December 2013
V1 N3

HOT ROD PROFESSIONAL

Tools, Part 2

Turbochargers, Part 2

Vapor Lock

HP Brake Calipers

Valve Springs

Performance Enhancement Knowledge for Service Technicians

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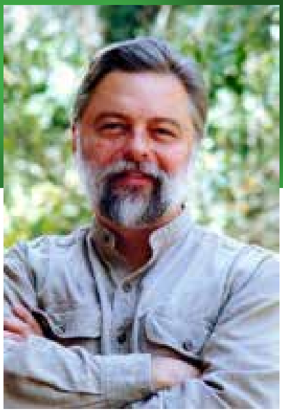
Starting Line

by Bob Freudenberger



A Very Short History of Hot Rodding

When I was a boy, two of my favorite magazines were HOT ROD and Car Craft. Of course, with the wherewithal of a typical farm kid, all I could do was dream about the cars I'd like to build (not own -- there's a difference), but they were pleasant fantasies through which I learned quite a bit about how engines work and how they were modified.

Many years later after stints as a Ford dealership mechanic and an associate on the Motor's Manuals, I became the editor of Speed Shop Magazine (100K circulation through -- you guessed it -- speed shops). One of my main memories of that sojourn was being driven around the NHRA Summer Nationals in a golf cart by Linda Vaughn ("Miss Hurst") while I took photos of notables such as Don Garlits and Grumpy Jenkins.

Other recollections of that era revolve around how cheaply you could dramatically improve the performance of '60s and '70s domestics. You could bolt a "Duntov" 350-horse cam into a 250/327 for maybe 25 bucks, and just hundreds spent on a high-rise, big Holley, solid-lifter cam, and headers could put a 428 Cobra Jet solidly into the 12s.

About that time, a friend found his dad's collection of Car Crafts from the 1950s, which he gave me. What a trip! All those souped-up Ford flathead, Olds, Cadillac, and Lincoln V8s, not to mention Chrysler Hemis, powering everything from mean-looking gassers to street rods, lakesters, and "slingshot" rails, really got my imagination churning. The colorful terminology of the era included three-quarter cams, chopped and channeled, three deuces, stroked and bored, welded spiders, adjustables (lifters for flatheads), ported and relieved, and planed heads. Since stock motors were mostly stodgy during that decade (with a few incredible exceptions, such as the blown '57 T-Bird 312), there was tremendous potential for increasing horsepower, even on a tight budget.

I'd thought of that as the beginnings of the uniquely-American hobby of hot rodding, but I was way off. After becoming the tech editor, then editorial director, of Motor Service magazine (R.I.P.), I discovered a copy of the premier issue from September, 1921 in the archives. In it was an article entitled "I Make 'Em Jazz," illustrated with a clever stick drawing of one Model T eating the dust of another as they were racing up a hill. It seems that the writer owned a shop that specialized in "regrinding" those heavy iron fours, and installing racing pistons and rings. It was a successful business with many repeat customers. From elderly people I talked to then, I'm speculating that bootlegging during Prohibition had a lot to do with the desire to get more power out of stock engines -- outrunning "revenooers" was a financial imperative.

Of course, NASCAR's beginnings had some of the same incentives. The prospect of making profitable "moonshine" runs prompted mostly southern hill-country boys to figure out how to make a car go fast and still hold together. Some of them got so good at it they went into the business of building legitimate race cars rather than "tanker" hot rods.

Where did the term "hot rod" come from, anyway? One etymological theory for its source holds that a "rod" was a nickname for a camshaft, while another says it came from "hot roadster." Regardless, it probably became current after WWII when returning vets with a little extra money and lots of skills started having fun modifying cars.

Now, of course, the business of wringing more power out of factory iron (aluminum?) is another whole smoke. We've actually become scientific about it, the parts and equipment involved are seriously high-tech, and spending $20K on an engine is nothing unusual. Yes, I feel nostalgia for the low-bucks old days, but I'm also very impressed by how far we've come.

Boosting Horsepower with Turbochargers, Part 2

by Greg McConiga

Last time, we covered history, operating principles, and design fundamentals. Now, for failures, diagnostics, and replacement alternatives

Let's start by putting detonation into perspective: It's the biggest problem with the high cylinder pressures that turbocharging can produce. Charge air coolers, proper compression ratios, proper turbo sizing and waste gate settings, engine temperature and fuel control, timing rates, quality fuels and tight oil control all help stave off these explosions.

Sub or supersonic

While we're on the topic, detonation is NOT and never has been colliding flame fronts. Flame fronts do not make noise when they hit. You can collide flame fronts all day long and never enter detonation. Ford twin-plug 2.3 and Nissan Nap-Z engines intentionally created two flame fronts, as have innumerable aircraft, racing and specialty engines. Normal combustion proceeds at subsonic speeds and spreads by thermal conductivity. Detonation is supersonic and spreads by shock compression. Subsonic and supersonic: propagated by heat, propagated by shock; that's the difference. Detonation occurs when the cylinder pressure and temperature cause the last bit of unburned fuel in the cylinder – called "end gases" – to spontaneously explode in uncontrolled combustion. Normally, a flame front rolls or proceeds through the air-fuel mixture in a few thousandths of a second – depending on air-fuel ratio and cylinder design it varies between .001 and .004 seconds – but the explosion of detonation occurs so quickly it's measured in microseconds – literally thousands of times faster than a normal combustion process.

Opposite Page: If you spin it too fast, it comes apart! Now you know what a burst wheel failure looks like.

Detonation exists in three phases: Inaudible (can't even hear it over normal engine sounds), audible (the BBs or marbles-in-a-can sound we're all familiar with), and hard detonation, which sounds like a really bad rod knock or someone with a big ball-peen under the hood. Trust me, you'll know it if you hear it, and you won't hear it long before you end up walking! In over thirty years I've only seen it a couple of times in a street vehicle, and in both cases it was too late. Depending on severity, detonation unseats rings, anneals parts, turns valves inside-out, sets up violent ringing vibrations in the assembly, breaks rings, cracks heads and blocks, destroys head gaskets, fractures piston tops and pounds the tar out of the reciprocating assembly.

Diagnosing a tornado

Diagnosing detonation is easy -- the damage is so pervasive it's like diagnosing a tornado. On a teardown, the piston top will be clean and appear almost sandblasted. The land above the upper ring may be beaten down and the second ring pinched. In a lot of cases, the piston will be burned down the side or have a hole burned through the dome. The upper half of the rod bearings and the lower half of the mains will show signs of fretting or damage. Piston pins may be stuck or sticky, rods twisted or cracked and crankshafts fractured. On spark plugs, you'll see clean, almost sand-blasted appearing porcelain and under magnification you'll see tiny blue-black balls of molten aluminum stuck to the insulator. In loud high-performance engines, you'll feel it before you hear it, and if it's hard detonation you can't lift fast enough to keep from tearing something up.

For causes, think lean (less evaporative cooling during the gas exchange cycle), insufficient octane (the numerical measure of a fuel's ability to withstand detonation), secondary ignition sources and over-advanced timing (lights the mixture early, and pressure builds while the piston is still trying to rise in the bore), too much compression or boost (or any other cause of high cylinder pressures), cam timing and profiles (early or late intake closing affects cylinder pressure) and overheating, either generally or locally (heat is pressure in a closed system.)

