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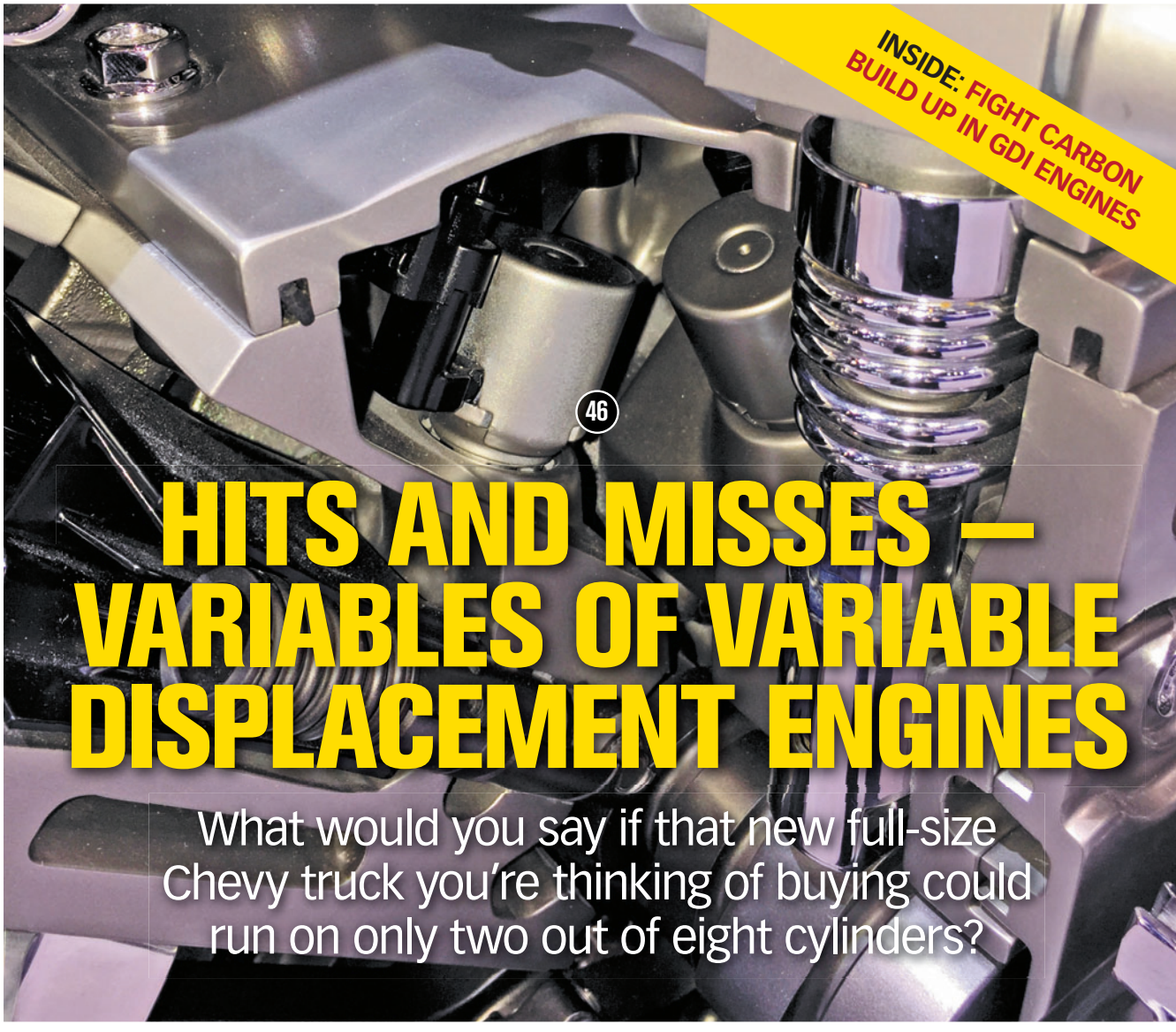

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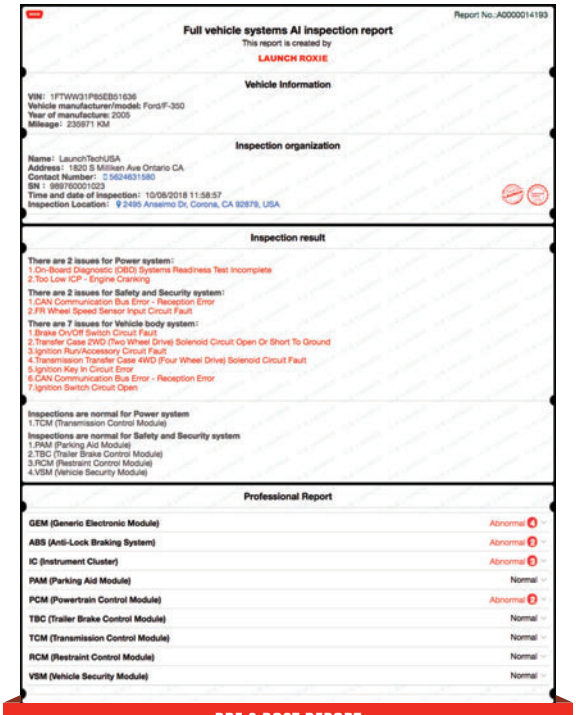

Full vehicle systems AI inspection report

This report is created by LAUNCH ROXIE

Report No.:A0000014193

Vehicle Information

VIN: 1FTWW31P85EB51636
Vehicle manufacturer/model: Ford/F-350
Year of manufacture: 2005
Mileage: 235971 KM

Inspection organization

Name: LaunchTechUSA
Address: 1820 S Milliken Ave Ontario CA
Contact Number: 5624631580
SN: 98976001023
Time and date of inspection: 10/08/2018 11:58:57
Inspection Location: 2495 Anselmo Dr, Corona, CA 92879, USA

Inspection result

There are 2 issues for Power system:
1.On-Board Diagnostic (OBD) Systems Readiness Test Incomplete
2.Too Low ICP - Engine Cranking

There are 2 issues for Safety and Security system:
1.CAN Communication Bus Error - Reception Error
2.FR Wheel Speed Sensor Input Circuit Fault

There are 7 issues for Vehicle body system:
1.Brake On/Off Switch Circuit Fault
2.Transfer Case 2WD (Two Wheel Drive) Solenoid Circuit Open Or Short To Ground
3.Ignition Run/Accessory Circuit Fault
4.Transmission Transfer Case 4WD (Four Wheel Drive) Solenoid Circuit Fault
5.Ignition Key In Circuit Error
6.CAN Communication Bus Error - Reception Error
7.Ignition Switch Circuit Open

Inspections are normal for Power system
1.TCM (Transmission Control Module)

Inspections are normal for Safety and Security system
1.PAM (Parking Aid Module)
2.TBC (Trailer Brake Control Module)
3.RCM (Restraint Control Module)
4.VSM (Vehicle Security Module)

Professional Report

GEM (Generic Electronic Module)	Abnormal 4
ABS (Anti-Lock Braking System)	Abnormal 2
IC (Instrument Cluster)	Abnormal 3
PAM (Parking Aid Module)	Normal
PCM (Powertrain Control Module)	Abnormal 2
TBC (Trailer Brake Control Module)	Normal
TCM (Transmission Control Module)	Normal
RCM (Restraint Control Module)	Normal
VSM (Vehicle Security Module)	Normal

- PRE & POST REPORT -
WILL AUTOMATICALLY SEND UP TO 5 EMAIL ADDRESSES

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Talk Shop Anytime

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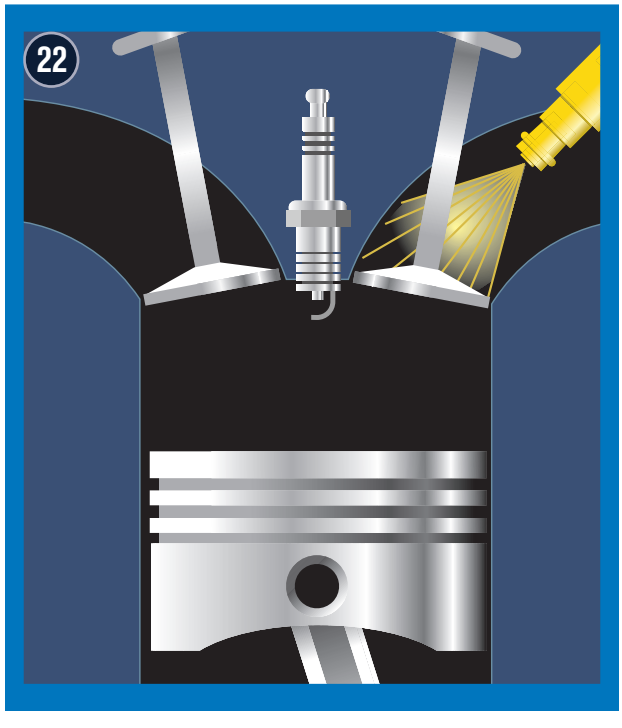
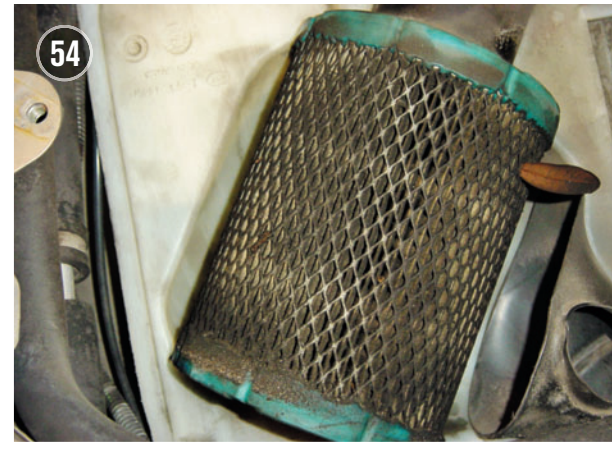
OPERATIONS





TECHNICAL

IN EVERY ISSUE

WEB EXCLUSIVES // MOTORAGE.COM

FINDING THE RIGHT TSBS

TSBs are the piece of the repair puzzle you cannot miss. But there are hundreds of thousands of TSBs. How do you know what you need? Let's start with what a TSB is — and isn't — and how it differs from a recall and campaign.

That's the start of Finding and Using the Right TSB, brought to you by Mitchell 1.

Gary Hixson, a senior market manager with Mitchell 1, returns to teach you when to look for bulletins, how to determine what applies to your vehicle, new technology available within a TSB and much more!

With more than 5,000 new TSBs added by OEMs annually, this piece of the diagnostic puzzle is one you must fully understand.

MOTORAGE.COM/RIGHTTSBS

Motor Age

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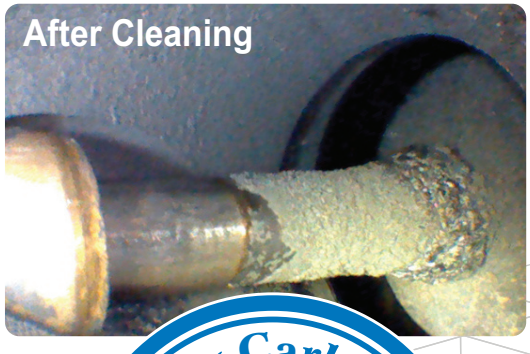

- "At Independent Vehicle Service we have used all of the industry's big name induction cleaning chemicals over the years, however all of these chemicals have fallen short of our expectation. They just don't work. The 3C is the first carbon removal system that I have used that works well and I can confidently recommend to our customers."

David Lang 2017 Bosch Master Mechanic of the Year.
AES Master Certified Technician with L1, L2, L3.

- "We had previously been performing walnut blasting to clean carbon buildup. Some walnut blasting operations were taking us as long as 9 hours, but with the ATS induction machine (in most cases) you are done in less than half an hour, with equally good results. I highly recommend the 3C Intelligent Induction Cleaner. It works just as advertised. This is just another way to save your customer money while making your shop more efficient and profitable."

Andreas Wittler Owner Hans Wittler's Automotive

- "We have used most major brands carbon cleaning chemicals with disappointing results. The 3C induction cleaning machine is the first cleaning process I have used that actually works. I highly recommend this system."

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ADAS

ADAS ADAPTION HEADING TOWARD CATEGORY GROWTH

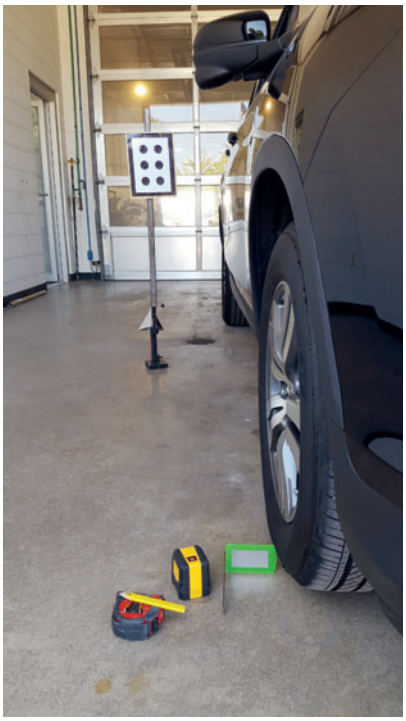
JAMES E. GUYETTE //
Contributing Editor

As OEM-installed and retrofitted Advanced Driver-Assistance Systems (ADAS) continue to gain popularity, the aftermarket is well-positioned to provide much-needed education and training for installers, repairers and motorists along with benefitting by selling the numerous ad-on products that are becoming available within the category.

"ADAS is among the fastest-growing automotive segments today, and it presents a significant opportunity for aftermarket retrofitting and new vehicle upgrades," says Chris Kersting, president and CEO of the Specialty Equipment Market Association (SEMA), which has produced an analysis, Advanced Vehicle Technology Opportunities, offering insights about the category's prospects.

In 2017 the segment was valued at just under $1 billion, and it is expected to grow to more than $1.5 billion by 2021, according to a SEMA-commissioned study conducted by Ducker Worldwide and the Center for Automotive Research (CAR).

Establishing just what this category actually entails is a topic requiring clarification, as both the Motor & Equipment



Manufacturers Association (MEMA) and the American Automobile Association (AAA) are calling on the industry to precisely define universal nomenclature along with detailing the product lines, properties and capabilities of the equipment.

At a SEMA-sponsored briefing in January, Chris Gardner, senior vice pres-

>> CONTINUES ON PAGE 5

BREAKING NEWS

CONTEST

CARDONE LAUNCHES COMPETITION TO SHARE KNOWLEDGE

CARDONE Industries, a leader in the automotive aftermarket, has announced the latest edition of its popular video competition for automotive technicians to share their installation skills and enter to win $5,000. Based on the success of the first two contests, CARDONE has renewed its challenge to technicians of all skill levels, from professional automotive technicians to enthusiastic DIYers, to create and share an original video featuring the installation or service of an under-the-hood or under-the-car automotive part.

"We're particularly excited to launch this next round of our video contest after learning what our most recent winner chose to do with his prize. He decided to use the entire $5,000 to purchase and restore a car that he donated to a single mother

>> CONTINUES ON PAGE 5

TRENDING

EV SALES INCREASE, GAS STILL PREFERRED

The California green vehicle market continues to experience increases year over year, but consumers — 85 percent — still strongly prefer gasoline-powered vehicles, research shows.

MOTORAGE.COM/EVSALES

ICAHN AUTOMOTIVE TO OFFER SCHOLARSHIPS TO FUTURE TECHS

Icahn Automotive will award scholarships to students as part of the Race to 2026 initiative aiming to increase the number of trained technicians in the industry.

MOTORAGE.COM/2026

2019 WORLD CLASS TECHNICIANS ANNOUNCED

The Auto Care Association and the National Institute for Automotive Service Excellence (ASE) announced the 2019 World Class Technician recipients.

MOTORAGE.COM/CLASS

MACS 2019 ENGAGED, ENTHUSIASTIC

The MACS 2019 Training Event saw attendees who were engaged and enthusiastic about training classes and grateful for the presenters, exhibitors and supporters who participated.

MOTORAGE.COM/EVENT

AAPEX TO WELCOME GLOBAL AFTERMARKET

AAPEX 2019, set for Nov. 5-7, will feature new product introductions, advanced training and current and futuristic technology demonstrations at this year's Las Vegas event.

MOTORAGE.COM/NOV5

>> CONTINUED FROM PAGE 4

ident of operations at MEMA's Automotive Aftermarket Suppliers Association (AASA), discussed the need for cross-industry collaboration on standardizing ADAS procedures, terminology, training and certification pertaining to business owners and technicians.

AAA's research reports that there is at least one ADAS feature available on nearly 93 percent of all new vehicles sold in the U.S. Ellen Edmonds, the organization's public relations manager, points out that as ADAS units achieve broader acceptance, "it is becoming increasingly important for consumers to have a solid understanding of their functionality."

>> CONTINUED FROM PAGE 4

in his community who was in need of reliable transportation. His generosity is a perfect example of the spirit and atmosphere we hope to inspire with this competition," said Stephen Sigg, Vice President of Customer Experience & Marketing.

To enter the content, videos must be submitted through videocontest.cardone.com. The entry period runs from now to July 17, 2019. CARDONE will determine the $5,000 winner based on a point system that tallies online votes and views tied to a specific video. Points can be gathered throughout the contest and will continue after the video deadline with a final count on July 31, 2019.

CARDONE will announce the winner on August 14, 2019 through the contest website and on cardone.com. The winner and other top-rated contestant videos will also join entries from the last contest on CARDONE's YouTube channel.

The complete list of rules and entry requirements are available online at videocontest.cardone.com/terms-and-conditions. Visit videocontest.cardone.com for more information about the contest.

VIRTUAL PERSONAL ASSISTANTS POISED AS THE NEXT TARGET VEHICLE INTEGRATION

BRIAN ALBRIGHT //
Contributing Editor

At the Consumer Electronics Show (CES) in January, in-vehicle infotainment was a hot topic, with both OEMs and tech companies announcing partnerships and new products that will make vehicles more connected than ever.

Virtual personal assistants (VPAs) like Siri, Google Assistant and Amazon's Alexa are also making their way into vehicles. According to new research from IHS Markit, nearly 700 million of these software platforms will be used in vehicles by 2024. That includes embedded systems, smartphone-based solutions, or connections to smart home solutions.

A survey by Voicebot.ai found that 77 million U.S. adults use voice assistants in their cars at least monthly. Google and Amazon have both made strong plays for in-vehicle assistant use.

"What's driving this is consumer dissatisfaction with voice recognition systems that come in the vehicles from OEM suppliers," says Colin Bird-Martinez, senior analyst of automotive software and services at IHS Markit.

According to the IHS Markit report, Google Assistant and Alexa are projected to be the first significant embedded VPA solutions available in cars via infotainment head unit integration and other systems. Approximately 12 million light vehicles will have this type of system by 2024.

Smartphone integration, however, will account for the largest chunk of the market, with more than 300 million vehicles equipped with such systems in the same period. Roughly 40 million vehicles will have device-to-car systems that take commands from a home device like Amazon Echo or Google Home.

"Some automakers have not made an investment in this technology, and partnering with Google or Amazon helps raise brand awareness and excitement from consumers," Bird-Martinez says.

Others are hesitant to adopt third-party technology because they don't want to lose control of branding and driver data. There are also data privacy and data monetization issues, as well as perceived competition for services between the OEMs and providers like Amazon.

At CES, Bird-Matinez says he also saw companies trying to develop solutions that would allow access to the full gamut of VPAs through third-party devices. "They were software agnostic and really show the ease of use of these VPAs," he says. "This goes back to the marketplace idea that GM and Hyundai have followed so that consumers can download different apps and payments for things like gas and food."

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How to master the art of persuasion

People will forget what you said and did, but not how you made them feel

What's possible if you become a master of persuasion? Let's listen to ATI Coach Eric Twiggs explain how you can accomplish this in your shop.

As I ponder this question, I'm reminded of something that happened back when I was a shop manager in need of a new car. The shop was 45 minutes away from home, so I was looking for a reliable and dependable vehicle. The plan was to get a car that I could drive until the wheels fell off!

