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OPERATIONS
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ENDEAVOR BUSINESS MEDIA
AUGUST 2020
VOL. 139, NO. 8 // MOTORAGE.COM

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# NISSAN'S VARIABLE COMPRESSION SYSTEM

A look at considerations for service and repair for the first truly variable compression system that changes the stroke of the engine through electromechanical technology


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Talk Shop Anytime

AUGUST 2020
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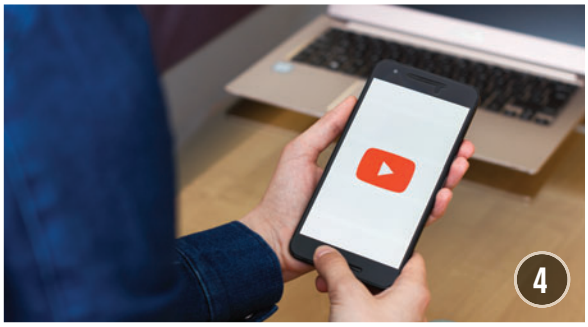
## OPERATIONS






## TECHNICAL

# IN EVERY ISSUE





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### BEING DIGITAL: CREATING A TRANSPARENT REPAIR PROCESS FOR INCREASED SALES AND CLIENT SATISFACTION

Welcome to a new age of consumer engagement, one that requires the service advisor to be an expert at delivering an amazing digital service experience. During our webinar, presented by Advisor Fix's Jeremy O'Neal, you will learn the top 5 things auto repair customers want during the repair process; making the transition to a digital sales process; how to set up an automated communication system with your customer;

the top 3 pitfalls in a digital sales presentation and how to avoid them; increasing technician productivity through digital communication; dealing with sales objections; and how to harvest more organic 5-star reviews.

***MOTORAGE.COM/BEINGDIGITAL***




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SOCIAL MEDIA

# MOTOR AGE YOUTUBE CHANNEL SURPASSES 50,000 SUBSCRIBERS

**MOTOR AGE STAFF //**

*Motor Age* magazine's YouTube channel has hit a new milestone: the channel now has over 50,000 subscribers. Primarily featuring technical and manufacturer content, the channel has evolved and grown over the years to keep service repair professionals of all levels of expertise up to date with accurate information. With video topics such as "A Five Second Test Your Customers Will Thank You For," "Scan Tool Tips For Drivability Concerns," and "How Do You Say 'MAHLE?'" the channel is a one-stop shop to keep subscribers engaged with the latest on vehicle repair, the industry at large, and training.

*Motor Age* first began its YouTube channel almost 10 years ago in September 2010 — not long after current Director of Training, Pete Meier, joined the *Motor Age* team. He notes, "The reason I started the YouTube channel was simple: In order to reach the working men and women of our industry, we needed to be where they are, and I wanted to be

>> CONTINUES ON PAGE 5

BREAKING NEWS

ASSOCIATION NEWS

# RICH WHITE STEPS DOWN FROM AUTO CARE ASSOCIATION

After serving more than 20 years as executive director of the Car Care Council, Rich White stepped down from leading the non-profit organization and its popular "Be Car Care Aware" consumer education campaign.

During his tenure, White led the workgroup that developed the "Be Car Care Aware" campaign and spearheaded the development of the popular Car Care Guide.

Most recently, White established Car Care Council North America, a partnership with Automotive Industries of Canada, a trade association representing the Canadian automotive aftermarket supply and service chain, and ARIDRA, an association in Mexico City representing manufacturers, importers and distributors of automotive parts and accessories.

TRENDING

### NEW ONLINE SERVICE ADVISOR TRAINING

Elite has launched Sales Master University, an ongoing online course that provides service advisors with a consistent flow of sales training. The service is sponsored by Jasper Engines & Transmissions.

*MOTORAGE.COM/MASTERU*

### JOIN SNAP-ON FOR LIVE ONLINE TRAINING

Snap-on Diagnostics National Trainer Jason Gabrenas will offer online training sessions that cover multiple topics including ADAS, component testing and ignition scope testing.

*MOTORAGE.COM/JASON*

### ASE TEST CENTERS, REGISTRATION OPEN

ASE test centers are open and registration for the summer testing window is available through Sept. 30. More than 54 ASE certification tests are offered, and you will have 90 days to schedule.

*MOTORAGE.COM/ASETEST*

### MORE CHALLENGES AHEAD FOR INDUSTRY

In the latest Market Insights with Mike, he reveals that the continued increase is COVID-19 cases is leading to mandates restricting activity, negatively impacting the aftermarket.

*MOTORAGE.COM/INCREASE*

### ASA ASKS FOR CASH FOR CLUNKERS EXCLUSION

The Automotive Service Association is urging members to oppose a Cash for Clunkers program in the next COVID-19 economic stimulus legislation.

*MOTORAGE.COM/OPPOSE*

>> CONTINUED FROM PAGE 4

able to provide technical resources and training that would help them succeed."

Since then, Meier has become the face of *Motor Age*'s YouTube channel and has created multiple series within it such as "The Trainer," which features technical content and has over 100 installments; "The Mighty Minute," which features short, quick videos on vehicle repair; and "Shop Talk Live," in which Meier speaks with other industry professionals about the latest training opportunities.

While *Motor Age* magazine is only distributed in the U.S., with the popularity and accessibility of online video content, its YouTube channel has reached a broader — even global — audience. Meier notes, "Our YouTube growth has helped us meet and interact with technicians and shop owners that would never have met us before, even though we are the oldest automotive trade publication in the nation. It has helped us grow a personal relationship with our readers — many of whom I am proud to call my friends."

Meier is looking forward to the future of the automotive aftermarket and how *Motor Age* and its YouTube channel can help elevate the industry. He adds, "With the addition of Brandon Steckler to the technical team, I hope to be able to spend more time developing video content for *Motor Age* and for our sister publications, covering the entire aftermarket spectrum. Our efforts on YouTube and our other platforms is all aimed at one thing — advancing the automotive service professional. It is imperative that the information we present is current, accurate and keeping with the times."

## NOMINATIONS OPEN FOR AAPEX SERVICE AWARDS

Nominations are now open for three new AAPEX awards to recognize and elevate the essential services that service advisors, shop owners and technicians provide to keep the motoring public on the road, even during times of crisis. AAPEX is scheduled for Tuesday, Nov. 3 through Thursday, Nov. 5, at the Sands Expo and Caesars Forum Conference Center in Las Vegas.

Nominations for the AAPEX Service Advisor of the Year, AAPEX Shop Owner of the Year and AAPEX Technician of the Year awards can be completed at: www.aapexshow.com/serviceawards.

Judging will be conducted by an independent panel of shop owners and industry leaders. The award recipients will be announced at AAPEX 2020.

# Considerations to make before the hiring process

Here are seven questions to ask before looking to bring on someone new

This month, let's listen to veteran Performance Coach Brian Hunnicutt explain how to find great technicians: When I started with ATI over 12 years ago, the No. 1 concern was car count. Now, the No. 1 concern by far is about finding employees. When we talk about this, I wonder if hiring is truly the issue. If you constantly find yourself hiring new techs, shouldn't the focus change to how to keep and develop the employees you have? Don't get me wrong, we need to find them as well, and I'm going to tell you how, but we need to weigh our options. And, if you truly need to hire, be sure that you're putting your best foot forward.

Below are seven questions to ask yourself before starting the hiring process. You can also reference related tips in ATI's Hiring Checklist.

**1. How are you advertising?**

You can easily spend a fortune on Indeed or Zip Recruiter, but there are other less expensive methods like Craigslist. I know what you are thinking when you hear the name Craigslist. A common complaint I hear is: "All I get are the dregs of society." But, before you judge the results of the ad (on any of these sites), ask yourself if you're putting your best foot forward to attract quality candidates. Are you featuring a picture of your smiling, welcoming team standing in front of your attractive shop in the ad? Are you highlighting the key benefits of coming to work for you before putting what you need? If not, then their attention span is already over the rev limiter, and it's less likely they'll get to your benefits offered. Start with all the bells and whistles first to attract the best candidates.

**2. Is your compensation competitive?**

Be aware of what your competition is offering and be prepared to match or exceed it. Before you say you don't have the money for competitive benefits, revisit your labor rate. Ask yourself when the last time was you raised it. One of my clients got outbid on a fantastic tech who would have been a truly great fit for his team. After walking him through his labor rate, we discovered he was underpaying by $20 an hour. His labor rate had not been raised in a very long time. He could have easily afforded the tech.

Having better employees helps us justify the higher rates we have to charge and compete in the job market. It also allows you to keep the employees you hire. Consider offering a competitive sign-on bonus.

**BE AWARE OF WHAT YOUR COMPETITION IS OFFERING AND BE PREPARED TO MATCH OR EXCEED IT. BEFORE YOU SAY YOU DON'T HAVE THE MONEY FOR COMPETITIVE BENEFITS, REVISIT YOUR LABOR RATE.**

**3. Are you thinking outside the box?**

Get creative with the headline and strategy of your advertising to get the candidates you truly want. A headline by one of my clients targeted waiters and waitresses to work in his shop. He realized they were ideal candidates because the job skills were transferable. He knew that if a prospective employee was really good, he could train them as a service advisor. The ad worked really well, and he hired a good entry-level service writer who was affordable, willing to learn and could sell right from the gate.

**4. Have you tried social media?**

Believe it or not, Facebook works extremely well for attracting employees. Write a great ad and then make a great video explaining the opportunities in working with your team and what's in it for them to join. Invite page followers


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to like and share the post. You can even boost the post for about $5 a day, and you'll instantly start getting candidates for interviews. The video can also be put on the career page of your website — which you should have, if you don't.

**5. How's your online reputation?**

Google reviews are very important. Would you want to work for a company that has a bad score on Google or for one with a five-star rating? What is your reputation in your area? What are the people in your town saying about you and your shop and its customer service? The word will get out about your attitude and reputation, be it good or bad. It's best to be on the winning side. Great Google reviews will attract higher quality candidates.

**6. Are you asking others to spread the word?**

Word-of-mouth marketing or referrals are one of the most effective recruiting strategies. You can turn everyone you know into a headhunter. If someone finds you an employee that you keep for over six months, what would you give that person? What does it cost to be without a tech who produces at least 35 hours a week? That's 35 times a labor rate of $120 and equals $4,200 in labor. Take that number and multiply it by 2 to get the parts in there and you have $8,400. So, given the cost of an open position, I would think that paying people for referring good hires would be justified.

**7. Are you focused on engaging the talent you have?**

Of all these options, I've found that keeping and developing your employees is the way to go. If you can keep them engaged and happy to do their jobs, then you'll have a much better chance of staying fully staffed. How many of us grew up during the time of the boss saying, "Just do your job or someone else will?" It was a common catch phrase and seemed to work at the time. Nowadays, it would not work because we're in an employees' market. This means that for the first time in decades, employers don't have the upper hand.

Treating your employees the way they want to be treated, instead of the way you were treated, can be a huge step outside of an employer's comfort zone — and many are struggling to do it. They struggle to find out what makes each employee tick. What are their hesitations, doubts, concerns and fears? Are you treating each one as an individual or only as a team? Don't get me wrong, I want them working together, but do they have the right mindset when doing so? They must be united in the common goal of taking care of customers. They must understand that you're in the people business, not the car business.

## Employee engagement is the best long-term solution

When creating an employee-engaged culture, you have to make it about something bigger than yourself. You have to make it about something bigger than the employee. You must make it about the customer, because that is why we are here. If you bring the focus back to the customer, then no one can really argue about it. We show up to work on time to be there ready, willing and able for the customer. We wear our uniform, so the customer knows that we are all on the same page in taking care of their car. We do the digital courtesy check so the customer knows what is going on with their car and can make an informed decision about it. I hope you get the picture.

A weekly one-on-one meeting with each employee is the best way for them to be heard and for you to connect with them. They are, after all, internal customers. We can find out what it is that motivates them. If you help your employees get what they want and they help you get what you want, how can that be a problem? We must make this a win-win. The biggest tool in a shop owner's toolbox is time and how you use it. Use it to make your internal customers feel like they matter and count. The weekly one-on-one is not an option anymore — it is a must-do.

If you are ready to start building your employee bench after COVID-19, simply go to *www.ationlinetraining.com/2020-08* for a limited time to receive your own copy of ATI's Hiring Checklist.

## KEEPING EMPLOYEES HAPPY

**TIM SRAMCIK //** Contributing Editor

When it comes to dealing with staff turnover issues, small businesses are at a distinct disadvantage compared to large companies. They typically don't possess the finances to keep a full-time human resource (HR) professional on staff. The good news is help is available. Management training, advice from HR experts and input from your colleagues can help you put a plan into action to keep your staff on board.

To continue reading, go to **MotorAge.com/Happy**.

**CHRIS "CHUBBY" FREDERICK** is the CEO and founder of the Automotive Training Institute. ATI's 130 full-time associates train and coach more than 1,700 shop owners every week across North America to drive profits and dreams home to their families. Our 32 full-time Certified Performance coaches have helped our members earn over ONE BILLION DOLLARS in return on their coaching investment since ATI was founded. This month's article was written with the help of ATI Performance Coach Brian Hunnicutt.
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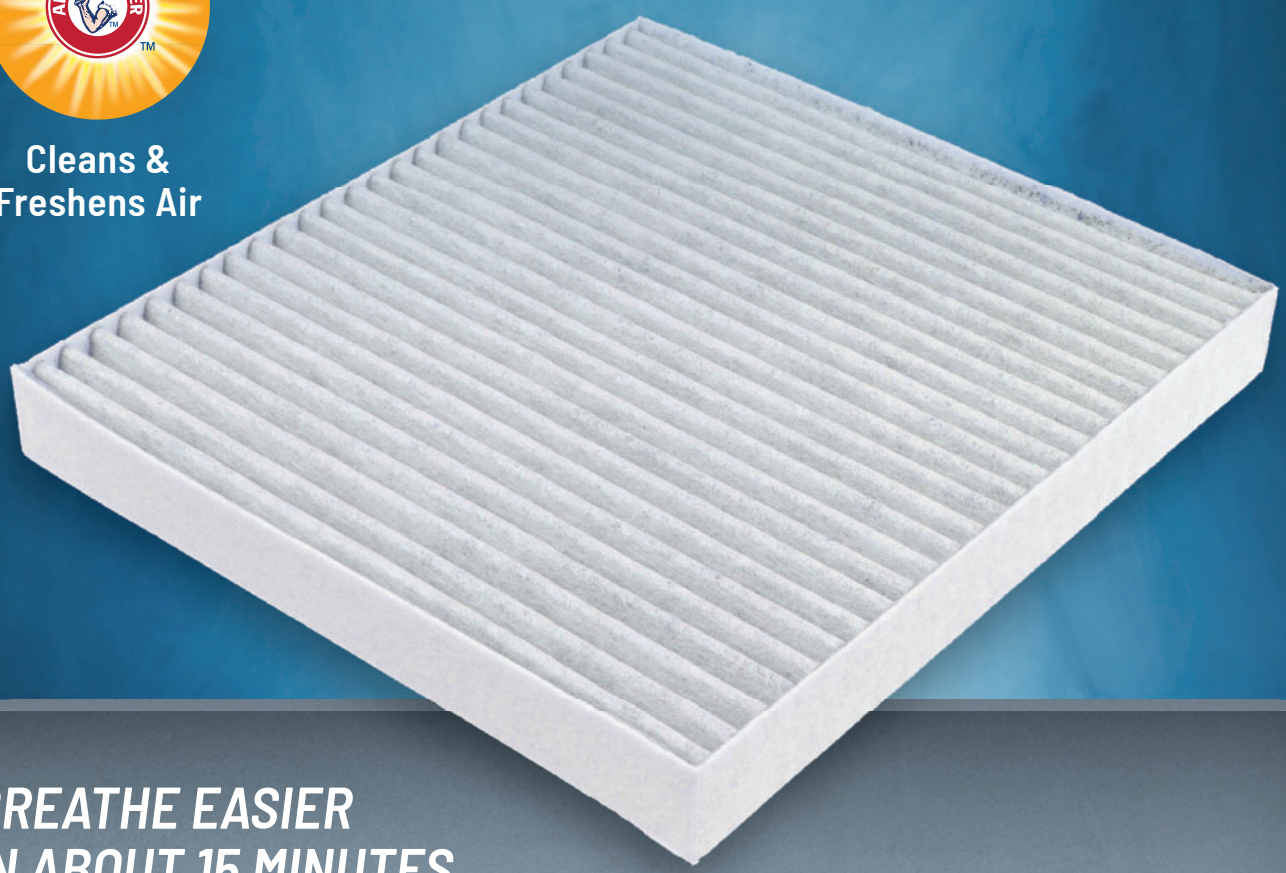

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# GETTING BACK ON TRACK POST-PANDEMIC


Keep your staff educated about what is expected

**TIM ROSS AND NELSON RODENMAYER** // Contributing Editors

There's no doubt that the coronavirus has had a huge impact on the auto repair industry. While auto repair was considered an essential service in many areas, concerns about the pandemic led many consumers to avoid venturing out for anything besides food and prescriptions, leading to a major downturn in business. In response, some shop owners opted to temporarily close up shop, while others tried to operate normally or furlough staff to survive the slowdown. In April, the *San Francisco Chronicle* reported that nearly all of the city's top 50 rated auto repair shops on Yelp had cut hours or laid off staff.

