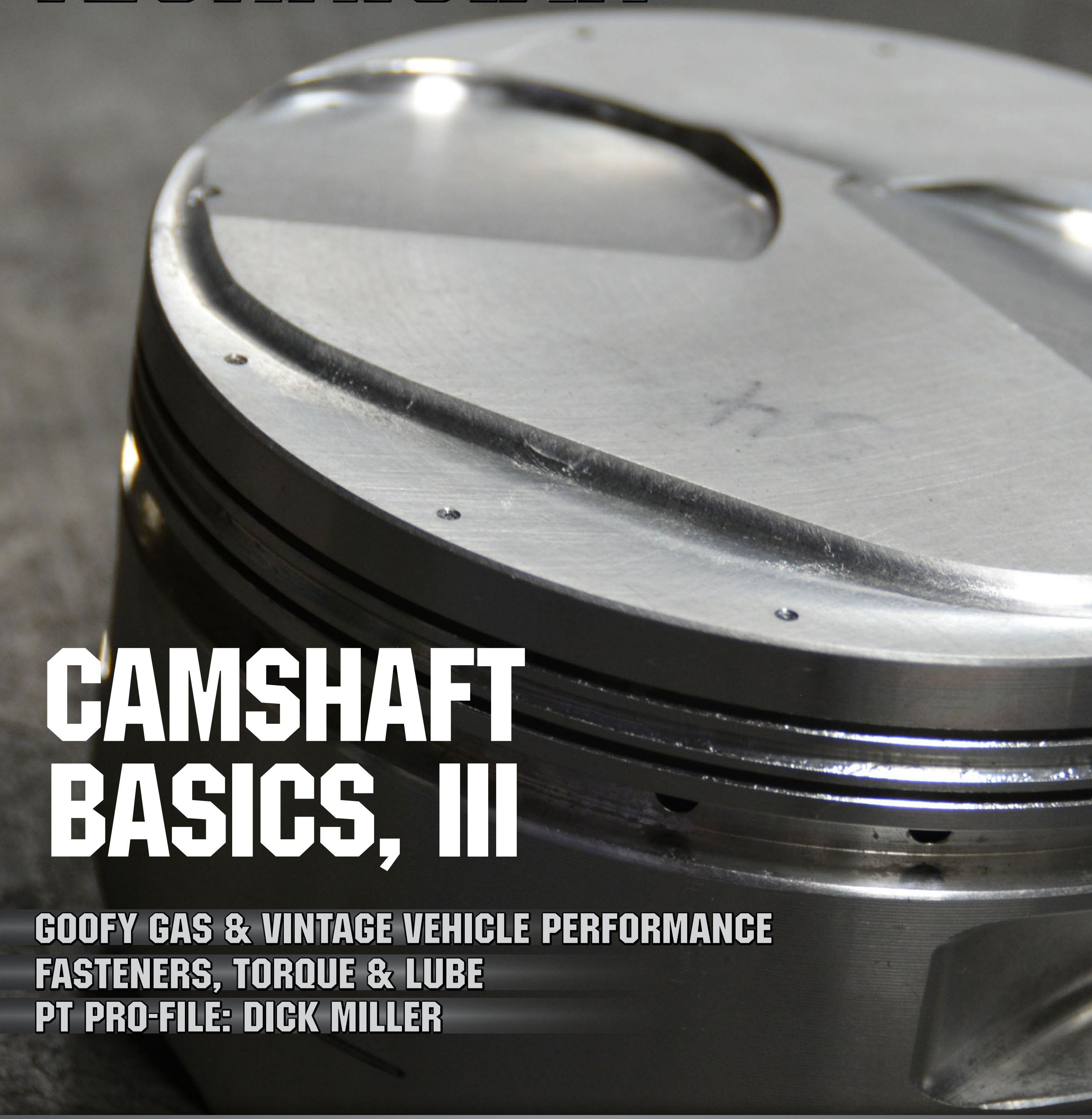
March/April 2016 | V3 N2

PERFORMANCE TECHNICIAN



CAMSHAFT BASICS, III

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PT PRO-FILE: DICK MILLER

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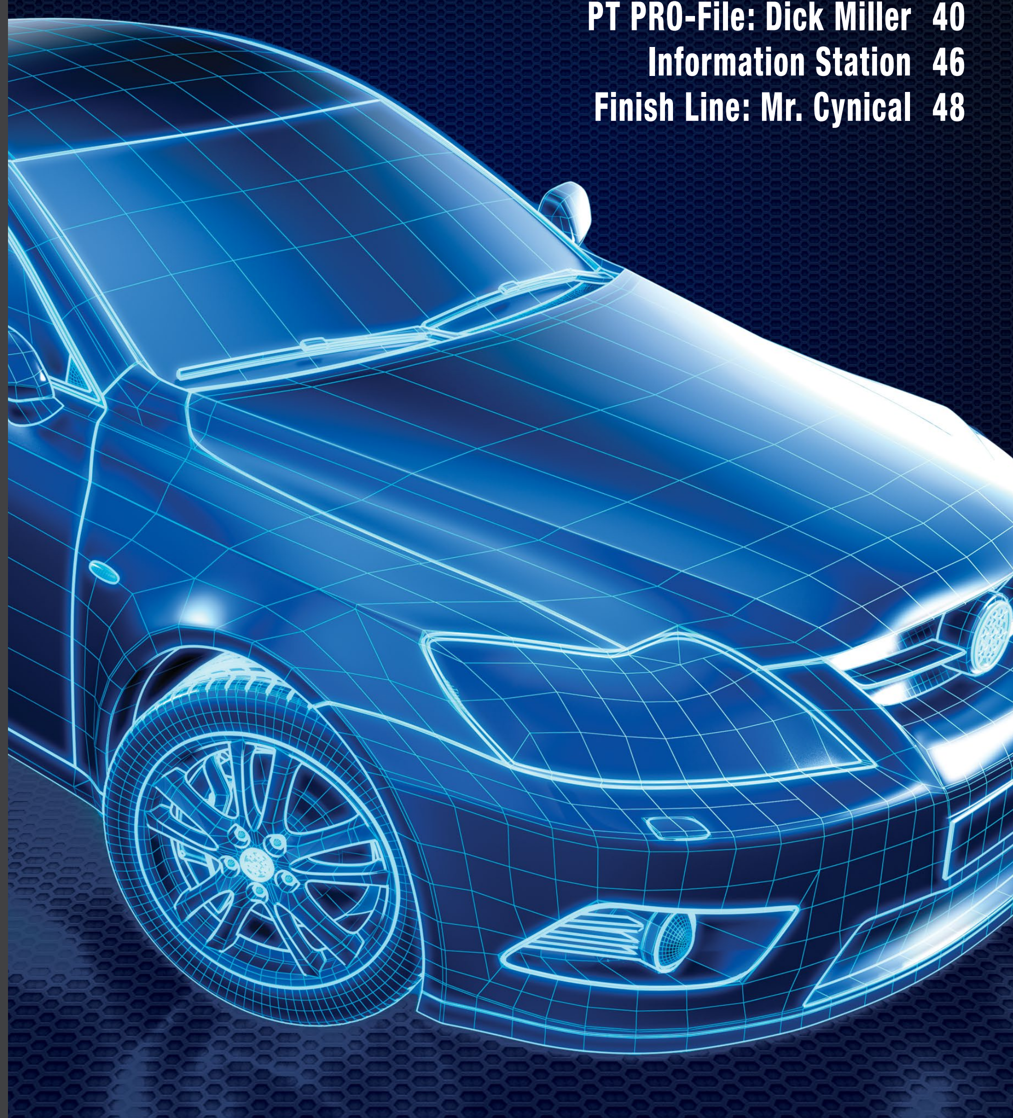

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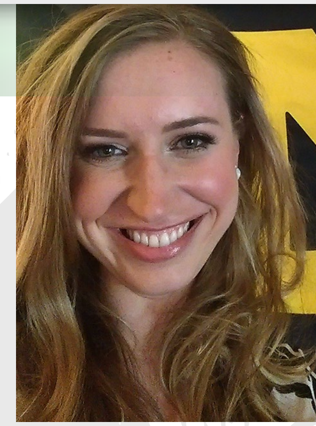
STARTING LINE

-Tamra Ayers Banz



Hello PT Readers,

As we embark on our third year of publishing, we thank you for your continued interest in PerformanceTechnician.com – the free website and digital magazine that provides power and performance knowledge for professional automotive service technicians, shop owners and technically savvy vehicle enthusiasts. In Performance Technician, our goal is to define and "redefine" performance based on application. We do this by covering a wide range of subject matter that addresses the traditional interests in vehicle power, in addition to an evolving definition (with a focus on efficient operating performance of sophisticated vehicle systems). We have worked hard to bring you helpful content on a variety of systems and components that drives pure power, like "The Heart of the Engine: Camshaft Basics" series by Greg McConiga, and the street-smart "Reading the Air/Fuel Mixture: Art or Science," by Henry Olson. We also included some fun (and interesting) entries to peak your interest, such as "The Experiment", and Glenn Quagmire's Weekend Warrior and ProFiles.

As we move forward, we will continue to bring you in-depth technical knowledge, as well as look for ways to support you in improving other aspects of your business. In this issue, we feature our first Business Brief: "Earn more, Work less, and Dominate!" – a look into customer service and key tips you may want to consider incorporating into your every-day shop business profile. We also share important safety information on Absorbed Glass Mat (AGM) batteries in our Health and Safety Department. We hope these short entries will address additional aspects of your business – and help enhance your shop's performance and, ultimately, success.

We invite you to stick around, provide your feedback (via "Contact Us") and share what you liked with a friend. Visit PerformanceTechnician.com and take advantage of our searchable archives of PT articles (as well as technical information from our 30+ years of publishing, including articles from Import Service, Hot Rod Professional and other technical repair magazines).

If you like (or don't like) what you see, please let us know. Your feedback is invaluable, as we look to increase our readership by providing useful information to technicians nationwide.

Kind regards,

Tamra Ayers Banz

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CAMSHAFT BASICS, III
THE HEART OF THE ENGINE

-Greg McConiga

Holy smokes! We'll bet you've never seen the an article with this level of tech before. It's like an engineering course, only much more readable.

The cam on the left is a 60 mm (2.362 in.) and the cam on the right is a stock diameter at 1.948 in. To see them in person is even more impressive – it's a huge difference. Camshaft operation is heavily dependent on being able to make the cam motion ground into the cam appear at the valve. Whenever you check your cam, we suggest you check them at the valve with the valve springs installed at the retainer. Any other way of checking or degreeing-in a cam is less accurate, in our opinion. If the core is undercut to achieve the lift, as it is on the stock-diameter cam core, then the core flexes under high spring pressures and lift is reduced. The larger 60 mm core also makes it possible to smooth out the profile, have more material left over in which to place the five-step event sequence and allows for more lift, since overall lift is the difference between the base circle and the nose multiplied by the rocker ratio, less any deflection or geometrical loss due to component misalignment.

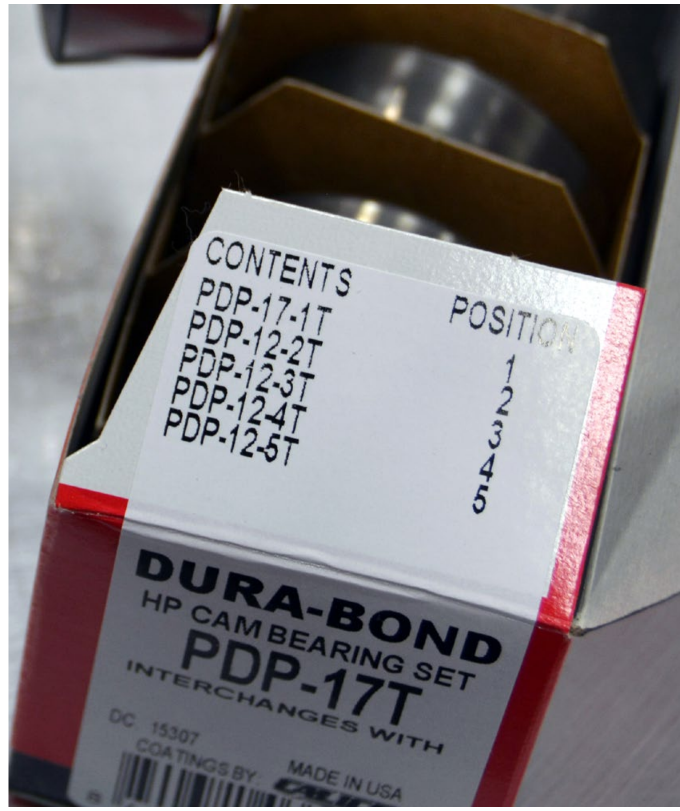
All right, let's review what we think we know. First, horsepower production is torque- and rpm-dependent based on the equation:

$$HP = \frac{(TORQUE \times RPM)}{5252}$$

So, what does this mean? Torque is a function of the average pressure on the piston top and the diameter of that piston (pounds per square inch times square inches against which that pressure is applied) and the moment arm (stroke) of the crankshaft, in feet. Engine torque is exactly the same as the torque you apply with a torque wrench or break-over bar; every one of us knows that if the bolt is tight, a longer handle makes it much easier to move. Force in pounds times the moment arm length in feet is pounds-feet, which is the unit of measure for torque. It's really just that simple.

A low-torque engine can produce huge horsepower if you spin it fast enough (think F-1). If you multiply the torque produced at the rpm at which it's produced and divide the result by 5252, you'll get the horsepower produced at that rpm. If you fill the cylinder with more air and more fuel and create a controlled combustion event, you'll make more pressure over a longer duration (more torque), which will make more horsepower at a given crankshaft speed. Even as the torque falls with increasing rpm, you'll produce more horsepower because you're multiplying a decreasing number by an increasing number and as long as the torque decrease is less than the rpm increase you'll produce more horsepower.

