Aug 2014 V1 N1

PERFORMANCE TECHNICIAN

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STEP-BY-STEP

FLAT-TAPPET OILS
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STARTING LINE

(WHAT'S) UNDER THE HOOD

You may have noticed that ***HOT ROD Professional*** has morphed into ***Performance Technician***. What does that mean? Initially, it means a renewed commitment to a wider variety of performance-related topics of interest to you, our tech-savvy readers.

Vehicle technology, systems relationship management, and control are redefining the evolving parameters of power and performance. Creating power and controlling the transfer of power from the engine to the ground requires the correct tools, an understanding of component capabilities, and an extremely good sense of the balance among vehicle systems. The consequences of not "getting it right" can be profound, devastating, and expensive. In addition to subject matter that is just plain fun to read, we will attempt to provide you with the product and procedural knowledge that we hope will help you to make the right choices.

Research tells us that as a working tech, part of your customer base may be interested in power enhancements; or you may have an interest just because it fits with your "weekend warrior" activities. In either case, we'll deliver a diet of articles and information that we hope will satisfy your level of interest and curiosity.

You also told us, however, that you are faced with "performance"-related diagnostic and repair issue every day on the job. The OEMs are particularly sensitive to some of the more recent definitions of performance that include the efficient operations of inter-dependant vehicle systems. So expect to see articles from (among other sources) the OEMs on the ***PT*** website that provide their recommendations for proper diagnostic/repair procedures.

We intend to cater to readers who have a deep understanding of vehicle systems, including electronic engine management, internal combustion principles, EFI, ignition systems, emissions controls, brakes, etc.

Which brings us to execution. As the old song says, "Nobody does it better." Our staff is led by a pair of seasoned veterans: Editor, Bob Freudenberger, and Executive Technical Editor, Greg McConiga.

Bob is one of the most experienced mechanical minds in this business. He commands an intuitive understanding of vehicle power and performance that he began honing as a youngster, when his imagination was occupied with cramming big OHV V8s in '53 Chevy and '54 Ford coupes, and doing some strange things such as powering VW Beetles with two-stroke outboard engines. His instincts only became sharper with 40+ years of experience. Bob, therefore, has an innate appreciation for what is fluff and what is real meat, and manages the flow of information that makes it to these pages. We are fortunate that he is willing to put his knowledge and experience on the table to ensure the success of ***Performance Technician***.

Greg decided that after intensive training in the sciences and technology (including metallurgy) and five years as a nuclear sub engineer for the U.S. Navy, he was far more interested in working on cars than in patrolling under ice caps. So, he became an auto tech, service manager, and an engine

builder for a drag racing team. That led to a very successful business of building high-performance street and track engines for professional racers and weekend warriors alike. The fact that he's also one of the most honorable people I've ever met, and an excellent writer with a flair for humor and irony is a blessing for all of us.

We also are fortunate to have a number of contributors who give us guidance and content in specialized areas of power and performance. We will be posting bios on the ***PT*** site in the very near future.

What's the takeaway? Just that ***Performance Technician*** will take the best of what we created in ***HRP*** and give it a boost. Between ***Performance Technician*** magazine and host website, you'll see some highly-technical content, a regular diet of technical repair information for imports and domestics, training info, and some general interest items you told us you would like to see. We welcome your suggestions, so please feel free to contact me via email, phone, or the "contact us" form on this site. ■

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FLAT TAPPET OILS & ADDITIVES

-Frank Walker

The plain rocker/lifters in this Honda Si engine don't have rollers to cut friction, either.

In spite of the wholesale O.E. switch to roller lifters that started a couple of decades ago, if you've got a vintage rod chances are it has flat tappets, and maybe you don't want to go to the trouble and expense to retrofit to rollers. Plus, some racing venues only allow flat tappets. These operate at higher temperature and pressure levels at the lobe/lifter interface than rollers do, so require greater wear protection. The primary anti-wear additive for flat tappet camshafts and lifters is ZDDP (zinc dialkyl dithiophosphate), but that's been phased out of ordinary motor oils mostly because of fears that it'll foul the cat. Racing oil and additives provide zinc in adequate quantity to provide the protection you need to prevent catastrophic lobe and lifter wear.

Lubricant requirements of racing engines differ from those of street machines in many key ways. Compared to the latter, race engines operate at higher rpm and temperature levels, and have more aggressive cam grinds and higher-pressure valve springs, which necessitate more anti-wear additives. Also, race cars typically don't have emissions controls, and they have far shorter oil drain intervals, so there is less need for detergents, dispersants, and acid neutralizers, which can sometimes conflict with wear protection and friction modifiers.

Flat tappet cams operate in a terrifically high-pressure environment where metal-to-metal contact is apt to occur. While we're not going to try to make you a tribologist or lubrication engineer, there are some basics you should know. First, there's hydrodynamic lubrication as you'd find in, say, a main bearing. During operation, the journal and the bearing surface are separated by an oil film, which is facilitated by a curved wedge-shaped "converging" gap between the two that produces something called hydrodynamic lift. Virtually no wear occurs.

Then there's elastohydrodynamic lubrication (EHD), a much more subtle phenomenon in which the surfaces are separated by a very thin film of fluid. It seems that an oil's viscosity responds to extreme pressure by becoming a semi-solid, so even a microscopic layer can support a load.

Mixed lubrication is where two surfaces are partly separated, but also partly in contact. The thickness of the fluid film is slightly greater than the surface roughness (the high points or peaks are called "asperities"), so there is little actual high point contact, and the asperities themselves can form miniature regions of EHD.

OUT OF BOUNDS

Which brings us to boundary lubrication, the basic topic of this discussion. This occurs when the lubricating film is about the same thickness as the roughness of the two surfaces (RMS), so that the high points actually make contact. It should be obvious that this isn't a good situation, but under the incredible pressures between a flat tappet and a cam lobe, it happens.

To avoid immediate mutual destruction, oil additives that provide a different form of lubrication have been developed. These have long polar molecules that attach to the wear surfaces -- one expert describes them as a "molecular shag carpet." This is what boundary lubrication is all about, and the only thing that ultimately protects cam lobe and lifter surfaces from scraping against each other and causing instant catastrophic wear. These molecules keep the metal surfaces apart. They rub against each other, and are considered sacrificial.

These helpful oil additives must bond to the metal and remain as a thin film if the oil is squeezed out under extreme pressure. This coating on each of the two metal surfaces then grinds against itself, acting as a shield for the moving parts.

TOUGHER AT THE TOP

Under normal operating conditions, the bottom and sides of a flat tappet cam lobe are protected by a mixed film. Oil through the galleries, running down from the rockers, and just generally splashed around keep the lobes and lifters lubed. With stock cams and springs, the mixed film combo may remain intact.

As the lifter rises up the ramps and reaches the nose of the lobe, the force of the compressed valve spring pushes the lifter against the lobe at pressures that might sometimes be high enough to squeeze any oil out from between the two metal surfaces.

This creates a boundary lube condition in which there is no longer any actual liquid oil present to keep the lobe and lifter surfaces from scraping against each other as the cam rotates. The asperites tear into each other, break off, and presto – you've got wear. These metallic particles scratch the lobe and lifter surfaces, too, and circulate doing damage wherever they go.

More aggressive cam profiles and higher spring pressures in high-performance and race engines make the load at the top of the cam lobe even more potentially-damaging. To prevent wear as the lobe raises the lifter to its maximum height, engine oil has historically been formulated with zinc and molybdenum

These old Ford Y-Blocks had mushroom lifters. Are you going to put a roller cam in it?

additives that form the needed protective film coating -- the boundary lubrication.

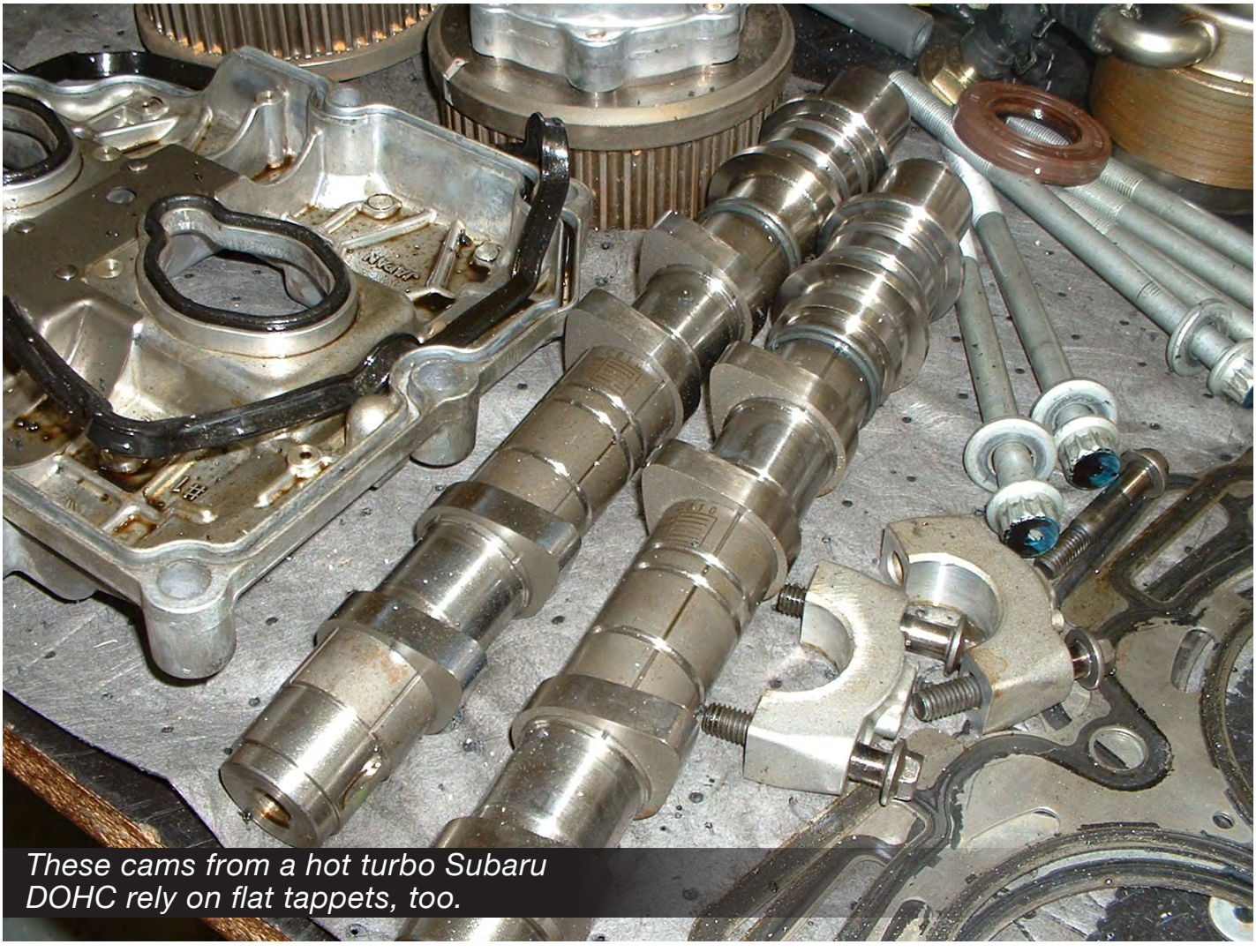
This worked well for many decades, but flat tappet cam wear problems increased dramatically in the 1990s. Technicians originally blamed the higher incidence of wear on “soft” cam lobes and poor lifter quality.

Substandard lifters may indeed have been part of the problem as a result of a rise in imports from manufacturers with lower quality control requirements than those of traditional “Made in U.S.A.” companies. Although the quality of some imported lifters has improved, the old adage “You get what you pay for” applies here, so be careful not to choose lifters based on price alone.

FINDING OUT THE HARD WAY

Meanwhile, research proved cam lobes had not become softer. Instead, flat tappet cam failures increased due to the Environmental Protection Agency-mandated reduction of ZDDP in engine oils, the increase in detergent and dispersant additives, and the shift to lower viscosity motor oils.

Reducing the amount of zinc and phosphate in oil helps prevent plugged catalytic converters. Higher detergent and dispersant levels keep exhaust gas recirculation (EGR) and other emissions-reduction technologies functioning properly. Lower viscosity oil helps meet tougher fuel economy standards.



These cams from a hot turbo Subaru DOHC rely on flat tappets, too.

The new regulations were not usually a problem for street-only vehicles. Most manufacturers had already switched to roller lifters, which create much less friction and don't need the high level of anti-wear protection provided by ZDDP.

For race applications and classic cars, however, it's a different story. To keep racing from becoming a game in which only the deepest pockets reach the winner's circle, NASCAR and many dirt track, circle track, and drag race classes prohibit the use of roller cams and other more expensive engine technologies. Racers cannot easily convert to technologies that work well with low-ZDDP oils.

ZDDP carries both phosphorus and zinc. Lower ZDDP limits mean less protection for engines with flat tappets. We just had to find out the hard way.

TRUST, BUT VERIFY

Some lubricant manufacturers claim that their oils meet current reduced ZDDP specifications without risking harm to flat tappet cam systems. Check for verification of these claims.

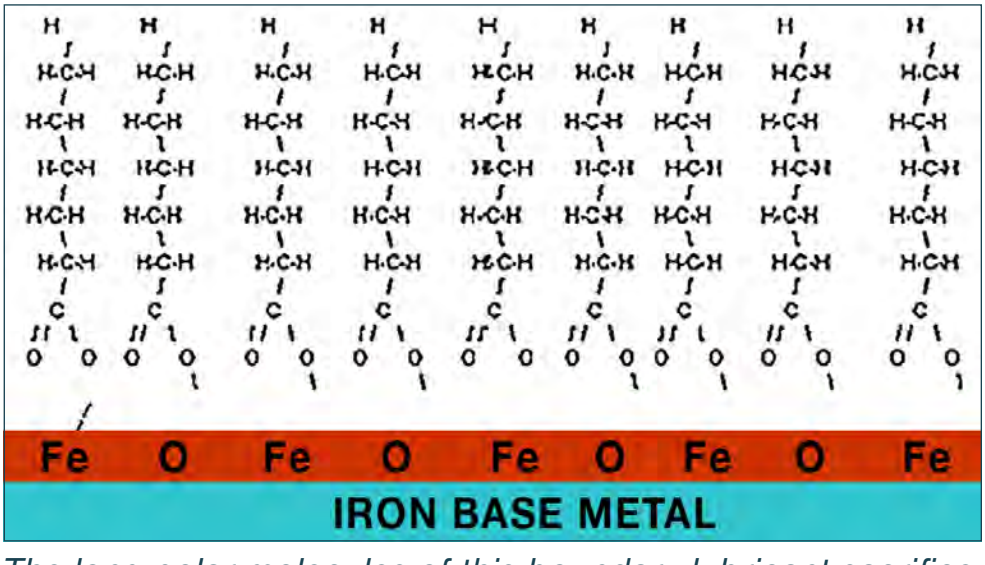
Some are based on tests of systems with mild cam profiles and low spring rates. Even an entry-level "tweaked" engine may require higher wear protection than afforded by these low-ZDDP oils. The good guys publish their levels of ZDDP and other wear additives. Check their websites, or ask to see the tech sheet from your supplier.

ZDDP additive packs are available everywhere, but be careful. Oil is a complex mix of basestock and additives, many of which have conflicting effects.

Engineers include additives in the exact amounts and formulating methods (blending order and temperature, etc.) that extensive testing has determined provide the desired protection for a given application. Off-the-shelf additives that are not recommended by your camshaft manufacturer may alter the balance in ways that negatively affect lubricant performance.

ZDDP IS A "SMART" MOLECULE

Zinc is not really a lubricant until activated by high heat and heavy load. Once activated, the zinc in ZDDP creates the protective film that prevents damaging metal-to-metal contact between the cam lobes and lifters. It works because ZDDP is a friction modifier -- a polar molecule that is attracted to ferrous metals. The polar end "stands" the molecule up on the metal surface to which it adheres.



The long polar molecules of this boundary lubricant sacrifice themselves to shield the parts (courtesy STLE).

How quickly the film forms and how long it protects varies depending on the level of ZDDP and other additives, and the amount of pressure and friction between the surfaces. Some zinc additives require higher heat and load to activate the chemical reactions that cause film formation. Break-in oil should have a rapid zinc activation rate, so it can form the protective film as quickly as possible upon initial startup of a new or rebuilt engine.

Even when most or all of the oil is squeezed out from between the cam lobe and lifter as they slide against each other, the zinc film remains. The film becomes a sacrificial surface layer that minimizes direct contact between the lobe and flat tappet surfaces.

A LITTLE WEAR IS A GOOD THING (REALLY)

New flat tappet cam and lifter pairs have to seat to each other during the initial break-in period in order to ensure smooth operation. This is accomplished by using break-in oil for initial startup. The special additive package in break-in oil provides extra anti-wear protection for the cam and lifter surfaces, while at the same time allowing just enough wear at the piston rings to properly seat them.

Don't think because synthetic oil is great stuff that you should automatically use it as a break-in lubricant for a new or rebuilt engine. While a super-slippery synthetic can protect the cam and lifters, it may not allow the slight amount of wear required for rapid seating of the piston rings.

Many manufacturers combine a mineral oil base with friction modifiers and other additives to create a high-quality break-in lubricant.

Additionally, the traditional seal materials in many pre-1992 engines are not compatible

with synthetic lubricants. The free-flowing nature of a low-viscosity synthetic makes it more likely to find a leak path.

Today, every NASCAR team uses flat tappet cams and lubricates its engines with synthetic oils. However, the synthetics are special formulations with a higher proportion of ZDDP than in API-certified street-use oils.

DETERGENTS AND DISPERSANTS DON'T LIKE ZINC

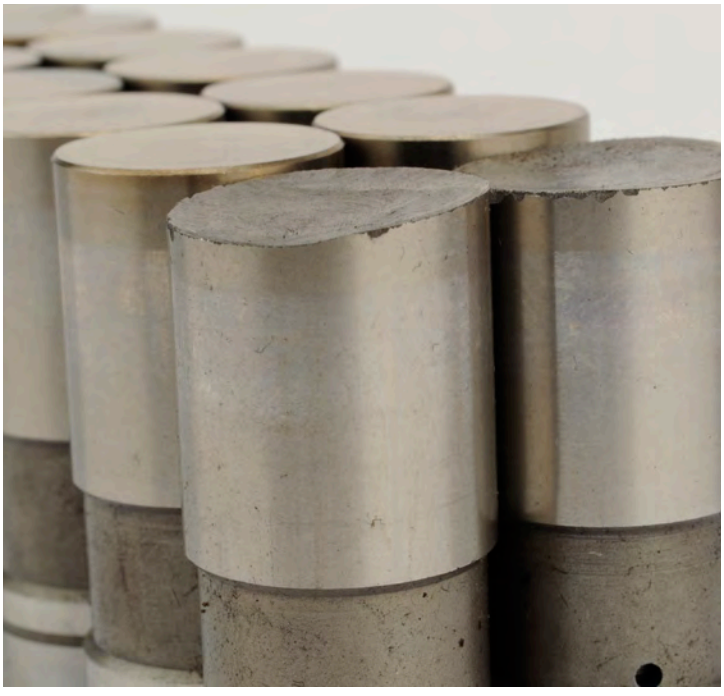
Like zinc, detergent and dispersants are polar molecules, so they compete with ZDDP for ferrous surface area to which they can adhere. They're great for cleaning sludge and varnish, but detergents and dispersants can also clean away zinc.

Unfortunately, oils that meet current API certification for street use contain higher levels of detergent and dispersant to help keep the EGR system, the oil rings, and tiny passages elsewhere in the engine from clogging.

Historically, high-performance engine builders used non-detergent oils for break-in, thus eliminating a potential barrier to activation of the zinc additive in the oil. Today, look for break-in oil that offers anti-wear additives and detergent and dispersant in a balanced formula that won't prevent zinc-film formation.

DIESEL OIL IS NOT WHAT IT USED TO BE

While gasoline-engine lubricant standards were reducing ZDDP beginning as early as the 1990s, oil for diesel applications retained a higher content until 2007 when API reduced the ZDDP level for diesel from 1,500 to 1,200 ppm. For over a decade, some high-performance engine owners swore by diesel as the savior of their cam lobes and flat tappets. Although still higher than the current 800 ppm for passenger cars and light trucks, the lower ZDDP and higher detergent levels have made heavy-duty diesel oils no longer an attractive alternative for use with flat tappet cam systems.



When you lose boundary lubrication with an aggressive cam grind and strong springs, you'll get this...

...and this.

BUILDING TIPS

Keep the following suggestions in mind during an engine build:

- Measure clearances between the lifter body and lifter bore, the camshaft and its bearings, and the engine main and rod bearings. If you hone or otherwise refinish surfaces in used engines, you may open things up enough to reduce hot oil pressure.
- Inspect the camshaft side of the lifter opening in the block. Look for egg-shaped wear on the opening. This allows the lifter bottom to shift off center as it contacts the camshaft lobe. An off-center lifter can scrape or push the oil film out from between the lifter and lobe, causing metal-to-metal contact and premature wear.
- Use a special break-in lubricant for the first startup of the engine after rebuild. Flat tappets rotate in their bores to spread the load around the entire bottom, and help extend the life of the lifter. Designers include a slight crown or convex surface on the lifter foot and a small taper angle on the cam lobe. This crown may measure only in the ten thousandths of an inch, but it is necessary to force the lifter to rotate as the lobe pushes against it. The break-in period helps wear-mate the lifters to their respective cam lobes.
- Pay attention to any lubricant recommendations provided by the manufacturer of your cam and lifters. Use oil designed for your engine type (air-cooled, or water-cooled).
- Don't substitute thicker oil because your uncle told you it worked in the car he took to the dirt track as a teenager. The oil passages in some late-model high-performance engines don't allow the proper flow with thicker oils.
- Don't use lower viscosity oil than recommended in an attempt to lower friction. More often than not, reducing viscosity will increase friction due to higher load at the cam lobe crown causing boundary lube conditions in that area.
- We'll conclude with an interesting note we just got about high-performance engine building from PT's exec tech editor, Greg McConiga: There is a ton of work going on with micropolishing and high-tech surface preparation systems that reduce the RMS to near zero, which acts to delay boundary lubrication because the peaks are much smaller and therefore less likely to collide under extreme pressure. Surface preparation is one way to reduce extreme wear. ■

What this all boils down to is to go with a brand of high-performance oil you can trust for your application. Read the lit.

TORQUE BENDERS, 2: DETAILED PROCEDURES

-Bob Freudendberger

Last time, we discussed the basic design, failures, and what it takes to freshen up a differential. Here, we're going to get deeply hands-on.

Ford pinion depth shims.

