

3C Intelligent Induction cleaner

was the clear winner!

Not only was the cleaning time much shorter but the 3C clearly provided superior cleaning results; cleaning down to the metal in most cases.

*Testing completed by third party

All of our chemistries have a low HMIS health rating of 2. None of our chemicals are on the California Proposition 65 list.

ATS | AUTOMOTIVE Test Solutions

Proud to be a U.S. based company

automotivetestsolutions.com 800.572.6112

Available at AE TOOLS &COMPUTERS, NAPA AUTO PARTS, WORLDPAC Wholesale Distributor of Original Equipment Automotive Parts, CARQUEST when the vehicle is floored. The amount of air flowing through the engine is less than it should be, but is still being measured accurately. The PCM is still injecting the appropriate amount of fuel for the given air mass measurement, and the oxygen sensors report accordingly — rich. If the oxygen sensors report a very lean condition, then the fault is most likely not a restricted exhaust. In that case, we would suspect another culprit such as an MAF sensor or other air metering fault.

Figure 1 is a scan data recording of a 3.5 liter General Motors vehicle that exhibits low power due to a restricted exhaust. Engine RPM (red) is shown so we can see where the wide-open-throttle acceleration occurred. The oxygen sensor (green) does in fact go rich under load. **Figure 2** shows a VE calculation, from the same test drive, of 60 percent, which indicates the engine cannot breathe.

Finally, as a bonus, fuel trim numbers are observed when the vehicle is operating in closed loop. Exhaust restrictions have little effect on fuel trim numbers unless there are two banks with two catalytic converters. In that case, if one converter was restricted, the fuel trim numbers from bank to bank will move in opposite directions from one another. If the low power complaint were to be caused by a failed MAF sensor, or weak fuel delivery, then our trim numbers would climb higher and higher into the positive range. In the previous example, fuel trim numbers were slightly negative but still within an acceptable range.

To summarize the data analysis: if the VE measurement is low, the oxygen sensors display rich and fuel trim numbers are not ridiculously positive, then a restricted exhaust is suspect. Once we have analyzed the data, and our conclusions strongly suggest a restricted exhaust, it's time to get dirty and confirm our hypothesis.

Physical testing

There are quite a few methods used to test for exhaust restrictions. Some are better than others. They will be covered one by one.

Drop the exhaust and drive the car

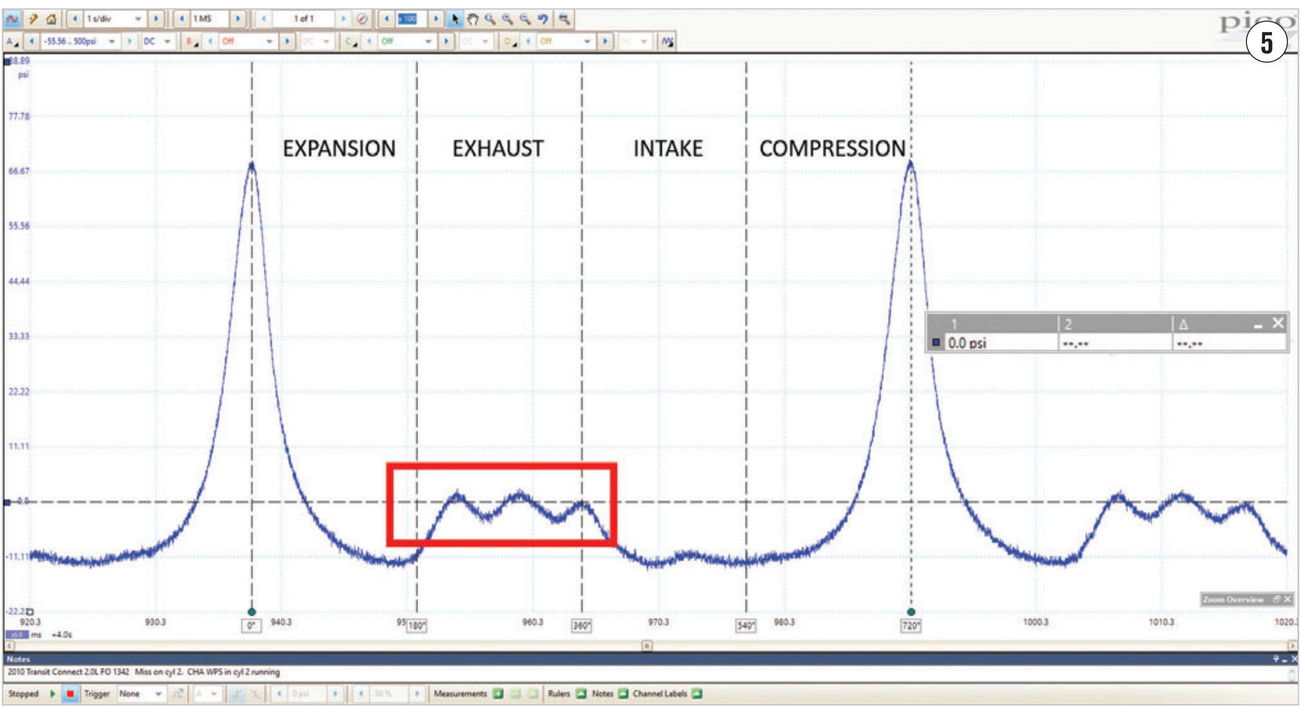
This method to me is pretty "shade tree" to say it politely. It involves disconnecting the exhaust before the catalytic converter and test driving the vehicle again to see if power returns. Although this technique is somewhat effective, it can be labor intensive and will definitely be very loud during the drive. I think there are better options.

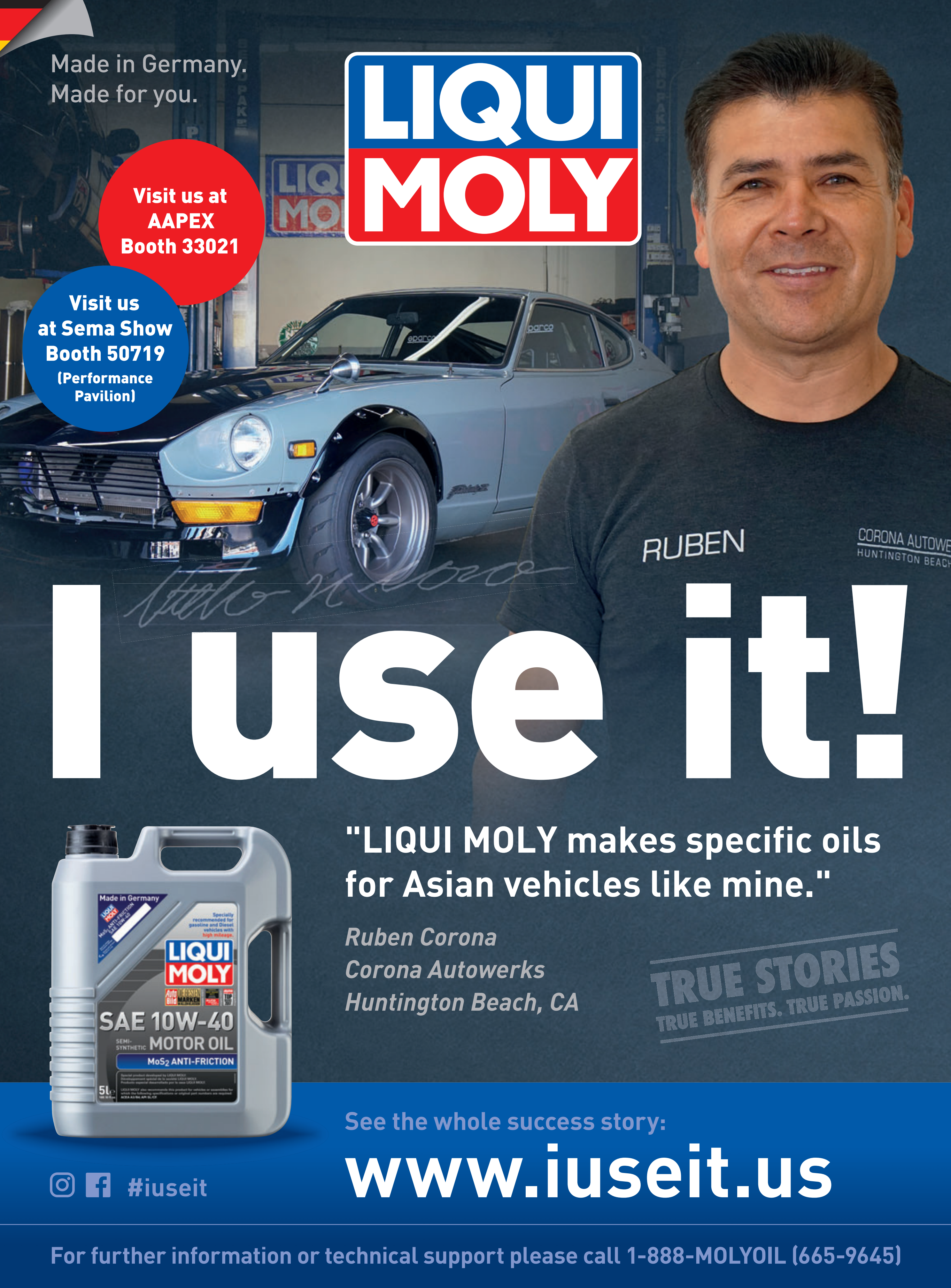
Vacuum testing method

This method involves connecting a vacuum gauge to the intake manifold and revving the engine up while observing the gauge. I believe this test is flawed because an exhaust would have to be extremely restricted to see any discernable change in manifold vacuum. Again, I feel there are better — and more accurate — methods of proving our hypothesis.