Increasing engine speed isn't free — or without risks. A number of parts and components are subject to speed-related stresses, and some of the stresses increase



Most racing engines use the same part number bearing in every location, but stock blocks typically use a specific part number in a specific location. Make sure you read the end tab on the box and double-check every part number during the inventorying process when your parts arrive. Putting the wrong bearing in the wrong location will either result in no clearance or too much clearance and a loss of oil pressure. Smaller bearings have an advantage in terms of relative bearing speed, but larger bearings have more surface area over which the load is spread. Late-model engines and racing engines typically use the same part number in all locations, but if you're using an older block for your build you need to remember to check bearing part numbers and location to make sure they get installed correctly.

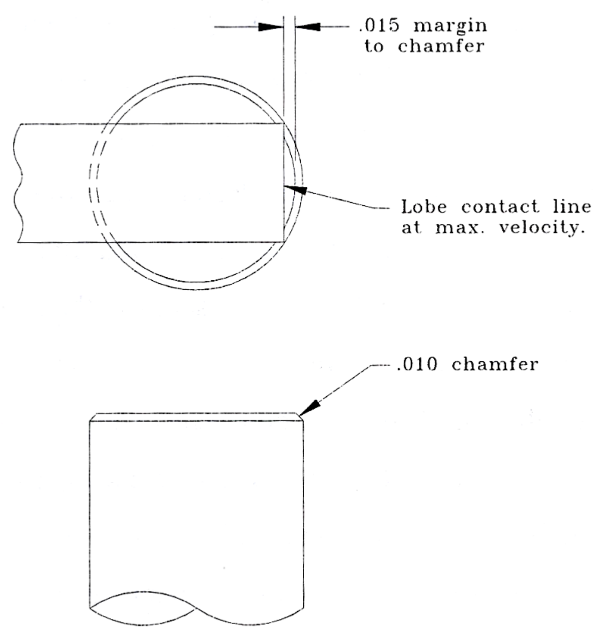
Large combustion chambers require a large dome to bring up the compression ratio if you're using a racing camshaft with a late intake close. Dynamic compression is a function of static compression and the point at which the intake valve seals up. Domes bring their own trouble in terms of interfering with flame propagation and having excessive surface area that absorbs heat, so moving from the "old school" heads with chambers like a bathtub to the "new school" shallow-angled, heart-shaped combustion chambers will help you make more power, with better quench, better and more consistent ignition across the bore with less ignition timing required. The piston also makes up the "floor" that the valve (and through the valve, the cam) sees as a limiting factor when it comes to fitting the required lift and duration into the package.

exponentially (as a square or cube or more! If you've forgotten your math, squaring a number is multiplying times itself… $2^2 = 2 X 2 = 4$, for example, and $2^3 = 8$, 2 X 2 X 2). All the parts have to get lighter, friction losses increase, the valve train design becomes more critical, and key reciprocating components like rod bolts, rods, pistons, pins, and rings all become very, very expensive. Not to mention that your maintenance requirements go up! The closer to the edge your little bucket of bolts runs, the more often you have to look at everything to make sure it's not approaching failure.

By now you're probably thinking, "I thought we were talking about camshaft selection here," and we are. Let's go back a second and consider what also comes with increased rpm, and that will be decreased power duration. Power duration is functionally set by the exhaust valve opening point and that gets earlier as rpm increases, which means power duration decreases as rpm increases. High rpm produces higher reciprocating velocities and a faster piston fall during the power stroke, which means piston velocity approaches, or equalizes with, the speed of the expanding gas velocity earlier in the power stroke. The effects are that the accelerating piston drops trapped pressure, work extraction stalls earlier in piston travel, and the time (on the clock, in milliseconds) for blowdown decreases. The only solution is popping the valve open earlier to stop exhaust side friction losses and "gain back" the time for full gas exchange by shortening the time the exhaust valve is held closed.

On the intake side, the problem is the same, except now we hold the intake valve open longer because the inertial ramming forces that drive "overfilling" the cylinder are strong enough to hold off rising piston-driven cylinder pressures from becoming reversion that backs up inflow into the intake. We are effectively rolling the exhaust into the direction of rotation and the intake with the direction of rotation and opening the lobe separation angle as the rpm climbs.

We've established that there are pretty good guidelines that we can use to set lift, based on a percentage of valve diameter. Once we get to a lift number, the next question we face is how much duration does it take to get to the required lift? For a flat tappet cam, hydraulic or solid, the physical constraints imposed by the diameters of the cam and the lifter base places a fixed limit on the velocity in inches per degree of rotation (inches/degree) that the lifter can withstand before destruction. A roller lifter, either hydraulic or solid, has no velocity limit, other than those imposed by the necessary change of direction and approach to the seated position of the valve, but they are acceleration-limited in inches of lift per degree of rotation squared (Inches/degree^2) because of axle and bearing loads. It is interesting to note that a flat tappet lifter up to about 270-275 degrees seat-to-seat duration will likely have more effective area under the curve than a roller of similar duration because the initial motion of the flat lifter can be quicker since it's not acceleration-limited (up to the limits



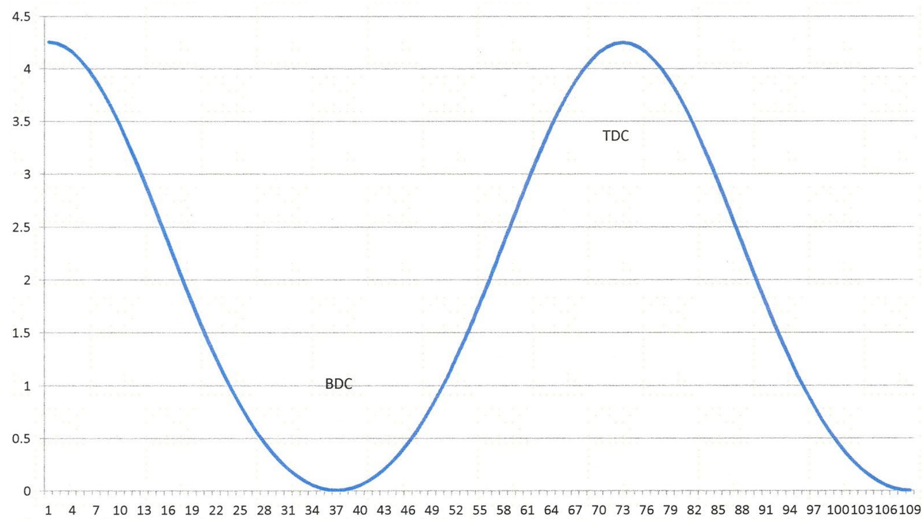
The velocity limit of a flat faced lifter is a simple geometry problem. You simply cannot have the lobe of the lifter extend past the chamfer on the lifter base or else you go from lifting the follower to trying to knock the bottom of it through the side of the bore that contains it. Larger lifter diameters help the problem, but there are physical limits to how large the lifter can be made unless the engine is designed from scratch to accommodate a larger lifter foot (courtesy D. Hubbard).

We've used a standard cam installation tool to put in thousands of cam bearings and it works just fine as long as you go slowly and remember a couple of rules. First, the bearing must start into the bore straight, and, second, you must swing the driver (hammer) in line with the installation bar so you don't knock it off center as you drive the bearing in. Check every bearing for a good chamfer and if there is a notably better chamfer on one side, start the bearing in from that side. Cam bearings are normally installed dry, but you can lubricate the bore and bearing if you choose to. Cam bearings may be Babbitt, aluminum, or tri-metal depending on how much load they experience, with Babbitt tolerating about 1,800 psi, aluminum 5,000 psi, and tri-metal roughly 8,000 psi. They are available coated or uncoated, and I recommend coating all bearings on every build. If the bearings come with an annular groove to supply oil and don't have to be installed with specific oil feed holes aligned, the best place for the oil to enter the bearing is at about the two o'clock position on an engine with standard clockwise rotation. For some applications, you may elect to pull the bearings into place, which generally results in a better install. It's always possible to deform a bearing while driving it. If you pull them in, always make sure that the tool does not rotate during the installation or else the bearing may rotate with the tool, misaligning the oil feed holes.

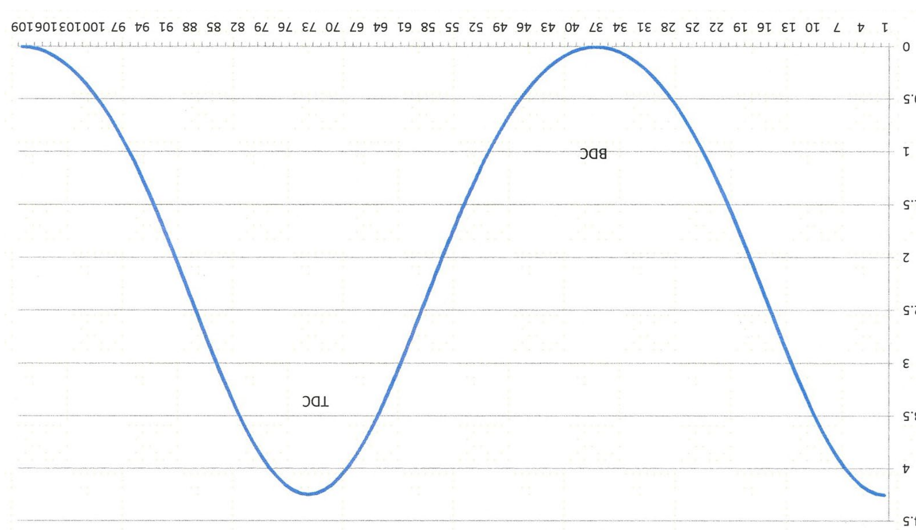
of the hydraulic design if it's a hydraulic lifter instead of a solid).

As the required lift increases, there is a point at which the flat tappet cam will not provide the lift needed and you simply must transition to a roller cam design. Another consideration is lubrication requirements if you are building street engines. Flat tappet systems required oils blended with more extreme pressure additives that are not compatible with catalytic converters. In fact, it's getting harder all the time to find affordable oils that allow the use of flat tappet (solid or hydraulic) cams, which makes upgrading old muscle car engines to roller cams attractive. Just remember that flat tappets can be a very cost-effective and streetable alternative to roller cams, but there has to be a serious conversation with the engine owner about which specific oils he or she can use with that cam.

The velocity limits of a flat tappet are imposed by the physical architecture, the base diameter of the lifter, how sharp the nose of the cam must become with lift increases and the cam lobe starting contact point on the base as well as the amount of spring pressure needed to control the valve (eventually, you'll push through the oil film unless you take extreme measures by drilling the lifter foot or creating an oil feed



Piston motion isnt uniform over tdc and bdc.



Inverted the diagram shows how extreme the difference in piston motion.

These graphs represent piston motion on the vertical against degrees of rotation along the horizontal axis. It would seem counterintuitive that the piston rise and fall varies in speed over top dead center and bottom dead center, but it does. This explains why peak piston speed isn't at 45 degrees after top dead center. Over TDC, the piston slows and accelerates away much more rapidly than over BDC.

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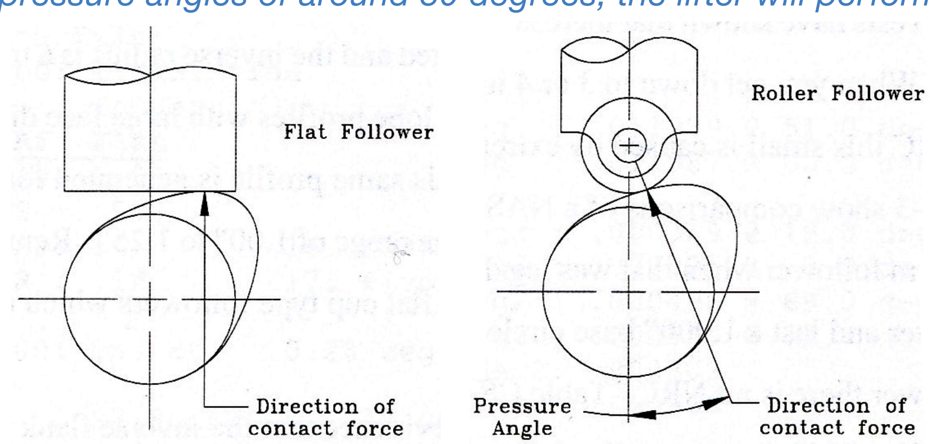
in the lifter bore, but even at that when spring pressures are high enough you'll be unable to control friction).

The acceleration limits of a roller are also limited by the mechanical limitation of the design. Over accelerating the body imposes unsustainable loads on the lifter axle and bearing system and increases the load on the cam core to the point where it fails due to high-pressure cyclic loading (Hertz loading) that will eventually result in subsurface work-hardening that leads to spalling or chipping of the cam surface. There are design changes you can make to help control or reduce these characteristics,

This piston is for a rolled, 12-degree cylinder head. By rolling the head, we stand the intake port up, make the chamber very tight at 65 cc on a bore that's over 4.5 inches, increase the quench area, and use almost no dome to achieve an overall compression ratio that's over 16.5:1. The valve notches do have to be deep to allow for the lifts we're using, so the net piston volume is about 2 cc positive dome. This is important because your cam grinder has to know how much room he has to stuff those valves in during overlap.

including larger cam cores that move more lift onto the cam and reduce the need for high rocker ratios, larger lifter bodies, solid-bushing axle lifters, or lifters designed with larger needles, and larger-diameter roller wheels. Lifter mass can be further reduced by using keyed lifter systems that eliminate the tie bars and the longer bodies needed to mount them.