When you've blown a rear and the ring and pinion are destroyed, you'll need new gears, bearings, crush sleeve, gaskets and seals, a way to measure pinion depth and a shim assortment for both depth and backlash/bearing pre-load. To ease pinion depth checking, we have several bearings that we've honed out to make them slip bearings. If you want to lighten the load, you can check your honed bearings against the final press-on bearing with a micrometer to verify that the inner race height is the same. In our experience, they are nearly always within a half-thousandth (.0005 in.). If in doubt of the country of origin, measure to be sure -- some of the off-shore companies don't hold dimensional tolerance worth a damn. If there's a significant difference, just add or subtract shim thickness to compensate for the difference between your slip-fit test bearings and the final pressed version.

Pinion depth is the distance between the centerline of the ring gear and the nose of the pinion; the flat face of the pinion for most applications, but on a Ford nine-inch it's measured from the small nose that fits into the rear pinion pilot or support

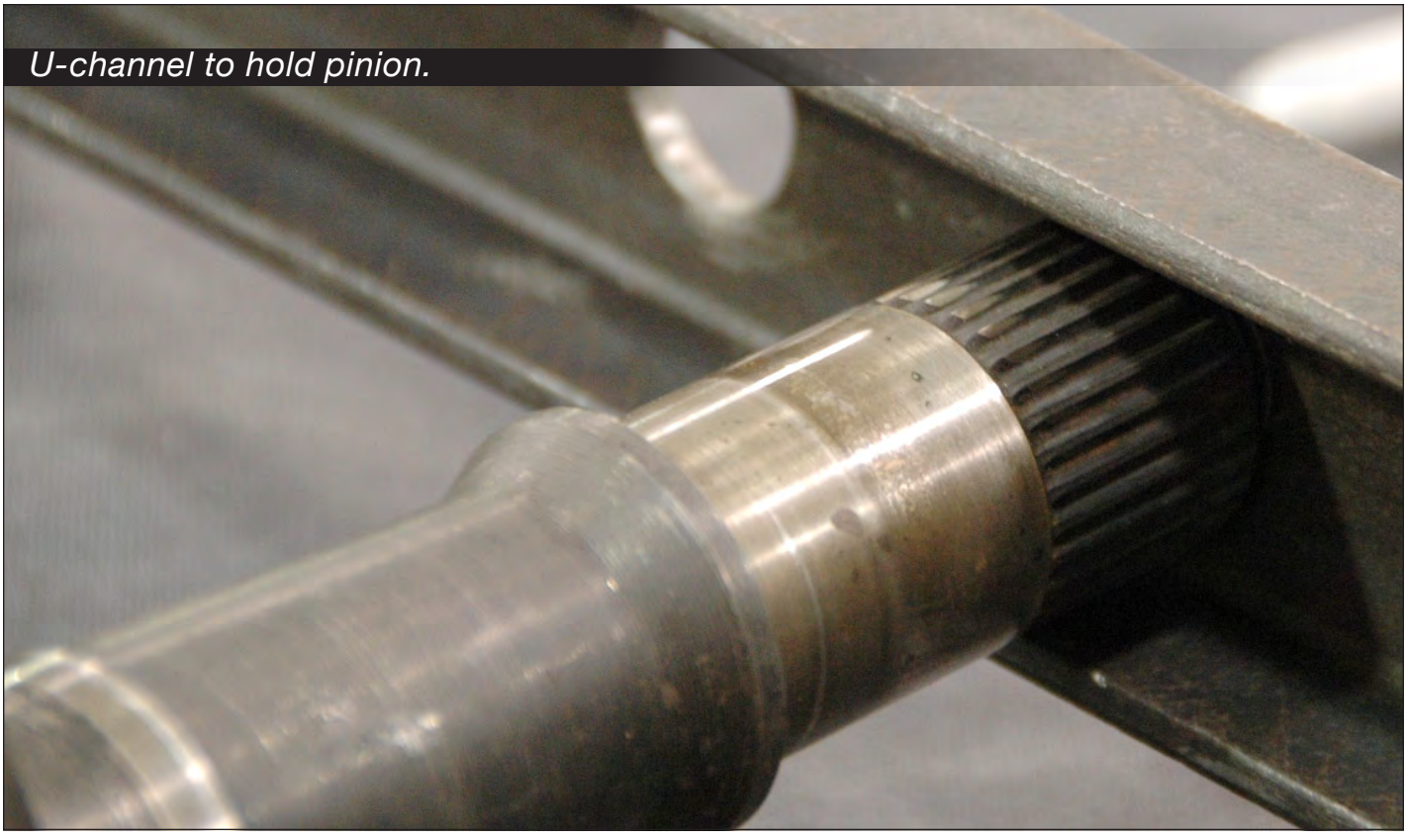
Honed-out bearings.

bearing. Moving the pinion into or out of mesh changes the contact points between the gears, which moves the mesh pattern up and out of the ring gear, or down into root of the gear. Incorrect mesh is noisy and will wear the gear out in short order.

To set pinion depth, install the pinion races and fit the pinion with a depth shim under your slip bearing. We start with the factory shim. You can install the front pinion bearing and flange, or you can do what we do and use a large washer or piece of U-channel across the nose of the housing with an un-staked nut to hold the pinion tightly against its race. The quickest way to find the right shim for the pinion is by measuring the old and new pinion head thicknesses and comparing them. Look, if both are the same thickness, then the same factory shim will be correct.

The shim is used to move the pinion head into or out of mesh. Ideally, you'd like to center the pinion on the center of the ring so that both gears are engaged at their maximum thickness and therefore at the point of maximum strength. Let's face it: Gear cutting is hard on materials and there are tons of opportunities to induce all kinds of stress risers into the parts. The only reason to move off of gear center is because of noise -- in some cases moving the pinion slightly in or out of mesh by a few thousandths is enough to completely change the acoustic characteristics of the gear set. In the bad old days, they used to run the gears in what was known as a Gleason machine to determine the ideal pinion depth, which was then marked on the pinion face. We can only assume they still do something similar.

If you think it through, the housing that everything bolts into is unchanged if it's



U-channel to hold pinion.

undamaged. The bearings are precision, or should be, because there's no way a bearing maker knows what application the bearing is going into. If bearings DID vary a significant amount, then every machine or shaft that used a bearing would have to be rebuilt or redesigned every time a bearing failed! So, you SHOULD be able to duplicate the original setup and get the same result, with the following exception: If the housing is unchanged and the bearings are all identical, then the only thing that can change is the type of cut used to make the ring gear and the thickness of the pinion head from where the bearing mounts to the top of the head. Let's say that the new pinion head is .005 in. thinner than the old pinion head. That means that from the centerline of the pinion gear to each end of the pinion it's .0025 in. less. So, the new pinion will need to be moved .0025 in. deeper into mesh in order to put the new pinion centerline

Filing the ring.

back where the old pinion centerline was.

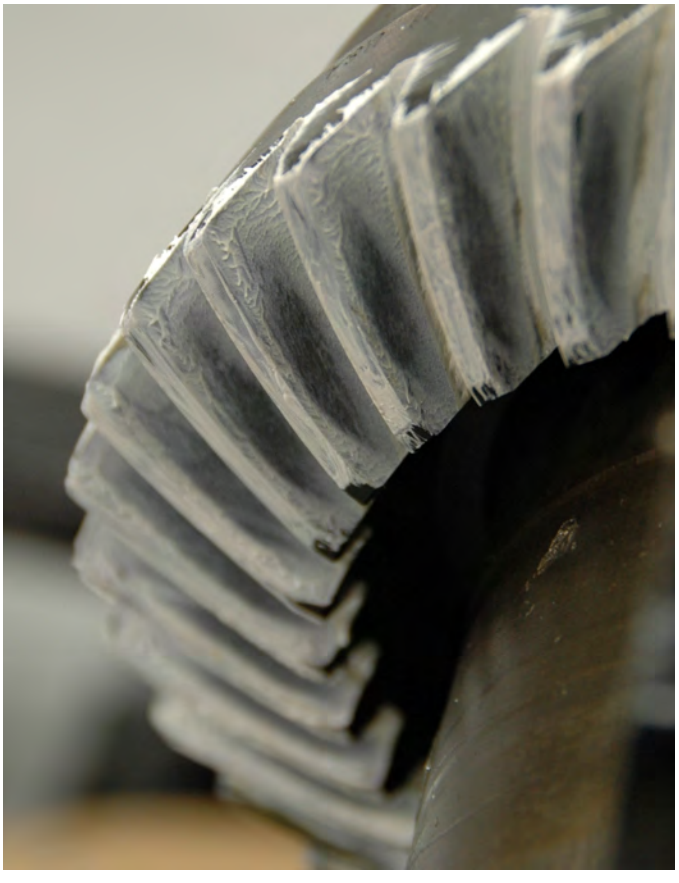
Then set up your pinion depth checking tool and verify that the checking height is correct. Install the pinion with the press bearings and set the preload and recheck depth and you're done with the pinion.

Installing a new ring on the carrier requires a few extra steps. Using a large file, draw-file

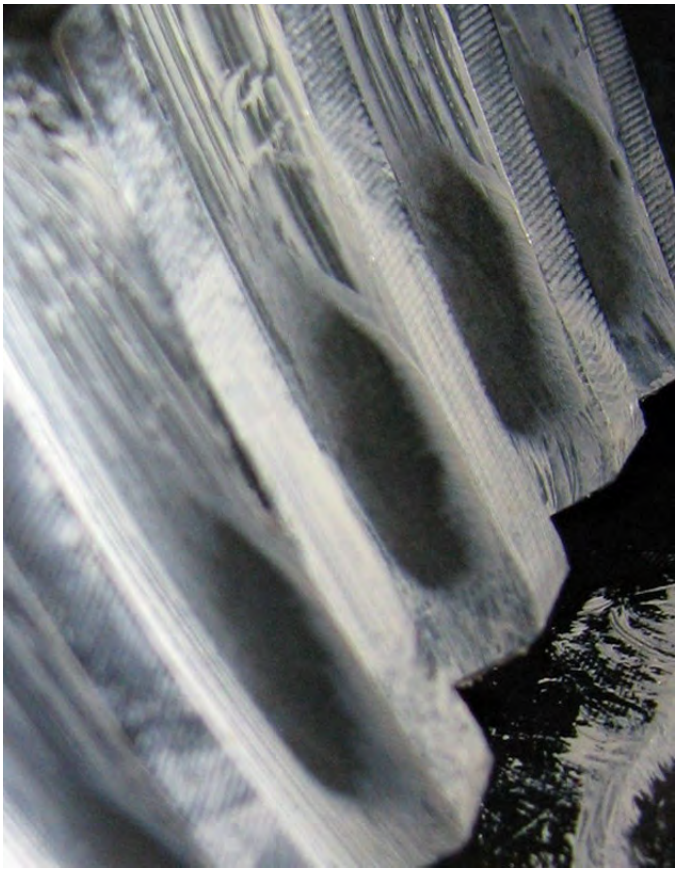
the back of the ring to remove any burrs or imperfections. Lightly file the carrier mounting flange, and then solvent wash both and air dry. We've made a set of studs for the ring gear that we use to align the bolt holes as we sit the ring down over the carrier. Using Loctite prep, we clean the holes and bolts and install and torque the bolts in a criss-cross pattern with red Loctite on the threads (Yes, even if the bolts use a lock washer. Don't ask us why we know this is important. It involves some very expensive parts that got converted to scrap).

A bad coast pattern.

Press the carrier bearings onto the carrier, install the carrier into the housing with the factory shims, check how far off you are on backlash and move shim out of one side and into the other until backlash comes into specification. You should move about 1.5 times the backlash needed in shims. For example, if you're trying to add an additional .004 in. backlash, move a .006 in. shim from the non-pinion side of the carrier to the pinion side. You have to move the ring gear away from the pinion centerline to increase lash and toward the pinion centerline to decrease lash. The actual amount of shim you have to move varies with ring gear size and ratio, but one and a half times will get you in the



Now, a good coast pattern...



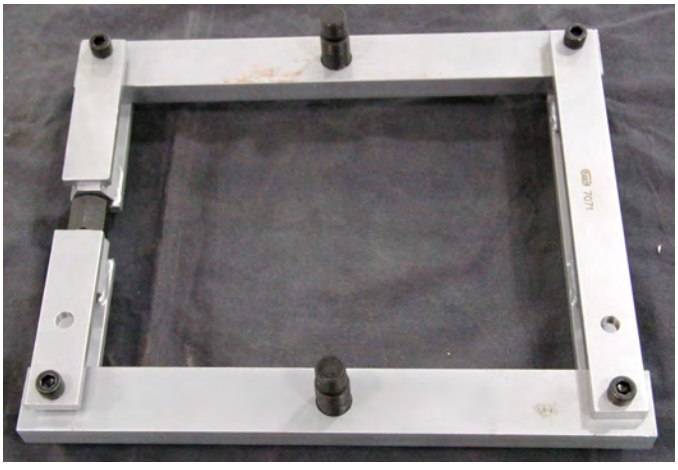
...and a good drive pattern.

ballpark. Oh, and don't just take out .006 in. -- you have to move it from one side to the other to maintain carrier bearing preload. Remember what we said about preload: It is critical with highly-loaded assemblies. The higher the mechanical forces exerted on the assembly the higher the preload has to be to account for distortion or movement.

Finally, ALWAYS check your work with marking compound. Paint four or five teeth on both the drive and coast side, hold the pinion flange with channel locks, or twist a rag around the input to create load, and using a wrench on the head of the ring gear mounting bolts turn the ring against the pinion in both the drive and coast directions. The reason you load up the pinion is to apply pressure between the gears so that the gear marking compound will be squeezed out showing a clear pattern. Compare your results with the pictures supplied by the gear manufacturer and if everything looks good button it up and take it for a test drive.

RANDOM FACTOIDS

- Case spreaders make life much easier when installing side bearing shims. If you have to pound the side shims and carrier races in, use brass or lead. Brass and lead will pass through the gears without damaging them.
- Drive pinions and ring gears come in right-hand and left-hand configurations, and a gear set comprises one right-hand gear and one left-hand gear. Place the gears on a table and you'll see that the gear teeth cant up and down. Look for the gear tip that's lowest -- which of your hands is it on? The low gear tooth closest to your left hand or right hand determines the gear's "handedness." See the accompanying photos to clarify.
- You can rough in carrier bearing preload by subtracting the pinion bearing pre-load from the total assembly turning torque. I'd expect to see something in the 30-40 inch-pound range for the complete assembly with new bearings, without axles.
- Measure and record things as you take them apart. Measure the old pinion bearing inner race, the old carrier bearing inner race, the carrier and pinion shims, and distance from the cap mounting surface to the pinion head. If old bearing dimensions and new are the same, it'll go together just like it was and you can confirm it with the pinion measurement.
- New gear sets are pre-lapped, but nearly all come with lubrication and break-in recommendations. Follow them.
- Pinion depth shims can either go under the rear pinion race, or on the pinion shaft under the rear pinion bearing. The Ford nine-inch uses a variable thickness shim under the pinion carrier assembly.
- Bearing pre-load can be set by crush sleeve or by shim. You can also use a crush sleeve elimination kit to convert a crush-sleeve application to a shim application for high-performance work.
- Backlash and carrier bearing pre-load



A case spreader sure makes things easier.


HE'S BUILDING
HIS BUSINESS
ONE PANT LEG
AT A TIME.
Greg Adler
CEO / 4 Wheel Parts
In business, impressions are formed in a matter of seconds, usually based on a person's overall appearance. With 64 stores nationwide, Greg Adler understands the importance of making the right first impression and does not leave it to chance. That is why he turns to Red Kap to dress his team for success.
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can be set by shim or by adjusting nuts. Shims can be placed under the bearings or under the races. Some Fords use an adjusting nut with holes drilled in it to accept a spanner, and some Chryslers use a nut with a hex in the middle of it. There's a special tool to reach down the axle tube to engage the hex on a Chrysler. Oil the adjusting nut threads and make your last adjustment on the pinion side nut to set backlash and pre-load at the same time. We try to get about two-thirds of the backlash before the final adjustment, and gather up the last third we need while we preload the bearings by tightening the pinion side nut.

- When crushing a crush sleeve, move slowly and with intent. It'll go from no pre-load to locked-up in no time flat. You can use an impact, but it'll take finesse. Short bursts are the safest way to go with an impact. Remember, you can damage a bearing with an impact. We've got a big flange-holding tool and a four-foot break-over bar in ¾ in. we like to use. If you over crush it, you'll need a new sleeve. Go with 12-18 in. lbs. of pre-load on used bearings, and 25-30 in. lbs. with new bearings.
- Check backlash at six or seven points around the ring gear. Adjust the tightest point to specification.
- Make sure everything is clean and dry for assembly. Dirt on the shims can make the pre-load settings read correctly on assembly only to have it go away when the dirt crushes or washes out. Lose the preload, and bearings quickly fail.
- Don't pattern check a gear until the backlash is set. Take a look at the differences between the patterns made by two cut and five cut gears. A two cut, or face-hobbed gear pattern is slightly different than a five cut, or face-milled ring gear. The patterns will look largely the same, but wider or narrower and will move across the gear face. Look at the top of the gear tooth: if it's uniform in width from end to end it's a two cut and if it tapers from end to end it's a five cut. Then make sure to use the correct pattern chart because it may appear that you are too far in mesh with one cut and out of mesh on the other. Know your gear and your patterns. A pattern that's centered between the root and top of the tooth is usually correct so long as the ends of the pattern on both the drive and coast sides resemble a round nosed bullet. We've also found it's easier for us to judge the coast side of the pattern. ■

This is a left-hand pinion.

DETERMINE PINION DEPTH USING MASTER HOUSING DEPTH DIMENSIONS

Determining pinion depth on pinions that are not marked can be done using the Master Housing Depth Dimension and a pinion depth setting tool. Refer to the drawing to see how to determine your initial settings. We've included as many MHD dimensions as we were able to find. Where bolt counts are mentioned, they refer to the number of bolts attaching the ring to the carrier. Ring gears are measured face-up across the teeth, outside edge of tooth to outside edge of tooth. Just do the following:

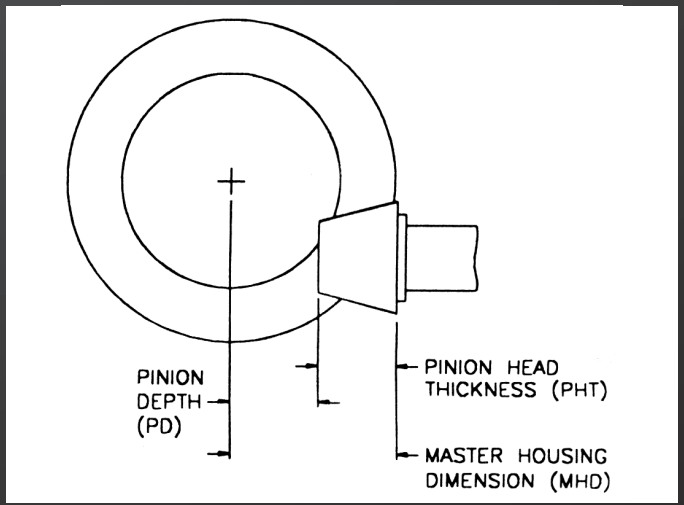
1. Measure the pinion head thickness (from the top of the head to the bearing mounting surface.)
2. Subtract your measurement from the Master Housing Dimension.
3. The result is the pinion depth.

We've tried this method several times with very good results. In fact, if you have a marked ring and pinion, try measuring the head thickness and subtracting it from the MHD and see if the result is the same as the markings on the pinion for depth. So far, every one we've measured has been the same. Remember, your final quality check has to be done with gear marking compound. ■

GENERAL MOTORS

10 Bolt Differentials

- 7.2 inch 3.693 MHD
- 7.5 inch 3.787 MHD
- 8.2 inch by 25 spline pinion 4.175 MHD
- 8.2 inch by 27 spline pinion 4.175 MHD
- 8.2 inch by thin 55-64 Corvette 4.125 MHD
- 8.5 inch by 30 spline pinion 4.262 MHD
- 8.5 inch by 27 spline pinion 4.262 MHD
- 1955-1965 10 bolt 4.125 MHD
- 1957-1964 Olds and Pontiac 4.620 MHD



12 Bolt Differentials

- Corvette and 4WD Chevy trucks
- 3.9 ratio and higher 4.575 MHD
- 3.7 ration and lower 4.565 MHD
- 8.875 inch by 1.438 pinion diameter 4.556 MHD
- 8.875 inch by 1.625 pinion diameter 4.670 MHD
- 9.3 inch 4.620 MHD

CHRYSLER

- 10 bolt 8.250 inch 4.124 MHD
- 10 bolt 8.750 inch by 1.750 pinion stem 4.350 MHD
- 12 bolt 8.750 inch by 1.875 pinion stem 4.344 MHD
- 12 bolt 9.250 inch 4.625 MHD

FORD

- 6.625 inch 3.500 MHD
- 7.5 inch 4.040 MHD
- 8.0 inch 4.000 MHD
- 8-bolt Pinto 3.450 MHD
- 8.8 inch 4.415 MHD
- 9.0 inch 4.375 MHD

AMC

- 8 bolt 8.875 inch 4.500 MHD

DANA

- Dana 30 3.625 MHD
- Dana 36 3.391 MHD
- Dana 44 4.312 MHD
- Dana 50 4.616 MHD
- Dana 60 5.000 MHD
- Dana 70 5.375 MHD

Pinion Depth for Dana Rear Axles (PINION DEPTH, not Master Housing Dimension)

- Dana 27 2.094
- Dana 40 2.625
- Dana 53 2.500
- Dana 70 3.500

VACUUM READINGS FOR TUNING AND DIAGNOSIS

-Henry P. Olsen

Once you learn to properly interpret its readings, a vacuum gauge can be one of the most useful tools in your toolbox.

Some people consider the vacuum gauge a lowly instrument that might have been part of a DYI tune-up kit decades ago. Think about it for a minute, though, and you'll realize how basic and important the info it gives you really is.

Some people consider the vacuum gauge a lowly instrument that might have been part of a DYI tune-up kit decades ago. Think about it for a minute, though, and you'll realize how basic and important the info it gives you really is.

A vacuum gauge may be one of the most powerful diagnostic tools in your toolbox because it shows you the actual vacuum produced as the pistons draw air into the cylinders. The readings that you can see can help you diagnosis many engine problems such as vacuum leaks, sticking or burned valves, flat camshaft lobes, weak valve springs, leaky piston rings or head gaskets, worn valve guides, and a restricted exhaust system. The readings can also help in tuning the ignition spark timing and the air/fuel mixture.