Backpressure at the O_2

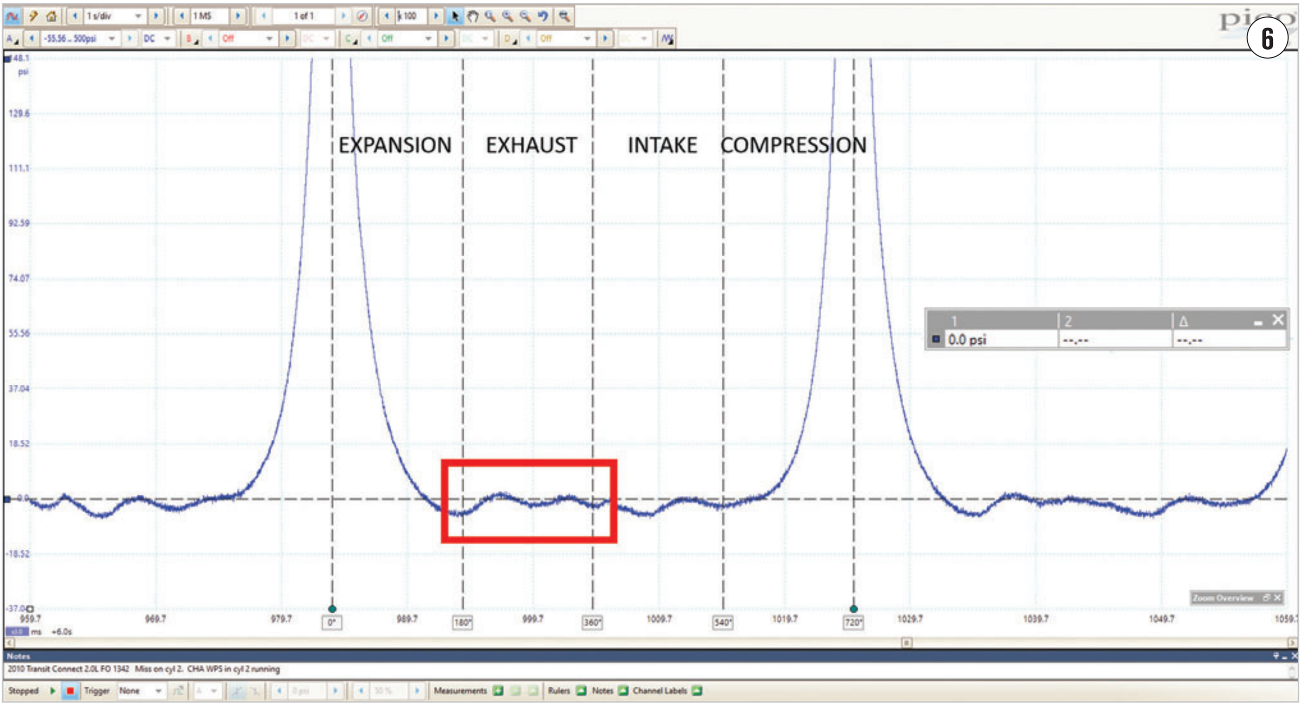
This technique is the most common test that has been used by technicians for many years. It requires either a

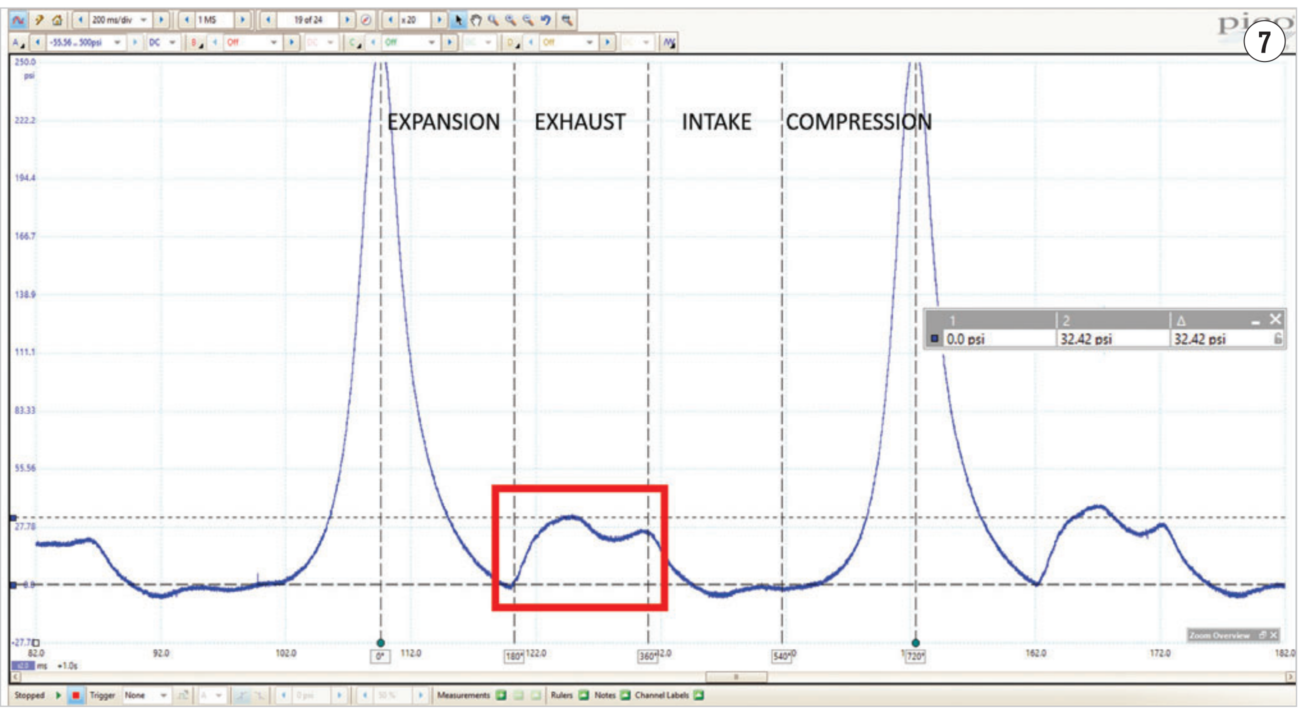



Made in Germany.
Made for you.
LIQUI MOLY
Visit us at AAPEX Booth 33021
Visit us at Sema Show Booth 50719 (Performance Pavilion)
RUBEN
CORONA AUTOWE
HUNTINGTON BEACH
I use it!
"LIQUI MOLY makes specific oils for Asian vehicles like mine."
Ruben Corona
Corona Autowerks
Huntington Beach, CA
TRUE STORIES
TRUE BENEFITS. TRUE PASSION.
Made in Germany
LIQUI MOLY
SAE 10W-40
SEMI-SYNTHETIC MOTOR OIL
MoS2 ANTI-FRICTION
5l
See the whole success story:
www.iuseit.us
#iuseit
For further information or technical support please call 1-888-MOLYOIL (665-9645)

dedicated backpressure tester or some creative connections with tooling you may already have. This creative tooling includes a compression gauge hose and a standard vacuum pressure gauge. If present, the Schrader valve should be removed from the compression hose, and the gauge can be connected to the end of the hose with a piece of vacuum line or similar tubing. Essentially, you are building your own backpressure gauge.

The backpressure tester, dedicated (**Figure 3**) or homemade, is designed to be screwed into the oxygen sensor mounting bung just before the converter. The vehicle is started and the throttle is snapped. A good vehicle should have little or no backpressure, which indicates that the exhaust is freely exiting the engine and exhaust






Expect More. Expect TYC.
TYC®
THE PERFECT FIT FOR YOUR WINDOW
Unitized window regulator assembly for ease of replacement, faster cycle time and longevity with all new components
100% door tested to ensure perfect fit, form and function
Non-universal motors that are designed to the specification of their OE counterpart to ensure similar performance
WINDOW REGULATORS
NOVITAS FOUNDATION
International Relief • Innovation • Sustainable Development
TYC is a Proud Supporter of Novitas Foundation
Your gift can save lives, bring hope, and build a future for a world in need. Go to NovitasFoundation.org.
For more information about TYC™ replacement automotive parts, consult your local TYC™ parts distributor or look up parts online at www.TYCUSA.com

system. If the backpressure gauge spikes 4 psi…10 psi…or sometimes even worse, then an exhaust restriction is present.

There are some problems with this test. First, access to oxygen sensors on some vehicles can be very difficult and time consuming. Second, if you live in an area that is prone to rust, removing the sensor can be even more difficult and can result in thread damage of the mounting bung, oxygen sensor or both. Again, more time consumption.

However, this test does have an advantage over some of the testing that will be covered shortly. If this test is repeated with the gauge connected to the downstream oxygen sensor location and the results indicate high pressure, then the restriction is further back in the system and not the catalytic converter.

Backpressure with a drill

This technique works exactly the same as the previous method but requires the technician to drill a hole in the exhaust ahead of the converter, install an adapter and connect the backpressure gauge. Although this test allows easier access, it requires damaging the exhaust and then an additional repair after the test is complete.

In-cylinder

This test is by far the easiest to perform, in my opinion. It does require the use of an oscilloscope and a pressure transducer. It also has an advantage that I believe is extremely valuable: ease of access to a test point. The only component we need to access on the vehicle is a spark plug. I know that some spark plugs can be located in some difficult spots, but it has been my experience that it is almost always easier to get to ONE of the spark plugs as opposed to an oxygen sensor. In addition, unlike oxygen sensors, spark plugs almost always come out. Unless you are working on a 5.4 liter 3 valve Ford…but I digress.

To perform the test, a pressure transducer is installed in one of the spark plug holes as shown in **Figure 4**. Either disable the spark for that cylinder or install a spark tester and be very careful not to expose the pressure transducer to the resulting secondary voltage. Some of the transducers on the market do not like to take a 60 KV hit, and I would hate to damage a potentially expensive piece of diagnostic equipment. Next, the engine is started, a throttle snap is performed and the resulting pressures are observed on an oscilloscope. In order to explain how a restricted exhaust behaves, we should know what good is first.

Figure 5 shows a known good engine running at idle. All four strokes of the cylinder are visible in the capture. The red box is calling attention to the pressure in the cylinder during the exhaust stroke. At this point in the four stroke cycle, the exhaust valve is open the cylinder is directly connected to the exhaust system. Therefore, the pressure in the cylinder is the same as the pressure in the exhaust. In this case, I placed the horizontal cursor at 0 psi and no exhaust backpressure can be seen.

Figure 6 is the same vehicle as **Figure 5** when the throttle is snapped. In the capture we can also see 0 psi during the exhaust stroke. This confirms the vehicle does not have an exhaust restriction.

Now that we know what known good looks like, let's take a look at how a restriction behaves. The subject vehicle is a 2006 Buick Rendezvous with a 3.5 liter engine. The customer's complaint was low power on acceleration. The test drive and VE calculation mentioned earlier in this article (**Figure 1 and Figure 2**) were performed. Scan data indicated poor VE, rich oxygen sensor readings and relatively normal fuel trim numbers. This was enough to warrant testing exhaust back pressure. **Figure 7** is an in-cylinder capture that was obtained when the throttle was snapped in the bay. The labeling of the image is the same as the previous two images. However, I added a second horizontal cursor to measure the pressure in the cylinder. In this case, the vehicle was generating in excess of 32 psi on the exhaust stroke. This would be the same measurement we would obtain if we had installed a backpressure gauge in the exhaust system. This vehicle had a very restricted exhaust system. Replacing the catalytic converter resolved the issue and restored the vehicle's acceleration. Access to a spark plug, scope connections and obtaining the capture were extremely quick and easy. I hope this helps illustrate the value of using a pressure transducer and oscilloscope over the older, but still effective, exhaust backpressure testing methods.

Catalyst efficiency side note

I know that catalyst efficiency DTCs do not exactly fit this article, but I wanted to take a moment to address a question that has been asked many times while I have been teaching around the country. The question: Why does a restricted catalyst usually not set a P0420 or P0430? The two most common reasons for this are 1) the catalyst efficiency monitor is suspended or 2) the enable criteria to run the catalyst monitor have not been met. First, if there is a current misfire, or even a history misfire DTC stored, then the catalyst monitor will be suspended. There is a strong possibility that the misfire was the cause of the catalyst failure to begin with and the PCM will not even attempt to run the monitor in these cases. Second, if a catalyst becomes restricted for whatever reason, the engine load PID (or other possible data) can be out of the range of the enable criteria for the catalyst monitor to run. If this is the case, the vehicle will continue to operate while the converter continues to degrade and the PCM will not execute the monitor and set a catalyst efficiency DTC.

Remember, a catalytic converter can fail in two ways: efficiency or restriction. This article covered the restriction aspect. Efficiency issues require a different logical diagnostic approach.