How the industry will rebound post-pandemic is anyone's guess. However, preparing now to meet pent-up demand is crucial. Depending on whether you furloughed employees, you may have to ramp up your staffing levels to accommodate increased business. The next step is to study the guidelines in your local jurisdiction regarding how to operate safely. You'll also need to ask yourself what your customers will need to feel comfortable doing business with your shop. Contactless drop-off and pick-up, touch-free payment, masked staff members and social distancing may continue to be standard operating procedures, particularly in areas that have eased restrictions more slowly. Having hand sanitizer available and maintaining extensive cleaning protocols for vehicles will also help put your customers at ease.

Whatever practices you establish, make sure your staff is educated about what is expected. Mandate frequent hand washing and encourage employees to stay home when feeling sick. Your customers are most likely to return if they feel you and your staff are taking the potential health risks seriously.

## Spreading the word

Once your staff is up to speed, you should feel confident letting customers know you're open for business and fully operational. Even if you stayed open during the shutdown, it's important to inform customers about updated hours or new policies you may have recently implemented. Make sure that information is posted prominently on your website and social media channels and communicated through newsletters or whatever communication tools you use. Posting signage on the exterior of your building to tout services like contact-

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less drop-off and pickup is also worth considering.

While those efforts are designed to reach the masses, it also makes sense to conduct targeted outreach through more strategic campaigns. To start, you'll need to identify your best audiences. Chances are, you'll want to market to your loyal customers first. These are folks who have visited your shop frequently in the past and may have services or maintenance coming due. You may also want to target customers who have spent money with you on higher-priced services. Their past habits increase the odds of them returning to your shop first.

After reaching out to your existing customers, you should cast a wider net, focusing on the best potential customers in a three-mile radius of your shop. How you define the best customers will be up to you. If you specialize in European imports, you might target specific models such as BMWs and Mercedes. Alternatively, you might reach out more generally around your shop to target domestic vehicles of people who have spendable income and might need your service.

## Let's make a deal

The next order of business is to figure out which offers will motivate your customers (and potential customers) to take action. For your loyal customers, researching what offers succeeded in the past and sending offers that address the services their vehicles need will help drive them in and ensure strong redemptions. Existing customers might have declined past services on their last visit, so offering a percentage off those services could encourage them to come back to the shop sooner rather than later.

For the wider pool of consumers, a discounted oil changes is typically a good way to drive traffic. Another option is to connect with your vendors to see what type of discounts they're offering on parts and accessories. Maybe your tire distributor is offering a two-for-one deal that you share with your customers. It's always nice to be able to include a promotion that doesn't cost you anything.

In addition, make sure you have some kind of finance program available. You can make the most enticing offer in the world, but it won't do you any good if your customers can't afford to take advantage of it. And with our current economic decline, chances are you'll see more customers who need repair services but are short on cash. While Top Tier credit programs like Synchrony and Car Care One are great options, many customers will not qualify for these programs. It is important that shop owners offer secondary finance options for customers with lower credit scores or challenging credit histories. This will allow you to close more sales while helping your customers manage their auto repair expenses.

## Get expert advice

In our business, we always advise customers to take a multi-channel approach to their campaigns. If you send out a postcard offer and reinforce those messages with strong paid search efforts, you'll improve your visibility. The next time that customer searches for auto repair they'll see your name and realize they already have a coupon for your shop sitting on their coffee table. Of course, you may not have the ability to market on a variety of platforms, so maintaining a presence on even one channel is better than forgoing advertising altogether.

To maximize your advertising spend, partner with a marketing agency that can identify the mix of media that will deliver the highest return on investment given your budget. Look for a company that specializes in the auto repair industry and has experience producing results for both small shops and national players. You'll also want a company that is well-versed in a variety of platforms and uses data to drive decision-making. If you're falling short, your marketing firm should be able to make adjustments to yield better results.

The partner you choose should be able to provide you with metrics showing how well your campaign is performing. That means tracking not only sales, but possibly car counts, coupon redemptions, return customers and other key indicators to determine if you're meeting your goals.

Finally, don't forget to inform your staff about your marketing campaigns. There's nothing more frustrating than when a customer calls to take advantage of an offer and they encounter an employee who doesn't know what they're talking about. Train your staff to not only be aware of your offers and where they're being placed, but to also actively promote those offers during any customer interaction. A weekly email or a meeting is a good way to keep staff abreast of any new promotions.

Although we are facing challenging times, if you make the right moves now, you'll be well-positioned to increase your share of the market when the economy rebounds.

**TIM ROSS** is co-founder and president of UpSwell, a provider of direct mail services for the automotive service industry. He has been with UpSwell since 2008.

**NELSON RODENMAYER** is SVP of Sales & Marketing for UpSwell. He is a seasoned sales, marketing and public relations executive with over 30 years' experience in a variety of industries.

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# Time to calculate costs — accurately

The way you measure the true cost of running your business needs to evolve

More and more people in our industry recognize that auto repair is not a trade or a craft, but a true profession that requires ethics, protocols, and ongoing training. We must all acknowledge that the "trade" days are over.

A new era has arrived, and with it comes new management benchmarks and measurements. Simple sales data and car count will no longer cut it.

In this new era, the focus has to be productivity, not activity. Once you grasp the distinction, you'll see how critical productivity is to moving your business forward.

We have learned that 60 to 65 percent of the business coming through a service shop today does not create a single dollar of net profit. It simply creates sales and gross profit. People out there still believe that when sales are up, they're doing better. But that's not necessarily the case. In fact, with the increasing complexity of today's vehicles, it is likely that increased activity takes you farther from profitability.

It is mathematically impossible to create net profit on every job. But if you get the "busy work" down to a more reasonable 35 or 40 percent, your net profit will undoubtedly soar.

For most, the question becomes, what should I be measuring?

Many shop operators measure the cost of doing business by dividing their total annual expenses (taken directly from their financial statement) by 365 to provide an average-cost-per-day. Others, however, divide it by the number of days that they're actually open in a year, which gives them an average-cost-per-operating-day. This second method is more accurate and is a good starting point for measuring your business if you've never had one before. Given the challenges of running an automotive maintenance shop, it doesn't really matter how many days or hours you're open. It matters how many hours you bill.

Now, if you were to take your total labor revenue from last year in each labor category (maintenance, diagnostic, reflash, etc.) and divide it by the appropriate labor rate for that category, you'd have the total number of labor-hours-billed for each category. Add the hours up and you have the total number of hours-billed last year.

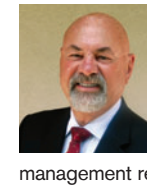
## KEEP IT SIMPLE, BUT KNOW YOUR FACTS, BECAUSE THE MATH DOES NOT LIE.

If you were to take your total expenses for the year (from your accountant's financial statement) and add the non-commodity purchases such as technician wages, freight, and anything else that your accountant put into "cost of goods sold" category, you'd have your total-operating-expenses for the year.

Finally, if you were to divide the total expenses by the total labor hours billed for the year, you'd have your average cost of running the business per billed labor hour. Take your total net from profit last year and divide it by the total billed hours to see what you made in net-profit-per-billed-hour last year.

Once you know these numbers, you can measure each job very quickly and quite accurately. First, calculate the total gross profit made (include total labor revenue) on the RO. Next, take the actual hours billed on that RO and multiply the hours by your average cost per billed hour that you calculated above. Take the total gross profit dollars and subtract the total cost which now gives you a reasonably accurate account of the net profit you will make on that service work. Compare that to your average net profit per billed hour last year. Are you higher or lower than last year's average? Remember, you are in business to create net profit, not just create activity.

It is recommended that you fine tune this each month using your year-to-date numbers, always divided by the number of months to come up with your average so you know the actual average labor hours billed every month as you go through the year. When comparing your numbers to the same month of the previous year, don't look at sales; look at the labor hours billed. If your hours billed goes up this year, then you were actually more productive. Over time, it will lower your cost-per-billed-hour. You cannot say the same thing if you just measured sales. Sales measurement is a measurement of activity only. Increased productivity, however, dramatically leads to increased bottom-line profitability.



**BOB GREENWOOD, AMAM,** is president and CEO of Automotive Aftermarket E-Learning Centre Ltd. (AAEC), which provides business management resources for the automotive aftermarket. Bob has more than 36 years of business management experience and is one of 150 worldwide AMi-approved instructors.
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* Source: Proprietary Consumer Study of Automotive Aftermarket Parts Conducted by The NPD Group, 2019.

# NISSAN'S VARIABLE COMPRESSION SYSTEM

## A LOOK AT CONSIDERATIONS FOR SERVICE AND REPAIR FOR THE FIRST TRULY VARIABLE COMPRESSION SYSTEM THAT CHANGES THE STROKE OF THE ENGINE THROUGH ELECTROMECHANICAL TECHNOLOGY

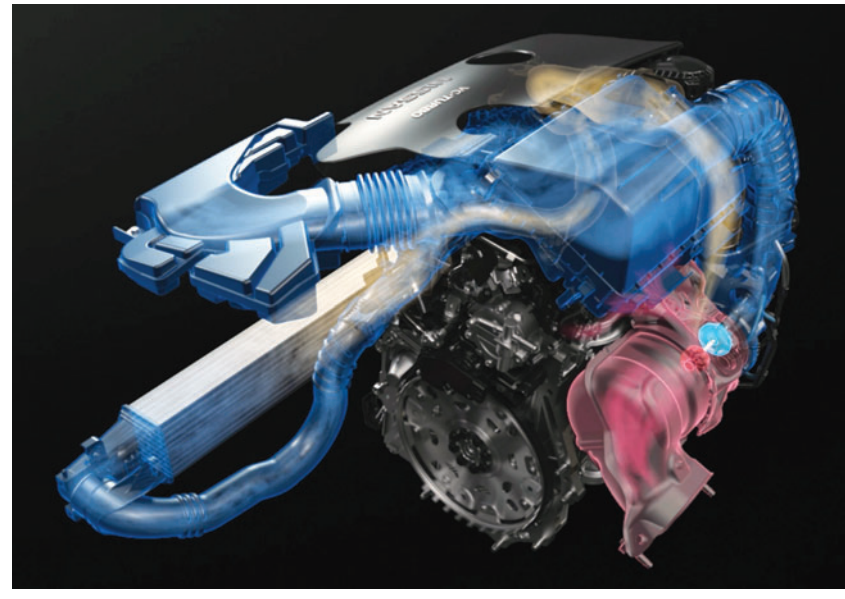
**DAVE MACHOLZ** // Contributing Editor

It's hard to imagine the internal combustion engine is more than 150 years old. What's even more surprising is that most of the advancements in engine technology that we are utilizing on today's engines have been developed in the last 20 years. For the longest time, engines were mechanically interconnected via timing chains or gears with little ability to make adjustments. Fast forward to today and we have engines capable of varying valve timing and simulating varying compression ratios. With the introduction of the 2019 Altima 2.0L, dubbed the VC Turbo, Nissan has taken the variable compression idea a step further by creating an engine that mechanically changes the compression ratio by altering the stroke of the piston. A look at the technology as well as the progression in technology leading up to it will help to put this in context and prepare the technician for seeing this vehicle in their bays.

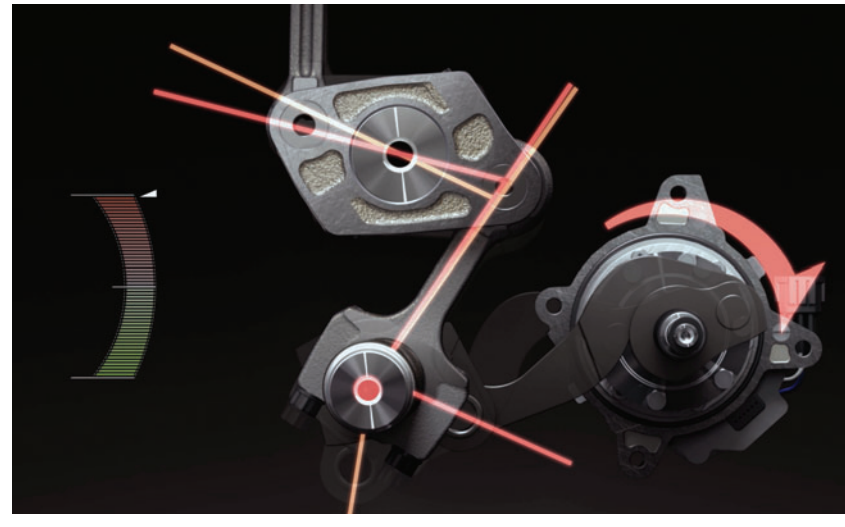
### A stroke of genius

A look at some concepts of engine operation will help you understand the importance of the development of Nissan's technology. While the actual operation of the engine on an engineering level is much more extensive, the definitions you see below are provided to give some context.

**Compression Ratio** – Compression



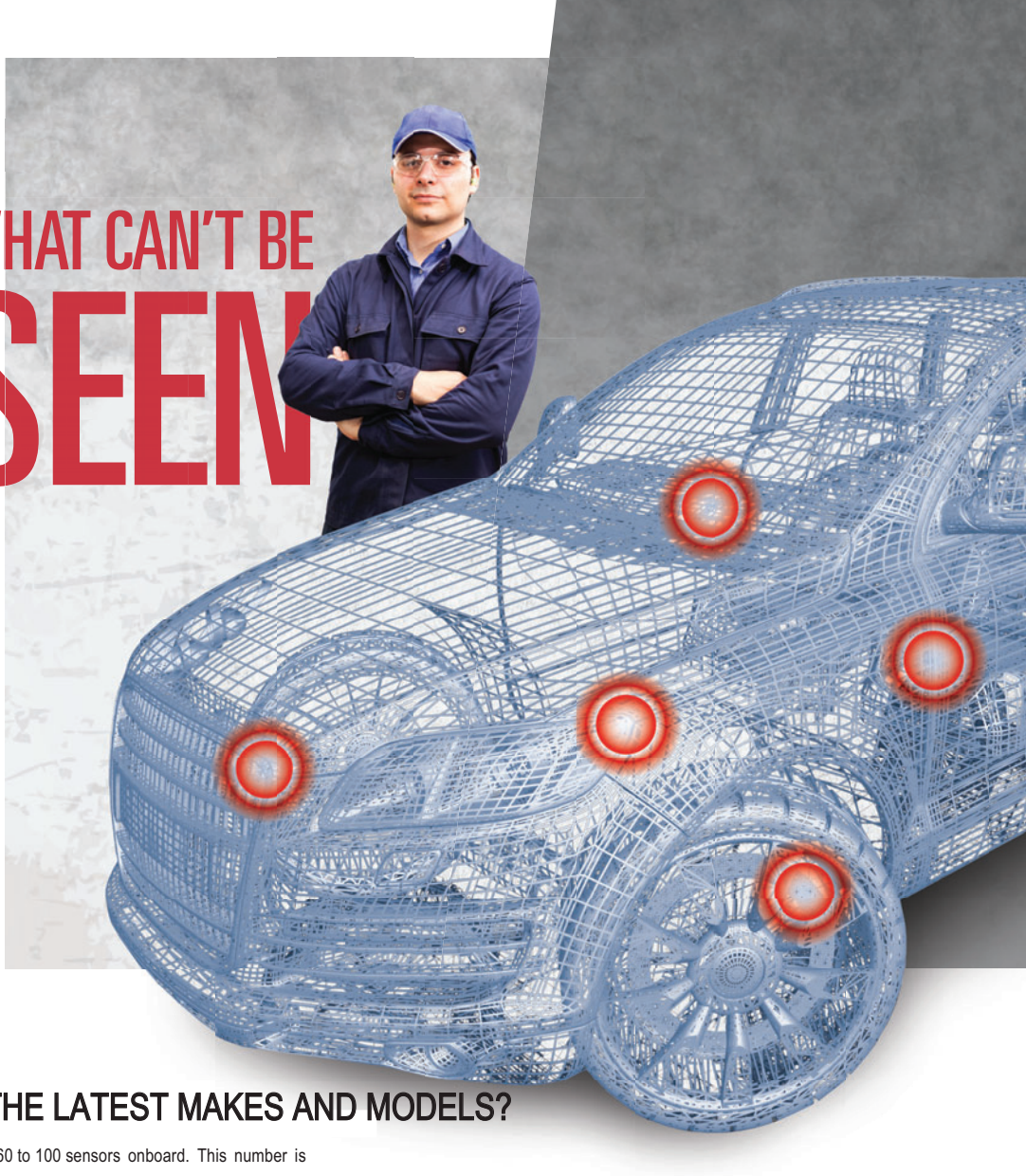
**THE NISSAN VC-TURBO SPORTS** a single-scroll turbo induction system.



**A UNIQUE MOTOR AND ECCENTRIC SYSTEM** allow the engine's compression ratio to be changed by altering the TDC location of the piston.