Brave new world

Growing population aside, there are a lot of things looming on the horizon. Like all old technologies that grew into modern applications, turbocharging is evolving. The improved efficiencies of variable nozzle turbines, wastegate elimination and ball bearing center housing rotating assemblies are just the start. Compressor and turbine wheel shapes are evolving, housing designs with multiple flow paths are on the market, and lighter titanium wheels and machined-from-solid parts are just entering the world of automotive turbocharging (you'll recognize the titanium compressors – they will have cast iron compressor housings instead of alloy to meet burst wheel containment requirements -- think a scattershield for 20 times the rpm of an engine).

Even wheel-to-shaft attachment methods are changing. The oldest design bore is smooth, with no threads in the wheel, retained on the shaft by a nut.

The treaded bore is just that; the wheel bore is threaded and screws right onto the shaft.

New compressor and turbine wheels are not through-bored. On this "boreless" wheel, a partial bore-through is threaded, and the wheel threads directly onto the shaft.

The latest wheels are boreless; they are bored and threaded part way through the wheel to eliminate the stress risers that emanate from a through-bored wheel face, which is a good thing at 100,000 rpm. Expect to see even more advances in gas and air flow control, and more improved oil control, better cooling, and reduced turbo lag.

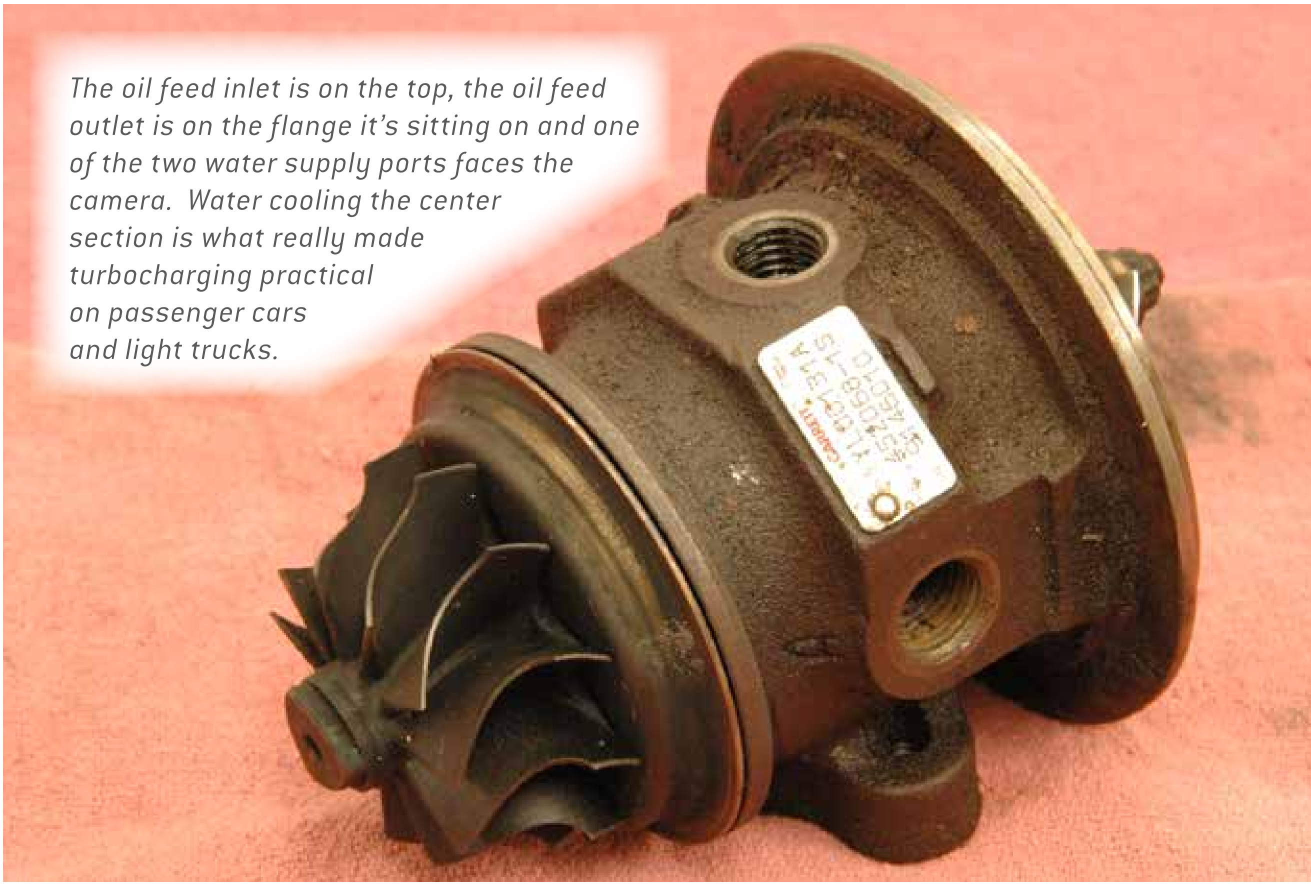
Diagnosis and repeat failure prevention

Given good fuel control and normal exhaust temperatures, clean, properly maintained and undiluted engine oil, water-cooled center housings, properly maintained air filtration and just a few precautions on the part of the owner, a turbocharger will last the life of the car. If these conditions aren't met, there will be a failure, and if there is a failure there is very often little left to rebuild, especially in the event of foreign object damage (FOD), or lack of lubrication, the two most common turbo disasters. This is one reason that more and more rebuilding is moving to the manufacturers. Shafts, housings, wheels and bearings are often completely destroyed, making field rebuilding financially impractical.

Before grabbing a fistful of tools and tearing something apart, stop, look and listen. Most people know what a turbo-equipped vehicle sounds like. There's that characteristic turbo sound, sort of a low pitched whistle that rises in pitch with engine speed. Take the time to road test the vehicle and see if you're hearing and feeling what you should be hearing and feeling. You might just uncover an exhaust or intake system leak by listening, or you might hear something whirring or screeching that ought to be silent. Plus, if you know what it did before you'll know that you fixed it when you do your final quality control road test.


Boreless compressor wheel. Note the compound curves and flow path from inducer to exducer.

Oil-related failures are usually due to some manufacturer's incredibly long recommended oil drain interval (What the hell are they thinking? Let's see... $30 oil change, or $2,000 turbo? Brains not necessary, apparently), or poor maintenance on the part of the owner. Turbos handle and retain a huge amount of heat, even after shutdown. You must use the correct oil type and viscosity. Many of these engines specify synthetic oils, so pay attention. After the oil change, never rev the