My first stop was to the Honda dealer. The salesman told me all about the affordable price and superior fuel economy while I was test driving a blue Honda Accord Ex.

It made sense logically, but I left without buying and went to the Toyota dealer. At Toyota, the salesman and I looked at a black Toyota Camry LE, and he told me all about the smooth-riding, long-wearing tires, and how that model was ranked as the No. 1 mid-size car according to Consumer Reports.

The Camry seemed to be a logical choice, but I decided to keep looking. On my way home, I stopped by the local BMW dealer just to window-shop.

The salesman had me test drive a silver BMW 325I and asked me to imagine the look on my friends' faces as I drove by in my "Bimmer." I threw up an objection by mentioning that my financial documents were at home. He responded by allowing me to drive the BMW home to get the necessary paperwork!

This may surprise you, but I decided to purchase the BMW! Later, whenever people asked me why, I would tell them about how well it handled on the highway, the ABS brake system, and its durability. In reality, I made an emotional decision that I used logic to justify. Your customers are just like me. When they make a purchase decision, emotion is the ultimate driving machine.

So, the key to mastering the art of persuasion is to focus on making emotional connections. Keep reading as I use logic to justify my previous statement.

WE TEND TO ARRIVE AT PURCHASE DECISIONS BASED ON AN INTUITIVE EMOTIONAL RESPONSE THAT WE LATER EXPLAIN USING LOGIC.

What science says

By now you're probably thinking, "Nice try, Twiggs, but my customers are different!" Well, according to research conducted by Harvard University professor Gerald Zaltman, they aren't.

His study found that 95 percent of all purchase decisions take place unconsciously. In other words, we tend to arrive at purchase decisions based on an intuitive emotional response that we later explain using logic.

When it comes to automotive service, is your shop merely the logical choice? You've been in business for 30 years, you're family owned and operated, you're cheaper than the dealer, and you even have WiFi in your waiting room. Yet, in spite of these logical reasons, you have customers who leave your shop without buying, because they've decided to keep looking.

So, what can you do to master the art of persuasion? Read on to discover the three building blocks of effective persuasion as outlined by the Greek philosopher Aristotle in his book, *Rhetoric*.

Authority

The Greek word that Aristotle uses for authority is "ethos." This refers to the perceived credibility of the individual or business. We tend to be persuaded by people we perceive to be an established authority and will defer to them when making purchase decisions.

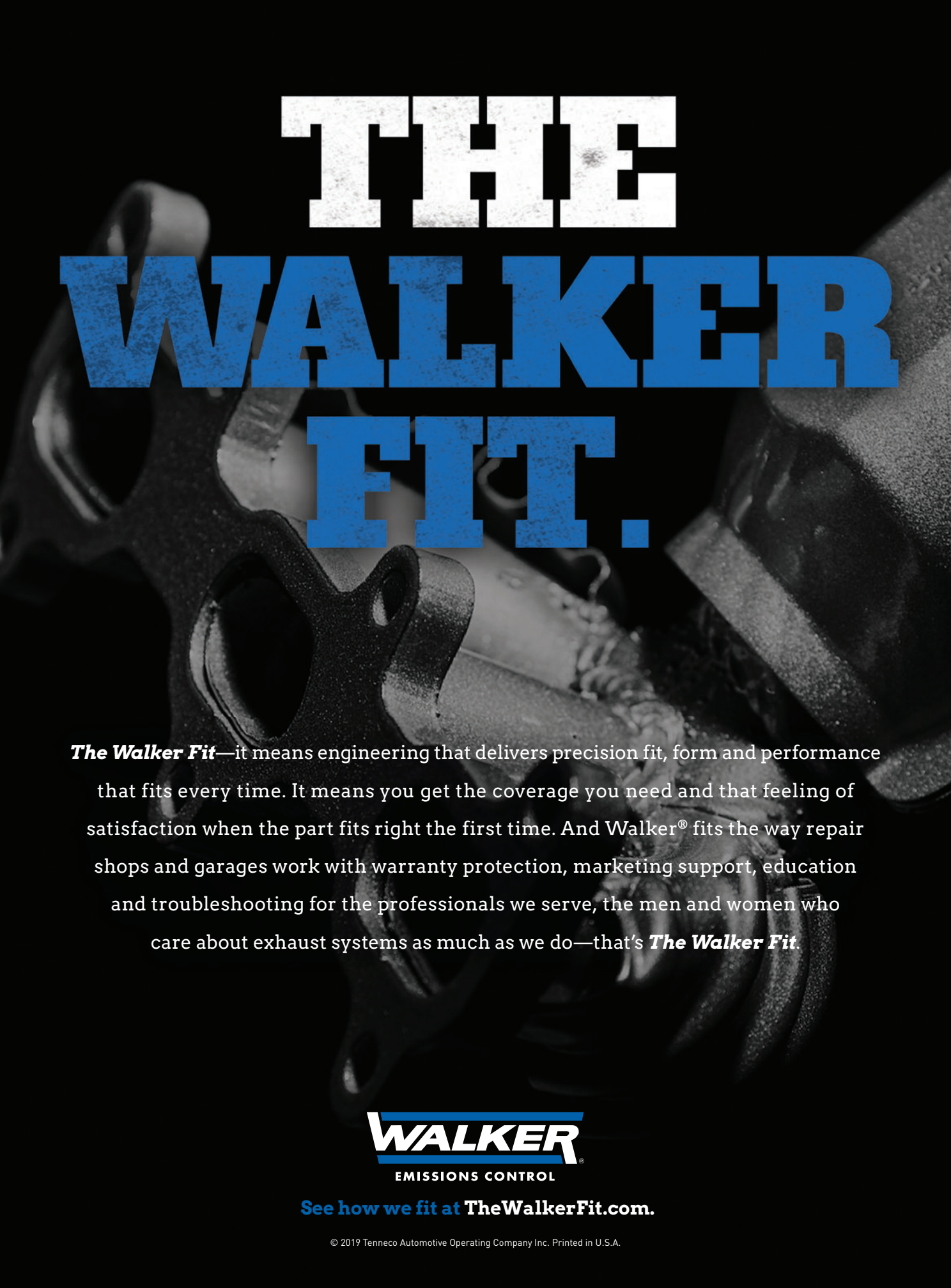
Advertisers leverage this principle by having your favorite celebrity in their commercial driving the car they want you to buy. Your accountant may tell you it's not in the budget, but the authority of the celebrity could sway you to make the purchase anyway.

At your shop, getting five-star internet reviews, writing blog posts (the root word for "authority" is "author") and being interviewed on your local TV and radio stations, are ways you can position yourself as the automotive authority in your community.

Logic

The Greek word for logic is "logos." This is where data, facts and reason are used to persuade. Yes, logic does factor into the persuasion equation. However, my previously mentioned Honda and Toyota salesmen would agree that attempting to persuade solely on logic is a recipe for failure.

In a selling situation, the features of a product or service represent the logic,



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while the benefits tie back to the emotion.

Here's the most common mistake I come across when I role play selling scenarios with service writers: They use what I've coined as, "The all AND nothing approach!" They run down the list of ALL the features and say NOTHING about the benefits to the customer.

I recommend using the 30/70 rule of selling by talking about the features 30 percent of the time and spending 70 percent of your time FOCUSED ON THE BENEFITS!

Emotion

The Greek word for emotion is "pathos." This involves persuading through emotion and empathy. The BMW salesman convinced me to purchase the car by focusing on my favorite radio station: — WIIFM: What's In It For Me!

He recognized that I wasn't just buying a car. I was investing in status and prestige. Your customer listens to WIIFM as well. As a result, she's not really buying what you may think. For example, she's not just buying front brakes. She's investing in her daughter's safety while she's away at school. She's not just buying four tires. She's buying a secure trip to soccer practice.

This makes visiting the car with the customer a critical step in the process. At the car, you have a golden opportunity to ask questions to discover what she really wants, and to tailor your conversation accordingly.

We've already established that emotion is the ultimate driving machine. Focusing on what they really want will ensure that you make an emotional connection with your customers.

Conclusion

So, there you have it. Making an emotional connection by leveraging the three building blocks will allow you to master the art of persuasion!

I'm living proof that this works. Recently while shopping for a car, my wife persuaded me to buy a shiny, silver Toyota Camry.

Do you want to get better at the art of persuasion? Do you want to have better communication with your staff and customers? Then you need to get your copy of the "7 Triggers to Yes Checklist." To get your free copy, simply go to ***www.ationlinetraining.com/2019-04*** for a limited time.

LESSONS LEARNED FROM AN FBI NEGOTIATOR

SHERYL DRIGGERS //
Contributing Editor

One thing we all do every day is negotiate. Any time we are trying to get someone to do something, we are negotiating. That is why I love the book *Never Split the Difference* by Chris Voss, the former lead international hostage negotiator for the FBI.

Successful negotiations are not bully sessions. Most importantly, negotiation is the heart of collaboration.

Mirroring is simply an imitation of what the other person is saying — repeating back the last two to three key words of what someone said. When you do this, you signal to their subconscious we are alike, and it keeps people talking in order to gather information and build trust. Using a mirror is a great way to encourage your counterpart to expand on what they said and show them you have been paying attention. This also helps you get to the bottom of why they don't want to do what you want. One important thing Voss points out is to never ask "why." We were ingrained from an early age that asking why is negative. As a child, did you ever hear, "Why did you do that?" You immediately knew you did something wrong. Instead of asking "Why?" replace it with how, what or when. Continue reading at MotorAge.com/negotiate.

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

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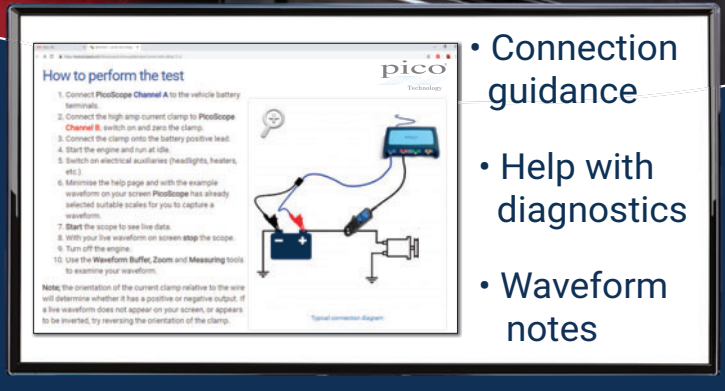

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Dad, stop filtering the information

Succession plans only work when the successor is completely immersed

The industry has to get through succession sooner than later; however, the older generation is having a very difficult time. For businesses that have sons or daughters (or both) who are interested in taking over the business, we hear from parents that their child or children are not ready for this business yet, as they are only 21 (ish) years old. Based on that statement it is clear how parents are not engaging or involving the son or daughter properly.

First, the parent must acknowledge that the 21-year-old is a young adult, not a child. If you, the parent, have always kept them there with your daily approach to them, ask yourself why you are doing that. Are your own insecurities today getting in the way of the future?

Second, in order for a successful succession to take place, an apprenticeship training period must happen. This means that the successor is fully exposed to all issues within the business and industry from all points of view. A good apprenticeship can take up to 5 to 10 years, in which the successor becomes the "right-hand person" with their opinions and views fully expressed at closed-door meetings. Now they are making an informed decision as to whether they want this business to be their career.

The problems I have witnessed are when the dad will not let go and takes the attitude that "Dad is always right." However, the successor desires to go down a more modern road by introducing better business processes and/or newer technologies to streamline and operate more efficiently and professionally. Dad is having a tough time grasping the new ways, so he rationalizes by imploring, "We have done well — why change? Who says that stuff is right for *our* business?"

If succession is going to move forward, Dad has to start listening, understanding and respecting his child's opinions, as well as stop cherry-picking what information the successor sees or is involved with. They must be properly exposed to all issues within the shop and be part of all discussions leading to solutions. Their opinions must be supported, respected, and, in the end, they too must be held accountable. Accountability will teach the next generation where mistakes are/have been made and where successes are realized to embrace.

A SUCCESSOR'S OPINIONS MUST BE SUPPORTED, RESPECTED AND, IN THE END, THEY TOO MUST BE HELD ACCOUNTABLE.

They must attend as many courses on business management as they can find and if travel is involved, make sure the investment is made. Ensure the content within the course is truly relevant. They will require a minimum of six to eight days of business management courses per year to ensure the business depth is fully understood in this forever-changing auto care industry.

The next generation should be attending some key technical classes with the shop's technicians to also get an overview on vehicle technology and build positive, respectful relationships with the staff.

The successor must be exposed to all industry association meetings and events to interact, network, connect and understand the industry, which helps them to understand their own business.

Accept that mistakes will be made — and Dad, is that not how you learned as well? The experiences for the successor are invaluable.

There are also times when the parents do not have the skill or confidence to proceed down this succession road with their sons or daughters, and that is the time when additional help must be brought in to facilitate the discussion and keep the process moving. Take the time and seek out the right individual who you would be comfortable with and engage in the succession discussion. If after the discussion period you are comfortable, then it is time to introduce that professional coach to the son or daughter so everyone can start the process.

Time is growing short for a proper succession period to take place. Make this step a priority to ensure absolute success for both sides of the family.

BOB GREENWOOD, AMAM, is president and CEO of Automotive Aftermarket E-Learning Centre Ltd. (AAEC), which provides business management resources for the automotive aftermarket. Bob has more than 36 years of business management experience and is one of 150 worldwide AMi-approved instructors.
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Missouri on track to cut safety inspection program

Aftermarket calls on legislators to oppose House Bill 451

House Bill 451, introduced by Missouri State Representative J. Eggleston, seeks to eliminate the Missouri vehicle safety inspection program. This legislation is similar to House Bill 1444, which did not pass in 2018. The Automotive Service Association (ASA) and other aftermarket associations oppose the legislation. For many years, the Missouri program has been touted as one of the best programs in the U.S.

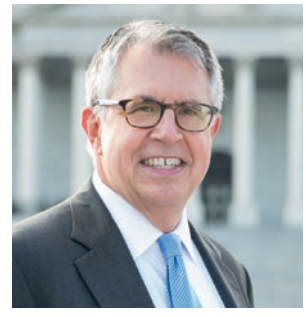
In addition to the Missouri State Patrol, the Pennsylvania Department of Transportation and most recently the Center for Transportation Research at the University of Texas published reports supporting the value of their home-state programs in preventing accidents, injuries and deaths.

Presently, there are 15 state inspection programs. There were over 30 programs when Congress tied state vehicle inspection to federal highway funds. Once these programs were not mandated, the numbers decreased rapidly.

In addition to preventing accidents, injuries and death, vehicle inspection proponents encouraged the use of these programs to educate consumers about vehicle recalls. Airbag and other recall notices have overwhelmed consumers and the National Highway Traffic Safety Administration (NHTSA). Despite website revisions and partnerships, NHTSA has lagged in educating vehicle owners and assuring responses to recall notices.

The Missouri legislation is particularly troublesome with its track record of moving in the state House. As of this writing, the bill is nearing floor consideration.

In a letter to the Speaker of the Missouri House of Representatives, ASA stated: "ASA is a proponent of state vehicle safety inspection. Study after study has demonstrated that these programs prevent accidents, injuries and deaths. ASA has used the Missouri program as an example for other states of a successful vehicle safety inspection program. Data collected by Missouri in years past has been helpful in better understanding the importance of these programs by comparing states that have vehicle safety inspection programs with those states that do not."



Recently, aftermarket partners Auto Care Association and the Tire Industry Association (TIA) also joined together to oppose Missouri House Bill 451.

The Auto Care Association, in a letter to Missouri legislators, highlighted a comprehensive University of Texas study: "After conducting a thorough investigation of the costs and safety impacts of eliminating the motor vehicle safety inspection for passenger vehicles, the findings from this study's analysis indicate that the Inspection Program saves lives and enhances safety. The research team strongly recommends the following: **Retaining the Inspection Program and conducting a further study to consider whether potential additional inspection items, such as tire age and recall information, should be included in the Inspection Program to further enhance highway safety in Texas."**

TIA called for Missouri legislators to oppose the bill: "TIA believes the Inspection Program in Missouri saves lives and enhances safety. Strong research has been conducted to support this claim. Removing the state inspection program could lead to more fatalities on Missouri roads, unsafe vehicles and a loss of revenue to businesses and the state. The average age of vehicles on the road today is nearly 12 years, and the largest growing segment of vehicles is 16 years and older. These aging vehicles need to be able to meet safety standards for repair and maintenance in the interest of public safety for all motorists on the road."

Members of the Missouri aftermarket and consumers are encouraged to contact their legislators asking them to oppose HB 451.

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

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Diagnostic agenda

Shop aims to fix what is concerning quickly and not oversell

ROBERT BRAVENDER // Contributing Editor

Around the time diagnostic technology had taken hold in the independent market, a very sage shop owner once noted that a big swap had occurred in the way problems were investigated: what used to take minutes to diagnose and a couple hours to fix now took hours to diagnose and minutes to fix. Of course, knowing how to interpret the diagnostic data is what adds the hours to this adage.

Rusty Flake wasn't that particular shop owner, but he's keenly aware of this crucial fact. "I don't like 'silver bullets,'" he proclaims. "That's where generic scan tools have a database of previous fixes by other shops. Say a car has a cam code; it gives you quick fixes kind of like Google or YouTube searches. Although they're not supposed to be used for that, a lot of folks do, and I just refuse to do it. Pulling codes is one thing; that doesn't tell you what's wrong with the car."

It's like seeing a doctor who examines symptoms and writes a prescription without really looking into the patients themselves. "A lot of people tell me I'm wrong, but I don't want to find absolutely everything wrong with every car that comes in," states Flake. "We make sure there aren't any safety issues of course, but we [primarily] look for things that concern the customers."

A specialist in diagnostics, Flake has been in the industry for over 35 years, but it wasn't until 2013 that he opened his own shop, Advanced Automotive Diagnostic and Repair. Located in rural Whiteland, Ind., about 20 miles south of Indianapolis, he notes that "nit-picking every car would never work; the income here is not all that high. If you did, you'd put yourself out of business in a hurry."

But Flake wasn't in a hurry to open either, as his long grey beard attests. "I would have liked to have done it earlier in my career," he muses, "but I had worked at a couple of good places early on." A decade earlier Flake had bought a small partnership in another business but not big enough to make some of the changes he wanted. Eventually he sold off his share and went independent.

"Sink or swim, I took what few funds I had from my retirement accounts," he explains, "and my wife took hers out and we went out on our own."

Due to a two-year non-compete clause, he also started with nearly no customer base. "If they contacted me that was fine, but I couldn't contact them," he recalls. "And I had to move at least eight miles away from the other shop. Since I couldn't find a [suitable] building anywhere, the first place we went to was in the back of an industrial park."

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Rusty A. Flake Owner	**4** No. of bays
1 No. of shops	**3** No. of lifts
5 Years in business	**22** No. of customer vehicles per week
5 No. of employees	**$422,000** Annual gross revenue
2,100 Total square footage of shops	

This would prove a hindrance to drive-by traffic, and any budget for marketing initially went to fixing up the facility and paying rent. On the plus side, Flake owned a huge inventory of scan and hand tools, "plus I had one lift at home," he adds, as his previous employer had allowed him to do side work on vehicles that couldn't find solutions at any other shops.

"Even though I wasn't a real extrovert," says Flake, "I knew how to talk to people and how to troubleshoot cars and find out what was wrong. I didn't need to make a ton of money right

PHOTOS: ADVANCED AUTOMOTIVE DIAGNOSTICS AND REPAIR

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from the get-go, but I could explain to customers what was going on, get their car fixed as quickly as possible at a reasonable price, and treat them like family. That's what I was thinking I would do when we opened, and it seems to have worked out fairly well."