Summary

When an exhaust restriction is suspected, analyze some scan data to back up your theory, choose your physical testing method to prove the restriction, make the repair and perform a repair verification test drive (with a scan tool) to confirm your success!

SCOTT SHOTTON is owner of The Driveability Guys, and he performs mobile diagnostics, reprogramming, industry training and has been a college instructor for the past 14 years. With a degree in Automotive Service Technology, Scott holds more than 21 ASE certifications.
scott@driveabilityguys.com

UNIVERSAL JOINT DIFFERENCES

LEARN THE RIGHT WAY TO TROUBLESHOOT AND SERVICE THESE IMPORTANT DRIVELINE COMPONENTS

JOHN D. KELLY // Contributing Editor

I have an embarrassing admission to make: up until a few years ago, I thought I knew all there was to know about diagnosing and replacing universal joints (u-joint); I was very wrong. I had been mentored by older technicians 40 years ago when I was the young, impressionable new guy in the shop, and I assumed that they knew what they were doing. Over the years, I diagnosed and replaced u-joints in the same manner. Most of the time I thought I was successful, but there were times when I knew something was not right with my installation, but I did not know why.

A few years ago, while preparing for a manual drivetrain class, which I teach, I began researching the proper method of diagnosing, removing and installing u-joints. I found that some manufacturers' service diagnostic and replacement information was very limited, while other manufacturers (including manufacturers of u-joints) give you detailed step-by-step service instructions including specific tools to use and measurements to take. Measurements? What measurements?

I had never been taught about centering a u-joint in the driveshaft yoke ears. I had never been taught to measure and adjust the axial end play of the u-joint with selective color-coded snap rings. I had never seen a u-joint with selective snap rings. After a little more research, I found out that aftermarket u-joints do not come with selective snap rings! I had always purchased aftermarket u-joints. As it turns out, all u-joints are not equal. In this article, we will look at the potential differences in u-joints and how they can impact you and your customer.

I have a few questions to get you thinking about u-joints. We will answer each question in this article.

1. What is the difference between a new $8.99 u-joint and a new $135 u-joint kit for the exact same vehicle application?

2. Have you ever installed a new u-joint and had the customer complain of a vehicle vibration afterward?

3. Why do the original factory-installed u-joints in vehicles seem to last forever?

4. Why are a large majority of factory installed u-joints the "sealed" type without a grease fitting?

5. Why are there colored snap rings on many of the factory-installed u-joints?

Warning! Historical content

Before we discuss u-joints, we need to clarify a little history and terminology. First, it is unknown who invented the original two-axis u-joint or whatever it was called, but it happened sometime in antiquity (thousands of years ago). Although today the name "Universal Joint" is defined by the Society of Automotive Engineers (SAE) in standard J901, here are the three most commonly used names for u-joints in service information, parts stores, etc.:

1. The Cardan Joint — Incorrectly named in honor of Italian mathematician Hieronymus Cardano (1501-1576) who is credited with describing/inventing a swiveling gimbal with three degrees of freedom (for holding a ship's

2017 RAM 2500 FACTORY U-JOINTS come with green and blue selective snap rings

SPICER U-JOINT BOXES from 1933, 1957, and 2019

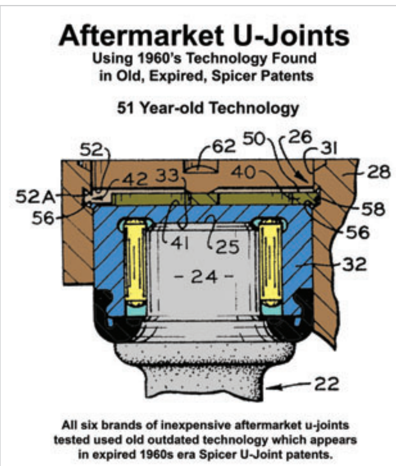
PHOTOS: JOHN D. KELLY

compass level in the ocean waves) in 1557. A gimbal is not a u-joint and functions quite differently.

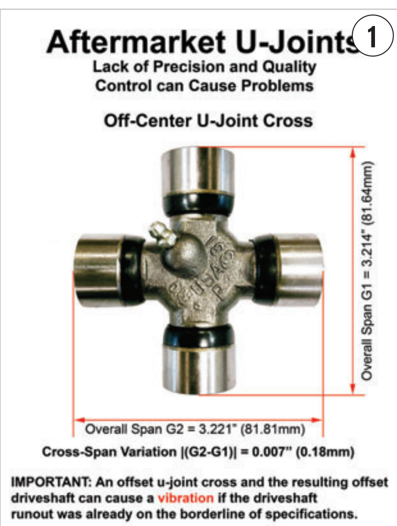
2. The Hooke's Joint — Correctly named in honor of English mathematician Robert E. Hooke (1635-1703) who in 1675 demonstrated that an angled shaft connected to a u-joint with two degrees of freedom does not rotate at a constant velocity. Hooke also discovered and demonstrated that connecting two u-joints together causes an angled shaft connected to them to rotate at a constant velocity. Today, this constant velocity joint configuration is incorrectly called a "Double Cardan Joint." Hooke used his inventions in an attempt to display the time of day from a sundial onto a vertical wall so people passing by could easily see the time of day.

3. The "Polhem Knot" Joint — Incorrectly named after Swedish inventor Christopher Polhem (1661-1751) who, after visiting England and studying Robert Hooke's work, went back to Sweden in 1697 and "re-invented" the u-joint under his name.

Prior to the rise in popularity of the horseless carriage (automotive industry) in the late 1800s, u-joints were primarily used in industrial applications to connect two machines together. These early u-joints required constant main-



51-YEAR-OLD TECHNOLOGY from Expired Patents



LACK OF PRECISION RESULTED in a cross-span variation of 0.007" (0.18mm) tenance, cleaning and lubrication.

In 1902, Clarence W. Spicer (1875-1939), engineer and inventor, invented an enclosure for u-joints to protect them and make them self-lubricating. He obtained 40 U.S. patents between 1903 and 1934 for various designs of improved u-joints and driveshafts. His inventions led to the replacement of the chain-driven axle with shaft-driven axles at the dawn of the automotive industry.

In 1919, Charles A. Dana (1881-1975), businessman, partnered with Spicer, purchased a controlling interest in the Spicer Manufacturing Company and managed the company while Spicer continued innovating and improving u-joints and driveshafts. Dana managed Spicer Manufacturing for 30 years.

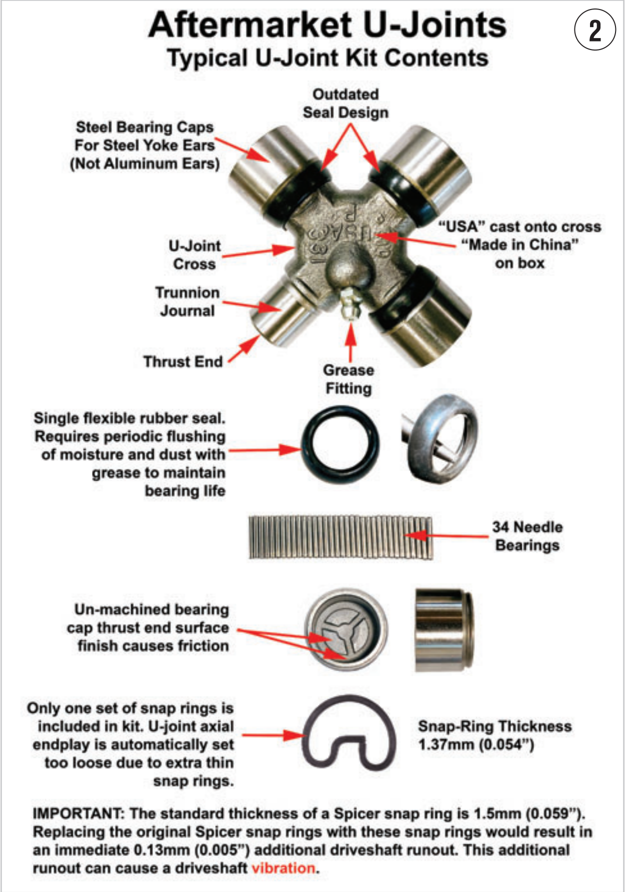
In 1946, in honor of Charles Dana, Spicer's company was renamed to Dana Corporation, which has continued to innovate and produce top quality u-joints and drivelines under the "Spicer Drivetrain Products" brand. Spicer is still a major supplier of factory-installed u-joints and driveshafts.

IMPORTANT: In 1982, the Spicer Driveshaft Division of Dana Corporation developed the first all-aluminum driveshaft. Today's aluminum driveshafts require special Zinc-Phosphate coated steel bearing caps and snap rings in order to avoid severe corrosion caused by electrolysis.

The difference between universal joints

As part of the u-joint research for my classes, I tested six different brands of aftermarket u-joints, two original equipment manufacturer (OEM) u-joints, and two Spicer u-joints for the same application. These u-joints cost anywhere between $8.99 and $135 each. I tested each u-joint for the following characteristics:

- Weight of the complete u-joint with snap rings. Always replace both (all) u-joints as a set on the same driveline to maintain balance and reduce moments of inertia.
- The materials from which the u-joint was constructed
- The cross-span variation of the trunnion cross
- The cross-span variation of the trunnion cross with bearing caps
- The bearing cap diameter
- The design of the grease seal(s)
- The recommended bearing lubrication type
- Lubrication service intervals for u-joints with grease fittings
- Lubrication reservoir precautions for sealed u-joints
- Method of reduction of metal-on-metal friction from trunnion thrust surface to bearing cap
- Method of reduction of metal-on-metal friction from needle bearing ends to bearing cap
- Method of needle bearing retention
- Methods of corrosion protection



TYPICAL AFTERMARKET U-Joint Kit Contents

- The thickness of snap ring set(s)

Both $135 OEM u-joint kits contained a Spicer u-joint kit inside the box. The $35 Spicer u-joint kits contained the exact same instruction sheet and part numbers as the OEM kits.

All six brands of aftermarket u-joints were almost identical in appearance, but some had some serious quality and precision issues. To illustrate these issues, let's look at the answer to the first question at the start of this article: What is the difference between a new $8.99 u-joint and a new $31.99 (or higher priced) u-joint for the exact same vehicle application?

The $8.99 universal joint — Figure 1 depicts an $8.99 u-joint available today online and in many auto parts stores. At first glance, you may not realize that you are actually looking at technology from a 1968 Dana patent (US3369378A) that expired in 1985. When a patent expires, the technology is open for the rest of the world to use. It appears that many suppliers of aftermarket u-joints simply copy the technology from old, outdated, expired patents and hope that the general consumer will not know any different. In reality, today's modern u-joints can outlast this old technology by a factor of 10 to 1.

Quality Control? — Five out of the six aftermarket u-joints I tested had less than impressive quality controls regarding precision machine work. Some were worse than others. The worst can be seen in **Figure 1**. The cross-span variation measurement across the two sets of opposing bearing caps was 0.180mm (0.007”). By comparison, the same measurement on the OEM and Spicer u-joints was 0.025mm (0.001”). Any cross-span variation can result in an offset u-joint cross centerline. An offset u-joint cross and the resulting offset driveshaft can cause a vibration if the driveshaft runout was already on the borderline of specifications. In other words, installing this u-joint could cause a vibration. This is one of the answers to Question 2 at the start of this article.

