




12 OPERATIONS
HOW TO AVOID PITFALLS AND
GET RESULTS FROM YOUR KPIs

A SYSTEMATIC APPROACH
TO FINDING THE

RIGHT SCAN TOOL

A 3D model of an engine is shown on a tablet screen, with a scan tool interface overlaid. The interface includes a 'Check error code:' section with a list of error codes: P0011 Heated Oil Service Circuit Low Voltage (Bank 1, Sensor B), P0012 Heated Oil Service Circuit High Voltage (Bank 1, Sensor B), and P0013 Heated Oil Service Circuit Low Resistance (Bank 1, Sensor B).

If you are in the market for
a scan tool, there is more
to consider than cost.

**26 HOW BRAKE PAD
FRICTION AFFECTS ADAS**

Using the wrong type of replacement pads on an ADAS-equipped vehicle could have far-reaching consequences.

**32 THE INS AND OUTS OF
FORD'S ELECTRONIC
AUTOMATIC
TEMPERATURE CONTROL**

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MOTOR AGE

Talk Shop Anytime



JULY 2023

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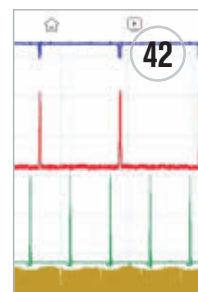
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TOOL REVIEW: DISCOVERING THE AUTEL DIAGNOSTIC TABLETS QUICK SERVICE MENU

Learn about Autel's expansion into electric vehicle diagnostics with the new MaxiSYS 909EV tablet. The tablet offers comprehensive vehicle coverage for U.S., European, and Asian electric, gas, diesel, and hybrid vehicles.

In this Tool Review video, follow along with Scott Brown, contributing technical editor for Motor Age, as he reviews the Quick Service Menu found on any of the modern Autel diagnostic tablets, including how this feature can offer quick access to many common service and maintenance reset procedures.



WEB EXCLUSIVES

Service Done Right #20: Diagnosing Noise And Vibration Complaints - The Science Of NVH

SERVICE DONE RIGHT #20: DIAGNOSING NOISE AND VIBRATION COMPLAINTS - THE SCIENCE OF NVH

In this Service Done Right video, sponsored by Advance Auto Parts, Pete Meier discusses how EV vehicles are susceptible to NVH (Noise, Vibration, and Harshness), and how you can address it in your shop.



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GUEST EDITORIAL: AI DOES NOT REPLACE THE HUMAN ELEMENT IN ENSURING ROADWAY SAFETY

BEN SHARP // Contributing Editor

➔ It's not too late for NHTSA to update its National Roadway Safety Strategy by adding inspections and advancing a more holistic approach.

Artificial intelligence will not solve our country's pressing road safety problems on its own. Humans must play a role in ensuring all cars are fit to drive. Unfortunately, in this political environment that favors hyperbolic soundbites over nuanced examination of public policy, some lawmakers have opted to ignore how regular vehicle safety inspections conducted by humans save thousands of lives annually. These programs will also continue to save lives in the future, even as newer vehicles grow increasingly reliant on autonomous vehicle (AV) and advanced driver assistance systems (ADAS) technologies.

Science and data prove vehicle safety inspection programs are effective. States that run these programs experience 2.8 percent fewer roadway fatalities than those that don't. That relationship is causal, according to a national study recently published by Carnegie Mellon University. A 2018 study from the University of Texas at Austin found that the most common type of car defect related to fatal crashes is bald or defective tires. Roughly 23.5 percent of the Texas drivers surveyed for the report reported having been instructed by an inspector to fix a tire concern at some point. Given this information, you would think that the U.S. Department of Transportation (DOT) would seek to harness this tool in its "National Roadway Safety Strategy" (NRSS), publicized in January 2022, which aims to eliminate avoidable tragedies on the road.

The NRSS segments its approach into five categories: safer people, safer roads, safer vehicles, safer speeds, and post-



crash care. It summarizes "safer vehicles" as the effort to "Expand the availability of vehicle systems and features that help to prevent crashes and minimize the impact of crashes on both occupants and non-occupants." DOT noted that "The role of vehicle safety performance in avoiding or mitigating the harm of crashes cannot be overstated." Safe driving advocates were therefore dismayed when they realized this plan only mentions these programs once. In passing, it states, "To ensure the safe operations of commercial trucks and motor carriers, the Department continues to identify high risk companies and operators of commercial motor vehicles using a data-driven and performance-based approach, including roadside commercial vehicle safety inspections." However, the safer vehicle approach focuses on ADAS and AV technology as if it were a panacea.

There's a troubling disconnect between the NRSS's stated goals and the tactics prioritized. That disconnect widens when one considers the heightened need for AVs and vehicles equipped with AV technology to undergo regular safety inspections. The

cameras and sensors that allow such vehicles to navigate the environment around them and detect problems in the vehicle's own condition are prone to misalignment throughout life on the road. These sensors are often mounted on very thin metal brackets and are sometimes exposed rather than being contained safely behind a bumper. A light collision causing no visual damage or a bump from a shopping cart can easily cause misalignment.

Furthermore, driverless cars can't rely on a human to detect signs of a defect, such as screeching brakes, that a car owner would ordinarily notice. In fact, their owners could likely reside hundreds of miles away and be occupied managing large fleets. While cars do have sensors that alert drivers and passengers when tire pressure or engine oil is low, the scope of issues these sensors can detect is limited and they cannot be relied upon to indicate issue severity. Vehicles with misaligned sensors will not operate as intended and could constitute a safety hazard.

>> CONTINUES ON PAGE 8



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TRAINING



AUTEL TRAINING ACADEMY LAUNCHES IN JULY

➔ Autel will launch its Autel Training Academy in July to provide technicians and shop owners with hands-on one-day and two-day training courses. The first set of classes will be an intensive two-day course focusing on diagnostics, alignment, and ADAS calibrations.

The first onsite training, scheduled to take place July 24 and 25, will offer comprehensive education and instruction on ADAS calibration. The two-day, 16-hour course will provide students with a deeper understanding of the technology and functionality of these safety systems. The training comprises classroom lectures in Autel's 30-seat classroom with hands-on instruction on Autel products in the newly constructed 2,800-square-foot demonstration and training facility featuring the new Autel ADAS Bay Max 14K flush-mounted alignment lift.

In the training facility, students will be shown on a range of vehicle brands how to perform multiple types of calibrations, including camera and radar for numerous safety systems, including automatic emergency braking, lane keep

assist, and blind spot monitoring using Autel tablets, software, calibration frame systems, and alignment and ADAS lift.

Further, the class will review calibration space requirements, technician skill set, the importance of vehicle preconditioning, producing insurer-ready documentation, and calibration troubleshooting.

"ADAS calibration is the fastest-growing segment in automobile service and repair. North America has over 90,000,000 ADAS-equipped vehicles as of December 2022, with more than 15,000,000 expected to enter service this year," said George Lesniak, Autel vice president of training. "Today, nearly 100 percent of new passenger vehicles manufactured for the North American market are equipped with one or more ADAS features. With the rise in advanced driver assistance systems (ADAS), learning how to calibrate these systems accurately is more important than ever."

Classes are intended for current and potential owners of Autel ADAS calibration equipment. **TL**

>> CONTINUED FROM PAGE 6

DOT's absence of leadership by not integrating vehicle safety inspections into the NRSS has consequences. Last week, the Texas Legislature passed a bill that completely eliminates the annually required inspection. Opponents of vehicle safety inspection in that body singled-out the program to provide a victory in their political war against bureaucracy. Governor Abbott will likely sign House Bill 3297 into law, and it would take effect in 2025. This decision directly contradicts the 2018 University of Texas study mandated by legislation that Governor Abbott signed into law in 2017. That study found that "the Inspection Program saves lives and enhances safety." It recommended "a further study to consider whether potential additional inspection items... should be included in the Inspection Program to further enhance highway safety in Texas." Texas is making a deadly mistake by rolling this program back instead of expanding it.

It's not too late for NHTSA to update the NRSS by adding inspections and advance a more holistic approach. Congress can act, too. Any new legislation concerning vehicle safety must include regular inspections by a qualified human inspector, as well as post-repair inspections following a collision repair. Some members of Congress are pursuing legislation that would establish a nationwide AV regulatory regime. This bill presents an ideal vehicle (no pun intended) to mandate regular inspections by a human and ensure AVs are part of the safety solution, not the problem. **TL**

BEN SHARP is a D.C. legislative representative for the Automotive Service Association (ASA). His previous experience in policy and politics includes working for several members of congress and congressional candidates, fortune 500 companies, and a labor union. Ben is a proud graduate of the University of Texas at Austin, where he received a Bachelor's Degree in International Relations and Global Studies and the Plan II Honors Program.



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LEGISLATION



NHTSA PROPOSES AUTOMATIC EMERGENCY BRAKING STANDARD FOR NEW VEHICLES

→ The National Highway Traffic Safety Administration (NHTSA) has issued a proposed rule to require automatic emergency braking (AEB) and pedestrian AEB systems on new passenger cars and light trucks weighing up to 10,000 lbs. Once finalized, the rule would be phased in over three years, with an additional year for small-volume final-stage manufacturers to comply.

In 2016, recognizing the proposed rule's potential to help save lives and reduce injuries, most automakers voluntarily agree to begin installing AEB systems. About 95 percent of all model-year 2023 light-duty cars and trucks have such equipment. The systems use sensors and software to identify dangers and apply brakes if the driver hasn't responded quickly enough or with sufficient braking force.

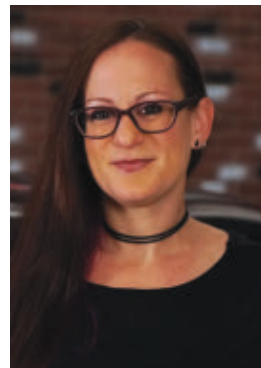
NHTSA added AEB systems to its five-star New Car Assessment Program (NCAP) starting in model-year 2018. The agency is now considering including pedestrian protection in the consumer information program. Under the 2021 Infrastructure Investment and Jobs Act, Congress directed NHTSA to pursue a safety standard for AEB and pedestrian detection. NHTSA's proposed rule would require a vehicle traveling as fast as 62 miles an hour to stop to avoid colliding with a vehicle or pedestrian. Testing conditions would include daylight and darkness with both lower beam and upper beam headlights activated.

SEMA is reviewing the rule to understand its potential impact on the industry. Comments will be due 60 days after publication in the Federal Register. **TZ**

CERTIFICATION

ASE PARTNERS WITH MASTER TECHNICIAN BOGI LATEINER

→ The National Institute for Automotive Service Excellence (ASE) has joined forces with Bogi Lateiner, ASE Master Technician, to promote the benefits of ASE testing and certification and help the ASE Education Foundation pursue its goal of increasing diversity in the automotive service industry.



Lateiner's partnership with ASE will kick-off at the 2023 ASE Instructor Training Conference held in July in Concord, North Carolina. At the conference, Lateiner will meet with conference attendees, including high school and college instructors of auto, truck, and collision repair programs nationwide. She will help them implement tactics that support increased diversity among students in their programs.

In addition, Lateiner will promote ASE testing and certification through a variety of ongoing activities such as podcasts and videos.

"Bogi Lateiner is one of the most recognizable figures in the industry. She is an ASE Master Technician, experienced shop owner and leading voice, encouraging women to enter the automotive field as service professionals," said Tim Zilke, ASE president and CEO. "We are very pleased to have her join us in our efforts to share the value of ASE certification and promote automotive career opportunities to women and underrepresented groups."

Lateiner is noted for encouraging and promoting women in the automotive trades. As a shop owner, Lateiner has served as an industry management instructor for 10 years and has developed programs, such as "Girl Gang Garage," that train and help women enter the automotive field. As well as this, she hosts the popular television show "All Girls Garage" and podcast "With her Two Hands."

"I couldn't be happier to be partnering with ASE," Lateiner said. "ASE certification has always been extremely important to me. As a technician, I see it as my doctor credentials, and as a shop owner, it helps convey to my customers that we take pride in our craft and our continuing education. However, ASE does so much more that many aren't aware of and I'm excited and honored to help spread the word about all they do to help shape the future of the industry." **TZ**

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How to avoid pitfalls and get results from your KPIs

Trying to hit a KPI without proper education and mentorship can be dangerous to the health of the business.

BY DAVID ROGERS // Contributing Editor

The three most misunderstood letters in shop management today are K, P, and I.

I'm positive no corner of the industry has escaped hearing about the latest key performance indicators (KPIs) being touted by so-called gurus and experts.

The problem is that in a vacuum, KPIs are just numbers. They don't inherently mean anything. Measuring that number may tell you the effi-

ciency of this or the profit of that, but it doesn't answer critical questions. Why is that important? What does it mean for the business? What other numbers are related? Is it bad if you overshoot your target?

Trying to hit a KPI without proper education and mentorship is worse than useless; it can be downright dangerous to the health of the business.

Does that mean shops shouldn't have benchmarks for critical numbers? Of course not! But there are critical

things to consider before you change your systems and processes to try to hit a KPI just because somebody said it's important.

Chasing one KPI may affect another

One of the first and most critical dangers in following a new KPI is just how interconnected every area of the shop is. In your goal to change systems and processes to hit a new number, you are almost certainly affecting other num-

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bers. If you weren't given proper training and ongoing guidance, that could have long-lasting consequences.

Take car count as an example. On the surface, there's nothing wrong with setting a target for how many cars you want to see per day. It may even be a good indication of how you need to adjust your advertising budget to avoid an approaching slowdown.

But car count doesn't happen in a vacuum; the quality of those customers is even more important. If your car count is increasing, what effect is that increase having on your new customer average repair order? In other words, are you attracting customers who that are improving your customer base or just making you busier?

The long-term effect is even more critical. As the shop tries to increase car count to hit its desired KPI, what is happening to the shop's attrition rate? Is the marketing driving customers who come in once and then never again? Worse, did you make your shop so busy you can't take care of long-term customers who are now going to another shop instead of waiting two weeks for an appointment with you?

What if you reach your car count target accidentally? If a shop down the street closes, and you get a big influx of customers without even trying, is it a good thing? In a vacuum, it looks like it. Your KPI says you're right on target for growing your shop. All the while, your loyal customer base could be rotting away through neglect.

This is why numbers – KPIs, benchmarks, targets, whatever the term – are useless on their own. Whether you're getting your numbers reporting from a coach's spreadsheet, a shop management system's reporting, or the books you're bringing to your 20-Group, the point isn't just to measure or hit a target. To create long-term success, KPIs must come with training, education, and mentorship so you understand how to control that number, how it affects other numbers, and critically, how that number can cause problems elsewhere.

For instance, there's danger in over-

shooting targets! Blowing past your targets for profit and hours billed can cause significant harm in other areas of the business, yet this danger is rarely discussed!