We now know that lift moves with application and is tied to valve diameter as a percentage, and we know that we can only move things just so quickly before we cause damage. A general rule appears to be that we can move the valve .002 in. per degree of rotation. You'll notice that we are at the valve because that's where we should always measure. Pushrod geometry, rocker ratio, and system configuration and design all can consume cam lift by moving parts in a plane, not in line with the valve stem or lifter body, plus it induces side loads that deflect parts, losing even more lift before it makes it to the valve. If you go into any one of several cam company catalogs you'll see that for any given lift the duration, either advertised or net at .050 in., will be very close. You'll also note that the suggested compression ratio, lobe separation angles, and power band will be very close. Bear in mind that these are off-the-shelf units, so they tend to be more generic than a custom-ground piece, but it illustrates that there are broad guidelines that are being used to develop these profiles. For example, cam "A" measures an advertised duration of 296/302 degrees (by convention, intake/exhaust, and I'll use that convention throughout) and a net duration at .050 in. of 256/266 degrees with lifts of .641/.636 in. Power band is 4,000 to 7,500, LSA is 107 degrees, and valve motion per degree is .00216/.00210 in. (I'm using advertised duration to calculate valve motion per degree throughout this discussion). Cam "B" is 300/312 degrees, 270/276 at .050 in., with lifts of .657/.620 valve motion is .00219/.00198 in. per degree, the LSA of 110 degrees and the

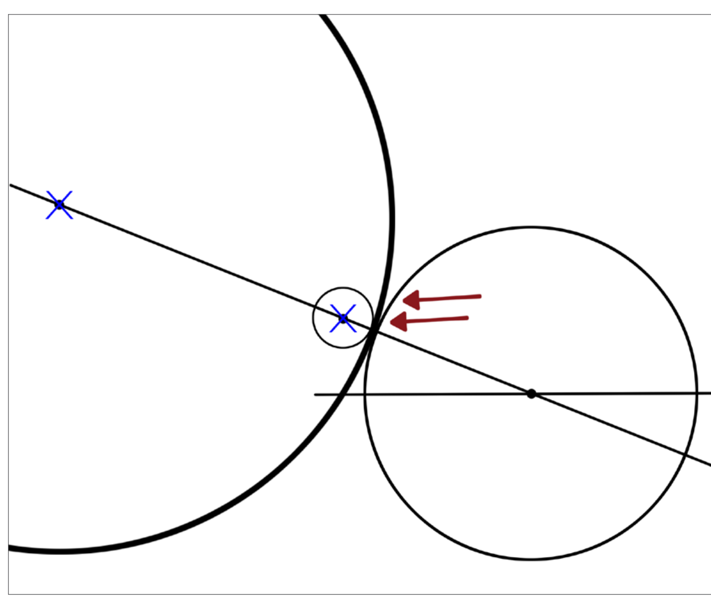


On a flat follower, the velocity limit is set by the physical layout. The lobe must lie inside the lifter foot chamfer and the nose of the cam can only be so narrow before the cam is overloaded or wipes through the oil film. On the roller lifter, the pressure angle is the angle difference between the wheel's contact point and the angle of the lifter bore. At pressure angles of around 30 degrees, the lifter will perform well, but over that things begin to fail due to the attempt to over-accelerate the lifter. It goes from lifting the follower to trying to gnaw the bottom off of the follower. Bore side loads go sky high and any excessive bore clearance or rough spots on the lifter body will accelerate the failure (courtesy D. Hubbard).

suggested power band is 4,600 to 8,000. Cam "C" is rated at 310/320 advertised, 270/280 at .050 in., .638/.638 in. lift, which gives us valve motion of .00206/.00199 in. of valve motion per degree, the LSA is 110 degrees, and the suggested power band is 4,500 to 7,500 rpm. As you can see, if the lift is very close, the duration and LSA is also very close. Will these cams perform differently? Very likely because small differences in specifications can make notable differences in performance.

While we're talking about lobe separation angles, let's take a quick look at what exactly LSA is and how it changes with engine design. The lobe separation angle is the number of degrees between the intake cam lobe centerline and the exhaust lobe centerline, and they can run anywhere in a rough range between 95 and 130 degrees with most falling between 100 and 125 degrees. In general, performance camshafts sporting narrow LSAs have a more unstable idle, lower intake manifold vacuum, sharper power peaks, narrower power bands, and more explosive power transitions. While in many cases people talk about widening LSAs to tame cam performance, it's really the result of the lift, duration, application, and overlap period that is defined by engine use and desired power output. It's not really an adjustable element, as some might suggest.

Here are a few things that change LSA requirements: For each of the following characteristics, you open or widen the LSA, and, of course, close the LSA for the opposite attribute; smaller cylinder, more low-flow lift, more compression (about a degree per point of compression over 10:1), higher rate of lift and higher rpm. Close up the LSA for a larger cylinder, less low-lift flow, less compression, lower rate of lift, or lower rpm.

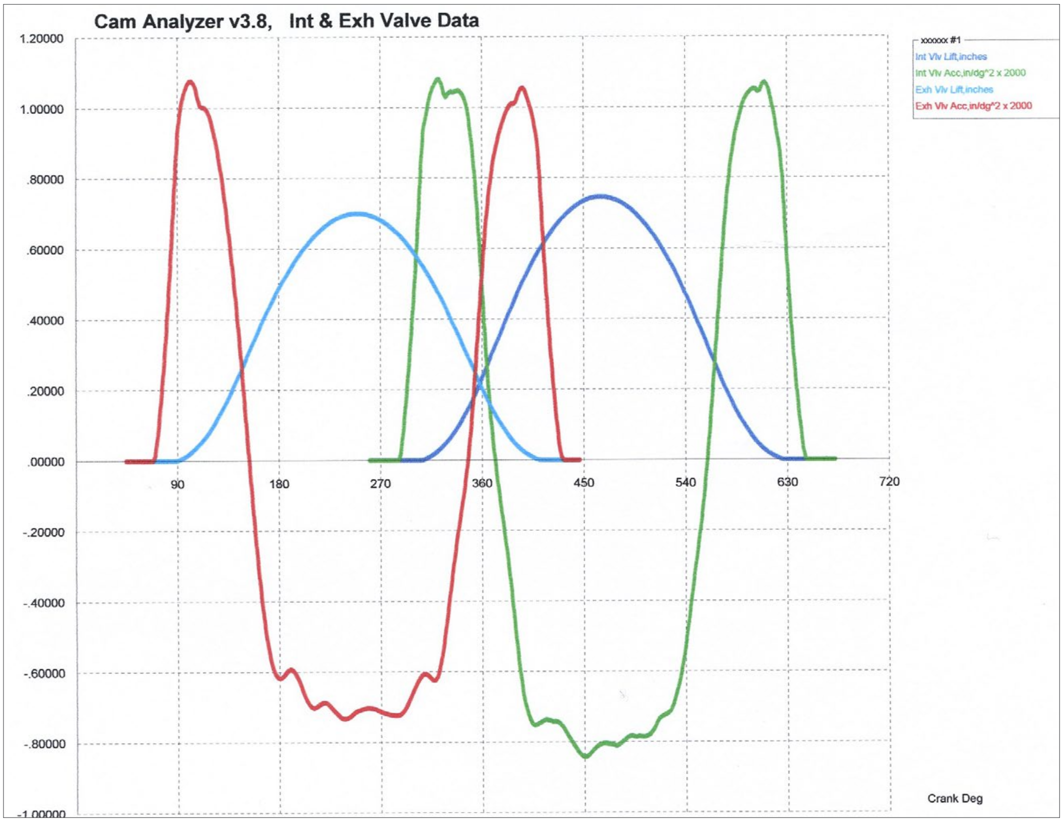


We sketched this out with a compass just to show you how the size of the wheel on the roller lifter will affect the cam duration. The lift will not change because the lift is set by the distance from base circle to nose, and the wheel only follows that difference. But duration will change slightly. Obviously, we exaggerated the difference in this drawing to make the point, but you'll really only see a couple of degrees on a typical installation if you move from a .700 wheel to a .810 wheel. Just remember to check that the lifter doesn't come up out of the bore far enough to expose the oil band or oiling groove on the lifter if you use a larger wheel on the lifter. That would be a pretty serious pressure loss if you did it on sixteen lifters.

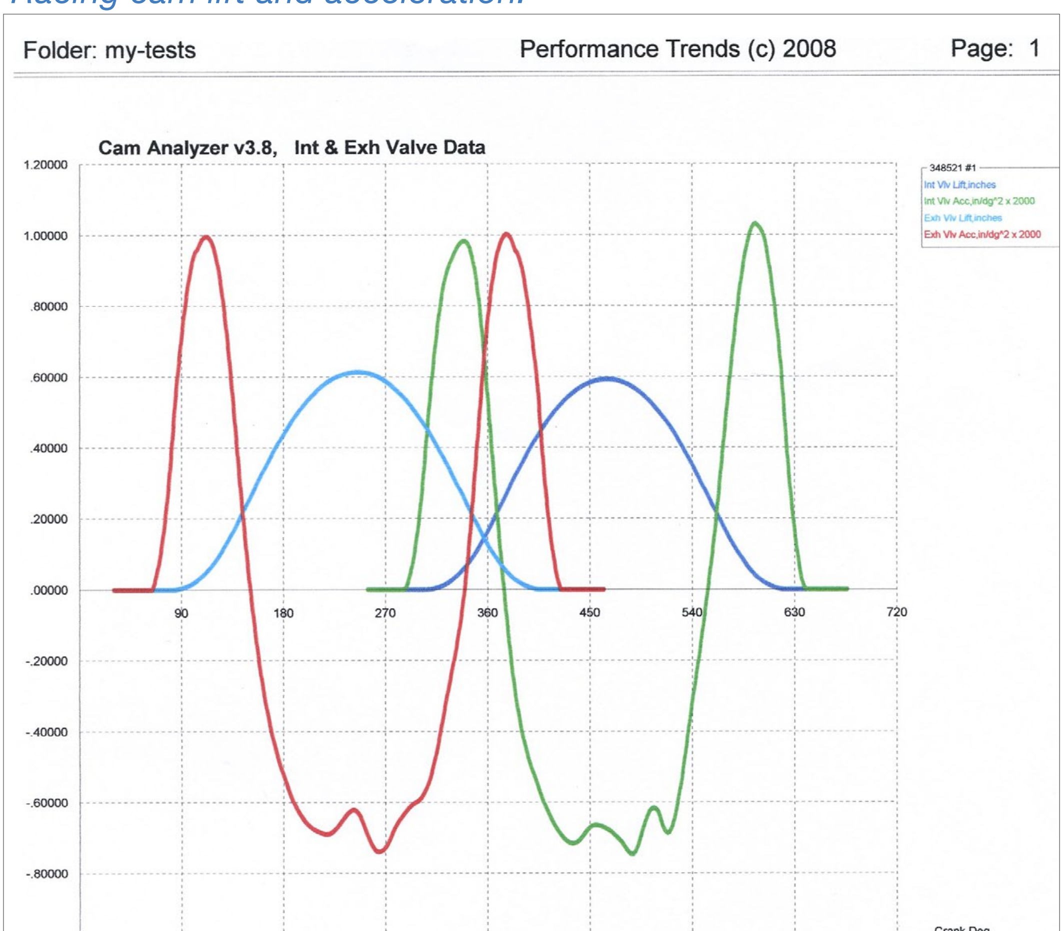
Now, performance should also include durability and valve train stability. In fact, that is the area most cam grinders are working in today. Valve motion, as translated from the cam to the valve, occurs over five distinct zones. There is an opening ramp designed to slowly start the lift and bring up the valve train loads in a controllable manner, there is a period of main lift, which brackets piston speed and generates the valve open area needed for maximum cylinder flow, a dwell period during which valve opening remains at or near maximum, the transition from dwell to the closing ramp, and a closing ramp designed to slow the valve and gently seat it without inducing valve bounce. The ramps determine how fast the valve leaves and returns to its seat, and they are a major contributor to engine durability, noise levels, and performance. Valves must remain on the seat for as much of the base circle as possible to allow them to cool, and bouncing the valve off the seat even a few thousandths will dramatically reduce durability. The valves of a stock or long-distance racing engine should hit the seat at about 1.4 miles per hour, or 25 inches per second. An oval track engine can sustain seating speeds of about 30 inches per second, and a drag racer can live with valves seating at around 35 inches per second, although it's not uncommon to see seating velocities of up to 55-65 inches per second in drag applications. The lesson with that is that there's no free lunch. The performance gains made by increasing lift and duration automatically mean there's less cam core over which to place the five zones, and the opening and closing ramps become shorter as the duration increases to keep the acceleration or velocity limits caused by increased lift under control. And that, gentle reader, is why we just LOVE those large cam cores! Well, that and the fact that you can grind more valve motion on the cam and move the rocker ratio back a bit if you need to.

More to come next issue. We'll try to get all this tied together and put this topic to bed! ■

NOTE: I'd like to encourage you to purchase a copy of a book that I've used to study camshaft design and limits while writing this. It's by a gentlemen named Don Hubbard and the title is "Camshaft Reference Handbook," last printed in 2005. Unfortunately for engine enthusiasts everywhere, Don passed away in the last few years, but his widow still has a couple of hundred copies available and she can be reached by email at dhubbard7@earthlink.net to check prices and availability. The line art and much of my understanding came from this book with Mrs. Hubbard's permission, and I'm grateful to her for that.



Racing cam lift and acceleration.