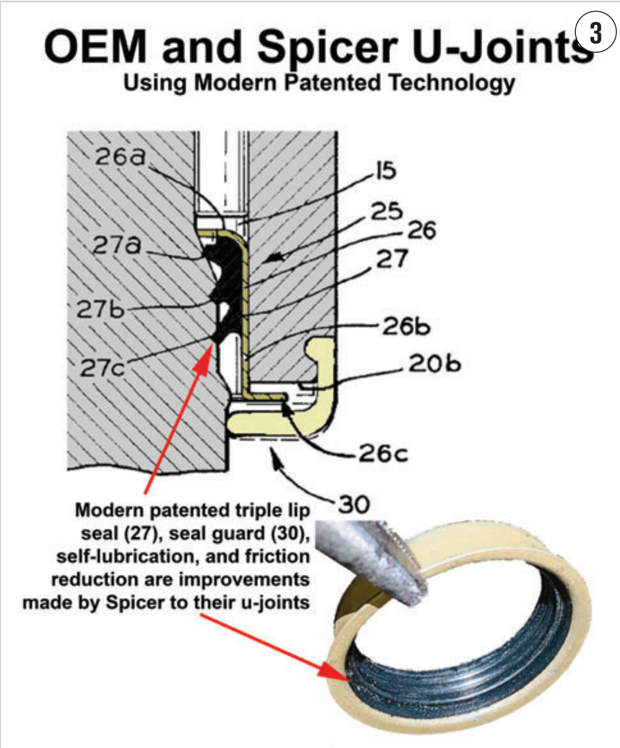
The typical contents of an aftermarket u-joint kit can be seen in **Figure 2**. This 51-year-old design has several disadvantages when compared to a modern Spicer design.

Single Flexible Rubber Seal — This design of grease seal does a poor job of keeping the grease inside the bearing caps. It also does a poor job of keeping dust and moisture out of the bearing caps. Because this seal does such a poor job, periodic flushing of the old grease, dust, and moisture with new grease is required to maintain bearing life. This explains the need for a grease fitting.

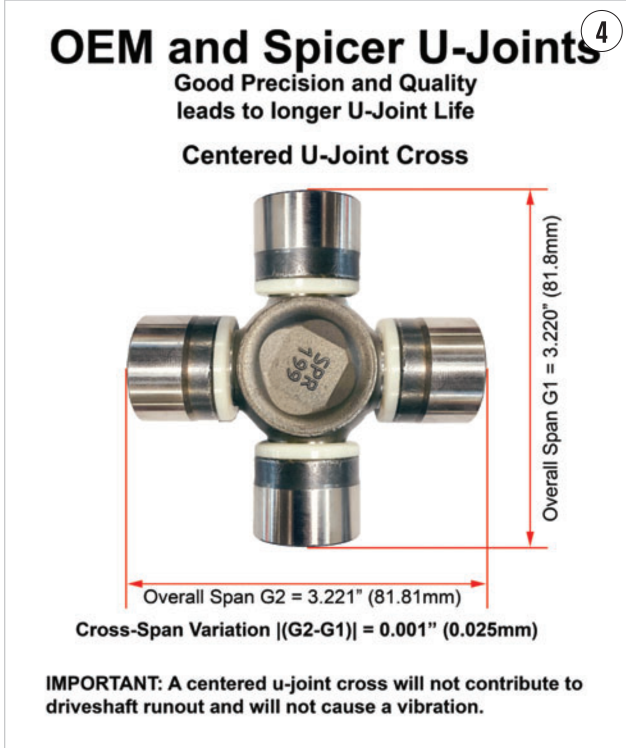
Grease fitting — I used to think a u-joint with a grease fitting was a good thing, but I no longer think that way. The problem with using a u-joint with a grease fitting is remembering to have it greased properly (the flushing process). I personally have been to national chain stores for an oil change in my own vehicle. When they were finished servicing my vehicle, I asked them how many grease fittings they lubricated; they told me my vehicle had sealed joints and no lubrication was necessary. I knew it had several grease fittings, and I had to tell them where they were. I am sure they hated having me for a customer.

Snap Rings — All six aftermarket u-joint kits I tested came with one set of snap rings (4). The thickness of the snap rings averaged 1.37mm (0.054”). The average typical snap ring thickness used with Spicer u-joints is 1.50mm (0.059”). One benefit to using snap rings that are too thin is tthat they fit into the snap ring groove easier than thicker snap rings do.

Replacing the original snap rings with these thinner snap rings would result in an increase in the driveshaft runout of 0.13mm (0.005”) because of



PATENTED TRIPLE LIP SEAL DESIGN



VERY LOW CROSS-SPAN VARIATION

the additional axial end play in the u-joint assembly. This condition will cause the driveshaft to orbit rather than rotate on a centerline. This additional runout can cause a driveshaft vibration. This is also one of the answers to Question 2 at the start of this article.

Now, imagine the vibration caused by the wrong combination of an offset u-joint cross and these snap rings. The worst-case scenario with this u-joint could have an additional 0.30mm (0.012") of driveshaft runout just from changing a single u-joint! Many driveshafts have a maximum runout specification of 0.51mm (0.020"). Almost all driveshafts I have tested for runout measured at least half of their specification, even on brand new vehicles. It would not take much more runout to exceed the maximum allowed.

Friction Producing Design — All six aftermarket u-joints I tested were designed with the thrust end of the trunnion cross rubbing metal-to-metal on the bottom of an unmachined bearing cup. Additionally, the bottom of the needle bearings makes metal-to-metal contact with the bottom of an unmachined bearing cup.

Misleading Advertising/Markings — One of the six aftermarket u-joints I tested came from a major auto parts chain here in the U.S.A. "Made in China" was printed on the outside of the box, yet the letters "USA" were cast into the u-joint cross. It makes me wonder if this is a knock-off u-joint.

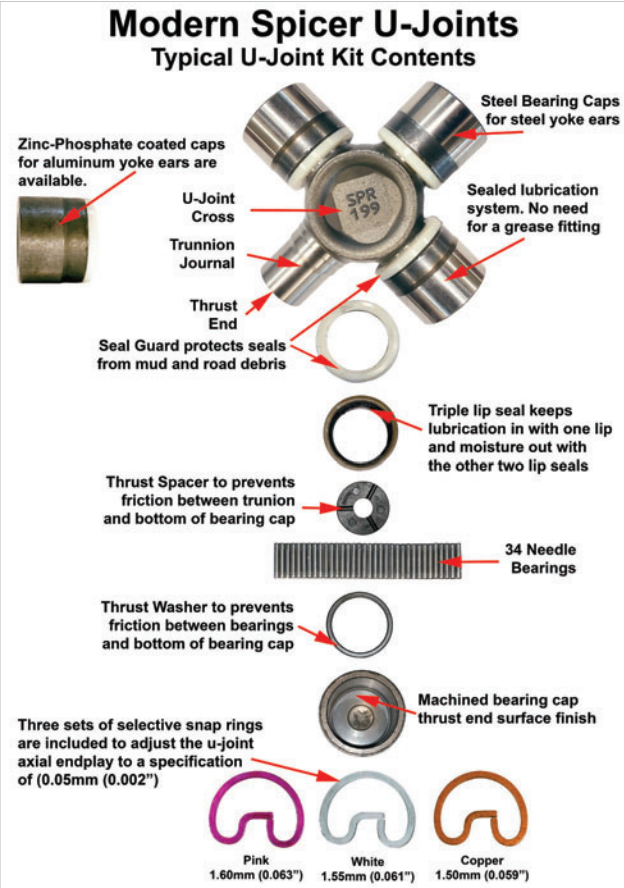
The $35 to $135 Universal Joint – The patented technology used in OEM and Spicer u-joints allows them to last 10 times longer than the $8.99 u-joint. Let's look at this technology.

Triple Lip Seal Design — As shown in **Figure 3**, the inside lip seal faces the bearing cap and keeps the grease inside the bearing caps and lubrication reservoir. The other two lips are facing the trunnion cross and keep dust and moisture out of the bearings. Because this seal does such a good job, no external grease fitting is required for grease flushing and bearing life is extended. This answers Questions 3 and 4 at the start of this article.

Seal Guard — The seal guard protects the triple lip seal from damage from mud or road debris as you drive. The seal guard is an important improvement in u-joint design.

Quality Control — The two OEM and the two Spicer u-joints I tested had impressive quality controls regarding precision machine work. As can be seen in **Figure 4**, the cross-span variation measurement across the two sets of opposing bearing caps was a consistent 0.025mm (0.001") or less.

Corrosion Protection — As mentioned before, aluminum driveshafts require special Zinc-Phosphate coated steel bearing caps and snap rings in order to avoid severe corrosion caused by electrolysis. OEM and Spicer u-joints may have just two of the bearing caps coated with zinc-phosphate (dark brown/grey coating). Those two bearing caps are to



TYPICAL OEM AND SPICER U-JOINT KIT CONTENTS

be installed into the aluminum yoke ears of the driveshaft; the steel bearing caps are to be installed into the steel companion yoke ears. When replacing a u-joint in an aluminum driveshaft, be sure to use the coated bearing caps and coated selective snap rings.

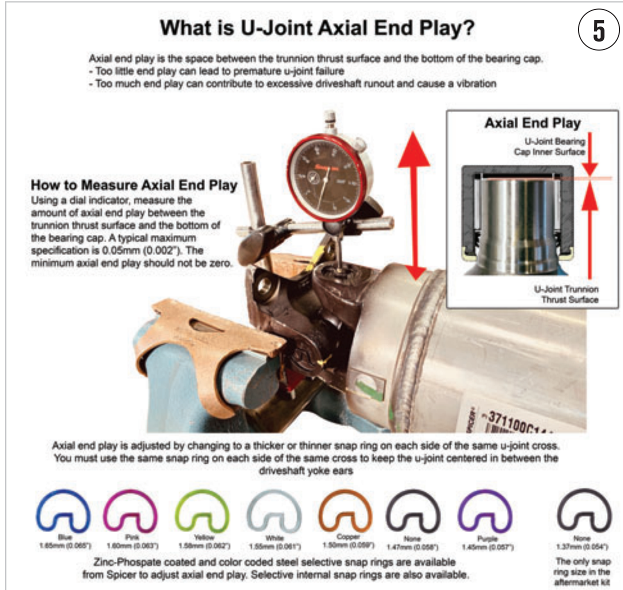
Thrust spacer — These kits were designed with a nylon spacer on the thrust end of the trunnion cross to prevent metal-to-metal friction with the bottom of the machined bearing cap.

Thrust Washer — These kits were designed with a nylon thrust washer installed between the bottom of the needle bearings and the bottom of the bearing cup. The purpose of the thrust washer is to prevent metal-to-metal friction.

Snap Ring Sets — The OEM and Spicer u-joint kits contain three sets of (4) color-coded selective snap rings. U-joint kits for aluminum driveshafts also contain three sets of selective snap rings, but they are not color-coded since they are coated with zinc-phosphate.

