



NOBODY LIKES A YES-MAN.

Unless you're calling for a part.



- Since 1925 -
NINETY
YEARS
OF KNOW HOW



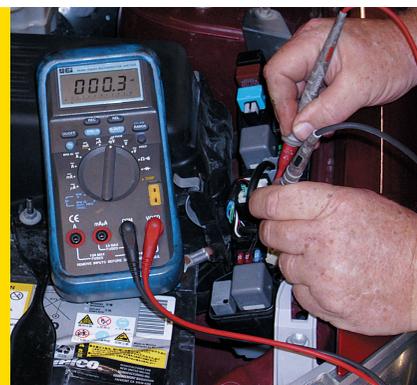
8 HAVE YOU MADE A BAD HIRE?

Evaluate your employee using the head, heart, hands method

34 PERILS OF DIAGNOSIS AND REPAIR

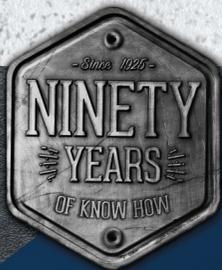
Some people will believe a half-baked diagnosis, and some mistakes are easily made

**ELECTRICAL
LAWS ARE KEY
TO DIAGNOSTIC
SUCCESS**



MORE SENSORS MEAN MORE PROBLEMS.

That's why we've got even more solutions.



Our advanced tech solutions take the guessing game out of replacing engine sensors. And with the widest array of components out there, we make sure those little jobs stay little jobs. That's NAPA KNOW HOW.





14 PARALLEL AXIS HYBRID TRANSAXLES

A look at what's new and what's not so new in the latest hybrid transaxles

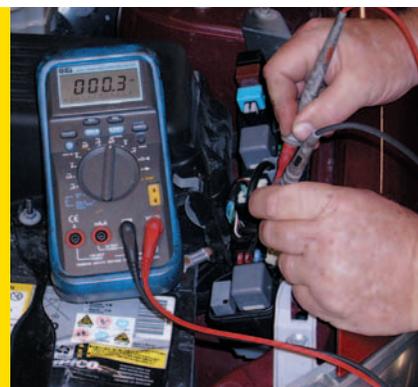
8 HAVE YOU MADE A BAD HIRE?

Evaluate your employee using the head, heart, hands method

34 PERILS OF DIAGNOSIS AND REPAIR

Some people will believe a half-baked diagnosis, and some mistakes are easily made

**ELECTRICAL
LAWS ARE KEY
TO DIAGNOSTIC
SUCCESS**





PREMIUM ENGINEERED CHASSIS

INTRODUCING DORMAN FULL LINE CHASSIS



Now Includes:

- Ball Joints
- Bushings
- Control Arms
- Sway Bar Links
- Tie Rod Ends
- and much more!



Unique application-based engineering.

Quality • Innovation • Value

Validated against OE | Engineered for optimal performance.

Over 40+ Categories in Chassis, Steering and Suspension

OPERATIONS

PROFIT MOTIVE

8 HOW TO KNOW IF YOU'VE MADE A BAD HIRE

Evaluate your employee using the head, heart, hands method
CHRIS "CHUBBY" FREDERICK // Contributing Editor

FINANCIAL FIGURES

10 ARE YOU TRULY READY FOR THE NEW AFTERMARKET?

The independent market opportunities are real, but require work
BOB GREENWOOD // Contributing Editor




12 8 KEYS TO SELLING AUTOMOTIVE SERVICE

Set your team up with this guide to ensure year-round success

BOB COOPER // Contributing Editor


SOCIAL INSIGHTS, WATCH & LEARN, TRAINING EVENTS



TECHNICAL

14 PARALLEL AXIS HYBRID TRANSAXLES

A technical look at what's new and what's not so new in the latest hybrid transaxles from Chrysler, Toyota and Ford

JOHN D. KELLY // Contributing Editor

22 MASTER 12 VOLTS TO MASTER HIGH VOLTS

Before you can become proficient with an advanced topic, you must have a solid foundation of the basics

JEFF MINTER // Contributing Editor

28 THE NEXT GENERATION

With the introduction of the 2018 Prius, the fourth generation of Toyota hybrids is here

JEFF MINTER // Contributing Editor

32 THINKING CAPS ON PLEASE!

Good diagnosticians share many things in common — one is the ability to apply critical thinking skills to the diagnostic dilemmas they face

PETE MEIER // Technical Editor

34 PERILS OF DIAGNOSIS AND REPAIR

Some people will almost always believe a half-baked diagnosis. And some mistakes are very easily made.

RICHARD MCCUISTIAN // Contributing Editor

40 ELECTRICAL LAWS: THE KEY TO DIAGNOSTIC SUCCESS!

Obey these laws, like society's laws, to stay out of trouble

PETE MEIER // Technical Editor



IN EVERY ISSUE



4 INDUSTRY NEWS

MOTOR AGE, ASE NAME THE TECHNICIAN OF THE YEAR

KRISTA MCNAMARA // Content Channel Director

**ADVANCE AUTO PARTS HELPS
IN HURRICANE IRMA RELIEF**

38 AUTOMOTIVE PRODUCT GUIDE

39 MARKETPLACE

39 AD INDEX



SPECIAL SUPPLEMENT

KIA QUALITY CONNECTION

Check out Kia's newest supplement at MotorAge.com/KQCFall17



WEB EXCLUSIVES // MOTORAGE.COM

WHEN DID WE STOP CHANGING SPARK PLUGS?

Gone are the days of the "100,000 Mile" tune up. Actually, gone are the days of changing spark plugs at nearly any regular interval. So what are the change intervals, and what really happens when spark plugs are not changed? Check out this whitepaper from Autolite Spark Plugs' Jay Buckley to understand today's spark plugs.

MOTORAGE.COM/SPARKPLUGS

WHY CONSUMER AND COMMERCIAL FINANCING IS RIGHT FOR A SHOP

Shop owners Brian Bates and Randy Pickering share in the latest podcast from NAPA AutoCare Experts and *Motor Age* to help you decide if customer and commercial financing is right for your shop.

MOTORAGE.COM/FINANCING

MotorAge

MOTORAGE.COM

24950 Country Club Blvd, Suite 200 // North Olmsted, OH 44070

Phone: (440) 243-8100 // Fax: (440) 891-2675

EDITORIAL STAFF

MICHAEL WILLIAMS
GROUP CONTENT DIRECTOR
michael.williams@ubm.com
(440) 891-2604

KRISTA MCNAMARA
CONTENT CHANNEL DIRECTOR
krista.mcnamara@ubm.com
(440) 891-2646

CHELSEA FREY
SENIOR ASSOCIATE EDITOR
chelsea.frey@ubm.com
(440) 891-2645

PETE MEIER ASE
TECHNICAL EDITOR
pete.meier@ubm.com

STEPH BENTZ
ART DIRECTOR

STALIN ANNADURAI
SENIOR DESIGNER

JAMES HWANG
EDITORIAL DIRECTOR, ASE STUDY GUIDES
james.hwang@ubm.com
(714) 513-8473

CONTRIBUTORS

VANESSA ATTWELL
BRIAN CANNING
MARK DEKOSTER
CHRIS FREDERICK
BILL HAAS
DAVE HOBBS
TONY MARTIN
TIM JANELLO
JOHN D. KELLY
DAVE MACHOLZ
RICHARD MCCUJSTIAN
MIKE MILLER
ALBIN MOORE
MARK QUARTO
G. JERRY TRUGLIA

PRINTED IN U.S.A.



Motor Age welcomes unsolicited articles manuscripts, photographs, illustrations and other materials but cannot be held responsible for their safekeeping or return.



MEMBER OF:



BUSINESS STAFF

JIM SAVAS
VICE PRESIDENT/GENERAL MANAGER

TERRI MCMENAMIN
GROUP PUBLISHER
terri.mcmenamini@ubm.com
(610) 397-1667

DAVID PASQUILL
COMMERCIAL FINANCE PARTNER

SOFIA RENTERIA
BUSINESS ANALYST

JILLENE WILLIAMS
SALES COORDINATOR

KAREN LENZEN
SR. PRODUCTION MANAGER
(218) 740-6371

KRISTINA BILDEAUX
CIRCULATION DIRECTOR

TRACY WHITE
CIRCULATION MANAGER
(218) 740-6540

BORIS CHERNIN
MARKETING DIRECTOR
boris.chernin@ubm.com
(310) 857-7632

BALA VISHAL
DIRECTOR OF DIGITAL MARKETING

TSCHANEN BRANDYBERRY
SPECIAL PROJECTS EDITOR

DANIEL MELKONYAN
SEO ANALYST/WEB MASTER

DOMESTIC SALES

MIDWEST & WESTERN STATES

MICHAEL PARRA
michael.parra@ubm.com
(704) 919-1931

ILLINOIS, EASTERN & SOUTHERN STATES

PAUL ROPSKI
paul.ropski@ubm.com
(312) 566-9885
Fax: (312) 566-9884

OHIO, MICHIGAN & CALIFORNIA

LISA MEND
lisa.mend@ubm.com
(773) 866-1514

ACCOUNT EXEC./CLASSIFIED SALES

KEITH HAVEMANN
keith.havemann@ubm.com
(818) 227-4469
Fax: (818) 227-4023

CUSTOMER SERVICE

SUBSCRIPTION CHANGES
(888) 527-7008
(218) 740-6395

PERMISSIONS/INTERNATIONAL LICENSING

MAUREN CANNON
(440) 891-2742

REPRINT SERVICES
877-652-5295 ext. 121

kolb@wrightsmedia.com
Outside US, UK, direct dial:
281-419-5725. Ext. 121

Motor Age (Print ISSN: 1520-9385, Digital ISSN: 1558-2892) is published monthly, by UBM LLC 131 W. 1st Street, Duluth, MN 55802-2065. Periodicals postage paid at Duluth, MN 55806 and additional mailing offices. POSTMASTER: Send address changes to Motor Age, P.O. Box 6019, Duluth, MN 55806-6019. Please address subscription mail to Motor Age, 131 W. 1st Street, Duluth, MN 55802-2065. Canadian G.T.S. number: R-124213133RT001. Publications Mail Agreement Number 40612608. Return Undeliverable Canadian Addresses to: IMEX Global Solutions PO Box 25542 London, ON N6C 8B2 CANADA One-year rates for non-qualified subscriptions: U.S. \$70.00; Canada/Mexico \$106.00; International surface \$106.00. For information please call (866) 529-2922 (Domestic inquiries); (218) 740-6395 (Canadian/Foreign). Printed in the U.S.A.

©2018 UBM. All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical including by photocopy, recording, or information storage and retrieval without permission in writing from the publisher. Authorization to photocopy items for internal/educational or personal use, or the internal/educational or personal use of specific clients is granted by UBM for libraries and other users registered with the Copyright Clearance Center, 222 Rosewood Dr., Danvers, MA 01923, 978-750-8400 fax 978-846-8700 or visit <http://www.copyright.com> online. For uses beyond those listed above, please direct your written request to Permission Dept. fax 440-756-5255 or email: mcannon@adnanstar.com.

UBM provides certain customer contact data (such as customers' names, addresses, phone numbers, and e-mail addresses) to third parties who wish to promote relevant products, services, and other opportunities that may be of interest to you. If you do not want UBM to make your contact information available to third parties for marketing purposes, simply call toll-free 866-529-2922 between the hours of 7:30 a.m. and 5 p.m. CST and a customer service representative will assist you in removing your name from UBM's lists. Outside the U.S., please phone 218-740-6477.

Motor Age does not verify any claims or other information appearing in any of the advertisements contained in the publication, and cannot take responsibility for any losses or other damages incurred by readers in reliance of such content.

While every precaution is taken to ensure the accuracy of the ad index, its correctness cannot be guaranteed, and the publisher waives all responsibility for errors and omissions.

AD DEADLINES: Insertion orders-1st of month preceding issue date. Ad materials-5th of month preceding issue date.

To subscribe, call toll-free 888-527-7008. Outside the U.S. call 218-740-6477.

ORDER ONLINE!
WWW.PARTSOLOGY.COM

ENGINE PARTS

GET IT!
TOMORROW!

- ✓ **Great Quality Parts**
- ✓ **Excellent Pricing**
- ✓ **Warranty on all Parts**
- ✓ **Largest Selection of Engine Parts and Kits**



Featured Part

**TIMING CHAIN
VARIABLE VALVE KIT**

04-14 FORD / LINCOLN / 5.4L V8

[Triton]

~~\$453.18~~

\$228.79

QUESTIONS?

TOLL FREE 1-844-800-6866

HABLAMOS ESPAÑOL



FREE
NEXT DAY DELIVERY

Prices subject to change.





TECHNICIAN AWARD

MOTOR AGE, ASE NAME THE TECHNICIAN OF THE YEAR

KRISTA MCNAMARA //
Content Channel Director

➔ Thirty-four year industry veteran Kevin Dwyer has been named the *Motor Age* Training/ASE Master Automobile + L1 Technician of the Year.

Master Tech Dwyer, of Clarksville, Tenn., was honored for being the top scoring tech for the L1 exam. He has been with the Avis Budget Group for 30 years and deems one of his best professional accomplishments becoming a trainer for his colleagues and peers within the group.

He and 46 other technicians were honored this fall at the annual Board of Governors meeting of the National Institute for Automotive Service Excellence (ASE). The annual award banquet spotlights top scorers of the ASE Certification Tests.

“There’s not a lot of glory that comes with this job. You can take pride in resolving a difficult vehicle problem, but to the customer you’re simply doing what’s expected of you,” Dwyer said. “This has

>> CONTINUES ON PAGE 6

BREAKING NEWS

HURRICANE RELIEF

ADVANCE AUTO PARTS HELPS IN HURRICANE IRMA RELIEF

➔ On a recent visit to southwest Florida, Advance Auto Parts (NYSE:AAP) President and Chief Executive Officer Tom Greco met with team members in Fort Myers, Bonita Springs and Naples who were affected by Hurricane Irma and visited with the company’s field team who led hurricane preparedness, response and relief efforts. Greco visited several of Advance’s 45 stores along the southwest Florida coast and met with local professional customers that rely on Advance to deliver them auto parts.

Advance Auto Parts, Inc., a leading automotive aftermarket parts provider that serves both professional installer and do-it-yourself (DIY) customers, operates 427 stores in Florida and has more than 5,000 team members that work in the state. All full- and part-time Advance

>> CONTINUES ON PAGE 6

TRENDING

DELPHI COMPLETES POWERTRAIN SPINOFF COMPANY

The spinoff sees Delphi Technologies separate from Delphi Automotive, which will become Aptiv, a global technology company that is enabling the future of mobility.

MOTORAGE.COM/APTIV

NEW ROTARY VIDEO COVERS 8 STEPS FOR DAILY LIFT INSPECTIONS

Rotary Lift’s newest “90 Second Know How” instructional video details a checklist of 8 steps techs should take daily to ensure their four-post lifts are operating properly.