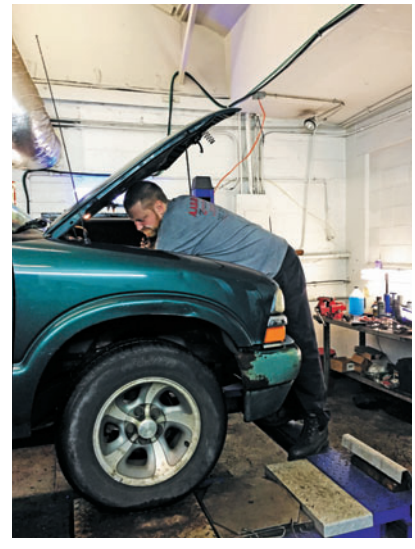
Now in his second facility, it's a smaller building, but being just a mile and half from I-65, they get occasional referrals whenever the semi-truck shops at the exit receive a car repair. "I'm not a huge shop," he confirms, "but we stay fairly busy and we all seem to get along with customers and the guys in the shop as well."

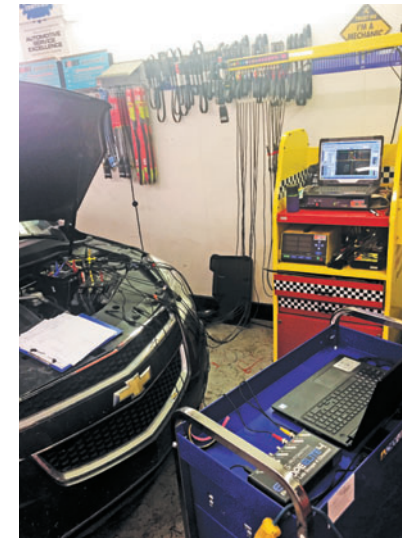
Outside of diagnostics, they don't really specialize in anything. "We do air conditioning, suspension, brakes, electrical problems, pretty much any running problems," lists Flake. "Drivability, electrical; we're not afraid to dive into anything there, and some cars are sent here from other shops — some of them 50-60 miles away."

But perhaps what makes Flake himself unique is his alter ego around Christmas — Harley Santa.

"I started it in '09," he recalls. "I wanted to ride in the wintertime and my wife told me I was crazy — there was no purpose to ride in the winter. So I needed to create a purpose, and I thought I'd do this Harley Santa thing."

Armed with packets made up of custom coloring pages, donated crayons and candy canes, Flake makes daily forays after work on his '07 Road King, stopping in shopping mall parking lots to hand out packets to kids and have pictures taken.



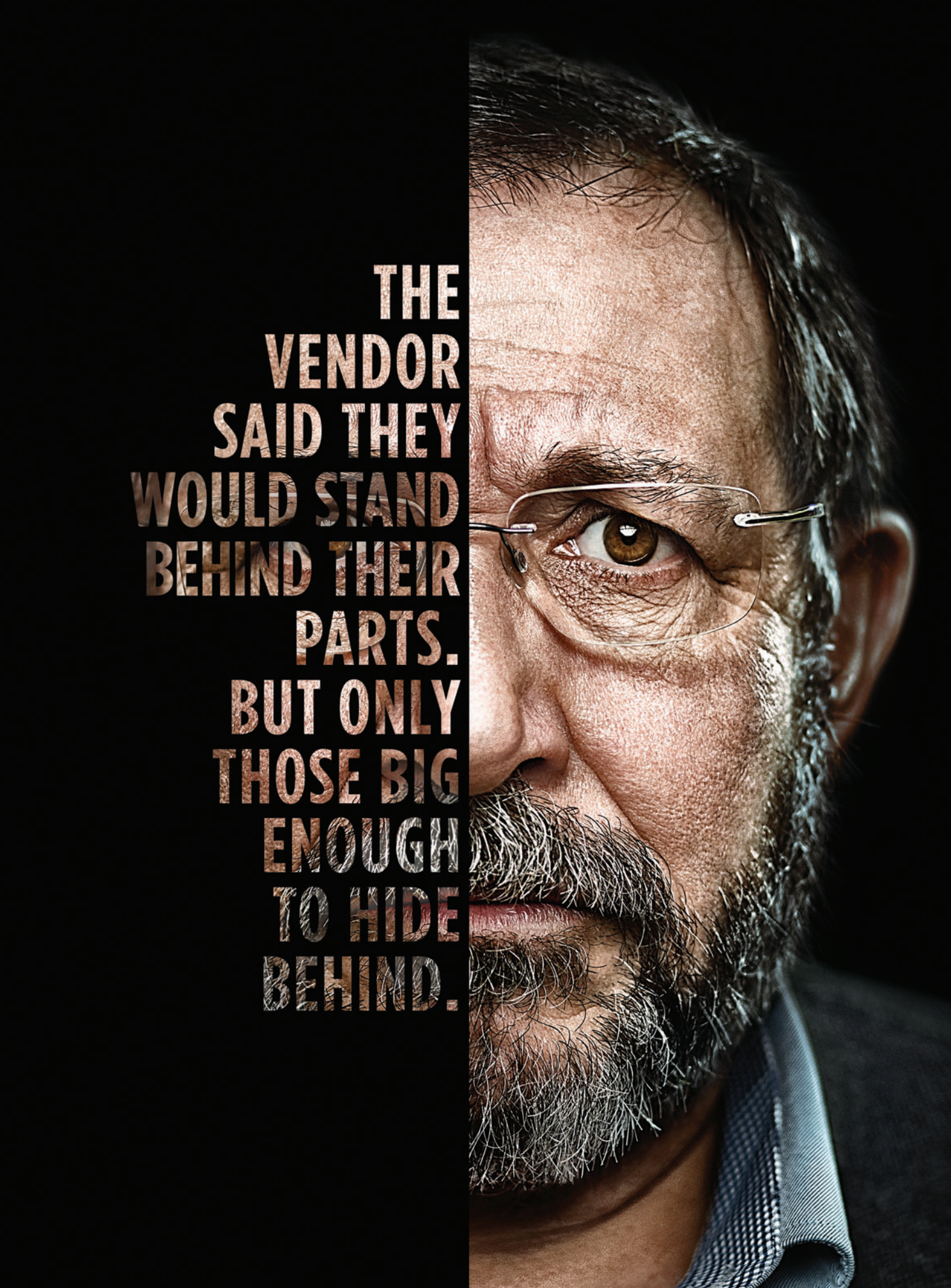


Eventually he works his way north to downtown Indianapolis and the famous Monument Circle. There he'll finish off giving out his kits before heading home to repeat the whole thing the next day.

Frankly, Rusty, we're siding with your wife on this one. "Well, when you have your thermals on for work and your outer clothing, after you put on a leather jacket and the Santa suit, it's really hot. And with the natural beard and the hat, it's really not cold unless you get to single-digit degrees and hit the interstate at 80 miles an hour." Weather permitting, Flake makes this daily ride starting the day after Thanksgiving until Christmas Eve.

"A lot of people thought some crazy old man was doing it at first," Flake laughs. "Since then it's grown pretty much every year — we do about 2,500 packets. Now I do it because it's such a blast; the kids seem to enjoy it, and a lot of them come back year after year." A lot like his business. Maybe Flake's onto something there.

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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CARBON BUILD UP IN GDI ENGINES

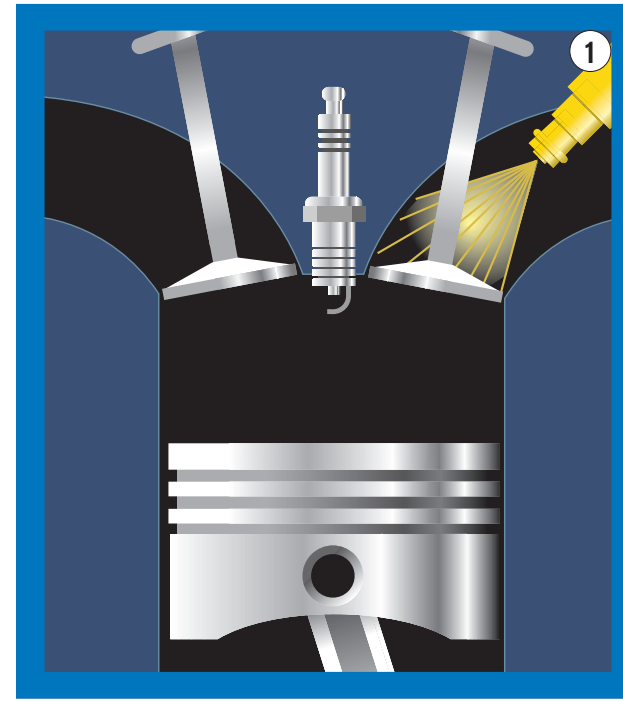
A RELATIVELY NEW CHALLENGE FACING TECHNICIANS IS IN DEALING WITH THE DRIVABILITY EFFECTS OF CARBON IN THE INTAKE TRACK AND COMBUSTION CHAMBER

BERNIE THOMPSON // Contributing Editor

Anyone familiar with the internal combustion engine understands that these devices produce carbon. This is a result of using hydrocarbon fuel stocks and lubrication oil within the engine. There are many different types of fuels currently used in the U.S. and abroad; however, the two primary fuel stocks used in the U.S. for on-highway transportation are gasoline and diesel. Either of these fuel stocks will produce carbon as a result of the combustion process within the cylinder.

The fuel is comprised of chains, rings and branches of hydrogen and carbon. When fuel reacts with oxygen during the combustion process carbon and hydrogen atoms from the fuel disassociate from one another and form new chemical bonds with oxygen. Hydrogen atoms react with oxygen to form dihydrogen monoxide (H_2O — water), and carbon atoms react with other oxygen to form carbon dioxide (CO_2). If the amount of hydrogen, carbon and oxygen atoms are not in the exact ratio to complete these reactions then some hydrocarbons are not completely combusted. The hydrocarbons that do not combust or do not burn completely either stay as hydrocarbons or form other chemical compounds such as carbon monoxide (CO).

When an organic compound, such as a hydrocarbon-based fuel, has a combustion reaction it produces heat. If there is a lack of oxygen during the burning of the fuel then pyrolysis occurs, which is a type of thermal decomposition that occurs in organic materials exposed to high temperatures. Pyrolysis of organic substances, such as fuel and oils, produces gas and liquid products but also a solid residue rich in carbon. Heavy pyrolysis leaves mostly carbon as a residue and is referred to as carbonization. Pyrolysis can occur rapidly or slowly depending on the temperature. An example of slow pyrolysis is the formation of carbon deposits within the induction system of the engine. Lubricating oils and fuels accumulate in the intake system and, when exposed to heat over a period of time, pyrolysis bakes off some of these oils and fuels as light chemicals and leaves heavier chemicals. Over time this becomes heavy carbonization (carbon deposits).



Same but different

It is important to understand that the carbon produced within an engine is not all the same. The carbon in the combustion chamber is produced under high heat and high pressure. Due to the conditions within the combustion chamber the

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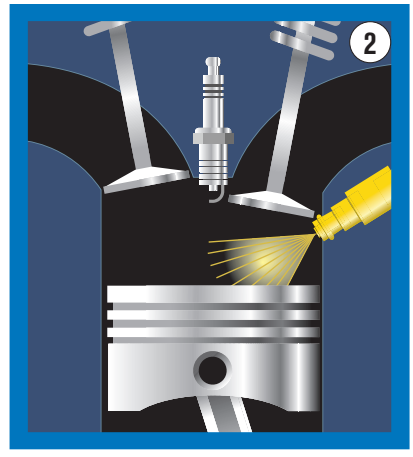

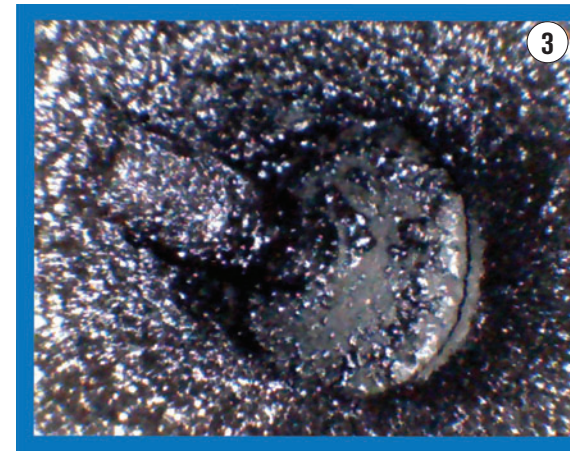

carbon produced is denser and has low porosity; additionally, the carbon thickness is usually low. The carbon that is produced within the induction system is created under very different conditions than the combustion chamber deposits. The carbon in the intake is produced under low heat and low pressure. Due to the conditions within the induction system the carbon produced has high porosity; additionally, the carbon thickness can be quite high. Thus, due to the conditions that they were produced under, these are two different carbon types.

Another way to produce different carbon types within the engine is the use of different fuel delivery systems. When fueling the engine with a carburetor or port fuel injection the fuel is delivered into the intake manifold of the engine, as illustrated in **Figure 1**. Thus, the carbon within the intake port area is constantly washed by gasoline. As you already know, gasoline is a very good cleaner and can wash oils and sludge off of parts. Gasoline can remove some of the carbon accumulation from the induction port as well. The gasoline being in contact with the carbon deposit as it is forming will also change the configuration of carbon bonds in the induction system's carbon deposit.

On modern engines that incorporate the method of Gasoline Direct Injection (GDI), the fuel is delivered directly into the combustion chamber as illustrated in **Figure 2**. Therefore, there is no fuel available to wash the carbon deposit in the intake manifold, as occurs with the port fuel injection method. This creates a problem in that the carbon deposits will build without opposition. Additionally, the lack of gasoline within the induction system can create a carbon bond configuration that is again quite different. Under these conditions the carbon deposits can become quite large and create drivability problems. On some GDI engines these carbon accumulations that create drivability problems can occur in as little as 15,000 miles. The very design of the GDI engine leads itself to carbon deposit in the induction system. No GDI engine is immune from these inherent carbon deposits.

Some carbon deposits within the GDI intake port area can be as great as ¼- to ½-inch thick as shown in **Figure 3**. These heavy carbon deposits can cause problems such as misfiring cylinder(s), hesitation during throttling, low power, rough idle, surging, pinging, fuel trim adaptions, high tailpipe emissions, MAF range or performance DTC.

The effects of carbon build up

In order to know if there are carbon deposits in the induction system of the engine you are working on, a visual inspection using a borescope is the preferred method. One can find an entry point through a vacuum port or by removing a sensor, such as the MAP sensor or IAT sensor. If these will not provide access, with the ignition key off, the throttle plate can be opened and the borescope can be fed through this opening.

The carbon accumulations within the intake port area will create turbulent airflow. Additionally, if the carbon deposits are not deposited uniformly, they can create additional turbulent airflow. It is important to understand that these carbon deposits do not need to be heavy in order to create many of these problems. On the GDI engine, small carbon accumulations in the intake port area can cause drivability problems. Every racer that has ported heads on a flow bench will attest to the fact that very small changes made within the intake runner and intake port area will create flow differences, both good and bad. These uneven intake carbon accumulations rob power, torque and fuel economy.

The turbulent air caused by carbon deposits is especially harmful in the GDI engine. This can best be understood by analyzing both the port fuel injection and GDI methods. When the port fuel injection method is utilized, the fuel is injected directly at the back of the closed intake valve. The intake valve being the hottest part of the intake port, at 400°F to 800°F, will help vaporize some of the fuel so it can burn during the combustion process. Once the fuel is injected the intake valve opens, allowing the air-fuel mixture to be mixed by the swirling air movement past the valve. Additionally, the piston's upward movement during the compression stroke forces this mixture together,

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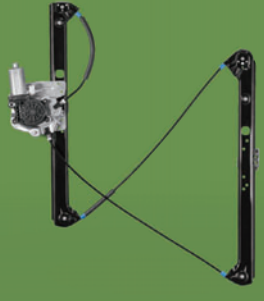

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further mixing the air-fuel charge.

What this accomplishes is a very well mixed air-fuel charge that is very close to a truly homogenous mixture, which means that the charge mixture (air and fuel) has a uniform composition throughout the cylinder. When the spark occurs, it takes the fuel beyond its auto-ignition point and the flame front propagates across the combustion chamber. If the air-fuel charge is unevenly mixed, the propagation of the flame front will be impeded. This will cause incomplete combustion of the charge. If the air-fuel charge is homogenous, this flame front will propagate through the combustion chamber, allowing complete combustion to occur.

In the GDI engine, the fuel is directly injected into the cylinder. With this type of fuel injection there is no ability to premix the air-fuel charge prior to the intake valve opening. Additionally, the swirl or tumble effect as the intake valve opens cannot be utilized. Therefore, the airflow into the cylinder is critical. This airflow must enter the cylinder and swirl correctly in order to catch the aerosolized fuel and completely mix these two components together, as illustrated in **Figure 4**. Time is another constraint in the mixing of these two components together. There is very little time for the air charge to mix with the fuel delivery, so the conditions must be correct in order to get this event to occur properly.

If the GDI engine's intake port area and/or intake valve becomes carbonized with deposits to the point where it affects this incoming airflow, then the proper mixing of the air and fuel cannot take place. If this air charge is not properly formed the fuel mixing event will not create a good homogenous mixture, which will lead to incomplete combustion.

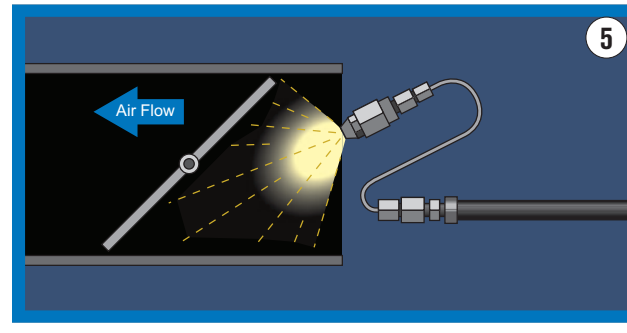
Since the internal combustion engine is a heat engine, the fundamental operation of the device is the production and use of heat that can then be converted to mechanical energy. In these engines everything that is done prior to the combustion of the fuel type is to set up the air-fuel in the cylinder so the charge can be ignited, burned and combusted. In the spark ignition gasoline engine, a well-mixed air-fuel blend will have a greater chemical conversion rate during the combustion process. If this mixture is not a homogenous charge, the maximum chemical potential will not be converted into thermal energy and hence mechanical energy.

Dealing with carbon build up

Therefore, it is imperative to keep carbon accumulations to a minimum in these GDI engines. But how can we accomplish this? Obviously, disassembly of the engine and hand cleaning is one possibility. In order to accomplish this the intake manifold will need to be removed from the head. Now that access to the intake port area is provided, rotate the engine until both valves for the port to be cleaned are closed. Now, using a plastic scraper carefully hand scrape the large carbon deposits from the port area. Do not put force behind the scraper. You are just removing the main body of carbon so the media blaster can be more effective. Once you are done, use an air nozzle to blow out any remaining carbon from the port. Next, use a walnut shell blaster to clean the remaining carbon from the port area. Clean each cylinder's intake port area while the intake is off. Additionally, while the intake manifold is off don't forget to clean the intake runners. GDI engines can have large carbon accumulations within the manifold.

New media and/or walnut shell blasters are available and provide good results. However, these solutions are time intensive and expensive. Due to these limitations this can only be done when the engine has large carbon accumulations that create severe drivability issues.