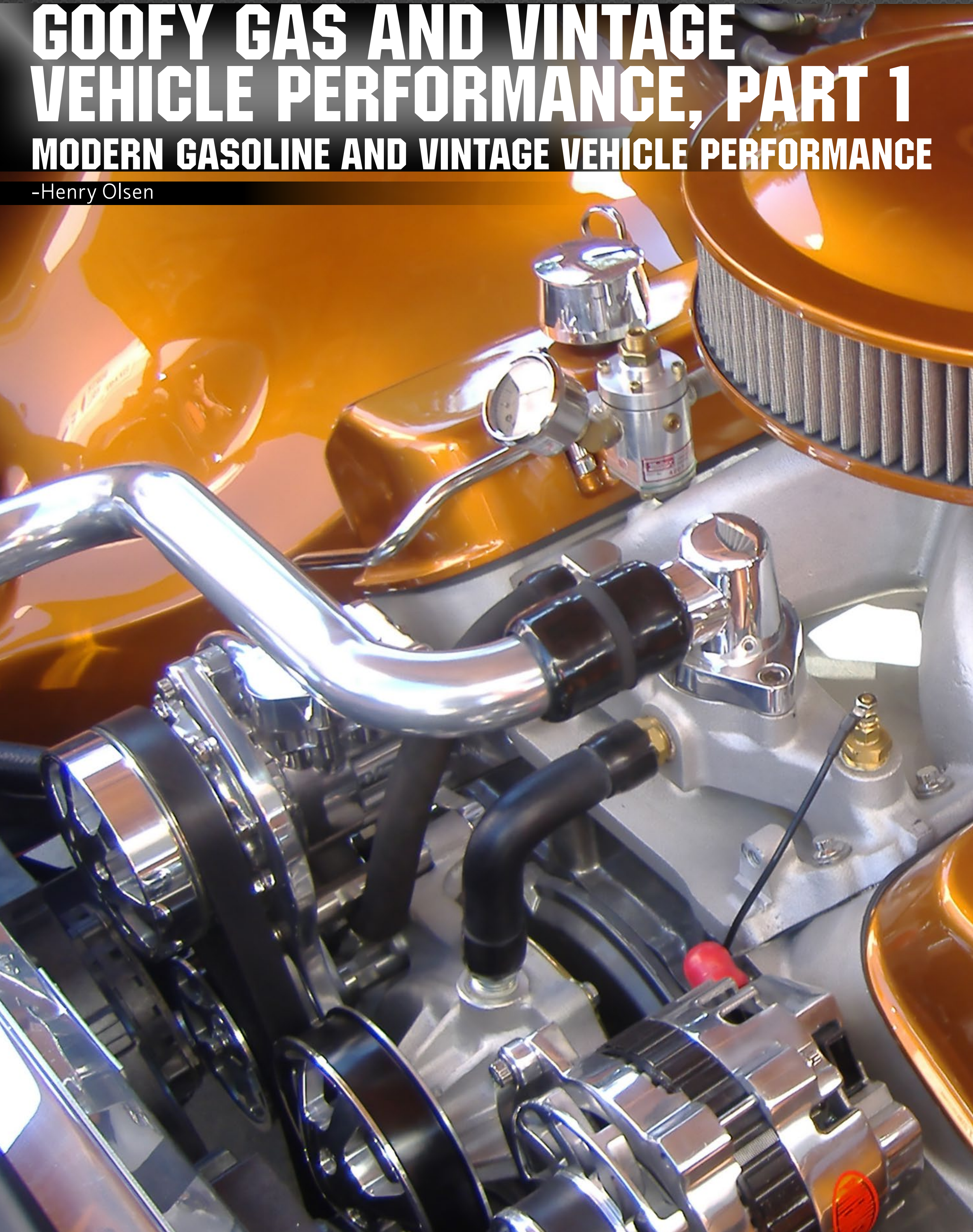
This solid street cam graph shows acceleratioion and lift.

These graphs are of a BBC racing engine and a stroker Ford street engine, both solid-lifter roller cams. The blue lines show the intake and exhaust lobe motion at the cam and the red and green lines show valve acceleration rates (smoothed by the program). For this to work well in a shop environment, you need to have a really good digital dial indicator capable of reading 1/100,000th of an inch. Everything has to be spotless — even dust will cause some variation in your readings. What you'd like to have is a Cam Doctor or something similar, but that's more money than we have (or are willing to spend!). If you're careful setting up your degree wheel and indicator, you'll get very repeatable results, which will let you compare one camshaft profile to another.

GOOFY GAS AND VINTAGE VEHICLE PERFORMANCE, PART 1

MODERN GASOLINE AND VINTAGE VEHICLE PERFORMANCE

-Henry Olsen



Is it still gasoline, or has it become "Frankenfuel?" Also, how to handle volatility and vapor lock.

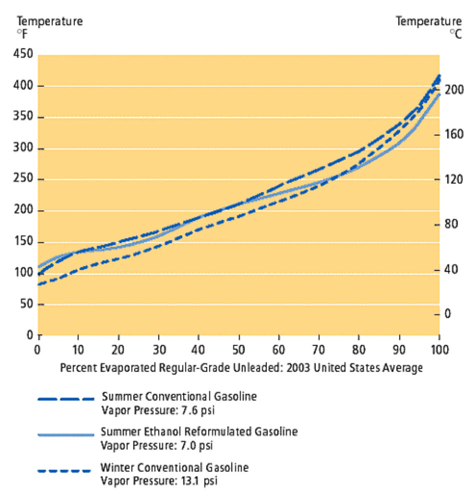
The gasoline you burn to power your vehicle down the road is blended with several different goals in mind. Gasoline is a blend of hundreds of different hydrocarbons that vaporize/boil at temperatures as low as about 80° F. to a maximum that is in the 425° F. range. What you buy at your local gas station is blended for the expected temperature and the altitude in the area where it is sold, plus it is also blended to meet the federal, state, and local environmental regulations. There is also a push on to increase the use of ethanol or alcohol-based additives to both reduce fuel-related emissions and lessen our dependence on foreign oil. Each brand of gasoline will add an additive package to the gasoline that is designed to reduce combustion chamber deposits, clean the intake valves and clean the fuel injectors. This means that the blend of gasoline you use will not only vary from brand to brand, but also will change by the season and the part of the country you buy it in.

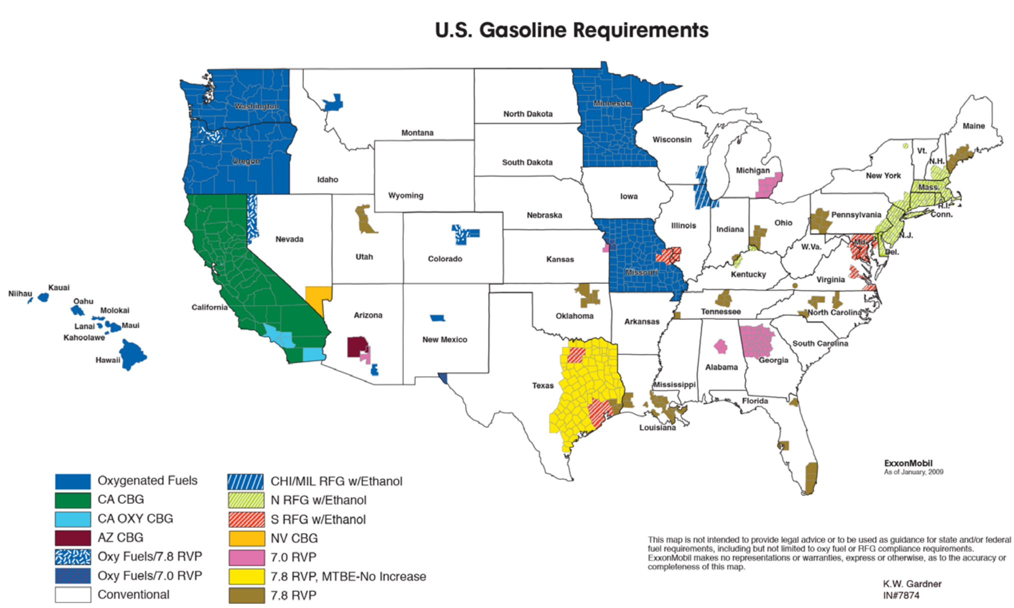
The distillation/vaporization curve of today's reformulated gasoline has been changed to make it burn cleaner. Some of the lighter/more volatile portions have been removed in order to reduce evaporative emissions, and some of the heavier/less volatile components have also been eliminated to cut engine emissions. These new blends have a higher content of fuel that vaporizes in the middle temperature range and are therefore somewhat harder to light off, but are somewhat faster burning than the leaded gasoline of the 1960s and 1970s.

The formulation changes that affect how an engine will perform are:

- The density of the fuel (specific gravity),
- The percentage of ethanol content (if used)
- Front-end volatility

This chart shows the percentage of the gasoline that will evaporate by temperature.





Blend requirements vary according to where you live.

Each of these factors can vary as the formulation is blended to conform to local environmental regulations, the season of the year, and how well the ethanol (if used) was blended with the gasoline. Front-end volatility can be measured in the field with a Reid vapor pressure tester, but in a laboratory it is measured via the API-D86 Distillation Curve Test.

DENSITY OF GASOLINE

The measurement of density is referred to as the specific gravity. When it is altered, it will change the air/fuel mixture you would get from a carburetor because the fuel

In the field, a Reid pressure tester is used to measure the front-end volatility of gasoline.

will flow through the jets at a different rate. Density differences can also change the level in a carburetor's fuel bowl because the float will sit higher in a fuel that is denser than it would in one that's lighter. The rule of thumb is that if you're moving from a high specific gravity to a lower one, you will need to adjust the air/fuel mixture leaner by going to smaller jets, and vice versa. This may be counter-intuitive, but lighter specific gravity gasoline will lift more readily and in increased volume in the emulsion wells and out through the emulsion boosters, thereby richening the mixture. The opposite occurs with higher density, heavier specific gravity gasolines. Race fuel companies such as ERC, Rockett, or VP can supply you with the SG measurement of the gasoline they sell.

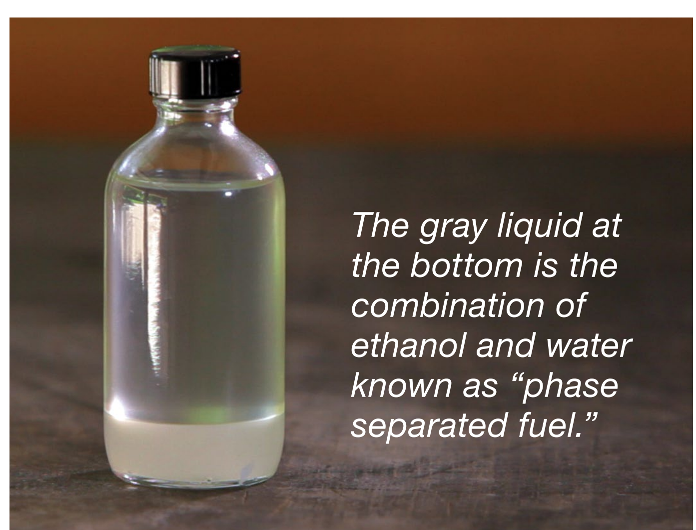
ETHANOL CONTENT

If the gasoline in your part of the country contains ethanol, the fuel efficiency of the engine will decrease as the level of ethanol is increased. This is because gasoline has more energy (Btus) per gallon than ethanol/alcohol-based fuels. An engine running on alcohol needs a richer air-to-fuel ratio than an engine running on gasoline. The ethanol is added as fuel is loaded into the delivery tanker truck, and it's mixed with the gasoline through a process that is referred to as "stop light blending." This process assumes that the ethanol will mix together with the gasoline as the tanker stops and starts on its way to the gas station, but sometimes that isn't very thorough and there may be portions of the fuel mixture that have a higher ethanol content than other portions of the same tanker load.

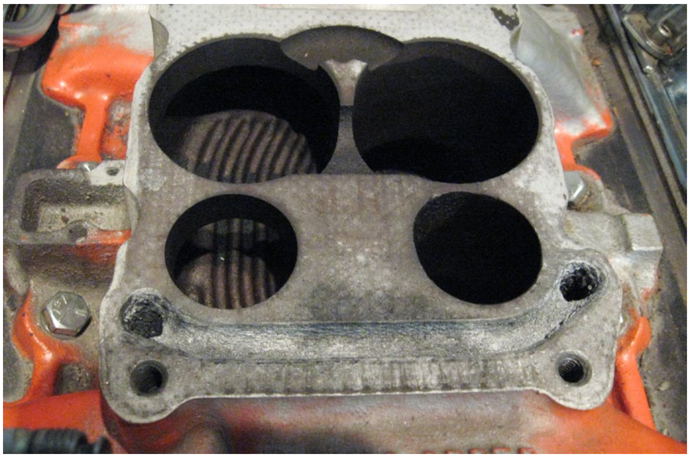
VOLATILITY

Reid vapor pressure is basically a measurement of the gross volatility of the gasoline. In other words, how easy the engine is able convert the liquid gasoline into vaporized gasoline. The lighter or more volatile portions are important when first starting an engine, so winter fuel is blended with a higher RVP than summer fuel. So, southern California summer grade gasoline

You can also measure the ethanol content of gasoline in the real world with this type of equipment.



The gray liquid at the bottom is the combination of ethanol and water known as "phase separated fuel."



Among many other car makers prior to 1970, General Motors used exhaust heat through the carburetor base plate to prevent carburetor icing and improve cold engine driveability. But this extra heat can cause hot-engine vapor lock problems, plus swelling of the rubber components in the fuel system.