MOTORAGE.COM/8STEPS

STANDARD MOTOR PRODUCTS FORMS JOINT VENTURE

Standard Motor Products will invest \$12.5 million with Foshan Guangdong Automotive Air Conditioning Co., Ltd., a China-based manufacturer of A/C compressors.

MOTORAGE.COM/INVEST

REGISTER FOR THE WOMEN IN AUTO CARE CONFERENCE

Registration is now open for the Women In Auto Care 2018 Winter Leadership Conference, Jan. 31-Feb. 1 at the Scottsdale Plaza Resort in Scottsdale, Ariz.

MOTORAGE.COM/WINTER

MITCHELL 1, ASE PRESENT TECH OF THE FUTURE AWARD

Jacob Tully of Alexandria, Ky., was named the 2017 Mitchell 1/Automotive Service Excellence Technician of the Future, a graduate from Universal Technical Institute.

MOTORAGE.COM/TULLY

WILL YOUR SHOP BE FEDERATED SHOP OF THE YEAR?



Federated is now accepting nominations for the
Federated Shop of the Year award.

For more information, contact your Federated Auto Parts supplier.



www.FederatedAutoParts.com

>> CONTINUED FROM PAGE 4

been an exceptional experience, and I'm very grateful to *Motor Age* and ASE for the recognition of my efforts in this profession. It was literally my moment in the spotlight!"

With a trade school education and GM, Ford and Toyota dealership level training, Dwyer has persevered in the automotive industry. "I enjoy the mental and physical challenges involved in auto repair," he said.

His focus on training has been spurred by his own commitment to ASE certification. "There has been a steady demand for technicians, and ASE cer-

tification is highly valued," Dwyer said. "Constant training and practice is simply the job description of an automotive technician. Looking back, the gradual but relentless advance of vehicle complexity over my career is really amazing. A diligent training program is required to keep pace with this progress."

Dwyer hopes more technicians continue to enter the field and offered this piece of advice: "A mentor is essential when you are first starting out. Whether it's a formal program or an informal personal relationship, search for a workplace that is willing to invest the time, money and patience it takes

to support and develop a skilled technician," he said.

Married to wife Dawn, the couple has three children — Matt, 30; Amber, 28 and Julia, 20. Dwyer's professional focus appears to have rubbed off on his offspring. Matt has a PhD in Computational Engineering and is working with NASA; Amber has a Masters in Predictive Analytics and is working for the state of Tennessee; and Julia is in college pursuing a dual major in Computer Science and Biology.

When not working in the shop, Dwyer said he enjoys spending time with his family outdoors, camping, hiking and bike riding. **MZ**

>> CONTINUED FROM PAGE 4

team members were paid for their scheduled hours during and after Hurricane Irma, even if a location was closed due to the storm or flooding.

Thanks to early preparation and tireless response efforts of the Advance team as well as the support of local communities, all but one Advance location in Florida reopened within days of Irma passing to serve DIY and professional customers in the area. An Advance store in Marathon, Fla., sustained significant wind damage and remains closed. Team members displaced from that store were moved to other locations so they could continue working, and Advance added additional delivery routes to ensure professional customers in the market continue to receive the parts they need to keep their businesses running.

"I am extremely proud of the efforts by our Florida team, who have showed what it means to have a passion for caring for our people and our customers," said Greco. "Hurricane Irma significantly impacted many of our team members and their families, some of whom suffered significant damage to their homes or loss of

personal belongings. Our entire company has rallied around these team members as well as our customers throughout Florida. On behalf of all of us at Advance Auto Parts, I want to commend our entire Florida leadership team for standing tall against adversity and being prepared and quick to respond to help our people and our customers in a time of great need. Our company's mission is 'Passion for Customers ... Passion for Yes!' — and these efforts certainly exemplify that mission. We are proud to continue to support recovery efforts for our team, our customers and the communities we serve in Florida."

Greco's visit continues a series of proactive disaster plan and recovery efforts led by Advance, which have raised more than \$450,000 through a Team Member Assistance Fund to support the company's team members in impacted areas. Funds have already been distributed to support more than 50 team members in Florida who were impacted or suffered significant home damage by Hurricane Irma. The Team Member Assistance Fund is a non-profit fund, providing help to Advance team members who experience

hardship due to a natural disaster or other events beyond their control.

Support from Advance for Florida communities is ongoing as Advance works with customers to ensure product availability and the supplies needed to do business are available to the region's automotive industry.

"We go to great lengths to take care of our team members and customers in times of need. Preparing for and responding to an event like Hurricane Irma is just one example of how Advance is prepared to do what is necessary to serve its customers and make sure our team members get back on their feet," said Ayres.

Advance locations in Florida were proactively closed on a rolling basis to allow team members to evacuate or seek shelter, and the company's field leadership team stayed in contact with every team member in markets impacted by Irma to ensure they were safe. Advance also coordinated deliveries of emergency supplies such as water, generators and gas to impacted markets to ensure professional repair shops and stores could reopen to serve customers as quickly as possible. **MZ**



Expect More. Expect TYC.

OPEN YOUR WINDOW TO THE TYC DIFFERENCE

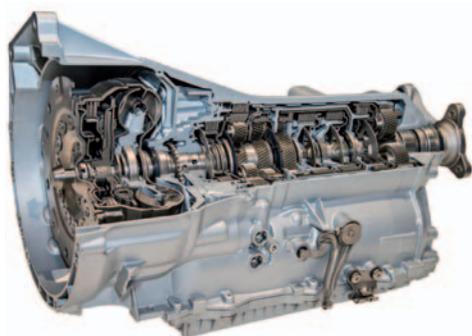
TYC™'s Window Regulators feature anti-pinch safety mechanisms to prevent windows from pinching fingers, arms and necks. The window will auto-stop when met with any obstruction. Our OE-comparable designs provide unsurpassed interchangeability and convenience in repairs.

For more information about TYC™ replacement automotive parts, consult your local TYC™ parts distributor or look up parts online at www.TYCUSA.com



How to know if you've made a bad hire

Evaluate your employee using the head, heart, hands method



**\$100
OFF**

**YOUR FIRST
TRANSMISSION
ORDER**

www.eurotransspecialists.com/100

Top Quality **European** Transmissions & Parts

- Remanufactured by Experts in the Field
- 24 Months/Unlimited Warranty
- Free Shipping within the continental US

JAGUAR

LAND ROVER

AUDI

MASERATI

BMW

PORSCHE

ASTON MARTIN

BENTLEY



310-231-8962

In 2004, Sony released the hit movie *50 First Dates*. Henry meets Lucy in a restaurant and after years of searching, he believes he has finally found the right girl.

But there's one slight problem: Lucy suffers from short-term memory loss, and can't remember anything that happened from the previous day. As a result, every date is like the first date.

Does your experience with your latest hire feel like this? Each day you talk about making exit appointments or review the courtesy check process, but it's like he or she is hearing it for the first time.

Like Henry, you initially felt like you found the right one, but now you feel like every day is their first day.

It's possible that you've made a bad hire. But how can you know for sure? Studies show that a bad hire can cost a shop as much as six times the employee's salary, so the sooner you find out, the better! Let's read how Coach Eric Twigg helps shop owners learn the "head, heart, hands" evaluation method. It can help you answer this question.

Head

Years ago, I worked as a corporate trainer for a national automotive service corporation. One of the classes I facilitated was phone training. At the end of each session, the students had to demonstrate via role play that they knew how to answer the phones and follow the phone outline.

One student named Jeff passed the final exercise with a perfect score. In the following weeks Jeff, my star student,

went back to his location and failed his next three phone shops!

His manager blamed training as the issue, and wanted to send him back through my sessions again. I disagreed, because Jeff demonstrated through the role plays that he knew what to do.

When evaluating whether it's a head issue, the question is, "Does your employee know what to do?" If the employee can demonstrate the task, then the answer is yes. If after repeated training and follow-up, he's still unable to do it, then you may have hired someone who doesn't have the aptitude for the job.

Create random role plays for those tasks that aren't getting executed, even though you keep telling them to do it. In other words: "When it feels like their first day, it's time to role play!"

Heart

Back when I was a store manager, I met with my team to discuss the courtesy check process. I reviewed why it was good for the car, the customer and the company. I also explained how they could make more money.

I felt like the message was clear, until a technician interrupted me with the following question: "What's really in it for me?" To which I replied: "You get the benefit of continuing to work here!"

After that, I never had another issue with his courtesy checks! I had addressed the following heart question: "Does your employee know why he is doing it?" In other words, what is their motivation to perform the task?

People are motivated by either approach or avoidance. Approach means that doing the task will help them to approach something they want.

For example, completing the courtesy check will help your tech to make more money. Someone motivated by avoidance is looking to avoid the consequences of not performing the task. My tech was looking to avoid termination,

which motivated him to execute.

If you've addressed the head issue, the benefits and the consequences and it still feels like their first day, it's possible that the person has a limiting belief that they are unwilling to overcome. This is the most common heart issue, and it's a sure sign that you have made a bad hire.

STUDIES SHOW THAT A BAD HIRE CAN COST A SHOP AS MUCH AS SIX TIMES THE EMPLOYEE'S SALARY, SO THE SOONER YOU FIND OUT, THE BETTER!

Hands

When I was a corporate trainer, several other company executives and I were sent out to a troubled location because a disgruntled employee had filed a grievance with the local labor union.

The union drive, which made national news, was started because of a tire technician who didn't have the right tool to perform flat repairs. He kept telling his manager, but his requests went ignored. He knew what to do (head), why he should do it (heart), but lacked the right tool to do the job (hands).

Here's the hand question: "Does your employee have the necessary tools and resources to do the job?" If you are

coaching your tech on productivity, and you believe he has a hands issue, a question to ask is: "What do you need from me to help improve your productivity?"

If he says, "I need you to get the lift fixed in bay number three," you have a hands issue. If your new "B" tech knows what to do, why he's doing it, has the tools, but still averages five billed hours during a 40-hour week, you made a bad hire!

Ask the right questions

If every day feels like your employee's first day, check the head, heart and hands before deeming it a bad hire. If you follow this formula, it won't take 50 first dates to know the difference between Mr. Right and Mr. Right Now!

Most people love the concept and would like to start with the next interview. The only problem is having the right questions. For a list of questions that test the prospect for 13 different behavioral categories, simply go to www.automationtraining.com/2018-01 for a very limited time. 



CHRIS "CHUBBY" FREDERICK is the CEO and founder of the Automotive Training Institute. ATI's 115 associates train and coach more than 1,400 shop owners every week

across North America to drive profits and dreams home to their families. This month's article was written with the help of Coach Eric Twiggs. chubby@autotraining.net

Stop Losing To The Competition

Our life-changing 1-Day Workshops are coming to venues all over the US and Canada!

- The average attendee picks up 3-8% profit
- We've helped more than 25,000 shops over 35-plus years
- Rated the #1 management consulting firm in the industry by Frost & Sullivan



Spots are limited. Find out when we'll be near you and sign up online at atiworkshops.com

Chris "Chubby" Frederick, CEO



Are you truly ready for the new aftermarket?

The independent market opportunities are real but require work

The new aftermarket is rapidly developing, yet I witness so many shop owners not understanding what is really going on.

Consider the following developments taking place:

- The aftermarket business landscape is undergoing profound changes because of telematics, big data analytics, deep learning AI (artificial intelligence) and fleet service management.

- In the not-too-distant future, we will have autonomous vehicles and a shift from vehicle ownership to transportation as a service. Companies like Uber and Lyft are leading the way, but expect vehicle manufacturers, dealerships and car rental companies to shift their business models towards transportation as a service where autonomous vehicles are used by multiple riders.

- Competition has/is designing an aggressive business model to carve out a large piece of market share.

- Consider a vertical structure developing now over the horizontal structure — manufacturer to distributor to jobber to retailer with quality parts by one company. The competition is looking to own the entire vertical — from the raw materials to make the parts to installing and throwing the box away.

- Big-box stores are now open seven days a week with long open hours in the service bays.

- Targeting fleets such as Uber

and others

- Much higher-than-average tech wages are being offered to attract top young technicians, and then companies are training the heck out of them.

- The OE arena is aggressively going after “service” business using their bays to promote used vehicle sales, as well as offering incentives encouraging used car buyers to return to their bays for service. Used vehicles are enabling dealers to expand their service bay activities to a broader mix of vehicle age groups and nameplates.

IN THE NEAR FUTURE, WE WILL HAVE AUTONOMOUS VEHICLES AND A SHIFT FROM VEHICLE OWNERSHIP TO TRANSPORTATION AS A SERVICE.

- Uber, fleets, cars to go and ride sharing is taking hold — many of the next generation has lost interest in owning a vehicle or even having a driver’s license. The number of 18-year-olds who don’t have a driver’s license is the highest it has ever been. Getting around another way works for them, and this will continue the evolution of the car share model.

- Maintenance is spinning down, so we must consider adjustments to the current model and rev it up.

Solutions to understand

Learn to think like this: Here is what I

do, as it won’t hurt my business to incorporate changes in this direction. A clear focus must be on the operations of the shop.

Here are some specific examples:

- This business model won’t hurt the independent when the shop owner is able to learn how to be an industry analyst to study other industries and see the effect of change and what it does. If this happened in that industry, how would such a change affect my industry? Analyze carefully and fix it.

- We are no longer paid for what we do; we are paid for what we know. We are now in a knowledge-based business, and we must have a continuous learning culture within the business itself. Consider that the consumer is looking for solutions to their vehicle issues. You provide that because you have the right ongoing training throughout the shop at every level that provides and maintains the depth of knowledge required in order to successfully educate the client, counsel them and effectively resolve their issues.

- Change only two things at a time in your business but complete depth of the change during this time, meaning a full overhaul of the change.

- The business model of the independent must be to own the client’s loyalty and returned business through extreme personalized service. This can be done through managing all service intervals for their vehicle for them based on their mileage, how

they use the vehicle and the clients' expectations with their vehicle. There must also be ongoing clear communication and continuous education of the client based on what is in their best interest. Become the family fleet manager and embrace the independent shop revolution called "Careful Customer Care." To do this, follow these steps:

- Order a Car Care Guide for your customer/client base.
- Stay up to date on telematics.
- Consider loaner vehicles such as hybrids.
- Also, you may have to look at managing fleets that are owned by small companies. Build that relationship and prove to these businesses that you can save them money with proper ongoing maintenance for safety and reliability. Do the math for them.

- Avoid clumsy upselling. Instead, become a dedicated counselor as to what is in the client's best interest for their vehicle maintenance and service.