Another less labor intensive and less expensive option is to chemically clean these engines. It is always recommended to borescope the induction system before and after a cleaning. Never assume that because the engine has been cleaned that the carbon has been removed. This may allow you to think the carbon is not creating the drivability problem when in fact the carbon has not been changed by the cleaning. Over the years chemical cleaning has proven to not be a very effective method. Anyone who has checked the carbon deposits with a borescope before and



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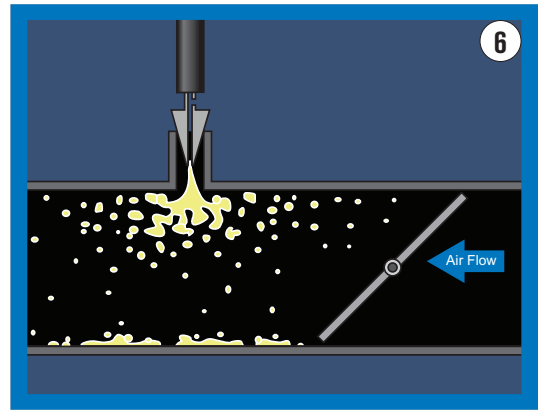
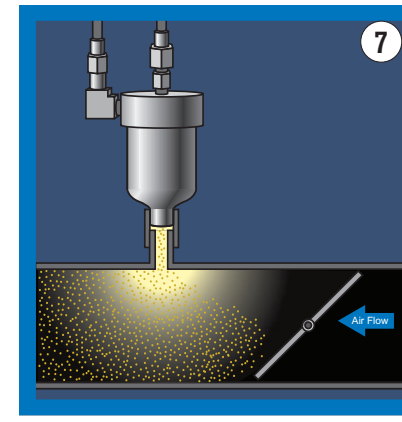
after cleaning knows how ineffective the industry chemicals really are.

However, there have been recent developments in the chemicals and delivery systems that now provide excellent results on GDI engines. In order to remove these unwanted carbon deposits, we need to understand that this is a two-part problem. The first problem is the effectiveness of the chemical itself. The second problem is getting the chemical to the carbon deposits. Both the chemical and application method will need to be designed to work together in order to optimize results.





Revisiting chemical cleaning options

In order to understand how these carbon deposits can be chemically removed we must first understand the carbon itself. The carbon structures that are produced in the GDI are very different from engine to engine. The carbon accumulation within an engine will vary depending on many different variables such as the type of hydrocarbons the fuel is made of, the detergents added to the fuel base, the type of hydrocarbons the motor oil is made of, the anti-friction additives added into the oil, the operating temperature of the engine, the pressure the carbon is produced under, the load on the engine, the engine drive time, the engine drive cycle and the engine design. Each of these variables will affect the type of carbon that will be produced and amount of carbon accumulation within the engine.

Perhaps the largest contributor to these GDI carbon accumulations is the engine lubricant. In the GDI engine there are different anti-friction additives put into the oil base. The purpose of these additives is to help the oil during the extreme loads put on the cam lobe that drives the high-pressure fuel pump. The engine oil passes into the induction system through the Positive Crankcase Ventilation (PCV) system, along with the anti-friction additives that have been put in the oil base. These oil and anti-friction additives will change the carbon's structure. Thus, different oils and additive packages will make different carbon types.

Each type of carbon has a different chemical bonding structure that may interact with the cleaning chemical very differently. This means that the chemical will need to be formulated to work on a wide variety of carbon types. The better the chemical is formulated to work on many different carbon types, the better it can remove them from the largest variety of makes and model vehicles. In order to remove multiple carbon types from diverse engines, a new technology has been developed using an entirely new base of chemicals. These new chemicals can rapidly dissolve multiple carbon types within the engine.

The second problem is delivering the chemical to the carbon deposit site. If you have engineered the best chemical and cannot deliver it to the carbon deposit then you still cannot remove the unwanted carbon accumulations.

For the last 30 years the industry standard has been the use of an oil burner nozzle placed in front of the throttle plate as illustrated in **Figure 5**. The oil burner nozzle provides a fine spray that puts the chemical in an aerosol format needed to keep the chemical suspended in the airflow that is moving into the running engine. The problem is that the nozzle's fine spray is hitting the throttle body and throttle plate. This allows the fine spray to impinge on the throttle components, thus no longer being in an aerosol format.

One may think that once the chemical has impinged on the throttle plate and housing and is pulled into the gap between the throttle bore and throttle plate (shear plain) that the airflow would break these droplets up. However, when the chemical enters the shear plain there is turbulent airflow that carries the chemical droplets and redeposits them on the back side of the throttle plate. The chemical droplets then congeal together and become larger. The moving airflow then picks these chemical droplets off of the throttle plate. At this point the droplets are too large to be suspended and carried by the moving air column, so they fall out and pool in the intake manifold. The airflow moving through the engine will drive these pools of chemicals along the manifold floor. If the chemical can in fact remove the type of carbon that is in the engine, it will cut a channel through the carbon. This carbon channel will now create turbulent airflow that will cause incomplete combustion events decreasing fuel mileage

between 1-3 miles per gallon. This channel can be seen by using a borescope after the cleaning process has been completed. As you can see, the chemical must be delivered in a manner that completely covers the entire intake valve and intake port area in order to properly remove the carbon deposits.

Yet another industry standard that has been used for many years to apply chemicals to the engine is the use of a pressure differential (vacuum) created by the engine. In this method the engine is used to suck the chemical out of a reservoir. These systems use a type of aerator that bleeds air into the chemical flow, thus aerating it. Over the years these systems have also been proven to be ineffective. This is because the droplet size produced by this type of device is too large to be suspended and carried by the airflow into the running engine, as illustrated in **Figure 6**. These chemical droplets will fall out of the airflow and pool in the intake floor, thus only cleaning the port floor area, as can be observed by the use of a borescope before and after cleaning.

Making it work

One can clearly see that the chemical will need to be put behind the throttle plate in the form of an aerosol consisting of small droplets of chemical that can be suspended and carried by the moving airflow that will completely cover the intake valve and port area. If the chemical can reach the carbon deposit, and is effective at dissolving the carbon type, the carbon deposit can be removed.

To create this chemical aerosol, a high-pressure device such as an injector is needed. This must be located behind the throttle plate in order to prevent the chemical from impinging on the throttle components, as illustrated in **Figure 7**. This will create a chemical aerosol format that the airflow can actually carry. Now that we have addressed the second problem, the application method, it will be important to address what effect the chemical mixture has on your health.

Many of the industry chemicals used are not good for one's health. Take one such chemical that is in many of the industry chemical mixtures, N-methyl-2-pyrrolidne (NMP). This is a known carcinogen that can cause testicular cancer in males. This chemical will also damage the paint and plastic components on the vehicle. Therefore, care must be taken when using these chemicals. It is important to always read the Safety Data Sheet (SDS) and to understand what health hazards these chemicals might present. Many of the chemical mixtures commonly used in this industry contain chemicals that are rated at a class 3 or class 4 health hazard in the HMIS system. Always follow the proper safety procedures when handling these type chemicals. At one time it was thought these type chemicals were needed to remove the carbon deposits from the engine. New technology has found less harmful chemical mixtures that can effectively remove carbon deposits without these extreme health hazards.

The gain that chemical cleaning provides on these GDI engines is exponential. The chemical cleaning can remove these unwanted carbon deposits from these GDI engine at a cost-effective point. Additionally, if you think the carbon deposits are creating a drivability problem you can clean the engine and eliminate the carbon as a possibility without the costly manual cleaning procedure. The GDI engine can now be cleaned as a maintenance service every 30,000 miles, thus keeping these unwanted carbon deposits to a minimum so the engine performs at its designed horsepower and torque output. This will add revenue for your shop as well as provide a needed service for your customer. The power and response that a cleaned GDI engine will produce will astound you and your customer.

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IGNITION TIMING: THE FORGOTTEN TEST

WHEN WAS THE LAST TIME YOU CHECKED IGNITION TIMING? THE LACK OF TIMING MARKS ON MODERN ENGINES DOESN'T MEAN THAT TIMING CAN'T CHANGE!

SCOTT SHOTTON // Contributing Editor

Do you own a timing light? When was the last time you used it? Old guys like me know what it is, but do younger technicians have a clue? To be fair, the answers to these questions vary based on geographic location. I am in the Chicago area and I cannot remember the last time I used a timing light. Salted roads, rust, emissions testing and "cash for clunkers" eliminated 99 percent of the vehicles that required ignition timing adjustments in my area. I own a fancy timing light, but it probably has a thick layer of dust on it… if I can even find it. If I lived in an area like Phoenix or San Diego, this story might be completely different. Environmental/geographic issues such as this can often result in a 2018 vehicle in one bay of a shop while a 1976 vehicle could be right next to it. Not in Chicago! I rarely see something older than 1996, but I still own a blue wrench just in case. Regardless, ignition timing is a very important aspect of engine performance.

The demise of timing marks

For those of you who are green, or entry-level technicians, let me paint this picture. There used to be a device on the engine that looked like an octopus (**Figure 1**). This "octopus" was actually called the distributor. It had ignition cables that plugged into the spark plug for each cylinder on the engine and often had an additional wire that connected to a single ignition coil. Yes, believe it or not, only one ignition coil. The octopus' job was to distribute spark at the appropriate time to each individual cylinder. In order to do so, the distributor, or the head of the octopus, needed to be installed correctly. It could be turned, in one direction or another, to establish base ignition timing. From there the engine computer would take over and advance or retard ignition timing, or when the spark fired, based on operating conditions at that moment.

A side note that should be addressed: For a few years in the mid-1990s and early 2000s, distributors existed on vehicles, but ignition timing adjustments were not possible. Even though it was possible to turn the distributor, this only affected camshaft sensor timing, not ignition timing. Ignition timing was now based on the crankshaft position sensor input to the PCM. An example of this would be a General Motors 5.7- and 5.0-liter engine as recently as the 2000 model year and the General Motors 4.3-liter engine all the way up to the 2004 model year.

With the introduction of DIS (Direct Ignition Systems) in the early 1980s and COP (Coil over Plug) ignition systems shortly after that, the octopus became obsolete. As a result, ignition timing adjustments became obsolete as well.

A DISTRIBUTOR, OR AN "OCTOPUS," on a 1970 Challenger R/T.

A WORN KEYWAY allowed a skewed CKP signal that results in retarded ignition timing.

PHOTOS: SCOTT SHOTTON

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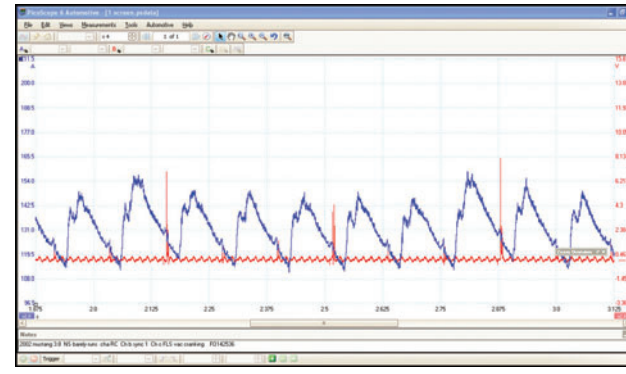
These changes did not mean that ignition timing was any less important; it just became a non-adjustable part of the technician's service procedure because mechanical components were eliminated and computerized ignition controls took charge of all ignition functions.

Gone but not forgotten

Now that the history lesson is complete, we come to how ignition timing is controlled on a modern vehicle. Ignition timing on almost all modern vehicles is based on the crankshaft position sensor input. The aspects for the operation of a four-stroke engine are still the same as it always has been, including ignition timing, and service information has kept up pertaining to most areas as engines have changed and advanced. However, service information lacks when it comes to the important variable of ignition timing. Because ignition timing is non-adjustable on modern vehicles, the engineers designing the vehicles and the individuals writing the service information do not give us technicians all of the information we may need because ignition timing is something "we should no longer mess with." Allow me to share a story that illustrates the need for ignition timing specifications.

An early 2000s Ford with a 4.2-liter V-6 engine is in the shop for a low-power issue. The shop had already used the usual shotgun approach and replaced the fuel pump, fuel filter, mass airflow sensor, entire exhaust system (everything except the exhaust manifolds), camshaft position sensor, spark plugs, ignition wires and coil pack. In a very inefficient and costly way, the shop covered most of the bases for a low-power issue. Upon my arrival at the shop, a test drive of the vehicle confirmed that the low power issue remained. A double check of the parts/components that were replaced was performed and no faults were found. What was missed? Was ignition timing checked? Us old guys know retarded ignition timing can cause a very similar-feeling drivability result, but, as stated before, there were no timing marks or specifications for the checking of ignition timing. What do we do next?

A quick test of ignition timing, using some modern techniques (to be addressed shortly,) revealed that the ignition timing was in fact retarded. Because the ignition timing is based on the crankshaft position sensor signal, the CKP reluctor was the next thing on the list to check. In this case, the CKP reluctor was mounted on the crankshaft pulley. Removing the crankshaft pulley revealed a worn keyway that allowed the crankshaft pulley to shift (**Figure 2**). This shift resulted in a CKP signal that was late. The late CKP input signal to the PCM resulted in a late, or retarded, ignition timing trigger signal to the ignition coils. The only thing that was required to resolve the low-power issue on the vehicle in question was a crankshaft pulley. The new pulley resulted in an accurate CKP signal to the PCM and consequently a correct ignition timing command.



THE IGNITION SYNC falls well to the right, indicating retarded ignition timing.

A BROKEN CRANKSHAFT BALANCER caused the CKP reluctor to shift.

My point of this whole story is that technicians nowadays — seasoned techs and green techs alike — overlook ignition timing because it is "non-adjustable." Technically it is not adjustable, but it can change… if something is broken.

Checking ignition timing without a timing light

So how do we check ignition timing, you may ask? A few paragraphs ago I referred to a "quick test" to check ignition timing on a modern vehicle. With the appropriate equipment, and knowledge of how engines work, this is actually an easy task. There are two methods that I am aware of that can be used to check ignition timing. Both of these tests require an oscilloscope. In addition, a high current probe and/or a pressure transducer will be needed. The current probe or the pressure transducer will provide a top dead center reference. Another channel of the scope will be used as an ignition reference and can be accomplished in a variety of ways depending on vehicle application and available scope probes. The first technique is a "ballpark" test and the second technique is much more accurate than the first.

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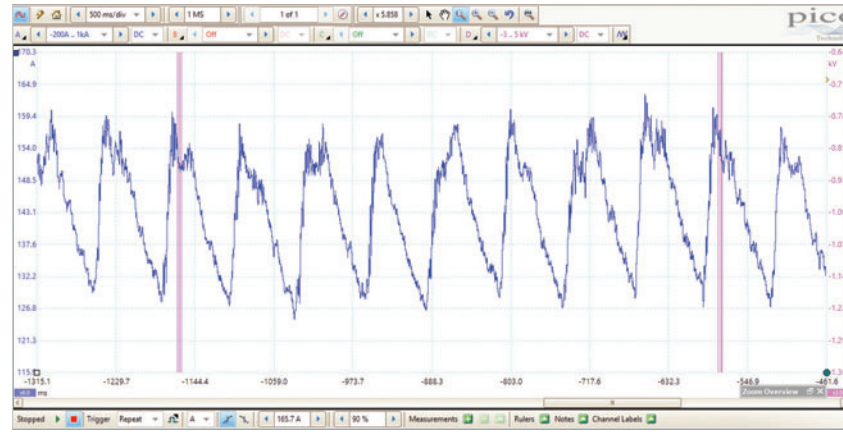
Method #1: Relative compression in relation to sync

Relative compression involves connecting a current probe around a battery cable, disabling the fuel system to force a crank no-start condition and using some type of ignition sync. The engine is then cranked over and the starter motor's current peaks can be observed. The current peaks equate to the higher effort required by the starter motor to compress the contents of each cylinder. Equal current peaks indicate that all cylinders have equal compression. For our discussion today, the ignition sync should fall near the apex of one of the current peaks in the capture. This technique is not exact, but can give us a pretty good idea if ignition timing is close. Think about it — during cranking, most engine applications use base ignition timing. If we use what we have learned from older vehicles, calling on you seasoned technicians, the base timing should be (most likely) somewhere between O degrees to 10 degrees BTDC (Before Top Dead Center). This means that the ignition sync should occur very close to one of the current peaks or slightly to the left of the relative capture. If the ignition sync falls too far to the right of the current peak then the ignition timing is retarded. Conversely, if it falls too far to the left, the ignition timing is advanced.

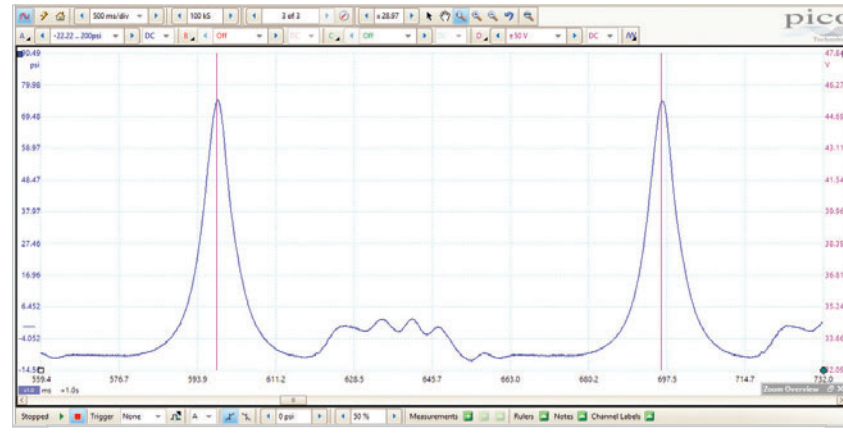
The following relative compression capture (**Figure 3**) is from a 2002 Ford Mustang with a 3.8 liter engine. The vehicle barely ran and the relative compression capture explains why — Ignition timing is severely retarded.

Further investigation, focusing on the crankshaft position sensor, revealed a damaged (**Figure 4**) crankshaft balancer.

Another example could be this next capture of another Ford vehicle. **Figure 5** illustrates ignition timing that is questionable. The ignition firing (purple) appears to be near Top Dead Center (TDC) or even a bit to the right, or retarded. In this case, ignition timing is suspect and more testing should be performed.



A RELATIVE COMPRESSION CAPTURE with slightly questionable ignition timing.



IGNITION TIMING while running should be advanced. This capture shows near top dead center.

Method #2: In-cylinder compression in relation to sync

In-cylinder testing is a much more accurate way to measure ignition timing and would be the next diagnostic step in the case of the vehicle used in **Figure 5**. This technique will still require an ignition sync, but will also require the use of a pressure transducer to establish TDC and 720° of crankshaft rotation. Unlike the relative compression test, this test can be done during engine cranking or while the engine is running. In addition, very accurate ignition timing measurements can be made.

To facilitate this test a spark plug is removed and a pressure transducer is installed in its place. The engine is then cranked over or started. The highest point in the pressure capture is TDC. The ignition sync can then be compared to actual TDC and, if desired, can be measured with more accuracy.

Figure 6 is an in-cylinder capture from a different vehicle. The vehicle is running at idle and it is obvious that the spark firing event occurs almost exactly at TDC.

The timing of this ignition event should raise a question: When a vehicle is running shouldn't the ignition timing be advanced? The answer is yes, and the conclusion is that something is broken.

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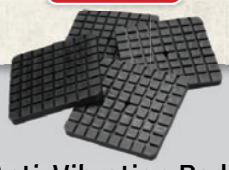

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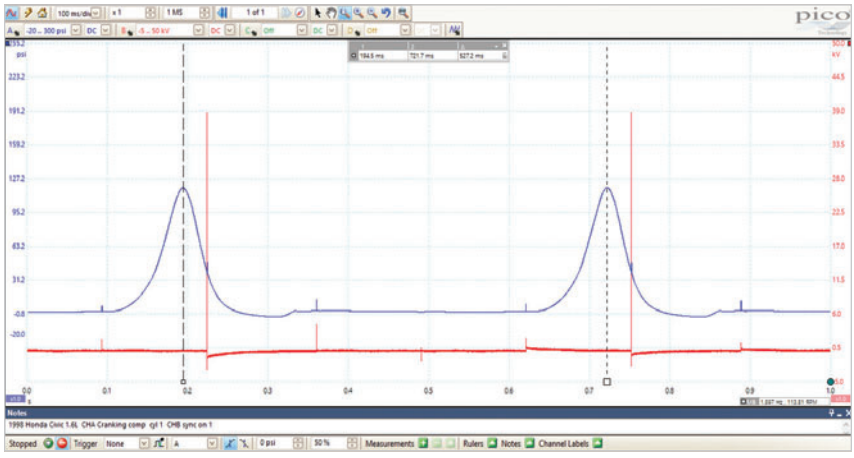
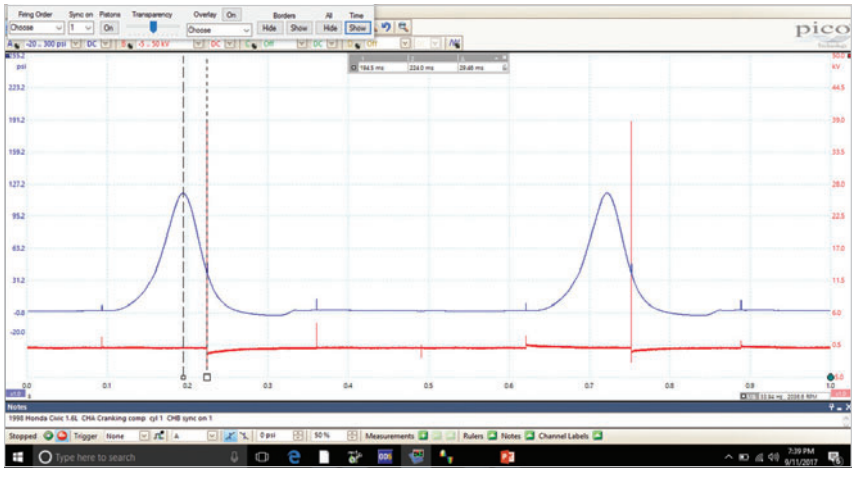


A 720-DEGREE EVENT is measured to be 527.2 milliseconds.