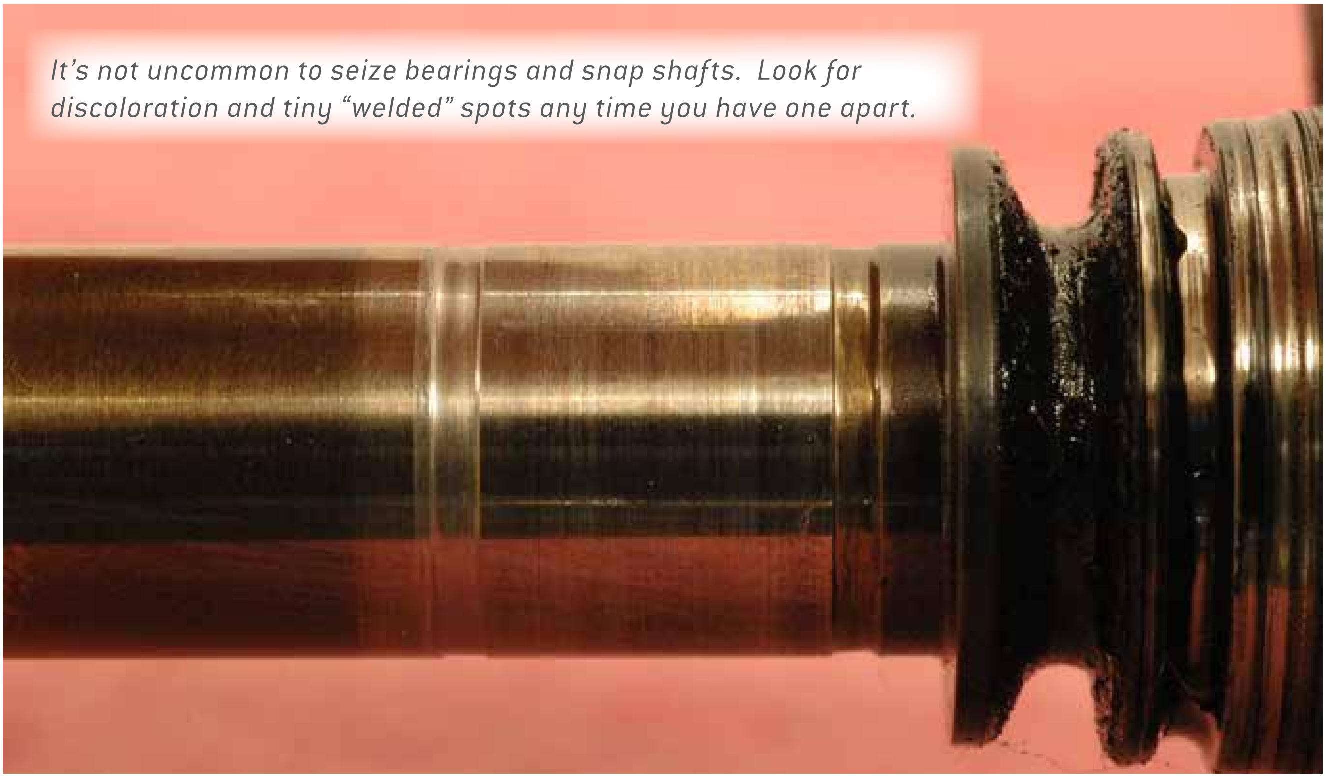


The oil feed inlet is on the top, the oil feed outlet is on the flange it's sitting on and one of the two water supply ports faces the camera. Water cooling the center section is what really made turbocharging practical on passenger cars and light trucks.

engine until oil pressure builds. If you don't get proper gauge movement, or the engine low-pressure oil light isn't out in 15 seconds, shut 'er down and investigate. Even at idle speeds it only takes about thirty seconds to damage the turbocharger bearings. If you rev the engine right after oil change, you might damage the bearings instantly. Don't do it! If you get a lubrication-related turbo failure and it's a water-cooled unit make sure the cooling supply in and out is unrestricted and that the cooling system is operating properly. It's also a good idea to replace the oil supply and return lines at the same time since there have been many instances of these lines coking shut with heat. I'd advise anybody with a turbocharged car to allow 30 seconds of idle time prior to each shutdown after a normal drive cycle. I know it's a pain, but those few seconds will extend turbo life and save money. I'd also advise that if they've been

Journal bearings are oil-fed plain bronze bearings.

out "whuppin' it up" to allow two or three minutes of cool-down time prior to securing the engine. It's a small price to pay.



It's not uncommon to seize bearings and snap shafts. Look for discoloration and tiny "welded" spots any time you have one apart.

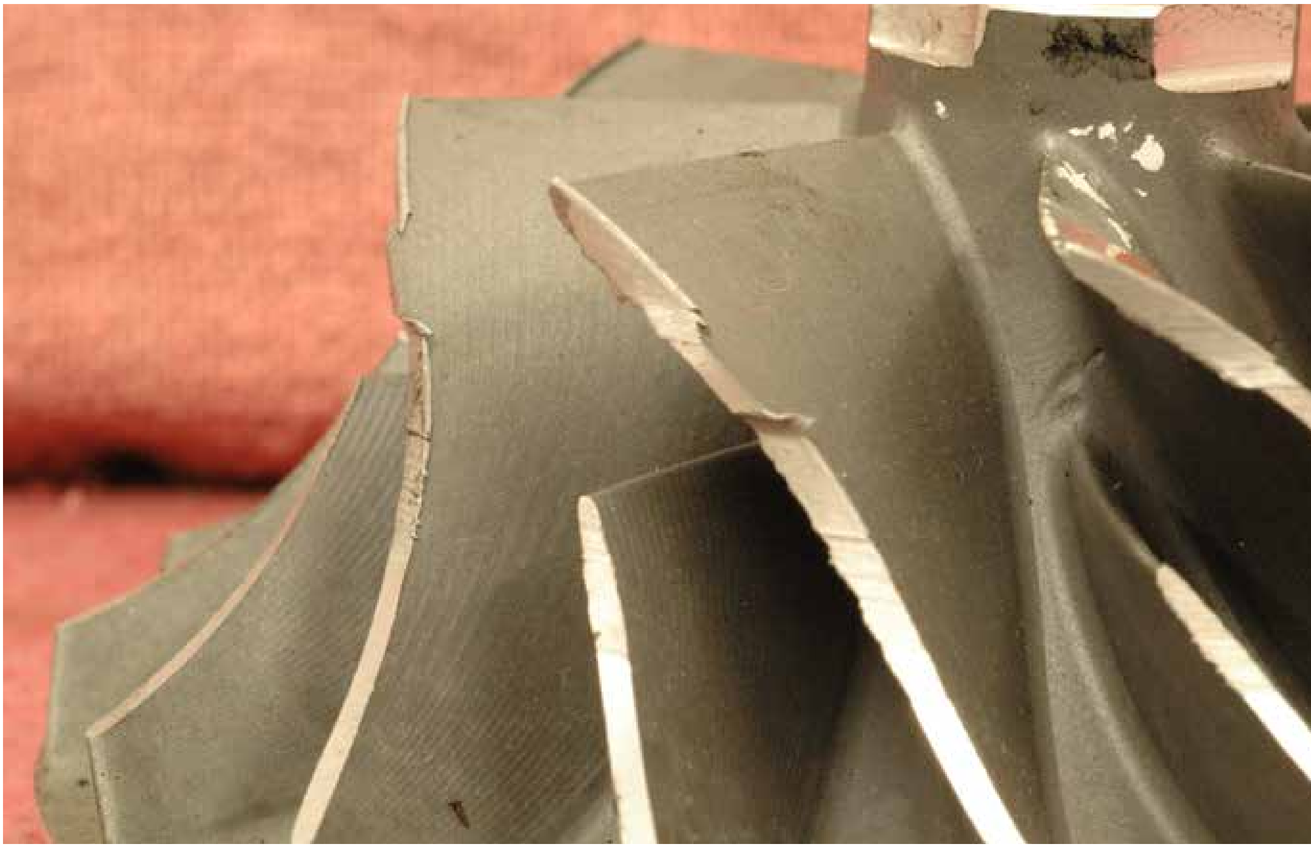
So, tell me what happens when the nut from the wheel comes off and gets sucked up into the compressor wheel? On car machining!