Does this mean you shouldn't measure, that KPIs don't matter, that shops should never seek to improve? Of course not. It does mean operators should be very careful who they take KPI advice from, however.

Expertise is proven through results

One common way operators get recommendations about KPIs, for example, is their 20-Group.

The obvious downside to this is that choosing KPIs on the advice of 19 other shops who may or may not even be sharing their real numbers does not tell you where your unique shop should be focused.

The less obvious downside is that choosing a KPI agreed to with the advice of 19 other shops is that you're almost certain to set your target at the average of the averages from below-average shops. Nothing comes from this but mediocrity and stagnation.

But even if you escape the trap of letting your 20-Group help set your KPIs, there's no guarantee trusting somebody claiming to be an expert will give you the real answers, either.

Does that "expert" still own a shop? Or did he or she sell it 20 years ago?

If it feels like I'm being unfair to that coach simply because he or she sold his or her shop, ask yourself these critical questions: how similar are shops now to how they were 20 years ago? How relevant is experience from 20 years ago?

It doesn't take decades for shop operation knowledge to become obsolete, either. Case in point, how different is operating a shop now compared to two years ago due to inflation?

Ultimately, you should be taking advice on KPIs from a coach or mentor who is currently running a successful shop. If

you're following the advice of somebody not operating in today's environment, you won't be able to make decisions that work in today's world.

Beyond that, you should be listening to mentors who teach the process and system required to hit and maintain KPIs, and the way those KPIs fit into the rest of the shop.

This kind of expertise is proven through results. They should be able to demonstrate, in this economy and in your unique operation and circumstances, how they've helped owners create lasting, meaningful, sustainable success in their operation.

If it seems like I'm ruling out the vast majority of coaches, mentors, and groups when it comes to whom to trust, you're right. The stakes are too high for owners like you who put their family and livelihood on the line every day to run a business.

You don't have to accept the mediocrity and averages of averages. You don't have to settle for hitting arbitrary KPIs with strategies that may or may not cause serious harm to your business.

With the right mentor teaching you the correct processes and systems needed to hit and maintain appropriate KPIs, you can create the shop of your dreams, with a fully bought-in team that wants you to succeed. The choice should be clear! **ZZ**



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COO of Keller Bros. Auto Repair in Littleton, Colo. Together, these companies form an ecosystem of success for shop owners, offering proven, sustainable solutions for maximizing efficiency and growth, growing customer bases, and creating a culture of excellence. With nearly half a century of experience in the automotive industry (and they're still growing exponentially), Auto Profit Masters and Automated Marketing Group have the tools and resources to help set your shop apart from your competition and elevate your business to the next level.

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Maximize Your Shop's Potential >>>

By: Allison Whitney

When Autel debuted the MaxiSYS ADAS IA900WA all-in-one wheel alignment and ADAS calibration system last Spring, it proudly declared its compatibility with any standard four-wheel alignment lift.

As a result of combining the IA900WA with their lifts, customers increase shop efficiency and quickly recoup their investment.

Shops can use the IA900WA with their standard lifts because of the system's six-high resolution tracking cameras that detect the vehicle's height and adjust the software metrics accordingly to quickly perform alignment checks and front-facing camera calibrations.

Still, it became clear that the design of available lifts limited technicians' ability to take full advantage of the IA900WA's exceptional functionality and comprehensive approach to modern-day vehicle repair and servicing.

Enter the Autel ADAS Bay Max Lifts.

The North American-made Bay Max 12K and Bay Max 14K lifts are flush-mounted hydraulic scissor lifts with twin 6K and 7K Jacking Beams, respectively, and a Floor Lift Table. The Floor Lift Table is a distinctive feature that enables the technician to safely stand under the entire length of the raised vehicle to make repairs. When the lift is lowered and flush with the ground, the technician can position the vehicle anywhere in the bay to perform nearly any ADAS calibrations, regardless of the vehicle's distance to the calibrator, pattern, or target.

"We had several goals in mind when we designed the Bay Max lifts. First and foremost, we wanted to sell a quality, dependable, and durable piece of equipment. We also wanted a lift that could capitalize on the Autel IA900's extensive capabilities and maximize a shop's space, efficiency, and profits, said Stewart Peregrine, Autel's Senior Executive of ADAS Sales, adding that the Bay Max lifts achieve this goal and more.

"The IA900 and the Bay Max offer techs a new comprehensive approach to vehicle repair essential to servicing

the sophisticated modern vehicle, in which every repair and every system affects another system and component operation," Peregrine said.

The lifts' design enables technicians to perform every needed vehicle service in the same shop bay, from pre-scan, visual inspection, and mechanical repair to a four-wheel alignment and calibration of all ADAS systems.

The Autel MaxiSYS IA900WA, an industry-first all-in-one wheel alignment system and ADAS calibration unit, presents a new, comprehensive approach to vehicle servicing, the type required by today's sophisticated vehicles.



The IA900WA guides the technician through an all-systems diagnostic, a digital chassis and tire inspection, a four-wheel alignment, and ADAS calibration. The IA900WA offers a streamlined, technology-rich design with a folding crossbar and six in-frame high-resolution tracking cameras that automatically monitor vehicle height on the shop lift and robotic frame movement for efficient use and alignment reading accuracy to 0.02 degrees.

Offering comprehensive alignment coverage for U.S., Asian, and European vehicles, the system guides the user through the process with illustrated instructions, live readings, and action steps. Alignment readings displayed on a mounted 24-inch touchscreen monitor mirror those on the Ultra ADAS tablet, enabling the technician to manipulate the vehicle and monitor the adjustment effects freely.

Regarding ADAS calibration systems, Autel offers the industry's most expansive vehicle and safety-system camera and component coverage. Whether you need to calibrate lidar on an Audi, an Eyesight camera on a Subaru, or radar on a Honda, Autel has the target, the pattern, and the calibrator you need.

To grasp how innovative the IA900WA system is, one only must look at the most time-consuming and laborious part of any ADAS calibration, the pre-calibration vehicle-to-target positioning. It takes, on average, 40 minutes to align and center a vehicle using mechanical aids like lasers, mirrors, plumb bobs, and chalk. The IA900WA employs its tracking cameras, targeted wheel clamps, and location software, transforming the frame into a rapid yet precise centering and positioning unit, enabling technicians to accomplish target-to-vehicle placement in as little as three minutes.

With 99 million ADAS-equipped vehicles already on North American roads and 210 million projected by 2030, ADAS calibrations will likely become a commonplace last step in mechanical repair services.

And for general repair shops, the time is now to take on ADAS calibrations, as any engine or transmission repair or replacement that involves the removal of the front grill housing a radar or camera unit will necessitate a calibration once the grill is reinstalled. Further, most experts recommend an ADAS calibration after any alignment that changes a vehicle's thrust angle or ride height.

The simple truth is that if your shop is doing alignments or a host of any number of repairs, your shop should be doing ADAS calibrations. If lack of bay space was the reason shops sublet ADAS calibrations, a Bay Max lift, and the IA900WA is the solution your shop has been waiting for.

Check out Autel's Bay Maximizing solution at [Autel.com](https://www.autel.com).

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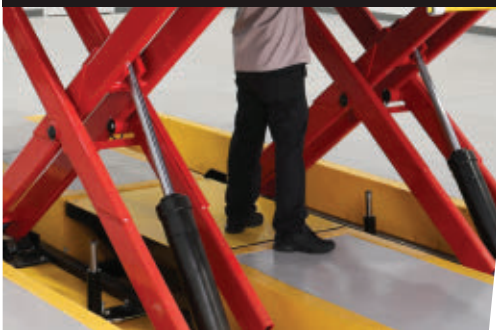


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HOW TO BUY QUALITY SHOP EQUIPMENT ONLINE

You can buy just about anything online, from clothes to cars. And why not? Shopping online is super convenient. You can shop when and where you want, plus, it's easy to compare products and brands.

You can get much of what you need for your business online, too, from shop towels, hand tools and gloves to tire changers, workbenches, and car lifts. The tricky part can be figuring out where to buy and exactly what you're getting.

To minimize disappointment and maximize efficiency, here are 5 tips for buying quality shop equipment online:

1. Consider the company history. Check the "About" page of the website. How long has the company been in business? A company that doesn't meet customer expectations isn't going to last as long as one that does. You may not be concerned about placing a \$20 order through a newer website, but if you're dropping several thousand dollars, stick with a proven provider.

2. Read the reviews. One of the best things about shopping online is how easy it is to find out what other people think about a product or company. Consider reviews directly on the website, on Google, and search for reviews on YouTube. Reviews are useful for making informed decisions.



3. Evaluate the brands. Some people have no qualms about buying everything generic. For them, the cheaper something is, the better. But cheap is not the same as "good value." If your priority is quality, start with the name-recognition of the brands the site carries. Are you familiar with them? Generic wipes are one thing. But do you want to stand under a generic lift or trust a no-name brake lathe? Companies that invest in building their brands also invest in their products. Look for websites that carry category-leading brands.

4. Consider product safety and certification requirements. Most equipment used for vehicle service and repair is covered by ANSI/UL 201 – UL Standard for Safety: Garage Equipment. Car lifts are covered by ANSI/ALI ALCTV:

Safety Requirements for Construction, Testing and Validation of Automotive Lifts. Manufacturers are not required to certify their products, so protect yourself by weeding out the uncertified equipment from the beginning.

5. Who has your back? Buy yourself some peace of mind by shopping at websites backed by people who will help you when you need it. Look for companies that help coordinate delivery, installation, and service. Investigate their policies on returns and warranties. Product specifications and owner's manuals should be easy to download.

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A SYSTEMATIC APPROACH TO FINDING THE RIGHT SCAN TOOL

IF YOU ARE IN THE MARKET FOR A SCAN TOOL,
THERE IS MORE TO CONSIDER THAN COST.

BY BRANDON STECKLER // Technical Editor

As a technician in the industry for about 25 years, I have had my hands on many different scan tools. Many of them were factory tools and many more were aftermarket tools. With the ever-changing advancements in technology, I have seen so many new convenient features implemented that make the scan tool ever more powerful today.

However, one thing is certain. The scan tool will always serve as a liaison between the technician and the vehicle. Regardless of how much or how little capability the tool features, if it doesn't do what you need it to do, it is not a wise investment.

Cost

Obviously, one of the first items to factor in is how much the scan tool is going to cost. There are functional scan tools that can be purchased for under \$200.00.

Probably unsurprisingly, the functionality of that tool is likely limited to simple and basic functions, like requests for OBDII stored DTCs (Mode \$03) and perhaps the ability to request a list of completed monitors (Mode \$06). Although this data is useful, it certainly won't suffice as the tool to always get the job done, especially for a professional automotive technician. However, a technician needing a simple device to verify that OBD monitors have run to completion would need little more

than the capability of a device like this one from Innova (**Figure 1**). The key is to realize the limitation of the device before making the investment.

Vehicle coverage

Vehicle coverage should be an important factor to consider when choosing a scan tool for obvious reasons. It's true that scan tools have come a very long way and the coverage they now provide is very extensive compared to how they used to. But

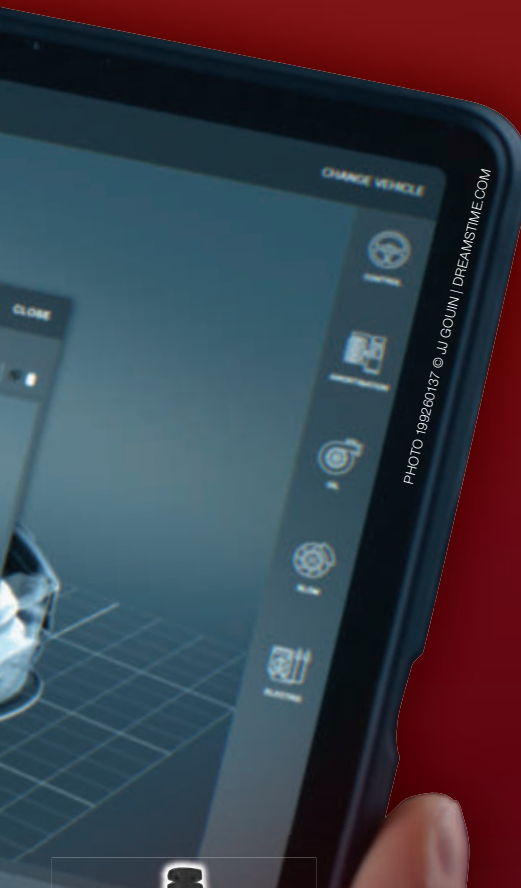
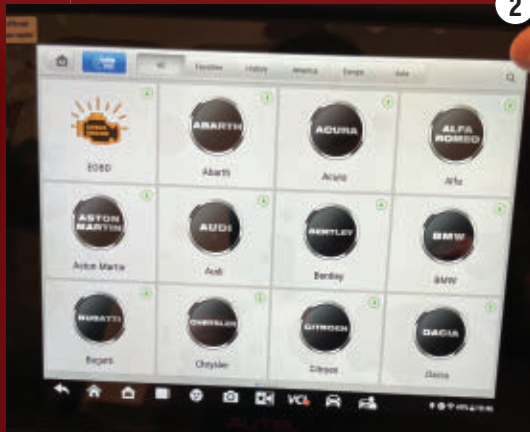


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2

HAVING A SCAN TOOL that offers a wide range of vehicle coverage is prudent, especially with shops providing service for many makes and models.

good news is that almost every scan tool a professional technician will encounter possesses those features. However, those need-to-have features can be complemented by nice-to-have features.

pair (R2R) and the availability of factory-level scan tools and service information, these serve as a tremendous supplement to a more general scan tool (**Figure 3**).

Scanning functions

I have mentioned many times in my previous articles that I see the scan tool as a device that should offer us the ability to view data in a fashion that tells a story. With the data arranged properly, we should be able to easily perform a comparison of:

- Inputs
- ECU processing (response/reaction)
- Outputs
- Default/adaptive strategies

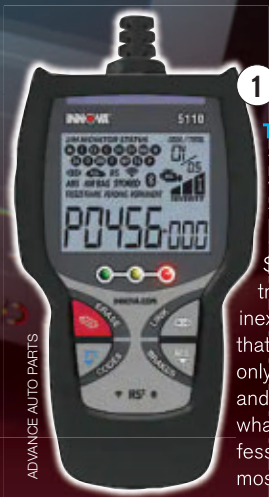
Having this ability will allow us to make diagnostic decisions from the driver's seat. What is the takeaway? This technique not only guides you to the next logical test but prevents you from performing a multitude of unnecessary tests, such as this Snap-on MODIS capture (**Figure 3**). In this instance, a slippage is occurring internally to a transaxle at the main shaft. Did I mention all of this is carried out from the driver's seat and without disassembling a thing?

Added features

Described above are necessities every professional technician needs to consider when purchasing a scan tool. The

Many scan tools now offer a topological view of the ECUs sharing information on the data bus. This feature is incredibly efficient, as it allows for several time-saving techniques to be carried out. For instance, the tech can see which ECUs are communicating. This is tremendously handy to know when dealing with communication issues. This helps the tech triangulate where a fault is located.