THE IGNITION FIRING EVENT is measured and occurs at 29.46 milliseconds after top dead center.

ing of an event is relatively easy. The rulers can be used to mark two consecutive TDC pressure events to give the scope a 720° reference. Then a cursor can be dragged to line up with the timing event that you desire to measure. A box will appear at the top of the scope screen and the difference in degrees will be displayed.

If you are using a scope that does not offer this option, such as a Snap-On product, this task can still be performed relatively easily with a little bit of math. First, use your cursors to mark a 720° event from TDC to TDC. The scope will display the amount of time that the 720° event took (**Figure 7**). In this case, that measurement is 527.2 milliseconds. Second, divide the amount of time of the event displayed on the scope by 720. This will tell us how much time each degree of crankshaft rotation is responsible for. In our example, 527.2 milliseconds divided by 720 degrees, which equals .73 milliseconds per crankshaft degree. Third, leave the first cursor at TDC and move the second cursor to the timing event you wish to measure (**Figure 8**). A new time measurement will be displayed on the scope screen. In our case, that number is 29.46 milliseconds. Finally, divide this new time measurement by the number obtained during the second step. In our example, 29.46 milliseconds divided by .73 milliseconds equals 40 degrees. This number represents the amount of timing advance, or retard, for the given capture. In this case, the ignition timing is retarded 40 degrees. Remember, no matter which tool or method you are using, if the event occurs to the right of TDC, this indicates a retarded timing event and to the left of TDC would indicate an advanced event.

Summary

Ignition timing is just as important as it always has been for the proper operation of a spark ignition internal combustion engine, even though technological advancements have eliminated the technician's ability to adjust, or even check, base ignition timing. The obsolescence of timing lights, timing marks and timing adjustments have resulted in an industry mentality that tends to forget this important issue.

Technically, ignition timing should never have to be checked on a modern vehicle. The engineers, as a result, did not give us the ability to do so. However, in the engineers' defense, every potential failure cannot be anticipated. Yet components do break, and we technicians have to adjust our diagnostics to these unforeseen situations. Who knows, maybe some day we will see the return of timing marks on a crank pulley for the purpose of diagnostics. I doubt it. Maybe we can get a diagnostic trouble chart that actually leads us to a vehicle fault in a timely and accurate manner. There is a saying that has something to do with which hand fills up faster: "Wish in one hand and…"

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

THE DIAGNOSTIC TEST DRIVE

KEEPING YOUR DIAGNOSTIC ROUTINE CONSISTENT YIELDS MANY BENEFITS, INCLUDING FEWER MISTAKES AND FASTER SOLUTIONS TO YOUR CUSTOMERS' CONCERNS

ERIC ZIEGLER // Contributing Editor

How many times has this scenario played out at your shop? A regular customer comes in late in the day, perhaps close to closing time, complaining about a drivability problem that you have been chasing intermittently. Moreover, they exclaim "it's doing it right now. Do you have a minute to go for a ride with me?" Your instinct as a consummate service professional kicks in — you grab a shop towel, wipe your hands and grab a floormat — and away you go. If you are lucky, you get to duplicate the customer's complaint, at which point you use your power of observation and keenly honed senses to make a judgement on what ails the vehicle. Perhaps you suspect a misfire and use the old "I feel it in the seat of my pants" so it has to be ignition adage…and so on.

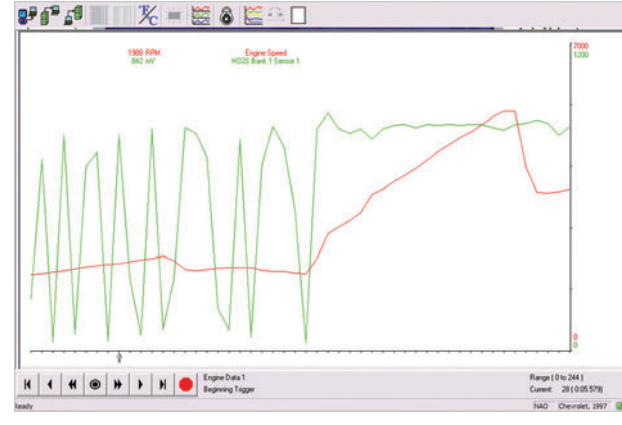
Wasted effort

We have all operated at one point or another this way for many years. However, there is one distinct flaw in the methodology that was overlooked. Anyone who has attended any of my training classes has heard me rail on this. There are few things in drivability diagnostics that I feel are more useless than driving a vehicle on a diagnostic test drive without having a scan tool hooked up to the DLC. The second thing that drives me crazy is when a tech test drives a vehicle for a diagnostic issue and fails to record and save a snapshot. Our scan tools have gotten so much more powerful than they were in years past.

The buffer size — the scan tool memory — stores valuable diagnostic data that can improve the diagnostic process. This article will examine some diagnostic test drive techniques that will help techs gain valuable diagnostic direction and eliminate certain possible causes by using scan data analysis.

My friend Scott Shotton (and author of the Training article on page 22 this month) once stated something in a class that resonated with me, "There is a fine line between efficiency and laziness…I choose to be efficient." I can think of no greater way to maximize efficiency other than using a scan tool to garner as much information with the least amount of effort! This method involves diagnosing a vehicle by simply analyzing scan data and creating a plan of attack (POA) and "designing the experiment" to test the system(s) believed to be at fault. Furthermore, if I have the snapshot saved, I have valuable sales tools and documentation to share with the boss or the vehicle's owner. In addition, we now have a pre-repair movie that we can use for comparison post-repair.

THE DIAGNOSTIC TEST DRIVE is pointing the finger at a bad MAF.



WHEN THE O_2 SENSOR PEGS HIGH during a WOT pass, it indicates that adequate fuel supply is not the cause of the concern.

PHOTOS: ERIC ZIEGLER

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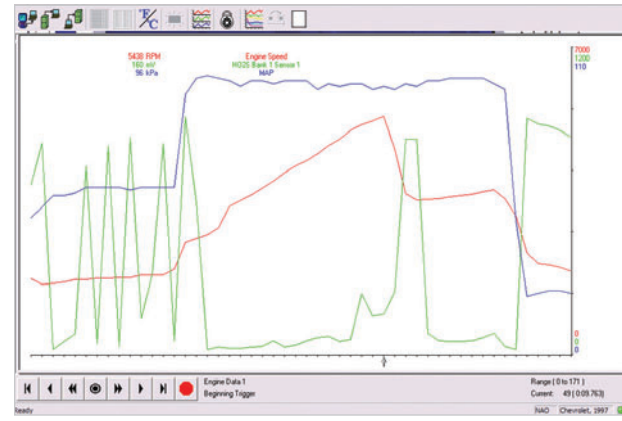
What's the point?

So how do we leverage the technology of the scan tool buffer and combine it with a diagnostic test drive? First, I want to be able to use scan data to learn a couple of fundamental things: how well is the engine being fueled and how well is the engine able to breathe.

We are going to use the oxygen sensors and fuel trims to tell how well the engine is "fueled" and learn if the Engine Control Module (ECM) is in control over the fuel system. We can accomplish this by performing a Wide Open Throttle (WOT) acceleration or by an aggressive brake torque in reverse. On most vehicles, when we go WOT, the ECM drops out of closed loop operation to a fixed open loop fuel map that allows for maximum fuel enrichment that should reveal itself in the upstream oxygen sensor(s) going full rich, or well north of 800mv on a traditional zirconia style (Lambda) sensor. If I have a hesitation under load complaint and I aggressively accelerate and see the upstream sensors going to 850-900mv, what does that tell me about the fuel delivery system and the ECM's ability to fuel the engine? I can, with a fair degree of certainty, eliminate the fuel pump, fuel filter (if equipped) or restricted/dirty injectors as a probable cause of this.

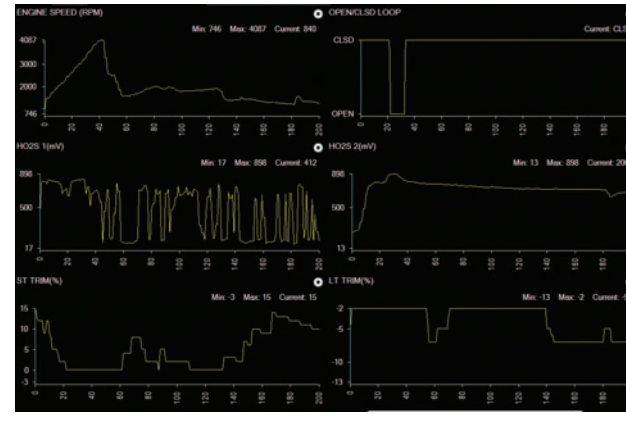
What other Parameter Identifiers (PIDs) should I be recording? How about the ones that will allow me to make a Volumetric Efficiency (VE) calculation on an MAF engine if necessary? VE is an engineering term that formulates how well a pump can move a liquid or gas compared to its physical limitations. First, we need to know the size of the pump, which in our case is the engine. An automotive engine is an air pump of sorts, so we need to consider its displacement. Pump speed is also critical for the equation, so we use engine RPM. These two things are used in the equation or VE calculator to figure out what is referred to as the theoretical maximum.

The next variable is the amount of air entering the engine at maximum airflow, so we will need to capture the MAF in Grams Per Second (GPS) and RPM to do this. In addition, some VE calculators require ambient air temperature and elevation as well. Fuel Trims and Loop Status PIDs are not required to calculate VE but can be a handy reference. So, what can I expect from a known good VE run? It depends on a couple of factors, but at my elevation of 510 feet above sea level I expect to see 75 percent to 85 percent on a normally aspirated engine. Obviously, forced induction engines (turbos and superchargers) are much greater and usually surpass 100 percent, due to the fact they are "forcing" air in to the engine via an additional mechanical device. These are my rule-of-thumb numbers, which have worked well for me, but be mindful that your results may differ dependent on atmospheric conditions, calculator choice and your experience.



IN THIS SNAPSHOT, the map sensor is responding as expected but the O_2 sensor is not.

THIS IS HOW WE WANT a MAP sensor to react.



NOT ALL SCAN TOOLS will overlay the data on one graph, but that doesn't mean the answer you're seeking isn't there.

Choosing additional PIDs

I like to make a custom data list, which allows me to choose the PIDs I want to look at as opposed to the groupings the scan tool software developer choses for me. This usually ends up speeding up the refresh rate of the scan tool by not looking at unnecessary PIDs not related to the diagnosis at hand. Once I have my list

of the PIDs I want, I then go on a diagnostic test drive and make a couple of VE test runs in which I aggressively accelerate through a shift while recording the snapshot on the scan tool. This is going to give me my max RPM and MAF GPS just slightly prior to the shift.

When I say aggressively accelerate, I mean the proverbial "drive it like you stole it" through a shift. A trainer friend once said if you are unsure of how to make an aggressive WOT run, grab the 19-year-old in the lube bay. They can show you! (*Editor's note: Be sure to follow all local laws and perform your diagnostic test drive in a safe area.*)

So on to the diagnostic — sometimes referred to as the flatrater — test drive. After making several heavy accelerations noting if the upstream oxygen sensors go full rich, pay attention to your five senses and how the vehicle behaves.

Misfires in some conditions may be noticed and can point you in the right direction. Trust your sense of hearing. Do you notice any unusual noises? Your sense of sight tells if the CEL/SES MIL comes on or is flashing etc. These things are a process that most of us use regularly. It is almost second nature to the seasoned drivability tech. What is imperative is that we have the scan tool set up properly beforehand and are recording the whole diagnostic test drive into the buffer.

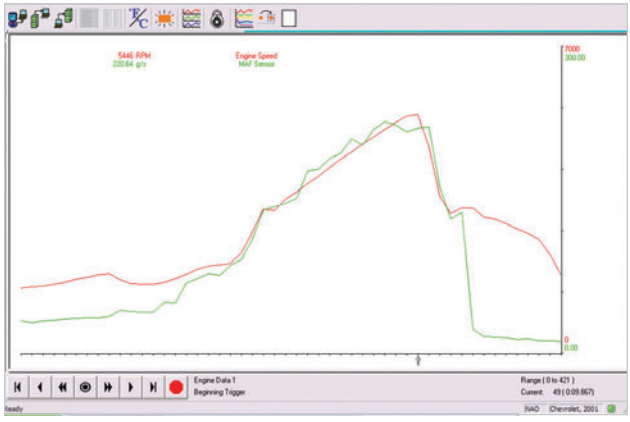
If I am on a really long test drive, I will pause the recording of the snapshot and save the file. This ensures that I have my data stored into the memory or internal drive of the scan tool, and it will be there for analyzing later.

Reviewing the data

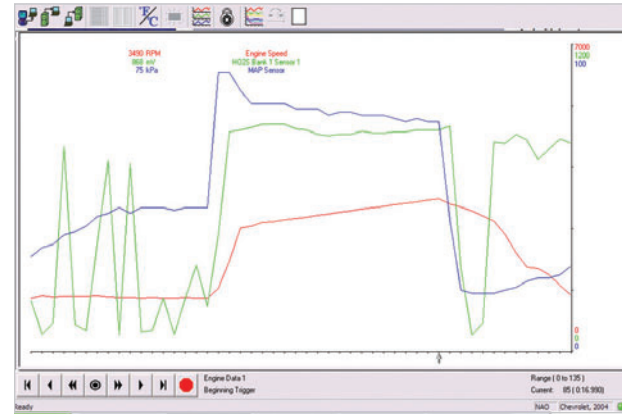
There are three things I like to analyze back at the shop when reviewing my snapshots or scanner movies. I make my observations under two distinctly different operation conditions: normal cruise state driving and WOT. In general, this is what I expect to see:

The upstream oxygen sensors should cycle rich/lean in "Closed Loop" and should peg full rich on most vehicles under the heavy load created during my WOT acceleration. I also want to examine my MAP PID as well at idle or steady rate cruise. I want to see it steady, and when I accelerated aggressively and deplete the vacuum in the intake manifold, I want to see it go very close to Baro or atmospheric pressure.

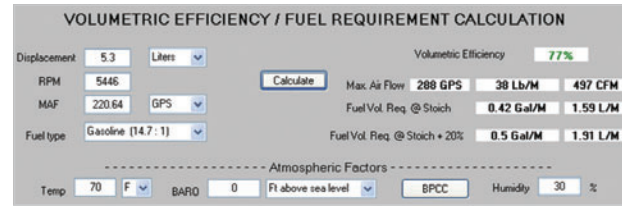
Consequently, under the aforementioned conditions, I should see my fuel trims in closed loop slightly switch or moving about under steady state cruise revealing the subtle PCM correction to



WE'LL NEED A PEAK MAF READING for our ve calculation.



THIS DIAGNOSTIC DATA is pointing to restricted flow on the intake side.



THE USE OF A VE CALCULATOR will help you determine how well the engine can "breathe."

Condition	VE	O2	MAP	Trims
Good	Good	Rich	Normal	Normal
Fuel Delivery	OK	Lean	Normal	Positive #'s
Air Metering	Poor	Lean	Normal	Erratic
Rest. Exh.	Poor	Rich	Normal	Negative #'s
Rest. Int.	Poor	Rich	Ratchets	Normal

PHOTOS: SCOTT SHOTTON

KEEP THIS CHEAT SHEET handy as you learn how to read the data collected on your diagnostic test drive.

achieve and maintain something close to stoichiometry. How should fuel trims behave when I go to WOT? It depends. But what I should expect is my loop status to change from closed loop to open loop. This is what allows my PCM to change to fixed-fuel mapping that allows for full enrichment on WOT on most vehicles.

I can test drive a vehicle in a consistent manner and capture a snapshot or scanner movie of the data. Then, later in the safety and comfort of the shop, I can calculate VE and also observe the three key things: O_2, MAP and fuel trims. Using this fundamental data, I can usually gain some significant diagnostic direction as to where to concentrate my testing efforts. Let's analyze some different scenarios. My friend and co-Driveability Guys trainer, Scott Shotton, developed this cheat sheet, which we can use to plug the information into to help us find the most probable cause of the drivability concern we're chasing.

Understanding the data

Say we have a naturally aspirated vehicle that has a hesitation under load/low power complaint. The condition can be duplicated and during the test drive the oxygen sensors go low instead of high during WOT, the VE calculates at 77 percent, the MAP reaches very close to Baro, and the fuel trims were overly positive at cruise, going into Open Loop under heavy acceleration. These things should lead you to the following conclusions. First, the engine can breathe properly — the VE reflects this — so no clogged cat. Second, the intake is not restricted — the MAP reflects this — so a dirty air filter is out of the question. Third, the fuel trims point to a lean condition. And finally, the oxygen sensors not going full rich point to a fuel delivery issue. This is where I want to concentrate my testing efforts. Perhaps a fuel pressure and volume test as well as current ramping the fuel pump would be the next diagnostic steps to take.

Here's our second scenario: a similar vehicle to the one above with a complaint of a hesitation. The test drive reveals the oxygen sensors are falling short of full rich, the VE is calculated at 58 percent, the MAP makes Baro and the fuel trims under cruise are erratic and appear to "follow the throttle blade" with their positive trim trends. The vehicle may exhibit some of the same drivability symptoms, but what differentiates this failure from the previous example? The answer is VE. Does a failed fuel pump affect the engine's ability to breathe? It does not. So, what could cause a hesitation compliant that mimicked a fuel delivery issue and reflected itself as low VE?

The answer is an air measurement error. What measures the air entering our engine and its PID is mission critical to the VE Calculation? The MAF sensor. It has been my experience that most MAF sensor failures tend to overestimate airflow at idle and underestimate airflow under load. While a failed MAF doesn't affect the engine's ability to breathe, it does affect the VE calculation.

Now let's switch things up a bit and look into some issues that may exhibit some of the same drivability symptoms and are revealed in the flatrater test drive by low VE. They are issues that deal with engine breathing restrictions. The first is relatively common to low power/hesitation complaints — the exhaust restriction.

After duplicating the complaint and analyzing my snapshot, I calculate my VE, and it's low at 65 percent. Looking at my other three key data points, I want to be mindful of the oxygen sensors going full rich and making almost 900mv. Second, my MAP sensor at WOT reads very close to Baro at 97kPa. Finally, my fuel trims appear to be irregular, but less so than the bad MAF example mentioned earlier, trending towards the negative rather than the positive. These all point me in the direction of a restricted exhaust/clogged cat, which I now can focus my testing efforts on, using either a backpressure gauge or an in-cylinder transducer.