FOD

The second most common failure is foreign object damage (or FOD.) Make sure that during routine service all shop towels, nuts, bolts and wrenches are accounted for prior to startup. Foreign objects may be introduced by others, may fall off the turbo itself – like the nut holding the compressor wheel on the shaft – or in the case of a severely restricted air filter they may come from the inlet system. A restricted air filter could collapse and shred and become the source of all kinds of debris in the intake tract, and anything that touches either wheel guarantees instant shrapnel. There is no forgiveness if something is ingested into a wheel spinning at 50,000-125,000 rpm. If you have a FOD failure, you'll need to clean the inlet and charge air cooler to prevent a repeat. If there's any question about whether the charge air cooler got clean, replace it. On diesel engines, remember that whatever you used to clean the charge air cooler cannot be combustible unless you're willing to risk a runaway engine.

Weakling?

Low-power concerns are often assigned to the turbocharger immediately, but that's not always a good idea. First of all, see if there's a lot of detonation sensor activity. On late-model turbocharged vehicles, not only will



It doesn't take a lot to trim off the ends of the blades. Even opening up the relationship between wheel and housing a few thousands will dramatically change the pump efficiency.

timing be retarded, but boost may be shut off or limited. I'd certainly put a pressure gauge on the intake side, but don't forget to look at overheating, timing belt/cam timing issues, restricted exhaust systems, fuel pressure and volume and base timing, if adjustable. Don't step over the obvious to get to the obscure. Once the basics are covered, check waste gate operation. I don't have a dedicated tester for waste gates, but I do have a radiator pressure tester that I've adapted to check the pressure at which the waste gate starts to open. If that's good, and you're still not making boost, then you may find yourself pulling the turbo off to examine the wheels and shaft, which is not always a pleasant job.

If you have to pull the turbo, now's the time to check for oil in the intake manifold after the turbo, and the exhaust system ahead of the turbine and after. Even if you don't have oil consumption complaints, remember that most people don't check their oil and that catalytic converters may "eat" the oil smoke. Some turbos use a mechanical oil seal, some use a labyrinth seal and others rely on the high shaft speed combined with dams and diverters to sling the oil away from the area where the shaft passes through to the wheel. In most cases, oil consumption will be the result of shaft and bearing damage, which should also show up as rub marks on wheels and housings. If you find a compressor or turbine wheel coked or carboned up, it's okay to clean it, but never with any kind of metal object, including a wire brush. The slightest scoring on the wheel will create a stress riser that will lead to a burst wheel. Soft bristled brushes and solvent only, please.

Intercooled Regal

When we were putting this story together, we came across a review we did back in 1987 of the Buick Regal Grand National 3.8L V6 ("Last of the Brutal Buicks"), the first turbocharged car that had ever really impressed us. On a cool day with good gas and sticky tires, it could turn in the high 13s, yet we got 27 mpg on the highway. Part of that excellent performance was due to an intercooler, the operation of which we explained as follows:

Chiller

The addition of an air-to-air intercooler really pumped up this powerplant . . . A turbocharger, of course, compresses the intake stream, and that raises the temperature of the air. Add to this the heat radiated into it from all that warm metal, and you get a very steamy charge entering the cylinders, which tends to cause detonation. So, boost and timing have to be kept down considerably below their optimum levels.

Enter the intercooler -- actually just a radiator for air (this one flows 350 cfm). This substantially lowers the temperature of the intake stream, increasing its density while reducing the danger of pinging. Ergo, boost pressure can be increased (up to 13-14 psi can be tolerated), and the knock sensor-controlled electronic spark advance (ESA), which operates within a 30-degree range, allows plenty of ignition lead. The 12 lb. intercooler, by the way, is mounted low behind the radiator and has a continual flow of air drawn over its fins by a little plastic fan on the crank pulley.

-Bob Freudenberger

The gas/oil seal is a simple metal part resembling a piston ring.

Once removed, examine the compressor wheel, turbine wheel and their respective housings for signs of damage or rubbing. Using a bright light, take a careful look at the compressor wheel. It should not have a sandblasted or "softened edges" appearance. If it does, it may have been damaged by running without an air filter. Turn the turbo by hand. It should spin freely with no scraping or rubbing. Next, push in on one of the wheels and turn it by hand. Again, there should be no rubbing. Finally, push in on the other wheel and turn it by hand and check for rubbing. Any failure that changes the shape of the wheel or the contour bore renders the turbo useless.

One last failure to mention: overboost. If there is a waste gate or VNT system failure, you could end up with more intake pressure than the engine was designed to handle. In many cases, overboost is the result of an overzealous owner bolting on power-up parts to gain that extra edge when he and his buddies are out drag racing their three-quarter ton pickups in the country (Hey! I'm a Hoosier, remember? I never said I was sophisticated!) Okay, here's the story. I won't say who was involved in this, but I have intimate knowledge of a certain middle-aged fellow who once owned a GMC Syclone turbocharged pickup truck. Said middle-aged crazy individual expressed a need for more speed, and mysteriously an extra "tee" appeared in the wastegate line and said line was terminated with a carburetor jet as a calibrated air leak. Seems that the computer control system was smart enough to shut the fuel off in the event of gross overboost (and you haven't experienced something lying down hard until you hit fuel shut-off on a turbocharged engine that's building boost like an Atlas 5 launch vehicle – you'll leave teeth marks in the steering wheel), but not smart enough to detect, say, 2.5-3.0 psi of extra intake pressure.

After a good many fun Fridays nights laying waste to members of the local street-racing crowd, the truck appeared one day with a rather annoying ticking sound going on in the engine. On further investigation, it was determined that the noise was low, and seemed to be at crankshaft cadence. On teardown, we discovered that one connecting rod was twisted about 8-10 degrees, and shortened just enough for the pin boss to hit the counterweight of the crankshaft as the piston swung through bottom dead center. Now THAT is cutting it pretty close! Moral of the story? If you get complaints of sudden violent shut down, or if you see overboost occurring during your diagnosis, remember there may be some other clown like that (moi?) out there trying to get that extra little edge by modifying the boost map.

It's pretty obvious what we're doing here. If you open the gate, the exhaust gases bypass the turbine wheel, slowing shaft speed.

Finding replacments

Turbochargers aren't really that complicated. For the most part, they are no longer field-serviceable, and repairs are confined to replacement AND making sure that the root cause of failure is identified – nothing is worse than calling your supplier with a "defective part" only to find that the swarf from the last failure clobbered your new unit. In my case, I'd see our friends at Fort Wayne Diesel for remanufactured replacement turbos (and they have other locations; check the website below), but Googling "remanufactured turbocharger" brought up dozens of potential suppliers. Depending on the application and mileage, having a good reman supplier could save you and your customers a lot of time and money. The majority of remanufactured units out there are probably going to have a new center housing rotating assembly with used compressor and turbine housings around it, so service life should be good. Keep it oiled, keep it cooled, and keep debris out and you and everybody will be happy.

Special thanks to Pat Kiel of Fort Wayne Diesel (part of Diesel Injection Service Company - www.dieselusa.com/) for several hours of help. Pat donated three boxes of parts and pieces, new and used for my use over a weekend to get this story done.

I would also like to thank an extraordinarily professional group of people at Garrett Turbo (www.turbobygarrett.com), including Kyle Snyder and Craig Gibbs for sending us photos and answering some very technical questions on short notice. Check out their website for more technical information about turbocharging. If these guys don't know it, it isn't worth knowing!

A non-removable backplate rebuilt Holset turbocharger.