The vacuum produced by an engine as it is powering a vehicle down the road is a very good indicator of the operating load conditions. A typical engine should produce 17 to 21 in. Hg (inches of mercury) of vacuum during light load, but this will drop below 5 in. Hg when it is operating at high-load conditions such as wide-open throttle acceleration, or pulling a trailer up a steep grade.

The normal vacuum reading of a properly-tuned engine with a stock/mild cam is in the 15 to 21 in. Hg range at idle speed or faster with the engine unloaded. When the engine is accelerated under load, the vacuum should drop to near zero then slowly rise up as engine rpm increases. During decel, the vacuum may rise to 25 in. Hg inches or higher. An engine with a high-performance cam will have a lower vacuum reading at idle, but it should be close to that of a stock engine at higher engine speeds.

A stock engine with worn piston rings will have a slightly lower vacuum reading at idle, plus the vacuum will not get as high on deceleration as in a healthy engine. An engine with “sticky valves” will cause the vacuum gauge to pulse or flicker at low engine speeds. An engine with worn valve guides, burned valves, leaking or poorly-seated valves will cause the needle to move in a regular sweep or pulse of 3 to 8 in. Hg at idle speeds. If the vacuum readings are normal at idle, but begin to pulse or flicker as the engine speed is increased, broken or weak valve springs are most likely the problem.

Low engine vacuum can be the result of a lean air/fuel mixture and/or retarded ignition timing. A lean mix at idle can cause surging, and the reading will slowly sweep up and down. A restricted or plugged exhaust system can cause the vacuum reading to gradually drop as an unloaded engine is sped up.

Vacuum will be at its highest when the ignition timing and air/fuel mixture are tuned for maximum power, but avoid over-advancing the

spark timing because it can lead piston failure from detonation/pinging issues.

The computer of a modern fuel injected engine references the vacuum along with the throttle position, the density of the air and the volume of air, as determined by mass, that the engine is consuming to determine what ignition spark advance setting is needed at any given time. The vacuum signal is used as part of the calculations that determine when the engine needs to be fed a richer air/fuel mixture when operating under high-load conditions.

TUNING TIMING VIA THE GAUGE

The first rule in performance tuning is to tune the ignition system before tuning the air/fuel mixture. Adjusting the ignition timing using a vacuum gauge can be done, but it isn't as simple as it sounds because many older engines have an initial spark timing setting plus both mechanical (rpm) and vacuum spark timing advance systems. The ideal spark timing will cause the pressure in the combustion chamber to be at its maximum when the piston is at approximately 12 deg. after top dead center. The amount of ignition spark advance it takes to get the combustion timed correctly varies with the rpm, the air/fuel mixture, the temperature inside the combustion chamber, and cylinder pressure (how full each cylinder is, which will vary by the throttle position).

The initial timing that will cause the engine to create the highest vacuum reading will often also cause it to kick back against the

VACUUM GAUGE PRESSURE TESTER KIT INSTRUCTIONS

CRANKING VACUUM TESTS
Engine Condition Test
1. Start engine and allow it to warm to normal operating temperature. Stop engine. To prevent the engine from starting disable the ignition system.
2. Remove the air filter. Back out the idle speed screw (see Figure 1) until the throttle valve is tighly closed. If the carburetor is also equipped with an idle air bleed screw, turn the screw clockwise until it bottoms lightly. In both cases count the number of turns so the screws can be returned to their original positions after the tests
3. If the vehicle is equipped with an idle stop solenoid (See Figure 1), disconnect the electrical wire at the base of the solenoid under the rubber boot or at the connector as shown.
4. If the engine is equipped with a PCV (Positive Crankcase Ventilation) system, remove the PCV valve at the engine rocker arm cover (see Figure Figure2)

Fig. 1

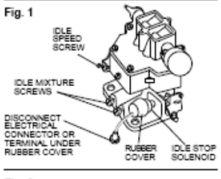
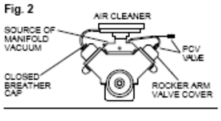
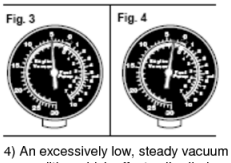


Fig. 2



and plug the valve on the bottom with tape or other suitable means.
5. Using the hose supplied, connect the Vacuum Gauge to a source of manifold vacuum. This may be a fitting on the carburetor below the throttle plate, or a fitting in the intake manifold. See figures 2 and 9.
6. Crank the engine and note Vacuum Gauge reading (After testing, return adjustment screws to their original positions.)
Test Results
The general condition of an engine is indicated by one of three possible gauge readings:
A.(Figure 3) A reasonably steady vacuum reading of 4 inches or more on emission controlled engines, and 10 inches or more on non-emission controlled engines (pre-1968) indicates correct engine vacuum. Readings may vary considerably on different engines, but should not fall below these minimums. (See manufacturer's specifications).

Fig. 3 Fig. 4

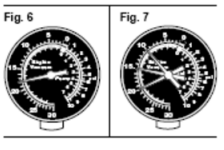


B.(Figure 4) An excessively low, steady vacuum is caused by a condition which affects all cylinders equally. Check for
1. Leaking carburetor flange gasket.
2. Worn carburetor throttle shaft.
3. Leaking vacuum lines.
4. Improper valve timing.
5. Slow engine cranking due to:
A. Battery
B. Battery cable connections
C. Defective starter motor
D. Excessive mechanical drag in engine caused by:
1. Tight fitting pistons in rebuilt engine.
2. Thickened oil due to excessive oxidation.
C.(Figure 5) A reading which pulses unevenly indicates a leaky condition which affects one or more, but not all cylinders.
NOTE: A certain amount of even pulsing is normal, notably on 6 and 4 cylinder engines, and does not necessarily indicate a leaky condition. Check for:
1. Burned or stuck valve.
2. Intake manifold leak at one cylinder.
3. Worn intake valve guide.
4. Broken piston or piston rings.

Fig. 5

RUNNING VACUUM TEST
Engine Condition Test
While performing a running vacuum test, it is possible to obtain a different gauge indication than that obtained under the cranking vacuum test.
1. Connect the vacuum gauge to a source of manifold vacuum. See Figures 2 and 9.
2. Run the engine at normal operating temperature and idle speed.

Fig. 6 Fig. 7



Test Results
A. (Figure 6) A steady reading between 15 and 22 inches indicates a mechanically sound engine.
B. (Figure 7) A pointer which sweeps or wanders erratically through several inches indicates a malfunction affecting all cylinders unequally and inconsistently. To help isolate the troubled area, run the engine at about 2000 RPM. If the
Pointer steadies, check for:
1. Ignition and/or timing.
2. Carburetor mixture adjustment at idle If the sweep gets larger, check for weak or broken valve springs. If the sweep becomes shorter and more rapid, check for:
1. Carburetor or intake manifold leaks.
2. Sticky valves.

Fig. 5 EXHAUST RESTRICTION TEST
With vacuum gauge connected to a source of manifold vacuum, increase engine speed to 2000 RPM, maintain this speed, and note the vacuum gauge reading. A gradually decreasing vacuum reading may indicate a restricted exhaust system. (Partially blocked muffler or tailpipe.)

POSITIVE CRANKCASE VENTILATION (PCV) VALVE TEST
1. Unplug the PCV valve, plugged previously with a piece of tape (Step 4, Cranking Vacuum Tests) and crank engine.
A. If the PCV valve is operating properly, the vacuum will drop to about one-half the value noted in Step 6, Cranking Vacuum Tests.
B. A reading much lower than one-half indicates excessive flow which could upset the prope carburetor air/fuel ratio causing rough idling and burned valves.
C. No change in the vacuum indicates a clogged PCV valve.
2. Return the idle screw (and idle air bleed screw) to its original position. (See Step 2, Cranking Vacuum Tests).
3. Re-enable the ignition system.
4. Re-connect the wire to the idle stop solenoid.
5. Re-connect all hoses and vacuum lines.
6. Re-install the PCV valve in its proper location.

PCV SYSTEM TEST
1. Operate the engine at normal temperature and idle speed.
2. Remove the hose connected between the air cleaner and valve cover or oil filler/breather cap as shown in Figure 8. Plug the oil dipstick tube to prevent an air leak.

This set of instructions that came with one of our vacuum gauges shows a few of the tests it can be used for.

starter during hot engine cranking. Typically, 10 to12 deg. BTDC of initial timing works quite well on an engine with a stock/mild camshaft (duration of the camshaft is less than 220 deg. at 0.050 in. of valve lift), but if the engine has a high-performance grind it may respond well to more initial timing. The initial timing settings we use for an engine with a high-performance camshaft with a duration of less than 240 deg. at 0.050 in. is 14 to 16 deg. BTDC. If the duration is more than 240 deg., but less than 260 deg. at 0.050 in. of valve lift, we use an initial timing setting of 18 to 20 deg. BTDC.

This vacuum gauge is being used to observe what the manifold vacuum is on this 348 Chevy while the automatic transmission is in Drive.

The timing at idle will also vary depending on whether the engine uses ported or manifold vacuum for the vacuum advance system. Many tuners prefer ported vacuum for the vacuum advance because the timing at idle will remain the same regardless of the vacuum level at idle, but some tuners prefer manifold vacuum for the advance system. If you use manifold vacuum for advance, the mechanism should be fully advanced at 2 in. Hg lower than the engine will have at idle (in gear with an automatic transmission). Always remember that the vacuum at idle will also be lower at higher elevations such as during a trip to the mountains.

The method many people use to adjust the timing with a vacuum gauge is to advance or retard the ignition until the highest steady

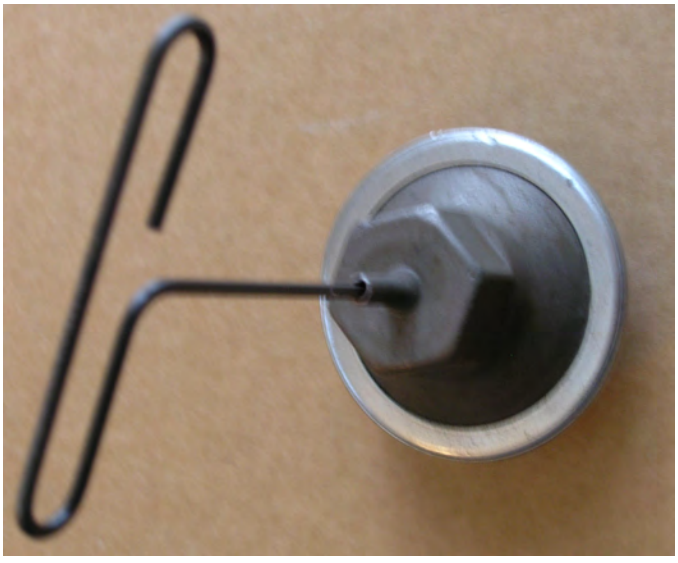
The arrow in this picture points to the bushing that was used to limit the vacuum advance to 10 degrees of spark timing.

vacuum reading is obtained, and then retard the timing until the vacuum gauge reading drops slightly. But remember most carburetor-equipped engines have both mechanical and vacuum advance systems. The mechanical advance is used to provide the amount of spark advance it needs for maximum power, and the vacuum system adds the extra advance an engine needs to burn the leaner air/fuel mixtures encountered at part throttle, thus providing the best fuel economy. In both cases, you may need to retard the timing from the setting that gives you the highest vacuum reading to prevent engine damage from detonation/pinging problems.

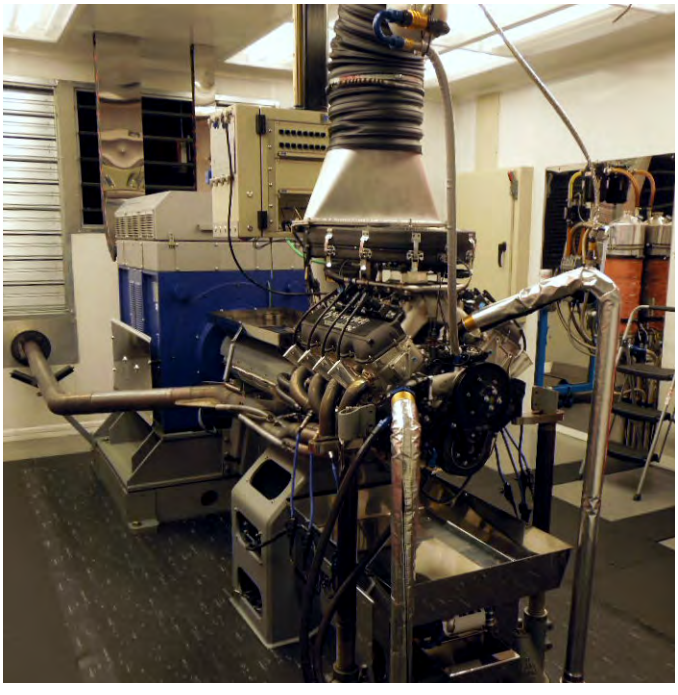
Most vacuum advance units were designed and calibrated for leaded gasoline (which was phased out beginning in 1975). Today's reformulated unleaded gasoline burns somewhat faster, which means that most vacuum advance units supply too much spark advance for modern gas. In order to allow the engine to achieve the ideal peak combustion pressure at the 12 deg. ATDC setting we most often reduce the vacuum-based advance. The amount of advance from most diaphragm can mechanisms is in the 18 deg. range or slightly higher, but most performance tuners limit this to 10 to 12 deg. to avoid engine misfire problems at cruising conditions.

VACUUM & THE AIR/FUEL MIXTURE

With carburetors, the vacuum gauge can be used to adjust the air/fuel mixture for the highest reading, but the resulting air/fuel mixture will be on the rich side of what the engine needs at idle or normal driving conditions. To adjust the idle mixture, you would start by turning each idle mixture screw until the vacuum gauge gives you the highest reading, then adjust the mixture from each screw slightly leaner.

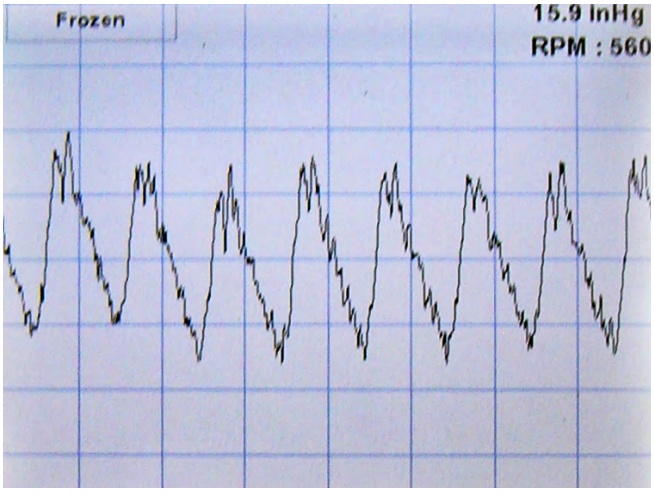


The Allen wrench in this Ford vacuum advance can is used to adjust how much spark timing advance the engine will get from this mechanism.

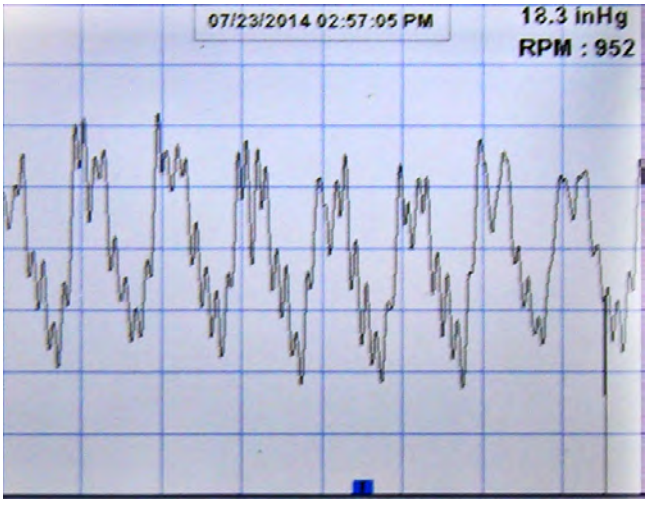


Both the intake manifold vacuum and the air charge temperature readings of this Hendrick Motorsports engine are being monitored on the dyno so tuning can be done to match the conditions of real-world racing. Attention to details such as these is part of the reason the team wins so many NASCAR races.

The vacuum gauge air/fuel mixture tuning method could also be used the tune the cruise- and power-circuit air/fuel mixtures, but the mixture that will cause an engine to create the highest vacuum readings would be a richer setting that is better suited to allowing the engine to make maximum power than it would be for the best fuel mileage and lowest exhaust emissions. The best tool to determine what air/fuel mixture an engine wants is an exhaust gas analyzer because the readings can show the tuner the misfire rate, efficiency, and the air/fuel ratio the engine is burning. Another very valuable tool is a digital air/fuel meter, but the tuner will need to know what air/fuel mixture setting the engine needs for the various operating conditions at which it will most likely be driven.



This digital vacuum waveform screen shot from a Bosch MTS5200 engine analyzer shows a normal vacuum signal waveform of a small-block Chevrolet V8.



This screen shot shows that the vacuum signal the engine is producing has some anomalies. The readings indicate that the engine will need further diagnostic attention.

The vacuum produced at wide-open throttle at peak-power rpm can be used to determine if the air-flow/cfm rating of a carburetor is correct for the needs of an engine. A reading of one in. Hg under those conditions is the most common target. If it is higher, the carburetor may be too small and thus acting as a restriction to the engine's demand. If it is lower than the target the carburetor may be too large causing the air speed through the venturis to be too slow, which can result in the air and fuel not being properly mixed into the vaporized charge that's necessary for the engine to turn it into horsepower!

VACUUM DIAGNOSIS IN THE DIGITAL AGE

The digital age has expanded the diagnostic information that's available from the vacuum signal an engine produces. A technician can now use a modern lab scope with a vacuum module to observe the vacuum signal produced by each cylinder during cranking and while the engine is running. The vacuum waveform that's displayed allows you to view the properties of the intake stroke of each cylinder and thus you will be able to get a look at the internal health of the engine.

The diagnostic tool we are using to observe these vacuum signals is the Bosch MTS5200 engine analyzer. The MTS5200

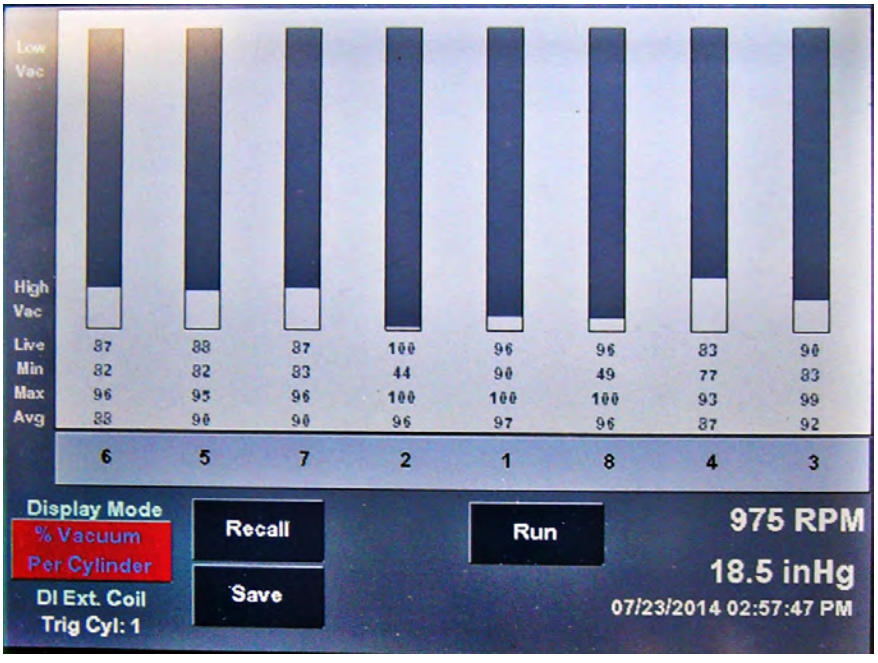
has both ignition scope and digital vacuum waveform functions so the user can perform vacuum, ignition, and cylinder balance tests on individual cylinders. The vacuum signal is synchronized to #1 cylinder so the vacuum waveform display will be listed by the cylinder, thus making it easier to diagnose which one is creating any problems.

The signal should be the same for each cylinder; therefore the waveforms should be almost identical. The display is a picture of each cylinder's vacuum signal so it can identify the culprit, then you can use whatever means of diagnosis you choose to find out what the mechanical or sealing problem is.

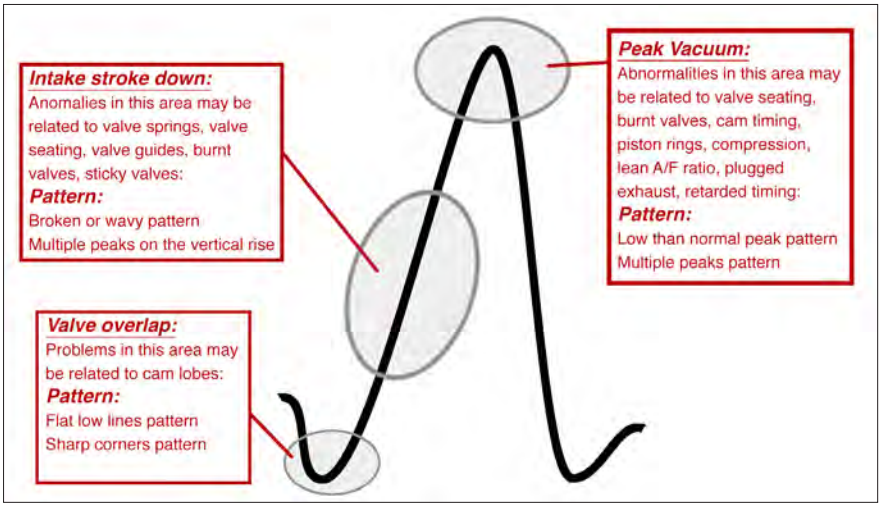
Note: Even if a cylinder has no spark or the air/fuel mixture is not correct for the needs of the engine, it will still produce a “normal” vacuum signal.

Bad vacuum waveforms can be caused by poor piston ring sealing, improper valve opening due to worn camshaft lobes, damaged pushrods, improperly-adjusted rocker arms, poor valve sealing due to weak/damaged valve springs, sticky valves, burned valves, or an intake manifold vacuum leak. The hardest part of this diagnosis is identifying which cylinder is creating an irregular vacuum signal. Next, perform a compression test of the affected cylinder and look for vacuum leaks or mechanical problems that are causing the problem.