Again, VE is calculated and appears to be low, say 58 percent. The review of the other three things show that the O_2 went full rich over 850mv revealing no issues with the fueling of the engine. The fuel trims are very close to normal, in this case total trim being +3 percent. But what was the third thing we wanted to analyze? If you are thinking the MAP sensor's behavior under WOT, you are absolutely correct! This is the telltale: the MAP usually falls short of making Baro or may make it for a brief moment but then falls away from it. I like the description that the MAP will "ratchet away" from Baro. These things and low VE all point to a breathing issue with the engine but on the intake side. You may be asking how can the intake get restricted? The obvious cause is a SEVERELY neglected/clogged solid air filter. I have also seen those supermarket plastic bags get sucked up in the air cleaner box and cover the air filter, thus restricting the intake.

I tell techs repeatedly in my classes that the most powerful tool in their diagnostic arsenal doesn't rest on the tool box — it rests on their shoulders. Analyzing scan data is doing just that, using the most powerful diagnostic tool you have. It illustrates the old adage that states "Work smarter, not harder!" I think that we as techs have been test driving cars ever since we have been working on vehicles. The crux of my argument is if you are going to test drive a vehicle do so with a scan tool hooked up to it. Moreover, if you are test driving a vehicle with a scanner hooked up **RECORD A SNAPSHOT!** Our scan tools have gotten so much more powerful than years past, and few techs tend to take advantage of all their features. The scan tool allows me to garner as much info as I can with the least amount of effort. As with anything in automotive there are exceptions. However, speaking from my experience, the flatrater or diagnostic test and recording a snapshot and calculating VE and being mindful of how my O_2s, my MAP (if equipped) and my fuel trims behave has served me well over the years. I hope you are using these techniques or are open trying them and it helps you streamline your diagnostic process and point you in the direction you need to focus your testing!

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HITS AND MISSES – VARIABLES OF VARIABLE DISPLACEMENT ENGINES

WHAT WOULD YOU SAY IF THAT NEW FULL-SIZE CHEVY TRUCK YOU'RE THINKING ABOUT BUYING COULD RUN ON ONLY TWO OUT OF EIGHT CYLINDERS?

DAVE HOBBS // Contributing Editor

For 2019 and for the last 20 years there have been plenty of models that can run on half of their cylinders thanks to the continually advancing technology of variable displacement engine technology. In this article, I'll share how the brand new and older systems work plus give some diagnostic tips on what to do when you get common variable displacement engine complaints like misfires and oil consumption.

Variable displacement? The whys and the variations

To meet CAFÉ requirements, OEMs have been downsizing engine sizes and adding technologies such as turbocharging and GDI for years. Another technology is variable displacement. A full-size pickup or SUV weighing over 2.5 tons travelling 65 miles per hour only needs around 25 HP to maintain speed on a level surface. In 2005, the Generation IV Vortec 5.3L engine in the GMT 360 platform (Chevrolet Trailblazer and GMC Envoy) were the first engines equipped with Displacement on Demand (DoD). The DoD engine control system has the ability, under certain light load driving conditions, to provide maximum fuel economy and reduce emissions by deactivating four of the eight engine cylinders. Cylinders 1 and 7 on left bank and 4 and 6 on right bank are always the cylinders disabled. GM changed the name to "Active Fuel Management" or AFM shortly after that and other OEMs joined in with their own variable displacement technologies such as Chrysler/Dodge/Jeep's Multiple Displacement System (MDS) and Honda/Acura with their Variable Cylinder Management (VCM) system. Each manufacturer has released subsequent variations with minor changes over the years. Until the 2019 GM full-size pick-up/SUV model engines (5.3 L84 and 6.2 L87) debuted this year with Dynamic Fuel Management (DFM), there had been one aspect of commonality — the same cylinders were always shut down during reduced displacement operation. With DFM, countless combinations of cylinders activated and deactivated will likely become the new normal for variable displacement technology. Delphi and software company Tula created GM's DFM, utilizing eight separate solenoids (**Figure 1**) to control all 16 valves in cylinder deactivation as well as fixed patterns. DFM differs from other systems in its charge-trapping strategy with a low-pressure combustion charge trapped in deactivated cylinders, requiring deactivating and activating the intake valve before the exhaust valve. For rotating patterns, which cylinders are being deactivated can change with each subsequent engine cycle.

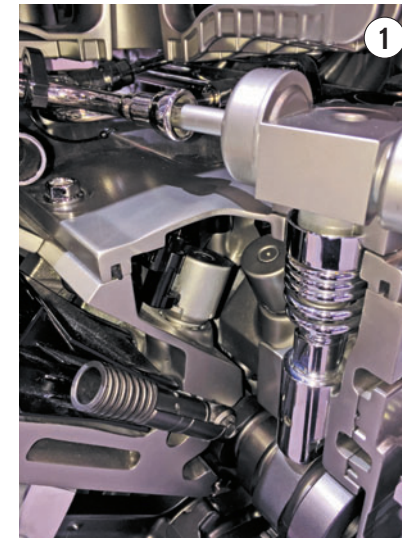


PHOTO: DAVE HOBBS

AFM and MDS mechanical operation

GM and Chrysler/Dodge/Jeep use oil pressure control solenoids to move a spring-loaded pin in both the intake and exhaust lifters essentially allowing the lifter to collapse/shorten on command. The solenoids are housed in a common assembly GM refers to as a LOMA (Lifter Oil Manifold Assembly), as seen in **Figure 2**. On both OEMs, these locking pins connect the inner mechanism of the lifter

to the outer housing. The inner mechanism interfaces with the pushrod; the outer housing contacts the camshaft lobe through a roller. Thus, the lifter doesn't lift as far when the cam lobe moves it up; therefore, the push rod doesn't push as high and the rocker arm doesn't open the valves (**Figure 3**). Although one solenoid controls lifter pin release pressures for both intake and exhaust valves, solenoid activation is timed so the exhaust valve is disabled first. This traps a burnt exhaust charge in the cylinder, which contributes to a reduction in oil consumption, noise and vibration levels and exhaust emissions. If all enabling conditions are maintained for variable displacement operation, the PCM calibrations will limit cylinder deactivation to a cycle time of 10 minutes in V4 mode, and then return to V8 mode for one minute. Fuel is disabled while spark remains active to reduce the potential for plug fouling and cylinder wall wash.

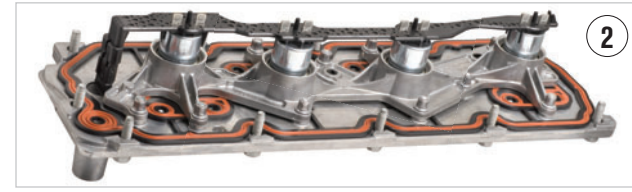
Honda/Acura's VCM system differs in that it uses solenoid-controlled oil pressure circuits to move spring-loaded pins to cause the overhead cam's rocker arm assemblies to uncouple from the cam lobe followers (**Figures 4 and 5**).

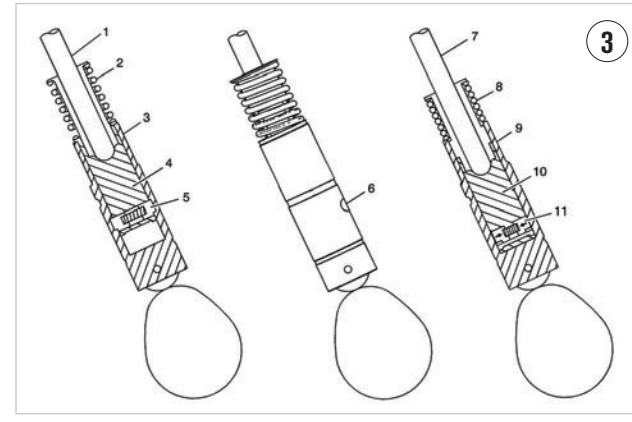
Electronics and software strategies

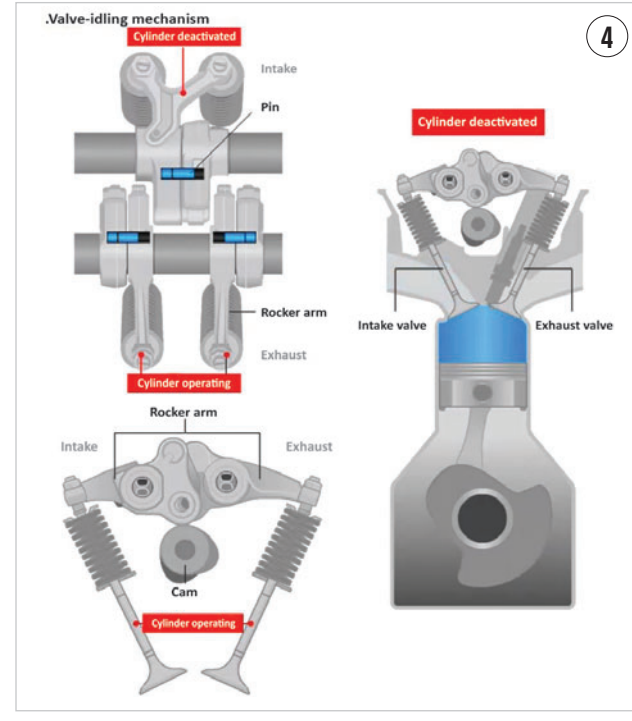
All variable displacement systems work via oil pressure control solenoids. The engine management computer's job is to activate these solenoids while monitoring for current draw and voltage status. Resistance for each solenoid is around 12 ohms. If, for example, the solenoid's low-side ground control circuit is NOT commanded to ground, the circuit should be at battery voltage. If the solenoid's low-side ground control is being grounded (to activate the solenoid) the low-side control circuit should be near zero volts. In either state, the voltage should be as predicted and if not, a DTC sets for a circuit fault. Basically, there can be no high load or over heat condition nor any DTC setting conditions present for these systems to activate.

Hemi MSD crazy case study

An interesting case study came up in a John Thornton class I attended a couple of years ago. It brought to light an unusual side effect of a faulty COP (Coil on Plug) on a Dodge Hemi engine. The faulty COP was spiking the PCM that controlled the coil's primary winding. That spike sent the PCM into a software tail spin referred to as a PCM reset. When the PCM resets on a Dodge, the ASD (Auto Shutdown Relay) turns off. PCM resets can occur occasionally or several times per second. In the car John was diagnosing, the reset occurred multiple times per second, causing a buzzing sound at the ASD relay. Along with a drivability fit, the car had an MIL for numerous DTCs. The DTC that seemed to set most often was an MSD solenoid circuit fault. Presumably the ASD clicking on/off rapidly as the PCM reset caused the MSD solenoid's voltage status to be one of the







first things the PCM looked at when it "regained consciousness" after each reset. The tech John was assisting had naturally focused on the MSD relay circuit DTC, which was only a symptom of the root cause — the faulty COP was causing the reset!

Variable displacement engine complaints and diagnostics

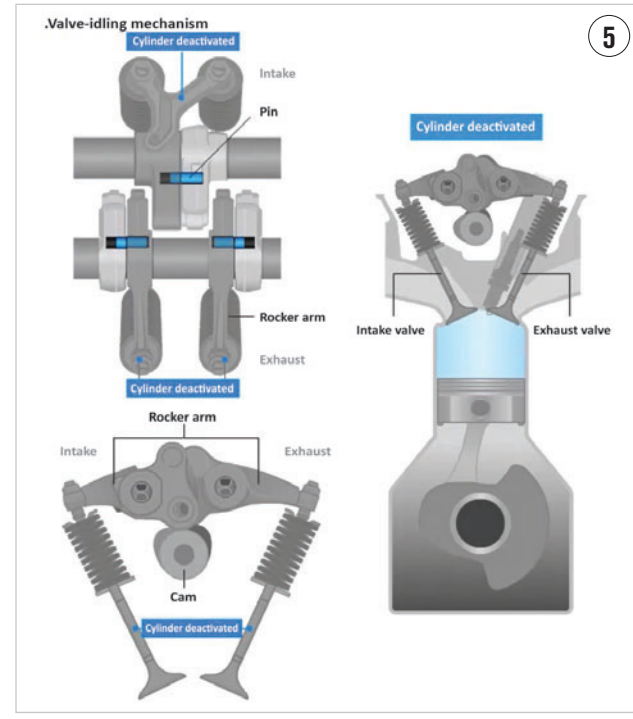
1. Transition too abrupt. Some drivers on today's variable displacement vehicles can feel the transition. Some calibra-

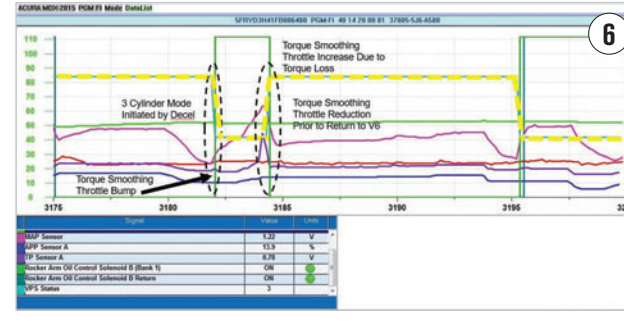
tion changes have been made to reduce the noticeability of the feature either by increasing torque smoothing strategies (**Figure 6**) or reducing the instances on when the system activates. The Acura I worked on recently had received a software update to address VCM issues (including oil consumption), which significantly reduced highway apply time for the system. On road tests with the Honda factory scan tool, I ran out of patience trying to capture the apply of VCM cylinder shut-off during steady interstate driving. As soon as I left the interstate, transitioning to moderate highway/rural driving conditions, the system began its process of running in 3-cylinder mode. I had a hard time feeling any transition though. Performance-minded drivers of GM AFM and Dodge MDS equipped vehicles may complain that they can feel their V-8s transition to 4-cylinder mode or dislike throttle response. Despite tremendous improvements in these systems today, there are still problems and disadvantages that some owners are unwilling to put up with. The processes involved with deleting this feature on today's vehicles is covered in numerous owner web blogs.

2. Contamination/oil sludging issues. As with engines equipped with variable valve timing and variable valve lift, variable displacement models are every bit as dependent on an ample supply of clean oil. Engine oil sludge and other sources of contamination can cause the pins in the lifters or rocker assemblies to lock in the deactivation state or activation state, resulting in drivability and DTC complaints. Many variable displacement engines include a screen near the oil passages feeding the displacement control solenoids (**Figure 7**). Today's variable displacement engines require preventative maintenance services (in this case the common LOF) at intervals based on factory recommendations, real-world experience and the customer's driving habits. As important as the oil's viscosity and synthetic/semi-synthetic status is the engine builder's spec for that application.

3. Oil consumption and fouled spark plugs. Regarding motor oil, a common complaint on variable displacement engines is oil consumption. Theories vary as to why extra oil consumption seems to plague these vehicles compared to their fixed displacement counterparts. There are lots of folks in the aftermarket promoting the deletion of AFM and MDS on GM and Chrysler products. I prefer to stick with what the OEM says on the subject of 2007-2011 models equipped with AFM. Take a look at this abbreviated summary of the General Motors TSB 10-06-01-008F:

Condition — This TSB focuses on the common problem of engine oil consumption of vehicles with higher mileage

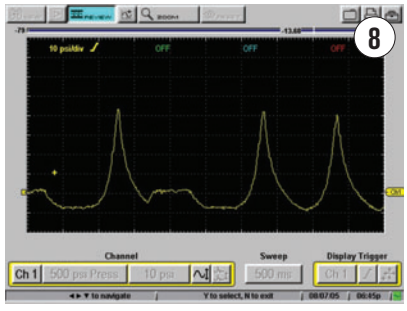


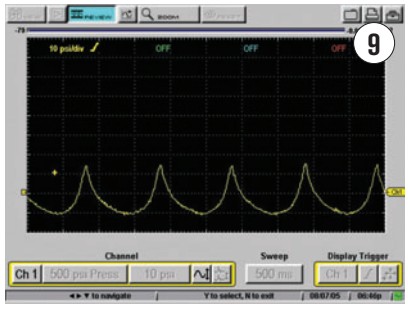


[approximately 48,000 to 64,000 km (30,000 to 40,000 mi)] experiencing an MIL and/or rough running engine. Verify that the PCV system is functioning properly. If the customer understands that some oil consumption is normal and still feels the consumption level is excessive, more than 1 quart per 2,000 to 3,000 miles of driving, perform the service indicated in this bulletin.

Cause — This condition may be caused by two conditions:

1. Oil pulled through the PCV system.
2. Oil spray that is discharged from the AFM pressure relief valve within the crankcase. Under most driving conditions and drive cycles, the discharged oil does not create any problems. Under certain drive cycles (extended high engine speed operation), in combination with parts at the high end of their tolerance specification, the oil spray quantity may be more than usual, resulting in excessive deposit formation in the piston ring grooves, causing increased oil consumption and cracked or fouled spark plugs (#1 and/or #7)





PHOTOS: SCOT MANNA

Correction — Redesigned rocker covers address the PCV oil usage issue. For the excessive oil discharge from the pressure relief valve, GM says you may also need to install an oil reflector in the crankcase oil pan near the pressure relief valve and clean/free up the piston rings or even replace the pistons in severe cases along with the spark plugs if they are oil/carbon fouled. See the TSB in its entirety for complete details.

4. Engine mechanical misfires and noise — Regardless of whether lifters don't lift or rockers don't rock, it's a small pin operated by the electronic control of oil pressure that does the job. When it doesn't move to allow for cylinder deactivation, there are torque management processes still going on to prevent the driver from feeling cylinders cut in and out. Torque management will continue for cylinders that are NOT deactivated properly until a DTC sets, meaning if the cylinders aren't shutting off due to stuck mechanical parts, there will be surges noticed under steady cruise conditions. If the engine enters reduced displacement and remains there due to sticky mechanical parts, a stumble is noticed followed by a misfire(s). Honda/Acura models will sometimes "hammer" when their V-6 Odyssey minivan models get one or more cylinders stuck in displacement reduction mode. Honda addresses normal noise and vibration on their VCM systems via special motor mounts and noise cancellation via the factory audio system. Whether your customer has excessive engine noise or a misfire DTC, you'll need to add variable displacement system testing to your diagnostic approach when working on these vehicles.

Tech tip

Kent Moore has a special tool (EN-46999) for GM's AFM systems that checks the oil control solenoids' electrical integrity as well as the actual flow from the solenoids via compressed air and a pressure gauge tied into the system. As with any OEM specialty tool with a high price tag, you may not purchase it. So one alternative is to perform a running compression test while activating the variable displacement system:

1. Connect a scan tool that has the bi-directional control capability to activate variable displacement oil control solenoids for the vehicle you're working on.
2. Disable the fuel and spark for one of the cylinders that is controlled by the variable displacement system. Choose two variable displacement-controlled cylinders — one that is NOT having a misfire and one that is for this test.
3. Remove the suspect cylinder's spark plug and install a compression gauge with the hose's Schrader valve removed. You should practice this procedure on a few known good vehicles to get your bearings on what to expect. Generally, the compression you get during a normal speed cranking compression test is at least twice as high as what you encounter on a running compression test.
4. Activate a suspect cylinder's variable displacement solenoid via your scan tool (or do so manually with fused test leads connected correctly) while observing the compression with the engine running. A properly functioning variable displacement system will cause the running compression readings to increase and decrease as you activate and deactivate that cylinder's oil control solenoids. If an oil passage way is plugged up, a solenoid is not functioning or there's a stuck pin in the lifter (GM or Dodge) or rocker (Honda/Acura) you will not see a change in running compression as you activate that cylinder's solenoid. A deactivated cylinder will typically run around 20 PSI on a running compression test while the same cylinder will jump up to around 50 PSI upon reactivation if that oil control solenoid is working, the oil passageways are clear, and the lifter is working as designed.

Note: If you know how to perform an in-cylinder pressure transducer test with your lab scope, use the transducer to look for changes in cylinder pressure as the oil control solenoids are actuated. Your initial pattern upon cylinder deactivation will show two larger pressure pulses for both intake and exhaust followed by lower and lower pulses until the cylinder is reactivated (**Figures 8 and 9**).

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A JUMP ACROSS THE POND

NO ONE PERSON CAN BE AN EXPERT IN EVERY AREA OF AUTOMOTIVE REPAIR. EXPAND YOUR SKILL SET THROUGH NETWORKING!