- When working on all makes and models, a shop may take in everything, but often can't go all the way on repairs — maybe 90 percent, but often not 100 percent. Review the core competencies of your business to help you make better business decisions. Should we specialize in two or three vehicle brands — instead of all makes and models — and be the absolute best when servicing these selected models? Servicing all makes and models will not be a realistic business model when looking seriously and long-term at training, equipment and facility investment required. Small-town operations will have to do their homework and really study this. Perhaps it will be time to change the business model in a small town to a hybrid, meaning more focused on specific services. Thought must go into (1) how to tool up to go deep into one or two brands and (2) what will be the ROI — what is it, keeping updates, software and ongoing training and tools.

- Vehicle technology will change how labor is measured — maintenance labor, diagnostic labor, inspection labor, re-flash labor and calibration labor. Key information as to the mix of each labor category within the shop will be necessary, as specific training will be required to ensure shops have the right skill set. Measuring the effective rate will be critical in order to determine how much labor we should be getting from each labor category in order to justify the staffing level.

- Better job quoting skills will have to be embraced because knowledge of how a job must be done and what kind of labor is involved to complete a job to total client satisfaction must be learned.

- We must be willing to continuously make small, posi-

tive changes to move forward and earn the clients' trust and their business. Building relationships is an advantage of the independent market and is building a business culture of excellence.

- There is \$60 billion of unperformed work out there, and 70 percent of it is hidden in aftermarket shop management systems databases. Mine the data that you have. Remember, it is for vehicle safety and reliability.

- The opportunities for the independent sector are very real and very exciting. The new aftermarket will create well-paid careers and not just jobs. Slow down and study everything in depth. Once understood, you will be excited about this new path because when you are clearly focused, you can and will beat the competition. *ZZ*



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



**AUTOMOTIVE
MANAGEMENT
INSTITUTE**

Management & Administrative

- **Training**
- **Education**
- **Career Paths**
- **Certificates**
- **Professional Designations**
- **Learning Support**

Convenient,
effective, online
courses and
advanced
instructor-led
classes.

*The knowledge
you need for the
business you
want.*

amionline.org



8 keys to selling automotive service

SET YOUR TEAM UP WITH THIS GUIDE TO ENSURE YEAR-ROUND SUCCESS

BOB COOPER // Contributing Editor

Selling automotive service is vital to keeping your automotive repair shop viable. So here are eight tips to ensure your employees are selling successfully.

1. Know your customers' buying habits. You should always request your first-time customers' service records, and ask them about their service histories as well. This can be helpful during any sales process, especially when it comes to selling maintenance. This information not only indicates which maintenance services are due, but will give you valuable insights to your customers' buying habits as well.

2. Have the right tools available. People believe what they see, so get your customers visually involved. Share photos throughout the service process to keep them engaged and to visually build value in the service.

3. Emphasize the benefits. Know the key benefits of every service you offer — in terms your customers will understand. Write down the benefits of each of your most popular maintenance services, and review the list before each sales presentation. When it comes to selling maintenance, the majority of

shop owners and advisors put the focus on parts and labor, and that's a mistake. Your customers will be motivated by the benefits they'll receive, not the parts and labor that go into the job.

4. Be prepared to cost-justify. Be able to quickly explain to your customers, in clear financial terms, why the service is a great investment. If you are not prepared to cost-justify the investment, then you can rest assured that the only number your customers will hear will be the price of the service. This will not only lead to lost sales, but if your customers don't experience a breakdown within the next few months (that is attributed to the declined service recommendation), then they'll look at the service you offered as nothing more than an attempt at an unwarranted upsell. At this point, you've not only lost the sale, but you've lost your credibility as well.

5. Let the customer know you have great news. When you call your customers, make sure you begin your presentation by telling them that you have some really great news. This will not only set the tone for your presentation and put your customers at ease, but it will send a strong message that as a professional, you feel the service you are about to recommend is truly a great value.

6. Use an assumptive close. Instead of asking your customers if they would like you to perform the recommended maintenance services, you should say, "All that I'll need is your go-ahead, and we'll get started on it right

away." Assumptive closes send a strong message that there is no logical reason for your customers to decline the services that were recommended.

7. Schedule the next appointment. There is no better time to schedule the next appointment than at the time of car delivery. Your customers are standing in front of you, they feel comfortable with you, and it's easy for them to say yes. If your customers leave without making an appointment, then they're going to be fair game for all of your competitors. In addition, taking good care of your customers' vehicles is a process, not an event, so it stands to reason that you'll need to see them again to perform the services that will be due at that time, to complete a periodic safety inspection, etc.

8. Never put money ahead of people. Here's one of the best-kept secrets to not only selling maintenance, but to building a great business. Customers are intuitive, and they can quickly tell if a service advisor is interested in their credit card or their well-being. If you sell from your heart, and if you never put money ahead of people, it will show through every single time. Not only will this help you increase your sales, but it will help you generate lifelong customers at the same time. *ZZ*

SUPPORTERS



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



WATCH + LEARN



Diagnosing secondary air injection system faults

MOTORAGE.COM/SecondaryAir



Dialogue and debate: Installing customer parts

MOTORAGE.COM/CustomerParts



How to hire and manage a bookkeeper

MOTORAGE.COM/Bookkeeper



Grow your own millennial technicians

MOTORAGE.COM/MillennialTech

MECHANICAL MOMENT

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

GMC CANYON VEHICLE OWNER FACING AN ISSUE WITH INTERMITTENT BRAKE LOCKUP

VEHICLE: 2005 GMC Canyon, 4WD, L5-3.5L, VIN 6, Automatic Transmission

MILEAGE: 198,003

PROBLEM: This vehicle came in to the shop with the antilock brake warning indicator on. The technician connected a scan tool and pulled the codes listed below. They test drove the vehicle and confirmed that the brakes would intermittently lock up.

- C0221 — Right Front ABS Channel in Release Too Long
- C0040 — Right Front Wheel Speed Sensor Circuit automatic Transmission

DETAILS: With the scan tool, the technician observed that the right front wheel speed sensor PID would drop out and the signal was erratic. After inspecting the right front wheel speed sensor and the hub assembly, he found that the wheel hub was damaged.

CONFIRMED REPAIR: The hub assembly was replaced, the DTCs cleared and the vehicle test driven. No DTCs returned and the brakes operated normally.

This tech tip and others come from ALL-DATA Tech-Assist, a diagnostic hotline of ASE-Certified Master Technicians.

Whatever technicians need – from creating alternative diagnostic strategies to providing step-by-step repair assistance – the Tech-Assist Team can deliver.

Learn more at ALLDATA.com.

TRAINING EVENTS

JANUARY 21

ATI Repair Shop Mastery
Hotel to be determined
Baton Rouge, Louisiana

JANUARY 31-FEBRUARY 1

Women in Auto Care Winter Conference
Scottsdale Plaza Resort
Scottsdale, Arizona

FEBRUARY 14-17

MACS 2018 Training Event and Trade Show
Caribe Royal
Orlando, Florida

MARCH 1-4

2018 VISION Hi-Tech Training & Expo
Overland Park Convention Center
Overland Park, Kansas

MARCH 17

TST 2018 15th Annual Big Event
Westchester Marriott
Tarrytown, New York

MAY 2-6

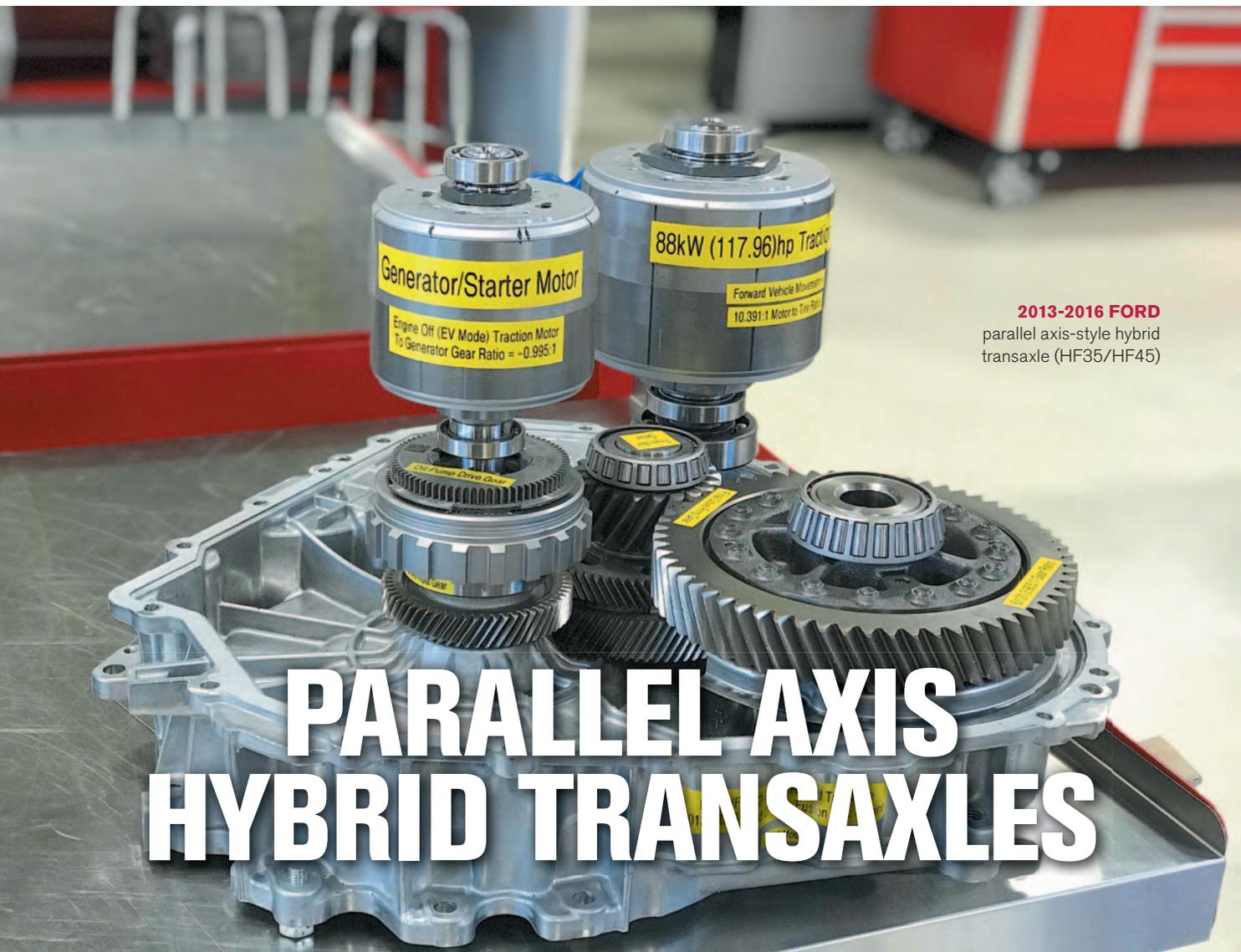
ASA Annual Meeting and Conference
Walt Disney World Swan and Dolphin
Orlando, Florida

JULY 23-26

2018 ASE Instructor Conference
Embassy Suites
Frisco, Texas

AUGUST 8-10

NACE Automechanika 2018
Georgia World Congress Center
Atlanta, Georgia



2013-2016 FORD
parallel axis-style hybrid
transaxle (HF35/HF45)

PARALLEL AXIS HYBRID TRANSAXLES

**A TECHNICAL LOOK AT WHAT'S NEW AND WHAT'S NOT SO NEW
IN THE LATEST HYBRID TRANSAXLES FROM CHRYSLER, TOYOTA AND FORD**

JOHN D. KELLY // Contributing Editor

If you are like most people I know, you have not paid much attention to what has been going on with hybrid vehicle powertrains over the years — why would you? Hybrids have been a very small percentage of overall vehicle sales, especially with gasoline prices being “so low.” The trendy vehicle to have today is a truck or an SUV.

While you may have been ignoring hybrids, there has been a quiet battle going on for the most efficient hybrid/plug-in hybrid powertrain design for the last 20 years. The results of this battle (so far) have surprised me, and I want to share with you what has happened. First, we need to define five boring — but necessary to understand — technical terms:

Parallel Hybrids: Parallel hybrids use an internal combustion engine

(ICE) and electric motor/generator(s) to simultaneously provide power to the wheels through the vehicle’s transmission. In addition to supplementing the power of the engine, the motor/generator can also charge the hybrid battery while the vehicle is in motion. Driving the vehicle with only the motor/generator is also possible. An example is the Honda Integrated Motor Assist (IMA) hybrid system.

Series Hybrids: A series hybrid system uses an electric motor to rotate the wheels through the transmission. The motor can be powered by a hybrid battery and/or an internal combustion engine (ICE)-driven generator. The generator is used to provide an electric power source for the motor and/or charge the HV battery. An example is the Chevrolet Volt Plug-in hybrid.

Series-Parallel Hybrids: A Series-Parallel hybrid system has two electric motor/generators. Electrical power can be generated by the first motor/generator using power from the internal combustion engine (ICE). The generated electrical power is used to charge the hybrid battery and also to provide power to the second motor/generator. The second motor/generator directly drives the wheels through the vehicle's transmission (series operation). The second motor/generator can also receive supplemental motive power from the ICE through the first motor/generator by way of a power-split gear set (parallel operation). Examples are the Toyota, Ford and Chrysler hybrid systems.

Inline Axis: A series parallel hybrid system with two electric motors that share a common axis of rotation. One motor is mounted directly above the other motor. They share a common centerline.

Parallel Axis: A series parallel hybrid system with two electric motors that do not share a common axis of rotation. One motor is mounted to the side (offset) of the other motor. They do not share a common centerline; they each have their own centerline.

Now that we understand the terminology, let's look at the major contenders in the hybrid powertrain battle.

Contender #1: Honda

This may surprise you, but Honda was first to market a hybrid vehicle, the Insight, in the U.S. for the 2000 model year.

The Insight powertrain used an IMA, single electric motor, parallel hybrid system with a 5-speed manual transmission or a belt-driven Continuously Variable Transaxle (CVT). The IMA system used its single electric motor to "assist" the engine's crankshaft in rotating, for regenerative braking, and it also started the engine after an idle stop event. Honda used the slow-selling IMA system for 17 model years in various vehicles ending with the 2016 CR-Z. I drove a Civic hybrid when I was considering buying a new car, but it was too gutless for my taste. In my opinion, the Honda IMA system could never quite compete with the Toyota hybrid system; it was always rated about 10 mpg lower in fuel economy than the Prius.

The IMA hybrids were plagued with high voltage Ni-MH battery problems as well. They had battery self-discharge problems and too short of a battery life. To make things worse, the 12-volt system is charged from the high-voltage system. When the high-voltage (HV) battery dies, there is nothing with which to charge the 12-volt battery, so it dies too, and then the engine can die while driving from lack of voltage. This was a huge safety problem for Honda, so they extended the warranty on the batteries. The used car market is full of Honda IMA vehicles with dead HV batteries. The cost of the HV battery is higher than the value of the car, so avoid them if possible. As if that was not bad enough, Honda also had problems with failed push-belts in their CVT transaxles that could leave the driver stranded.