Since the proper data arranged in an adequate format yields diagnostic decisions, better-arranged data may bring a diagnostician to those same conclusions easier and/or more efficiently. By taking the same collected data and arranging it in a different format, a certain pattern may stand out more easily. It's for those same reasons that pie charts, line graphs, and bar graphs exist in many industries

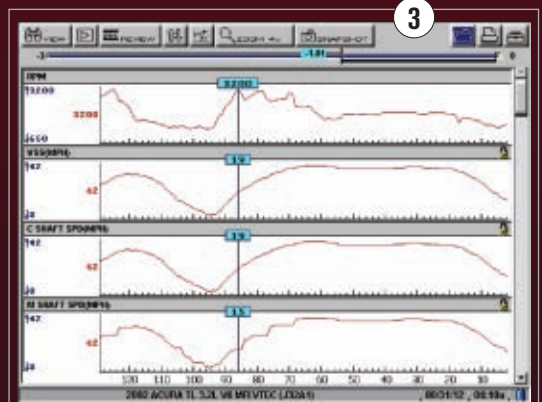


1

THIS SCAN TOOL from Innova is very functional for the cost of approximately \$200. However, the trade-off for such an inexpensive device is that it serves to provide only basic functions and will not support what is required for professional technicians in most situations.

be aware that certain scan tools shine brightly within certain car lines, and very dimly (or sometimes not at all) with other car lines. It's important to have a scan tool that is going to serve you and your shop well in as many conditions as possible (**Figure 2**). In other words, choose a tool that is going to give you the most "bang for your buck," and be prepared to add other scan tools that are better suited to specific car lines when called upon.

It's only fair to mention that with the ground gained regarding the right to re-



3

THIS GRAPHED SCAN TOOL DATA provides insight to an internal transmission slippage occurring within a clutch assembly at the main shaft. This was deduced in only minutes, from the driver's seat and without any disassembly.

(Figure 4). All are a form of comparative measure but each of the charts expresses different characteristics more easily.

Some scan tools will feature cellular charts data displaying a value at a cross-reference point of two different criteria. Having the ability to see all the possible cross-reference points at the same time (along with correlating data) is displaying not just a story but instead all the chapters of the book simultaneously. This is a great chart to discover trends. An example of this would be one from Automotive Test Solutions and its EScan Elite fuel trim chart (Figure 5).

Another example of a unique data arrangement would be merging graphed data to allow a superimposed view of two or more PIDs. A direct and easy-to-view comparison results and offers a quick view of like PIDs that differ from one another. For instance, is one from an old EASE scan tool (Figure 6).

For instance, viewing actual and desired camshaft position PIDs is a quick “go/no-go” test of the VVT system’s functionality. No need to chase anything else if the two pieces of graphed data remain superimposed throughout the entire operating range of the engine.

Bidirectional controls

The ability to take control of a system’s components allows the technician to virtually split a troublesome system in half, offering a “divide and conquer” strategy. Assume for a moment you are faced

with a power window concern with the passenger-front window being nonfunctional in the downward position of the master switch.

After viewing a wiring diagram, a logical approach would be to then view data displaying the command status of the right-front power window. Assuming the command was never issued by the ECU, it’s logical to verify the input request from the master switch. Regardless if the command was received, one would still like to know if the window functions as designed.

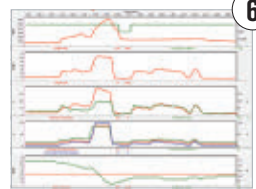
Using the bidirectional controls of the scan tool (like this screen capture from Autel) will bypass the switch input and directly command the ECU to roll the window down (Figure 7). Assuming that window then functioned, the integrity of the entire output side of the power window system has been verified. Again, there’s no need for wasted time disassembling components. The answer was determined from the driver’s seat.

J2534 functionality

This feature is one that should be particularly considered nowadays; more so if no other such capabilities exist in-house. Locating the source of a fault and properly diagnosing the root cause is important. But if the job can’t be completed due to the inability to place software in a barren ECU, you are forced to hire expensive outside assistance or pass the job along to a capable shop.

SUPERIMPOSING LINE GRAPHS

allow an easy-to-compare view of data (Like throttle position PIDs) that represents desired and actual positions. If the lines deviate from one another, an underlying fault exists.



6

BIDIRECTIONAL CONTROLS

allow the technician to take control of output devices, taking place of the controlling ECU and proving whether or not a fault exists on the output side of a system.



7

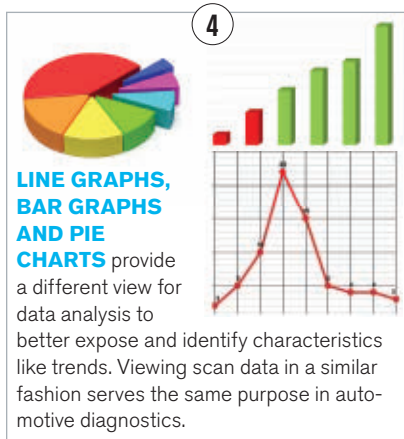
Keep in mind that in several scenarios, even having the ability to upload the appropriate software may not be enough. Some procedures known as post-programming routines may have to be performed (routines like a throttle angle relearn, steering angle sensor relearn, or some security system functions). Some scan tools will allow the software to upload but have no ability to perform certain post-programming routines. This could render a vehicle inoperative until the routine is complete.

A few scan tool providers even offer remote access ability to aid in these programming and post-flash routines. These paid-for sessions can also be used as a teaching guide to help a programming novice progress.

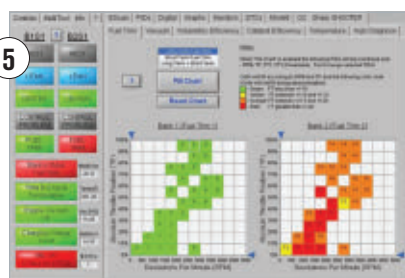
Export files

Today, many scan tools offer the ability to save data in a format like a PDF or one that is interactive. This allows for the ability to export. Transferring these stand-alone files will allow the data to be analyzed remotely and offer the same abilities (to a PC) as the actual scan tool offers.

How can this come in handy? Many shops are structured with a shop foreman overseeing productivity, dispatching jobs, and providing technical



4



5

GRAPHING FUEL TRIM DATA in color-coded load/rpm cells allows the analyst to see fuel trim trends under all operating conditions simultaneously. This helps identify a surplus or deficiency in fuel supply and under which operating conditions.



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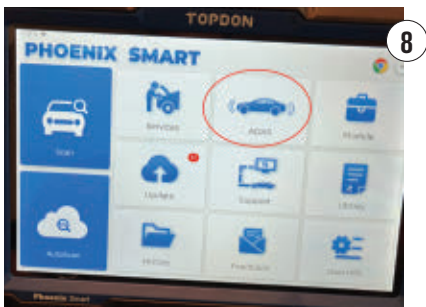
assistance to other technicians requiring it. With the ability to export files, the diagnostician/shop foreman can remain in an office or at a desk. And any technician can be easily trained to capture data and send files to the shop foreman.

With a structure like the above implemented, the technicians addressing the vehicles become the shop's eyes and ears. The experienced shop foreman/diagnostician becomes the brain not for one tech, but for any of the technicians in the shop. This can be a temporary or even a permanent solution to prevent inaccurate diagnoses. Reducing the need to have several A-techs on board can also be cost-effective.

These same files can be screen-captured and uploaded to free apps like Microsoft Paint, giving the ability to highlight, annotate, or otherwise call attention to certain characteristics of a particular capture. This same capture now becomes priceless training material to add to your archives or to reference for new tech trying to enhance his or her depth of knowledge.

ADAS functionality

Advanced driver assistance systems (ADAS) are prevalent in virtually all vehicles nowadays. After the repair or replacement of certain components, calibration of certain ADAS subsystems must be carried out. Some of these calibrations are



8

ADVANCED DRIVER ASSISTANCE SYSTEMS (ADAS) is prevalent in today's vehicle will be further implemented with time. Calibration of these systems will be required with even some of the most basic repairs we see in the shop on a daily basis. Scan tool functionality must support these required calibrations.

carried out dynamically, requiring them to be driven under certain specific operating conditions. Others are carried out statically, requiring objects and specific targets to be appropriately placed, and then registered by the vehicle's ECU.

In either scenario, the routines or calibrations must be initiated by the scan tool. Displayed here is an example from a Topdon Phoenix Smart (**Figure 8**). These are certain factors to consider, especially given the current and growing prevalence of ADAS and the subsystems and components they encompass.

Scan tool software updates

One thing that many shops and individual technicians fail to consider when purchasing a scan tool is the cost to maintain that tool. Some scan tool software annual upgrades can reach prices nearing \$1,000.

It's important to note or inquire about the consequences of not upgrading a tool when new software is available. In other words, will a lacking software upgrade simply omit new features, or will the scan tool performance degrade or cease to function at all?

Many scan tool companies will offer special deals which may include free software upgrades for a year (or maybe several years). Also, keep in mind that scan tools can be found online anywhere you look. It's true that many times, a lower cost scan tool found online may appear to be authentic but is not manufactured to function properly in the U.S. You may find yourself dead in the water when it comes time to upgrade the software and have nowhere to turn for technical assistance. Be sure to purchase your scan tool from a reputable source, regardless of the potential savings of purchasing online from an unknown source.

Scan tool specification guide

The scan tool features I've mentioned are just a few of many. Don't get yourself overwhelmed; these were merely suggested

9

THIS PARTIAL SCREEN CAPTURE of PTEN's Scan Tool Spec Guide (vehicleservicepros.com/21270448) factors in many of the desirable characteristics being discussed in this article. Referencing it serves as an aid to determine which scan tool is best for you and/or your shop.

features to keep in mind to help guide you and your shop to a tool that will be less likely to disappoint.

Understand that not one scan tool can do it all. If it could, everyone would own it and it would cost a lot of money. But be sure the tool you choose to go with is based on a decision that considers some of the factors mentioned above.


There has been research done across the industry to help narrow down the decision-making process for you. Information pertaining to many different scan tools can be found in a comparative chart like the one posted annually by *Motor Age's* sister magazine, *Professional Tool and Equipment News (PTEN)* (**Figure 9**). This chart allows one to easily compare one scan tool to the rest with all the factors mentioned above (and many more). Keeping this information in mind when shopping for a scan tool will steer you out of trouble and likely put one in your hand that will serve you and your shop well. **TZ**



BRANDON STECKLER is the technical editor of *Motor Age* magazine. He holds multiple ASE certifications. He is an active

instructor and provides telephone and live technical support, as well as private training, for technicians all across the world. bsteckler@endeavorb2b.com

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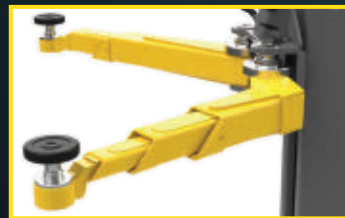


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HOW BRAKE PAD FRICTION AFFECTS ADAS

USING THE WRONG TYPE OF REPLACEMENT PADS ON AN ADAS-EQUIPPED VEHICLE COULD HAVE FAR-REACHING CONSEQUENCES.

BY TRACY MARTIN // Contributing Editor

A 2021 model year vehicle is in your shop for brake work. The car has an advanced driver assistance system (ADAS) that includes automatic emergency braking (AEB) and traction control. All four rotors look serviceable, but the brake pads are worn and you replace them with an inexpensive aftermarket pad (OEM pads are too expensive). Will your choice of brake pads cause an unhappy customer leading to a comeback, an accident, or even legal problems for your shop?

The customer picks up his vehicle, drives off and becomes distracted as he approaches a red light at a busy intersection. He fails to apply the brakes in a timely manner, but the ADAS attempts to come to the rescue. The ADAS uses

radar/lidar to determine that the vehicle is not slowing sufficiently to avoid hitting a vehicle stopped in the intersection, so it commands the brakes, through the automatic emergency braking system, to apply braking force.

The car starts to slow — but not enough — and it hits the other vehicle. Why did the AEB system fail?

The replacement low-quality brake pads were made with a compound that had too low of a coefficient of friction.



ADAS SYSTEMS FEATURE automatic braking that rely on brake pads with a specific coefficient of friction represented by the letters “Mu” or “CE”. If aftermarket pads are installed with less or more Mu than that of OE, the ADAS system may not function as designed.

tion (more on this later). Because the brake pad compound did not develop the same friction as quality aftermarket pads or OEM pads, the result was a fender-bender. This scenario could have been much worse—not stopping effectively for pedestrians in a crosswalk. Other issues with ADAS traction control can occur with brake pads that don't perform as expected.

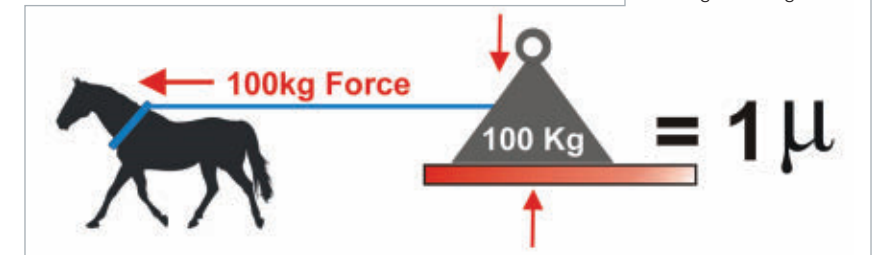
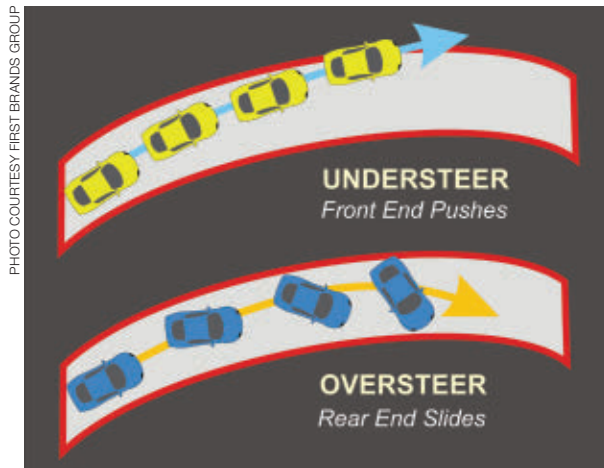
A vehicle's braking system uses software that controls ADAS, stability control and emergency braking systems. The software is programmed so that for a given amount of hydraulic brake pressure, the brakes will produce a specific amount of stopping power, or brake torque. The software assumes that the factory-installed brake pads, OEM service replacement, or quality aftermarket pads are installed with a specific coefficient of friction, or friction profile. When OE pads are replaced with pads that use a vastly different friction compound, the ADAS could have problems.