High-Performance Brake Basics: Calipers

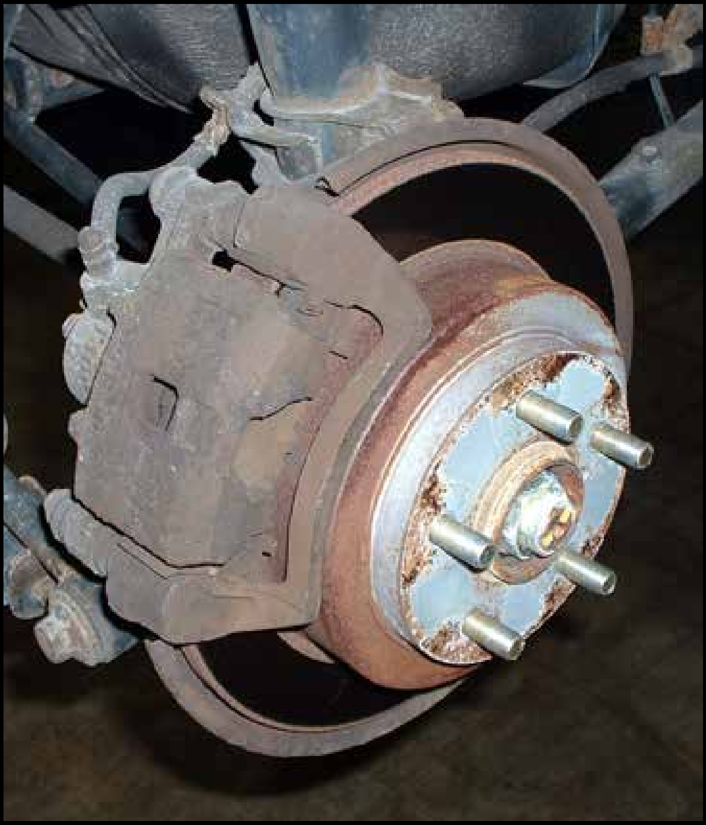
There's a whole lot of tech involved in high-performance brake systems, and here we'll start off our ongoing series on the subject with the parts that pinch the pads.

by Frank Walker and Bob Freudenberger

When it comes right down to it, stopping distance is limited by the adhesion of the tires, and unless you're driving a vintage vehicle the ABS is going to kick in whenever that's exceeded. All the stock brakes we know of are powerful enough to lock the wheels and induce this condition on dry pavement (we've always said one of the benefits of ABS is the avoidance of flat-spotting that expensive rubber during a panic stop).

The weakness of factory brake systems shows up during repeated heavy decel events in the form of the scary phenomenon known as "fade." You're apt to encounter it very quickly on a road course, or on a long, steep downhill run in the mountains, especially if you're towing a race car or a boat. We've experienced it to the point of simply not being able to come to a complete stop at all -- talk about white knuckles!

The main thing the installation of a "big brake kit," or of any wisely-chosen set of high-performance brake components, will give you is dependability during severe use. The combination of more leverage from bigger diameter rotors, powerful and even clamping force, better heat dissipation, and premium friction material formulas make for peace of mind. Enhanced pedal feel, mostly from the use of braided hoses, also inspires confidence.



This car isn't even that old, and look what an ugly, rusty lump that stock floating single-piston caliper is. It's a wonder they keep working.

Opposite Page: Quite a contrast to a premium HP caliper and rotor combo, not only in appearance, but also in feel and performance.

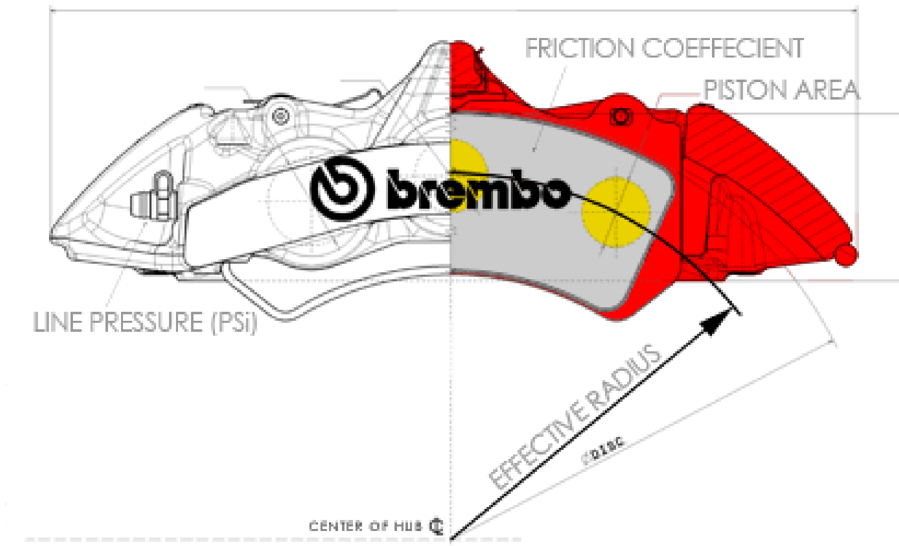
Appearance is another part of the mystique. No matter how neat a job you might do with your six-dollar can of red caliper paint, you're not really going to fool anybody who actually stoops down to take a look. There's no doubt that high-performance brake parts not only handle heat well, they look cool, too.

Our friend Pascal

In the early days of the automobile, some very clever engineering was employed to apply brakes mechanically. For example, the Italian Bugatti routed the cables over the top of the front axle so that the twisting action generated by stopping added force to the shoe cam lever.

No matter how ingenious the design, however, there was always a major drawback: Nothing could insure that braking force would be exactly equal at any pair of wheels, so there was a good chance that stepping on the pedal would cause swerving and skidding.

Here's where 17th-century French mathematician, physicist, inventor, and philosopher Blaise Pascal comes in. In simple terms, Pascal's Principle (also called Pascal's Law, or the principle of transmission of fluid pressure) states that any change of pressure at any point in a closed vessel or system containing a liquid or gas at rest will result in a change of pressure at every other point in the vessel or system. For example, when pressure is increased in the master cylinder of a brake hydraulic system, pressure will also increase an equal amount in all the wheel cylinders or calipers.

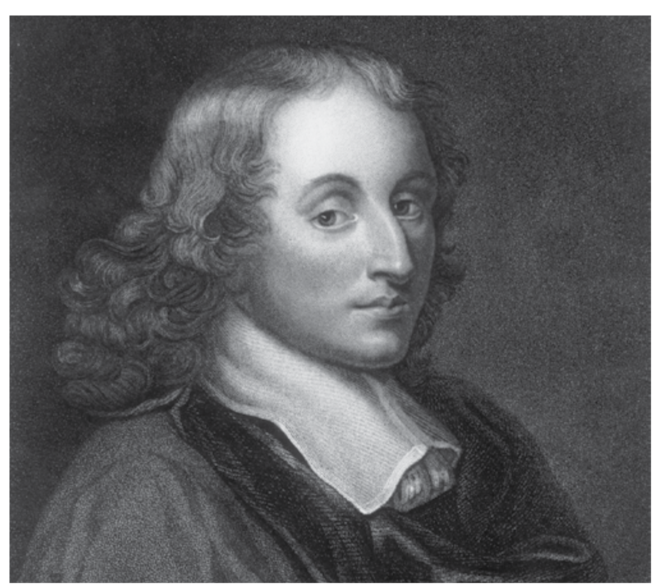


[effective-radius_diagram.gif, caption: A disc of a larger-than-stock diameter gives combined with a trim multi-piston caliper gives more brake torque through increased leverage (courtesy Brembo).