Modern diagnostic equipment such as the Bosch MTS5200 engine analyzer as well as the use of a traditional vacuum gauge can make it easier to diagnose mechanical problems with a vintage carburetor-equipped or even a modern fuel-injected engine so it can achieve its full potential power and driveability while avoiding the possible damage that can result from improper tuning.■



This display shows the percentage of vacuum each cylinder of the engine is producing. In this case, cylinder #2 is making very little vacuum.



This illustration shows what a good vacuum waveform should look like.

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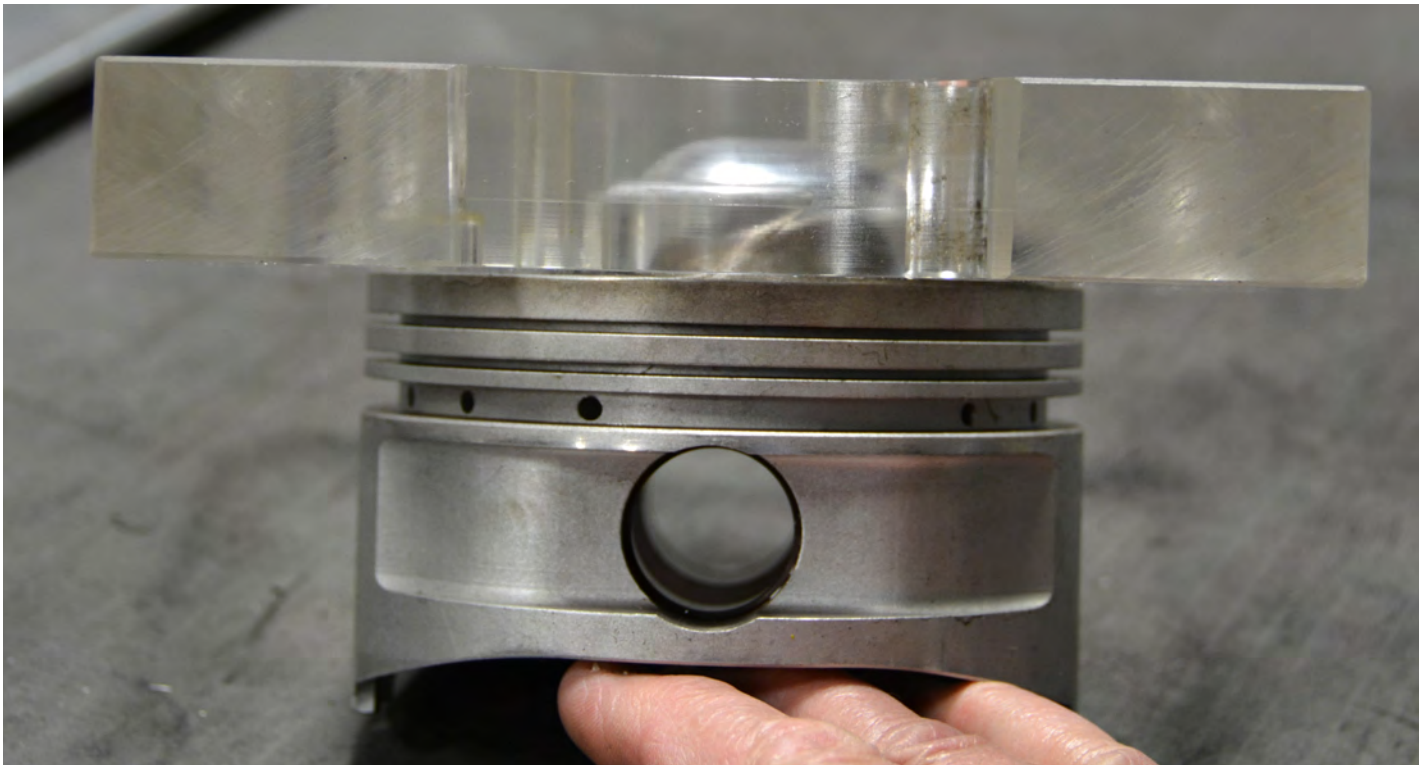
CC RIDER, PART 2: STEP-BY-STEP

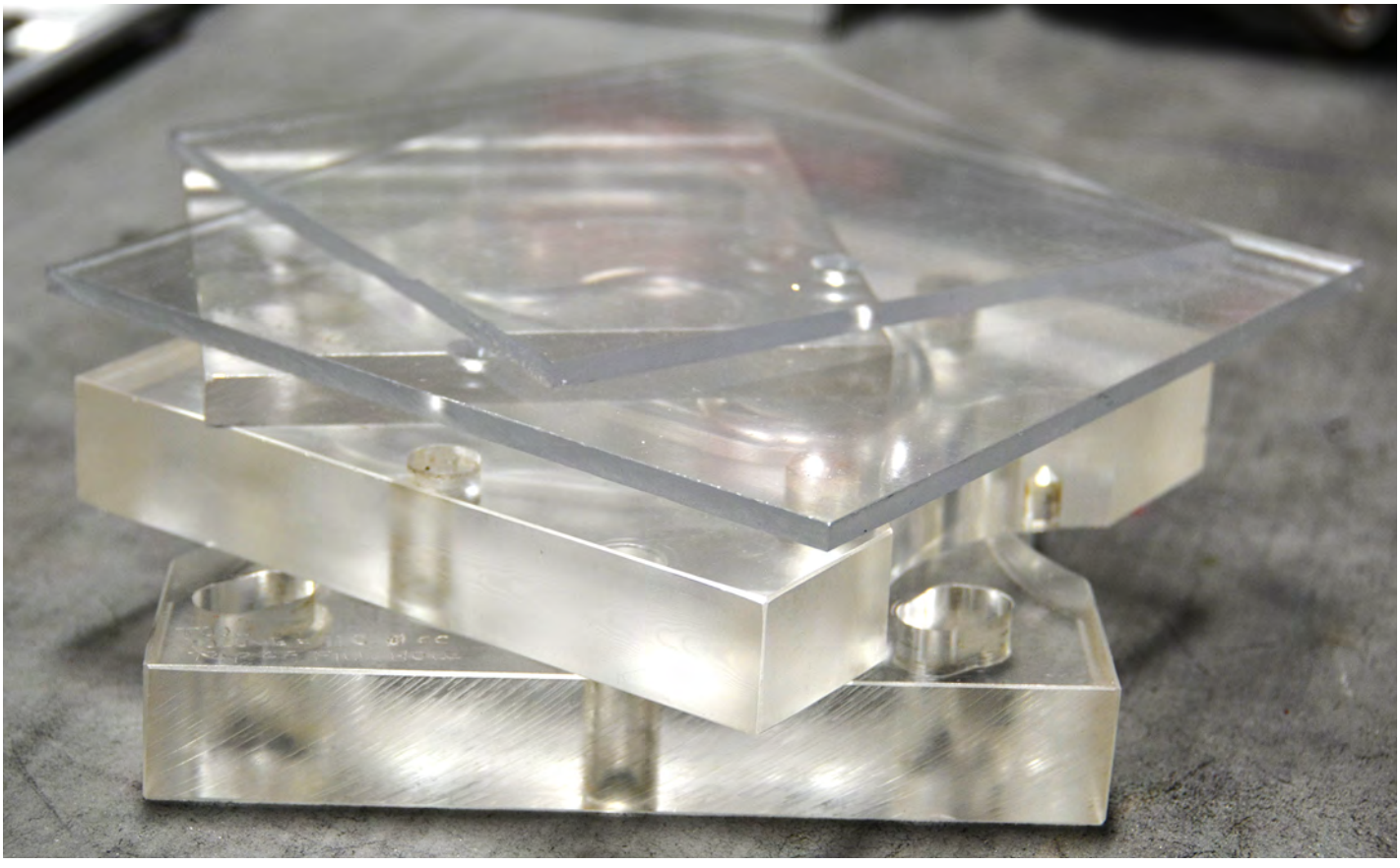
-Greg McConiga

Last time, Greg explained static and dynamic compression, the factors that determine them, and how to calculate what you're going to get. Now, he gives us the proper procedures for measurement.

Below & Opposite Page: Here's our old school big block Chevy piston tucked up into the cavity of the Smokey plate. The dome volume is the difference between the tool volume and the fill volume with the dome in place. To avoid doubling up the volume above the ring, you'll need to install the top ring, pack the area above the ring with petroleum jelly and push the piston up against the plate once it's bolted on the block. The Performance Trends software calculates and includes that volume based on the bore, piston top diameter, and ring depth. As you can see, you do not need any induced errors.

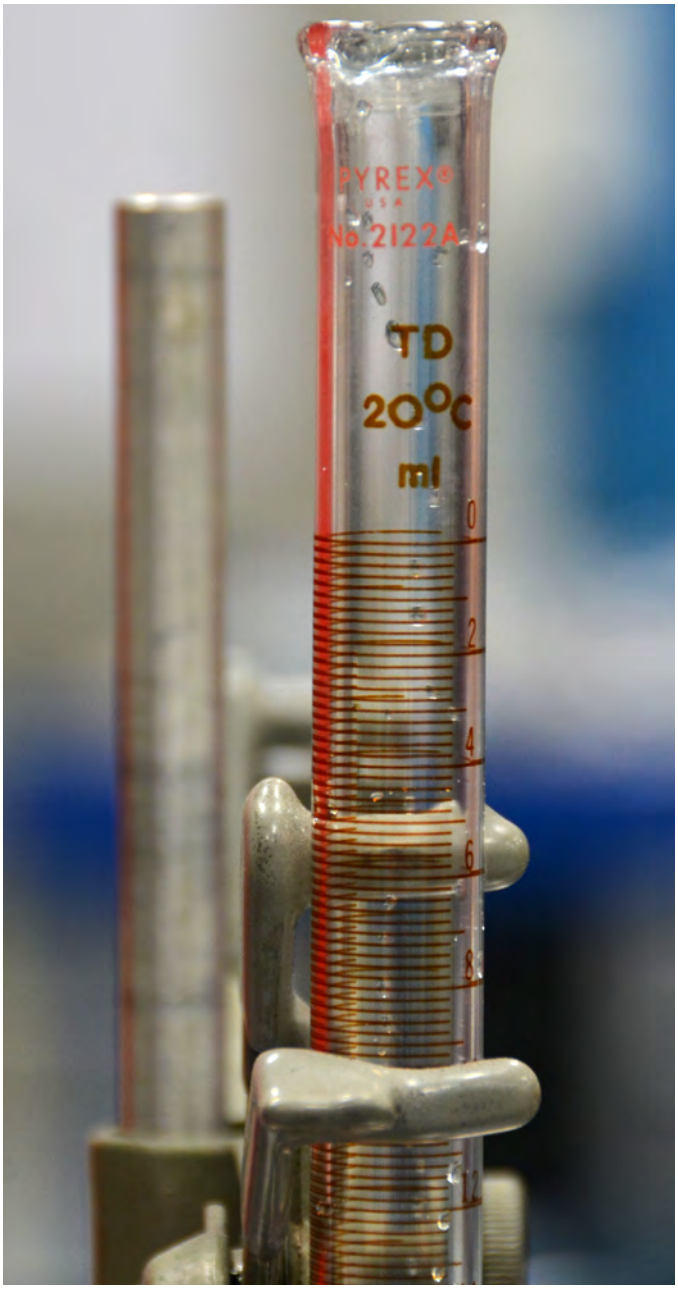
Can you have too much compression? You bet. At compression pressures over 15:1 the gains to be made are very small. There are gains, but they tend to become increasingly smaller with each step up in ratio. A second thing to consider is how difficult the engine becomes to tune with higher compression ratios and how fuel demands become more specific with higher cylinder pressures -- the higher the compression ratio the fussier the engine. Last, you still have to have enough volume to contain a compressed air-fuel ratio. At some point there is just not enough room to squeeze the mixture without going into hydraulic lock-up.





Above: If you do any serious cc work, you'll need a good selection of plates in different sizes to cover all your needs. The good news is that they are cheap and easy to make. The Smokey Plate is available through any of the speed merchants or directly from Moroso.

Right: Treating the chamber and the plastic plate with silicone breaks the surface tension and makes it much easier to get the space filled without bubbles. It takes very little error in the chamber measurement to make a big difference in the compression calculation.



I know this is a tough one, but working in a temperature-controlled environment is critical when measuring volumes and dimensions. It should be your goal to end up in a temperature-controlled workspace to avoid variations in measurements. If you want to see how critical it can be, just measure a wristpin (you'll need 1/10,000th of an inch gear) and measure it again after you hold it in your hand for five minutes. Same with your measurement tools. Buy and use mic stands.

Purging the dispensing chamber of air is something you do every time your break out the electronic burette. It's an "A" graded instrument, but it's only as accurate as your technique.

Higher ratios are good because they increase thermal efficiency and if they are the result of engines built with small combustion chambers and lots of quench they tend to be more detonation resistant. BUT there are always compromises and complex interactions that you have to be mindful of during the design phase. Also, remember that your compression ratio has a huge effect on cam selection. Settle on the compression number and work on the cam design to best fit the cylinder head flow rates, valve sizes, and operating requirements. Everything affects everything -- it's all interdependent.

IT'S NOT RIGHT - HOW DO I FIX THAT?

So, how do you fix a high or low compression ratio? You can add head gasket thickness, but that comes with a penalty in the form of increased quench. Opening the quench distance results in a less turbulent mixture at TDC, which in turn makes the chamber more prone to detonation. You can reduce head gasket thickness, but that has complications as well because you have to have a minimum distance to the head to allow for rod stretch and piston rock at operating temperature and rpm. In general, you need a minimum of .040 in. to the head with steel rods and around .060 in. with aluminum rods, but these are guidelines and I have run more or less. Also bear in mind that some engines like a touch more or less than these figures to produce peak power, so that's another variable to consider.

Other options include sinking the intake valve, installing new intake seats and raising the valve (the intake has the greater area

Pick a spot in the drilled hole and use that as your fill reference point every time. I've drilled the chamfer fairly deep so I use the transition between the chamfer and the straight portion of the hole as my fill reference point.

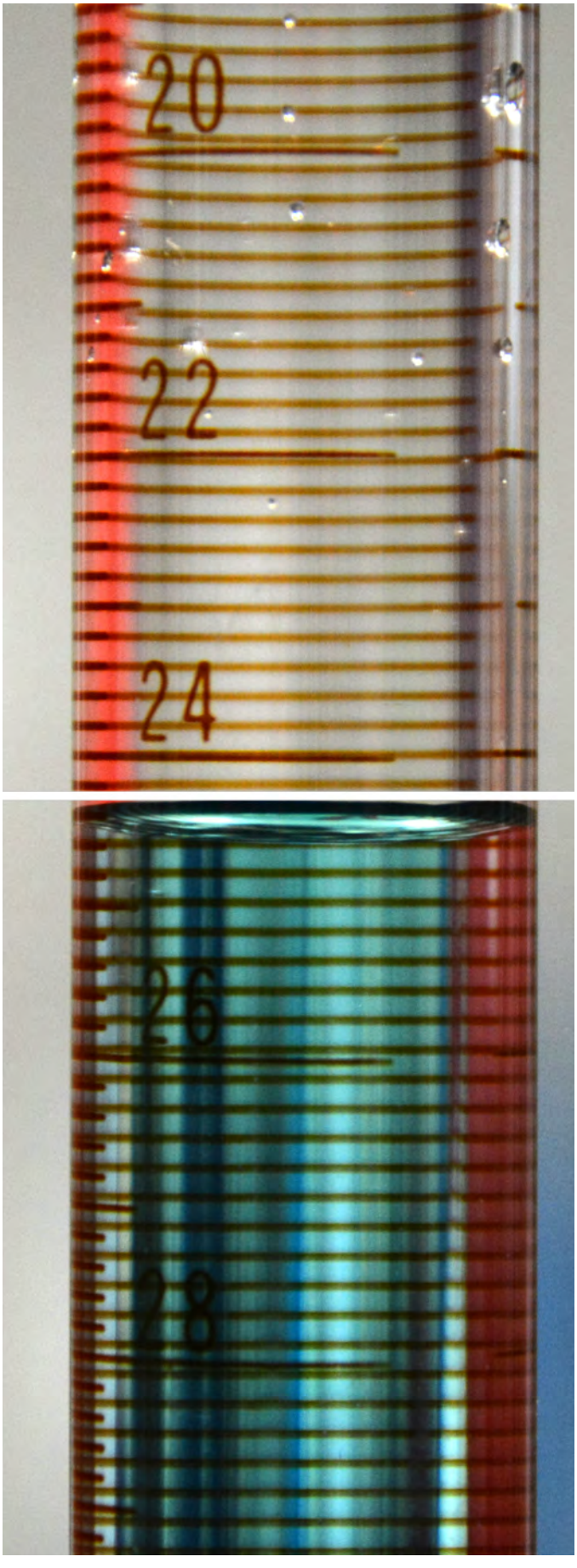
One of the big mistakes I see is putting a big glob of grease around the chamber to make the plate seal. It's not needed. You only need the lightest coat to make the seal. It can even have a few random voids in it. In this case the surface tension of the liquid works for you. Just a wipe will do the job. Experiment with it and see how little you can get away with -- and that will be just right.

and therefore the greater effect on chamber volume), opening up all the chambers an equal amount, or machining the deck of the block or the heads. There are limits to all these methods, of course. The amount of piston progression or regression determines how far you can deck the block and there are limits to how much of the cylinder head deck you can remove. Some aftermarket aluminum heads will have the thickness pad cast into them, a recessed circle that indicates how far you have to go to minimum deck thickness. When the recessed area disappears you get to buy new heads . . . and aren't we are having some fun now!

HELPFUL HINTS TO MAKE IT EASIER

I'll give you a few helpful hints for doing your cc work because once again accuracy counts. The closer the cylinders are to identical the better off you'll be because you're always tuning to your worst hole.

I use a silicone grease to treat all my cc plates. I discovered that it reduces bubbles trapped in the cylinder heads in the tight spaces between the plate and head. I wipe a coating of the grease in the chambers and on the plate and wipe or polish it, if you will, to leave a slight film on both. The silicone breaks the surface tension and fewer bubbles will form or stick in the chamber.



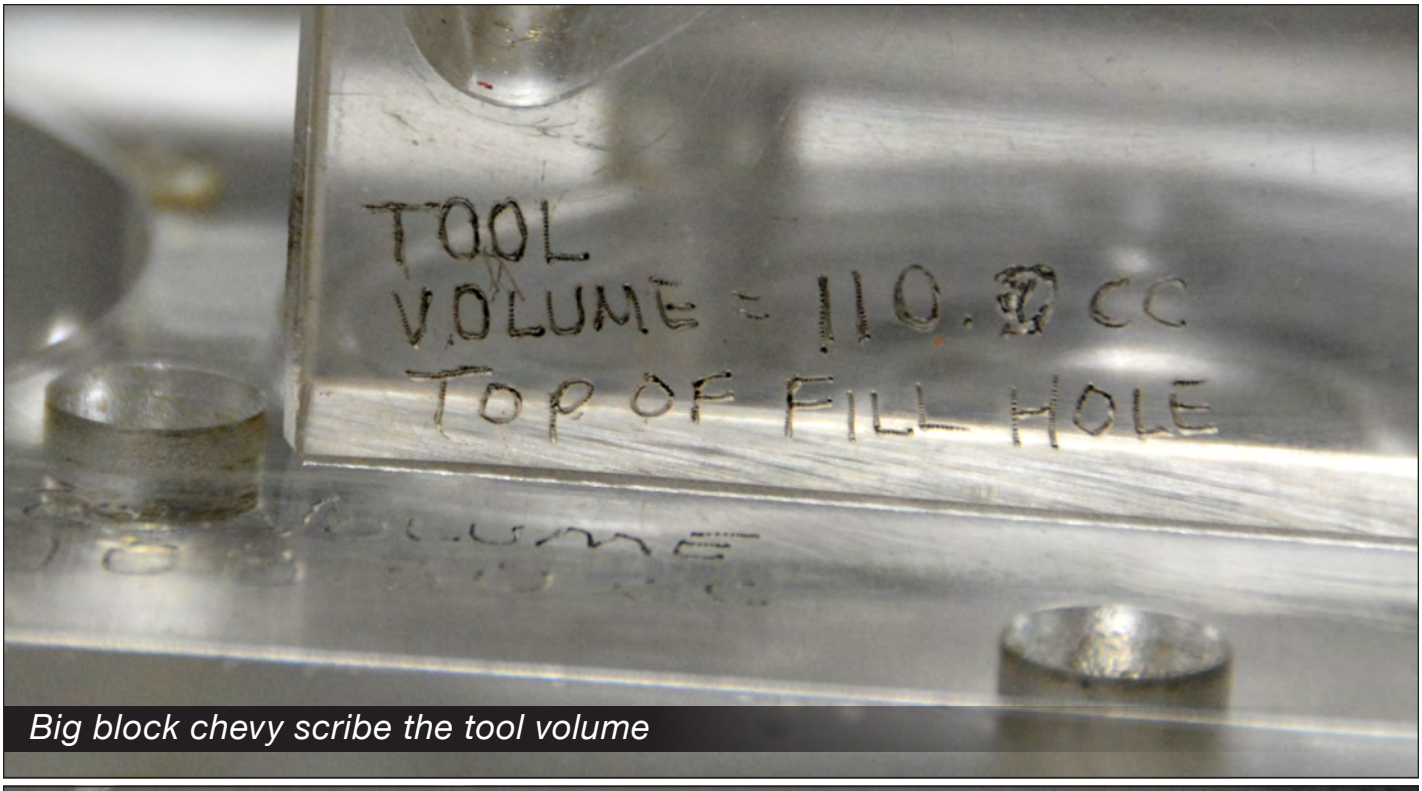
Right: Seeing the meniscus takes a little practice. I've drawn a reference line so you can see it. See the little silver-looking sliver below the white line? That's the meniscus… it forms because the fluid "sticks" to the walls of the tube while the center dips down. Take your readings at the bottom of the meniscus.

Burettes are rated or graded by accuracy as "A," "B," or "C". This grade "B" has a resolution of about .2 cc, as opposed to the Brand Titrette electronic grade "A" model, which measures in hundredths of a cc. It's overkill, but the electronic unit is also fast, fast, fast and as accurate as you'll ever need. Stone reliable, too.