The good news for Honda is that they started replacing the IMA system in the



2001-2016 TOYOTA inline axis-style hybrid transaxle (P410)

2014 model year with a more efficient two-motor, series-parallel transaxle system called "E-Drive." The new Honda two-motor hybrid transaxle system is totally unique. No other manufacturer uses this design. It uses one electric motor as a generator and one electric motor as a traction motor; the two motors are not connected together. The E-Drive system is only available in the hybrid and plug-in hybrid versions of the Honda Accord.

Contender #2: Toyota

Toyota was second to market a hybrid vehicle, the Prius, in the U.S. for the 2001 model year. The Prius used a twin-electric motor, inline axis, series-parallel hybrid transaxle. This transaxle design has been part of the Toyota Hybrid System (THS), Toyota Hybrid System II (THS-II) and the Toyota Hybrid Synergy Drive



2000-2016 HONDA IMA system stator and rotor

(HSD) for the last 17 model years. This inline axis design uses two motors that share a common centerline or axis, Motor-Generator One MG1 and Motor-Generator Two MG2.

Unlike Honda, Toyota's hybrid transaxles and HV batteries last a long time. I have been involved in replacing three Prius batteries. All of them were more than 10 years old with more than 150,000 miles on them. Of course, the cost of the HV battery is higher than the value of the car, but the Toyota hybrid powertrain can go for many more miles. A Toyota technician told me that a common complaint with Prius owners is that the odometer stops incrementing at 300,000 miles. The only way to fix it is to replace the instrument cluster.

The THS hybrid transaxle design made Toyota the overall fuel economy and efficiency champion for many years, but then other contenders (Ford, Chevrolet, Kia, Hyundai) started to catch up and even challenge Toyota's championship status. Toyota was falling behind in hybrid technology and needed to do something in an attempt to establish dominance again.

To my great surprise, Toyota dropped their inline axis transaxle design and began using a parallel axis transaxle design with the fourth generation Prius for the 2016 model year. This new parallel axis transaxle appears to be a highly refined version of the original 2005 Ford Escape parallel axis hybrid transaxle. The new transaxle, called the P610, is 23 lbs (10.4 kg) lighter and 2 inches (51mm) narrower than the previous transaxle, the P410, that it replaced.

If you have the new 2017 Prius Prime (or Prius Plug-in outside the US), the P610 transaxle can use both electric motors to propel the vehicle at the same time (under certain conditions) in electric vehicle mode. It uses a one-way sprag clutch to prevent the engine crankshaft from spinning back-



2005 FORD ESCAPE hybrid one-way sprag (HD-10)

wards when the MG1 motor is helping the MG2 motor propel the vehicle. The one-way sprag is not a new idea, the 2005 Ford Escape Hybrid used the same method of preventing the engine from spinning backwards, but it is unclear if Ford ever used their generator to help drive the vehicle.

Contender #3: Ford

Ford has used four generations of their two-motor, parallel axis, series-parallel hybrid transaxle system since the 2005 model year Ford Escape hybrid. They keep refining the hybrid transaxle design, and it keeps getting better and better. The first two generations of Ford hybrid transaxles were made by Aisin AW, models HD-10 and HD-20. There was nothing serviceable on these transaxles; you had to replace the entire unit if there was a failure. Luckily, they were very reliable and many are still on the road today being used in taxis.

The third- and fourth-generation transaxles made by Ford are the models HF35 and HF45. You would have to look closely to detect any major physical difference inside these four generations of transaxles (besides gear ratios). They all operate almost identically internally.

Externally the Ford versions look quite different than the Aisin versions because Ford separated the inverter assembly (Ford calls it the Transmission Control Module (TCM)) from the transaxle and Aisin did not. The top side of the Aisin transaxles looks like the



2016-2018 TOYOTA parallel axis style hybrid transaxle (P610/P710)

monster from the *Alien* movies is hiding under your hood.

The third- and fourth-generation transaxles are used in the 2013 and above Fusion and C-Max hybrid and Energi Plug-in Hybrids. The Ford hybrids are great and get fantastic fuel economy and in my opinion, the Fusion is a beautiful car. The Fusion hybrid was selling almost as well as the Toyota Prius for quite a while last year. Personally, I think Ford needs to do something to get better batteries in their plug-in hybrids if they want to compete with the other offerings out there. They cost as much as competitors that have twice the electric vehicle (EV) range.

Contender #4: GM

General Motors has produced a variety of hybrid powertrain designs over the last 14 years, but none of them were very impressive, efficient or cost effective until the Chevrolet Volt appeared for the 2011 model year. I actually traded in my 2010 Prius to get a 2012 Volt! The dealership I bought the Volt from had never had anyone trade in a Prius for any Chevrolet before; they did not know what to do at first.

The Volt powertrain, a series hybrid powertrain design (in most driving conditions), was a game changer for plug-in hybrid vehicles. Its transaxle, the 4ET50, used an inline axis, two-motor system with hydraulic clutch packs to connect or disconnect the motors from the final drive and from each other and even the



TYC®

Expect More. Expect TYC.

DON'T LOSE YOUR COOL

TYC™'s Transmission Oil Coolers and Charge Air Coolers are designed to be application-specific (non-universal) for drop-in fit and include additional hoses (where applicable), adding convenience and value. Select TYC™ replacement external Transmission Oil Coolers and Charge Air Coolers to keep your vehicle, and yourself, COOL.

For more information about TYC™ replacement automotive parts, consult your local TYC™ parts distributor or look up parts online at www.TYCUSA.com



engine crankshaft on rare occasions.

The Volt transaxle is an amazing design, but it is heavy, complex and expensive. The 2017 Chevrolet Malibu Hybrid uses the second-generation Volt transaxle, the 5ET50, which is lighter and more efficient than the previous design. The Malibu hybrid is rated at 49 mpg city! Too bad nobody wants a car anymore. This would be a great pick.

Contender #5: FCA

FCA's 2017 Chrysler Pacifica Plug-in Hybrid Mini Van is new to the battle and Chrysler's first mass-produced hybrid vehicle. Their new two-motor, series-parallel, parallel axis transaxle is called the "Single Input Electronic Variable Transaxle" (Si-EVT). It is new to FCA, but it is hardly a new design. I have to chuckle to myself at times when I am talking to Chrysler trainers and technicians because everything hybrid is new to them, and they act like it is new to everyone.



2005-2012 FORD Aisin AW "Alien Edition" transaxle (HF-10 and HD-20)



2014 CHEVROLET VOLT inline axis transaxle (4ET50)

I had one trainer tell me about the unique design that Chrysler had developed for the Pacifica hybrid transaxle. I told him it was a modified copy of a 2005 Ford Escape transaxle and took him back to my storage room and showed him. Obviously, he was a little surprised to see and learn this. He said, "But the engineers told us they designed it in-house." I chuckled a little more inside. The Pacifica transaxle is old-school brute force hybrid technology with a few refinements. The cool thing about the Pacifica plug-in hybrid is that it is currently the only plug-in minivan on the market in the US. There are a few others outside the US.

The design trend

Are you seeing the hybrid transaxle trend now? Parallel axis hybrid transaxles in a series-parallel hybrid vehicle seem to be the configuration of choice for efficiency, space utilization, weight reduction, simplicity and configurability. Let's look at what is common to all three transaxles from Ford, Toyota and Chrysler.

They all have a large traction motor that has only two functions: 1.) it simply propels the vehicle with or without the assistance of the engine; and 2.) it is used as a generator when decelerating to provide regenerative braking when possible. Toyota calls the large motor "MG2;" Ford calls it the "Motor;" Chrysler calls it "Motor B."

They all have a small motor/generator that has four functions: 1.) it starts the engine; 2.) it acts as a generator to charge the high-voltage battery; 3.) it acts as a generator to provide electrical power to the traction motor; and 4.) it, along with a power-split planetary gear set, is used to vary how much torque the engine can contribute to traction motor to help propel the vehicle as you drive. Toyota calls the large motor "MG1;" Ford calls it the "Generator;" Chrysler calls it "Motor A."



2017-2018 CHRYSLER Pacifica parallel axis style hybrid transaxle (Si-EVT)

Now for some mild humor

China recently announced that they will require 10 percent of all vehicles sold in China (28 million sold last year) by 2019 be plug-in hybrids (PHEV) or Battery Electric Vehicles (BEV). According to what I have read, PHEV and BEV production last year was around 1 million vehicles. About 2.8 million will be needed in China just one year from now.

The required percentage of these vehicles will go up every year until 100 percent is reached. Not many days after China's announcement, almost every vehicle manufacturer in the world announced that they will produce and sell an all-electric or plug-in lineup by 2020-2025 (yes, that is the humorous part). The auto market in China is almost double what the market is here in the US. What does this mean for you? Expect to see a lot more PHEVs and BEVs available in the US in the next few years. I expect to see the powertrain types of most PHEVs and BEVs to converge on one or two really efficient designs. The world's automotive market is changing again; get ready for it by furthering your electrical and hybrid education. **TZ**



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

jkelly1@weber.edu



When the hard part repair just isn't an option...

BlueDevil® OIL STOP LEAK

Part #49499 | 8 Oz. | Made in the USA

BlueDevil Oil Stop Leak seals engine oil leaks permanently. It is non-clogging and will not harm your engine. BlueDevil is safe and easy to use and is compatible in gasoline or diesel engines. It's guaranteed or your money back. BlueDevil Oil Stop Leak is an oil leak sealer that will stop leaks permanently.

- Guaranteed to permanently seal seeping or dripping oil leaks
- Repairs and reconditions rubber seals
- Works in gas or diesel engines



1.888.863.0426

www.gobdp.com





More than parts

Access to over 300,000 Genuine Mercedes-Benz Parts.

A dedicated wholesale team.

Customer-centric delivery options.

Technical resources and repair assistance.

Find a certified PartsPro dealership at mbwholesaleparts.com/PartsPro.



it's a partnership.

 PartsPro



SERIES CONNECTED

NiMh battery modules in a Toyota Prius battery pack

MASTER 12 VOLTS TO MASTER HIGH VOLTS

**BEFORE YOU CAN BECOME PROFICIENT WITH
AN ADVANCED TOPIC, YOU MUST HAVE A SOLID FOUNDATION OF THE BASICS**

JEFF MINTER // Contributing Editor

High-voltage drive systems aren't really new anymore; after all, they've been on the market in the United States since late 1999. Shortly after those first hybrid vehicles entered the market, specialized hybrid vehicle training started being offered to the aftermarket as well. Over the years I've been fortunate enough to attend classes from numerous providers nationwide, and I was even luckier to be able to develop and run training classes on the subject for

technicians, shop owners and educators all over the country. One lesson that all of those experiences taught me was something that I instinctively already knew as an educator, but sometimes forgot as a technician. That lesson was that unless you have a solid understanding of the "basics," all of the advanced training in the world won't help you very much. This article will take a look at some electrical system basics and explain how that information can transfer to high-voltage system understanding and diagnostics. Before you flip the page thinking, "I already know the basics of

electricity," stop and give the subject a chance! While this article will cover some electrical basics, they will all be tied into the high-voltage system operation and diagnosis, and a review of a topic never hurts!

This article will focus on the following electrical basics and will explain how they relate to the high-voltage drive systems:

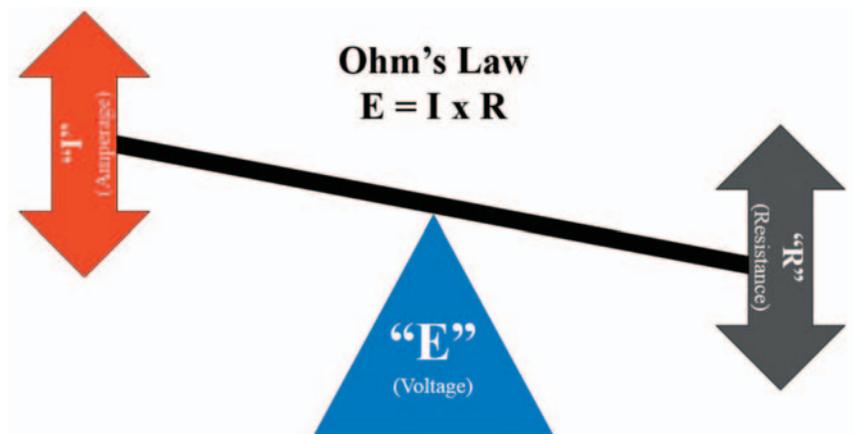
- Ohm's Law – trust me, this is still important!
- Watt's Law
- Series & Parallel Circuit design
- Voltage drop

- Magnetic Induction
- Counter Electromotive Force (CEMF)

Ohm's Law and HV Design

As basic as it may seem, Ohm's Law is the foundation of virtually all electrical diagnosis. No, I'm not implying you'll be running calculations to figure out the missing part of the equation! What I am saying is that without a firm understanding of the relationship between Ohms, amperage and voltage you'll struggle to understand even the most basic electrical circuit. For instance, have you ever heard a technician say they thought a blown fuse was caused by a corroded (bad) connection? An understanding of Ohm's Law would have made the technician realize that with a few minor exceptions that simply isn't a possible reason for the blown fuse.

In high-voltage systems, high resistance may cause symptoms such as limited power output from the hybrid/electric drive system (caused by lower amperage for the motors). In high-voltage systems a "typical" low-resistance failure is very unlikely to result in a blown fuse. This can be a little confusing because Ohm's Law would indicate blown fuses should occur when resistance drops enough. The low resistance does cause an increase in amperage as you'd expect; however, the fuses used in high-voltage systems are typically "slow blow" fuses. The amperage does increase as it did in the 12V example; however, the slow-blow fuse doesn't immediately fail. Instead, the computer system senses the increased amperage and attempts to protect itself from damage. In addition to these self-preservation tactics, the system will set one or more diagnostic trouble codes. So, if you see a high-voltage system trouble code stored that references excessive current flow, you should immediately think "low resistance." With that knowl-



edge, you can start testing the related components, which are most likely to have a low-resistance failure mode, such as motor windings.

Watts – Electrical power

The next logical step after understanding Ohm's Law is to take a look at Watt's Law. While Ohm's Law explains the relationship of Voltage, Amperage and Resistance, Watt's Law explains how voltage and amperage work together to create power. Watt's Law is typically stated as "P = E x I." "P" = power in Watts, "E" still represents voltage (Electromotive Force), and "I" still represents the amperage (Intensity). In a typical 12V system, this law helps explain why a headlight appears dimmer if there is a high-resistance connection. Let's walk through these two to understand the dim light scenario. First, a high-resistance circuit develops due to something like corrosion in a wire or connector. Ohm's Law dictates this increase in circuit resistance will cause a drop in amperage flowing through the circuit. Watt's Law would then indicate that a drop in amperage will reduce the watts output from the bulb. As we all know, a lower wattage bulb will put out less light, hence the dimmer appearance of the bulb.