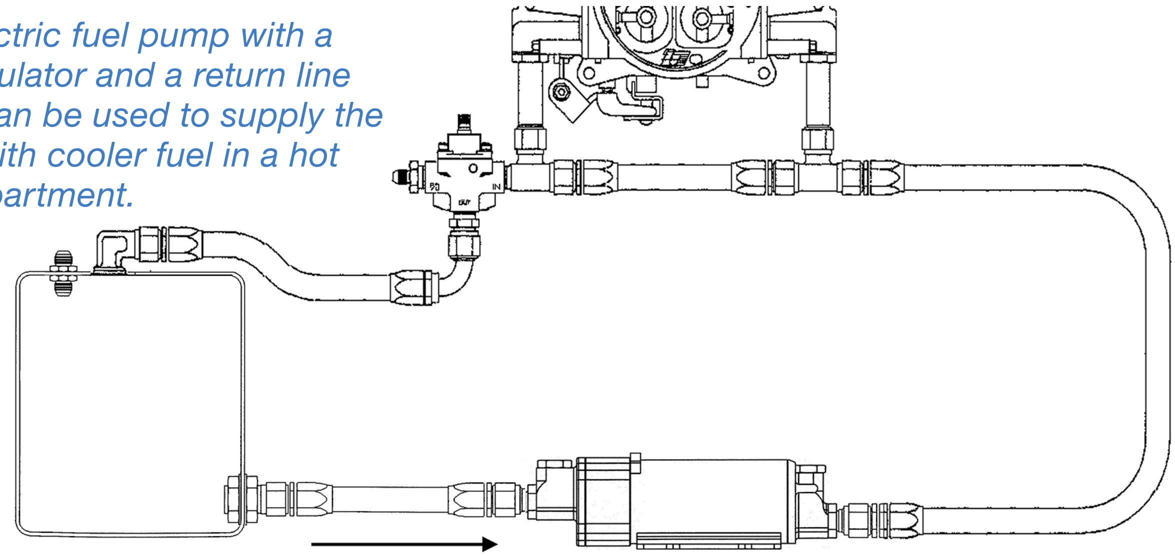
A phenolic carburetor spacer can help reduce vapor lock.

has relatively low volatility to avoid vapor lock while the winter grade sold in Michigan has high volatility in order to make starting easier in sub-zero temperatures.

FUEL VAPORIZATION AND VAPOR LOCK

Vapor lock, caused by the boiling of gasoline in the fuel pump, fuel lines, or carburetor, has been a perennial problem with carburetor-equipped vehicles. The unleaded reformulated gasoline of today is engineered to allow modern fuel injection to produce the lowest possible exhaust emissions along with good fuel economy. It is also blended so that it will have the lowest possible evaporative emissions, but it still has to have enough volatility to allow the engine to actually burn the fuel. These new blends are not really designed for a vintage carburetor-equipped engine that has a mechanical fuel pump and fuel lines that are exposed to high under-hood heat. The carburetor itself is also exposed to plenty of heat, and, unlike with a set of fuel injectors, the fuel can easily evaporate out of the bowl through its vents. Vapor lock is not common with fuel injection mainly because of the 40 or more lbs. of fuel pressure, which raises the boiling point.

An engine can only burn fuel vapors, not liquid gasoline, thus there needs to be enough heat in its induction system to vaporize the fuel, but too much heat will cause vapor lock problems. Intake manifolds such as the Edelbrock Air-Gap series are designed to reduce the heat in the manifold ports, but if they get too cold the fuel may not stay vaporized at lower engine speeds. In the 1950s and 1960s, *Using an electric fuel pump with a pressure regulator and a return line to the tank can be used to supply the carburetor with cooler fuel in a hot engine compartment.*



General Motors designed many of its V8 intake manifolds so that exhaust gases pass across the base of the carburetor to prevent icing and aid vaporization. When using today's gasoline blends with such a design, it is often advisable to block off the exhaust passages through the base plate of the carburetor and also reduce the exhaust flow through the crossover *[Editor's Note: In the days of flathead Fords, people used to put pennies over the crossover ports before installing the intake manifold].*

The starting and stopping of a tank truck on its way to deliver a load of gasoline is referred to as "stop light blending," which is how the ethanol is mixed together with the gasoline in the tanker.

Gasoline in a mechanical fuel pump or fuel lines is exposed to the heat directly from the engine and radiator fan wash, which can lead to vapor lock. We've had vehicles where we could watch the fuel foaming through the fuel bowl sight plug. In some cases, the fuel gets so hot that once it goes from the six lbs. of fuel line pressure to atmospheric pressure in the bowl it begins to boil, and this can happen even with a heat-insulating spacer under the carb. It is always advisable to route the fuel lines as far away from any heat sources as possible to avoid this, and you can run the lines through an insulation sleeve. In some extreme cases, the cure may be to install an electric fuel pump with a bypass pressure regulator so that relatively cool gasoline from the tank is always flowing through the lines, then returned to the tank (providing the tank is in a cool location away from the exhaust pipes). Heat is also a factor to consider in how quickly the rubber and plastic compounds used in fuel system components will degrade with exposure to gasoline because the rate of reaction doubles for every 50° F. (10°C) rise in temperature. ■

TECH MINUTE:
FASTENERS, TORQUE & LUBE

-Greg McConiga

Usually, our "Tech Minutes" are short pieces, but this is such an important topic that our man Greg has given us what amounts to a full-fledged feature. As they say, "read and heed."

Bolted assemblies — we use them by the hundreds in machines. Making something as one part is impractical or prohibitively expensive because machines need to be serviced or maintained and that process can't be so complicated that only an engineer can do it, particularly if the machine is mass produced and widely used.

In bespoke engines, like the Offenhauser for example, one-piece barrel crankshaft housings, clamshell main bearing supports, full gear drive systems, and one-piece cylinder/head assemblies make perfect sense, but in a production engine where cost, noise, vibration, and serviceability are most important this wouldn't be the best solution.

The problem with bolted assemblies is that they have to maintain structural integrity to combat tensile and compressive forces, seal if there are pressures and fluids involved, and allow movement if there are dissimilar materials used or wide temperature gradients across the assembly. Taking all that into account, bolt or fastener specifications become very, very critical in racing applications, and the installation of the fastener — the prep work, the lubrication, the method of tightening and the post work to evaluate the fastener's performance — becomes very important to a successful engine building program.

How do you know if your fastening system is doing what it's supposed to do? In part it's an article of faith. You take the information provided from the supplier, inspect the parts for nicks or damage, chase the threads on the fastener

Opposite: Here you can see what happens over time if the stud threaded length is insufficient to seat all the way to the bottom of the hole. This engine has been in service a number of seasons — six or seven, if I remember right. When it first came out, the stud kit supplied used the same length of stud as a stock block application, where this aftermarket tall deck block has a much deeper hole. As a result, over time, the pull concentrated in the upper two thirds of the bore and eventually the block failed in three spots at this same head bolt hole on three cylinders. It's the hole closest to the bore, with the least amount of support material around it, and time and runs (over 700) took its toll.

Now, were we close to the end of life with this block? Yes, it needed to be honed out and fitted with custom pistons a season or two ago, but we could have gotten another three or four years out of it had this not occurred. The lesson is this: always double check thread engagement. While the books tell you that minimum engagement is one and a half times the bolt diameter, that may not be good enough in highly-stressed racing applications. The threaded portion of the stud or bolt should always have maximum engagement. You can either turn a "bullet" nose on the end of the stud and seat the bullet against the bottom of the hole (if there's enough threaded length to allow it), or you can use a small ball bearing and Loctite the stud into the block seated against the ball bearing to lock the threads into one another.

and in the hole, assume that there are no inclusions or hidden defects, and torque or stretch it to the specification with the recommended lubricant, and run it. If it grenades, oh well. That's why it's called "racing" and not "winning."

Now this is going to sound like I've got an obsessive-compulsive issue (and that, along with what has to be a touch of ADHD, can make one's life very interesting...), but I constantly re-evaluate what I do on every engine. I'm constantly reviewing, thinking, checking, re-checking, and improving as many things as I can (time and money do enter into this equation). Fasteners, clamping pressure, and a successful building program go hand in glove. You just can't be successful unless you get through the season or the race without mechanical failures. The odds of success in racing are pretty poor anyway. There isn't one competitor out there who can't have a good day, or one who can't have a bad day, and if the class you race in is big enough and competitive enough, you need every single advantage you can get to end up in the money.

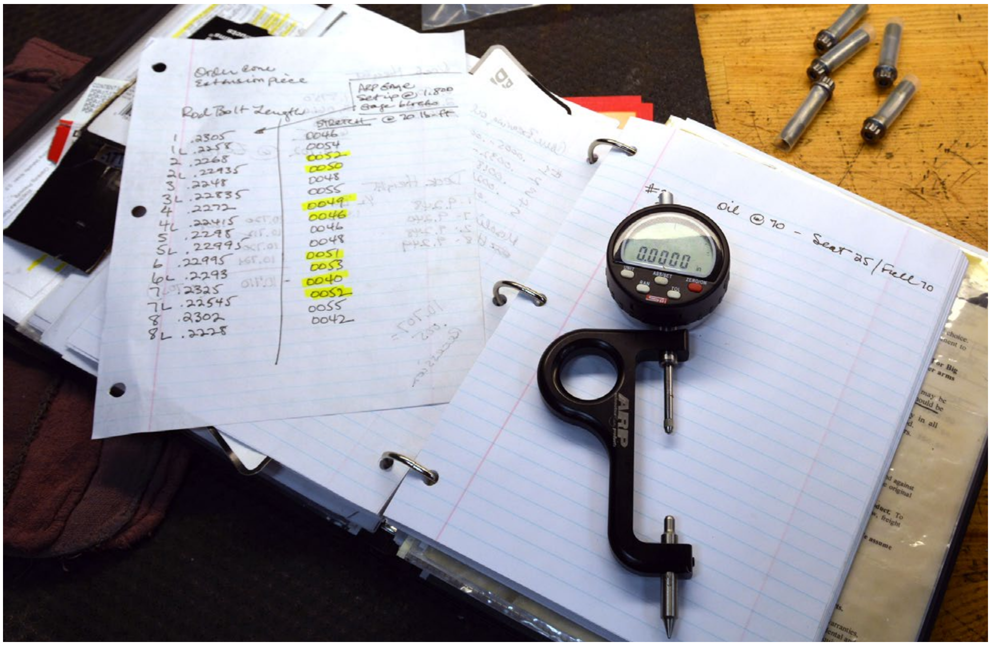
I've done this long enough now to begin to see the results of our little in-house R and D, both good and bad, so I thought

Technology is a wonderful thing. The newest generation of electronic digital torque wrenches uses LEDs to show that you're approaching your setpoint as you turn the wrench, and can be adjusted between inch-pounds, foot-pounds, newton-meters, and turn angle with the touch of a button. Plus, they are amazingly accurate, often to within a few tenths of a percent in repeatability. Yes, they're pricey, but think about the downside if you break something while under power. You absolutely have to have reliability, repeatability and accuracy to keep from inducing error into your building process that creates failures. At this level, failures are so expensive that it's irresponsible to do otherwise. If the customer trusts you to work at this level, you have to do everything you can to conserve his funds. With travel, fuel, entry fees, and the cost of a rig to haul everything, building a bulletproof engine just keeps one more racer in the sport for a while longer.

I'd share a few things today. A few of our engines run bores that are right out near the maximum on a 4.840 bore spacing big-block Chevy-based engine. At max bore, the thickness of the deck between cylinders gets pretty narrow and cylinder-to-cylinder leakage can occur as the season progresses if the clamping pressure isn't where it needs to be.

Clamping pressure is a function of the bolt size, gasket design, bolt spacing, number of bolts around the bore, overall fastener length, whether it's a bolt or a stud, how the stud is mounted to the deck, thread engagement, material, and special treatments to the fastener diameter, such as necking or undercutting. Shorter fasteners of the same diameter are stiffer and apply more clamping force than longer fasteners.

On aluminum head applications, the scrubbing that occurs with head growth can damage gaskets if the clamping force isn't both sufficient to avoid lift-off at full cylinder pressure and low enough to allow for growth and movement during warm-up, and gasket coatings, deck and head surface finish, and proper installation technique all enter into the equation. How much



Whatever you do, keep a notebook and fill it with all the technical data sheets, part numbers, and modifications to your process as you complete your builds. Fill them out each day, note the date and time on each page (in case someone drops your notebook and it springs open — don't ask me how I know this...), and keep complete notes for each engine you build. If you make changes, record them. Talk to someone and learn something new? Write it down. Locate a good chart, or helpful article? Print it out and bind it up. Once you find a process that works, repeat it the same way and don't deviate until you can prove that it didn't work or didn't give you the result you were looking for. If you come up with a minor change that makes it easier or makes repeatability easier to prove, write it down.

Buy 1/10,000th reading everything, and when you do that start recording shop temperatures when you measure because it's going to change a tenth or two if the temperature is 15 or 20 degrees different! If you need to, take photos and bind them in, or keep them on your computer in individual folders labeled with names, dates, times, and engine serial numbers. If something goes wrong, you need to be able and go back and reconstruct your steps because in many cases you won't get a clear read from what's left of the engine should it fail. If things go right, you want to be able to do it again the same way.

pressure are we trying to contain? A bunch! With a cranking compression pressure of 280 psi, you're at 4,707 psi on a 4.625 bore (pressure times area) before we even start combustion. A good rule of thumb to guessimate combustion pressures is to multiply cranking compression pressure times four to get pressure under combustion, so now we're containing 18,816 psi and our clamping pressure needs to be about three times this figure to prevent lift-off, so we need 56,448 pounds of clamping pressure around each bore to successfully control this head gasket. On a cylinder with four head bolts that's 14,112 pounds per bolt, and with five bolts that's 11,289 per bolt. From a fastener perspective, is that possible? Yes, easily. A 7/16 bolt made from 220,000 psi tensile strength material will provide 15,060 pounds in preload at full torque and a half-inch bolt (a more common diameter on four bolts per bore engines) will provide over 20,500 pound of preload per bolt.

A tool that is a must-have during the design phase of your build is a product from FujiFilm: Prescale pressure sensitive film. It's a direct-reading color-changing film that is installed with the head gasket and read after the assembly is brought to full torque. It can help you adjust your process and fine tune the torque sequence and torque settings to most effectively and uniformly clamp the gasket. Cylinder heads and blocks aren't uniformly stiff from bolting point to bolting point and you may need 80 pounds-feet on one bolt or stud and only 68 on another to attain the most uniform clamping force across the assembly. I've attached several PDFs from the company here so you can read through the literature and see just what's offered and how it applies to your engine-building program. Used correctly, it will help you make the right decision on gasket and head bolt type. This is a topic we will investigate more fully at a later time, but for now it's helpful to know that tool is out there for you.