This made the idea of hydraulically-actuated brakes attractive, but it took many years to develop reasonable dependability. The first car of any consequence to carry four-wheel hydraulic brakes was the 1921 Dusenberg, followed shortly by the first Chrysler.

No, painting your stock calipers ain't gonna cut it.

But how can a puny human leg generate enough pressure to stop a couple of tons of hurtling steel? Again, the science of hydraulics provides the answer. Say, you have a master cylinder piston with a diameter of one inch. If the total of the diameters of the caliper pistons is three inches, the force applied to the master is multiplied by three BUT the distance the master cylinder's piston travels is three times as far. Think of a hydraulic bottle jack. You've got to pump lots and lots of times for the small cylinder to feed the big one to get your mechanical advantage



Blaise Pascal, 1623 to 1662

and lift the car. Add to that the leveraged force of the brake pedal linkage (typically three to one) and the assistance of the brake booster, and that tiny column of fluid can transmit sufficient force to the cylinders to stop a vehicle, and then some.

Rigid vs. floating

When disc brakes first started showing up on domestic cars in the 1960s, the calipers were of the rigidly-mounted four-piston variety. They were heavily-built, and their pads wore evenly and lasted for a long, long time. Our editor particularly remembers a '67 Thunderbird, all 5,000+ lbs. of it, that still had plenty of (asbestos!) lining left at more than 70,000 miles.

Then the idea was promulgated that you didn't need to have pistons pushing on both sides of the rotor. Couldn't the clamping force be transferred from one side to the other by using a sliding or floating caliper design? Not only would using a single piston reduce the possibility of seal leaks (fewer seals, fewer leaks), but it would also be a lot cheaper to manufacture. One more factor was that since rigidly-mounted calipers have no tolerance for side-to-side movement, as little as .004 in. of rear axle end play could push the pistons into their bores enough so that extra fluid displacement is needed before the pads touch the rotor, which can cause a low-pedal condition. Ditto for rotor run-out -- the caliper can't float to follow the waves, so they knock against the pads, and the increased lining-to-rotor clearance is only taken up when the pedal is pumped. The carmakers avoided this potential problem by embracing the floating design.

We've always considered this a cost compromise, but apparently it was so compelling to the auto companies that, except for certain imports and sporty cars that continued with two or four pistons, single-piston calipers became the norm. Really, though, when was the last time you saw a leaky caliper, multi- or single piston? Also, since floating types were prone to fore-and-aft rocking, pads mostly exhibited tapered wear, thinner at one end than the other -- not something any mechanically-inclined person likes to see. It implies crude engineering and sloppy tolerances.

Multi pot

[hrphpbrakecaliper.jpg, caption: The differential bore sizes are clearly visible in this six-piston caliper. Engineers juggle this to even out the force on the pads (courtesy StopTech).

A calipers may have one to eight (or even more!) pistons. The count, however, isn't as important as the total piston surface area, and how the force provided is distributed over the brake pad.

The more caliper piston area, the more force is exerted by a given amount of fluid displacement from the master cylinder. A caliper can have a single large piston that offers more surface area than a design featuring multiple smaller pistons.

But a huge piston requires a very large caliper body, which presents problems with fitting the system inside the wheel. Multiple smaller pistons allow engineers to design a longer, narrower caliper that fits in the available space.

More importantly, multiple pistons with different displacements allow a thoughtful distribution of force over the brake pad. To reduce the potential for the leading edge of the pad to wear at a faster rate than the trailing edge, designers place smaller pistons near the leading edge.

These unfinished calipers sure look like bling (courtesy StopTech)

Larger pistons placed near the point of rotor exit from the caliper provide slightly greater clamping force to compensate for pad taper. This helps balance pad loading, ensure high pad pressure against a greater portion of the rotor contact area, and increase stopping power.

Calipers with differential piston bore design are directional and cannot be interchanged from side to side. There is a left hand and a right hand caliper, and each should be marked with a rotor rotation arrow that indicates the direction of rotor entry and exit to and from the caliper.

This cleverly-designed stainless-steel piston has gaps that permit air flow between it and the back of the pad (courtesy AP Racing).

Stressed out

Wheel components take a hit every time you accelerate, stomp on the brake pedal, or tilt through a curve. If you race, drive in the mountains, tow a heavy load, you must also include excessive temperature in the assessment of the amount of stress on your brake components.

As this stress builds, brake components can flex, altering the delivery of fluid pressure throughout the system. Brake hydraulics work well only if the pressure generated by the brake pedal, multiplied by the master cylinder, and transferred to the pads by the caliper has an unaltered path to its destination.

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The belt of choice for many European and Asian manufacturers, ContiTech is also a supplier of OE-quality serpentine belts for domestic manufacturers such as Chrysler, Ford, and GM. ContiTech Serpentine belts require no-retensioning and are available in both metric and inch sizes. To make things even easier for the professional repair technician, ContiTech also offers a **NEW Complete Accessory Drive Kit that includes all the belts, tensioners, and idlers needed for a proper replacement.**

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Flexing of the pedal lever or its mount, the master cylinder mount, caliper mountings, or the caliper itself can cause the component to reach its movement limit before enough pressure has been created to accomplish the goal. Air trapped in the system, expansion of non-reinforced or aging hoses, unevenly worn pads, and worn wheel components can also cause unwanted deflection.

The result is inconsistent braking performance and a spongy pedal feel. Under severe conditions, these factors can result in a pedal that hits the floor before maximum braking force is achieved.

Things get pretty wild and high-tech when you move up to sprint cars where you have to do some of the engineering.

High performance brake makers upgrade components in many ways to minimize deflection. Assuming no air is in the system and other wheel components are in good condition, you can reduce deflection by installing stiffer calipers, better quality hoses, and stronger mountings and pedals.

Race-bred calipers are machined from substantially higher tensile strength billet aluminum. The higher psi capabilities of the premium grade material makes caliper weight reduction possible without sacrificing rigidity.

Two-piece aluminum calipers may achieve rigidity by using high-strength steel cross bolts or steel crossmembers and support plates. High-strength steel bolts have an elastic modulus (a measure of the tensile strength of a material) approximately three times stronger than that of aluminum. Steel has another advantage – it maintains its tensile strength longer than aluminum as temperatures rise.

Besides the caliper body, the design and material of the pistons is important. Stainless steel pistons are superior to aluminum at creating a thermal barrier. They help prevent a soft pedal by reducing heat-related brake fluid fade. Some have a castellated edge on the contact face. The gaps allow a cooling air circulation between the pad and piston, thus slowing the flow of heat into the fluid. Others use a separate metal insulating plate that sits on the piston face and prevents direct contact between the hot brake pad and the piston body.

Boiled down

We thought it was important to make sure you knew about all the scientific and technological concepts described above, but you know what? Unless you're putting a hydraulic system together from scratch for a pure race car, most of the subtleties have already been worked out for you by the brand-name high-performance aftermarket brake manufacturers.

A quality brand's "big brake kit" will typically include these items, and will bolt right on. The difference, as they say, is like night and day (courtesy StopTech).

Goodridge braided steel hose combines a smooth PTFE inner lining with a strong braided stainless steel outer mesh. You get unrestricted flow, a brake line with a high bend radius and superior resistance to abrasion, corrosion, and heat-induced expansion. Not only does it look great, but it gives a solid pedal feel.