In high-voltage systems, Watt's Law doesn't change. If you want more power from an electric drive system you only have two options. Option

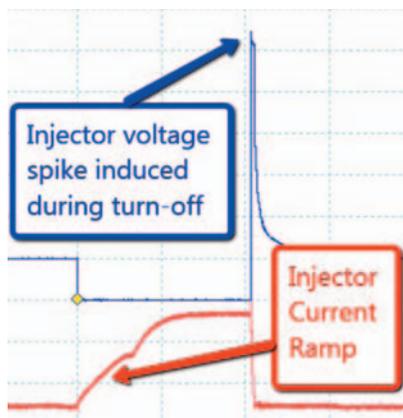
#1 – increase the amperage; option #2 – increase the voltage. Increasing amperage in an electric drive system comes with a pretty high cost in terms of weight and "real estate." Higher amperage needs larger conductors (wires), including those in the motor windings. The extra amount of copper takes more space and increases vehicle weight. That means the seemingly obvious solution to more watts is higher voltage. Unfortunately, if a battery is your electrical source, higher voltage would also require more weight and space. So instead of a larger battery with higher voltage, many systems leverage a boost inverter capable of increasing voltage (and thereby power) under peak loads for limited amounts of time. Think of this as an electrical drive system's version of a supercharger.

Series vs. parallel

Since the Watt's Law examples referenced information related to battery voltage and amperage availability, we should really discuss the difference between series and parallel circuits. For high voltage systems, understanding how each of these circuit types relates to battery configuration is important. In a series circuit there is only a single path for current to flow. Think of this circuit as a one-lane road with no shoulders or passing lanes. Any problems along that road will result in a slowdown of the traf-

fic. In electrical terms, these road problems would be an increase in resistance, which according to Ohm's Law, causes a decrease in current flow (the slowdown of the cars on the road). That means the entire circuit is limited in flow by the "weakest" point in the circuit. In 12V system terms think of this as a starter cable where the entire cable appears in good condition, but has one small section that has become mostly severed. That one small section of cable will prevent the starter from working properly even though the rest of the cable is fine.

In high-voltage systems, the high-voltage batteries are made up of numerous low-voltage modules wired in series. As those modules are connected end to end (+ to -), the voltage of the assembly increases. 12 Volt batteries are actually designed using this same model. A typical 12V lead acid battery is actually made up of six battery cells, each of which has a resting voltage of approximately 2.1V. When all six are wired in series, you end up with the 12.6V lead acid battery that we are used to seeing in automotive starting systems. As we all know from experience, a failure or limitation in any cell within that 12V battery will result in it not operating properly (because of the series configuration). The high-voltage battery is constructed in much the same way, although using different battery chemistries. If the hybrid drive system utilizes a NiMh (Nickel Metal Hydride), each cell will have a nominal rating of 1.2V. In a configuration such as a Toyota Prius there are six cells wired in series within each battery module. This results in 7.2V battery modules, which are also connected in series until the desired battery voltage for the drive system is achieved. The 2010 vintage "standard" Prius model, for instance, connects 28 of those 7.2V modules in series to create a 201.6V battery. Just like in the 12V system, however, the



FUEL INJECTOR WAVEFORMS – current ramp and inductive spike

series configuration means the entire battery pack is only as good as the single weakest cell within the pack. In this case there are 168 individual 1.2V NiMh cells you are depending on.

Parallel circuits are very different from series circuits. Instead of a single path for current to flow like a series circuit has, a parallel circuit has at least two separate current paths. That means if one path fails, the other can still work independently. Let's relate this back to the road analogy I used in the series circuit discussion. A parallel circuit now has multiple lanes running in the same direction. This means you can now get more cars through at a time (lower resistance) and if one lane has an issue the others are still operational. So, while a single point failure will result in a decrease in flow, it won't totally prevent flow like a failure in a series circuit would. In battery terms, a parallel connection works much differently as well. If two 12V batteries are wired in parallel (both + terminals connected together, and both - terminals connected together) like they are in light-duty diesel engine starting systems, the system voltage is still 12V. Wiring batteries in parallel doesn't increase the voltage, but it does increase the available amperage. This means if you connect two high-voltage batteries in parallel, you

can do things like increase the available current to the electric drive system, or more likely, increase the available amp hours for the system (the latter is more likely to be seen in PHEV and EV applications than in traditional hybrids to increase the available range). The Tesla Model S, for instance, uses a combination of series and parallel configurations for the battery pack to build the voltage to the desired level (series connections) and then increase the available amp hours (parallel connections) to increase the range.

Voltage drop

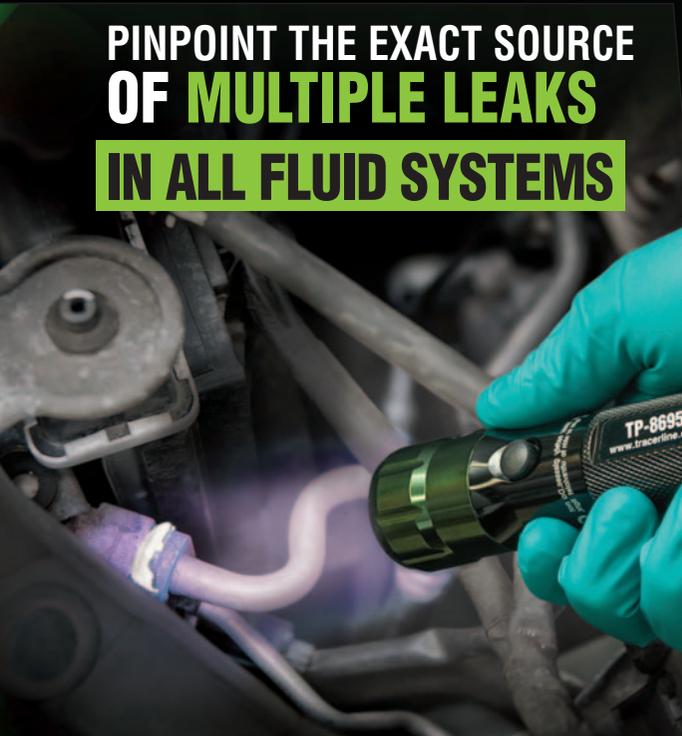
To further explain high-voltage battery issues and monitoring, you need to understand voltage drops. In my opinion, voltage drop testing is one of the most important electrical tests every technician should be proficient in doing. I typically refer to this as where voltage is "used" when current is flowing. In simple terms, a 12V battery has 12 volts of "push" available at one terminal, which must be completely "used" (dropped) by the time it returns to the opposite terminal. If a circuit only has one load (a single bulb in series for instance) then virtually all of that 12V should be used (dropped) by that single load. If voltage is being "used" (or dropped) elsewhere in the circuit, there is less voltage available for the load. Think back to the example of the dim headlight earlier in this article. In that example I mentioned the high-resistance circuit causing a decrease in the circuit amperage. What I left out, however, was the voltage drop associated with that high-resistance circuit. Any time there is additional (undesired) resistance in a circuit, it will cause a drop in the voltage available to be "used" by the intended load of the circuit. That means in the light bulb example, if the high-resistance wire or connector "uses" (drops) 2V, the light bulb can only "use" 10V (instead of the 12V it was designed

TRACERLINE®

COLOR-CODED DYES



PINPOINT THE EXACT SOURCE
OF **MULTIPLE LEAKS**
IN ALL FLUID SYSTEMS



TP-8692 UV MULTI-COLORED FLUID DYE KIT

Includes: TP-8695 cordless, high-intensity UV LED flashlight and 1 oz (30 ml) bottles of each of these dyes:



For Petroleum- or Synthetic-Based Fluid Systems:			For Conventional Coolants:
TP-3320	TP-3340	TP-3380	TP-3900
WHITE	BLUE	YELLOW	GREEN

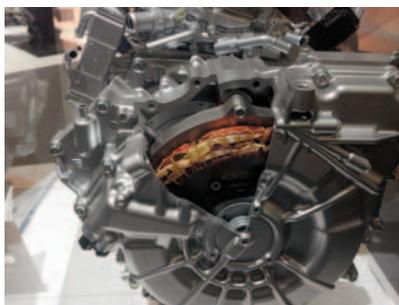


TO LEARN MORE,
SCAN QR CODE OR VISIT:
WWW.TRACERPRODUCTS.COM

to “use”). In terms of high-voltage batteries, any undesired resistance within the pack itself (internal within the cells, bus bar connections, etc.) will cause a voltage drop within the pack whenever current is flowing. Battery packs utilize sensor connections to monitor sections of the pack for these drops. The sections of the packs are typically referred to as voltage blocks (or V-blocks) and any excessive variance within that pack is likely to set a battery pack imbalance code and restrict performance to the capabilities of the weakest section of the pack.

Magnetic induction

So, even if that battery is working correctly, how can you get more power from the battery to the high-voltage drive motor? As mentioned earlier in the article, to increase the available power the preferred option is to increase the voltage. One way manufacturers increase this voltage above what the battery pack supplies is to use a boost inverter. This utilizes the same magnetic induction (self-induction) concept as the primary coil of an ignition coil or the voltage spike seen at turn off when scoping a fuel injector voltage waveform. When current flows through a coil of wire, a magnetic field is created. When that field collapses across the coil, it induces a voltage “spike” into the coil, and the coil becomes a voltage source. In traditional 12V ignition systems, the primary coil spike isn’t utilized (in fact it has to be managed to prevent damage), but it can be seen if using an oscilloscope to monitor the ignition primary voltage triggering. In high-voltage boost inverters, the boost reactor coil is wired in series between the battery and the DC bus circuit in the inverter assembly. To increase the available voltage, current through that reactor coil is increased (higher current draw from the battery pack and/or generator). The increase in current causes an increased magnetic field strength surrounding the reactor coil. When that



EXAMPLE OF MOTOR WINDINGS
(inductor) in high-voltage drive systems

current is decreased again (but not fully shut off), the magnetic field partially collapses across the coil, inducing a voltage “spike.” If the switching is done at a high enough frequency (and filtered through the control circuitry) the output appears as an increased DC bus voltage available for the motor drive. Because the boost reactor needs an increase in current to function, a battery pack that is current limited (increased internal resistance or decreased capacity) will limit the amount of boost available. This could be seen as a decrease in the acceleration performance of the vehicle.

CEMF

Lastly, let’s take a look at the concept of Counter Electromotive Force (CEMF). This simply states that any current flowing through an inductor (a coil wire) will create a voltage within that inductor that “pushes” back against the initial voltage source. The cause of that “push” back is the expansion of the magnetic field building around the coil as current begins to flow. If you do current ramping of 12V system components, such as ignition coils or fuel injectors, you are already familiar with this concept. In fact, it’s the CEMF that causes the current to ramp up instead of climbing quickly. The reason we see a decrease in ramping when a coil or injector shorts is because the shorted coil develops a weaker magnetic field, which in turn results in less CEMF. This same concept holds true with the windings in a high-voltage drive

motor. The main difference in a shorted high-voltage drive motor is that the current flowing through the motor windings (coils) is continually being monitored. If the controller senses the rate of current increase is occurring too quickly, it will still attempt to regulate the drive motor supply but the switching from the motor controller will have to be modified to do so. This results in a more aggressive switching of the current going from the inverter to the electric drive motor because the current isn’t ramping up correctly. Typically that will result in diagnostic trouble codes related to a “short.” The aggressive switching can be seen using an oscilloscope equipped with the right current monitoring clamps to help confirm the diagnostic codes but, if it’s gotten to that point, the electric machine (motor/generator) likely will need to be replaced, and it’s possible the inverter will have suffered damage as well. Analysis of the current waveform may allow you to confirm the ability of the inverter to operate correctly for the time being if a new electric machine is installed; however, the long-term potential damage caused by the aggressive switching will be impossible to know.

This article really just scratches the surface of the connection between basic electrical principles and the high-voltage drive systems. Overall, if you take time to really understand electrical basics you’ll have a much easier time picking up the advanced content as it relates to not only hybrid/electric drive systems but also for drivability-related diagnostics on the base engine system. *TV*



JEFF MINTER is currently serving as the service director for a group of dealerships in the heavy-duty vehicle industry. He is an ASE certified Master/

L1/L3/F1 technician with OEM training from numerous manufacturers.

jeff@advancedvehiclespecialists.com

A Genuine Part of You.



When your customers are behind the wheel,
Kia is more than just the sum of its parts.

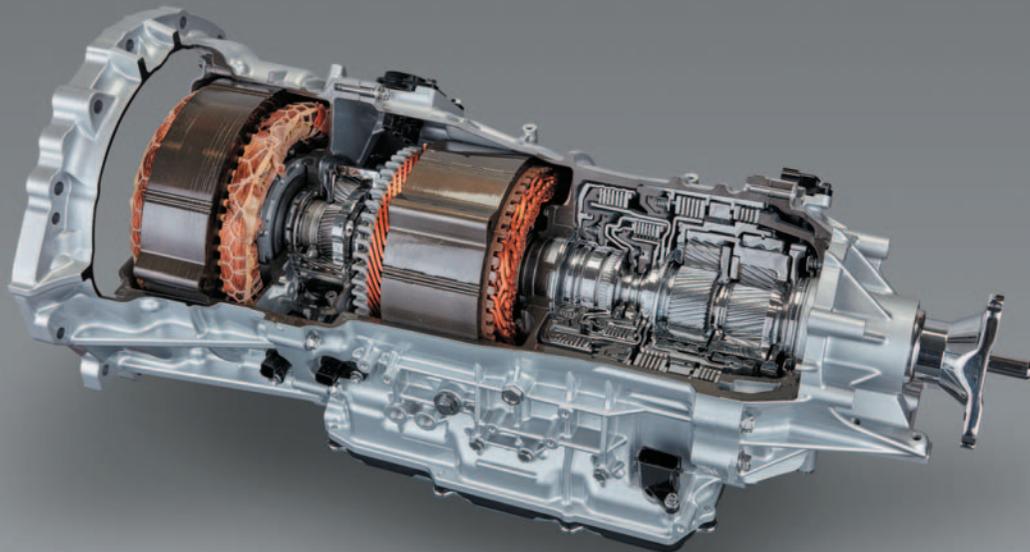
Your customers and Kia are built for each other, and Genuine Kia replacement parts bring the superior quality and fit that they've come to expect. Backed by the Kia warranty,* **Genuine Kia Parts** and **Genuine Kia Remanufactured Parts** give added confidence on the road. Customers work hard, Genuine Kia Parts work even harder."



