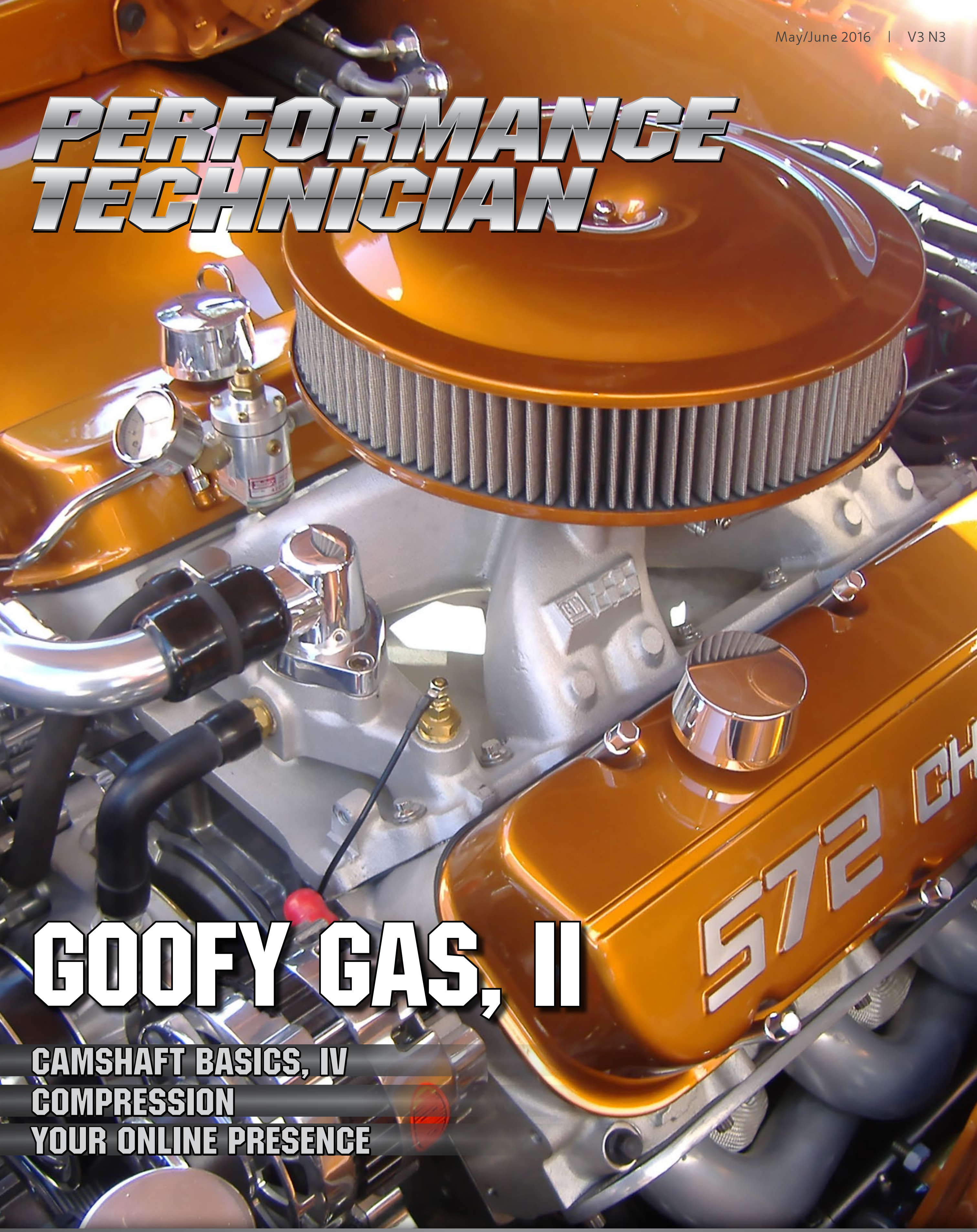
May/June 2016 | V3 N3

PERFORMANCE TECHNICIAN



GOOFY GAS, II

CAMSHAFT BASICS, IV

COMPRESSION

YOUR ONLINE PRESENCE

Vehicle Power & Performance Knowledge for Professionals

Engine and Transmission Repair Stand by Werner Weitner

521-WW-MG-600V-MB

Applicable in all automobile workshops. Developed for repairing engines and transmissions, up to 1,102 lbs. / 500 kg (especially for 8 up to 12 cylinders). Easy to maneuver even with engine or transmission placed in the stand. 260-degree rotations with load. Compact space-saving design. Self-locking worn gear and lockable rear wheels allow safe positioning. Hydraulic adjustment of load holder height up to 180 mm. Ready to use with removable oil pan and handy tool reack. Engine and transmission support sold seperately.

- 360º rotatable
- Single-person operation.
- Adjustable height
- Time and space saving.
- Safe in all positions.
- Ready to use with oil pan & tool rack.
- Max. Width: 31.1” (790 mm).
- Max. Length: 41.73” (1060 mm).
- Total Height at Center: 35.43” (900 mm).
- Flange diameter: 8.66” (220 mm).
- Load capacity: 1,322 lbs. (600 kg).

RAE
RELIABLE AUTOMOTIVE EQUIPMENT, INC.

Universal Transmission Adaptor

521-WW-GA-400

- Load capacity 400kg.
- Perfect accessibility for all types of transmissions. Suitable for common transmissions and axles.
- Quick and easy fixing possibilty.
- Also suitable for Mercedes-Benz OM651 & M271 EVO.
- Designed for the stands MG-250, MG-500 and MG-600V.

Universal Engine Adapter

521-WW-6/140MB

Designed for stands MG-150V, MG-250, MG-500 and MG-600V

Mobile Workshop Crane by Werner Weltner

521-WW-W5K-1000

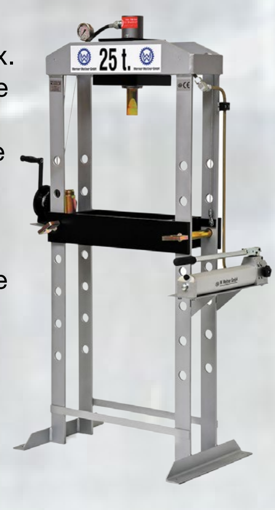
Applicable in all automobile and commercial vehicle workshops.

Perfectly suitable for assembling and disassembling of engines, components and transmissions. Usable for 8 up to 12 cylinder engines. Boom can be adjusted to 5 positions (in increments of 125 mm) and can be applied in different kind of works. Equipped with high-performance hydraulic pump. Maneuverable in tilted position, easy and space-saving storage. Designed for parallel carriage in Euro-pallet width.

25 Ton Workshop Press

521-WW-HP-25T

- Capacity 25t max.
- Working pressure 700 bar.
- Maintenance free construction.
- Foot or hand pump operation.
- Quick press table adjustment.
- Spring return cylinder, 150mm stroke.
- Comes with air hydraulic pump.



Phone: 732-495-7900
e-mail: info@rae1.com
www.raeservice.com
Like us on Facebook at:
facebook.com/ReliableAutomotiveEquipment

PERFORMANCE TECHNICIAN

FEATURES

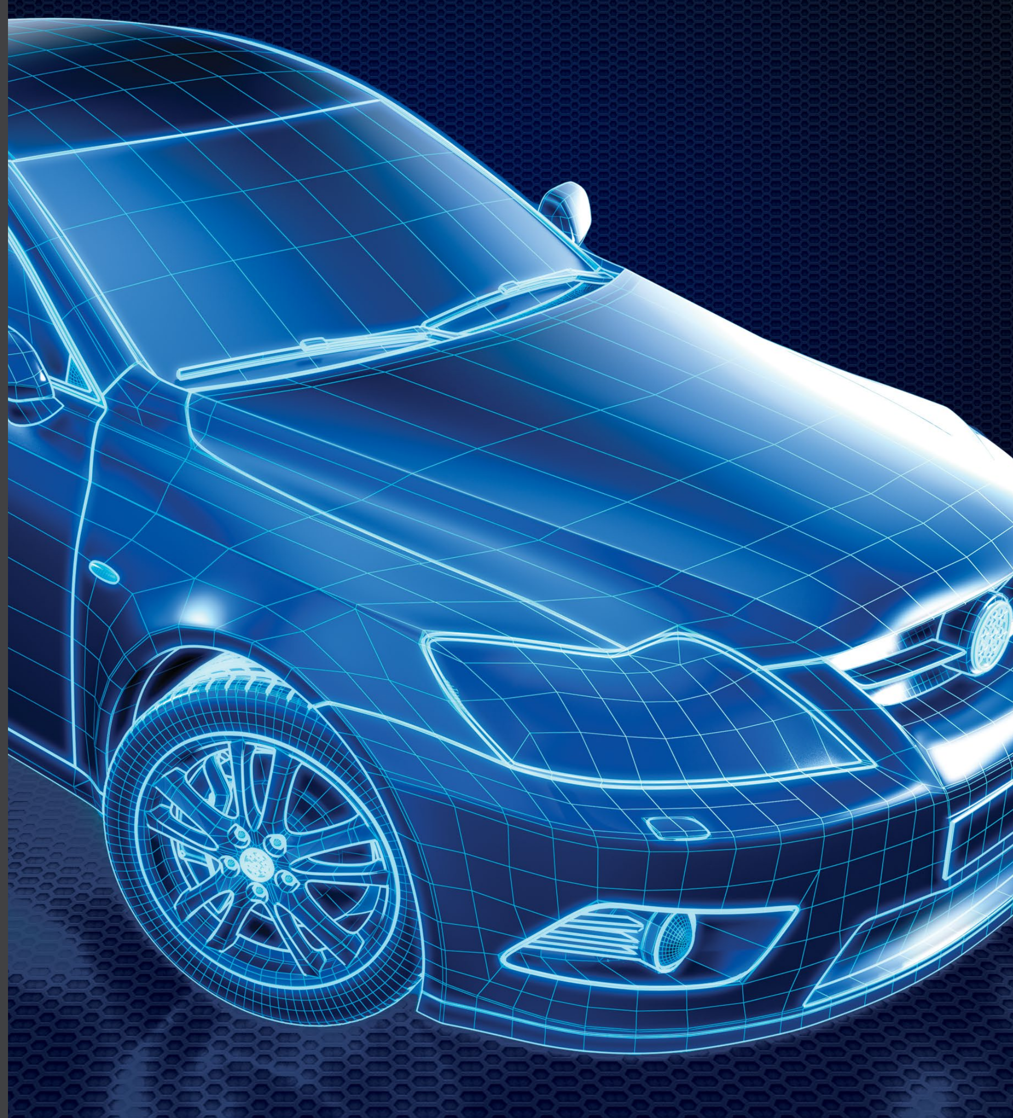
Camshaft Basics, IV 6
Okay, let's do a quick review and then put a bow on this thing called the camshaft.

Goofy Gas and Vintage Vehicle Performance, II 18
Degradation in the tank and carb bowl, light fractions, olefins, carbon deposits, ethanol and phase separation, tuning the mixture, and racing gas.

Why do we need Comression anyway? 28
Pressure. I love pressure. Let's talk pressure.

DEPARTMENTS

Business Briefs: Online Presence 36
Information Station 38
Finish Line 40



Christopher M. Ayers, Jr.
Publisher / Editorial Director
cayers@performancetechnician.com

Bob Freudenberger
Editorial Director
bfreud@performancetechnician.com

Greg McConiga
Executive Technical Editor
gmcconiga@performancetechnician.com

Contributors:
Steve Campbell, Tom Nash, Henry Olsen, Frank Walker, Glenn Quagmire

Tamra Ayers Banz
VP, Business Development
tayers@performancetechnician.com

Christopher Ayers, III
Art Director, Webmaster
ayersc3@performancetechnician.com

Editorial, Circulation, Advertising Sales & Business Office:
134B River Rd.
Montague, NJ 07827
P.330.620.3929

Performance Technician is published by Automotive Data Media, LLC. The publisher and editors of this magazine and website accept no responsibility for statements made herein by advertisers or for the opinions expressed by authors of bylined articles or contributed text.