There are two reasons for using selective snap rings (from Question 5 at the start of this article):

1. As seen in **Figure 5**, the snap rings are used to adjust



HOW TO MEASURE AND ADJUST AXIAL END PLAY

the axial end play in the u-joint. Axial end play is the space between the trunnion thrust surface and the bottom of the bearing cap and is measured with a dial indicator. Axial end play is adjusted by changing to a thicker or thinner snap ring on each side of the same u-joint cross.

a. Too little end play can lead to premature u-joint failure due to friction and lubrication blockage.

b. Too much end play can contribute to excessive driveshaft run out and cause a vibration

2. The snap rings are also used to center the u-joint cross in between the yoke ears of the driveshaft. You must use the same thickness of snap ring on each side of the same cross to keep the u-joint centered in between the driveshaft yoke ears. Always measure each snap ring and keep track of where you install it.

Snap rings are easily damaged and should not be reused if they do not spring back to their original dimensions (compare to a new snap ring).

Summary

Hopefully, you have learned enough to know what to look for, and what to look out for, when purchasing and servicing u-joints. As for me, I will always use the better quality, more expensive Spicer u-joints in any vehicle of mine. Best wishes!

JOHN D. KELLY is a professor of automotive technology at Weber State University in Ogden, Utah, and a former technician. He specializes in automatic and manual drivetrain and NVH diagnosis and hybrid and electric vehicle technology.
Jkelly1@weber.edu

A PID-O-FULL DIAGNOSIS

GAS OR DIESEL? IT DOESN'T MATTER IF YOU APPLY A DIAGNOSTIC PROCESS AND FOLLOW IT!

BRANDON STECKLER //
Contributing Editor

Those of you who have come to know me are aware that my experience with diesel drivability concerns is extremely limited. For good reason, though. I'm not properly equipped to take on the job efficiently and don't see a need to take myself in that direction. With that being said, when an opportunity arises to get involved with a job like that, I'm happy to provide a set of eyes for evaluation. I'm always in the mindset to learn something new, to broaden my skillset and to aid and support others. For years, I've had the attitude that if I have fundamental knowledge of how a component is designed to work, information supporting how a system strategizes to carry out a goal and a thorough understanding of the limitations my tools/test procedures provide, I can solve any issue.

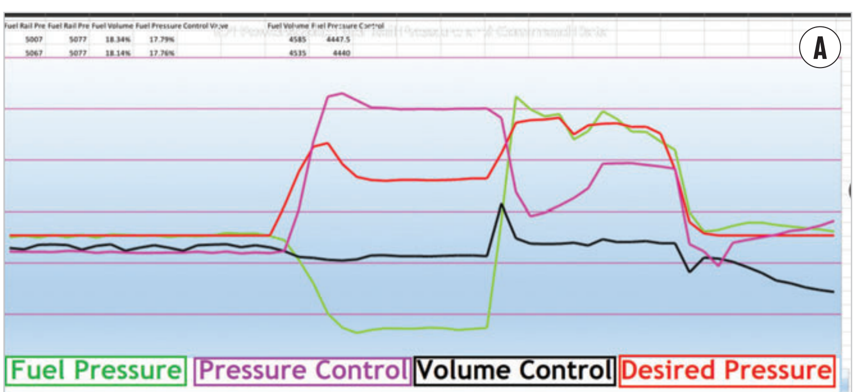
The unfamiliar adversary

This case comes to us from a great friend and co-instructor of mine (with CarQuest Technical Institute) Brent Delfel, of Advanced Diagnostic Consulting in Snohomish, Wash. Brent was called to a jobsite with the complaint originating from a 2008 Ford F-250, equipped with a 6.4L diesel engine. It seems upon initial start-up, there is a noticeable hesitation upon acceleration. This fault vanishes shortly thereafter, but symptoms will return each time the engine is shut down and re-started. Brent gathered some data, first with a basic scan tool and then the result of the PIDs led him to pinpointed scope testing. Brent had a theory and asked for my input. He sent the captures to me for evaluation, and well…here we are.

The elementary approach

For me, it always starts at the beginning, especially when I'm dealing with the unfamiliar. This is what I've learned about this common rail diesel fuel system:

Diesel fuel is carried from the fuel tank through a fuel conditioning module where fuel is filtered and pressurized (to about 3-8 psi). It is then sent to the engine compartment where it is once again filtered before entering a camshaft-driven, high-pressure fuel pump assembly. The HP fuel pump is capable of outputting pressures exceeding 24,000 psi! Some of the diesel is used to simply cool and lubricate the pump assembly. The pressure is sent from the pump to parallel standing injector rails (one per bank of the engine). The pump's pressure output is grossly controlled by a fuel volume control solenoid and curtailed further with a fuel pressure control solenoid. Both are controlled by the PCM to maintain swift and accurate control of the pressure within the fuel rails. When pressurized diesel leaves the pump, it's routed to the injectors. Pressure in the injectors is equal on ei-



PHOTOS: BRANDON STECKLER

ther side of a nozzle needle. When the injector is commanded to fire, a pressure differential takes place within the injector, and a control piston initiates delivery of a highly vaporized/atomized mist of diesel to the combustion chamber. The small dose of fuel being displaced to generate the pressure differential is referred to as "return fuel." This is because this volume of diesel is recirculated back through the low-side fuel system to start the process over again.

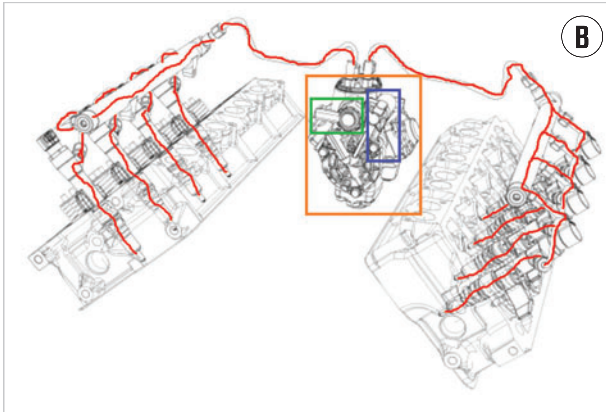
I apologize, as that system description/operation was a bit lengthy, but there is a method to my madness, and it will all come together in the end.

Let the games begin

Now, having a brief overview of how the system is constructed and what components are operated as a strategy to control the diesel injection system, it's time to come up with a game plan. This game plan will vary on any vehicle or problem you are encountering, but the object of the game plan is ALWAYS the same: How can I test most efficiently to give me as much information with as little time invested as possible? This depends a lot on how accessible components are for testing, what tools I have at my disposal and how capable my available scan tool is, along with the robustness of the PCM's software (what information is it willing to give up in a PID list).

So, recalling that I'm viewing this from the other side of the country, I'm limited to viewing only what data has been captured. Let's begin at what I call "the low-hanging fruit." Information like this is very easy to obtain, usually right from the DLC, and answers a few basic questions for me. In this case:

- What am I "feeling" from the driver's seat (the symptom/customer-concern)?
- What is causing the concern (incorrect fuel delivery)?

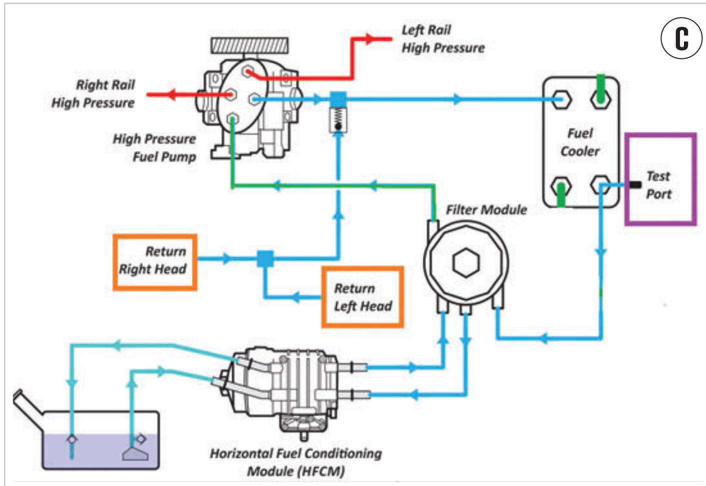


- Is the problem being seen and compensated for by the PCM (control issue or mechanical fault)?

The significance? The answers to those questions can be seen easily in the PID list on even a basic professional scan tool. More importantly, the answers to those questions will point me in the direction of which testing to deploy. Every step taken from this point forward will be justified and will lead to yet another conclusive answer on which component or part of a system to test next. The PIDs chosen to monitor were:

- Desired Fuel Rail Pressure
- Actual Fuel Rail Pressure
- Fuel Volume Control Solenoid
- Fuel Pressure Control Solenoid

As mentioned above, these PIDs will tell me if what I'm feeling as a symptom is due to a fuel delivery issue and why. It will also tell me if the PCM is seeing what I feel and trying to fix the issue. Looking at PIDs in a graphed format offers some distinct advantages over numerical forms of data analysis. The graphs not only allow the viewer to see a history of the PID, but also allows for a comparison of multiple PIDs simultaneously. This provides for the action/reaction point of view, and a means to see a fault present itself and a PCM's response to the fault. Unfortunately, the available scan tool chosen isn't capable of graphical formatting, meaning we can only look at a numerical value at a single moment in time. This provides for a disadvantage. But all is not lost.