ADAS vs. Brake pad problems

Brake pads that don't develop sufficient friction could take more time to control the vehicle. If pad material is too aggressive, it could abruptly correct or overcorrect when used for adaptive cruise control, causing uneven brake performance.

Using aftermarket brake pads that have a significant difference in their coefficient of friction from OE pads can cause problems with stability control systems. Often, this can result in overcorrections when the stability control system tries to correct for understeer, which turns the situation into an oversteer condition, with the vehicle possibly ending up unintentionally going off-road.

Understeer, or “pushing,” is when a car turns less than the steering input from the driver, resulting in the car traveling wide of the intended path and occurs when the front wheels lose trac-



AFTERMARKET BRAKE PADS that have lower or higher friction values from OE pads can affect ADAS traction control trying to correct for oversteer or understeer.

THE COEFFICIENT OF FRICTION of 1 (μ) (“μ” is the frictional value) takes place when 100kg (kilograms) of force is required to move an object that weighs 100kg.



A TECHNICIAN TESTS BRAKE PADS with this Link Engineering brake dynamometer that simulates driving conditions and assesses stopping ability, noise, durability and heat ranges of brake pads.

tion before the rears.

Oversteer occurs when a vehicle turns more than the driver's input to the steering wheel. This takes place

when the rear wheels lose traction before the fronts, resulting in the rear-end sliding out, or a complete spin.

Another issue is the ADAS soft-

PHOTO COURTESY FIRST BRANDS GROUP

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PHOTO COURTESY RAYBESTOS, MCHENRY, ILL.

ware's ability to estimate brake pad temperature. The brake controller monitors how much the brakes are used (based on ADAS, ABS, and stability control system inputs) and calculates if the brake pads are overheating, which causes brake fade. This condition may cause the controller to temporarily stop the use of stability or traction control until the pads cool down. This scenario is sometimes called brake fade compensation, and because it's programmed for the friction produced by OE brake pads, any replacement pads should have much the same, or similar, friction characteristics.

Coefficient of friction?

Braking takes place when hydraulic pressure is applied by the driver pressing the brake pedal. The caliper pistons force the brake pads against the spinning rotor to create friction. Friction transforms the kinetic energy of the moving vehicle into heat as the vehicle slows. Braking is simply a matter of converting energy from one form to another. Think of this concept as "horsepower" absorbed by brake systems.

Engines make horsepower by creating heat; braking systems reverse this process by absorbing energy to create heat. Kinetic energy is the weight, or mass, of a vehicle traveling along a road at speed. When the brakes are applied, this energy is converted to heat caused by friction between the brake pads and rotors. And the more heat these components can generate, the more efficiently a vehicle will stop.

If a pickup truck has a weight of 6,400 lbs. and is moving at 60 mph, it has an amount of kinetic energy. When the truck comes to a stop from 60 mph, the kinetic energy is transferred into the braking system as heat. The time elapsed to come to a complete stop from 60 mph is also a

factor in how much heat is transferred. If the truck stops in 140 feet, the kinetic energy must be absorbed in around three seconds. Energy transferred in a given time can be expressed as power. In this example, the brakes must absorb 465 hp.

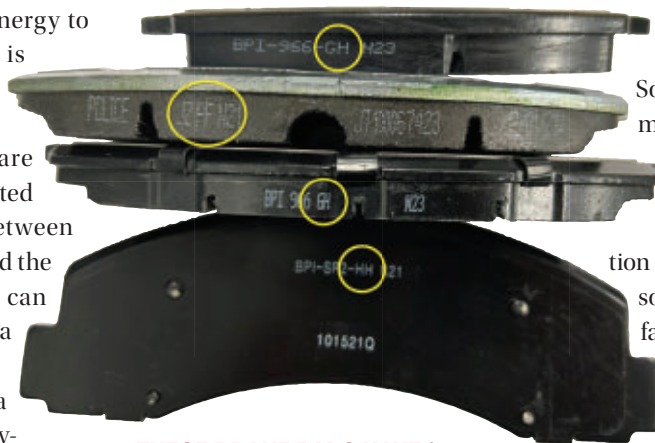
One factor used to rate brake pads is the pad material's coefficient of friction. This is the ratio of the frictional force between two surfaces (brake pads and rotors) and the force pushing them together (hydraulic pressure on the brake caliper pistons). Friction is the force in which one surface or object (such as a brake pad) rubs against another (such as a rotor) to resist motion. The symbol for coefficient of friction is Mu, or "μ," the 12th letter of the Greek alphabet.

The coefficient of friction that equals 1 takes place when 100kg (kilograms) of force is required to move an object that weighs 100kg. If the same object can be moved with 50kg, the μ is 0.5. The braking torque that takes place during braking, and the hydraulic pressure causing the calipers to push the brake pad material against the rotor's surface are used to calculate coefficient of friction. The smaller the coefficient of friction, the less force that

is required for the brake pads and rotor to slide past each other. The higher the coefficient of friction, the more force that is necessary for the pads and rotors to slide.

There are three factors that relate to the coefficient of friction. Most importantly is for the brake pads to reach their maximum friction level instantly after the brakes are applied. Poor braking power can be attributed to brake pads that do not have a good initial bite against the rotors. The second important factor is the stability of the coefficient of friction at various temperatures. It is common for the coefficient of friction to be lower at low and extremely high temperatures.

The third factor is the stability of the coefficient of friction at different vehicle speeds. Brake pads used for passenger vehicles would be dangerous if a stable coefficient of friction was achieved during braking at 100 mph but the coefficient of friction during braking at 40 mph was unstable. Pads with this μ would work well at a racetrack where vehicle speeds are constantly high but be a disaster on the street because of the lower speeds at which the brakes operate most of the time.



Brake pad friction codes

Some aftermarket brake pads are marked with friction code letters that indicate friction performance. These codes are not U.S. Department of Transportation (DOT) regulated but are used by some, but not all, brake pad manufacturers. Using OE brake pads as a guideline, quality brake pad manufacturers use their own standards for testing to determine friction codes. Friction ratings for brake pads, expressed as μ, or Mu, range from 0.20 to 0.60. On average, OE brake pads have a coefficient of friction of 0.3 to 0.4, and performance brake pads have a coefficient of friction

THESE BRAKE PADS HAVE friction codes (GH, FF and HH — yellow circles) that show various levels of the friction material used in their compounds. Not all aftermarket or OEM brands use brake pad friction codes, as they are not mandated by government regulations.

PHOTO COURTESY RAYBESTOS, MCHENRY, IL.



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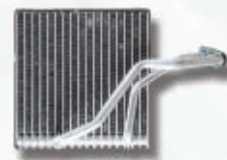
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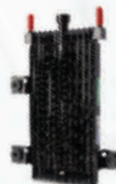
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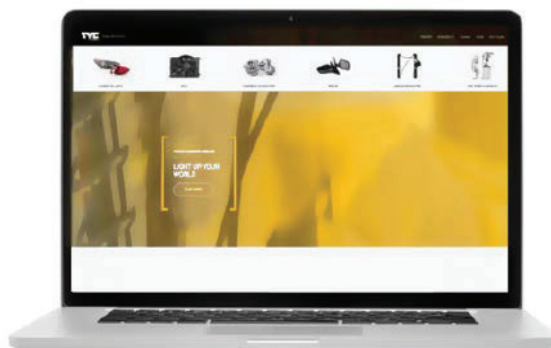
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of 0.4 to 0.5. For comparison, full-racing pads can be 0.60 or higher.

A two-letter code is used (SAE Standard J866) to identify the temperatures for pads designed for street use. The first letter designates the normal, low-temperature (200 degrees F to 400 degrees F) friction performance and the second letter the high-temperature (300 degrees F to 650 degrees F) performance. The code letters stand for friction potential with letters in alphabetical order. For example, pads with a “D” rating would not indicate as much friction potential as “E” rated pads. Ideally, street brake pads should have good friction at both high and low tempera-

tures, in which case both letters would be the same, or near the midpoint of the available letter-sequence, like “FF.”

If the first letter is lower than the second letter, it means the pad works better at high temperatures and requires some heat to be fully effective; if the second letter is lower than the first, the pad may fade at high temperatures. Many of the better brake pads intended for street use have a GG friction rating (the highest rating available for street-legal pads). A typical auto parts store carries economy pads that have EE or EF ratings. These pads will work well for most vehicles and drivers. However, if better braking performance is the goal, then pads with minimum FF, GF or FG ratings are a good choice. High-end premium pads are available with ratings like FG or GG. Brake pads used for closed-circuit racing can have HH ratings or higher. The downside of pads with this high friction rating is that they wear out quickly, and many are designed for single-race use.

Identifying codes/letters can be found on the edge of the pads or on the backing plate. Many manufacturers use three groups of alphanumeric characters. The first identifies the manufacturer of the pad material; the second number is the formulation, or composition, of the pad material; and the third group of letters is the coefficient of friction rating and effective temperature range.

Other numbers could be present, including part numbers, manufacturing date codes, and an environmental code that represents the percentage of heavy metals and asbestos fibers used. The environmental code and manufacturing year are usually the very last three digits in the full sequence, but the exact position of the three standard groups of preceding numbers may vary. Some manufacturers use proprietary classifications, such as color-coding the pads or even their own numbering schemes.

Types of brake pads

What matters most with any brake pad replacement is the coefficient of friction between the pad and the rotor. There are three types of brake pad material: organic (non-metallic), semi-metallic and ceramic. Knowing the characteristics of each type will help you select the right material for your customer’s vehicle.

Organic

Organic brake pads provide a low level of friction without producing a lot of heat, making them appropriate for drivers who use their cars for commuting and everyday driving. Organic pads are not a good choice for high-performance cars or heavy-duty applications like SUVs and pickup trucks, as they don’t provide the required stopping power and are prone to brake fade during repeated, heavy braking.

With the high cost of brake rotor replacement, organic pads offer an advantage in that they minimize rotor wear compared to other pad compounds. In use, organic pads provide quiet operation. Another advantage of organic pads is their cost as they are the least expensive of brake pad types. Around 50 percent of new cars sold in the U.S. are factory-equipped with organic brake pads, which are made of a mixture of fibers and other materials, including rubber, carbon compounds,



RAYBESTOS ELEMENT3 BRAKE PADS use a hybrid combination of semi-metallic and ceramic compounds in their friction material.

PHOTO COURTESY RAYBESTOS, MCHENRY, IL



THIS MACHINE IS A POSITIVE MOLD TOOL AND FRICTION HOT PRESS. The pad material mix is poured into the mold cavity and cured using heat and pressure. A set of brake pads can be pressed and cured (heated) in about five minutes.

glass or fiberglass, and Kevlar and bound together with resin.

Semi-metallic

These pads come standard for high-performance cars, SUVs and light trucks. Using metal as part of the pad compound makes them ideal for vehicles that continually require high or frequent braking forces to absorb the energy created by heavy vehicles and/or high speeds.

The metal used in these pads makes them more resistant to heat and wear than organic brake pads. However, the metal in the pad compound has a lower coefficient of friction at low temperatures, and more pedal power is required to create the same braking force as organic pads. Semi-metallic pads are made using a blend for synthetics and metals that form a metallic hybrid pad compound. They do have some disadvantages compared to organic pads as they cost more, wear rotors faster and create brake dust and noise.

Ceramic

When ceramic pads for passenger vehicles started showing up in the late '90s, they were found only on small Asian

cars. As the formulations for ceramic pad materials improved, they were fitted to larger vehicles, including SUVs and light trucks.

Clay and other materials molded into the ceramic pad compound provide a high coefficient of friction, giving them lots of stopping power, the ability to absorb high braking heat, and a high tolerance to brake fade. Don't confuse ceramic brake pads for passenger cars and light trucks with those intended for use at the racetrack.

When designed for high-performance cars that may be driven on a racetrack, ceramic brake pads excel at absorbing heat once they are up to operating temperature. But that is the inherent problem with using them for normal street driving, as they don't provide good stopping power when cold.

For example, imagine driving along the Interstate for several hours with no slowing down or stopping. A deer crosses the highway in front of the vehicle and the driver slams on the brakes. Because the racetrack-oriented pads are cold, the vehicle fails to slow down, and the result is an expensive trip to the body shop.

Another disadvantage is that their

manufacturing costs are high, as they are the most expensive of brake pad types. Also, because the ceramic pad material doesn't absorb as much heat as other types of pads, more of the heat from braking will have to be dissipated by the rotors and brake calipers.

What to look for in a pad

Be aware of the friction codes on aftermarket brake pads that you use for replacements. Make sure you have the proper type of pad for the vehicle you are servicing and its intended use. As a rule-of-thumb, brake pads can either provide superior stopping power, last a long time, or have quiet operation — you can't get all three in one pad.

Use quality aftermarket or OEM pads that come in a box with the company's name on it. Name brands will have friction rating testing and other information available if there are legal problems related to a possible future accident. Avoid brake pads that come in a "white box" with no markings, as they may not have friction rating test data available, or even identify the manufacturer who made them. The proverb "You get what you pay for" applies, and saving a few dollars using economy, no-name brake pads of a questionable origin may put the "brakes" on your business. **ZZ**



TRACY MARTIN has written feature articles for the power sports industry since 1998. He is also the author of six Motorbooks

Workshop Series books published by the Quarto Publishing Group. His latest book, "How to Use Automotive Diagnostic Scanners," was published in August of 2015 and is available in book stores and online. Contact him through his website, www.tracymartin.com.

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8.5



THE INS AND OUTS OF FORD'S ELECTRONIC AUTOMATIC TEMPERATURE CONTROL

TODAY'S WORLD MANDATES A ONE-TOUCH SOLUTION TO CABIN COMFORT.

BY ROY DENNIS RIPPLE // Contributing Editor

There was a time when automotive air conditioning was an option, and dashboard heat had two settings: “not very hot” and “melt your floor mats.” Maintaining a comfortable cabin climate required a choreography of heat on, heat off, and opening the windows (“just a crack”). Today’s set it-and-forget-it world mandates a one-touch solution to cabin creature comfort.

Ford’s Electronic Automatic Temperature Control (EATC) uses sensors, modules (computers), and electric motors to maintain a desired temperature inside the passenger compartment. The system controls airflow, air temperature, and air volume to sustain the comfort level selected by the vehicle’s occupants. Dual Automatic Temperature Control (DATC) allows the driver and the passenger to enjoy their own individual temperature zones.

This article will discuss the inputs, the outputs, the components, and the strategies that drive Ford EATC. We’ll

spend very little time discussing base climate control. I’m sure you understand how an A/C compressor and a heater core operate.

It begins with airflow

The plenum is the base of operations for EATC. The plenum houses a maze of doors designed to direct pressurized air through a series of passageways and corridors. Air temperature, air distribution, and air speed are determined inside the plenum located behind the dash panel.

EATC mode of operation can vary significantly due to the model and model year. So instead of trying to cover every quirk of every model, let’s concentrate on the areas that can be the most beneficial in helping you diagnose and repair an EATC concern. We’ll start with airflow and distribution.