The current Issue of the *Performance Technician* Emag and information posted to performancetechnician.com, is free on a subscription basis to professional vehicle service technicians, repair shop owners & managers, and automotive performance enthusiasts who have agreed to the terms and conditions as part of registering for access. Contact ayersc3@performancetechnician.com for more information.

If you have a letter to the editor, a Tech Tip or a story idea, Email: gmcconiga@performancetechnician.com or visit: performancetechnician.com.

Performance Technician seeks contributors to add to our growing team. You provide the knowledge – our editors do the rest. Our technician contributors work in, or have shops of their own, while contributing technical articles on a paid (per article) basis to PT readers.

Performance Technician provides power and performance knowledge for professional automotive service technicians, shop owners and technically savvy vehicle enthusiasts.

We welcome you to inquire about being a part of our team. Please call or write Chris Ayers, Jr., Publisher, at 330-620-3929 or cayers@PerformanceTechnician.com.

THE HEART OF THE ENGINE:
CAMSHAFT BASICS, PART 4

-Greg McConiga

Okay, let's do a quick review and then put a bow on this thing called the camshaft.

For this installation, you can see the bronze bushings, the oil groove, and the key slot. Cast iron does a good job acting as an oiled bearing surface to support a steel bodied lifter in mild applications, but for maximum performance bushed lifter bores are the only way to go. If you have a wear problem over time they are easier to replace. It won't take a huge amount of wear in the lifter bore to create a big increase in oil volume and the resultant loss of oil pressure. There are sixteen bores involved and opening up a bore from .002 in. clearance to .005 will result in a noticeable loss of oil pressure.

Here's what we know: We know that we're trying to get our valve to "disappear" from the conduit by lifting it high enough that we get full flow into or out of the cylinder even with our frictional losses, flow separations, turbulence, and shrouding, and this full rate of flow needs to occur in a window around peak piston speeds.

We know that, theoretically, the valve disappears at .25D, or one fourth of the valve head diameter, because at that point the curtain area formed between the valve head and the seat is the same as the area of the valve seat with the valve removed. So, we have to be at or over .25D several degrees before and after peak piston speeds, which occur at 72-80 degrees after TDC (or before TDC on the exhaust valve) on most engines. We know that it's not 90 degrees after as one might think because we've seen that the reciprocating cycle isn't symmetrical over bottom and top and we know that we can adjust it somewhat by changing our rod length-to-stroke ratio (longer rods increase the piston dwell period over top dead center).

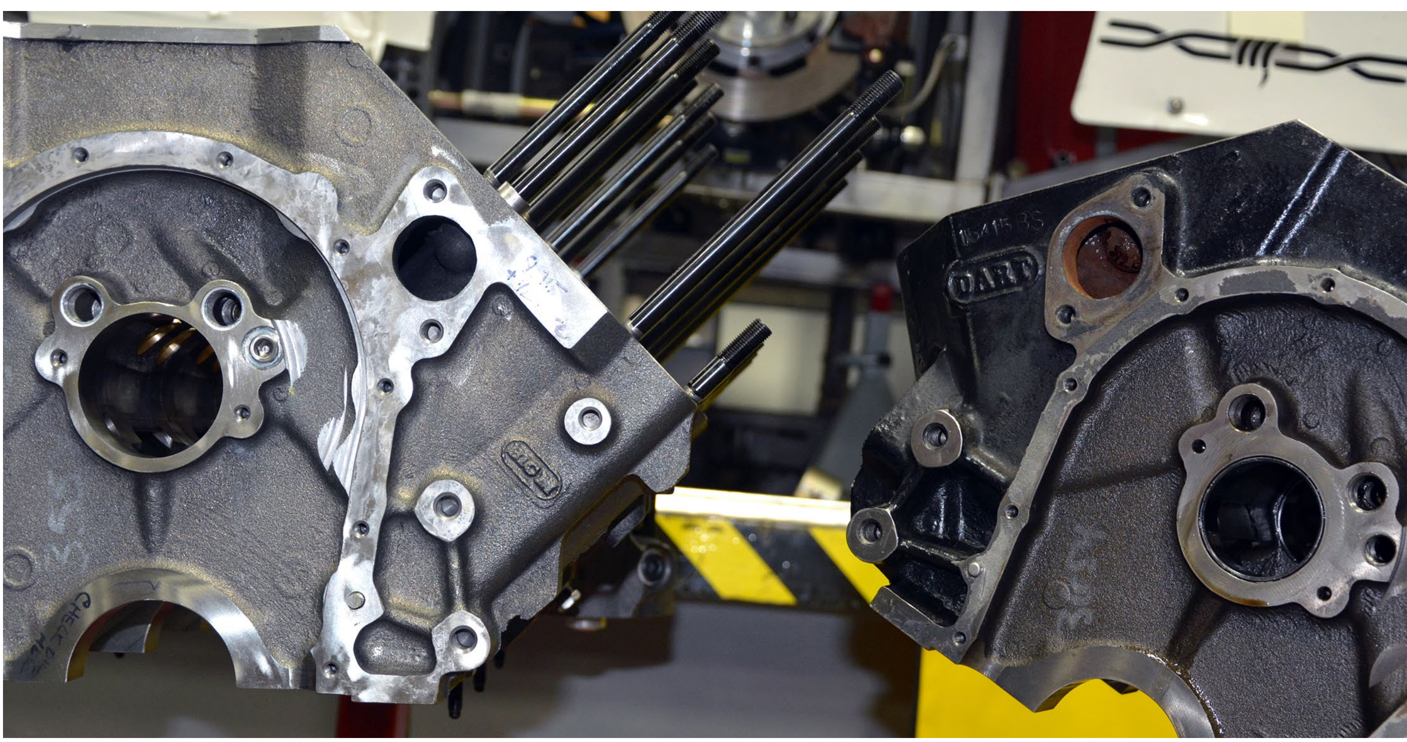
JUST LIKE FOR A CAKE, THERE'S A RECIPE

We know that our lift numbers can be determined by using a simple correlation between valve diameter and application, and that once our desired lift is determined we know that our type of cam and the necessary minimum duration will be set because we have physical limits on how fast we can move the valve train based on the lifter design (we are acceleration limited on rollers and velocity limited on flat-tappet cams).

We also know that once we have a duration event calculated, we then also know that that event has to have a midpoint, and we know that the midpoint of those events have to be placed in a narrow window that corresponds to the peak piston speed (intake lobe centerline and exhaust lobe centerline) and that those centerline positions will determine our lobe separation angles, which, when combined with the duration event beginning and end points, will set overlap.

We've reviewed those things that relate to lobe separation angles and how some features of our little monster will have an effect on proper LSA selection. We now know that for higher low-lift flow rates, higher rocker ratios, shorter rods, increased compression, smaller bore volume-to-valve area ratios, increased cross-flow (as on a hemi or big block Chevy) and higher operating rpm we want to spread the LSA, and for the opposite attribute we want to close it up.

Lobe placement and event timing are why we have camshafts, and we are balancing a number of factors to arrive at the grind best suited to our application. The engine is responding to seven major events, which are intake valve close, exhaust valve open, lift and lift placement relative to peak piston



The block on the left is up-fitted with a 60 millimeter core camshaft. The block on the right is a standard big block Chevy cam core and you can see from the material around the bore just how much bigger that 60 mm cam is. Putting more lift and duration over a larger core allows us to grind a smoother, more controlled profile, reduce the pressure angle and use less rocker ratio. If you've got the room and the cores are out there, bigger is better when it comes to camshaft size.

If you run a camshaft program like that of Performance Trends and you don't have a Cam Doctor or similar piece of equipment, you can get decent results hand reading the cam profile, but you'll have to invest in as good a dial indicator as you can afford. The cam will need to be spotless, even dust and lint will give you all sorts of strange readings when you're looking at readings of .00005 in. or less. Slight variations will show up in acceleration and jerk with your hand readings, but lift, duration, overlap, and installed centerline will be very accurate if you take your time and make sure the indicator follows the lobe. Just spend a little time with an alcohol-based solvent and high-pressure air on the lobe and lifters and you'll be amazed at how good your results will be.

Every time you increase the size of a component to make it stronger or take advantage of the benefits that a larger size might bring you will pay a price in terms of proximity to other parts of the engine. In this case, the engine uses a 4.625 stroke crankshaft and that, combined with this huge tunnel, made getting it all stuffed into the block with sufficient operating clearance a real challenge. It also meant that we had to go to a different design of lifter in order to keep the lifter from rising up out of the bore and exposing the oil gallery and creating an internal oil leak.

speeds, overlap, lobe separation angle, duration, intake open, and exhaust close.

Of these, intake close and exhaust valve open are arguably the most important because they set the volumetric efficiency and the power duration, but lobe separation angle also comes into play since adjusting LSA essentially “rolls” the lobes around the axis of the cam core and in doing so moves the valve opening and closing points. Intake valve opening is a compromise between loss of volumetric efficiency caused when exhaust backflows into the intake for an early opening cam versus the cylinder inflow losses caused by inlet

In this case, we just could not get everything to work, so we ended up grinding a small portion of the shoulder off the connecting rod to get it to clear the lobes of the camshaft. It just took a light kiss with the grinding wheel to get our minimum clearance of .060 in. Once the shoulder was ground away, the next problem became apparent — the square end of the rod bolt was exposed, so a bit of quick work on a flap wheel while spinning the bolt with a drill trimmed the edge away and we are now good to go!

Traditional tie-bar lifters works well, but they come with two problems. One is mass — they are heavier because they need an ear on them to extend up enough to give them an anchor point for the tie bar, and they typically have must higher pushrod seating cups to get the geometry right so that the pushrod will clear the extra body length needed for the tie bar mount. By seating low in the lifter body, the thrust imparted by the pressure angle and the pushrod angularity is more centered in the lifter bushing and wear rates are much better. These lifters were also specified with an .850 in. wheel instead of the traditional .750 in., and they use solid bushing axles instead of needle bearings.

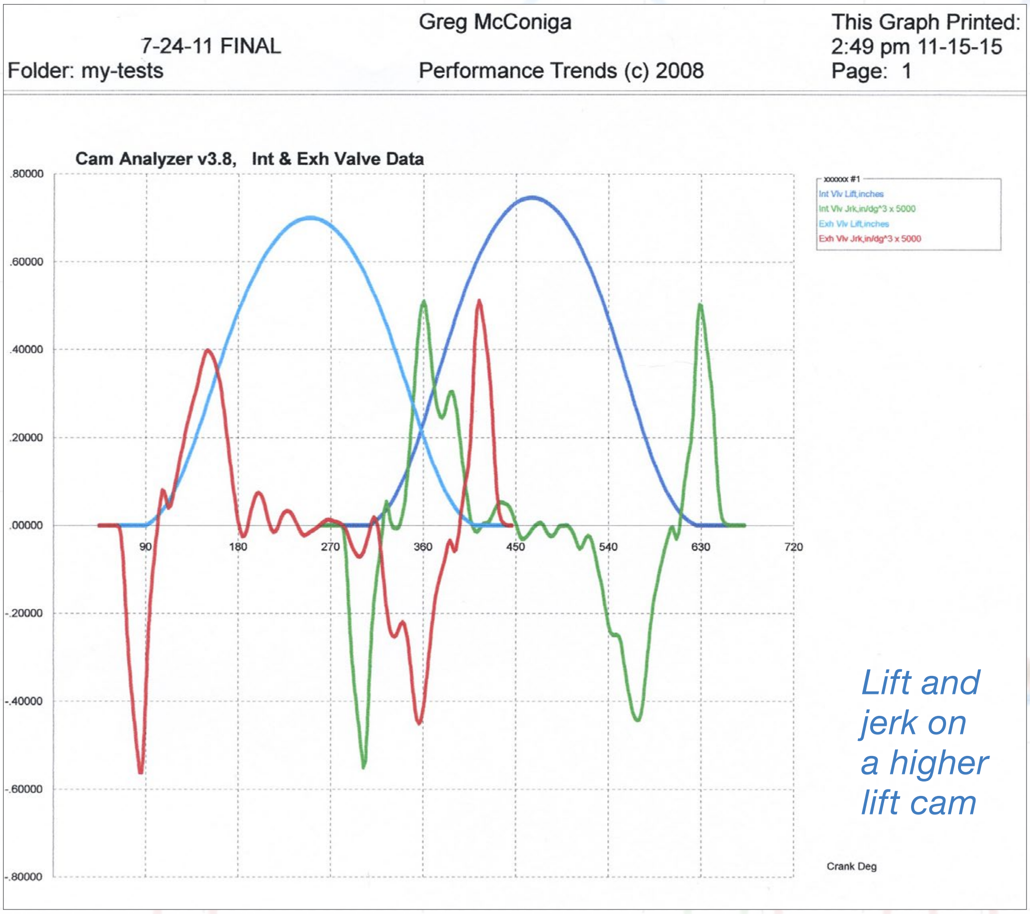
conduit restriction and the loss of any gains driven by the exhaust induction cycle caused by the low-pressure pulse of the exhaust "jump-starting" the piston-driven induction cycle (by pulling through the exhaust valve creating a low pressure in the cylinder, which increases the pressure differential seen across the intake valve head). If we time this right, the high pressure column standing on the back of the intake valve is now being sucked into the cylinder by the negative exhaust pulses.