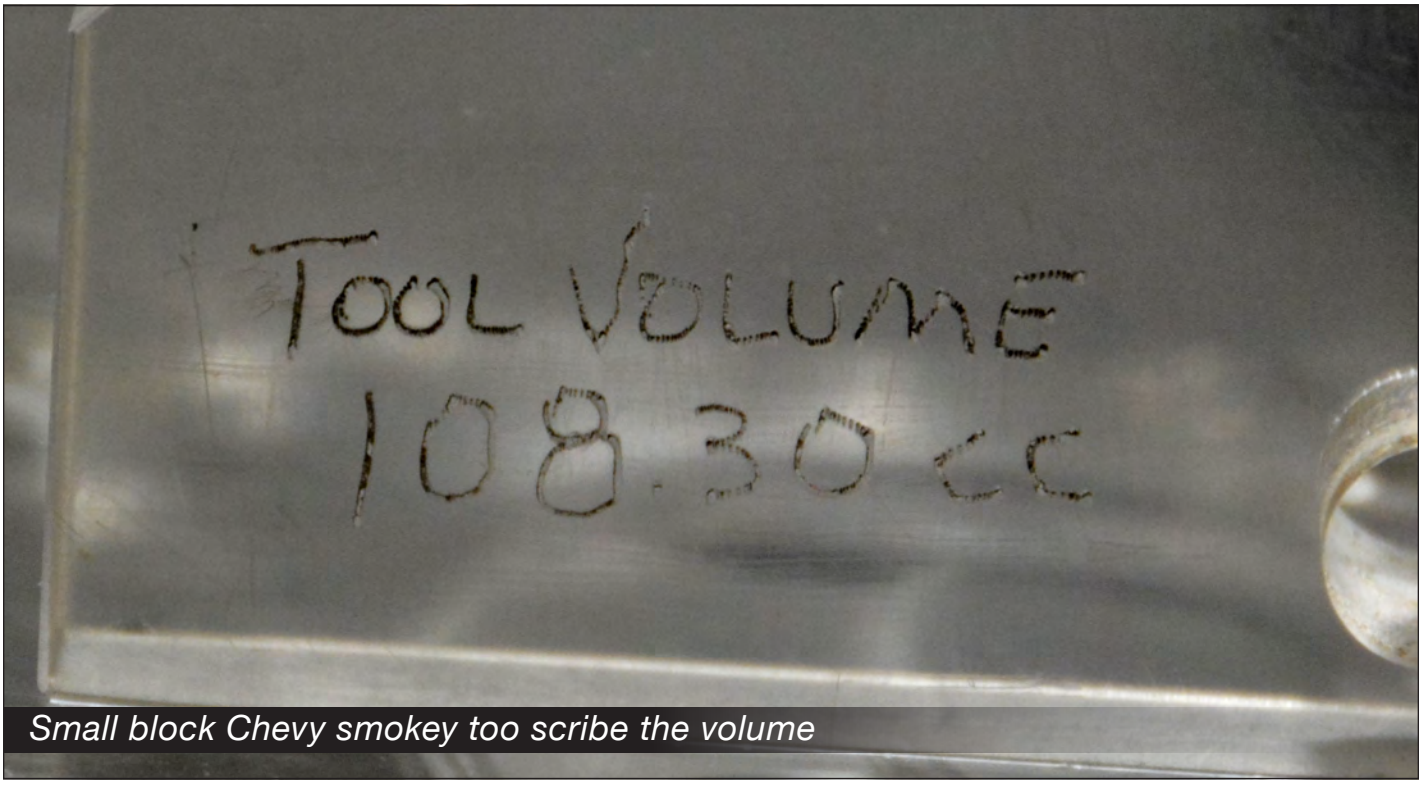
Don't get carried away with the grease used to seal the plate to the deck or the head. I use petroleum jelly and it only takes the lightest film to seal the plate. I've seen people induce an error by using a big glob of grease

Right: This is just before mounting the plate. You'll have to look closely to see the layer of petroleum jelly that's been applied. Don't do what some do and smear on a big glob on. It's like Brylcreem: "A little dab will do ya." Just dated myself, didn't I?

Here's some old-school technology -- and a perfect example of why you'll find a Smokey plate so handy. In the bad old days we had chambers as big as a bath tub and the only way to get the compression up where we needed it was to stuff a big dome up into the cavity. It gets the job done, but not without drawbacks. The dome interferes with flame propagation, so you'll notice a big notch in the right center of the dome that provides plug clearance and a ditch for the flame to spread out into the shrouded part of the chamber.



Big block chevy scribe the tool volume



Small block Chevy smokey too scribe the volume

When you first get your new Smokey Plate, you have to measure the machined cavity volume so that you know the number you must add or subtract from when you measure the piston. I'm a big believer in writing everything down or scribing it where it can be found. In this case, I fill the tool to the top of the drilled fill hole. You can buy tools for both the big block and small block on standard bore centers, but you can see how easy it would be to make whatever you need for whatever application you're working with.

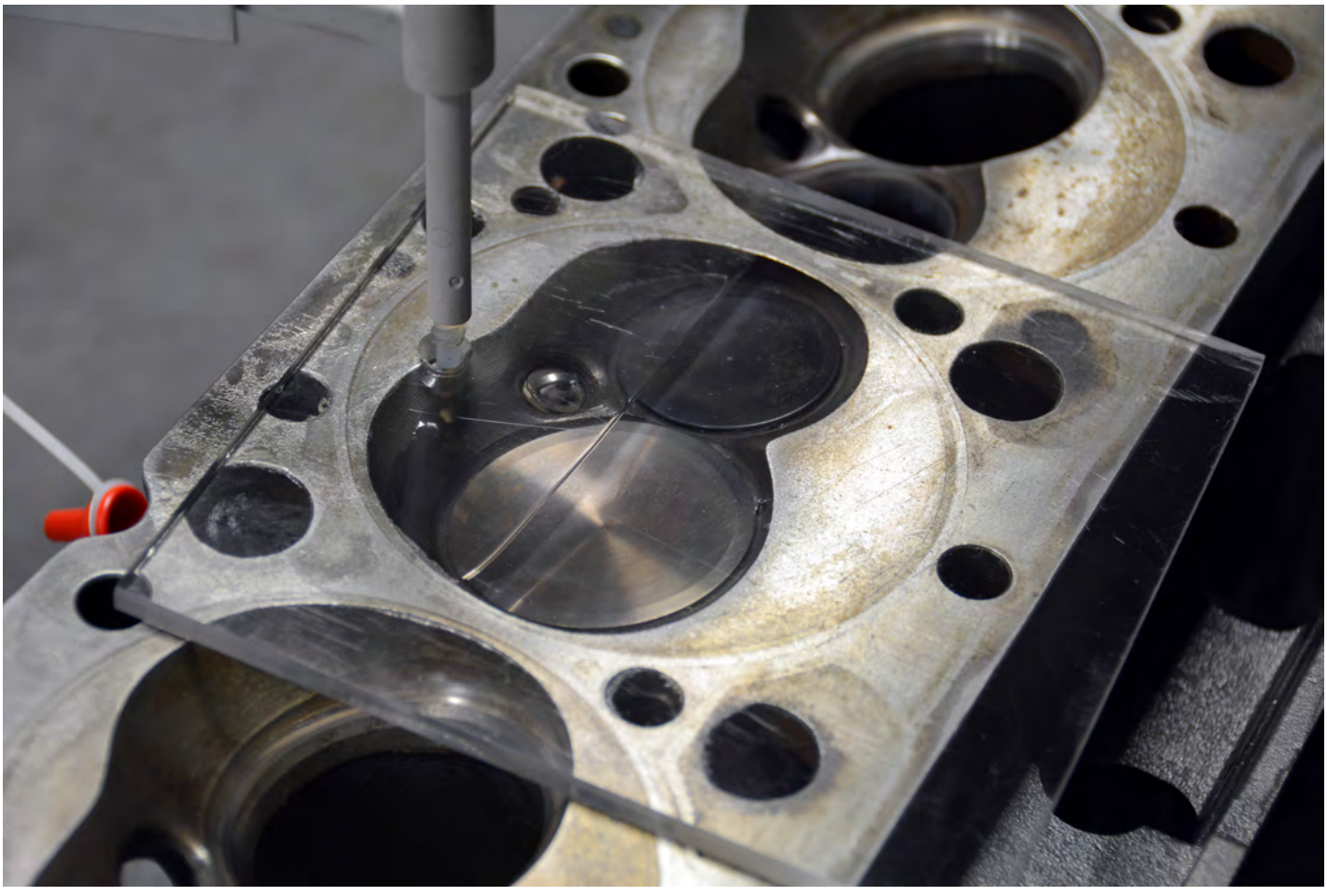
that then gets squeezed into the chamber changing the volume readings. You only have to use enough to just make the plate leak proof, and it's not near as much as you think it would be. Just a tiny bit gets the job done.

I use windshield washer fluid for my cc work. It's cheap, readily available, and it's dyed a nice blue to make it more visible. It contains alcohol and it dries quickly with a blast of compressed air. It's also something that you already have an MSDS for, so that's one less thing to worry about.

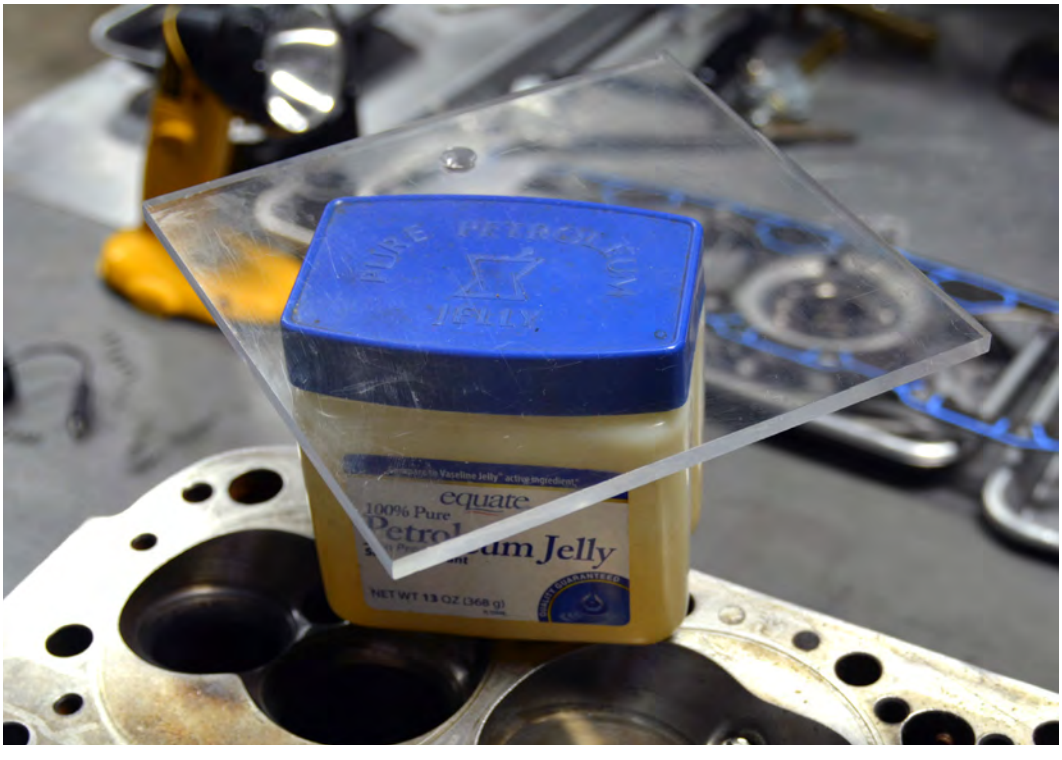
If you're going to be doing a lot of cc work, you'll need to invest in a good burette or an electronic one like the Brand Titrette. A good grade-A glass burette will set you back $175 or so. A grade-B will be about $135, and a burette stand will set you back between $85 and $220 depending on which model you buy. The Brand can be found for $750 (and up) depending on the day and the deals that are out there. The Brand is my personal choice because it's accurate and repeatable and reads out to .01 cc. A glass burette is fussy to read and delicate, so think about how many you might break it, or the time spent filling and zeroing the starting point and suddenly the Brand becomes more affordable. If you do opt to go with the glass burette, you must remember to read at the bottom of the little curve of the liquid layer. Surface tension causes the fluid to ride up the tube walls

Any kind of silicone lube will do the trick, but it's important to coat the plate and chamber with a little silicone to keep bubbles from sticking to the surfaces. You can dislodge them by tapping the head or the plate, or rolling the head around so that gravity does the job, but it's a hassle you can avoid with a minute of preparation.

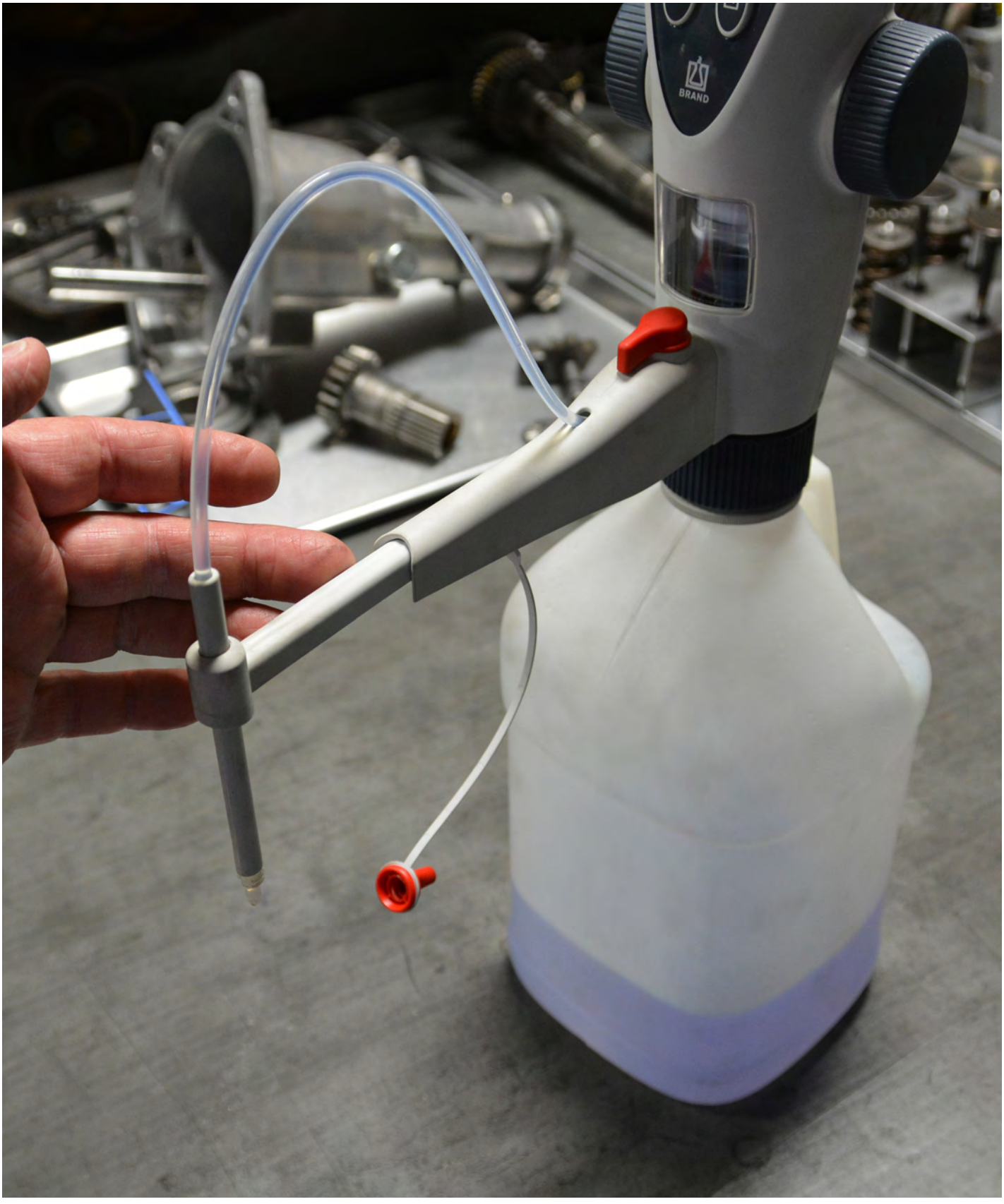
As the chamber fills, you may have to tip or roll the head slightly to move the bubble up under the nozzle. After you've done enough heads, you'll get a pretty good feel for how to position the plate for the best possible fill. Gravity never fails -- fluid goes downhill and trapped air goes uphill!



A nice clean fill. The silicone applied to the plate and chamber stops air bubbles from forming and the tiny bit of petroleum jelly seals the plate. No muss, no fuss.



Left: A Plexiglas or Lexan plate, a little petroleum jelly, and a burette and you're ready to begin the process of calculating the static compression ratio.



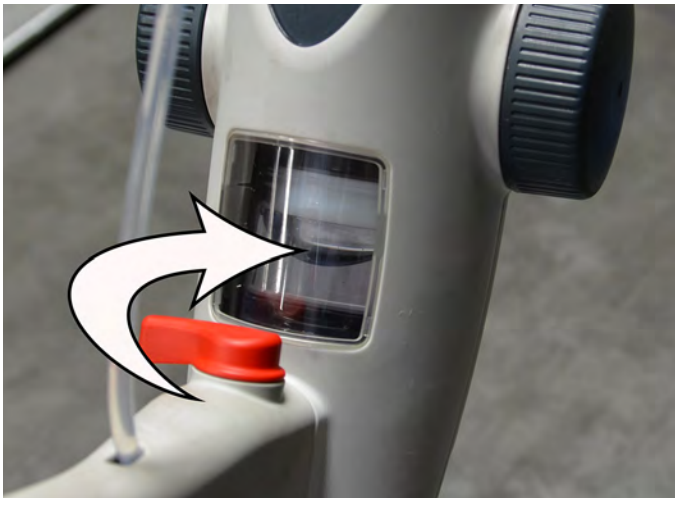
The Brand Titrette discharge nozzle extends and can be raised and lowered so it's easy to put it exactly where it's needed. If need be, I'll use a wood block or a 4-5-6 block to raise the jug up on a steady platform if the heads are on stands, for example.

Once the chamber is cleared, the burette is ready for use. Just power it on, zero it out, and put the red valve handle in line with the nozzle and start your cc'ing work.

When the red valve handle is crossways to the nozzle the fluid is bypassing the discharge nozzle and returned to the jug. Since this burette is used in medical and industrial chemistry it wastes no product during the purge.

slightly, so your reading is taken at the lowest part of the curve, called the meniscus.

If you are using the Smokey Plate (named for the late, great Smokey Yunick), you will first have to measure the plate volume and engrave it into the plate for future reference. Treat the cavity with silicone grease or paste and seal the plate to a piece of Plexiglas, fill the cavity, and record the cavity volume. Now any piston volume you measure with or without a dome will be a snap. When using the plate, just put the top ring in its groove, load the piston into the bore without a connecting rod on it, put a light film of petroleum jelly in the bore above the piston, mount the plate and shove the piston up against the plate. Remove the plate, clean off any excess petroleum jelly, clean the plate, and remount it. Then verify the piston is at the top of the bore and measure the volume it takes to fill the tool. If you do this you don't have to worry about duplicating the deck height or piston head-to-ring crevice volumes in your clearance volume calculations.



If the burette sits a while, it may gather a little air in the discharge chamber. Purging is as simple as running the plunger to the bottom of travel a few times and watching the chamber to ensure that all trapped air is cleared.

If it takes more to fill the tool than the tool cavity volume you first measured, then you have a negative net dome volume and if it takes less volume to fill the plate you've got a positive net dome volume. While the piston supplier often tells you the net volume, I always measure it because the "nominal" value recorded may be an average taken over a large run of pistons. With the large valve reliefs dictated by the big valves we typically run, it's impossible to know if you are net positive or net negative unless you measure it directly.

OTHER HELPFUL THINGS

- The formula for bore volume is QUOTE h, where QUOTE is equal to 3.14159, "r" squared is half the bore diameter multiplied times itself and "h" is the stroke. If you use inches you can convert by using the following.
- To convert cubic inches to cubic centimeters multiply cubic inches by 16.387
- 1 cubic inch is equal to 16.387 cc's
- 20 drops equals 1 cc
- 1 milliliter equals 1 cc
- 1 ounce is 29.574 cc's
- 1 pint is 473.176 cc's
- 1 quart is 746.353 cc's
- 1 gallon is 3785.412 cc's
- If you find yourself measuring large volumes, you can simply weigh out a known volume of the fluid you use and then weigh the total amount used. For example, if you wanted to measure the total intake manifold volume, you could measure out and weigh 100 cc's of washer fluid, weigh a gallon of washer fluid, subtract the empty jug weight and you'd have an easy conversion of weight to volume. ■

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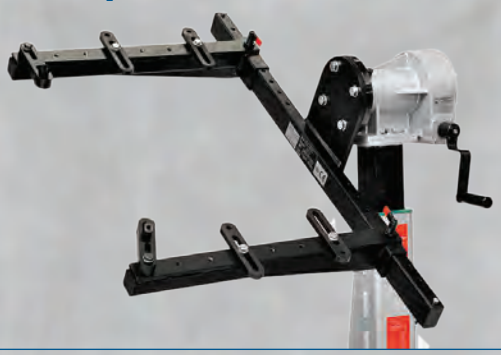

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HANDLING THE CHANGE, OR CHANGING THE HANDLING, 3

-Kerry Jonsson

In the past two installments we discussed how the dimensions of a car and its overall weight distribution can affect cornering and handling. Let's see how we can utilize this information and begin to upgrade the suspension.

These high-quality fully-adjustable coil-overs will give you all the options you need to tailor your suspension to your liking (courtesy Koni).

The weight of any car is obviously an important factor in cornering and handling, as well as outright performance. When accelerating, the less the car weighs the better. When braking, the less mass of the vehicle the shorter the stopping distances. As a lighter car corners, the suspension system has to handle less mass as it keeps the wheels in contact with the road, especially over rough road surfaces. Less stress on the suspension will allow the shock units to maintain a consistent dampening rate over the course of a race.

Weight distribution can have a great effect on how a car corners and handles. A vehicle with more than 50% of its weight on the front end of the car will overload the front tires at their traction limit under both braking and cornering, and cause the front end to "push" or slide away from the apex of the corner when the car is turning in a phenomenon called "understeer."

If the weight is biased toward the rear of the car, the back tires will tend to "oversteer," or slide out while cornering when they are at the limit of traction. Depending on the type of racing you do, you may want to move components around to tailor the weight distribution to match your needs as best you can, if the race rules allow.

Side-to-side weight distribution is just as important -- a road racing car, needing to make left and right hand turns throughout the race -- will want close to even, or "neutral," weight distribution for more stable cornering in both directions. On a rear-wheel-drive oval-track car turning left only, the driver would usually want more weight on the left side of the car. Under acceleration, the pinion gear in the rear axle slams the ring gear upward, raising the left rear of the car. If it is severe enough it will cause a loss of traction at the left rear wheel. By adding more weight to the left rear we can offset this torque reaction, promoting even contact patches and more uniform traction from both rear wheels.