Genuine Parts

* Kia Genuine replacement parts (except battery) sold by an Authorized Kia Dealer under warranty are covered for the greater of (1) the duration of the New Vehicle Limited Warranty or (2) the first 12 months from the date of installation of the Kia Genuine replacement parts or 12,000 miles. Labor charges not included when not installed by an Authorized Kia Dealer. Warranty is limited. See Kia's Replacement Parts and Accessories Limited Warranty for further details.

THE NEXT GENERATION



WITH THE INTRODUCTION OF THE 2018 PRIUS,
THE FOURTH GENERATION OF TOYOTA HYBRIDS IS HERE

A NEWLY DESIGNED
rear-wheel drive transmission
developed under TNGA.

DAVE MACHOLZ // Contributing Editor

Nearly 20 years ago, Toyota Motor Sales introduced a vehicle that would change the way the world saw hybrids. With more than 3.5 million units sold, the fourth generation of Prius seeks to build on a legacy while ushering in a new generation of Toyota hybrid technology. With a re-engineered design, the new Prius utilizes the Toyota New Global Architecture (TNGA) chassis as well as body, engine and technology improvements. With estimated combined EPA fuel economy numbers of 52 MPG on regular gasoline and retail pricing at under \$30,000, this platform is sure to see continued success. We will look at the fourth generation THS technology and what you will need to know to repair these vehicles in the independent repair market.

1.8L engine

While Toyota has used a 1.8L engine in the Prius in the past, this newly designed 1.8L has been completely reimagined with fuel economy, overall performance and emissions in mind. Every manufacturer seeks to squeeze every bit of thermal ef-

ficiency and light weighting; Prius' 1.8 is exemplary. Toyota claims a 40 percent maximum thermal efficiency achieved through the use of a new large-volume, cooled EGR system that has the ability to operate at maximum engine loads (unlike EGR systems we have been familiar with in years past) as well as advances in combustion chamber and intake design.

Running an internal combustion engine in a hybrid brings with it the challenge of establishing operating temperature quickly. In order to achieve this, exhaust gasses are used to heat the coolant to speed engine warm-up. A motorized shutter-style grille is also used to block the flow of air in cold climates to speed engine warm-up.

P610 transaxle

The transaxle in the Prius has been completely redesigned. While it still uses two motor-generators (MG1 + MG2), the planetary gear set has been refined with the use of parallel gears.

High-voltage battery

The heavy nickel-metal hydride batteries have been replaced with new, more energy-dense units that allow for a smaller bat-



THE NEW PRIUS looks toward the horizon of the next generation of Toyota hybrids.

tery that fits under the seat as opposed to earlier generations that sacrifice precious cargo space. A new lithium-ion battery will replace most of the nickel-metal hydride batteries.

Toyota Safety Sense

Toyota's proprietary safety system includes advance collision avoidance technologies such as a pre-collision system with pedestrian detection, lane departure warning with steering assist, automatic high-beam lighting and dynamic radar cruise control that works at a range of speeds and down to a full stop. The TSS-P system on the 2018 Prius is the first among Toyota's fleet to offer this dynamic set of safety features that will be making their way across the Toyota lineup.

TNGA

Toyota's new global architecture seeks to "change how Toyota cars drive" by



A MILLIOHMMETER is now an essential tool for Toyota hybrid diagnostics.



THE FOURTH GENERATION TOYOTA PRIUS

PHOTOS: TOYOTA MEDIA

creating platforms that are "direct and smooth" and "fun to drive," according to Toyota Media. The global architecture affects all areas of the vehicle and is leading to the production of an array of new powertrain units that began with the introduction of the 2.4L Direct Injection motor on the 2018 Camry. In all, Toyota plans to release 17 versions of nine new engines, 10 versions of four new transmissions and 10 versions of six hybrid systems over the next five model years.

The array of new technologies found on the Prius are immense and some of the new twists on servicing these vehicles are particularly interesting to those who will be repairing them.

Seven-digit DTCs

As technology progresses, so has the need for new diagnostic trouble codes. Beginning with the 2016 Toyota Prius and Highlander, Toyota has transitioned to the new format for DTC structure. Gone are the days of alpha-numeric categorization that we have become accustomed to. New DTCs such as a P0A7F began a transition into this new era of DTC structure. Each DTC now features an additional two-digit identifier that helps further narrow a diagnostic process by providing the technician with more information. While this can be initially confusing, it is further proof of the need for good information and



THE NEW, IMPROVED TOYOTA 1.8L

appropriate tooling.

HV Operation History

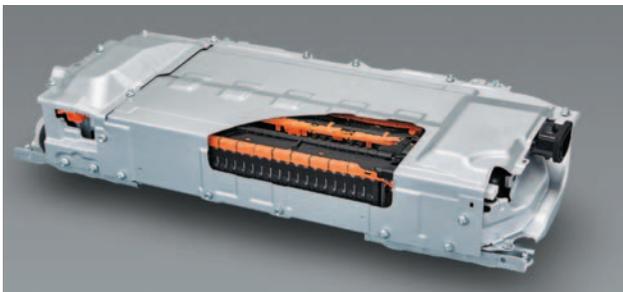
Imagine a scenario in which a customer purchases a vehicle and comes to find out that the shifter has been replaced by an Atari-like joystick. This joystick is an entirely new concept, which is not attached to any type of mechanical function and does not provide a resistance such as felt in the "shifter" on a traditional automatic transmission vehicle. Adding to this confusion is the fact that the joystick shift pattern is non-linear and requires pushing an additional button to park the vehicle. This is exactly how the "shifting" is laid out on the Toyota Prius and many other Toyota hybrid vehicles. To put this into context, imagine an elderly relative or another person who lacks tech savvy purchasing this vehicle. Then

multiply that by millions of customers and you have the reason for the development of HV Operation History.

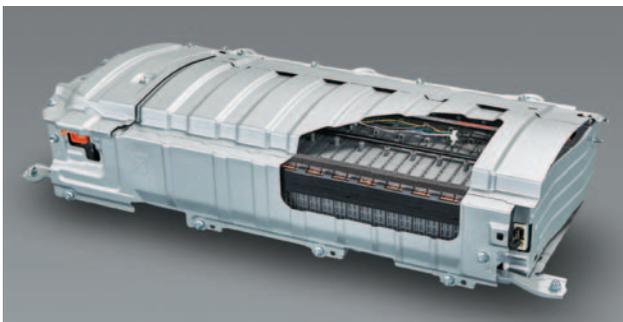
Mr. Customer drives his newly purchased Prius into the dealership and complains that his new joystick-operated HEV is not “shifting” properly and does not respond the way that he anticipated. The service advisor creates a work order and the technician is now spending time to determine what the “problem” is with Mr. Customer’s vehicle. You will recall that in any diagnostic routine the first step is to verify the concern. As you may have guessed, this vehicle is scanned for diagnostic trouble codes with none found and the technician has very little information to go on. There is little to no data available to capture this type of complaint and if there was, it would be difficult to find the answer for the problem within the data. The technician returns the clipboard and work order to the advisor with the letters “NPF” for No Problem Found. This is the result of the technician’s work that could have been anywhere between 10 minutes to two hours. The result of this expedition is a frustrated customer, technician and service department. If only there was a way to determine what the



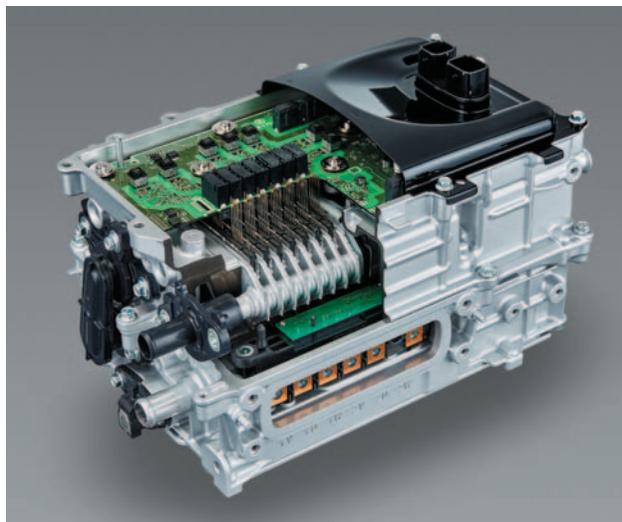
THE LED HEADLAMPS on the new Toyota Prius.



NEWLY DESIGNED Toyota Lithium Ion Battery pack.



NEWLY DESIGNED Nickel-metal hydride battery pack.



TOYOTA'S NEW INVERTER improves on its predecessors.

customer’s problem actually was. Now there is in the form of HV Operation History.

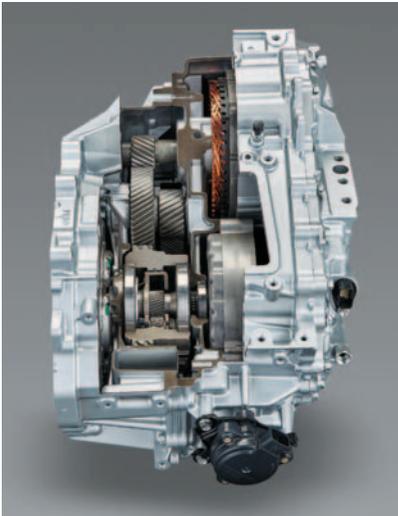
HV Operation History is a data value set that is available within the hybrid control ECU. This data list can be accessed through the Techstream software by visiting the data list and selecting a custom menu of operation history data. Don’t have a Techstream? These types of repairs make it an attractive option (see below). Within the HV Operation History is a variety of PIDs that make it easier to pinpoint unusual behavior of the hybrid system that may not result in a DTC. Keep in mind that as with DTCs and freeze-frame data, HV Operation History will be lost with the clearing of all DTCs, as well as with the interruption of battery power.

The data in the HV Operation menu is a bit difficult to discern, and as such Toyota corporate has created a Quick Training Guide (QTG) that is available with the purchase of a TIS subscription and can be bought on a 2-day basis if a short-term subscription suits your needs better than a full-year subscription. Toyota’s QTG provides valuable insight into a variety of Toyota vehicle diagnostic scenarios. In particular, the QT014A guide provides some great information on dealing with HV operation data. For more information on accessing Toyota service information, keep reading.

A complete understanding of the operation of HV Operation History will help you to get to a conclusion of whether a customer’s complaint was perceived or actual.

New tooling

Megohmmeter – The need for a Megohmmeter continues with the Gen IV vehicles to properly test high resistance components such as the motor-generator windings and related insulated high-voltage cables. Toyota specified a Fluke 1507



THE PRIUS P610 TRANSAXLE features a newly improved, dual shaft electronically controlled transmission assembly.

or 1587, which retail for around \$600. These meters are not the same as your typical DMM/DVOM, as they perform an internal voltage drop measurement by delivering a high voltage through the test leads to determine the overall resistance of high-resistance components.

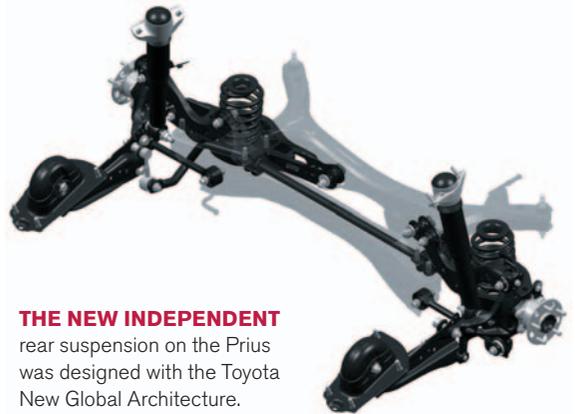
Milliohmmer — While many are still adjusting to the concept of Megohmmeter usage, certain DTCs relating to the motor-generator units will now require testing with a Milliohmmer. The Milliohmmer specified by Toyota is the Hioki RM3548, which retails for about \$1,200.

TIS Subscription — My grandfather ran a busy service station in the '50s and fixed many customer concerns by opening the hood and performing a thorough visual inspection that included a bit of poking and prodding to

locate problems such as bad water pumps, loose belts and other fairly obvious mechanical faults. Today's advanced diagnostics require an additional set of diagnostic skills. By day, yours truly is the Academic Chair of the Automotive Department at Suffolk County Community College and oversees such programs

as the Toyota T-TEN program. One of the entrance requirements to the T-TEN program is that a student must be proficient in reading comprehension. Why you ask? The reason is simple. With the advancements in today's HEVs and related technologies, diagnostic strategies will need to be built on sound information. The technician of today needs to build a diagnostic plan based on the reading, interpretation and metacognitive interpretation of raw information and data.

Data in the form of factory service info is a recommended starting point. A visit to www.techinfo.toyota.com will reveal the ability to access this information on a two-day, monthly or yearly subscription basis. This information includes more than just repair manual information and provides a wealth of background, diagnostic information and training that makes a subscription worthwhile. The next time you have a troublesome Toyota hybrid in your bay, consider what a two-day subscription



THE NEW INDEPENDENT rear suspension on the Prius was designed with the Toyota New Global Architecture.

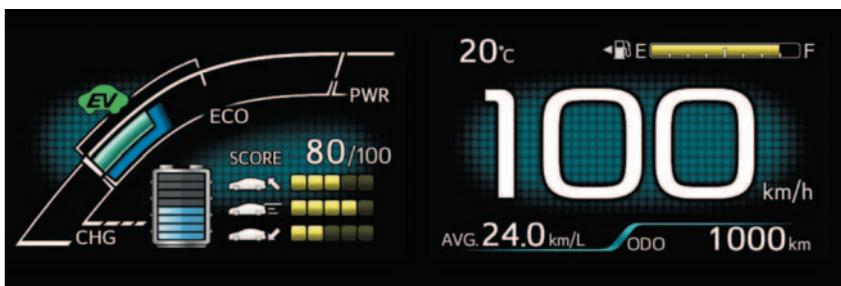
will do in your quest for good information. It's well worth incorporating the cost into your diagnostic fee structure.

Factory tooling

There are some fantastic aftermarket tools on the market, but nothing compares to factory capability. Toyota provides the least expensive platform on the market with a Techstream Lite interface costing less than \$500 and a yearly subscription of about \$1,100. Yes, you read that correctly — full factory functionality for about \$1,500.

Not ready to take the leap into factory diagnostics? There are now scan tool companies such as Autologic and Farsight that offer a support service to have a factory-trained product specialist help you through your diagnostic issues.

As technology trends toward the driverless vehicle, Toyota continues to raise the bar. Prepare yourself for new technologies by reading, attending training events and applying what you know to establish good diagnostic habits. *TLZ*



THE DASH DISPLAY on the new Prius.



DAVE MACHOLZ is an instructor for the Toyota T-TEN, Honda PACT and general automotive programs at Suffolk County Community College in Selden, N.Y.

He is an ASE CMAT and L1 technician and holds a New York State teaching certification in vehicle repair.

liautotraining@gmail.com

THINKING CAPS ON PLEASE!