For intake close, we balance reversion, where piston motion forces the incoming charge to a standstill and then back up into the intake manifold, with the significant gains in volumetric efficiency that occur with the inertial filling of the cylinder for several degrees as the piston "dwells" over bottom dead center. An important side benefit to an extended and violent inertial fill is the turbulence and mixing that occurs as the incoming charge slams into the piston and rolls and spins in the close confines of the cylinder, creating a homogeneous mix of air and fuel.

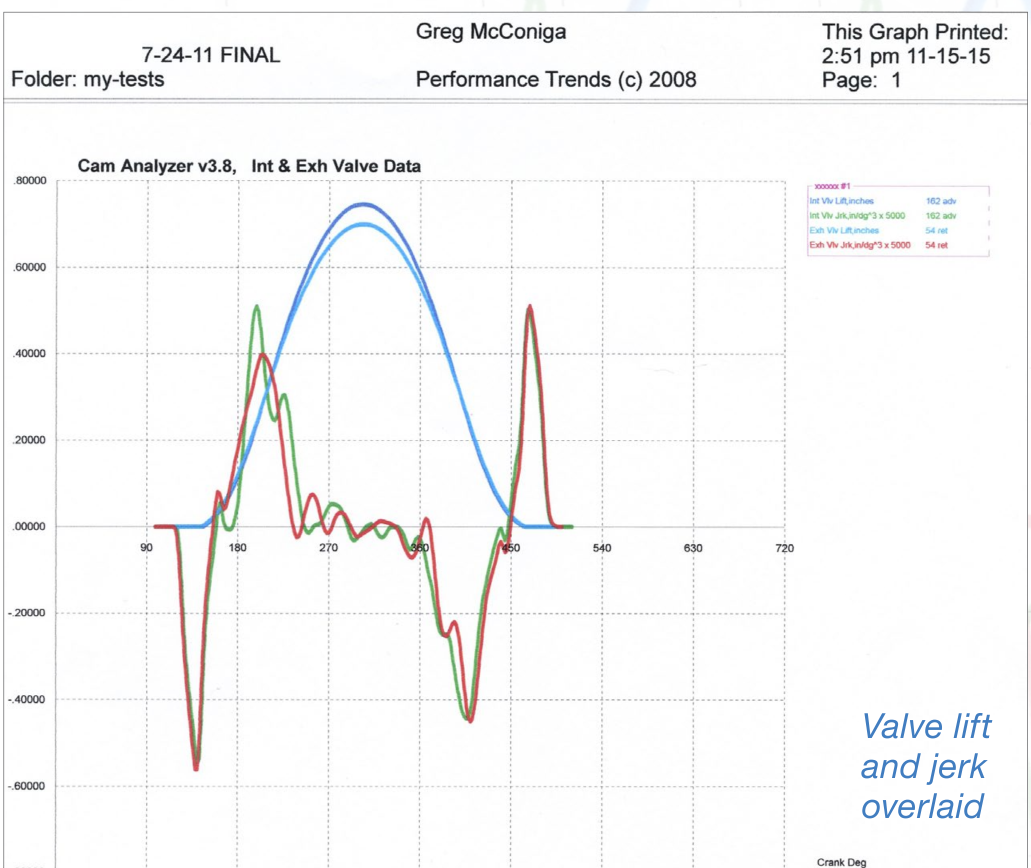
USE THE EXPERTS

Last, we know that there are people out there who have made a career out of camshaft development, folks that have spent their entire lives learning what others might consider unknowable, and we also know that we don't have the time to learn, or even necessarily want to know, all that they know. We just need to know who those people are when it comes time to select the right camshaft for our application. We also know that when we call these special few

One big disadvantage to a larger core is that the cam bearings are huge! So big that they can't be placed down into the tunnel area and turned into position along the camshaft centerline for installation, so you have to pull them all the way from one end or the other into position. Basically, you have to pull number three into and through number five bore and number four bore and finally install it into number three bore. With a little fiddling around, we discovered that we could get a bearing twisted into position just ahead of number five, so we only had to pull number three through number four first. Of course, we also had to pull number two through the front cam bore and then install number one, number four and number five last. What a pain — who was it who said, "The price of progress is trouble"?



Lift and jerk on a higher lift cam



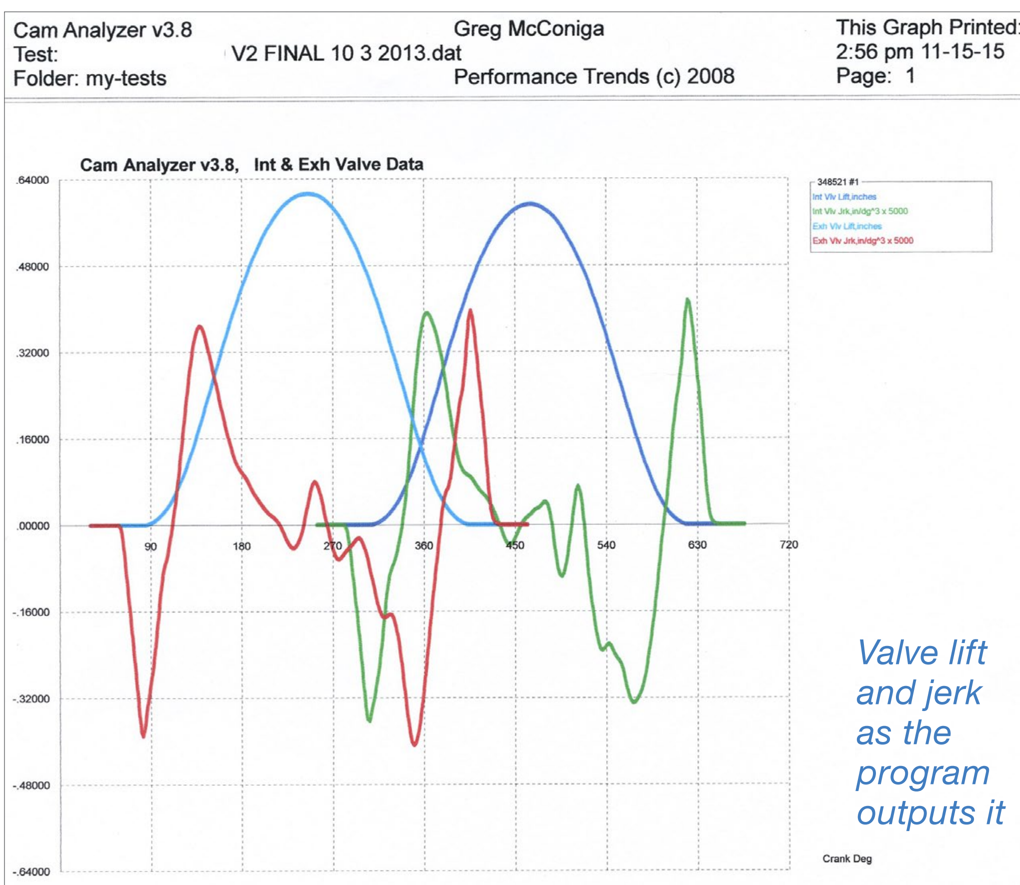
Valve lift and jerk overlaid

This is what the graphed output of a hand-measured camshaft that we used back in 2011 looks like. Valve lift is in blue, light blue for the intake and darker blue for the exhaust. The red line is intake jerk and the green line is exhaust jerk. The legend to read all of the graphs attached is located in the upper right hand side of the graph. Jerk is the rate of change of acceleration of the valve. The nice part about this program is that you can offset the graph to overlay the curves to see how close your hand measurements are, just as I've done on the second example. You can see they are very close, and I'm certain that some of the error you see in the overlaid graphs is due to dust, lint, and my technique. There may also be slight variations in the cam itself since the beginning and end of the jerk graphs are so close. Close study of lift, velocity, and jerk graphs will often give you clues as to what the grinder is doing to control valve operation.

experts that we MUST respect their time and knowledge and be prepared to answer any question they might have about our little bucket of bolts so we don't waste their time and so they can give us their very best advice on the first call. I guarantee you that if you approach them as professionals they will treat you as such, so know your combination inside and out before you pick up that phone.

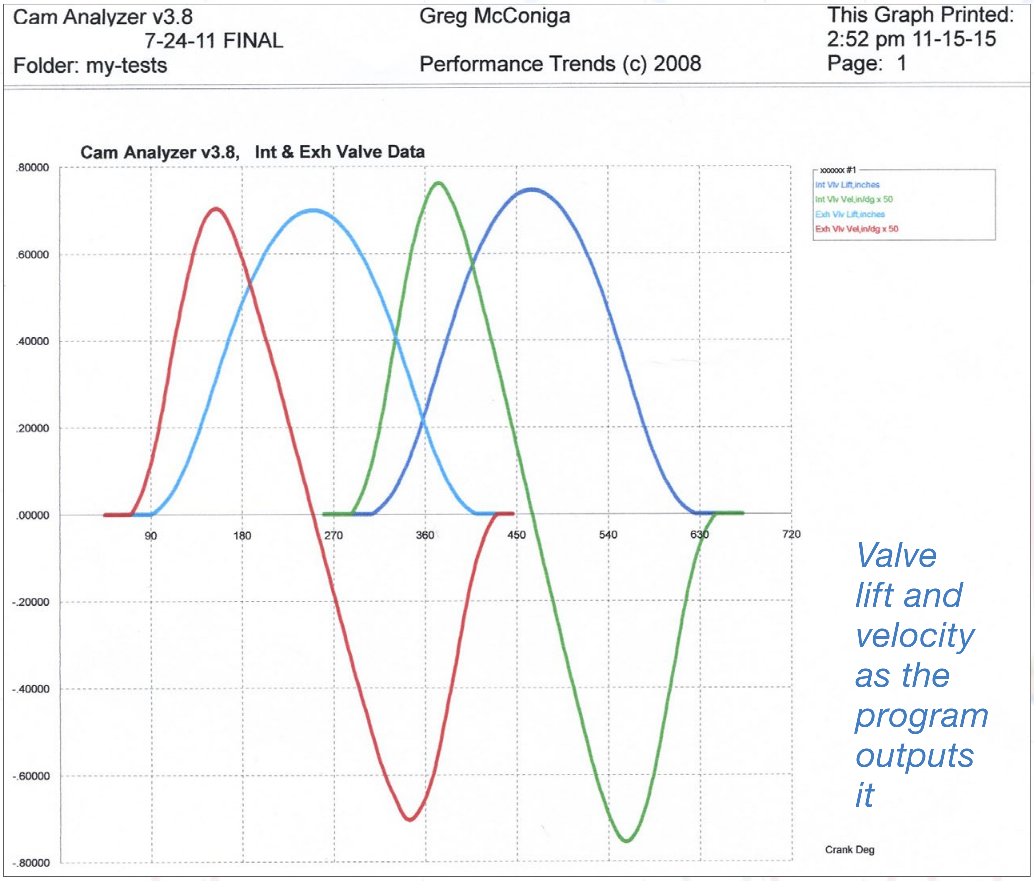
We have also discovered that at just .015 in. loss of lift, you'll begin to see power losses appear, so we know that it's not just the camshaft that requires our attention — we also have to do a good job picking all the system components that connect the lobe to the valve. The cam is only one part of a system designed to move the valve as measured at the retainer, so system stiffness and close attention to harmonics and resonant frequencies and excitation forces is just as important as lift and duration. The watchword of the day in cam design is "system stability." The Spintron work that everyone is doing now is beginning to show huge results as they are now able to measure proximity, load, and resonance in a controlled environment on a test engine spinning at full speed.