A BRIEF REVIEW

On oval tracks when cornering left, the weight of the car will be transferred from the left side of the car to the right side, providing an even "footprint" for each corner of the car. This "static" weight distribution is a good place to start, but you can also change the weight by adjusting the height of the suspension at an individual corner. This is known as "preloading" the suspension.

If you make the suspension unit at one of the corners longer, that corner and the diagonal opposite corner will carry more of the weight of the car. We have already learned this is known as "wedge." If the wedge is 50%, the cars handling would be considered neutral, all other things being equal.

Adding more weight to the right front or left rear wheels would be considered positive or

+50% wedge. If the weight were directed to the left rear or right rear wheels, this would be considered a negative or -50% wedge. Wedge is used to fix problems with oval track cars and drag racers that can take advantage of only turning in one direction, or going straight and reacting to torque loads. Road racing cars may only benefit from a slight wedge if the course favors more left-hand turns than CART or IRL cars normally experience, driving counter-clockwise on a race track. It was widely reported that Formula 1 race car driver Jacques Villeneuve was recruited by the Williams Formula 1 team because of his ability to set up a car with some wedge for tracks that favored either more left- or more right-hand turns, even though they were road courses.

WHAT'S NEXT

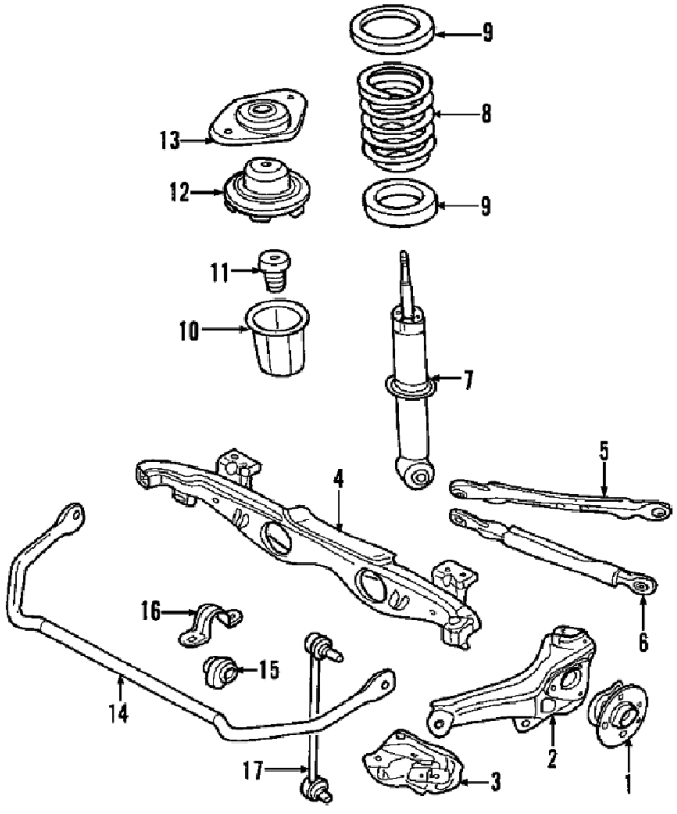
While weight distribution will change the way a car handles, it is static, and we should not make changes to weight distribution from race to race. Once in a season maybe, if a significant development occurred, but generally the car is the car. In fact, many believe that the more changes you make to a car the less reliable it may be. It is difficult for an engineer to determine how things like heat and vibration will affect newly mounted components.

So if the car is the car, how can you tailor it to the track?

Chassis preloading – often with performance coil-over-shock absorbers -- will allow you to make the adjustment from road course to road course, and the one thing we must look for is adjustability! This will be the deciding factor in selecting a suspension coil-over-shock upgrade to give us the handling we seek. The key things to remember are:

- adjustable shock absorber length
- independent spring preload
- multiple adjustments for compression
- rebound dampening.
- Not all coil-overs are created equal, so let's talk about what's out there.

An upgraded suspension will have no effect on the track width on the car -- the only way we may modify that is with offset tire rims. Suspension height will have a much greater effect on lowering the center of gravity of the car, and if you are setting up a track car rather than a street car, you may not care as much about raising the ride height. The goal of our suspension tuning series, "Handling the Change, or Change the Handling," is to remind the professional technician on the engineering goals of a race car.

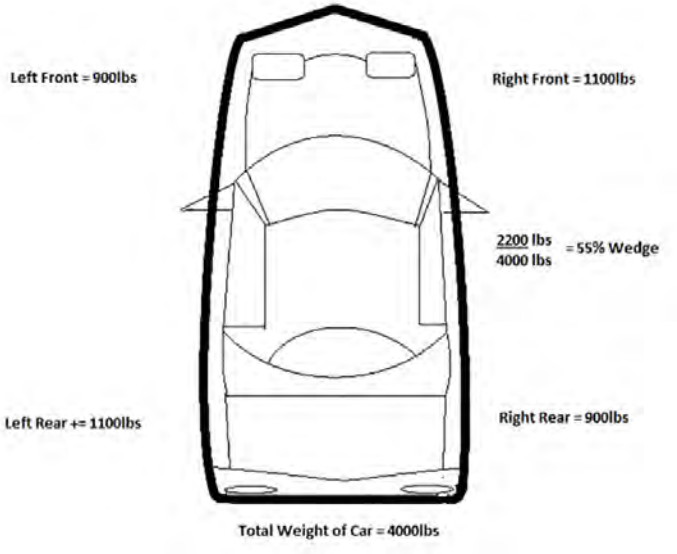


The Mini's suspension is pretty simple and light, and the struts place the weight up high for better cornering dynamics. Note the long stabilizer bar link (courtesy BMW).

Most of us will be modifying a production chassis, as it is the fastest way to get a sports car on a road course. We may cover some race chassis dimensions building techniques, but only to illustrate a point -- chances are if you a building a chassis you're probably not going to be referring to this series for advice.

THE MITIGATING FACTOR

Adjustability is the most important factor in our decision to upgrade with performance-type coil-over-shock absorbers, and we need to understand the full purpose of a coil-over suspension. Obviously, suspension springs support the weight of the car and while the car is traveling over road irregularities – or cornering -- the springs absorb the initial shock of the car hitting a bump, or absorbing weight transfer. As we know, a spring while coiled up has absorbed energy and wants to return to its normal position as soon as it can. The stiffer the spring, the stronger the reaction to being compressed and desire to return to normal length. In theory, inertia will cause a spring to expand to more than its normal size, and shock absorbers can and do offer compression dampening to assist the spring. But their main job is to control the rate of return of the spring to its normal position, and slow down that return.



We've used this drawing in a previous installment of this series to illustrate "wedge." That is, on road-race cars with over 50% cross-weight, weight bias or running a wedge will understeer or "push" in a turn, but will have good traction coming out of corners because the set-up favors the two tires that have the optimal weight on them while under high torque and high acceleration. You or your driver must decide if wedge or reverse-wedge is helping you go faster.

The coil-over-shock absorber is a compact design that saves space and precious weight. Luckily for us, most manufacturers of the small sports cars we modify for some racing fun have migrated to the MacPherson strut, comprising a coil spring over a strut that contains the shock absorber unit. This usually makes the upgrade to more race-ready coil-overs much easier. One thing to note, though, is that a MacPherson strut design only has one pivot point for the lower control arm. Depending on the design, this may allow a significant amount of bump steer and change the camber angle as the suspension compresses.

Bump steer is the change in steering angle or toe as the suspension moves through its travel. If the steering angle changes as the suspension compresses, the driver will have to contend with subtle changes in steering as the car negotiates a bumpy turn, and it may make the front end feel unstable. Bump steer can occur on rear suspension systems, too, but can be controlled since there are no steering inputs.

DECISIONS . . .

This is one reason why wheel alignment adjustments are critical as we set up the suspension, but we will go into wheel alignment in more depth in future installments. For now, we're looking to purchase and install some performance coil-overs. As we noted in the discussion of ride height, we want a coil-over that will allow us to adjust the overall height of the assembly, and we want to be able to adjust the length of the shock absorber without affecting spring tension.

You can install lowering springs instead of full coil-overs -- maybe your cheapest option -- but you will not have the adjustability.

There are less expensive coil-overs that do not allow adjusting the length of the shock absorber. With these units, you control ride height by moving the lower spring perches up and down, allowing ride height adjustment, but not suspension preload.

To create a fully-adjustable suspension system capable of being tuned to different tracks, make sure the shock absorber length is independently adjustable from both upper and lower spring perches. This will allow changing the spring preload at each corner of the car, or at least the front, and provide more control over corner weights. These static changes will allow tailoring handling to different situations.

Of course, coil-overs are more than just mounts for your springs. Part of the weight-saving package is the shock absorber itself. A quality coil-over will have fully adjustable compression and rebound dampening settings. Depending on how serious you are about racing, you can also purchase springs with different rates -- but with spring preload being adjustable, you will probably not need to. There are differences in construction of even high-quality coil-overs.

THE DETAIL DEVIL

This is probably overkill, but a dual-tube shock absorber will manage the heat generated as the shock plunges up and down hundreds of times during a lap. Most of us running in club events and track days will probably not overwork the shock absorber, since our events have short distances to cover; a mono-tube design will probably give us all the benefits without the added expense. Usually, the coil-overs will be offered with either a streetable spring that is not so stiff, or a racing spring that is much stiffer.

This may not be a problem for most tuner cars, but early-2000s Mini Coopers may be the exception. The stock vehicle does have a small problem with front strut towers flexing when the suspension bottoms out. Stiff racing type springs will put added stress on the strut towers as the car is being driven, so keep that in mind while making your purchase for your application. In our next installment we will go over compression and rebound dampening, and what they mean to us. ■

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HEALTH & WELLNESS
PROTECTING YOUR EYES & HEARING

-Tom Nash

Protecting your eyes and hearing is your responsibility. It's easy to do, but many technicians do not make the effort to protect themselves. Change that habit!

It's no big secret that working in an automotive service facility can be dangerous. The U.S. Bureau of Labor Statistics (BLS) and OSHA reports bear that out. While BLS merely reports the facts, OSHA sets rules and guidelines to avoid injuries and punishes those who don't follow the laws.

Unlike many federally-regulated industries, such as manufacturing, logging, mining and commercial fishing, safety in the automotive service repair industry is only regulated by OSHA, local authorities and the requirements of insurance carriers. The main difference is in the daily operation of the facility in meeting those requirements and the willingness of employees to "follow the rules." In a business that stresses production output and where workers are paid by what they do, rather than a salary, automotive technicians don't always take the time to "follow the rules."

But, when you stop and think about it, those rules are in place to protect you and your livelihood. That's right – the rules are there for you. If you cut corners, don't follow the rules of shop safety and get injured, you only have yourself to blame. So let's stress that point: only you can protect yourself best.

PROTECT THOSE PEEPERS

One of the most easily damaged parts of your body is your eyes. They're also the easiest to protect. The eyes are very fragile, the softest external part of the body. If damaged, chances are they will not recover or heal completely and your vision will be lost or restricted.

Eons ago, some prehistoric humanoid discovered that if he threw dirt or sand in his enemy's eyes, it would render his foe vulnerable and defenseless. So it is with automotive technicians; without your vision, your career is in jeopardy. The simple solution is to wear eye protection.

BLS figures show that each day, approximately 2,000 workers suffer eye injuries. The State of Washington's Department of Labor and Industries research shows that eye injury accounts for about 30 percent of reported injuries in auto service shops. Taking into consideration that there are somewhere in the neighborhood of 900,000 automotive service technicians (according to recent BLS figures) working today, the number of eye injuries is a major problem. As Daniel D. Garrett, Prevent Blindness America (PBA) spokesperson put it, "90 percent of all workplace eye injuries are preventable with the use of proper eyewear and safety measures."

WHAT CAN CAUSE EYE INJURIES?

The causes of possible eye injury in an automotive service shop are incalculable, but here are the main culprits:

- **Flying particles.** BLS found that almost 70 per cent of the accidents studied resulted from flying or falling objects or

sparks striking the eye. Injured workers estimated that nearly three-fifths of the objects were smaller than a pinhead.

- **Contact with chemicals** (liquid or vapors) caused one-fifth of the injuries. In the auto shop environment, these include fuels, oils, solvents, aerosol products and pressurize fluids like coolants or hydraulic fluids.
- **Falling items.** This may happen when a tech is working near the floor underneath or alongside a vehicle. Among such items can be tools left on top of a vehicle, cabinet, or piece of shop equipment. Injury can also occur from unsecured droplights or vehicle parts suspended during repair procedures.
- **Small explosions.** The possibilities here are batteries exploding during charging, tires popping from over-inflation, air bags accidentally tripping during service, etc. Even removing or attaching air tools to a pressurized air line can cause a burst of air to blow dust or other small particles into your face and eyes.
- **Lack of attention.** This category is more common than you might think. It covers walking into or tripping over tools, parts, equipment, hoses or wires on the floor – or even other people. Ever walk into a lift or piece of shop equipment? Welcome to the club!

The possibilities are endless. That's why you should wear eye protection at all times.

PROTECT, PARTICIPATE AND PLAN

Here's the program. Follow it and the possibility of eye injury is greatly lessened.

- **Protect.** Make sure everyone in the shop area has properly-fitting eye protection. Special protectors should be used for special jobs such as face masks (over glasses) for grinding, cutting and using lathes. This will afford double protection against small pieces and splinters from ricocheting into the eyes.

Of course, welding masks must be worn for welding. This will protect the eyes not only from sparks, but also from excessive light that can cause temporary or even

Always be sure to wear eye protection when using any kind of chemicals. Damage from liquids and vapors accounts for 20 percent of auto shop eye injuries.

Many shops post signs reminding workers and visitors to wear eye protection. Some shops have safety glasses available. OSHA and local regulations require safety procedures.

permanent blindness by damaging the retinas. UV radiation burns (welder's flash) can damage your eyes and surrounding tissue. Always wear darkened goggles for cutting with a torch as they offer the best protection against light flash and flying particles.

- **Participate.** Make the requirement to wear proper eye protection at all times mandatory in your shop. OSHA and state-level programs require it. An OSHA or local law violation can cause big problems for the shop. Most insurance company's policies require a safety plan too, so don't take a risk on insurance not covering an eye injury. Be sure to check your shop's insurance policy for details.
- **Plan.** Have an emergency plan in place for eye injuries. You should have a dedicated eye flush fountain or at least eye flush bottles. Know when to call for emergency help. Post the phone numbers for emergency help or urgent care facilities.

Goggles are more practical than just safety glasses when trying to avoid dust particles from grinding, cutting or splashing liquids.

An important part of the plan should be training and communication to everyone in the shop. If someone in the shop suffers an eye injury, more than likely, he is going to need help from fellow workers to flush his eyes of debris or determine the severity of the injury and what steps to take next. Everyone should know what to do next and do it as rapidly as possible, if needed.

Whenever you are using a cutting torch, be sure to wear darkened goggles to avoid damaging your vision.

Every shop should have an eye flush fountain, or at least, eye flush bottles.

LIGHT IT UP

While this may sound odd, one of the best eye injury prevention measures is a well-lit shop. If you can easily see your surroundings, the chance of tripping over or bumping into something is greatly lessened. Often too, a tech may take off his safety glasses, because they are dusty or scratched, in order to see better in darkened conditions. If the shop has sufficient lighting to perform the work, there's no need to remove your safety glasses. Take the time to find a droplight if needed. Clean dirty glasses and goggles and replace them if they are scratched or damaged.

WHA'D YA SAY?

It's also no secret that working in a noisy environment can cause hearing loss. And, auto service facilities are among the noisiest places to work. With that in mind, let's look and how you can protect your hearing for as long as possible.

Hearing loss is the product of many things: age, genetics, disease and other factors. However, the biggest single cause of hearing loss is the exposure to loud noise. Avoiding loss of hearing is relatively simple if you know a few facts and take precautions.

Every day, we hear loud sounds, but prolonged exposure to loud noise accelerates the loss of hearing. Sounds at high levels for short times (like explosions, gunfire or fireworks) can be damaging, but so too can sounds at lower levels (such as engines or power tools) for longer periods of time.

The National Institutes of Health (NIH) says loud sounds can damage sensitive structures in the inner ear and cause noise-induced hearing loss (NIHL). It can affect one or both ears, but will eventually lead to increasing deafness if not controlled by precautions such as the use of ear plugs or muffs.

The NIH says sounds of less than 75 decibels, even after long exposure, are unlikely to cause hearing loss. However, long or repeated exposure to sounds at or above 85 decibels can cause hearing loss. The louder the sound, the shorter the amount of time it takes for hearing loss to happen. Further, your distance from the source of the sound and the length of time you are exposed to the sound are also important factors in protecting your hearing. NIH says a good rule of thumb is to avoid noises that are too loud, too close, or last too long.

NIH also warns that exposure to loud noise can cause tinnitus, a ringing or buzzing in the ears or head. Tinnitus may subside with treatment or over time, but can be permanent.

The National Institute for Occupational Safety and Health (NIOSH), a division of the Center for Disease Control and Prevention (CDC) has set accepted standards for exposure to noise and has created a formula for determining when damage to the ears occurs. Note that for every 3 decibels (dB) of noise increase over 85 dB, the permissible exposure time before possible damage is cut in half.In 1974, the U.S. EPA identified the level of 70 dB for 24 hour exposure as the level necessary to protect the public from hearing loss and other disruptive effects from noise, such as sleep disturbance, stress-related problems, learning detriment, etc. Several states have adopted these standards, or ones very close. Additionally, exposure to noise levels higher than 90 dB over an 8-hour period is against OSHA regulations.

While the regulations and standards cited by all these government agencies may sound

Use ear plugs or muffs when operating noisy tools under a hood.

intrusive, they exist for one reason: to protect your hearing. But, you are the only one who can ensure avoiding hearing loss. Obtain ear plugs and muffs, keep them handy and use them. Why risk losing your hearing? ■

Continuous dB	Permissible Exposure Time
85 dB	8 Hours
88 dB	4 Hours
91 dB	2 Hours
94 dB	1 Hour
97 dB	30 Minutes
100 dB	15 Minutes
103 dB	7.5 Minutes
106 dB	3.75 Minutes (< 4 Min.)
109 dB	1.875 Minutes (< 2 Min.)
112 dB	.9375 Minute (1 Min.)
115 dB	.46875 Minute (30 Sec.)

Keep a set of ear plugs handy for use around noisy vehicles and equipment. When the sound level gets really loud, use muffs to reduce the sound by at least 25 decibels.

TRAINING CAMP
UNIVERSAL TECHNICAL INSTITUTE

-Tom Nash

In this first article of the Training Camp series, we visit Universal Technical Institute, the largest automotive education program.

The growing population in the United States means more cars will be on the road, there will be more farming to feed the masses, more building and construction will occur, larger numbers of trucks will be needed to deliver goods and more people will have leisure time to enjoy with their cars, boats and motorcycles. We will need more technicians to service those vehicles.

The U.S. Department of Labor says that in the next five years, there will be nearly 1.5 million jobs in the automotive, collision, diesel, marine and motorcycle industries. The key to luring people into the industry and creating qualified technicians is, of course, quality education and training.

There are many automotive training programs available to young people seeking a career in the automotive service industry. From high school auto shop to college programs, private schools and industry-sponsored classes, the list is long. However, certain programs standout because of the quality of the program, the size of the program, multiple locations, the variety of studies and the number of students the institution graduates and places into the industry. At the very top of the heap is Universal Technical Institute.

UNIVERSAL TECHNICAL INSTITUTE
Chosen by Industry. Ready to Work.

Founded in1965 in Phoenix, Arizona as a small transmission training program, UTI has grown to eleven campuses across the country and has become the leading provider of technical education in the automotive, diesel, collision repair, marine and motorcycle service industry.

UTI is unique because of the number its locations and number of students served. Currently, there are over 15,000 full-time students enrolled in dozens of UTI programs. In the past 49 years, UTI has graduated nearly 200,000 students. There's not another automotive education program that even comes close to those numbers.

UTI AUTOMOTIVE EDUCATION PROGRAMS

The vast core of UTI education programs is in the automotive sector. Offered at all eleven campuses, the automotive education program is bolstered by partnerships with major automobile and light truck manufacturers. These OE-sponsored advanced programs immerse students in the latest products and technology from the individual companies and provide a source of trained techs ready to move into dealerships.

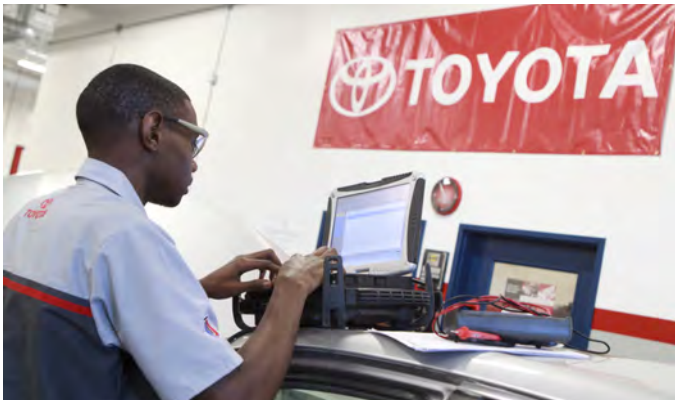
The benefit to the graduates of such courses is immense. They are first in line for jobs at dealerships over applicants with no training on the brand and models the dealership sells and services. On-the-job training is a slow and costly proposition for dealers. It makes sense to hire someone who is "up to speed" on the dealer's vehicles.

"UTI's direct partnerships with the world's top automakers are what sets us apart from other auto training programs out there today," said Bob Kessler, Campus President at UTI in Pennsylvania. "Our innovative programs are designed to meet the specific needs of our industry partners and that means our students are ready to work at leading dealers the moment they graduate. The auto industry is ripe with career opportunities and our graduates are a step above the competition. Top automakers want UTI graduates to work in their dealerships," said Kessler.

These are the programs offered by UTI in conjunction with OEs:

- BMW FastTrack and STEP
- Ford/Lincoln FACT (Ford Accelerated Credential Training)
- GM Technician Career Training
- Honda PACT (Professional Automotive Career Training)
- Mercedes-Benz ELITE START and ELITE ADVANCED
- MINI STEP (Service Technician Education Program)
- Nissan/Infiniti NATT (Nissan Automotive Technician Training)
- Porsche PTAP (Porsche Technology Apprentice Program)
- Toyota/Lexus/Scion TPAT (Toyota Professional Automotive Technician)
- Volvo SAFE (Service Automotive Factory Education)

For those hoping for a career in the racing industry, UTI offers the NASCAR Technician



Students in the advanced automotive programs enjoy learning on the newest vehicles and using the latest technology.

Ford/Lincoln FACT (Ford Accelerated Credential Training) is one of the many programs offered by UTI in conjunction with OEs.