GOOD DIAGNOSTICIANS SHARE MANY THINGS IN COMMON – ONE IS THE ABILITY TO APPLY CRITICAL THINKING SKILLS TO THE DIAGNOSTIC DILEMMAS THEY FACE.

PETE MEIER // Technical Editor

My wife often comments that I have book sense but not a lick of common sense. I guess she's right, to an extent. I learned a long time ago that feigning ignorance was a sure-fire way of getting out of those "honey-do" items I really didn't want to do.

But maybe she has a point. Maybe that's why I was only an OK — and not a great — diagnostic tech. Don't get me wrong, I won more than I lost, but often it took me a while to nail down the cause of an especially irritating customer concern. To be a great diagnostic technician, you need to constantly add to your knowledge (through quality training from any source) and be able to apply what you know to any given situation. You have to be able to understand how things interact, and how one element of a system can impact another. These are all critical thinking skills and some are born with a greater abundance of these skills than others.

But that doesn't mean you can't improve on what God gave you. Let me share a few tales that helped me improve my critical thinking skills. If I can do it, I know you can!

A Pontiac Grand Am

If you've been reading my work for any length of time, you know how I harp on voltage drop testing. The reason I am so adamant that every technician master this technique is because of the hundreds of concerns I've personally been faced with where this technique came into play. And this Pontiac is one early case where I wished I had known then what I know now!

The customer's complaint was unusual. While driving, the car would simply shut off and fail to restart. It was an intermittent failure that the shop where I worked at the time had tried to address several times before without success. Every time the car came in on a hook, it would start and run just fine. We never were able to duplicate the complaint.

I drew the ticket this time around and got a break. This time the car would not start. More accurately, it was a "crank no-start." The spinning engine seemed healthy enough and a mechanical issue didn't sound right anyway for the concern. I checked for fuel pressure at the rail and was rewarded with a good squirt from the Schrader valve. Last item was spark, and sure enough no spark was present. Was I dealing with a fundamental ignition problem or was there something else? A quick check



with a screwdriver to the ear revealed no injector operation either. On this 3.8 V-6, it had to be something related to the CKP/CMP (Crankshaft Position Sensor/Camshaft Position Sensor) circuit or signal. That was the only thing I could think of right off the bat that would cause no spark or injector pulse.

To do any more testing, I needed my scope. At the time, I had a UEI 2-channel scope (Figure 1) that had no record capability, so whatever was causing the problem, I had to be able to see it when it happened or catch it with the freeze screen button on the tool. I backprobed the signal wires at the ignition module, located under the DIS coil pack, and had another tech crank it over so I could see the signal. The first go round didn't look right at all — very "hashy" as if I didn't have good contact with the terminal pins. On the second attempt, the car unfortunately started and the patterns looked normal.



I tugged and pulled on the wiring leading to the sensors in an attempt to duplicate the problem without success. According to the history, the sensors had been replaced, but even if they hadn't, an intermittent drop out or one that looked "hashy" is not a symptom that usually resulted from a failed component. What was more likely was an issue in the wiring or the ground circuit. In other words, a voltage drop of some kind.

I was able to remove the section of harness leading to the sensors and in doing so, I noticed where they had been misrouted. It was very tight in spots — so much so that the mating connector to the main harness was out of position by at least two inches. Luckily, this harness was easy to remove, and after stripping away the insulation, here is what I found (Figure 2). This is the ground splice from the ICM to the sensors, and there was literally only one strand of wire left to complete this circuit.

Testing this circuit path with an ohmmeter would have resulted in a passing reading. The single strand would measure the same static resistance as the complete multiple strand wire would have and could have caused my diagnostic process to go off in a completely different direction. At the time, I was not familiar with the use of a headlight as a substitute load, but today, I would have used that method to verify my suspicions and then I would have dismantled the harness. I fixed the car, but the process was as much luck as it was skill.

A Nissan Sentra

While working for the same shop, I had the opportunity to improve my luck/skills

ratio on this 2002 Sentra. The young lady who owned the car was complaining of an intermittent stalling on initial start up and the MIL light was on when I got in the car to drive it into my bay.

As soon as I started the car to drive in, I understood the customer's complaint. It started rough, almost like it's flooded, and at least one cylinder out of the four was not home. The MIL was on, but not flashing. It's only about 50 feet to my bay, so I decide to limp it in. In the time it takes to pull in, the miss and rough running are gone and the car is as smooth as silk.

Checking for codes revealed nothing surprising. There was a P0300 (Random Misfire) stored and the related freeze frame data painted a clear picture of a problem occurring when the engine was cold. This lined up with the customer's concern and my observations when I drove the car in. Opening the hood, I took a quick look around the engine compartment and noted that the coolant level in the reservoir was low but not empty. Am I dealing with a head gasket issue?

Pulling out the UEI scope, I did a relative compression test that showed no appreciable loss of compression. My next step was to check for cooling system leaks, looking for the reason the reservoir was low. I pressurized the system and let it sit, but surprisingly no loss of pressure was noted.

Of course, now the engine was slightly warm and getting warmer every time I started it up. I tried a combustion leak detector test (that passed) and looked for signs of the pressure rising with the engine running (also passed). My gut insisted it was a head gasket problem, but so far I was having a tough time proving it!

Here's when I started a diagnostic step I've used ever since. When I think I've reached a roadblock, I take a moment to step back and review what I've



learned to that point. Keep in mind, knowing what isn't causing a problem can be as significant as knowing what may be the cause of a problem. The engine, warm and above, was doing just fine. What about when it was cold?

I left my radiator pressure tester installed on the now fully warmed up engine and let the car sit for the rest of the day (Figure 3). Periodically, I would walk over to check the pressure reading. Slowly, the pressure dropped, and I knew I was on to something! Once the pressure dropped to nothing, I removed all four spark plugs and peered down into the combustion chambers.

Looking back at me in cylinders 2 and 3 were droplets of green coolant! My hypothesis is justified!

My idea was this — when the engine was warm, the head gasket would begin to leak ever so slightly. Running, this was no problem. The small amount of coolant entering the chamber would be burned off with the fuel charge and wasn't enough to cause a drivability issue. But once the engine shut off, the leak would allow coolant to pool on the piston tops, waiting for that restart. Replacing the head gasket cured the complaint. No luck here! Just good old fashioned common sense! 



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

pete.meier@ubm.com

PERILS OF DIAGNOSIS AND REPAIR

SOME PEOPLE WILL ALMOST ALWAYS BELIEVE A HALF-BAKED DIAGNOSIS. AND SOME MISTAKES ARE VERY EASILY MADE.

RICHARD MCCUISTIAN //

Contributing Editor

Years ago we troubleshot a Grand Prix that had run just fine until the owner's cousin had changed the intake manifold gasket and afterwards it was skipping dead on cylinder 2, so she asked if we could have a look at it. This was an engine skip — how hard could it be? First, we checked the obvious stuff (spark plug, compression, etc.) and came up short. But what we did find was that the No. 2 injector didn't sound right with the stethoscope, so we replaced that injector with a known good one — but to no avail. We then checked the entire injector circuit for shorts of any kind and excessive resistance, pin fit at the ECM and the injector, current flow through that circuit with the injector artificially energized (0.8 amps) and ran a temporary circuit overlay. Nothing changed.

When I finally scoped the injector pulse and compared it to the others, the pulse was strangely narrow, so I called a local salvage yard and obtained a replacement ECM. No cigar. Not even close. I replaced that ECM with a second one, because the salvage yard had a bunch of them on hand and they were only \$20 each. I double checked everything. This made no sense at all. Finally, I Scotch-locked that injector's



A 2011 CHEVY HHR, 2.2L Ecotec with 123,598 miles

trigger wire to the adjacent injector's trigger and the car ran great from then on with no more problems. Remember, this was an OBDI system.

I didn't like that temporary fix, but one of the GM engineers who was as stumped as I was told me those early GM ECM injector drivers can each handle 4 amps, and it'd be just fine carrying two 0.8 amp nozzles. Even if it had burned out a driver and I needed to keep digging, I still had two other good ECMs on hand. One way or another, that Grand Prix holds the distinction of being a grueling fueling enigma that still has me wondering to this day.

Burning in bad info

In the world of politics, news media and other sensitive areas, some have

discovered that you can repeat a supposed fact enough so that eventually most of the hearers begin to believe it, regardless of its veracity. Our customers — some of them anyway — can also convince themselves that they know what's wrong when they have little or no useful data except the symptom. Then there are those who have a vehicle concern and somebody they know who seems to have a bit of automotive knowledge makes a superficial jackrabbit diagnosis, hopping quickly across the high points without doing much else. And don't you love those customers who bring you some parts they want installed based on an offhand diagnosis made by somebody who either doesn't know how to do the work or "doesn't have time"?



THIS IS A COMPARISON of the actual scope trace of the narrow pulse (left) and the normal pulse. These patterns were captured with the old Snap-on DDC.



WHEN WE PULLED THE VALVE COVER ON THE HHR, we found several broken roller rockers. Something catastrophic happened here, so we decided to stuff a used engine in it.

Even when we begin to gather data scientifically, we can still misfire on our diagnosis, and anybody who claims they haven't been there isn't being truthful. For just one example among many, I would have sworn in a court of law that the left rear axle bearing was ruined on my aunt's '92 Crown Vic — after all, that's where the noise seemed to be coming from, and it changed for the worse with a swerve to the right. As it turned out, she had a noisy left front tire and for some reason the noise was telegraphing to the left rear.

Back in the early '80s, a guy wanted me to replace his carburetor because two different shops using offhand diagnostics told him they didn't do carburetor work but that it needed replacing. One of them even claimed to have used an ignition scope and was a tune-up shop. It was a small carburetor on an inline six, so first, I bought a \$6 Delco

carb kit before I did anything else. Afterwards, I did a mild throttle snap and found it dropping a cylinder under load. I identified the cylinder, replaced a bad brand-new spark plug and fixed that one.

And then there are quite a lot of people who will play the blown head gasket card without having seen anything other than an overheating issue. I don't know how many times I've heard that, and I experienced it once myself on a 1993 Camry I checked for a friend beside the road. That one had split its radiator, overheated and was puking hot, sweet-smelling geysers out of the filler neck when we refilled it and fired it up. After it came to the shop on the hook, I wanted to show the class how that kind of head gasket failure looks and smells, but all those symptoms were gone — all it needed was a radiator. Go figure.

I have a 1989 Ford Bronco that was donated because the owner believed the head gasket was blown, but it was running crappy and puking coolant out the neck because it was a 5.8L, and he had wired it up using an old 5.0L firing order. When we wired it up with the right firing order, all the filler neck geysers went away.

A few years ago, we checked a 2.4L Dodge Stratus with a horrible oil leak that a shop had pegged as a rear main seal (how many offhand rear main seal diagnoses have we seen?) and used dye to find it coming from under the corner of the head.

Those of us who teach for a living know from experience that people who already believe they have all the facts are kind of difficult to convince otherwise.

Bearing bad news

The owner of a 2011 Chevy HHR, 2.2L Ecotec with 123,598 miles had spent some time and money doing his own offhand diagnosis trying to get it started.



THIS XTERRA WAS RIGHT IN TIME, but we put a new water pump, tensioner, timing belt and front crank seal in. That seal was easy to remove but hard to re-install because the step the seal lip rides on has such a sharp leading edge — so I manufactured a seal protector to get it on there.

He had checked the fuel pressure with a rented gauge, replaced the fuel pump and fiddled around some with a scan tool before realizing that he was in over his head. The HHR had been sitting for a few months when it came in on a trailer. They had determined that it had to be something simple and were hoping we could get it going for just a few bucks. Somebody had postulated that it might have a bad crank sensor, and they brought it to us with the hope that we'd find out it was something simple. Well, it wasn't. This one spun with very uneven

compression, and when we removed the valve cover, we found some broken roller rockers, which typically means valves had contacted pistons, usually the result of timing component failure. But the timing chain was nice and tight, and looking down into the chain area I didn't see any looseness or shattered sliders. Could it have been over-revved enough to float a valve? We didn't do exploratory surgery, but we sold them on the idea of replacing the bad engine with a good used one.

The salvage yard sent an engine for that one with a few minor differences — the fuel rail had a different shape, along with a couple milder changes. When we were done, that one ran like a top and when we fixed an A/C leak and juiced up the icebox, it even had cold air.

The Expedition and the Crown Vic

A very regular customer brought her 2001 Expedition to us with a nasty coolant leak — this one's a Triton and they tend to protect themselves from engine damage, but she just kept driving it. The water pipe that travels through the valley under the intake had rusted through and was dumping water almost as fast as you could pour it in. Initially we just removed the intake manifold, cut the rusted-through portion of that pipe out and replaced it with a hose and some clamps along with a new intake, but when we filled it with coolant, put a new thermostat in it and started warming it up, the warming never stopped — pressure was building very rapidly throughout the system and it was evident that this one had indeed blown a gasket.

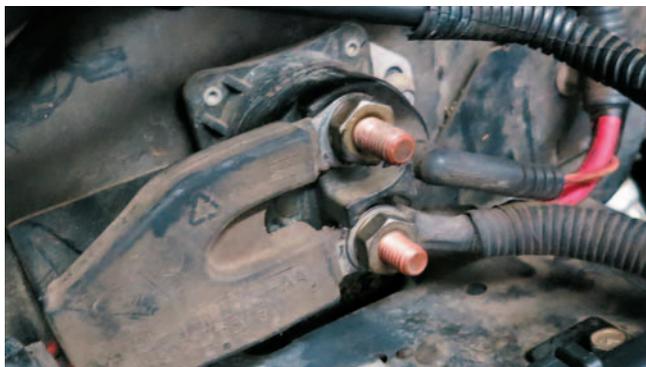
She's a hands-on shopper, so she did her own search for a replacement engine at a price she liked, found one somewhere in Florida, and had it delivered to the shop. It had the heat pucks in some of the expansion plugs and so I knew it came from a reasonably savvy salvage yard. I crossed my fingers, hoping they didn't turn the engine backwards while removing the



THE ACTUAL CAUSE FOR THE CUSTOMER'S CONCERN was deep in the distributor — it'd spark and then it wouldn't and vice versa. We didn't want to take a chance on that kind of "maybe," so this one also got a brand new one.

torque converter bolts! Sometimes that flips one out of time.

Since I had people doing transmissions this time around, we went ahead and jerked the transmission out first, then I had another guy remove the original engine, and we carried it on the hoist over to the area where we do component swaps. One of the first things we noticed was the narrow pulleys on the replacement engine — apparently this one had come from a Crown Victoria or a Town Car, but I couldn't be sure. Oddly enough, a power steering pump came with the replacement engine, so we took that narrow pulley and put it on the Expedition's PS pump. We also replaced the idler and the belt tensioner, because those wide ones wouldn't work on the replacement engine's timing cover — and we weren't about to swap out the timing cover if we could get out of it.