The best illustration of what additive and subtractive excitation forces can do to a system is found on a kid's playground. If your buddy is pushing you at the height of your backswing every time, you end up swinging higher and higher each time until your system "overloads," the chains

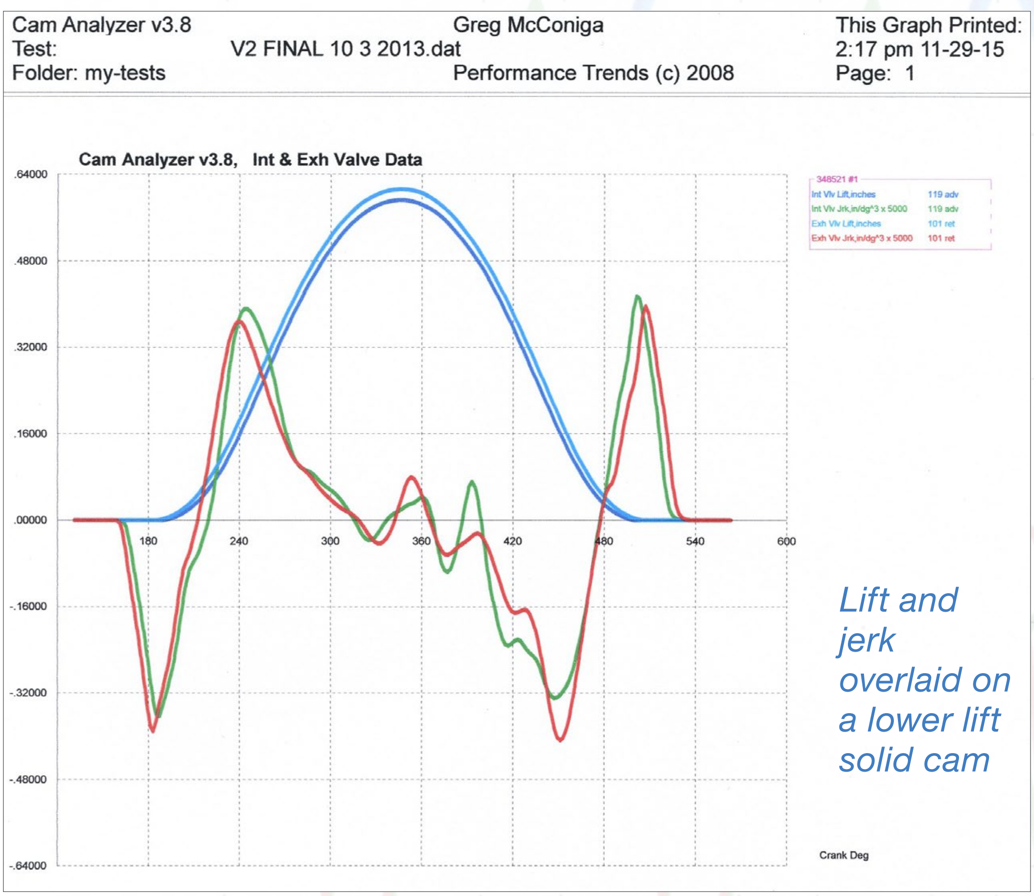


Valve lift and jerk as the program outputs it

3 graphs on pages 14-15: This solid camshaft grind is from a different manufacturer from the higher lift cam shown before, but look at the similarities on the jerk graph. The overall general shapes of the curves are remarkably similar, despite the fact that there's a .200 in. difference in lift between the two cams. There are a lot of smart people grinding cams right now, and it looks as if they're all working along the



Valve lift and velocity as the program outputs it



Lift and jerk overlaid on a lower lift solid cam

same or similar lines when it comes to stabilizing valve train operation. The lift and velocity graph is also revealing — again, the blue lines are valve lift and the red and green represent velocity in this case. You can see the opening and closing ramps on the lift and velocity ramps and how the approaches to the transition zones are ground into the cam profile. The slope of the velocity line tells you if velocity is increasing or decreasing; if the line stands more upright, it's increasing. The direction of the line tells you if it's positive or negative velocity. So, the lift curve defines the total flow area under the curve, the velocity line shows us what the direction and amplitude of valve velocity is, and the jerk line shows us the rate of change of the velocity of the valve. Spend a little time to sit and think about all that and I'm betting you see and learn things you've never really thought about before.

go slack at the apogee and you fall out of the air. If the push is delivered late it has one effect, early another effect, and if your buddy catches you on the backswing and counters your energy you stall, hanging stationary with no movement.

An engine is just chock full of excitation forces. Every part of the valve train is loading and unloading, vibrating and shaking, and the system is jerked and loaded by the firing impulses, and forces sent up from the tires to the crankshaft, any one of which might be additive or subtractive to the natural resonant frequency of a valve train part. So the real work that's getting done these days has more to do with stabilizing all those bits and keeping them from creating sympathetic destructive forces by working with mass and materials than with creating a new and unheard-of cam profile.

MAGAZINE CAMS

You can make all kinds of power if you don't have to worry about durability. I want to caution you about "magazine cams" that get ground and put out there for public consumption every so often. It's a tight field out there — there are a lot of really, really smart people grinding cams and as a performance enthusiast you have to remember that the goal of a magazine is to get you to buy products (advertising pays the freight) and since you're an enthusiast, what better way to influence your next purchase than to lay out a six-page spread on an engine making a ton of power on the dyno? You might be tempted to go through the parts list and just gobble up everything you see there in an attempt to replicate what they just did, but that might not be possible, or even desirable.

BELIEVE IT IF YOU SEE IT AT THE TRACK

Sometimes a cam is ground that makes all kinds of power, but it just beats the daylights out of the valve train. Unless you're willing to tear it down every ten runs and overhaul the top end you might want to rethink this program. I'm not giving up any trade secrets here, but just remember that if it sounds too good to be true, it's too good to be true. Everyone likes to hit that magical 1,000 horsepower mark these days — or 500, or 600, or whatever the number of the week is for the engine of choice. I'm here to tell you that you need to believe about 25% of what you read when it comes to power numbers, because it's not nearly as easy as they like to make it sound. You can "tune" as much dyno power in or out of a combination as you like just fooling around with correction factors or by putting a bomb together that pulls big numbers, but can't be driven or controlled. Reality TV does what it does to gain viewers and magazines do what they do to increase subscriptions and ad sales. The real world exists between the start and finish lines of a race track, and that's the only result that really counts.

Can you make big power on the cheap? You bet! Can you make big power on the cheap that will run a full season with only a spring check and lash adjustment every weekend? Probably not. Not saying it's impossible… just improbable. ■

GOOFY GAS AND VINTAGE VEHICLE PERFORMANCE, II

-Henry P. Olsen

Degradation in the tank and carb bowl, light fractions, olefins, carbon deposits, ethanol and phase separation, tuning the mixture, and racing gas.

How long will modern gasoline live in your tank? What's sold at your local gas station will begin to degrade in one to six months after it is blended at the refinery. The factors that help determine how quickly it deteriorates are the quality of the gasoline in the first place, and the additive package that is blended into it, plus the temperature, humidity, and the amount of outside air that fuel is exposed to.

Degradation begins as some of the lighter elements of the gasoline, such as propane and butane, evaporate, and the hotter the environment, the faster this occurs. These lighter elements are not only needed for good startability, but since they are also the higher-octane components their loss can cause detonation, which can destroy an engine.

The best way to store gasoline is in a cool area in a sealed tank that prevents exposure to air and moisture. But the fuel tank of a vehicle is often exposed to high heat, and is not truly sealed because of the necessary vent, either straight to the atmosphere on vintage cars, or through the charcoal canister of an EVAP system.

Most of the gasoline available at your local gas station contains components known as olefins, which will begin to form sticky gum-like deposits as gasoline ages and is exposed to the heat of an engine compartment, especially if it's hot enough to boil off. These deposits will cause problems with every part of a carbureted or fuel-injected engine's fuel system. On the other hand, a high-quality unleaded race fuel is designed to have a shelf life of up to two years; part of this longer life is achieved because it typically will contain less than 0.5% olefins. Depending on the local and state environmental regulations you have in your part of the country, the gasoline you buy at your corner station may have up to 20% olefins in it. A gasoline storage stabilizer such as STA-BIL from Gold Eagle can be used to help slow the gasoline's aging process, but you are ahead of the game if you start with a low-olefin gasoline such as Rockett Brand 100 unleaded racing fuel, or ERC MUL-C Unleaded 100 octane racing fuel.

Opposite page: Investing in a five-gas exhaust analyzer enables you to read and tune the air/fuel mixture of an engine, plus it can also be used to interpret combustion efficiency and engine misfire rate, and look for over-advanced spark timing.

EXPOSURE TO HEAT, AIR, AND MOISTURE

The temperature of the fuel in the gas tank of a motor vehicle can get up to 145 deg. F. due to engine heat, exhaust heat, heat returned to the fuel tank by a full-flow fuel injection system, and heat reflected from the pavement. When gasoline is exposed to anything over 80 deg. F., it will "weather" as the heat causes the more volatile elements in the fuel to evaporate out. Especially during winter conditions, this weathering effect can cause hard-starting since the lighter, more-volatile "front-end" portions of the gasoline will be decreased or gone, and only gasoline vapor can be ignited. No vaporization, no start. *[Editor's Note: Case in point, we've gotten many motorcycles started that had been stored for long periods and had stubbornly refused to fire up simply by draining the carb bowls and tank and refilling with fresh gas.]*

Older vehicles with vented gas tanks allow both the lighter front-end portions of the gasoline to evaporate out into the environment and also admit outside air into the fuel tank as it breathes whenever the temperature changes. As the lighter components disappear, you'll get cold staring and driveability problems. Exposing the gasoline to outside air causes the gasoline to age at a much quicker rate than if it were properly stored — away from heat, outside air, and sunlight. If you are using gasoline with ethanol, you also need to be aware of the fact that ethanol is hygroscopic, which means it easily bonds with the moisture that is the air. Once the fuel has reached its saturation point, the ethanol and water will phase-separate from the gasoline and drop to the bottom of the tank or carburetor fuel bowl. This phase-separated substance is very corrosive, and if it is left untreated can lead to major fuel system issues or engine performance problems.

At our shop, we've had many cases of phase-separated gasoline in vehicles with vented gas tanks, especially if they've been stored in humid areas. The best way to store a vehicle is with a full gas tank so there is very little air for the fuel to be exposed to. Or, store it with a totally empty fuel tank and carb bowl. We have also had vehicles

This test tube has a sample of contaminated fuel that was purchased from a gas station with underground tanks that were not properly maintained.

brought to us with driveability problems that started just after their tanks were filled. Upon sampling the fuel, we noticed that it appeared cloudy, and after it sat for a few minutes in a beaker we could see the water and ethanol drop to the bottom. Our conclusion was that the owner had purchased phase-separated gasoline from the local station. The most likely cause for the existence of this troublesome so-called fuel is that the underground tank vent system only controls the outgoing vapors from the tank (or fuel pumps). The air that is drawn into the tank through the vent system to replace the volume of fuel that is being pumped out expose the gas to moisture, especially if the station is located in an area that has a lot of humidity in the air.

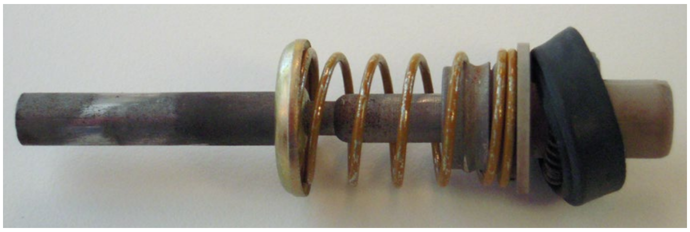
POWER-ROBBING FUEL-RELATED DEPOSITS

As your engine consumes fuel to make the rotational force that moves your vehicle down the highway, deposits are building up in the combustion chamber and on the valves that will gradually reduce power output. Most of the gasolines that you buy today contain additives designed to reduce the formation of these power-robbing fuel-related deposits, but it may not be in high enough concentration to prevent this from occurring, or to remove any existing deposits. The use of a fuel system cleaner such as Techron Concentrate Plus from Chevron on the same schedule at which you change your oil should be part of normal vehicle maintenance on both fuel-injected and carburetor-equipped engines. A high-quality fuel system treatment product will go a long way in preventing the carbon deposits that form in the combustion chamber and on the intake valves.