PHOTOS: NISSAN

# SEE WHAT CAN'T BE SEEN



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ratio can be defined by comparing the volume of the combined cylinder and combustion chamber at Bottom Dead Center (BDC), or lowest point of piston travel, against the volume of the cylinder and combustion chamber at top dead center (TDC), the highest point of piston travel.

This concept of compression ratio has existed since the beginning of internal combustion engine design. In terms of performance, engine builders have long desired high compression ratios, which take a given volume of air and fuel and squeeze it into a high-temperature event that results in a highly excited power stroke. While high compression ratios are quite desirable for performance, they are not ideal or desirable when attempting to force induction. More induction typically means more pressure and temperature. For example, a compression ratio of 12:1 would result in a catastrophic failure should it be enhanced by the boost from a supercharger or turbo on a production engine.

With many manufacturers seeking to downsize their engines for weight reduction, many have begun to adopt turbos to compensate for the loss in displacement. In this case, manufacturers desire to utilize the full ability of high compression ratio while also utilizing forced induction to provide peak volumetric efficiency.

**Otto Cycle** – The Otto cycle, named for German scientist Nicholaus Otto, is the traditional engine cycle that we know as automotive technicians. The four-stroke, five-event cycle that consists of intake, compression, combustion, power and exhaust, has been utilized across internal combustion engines for a long, long time. In this cycle, we typically think of the four strokes, or movements up or down of the piston, to be equal in length. This cycle is flawed in the aspect that some of the movement is essentially a wasted opportunity to create efficiency and power. For example, the engine's displacement and ability to take in air and fuel are dictated by the length of the intake stroke and the physical limitations of the induction system. The same can be said for the compression, power and exhaust stroke. The equality of the strokes is prohibitive.

Now imagine altering the length of the strokes


**THE NISSAN VC-TURBO** is the first of its kind with truly variable compression ratios.

**A VISUAL OF THE SHAFT UTILIZED** to alter the height of piston travel via an electric motor and ECM input.

**A SIDE-BY-SIDE COMPARISON OF TDC HEIGHTS** achievable through the use of the VC-Turbo's unique system.

PHOTOS: NISSAN

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to our advantage. If we could utilize less fuel, less physical loss during compression, and ultimately utilize a long power stroke to fully harness the power generated during combustion, we would have an engine capable of performing much more efficiently. Segue to the Atkinson Cycle.

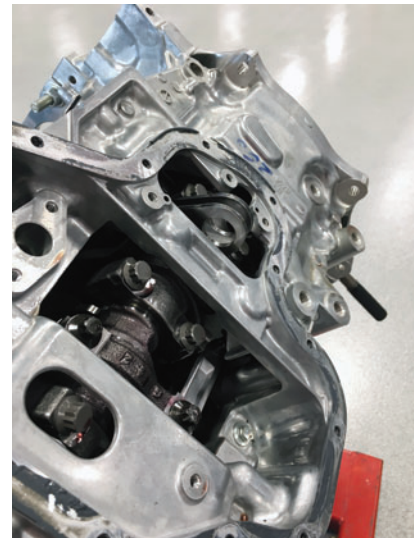
When Toyota first released its Prius, it boasted the ability to gain efficiency through the use of an Atkinson cycle. This raised many eyebrows across the automotive community, as an Atkinson cycle engine typically has four unequal strokes of the piston. The Atkinson cycle can often be found on old farm machinery.

**Atkinson Cycle** – The Atkinson Cycle typically had a mechanism to allow for an adjusted stroke of the piston. This enabled the engine to utilize a short intake stroke, followed by a short compression stroke then resulting in a full-length power and exhaust stroke. In a nutshell: a small amount of air and fuel and work with an output that is proportionally greater. In one word: "efficiency."

So how did Toyota achieve this without altering the stroke of the piston? They utilized the variable valve timing to alter the effective "bottom" of the cylinder. By changing the closing-point of the intake valve, the effective length of the intake stroke is shortened, as is the compression stroke. This results in the effect of the Atkinson cycle without the fancy mechanical gear in the crankcase to change the compression ratio. This system is ultimately limited by the valves' ability to open and close, which is usually dependent on the camshaft and cam phasing technology. These fixed constants do not allow for an infinitely variable compression ratio for a variety of different circumstances, which is where Nissan has picked up the ball with the 2.0L VC-Turbo engine.

PHOTO: NISSAN

**THIS IMAGE PROVIDES A VISUAL** of the movement within the VC system's inner workings.



**AN UNDERSIDE VIEW OF THE VC-TURBO** with actuating motor and oil pan assembly removed.


PHOTOS: DAVE MACHOLZ

**THE VC-TURBO IS A UNIQUE COMBINATION** of variable compression, turbo, direct injection and other technologies.

## Nissan 2.0L VC Turbo

This Nissan 2.0L turbo, named by Nissan the "VC-Turbo", is a limited production engine that made its debut in the 2019 Nissan Altima as a replacement for the long-standing 3.5L V-6, which has reached its end. The VC-Turbo also appears on the INFINITI QX50 crossover. The majority of the Altima line will receive the 2.5-liter cousin of the VC-Turbo, which indicates that the VC-Turbo is being "piloted" rather than fully releasing it on one of the most popular car platforms. The VC-Turbo has been 20 years in development, but the limited release causes one to wonder if Nissan wants to further vet this technology.

Unlike the previously claimed Atkinson cycle engines, Nissan's VC-Turbo is a true variable compression engine and Nissan claims it to be the world's first. According to Nissan, "VC-Turbo changes its compression ratio seamlessly through an advanced multi-link system, continuously raising or lowering the pistons' reach to

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transform compression ratio — offering both power and efficiency on demand. A high compression ratio gives greater efficiency, but in certain applications poses the risk of premature combustion (knocking). A low compression ratio allows for greater power and torque and avoids knocking."

The multi-link system is controlled through the use of a motor mounted below/adjacent to the engine oil pan. The system utilizes typical powertrain inputs as well as inputs from a somewhat-sophisticated variable valve timing and cam sensor setup (that could be a *Motor Age* article in itself). The multi-link motor moves an eccentric-like mechanism that alters the high and low point of travel of the pistons, ultimately, changing the compression ratio. This change in compression is applied to all four cylinders equally. This alteration allows Nissan the ability to utilize high compression ratios for greater efficiency. The downside to higher compression in some cases is the risk of premature combustion known as knocking. In these cases, Nissan utilizes a lower compression ratio for greater power and torque while avoiding knocking. The range of compression ratios on this engine varies between 8:1, an ideal ratio for forced induction, to 14:1, a ratio which was once inconceivable to utilize on a forced-induction engine. The overall variability of the compression ratios in conjunction with variable valve timing and forced induction allows for a great performing engine with excellent fuel economy, low emissions and an increase of 8 horsepower (248@5600RPM) over its 3.5L predecessor while arriving in a lighter 4 cylinder package. Nissan claims that this engine utilizes two engine cycles: Atkinson and a "regular" cycle (see Otto). The Atkinson cycle in this case is achieved through a change in the piston and a change in variable valve timing.

## Service and diagnostic considerations

As in all science, the details are in the data. With this engine being so new, it is difficult to provide concrete detail of case studies and failure analysis. However, there are a few simple observations we can make as technicians that will certainly weigh in to how this engine stands over the test of time. Having had one of these engines apart on a stand allowed for some observations. First, it seems like the eccentric mechanism that controls the travel of the pistons is quite robust. According to Nissan, these components are made from a high-carbon steel alloy. It is highly unlikely that these will be subject to component failure, providing the engine is serviced and oil is replaced at recommended (or better) service intervals. Service and regular oil changes are critical. Second, the motor that controls the multi-link mechanism also looks to be very robust. My thoughts on the system were: "What happens if the motor fails?"

PHOTO: DAVE MACHOLZ

**THIS MOTOR IS RESPONSIBLE FOR THE ACTUATION** of the change in piston TDC height, resulting in variable compression ratios.

As with most other technologies, it seems there is a fail-safe strategy that would allow the engine to operate while setting a DTC and illuminating the MIL. The driver could still operate the vehicle somewhat normally until it can be repaired.

It would be helpful for the technician working on this vehicle to have access to accurate service information and capable scan tools. Factory access for Nissan is available on a subscription basis starting at $19.99 per day. While it is somewhat cumbersome to navigate, it will provide the technician with the most complete package of service information for the Nissan platform.

In summary, the combination of technologies utilized in this engine is impressive and the first of its kind, according to Nissan. While many other manufacturers have claimed to utilize the Atkinson cycle with smoke and mirrors (VVT), Nissan is doing it through changes in the stroke of the piston. How this plays out over time remains to be seen, but hopefully, when you find one of these in your bays you will quickly recognize this engine as unique.

**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*

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# A BREATH OF FRESH AIR

## IMPROVE YOUR CUSTOMERS' WELL-BEING AND SHOP PROFITABILITY THROUGH CABIN AIR FILTER EDUCATION

**BRANDON STECKLER** // Technical Editor

For a few decades now, the staff in shops across the world that represent the automotive service industry have become comfortable with the cabin air filter and its place in the periodic maintenance schedule of today's vehicles. We've all grown to the awareness of average filter life and sometimes struggle to show our customers "the light" on how much of an important role the cabin air filter plays in not only driver and passenger comfort, but also the longevity of their HVAC systems' components and the interior of their vehicles. This important component is almost always taken for granted. And, if we can educate ourselves as well as our customers, we have a better chance of improving their well-being and our profitability in the shop.

### A step backward in time

The cabin air filter was invented almost 70 years ago. The former CEO of Freudenberg Filtration was riding along in a car with his chauffeur. The chauffer noticed that his clothing was frequently soiled by the polluted air entering the vehicle. Frustrated by this, the chauffeur thought it best to rectify the situation. He had the idea of placing a piece of non-woven fabric in front of the vehicle's intake vents, which seemed to greatly improve the situation. The very first Freudenberg filtering solution came to be due to this inspiring discovery and was dubbed the "Viledon Filter Mat." It hit the market in 1957 and is still the filter media basis for today's cabin air filters.

It is amazing to think that nearly every vehicle in the world now utilizes cabin air filtration, and the technology has grown leaps and bounds, since its inception. Freudenberg is still a market leader as an OEM supplier in today's market. In 1989, Freudenberg's first year of production yielded a mere 35,000 filters (**Figure 1**). In only four years, production increased more than 100 times over, at 3.6 million filters manufactured in 1993 (and numbers continued to trend higher, as the years went by). Like many of the other manufacturers to be mentioned, Freudenberg invested time and energy, working alongside the automotive industry, air conditioning manufacturers, research institutes, regulatory bodies and public institutes to provide the best filtration technology has to offer. As



a Freudenberg filtration application engineer, Dr. Hans Reinhardt stated it, "It [Freudenberg's] was our mission to improve human health and well being that inspired the change in focus from the engine to the people inside the vehicle."

It began with the micronair filter when more than 30 years ago, it became the first cabin air filter for serial production, beginning with the Mercedes-Benz SL Roadster in 1989. In 1991, the Opel Astra was the first mass-market vehicle with the micronair filter (**Figure 2**). This initiated not only a new product category, but also an entirely new industrial branch. Designs initially used an innovative pleated filter medium, providing unprecedented protection against pollen and dust particles that could also be tailored to create different levels

PHOTOS: BRANDON STECKLER

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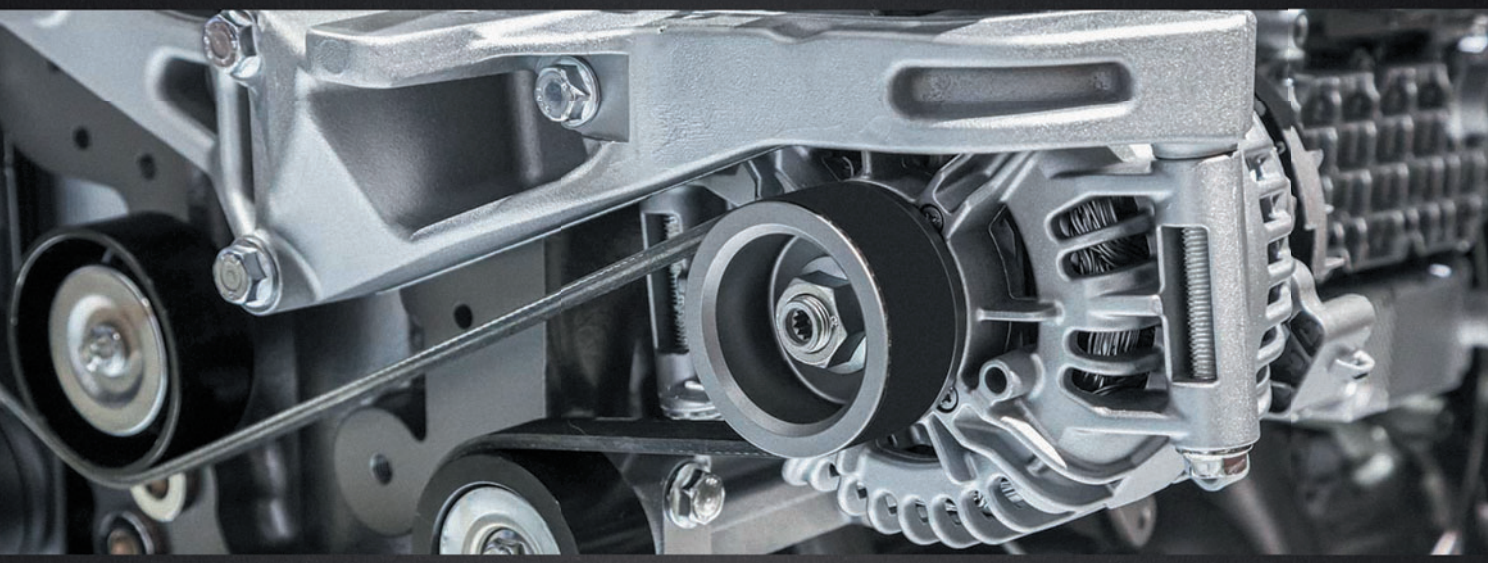
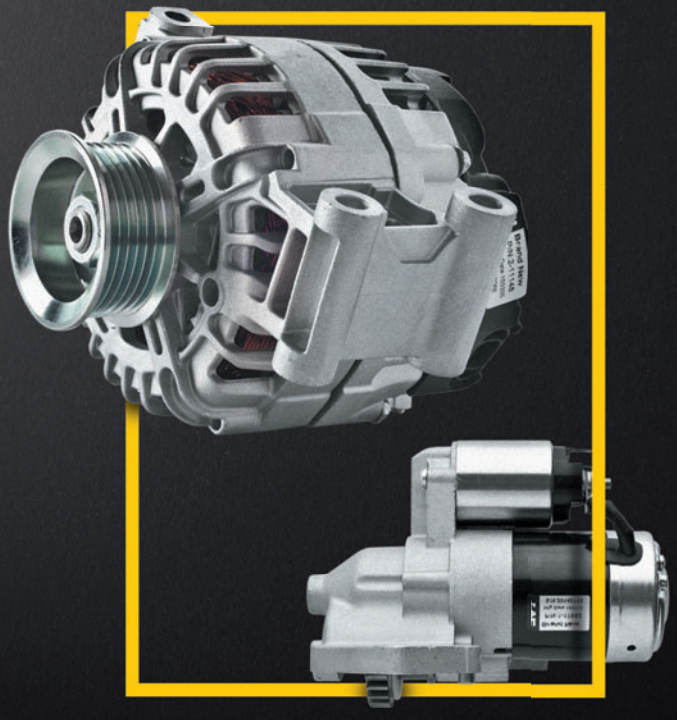


# No Time for Core Worries?



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of efficiency. Premium manufacturers can specify the highest possible filtration performance, while manufacturers in the mass markets can make sensible compromises between efficiency and price. This left a few options for both shops and customers to choose from.

As time went by, so did the customers' demand for cleaner, healthier in-cabin air quality. In 1995, the first combination of filters (combifilters) rolled off the production line. These filters boasted a layer of activated carbon; the filter medium provided added protection against harmful gases and unpleasant odors. The filters were then not only capable of small particulate filtration (like sand, dust, diesel soot) but also capable of filtering harmful gasses like Hydrocarbon (gasoline vapors) Sulphur-dioxide and Nitrogen-dioxide as well. This advancement in technology greatly improved the air quality within the vehicles' cabins. This is the baseline for what we know as cabin filtration.

## Why make such a "stink" over the air quality of the cabin?

Considering Americans drive (on average) more than 13,000 miles per year with an average of 100 miles of daily driving, we place ourselves within the cabin of our vehicles quite frequently and for long durations of time. That's a combined total of 6.9 billion hours in the cabin each year! This is the reason why more than 90 percent of all vehicles sold within the US utilize cabin filtration technology. Studies show that the air quality within the vehicle tends to be upwards of six times as polluted as that of the air outside the vehicle. Traffic congestion is a large contributor to deteriorated air quality. As we sit still, the harmful gasses that leave the exhaust systems of nearby vehicles make their way into the cabin of the vehicle we (and our passengers) are seated in. Dust from worn tires and soot from diesel emissions finds its way in, too. And for those who suffer from allergies and other lung health issues, spores/mold/mildew/fungi will also tend to infiltrate, threatening our health and well-being. These concerns were the driving factors in the development of the cabin air filtration technologies that exist today.