We've talked before about how a torque wrench is just a roughly calibrated friction meter, and how thread condition, material, and lubrication makes all the difference in the world when it comes to final true clamping force. Using the FujiFilm and experimenting with different lubricants you may find a better option for bolt or stud installation than what you're using now. With rod bolts it's a bit easier to test your process since you can reach both ends of the bolt and determine the stretch you achieve at the recommended torque. I did a little experiment on this just to satisfy my curiosity about lubrication types and the effect they had on bolt elongation and here are my results.

I had a set of new connecting rods that I was about to install, and they had been torqued up a number of times with the recommended lubricant — ARP Super Lube — to pre-condition them prior to final installation. The threads and holes were well polished after six pulls to full torque, so I cleaned everything up with mineral spirits and alcohol and re-lubed four pairs of the ARP-2000 rod bolts with the following lubricants: engine oil, the old ARP moly paste lube, the new ARP Super Lube, and CMD #3 extreme pressure dead center lubricant.

My process was to set up my two Snap-on electronic torque wrenches (previously tested against a precision Torque-O-Meter), lubricated under the head and collar of the bolt, the contact point on the rod where the head and collar came in contact, as well as the threads of the rod bolt, and brought every bolt to the recommended torque in two steps — first 25 pounds-feet, then 70 pounds-feet — and recorded the stretch of each bolt with no more final torque variation exceeding 1.5 pounds-feet across all eight fasteners.

The engine oil pair averaged .0046 in. +/- .0002 in., the old ARP lubed pair averaged .0053 in. +/- .0003 in., the ARP Super Lubed pair measured .0055 in. +/- .0004 in., and the CMD #3 pair measured .00585 in. +/- .00015 in. against a recommended maximum stretch of .006 in.. For this bolt, I know that the bolt stretch range is safe up to .007 in., after which permanent deformation can occur. I've been experimenting with the CMD lube for a lot of years now and it's just about the slickest thing I've found

The process of accurately fastening parts together is equal parts skill, repetition, luck, and black magic. Everyone has a process they follow, so here's a short version of mine.

After full clean up, I run every hole, bolt, and stud with a thread chaser kit. Not a tap and die — I don't want to cut threads, I just want to chase them and make sure they are all made to SAE standards. I blow everything out, verify and mark blind holes and holes into water, pre-fit any part that passes through the block potentially impacting a cylinder wall or bottoming out on part of the internal structure, and confirm lengths.

I run rod bolts up to full torque a few times, checking the bores, fitting the bearings and calculating the oil clearances while that's being done. I do the same with the head bolts or studs and main bolts or studs, using a head gasket identical to the one I'll run to check bore concentricity, taper and out-of-round from the bottom up. You're either going to use the recommended lube that's supplied, or else you'll have to spend the time to develop an alternative technique to attain the right result, either in clamping force or fastener stretch. In my opinion, either way works, it's only limited by the time and resources you're willing to spend to find the answer. For most of us, if we're confident the parts manufacturer has done its job correctly, we can just use the recommended lubricant and follow the recommended procedure and be confident in the result.

for bolt or parts lubricant when you're pressing or tightening something and need as little friction as possible. I know this might be heresy, but I really think that if you understand what you're trying to do, it may be the best lubrication option for you under some circumstances. As you pull a bolt up to final, full torque, it must be done in one motion after the setting torque (in this case the 25 pounds-feet) is applied. You must NEVER chase the stretch by continuing to pull over and over once the torque reading is up over the setting torque. Otherwise you'll just twist the shank of the bolt between the head and collar and the threads and you will absolutely break rod bolts put into service if you make that mistake (don't ask me how I know that...)

What you want to avoid in every case with every technique (in my opinion) is winding up the bolt shank between the head and the thread, because that can induce damage into the shank, possibly leading to bolt failure, even if you don't stop and start the process as you do when you chase the stretch number.

I've also noticed that the bolt feels different under turning load with different lubricants. The bolt feels smoothest and the easiest to turn throughout its motion with the CMD, which tells me that you might get "more for less" and that you'll need to sneak up on any stretch value you are trying to attain. To be fair, the Ultra Torque does a good job as well, IF it's fresh and hasn't gotten "grainy" or "gritty" with age. As you can see above, there is less stretch scatter (difference) and a higher final stretch with the CMD at the torque level (70 pounds-feet) that we selected. This has been a consistent result I've recorded over hundreds of bolts of different brands and materials.

Ultimately, I've had the best overall results using a torque plus degrees of rotation method on engine fasteners, essentially the same technique the car makers have been recommending for their one-use-and-discard "torque to yield" fasteners for years now. If the bolt or stud supplier doesn't give you a setting torque plus degrees of rotation specification, you'll have to develop your own through trial and error.

You're using a very low value setting torque as a starting point so that the assembly can't rock up or move as opposing fasteners are rotated to full torque. I don't believe that the choice of lubricant matters nearly as much for this technique as it does if you're sticking strictly with a fixed "turn it and click it" torque reading, but that's just my opinion.

Just remember, once you begin to pull keep the rate of rotation steady and don't stop rotation in mid-stride. Otherwise, you must loosen it back up, re-lubricate the fastener, and start over. Think it through. Figure out where you'll start and end up so you can position your body to make the full pull. And don't forget to lock down the engine stand so it can't move during rotation and screw up your reading! You'll get your best results if you can maintain a steady, even pull of roughly 20 degrees of rotation per second. Modern digital torque wrenches have a rotation reader in them and the best of these are very accurate and give you an alarm once the set point is attained. NEVER jerk, or snap a torque wrench. “Ballistic” torqueing like that is a waste of time and is completely wrong! Maintain the same 20 degrees per second rotation for regular torquing that you do for torque-plus-turns, and never stop part way and attempt to restart.

Of course, the last thing we need to talk about is something rarely done, and that is torque wrench calibration. Remember two things… a torque wrench is most accurate in the range from 20% to 80% of full scale (20-80 pounds-feet for a 100 pound torque wrench, for example), and have them checked at least once a year during the off season. No point in risking $25,000 or more in expensive parts over a $75.00 calibration charge, is there? ■

PRESCALE

Click here for the sales and sample literature for the Fuji Prescale product, previously mentioned. A variety of pressure ranges are offered, with the higher ranges being the ones we would normally use. There’s a fair bit of information here, so take the time to look it over and see if this is something that might be useful to you in your building programs. It’s expensive (roughly $65 a foot), but if you’re careful and record your process accurately you should only have two or three attempts before you home in on the best way to get the most even clamping force on your gasket.

ABSORBED GLASS MAT (AGM) BATTERIES

WHAT'S ALL THE FUSS?

There are many types of batteries in use today. The most common batteries used in automotive applications include:

- Lead Acid
- Nickel Metal Hydride
- Lithium Ion
- Lithium Polymer
- Lithium Metal
- Sealed Lead Acid: Gel-Cells and Absorbed Glass Mat

The type of battery used will vary by application and will depend on energy and cost requirements.

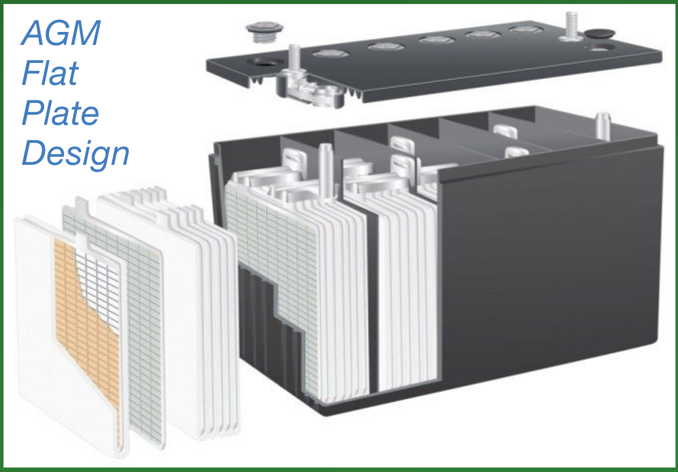
Absorbed Glass Mat (AGM) batteries have many advantages over conventional "flooded" lead-acid batteries including the ability to deliver high currents on demand, good electrical reliability and relatively long service life, even when deep-cycled. AGM batteries have been installed in cars since the late 1990s, and with the growing popularity of hybrid vehicles as well as with vehicles incorporating start-stop technology, some experts predict that AGM batteries will be used in 50% of all new vehicles sold in 2017.

AGM batteries are sealed and are non-spillable, meaning that they can be mounted in non-traditional locations (i.e. somewhere other than under the hood) and in non-traditional angles (i.e. not always completely horizontal). They are vibration-resistant, so in addition to finding them in vehicles they are also found in some motorcycles, ATV's, and in many marine applications (note; do not confuse AGM's with gel-cell batteries, which are different). So if AGM's don't have the leak hazard that traditional lead-acid batteries do, what are the dangers?

Because they are sealed units, AGM's are inherently vulnerable to being overcharged. Conventional lead-acid battery chargers oftentimes have outputs of 16 to 18 volts – well above the 14.4 volt maximum stipulated for the AGM design. So what's the worst-case scenario here?

Using a conventional battery charger on an AGM battery could cause severe damage to the electrolytes and premature failure to the battery. Conventional chargers also have the potential to cause an AGM battery to literally explode – a hazard that we never (ever) want to expose to our technicians.

AGM Spiral Design



AGM Flat Plate Design

Traditional lead-acid batteries and AGM batteries are oftentimes very similar in their outward appearance. Before connecting a conventional charger to a battery in a vehicle (in particular if it is located away from the engine compartment) – see if it is labeled "non-spillable". If so, only use chargers that are designed for AGM (and/or gel-cell) batteries.

Last year the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) and the Coordinating Committee For Automotive Repair (CCAR) renewed their alliance and will continue joint efforts to promote safety and health in the automotive industry workplace. Initial emphasis will be in areas of lift safety, Absorbed Glass Mat (AGM) batteries and contaminated refrigerants.

CCAR was established in 1994, as a non-profit organization that works internationally with the automotive industry, original equipment manufacturers, career and technical schools, collision and automotive repair shops, governments, municipalities and other organizations to provide best practices information and training.

For more information, visit ccar.education or call CCAR at 888/476-5465. ■❖

CCAR
COORDINATING COMMITTEE FOR AUTOMOTIVE REPAIR

EARN MORE, WORK LESS AND DOMINATE!

OK, so where to start…….? This subject could use 20 pages to explain adequately and since we don't have that much room, please understand that this is simply a small sampling of what can be done. Your "take away" should be the thought process more than these actual scenario's!

So, let's start by asking a simple question; how would you like to average 5 hours (or more) per repair order? Can you imagine only having to road test, rack, and work on 1 and 1/2 cars a day? How much easier would your day be, how much more could you get accomplished?? We work with many repair shops across the country that are able to achieve this and today we are going to share a couple ideas that they (our clients) have learned and done throughout the years to accomplish just this.

Let's start off by talking about what your job is, what your customers should expect from you, and what, as a technician you can do to better the customer's experience! "Wait" you say, "the customer experience isn't my job, that's the Service Advisors job…..right? Short answer, it is everyone's job! You see, if the basic playing field is even with most quality facilities, you use skilled Technicians, you use the best parts and you all have good to great warranties, the difference between you is, "The Customer Experience"! And a great customer experience starts with a thorough vehicle inspection! A thorough inspection on every car, every time a vehicle comes in is the cornerstone of making the best customer experience possible. This sometimes requires an extremely skilled Service Advisor, because not every customer always understands the benefits of a good inspection, but that is another article some other time. So, if this is such an important part of the process, make sure your service advisor assigns you an inspection task, every time!

Utilize as much of today's technology as possible, like; Electronic Inspection forms (when available), TSB's (Technical Service Bulletins) and SSM's (Special Service Message's) to build value in the inspections AND save you time (money).

Many repair facilities are using some form of an electronic inspection process that has given them the capability to take not only have a more thorough inspection process but to also be able to take photos and videos of the client's repair needs. That is one more tool you have to sell more hours on more jobs, resulting in a higher ARO than ever before. Your customers love feeling like they are involved with the repair process of their vehicles more today than ever before because technology has come so far! And for those clients that may sometimes doubt us, we now have proof in the form of pictures or video's, they can see it for themselves, its staring at them on their screen. This will also save the Advisor time, because they now have the proof that the repair (whatever it maybe) "needs" to be done making it easier for them to sell without getting up going out to the shop to look. If the advisor is convinced it's almost a guaranteed sale, which leads me to my final topic.

Have you ever heard of the 4-C's? If not, let me briefly explain. The first "C" is:

- Concern or Complaint—the customer's concern or complaint. The Service Advisor is responsible for gathering this information from the client.
- The other 3 C's are up to you as a Technician and if you do a good job of documenting them your advisor is more likely to sell what you are recommending:
  - Cause—what caused this initial issue
  - Correction—what we are recommending for the repair
  - Confirmation—What you did to confirm the correction

When it comes to making an upsell, we coach our Service Advisors to break down the needed repair(s) or recommended service(s) to the client by explaining to them: what caused the complaint, the correction and why it matters, as well as what will happen if the client does not repair or maintain it, and how we verified the issue was corrected. It is your job, as a technician to help the Advisors with every step in that process!! ■

Written by Rena Rennebohm of the Automotive Coaching and Training (ACT) Group!

If you have any questions or comments on this or any of our articles please contact, The ACT Group at 916-588-0775, we would be happy to get back to you ASAP!

WANT TO HOOK UP? DICK MILLER'S YOUR GUY...

-Glenn Quagmire

No, he doesn't run a dating service, but he sure can help drag racers off the line...

Most drag racers will agree that the most critical second in a run is the very first one. Reaction times show up at every position on the strip, including the very last one at the trap. But even after your diligence in minimizing reaction times, the very next event is your launch, which can easily determine whether you make the podium or not.