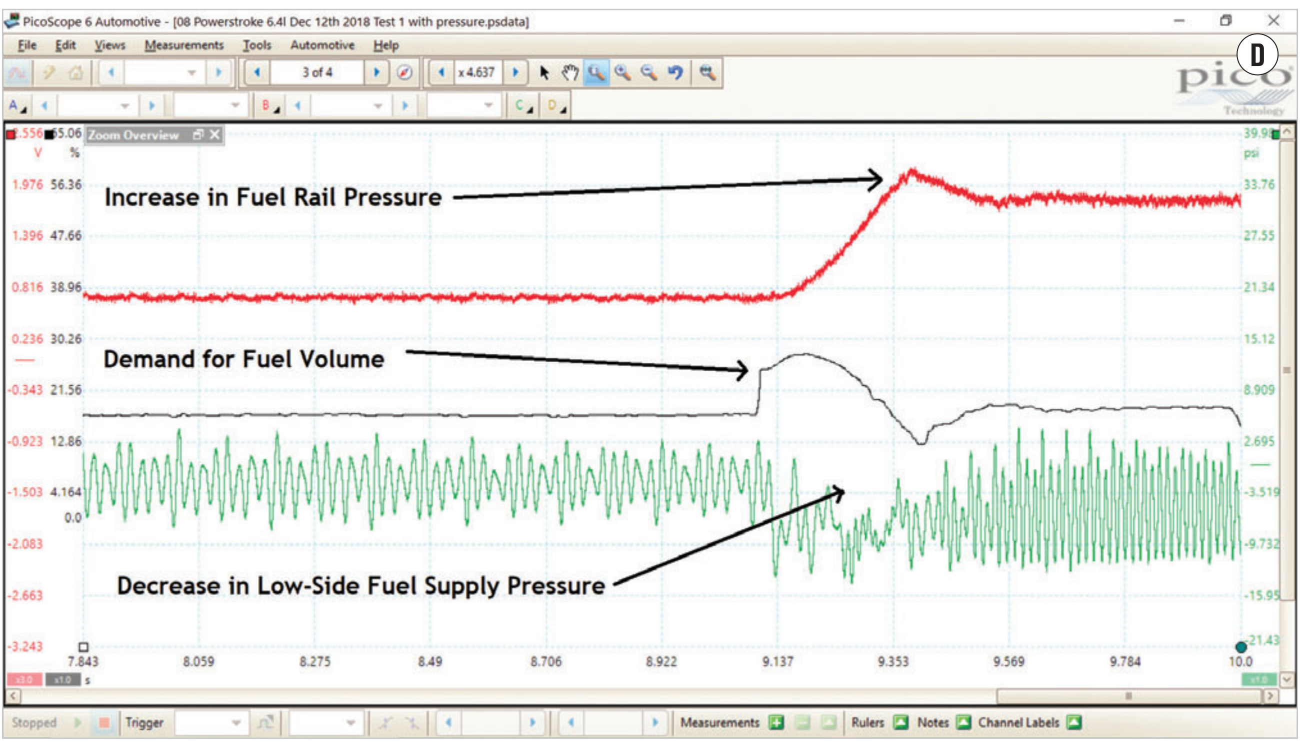


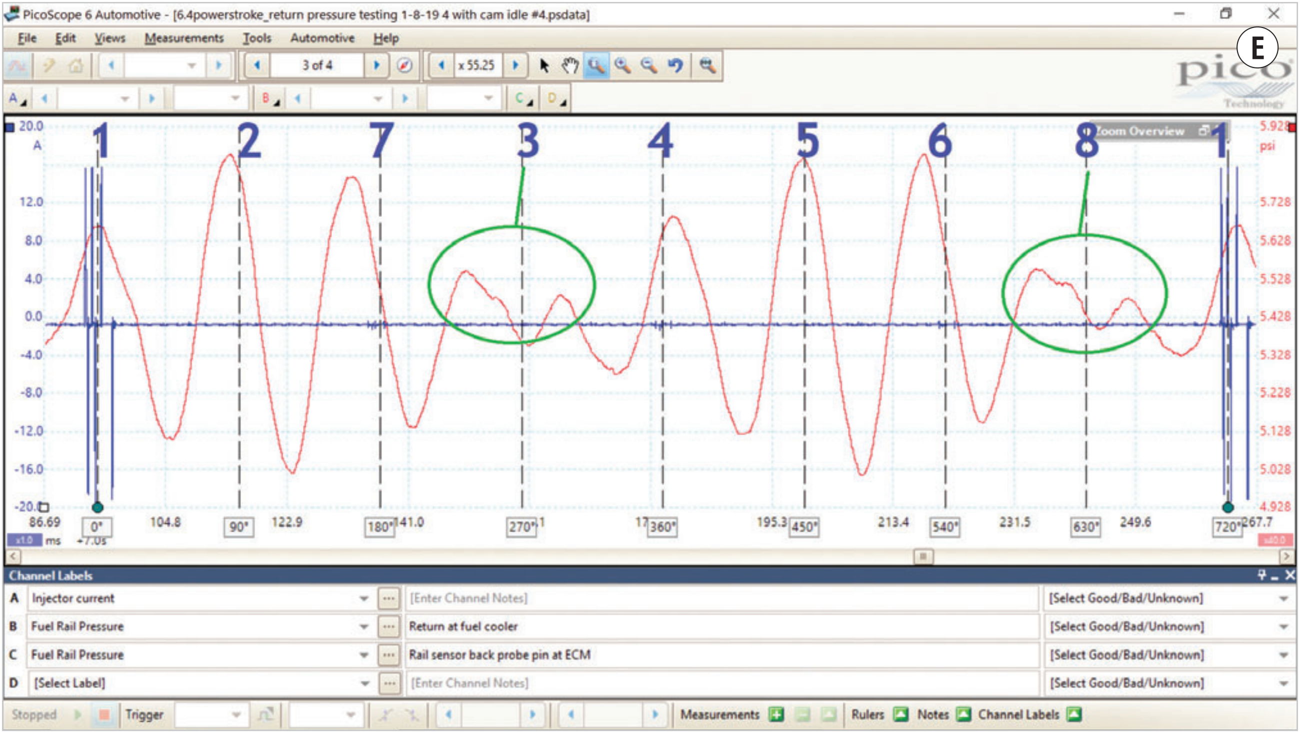
"Excel" to excel

Although the scan tool isn't capable of graphing, Brent simply took the data from each individual frame captured. He then uploaded these PIDs over time into a Microsoft Excel graph program. If you refer to **Figure A,** the fault, as well as the computer's reaction, is visible. The graph clearly displays a severe lack of fuel pressure, along with the PCM's command to increase fuel volume to the rail and boost pressure. This means the rail lost pressure and the PCM tried to fix it.

So, referring to **Figure B**, we can see the lay of the land regarding the entire HP fuel system. The HP pump assembly is surrounded by a red square. Within that is the pressure control valve, surrounded in the green square, and the volume control valve surrounded by the blue square. Both of these components are self-contained within the pump assembly. The highly pressurized diesel leaving the pump travels in red through the rails and to each injector. Pictured in **Figure C** is the return fuel system. Light blue represents the lube/cooling fuel from the HP pump, the return fuel from the left cylinder head and the return fuel for the right cylinder head. They join together in a "T" and enter a return fuel cooler. This cooler has a test port making pressure samples available to us.

After analyzing the graphed PIDs, it's time to pinpoint the location of the fault. We should all understand that the HP system can only function properly if it receives a healthy supply of low-pressure fuel from the low-pressure pump and filter assemblies. This was verified by Brent with a pressure test under load when the fault occurred. Brent "tee'd-in" to





the low-side supply line leading from the fuel conditioning module to the filter module. There was no decay (exceeding specification) of low-pressure fuel during the exhibited symptom. So, logic will tell you that we can eliminate the low-side fuel system as a contributor to this fault. The focus will be on the HP side of the fueling system only, and the only test we performed was by placing a gauge on the low-pressure side. Not a lot of time/energy invested at this point. Eluding to the fault being on the HP side left a few items as potential failure points. The pump itself could surely be at fault, but so, too, could any of the injectors. Now, the nature of the HP leak would tell us if an injector was over-delivering, as we should see this reflected in the smoke bellowing from the tailpipe. This vehicle did not experience this fault. If the injector was leaking to the crankcase, we should be seeing evidence of that in the oil, but that, too, revealed no evidence of diesel contamination. However, the injectors could be leaking excessive fuel back to the return-side of the system. How could we tell? Even if there was no specification found for this type of test?

Let's scope it out

I've mentioned many times before that having a thorough understanding of the tools you use makes that tool an extension of your mind. It allows you to make inquiries of the components you desire and offer you the ability to evaluate an entire system dynamically. With that notion in mind, Brent

STATEMENT OF OWNERSHIP MANAGEMENT, AND CIRCULATION

(Requester Publications Only) (Required by 39 USC 3685)

1. **Publication Title:** *Motor Age*
2. **Publication Number:** *925-560*
3. **Filing Date:** *9/10/2019*
4. **Issue Frequency:** *Monthly*
5. **Number of Issues Published Annually:** *12*
6. **Annual Subscription Price:** *Free to Qualified*
7. **Complete Mailing Address of Known Office of Publication (Not Printer):** *UBM/Informa, 325 W 1st St., Ste 300, Duluth, MN 55802*
   Contact Person: *Tracy Skallman,* **Telephone:** *612-513-1918*
8. **Complete Mailing Address of Headquarters or General Business Office of Publisher (Not Printer):** *UBM/Informa, 605 Third Avenue, New York, NY 10158*
9. **Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor:**
   Publisher: *Terri McMenamin, Publisher, UBM/Informa, 1100 Superior Avenue, 8th Floor, Cleveland, OH 44114-2518*
   Editor: *Krista McNamara, Channel Content Director, UBM/Informa, 1100 Superior Avenue, 8th Floor, Cleveland, OH 44114-2518*
   Managing Editor: *Mike Willins, Group Content Director, UBM/Informa, 1100 Superior Avenue, 8th Floor, Cleveland, OH 44114-2518*
10. **Owner - Full name and complete mailing address:** *Informa Media Inc., 605 Third Avenue, New York, NY 10158; Informa Operating Holdings, Inc. (owns 100% of the stock of Informa Media, Inc.), 605 Third Avenue, New York, NY 10158*
11. **Known Bondholders, Mortgages, and Other Security Holders Owning or Holding 1 Percent or More of Total Amounts of Bonds, Mortgages, or Other Securities:** *None*
12. **Tax status (For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one)**
    The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: *N/A*
13. **Publication Title:** *Motor Age*
14. **Issue Date for Circulation Data Below:** *August 2019*

15. Extent and Nature of Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a Total Number of Copies (Net press run)	103,951	99,371
b. Legitimate Paid and/or Requested Distribution (by mail and outside the Mail)		
1. Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	82,205	76,991
2. In-County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	0	0
3. Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid or Requested Distribution Outside USPS®	32	18
4. Requested Copies Distributed by Other Mail Classes Through the USPS (e.g. First-Class Mail®)	0	0
c. Total Paid and /or Requested Circulation (Sum of 15b (1), (2), (3), and (4)	82,237	77,009
d. Non-requested Distribution (By Mail and Outside the Mail)		
1. Outside County Nonrequested Copies Stated on PS Form 3541 (include Sample copies, Requests Over 3 years old, Requests induced by a Premium, Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists, and other sources)	21,320	22,095
2. In-County Nonrequested Copies Stated on PS Form 3541 (include Sample copies, Requests Over 3 years old, Requests induced by a Premium, Bulk Sales and Requests including Association Requests, Names obtained from Business Directories, Lists, and other sources)	0	0
3. Nonrequested Copies Distributed Through the USPS by Other Classes of Mail (e.g. First-Class Mail, Nonrequestor Copies mailed in excess of 10% Limit mailed at Standard Mail® or Package Services Rates)	0	0
4. Nonrequested Copies Distributed Outside the Mail (Include Pickup Stands, Trade Shows, Showrooms and Other Sources)	346	233
e. Total Nonrequested Distribution (Sum of 15d (1), (2), (3) and (4)	21,666	22,328
f. Total Distribution (Sum of 15c and e)	103,903	99,337
g. Copies not Distributed	48	34
h. Total (Sum of 15f and g)	103,951	99,371
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100)	79.15%	77.52%
16. Electronic Copy Circulation		
a. Requested and Paid Electronic Copies	-	-
b. Total Requested and Paid Print Copies (Line 15c) + Requested/Paid Electronic Copies (Line 16a)	82,237	77,009
c. Total Requested Copy Distribution (Line 15F) + Requested/Paid Electronic Copies (Line 16a)	103,903	99,337
d. Percent Paid and/or Requested Circulation (Both Print & Electronic Copies) (16b devided by 16c x 100)	79.15%	77.52%

☐ **I certify that 50% of all my distributed copies (electronic and print) are legitimate requests or paid copies.**

17. **Publication of Statement of Ownership for a Requester Publication is required and will be printed in the: Issue of this publication.** Oct-19

Tracy Skallman

Date: *09/10/19*

I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

deployed the scope to monitor the action/reaction display of the system when it is malfunctioning. Looking at **Figure D**, in red is the signal from the fuel rail pressure sensor. In green is a pressure transducer connected to the low-side fuel supply system. The black trace is a math-channel on the scope. It is a derivative of fuel volume control solenoid command and is displayed in "duty-cycle percentage." It represents the PCM commanding more fuel pressure generation. The story told by the capture is that under high demand situations that we placed the vehicle under, the PCM commanded a high amount of fuel volume to the HP pump. This allowed the HP pump to produce a steep increase in pressure, as it should. The lack of performance from the engine could be felt, meaning the fuel never made it to the cylinders. Now, the loss of low-side supply typically causes a loss in HP output. It did not do so in this case. (Further explanation to follow). Clearly the HP pump could produce the pressure, so why didn't it make it to the cylinders? This is the question that will be answered in the next justified test.