These deposits can create a wide variety of performance problems. The engine will produce less power as the deposits on the intake valves and in the intake ports restrict the airflow into the cylinder. They can also absorb gasoline like a sponge when you are trying to start a cold engine, resulting in long crank times. The carbon deposits that build up on the piston and in the combustion chamber can cause the engine to suffer detonation, pre-ignition, or other combustion abnormalities. Many of today's computer-controlled fuel-injected engines have a knock sensor system that will retard the ignition spark timing when it senses detonation, but that can significantly reduce engine power and fuel mileage.

PERFORMANCE TUNING

Before you begin tuning any engine, you should be sure the gasoline is fresh and



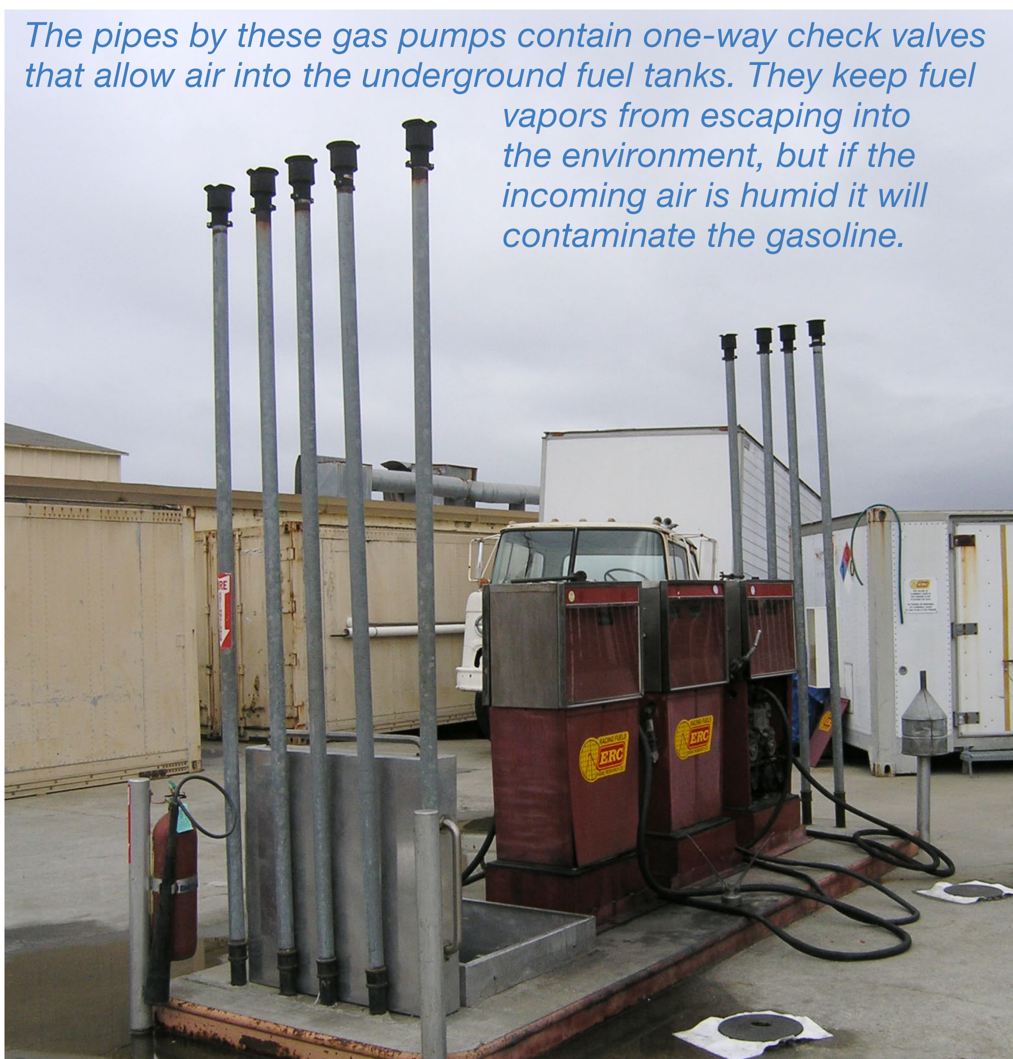
This accelerator pump cup is swollen from the ethanol in modern gasoline.

Ditto for the rubber needle tip on the left.

the engine is in good shape — it would be wise to address any engine valve train or combustion chamber deposit issues as a starting point.

The bottom of this AFB carburetor fuel bowl has been damaged by phase-separated gasoline.

The fuel pressure and fuel volume must match the demands of the engine, along with proper fuel tank venting, the ignition system must be in great shape including spark plug wires and the correct plug gap if you expect the engine to perform as well as it should. The first rule of performance tuning is to begin by tuning the ignition system (initial timing, mechanical spark advance and vacuum-based spark advance) before you attend to the air/fuel mixture curves because it turns out aht 90% of all the perceived air/fuel problems are actually ignition problems!



The pipes by these gas pumps contain one-way check valves that allow air into the underground fuel tanks. They keep fuel vapors from escaping into the environment, but if the incoming air is humid it will contaminate the gasoline.

The best way to tune the air/fuel mixture is by reading the composition of the

exhaust gases. The two most common ways of doing this are the use of a wide-band "oxygen" sensor-based (actually an air/fuel ratio sensor) digital air/fuel meter, or an infrared exhaust gas analyzer. The AFR-type meter is a great tuning device that can allow you to determine the air/fuel mixture when used properly, but they can lie to you. The output of the sensor is used to measure the oxygen content of the exhaust compared to that of the ambient air. The meter then makes calculations and displays the a/f mixture. The problem with this method is that anything that causes an engine to not properly burn the air/fuel mixture (such as a misfire) or anything that dilutes the exhaust gas the sensor is reading (such as an exhaust leak) can cause the meter to produce inaccurate readings.

A five-gas infrared exhaust gas analyzer is a very accurate means of seeing what is happening in the combustion chambers. The CO reading is used to observe the air/fuel mixture, plus the HC readings can be used to determine if the engine has a misfire problem. The NOx reading is an indicator of excessive combustion temperatures, and the CO_2 reading indicates the combustion efficiency of the engine. The downside of infrared analyzers is that the readings aren't real-time, but are delayed by about two to 10 seconds (depending on the analyzer being used). Our preferred method is to use the reading from a five-gas analyzer to set a baseline tune, then to use the digital air/fuel meter for more advanced tuning. When the air/fuel mixture readings from the AFR meter and the five-gas analyzer agree, you can be sure the readings are accurate.

THE AIR/FUEL EQUATION

The stoichiometric or chemically-ideal air/fuel mixture for an engine running on pure gasoline is 14.7:1 by weight, while one running on pure ethanol has a stoichiometric air/fuel mixture of 9.0:1. With the E-10 (10% ethanol and 90% gasoline) that is sold in many parts of the country, stoichiometry is achieved at 14.13:1 (14.7 x 0.90 + 9.00 x 0.10 = 14.13:1 AFR). A modern computer-controlled fuel-injected engine is continually being "fine-tuned" by its PCM to run its best for current operating conditions and the blend of gasoline the engine is burning. A vintage carburetor-equipped

This pump is used to dispense street-legal 100 octane unleaded gasoline.

Above: The use of STA-BIL for Ethanol is a good way to help prevent the damage that ethanol and phase-separated fuel can do to fuel system.

Techron Concentrate Plus is one of the better fuel system and combustion chamber cleaning chemicals on the market.

engine that was in most vehicles built before the 1980s was tuned for a blend of gasoline that no longer exists. The biggest changes were, first in 1975, the removal of lead from gasoline, then the addition of oxygenates. What you get at the pump today has been reformulated to both reduce exhaust emissions from the engine and evaporative emissions from the fuel system. The changes in today's reformulated gas cause it to burn somewhat faster than the leaded and non-reformulated gasoline of the 1960s and early 1970s, plus it is harder to ignite.

The ethanol and other alcohol-based additives that are blended into today's gasoline will cause a non-computer-controlled carbureted engine's air/fuel mixture to go leaner (typically, the air/fuel mixture shift is 3 to 5% leaner with an ethanol content under 10% than it was with the gasoline of the 1970s). This means that if you expect a carburetor-equipped engine to perform at its best, the air/fuel mixture and ignition timing should be checked and adjusted.

PERFORMANCE GASOLINE

If price and environmental regulations were not a concern, a custom fuel blender could make you a gasoline that would help an engine produce more power, but it would be very expensive. Gasoline can also be blended to match the needs of an engine that is supercharged, turbocharged, high-compression, nitrous oxide-injected, or is operated at very high rpm. The best way to get the most from any engine is to use a fuel that matches its needs. When gasoline is blended this way and the engine is tuned for it, engine performance and efficiency will be at its best.

There are several race fuel suppliers/ blenders that offer street-legal 100 octane unleaded gasoline that fits the needs of almost any vintage muscle car or modern fuel-injected high-performance engine. It is also a more stable fuel that is blended from a better grade of hydrocarbons, which means that it will not age/degrade as quickly as pump gasoline. Plus, the formulation (including the ethanol content) will be more consistent than commercial pump gasoline. If the vehicle is used for off-road performance sporting events, a blend of 25% of a fuel such as ERC Race Gasoline's 110K mixed with 75% 91 octane unleaded premium from a gas station pump is a great option for a high-compression muscle car engine. The computed octane of a 25%/75% blend of ERC 110K and 91octane unleaded premium pump gas is 95 to 97 octane. ■

This tank is used for custom blending of performance gasoline.

A digital air/fuel meter is another great means of reading the air/fuel mixture.


From the shop floor to the corporate office,
we have a career path for you.
AUTOCARE
CAREERS
www.autocarecareers.org
This is an initiative of the Auto Care Association.
autocare™
ASSOCIATION
Independence drives us.
www.autocare.org

TECHNICAL MINUTE:
WHY DO WE NEED COMPRESSION ANYWAY?

Pressure.

I love pressure.

Let's talk pressure.

Opposite Page: Every build every time measure every volume

Racing engines have to be taken down and rebuilt periodically, sometimes as often as after every run, as you see in the pits with the nitromethane-burning crowd. At the very least you have to go through them every year and look for signs of unwanted wear, movement, or fretting on bearings, bolts, cylinders, rings, springs, and valve train gear. You'll also probably have to touch up the seats and valves, and when you do that you'll end up changing the chamber volume because sinking a valve that's 2.5 in. in diameter just a few thousandths will increase chamber volume and change your compression ratio. If you've had a head gasket failure and the deck has eroded and needs to be touched up, if the valves and seats are machined, the pistons changed, or a different head gasket chosen, you must measure and recalculate the static compression ratio each and every time. Maybe last season you ran a conservative dynamic compression ratio and you need a bit more power, so you deck the block and heads and drop the head gasket thickness. If you're not changing the cam timing you have to put your new data into your compression ratio program and make sure you know where you are after your changes. Keeping track of the changes you make as the engine runs season after season will help you build a book of experience that will give you better and better results with each build and each passing season. Plus, if you experience a problem, it lets you go back and re-evaluate your data and helps you figure out what changes might have contributed to your failure.

There are three types of compression I've run into so far: static, dynamic, and effective. What are they and how do they affect our plans to dominate motorsports?

Static compression ratio is the one that everyone knows about, the one that most people talk about or are concerned with. It's the one the guy references when he says he put "12.5-to-one pop-ups" in it, which is often wrong as we shall soon see.