Training program at its Charlotte (Mooresville) campus. The course includes education and hands-on experience with racing engines, body, fabrication, chassis and even working on a pit crew. It's all right in the center of the NASCAR world and increases the chances of getting a job with a racing team.

COLLISION REPAIR/ REFINISHING TECHNOLOGY

UTI offers advanced hands-on collision and refinishing courses in state-of-the-industry classrooms under the instruction of certified instructors. The program is approved by the National Automotive Technicians Education Foundation (NATEF) and prepares students for ASE certification testing in: Structural Repair, Non-structural Repair, Mechanical & Electrical Repair and Painting & Refinishing. Students can also earn welding certifications, I-CAR Class Points and specialized training on Chief body system equipment, 3M and DuPont finishing methods.

DIESEL & INDUSTRIAL

Two types of diesel-oriented training are offered by UTI: Diesel and Industrial. The Diesel elective is dedicated to complete Class 3-8 diesel truck service while the Industrial elective is devoted to construction, excavation and agricultural equipment. The OE sponsored programs include Cummins Diesel (Engine), Cummins Power Generation, Daimler Trucks (Freightliner, Sterling & Western Star) and International Trucks.

MOTORCYCLE TECHNOLOGY

At the Phoenix and Orlando campuses, UTI offers motorcycle technology education and partners with major motorcycle manufacturers though its Motorcycle Mechanic Institute

WELCOME TO TRAINING CAMP

Training is the key to any profession and especially so in the automotive service industry. Every year, new technologies are incorporated into modern automobiles and trucks for safety, economy, environmental protection, connectivity and convenience. The result is that technicians are continually faced with new problems on systems and technologies that didn't even exist just a few years ago.

In the early 1990s, the automotive aftermarket service industry embarked on a mission to eradicate the word, "Mechanic" from the vocabulary of the American public and replace it with "Technician." A few decades ago, the "tools" auto service professionals used were wrenches and hammers. Today, those "tools" are more and more likely to be pieces of electronic equipment to diagnose and service the myriad of electronic components found on new vehicles.

In an effort to help you keep up with the rapidly changing knowledge of automotive service we will present the Training Camp series to make readers aware of some of the schools, institutions and organizations that offer education in the latest technologies and outstanding basic automotive programs.

Whether you are currently working in the field and want to upgrade your skills or wish to start a career – or know someone who is interested, we sincerely hope these articles will be helpful. ■

(MMI). Industry partners include BMW, Harley-Davidson, Honda, Kawasaki, Suzuki and Yamaha. MMI graduates are highly sought after for the motorcycle service industry.

MARINE TECHNOLOGY

The Orlando campus also houses the Marine Mechanic Institute at which students learn to diagnose, service and repair marine engine systems. Marine industry giants Honda, Mercury, Suzuki, Yamaha and Volvo-Penta sponsor training on outboard and stern drive systems. Diesel marine engines are also included in the program.

UTI LOCATIONS AND PROGRAMS

UTI currently has eleven locations. Not all campuses offer all courses, so we've included a list of locations with the courses each offers:

BOSTON, MASSACHUSETTS:

Automotive, Diesel & Industrial

Advanced Training: Ford, Mercedes-Benz, Nissan

CHARLOTTE, NORTH CAROLINA:

Automotive Technology

Advanced Training: NASCAR Technical Institute, Ford, Nissan

DALLAS, TEXAS:

Automotive, Diesel & Industrial

Advanced Training: Interactive Online Learning

HOUSTON, TEXAS:

Automotive, Diesel & Industrial, Collision Repair and Refinishing

Advanced Training: Ford, Nissan, Mercedes-Benz, Cummins Diesel

LISLE, ILLINOIS:

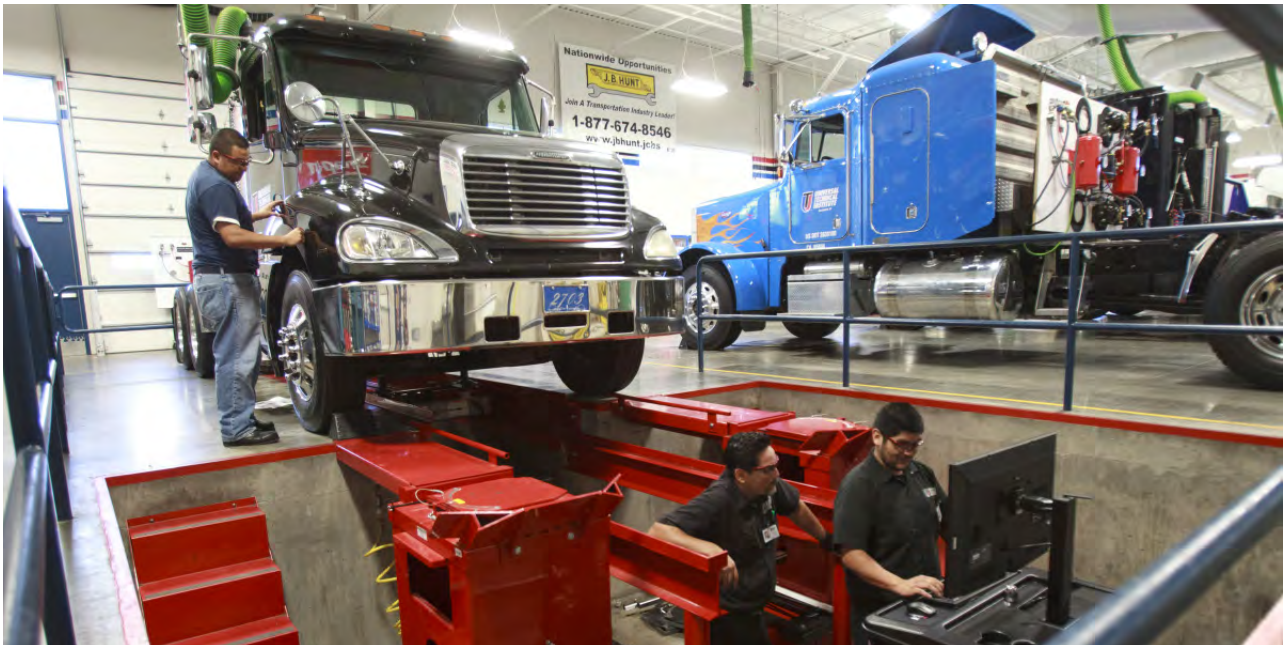
Automotive, Diesel & Industrial

Advanced Training: Ford, Honda, Toyota, International Diesel

LOS ANGELES, CALIFORNIA:

Automotive, Diesel & Industrial

Advanced Training: Ford, Mercedes-Benz, BMW



UTI offers Class 3-8 diesel truck service programs as well as industrial diesel training.

ORLANDO, FLORIDA:

Automotive, Marine Technology, Motorcycle Technology

Advanced Automotive Training: BMW, Ford, MINI, Nissan

Advanced Marine Training: Mercury, Honda, Suzuki, Volvo Penta, Yamaha

Advanced Motorcycle Training: Harley-Davidson, Honda, BMW, Kawasaki, Suzuki, Yamaha

PHILADELPHIA, PENNSYLVANIA:

Automotive, Diesel & Industrial

Advanced Training: Ford, Toyota, Cummins & International Diesel

PHOENIX, ARIZONA:

Automotive, Diesel & Industrial, Motorcycle Technology

Advanced Automotive Training: BMW, Ford, General Motors, Volvo, Cummins Diesel, Daimler Truck

Advanced Motorcycle Training: Harley-Davidson, Honda, BMW, Kawasaki, Suzuki, Yamaha

SACRAMENTO, CALIFORNIA:

Automotive, Diesel & Industrial, Collision Repair and Refinishing

Advanced Training: Ford, Nissan, Toyota

THE BENEFITS OF CHOOSING UTI

If the wide variety of class selections, industry sponsors and multiple locations aren't enough reasons to consider UTI for an automotive education, here are a few more things to consider:

UTI offers state-of-the-art facilities, current model vehicles, the latest tools and equipment, and hands-on learning. "Our students have access to state-of-the-art vehicles and tools to prepare them directly for the workforce," said Greg Gunter, Technical Team Leader for the Ford Accelerated Credential Training program at UTI-Pennsylvania. "These days, technicians spend more time at the computer than under the hood. Cars are more high-tech than ever before and our programs prepare students to work on these complex vehicles. And, our students don't have to sit through hours of lectures and philosophy discussions. Our students get

Hands-on learning on current models in state-of-the-art facilities gives UTI students an advantage for employment.

UTI students learn under qualified instructors.

hands-on training that prepares them for their career and professional values that will lead them through their lives," added Gunter.

UTI functions and operates like a state-run university. The school offers all the benefits, convenience and considerations of a liberal arts college.

- Scholarships – Scholarships are available to eligible students.
- Financial Aid Services – Assistance is available to help students apply for grants, scholarships and student loans.
- School/Career Counselors – Counselors can help students navigate through the school experience and into their desired career.
- Housing Assistance - UTI partners with Collegiate Housing Services (CHS) to assist students with locating and securing housing.
- Employment and Placement Services – Assistance is available to help students find a part-time, local job that doesn't interfere with their studies and helps cover living expenses, while attending school.
- Veterans G.I. Bill – UTI works with veterans who wish to transition into a civilian career.

Instruction is given by qualified, certified instructors, who are knowledgeable of the subject matter. Not all automotive training programs can boast that.

Students earn or prepare for several industry certifications. In the automotive area, this includes preparation for ASE certification testing and EPA Section 608 and 609 HVAC certification.

UTI boasts high graduation and placement rates. Two of every three UTI students graduate and four out of five find employment in their specialty.

For more information about Universal Technical Institute visit the school's website at www.uti.edu. ■

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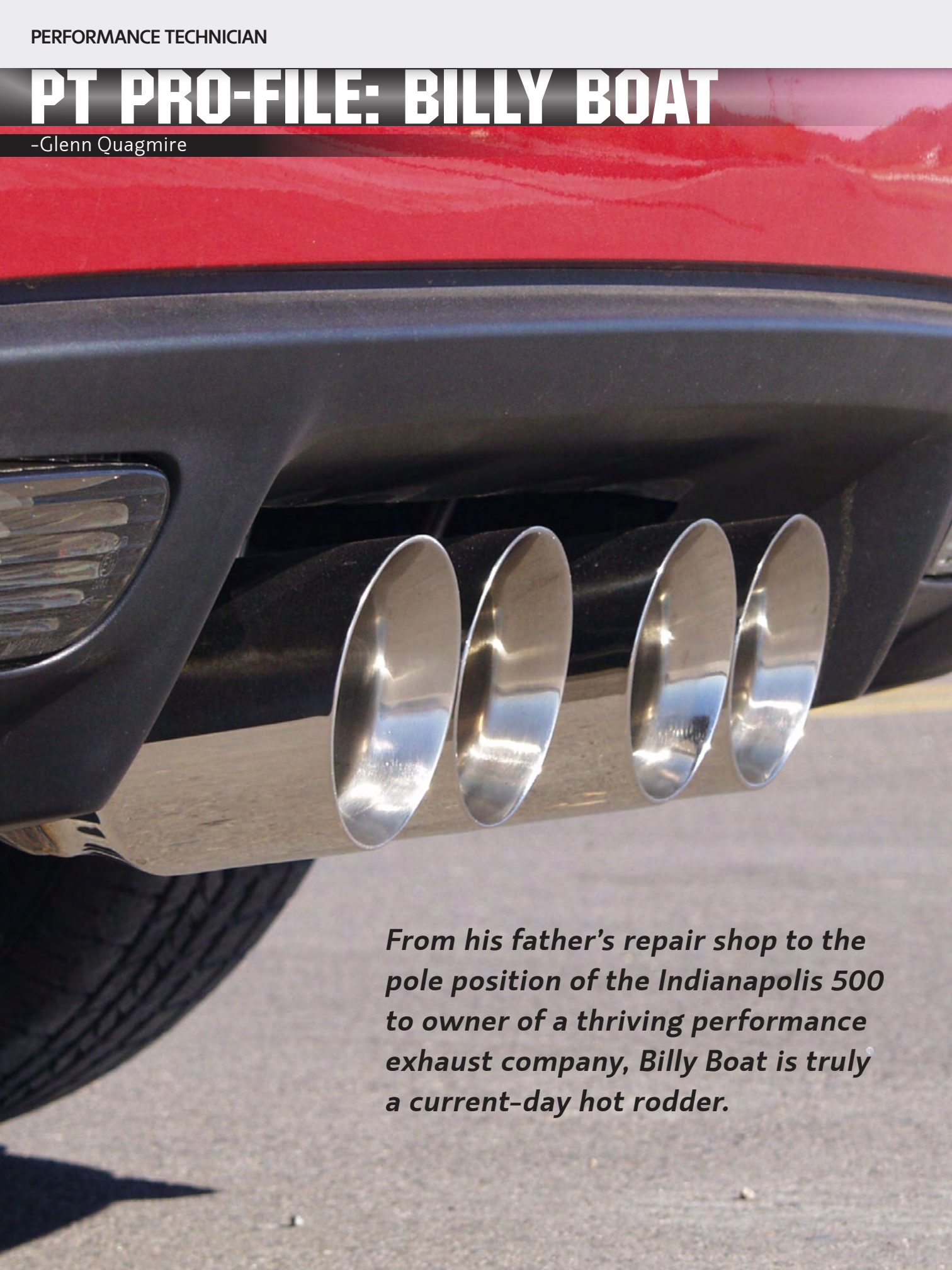
PT PRO-FILE: BILLY BOAT

-Glenn Quagmire



From his father's repair shop to the pole position of the Indianapolis 500 to owner of a thriving performance exhaust company, Billy Boat is truly a current-day hot rodder.

In our introductory article in which we laid the groundwork for this series of articles, you'll recall that we talked about the pioneers of hot-rodding -- those who, particularly after World War II, became enamored with speed and competition, on the street and at race tracks, in the cars of the day.

For sure southern California was a hotbed of such activity, but it was rampant all across the U.S. The need for speed was an epidemic, as it was an incubator for creativity and resourcefulness. And it produced some of the names that have become immortalized in the performance industry -- names like Ed Iskenderian, Vic Edelbrock Sr., Stuart Hilborn, Joe Hrudka (a.k.a. Mr. Gasket), Nick Arias, the Summers Brothers, and many, many more.

Billy learned fabrication at a very young age.

Measure twice, cut once...

These are the people who started in grassroots racing and backyard shops, each looking for ways to make their cars faster. Then they made other peoples' cars faster. And before they knew it they were selling parts out the back door of their garage. Then they opened a little storefront. And, finally, they built their ideas into enterprises. Big enterprises. Successful enterprises. And, for the most part, they built these enterprises from small and sometimes dingy backyard shops they shared with bicycles, lawn mowers, and who knows what else.

Interestingly, they nearly all seemed to share some common threads. Few, if any, inherited large businesses; most started with little -- some in a father's garage, and some trying to keep their fathers from finding out what they were doing on the sly.

Another feature common to most of them was their focus on a particular part or system within a car. Isky knew camshafts. Edelbrock focused on manifolds and induction systems. Hilborn knew fuel injection like nobody else. And the Summers Brothers found a way to transfer all that new-found power to the wheels without breaking axles.

Billy gets some instruction in the finer points of roundy-round racing from his father.

And that brings us to today, and a new generation of hot rodders. It would be easy to think that all the performance parts we'll ever need have already been invented and produced. But, truth be told, the situation is just the opposite. Just as automotive design technology has advanced, so has hot rodding. Vehicle electronics, Computer-Aided Design (CAD) capabilities, so many technologies that never existed a generation ago, all combine to form fertile ground for those who have the need for speed, the creativity, and the entrepreneurial spirit to become the new hot rodders of today. There are many. And what's especially interesting is that so many come from humble beginnings, and have focused on specific vehicle parts and systems.

LIKE BILLY BOAT.

Billy Boat was not born with a silver wrench in his hand. He was, however, fortunate enough to be born into a Phoenix-area family in which his father owned and operated a general auto repair shop at his home. Not a So-Cal kid, and not the spoiled son of a rich family, Billy was given the opportunity to learn basic fabrication skills at the ripe old age of 5, and learned to weld at 8.

These were helpful skills for the family business, which also built some engines and chassis for roundy-round customers.

During those same tender years Billy showed his competitive side by racing, first motorcycles, then go-karts and midgets. Along the way, his involvement in motorsports gave him the opportunity to work with David Schneider, of camshaft fame, and Stuart Hilborn, the fuel injection

L-R: Chad and Billy Boat @ Chili Bowl Nationals midget race

Brother Mike, Billy, and their father prepare for the next race.

Billy learned that welding and brazing are an important part of exhaust system fabrication.

guru, where he expanded his knowledge base of engine development.

By age 24 his skills and quest for success led him to start his own business out of his father's garage, building headers for the Porsche 930 turbo under contract from Porsche. During that time his racing career had grown and he was racing sprint cars around oval tracks all over the southwest. And the die was cast. In 1990 he opened a modest shop of just 800 square feet, fabricating headers and exhaust systems, which had become his specialty.

Since then, his business has grown to some 30,000 square feet, he's built headers for NASCAR racers and Indy Lights cars, and still produces headers for the Porsche 930 turbo.

A stainless steel cylinder forms the substrate around which the woven ceramic material is wrapped, providing excellent strength, durability, and noise attenuation.

Oh, and by the way, his racing career had enjoyed similar growth and success, culminating in his achieving the pole position for the 1998 Indy 500…

But today the essence of Billy Boat's enterprise is performance exhaust systems for high end sports cars. And what a business it is! The company produces custom-designed performance exhaust systems for the most advanced and sophisticated vehicles on the planet -- domestic models like Corvette, Viper and Cadillac XLR, imports from BMW,

This seemingly simple cone-shaped device is deceptive in its appearance. You'd think this sound-dampening component would necessary restrict the free flow of exhaust gases. But its ingenious design incorporates a collection of holes whose total area exceeds the area of an unmodified pipe, resulting in a tuning of the exhaust tone with no increase in back pressure.

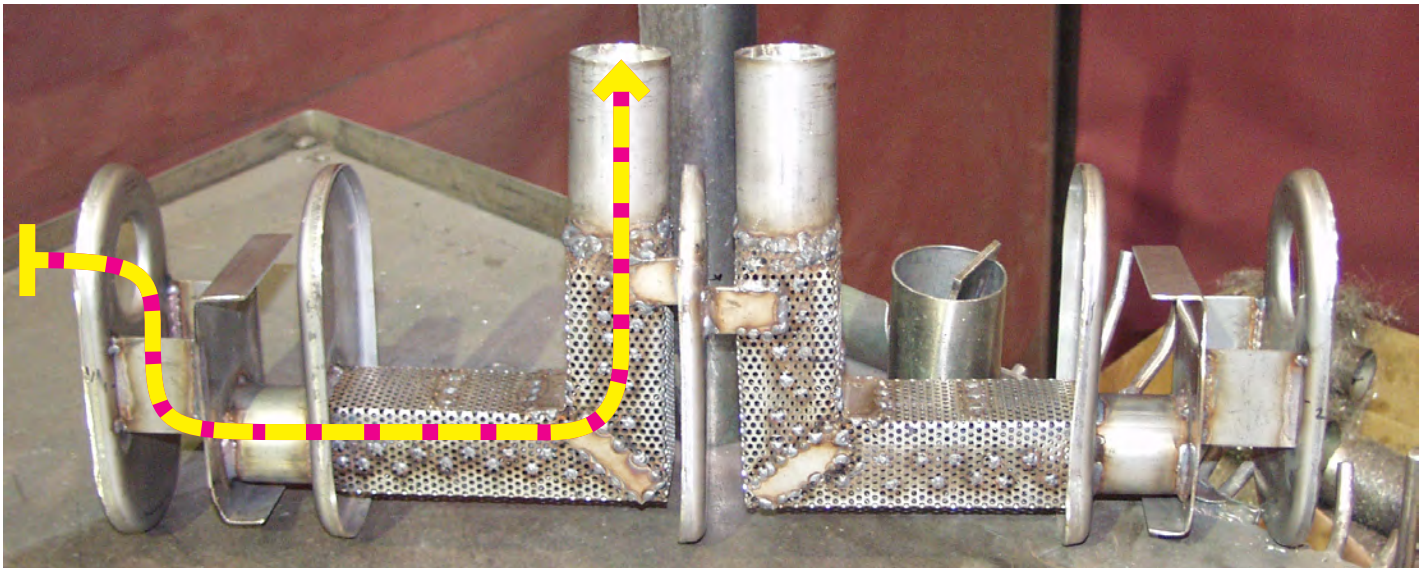
Porsche, Audi, all the way up to Ferrari and Lamborghini, and trucks and SUVs including Escalade, Hummer and many others.

And these are not just bling for the rich and famous. Nosirree, these are the result of advanced engineering, designed to provide maximum street performance along with an appropriately rich tone for each make and model.

During his decades of custom-fabricating exhaust systems, Billy has developed technical innovations that most folks would never associate with exhaust systems. Like the bi-modal system developed for the late-model Corvettes. We're all pretty much familiar with newer cars with multiple drive modes -- one for more aggressive driving, one for more sedate driving or for driving in snowy or slippery conditions.

And those of us with our share of gray hair will remember the simple mechanical cut-outs highlighted in the J.C. Whitney catalogs of old. While the premise is similar, the technology is anything but. With the Billy Boat bi-modal exhaust system, two routings are available based on parameters that include engine speed, engine vacuum, and throttle position. When the proper combination indicates that the driver wants more grunt, the exhaust system goes into "power" mode, re-routing exhaust gases through the less-restrictive path, with the expected result of increased horsepower, and a bit more "bark" to match.

While this technology has been incorporated into the latest-generation Corvettes on the assembly line, Billy Boat has gone the car companies one better by incorporating this technology into exhaust systems for multiple earlier-generation Corvettes, built when such technology had not even been thought of. It's this kind of ingenuity, applying new ideas to older cars, that is at the very heart of hot-rodding.



An innovative feature of the Billy Boat performance mufflers is the strategically-located baffle near the muffler's inlet. This baffle allows some exhaust gases to pass through a direct route into the sound deadening chamber, while other portions of the exhaust gases must traverse an indirect path, resulting in acoustic tuning even before the gases enter the sound chamber.

Another innovation that Billy has developed is a distinctive two-stage packing system within mufflers. This design features a blend of stainless steel surrounding the baffles at the core of the muffler, then encased in a ceramic capsule around the stainless steel. This combination provides sound wave cancellation along with supplemental thermal cooling. The result is a modest increase in power, longer life, and exhaust tone modulation and tuning.