3

For example, manufacturers like Airsept, PremiumGuard, Valeo, Mahle, Fram and TYCGenera (just to name a few) are companies that have invested a lot of time and energy into the research and development of a quality cabin air filter product to combat the undesirables mentioned above.

These filters are offered at different levels of efficiency (and this is reflected in the price) to provide the customer with a customized level of protection at an affordable price range. PremiumGuard's Particle cabin filter boasts 99 percent entrapment of airborne contaminants that enter the cabin (**Figure 3**). These include dust mites, sand, pollen, diesel soot and tire dust. The cabin filters work to remove these contaminants from the airstream without affecting the efficiency of the airflow within the HVAC system.

They also offer a filter product line with an advanced level of protection. Their activated charcoal cabin filters have charcoal embedded in the filter media. These filters not only protect against the undesirable particulate contaminants mentioned above, but they also can absorb harmful gasses like Nitrogen-dioxide ($NO_2$, which is absorbed through the lungs and can lead to heart failure and death, in heavier concentrations); Hydrocarbons (HC, found in gasoline and other fuels, another poisonous gas); as well as Ozone.

**What is a micron?** A micron is another measurement of particle size. A micron is one-millionth of a meter or one twenty-five thousanth of an inch.

4

| Sieve Mesh # | Inches | Microns | Typical Material |
|---|---|---|---|
| 14 | .0555 | 1400 | - |
| 28 | .028 | 700 | Beach Sand |
| 60 | .0098 | 250 | Fine Sand |
| 100 | .0059 | 150 | - |
| 200 | .0029 | 74 | Portland Cement |
| 325 | .0017 | 44 | Silt |
| 400 | .0015 | 37 | Plant Pollen |
| (1200) | .0005 | 12 | Red Blood Cell |
| (2400) | .0002 | 6 | - |
| (4800) | .0001 | 2 | Cigarette Smoke |

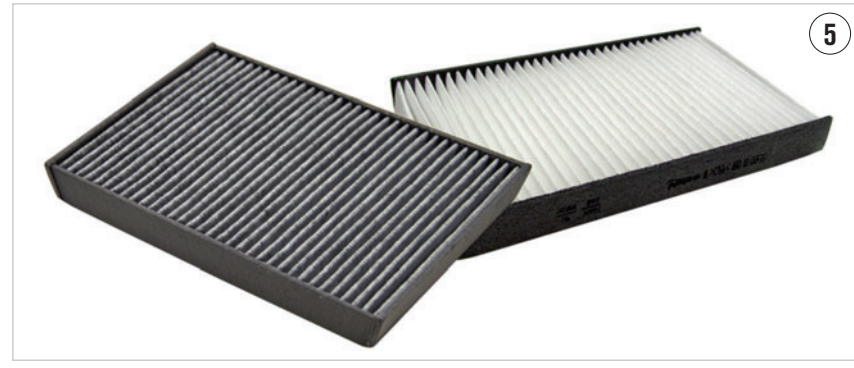
The mesh numbers in parentheses are too small to exist as actual screen sizes; they are estimates included for reference.

The filters even capture the particulates that, when combined with moisture from the evaporator's condensate, promote the growth of mold spores and fungus (a major contributor to the awful odors that tend to occur in an HVAC system).

There are three layers of filtration that take place within the PremiumGuard filters. The first is designed to eliminate the particulates larger than 10um (10 microns= .000394 inches in diameter). The second layer is designed to trap the mold spores and harmful gasses including Carbon-monoxide and Sulphur-dioxide (CO+ $SO_2$= both toxic bi-products of combustion where CO is odorless but $SO_2$ can tend to exhibit the smell of rotten eggs). The third layer has an amazing antibacterial property in which we will discuss below (**Figure 4**).

Valeo is the only supplier that not only designs its cabin filter, but also the AC systems they reside in. Their particulate cabin filters offer filtration of particles as small as 0.1um (that is only one-tenth of one millimeter in diameter. According to COVID-19 expert, Dr. Gregory Poland, the virus measures a diameter of 0.12um). They too, offer combifilters, but with up to four layers of filtration. The first layer is for rigidity and support. The absorbent layer is of a non-woven material with active charcoal particles embedded within, along with two additional filtering layers of porous pleated filter paper. Together, these four layers are capable of particulate filtration and filtration of gaseous contaminants (like the ones mentioned above). These include NOx, butane, toluene (Paint-thinner), and butadiene, using the activated carbon layer (**Figure 5**).

Mahle boasts maximum filtration capabilities with a minimum pressure drop across the filter (will not impede airflow). This is due to their extra-large surface area of filtration. Their "CareMetix" filter has a filter media capable of only 2.5-micron filtration, but retains ultra-high efficiency for airflow, which means longer service intervals for your customer (**Figure 6**).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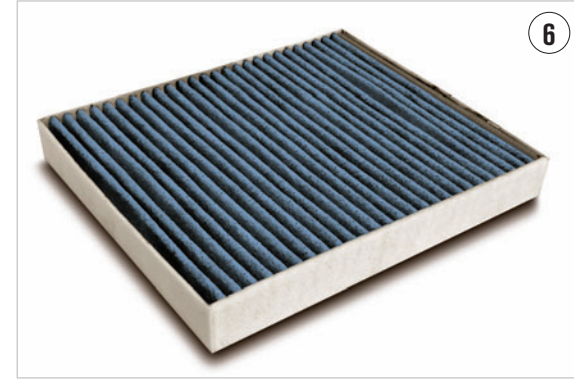
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Fram produces a filter they call FreshBreeze. Working hand in hand with Arm+Hammer baking soda, the filter traps and removes more than 98 percemt of road dust and pollen (5-100 microns) and uses the embedded baking soda as a deodorant, to deliver odor-free air to the cabin (**Figure 7**).

TYCGenera tests its filters to ensure that they meet and/or exceed the OEs for pressure drops in simulated dust environments. They also utilize additional brackets, seals and gaskets for secure installation, but equally as important, optimum capture rate. In many cases, it is better filtration than that of the OE filter, without the price.

Regardless of the brand and level of air quality and filtration you desire, an important characteristic of the combifilter is its ability to neutralize allergens from pollen. It contains a natural surface treatment on the filter media called Polyphenol. Polyphenol is a chemical that can be found in items like a natural grape seed. It is known for its anti-allergenic properties and effectively eliminates pollen allergens like cedar and even dust mites (which measure as small as .3 microns). Polyphenol works by chemically deactivating the allergen molecule, reducing the effect by more than 88 percent. This offers a 150 percent improvement over conventional cabin filter entrapment of allergens. Furthermore, these combifilters are typically electrostatically charged, providing better particulate and allergen entrapment, once the Polyphenol coating has deactivated the contaminants.

Studies show that while running an HVAC system (on medium-low fan speed, in a recirculated fashion), 90 percent of the particulates airborne within the cabin were eliminated in under 5 minutes. 99.5 percent elimination of particulates was achieved in just 15 minutes! How's that for filtration?

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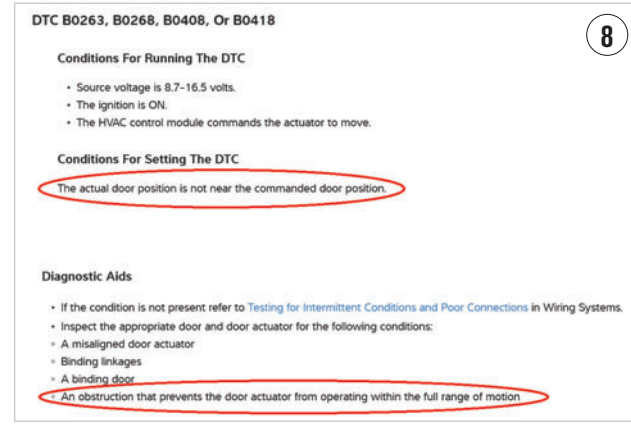

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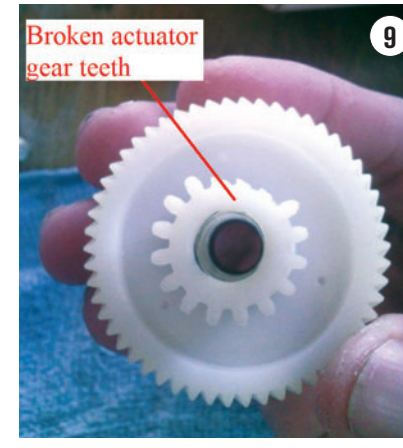
air quality with the use of cabin air filters, and ven more so for our customers that suffer from allergies, asthma and other health and lung disorders. But, let's talk about some of the other consequences of ignoring the simple and often neglected replacement of the vehicle's cabin filter.

The obnoxious odor is one of the first signs of the need for filter replacement, but it is not always that simple. I've personally seen vehicles enter the shop with the complaint of foul odor only to lead to expensive and time-consuming replacement of not only floor mats but also headliners, carpets and ozone treatments. The root cause was true, a neglected and contaminated cabin air filter. A simple replacement (at the factory recommended service interval) and a trip down the highway with the windows open, is all the vehicle needed.

How about the rest of the HVAC and heating system? How quick are most technicians (who are face-to-face with an AC performance complaint) to inspect the cabin air filter? After all, it's the convection that takes place between the air and the heat exchangers (heater core/evaporator) that make us comfortable within the cabin. If that air can't flow, the efficiency of both the heating system and the AC system suffers dramatically. How many unnecessary and expensive HVAC-misdiagnoses are there likely to be?

Considering that the cabin air filter is the last line of defense for the components within the dashboard, how likely is it that the longevity of the HVAC ventilation actuators and doors and the heat exchangers will suffer from premature failure? Logic will dictate that added dirt and other particulates will inhibit the smooth operation of the door and actuators. Most of the electronically controlled systems of today's vehicles are capable of self-diagnostics. Many times as technicians, we are faced with circuit codes due to mechanical deficiencies within the dashboard (**Figure 8**). Often, misdiagnosis leads to costly actuator replacement when, in fact, debris inhibited door movement was the root cause of the failure. Sometimes the actuators themselves are the weakest link, due to the plastic gears within them, driving the mechanical doors throughout the life of the vehicle (**Figure 9**). Needless to say, these repairs tend to be very expensive on some models. This example is from my own 2006 Chevy Silverado. The labor to replace the recirculation door actuator is six hours. Imagine the look on the customer's face when the root cause is due to filter that should've been replaced previously. Perhaps the shop replacing the actuator was the same shop that failed to inform the customer…ouch!



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That isn't the extent of the potential failures. Consider the growth of mold, bacteria and fungus that occurs when an abundance of organic material (like leaves and dust) collects on the surface of an evaporator (causing it to become compromised) or even the copper from a worn blower motor armature (this can have a galvanic reaction with the aluminum and cause the evaporator to leak). Never mind the smell!

Just a few tips to keep in mind when performing routine maintenance and courteous multi-point inspections of the vehicles we face daily. Be mindful of the factory maintenance schedule and realize that not every carline has a filter and that locations vary. Remember that there may be multiple options for a customer. Not every customer suffers from breathing issues, so a basic filter may suffice in those situations.

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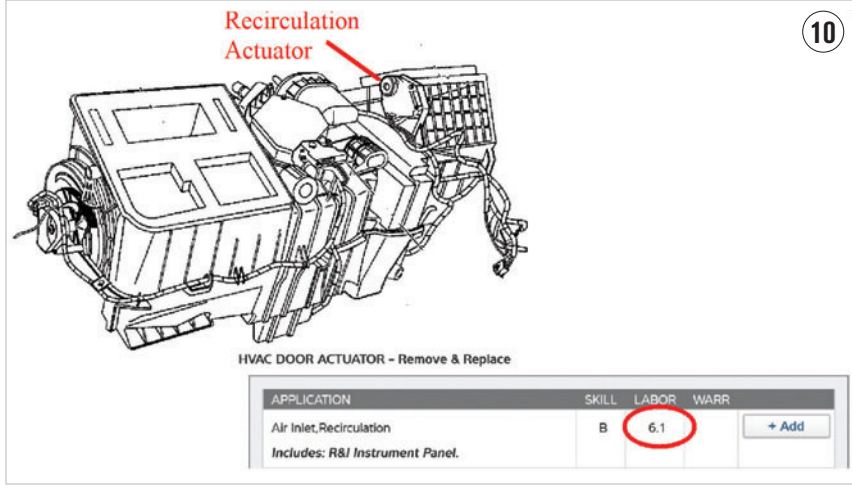
It is better to have a filter with less capability in place than none at all. Remember that with a little thought and understanding of a filter's location some diagnostic strategies can be derived. For instance:

If a severely-restricted cabin filter is located near the air inlet, the AC and heater performance/airflow will suffer, so long as the system is placed in "fresh-air" mode. If it is selected for "recirculation" the symptom tends to vanish (**Figure 10**). This would not be the case if the filter was located between the blower motor and the evaporator.



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## As technology progresses...

As you can see, technology has come a long way in the hunt for the healthiest cabin air we can provide for our customers. An adequately maintained HVAC system includes proper air flow within it. That means a regularly replaced cabin air filter. Although different filters require different intervals, it is common to see intervals call for replacement annually or every 15,000 miles.

You will be sure to see some auxiliary systems for air quality, working in tandem with cabin air filters, well into the future. These include:

**Cluster ionizers** — Generates electrically charged air molecules that attract the undesirables and then adhere to a collection plate

**Plasma-cutter ionizers** — Functions by chemically disassociating hydrogen molecules from a microbe to make it inactive. The microbes are then collected within the cabin filter, like particulates.

**Fragrancing** — Perfumes are offered by manufacturers like Mercedes-Benz to improve the scent within the cabin. They typically last a few months and are replaceable at the dealer.

**Aromatherapy** — Some manufacturers (Nissan) offer the ability to add aroma and humidity for better mental state and stimulation for the driver. Systems like these can alternate between a couple of different scents and can erratically alter volume and direction of the air leaving the ductwork to simulate a breeze in nature.

**Air-quality sensors** — Air-quality sensors can be found in today's vehicles. Manufacturers like Ford, GM, BMW, Volvo and Toyota all use them in newer vehicles. The components give the vehicle the ability to change between fresh air and recirculation, without driver input. It allows fresh air when there is an abundance of $CO_2$ (an abundance of $CO_2$ reduces driver's awareness and promotes drowsiness) and will command recirculated air when passing through tunnels and such that the abundance of harmful gasses is present outside of the vehicle.

Like any other technology we are faced with, knowledge is not only power but, it's also profitable.



**BRANDON STECKLER** is Techical Editor of *Motor Age*. He is a working tech at Lykon Automotive in Bristol, Pa. He has worked in the field for over 18 years and holds mulitple ASE certifications.
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# ASIAN CASE STUDIES

## DIAGNOSING AND FIXING CUSTOMER COMPLAINTS ON AN ACURA AND SEVERAL HONDAS

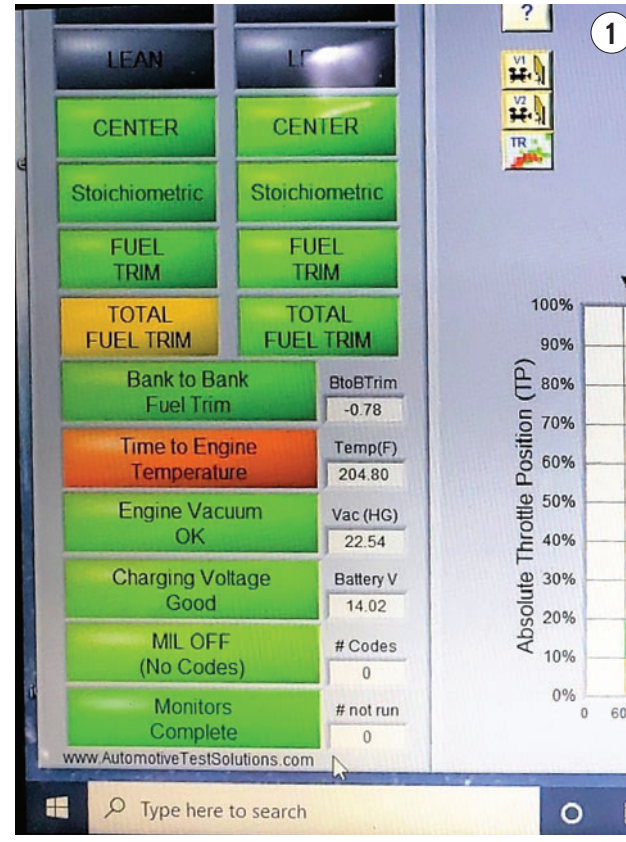
**G. JERRY TRUGLIA** // Contributing Editor

Our first vehicle is a 2006 Acura MDX 3.5L, with 178K miles on the clock. I was called on for some help by one of my students, Mike Pegan from New Jersey. His concern on this vehicle was a complaint about a bad hesitation from a stop and poor fuel-economy of only 11 mpg. Mike started his diagnostics on this MDX by connecting the ATS EScan to the vehicle. The scan of the vehicle revealed that all the monitors were Ready. There were no DTCs, but a "time to temperature" warning was displayed. Not thinking much about it, Mike assumed the problem was something else, since the engine temperature did indeed reach 195 deg-F. The engine was not overheating but did provide good heat.