The job of the blower motor is simple. It pulls air in then pushes the air throughout the plenum. Blower speed is regulated by the blower speed controller when in auto mode,

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THIS BLOWER SPEED CONTROLLER and harness connector melted from excessive heat caused by resistance in the controller.

and the controller is commanded by the HVAC module. Not all models are equipped with an HVAC module. On some models the front control interface module (FCIM) oversees EATC functions.

The blower motor speed controller governs the blower motor's ground side resistance, much like a manual resistor. The controller receives a pulse-width-modulated (PWM) signal

from the control module and provides a variable ground circuit to the blower motor. The positive side of the blower motor receives power from the blower motor relay. On some models, this current is diverted through the blower speed controller on its way to the blower motor.

When diagnosing an inoperative blower motor in a Ford EATC system, start with the basics. With the circuit intact, hook up your test light across both pins at the blower motor connector and turn it on. If the light illuminates (indicating available voltage and ground), and the blower motor doesn't turn on, you have a faulty blower motor. If the test light doesn't illuminate, jiggle the harness connector at the blower speed controller. Remove the connector and examine it for signs of terminal tension issues. There have been many issues with the connectors and the pins getting a bit crispy due to heat generated by the controller (**Figure 1**). If you don't find a problem there, you'll need to determine if the blower motor is missing either voltage or ground supply. You'll need to test both sides individually with your test light.

By now, you should have the wiring schematic opened. If voltage is missing, check the fuses. If the fuses are good, swap the blower motor relay (You can remove a different relay

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Saturday Morning March 11th at Crazy Tom's Auto Repair photo courtesy of Dale Pepparoni

"Take us to your torque converter!"

Shocker! Aliens eat auto parts.

LUFKIN, TX -- An alien spacecraft arrived at "Crazy Tom" Vierlington's Auto Repair Shop in Lufkin last Thursday insisting they wanted to eat an entire 2012 Buick. "I told them Martians what they could do with that idea," Crazy Tom protested. After some tense negotiations, the aliens agreed on a hubcap from a '98 Pontiac, and an ETE remanufactured 6R80 transmission, which they consumed on the spot. "Them Martians know their transmissions, ETE's are by far the best," Tom exclaimed. For his "end," Mr. Vierlington received a jar of guava jelly and a certificate for a free alien probe. (Story continues page 12)

It's Alive!

Following torque converter transplant, transmission becomes undead, sings show tunes.

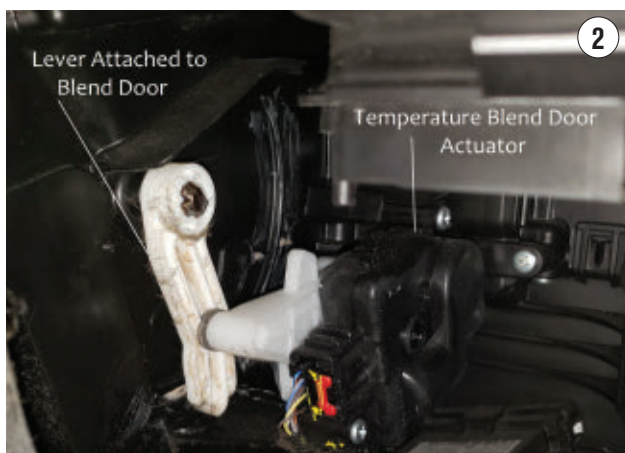
MILWAUKEE, WI -- Mad Scientist and grave robber, Dr. Noah Rickunstein, was stunned when a dead transmission "core" he'd recently dug up came back to life and started singing It's a Hard Knock Life. "It was unreal, said Dr. Rickunstein, that transmission was kaput, but after a bit of reman magic, the thing won't stop! Three years, unlimited miles, that 6L80 keeps humming along. It's like new, only better." (Story continues page 38)

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LEVER-OPERATED temperature blend door actuator.

from the battery junction box [BJB] and use it to replace the blower motor relay temporarily). Be careful when choosing the surrogate relay. Not every relay is the same. Be sure that the part numbers on both relays match. If the blower is still inoperative, it's time to hook up the scanner. If you were not lucky enough to locate the problem during the basic electrical pre-diagnosis, you should hook up the scanner and follow the pinpoint test. Always proceed with the test that is specific to any DTC that may have been generated. If there is no DTC, perform the diagnosis by symptom pinpoint test.

Numerous steps in the pinpoint tests require you to install a fused jumper wire between designated circuits and record the results. Don't get lazy and use a non-fused jumper wire; keep in mind that you're testing a system with an unknown fault. Any wire could be shorted to ground or shorted to voltage. Even a defective blower speed controller can become a straight path to ground. It only takes a minute to fuse a jumper wire.

Next, it's about air distribution

The forced air that leaves the blower motor is directed to the defroster vents, panel vents, and floor vents utilizing a series of doors. Earlier EATC systems used as many as three doors to direct air through the plenum. Each airflow door was independently actuated by a vacuum motor or an electric actuator. Over the years, this configuration has been streamlined to one door and one actuator.

An electric actuator containing an electric motor operates the defrost/panel/floor mode door. A potentiometer located inside the actuator reports the mode door position back to the ECM.

When EATC is in the "auto" position, the ECM determines air distribution mode based on temperature requirements. If it fails, the air distribution actuator will usually generate DTC B1086. DTC B1086:07 indicates a mechanical failure.



AIR CONDITIONING PRESSURE TRANSDUCER located on the discharge line between the compressor and the condenser.

A stored B1086:07 (without accompanying circuit codes) means that either the mode door is binding, the actuator isn't moving, or the potentiometer isn't reporting the position's change to the ECM.

It's imperative to check for a binding mode door or linkage before condemning the actuator. The only sure way to do this is to remove the actuator and work the mode door by hand. The door should move smoothly and effortlessly throughout its entire range of motion. If the door moves freely, and you have no circuit codes, replace the actuator (**Figure 2**).

An electric actuator also manages the inlet air door. Whether fresh air or recirculation mode is selected, the actuator moves the inlet door to the desired position. The inlet door will always remain in recirculation mode when the AC is in the "max" position.

The most common concern with EATC is insufficient air discharge temperature. Before digging into EATC diagnosis, be sure to check climate control basics. EATC is an operating strategy and can only work as well as the system it operates.

Monitor inputs to troubleshoot the outputs

Several inputs need to be within range for the ECM to engage the A/C clutch coil. One such input is the evaporator temperature sensor. The evaporator temperature sensor is used in place of a low-pressure cycling switch to regulate the A/C clutch's on/off times. The ECM turns the clutch off when evaporator temperature drops below 32 degrees F and turns it on at 35.6 degrees F. Since the purpose of cycling the clutch is to prevent evaporator freeze-up, shutting it down at 32 degrees F is a lot more efficient than using low side pressure to determine clutch cycling downtime.

When an evaporator temperature sensor malfunctions, the ECM usually defaults to -40 degrees F, which prevents A/C clutch activation. This is a common scenario, and after checking the basics, it should be the first thing you look at when di-

agnosing an inoperative A/C clutch coil. View the EVAP_TEMP PID on your scan tool. If the value is above 35.6 degrees F, the evaporator temperature sensor isn't the cause of the problem. A defective evaporator temperature sensor might generate circuit DTC B1B71, but don't count on it.

The A/C pressure transducer (ACP) is another input that will inhibit A/C clutch engagement. Located on the discharge line between the compressor and the condenser, the ACP reports A/C discharge pressure to the ECM. The ECM will not engage the A/C clutch if the transducer reports that A/C pressure is too high or too low. To check ACP operation, hook up your manifold gauges while viewing the ACP_PRESS PID on a scan tool. The PID should show within ± 15 psi of actual pressure (**Figure 3**).

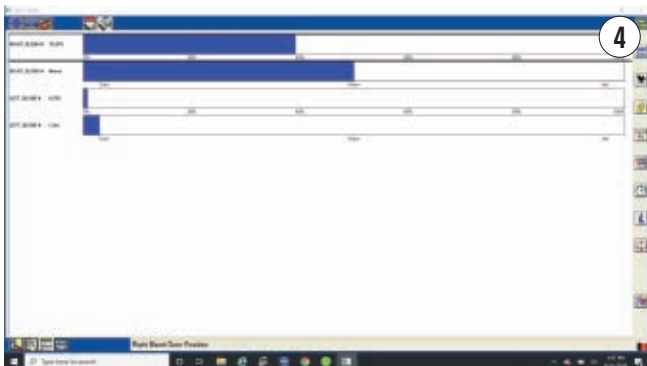
A customer recently brought in his 2015 Explorer complaining that the air conditioner would intermittently stop blowing cold air. I wasn't able to reproduce the issue. I found that the ACP was showing 71 psi over actual discharge pressure. Based on the ACP's erroneous value, the ECM was shutting the compressor down 71 psi too soon. Replacing the ACP fixed the concern.

The ECM will also shut down the A/C compressor if engine temperature is too high, or if ambient temperature is too low. So, monitor engine coolant temperature (ECT), cylinder head temperature (CHT), and ambient air temperature (AAT) when diagnosing an inoperative A/C clutch.

Hooking up a scan tool to a vehicle after an overnight cold soak is a good way to check the temperature sensors. The AAT, CHT, ECT, and the intake air temperature sensor (IAT) should all be reading about the same temperature after an overnight rest. The powertrain control module (PCM) runs this exact test after a cold soak of about six to eight hours and will inhibit A/C clutch engagement if just one sensor differs greater than a calibrated value.

It's always about temperature

Faulty temperature blend door operation is a common cause of



THIS IS A SCAN TOOL VIEW of left-side and right-side temperature blend door operation on a DATC system. On this vehicle, the left-side temperature selected is lower than the temperature selected on the right side. The actuators are being commanded accordingly.

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THIS INTERNAL VIEW of an inlet door actuator shows missing teeth on the driven gear, causing the actuator to make a banging noise during operation.

unsuitable climate control discharge temperatures. A temperature blend door actuator is an electric motor, not unlike the ones we've previously discussed. They manipulate the temperature blend door to direct airflow through the heater core and the evaporator as needed to maintain the desired cabin temperature. Dual automatic temperature control (DATC) utilizes two blend door actuators, one for each side.

Monitor blend door PIDs using a diagnostic scan tool. When diagnosing DATC, monitor the LEFT_BLEND and the RIGHT_BLEND PIDs and operate the actuators using

the scan tool. If the PIDs show an increase and a decrease in percentage value, and the air temperature changes correspond, the blend doors are working (**Figure 4**).

Sometimes when an actuator experiences a mechanical failure, it will make a banging noise during attempted operation. This is the case with temperature blend door actuators, recirculation door actuators, and air distribution door actuators. The banging sound results from either the nylon drive gear or the nylon driven gear inside the actuator missing a few teeth. The actuator gets stuck on that spot, and since the potentiometer is reporting no change of position to the ECU, it keeps trying to change the actuator position.

To locate the jammed actuator, operate the controls. The change you initiate that causes the actuator to start banging determines which actuator is bad. If you can access it with your hand, you can feel the actuator banging. Be sure to check the door for binding after removing the actuator (**Figure 5**).

Actuators mesh with their respective doors utilizing a lever or a splined shaft. The splined shaft is keyed to assure that the actuator is installed in the correct position. Here's a helpful hint. Cut the shaft off of an old actuator and use it to manually operate the blend door when checking for binding or sticking.

The get-up-and-go of EATC

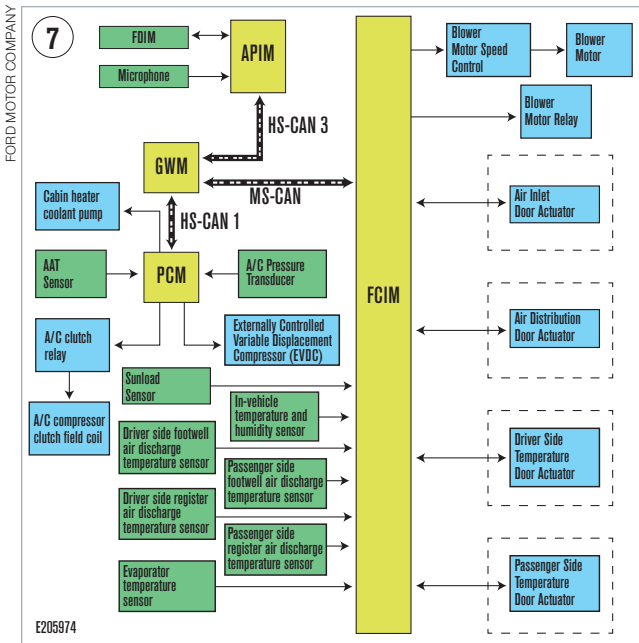
Here's an overview of the operation of DATC on a 2014 Ford Fusion with the selector set to auto and the desired temperature set to 64 degrees F. for the left side and 75 degrees F. for the right side. The ambient temperature is 90 degrees F.

The driver selects "auto" and sets the temperature using either the buttons on the front control interface module (FCIM) or the touchscreen on the front display interface module (FDIM). An 8" touchscreen is an option on vehicles equipped with the Ford Sync System (Sync) (**Figure 6**). The driver can also use Sync voice commands to make climate control requests. Orders initiated using Sync are received by the accessory protocol interface module (APIM) and sent to the gateway module (GWM).

The GWM relays this information to the PCM and the FCIM. The FCIM monitors the in-vehicle temperature and humidity sensor to determine if air conditioning or heat is needed to achieve the desired cabin temperature. If all the critical conditions are met, the



HERE IS THE 8" TOUCHSCREEN opened to the climate control screen on a DATC system.



THIS IS A DIAGRAM of DATC network communication on a 2014 Ford Fusion. Notice how the FCIM receives all sensor inputs, then communicates this information to other modules. Picture taken from the 2014 Ford Fusion workshop manual. Section 412-00

PCM energizes the A/C clutch coil. The PCM monitors ACP and interrupts the A/C Displacement operation if A/C discharge pressures go too high.

The FCIM monitors and adjusts the air inlet door based on cabin humidity and temperature. The module switches to outside air if the cabin becomes too humid, and if more cooling is needed, it will open the door to recirculation. Air is distributed to the panel vents for air conditioning and the floor vents for heat. The driver selects “defrost”. The FCIM also coordinates the temperature blend door actuators to meet the driver’s and the passenger’s temperature requirements.

In the case of this 2014 Fusion, the FCIM will direct colder air to the driver’s side for an extended amount of time to compensate for the difference in desired temperatures.

The blower motor relay is energized by the FCIM, which sends power to the blower speed controller. The controller changes blower motor speed by alternating the blower motor ground side resistance. Blower speed will always go to high if MAX AIR or defroster is selected. Blower speed will decrease as cabin temperature gets closer to desired. The operator can change the blower motor speed at any time.

The superhighway of network communication

All this chatter between modules means that climate control diagnosis can quickly morph into network diagnosis. If a network issue is causing an EATC concern, you should retrieve at least one “U” code from at least one module.