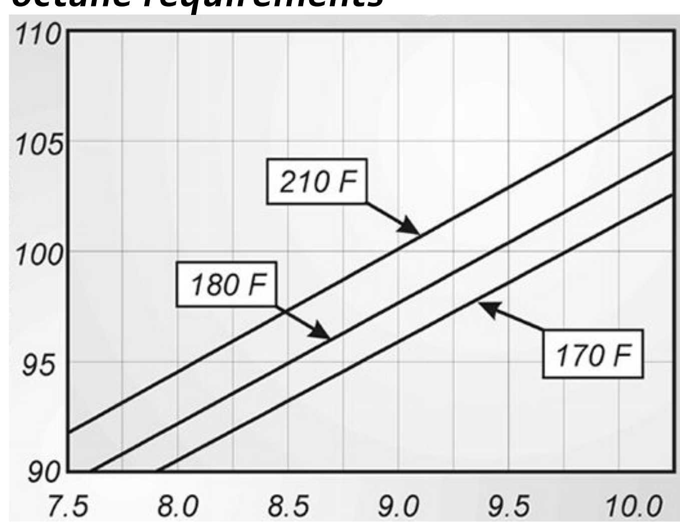
Static compression is a hard physical number, a simple mathematical calculation. It's the total swept volume of the cylinder (the volume the piston displaces as it moves from bottom dead center to top dead center), plus the clearance volume (the volume left above the piston when the piston is parked at TDC) divided by the clearance volume.

Static compression must account for all volumes above the top ring between the piston head and cylinder wall including the deck height and the head gasket volume, and must also account for any changing engine volumes affected during a freshening up, such as milling the heads, decking the block, or sinking the valves. You must check it at each build or every refresh to make sure you're still in your design window. There is no way to know static compression unless you measure all the contributing volumes and do the division to get the number; you **must** redo your volume checks every time. You can't just stick a bunch of parts together and expect the number to be anything near close, which is why when you hear someone say they stuck a set of "12.5-to-one pop-ups" in it, you should step back, because engine parts hurt when they come through the side of the block and hit your legs — don't ask me how I know that.

Dynamic compression is also a hard number, and it's the most important one because it's a true reflection of what your design will yield in terms of torque and power. And here is where we tie the static compression to the camshaft. The dynamic compression ratio is the "real" compression ratio because it's what exists at intake valve sealing. The exact point of intake closing is subject to interpretation by builders, but we like to use .002 in., measured at the valve retainer. A valve that's .002 in. off the seat still presents a hole nearly .010 in. in diameter, which at pressures of 250-325 pounds per square inch (typical compression readings on a racing engine) represents a significant leak and loss of trapped mass.

Late-closing intake timing lowers dynamic compression and early-intake closing raises it. Dynamic compression is the swept volume of the cylinder *measured from the time the intake valve seals on the seat*, plus the clearance volume, divided by the clearance volume. Since intake valves always close past bottom dead center, significantly so on a high-speed racing engine, dynamic compression ratios are always significantly less than static compression ratios. Dynamic compression is what determines cranking compression

Dynamic compression versus octane requirements



This graph shows the correlation between water jacket temperatures, R + M / 2 octane rating, and the maximum dynamic compression ratio you can build into your engine, with octane rating up the left side and dynamic compression ratio along the bottom. Maximizing dynamic compression ratio for your application results in more engine torque, which when combined with rpm makes more engine horsepower. Torque is the result of pounds per square inch applied to the piston, times the piston area times the stroke of the crankshaft, and since cylinder pressure rises by a fixed factor of roughly four with combustion, starting with higher pressure results in higher total pressure applied to the piston, which increases engine torque. As much as practical, your design should keep the inlet air as cold as possible, your fuel as finely atomized as possible to take advantage of the evaporative cooling effect in the intake manifold, and your water jacket temperatures as stable as possible to help prevent detonation. Don't experiment with your fuel supplies! Find a fuel that works, has the right octane, distillation rates, and consistency from batch to batch and stick with it. Don't introduce variables, keep your combination the same until you prove that it's not working, then change one thing at a time until you can verify if you've made things better or worse.

High compression extracts more power and efficiency

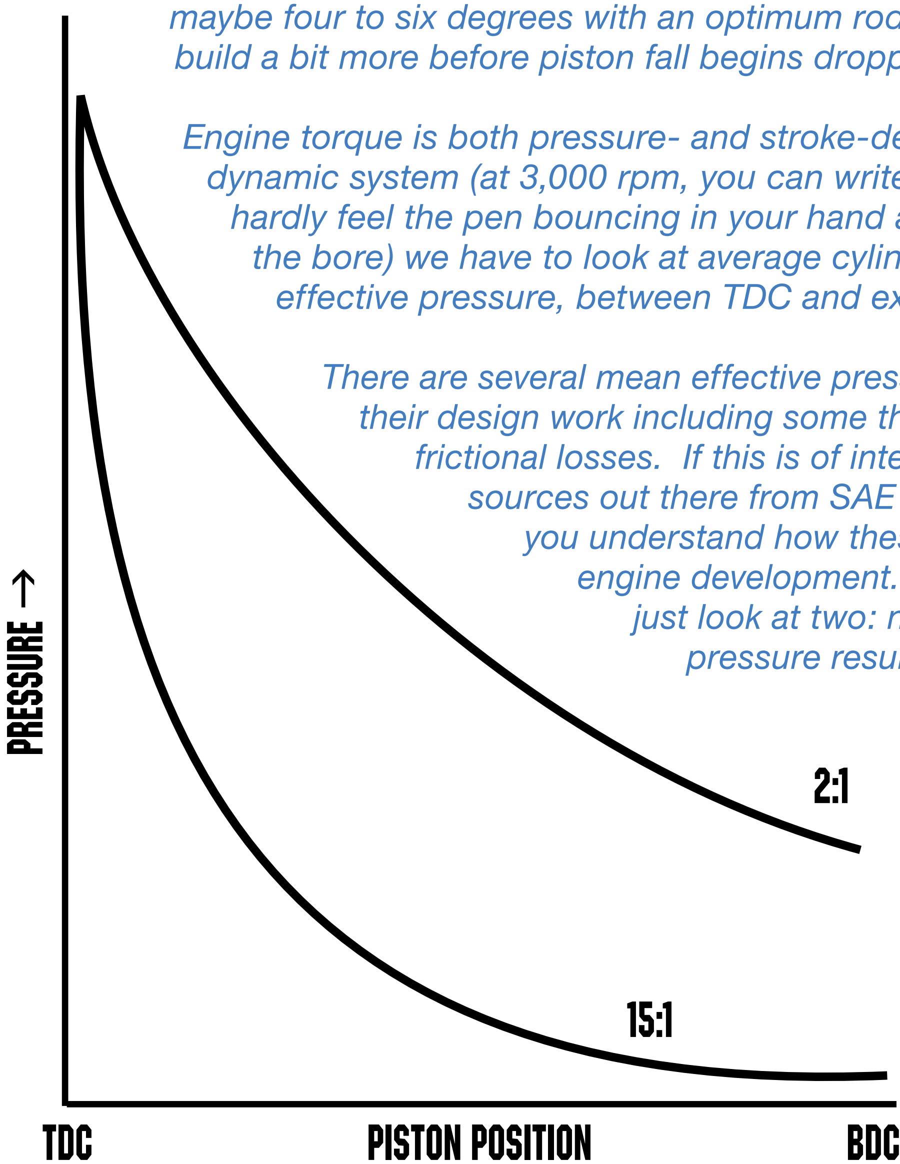
With cylinder pressure along the vertical axis and piston position along the horizontal axis you can see how higher compression ratios help us increase power and efficiency.

Very low compression ratios have very low pressure ratios (2.64:1 in the case of a 2:1 CR), and that requires that we hold the exhaust valve on the seat to nearly TDC in order to have a power duration cycle long enough to extract the usable power from the combustion process.

Part of the magic of high compression is that we have a quicker "shove" on the piston because the pressure ratio is so much higher (44.31:1 for our 15:1 engine) and that shove decays quickly as the piston drops so we can extract more power earlier in the crankshaft rotation and then blow the cylinder down with left-over pressure, which reduces pumping losses associated with the upward exhaust stroke. You might get even better results if you combine high compression with as long a connecting rod as you can physically fit in the engine you also increase piston dwell over TDC slightly (typically just a few degrees – maybe four to six degrees with an optimum rod length), which lets pressure build a bit more before piston fall begins dropping the pressure.

Engine torque is both pressure- and stroke-dependent, but since this is a dynamic system (at 3,000 rpm, you can write your name on a piston and hardly feel the pen bouncing in your hand as the piston rises and falls in the bore) we have to look at average cylinder pressure, also called mean effective pressure, between TDC and exhaust valve opening.

There are several mean effective pressures that engineers use in their design work including some that account for pumping and frictional losses. If this is of interest to you, there are good sources out there from SAE and from Wiki that will help you understand how these pressures are used in engine development. For our purposes, we will just look at two: net indicated mean effective pressure results from direct cylinder pressure measurement using pressure transducers, and brake mean effective pressure, which is calculated from measured brake torque, and these are the terms you'll most likely encounter in your engine-building career. Typical BMEP values for gas engines will range from roughly 125 to 350 psi, with top fuel dragsters running as much as nearly 1,500 psi.



PRESSURE DECAY AT 15:1 AND 2:1 COMPRESSION RATIOS pressure and since cylinder pressure rises by a factor of roughly four under combustion, starting with more pressure means you end up with more pressure, which increases torque. In general, for street engines you're safe at about 8:1 maximum on dynamic so long as you don't exceed 200 psi cranking compression pressure on premium pump gas. Above that and you're dancing with the devil. You might get by with a few more pounds of cranking compression if you have a really good cooling system and aluminum heads, but the few pounds of torque you leave on the table might be better left there than risking entering into detonation. On a racing engine, more is better up to the point where you can't buy fuel to control the combustion process under all known or suspected operating conditions. Now, remember that for some applications you've got time between rounds, and for others you don't, so you lose engine cool down time. Also talk to your racer. Does he tow back after a run (more time to cool), or does he drive it back? For a drag racer that makes a difference. For an endurance racer you've got cooling system, track conditions, draft conditions, length of a typical race, and length of track to consider. There is no one perfect compression ratio — you build to the anticipated use and duty cycle.

Effective compression ratio is the result of supercharging, either by belt-driven or exhaust-driven means. It's calculated by adding the pounds of boost to atmospheric pressure, which is 14.7 psi at sea level at 68 degrees. It uses the increased intake pressure provided by your air mover to back calculate into the static compression ratio number it would take to get the same cylinder pressure without boost according to the formula:av

$$P_{final} = P_{initial} \times DCR^{1.3}$$

In fact, this formula can be used to calculate estimated cylinder pressure from either atmospheric or boosted initial pressures. All we are doing is factoring the dynamic compression ratio by the adiabatic expansion ratio of either an air fuel ratio (1.3) or pure air (1.4) to arrive at what final cylinder pressure will be under compression. Now there's a big word that needs defined: "adiabatic" means that that no heat is lost

Compression Ratio 'Plus' (C)2009 Performance Trends Inc.		
Registered to: Greg McConiga		
Engine File: stroker final approximation		
Time: 11:05:23:am	Date: 05:15:2016	
File Comment: 850 CFM	stroker kit	Edelbrock 76 CC heads pn 60059 Edelbrock intake 7105

Base Engine Inputs	
Bore, in	4.1
Stroke, in	4.25
# of Cylinders	8
Rod Length, in	6.7
Int Valve Closing, deg	82.5
Deck Height, in	10.158

Calculated Results	Cu. In.	CCs	Liters
Cylinder Size	56.11	919.7	0.92
Engine Size	448.89	7357.3	7.357
Chamber Size	5.56	91.1	0.091
Compression Ratio	**11.09**		
Eff. Comp. Ratio	11.09		
Dyn. Comp. Ratio	7.51		
Cranking Pres, PSI	199		
Bore/Stroke Ratio	.965		
Rod/Stroke Ratio	1.576		
Quench	.043		