The history on the MDX cooling system was that it had been serviced about a year ago, flushed and refilled with Acura antifreeze/coolant. Mike decided to contact me for a second opinion since two heads are better than one. I suggested to replace the thermostat as a good place to start since the Escan flagged it as a problem (**Figure 1**).

If you know something is wrong, and you have checked all the basics (the battery condition, engine mechanical, DTCs, etc.), then fix any simple issues (in this case, the thermostat).

The result of that decision to replace the thermostat changed the fuel mileage from 11 mpg to 18 mpg. A great improvement for replacing an inexpensive part (**Figure 2**). Since one problem was out of the way, Mike continued his diagnosis by running the fuel trim test (**Figure 3**). The test results did not look good, so he started to analyze the performance of the catalytic converter. During his investigation, he found that the converter did not have any physical damage, but the catalyst efficiency was down at 50 percent. Knowing that a possible cause of the hesitation could be from a catalytic converter issue, he was going to check it out thoroughly. The next step in that process was to check the exhaust back-pressure. The results were within specification, so that ruled out the converter as the cause. This was followed by an important and typically overlooked step (especially with fuel trim outside of specification), a PCM reset. This will bring the PCM adaptations back to their starting point. Mike filled the vehicle with premium fuel then drove home and back to work again. The results of the reset,




fill-up and test drive moved the efficiency reading of the converter to a passing level, but there was still something wrong.

Mike decided to contact ATS tech support where they log-on to your computer and review the scan tool data so they can help guide you through a diagnostic process to repair the problem. Mike explained the vehicle's situation, what he had tested and the repair he made. He knew that even without any DTCs, it did not mean that the engine, sensors and actuators were operating as designed, but he could not condemn anything yet.

During the tech support call, it was observed that the MAP sensor was not in the correct range during various engine RPMs. ATS tech support suggested that Mike carefully check the load sensor to make sure it stayed within specification at all rpm ranges. Taking their suggestion, he double-checked the data PIDs when he noticed the MAP engine vacuum reading was not in the correct range. His findings uncovered that

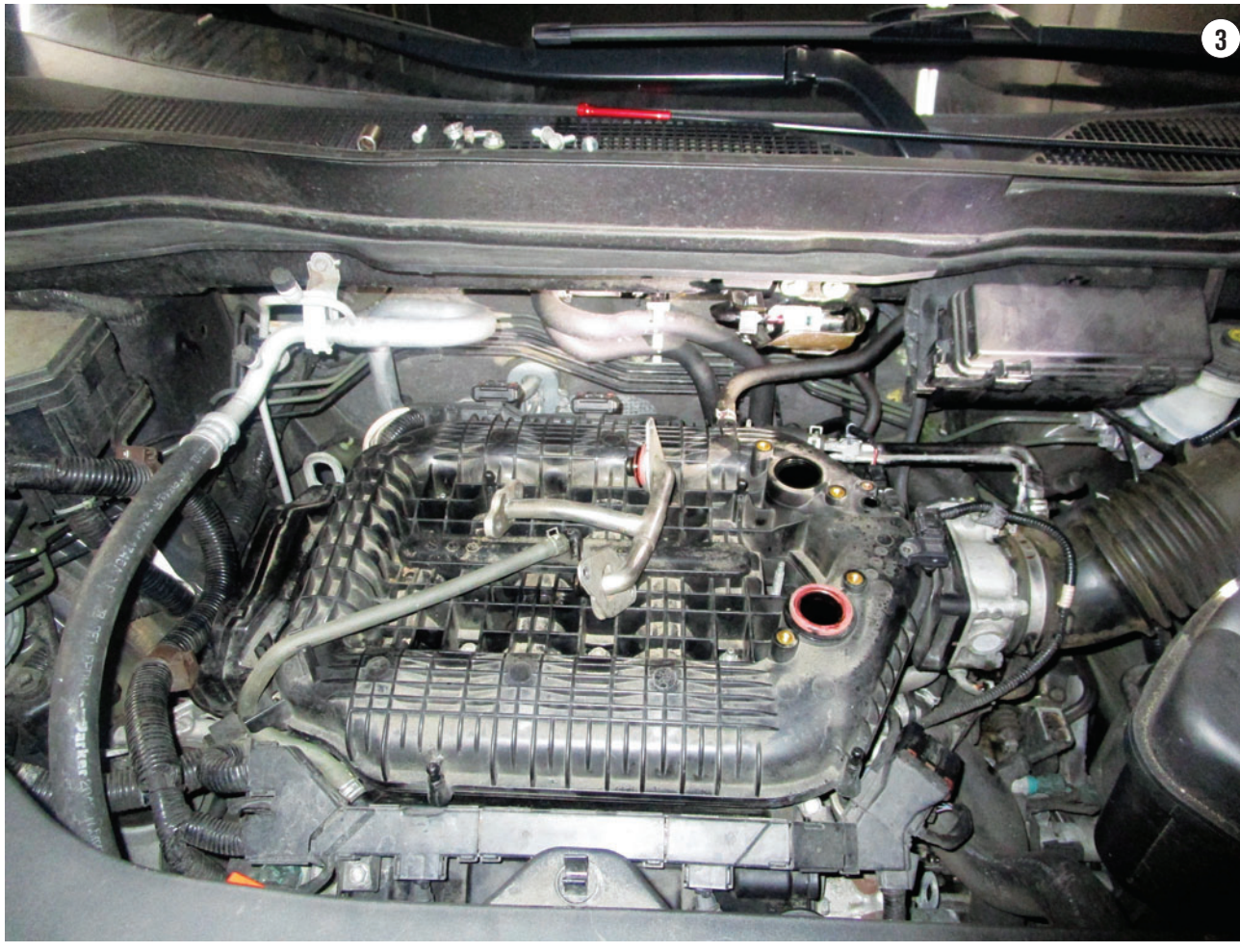
PHOTOS: G. JERRY TRUGLIA

the MAP was reading 22 inches of mercury, while the actual reading was 18 inches of mercury (per vacuum gauge). Since this engine does not use an MAF sensor, the load commands all come from the MAP sensor. If the MAP vacuum reading is skewed, the PCM will respond to the erroneous information and send the wrong commands to the fuel injectors. The MAP was replaced, and the fuel trim reading was positively affected, but still not perfect.

The hesitation still existed. This could be caused by an APP (Accelerator Pedal Position) sensor malfunctioning. I contacted Mike and told him that I had read up on the APP (in Identifix) on the location, specification and testing procedure. I suggested to Mike that he follow their test procedure for the APP. After he located the APP sensor on the firewall, he checked the accelerator cable that runs to it, along with a 6-wire black connector. He verified that pin #1 (the yellow/white wire) had 5 volts on it, (with KOEO) from the PCM and, that the black wire (pin #2) had a good connection to ground. He proceeded to check the APP #2 sensor-sweep on the pink/black wire (pin #3) to make sure the voltage-sweep was in the range of 0.2-0.3 volts. It was able to reach roughly 2.2-2.3 volts without any drop-out on the graph of the scan tool or lab scope. Since this part of the test checked out, he moved on to checking APP #1 sensor, to verify the black wire (pin #6) had a good ground path and, Pin #5 (a yellow/black wire) had 5 volts available. Mike ran another sweep test on the green/yellow signal wire (pin #4). The specification indicates it should rest closed at 0.5 volts and should sweep up to 4.5 volts as the pedal is depressed, without a glitch or drop-out (when testing at both the sensor and PCM). If any of the signals drop out, the APP sensor will need to be replaced. Neither of the two signals indicate a fault. Leaving


no stone unturned, Mike performed a throttle body cleaning and engine decarbonization process, using the Run Rite chemicals. As a result of the cleanings, there was a slight improvement in the engine running condition, but the hesitation still existed.

With the engine side of the equation out of the way, the only remaining possibility was an issue with the transmission. Mike asked me if I could get in touch with Wayne Colonna (from ATSG/ETE), the transmission expert. I contacted Wayne and asked him about the hesitation on this MDX. Wayne was able to shed some light on the hesitation issues that this transmission has, due to a common sprag-clutch problem. He also sent along a particularly important ATSG Service Bulletin titled, "Five Speed Neutralizing Downshift To 1st Gear." The bulletin goes on to state: "before or after an overhaul, Honda and Acura vehicles




equipped with a five-speed transaxle may exhibit a neutralizing condition on a downshift into 1st gear, or a 3-1 passing gear neutral. This condition may be intermittent. This neutralizing condition can be cleared up simply by placing the selector in the Manual 1 position. The cause may be a worn-low one-way clutch or a worn inner race for the low one-way clutch. Honda and Acura vehicles equipped with a five-speed transaxle utilize a low one-way clutch that locks in 1st gear for take off. If the low one-way does not hold in 1st gear, there will be no engagement until the selector is placed in manual 1st. In this position, the low-hold clutch is engaged, and 1st gear can be attained. The low-hold clutch is used to provide engine braking in manual low as well as backing up the sprag by holding 1st gear, should the sprag fail. This sprag failure is commonly overlooked, as the low-hold clutch hub must be driven out to inspect the sprag and races."

This important information from ATSG goes on to state (with pictures) what parts to replace, how to install and retest. This information can be purchased from the ATSG hotline or by purchasing one of their great transmission troubleshooting manuals. The problem with this Acura boiled down to the transmission. Mike informed me that the vehicle owner decided to live with the hesitation since the owner's uncle (that has the same vehicle with about the same high mileage) has the same hesitation. Go figure!

## Carbon bound

Our next problem vehicle came in from Patterson Auto Body. They had an issue on a 2016 Honda Pilot 3.5L with 126K miles on the odometer and a P0300 DTC. The shop told us that their customer complained of engine misfiring. This was confirmed by the P0300 they found stored when they scanned the vehicle. The shop performed a tune-up, spark plug and air filter replacement. It seemed that the shop made all the right moves by replacing all the worn-out components that have a major effect on engine misfires. The misfire was still an issue after the repairs, so the shop decided to run a fuel system cleaning using a national brand. They performed the GDI cleaning twice (with a company representative present), but did not see the results that they ex-

pected. When they looked inside the engine with their video scope, they noticed that carbon build-up was just as heavy after the cleanings as it was prior. After the cleanings were performed, the engine still misfired. The fuel-system cleaning-product representative thought that the GDI injectors were causing the problem and must be replaced. The shop followed the company's recommendation and ordered all six GDI injectors from Honda. After the shop installed the injectors, they drove the vehicle around only to find the same misfire issue. This was when Fred Byron (from Patterson Auto Body) called me and asked if I could diagnose this misfiring Honda. I told him to come down and we would check the vehicle out.

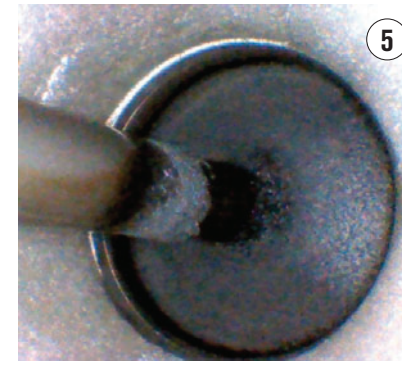
Our diagnosis revealed the engine misfire exhibited was not mechanical, ignition or fuel related. So, we waited until the engine cooled down. We then looked into the engine via the plenum and found a heavy carbon build-up on the intake valves and seats (**Figure 4**). We suggested an ATS Chemical carbon cleaning on this GDI engine to clean the carbon up. Fred was not 100 percent sure that the cleaning was going to prevent the engine from misfiring, but he trusted my recommendation. We performed the ATS Chemical cleaning and noticed a heavy amount of black smoke coming out of the tailpipe as the cleaning was being performed. Once the cleaning was completed, the valves and seats were noticeably cleaner, allowing the Honda to run as it should, performing well and free from misfires (**Figure 5**). I called Fred and told him to come down and pick up the Pilot. Fred was so amazed at how well the engine was running, he is waiting until the pandemic is over and will then purchase the ATS Chemical machine himself.

## Noisy 3.5L Honda

A 2011 Honda Pilot 3.5L, driven 172K miles, came in with a complaint of noise when the engine was at idle. The noise would worsen during acceleration. We needed to confirm where the noise was originating from by using a stethoscope to listen all around the engine. We found that the noise was from the right side of the engine and could be coming from a belt, pulley, water pump or alternator. We played the disconnect game to narrow down and locate what was generating the noise. What we usually do is remove the belt(s), depending on the system. If the noise goes away, we install our Grizzly make-a-belt (**Figure 6**) and attach it from the crankshaft to either the alternator, pulleys or water pump (not available since it's under the timing cover on this engine) or any other of the auxiliary rotating devices to pinpoint the problem. On this engine, we did not need to use the Grizzly to make a belt, since the noise was still audible with the belt removed.

Our next step was to call the Honda owner and suggest that we remove the timing cover and inspect all the components of the timing belt system. With the Pilot owner's OK, we removed the timing belt cover to expose the two camshafts, crank gear, water pump, idler pulley and adjuster pulley (that the timing belt goes around). We carefully started up the engine and used the stethoscope once again on each component. Our results concluded that most of the noise was coming from the water pump and the adjuster pulley. We recommended the timing belt, pulleys, water pump, thermostat and drive belt be replaced, along with a cooling system flush. Once we completed the job the engine ran noise-free.

Unfortunately, this was not the end of this story. A few months later (now with 174K on the clock), the vehicle was back in for the engine not running well, along with an oil leak. Our technician Bill checked out the engine area and found that the oil was leaking from the VTEC (Variable Timing/Electronic control)



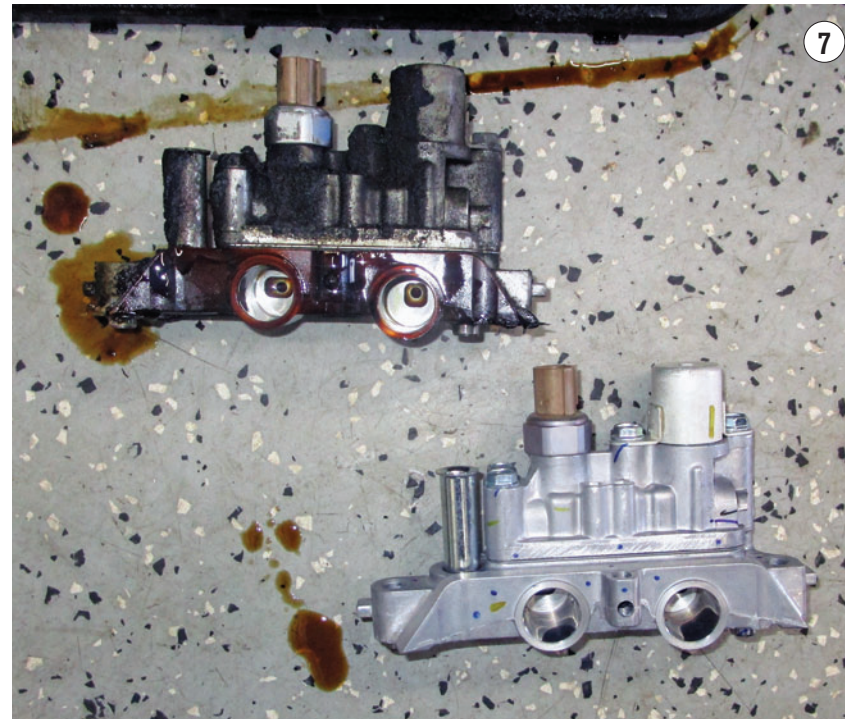
solenoid spool valve assembly on Bank 2 for cylinders 4, 5, and 6 (**Figure 7**). Since oil was leaking from the unit, we knew that the VTEC system was not operating correctly. There was no need to check the pressure switch or scan data to make sure it was functioning properly. Instead, it was time to call the owner and suggest a new spool valve. The fix for this spool valve entails removing the intake plenum, valve cover and the rocker assembly, which allows access to the spool valve. Bill removed and installed the new spool valve, followed by adjusting all the valves and performing an oil and filter change. Now the Pilot's repairs were complete and it's running like a top.