As Performance Technician has documented, there are a host of modern-day hot rodders who have specialized in various parts and systems, like gaskets, induction systems, and exhaust systems. And Dick Miller is one of them.

Like so many current-day hot rodding wizards, Dick started racing while still in his teens, first in a '56 Oldsmobile he "borrowed" from his father, and then a '57 Olds that disappeared from his father's garage on weekends. Sadly Dick managed to total both cars, and suffered the wrath of his father in the process. But despite these two "oops" moments, Dick's father encouraged him to pursue his interest in drag racing.

As a result, Dick went on to compete with both NHRA and IHRA, laying down ET's as low as 8.5 seconds at 159 miles per hour, and has been awarded the prestigious Walley award from both organizations. Dick was a champion in local, state, and national events, and is a former national record holder.

Dick Miller always built his own cars and engines. But his passion was always under the car, where suspension design determines launch, and launch determines the outcome of a race.

ONCE UPON AN OLDS...

As it is with most aspiring racers, the early days typically generate negative cash flow, as parts are replaced and upgraded, blown engines rebuilt or replaced, plus entry fees, race gas, and a host of other expenses. As a result Dick started out as an apprentice meatcutter and then as a purchasing agent for an auto parts company while attending a computer programming institute where he honed his digital skills. These would prove particularly helpful in his ultimate career as a drag racing chassis systems wizard. He subsequently founded a software company, which he left in 1992 to establish Dick Miller Racing, Inc. But he continues to use his software development skills in writing all of the software for his product development and web site.

Dick has always had a passion for Oldsmobiles, a love he clearly inherited from his Dad. He has owned and raced a 1970 Cutlass W-31 as well as a 1970 442, a 1974 Omega, and a custom-built 1991 tube chassis Cutlass of his own design.

After selling a variety of racing parts in the first few years of his racing business, in 1995 Dick decided to begin selling the rear bolt-on 4-link adjustable suspension system that had contributed to his many racing wins. Over the years he had perfected this system for optimal performance, while being the strongest, lightest, and most adjustable system on the market. Originally developed for his Cutlass, he offered variations that would fit other GM cars using similar suspension setups, like Chevelle, Buick GS, GTO, Camaro, and Firebird. And a companion system was designed and offered for the very popular Ford Mustang.

In the ensuing years, Dick has expanded his business into all things drag racing, including suspension system parts for rear wheel drive GM, Ford, and Chrysler cars as well as custom engine building.

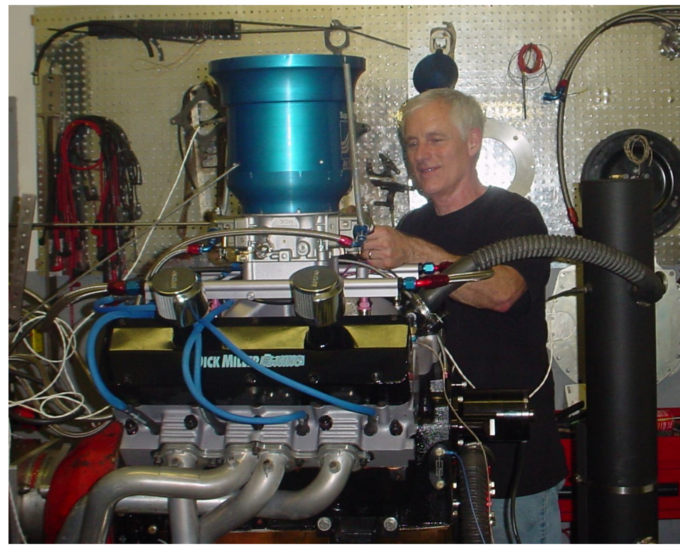
HE LITERALLY WROTE THE BOOK...

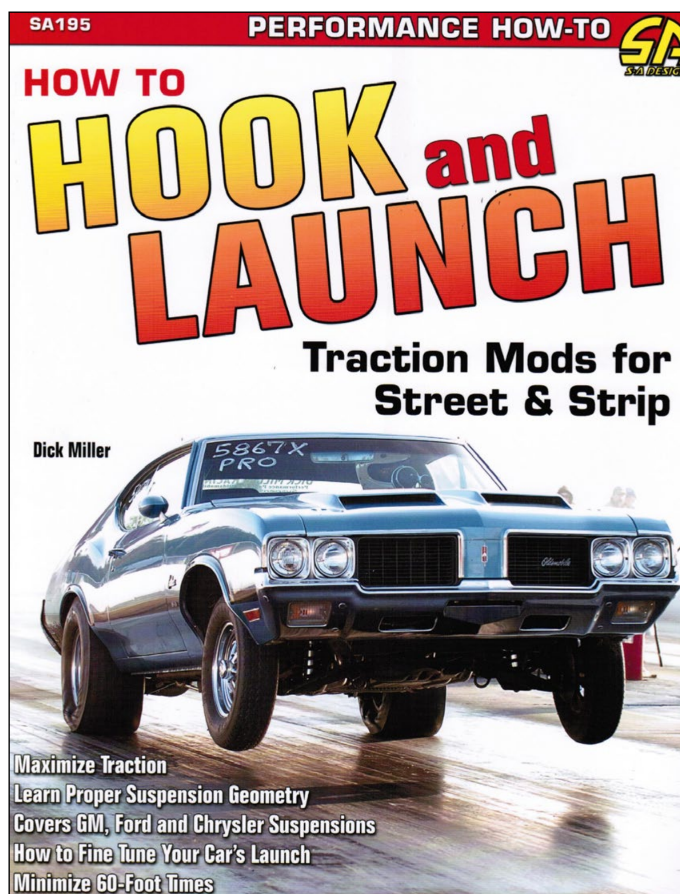
A crowning achievement on his racing career was Dick's recent publication of a tell-all book titled, "How to Hook and Launch," a compendium of all that he has learned and developed over some 40 years of chassis systems innovation for drag racing. At more than 125 pages, this fact-filled book details chassis development and tuning, as well as driving techniques and even tips for critical analysis of individual runs.

It is worth noting that this book is not a sales pitch for the products he makes and sells. Rather, it explains, in extraordinary detail, exactly how chassis and suspension systems work during launch, and steps to be taken to optimize them. Topics covered include:

- Suspension basics and drag racing dynamics
- Rear suspension systems, including those with leaf springs, coil springs, or coil springs and four-link.
- Front suspension systems, covering those with double A-arm, single A-arm, straight axles, and torsion bars.

Other chapters cover tire selection, mounting, pressures, and care; the fine points of pinion angles, chassis pre-load and offset axle housings; burnouts; video critique and data records; ignition systems and rpm limiters; and transmission brakes and shifting techniques.



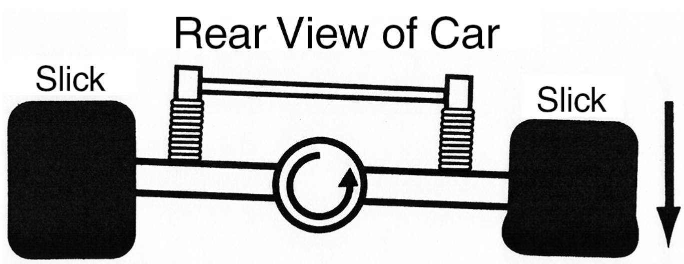


FASCINATING FACTS...

Here are some selected examples of the kind of information to be gleaned from a close reading of Miller's book.

> Engine torque through the drive shaft tries to twist the rear axle down onto the right rear tire. This squatting effectively makes the right rear tire shorter in height, and therefore smaller in diameter. The result is that the left rear tire, being effectively taller and greater in diameter, tries to make the car turn right upon acceleration. Pre-loading the car's suspension can correct this condition.

> A car that lifts in the rear on launch pushes down on the rear tires, increasing traction. This can be increased by moving the front mounting point of rear wheel leaf springs closer to the rear axle. However moving this mounting point too close to the axle can cause wheel spin or tire shake.

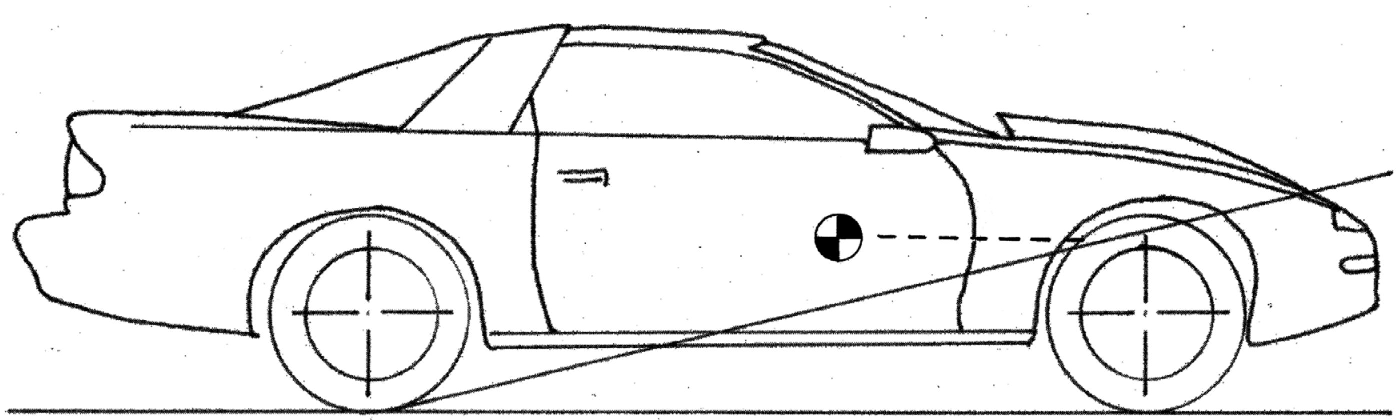


Looking from the rear of the car, the rotation of the drive shaft and differential pinion gear loads the two rear tires differently. Thus the need for pre-load in the car's suspension.

> The height, in the chassis, of the front mount of the leaf spring, also helps determine whether the rear suspension rises or squats on launch. If the mount is above the neutral line, the chassis lifts in the rear. If the mount is below the neutral line, the chassis squats in the rear.

> A wheelstand does not necessarily result in lower ET's. Actually, a wheelstand that puts the front wheels up to about a foot high is acceptable, since the front end of the car is moving up and forward at the same time. Any more lift than that means that vehicle weight is starting to move rearward, which will reduce ET's.

> Cars that are used exclusively for drag racing can benefit from optimizing camber and toe settings. Ideally camber and toe should be zero during a pass down the drag strip. Photos or videos of the car during a pass can be very helpful. Images of the car taken from the side under full acceleration and near the finish line can show the car's attitude. Then, the attitude can be replicated in the shop, with camber and toe adjustments made to zero.



In cars using a torque tube, if the intersection point of the torque tube and rear lower control arms is above the neutral line, the car raises while launching. This plants the rear tires harder.

> Rear tire diameter is directly related to maximum engine rpm. Rear tire size should be determined by the maximum engine speed the engine is expected to achieve through the traps. There is a specific formula for this calculation: (Rear axle rato x mph x transmission output ratio x 336)/tire diameter. Consider a car running a 26-inch tall tire crossing the finish line at 120 mph using a 4.56 rear axle ratio and a transmission with an output ratio of 1:1. Run the numbers and you should be seeing engine speed of 7,071 at the finish line. Varying the differential ratio or rear tire diameter can help fine-tune a car for optimal maximum engine speed.

> Differential pinion angle can affect launch. Too little pinion angle reduces the car's ability to hook up. Too much pinion angle and the car will hook, but at the expense of horsepower. However pinion angle affects other vehicle parameters. Optimizing pinion angle will cause the front of the car to lift. If the car squats in the rear, it will squat more. As a result, shock absorber settings will likely have to be changed. To be clear, the term pinion angle refers only to the included angle between the differential pinion and the driveshaft; it has nothing to do with the orientation of the transmission nor to the ground (true horizontal). It refers only to the angle between the pinion and the drivshaft. During acceleration, engine power tries to make this angle to be zero, so that the driveshaft and pinion are perfectly in line and the power is being used as a lever to push down on the tires.

> 60-foot times can be very revealing. Typically a variation in 60-foot times will translate into 2-3 times as much difference

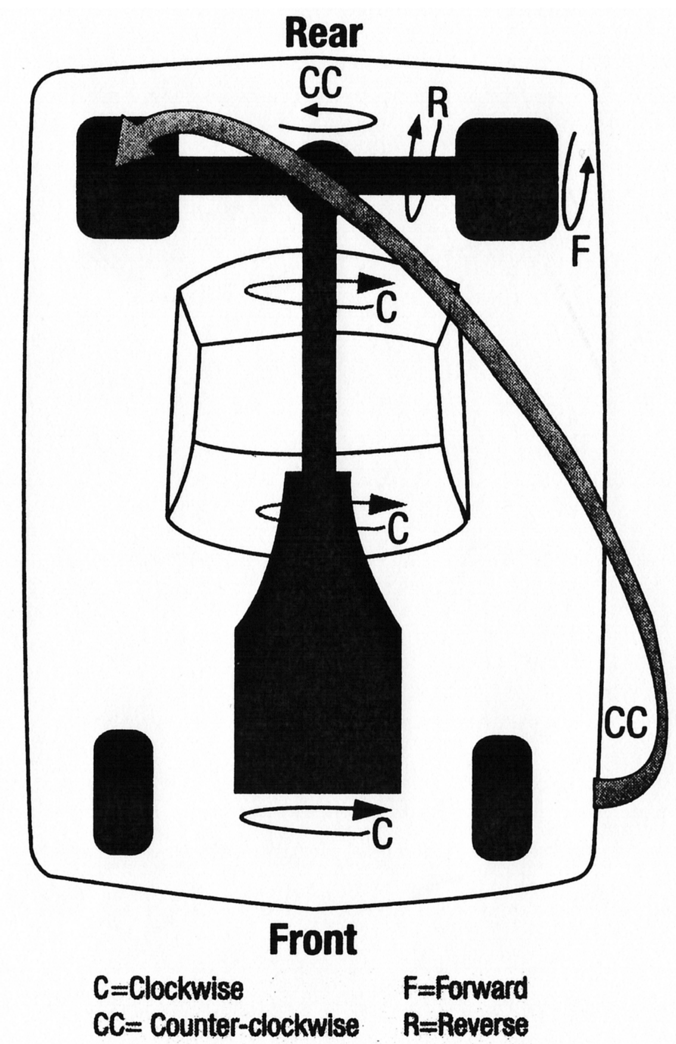
This car could benefit from proper chassis tuning. The height of the wheelstand actually serves to move the front of the car rearward rather than forward. And the fact that the driver's side is much higher than the passenger's side means that the car could benefit from the installation of a properly-designed anti-roll bar.