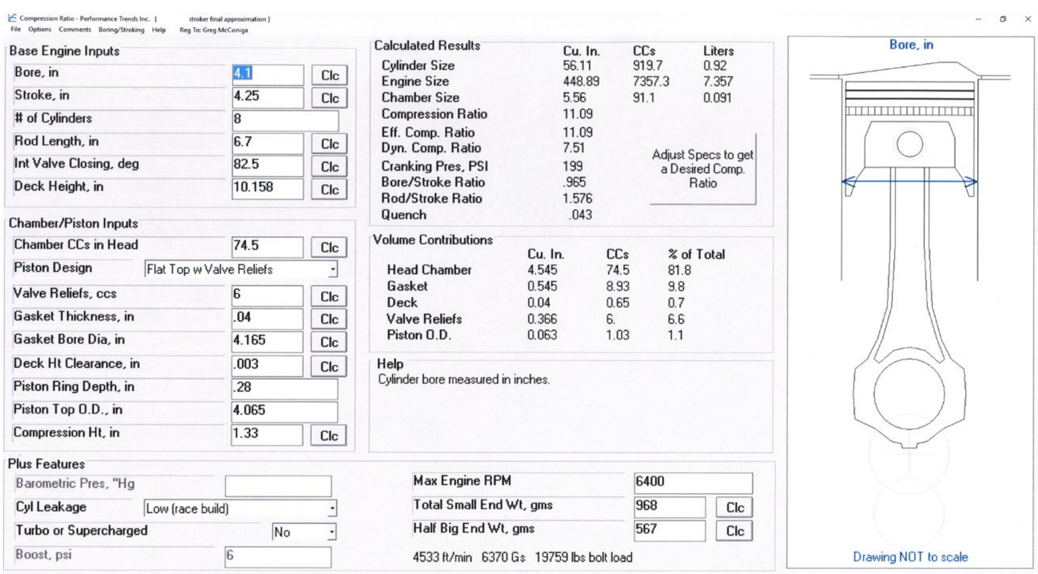
Chamber/Piston Inputs	
Chamber CCs in Head	74.5
Piston Design: Flat Top w Valve Reliefs	
Valve Reliefs, ccs	6
Gasket Thickness, in	.04
Gasket Bore Dia, in	4.165
Deck Ht Clearance, in	.003
Piston Ring Depth, in	.28
Piston Top O.D., in	4.065
Compression Ht, in	1.33

Volume Contributions	Cu. In.	CCs	% of Total
Head Chamber	4.545	74.5	81.8
Gasket	0.545	8.93	9.8
Deck	0.04	0.65	0.7
Valve Reliefs	0.366	6.	6.6
Piston O.D.	0.063	1.03	1.1

Plus Features			
Barometric Pres, "Hg		Max Engine RPM	6400
Cyl Leakage: Low (race build)		Total Small End Wt, gms	968
Turbo or Supercharged: No		Half Big End Wt, gms	567
Boost, psi	na	4533 ft/min 6370 Gs 19759 lbs bolt load	

The Trend compression program report output into or gained from the system surrounding our test rig. While temperature and pressure rise and fall together in a closed system, we are making the assumption here that whatever heat rise results from compression is perfectly retained with no loss due to temperature differentials or pressure gain results because of any temperature rise due to friction present in the system. We are assuming that the system is thermodynamically perfect.

Working these formulas isn't a daunting mathematical task these days as any scientific calculator or cell phone with a scientific calculator built in makes this easy work. For those who've been out of school a while (like me!), just remember that math is all about rules, and the big rule to remember is PEMDAS, which is the order of operations. It's a mnemonic for Parentheses, Exponents, Multiply, Divide, Add, Subtract, which is the order in which things must be done to get the correct answers. Working from left to right, do what's inside parentheses first, then apply any exponent, then multiply, then divide, then add, and then subtract. Piece of cake! The best part of technology is that it fixes our defective memories. A modern calculator will automatically perform the order of operations for you if you just input it correctly. Let's look at a couple of examples real quick.



If you prefer a graphical output

Performance Trends has several engine building software programs that we use, and they are great time savers. You can see your data in a graphical output or in a report file format, but in either case you have several critical engine parameters displayed for your evaluation. The nice part about these programs is the ability to "what if we…?" change any or several inputs and check to see what the outputs do instantly, without having to grind through a lot of paper or exhaustive calculations. I use the PT cam analyzer program, the engine builder notebook, and the compression ratio calculator on every build.

Assuming that we start with atmospheric pressure of 14.7 psi and a dynamic compression ratio of 8.5:1, you can expect to see cylinder pressures of about 237 psi. If we boost that up six pounds, instead of multiplying by 14.7 we multiply by 20.7 and our cylinder pressure goes up to 334 psi, which is the equivalent of a dynamic compression ratio of roughly 11.3:1. Is this considered an accurate number? Some use it as a tool or reference; others don't give it a lot of credence. The purpose of boost is to put more oxygen in the hole, to which you can add more fuel, not increase cylinder pressure and heat (hence, the intercoolers used with blower systems). It's all about how much mass you have to react, and boosting with any sort of supercharger drives volumetric efficiency through the roof.

So, why do we even need compression to begin with? If you think about it, compression is all loss. It's all work applied to the mass trapped in the cylinder; work that could be used to propel our little bucket of bolts. Do we care about compression, or is it just a necessary evil we put up with to get what we really want, which is the expansion ratio after plug fire? The work we harvest is done on the other side of compression during the power duration phase that extracts power from expansion between the time peak pressure occurs at 5-20 degrees after TDC and exhaust valve opening at 90 to 160 degrees after TDC.

So why do we need compression? Well, first of all, cylinder pressure is what makes torque and torque times rpm builds horsepower, so we need that pressure to make power. We also have to get the air and fuel mixture shoved into proximity of the spark plug. If you've read my "experiment" misadventure, you'll see that 14.7:1 is actually a faint enough mixture that it won't reliable light off without the concentrating effect afforded by compression. We also need the heat of compression to vaporize the fuel that's coming into the cylinder in liquid form because liquid won't burn and power is all about converting the most air and fuel into heat. It's self-evident that if it won't burn it can't make heat.

We also must concentrate the mixture and hold the oxygen and the fuel in close enough proximity long enough to get the highest rates of combination. High-compression engines get more power from less fuel because they keep a process that is trying to blow itself apart held together longer forcing more oxygen to combine with more fuel.

Before the start of combustion, we also need tumble, swirl, fill turbulence, and quench to keep our mixture thoroughly stirred and homogeneous so that the distance between oxygen and fuel molecules is as small and uniform across the mass as possible. So, if we're going to make our little bucket of bolts move like the wind, we need compression to cause that to happen!

Let's look at another formula, where E is efficiency, CR is the compression ratio, and K is the adiabatic expansion ratio. Once again, the value of K is 1.3 for an air fuel mixture and 1.4 for air:

$$E = 1 - (1/CR^{(K-1)})$$

So, assuming a compression ratio of 10.0:1 — and using the adiabatic expansion ratio for air fuel — we'd expect an efficiency of 60%. If we move the compression ratio up to 17.5:1 we now see efficiency just over 68%, and now you know another reason why we need compression: It greatly improves thermal efficiency, up to a maximum practical limit of roughly 17.5:1. Above that and the gains are so small and the tuning and fuel requirements so difficult that it's not practical. There are other benefits: More work extracted earlier translates into faster pressure and temperature drop, which exposes less cylinder wall area to less heat, which, in turn, creates less thermal load in the cooling system.

Let's look at one last formula, which shows us the heat of compression. T2 is the final temperature after compression, T1 is the starting temperature, P2 is the cylinder pressure after compression, P1 is the starting cylinder pressure (either atmospheric or atmospheric plus boost pressure), and K once again is the adiabatic expansion ratio of either air (1.4) or an air fuel mix (1.3):

$$T_2 = T_1 \times \left(\frac{P2}{P1}\right)^{\left(K - \frac{1}{K}\right)}$$

Using our numbers from above for our 8.5:1 example, here's what we find if we use K for air, or 1.4. The value for $(K-\frac{1}{K})$ is .6857; so 237 psi divided by 14.7 psi is 16.122, to the .6857 power is 6.72, which we multiply times our assumed ambient air temperature of 68 degrees F. to arrive at 457 degrees after compression. Will it actually be this high after accounting for fuel evaporation and thermal losses? Absolutely not. Remember that to keep this all simple we are not accounting for losses, we are treating our little bucket of bolts like it's thermodynamically perfect. If we were engineers looking for a perfect answer, this might be a problem, but we are racers and we are looking for information that is relative from one spec to another to see if there are gains to be made. For us, perfection is when we can reliably make it from one end of the track to the other for the entire season without scattering expensive engine parts to the four corners! ■

TUNE UP YOUR ONLINE PRESENCE

As an owner of an auto repair shop, there are daily changes to the way your customers are finding and interacting with you. Staying ahead of these changes will allow your business to be found more often and validated in ways that weren't possible just a few years ago.

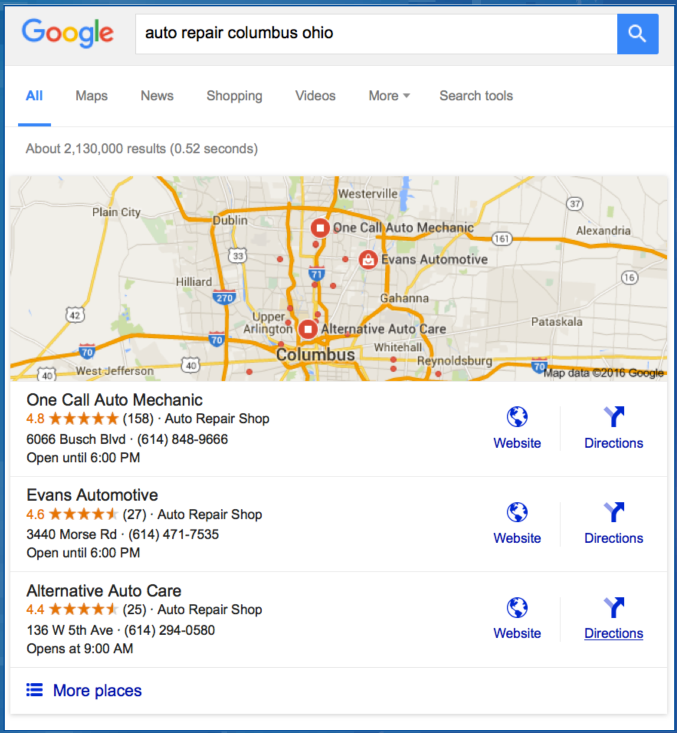
Today it is important to not only rely on your "word of mouth" business but also make sure that you can be found online when someone is searching for things like "auto repair near me" or "body shop near me." There are several key efforts that can be made by you, the owner; however just like with cars, to really increase performance and do it right, there are professionals out there to help.

Every effort made online should be done to appease Google® so they build trust with your business and show you more often. With that being said, Google® is not the only place online where effort needs to be put forth. There are also other major search engines like Bing, Yelp, Yahoo and even Facebook is used as a search engine to help people find local auto repair shops. On top of the major search engines there are hundreds of other directory sites, databases and search engines that store your business information.

With all of these sites out there the most important thing to consider is consistency with your Business Name, Address and Phone Number (NAP). The more times major search engines see consistent NAP "citations" across the internet, the more trust they can build with that information. Having an old address, incorrect phone number or alternative business name confuses Google® and makes it difficult for them to show your business with confidence.

Another huge trust factor that you as the business owner can work on is to get online reviews. Online reviews work for you in two major ways. First, they give your customers conviction to do business with you. A strong four of five-star review speaks volume to the type of service you provide. Think of online reviews as the new word of mouth.

The other way online reviews serve you is by giving search engines like Google® more reason to pay attention to you. If



Google search results for local businesses.