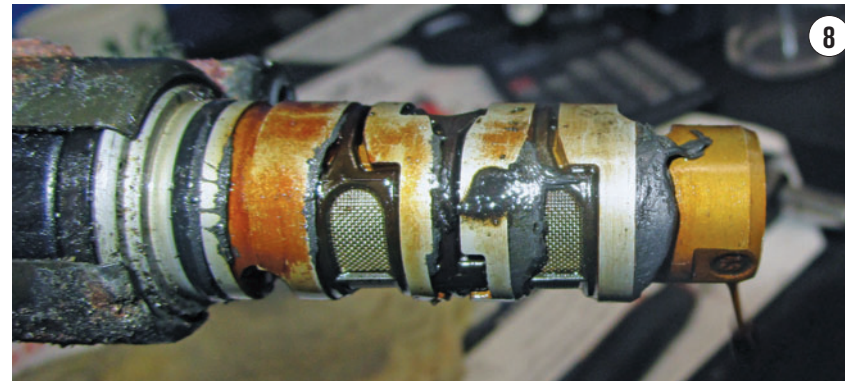
## Clogged Honda

Our next problem is a 2005 Honda Accord 2.4L that logged 203K miles and stored a DTC P2646 for a VTEC Pressure Switch Circuit, Voltage Low. The first place to start is to make sure that there is the proper voltage and ground at the pressure switch. This was followed by removing the VTEC pressure switch and installing a pressure gauge to determine if there is a pressure problem or just a bad switch. On this engine, Bill found that it had a good switch, so he proceeded to check the VTEC solenoid's functionality. When he removed the solenoid, he noticed that the screen assembly was clogged with RTV.

Bill installed a new solenoid and started the engine up only to have the MIL illuminated again, with DTC P0011 Timing Advanced Bank 1. He removed the VTEC solenoid again and found more RTV in the small screens of the solenoid. The RTV was a result of a head gasket repair that was previously performed by a different shop. Bill cleaned up all the RTV that he could see, but he knew that there was more in the engine. He suggested to the Accord owner that the engine be flushed and oil/filter changed. The vehicle owner refused to perform the engine flush and paid only for the repair that we performed on the vehicle.

This was not the last time we were going to see this Honda, either. It was back in less than 300 miles with the same DTC, due to another clog. Bill recommended the engine flush and oil change as he had done before at the previous visit. The Accord owner wanted to know what was wrong, so Bill explained the problem again, then suggested an engine flush and oil change was a good starting point. Bill made sure to explain that the flush and oil change may not remove all the RTV (**Figure 8**) causing the problem. If the flush and oil change did not clear the issue up, the oil pan would have to be removed. Believe me, we do not like flushing engines, especially with 204K miles on it. We did provide the Honda owner with the pros and cons of the oil flush. Our choice of engine flush chemical was the ATS 505 CRO additive that we poured in the engine and ran for 20 minutes. This was followed by a drain and replacement of the oil and filter. The outcome of the cleaning left engine was running well, without an illuminated check engine light. This turned out to be an easy fix.




My hope is that these case studies help you take a path in making your diagnosis easier. By opening your mind up to potential failures, the logic involved in uncovering them, and the available tools and solutions to alleviate them, I also hope to assist you and your shop to remain profitable and efficient, in future encounters.

**G. JERRY TRUGLIA,** ASE World Class Triple Master Technician Auto, Truck & School Bus, L1, L3, F1, A9, X1 C1, is president of Technicians Service Training and a nationally recognized trainer/author. He founded TST to bring affordable training to fellow techs and owners.
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# BRAKE-BY-WIRE SYSTEMS: THE NEW "NORMAL"

## SERVICING BRAKE-BY-WIRE SYSTEMS DEMANDS FULL KNOWLEDGE OF ADAS

**DAVE HOBBS //** Contributing Editor

You've undoubtedly heard that tomorrow's fully autonomous vehicles will be able to accelerate, steer and stop without ANY driver interaction. Vehicles with "drive-by-wire," however, are not just a future technology to simply be aware of. Drive-by-wire has been around for a few years. This month, let's peek into the "new normal" of brake-by-wire systems.

### Defining brake-by-wire

Anytime a vehicle's brakes are applied without the driver's foot doing the job can for all practical purposes be referred to as brake-by-wire. Many examples can be found in today's vehicles:

- Traction Control Systems (positive wheel slip)
- Stability Control Systems (excessive yaw / lateral acceleration)
- Active Cornering Systems (a form of stability control — w/o loss of control)
- Auto Dry Braking Systems (applies brakes lightly and periodically in rain)
- Hill Start / Hill Hold
- ADAS
  - — Adaptive (Radar) Cruise Control
  - — Collision Avoidance / Mitigation (frontal)
  - — Rear Automatic Emergency Braking (when backing up)
  - — Self-Parking
  - — Unattended self-steering systems (refuse to take the wheel while in some semi-autonomous models — the vehicle stops itself)

### What breaks in brake-by-wire systems?

Key players for problems with any brake-by-wire system are:

- Functional WSS (Wheel Speed Sensors)
- Functional and properly calibrated ADAS radar sensors and cameras (if equipped)
- Fully Operational ABS Hydraulic Modulator Assemblies (a.k.a. Brake Actuator Assemblies)
- Brake fluid (ample level, proper type, and contamination free)
- Clean connections for 12-volt power, grounds and CAN data

Let's look at the first two bullet points in more detail.

### WSS (Wheel Speed Sensors)

Wheel speed sensors have been around since the first days of ABS. Early "passive" designs built on VR (variable reluctance) technology was sufficient in accuracy for its day but had problems resulting in poor ABS performance. For many years now, OEMs have been using "active" MR style sensors, which aren't speed dependent and are more accurate. Diagnostics and common failure modes are different, however (**Figures 1-3**).

### Proper ADAS calibrations

ADAS (Advanced Driver-Assist Systems) sensors with problems can in some cases continue to operate, but not at their fullest potential. While it is true that most sensors that are grossly miss-calibrated will set a DTC and driver alert, lesser degrees sensor offsets can create performance issues. For brake-by-wire collision avoidance/mitigation, that could mean the vehicle's radar misinterpreting an approaching (or parked) vehicle in another lane as an impending collision with your customer's vehicle. The result on some occasions has been the customer's vehicle "slamming" on its brakes (without the driver's brake apply). In other incidents, a few degrees of offset have led to the brake-by-wire systems (such as radar cruise control) not detecting the other vehicle your customer is approaching. If a driver depends on their brake-by-wire too much, these kinds of incidents can lead to a rear-end collision with another vehicle. Therefore, it's important to learn all you can about ADAS even if you've elected to NOT purchase expensive static cali-

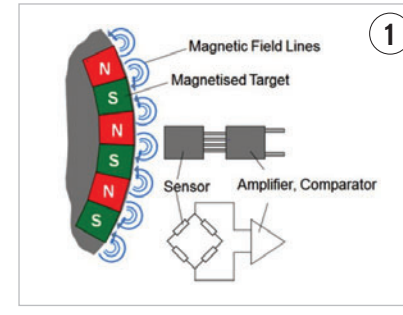



PHOTO: DELPHI TECHNOLOGIES

**THE ACTIVE WSS IS A "COUSIN" TO HALL EFFECT SENSORS,** but use two wires instead of three just like their passive WSS predecessors.

bration equipment. Knowing when a static (in the shop adjustment with targets) and/or subsequent dynamic calibration (electronic adjustment during a road test) is essential. Sensor removal (to gain access to another component), wheel alignment and windshield replacements are all potential lines in the sand for breaking out the ADAS calibration equipment or calling the diagnostic mobile tech with the correct calibration equipment and proper know-how. Brake-by-wire systems on ADAS equipped vehicles are typically activated during adaptive (radar) cruise control operation. This means the radar sensor in the grill would need to be properly calibrated if it were removed and replaced or its mounting bracket bent even slightly. What about the camera behind the windshield? On some ADAS vehicles, the grill mounted radar and windshield mounted camera (primarily for lane departure warning/lane keep assist) works in cooperation with each other. This means if you have a problem with the camera, the radar related systems might not perform properly and vice versa. In the case of some Volvo models, the long-range (millimeter) radar and "smart" camera is integrated into the same assembly and mounted behind the rear-view mirror (**Figure 4**).

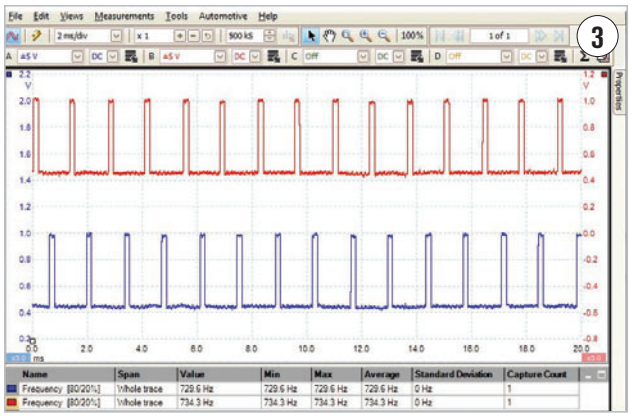



PHOTO: PICO SCOPE

**DIAGNOSING AN ACTIVE WSS DIFFERS FROM EARLIER PASSIVE SENSOR.** Instead of an amplitude and frequency that increase with wheel speed, active sensors produce a very small voltage (and current draw) shift, which make the use of an AC voltmeter (commonly used in older passive WSS) essentially useless. GM advises connecting an ammeter in series with an active WSS's signal line, but that requires removing a terminal from a connector (not always the easiest thing to do). Inductive amp clamps are not sensitive enough for the low current shift of the signal. All of these challenges add to up a sensor that requires a scope to display signals that often only shift a half of one volt in a digital square wave.


**HUNDREDS OF TINY MAGNETS ARE EMBEDDED INTO THE PLASTIC HUB BEARING RACE COVERS.** This rear hub bearing is screaming "bad encoder ring!" Minor flaking of the encoder ring on a front hub bearing hidden at the end of a half shaft is not so easy to spot. Either level of failure will set the same WSS DTC, but the encoder ring with minimal damage may not show up as a rhythmic signal drop out even if you graph the WSS PID. For minor encoder ring flaking, you're going to have to use a lab scope to determine if the problem is a flaky encoder ring (very rhythmic) or an intermittent signal drop out from the actual active wheel speed sensor itself.

## Understanding ADAS is the key

In addition to proper calibration, ADAS system operation MUST be understood. Since customers rarely educate themselves to the degree they should, this means you, the technician, service advisor or repair shop owner needs to be your customer's technical trainer on ADAS. For example, on some earlier Toyotas with adaptive cruise control systems, the brake-by-wire system will only brake itself and slow the vehicle down to 20 MPH when the vehicle approaches another vehicle that is stopped. On later Toyota and Lexus models, the adaptive (radar) cruise control will bring the vehicle to a complete stop if the vehicle being followed stops. If your customer complains their adaptive cruise control doesn't work, make sure they are not manually turning off their traction control. TRAC and VSV (stability controls) must be functional for their radar cruise to operate. Additionally, a thorough understanding of SWC (Steering Wheel Control) switches (**Figure 5**) and instrument cluster displays for followed vehicle "gap" adjustment (**Figure 6**) are paramount for ensuring you are NOT being asked by your customer to "fix something that's not broke!"

## Integral ABS returns . . . and leaves again

Antilock brakes (ABS) have been around for decades to give drivers more control of the steering while performing heavy braking. Probably the first form of brake-by-wire was TCS (Traction Control System), which added brake application to simple engine torque management. From the late 1980s into the mid-1990s, you may have noticed ABS systems taking two forms: integral and non-integral. Integral systems took a fresh design approach by completely changing the way the base brake hy-


**ON ADAS EQUIPPED VEHICLES, BRAKE-BY-WIRE SYSTEMS** are activated by CAN bus messages initiated by software interpretations of approaching vehicles/obstacles thanks to radar sensors and cameras. This Volvo RACAM module contains both a camera (round lens in upper center of unit) as well as a millimeter electronic scanning long range radar sensor (right 2/3 of unit) to detect other vehicles, lane markings and even interpret road signs as well as establish the range of other vehicles/pedestrians.


**THE SWC (STEERING WHEEL CONTROL) BUTTONS ON THIS 2020 TOYOTA CAMRY** use the typical "On" (far right), Set/Tap Down (bottom right) and Tap Up/Resume (top right) arrangement of switches in a circular rocker switch. The "Gap Switch" (upper left) allows the driver to adjust the distance following the next vehicle in front of them when the adaptive (radar) cruise control is in use.

draulics operated. Non-integral systems were simply "add on" ABS components to the traditional base brake hydraulics. With a typical non-integral ABS, the driver mechanically activates the two hydraulic brake circuits via the brake pedal/master cylinder to stop the vehicle. Now consider the typical integral ABS. Gone is the simple vacuum brake booster for power-assisted braking. Integral systems use an electric hydraulic pump along with a pressurized tank for their power assist feature. Instead of a brake actuator being located downstream from the master cylinder (as with non-integral ABS systems), the master cylinder and ABS hydraulic modulator are built into a single "integrated" unit. You may have serviced these older integral ABS systems over the years. Bosch 2U, Teves Mark II, Delco Moraine (Delphi) III, etc. to name a few, were overly complicated "Rube Goldberg" designs by today's standards. Eventually, non-integral ABS systems improved and began to overtake integral models. Improvements with the cheaper (and simpler) non-integral ABS system's ability to "create brake pressure" without the driver's foot pushing down the brake pedal had to occur for vehicles with these systems to work with traction and stability controls. Both TCS and stability controls require brake-by-wire activation. Just when we thought that those complicated and costly integral ABS systems were behind us, HEVs (Hybrid Electric Vehicles) and EVs (Electric Vehicles) began appearing with many similarities of the older complicated integral ABS systems. (**Figure 7**) Toyota's Gen II Prius (2004-2009) was a prime example of brake-by-wire complexity. When you applied the brake pedal, you were actually "requesting" brake apply. A remotely mounted (buried under the dash) "Skid Control ECU" (**Figure 8**) receives a "brake pedal stroke sensor" input as its cue to apply the brakes. Front friction brakes may not apply at all if the Skid Control ECU doesn't see a panic stop indication. It communicates on the CAN bus with the Hybrid Control ECU. If the Hybrid Control ECU is fine with the need for regenerative braking (it almost always is) it then commands the inverter to place opposing forces on MG (Motor Generator) 2 to slow the front wheels based on the degree of braking the Skid Control ECU has advised it that you were applying with your foot on the brake pedal. This creates electricity, which in turn charges the high volt-


**THIS 2019 CADILLAC CT6 IS EQUIPPED WITH SUPER CRUISE AND NIGHT VISION** (displayed under the "0 MPH" speedo read out). The "Gap Adjust" is the space between your vehicle and the vehicle in front of you during adaptive (radar) cruise control operation.


**HEVS (HYBRID ELECTRIC VEHICLES) HAVE UNIQUE BRAKE-BY-WIRE** needs: regenerative braking and lack of engine vacuum for traditional power assisted braking during engine stop periods of operation. As with earlier integral ABS systems, many HEVs use an electrically controlled high pressure hydraulic pump (silver cylindrical section located on upper side of ABS unit) and nitrogen gas filled brake pressure storage tank (black cylindrically shaped section on lower side of ABS unit).

age battery pack. For panic stops, stops under 5 MPH and normal application of the non-driven rear brakes, the Skid Control ECU signals the ABS/brake actuator assembly to turn on the ABS pump, activate the correct solenoids and apply the brakes in a traction control system fashion. If a major problem with this brake-by-wire system is detected, the master cylinder's "cut valve" is activated for there to be a mechanical connection between the driver's foot on the brake pedal and the hydraulic braking system. This back-up failsafe system from the cut valve doesn't employ any kind of power-assisted braking so don't assume your brakes are going to be easy to operate in this mode. I encountered a 2004 Prius that had a Skid Control ECU DTC. Braking power was nil to none. Apparently, the module couldn't command the cut-valve to go into the proper failsafe mode. A used Skid Control ECU from an auto recycler for $65 saved me from the $1200 (wholesale) cost of a new one! You can read more about that case study in a previous *Motor Age* article, "Cracking a Toyota's code," June 2012.