INITIALLY, THE GUY WHO PUT THE ENGINE in the Expedition had put the generator wire on the top post at the solenoid, and that kept the starter energized when the generator was trying to work. The starter was a casualty in this case, but it's an easy mistake for a beginner to make. The right photo shows the naked grooves in the generator pulley — the A/C compressor had the same issue, but we swapped out the power steering pump pulley to have the right one.

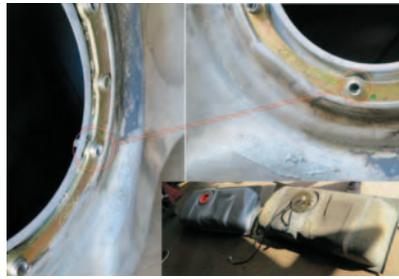
There were some other minor differences, but in the end, that engine was sitting in the frame with a new belt and everything plugged in, and the transmission was reinstalled. Having drained the transmission and replaced the filter, we needed to start it up to get all the fluid back in the gearbox. We started with five quarts and hit the key.

When we started the engine to finish refilling the trans, we noticed that it had a large vacuum leak, and we also heard strange noises and smelled something burning — never a good sign, and it wasn't the oil smoke from exhaust manifold handprints, either. As it turned out, the guy who replaced the engine did everything right except that he made one very easy mistake. He connected the alternator charge wire at the starter relay to the wrong post, which delivered alternator output current to the starter solenoid circuit while the engine was running, and that kept the starter energized, which destroyed the starter. Thankfully, it didn't destroy anything else. But with that heavy rubber sleeve on the wires leaving the solenoid, it was easy to make that mistake if you weren't ultra-familiar with the wiring.

The 2003 Crown Vic ran out of gas while the gauge was reading a half tank. We replaced the sending unit with a new one from Carquest. The guy who did the job used one bolt that was a bit too long when installing the pump and punctured the gas tank. We got a new replacement tank, but after it was filled with gas, the leak was worse than ever. But that leak wasn't around the gasket; it was around the plastic grommet where the wires pass through the mounting plate — I have not seen that before. Anyway, all's well that ends well, and there was no fire. Only a bit of wasted gas.

The Xterra

A 2001 Xterra came to us with the concern that it had quit in a parking lot and



THIS WAS ANOTHER EASY MISTAKE TO MAKE — put a bolt that's just a little too long in one of these and you've ruined a gas tank. We used the bolts and the gasket that came with the new tank, and so this leak really surprised us — even more so when we found out the new pump was faulty.

failed to start, and somebody's offhand diagnosis was that it had jumped time. This is a dicey situation, because that one isn't a free-spinner, but even on interference engines, a timing belt can slip enough to stop the engine without valves kissing pistons. Had that happened on this one? I asked her if she had tried to re-start it (of course she had), but she told me she had only tried once and was hoping there was no damage. We didn't want to do a lot of engine spinning on this one in the bay for fear of possibly making a simple no-start into something worse, so we checked the timing marks first.

On this one you can pull the upper part of the timing cover, slowly turn the engine with a breaker bar (feeling for

interference) until the cam gear marks line up, and then check the crank pulley for zero alignment. Well, when we did that, we found that the Xterra had NOT jumped time. We did decide to do a timing belt and a water pump while we were there, so we bought the kit. When we got the bottom part of the timing cover off, we found that the front crank seal was leaking, which is no surprise on a high miler like this one.

Putting the new crank seal in was something of a demanding process — we tried a few tricks, all of which unseated the garter spring and tried to roll the lip. I kept thinking of transmission seal protectors and how I could fabricate one for this job. Finally, I fetched a soft red plastic hole plug that had been protecting one of the ports on the 2011 HHR's replacement engine and modified the plug with my pocketknife, making a seal protector for the Xterra front crank seal that worked so well I should have patented it.

At the end of that job, we found the real reason for that no-start. The spark coming out of that distributor was a come-and-go event. We got no spark from the towers, and so, with the cap off, we checked it at the coil. On the first spin, there was no spark. On the second spin, spark was popping there, and so we reinstalled the cap and the engine fired up and ran like new.

Unwilling to trust that come-and-go spark, we replaced the distributor with a reman unit. Now she has a new timing belt, crank seal, water pump and distributor. Maybe that Xterra will be good for a while. *ZZ*



RICHARD MCCUISTIAN is an ASE-certified Master Auto Technician and was a professional mechanic for more than 25 years. Richard is now an auto mechanics

instructor at LBW Community College/ MacArthur Campus in Opp, Ala.
rwm19@mail.com

EUROPEAN AUTOMATIC TRANSMISSIONS

Euro Transmissions Specialists offers top quality remanufactured European automatic transmissions. The transmissions are remanufactured by experts in the field. Each transmission has its bad parts as well as all marginal and soft parts replaced. All factory updates are applied. They offer 24 months/unlimited miles warranty and free shipping in the continental U.S. Brands available include Jaguar, Land Rover, Audi, BMW, Porsche, Maserati, Bentley, Aston Martin and more. The company is offering \$100 off first order for a limited time.

WWW.EUROTRANSPECIALISTS.COM/100



HIGH CARBON BRAKE DISCS

Textar, the world's leading manufacturer of OE brake pads, offers a range of German engineered, high-carbon brake discs for European applications. Engineers have developed a brake disc to ensure ultimate braking performance, and the brake discs are available at WORLDPAAC.

WWW.WORLDPAC.COM



PREMIUM BATTERIES

NAPA's AGM premium batteries make sure trucks, cars, snowmobiles and ATVs get maximum starting power, even under the coldest temperatures, every time your customers turn the key. If anyone is unsure whether their battery has what it takes to survive the cold, make sure to test it. And if they need a replacement? Let them know NAPA's premium batteries won't let them down. Because when it comes to weathering the winter weather, your customers can depend on the bold power of NAPA AGM batteries to get them where they need to be.

WWW.NAPAONLINE.COM



GREASE SPONGE

Permatex® and the innovator of Fast Orange® has a brand new product designed to absorb oil spills and clean soiled surfaces. The Fast Orange Grime Magnet® is an advanced, soap-infused sponge that quickly and effortlessly absorbs oil and other petroleum products from vehicle surfaces, garage floors, shop tools, and hands and arms. Constructed from renewable, plant-based foam, the Fast Orange Grime Magnet can absorb 14 times its weight in petroleum products, while repelling water.

WWW.PERMATEX.COM



CAP AND THERMOSTAT CABINET

Stant has introduced a new cabinet program where customers can decide which free Stant products come inside. When purchasing a newly designed Stant cabinet, Stant customers can choose 100 points worth of free radiator, fuel and gas caps as well as thermostats for popular nameplates including GM, Ford, Chrysler and Toyota.

WWW.STANT.COM



REPAIR INFORMATION SOFTWARE

Mitchell 1 has enhanced its ProDemand auto repair information software with the addition of 1Search™ Plus. This new interface streamlines the user experience with an easy-to-use graphical design and intuitive workflow to help auto repair technicians work more efficiently. The interface takes repair information to a new level of intelligence with advanced search technology that scans the database of Mitchell 1 content and returns only the specific information the technician needs.

WWW.MITCHELL1.COM



PAINTED ROTORS

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

SHOP.ADVANCEAUTOPARTS.COM



TIRE INSPECTION TOOL

Bartec announces the Tech200Pro, which is designed to work with your existing Point of Sale system, or Bartec's Service Center System, and as a result, making it easy, fast and accurate to inform customers of their tire's condition. The first tool to combine Tread Depth, TPMS and Digital Pressure measuring, the Tech200Pro captures the right safety information. The Tech200Pro is set up for a specific Make, Model and Year by simply accepting the vehicle lookup from your point of sale.

WWW.BARTECUSA.COM



PARTS

TURBOCHARGERS



REBUILT EXCHANGE

Wholesale Prices
All Makes & Models, Gas & Diesel
Rebuilder Kits Available
Supercharger Repair

A-1 TURBO

310-630-0100 FAX: 310-630-0110
13978 S. Van Ness Ave., Gardena, CA 90249

800-535-8872 www.a1turbo.net

Let Marketplace Advertising
Work For You!

Generate sales leads, maintain market presence, conduct market testing, promote existing lines, introduce new products and services, or recruit the best.

MARKETPLACE OFFER YOU AN EXCELLENT RETURN ON INVESTMENT!

FOR MARKETPLACE OR CAREER OPPORTUNITY AD RATES/PLACEMENT:

Call **Keith Havemann** at
Ph: 310-857-7634
Fax 310-943-1465 or
E-mail: Keith.Havemann@ubm.com

Hit the fast lane of the Automotive Industry

for Web Exclusives and Advertising Opportunities Go to our Websites

www.searchautoparts.com

AD INDEX

ADVERTISER	PAGE #
AUTOMOTIVE MGMT INSTITUTE.....	11
AUTOMOTIVE TRAINING INSTITUTE.....	9
BLUEDEVIL PRODUCTS.....	19
DORMAN PRODUCTS, INC.....	CV2
EURO TRANSMISSION SPECIALISTS, INC.....	8
FEDERATED AUTO PARTS DIST.....	5
KIA MOTORS AMERICA.....	27
MERCEDES-BENZ USA.....	20, 21
NAPA.....	CV TIP
OREILLY AUTO PARTS.....	CV3
PARTSOLOGY.....	3
TRACER PRODUCTS.....	25
TYC GENERA.....	7, 17
WORLDPAK.....	CV4

PRODUCTS

ADVANCE AUTO PARTS.....	38
BARTEC USA.....	38
EURO TRANSMISSION SPECIALISTS, INC.....	38
MITCHELL 1.....	38
NAPA.....	38
PERMATEX.....	38
STANT.....	38
WORLDPAK.....	38

ELECTRICAL LAWS: THE KEY TO DIAGNOSTIC SUCCESS!

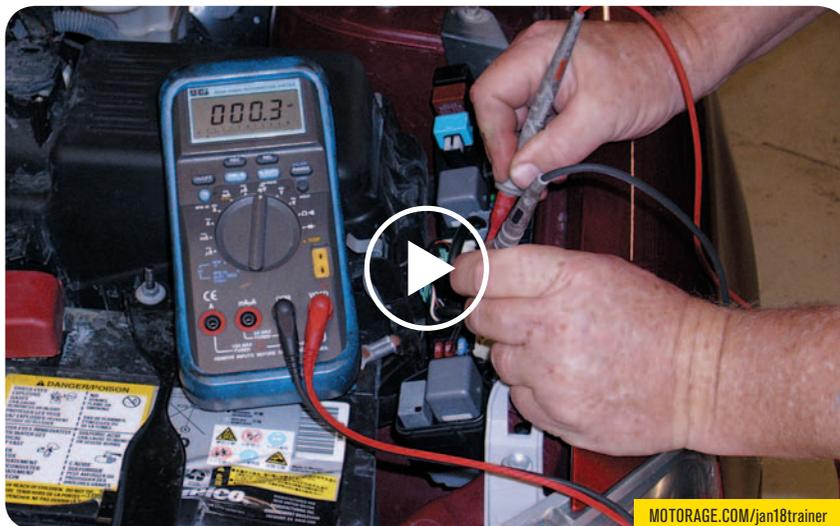
WE OBEY SOCIETY'S LAWS TO STAY OUT OF TROUBLE, RIGHT? IT'S THE SAME REASON YOU NEED TO OBEY THE ELECTRICAL LAWS!

PETE MEIER // Technical Editor

Electrical troubleshooting is, for many of us, a challenge. I think it's similar to a pilot who flies in VFR (Visual Flight Rules) conditions versus one who flies in IFR (Instrument Flight Rules) conditions. The VFR pilot relies on outside references to maintain control of his airplane — how the nose of the plane looks compared to the horizon, how the wing tip angles on either side align relative to the horizon, and the G-forces at play on his body. Sure, the instruments play a role just as they do when we drive a car, providing speed and other important information to further that control.

The IFR pilot, though, is dependent on those instruments and must actively ignore what his eyes and senses may be telling him. Often, there is no outside visual reference at all — nothing but sheer white caused by the enveloping clouds gathered around him. Imagine driving your car without outside visual clues!

Maybe it's the same here. Electrical problems are often hidden from view, if not entirely invisible to our sight. There are no audible clues, either, unless the



THE FIRST STEP IN ELECTRICAL TROUBLESHOOTING SUCCESS is learning to trust your meter and not your assumptions.

harness is on fire! We have to rely on our tools and our knowledge, often actively ignoring what our emotions may be telling us.

The tool part is easy. For the majority of problems we need to locate, our trusty DMM (Digital Multimeter) will do the job. The knowledge, on the other hand, may be lacking. We need to know our fundamentals inside and out, and understand the laws that govern elec-

trical circuits. And, just as the VFR pilot ill prepared for IFR conditions will succumb to vertigo and spiral to the ground, techs failing to master these fundamentals will find themselves flying in circles and wasting valuable time when dealing with electrical faults.

In this edition of The Trainer, we'll teach you how to fly IFR with your DMM and troubleshoot electrical concerns with confidence! **MZ**



MORE FROM THE TRAINER



DMM tips and tricks

MOTORAGE.COM/dec17trainer



The 411 on TPMS

MOTORAGE.COM/nov17trainer



EVAP testing tips

MOTORAGE.COM/oct17trainer



Making sense of VW/Audi PIDs

MOTORAGE.COM/sep17trainer

OFFER THE COMPLETE REPAIR



Over 78 sets for
both domestic and import
application available.

PRECISION & IMPORT DIRECT POWER STEERING HOSES

- All Precision & Import Direct power steering hoses are based on OEM research and OE examples
- Engineered using 3D laser scanning to determine specifications, sizes, angles, and special features of the original hose
- Sets are preassembled and in most cases include bracket bushings, rubber mounts and hose positioning clips where they are found for OE form, fit & function
- Available both individually and in sets which include the complete pressure and return hose assemblies
- Complete OE-fit units that offer entirely new assemblies for ease of installation and long life of the replacement part



MAKING IT FASTER AND EASIER
THAN EVER TO ORDER PARTS

First Call Online is a complete, internet-based electronic catalog designed exclusively for the Professional. Getting up and running with First Call Online is easy. From setup to follow-up, our trained sales force is there to answer any questions you may have. Log on to FirstCallOnline.com for a test drive today!

AVAILABLE EXCLUSIVELY AT



DEDICATED TO THE PROFESSIONAL

FirstCallOnline.com

ADV 1246



OEM PARTS & SOLUTIONS THAT DRIVE YOUR BUSINESS

Our Trusted Community of International Suppliers are Backed by a Minimum 24 Month / 24,000 Mile / 40,000 Kilometer Warranty



WORLD PAC
Wholesale Distributor of Original Equipment Automotive Parts

WIN! Apple Watch
worldpac.com/solutions5