For example, if you're contemplating an upgrade to one of the many quality "big brake kits" out there, you might be fretting about what kinds of modifications you'll have to make to the hydraulic system, say the substitution of a special master cylinder. You can stop worrying. All the quality suppliers have engineered their calipers to work just fine with what you've already got in the way of fluid pressure generating and controlling hardware.

The big names typically offer two or three levels of upgrades starting with what's variously called "Sport," or "Aggressive Street," which might include multi-piston calipers and direct-fit mounting brackets, premium pads with linings made using a proprietary friction recipe, rotors that are far superior to the stock items, and the braided stainless-steel reinforced hoses that help provide a great pedal feel, last forever, and look great. The next level might have even more highly-evolved calipers, and perhaps carbon/ceramic discs. Beyond that, it's serious track-only business, which will require a lot more research than an we can support here. ■

High-Performance Engine Building Basics:

Valve Spring Preparation and Installation

This series is as hands-on as possible, and informs you of subtleties you just won't find anywhere else.

Valve springs are among the most underappreciated, misunderstood, critical, and delicate components in the entire racing engine. They are primary contributors to the horsepower chain. They run astoundingly hot due to internal and external friction (plus some conductive heat from the combustion process through the head and valve stem), they cycle between 15 and 90 times per second, plus they bounce, surge, rotate, and rub against one another. All that makes them prone to failures that can result in the kind of engine catastrophes that are sure to make You Tube under the "biggest engine fails ever" category. In fact, I'd bet that most of the engine blow-ups you see are precipitated by failed valve springs.

Never assume that you are accurately measuring anything unless you've got standards to use for calibration. I want to know if my spring height micrometer is accurate. It should be close, but how close is it? At 20 threads per in., each turn of the body should be .050 in., so I set up my height gauge on a small granite surface plate and zero the gauge on the plate surface. I then raise it and lower it a few times to confirm that it returns to zero.

Selecting the right spring is critical to the performance, longevity, and power output you can expect from an engine. They are easily overlooked and often go undiagnosed as a source of lost horsepower. The purpose of a valve spring is to preload the valve on the seat and (by extension through the rocker and pushrod) the lifter on the cam face. What you need to be able to do is control these parts so that the lifter can accurately track the camshaft lobe profile. The valve must accurately open and close at the designed points and follow the camshaft ramp to full close without bouncing off the seat. Bounce is a bad thing. Although some exists in nearly all spring-loaded poppet valve systems, it must be minimized to prevent seat, lock, retainer, and valve damage and a loss of accurate valve timing. We know that accurate valve timing is critical -- some racing organizations spend millions on cams, often changing specifications just a degree at a time to arrive at the optimum cylinder filling and emptying event timing for a given application. If you can't control when the valve seats and seals the cylinder, what's the point? You're chasing horsepower ghosts if you can't control precisely when the cylinder seals and unseals. It doesn't do much good to degree-in a cam if the valve train doesn't follow the profile, does it?

Too Much is Just Right

How much spring pressure is enough spring pressure? The cam grinders often offer up a suggested pressure and rpm range for a cam and spring package. But those suggestions are pretty generic and they assume a few things. First of all, what kind of valve are they assuming that you're running? Stainless steel? Sodium filled? Hollow stem? 5MM stem or 3/8 stem? Titanium? So what assumptions do cam grinders make when they offer you a spring package? I certainly don't know, but the suggestions are just that -- suggestions. If you're running conical or beehives, ovate wire, small-stemmed titanium valves and titanium retainers, you can use less pressure because the self-damping action of conical springs, beehive springs, and ovate wire springs means better valve control with less pressure. Obviously, lighter components require less pressure to be controlled, but if you're running big, heavy stainless steel valves you'll need to run the seating pressure up to control the mass. As a side benefit, changing valve train mass changes spring requirements in part because changing mass changes the resonant frequency of a system; mass helps you tune in and out of resonance, acting as half of the spring pressure/mass equation that dictates at what rpm resonance affects operation.

You would like to hit the design criteria on the nose, of course, but if you have to err, err on the side of too much pressure. While increased spring pressure does increase turning force and friction (it can account for as much as 30% of total engine friction, number three on the list behind the coolant pump and oil pump) as one spring is compressed, you have to remember that somewhere on that engine another spring is uncompressing and putting energy back into

(Continued on p.28)

Next, using a two-in. certified standard I check to see that the height gauge reads out two in. -- and it does.

Once I've checked the height mic, I change its reading a few times, reset it to two in., and recheck it. Now I know it's accurate and repeatable and I can certify it for use. This particular one is supplied by PAC Springs, and the quality of the tool is exactly the kind of quality you see in the company's springs.

Common Valve Spring Terms and Definitions

Free height

Overall length of the unloaded, uninstalled spring.

Installed height

The suggested overall length of the spring as installed on the head measured with the valve on the seat. Installed height can be varied to achieve seat pressure so long as the spring doesn't go into bind.

Coil bind

The condition of a fully-compressed spring with each coil touching the one above it and below it. On a running engine, this is a bad thing and will cause a catastrophic emptying of your wallet.

Open height

The overall height of an installed spring at maximum lobe lift.

Seat or open pressure

The pressure in pounds per square inch of the installed spring with the valve on the seat.

Nose or open pressure

The pressure in pounds per square inch with the valve in the fully open position.

Spring rate

The amount of weight needed to compress a spring one inch, rated in pounds per square inch.

Spring rating

Spring load in pounds per square inch at both the open and closed position. Usually displayed as a range, for example "125#-425#."

Intake installed height.

Exhaust installed height.

Valve seat height check.

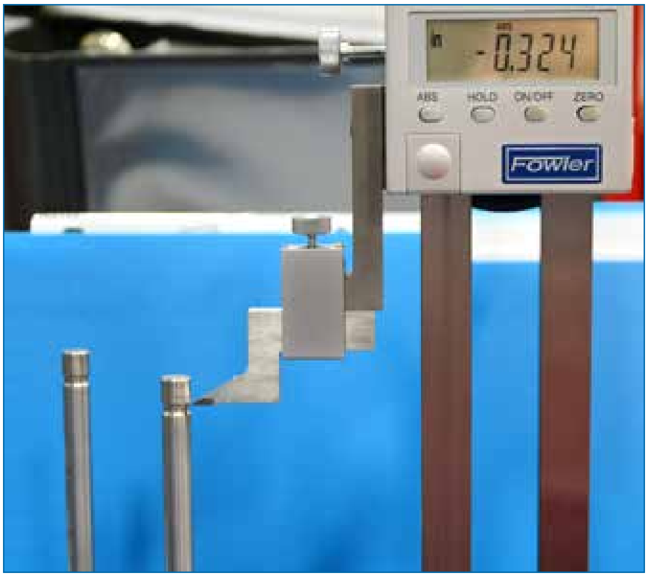
This intake valve measured 2.035 in. and is different from the exhaust at 1.9875. So why is this so common and what causes it? You'll only know if you do quite a bit of measuring the first time you lay hands on your new parts, which I do just to see if all the work that was done to the heads was consistent. I start by measuring the stem heights of all the valves and seeing how consistent they are. In this case, there's only a .003 in. difference between the intakes and exhausts. Since I'm set up, next I measure the valve tip length, since that will affect where the locks engage the retainer. Simply zero the height gauge on the top of the stem and drop it down to measure the tip. In this case, it's a 3/8th in. tip and it measures .374 -- within .001in. Next, I'll measure the valve seat height by laying the head down on a flat aluminum plate and dropping a transfer punch down through to guide so that it rests on the plate under the head. I then set up to measure between the plate surface and the spring perch surface and zero out the indicator. On these heads, there was only a couple of thousandths of

(Continued on page 27)

variation across 16 seats. Next, I measure the retainers and the valve spring seat locator cups (frankly, they are nearly always right on the money one to another), and that only leaves one thing: the depth of the seat and how precisely the face of the valve was finished to get the overall installed height of the springs. Now, I can tell how accurate the seat-cutting equipment was. On this example, it was nearly perfect. The maximum installed heights on eight intakes ranged between 2.035 in. and 2.050 in., and the installed heights on the exhausts measured between 1.985 in. and 1.995in. In the end, the springs were installed at 1.970 to 1.975in. to get the seat pressure and distance to bind where I wanted it. Why is all this important (other than for satisfying my overwhelming perfectionist tendencies)? Two reasons: First, as things wear it tells you what you need to check and what things you can say with near complete certainty will not need checking -- it helps you find problems more quickly. Second, the entire valve train (less the spring) is now a known quantity.