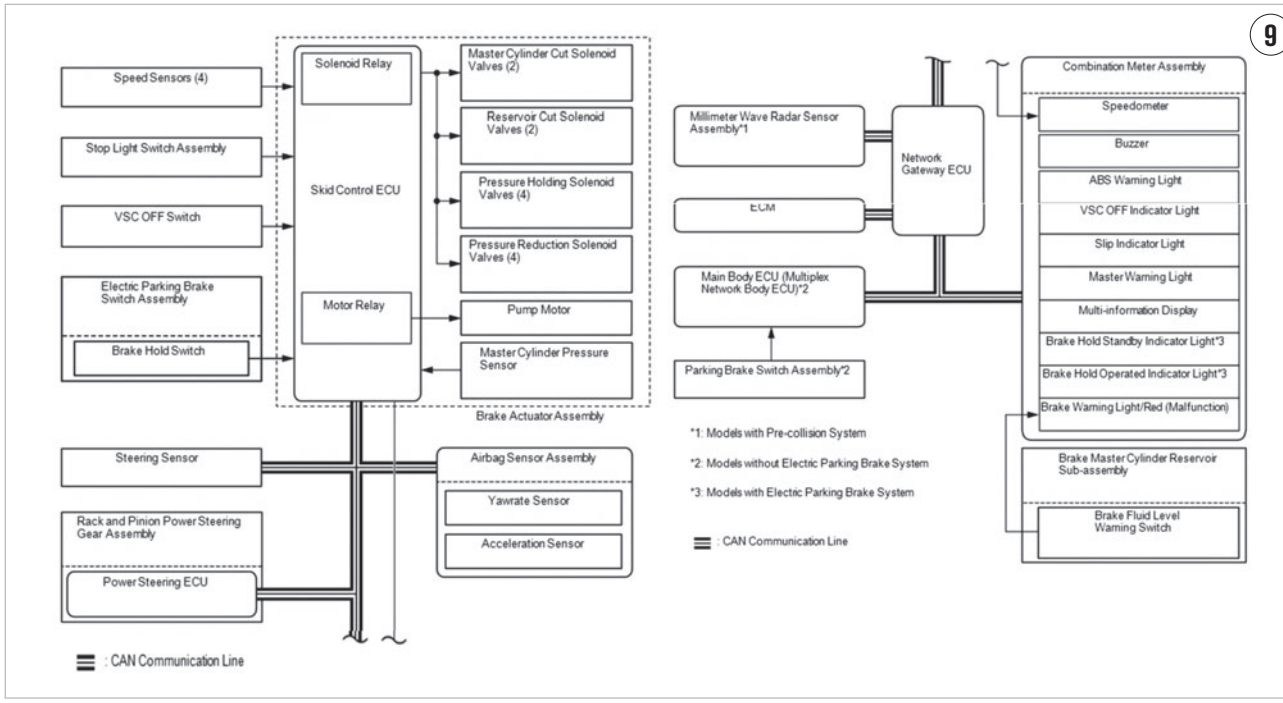
## Newer brake-by-wire vehicles

As non-integral ABS/TCS systems improved, brake-by-wire systems have become less mechanically complex. Their multi-system interactions, however, have increased in complexity exponentially. In the case of a new (2020) Camry (non-hybrid) with radar cruise, the remotely mounted "Skid Control ECU" is now integrated into the electronic module attached to the brake actuator (ABS) assembly. As with most of today's ABS/TCS systems, this vehicle's ABS brake actuator uses 12 solenoids and a pump motor to achieve whatever form of brake-by-wire the vehicle requests (**Figure 9**).


**EARLIER TOYOTA HEV (HYBRID ELECTRIC VEHICLE)** models (such as Prius) used a remote mounted skid control module.

## Checking operation, graphing brake-by-wire PIDs

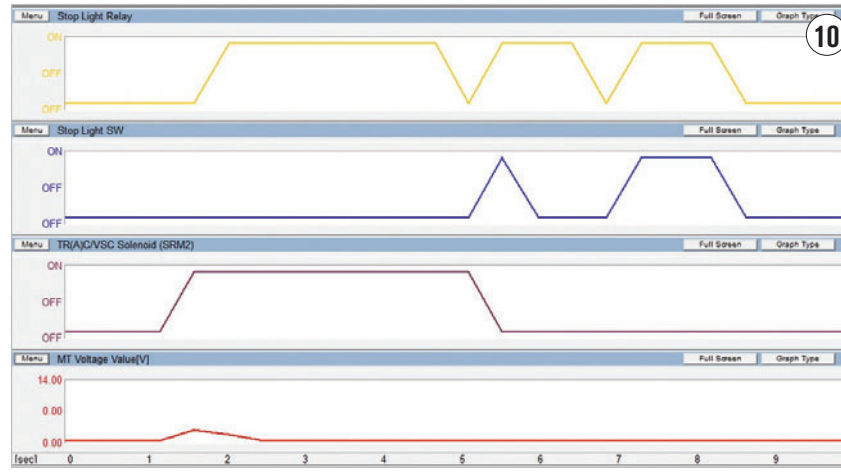
Graphing brake-by-wire scan tool Parameter IDs (PIDs) can be a benefit in diagnostics when you're trying to go beyond simple DTCs to determine if the advanced braking systems such as




DRAWING: TOYOTA

**THIS 2020 TOYOTA CAMRY'S DYNAMIC BRAKE CONTROL SYSTEM** uses a Skid Control ECU that performs conventional ABS along with advanced braking features such as VSV (Stability Controls) EBD (Electronic Braking Distribution), Hill Start Assist, TRAC (Traction Control) and Pre-Collision.

TCS, stability controls and radar cruise is applying the friction brakes on your customer's vehicle. Obviously, you can feel the harsher deceleration feel of friction brakes (compared to throttle down) while following another vehicle that applies its brakes when you're in radar cruise mode. While that seat-of-the-pants feeling is noticeable to you, documentation via a scan tool screen capture (**Figure 10**) can add some tangible evidence that braking is occurring when the radar senses another vehicle in front slowing more rapidly than the cruise control's throttle down can handle. A close look at **Figure 10** reveals what's going on when first the radar cruise, then the driver applies the vehicle's brakes. The top PID is the stoplight relay, which turns on the stoplights when the friction brakes are applied by either the driver's input to the brake switch or a brake-by-wire apply. The next row down is the PID for the stoplight switch on the brake pedal. The bottom PID (MT Voltage Value) is a bit of a mystery. Watching it during automated brake applications, it never rose over 4.5 volts, so one could conclude that the acronym "MT" might stand for "Motor Temp" Voltage Value. Regardless, this PID remained at 0-volts during non-braking as well as manual (pedal applied) braking occurrences. The second from the bottom row PID is one of the TRAC/VSV (Traction Control Stability Control) hydraulic solenoids in the brake actuator assembly. The bottom PID is the brake actuator's pump motor. Observing from left to right, the stoplight relay turned on 3X (top PID graph) while the TRAC/VSV solenoid (second from bottom) turned on once. Notice the second row from the top PID graph (Stop Light Switch) off during the first part of the recording. This proves the radar cruise interaction with the Skid Control ECU was braking the vehicle — not the driver. During the last half of the recording (right side of the graph) the stoplight switch status goes high (second row from top) at the same time as the brake light relay (top). Note the lack of TRAC/VSV actuation (bottom) during the right side of the graphs. This proves the driver applied the brakes manually. One failure on some radar cruise/brake-by-wire vehicles is a brake light activation that occurs when the driver applies the brakes (easy to check in the shop) but NOT when the radar cruise applies the brakes. This would be a big safety issue during radar cruise use and very hard to diagnose (without another vehicle following you on a road test) if you did graph advanced braking scan tool PIDs as shown in this figure.




**GRAPHING THE 2020 TOYOTA CAMRY'S ABS PIDS** reveals what's going on when first the radar cruise activates brake-by-wire (left side of graph) and when the driver applies the vehicle's brakes (right side of graph).

## Some reasons adaptive (radar) cruise control may not work (Courtesy Toyota)

- The forward recognition camera is temporarily unavailable
- The electric parking brake system is malfunctioning
- TRAC is turned off
- VSC is turned off
- Problem with stop light switch circuits
- Malfunction in the millimeter wave radar sensor assembly
- Beam axis of millimeter wave radar sensor assembly misaligned
- Millimeter wave radar sensor assembly becomes dirty
- Millimeter wave radar sensor assembly sensitivity reduced because of bad weather such as rain, fog, snow, or sandstorm

## Considering used ADAS parts?

According to the Toyota service manual, replacing the long-range (millimeter wave) radar sensor with a good used one from another vehicle can cause a mismatch of information between the two vehicles. On Toyota and Lexus models this may result in a C1A69 DTC in addition to an inoperative radar cruise feature. Looking at online prices for new radar sensors they appear to run between $400 and $2,000. Ouch! I'm guessing that's also the "new normal" for the convenience and safety of brake-by-wire systems!

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# THE RIGHT TOOL AT THE RIGHT TIME

## FOCUS ON MAXIMIZING THE FEATURES OF THE TOOLS YOU HAVE

**BRANDON STECKLER** // Technical Editor

You see it everywhere you look… humongous, towering toolboxes that someone of my tiny stature would require a stepladder to reach the uppermost drawers. I mean, let's face it — having the proper tools to service, diagnose and repair today's vehicles properly is not only a matter of efficiency, but is most likely a necessity. Specialized tooling is more in demand now than in years' past. We need them or we simply cannot complete the job. But that isn't my gripe. No, the issue I have is when I hear technicians tell others that the job simply can't be performed without "this exact" tool (whatever it may be, arbitrarily).

### Naivety, in the not-so-distant past

Not too much more than 10 years ago, I was a successful, factory-trained Honda master technician in the Philadelphia-area of Pennsylvania. I enjoyed my job each day, although many challenges drove me nuts (as I'm sure all of you can relate). Traveling the path of the OE technician, regardless of which manufacturer's patch you wear on your chest, can many times be one you travel with blinders on. The training we acquire at the OE, as well as the tools to be used to decipher different faults, are meant to support the technicians (at the dealership) to solve issues most efficiently (under warranty) and at a very high rate of success (more than 70 percent). The point is, not every technician's mind functions the same nor is their understanding of the individual components that make up the systems. The OE has to develop troubleshooting flow charts and implement tools that will help most technicians solve as many issues as possible at the smallest financial expense possible. It isn't necessarily the OE's goal to solve every problem every time. That just isn't likely to happen.


Becoming dependent upon the service information (rather than learning how the vehicle "ticks") is typically the result. Do problems get solved? They sure do, but the technicians don't necessarily grow from the diagnostic experience. Instead, they tend to reach for the service information each time, hindering their productivity, as well as their ability to learn and acquire the necessary skill set to be an efficient and accurate diagnostician. Learning how the systems, as well as the function of the individual components, at the most basic level, is what it takes to become a true master of the vehicles we tend to daily. This was proven to me many times as I started to venture away from factory training and began acquiring knowledge from other sources.

I remember clearly attending an aftermarket class conducted by none other than Jim Morton, of MATS (Morton's Automotive Technical Services). The class was cleverly named "The A, B, C and Ds of Ignition." What struck me about this class was not the "meat and potatoes" of the class, but more so the approach. Jim confidently claimed he could find the fault in any ignition system on the planet, in under 15 minutes of diagnostic time. In my eyes, that is one heck of a claim to make. It simply didn't make any sense to me at the time, and I was fascinated by this (**Figure 1,** myself on the left, Jim on the right). The reason? Like so many others, I was reliant on the bible we refer to as service information. I'm referring to the diagnostic flow charts. The charts didn't educate me; they told me what to do. And, since I wasn't learning from them,

PHOTOS: BRANDON STECKLER

I had to reference them each time I encountered an issue. It would be quite rare for me to solve almost any diagnostic issue in under 15 minutes. I needed to learn this new approach to diagnostics.


## Discovering the contents of the crystal ball

The fascination grew; I became obsessed with the idea of this brilliant approach, so I asked Jim for private training. He smirked at me (in doubt that I'd "persevere"), but told me to be at his home later in the week. This is the moment my career (as well as my mindset) changed forever.

In Jim's basement was a lab set up for learning. He had everything he needed to make the point come to life that he boasted about in class earlier in the week. You see, the basis for the aforementioned class was, again, not about how to diagnose a specific vehicle, but how to approach any vehicle. This all stemmed from a thorough understanding of the physics involved in each of the components' operation and theory behind how they all work together in a system. This was the making of the seemingly "crystal ball diagnostics" he spoke about just a few days prior (**Figure 2**).

For instance, the class regarded the ignition system diagnostic approach. He didn't once mention a specific vehicle. He did, however, teach me that any ignition system requires a source of voltage. He then described the ability of a step-up transformer (ignition coil) to store potential energy as it dwells. To do that required the current to flow through the primary windings of the ignition coil. There had to be a switching-device to provide a path to ground, to enable and disable current from through the primary windings. As that switching device ceased current from flowing, all of the potential energy that built up (within the primary coil windings) had to dissipate. It did that in the form of electricity. As long as there was a path for this kinetic energy to flow, we could then measure it with an ignition scope and analyze it, like a doctor views an X-ray.

Where was Jim going with this "A, B, C and Ds"? His point was "A was needed to make B and you certainly can't have D without C…which required B" (**Figure 3**).

There was now a logical path to follow for any vehicle ignition system I would ever encounter:

A= The system's source of the voltage supply

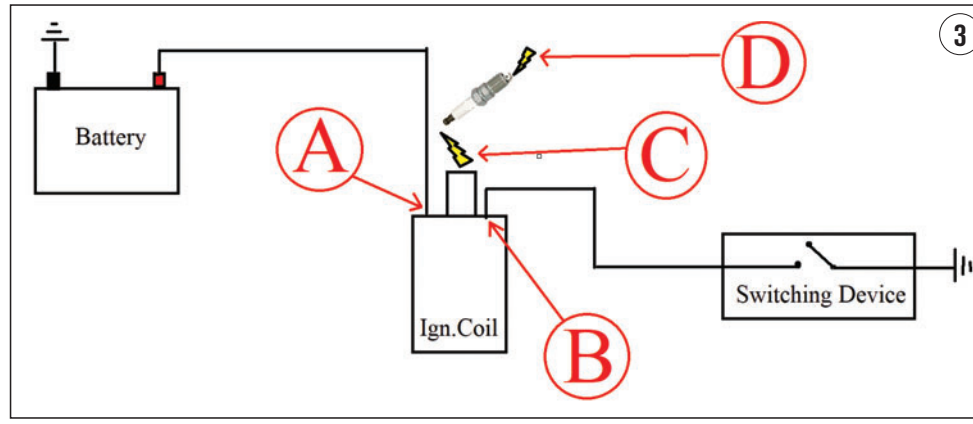
B= The switching device

C= Where the spark originates

D= Where the spark terminates

The very important lesson learned was to wrap my head around the physics. To understand that roughly 85 percent

of the events that occur on the automobile occur on all of them because you simply can't change the laws of physics. The 15 percent is how each manufacturer does it differently. Again, with the ignition system example. Jim's approach was to have a thorough understanding of the diagram drawn in **Figure 3**. But, that is just the 85 percent (how a spark is generated). How each manufacturer controls that series of events is what varies (for example:)




- Distributor with points and condenser and a pole piece
- Optical pick-up
- 2-wire COP
- 3-wire COP
- 4-wire COP
- Waste-Spark/Distributor-less ignition system

The approach is to master the 85 percent, but, know where to find the information pertinent to the 15 percent, when necessary.

## The right tool is always the one you know how to use

As I mentioned in the beginning, I see many monstrosities of toolboxes everywhere I've been. Many of which have the drawers, cabinets and lockers chocked full of expensive tooling. I'd be willing to bet a fair amount of money that many of the tools (purchased with the intent of fixing cars efficiently) are either rarely used at all or at least not to the full potential. What I consider to be a tool that is adequate for diagnostic capability, others may not agree and find the tool inferior. The point is, as long as you use the features of the tool(s) to the best of its capability, not only will get your money's worth, but you will become comfortable with the performance of the tools and develop an expectation of what that tool is going to display when components are functioning correctly and when they are not functioning correctly. Understanding the limitation of any tool or testing technique you choose to implement is crucial to accurate and efficient diagnostics. To develop this sense of trust is dependent on you, the technician, and your dedication of your free time to learn what to anticipate, as well as to push the tools to their limita-


## ASKING THE RIGHT QUESTIONS MEANS FINDING THE RIGHT SCAN TOOL FOR YOU

In order to purchase the right tool for your shop, you have to know what you are is looking for in a scan tool. That means asking questions — a lot of them.

Autel's national sales manager — strategic accounts Chad Schnitz offers a list of potential questions to ask yourself so you can better work with manufacturers to ensure you are buying the best scan tool to fit the needs of your business.

Here are some potential questions Schnitz recommends customers should ask themselves to think through a purchase and not have buyers' remorse.

- What vehicles do I work on?
- Do I currently do J-2534 programming?
- Do I want to do J-2534 programming?
- Do I have a TPMS tool?
- Do I have the need to program keys?
- What is my budget?

Asking the right questions means helping yourself find the right tool for your shop while saving yourself from overpaying for features you potentially wouldn't have used.

*Source: Professional Distributor*

tions. If we don't know what our tools can/cannot do, we won't know to trust the test results or not. This can't be read in a book or learned in the classroom; it has to be experienced firsthand.

To demonstrate what I'm trying to describe, I will use a common DVOM that many of us are familiar with (**Figure 4**). The device boasts a max sample rate of .0250 seconds (250 microseconds). Meaning, it takes a picture (or a sample) 40 times in a second. The functionality of the DVOM is that it averages those samples and will display the product of that rolling average on the display for us to view. We can see by the picture in **Figure 4** that the DVOM is displaying 12.5v. That means the DVOM is seeing a difference in electrical potential (between the red and the black lead) of 12.5v on average.

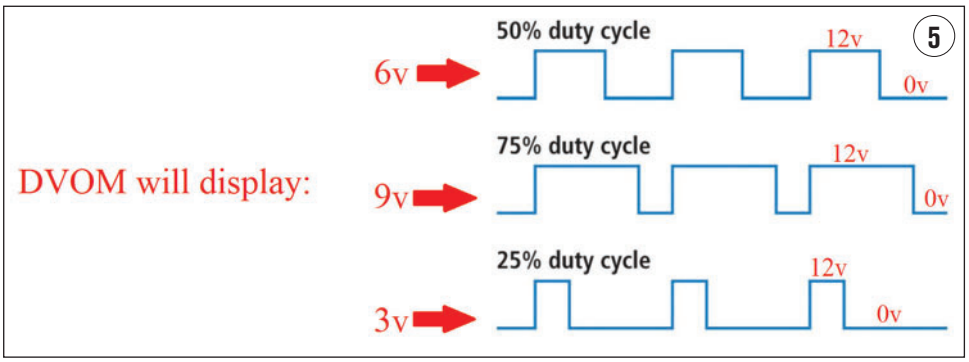
Imagine now that the DVOM is displaying 6v. Considering the functionality of the DVOM, this could be interpreted in a couple of different scenarios:

- There is truly a 6v difference in electrical potential, between the red and the black leads, 100 percent of the time
- There is a 12v difference in electrical potential, between the red and the black leads, 50 percent of the time and no difference between the leads, the other 50 percent of the time.