Look at **Figure E**. In blue is the injector current trace from injector #1 only. It is used simply as a point of reference along with the firing order. This will indicate which injector was firing at any given point in the engine cycle. You can see I've annotated the top of the capture to show the firing order and partitioned the capture eight different ways to represent each of the eight injectors firing. In red is a pressure transducer on the fuel cooler test port to represent pressure on the return-fuel side of the system. This is a zoom capture to represent one engine cycle, and it displays a variation in pressure, on the return fuel side, comparing each injector's firing to the other seven. What isn't important is the actual pressure value (not that we found a documented specification, anyway). What is important is the fact that the injectors don't return the same amount of fuel when they de-energize.

It's the combination of the captures that tells the entire story — the PIDs reflected a lack of fuel pressure when it was commanded, and the PCM was trying to compensate. A test of the low-pressure system was carried out and displayed the ability to deliver pressure under high-demand situations, allowing the HP pump to do its job. Although the low-pressure side of the system dissipated under load, it stayed within specification. The big increase in HP pump output (to pressurize the rail adequately and overcome a leak to the return-side was like turning on a faucet) caused the depletion in low-pressure supply. A lack of performance proved the fuel never made it to the combustion chambers and the final capture told us why. Under high-demand situations (when the symptom occurred), the return fuel pressure increased for all injectors except for two of them (#3 and #8). The HP pump made the pressure, but instead of delivering to the combustion chambers, six (of the eight) injectors dumped the fuel to the return-fuel system, condemning the injectors as being mechanically faulty. A specification for return-fuel pressure wasn't needed. The process of elimination determined where the fault lay.

Waiting to exhale

Now, it is almost unheard of for me to make a claim like the above without having concrete proof of a fix. Unfortunately, the customer chose not to invest the money in the suggested replacement of the all eight injectors. There is still some takeaway from this case study. The story never changes, just the characters. Have a thorough understanding of components/system's functionality, understand the basic fundamentals and the limitations of the tools/test you implement and there are very few tough-to-find faults you won't make quick work of. MA

BRANDON STECKLER is a working technician at Lykon Automotive in Bristol, Pa. He has worked in the field for over 18 years and holds ASE certifications A1-A9, X1, L1, L2 and L3 and C1.
theboywonder13@comcast.net

BRIDGING THE GAP

A TRIP ACROSS THE POND HELPED UNITE SOME OF THE U.K.'S BEST INSTRUCTORS WITH THOSE FROM THE UNITED STATES

BRANDON STECKLER // Contributing Editor

I have a lot of people to thank for being in my corner. My entire life consists of memories where people have been supportive of me, every step of the way. Whether it was family, friends, co-workers or even personal mentors of mine; I've always had a guiding hand. Many doors have opened as a result of efforts from people like the ones mentioned. My very first class (written on my own) was written to demonstrate the implementation of an unconventional testing method. One that many have found to be helpful to efficiently diagnose engine mechanical faults without expensive/time-consuming disassembly. The class has gained traction and popularity around the world and has brought me to the United Kingdom. That is

WHAT AN HONOR meeting two of the UK's best: Frank Massey (left) and his son, David (right).

PHOTOS: BRANDON STECKLER

where an opportunity of a lifetime had opened for all of us diagnosticians and will forever change the way we train in the automotive industry.

A flame has been ignited

It all started a few months ago (if you'll recall) when I assisted a young, talented technician in the UK named Ryan Colley (see "A jump across the pond," April 2019). I applied the techniques I teach in class and helped Ryan condemn the timing components of an engine without the need to disassemble. He thought this could be beneficial to his peers in the UK and invited me to deliver the class in person. Tremendously excited, I agreed to do so and the plans began to fall in place. Little did I know, we would be making history. We traveled the country, beginning in the south in the village of Taunton, Somerset, UK. There I met one of the UK's finest instructors, Mr. James Dillon, who was kind enough to offer his phenomenal training facility (known as Tech Topics Head Quarters) to host my debut class. The class was a great success, and I was very much looking forward to our tour of this fine country as well as the two other classes, scheduled for the remainder of the week. I also must take a moment to publicly thank James for the wonderful hand-made cheese, whiskey and beer he sent me home with, as a token of memory. It was very much enjoyed!

Establishing brotherhoods and future gatherings

Now, as exciting as the classroom was for me, I simply can't discount how much fun we have had behind the scenes. Traveling with me and accompanying me the entire time were my newest brothers ("me Mates") Ryan Colley and Steve Scott of Simply Diagnostics (check out his channel on YouTube), one of the UK's finest mobile diagnosticians and a popular YouTube contributor. I'd compare him to the likes of our own John Anello (Auto Tech On Wheels). Equally as clever and even more hysterical! These guys were an absolute necessity to the success of the trip, and it simply could not have occurred without their hard work and dedication to our industry.

Before hitting the open road, we enjoyed some food and beer with some phenomenally talented technicians. It's little places, like the pub we chose, where I met techs like Adam Critchley, (better known as "The Critch") where I witnessed him eat his own bodyweight in burgers and fries. He is a real sharp guy underneath his layers of muscle and body mass. Likely one of the most colorful characters I encountered on the whole expedition. I met his best friend, Neil Curry who, like "Critch," holds the coveted title for "UK's Top Automotive Technician!" What an honor!

We had a day's rest and enjoyed visiting places like The Tower in Blackpool, where we stood about 400 feet above the ground, standing on a clear-glass floor. Of course, Steve had to test the limitations of its integrity by jumping up and down with us all on it! We also celebrated "Chippy-Friday," a bit too soon (but how can you visit UK and not have a proper "Fish-n'-Chips with Mushy-Peas?") All in great fun, Steve even sent me home with a souvenir for my little girl, Makenna (a.k.a "The Bop"). We made our way up the western coast of England to the central part of the country, where the next venue was located and had a fantastic time with some of the attendees that would be present the next day. This is where I learned to properly drink a Guinness!

From the first initial sip, the surface of the beer must then rest between the word “Guinness” and the crest etched into the glass. That was a blast!

Star struck

On the day of my second presentation, we set up class in a beautiful shop in Preston, Lancashire. Automotive Diagnostic Solutions (A.D.S) was the venue and home to (and where I was greeted by) one of my heroes and his son, world renowned diagnosticians Frank and David Massey of *AutoInform Magazine*. The shop was fully prepared and specialized in the performance tuning of exotic machines from all over Europe. The place was extremely impressive. Frank even cut his Alps motorcycling tour vacation short, just to rush home and be a part of class. What an honor it was to be in the presence of such greatness and be treated like a peer. That was easily one of the greatest experiences of the entire trip. Not only was class a huge success, but the downtime at the local pub left my face in pain (from laughter) and some brilliant lasting memories. David has since become like a brother to me; and I can’t forget to mention his darling assistant, Annette Parkinson (the true boss). What a tremendous asset she is and so willing to help. I’m a huge fan of hers.

On the third and final venue, we finished the tour in Glasgow, Scotland, where class was held in the BOSCH training center. I met the likes of so many talented individuals, including some of my favorite mates, Craig Overfinch (and his lovely wife), Tommy Forrest, Stephen Marshall (and his cute little daughter) and “Joey Vauxhall” (you guessed it, a Vauxhall specialist). Joey took us all out to dinner to a restaurant owned by one of his closest friends. He wanted my first trip to UK to include healthy helping of Haggis, prepared as many ways as you can imagine. Honestly, it was quite nice!

Another wonderful class experience was carried out and the following day, spent the afternoon applying what we’d learned in class, hosted by Craig in his workshop called Phillips Garage. There I experienced a live, diesel-powered Vauxhall, where we successfully diagnosed a valve seating issue using some unconventional methods. Not one day goes by that I don’t miss each one of those fellas.

NOTHING LIKE APPLYING what you learned! And with brothers from “across the pond!”

The classroom has spanned the Atlantic

As important as this experience in the UK was to me, regarding the brotherhoods formed and the experience of how things are done on that side of the great Atlantic, the most important part would be the fact that we have successfully bridged the gap between the U.S. and UK. A kinship has been established, and some very important phone/email conversations have occurred. I’ve been in exchange with some of the United States’ best instructors and all are excited to carry their knowledge across the ocean in the near future, as I have. On the flip side, both Frank Massey and James Dillon have given me their blessing and agreed to teach here in the U.S. as well! Most impressively, this month, ASA is hosting an event in the Philadelphia-area of Pennsylvania called Super Saturday, and I am happy and proud to say that SEVEN of our UK counterparts are scheduled to arrive and attend the one-day event.

We have started a new culture of exchanging the way we do things over here (in the U.S.) and the way they do things over there (in the UK). With my short 20 years’ experience in the industry, I can tell you that these UK technicians are some of the most talented and intelligent I’ve ever encountered. The training and certification they implement “over there” is extremely impressive, and all of us here can stand to learn a lot from them. It’s all thanks to the incredible efforts made by that brave young man, Ryan Colley, who put a lot on the line to take a chance on me. As a result of his efforts, we have him to thank for what has occurred between these two great countries of ours. From this point forward, I will always refer to Ryan as “The Gatekeeper.” I truly hope the nickname sticks, because that is exactly who he is. We’ve made it to the UK...where will it lead us from here? The world is the limit!

BRANDON STECKLER is a working technician at Lykon Automotive in Bristol, Pa. He has worked in the field for over 18 years and holds ASE certifications A1-A9, X1, L1, L2 and L3 and C1.
theboywonder13@comcast.net

BUILDING HOMES FOR HEROES

From September 1 through October 31 at all Advance Auto Parts and Carquest Independent stores, for every ACDelco spark plug purchased, $.25 (up to $100,000) will be donated to Building Homes for Heroes, an organization that builds and gifts mortgage-free homes and completes home modifications for veterans and their families.

SHOP.ADVANCEAUTOPARTS.COM

TREAD DEPTH MEASURING TOOL

Quick Tread Edge™ is Hunter's latest drive-over tire tread depth measuring tool that delivers detailed tire condition diagnosis in less time and with added edge wear detection, providing a greater analysis of overall tire condition. Service providers can now better identify tire wear on the 'edge' of every tire, while providing customers with informative, in-depth results.