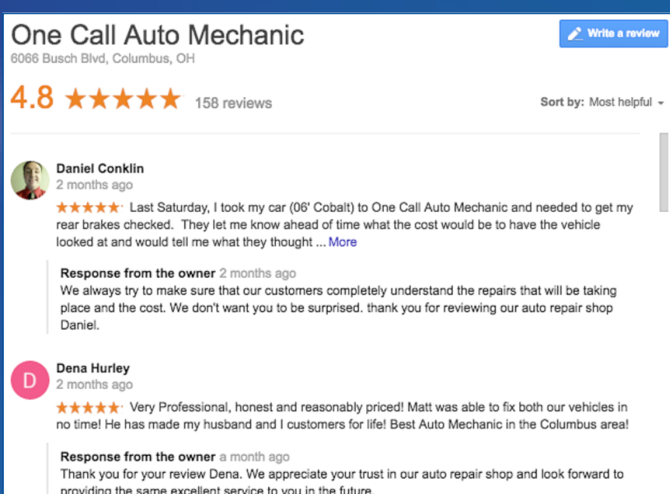
	Business Name	Address	Zip	Phone	RevLocal Certified
GETFAVE view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
WHITEPAGES view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
SWITCHBOARD view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
411 view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
LOCALCOM view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
MERCHANTCIRCLE view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
CITYSEARCH view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
MAPQUEST view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
TELENAV	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	PROCESSING
SUPERPAGES view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE
DEXKNOWS view listing	One Call Auto Mechanic	6066 BUSCH BLVD	43229	(614) 848-9666	LIVE

Consistency of your business listing is crucial in building trust.

your business has a lot of recent reviews compared to another shop where no one is talking about them, Google® is there to give the most relevant answer and the business where people are talking about them is more relevant than the auto repair shop that is sitting dormant.

With more and more of your customers using a mobile device like their smartphone or a tablet, like an iPad, it is important to make sure that your business is mobile friendly. Google® knows that over 50% of their searchers are done through some type of mobile device. Because of this, Google® is now giving precedence to businesses with mobile-friendly websites ahead of those older sites, which are not mobile friendly.

Your customers are no longer spending a lot of time on your website reading the "About Us" or "Services" page, they simply want to get the information they need and move on.



Online reviews example.

Because of this you want to make sure that your phone number and address are at the top of the page and are setup to click-to-dial or click-for-directions. If a potential customer can't find the information they are looking for quickly and easily, they are likely to move onto their next option.

All of these efforts improving your NAP citations, online reviews and making your website mobile friendly are some of the larger pillars to a strong online presence. There are of course other efforts that can continue to help validate you with your customers and give the search engines more reason to pay attention to you.

Some of these efforts are, routinely adding pictures to your business listing on Google®. This is fresh content and Google® loves fresh content. Add a blog to your website, again this is fresh content to your website and Google® will take notice that you are not simply sitting dormant. Add a YouTube page for your business and create YouTube videos. YouTube is a Google® product and Google® pays attention to you when you use their products. The list of other efforts goes on and on and is constantly changing.

As you might recommend any Do It Yourself'er to bring their vehicle in to be repaired professionally, don't leave your business's online presence to be done when you get some spare time. Contact a professional online expert and get some help fine-tuning the way your business shows up online. ■

Neal Resnik is a digital marketing Business Development Manager that has been helping small business owners for over a decade figure out how to improve their online presence. Neal and RevLocal work as an extension of your business to put forth the efforts needed to grow your online presence and your online reputation. Here are RevLocal we believe in the relationship with each client because we have no contracts. The burden is on us to show every client the value in the relationship each and every month. For any questions, please contact Neal by phone ((937) 670-0760) or email (nresnik@RevLocal.com).

INFORMATION STATION

LACK POLYURETHANE ADHESIVE

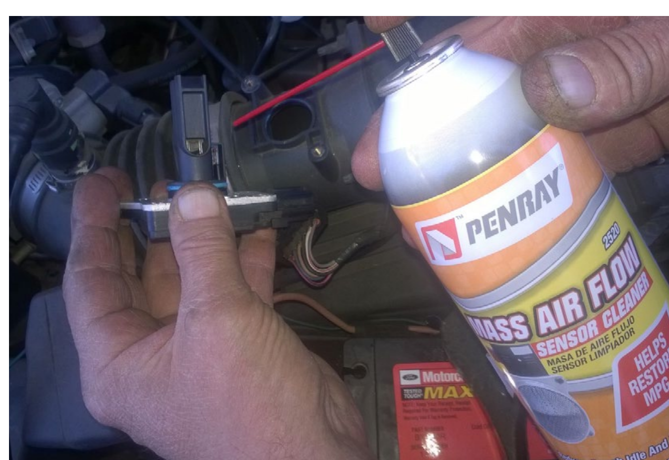
Permatex has developed Black Polyurethane Adhesive, a versatile and easy-to-use adhesive that can be used on both interior and exterior applications. The silicone-free, elastomeric adhesive is low odor, UV resistant, and has particularly low volume shrinkage. It remains flexible and provides a permanent bond to a wide range of materials. It is paintable and bonds easily to steel, stainless steel, aluminum, glass, fiberglass, rubber, plastic, ABS, and PVC. For details, contact your supplier.

TURN YOUR SMARTPHONE INTO AN OBD II SCAN TOOL

Wells Vehicle Electronics has unveiled an automotive diagnostic solution that transforms Bluetooth-enabled smartphones and tablets into an OBDII scan tool. The GoTech Mobile OBDII Diagnostic Tool enables iPhone, iPad and Android device users to diagnose powertrain trouble codes, clear check engine lights and perform a variety of other diagnostic functions via a free app. The device can store up to 10 vehicles. For more information, visit GoTech.com.

MAF SENSOR CLEANER

Penray has introduced its new plastic-friendly cleaner for mass air flow (MAF) sensors. It's specially formulated to effectively clean the sensitive sensor wire components without harming plastics, coatings or adhesives. The aerosol cleaner is said to be simple to use and safer than harsher, harmful solvent products like carburetor cleaner. Information can be found at penray.com.



AIR SPRING KITS FOR 2016 NISSAN TITAN XD

Air Lift Company has released its LoadLifter 5000 and LoadLifter 5000 ULTIMATE air springs for the 2016 Nissan Titan XD pickup.

Available for two- and four-wheel drive Titan, LoadLifter 5000 is the company's heaviest-rated air spring kit, designed to work with the existing suspension on many 3/4- and one-ton pickup trucks. The LoadLifter 5000 ULTIMATE adds an exclusive internal jounce bumper, which provides added shock absorption and extra protection for heavy loads. For more information, visit airliftcompany.com/products.

POWER CONTROLLER FOR RACE AND HIGH-END STREET ENGINES

MSD has released its latest power control unit. The Black Power Grid Controller is designed for use in racing and high-end streeters. Features include: a USB connection for ease of programming; timing based on engine rpm, gear value and time; advanced individual cylinder timing based on gear or time; five retard stages for nitrous; four steps of rpm limits for burnout, spool, launch and overrev; an output switch set on rpm, pressure or time; shift light settings for each gear; and ignition data acquisition records multiple runs. For details, log onto msdperformance.com.

PERFORMANCE SPRINGS FOR 2015 JEEP SRT8

Eibach now offers its PRO-Kit performance springs for the 2015 Jeep SRT8. The company says the kit lowers the center of gravity by 0.7 inches in the front and 1.3 inches in the rear, thereby reducing squat during acceleration, body roll in corners and excessive nose-dive under braking. The kit is covered by a million mile warranty. For information, visiteibach.com. ■

FINISH LINE

-Greg McConiga, Executive Technical Editor

WANDERING FULMINATIONS ON HIGH-PERFORMANCE

A PERPETUAL STATE OF LEARNING

I have got to learn to say "no!" Recently someone who apparently doesn't recognize my limitations added the responsibilities of facilities management to my already long and extended list of duties. If you aren't familiar with this term, it basically means that whatever goes wrong, at any location, in any system or piece of equipment, it's your fault. Roof, pavement, paint, building mechanicals — it's all mine to upkeep, oversee, schedule routine maintenance on, or get competitive quotes on to repair, should repairs be needed.

While I'm far from competent at my new assignment at this point, I did make an interesting discovery almost instantly during my first few days: Ours is not the only industry that is struggling to find, hire, educate, and retain good people. All of the construction and manual trades are just beside themselves trying to find young people who are willing to engage in physical work. It appears that while everyone loves a paycheck, they don't really want to engage in manual labor to earn it. As a result, the prices we all pay for skilled labor are on the rise, because the law of supply and demand dictates that scarcity raises prices.

What passes for education in a formal college environment today is largely brainwashing, in my opinion. I have a daughter in college and from what I can gather they aren't teaching her how to think critically, they are teaching her what to think — and those are profoundly different concepts. A formal degree of any kind is just the key to the lock. The hard work of becoming and remaining educated is something you do over a lifetime. This seems to be lost on more than just a few; some of the most ignorant people I've ever had the misfortune of working with completed their degree work and said, "That's it! I'm all finished learning," and never picked up another book or class again.

Real education requires drive, determination, resourcefulness, motivation, and an insatiable thirst to know more about a world, and a body of knowledge that changes by the minute. There is no longer one solution, one discipline that fits a lifetime in these times because the shelf life of any discipline or body of knowledge is so short — knowledge is perishable. Because technology advances by leaps and bounds, your ability to remain viable or employable is dependent on your willingness to work hard long hours during the day and still spend time with your nose in a book or on a website or in a classroom pursuing an unshakeable commitment to lifelong learning.

I believe that education always exacts a price tag in time, money and effort. For those who chose the route of formal education, the money involved is self-evident in the form of big checks, big student loans, and big interest that eats you alive for years after you've completed your degree. For those of us who follow a less traditional path, the money is less evident, but there is always a price to be paid.

In our case, the price we pay is in the form of money not collected for work we have done less efficiently than it should have been during our learning phase. Since most of us suffer at the hands of an archaic system of pay known as "flat rate," we work for less money as we learn and earn more as we learn the tricks and skills needed to get the job done in less and less time (and this assumes that we have the moral fiber to do the work right rather than pencil whip it or cheat it up, something that flat rate encourages, in my opinion). We might not write a check to a hidebound, ivy-covered institution of higher learning, but we do write a check to a system of labor cost control developed a hundred years ago. The key to surviving this system is to understand, and believe through and through, that you never lose or fail under it. You either win or succeed — or you learn, and that the payment for that learning is built into the system you work in.

When you learn, you pay, just as you would if you paid to attend any college pursuing any other degree. There is no free lunch; I don't care what any politician of any political stripe tells you. Nothing, and I mean absolutely nothing, is free.

You will also pay in terms of time, over the span of your life. While the college student pays dearly writing papers, attending lectures, and fulfilling course requirements, that process has a fixed beginning and end in the formal environment. Those of us who love dirty old cars aren't so lucky. In order for us to learn, we will work much longer and physically harder hours than our well-dressed counterparts who reside in high rise offices with clean clothes and hands.

I remember Smokey Yunick and I discussing this once, and I asked him how many hours a day he worked to get where he was. He said 18 or 19 hours a day seven days a week was pretty much the schedule. When I asked how he managed to stay married working those kinds of hours, he replied that it wasn't the work that got him in trouble, it was all the extracurricular (engagement with the fairer sex) that got him in all his marital trouble. If you knew him, you know I cleaned that up and that it was a typical Smokey response, one that nearly caused me to choke on my coffee.

In the end, it's my opinion that you should find what you love to do and then find a way to make a living doing it because that's the only way you'll get up out of bed every day cheerfully expecting to pay a price in order to keep doing what you love. Money is a necessary resource to have and manage in order to survive in our world today, but it isn't what you're paid that causes the problem, it's what you spend and how you spend it, and that includes the most precious resource of all: those few precious heartbeats that make up your years here on earth. Invest your time, money, and effort wisely so that you can live and die satisfied with what you've done and what you've left behind. ■

MEET YOUR MARGINS WITHOUT COMPROMISING QUALITY.

CRP Automotive offers OE-quality dealer alternative parts from Rein Automotive. From coolant and power steering hoses to anti-vibration and suspension components, Rein parts are identical in form, fit, and function to the parts supplied by the dealer at a price that still leaves room for a profit. Plus, they're backed by the service and support of CRP so you can trust they'll get the job done, every time.

TO LEARN MORE, VISIT REINAUTOMOTIVE.COM
OR EMAIL US AT INFO@CRPINDUSTRIES.COM

Brought to you by

CRP AUTOMOTIVE

CONTITECH | REIN | PENTOSIN
AJUSA | FERTAN | AAE

YOUR DEALER ALTERNATIVE FOR OE-QUALITY EUROPEAN PARTS

A/C PARTS • ANTI-VIBRATION PARTS • AXLE BOOT KITS • HARDWARE • HOSES • SUSPENSION PARTS • WHEEL BEARING KITS • FIRST AID