This is what I was referring to when I suggested finding the limitation of the tool. We can't tell if there is a steady voltage at the point of measure or if there is a signal switching from 0-12v/50 percent duty-cycle. For that, we would have to use a graphing multi-meter/lab scope that will visibly display the changes in voltage, over some time (**Figure 5**).

So, as can be seen to some, this song and dance we refer to as automotive diagnostics may appear to be an art form of sorts or, even magic. For those that are not yet in the know, please don't be discouraged; get inspired:

- Take something away from what you've just read and discover what it is you do not yet know.
- Take the time to experiment with the tools you do own and understand what they can and cannot do.
- Use the service information for pertinent data (like specifications) and read them — not blindly as to simply follow directions, but to understand what it is the Electronic Control Units (ECUs) are expecting to see when evaluating the operation of the systems they control.
- Reach for the wiring diagram before beginning an analysis so that you may anticipate what you should or should not see.




And last, but certainly not least, reach out to your fellow technicians for assistance (whether in the shop or across the world). Chances are great that there is someone out there that has experiences where you do not, and he/she is more than willing to lend a helping hand.

**BRANDON STECKLER** is Techical Editor of *Motor Age*. He is a working tech at Lykon Automotive in Bristol, Pa. He has worked in the field for over 18 years and holds mulitple ASE certifications.
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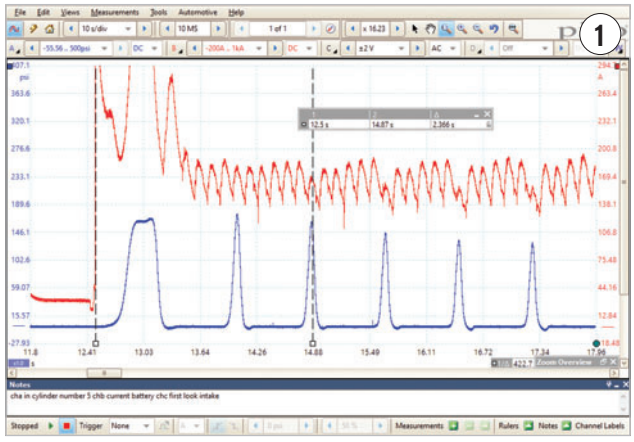
# BACK TO THE DRAWING BOARD

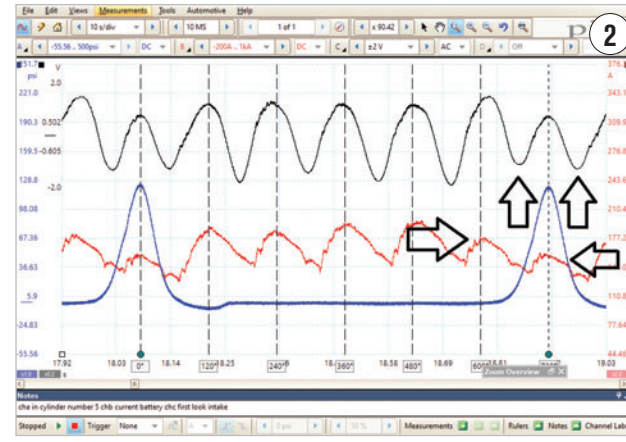
## OWNING UP TO YOUR FAILURES IS ONE OF THE BEST AND WORST WAYS TO LEARN HOW TO NOT MAKE THE SAME MISTAKE

**TIMOTHY JONES** // Contributing Editor

I've frequently seen this inspirational meme that states "Thomas Edison didn't fail to make the light bulb, but rather he found 10,000 ways how not to." When I think about my time as an automotive technician, it is filled with some good times and a lot of real horror stories. A lot of times I am beating my head against a wall because I want to know where I went wrong in my approach. To me, a misdiagnosis has never been a pride battle. To me, a misdiagnosis means I either wasted the customers' money or the team lost money. When that happens, I focus on my diagnostic process and where I failed. However, after all the money is down the drain, there is a silver lining, and that is that I learned something that will help me be


PHOTOS: TIMOTHY JONES





more proficient the next time around. There is a certain breed of technicians out there that strives to be the best in all that they do. If you are sitting reading this article on your lunch break, chances are you and I are quite alike. Most of the time for me it's not about the paycheck. Sometimes it's just about helping others and protecting their best interest. I love this quote, as it's loosely attributed to Aristotle's theological beliefs: "You are what you repeatedly do; therefore, excellence ought to be a habit, not an act." I do strive for excellence in my automotive career, but I often fall short. This article focuses on my responsibilities and failures as a shop foreman and a diagnostician, so you don't go down the same rabbit hole I did.

A 2008 Buick Lucerne with 119,000 miles is new to our shop, and we have no history on the vehicle other than the vehicle was just purchased. The customer reported the check engine light is on and that it is running poorly. Trouble codes were pulled from the vehicle, and a p0300 was present in the engine controller. This initial check out was done by my coworker Josh. We swapped once he ran into a dead end. Right from the get-go, my coworker had told me that this engine had a misfire only at idle. I told him that I highly suspected either an upper end sealing issue was present or a vacuum leak along that cylinder's intake runner. Early on he performed a clear flood crank and heard no cranking cadence issues. We quickly evaluated the engine with a mechanical gauge, and there was no obvious issue that would indicate a mechanical failure other than sometimes the manifold vacuum was low. It didn't exhibit an obvious bouncing needle as a typical valve train problem would. We looked at scan data to look at the fuel trims and we thought we may have found something. At idle the trims were 10 percent. Under load, the fuel trims went to right around 0. On most engines, especially with a fuel metering oxygen sensor on each bank, those trim numbers become less significant. I want to use some basic math here to explain my statement. Take a typical v6 engine where each bank has one upstream oxygen sensor. That means a bank of 3 cylinders makes up 100 percent of fuel control. We can say this another way: each injector makes up 33.33 percent of total fuel control. If you had a no fuel misfire due to a dead injector, for instance, I expect that the fuel trims should be right around 33 percent for the bank with the misfire. This engine is an oddball of sorts for fuel control. It has two oxygen sensors total, one downstream for catalyst monitoring, and one upstream for fuel trim metering for all 6 cylinders. If we do the math again, this engine has 6 cylinders contributing to 100 percent of fuel control. That means that one injector contributes to about 17 percent total trim. We get that number by taking 100 divided by 6. If I had a vacuum leak near one cylinder's intake runner or a partially clogged injector, 10 percent fuel trim can indicate a problem. Based on the trim numbers I had on this vehicle a smoke test and possibly an injector balance test may have been needed. Unfortunately for me, the fuel trims were just a broken PCV return hose near the intake boot. Once that was fixed the misfire was still present and trims were close to 0. At this point I decided I was going to attack mechanical testing heavily because vacuum leaks and fueling issues had been ruled out.

One of my greatest joys of being in a leadership role is that I get to teach my coworkers what I have learned. I love pushing others to be better, and I also love to learn from my guys on how I can be a better foreman. True leadership, in my opinion, is not based on how good of a technician you are or how experienced you are. Leadership is about your ability to influence those you manage to be their best. In my experience, lacking humility in a leadership role can prove to be unfruitful. For a long time, I struggled with the idea of leadership. My boss, Jason Brennan, saw a leader in me when I didn't believe in myself. I always thought that to be a shop foreman

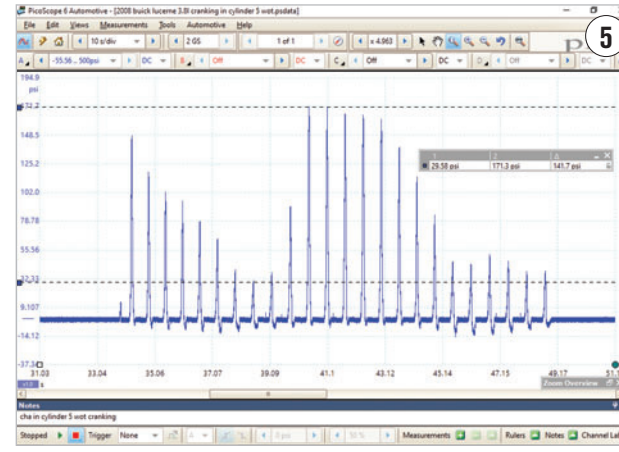
you needed to have an answer for every question brought about in the shop. As I grew as a diagnostician, I realized how incorrect my thinking was. Over the years at Finetune Automotive we have routinely experienced mechanical engine problems. Sometimes I feel like we're a drivability shop because of how much work we get that pertains to it. Everyone in our shop knows what a relative compression test is and what the benefits are. Something I failed to emphasize to my guys is how long to perform this test. Should I crank the engine over for 2 seconds or 15 seconds?

Earlier in the article, I talked about how my coworker performed a clear flood crank to listen to engine cadence. This car would have been diagnosed right then if two things would have been different. The first thing that hindered an accurate diagnosis was the condition of the battery. In this case, the battery was garbage. You couldn't crank this car for any period without the battery dying. The second thing is that I should have emphasized to my team that time is a great contributing factor to getting accurate results via a relative compression check. In this capture (**Figure 1**), we can see that the red trace is starter current fluctuation during a cranking event. Using an inductive current clamp around the battery or starter cable I can see the impact compression has on starter motor current. These voltage fluctuations represent top dead center for each compression event. I also used an in-cylinder pressure transducer as a sync. A sync on a gasoline engine represents an ignition or peak compression event to allow the user to identify which cylinder is which. As we can see, the compression is sometimes there and sometimes not. If we would have performed a clear flood crank with a 10-second crank, we would have heard the lack of compression. The condition of the battery would not allow for this, and I never emphasized that time could prove valuable to accurate testing. Now that we know we have a mechanical problem, let's try to figure out what's going on.

I try to do as little work as possible to determine what the problem is. Sometimes that doesn't work out in my favor. With that in mind, sometimes I'm going to use a couple of different methods to back my hypothesis. I would say I'm still new to vacuum waveform analysis. Typically, I will not back any hypothesis based on one test result. In this circumstance, I used cranking current, vacuum waveform via a homemade first look sensor and an in-cylinder pressure waveform to bring all my data together. There are certain vacuum waveforms that at first glance you can pick out patterns and associate common problems with. I don't recommend relying on patterns to drive your diagnostic path but with that in mind, sometimes the problem can be obvious. In my vacuum waveform capture (**Figure 2**), two cylinders have low compression. The arrows in the capture point to both the low compression and weak intake pulls. Above the two cylinders that have low compression are two vacuum pulls that are not as deep as the others. In my experience, this can likely be a leaking intake valve. The idea is simple enough — when a leak occurs at an intake valve, we have a positive pressure push in the intake manifold as the suspect cylinder approaches top dead center on the compression stroke. The intake valve should start to close shortly after bottom dead center. The amount of compression in a cylinder is primarily a function of when the intake valve closes during the compression stroke. A leaking exhaust valve will not show up in the intake manifold waveform above the suspect cylinder's low compression event. What you likely will see, however, is a deep pull in vacuum after the cylinder's low compression event. This has to do with the speed and rate of change in crankshaft rotation. As you have already seen in the waveform the pulls are not getting deeper after the low compression event. With this vacuum waveform analysis completed, I'm suspecting that the leak is at the intake valve. I want to use another technique to back up my hypothesis to make certain I'm headed in the right direction. I use an in-cylinder running/cranking compression waveform to test my hypothesis, and both of those tests supported a leaking intake valve. However, when using a leak down tester it passed the test on several different occasions. My boss was stumped at how a leaking


valve could pass a leak down test, and I explained to him that dynamic testing is always best to find an intermittent problem. I explained that as the engine rotates, the valves also rotate. As it rotates, it can hit an area of the seat that will not seal, and you have a leak.

We got the approval on this job to do cylinder heads. I thought that the evidence was clear that there was an upper end sealing issue. The job was given to one of my other teammates to do the head job, as I was backed up with other work. He got the heads pulled off, and I wanted to take the valves out of the cylinder that I suspected the intake sealing issue to be present on. I thought I had nailed the diagnosis. **Figure 3** shows that the valve is not sealing on half of the valve seat surface. The seat was also discolored and slightly pitted. We sent both heads to the machine shop and they informed us both heads were cracked near the intake seat and one of them was in need or replacement. The other head was able to be repaired. This built my confidence that we were going to fix this car. Fast forward to a couple of weeks later the engine is back together, and to my horror, it still has an idle only misfire on cylinder 5. My confidence was completely gone. I've had bad machine work before, and I was thinking to myself that the likelihood of a machine shop failing to do 3.8l heads is slim to none. Well, I wasn't wrong; they didn't do anything incorrectly — I had overlooked something big. I restarted the diagnosis and did all the tests again and then some more. I shared my captures with my colleague, Pedro De La Torre. Pedro agreed that I had diagnosed it correctly and that there is, in fact, an intake valve leaking. What did I miss? My boss is losing confidence in my diagnosis. I really had to convince him that we had to take the heads back off. A job no one wants to do for the second time. The heads came back off and went back to the machine shop and they checked OK. At this point, I think most of my hair fell out. I went over to the torn apart engine and we took the lifters out and inspected the camshaft. This is something I should have been aware of, but this was the first time I had seen this problem. On the 3.8l platform when the intake gaskets go bad, they leak coolant onto the cam lobes and destroy the cam. I've known this for years, but I didn't suspect this to be the problem. In my experience, usually it results in an intake path restriction or an exhaust path restriction when the lobe gets wiped out. In this situation, we have a leak present, not wiped out lobes. **Figure 4** shows the bottom of the lifter roller. It may be hard to see from the picture, but the roller is out of round and loose. We put our thinking caps on and worked together at the shop to understand how this can cause a leak. To understand this, we need to talk about the lifter design.




The hydraulic lash adjuster has been around since the 1930s when General Motors used them in a Cadillac engine. As we have all experienced, they're in almost all modern engines. This alleviates the need to adjust valve lash as maintenance. The lash adjuster is fed oil through the bore of the lifter via the oil gallery. This oil pumps up the pushrod seat. As oil enters the lifter body a hydraulic cushion is formed. This cushion takes up the slack in the valve train to maintain zero lash. A flat spot or faulty roller bearing will contact the lobe as the engine rotates. When this happens, momentarily lash is created in the system. Then the cushion expands via hydraulic filling to take up the clearance. As the engine continues to rotate and the flat spot loses contact with the lobe, lift is added back into the system. This extra lift that is added holds the valve open until oil can bleed back out of the lifter through spring pressure. Looking at the in-cylinder capture in **Figure 5**, while cranking the engine clearly shows how cyclical the pattern becomes. This pattern is not typical of an upper end sealing issue created by pitted valves. I have seen pitted valves, and it is best illustrated by a high low, high low compression peak. As I look back over this scenario, I learned a lot. It is through our failures that we should reflect and grow. Up until that day I had never experienced this exact scenario. What I hope that you all take from this article is a couple of things: crank the engine over for a long time, always inspect the camshaft, be open to being wrong, and have the courage to tell your misfortunes to help others.

**TIMOTHY JONES** has been in the automotive business for seven years. He currently holds a Master ASE certification including A9 and considers himself a humble technician that embraces continuous education, helping others, with the goal to become an instructor in the near future.
*tim@finetuneauto.com*

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# AD INDEX

## AD INDEX



## PRODUCTS

## TRAINING


# WHY WATER PUMPS DIE

## THERE ARE A NUMBER OF REASONS WATER PUMPS EVENTUALLY FAIL AND REQUIRE REPLACEMENT — AND CORRECTING THOSE UNDERLYING CAUSES IS KEY TO A SUCCESSFUL REPAIR

**PETE MEIER** // Director of Training

Water pumps, like nearly every other component on the engine, are highly sophisticated precision instruments. They are mated to the needs of the engine, both in terms of heat regulation and efficiency. As we've shared numerous times, it is always ultimately about emissions and fuel economy, and on today's engines, it's all about doing more with less.

If the vehicle — and particularly the engine — is properly inspected and serviced, the water pump should last the life of the vehicle. Unfortunately, that rarely occurs and problems occurring in other subsystems can directly impact the water pump's lifespan. For example, worn accessory drive components can lead to excess heat that may be transferred to the water pump's impeller shaft, bearing and seal. Coolant that isn't properly maintained becomes acidic and that begins to eat away to the impeller shaft and bearing assembly.

These underlying conditions need to be identified and corrected as part of the complete repair. Failing to do so will certainly shorten the lifespan of the replacement part, and all too often we blame the part rather than our process. In this edition of The Trainer, I'll show you why pumps fail and what you can do to insure your replacement pump has a fighting chance at living a long and happy life!

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