A network communication issue does not always mean that there’s a fault. Sometimes a module can lock up due to excessive traffic (messaging) on the controller area network. The FCIM seems to be prone to this sort of thing. Before diving into network diagnosis, perform a battery disconnect. Disconnect the negative battery cable, then touch the negative terminal to the positive post. This will discharge the modules and allow them to reset. Wait a couple of minutes, then reinstall the cable. Quite often, this fixes network communication issues. If the concern is still present, proceed with normal diagnosis (**Figure 7**).

A few more things

We haven’t talked much about the in-vehicle temperature and humidity sensor. These sensors rarely go bad, but they can become inaccurate due to dust and dirt. A hose attached to the blower motor housing pulls a slight vacuum on the cabin sensor duct. This vacuum creates a small amount of airflow through the sensor, allowing for an accurate cabin air temperature reading. Unfortunately, it also pulls in little dust bunnies that restrict airflow past the thermistor. So, if the system is having trouble sustaining a consistent temperature, check the cabin sensor for contamination.

Recent model years are using panel vent temperature sensors. These sensors are located in the ductwork behind the vents. Vent sensors are a good diagnostic tool if an evaporator temperature sensor is suspect. Evaporator temperature and vent temperature should be very close to the same. Monitoring both is a good way to see if there’s a problem.

Ford Motor Company’s quest to assure their vehicles’ occupants are comfortable goes way past what we’ve discussed in this article. There are climate-controlled seats, auxiliary climate control, and even heated steering wheels. Your most valuable tool to help you diagnose these features is your ability to understand how these things work. It’s so important that I need to repeat it. Be sure to read Description and Operation before attempting diagnosis. Keep cool. **ZZ**



ROY DENNIS RIPPLE is a Ford Senior Master Technician and an ASE Master Technician with more than 30 years’ experience in the automotive industry. As an automotive journalist, he is the recipient of a 2020 Azbees Award and a 2020 Tabbies Award.

Ripple is currently working full-time as the shop foreman at a Ford dealership. He lives in New Jersey with his wife, three dogs, and two motorcycles. He can be reached at ripkrypton@gmail.com.

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DO YOU 'SPEAK EURO?'

WORKING WITH EUROPEAN MODELS IS LIKE LEARNING TO SPEAK A DIFFERENT LANGUAGE.

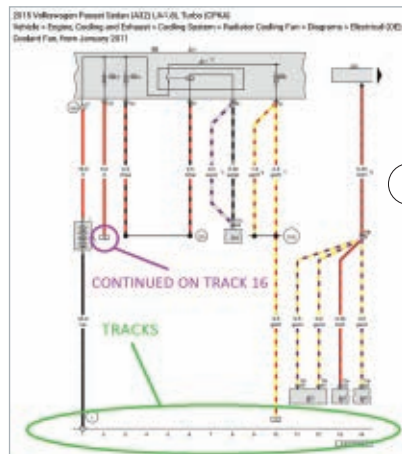
BY CHRIS FARLEY // Contributing Editor



Did you ever notice if you speak to a technician from a European shop, he or she seems to speak a different language? For example, it's not a "2018 BMW 320i with a 2.0L"; it's an "F30 with an N20 that has an issue in the CAS with the I-level." If you're not sure what this means, you are not alone. But let's see if I can help you learn enough of the acronyms to get by.

The saying "a car is a car, it's just a different emblem on the hood" is true, but there is a different language that is associated with some makes. In this article we will talk about some of them and compare them to popular domestic and Asian makes. I have a primarily domestic and Asian service background from when I was in the bays, with the occasional Euro car making an appearance, so I can relate to the issues. There was always extra time required to understand the different terminology, figure out the diagrams or locate components. When I went mobile, I had to learn to be able to understand and

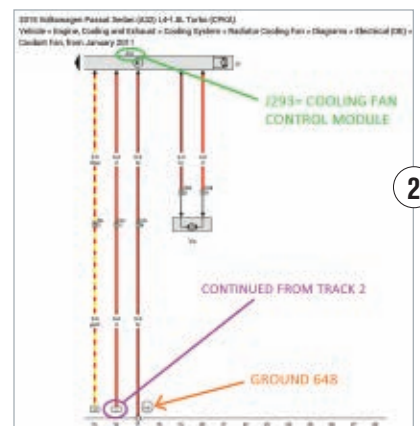
diagnose these vehicles more efficiently, or I would be in trouble. Although I can get through these systems and issues, I always get humbled when I talk to a Euro shop tech and realize how much more I must learn.



FACTORY DIN DIAGRAM of cooling fan circuit displaying tracks 1-14 at the bottom. This is where the circuits continue.

Let the troubles begin

Most often, the complaints I hear from the shop regard an inability to find information or diagrams for the system in ques-



COMPONENTS ARE LABELED in alphanumeric characters that will remain the same across DIN wiring diagrams. At the bottom, the numbers surrounded by the square and the circle represent a callout of where that circuit continues.

LEGEND

3

COMPONENT IDENTIFICATION

- J293 - Coolant fan control module See: [Vehicle > Components > Engine Compartment See: Radiator Cooling Fan Control Module > Connector Views > Coolant Fan Control Module - J293](#)
- T2af - Double connector
- T4x - 4-pin connector
- V7 - Coolant fan See: [Vehicle > Components > Engine Compartment See: Radiator Cooling Fan Control Module > Connector Views > Coolant Fan Control Module - J293](#)
- V35 - Right coolant fan See: [Vehicle > Components > Engine Compartment See: Radiator Cooling Fan Control Module > Connector Views > Coolant Fan Control Module - J293](#)
- (640) - Ground connection 2 in engine compartment, left See: [Vehicle > Components > Engine Compartment](#)
- Previous See: [Radiator Cooling Fan > Electrical > Diagram 10/2 \(Tracks 1-14\)](#)

THE LEGEND IS A KEY to decode the alphanumeric characters which represent the component in the wiring diagram.

tion. Sometimes it's that technicians can't find the location of a component (such as a specific relay or fuse in one of the multiple fuse blocks or holders hidden all over the vehicle). Most of this article relates to BMW/Mini & VW/Audi, but much of the info and terminology will carry over to other makes.

European vehicles are often identified by chassis numbers, such as a BMW F15 (2014-18 X5) or an Audi 4L9 (Q7 SUV 2007-up). Knowing these codes will make finding info from some sources much easier. My recommendation is to do a quick Google search for these lists and either print, bookmark them or, save them to an online drive so you always have access to them (as I do).

The elephant in the room

The number-one complaint I hear is, "I don't understand the wiring diagram," or, "I can't find any wiring diagrams." The truth is the technician simply can't find an aftermarket redrawn wiring diagram for the system in question and he or she doesn't know how to read a Deutsches Institut für Normung (DIN) track diagram.

I've heard techs complain about DIN diagrams since I started working on cars, and all these years later, I hear the same complaints. Like everything else in this business, it requires us to put in some effort and learn so we can understand and effectively use these diagrams. I admit they are a little confusing at first, but once you start getting used to them you will see the

simplicity and logic behind them.

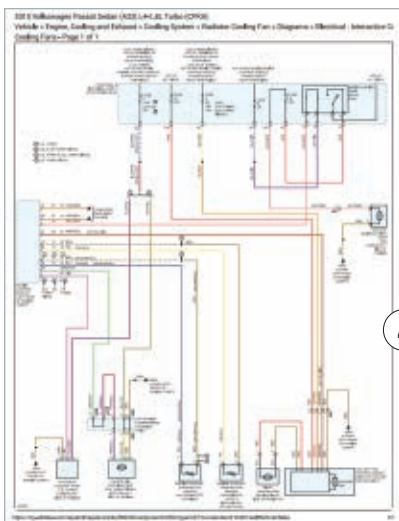
The first thing we need to understand when reading a DIN diagram is source power always starts at the top of the diagram and ground is always at the bottom (simple, right?). The part that gets confusing is the tracks (**Figure 1**). The numbers on the bottom of the page are the tracks. Notice in track 2 the (red) rt wire leaving



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A BENEFIT OF redrawn aftermarket wiring diagrams includes the components related to the system's functionality but not directly related to the circuits being addressed.

fuse 27 goes to a number 16 with a box around it; now go to track 16 (**Figure 2**) and you see the rt wire again, bringing current to the fan control module.

Personally, I use Alldata, and it has legends below the diagrams that identify each component, connector, fuse or ground is, along with hyperlinks for locations and additional info (**Figure 3**). In figure 2, track 17, this is a ground with the circled number 640 next to it. When we look in the legend, it's identified as ground connection 2 in the engine compartment. At the top of figure 2 there is a component labeled J293. Referencing the legend, J293 is labeled as the coolant fan control module and a hyperlink takes you to the connector view of the component.

I don't know about you, but for me, this is a huge time-saver and makes my testing a lot easier. Until recently, my go-to diagram has always been the redrawn ones. But with some manufacturers, I prefer to view the factory diagrams, as they tend to be more accurately drawn and have hyperlinks available. The benefit of the redrawn diagram is it includes other components (in this case, temperature sensors) related to the system (**Figure 4**). In this case, everything is on one page, but it also shows components that aren't used in this partic-

ular vehicle. The components may differ if the vehicle was equipped with a different engine package. I'm not here to tell you which one you should use; I'm just trying to demonstrate that the DIN diagrams aren't as difficult to read as most believe they are.

When diagnosing circuits on these vehicles, it is important to understand terminal designations used by the component and vehicle manufacturers. The practice of terminal designation was put into place to allow proper connection identification of the wires going to the components when diagnosing and repairing the vehicles. These terms come up often when following flow charts and test procedures and are also usually included in the legend. Some of the common terminal designations are Terminal 15 (switched ignition voltage supply), Terminal 30 (battery positive voltage supply) and Terminal 31 (vehicle ground supply). There are more, and they will definitely help you understand the operation of the circuits so you can make a faster and more accurate diagnosis, so I recommend looking them up and adding them to your files.

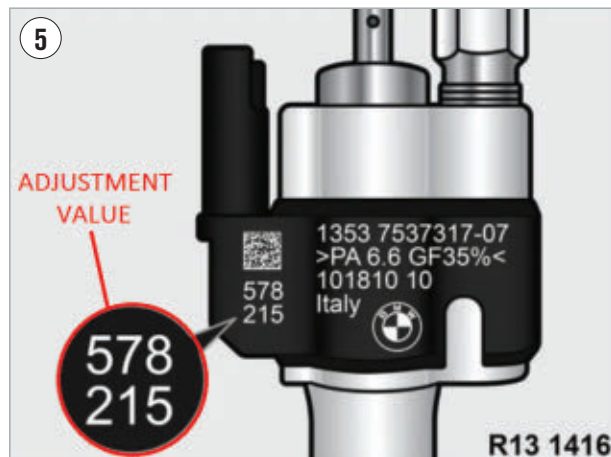
Coding and programming

The next topic I want to cover is the difference between encoding (coding) and programming. When it comes to these vehicles, "coding" is a word that is often mentioned. Many components that are replaced will need to be coded to work properly in the systems.

For example, headlight assemblies will need the modules coded to the vehicle before they will function. Some components will require programming and coding when replaced, while others may just require programming. What's the difference, you ask? Coding is basically setting up the module, providing the software needed to operate. You just need to configure the module so it knows the region it is operating in and the options that are equipped on the vehicle.

A module has just a base level of software (basic operating instructions) when first installed. Programming allows it to receive the operating software for the specific vehicle it is installed in (vehicle configuration). This procedure is more involved and may require additional procedures or modules to be updated. In the case of BMWs, the manufacturer calls for all modules to be brought to the same level. BMW calls this the "Integration level" (or I-level). For instance, if you replaced a steering rack in the vehicle, you will be unable to program just that module with the factory tool. The factory tool will go in and check the level in each module and determine which ones are behind. You will then have to update all of them.

That may not seem like a big deal to some. But with the number of modules in these vehicles and depending on the speed of your internet, you could be looking anywhere from 30 minutes to



THE INFORMATION BEING DISPLAYED HERE is an adjustment value unique to a fuel injector. This information must be shared with the ECU during the encoding process, as it represents injector flow rate.



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BOSCH

HARNESS THE POWER OF ORGANIZING CAPTURED DATA

YOU CAN'T USE THE DATA USED FOR YOUR PREVIOUS DIAGNOSTIC SUCCESSES IF YOU CAN'T RECALL WHAT YOU'VE NAMED IT OR WHERE YOU'VE STORED IT.

BY BRANDON STECKLER // Technical Editor

I have been an automotive technician for about 25 years. It wasn't until about my 10th year that I realized the power of analyzing captured data. Having the data in front of me allowed me to relax a bit and focus on fault-finding. It gave me an opportunity to step away from the vehicle and use the best tool any tech has at his or her disposal, his or her brain.

Let the tool tell the story

As an educator, I'm frequently asked, "Brandon, how do you diagnose faults?" Of course, my answer will vary greatly depending on a few things:

- The vehicle's configuration (what I can reach with my hands)
- Available tooling (what information is available for analysis)

- How the vehicle is equipped (system design/operating characteristics)

However, there are several straight answers to this question that I always offer:

"I capture the data in a fashion that tells a story." This statement applies whether we are referring to a scan tool, a graphing multimeter, or even a lab scope. These multi-trace devices allow more than one piece of data to be simultaneously displayed. This display offers a more dynamic view of a system (and the individual components of that system) in action. In other words, with the appropriate data captured, we have the ability to see:

- Operator intent (depression of the A/C request switch)
- Input response (ECU recognition of the switched-input request)

- Processing (command to A/C compressor clutch coil relay)
- Output response (A/C pressure transducer reaction)
- System performance (vent temperature sensor and refrigerant flow sensor response)

I always "reach for the low-hanging fruit." What I mean by that is my diagnostic approach is always structured around using easy-to-grab information to decide what test to invest in next. A strong takeaway from this type of testing above is that it is all done right from the driver's seat with nothing more than a capable scan tool.

A second benefit to this type of testing is that there is no wasted time. This takes some practice, but employing logic and truly understanding what the test



THE EGR VALVE acts as a vacuum leak when opened to the exhaust stream. This leads to anticipation of a rapid pressure change as seen in through the input of the MAP sensor signal. A lack in rapid change likely reveals a restriction of the EGR ports.

vacuum leak to fresh air, but it is a vacuum leak, nonetheless. Logic dictates that the vacuum (negative pressure) in the intake manifold will equalize to the almost-atmospheric pressure in the exhaust stream when the EGR valve is open (**Figure 1**).

The manifold absolute pressure (MAP) sensor will report the change in manifold pressure to the ECU. If the system is functioning as designed, and if the proper data is viewed, one will see a correlating (almost overlapping) change in both the MAP signal and EGR pintle position (**Figure 2**).