BRANDON STECKLER // Contributing Editor

Social media is an amazing thing. From a diagnostician's perspective, having the ability to reach out and communicate (in an instant) with like-minded individuals across the globe allows for some tremendous opportunities. Each one of us sees through a different perspective, has different experiences with different vehicles and can offer data that we might not encounter otherwise. With a group of like-minded individuals who both share a passion for the automotive industry and a desire to learn/share/educate equally, it's a winning combination. It's these very traits that helped to make an important and otherwise expensive diagnostic decision easy as pie.

Same problems, different terminology

Earlier this month, I crossed paths with a fellow tech by the name of Ryan Colley. Ryan works in a shop called Elite Automotive Diagnostics, located in a small village called Bishops Hull, in Taunton, United Kingdom! Ryan reached out to me because both of us network commonly with other techs through a few Facebook automotive groups. Each one of us in the groups has a particular arena that they are comfortable in. I happen to be comfortable analyzing pressure waveforms acquired from different points on the vehicle. This is the reason Ryan reached out to me. Ryan is faced with a 2006 Audi S4, housing a 4.2L DOHC-V8 engine under its hood (or should I say "bonnet?") as seen in **Figure 1**. The engine performs very poorly and was brought to his workshop for analysis. Ryan quickly recognized the symptoms the vehicle — with 77,564 miles and an automatic transmission — was exhibiting, as the cranking cadence of the engine indicated something mechanical is "going to pot." The vehicle's PCM was scanned for DTCs. Looking at the DTCs, we can see that misfires are being flagged for cylinders 5, 6, 7 and 8. The DTC pertaining to the

bank 2 camshaft position is the "cream on the plum pudding." All of the supportive evidence thus far indicates a shift in camshaft timing on bank 2 of the engine.

Logic told Ryan that the results of a relative compression test would further back up his theory. Ryan performed the test using an amp probe and a lab scope. The current flowing through the starter supply circuitry is measured and plotted over time on the lab scope. After the engine is disabled from starting and is cranked over (for a few cycles), the resulting current draw is plotted as a trace and presents as a series of "peaks." If this Audi exhibited no mechanical fault, and because all eight cylinders are engineered the same, they should place the same load on the starter (as they approach top dead-center of their respective compression strokes). Ryan's theory (due to the supporting evidence) is a mistimed camshaft on bank 2. Ryan anticipates a relative compression capture displaying a variation in "peak amplitude" comparing cylinders from one bank to the other bank. **Figure 2** is the result of the test and confirms Ryan's hypothesis. Ryan sees the variation in peaks, but it doesn't exactly represent the waveform he anticipated seeing. It appears to have a few back-to-back peaks of low amplitude and the fear is "engine

PHOTOS: BRANDON STECKLER

damage," sustained from the loss of camshaft timing. Ryan proceeds with the next logical test procedure, drawing him closer to a diagnosis and recommended course of action.

What would your next test be?

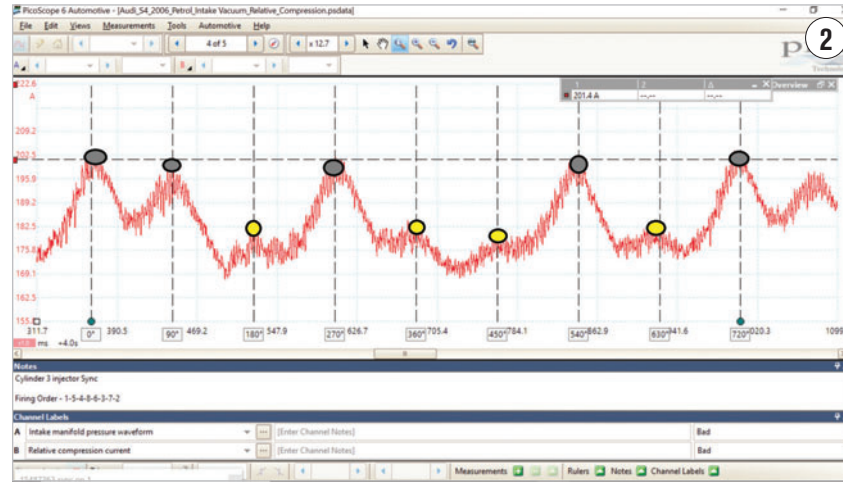
It's quite clear that the engine is out of time. The questions then become:

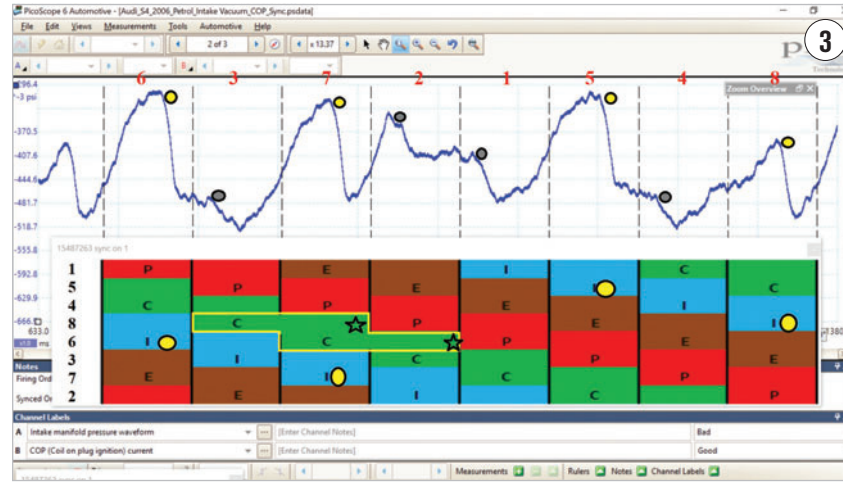
- Is the valve train damaged?
- Is there damage to the pistons/lower end?

The questions are logical but they hold a bit more significance than they first appear to. The configuration of this engine places the timing cover on the rear of the powerplant. To even visually inspect the timing components requires removal of the front-end of the vehicle, the engine/transmission assembly and they then must be separated from one another, as the timing components are sandwiched between the two units. To replace the timing components requires the better part of a 30-hour job! Completing the repair is no easy task, to say the least. Consider the situation if the timing components were replaced, but the engine sustained damage unknowingly!

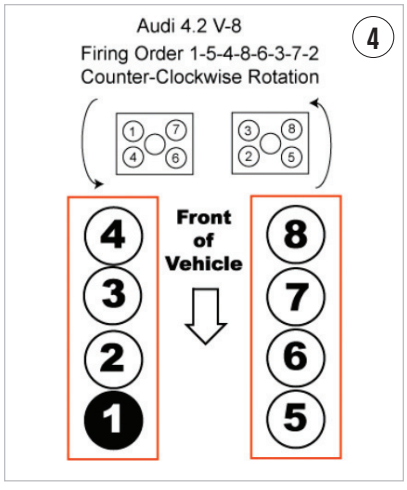
Ryan consulted with his coworkers and most all agreed the best course of action was to recommend replacement of the engine. He knew that acquiring the resulting pressure waveforms (from the intake manifold and within the cylinders) may offer a bit of insight as to the true condition of engine overall. It may also tell him if the resulting drivability fault was simply due to incorrect cam timing or not. This, of course, would allow him to offer the proper solution to the customer, and do so with confidence.

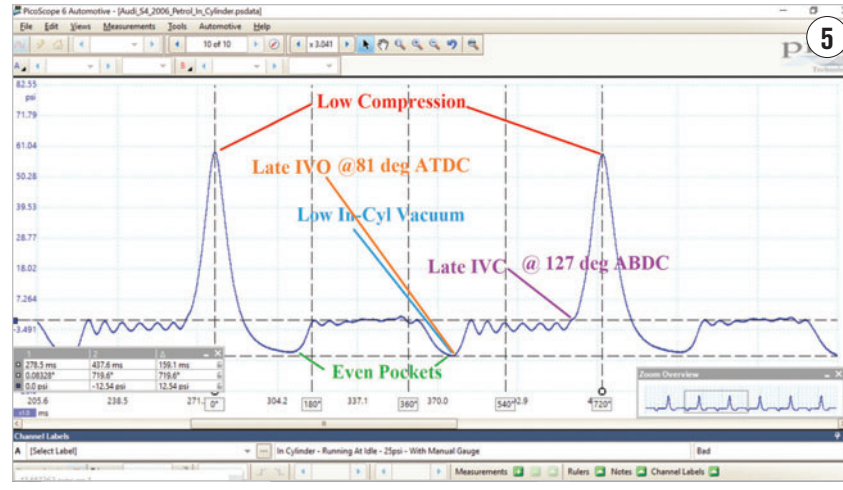
Figure 3 is a capture representing pressure changes inside the intake manifold. To acquire this data, Ryan affixed his pressure transducer to the intake manifold and coupled it to his PC-based lab scope. The engine is once again disabled from starting and the engine is cranked over for multiple engine cycles. What's great about these tools and process is that Ryan can acquire this data as an active file and share the resulting captures via email or through chat groups like Facebook offers directly. First, Ryan's concern was of the seemingly similar random-looking pressure changes in the intake manifold. He was interested in tying the results of the capture to a loss of cam timing on one bank. This is where I come in to play. Let's analyze the waveform.





First, using a point of reference (from a known ignition event) I was able to determine when an entire engine cycle began and ended. This allows me to capture the data reflecting each of the engine's pistons contributing to the intake manifold. Researching the firing order is necessary to determine how the activity in the intake manifold correlates with each of the cylinders. A piston chart was added to the capture to aid in analysis (and in explanation to Ryan) as to what I see occurring in the data. We have to first understand that as each cylinder enters the induction-stroke portion of the engine cycle, the intake valve for that cylinder is open. This piston will descend and inhale the fresh air from the intake manifold. Since we are viewing data from the perspective of the intake manifold, each one of these induction events results in





a momentary increase in intake manifold vacuum. This causes the trace from the pressure transducer to decrease in amplitude (or "head south"). We can call these events "pulls." We are interested in seeing which cylinder created which pull.

Cursors are spanned the entire engine cycle, which offer the ability to partition the capture into eight equally-spaced areas. These areas represent the eight cylinders contributing to the intake manifold vacuum trace. Using the cursors, I'm interested in seeing when these pulls occur, relative to the vertical cursors. A late pull will occur further from the cursor than a pull that occurred on time. Indicated by the gray circles, these represent the pulls from bank 1. Take notice of the cursor, just left of the circle. Indicated by the yellow circles are the pulls from bank 2. Take notice of the cursor, just to the left of the circle. If you compare the proximity of the circles to the cursors, it's clear to see that bank 2 pulls are occurring later than bank 1 pulls. This also explains the random-looking pattern of the cranking intake vacuum trace.

Using a piston chart to aid in analysis and explanation, and now referencing the yellow dots superimposed upon it, it too makes it clear to see that all of the bank 2 intake pulls are late, relative to the bank 1 intake pulls. Logic supports a bank-to-bank timing issue, and we would anticipate every other pull to be late. That would be true in many cases, but not in this Audi's case. Take a moment to view the engine configuration in **Figure 4**. The firing order on this engine's configuration supports a firing event that alternates between banks.... except when cylinders 6 and 8 fire. They are two cylinders that fire consecutively ON THE SAME BANK! This is what you see occurring in the intake trace for pulls 1 and 2 (as indicated by the red numbers, at the top of the capture). These numbers are calling out the cylinder responsible for the pull below it. If you then reference the piston chart, you will see that I have encapsulated an area with a yellow box. This area contains two black stars that indicate when cylinders 6 and 8 approach TDC/compression consecutively. Because the bank 2 intake cam is late, the intake valves for bank 2 cylinders will open late but close late as well, leaving more volume to be shed back to the intake manifold, as the pistons approach TDC/compression. This is why the intake trace rides "hi" for so long at this point (two consecutive cylinders pumping extra volume back to the intake manifold). This is why it has that random look to it. The appearance of the trace is due to engine configuration.

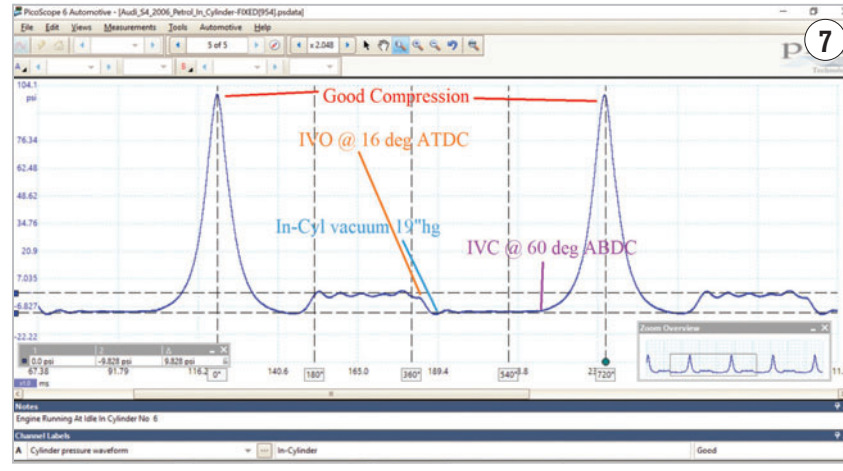
Figured that out! On to the next step

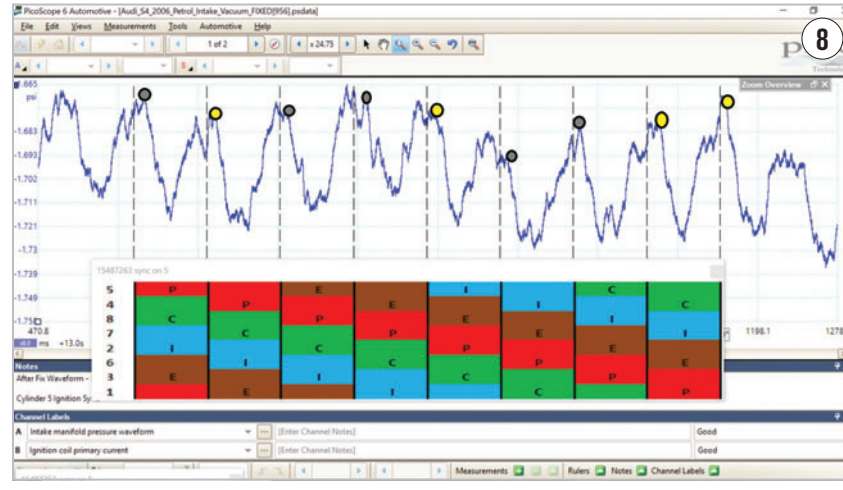
This data will tell us why the cranking intake vacuum waveform appears as it does, but more significantly, drives us further to the next logical test. A running in-cylinder pressure waveform was acquired from an easy-to-access cylinder on bank 2 (the suspect bank). The pressure transducer is used in place of a mechanical gauge and reveals a tremendous amount of data, and not just peak compression. Because the data is

captured on the lab scope, with cursors we can effectively associate time with the 720-degree engine cycle. In other words, we can confirm camshaft timing (to within a few degrees of accuracy) as well as monitor the breathing characteristics of the cylinder, dynamically.

As can be seen in **Figure 5**, the running in-cylinder compression waveform (for one from the suspect-bank) is captured and annotated. The cursors denote the characteristics supporting the late intake cam timing, as suspected. The red annotation indicates low running compression for this engine. The orange annotation demonstrates the point where the intake valve opened. The cause of the deep in-cylinder vacuum (at almost 24" hg) is due to the piston descending down the cylinder with the valves closed. Only when the intake valve opening finally occurs is the vacuum relieved. Finally, the intake valve is seen to be closing at about 127 degrees ABDC of the induction stroke. These are all key indications of a late intake camshaft. The key is that the captures display what the symptoms offer as suspect. The real prize is the fact that we can see a suspect bank's cylinder draw a vacuum and create compression with no leakage… all without disassembly and from the other side of the great Atlantic Ocean! Ryan now has the evidence to prove he may begin this saga of a repair. More importantly, he has the confidence to do so. This now perpetuated by his newfound knowledge — his understanding of the pressure waveform analysis!

The better part of a week goes by and I receive another Facebook video capture. Ryan completes the disassembly and confirmed bank 2 intake cam was indeed "late." The cause of the retarded camshaft was due to a damaged VVT actuator, where the locating pin interfaces to lock the actuator in place (**Figure 6**). Ryan replaced the timing components and reassembled the vehicle. The engine starts, runs smoothly but the best part was Ryan's excitement. He was dead chuffed! I only wish I could've been there to see the look on his fellow employees' faces!





Shortly thereafter, I received the resulting post-fix captures. The in-cylinder trace reflected strong running compression, an intake valve that now opened on-time at about 16 degrees ATDC. This allowed the piston to inhale freely and prevented the deep in-cylinder vacuum we witnessed earlier. The compression began to increase way earlier as well. The intake valve now seats at about 60 degrees ABDC. Much better than previously (**Figure 7**). The cranking intake vacuum waveform now exhibits pulls whose proximities are all very close to one another, regar ding where they fall, relative to the vertical cursors (**Figure 8**). This is indicated by displaying both the YELLOW dots (representing bank 2 pulls) and the GRAY dots (representing bank 1 pulls).

We can all now see how difficult gambles can be avoided by moving forward with technology. We can learn by sharing information with peers all over the world and employing newer testing techniques that allow you to make tough calls with the utmost confidence.

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.
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I NEED A TUNE-UP

DO CUSTOMERS STILL ASK YOU FOR "TUNE-UPS?" MORE IMPORTANTLY, ARE YOU STILL SELLING THEM?

PETE MEIER // Technical Editor

Way back in the day, vehicle owners had "tune-ups" performed on their cars every year, or every 15,000 miles or so. The reason was simple. Most of the engine management systems were mechanical and wore over time. The contact breaker points in the ignition system, for example, had to be cleaned (or replaced) and adjusted to keep ignition timing in specification. The idle mixture and choke linkages on the carburetors of the day needed tweaking once a year to maintain fuel efficiency and ease of starting. Today, though, these systems are electronic and computer controlled — never requiring adjustment or replacement.

So if these services are no longer needed, is a tune-up still a valid service to offer?

ONE OF THE MORE SEVERE FILTERS I've seen. But who's going to check it, if not you?

Tune-up defined

One definition of the term is "a general adjustment to ensure operation at peak efficiency." Some sources add "a process in which small changes are made to something (such as an engine) in order to make it work better." By either definition, using the term "tune-up" on your menu board may still be valid — though the processes included in that labor operation may have to be modified to reflect the needs of cars today.

For example, we aren't adjusting points or timing anymore, but we still service ignition spark plugs. Most cars don't require valve adjustment, but some do and including that operation in your offering would meet the definition of making a "general adjustment," wouldn't it? And how about the idea of removing carbon build-up, especially on those models we know are prone to them? Isn't that making a "change" that makes it work better? Based on these few examples, the term is still valid. But is it practical?

There, I think, the answer is a solid "No."