No-hop bars, like these designed by Dick Miller, can make a big difference in how a car launches. Bars that are too tall can re-locate the imaginary intersection point of the upper and lower rear control arms too far rearward. These shorter bars work well on cars up to about a thousand horsepower.

in the overall ET. So consistency is the key. Variations in 60-foot times of as little as 0.02-0.03 seconds call for corrective action.

As you can see, there is a tremendous amount of science that goes into leaving the starting line as quickly and efficiently as possible. And Dick Miller has perfected that science. He's been nice enough to package up much of what he's learned into a book available to all.

Next step? Getting his wife into the drag racing record books... ■



Engine torque generates a twisting in the entire body and chassis, generally lifting the driver's side front wheel as much as a foot higher than the passenger side front wheel. Proper chassis tuning can prevent this.

MPH	1/4 ET	DIFF	1/8 ET	DIFF	60'
92.80	14.00	5.00	9.00	7.15	1.85
94.80	13.75	4.92	8.83	7.01	1.82
96.70	13.50	4.84	8.66	6.87	1.79
98.70	13.25	4.76	8.49	6.73	1.76
100.40	13.00	4.68	8.32	6.59	1.73
102.30	12.75	4.60	8.15	6.45	1.70
104.20	12.50	4.52	7.98	6.31	1.67
106.80	12.25	4.44	7.81	6.17	1.64
109.50	12.00	4.36	7.64	6.03	1.61
112.20	11.75	4.28	7.47	5.89	1.58
115.00	11.50	4.20	7.30	5.75	1.55
118.00	11.25	4.11	7.14	5.62	1.52
121.00	11.00	4.02	6.98	5.49	1.49
123.50	10.75	3.94	6.81	5.35	1.46
126.00	10.50	3.85	6.65	5.22	1.43
130.20	10.25	3.76	6.49	5.09	1.40
134.50	10.00	3.67	6.33	4.96	1.37
138.10	9.75	3.58	6.17	4.83	1.34
141.60	9.50	3.49	6.01	4.70	1.31
146.80	9.25	3.40	5.85	4.57	1.28
151.20	9.00	3.31	5.69	4.44	1.25
156.00	8.75	3.22	5.53	4.31	1.22
160.80	8.50	3.13	5.37	4.18	1.19
165.60	8.25	3.04	5.21	4.05	1.16
170.40	8.00	2.95	5.05	3.92	1.13
176.40	7.75	2.85	4.90	3.80	1.10
182.40	7.50	2.76	4.74	3.67	1.07
188.70	7.25	2.66	4.59	3.55	1.04
195.10	7.00	2.57	4.43	3.42	1.01
203.70	6.75	2.48	4.27	3.29	0.98
212.30	6.50	2.38	4.12	3.17	0.95
220.90	6.25	2.29	3.96	3.04	0.92
230.00	6.00	2.19	3.81	2.92	0.89
243.70	5.75	2.11	3.66	2.80	0.86
257.40	5.50	2.01	3.49	2.66	0.83

You can use this 60-foot chart as a guide by using your typical ET, then looking for the corresponding 60-foot time. If your 60-foot time is significantly greater than that shown in the chart, then you need to work on getting your car to launch better.

INFORMATION STATION

TRANSMISSION SERVICE KIT FOR AUDI/VW

CRP Automotive has introduced the Pentosin FFL2 Transmission Service Kit. The kit is designed for the required 40K mile service call on the new generation of Audi/Volkswagen (AVW) double clutch gear transmissions (DSG). The kit makes the service easier and more convenient for shops. It includes the precise amount of Pentosin FFL2 Transmission Fluid in a 5L bottle, along with a Rein Automotive OE filter and drain plug washer. For more information, visit pentosin.net.

NEW ENDUROVISION LINE OF WIPER BLADES

DENSO has launched EnduroVision, a new line of conventional wiper blades competitively priced to meet the needs of the vast majority of cars and light trucks on the road today. Available in 12 to 28 inches, the blades have a durable steel frame with stainless steel backing to ensure reliable, long-lasting performance. A powder coating protects the frame from ultra-violet rays and corrosion, and steel brackets provide uniform pressure across the windshield to prevent chattering. Universal connectors are available with 9x3 and 9x4 hooks, 3/16- and 1/4-inch pins, and 7mm bayonets. For more information, go to densoautoparts.com.

NEW GENERATION 90MM LED MODULES

HELLA has just expanded their 90mm LED module series with the introduction of the L4060 LED series in low beam, high beam, and fog light modules. The design of the modules is very compact and allows up to three light functions in one module without the need for additional electronics. The modules are suitable for universal application on a wide range of both OE and aftermarket vehicles. The ultralight, chip-resistant, 40x60mm polycarbonate lenses and die-cast aluminum housings make the modules extremely resistant to stress and wear. The modules feature an extremely low power consumption of 20W. The SAE/DOT approved series is rated for

operation in 12V and 24V vehicle electrical systems and incorporate integrated driver electronics, so they can directly replace 90mm halogen modules. For more information, visit hellausa.com.

BED COVERS FOR 2016 NISSAN TITAN XD PICKUP

A.R.E. Accessories offers two pickup bed covers for the 2016 Nissan Titan XD crew cab short bed pickup: the Z Series truck cap and the LSII tonneau cover. The Z Series cap comes standard with a frameless compound curve rear door with OEM-quality integrated palm handle and vent screen side windows. Optional equipment includes tilt down or sliding front windows, a Yakima roof rack and remote keyless entry.

The LSII Series tonneau cover is equipped with a Lift Assist System; supportive gas struts that make it easy to open and close. Underneath the reinforced roof, the cover features a gray carpet-like lining. Optional equipment includes LED rope lighting, a sport wing, a sport wing with brake light, a 12V power strip, interior clothes rod and a remote keyless entry system. They are painted to match the owner's truck using the exact OEM paint code for a high-quality appearance and are backed by a limited lifetime warranty for the life of the original truck it is installed on. Visit 4are.com or call 330-830-7800 for additional details.

VERSATILE AUXILIARY HEATER

Maradyne offers the Santa Fe, a new auxiliary heater designed to provide hot rods and older vehicles with efficient heat and versatile mounting options. The compact, rugged 12-volt heater features adjustable airflow louvers and a built-in two-speed fan control switch. Capable of producing 13,200 BTUs per hour with a 6.0 amp draw, the internally-grounded, heavy-duty motor is housed in a durable, glass-filled nylon case. Measuring 7 3/8 in. wide by 7 1/4 in. deep and 9 7/8 in. high, the heater can be easily installed on the floor using included mounting hardware. For under-dash installation, an optional mounting bracket is available. To use for windshield defrosting, optional louver or defrost kits are sold separately. To learn more, visit maradyneHP.com.

FINISH LINE

-Greg McConiga, Executive Technical Editor

WANDERING FULMINATIONS ON HIGH-PERFORMANCE

HELLO, MISTER CYNICAL HERE AGAIN...

SEMA, the EPA and our hobby; Your federal tax dollars at work, destroying a 36 billion dollar industry and attempting to make the car culture in America something only our grandfathers remember.

We have become so politically correct that we are now politically crippled. We have been cheated, lied to and bamboozled by entities that we ought to be able to trust, but can't because money is involved and there is nothing that exposes mankind's frailty like the love of money. If we complain about the results we see then we are hung on the cross of we aren't "empathetic", "caring" or "concerned" or "environmentally aware"… or worse yet, we're some form of biased that can't be clearly defined. It's an invective hurled to put you off balance, a negative that can't be disproved. Today it isn't the other person's bad behavior that's the problem; the problem is that you NOTICED their bad behavior!

Here's the question of the day for you; given that we all ride the rock together, if we export our brownfields and pollution to the other side of the world… if we allow another country to pollute their little bit of paradise to the point where taking a deep breath in some cities in the Far East will chip your teeth; if we have zero control over their business model and they can pollute an area the size of Utah wholesale to the point where bulldozing it and burying it is the only solution, then how does that really effect "emissions?" Oh! Wait!! In NET terms, it's actually worse!

Let's face it, we are held hostage. They hold enough of our IOU's now that we're 19 trillion in debt that they can do whatever they choose and we can't say or do anything (you don't suppose that's what drives some of our trade agreements do you? Maybe our leaders have a figurative gun to their head….?)

If you haven't followed the news on this, here's the deal. The EPA, an arm of our friendly, benevolent and efficient government, is rewriting the language that defines non-road, heavy duty and competition vehicles and that language is "subject to interpretation." The way it's written at present, it allows the EPA to exercise control over any vehicle originally emission equipped that has been converted to racing use and allows fines in the tens of thousands of dollars per vehicle or per non-compliant part installed. EPA says it's always been that way and they've just ignored the small numbers of cars that were modified and went after bigger fish to fry (read: people with more money to confiscate with fines, also known as an uncontrolled tax.) But we've never been 19 trillion (and counting) in debt before, have we? Never needed to generate the vast volumes of vote-buying cash needed today… and while the owner of the modified car can only come up with a few bucks (if that… he's a racer, remember? He's broke most of the time buying race car parts…) the companies that MAKE the offending parts (all clearly labeled "NOT legal for street use") must have some spare change laying around, because they constitute a 36 billion dollar a year industry in this country! Let's go rob them! Let's drive them out of the country… along with steel, heavy industry, manufacturing and the wellspring of innovation they bring. Let's send every last industry we can over the pond into the waiting and loving arms of people who don't care a whit about air pollution or "climate change" or quality or safety. Yeah. Good plan.

Race tracks all over the country are struggling with reduced attendance, increase liability and fewer participants. Kids are driving appliances with tires on them and no one sings along to "409" blaring from the radio at ten decibels below the threshold of pain anymore… we can hardly afford one more attack. Let's strip every vestige of American design, independence, pride and culture from yet another industry. Let's all hang our heads in shame because we're Americans… resourceful, determined and innovative.

We have people in this country using the government as their personal wrecking ball. They tool up, spool up, put their cause on a 24/7 news cycle and somehow convince us that we are the problem. Then the low information voters support some knucklehead with some knuckleheaded idea and we lose another freedom… a death by a thousand cuts. We manage every exception and ignore every rule in an effort to wrap us in a cocoon of perfect outcomes… insulated from the vagaries and harshness of life.

It's government incrementalism at its finest, the slow creep that takes us generation by generation. We don't move, think or act as individuals… we think and act as the collective… the hive. Where we used to be proudly independent, now we celebrate our co-dependency. Where we used to hold our heads high and make do with what we had or could create or barter for now we hold our hands out, beg for leftovers and suffer the indignity of barely being sustained by a government that demands to be acknowledged for its contribution to our miserable and marginal existence. Where we once strived and thrived now we barely survive.

We are ashamed that we once took all that circumstances and the land could provide, as though that's not our rightful place as an industrious and free people on a constant search to find new and better ways to sustain ourselves, our families and, in the case of a business owner, our employees.

Here's what I know; government is good at killing people and breaking stuff and finding a way to steal more money from working people. It's not efficient, cost effective or responsive. It finds or creates corruption every time it's deployed, it's more expensive that it would be if it was run like a business and it is unreasonable, arbitrary and inflexible in its application of rules. It is exactly what you'd expect anything to be that exists to guarantee its own expansion and continuation. It's created and run by flawed people whose primary focus is their own self-interest. It IS fallible and it is fallible on a catastrophic scale. If you doubt this, you need to spend two hours researching the last 100 years of world conflict to see just how badly governments perform for their citizens, on average.

Using the government to impose your will on others is like using a howitzer to kill flies… the fly dies but the collateral damage is worse than the pest you got rid of. I know there's some true believers out there… people who think that the government cares about them. And it does… in much the same way a farm family cares about their chickens, milk cows and pigs; you are a resource to be managed and ultimately consumed.

If you think that anyone in power really cares about you, Mr. Cynical says you've lost your mind. The calculus here is "are there enough motorsports enthusiasts out there to present a powerful enough voting block to threaten our re-election if we decide to raid and destroy the motorsports manufacturing companies?"

So let's make a little noise. Go to the website below and register your displeasure and the folks at SEMA will make sure your voice is heard. Just once let's try to keep the mindless drones at bay and our freedom to enjoy our sport intact.

While you're at it, go out and buy from the good guys… the innovators… the guys making the good parts in this country. So what if it costs a few bucks more? If you're living that close to the bone you're in the wrong sport. I don't buy or use cheap crap because what I've discovered is this: when I buy cheap stuff I'm only happy the day I pay for it because every day thereafter I'm mad because it won't work or I have to keep patching it up. If I buy good stuff I'm only mad the day I buy it because every day after that it works and I don't have to keep fooling with it. Which is more valuable? Heartbeats or money? You can always get more money, but heartbeats…? Not so much. Think about it. ■

sema.org/news/2016/02/08/epa-seeks-to-prohibit-conversion-of-vehicles-into-racecars


From the shop floor to the corporate office,
we have a career path for you.
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