Consider an alternative scenario. With the same data being viewed and when that EGR valve opens, the MAP signal is slow to rise when the change in the EGR pintle position occurs (**Figure 3**). What do you immediately anticipate the fault is? I'm confident the first thought that comes to mind is a restriction of the EGR ports. Not only is this a logical thought, but

results are telling you (and their limitations, or what they are NOT telling you) will guide you like a steppingstone to the next logical test.

A third benefit of this type of testing approach, regardless of the time required, is that you will always be doing tests that bring you closer to the root cause of the fault. For instance, if all the previously captured data (the easy-to-grab data) points to an internal engine mechanical fault, I will have the engine disassembled with confidence. Understand there is a huge difference between disassembling an engine for exploratory surgery (hoping to find the fault with fingers crossed) and disassembling an engine to expose the fault (<https://www.vehicleservicepros.com/service-repair/diagnostics-and-drivability/article/21293621/lose-a-battle-to-win-the-war>).

Letting the tools become the tutor

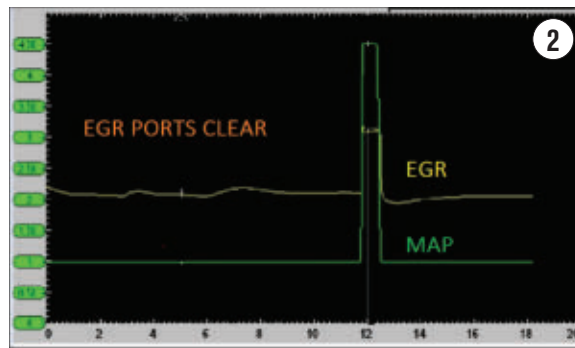
Implementing the technique described above offers an opportunity to gain tremendous insight into the functionality of a system. I'm simply talking about the action/reaction testing that occurs when data is captured and plotted in a graphical format.

When this information is collected simultaneously, the witnessed reaction that occurs is typically what is also being monitored by the ECU. This ECU is responsible for managing the system operation and flagging when performance faults are present. So how does this help us? I'll prove it to you.

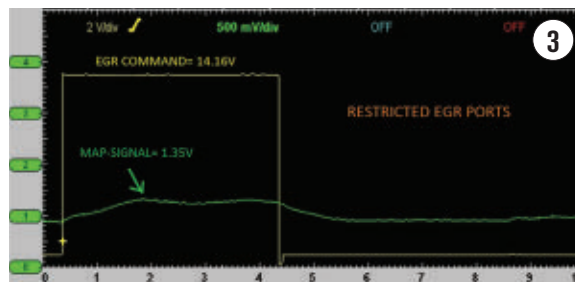
A scenario I like to use frequently is

one involving an EGR valve. The EGR valve will reintroduce inert exhaust gases to the intake manifold. The gases will displace some of the air/fuel charges from the cylinders and simply take up space, temporarily reducing the effective size of the combustion chambers. This reduction in the combustion chamber area also reduces the heat generated from combustion, which reduces the potential to form NOx.

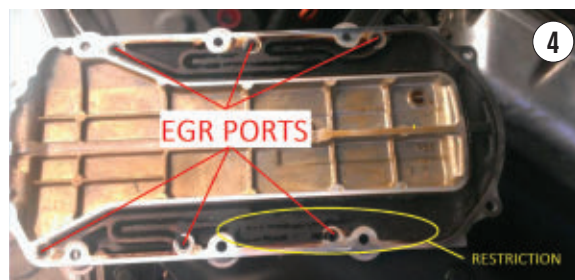
Let's break that down further. If the EGR valve connects the intake manifold to the exhaust stream, it will act as a vacuum leak when opened. True, it is not a



THE ANTICIPATED ACTION/REACTION RELATIONSHIP between MAP signal and EGR pintle movement.



DEFICIENT INCREASE in MAP signal during EGR pintle movement. Indicative of restricted EGR ports.



RESTRICTED EGR ports

it is also a theory developed right from the driver's seat. This will put you on a path to discovering where the fault is located, and it also offers confidence to begin disassembly.

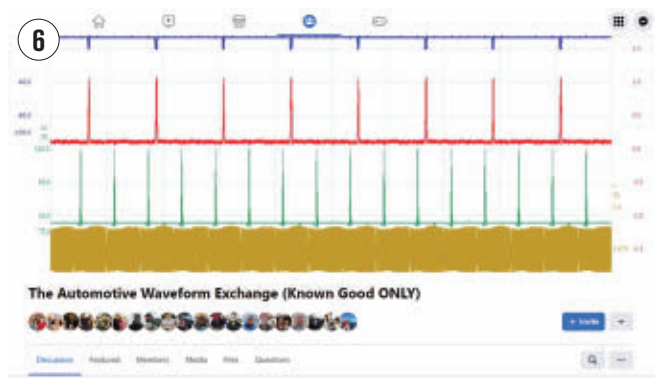
After only a few attempts at capturing data in this fashion, you will find great success as you will quickly learn what to expect from a properly operating system. When a restrictive EGR fault is present, it will stick out (in this same captured data) like a sore thumb (**Figure 4**). You will experience a drastic increase in not only productivity but also confidence. By allowing the tools to teach you how the system functions, you begin to learn dynamically and through practical experience instead of from a book.

Archiving collected data

As I previously mentioned, capturing and analyzing data away from the vehicle is the secret to my success as a diagnostician. However, what's to be done with this data once a successful diagnosis is drawn? Believe it or not, many technicians simply throw it away. They find no value in the data when the once-broken vehicle is now functioning after repair. This has always troubled me.

Whether you realize it or not, this data will serve you well for years to come. Keeping in mind that if you capture under faulted conditions, then repeat the capture once the vehicle is fixed, you then have a capture representing a known-good scenario. Be careful not to forget that it is rare to find this information in any book, and it's invaluable to a diagnostician. What is

FACEBOOK GROUPS LIKE THIS ONE are a breeding ground for thought and growth as a technician and give one the opportunity to collaborate with technicians from across the world.



my point? Don't simply get rid of it; save it.

There are several recommended ways to save or archive data captures. Years ago, I saved the information to thumb drives and eventually an external hard drive. As technology progressed with time, I transitioned to saving my data to cloud-based storage facilities. A few of them available are:

- Dropbox
- Microsoft OneDrive
- Google Drive
- iCloud

The benefit of choosing to use cloud-based storage is multifaceted. The storage limits vary by service, from 2 GB for Dropbox, 5GB for OneDrive, 15GB for Google Drive, and 5GB for iCloud; additional storage is available for a monthly fee.

I pay about \$120 annually for one cloud storage service (**Figure 5**). For those of you not too savvy, a terabyte took me several years to fill with data captures. Being "cloud-based" is the key. With the information stored in the cloud, the fear of losing data due to a computer crash or hardware mishap is no longer an issue. Simply boot your new device,

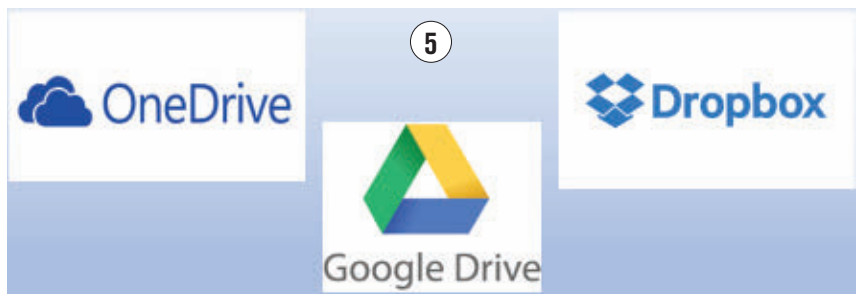
download the cloud app, and log in. You will have instant access to any previously stored data anywhere you have an internet connection.

This same feature also serves you well if you are an educator. Being able to organize and tag content with descriptive words will allow you to recall the capture you desire with simply a few keystrokes. This beats the heck out of scrolling through thousands of captures on several thumb drives. The cloud system functions as an organized filing system, not just a file cabinet. This becomes really handy when building classes and planning lessons or referring your students to examples of functional and faulted captures.

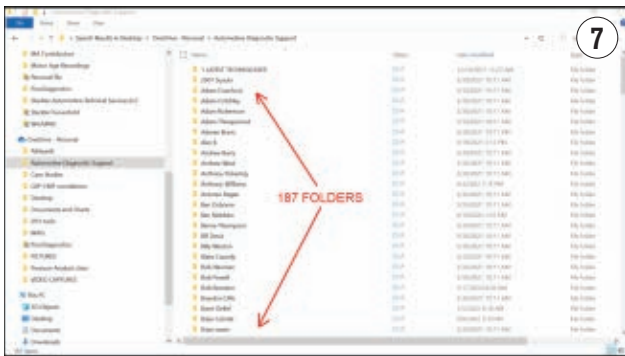
Regarding the sharing of knowledge and networking, being able to hold discussions in forums found on social media (such as Facebook) is enhanced and has more of an impact on learning/sharing when a visual interpretation of what is being discussed can be produced (**Figure 6**). Furthermore, sharing the file is now an easy task as one can do so with a hyperlink. Simply create a link in the cloud and copy/paste it to the forum or individual person you wish to share it with.

Identifying the captured data

Initially, this was the area I struggled most in. I was very capable of capturing the data that told the story well. I was also extremely comfortable analyzing the captured data to make a diagnostic decision. However, sorting the data in a way



CLOUD-BASED STORAGE FACILITIES like these three are a safe, organized and convenient way to secure and archive your captured data.



ORGANIZING DATA in folders allows for a logical filing system that will serve you well for years and allow you to easily recall information in just a few moments.

that made it easy to locate became a real burden for me. With that, I'd like to offer some advice to help you stay organized with the hundreds (if not, thousands) of captures you will view over the course of a single year.

I begin by organizing my cloud account in a series of folders and multiple sub-folders. Arranging them in a logical layout aids in efficiency. I build the main folders by the name of the person I'm assisting. The cloud can be configured to arrange them in alphabetical order as well (**Figure 7**).

Within each folder can be multiple subfolders. These subfolders represent the subject vehicle for which the inquiry was placed. There will be a subfolder for each individual vehicle (**Figure 8**). If necessary, the subfolder will include the VIN, the symptom, and any distinctive configuration characteristics required to properly identify the vehicle in service information and wiring diagrams. I like to place this information in the folder because this removes the need to tag each individual data capture with redundant information.

When it comes time to capture the data (using a scope or scan tool), be sure to

label the capture with the following pieces of information:

- Current operating conditions (idle/brake-torque/heavy-load, etc.)
- Whether the symptom is exhibited or not
- Brief description of what the data is displaying ("MAF signal dropout under load," for example)

Specific to scope channels, be sure to identify which circuit on the vehicle is associated with each channel utilized. This may seem like common sense, but you'd be surprised how many captures I'm asked to analyze that do not contain this very important information. It is absolutely crucial to a successful diagnosis. Many of the scope and scan tools offer this ability within the software. If not, do what I do: snip a screen and plot it in Microsoft Paint. It's free and will allow you to annotate directly on the capture or a photo.

Many don't give this much thought, but where the circuit is being sampled from is important information to know. What I'm getting at is a scenario where a suspect circuit contains an unwanted resistance/voltage drop and it will only be revealed if the test leads are placed appropriately. Be sure to include this information in the



IN THIS EXAMPLE, each one of my friends I offer assistance to has a subfolder for each vehicle challenge they present to me. This organization process helps keep me sane.

capture, preferably in the area where the channel of the scope is assigned to a specific circuit.

Finally, be sure to label or name the capture appropriately. Remember, it's this very information that you will likely have to revisit sometimes years after the data was captured. If you take the time to capture, label and identify appropriately, these data captures will serve to tell a story that is recognizable by other trained analysts, regardless of how much time has elapsed.

The strategies mentioned above for maintaining organization with captured data are a game-changer in the world of an automotive diagnostician. Don't take my word for it; give it a try. At first, it may seem tedious and a hindrance to productivity. But, in no time at all, you'll realize the power of organizing captured data. *TLZ*



BRANDON STECKLER

is the technical editor of *Motor Age* magazine.

He holds multiple ASE certifications. He is an active instructor and provides telephone and live technical support, as well as private training, for technicians all across the world. bsteckler@endeavorb2b.com

“IT WASN'T UNTIL ABOUT MY 10TH YEAR THAT I REALIZED THE POWER OF ANALYZING CAPTURED DATA. HAVING THE DATA IN FRONT OF ME ALLOWED ME TO RELAX A BIT AND FOCUS ON FAULT-FINDING. IT GAVE ME AN OPPORTUNITY TO STEP AWAY FROM THE VEHICLE AND USE THE BEST TOOL ANY TECH HAS AT HIS OR HER DISPOSAL, HIS OR HER BRAIN.”

SCAN THE QR CODE TO READ THIS AND RELATED ARTICLES ONLINE

OUT-OF-CONTROL FUEL DELIVERY

ANALYZING SCAN DATA MAKES DRIVEABILITY LESS CHALLENGING.

BY BRANDON STECKLER // Technical Editor



Very similar to last month's theme, I was providing technical assistance for a driveability complaint for a GDI platform. The vehicle was a 2019 Honda Fit with a 1.5L engine. The original complaint was for the only exhibited symptom, a DTC P0172—"system rich."

Preliminary data

After viewing some basic scan data uploaded to **ShopStream Connect** from

a **Snap-on Zeus**, it's clear to see that both the front and rear heated exhaust gas oxygen sensors (HEGOS) are telling the same story: the exhaust stream is oxygen-deficient (rich). With a measured lambda value of .925, the exhaust contents measure almost 9 percent too rich of the commanded stoichiometric Lambda value of 1.00 (**Figure 1**). As a result, the PCM is trying hard to regain control by negating total fuel trim by approximately 28 percent. So, as always, the question becomes "why?"

Never leaving the driver's seat unless I need to is the secret to my success and efficiency. One can obtain many answers simply by asking the correct questions. Idling engines should breathe approximately 1.5 times their displacement (in liters), which is re-

flected in grams per second (gps).

According to the data, at idle this engine is pumping 2.4 gps (**Figure 2**). According to the formula, that is almost spot-on. It should be clear that the MAF sensor is reporting correctly and is not the cause of the 28 percent surplus of fuel delivery.

The next logical test was to raise the rpm to change the operating conditions. The results of this quick test would quickly flush out a fault like a leaking EVAP purge valve or even a dripping injector. The increase in fuel demand from this test would actually require additional fuel. In those examples just given, we would expect fuel trim to begin to normalize when the engine was loaded. However, that is not the case here. The heavily negated

THE DATA DOESN'T LIE

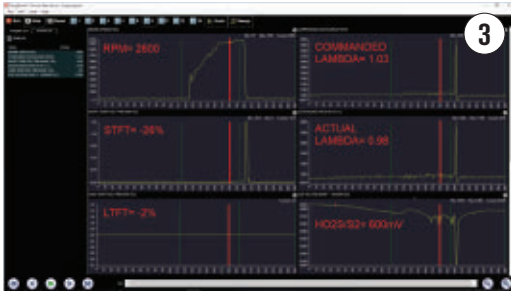
WELCOME BACK TO ANOTHER EDITION OF "THE DATA DOESN'T LIE," A REGULAR FEATURE IN WHICH I POSE A PUZZLING CASE STUDY, FOLLOWED BY THE ANSWERS TO THE PREVIOUS ISSUE'S PUZZLE.