WWW.HUNTER.COM/INSPECTION/QUICK-TREAD

FVP HIGH TEMP GREASE

FVP High Temp Grease is an exceptionally versatile multipurpose grease that provides a highdropping point to protect over wide temperature ranges. Fully additive treated with EP/antiwear, rust and oxidation inhibitors, and offers superior wheel bearing and chassis protection for a variety of severe duty automotive, trucking, industrial, mining and construction equipment.

FVPPARTS.COM

ORDER OE PARTS ONLINE

RepairLinkShop.com is your online OE parts marketplace where OEM part catalogs and illustrations make finding and ordering OE parts from your local dealers easy as clicking a button. Generate higher quality repairs while taking advantage of part discounts up to 38 percent with nine OEM-sponsored discount programs. Register for free at RepairLinkShop.com to get the right part, at the right time.

WWW.REPAIRLINKSHOP.COM

BATTERY CHARGER

Clore Automotive introduces Model PL6100, a new 12 Volt 100A Flashing Power Supply and 60/40/10A Battery Charger, from SOLAR. The PL6100 is designed to provide stable power, on demand up to 100 amps, to a vehicle electrical system to support module reprogramming. It also provides full service battery charging capability from 10 to 60 amps, to service everything from small vehicle batteries to Group 31 batteries.

WWW.CLOREAUTOMOTIVE.COM

PLAN AHEAD FOR AAPEX 2019

The Automotive Aftermarket Products Expo (AAPEX) is an event where you can connect with the more than $1 trillion global automotive aftermarket industry. In 2018, AAPEX featured 2,500 exhibitors and more than 51,000 target buyers. Save the date for AAPEX 2019, which will be held November 5-7 at the Sands Expo in Las Vegas. Visit the below site to register today.

WWW.AAPEXSHOW.COM

TECHNICAL TRAINING

WORLDPAC Training Institute (WTI) offers carline-specific advanced technical training, business management solutions and exclusive Smart Groups designed explicitly for independent repair shop professionals. Always developed and taught by experienced instructors, WTI training keeps you ahead of the learning curve to ensure your business remains competitive and profitable. View the complete class listing at the below website.

WWW.WORLDPAC.COM/TRAINING

OIL FILTERS

For over 50 years, NAPAGold™ oil filters have offered premium engine protection, from lawn mower engines to earthmovers and any type of vehicle in between. With 50 percent more dirt-holding capacity than economy oil filters, NAPAGold oil filters offer the best combination of capacity and efficiency of any oil filter on the market today. For more details about NAPAGold filters, go to the below website or visit your local NAPA AUTO PARTS store.

WWW.NAPAFILTERS.COM

BRAKE DISCS

Textar engineers have utilized the knowhow that comes from decades of producing premium OE brake pads to develop a perfectly matched brake disc that ensures the ultimate braking performance of your vehicle. The Textar range of brake discs is manufactured to precise German specification and are application engineered for cars driven in North America. Textar brake discs, Textar brake fluids (DOT 3, 4, 5.1), Textar anti-squeal pastes and Textar brake tools are available exclusively at WORLDPAC, as well as a full range of premier Textar brake pads, e-pads and brake shoes.

WWW.TEXTAR-WORLDPAC.COM

WHEEL AND TIRE CLEANER

Meguiar's, the world's leader in car care products, just introduced a new addition to their premium Ultimate line, Meguiar's® Ultimate Waterless Wheel & Tire. A car is never completely detailed unless the wheels and tires are done too. This brand-new product is a ground-breaking concept that allows you to clean your wheels without water and dress your tires in one easy step.

WWW.MEGUIARS.COM

WHEEL ALIGNMENT SYSTEM

Performing fast, accurate, quality alignments doesn't have to be a big investment anymore with the new, affordable John Bean® V2000 Imaging Wheel Alignment System. The John Bean V2000 offers customers the full-imaging experience, including 3-D vehicle measurements such as fast rolling run-out compensation and full vehicle dimensions, and the V2000 is less dependent on lift calibration, at an affordable price.

WWW.JOHNBEAN.COM

NEW ROTOR PART NUMBERS

Raybestos® has expanded its R-Line and Specialty line with the addition of new rotor part numbers for the 2019 RAM 1500 and Chevrolet Silverado 1500, according to Kristin Grons, marketing manager for Brake Parts Inc LLC (BPI). Created for everyday driving conditions, Raybestos R-Line rotors deliver the most complete application-specific line on the market.

WWW.RAYBESTOS.COM

AD INDEX

AD INDEX

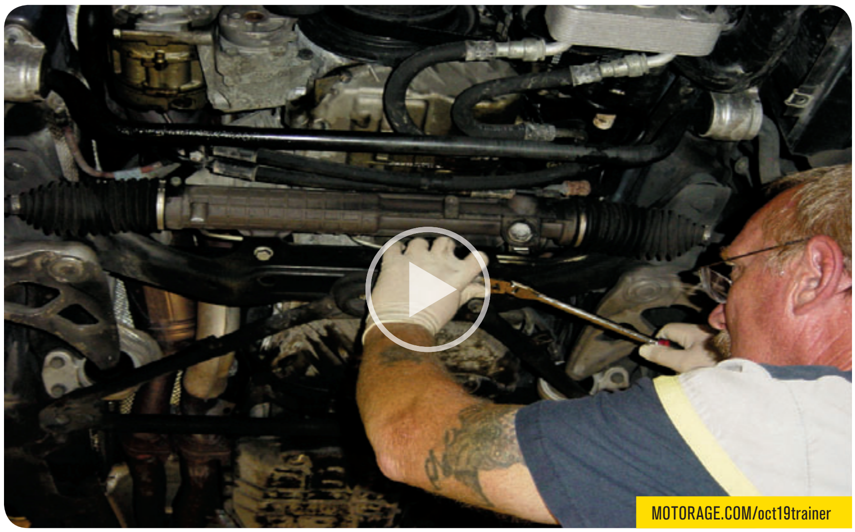
PRODUCTS

TRAINING

THE ONE AUTOMOTIVE TECHNOLOGY YOU NEED TO KNOW

UNDERSTANDING ADVANCED DRIVER-ASSISTANCE SYSTEMS IS NOT A CHOICE

PETE MEIER // Technical Editor



It's hard to believe that there are many of you reading this magazine who are content with your shop's "status quo." You send customers to the dealer when reprogramming or ECU replacements are deemed necessary, you're waiting until the last minute to add R1234yf service equipment to your business and you haven't attended a formal training event in ages.

In short, you're content doing business the way you've always done, relying on the fundamental services you learned and mastered decades ago to keep the doors open and the bills paid. You know services like steering and suspension work, oil changes and tire repairs, brake jobs and (ugh) tune-ups.

Oh, and alignments, too, right?

But there is a relatively new set of vehicle systems on the road today that are going to change all that — whether you like it or not. These are the Advanced Driver-Assistance Systems, or ADAS, and include systems like Blind Spot Monitoring, Active Cruise Control and others.

Knowing how these systems operate, and more importantly, how what you do while performing many routine repairs and services impacts how they operate, is not a choice — or shouldn't be. Even seemingly non-intrusive jobs like wheel alignments can alter the thrust angle of the vehicle, which can require recalibration of certain ADAS-related components.

These systems are designed to reduce injury and even save lives by preventing accidents often caused by momentary driving distractions we've all experienced. And you could be sending out customers today with cars unable to do that because you didn't take the time to understand how your normal, routine repair or service also changed the way one or more of these safety systems functions.

In this edition of The Trainer, we'll explore the fundamentals of ADAS and how our sponsor, Mitchell 1, can help you identify those cars in your bays equipped with these systems and what services or repairs made may require special procedures to ensure the systems work as intended when you return them to your customer. MA

SPONSORED BY

Mitchell1®

FIRST CALL ONLINE

MAKING IT FASTER AND EASIER THAN EVER TO ORDER PARTS

RECEIVE A 1% EARNBACK

ON ALL ELECTRONIC ORDERS PLACED THROUGH FIRST CALL ONLINE

FIRST CALL ONLINE IS A COMPLETE, INTERNET-BASED ELECTRONIC CATALOG DESIGNED EXCLUSIVELY FOR THE PROFESSIONAL.

FAST & EASY PARTS ORDERING
Look up parts and place the order in seconds

REAL TIME PRODUCT AVAILABILITY
Find the parts you need from your store, surrounding stores, hub or distribution center

E-PUBLICATIONS
Flyers and exclusive professional publications are just a click away

ONLINE PROMOTIONS
Access Parts Payoff and First Call Promo for additional rewards

BILLING STATEMENTS
View and print past and current billing information

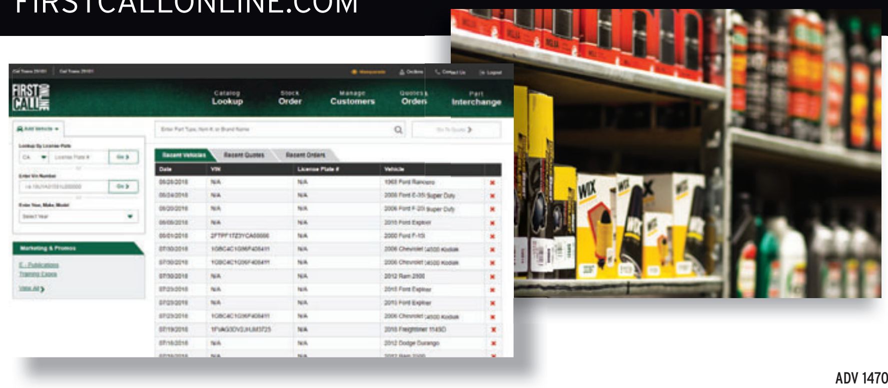
ONLINE ORDERING EARNBACK
Earn 1% back on qualifying electronic purchases

FIRSTCALLONLINE.COM

STOCK ORDER

FAST & EASY INVENTORY REPLENISHMENT
- Set your own customized stocking levels
- Create different stock orders for multiple part categories
- Templates include desired stocking & order quantities

PART DESCRIPTION & NOTES SECTION
- Add and remove items with a simple click
- Quick and easy navigation
- Access from anywhere, anytime



ADV 1470


WORLDPAC
Wholesale Distributor of Original Equipment Automotive Parts
QUALITY NEVER GOES OUT OF STYLE
BOSCH
HITACHI
akebono BRAKE EXPERTS
ADVICS
DENSO first time fit
KYB World Class Shocks & Struts
DELPHI
Valeo
TEXTAR BRAKE TECHNOLOGY
febi bilstein
CTR
Arnott Air Suspension Products
Hengst FILTER
BEHR HELLA SERVICE
LIQUI MOLY
Gates
CARDONE
AISIN
IDEMITSU
VAICO
VEMO
ACKOJA
HÜCO
Continental
MITSUBOSHI
GEBA
GKN
SACHS
STABILUS
TRW
LEMFÖRDER
ZF
rein AUTOMOTIVE
CORTECO
NGK SPARK PLUGS
NTK OXYGEN SENSORS
Nissens
HELLA
PENTOSIN
SCHAEFFLER
RED LINE
MOPAR
elring
MAVAL
Santech Automotive A/C Components
CSF
Walker
Zimmermann Brake Discs · Brake Drums
BCA BEARINGS by NTN
MEYLE
MAHLE ORIGINAL
serving independent import & domestic automotive service professionals
become a customer today
worldpac.com/quality