While some manufacturers of aftermarket headers and exhaust systems opt for whatever size tubing seems to fit best, that is not the regimen at Billy Boat Exhaust. Decades of building exhaust systems for race cars have brought a body of knowledge regarding optimal tubing size for typical upgrades in street performance engines as well as anticipated driving style.

One of the lessons learned over the many years was that exhaust tubing diameter and length have a direct impact on engine output. Smaller diameter tubing with greater length tends to provide more low-end torque, while larger diameter, shorter tubing generally makes for more top-end horsepower. So exhaust systems for various types of vehicles are individually designed based on typical powertrain upgrades and usage patterns. This approach provides optimal performance increases for each vehicle family rather than using a one-size-fits-all approach as used by some other companies. In addition, Billy Boat Exhaust will custom-make an exhaust system for an individual customer who may have unusual or innovative needs.

In an unusual effort to enhance the value of their exhaust systems to buyers, Billy Boat Exhaust systems offer some surprising features. For instance, all exhaust system components are stainless steel, which allows coverage by a lifetime warranty which is even transferable to a future owner. The stainless steel is extremely durable, and also does not require the buyer to send it off for costly coating with ceramic or other material.

All Billy Boat exhaust systems receive a double layer of insulation. First is a stainless steel packing, followed by a thermal wrapping of woven ceramic material that will not burn through. In fact, this proprietary woven ceramic material can actually become red hot and, when cooled, will revert to its original shape and soft composition. Both insulating layers are held securely in place with the stainless steel shell, so that loose internal baffles, a problem with other performance exhaust systems, are not possible.

Further, BBExhaust systems are direct replacements for OE systems, so there's no need for awkward adapters. And they even go so far as to supply unique clamps that do not distort or crimp pipes

when tightened. This certainly simplifies disassembly if it's ever needed. And, since these systems are not inexpensive, it is not uncommon for folks to remove this system before selling their car, re-installing the OE system that was removed, and re-selling the Billy Boat system, often recouping as much as half of the original cost, making these systems an even better investment.

Billy Boat started as a youngster working in his father's garage. He learned welding and fabricating skills there. He was fortunate to work under the direction of early-generation hot-rodders. He started racing as a kid and went on to pace the Indy 500, all while building a very successful business making and selling performance parts.

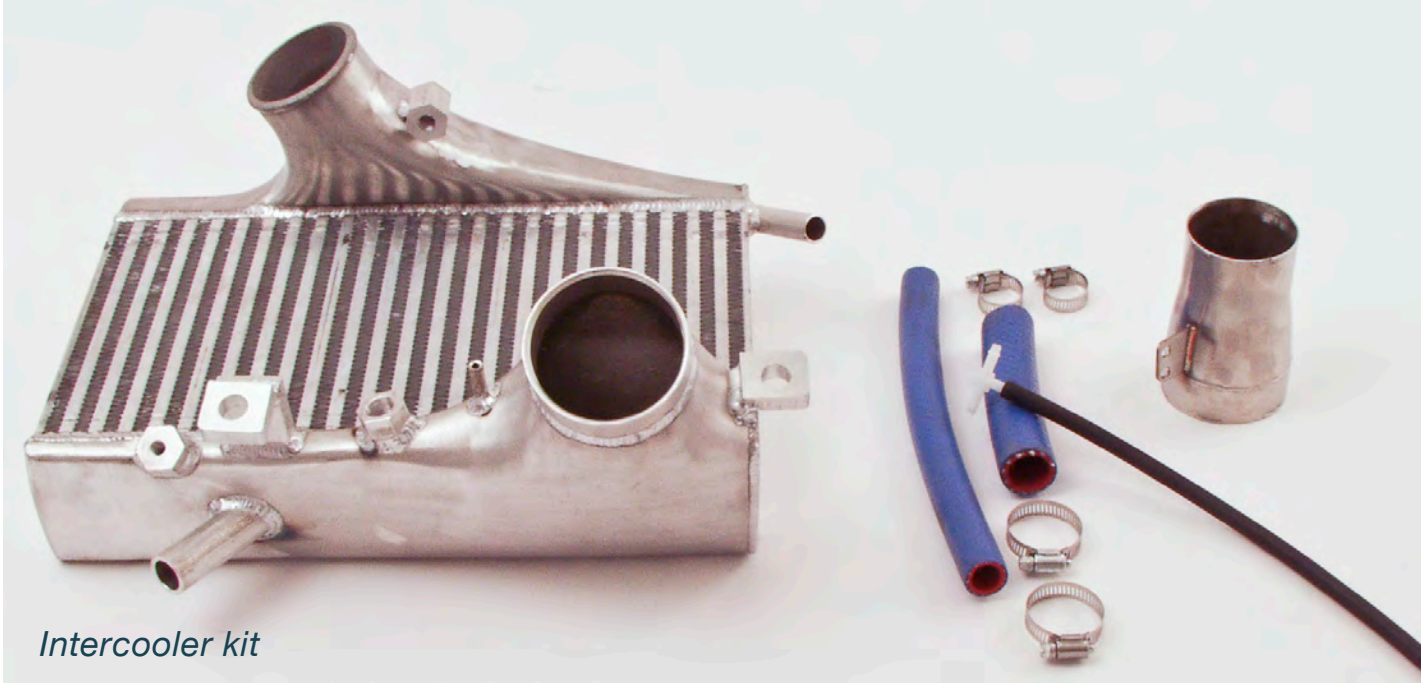
DOES ALL OF THAT SOUND LIKE A HOT-RODDER OF TODAY?

SURE SOUNDS LIKE IT TO ME... ■

Learn more at www.bbexhaust.com

C7 Corvette exhaust system

Porsche 997 exhaust system



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OEM NEWS
CAT OUTTA HELL!

2015 Dodge Challenger SRT Hellcat Is the Most Powerful Dodge Muscle Car Ever at 707 Horsepower.

Dodge has unveiled its latest SRT Challenger model for 2015, and it's a monster! The Hellcat version of the 2015 Challenger SRT will surpass standard 392/6.4-liter HEMI V8 485-horsepower SRT model. The new supercharged 6.2-liter HEMI Hellcat engine is rated at a whopping 707 horses and 650 lb.-ft. of torque, making it the most powerful Challenger ever, Dodge's most powerful V-8 ever and the most powerful muscle car ever. Moving past the 700+ hp threshold puts the Hellcat beyond the competition: Camaro Z28 (500 hp), Viper V10 (640 hp), Corvette Z06 (650 hp) and Mustang GT500 (662 hp).

If you think all they did was supercharge the existing 6.4-liter, you'd be wrong. In fact, they don't have much in common. Dodge says that 91 percent of the engine content is new, when compared to the 6.4-liter SRT engine.

The new supercharged engine features a forged-steel crankshaft with induction-hardened bearing surfaces. The crankshaft can withstand firing pressures of 110 bar (1,595 psi) and its unique, specially tuned crank damper has been tested to 13,000 rpm.

The huge 92-mm throttle body is needed to feed the 2,380cc blower.

High-strength, forged-alloy pistons – developed using advanced telemetry measurement – are coupled to powder-forged connecting rods with high-load-capacity bushings and diamond-like-carbon-coated piston pins. The new supercharged 6.2-liter HEMI V-8 has premium-grade, heat-treated aluminum-alloy cylinder heads that are optimized for superior thermal conductivity. The sodium-cooled exhaust valves feature hollow-stem construction and special, steel-alloy heads that stand up to temperatures as high as 1,472 Fahrenheit (800 Celsius). Cam profiles afford 14.25-mm inlet and 14.0 mm of exhaust lift. The engine block and die-cast aluminum rocker covers are HEMI Orange (of course).

The 2,380cc/rev blower features integral charge coolers and an integrated electronic bypass valve to regulate boost pressure to a maximum of 80 kPa (11.6 psi). Its twin-screw rotors are specially coated with a proprietary formula of polyimide and other resins. The supercharger gulps air through an Air Catcher inlet port in the driver's-side headlight and connects to a patented twin-inlet eight-liter air box. The blower further benefits from a 92-mm throttle body – the largest ever used in a Chrysler Group vehicle.

CAGING THE 'CAT

Chrysler has added a unique way to limit the power of the Hellcat engine for the occasional possible driver that the owner doesn't want to unleash the beast. The 2015 Dodge Challenger SRT with a Hellcat engine comes standard with two key fobs – one red and one black. The red key fob is the

only key that can unlock the full horsepower and torque potential of the Hellcat engine; while the black key fob limits the driver to a reduced engine output of 500 horsepower.

Also, a Valet Mode is offered on both Challenger SRT and Challenger SRT with a Hellcat engine. When Valet Mode is activated, the following vehicle configurations are enabled:

- Engine is remapped to significantly reduce horsepower and torque; limited to 4,000 rpm
- Transmission locks out access to first gear and upshifts earlier than normal
- Transmission will treat the manual shifter position the same as the drive position
- Traction, steering and suspension are set to their "Street" settings
- Steering-wheel paddle shifters are disabled
- Drive Mode functions are disabled
- Electronic Stability Control (ESC) is enabled to Full-on
- Launch Control is disabled

The owner can activate and deactivate Valet Mode with a four-digit PIN code they create.

BIG BREMBO BRAKES

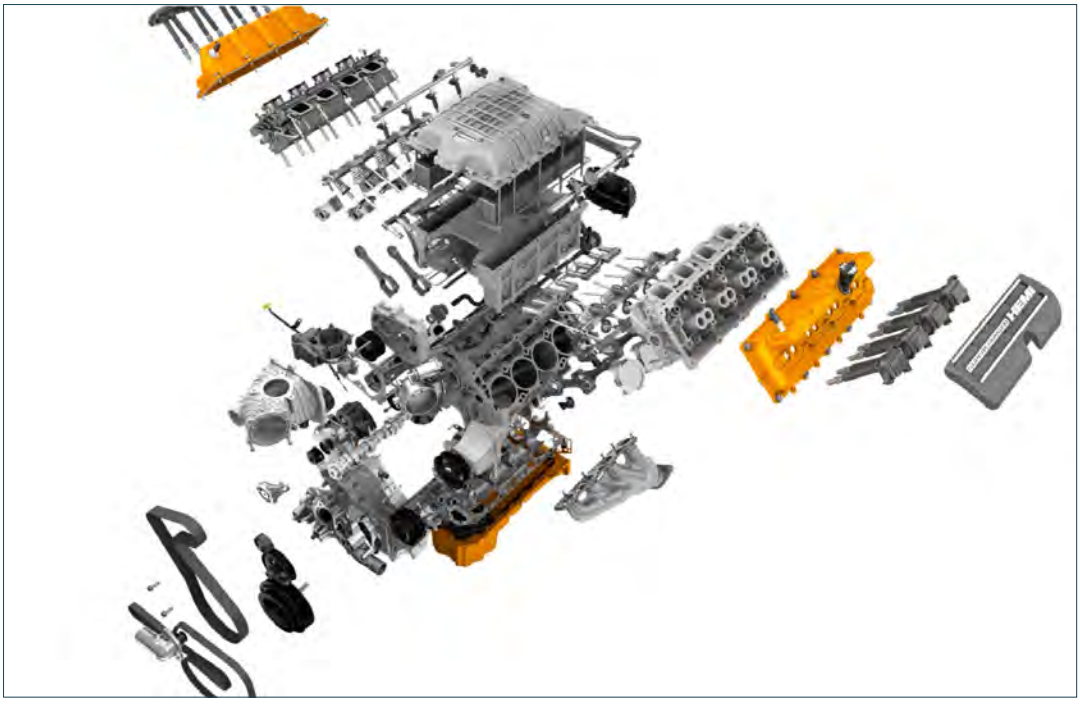
Standard on the 2015 Challenger SRT with the Hellcat engine is the largest front-brake package ever offered in an SRT vehicle, featuring all-new 15.4-inch Brembo two-piece rotors with six-piston calipers for outstanding heat management/thermal capacity and longevity.

New anti-lock braking system (ABS), ESC and traction control systems are uniquely tuned and configurable for specific tire and powertrain configurations. Available on the Challenger SRT Hellcat are 20 x 9.5-inch, lightweight forged-aluminum wheels with a Brass Monkey/dark bronze finish.

NEW INSIDE & OUTSIDE FEATURES

The hood on the new Dodge Challenger SRT with a Hellcat engine also includes dual air extractors to ensure effective removal of heat and reduced air turbulence in the engine compartment. The hood is standard in body color and is available in a Satin Black finish.

Another key design element on the Challenger SRT Hellcat is the exclusive Air Catcher inlet port, which feeds ram-



The Hellcat supercharged engine is quite different from the standard SRT 392 6.4-liter aspirated engine.

air directly into the engine air box through the driver-side parking lamp. All-new quad projector headlamps give a more detailed appearance, while a more aggressive brow "chops" the upper portion of the lamp design for an even more sinister attitude. The Dodge Challenger SRT with a Hellcat engine features a larger front splitter designed for optimal downforce to minimize lift.

For those who opt for the TorqueFlite eight-speed automatic transmission, a new electronic shifter with a driver-oriented T-handle provides the driver with intuitive gear selection and offers an Auto Stick selector gate for added control. For those who prefer having a third pedal, a Tremec TR6060 six-speed manual transmission is fitted with a throwback ball shifter.

A redesigned SRT-branded heated steering wheel features a flat bottom for the high-performance driver. Available paddle shifters (with automatic transmission) are located on the back of the upper spokes. The buttons to control the driver-configurable full-color thin-film transistor (TFT) display are large and illuminated.

Performance seats with large side bolsters provide maximum lateral support in hard cornering. The seats can be covered in Nappa leather/Alcantara material with embroidered SRT logos. Laguna premium leather, colored either sepia or black with embossed SRT logos, is available as part of an equipment package. Special badging and paint offerings (we like red!) will be included.

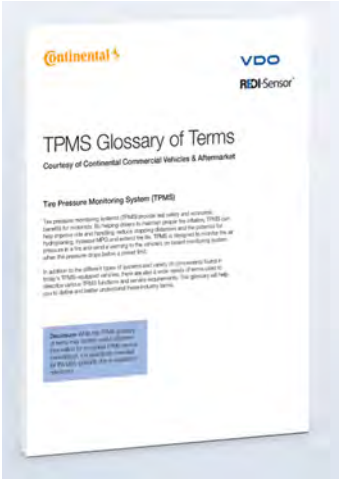
The exact price for the 2015 Dodge Challenger SRT with the Hellcat engine has not been established, but the company says it will begin delivering the cars this fall. That gives you time to start saving up for your very own Hellcat. ■

Do you see the Hellcat face?

The supercharged 6.2-liter Hellcat engine fits snugly under the hood.

INFORMATION STATION

FREE GLOSSARY OF INDUSTRY TPMS TERMS



Continental, maker of the VDO REDI-Sensor Multi-Application TPMS Sensor, offers a free glossary of industry terms that was recently developed for TPMS service. The new 10-page glossary includes definitions and descriptions for over 93 industry-wide TPMS service related and parts terms.

The new glossary is available on the VDO REDI-Sensor website at www.redi-sensor.com/glossary.php and can be downloaded for easy reference as a PDF. The glossary has also been indexed by Google for easy search.

DOOR EDGE AND DOOR SILL PROTECTION KITS

XPEL offers do-it-yourself paint protection film kits designed to protect vehicles from chips, scratches, scuffs and abrasions. The Door Edge Guard is an 8 mil polyurethane film. Invisible when applied, the kit includes enough material to protect four doors. Available in a 12-foot kit and a bulk 100-foot roll; Standard width - .38 inch, Extra wide - .5 inch.

The Door Sill Guard Kit includes one 60-inch x 2.75-inch strip of durable removable film that protects the doorsill plate. Available in a 12-foot kit and a bulk 100-foot roll in two styles: Clear - 8 mil polyurethane designed to be invisible once applied, and Black - 13 mil embossed PVC hides existing damage while preventing further scrapes and scuffs. For more information, call 800-447-9928.

SILICONE IGNITION WIRE PROTECTION KIT

Design Engineering has introduced its new Silicone Protect-A-Wire Kit to protect high voltage ignition wires using the latest silicone coated annealed fiberglass technology. This process provides a flexible, abrasion and chemical resistant cover.

The kit includes 25 feet of 3/8” ID silicone covered annealed silicone coated fiberglass sleeving with heat resistance to 400°F, eight DEI branded tube ends, and eight consecutively numbered (1-8) tube ends to label plug wires for added assurance they are connected to the correct cylinder. For details, contact your supplier or log onto www.designengineering.com.

FUEL AND OIL ADDITIVES FOR LIGHT-DUTY DIESEL ENGINES

Penray has introduced two new products that it says will help owners of diesel-powered cars and light trucks optimize the performance and economy of their vehicles -- Penray Plus Diesel Fuel Prep and Penray Plus Engine Oil Treatment.

The Diesel Fuel Prep is engineered to keep fuel systems free of deposits and contaminants that can compromise the performance of fuel injectors and other fuel system components, all of which are manufactured to extremely tight tolerances for diesel applications. Keeping injectors clean will minimize plugging of diesel particulate filters (DPF), thus extending the life of the emissions control system.

The Engine Oil Treatment combats sooty deposits and other contaminants by dissolving them and holding them in suspension where they can be removed by the oil filter, thus preventing soot and particulates from compromising engine performance and possibly causing engine damage and includes acid neutralizers to prevent corrosion, and also includes supplemental zinc, which fortifies the engine oil. Information can be found at www.penray.com.

AMI CELEBRATES 25 YEARS

This year marks the 25th anniversary of the Automotive Management Institute (AMI), the leading provider of management education for the automotive service and collision repair industry. The Institute currently offers more than 1,300 approved courses, a faculty of 300 approved instructors and the prestigious Accredited Automotive Manager (AAM) designation. To date, its programs have attracted 230,000 enrollments throughout North America.

The Institute will celebrate with special events throughout the year, starting with the International Autobody Congress & Exposition (NACE) and the Congress of Automotive Repair & Service (CARS), June 30-Aug. 1, in Detroit.

AMI offers the Accredited Automotive Manager (AAM) designation, the first business management accreditation exclusively for the automotive service professional. To date, AMI programs have attracted more than 230,000 enrollments throughout North America. For more information about the Institute or its curriculum, please visit the AMI website at www.AMIonline.org or call 800-272-7467 ext. 129. ■

FINISH LINE

MCCONIGA'S AXIOMS: *THEY AREN'T MY CLOWNS* & *THIS ISN'T MY CIRCUS*

-Greg McConiga, Executive Technical Editor

I don't know about you, but I'm fed up with political correctness, partial truths, and our lack of courage to face absolutes. There are absolutes in life -- in the character and nature of man, in our capacity to hear, learn and understand -- and they are revealed in what we see in the world around us. People can say anything, but their intentions become clear when you see what they do. Talk is cheap; actions reveal the man -- and more often than not you're likely to be disappointed in what you'll see.

Over the years I've written down a list of axioms, things that have proved to be universally true for me, 100% of the time. Things that apply to people, places, businesses, and events, and today I thought I'd share a few of these with you. The list is under constant revision and the delicate among you may find my opinions a bit strong. You are free to disagree and I don't care if you exercise that option as I will not attempt to change your mind. And you'll extend the same courtesy to me, okay? Not all are original; I'm not nearly that bright. Some you'll recognize as old truisms reworded, some a variation on previously-expressed thoughts, and some are all mine. In no particular order, we begin:

#48 *The good old days weren't always that good.*

From civil rights to quality of life to entertainment options to health care we've

made great strides in America. We have more quality and more options than ever before.

One of the things I do is work in a restoration shop and I can tell you this with complete authority: Those old cars can't compare to what we drive today. Don't get me wrong. I love the old muscle car era. From 1960 until 1972 or so, we built some beautiful cars -- sexy, curvy, loud, and powerful. But when it comes to build quality, overall performance, and reliability the old cars don't hold a candle to what we drive today. Some progress is good progress (powertrains and reliability), and some progress is bad progress (cookie cutter bodies and flat, formless body panels). What I'd like to have is a sexy old car with all modern running gear, electronics, and brakes. Now that would be good progress...

#36 *Your thoughts control your actions and your actions control your environment. You can't change your surroundings until you change your dominant patterns of thought.*

From the autonomic to the autonomous, brain activity or thought processes control our biological self. If you can't do the skull work, if you can't control your thoughts and beliefs, you can't control your physical output. Whatever you think about is monitored by your subconscious and becomes the set of filters through which you see the world. If you're an "I can't; I won't; I don't know how" person, then all you'll see are obstacles or ways to fail. If you're an "I can; I will; I'll find out how" kind of person, then you'll find a way to overcome just about any obstacle in your path as you drive toward success. Psychologists studying human behavior refer to "learned helplessness" (if you feel that you have no control, you give up and accept whatever situation you find yourself in), and "confirmation bias" (you only hear or see that which is in accord with your pre-existing beliefs) to explain some of the same effect.

How does this apply to our trade? Success begins with self-talk and that self-talk has to be in the affirmative. People talk themselves into and out of success at hundreds of points during the day. If you're involved in a first time build, or if you're managing a huge last-nut-and-bolt frame-off restoration, your self-talk and your internal mental moving picture must remain positive to get a positive result. You can't think left and head right; your skull work must be consistent with your desired outcome.

#24 *If it's not worth doing with 100% effort don't do it at all.*

You only get so many heartbeats and so many days. Don't spend your time doing things that don't fulfill you. You'll find that you will spend the same number of hours at work or engaged in your passion each day. Why make those hours anything other than full and complete? If you find yourself at work 10 hours, then fill those ten hours with all the effort you can muster. Don't spend a second being mediocre. If you're going to do it, give it everything you've got.

Finally, I'll leave you with the first six axioms I wrote down many years ago that pertain to what people will and will not do when confronted with new information that isn't in accord with what they think they already know and believe. We humans are incredibly adept at justifying what we think we know and we are equally adept at lying to ourselves about what constitutes acceptable behaviors. In spite of what several of the younger generations seem to believe, we don't ride this rock alone. So, learning how others think (or don't think) is key to mutual accountability and responsibility.

In one form or another, I think you'll find that all of the following apply to our lives, our families, our trade, and our business, either from employee-to-employee, or from business-to-customer. Give it a little thought and tell me what you think:

#1 You cannot teach those who will not learn.

#2 You cannot help those who will not be helped.

#3 You cannot convince those who will not be convinced.

#4 You cannot disprove a belief or an opinion.

#5 There is nothing that you can say or do that will have any effect on the chronically undereducated, the lazy, the stupid or the crazy.

#6 Some things are true even when you choose not to believe them; other things aren't true even when you choose to believe them. ■

PERFORMANCE TECHNICIAN

WE WANT TO HEAR FROM YOU!

QUESTIONS, COMMENTS, SHARE YOUR TECH TIPS, ARTICLE SUGGECTIONS - WHAT WOULD YOU LIKE TO SEE?

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