THIS CAPTURE TELLS A STORY.

The story is that the PCM desires an air/fuel ratio with a Lambda of 1.001. The actual Lambda is 9 percent rich (at .985), and the fuel trims display a corrective factor of about -28 percent.

AS SEEN BY THE negative fuel trims, an over-delivery of fuel is reflected in this reference point of the vehicle at idle (low-load and fuel demand). Changing the operating conditions will help determine if the fault only exists at idle and will help eliminate certain items for being the cause of the fault.



THE EXISTING NEGATIVE FUEL TRIMS (at idle) point to an over-fueling condition. By placing a load on the engine, the demand for fuel increases however, the abundance of fuel still exists. This eliminates a dribbling injector and evaporative emissions purge valve (being stuck open) as potential faults.

- Vehicle flags DTC P0172
- Scan data shows that the vehicle is rich (with negative fuel trims) under all conditions
- Scan data shows that the MAF (main input for fueling strategy) is reporting accurately
- Neither the fuel nor engine oil are contaminated

Given this information, what would you do next?

- Replace skewed primary WRAF sensor
- Perform available direct injector automated scan tool test
- Replace all four direct injectors
- Replace skewed-high fuel rail pressure sensor

Be sure to read the September Motor Age for the answer to this month's challenge and see what was discovered! [🔗](#)

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trim was present under all operating conditions (**Figure 3**). This leaves only several potential causes (and we haven't even left the driver's seat yet!).

Easy tests first

As mentioned, only several possibilities can cause a rich condition under all operating ranges. The engine oil was inspected for a high level /odor (which would indicate an internal fuel leak from the high-pressure fuel pump). Fuel vapors from fuel-contaminated oil will be ingested by the PCV system and will cause negative fuel trim. Though this trim tends to negate mostly under high-vacuum / low-load conditions, it is certainly an easy item to check. No fault was found. A fuel sample was then taken to see if

the tank contained any contaminants. Only gasoline with an ethanol content of 10 percent was found.

At this point, many of the potentially faulted items have been eliminated. Which direction you head in and the next subsequent test to be performed varies, mainly due to the vehicle and/or scan tool software. Some scan tools/vehicle software allow for some very accurate automated component testing, but others do not.

The data doesn't lie

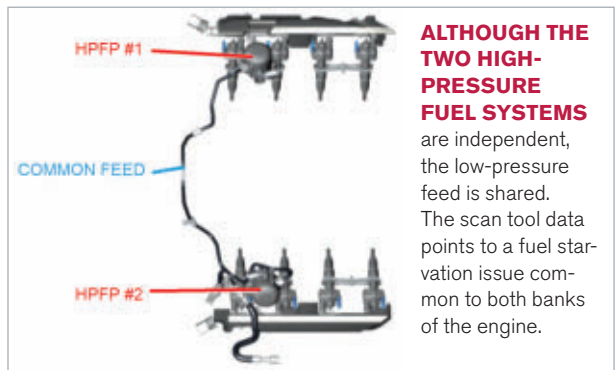
With all the information in front of us, we are faced with deciding how to proceed. Here are some bullet points of what we know to be factual, and I will ask all of you diligent readers for your input:

SOLVED: (June 2023 Motor Age) 2014 BMW X6, lean condition

What would you recommend doing next, given the data bullet points in last month's challenge?

- 1) Gather more information about the commanded rail pressure and low-pressure fuel delivery system
- 2) Replace in-tank low-pressure fuel supply pump
- 3) Replace GDI fuel injectors
- 4) Replace both high-pressure fuel pumps

For those of you who chose answer #1, congratulations. Although faulty high-pressure fuel pumps will cause similar symptoms, answer #4 would make sense, but these pumps cannot generate the pressure necessary without adequate supply from the low-pressure side of the fuel system. GDI injectors can most certainly create lean conditions, making answer #3 plausible, but they wouldn't cause a significant drop in rail pressure under sustained load. We simply cannot condemn any high-pressure fuel system components without first verifying the integrity and performance of the low-pressure fuel system (**Figure 4**). Replacing the low-pressure (in-tank) fuel pump is logical, as it



ALTHOUGH THE TWO HIGH-PRESSURE FUEL SYSTEMS are independent, the low-pressure feed is shared. The scan tool data points to a fuel starvation issue common to both banks of the engine.

is common to both banks (just like the fault), making answer #2 likely. But any good technician tests and doesn't guess. The best answer is answer #1.

There was no fix, as the customer decided not to pursue the fault any further. It's unfortunate, as I always like to prove my cases by demonstrating the capture of post-repair data. However, it is the approach that is important. Using the collected data directs us where to focus our testing efforts next. With that mindset, almost anything can be diagnosed correctly.



SHOP WEBSITES MADE EASY

With customers increasingly on the go and on mobile devices, you need to establish an online presence that sets your shop apart. Worldpac's MotoWeb is an easy, effective and affordable solution to that challenge, offering a professionally designed website for your shop and allowing your customers to engage online at their convenience. A website from MotoWeb makes it easy for customers to see what services your shop offers, access their personalized online garage, get exclusive coupons and book their next appointment. Visit us online to request a demonstration.

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24 hours (and that's if everything goes through without an issue).

There are some aftermarket tools that will allow you to go in and program just one module, but with that comes risk. If that module is now programmed at a higher level than the other modules in the vehicle, this can create problems with communication between the modules and systems can become inoperative, setting codes and fault messages. Now you are in a situation that can only be repaired with the factory scan tool.

My advice here is to tread lightly and know your pain tolerance before getting involved. While we are talking about BMW module programming, do your research before purchasing a used component to make sure you or someone you know has the ability to make that component work in that vehicle. This may require circuit board-level work and special tooling, as a lot of these modules are intended to be used one time on one vehicle.

Completing the process

Often when replacing components on these vehicles, they require additional steps before they will function properly. Again, this comes down to following service information. BMW calls these extra steps and procedures “adaptations.” An adaptation can be as simple as clearing values and relearning the crankshaft

position after replacing the sensor. It also could be inputting the adjustment value of the new fuel injectors you just installed (Figure 5). In the VW/Audi world, this is called “basic settings.” When replacing some components on these vehicles, you are required to clear out the existing settings, learned values, or calibrations, and then relearn them using the basic settings mode.

This mode is like an active test mode that will operate certain functions and perform procedures required to complete the necessary relearns or calibrations. For example, if you install a replacement ABS control unit (after coding the module), you will need to go into basic settings to perform brake system bleeding, relearn the steering angle sensor, and test the yaw rate sensor.

Basic settings are also used when setting up a new throttle body or transmission after repair or replacement. Aftermarket tools have good coverage when it comes to VW and Audi, but again, components may require coding and programming after replacement. Some components come with theft protection active and require a factory tool to remove the component protection before the module can be put into service. Read service info before attempting these procedures and verify your tools have the ability to complete the process, or you could end with a nonfunctioning component or vehicle.

Ending note

These vehicles require a lot of maintenance and can be highly profitable to service. But like most vehicles, they require specific fluids and procedures to be performed. The use of wrong oils or extended service miles can have detrimental effects on the longevity of the vehicle. Working on these vehicles can be involved and intimidating, but cover the emblem on the hood and go about your diagnostic process like you would any other vehicle.

Read the service info and understand the system you're working on. Formulate a test plan and follow it until your results lead you to the root cause of the problem. The component may go by a different name, but it's most likely the same component you see failing on the domestic models you usually service.

It's true; Euro vehicles do require you to speak a different language, but it's nothing you can't learn. *ZZ*



CHRIS FARLEY is a 25+ year veteran of the industry and the owner and operator of Automedic LLC, a mobile programming and diagnostic business servicing both auto body and repair shops in central New Jersey.

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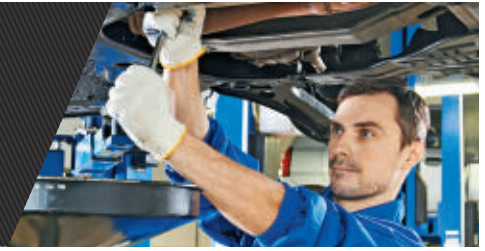
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BRANDON STECKLER // Technical Editor

Today's technologically advanced vehicle powertrains bring huge rewards to us as consumers. Compared to previous vehicles, they have remarkable fuel economy, abundant power output, and significantly reduced tailpipe emissions. But access to components for testing hasn't gotten any easier, I'm sure you'll agree.

When facing driveability faults, it's the symptoms felt by the consumers that drive what we are usually addressing as technicians. But a major factor in today's vehicle powertrain analysis is what we face under the hood. There is little room to conduct the testing we've grown to trust in pursuit of the symptom exhibited. This means carrying out those same tests can be extremely time-consuming. Of course, if the test is justified, it's worth the investment of time to conduct the test. But it may not be prudent to commit to that test first because of the amount of time that is needed to be invested.

However, there is an alternative approach, a test that offers great preliminary driveability data about what is happening



inside the combustion chamber. Even more significant is that this test can be applied to almost any vehicle with a spark ignition internal combustion engine. This type of testing is known as Ignition waveform analysis.

In this edition of "The Trainer," I will show you how to use the Autel DSO and related accessories to acquire and analyze these ignition waveforms. Even if you don't own an Autel scope, these techniques apply to whichever scope you do have. *TL*

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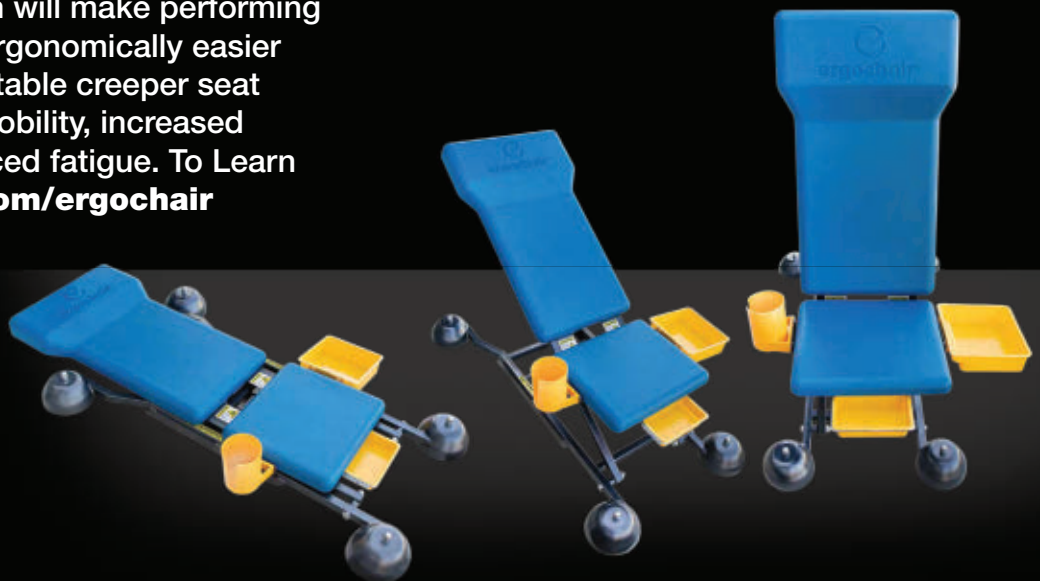
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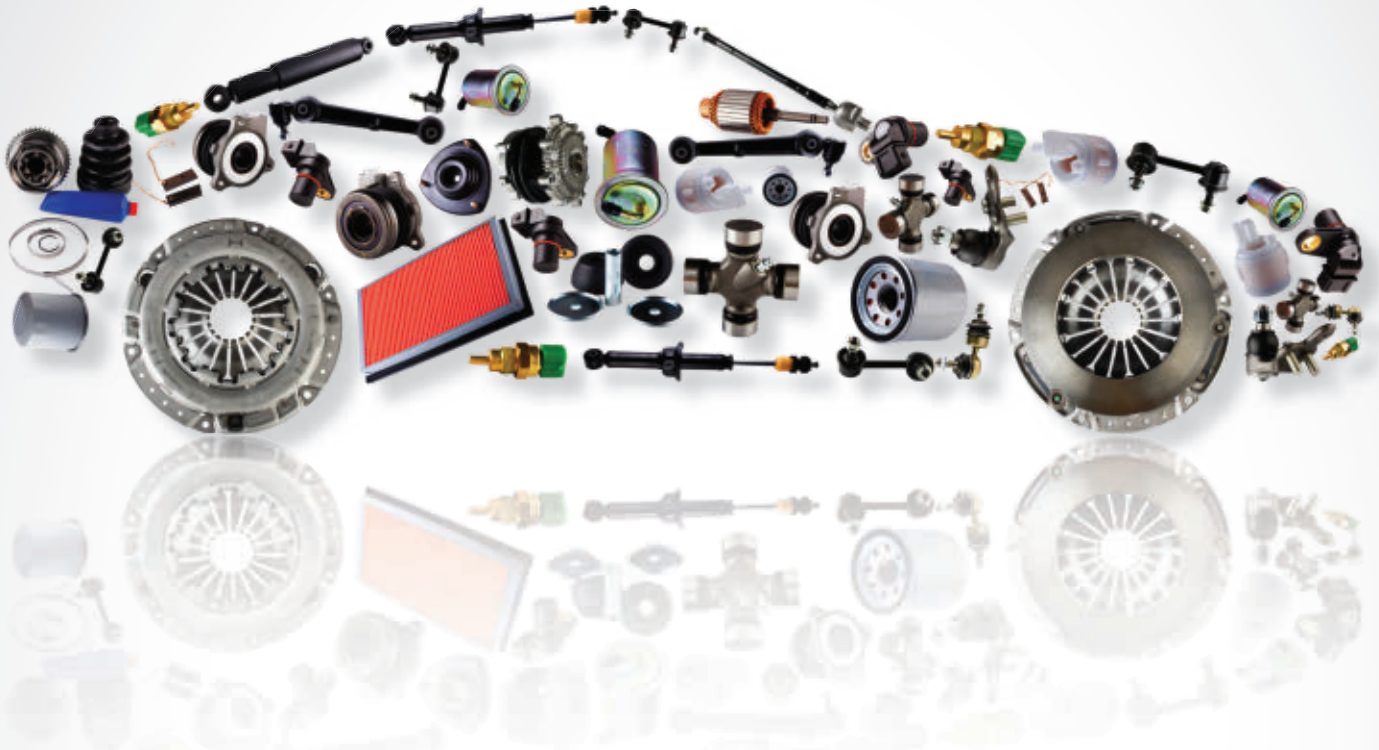
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