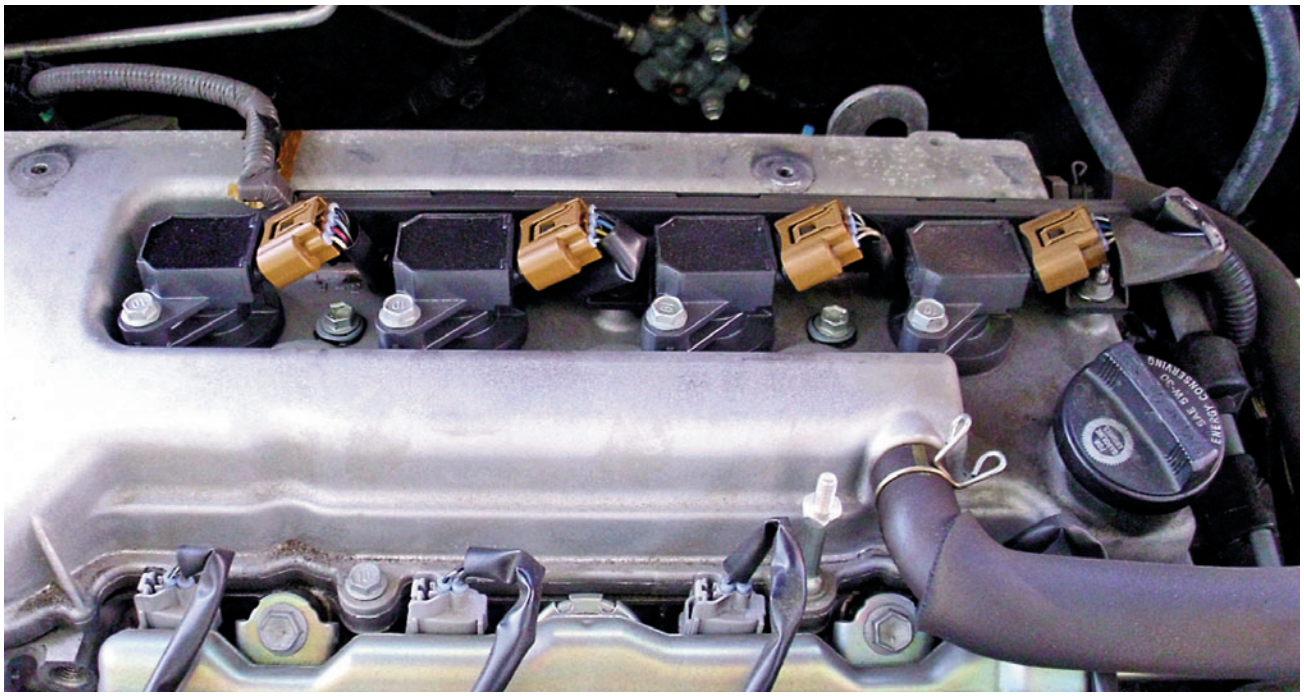
And for a few reasons. First is the impracticality of offering a general service item to fit a variety of applications. You just can't break it down like we used to and offer a 4-cylinder, 6-cylinder or 8-cylinder job. Second is the connotation that surrounds the word. Many customers still come in requesting a tune-up, thinking that it will cure whatever ails their car's drivability.

The 30-60-90 menu board

An option that gained popularity a few decades ago and still graces the menu boards of some shops is the concept of the "routine service" based on 30,000 mile intervals. Not a bad idea, for the most part, because these services often addressed the maintenance needs of the entire vehicle and not just the engine. Many of those offering these menu items included, at the least, transmission and coolant fluid exchanges as integrated parts of the service.

But this, too, is getting to be a bit archaic. Maintenance needs still exist,

PHOTOS: PETE MEIER



SPARK PLUG SERVICE is still a normal offering, but alone doesn't make a "tune-up."

though maybe not at the same levels as they used to. Better yet is the idea of setting up a routine maintenance plan for your customer based on the OEM's maintenance recommendations. These schedules can be found in both OE and aftermarket service information sources. Since they are included in the customer's owner's manual, there is additional justification for your recommendations.

If you're familiar with the OE schedules, you know most list two: one for "normal" service and one for "severe" service. So which do you recommend? To quote one OEM's criterion:

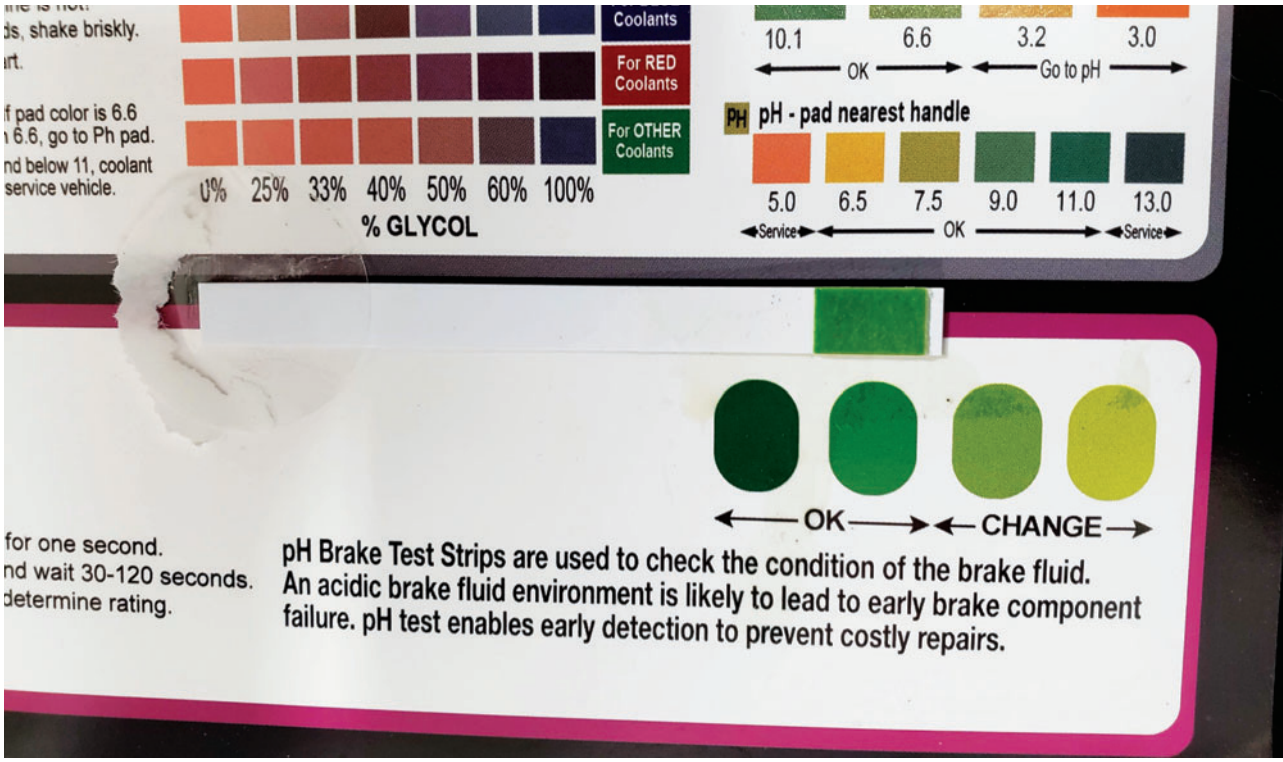
Follow the severe conditions maintenance schedule if you drive your vehicle MAINLY under one or more of the following conditions:

- *driving less than 5 miles per trip OR less than 10 miles per trip in freezing temperatures*
- *driving in extremely hot (over 90 degrees F) conditions*
- *extensive idling or long periods of stop-and-go driving, such as a taxi or commercial vehicle*
- *trailer towing, driving with a roof rack, or driving in mountainous conditions*
- *driving on muddy, dusty, or de-iced roads*

I don't know about you, but my primary driving habits meet at least one! Recommend using the "severe" schedule to your customers to help them "ensure operation at peak efficiency."

What if it's not on the schedule?

One maintenance item that comes to mind that is not on the



THE BEST WAY TO TEST BRAKE FLUID (and coolant) is to measure the acidity, or pH, of the fluid.

service schedule of some OEMs is the need for brake fluid replacement. It seems that no domestic maker lists a recommended service interval. Europeans, and some Asians, however, do specify service intervals for their vehicles. What should you do?

We all know that brake fluid is hygroscopic, meaning it absorbs moisture. As the moisture content builds, the boiling point of the fluid drops. This can reach a point where hard braking causes the water in the system to boil out, resulting in a loss of (or spongy) pedal. Moisture in the system was a problem back in the day but, like every other system now, they are sealed much better and the opportunities for water to enter more often come from the use of already contaminated fluid. Still an important check, but the absence of moisture does not mean the fluid is healthy.

As further studies were done, experts began recommending measuring the copper content of the fluid. This can be done by the use of specialty test strips and provides an indication of the condition of the anti-corrosion additives used in the fluid. But, according to the folks who make the test strips, copper content becomes almost useless if the brake system has had the fluid exchanged already. Why? The copper comes from the copper brazing in the brake lines and if the system has already had the fluid exchanged, those particles are flushed out. Now, the focus is on measuring the acidity, or pH, of brake fluid as

a key indicator. A highly acidic fluid is another indication of additive depletion and reason for a fluid service.

Another vehicle fluid that shouldn't become too acidic is the coolant. It, too, uses a type-specific additive package that is charged with keeping the coolant and the cooling system components healthy. Unlike the brake system, however, the cooling system is much more open to outside attack (from poor electrical grounds, improper water selection and undiagnosed head gasket leaks, to name a few enemies) — and premature failure of the fluid results. Here, you may find yourself testing and recommending a fluid exchange to a customer who just had one recently completed. Just be sure to correct the cause of the early coolant demise at the same time.

Assessing the condition of the engine oil is generally not an issue. Most consumers understand the need to change that one routinely, even if it's only because it's become ingrained in our society's psyche. What you may consider offering, though, is from a lesson learned from our Class 8 cousins — have the oil analyzed by a lab. These analyses can often help dial in a customer's individual maintenance schedule as well as detecting trace elements that may point to undiagnosed failures, or pending failures. For example, traces of coolant in the oil could indicate a slight leak in a head gasket that is causing no other problems than contamination of the coolant as I shared above. But, if left unchecked, it could lead to much worse.

Similar is the analysis of the vehicle's transmission fluid, even before it's changed. Some fluids are labeled as "lifetime" but we technicians treat that term with some pessimism. The fluid, if left alone and uncontaminated, may just last the lifetime of the vehicle, but we can't help but wonder, what if? An analysis will provide data on trace elements that will help you gauge the condition of the fluid as well as catch any internal issues before they become major problems.

Agreed, these are all more involved and higher scale services than what we may be used to offering our clients. But the vehicles they are driving are also on a much higher scale, aren't they? The cost of ownership is rising, the cost of repair and service is right behind it and helping your customer control that cost as much as possible will only help you earn, and keep, their business.

RECOMMEND FLUID SERVICES when the fluid service is required. Sometimes, that's before or after what the owner's manual might say.

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

Drive aftermarket success at AAPEX 2019

The road to success in the automotive aftermarket industry is paved with new products and advancements. To stay on top of all that's new — and meet the expectations of customers that are attuned to the latest innovation — it's critical that aftermarket industry professionals keep up with the trends, products, and innovations that will keep your customers loyal and your business going strong.

That's what AAPEX is all about. As the leading trade-only event for the automotive aftermarket industry, AAPEX is tailored to the needs of professionals whose livelihood depends upon immediate and effective response to vehicle mobility challenges. By providing all the latest insights, education, and innovation, AAPEX offers all you need to advance your business today and keep you at the forefront of what's coming next.

If you're looking to stay focused on the future of your industry, mark your calendar for AAPEX 2019, which will take place November 5-7, 2019, at the Sands Expo in Las Vegas. Featuring a wide variety of hands-on training, education, and networking events, AAPEX 2019 is the place to be for aftermarket professionals aiming to stay on the fast track to future success.

Highlights for AAPEX 2019 include:

Technical Training in the Mobility Garage

Keep up with standards and certifications in AAPEX's leading-edge Mobility Garage, where you'll take part in trainings throughout the event. This is your optimal opportunity to participate in hands-on demos and engage in one-on-one interactions with suppliers and exhibitors.

Interactive Learning at Let's Tech

Brush up on your tech savvy in fast-track 20-minute lessons highlighting emerging technologies that support various aspects of the automotive aftermarket. Here, you'll engage in quick learning on the hottest topics in the industry, including:

- ADAS and the Need for Calibration
- The Digital Advisor's Role in the Service Process
- Data Science and Technology for Inventory Optimization in the Aftermarket

The AAPEX Virtual Vehicle Challenge

A one-of-a-kind experience, this event tests your competitive spirit and your knowledge in parts and installation. This was a highlight in 2018, so stay tuned for what AAPEX 2019 has in store! The AAPEX Virtual Vehicle Challenge will take place on Level 2 in the Sands Expo upper lobby.

A Comprehensive Educational Curriculum

AAPEXedu provides the latest information on the most pressing topics in the industry through carefully-curated education sessions. For instance, last year, the Service Professionals General Session, Automotive Career Pathways: The Road to Great Technicians presented service professionals with an expert panel discussion on skills building and professional development. While the AAPEX 2019 schedule is still being finalized, you can be sure that the selected education sessions will hit all the relevant topics to help you drive your business forward.

AAPEX also offers resources that help you stay up to date on event details and

the latest aftermarket news and information through the AAPEX Blog, featuring posts on trends, technology, and all the hottest topics in the aftermarket. New blog posts are published every other week to help you stay current. Check out the latest blog posts on The State of the Automotive Aftermarket…and AAPEX and The Top Three Transformative Automotive Aftermarket Changes Requiring your Action at AAPEX 2019. Other great resources to take advantage of include AAPEX social media and AAPEX TV-360, which covers aftermarket news, insights, and tips. Find AAPEX TV-360 episodes at www.aapexshow.com.

With all this and so much more on tap, AAPEX 2019 will truly be an event that's not to be missed.

Mark your calendar for November 5-7, 2019! Registration is now open at www.aapexshow.com.

AAPEX is a trade-only event and is not open to the general public.

AAPEX is co-owned by the Auto Care Association and the Automotive Aftermarket Suppliers Association (AASA), the light vehicle aftermarket division of the Motor & Equipment Manufacturers Association (MEMA). For more information, visit www.aapexshow.com or e-mail: info@aapexshow.com. On social media, follow AAPEX at #AAPEX19.

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Multi-link suspensions – more comfort through more arms

Multi-link suspensions have largely replaced conventional wishbone suspensions. The modern design offers increased driving dynamics as well as substantial added comfort. This requires a great design engineering effort. One or both wishbones are broken down into multiple components so significantly more moving parts are installed.

How many vehicles have you worked on this week that have multi-link suspensions? 5? 10? Probably a lot more than that. Cars are becoming more complex each and every day, and the only way to stay on top of it all is through training and articles like the one you're reading right now.

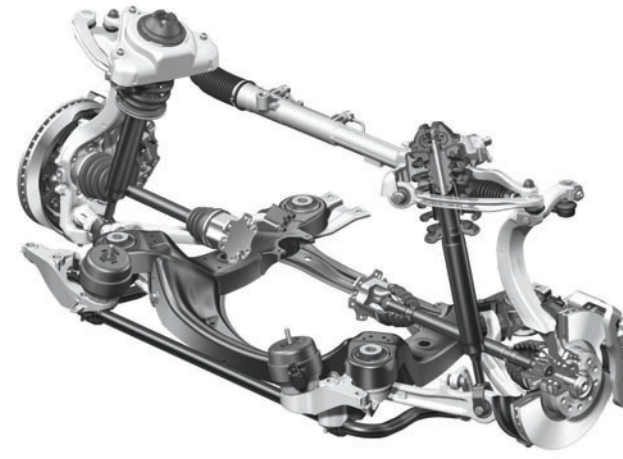
More moving parts also mean more joints connecting the parts — which means more places that are potential repair items. The development engineers try to keep these movements as small as possible ensuring, after cornering the front axle returns to center position independently and smoothly and the suspension responds more sensitively.

Today, so-called low-friction ball joints are used which have a substantially lower friction moment than previous types. While a smoothly moving ball pin used to indicate increased wear of the ball joint, this is no longer the case today. Modern ball joints have distinctly lower breakaway torques and running torques.

Maintenance & repair

Mechanics should observe several points when replacing individual components:

- When replacing a ball joint, the eye and the rubber contact surface where the joint is installed needs to be cleaned and any rust removed. The contact surface has to be free from rust as otherwise the rubber sleeve will rub against the rough surface and leak.
- Dirt and moisture can enter into the joint. This leads to premature failure of the joint.
- During installation, ensure the corrosion protection layer of the circlips is not damaged, as rust causes them to lose their spring force allowing moisture ingress into the joint, significantly affecting service life.
- Never tighten the ball joint with an impact wrench. There is a risk the ball pin could start to rotate so fast the plastic bearing shell becomes deformed by the frictional heat, leading to play in the system.



- Furthermore, the tightening torque can be exceeded causing the ball pin to move too high into the eye of the stub axle. This means the rubber sleeve can no longer fulfil its sealing function, allowing dirt and moisture to enter into the ball joint.
- The rubber bearing on a control arm may only be tightened when compressed and without load to avoid twisting and therefore applying pre-tension to the bearing.

The installation errors described can lead to premature wear or even failure of the replaced part. Workshops should always carry out a wheel alignment after replacing suspension parts, even if only axle components were released. If these simple rules are followed, all suspension repair work can be carried out successfully.

Learn & grow

So how can you keep up to date with all of this? ZF Aftermarket focuses their technical training activities on topics like this to help you succeed now and in the future. With ZF Technical Training and ZF [pro]Tech workshop service, technicians like yourself are ready to diagnose and repair each and every problem vehicle that enters your workshop. Learn and grow with Knowledge from the Pros at www.Aftermarket.ZF.com/US/proTech.

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WWW.TEXTAR-WORLDPAC.COM

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WWW.AAPEXSHOW.COM

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WWW.AFTERMARKET.ZF.COM/US

CABINET COLLECTION

Raybestos® has added two new designs to its cabinet collection — the Raybestos large-sized product-filled cabinet and the Raybestos "Into the Future" collector's edition medium-sized cabinet — both available while supplies last. The "Into the Future" medium-sized cabinet measures 19-3/4-inches high, 30-inches wide and 13-inches deep. The large Raybestos cabinet measures 38-inches high, 32-inches wide and 15-inches deep. The large cabinet also includes six sets of Raybestos brake pads.

WWW.RAYBESTOS.COM

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Carquest Platinum Painted Rotors, an exclusive line of premium rotors offered by Advance Professional and Carquest, are designed to meet professional repair facilities' need for a high-performing rotor product that is visually appealing to today's drivers. Engineered with a rust inhibiting barrier that provides more protection than non-painted rotors, Carquest Platinum Painted Rotors help decrease brake noise and increase the life of a vehicle's brake pads. For more information on quality Carquest products, call your local Advance Auto Parts or Carquest delivery location.

WWW.CARQUEST.COM

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Meguiar's, the worldwide leader in car care, introduced an exciting new product to its impressive line of premium car care products, Carpet & Upholstery Cleaner. This professional strength carpet and upholstery cleaner is formulated specifically for stain removal, performing general cleaning and freshening the entire interior with odor eliminating technology.

WWW.MEGUIARS.COM

AD INDEX

AD INDEX

PRODUCTS

TRAINING

CAN I CHECK UNDER THE HOOD FOR YOU?

PERFORMING AN UNDERHOOD INSPECTION IS AKIN TO A DOCTOR'S BASIC EXAM — PROVIDING YOU WITH CLUES ON THE HEALTH OF YOUR CUSTOMER'S CAR.

PETE MEIER // Technical Editor

My very first job in this industry was working as an attendant at a full service gas station. Many of you are too young to remember those days. The role of the attendant was to not only fill the gas tank for the customer, but to provide an exceptional customer experience by offering to check the tires, clean the windshield and inspect under the hood. This helped the customer take better care of their car and offered potential upsell opportunities to the business, while building customer loyalty to the station.

But these complimentary checks seemed to die off along with those neighborhood gas stations. In fact, some states have consumer protection laws preventing us from looking under the hood unless the original customer concern requires us to be there. Do you ask your customers for permission to perform a maintenance/safety inspection when they drop their cars off?

If not, you should. The opportunity to look over the car, though, should be viewed as a service first and a business opportunity second. You've heard me preach this before. I am a strong believer that it is our moral and ethical responsibility to help our customers keep their cars operating safely and to advise them of needed maintenance and repairs. Making recommendations on the basis of how it benefits the customer will always bring you more business than recommending services based on how they'll benefit you.

In this month's "The Trainer," we'll focus on inspecting the underhood items and discuss how they can impact both safety and vehicle longevity. These baseline observations are not much different from the baseline tests your doctor performs every time you see him or her. And just like those baseline tests, recording and monitoring them every time your customer pays you a visit will help you help them avoid costly repairs down the road.

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