Exhaust valve stem height.

Intake valve stem height.



Autozero, then measure tip height.

the assembly -- which you already know if you've ever lost control of a break-over bar while rotating a race engine with stout valve springs on it. All I'll say is if you're going to be careless while you're hanging onto that bar, you need to invest in an athletic cup, a mouth guard, and a full-face helmet because I'm telling you that a 30 in. bar will knock you stupid. Please don't ask me how I know that -- there are some things a man just doesn't need to relive. The point is that you must control the valve or risk losing significant power, even at the expense of a little additional friction from excessive valve spring pressures.

Now I know that there are those who believe that high pressures will pull the heads off the valves or pound the seats out, but that's not true. Race valves aren't two-piece with the head and stem formed separately like valves were in the bad old days, and once at rest on the seat total load on the valve is not that high. Worn guides, LOW spring pressures and poorly designed cam profiles cause those problems, not high spring pressures. Think about it: Rumor has it that some Pro Stock guys are running titanium valves with 5mm stems, seat pressures well over 400 lbs., and open pressures over 1,200 lbs. Do you have to maintain those systems? Hell yes, but maintenance is three-quarters of the racing game anyway, isn't it?

Spring preparation

Everyone approaches a problem differently, and I'm sure that there are many serious and capable engine builders out there who will not agree with the steps that I use to prepare a racing engine spring. I'm also sure that as time passes my rituals will change as I learn more and have more time to gather data. If there's a really sharp championship builder

(Continued on p.34)

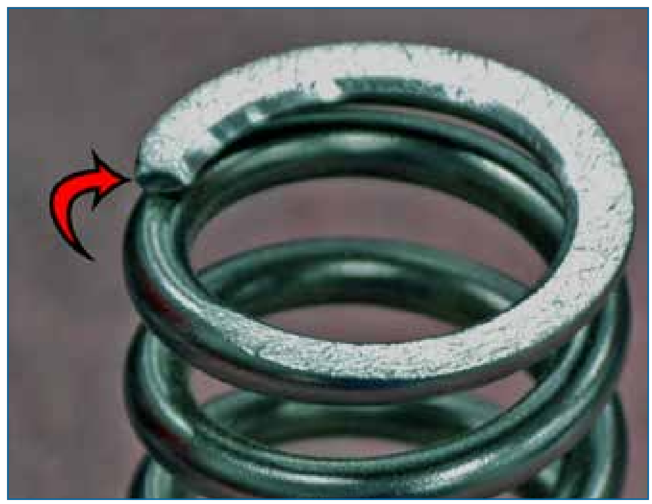
All springs are subject to sudden failure, but most will give some kind of warning, slowly losing pressure over time. This Buxton on-head valve spring tester is the Cadillac of all spring testers and displays the kind of accuracy and repeatability that a serious racer needs to keep track of spring life.

Spring preparation is some of the most tedious engine work, in my opinion. I start by removing the sharp tangs and edges on both ends of every spring. I lay the end of the last coil back so that it won't grab either the spring seat or the retainer face. I use a thin piece of aluminum and a plastic carpenter's shim (available at Menard's or Lowe's) to protect the spring from an unexpected nick as I work. My goal is to minimize the amount of "digging" that those sharp ends do as the spring moves or rotates. If you look at a spring closely, you'll see that as you compress it the coils try to roll, which imparts movement into the spring -- on some engines at certain rpms, the spring can rotate completely around at a fairly high rate. I don't want this little rotating shrapnel generator to remove material from the seat, the retainer, or the spring itself to share with other moving parts. Next, using the Manley tool shown I relieve the sharp edge on the inside of both end coils. Sharp is bad, radii are good. Then it goes in for polishing. When that's done, the spring is bright, shiny, deburred, and radiused, and if you push it into your hand and twist it (clockwise in this example) it should not grab or cut your palm.

Pencil grinder and chamfered and radiused spring.

Manley tool for chamfering the springs.

Must not nick the spring while grinding.



Polished deburred and chamfered.

Smooth enough not to catch.

Before and after polish.

The polishing rig is a repurposed cartridge tumbler.

After polishing cleaning and oiling.

I like to tumble polish for twenty four hours.

It's pretty obvious in these pictures what polishing accomplishes. The surfaces are almost silky smooth after twenty-four hours in the media. You see those flat-wound dampeners? On these two-spring sets that dampener acts like a soft coupler between the inner and outer coil. That little friction coupler acts to "share" resonance between springs, adding just a little mass to its larger or smaller partner and/or grabbing and slowing the companion spring as it moves out of time to its partner. Since the individual springs go in and out of resonance at different rpm, the dampener couples them up to tamp down surge or oscillation. On three-spring sets, the close fit of the springs one inside the other does the same job. The takeaway here is that you should find it difficult to remove and install the inner springsE it's how they're designed. I'll warn you about something here: When you grab the large outer spring to push the inners through, do not let the fleshy palm of your hand get in between the coils to where the inner coil you are pushing can pinch it between the outer-side of the inner coil and the inside of the outer coil. Acts just like a guillotine -- you will bleed and cuss. Wear gloves. Don't ask me how I know this.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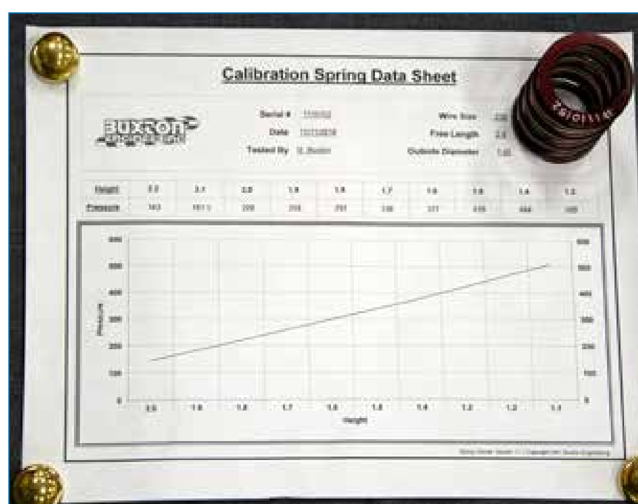
After polishing, deburring, binding, and cleaning I like to lay out a balancing grid on a large piece of paper. The Buxton manual spring compressor is dead accurate and fast for sorting and laying out springs. Again, you need to use standards to verify your equipment calibration -- when the equipment comes out, so does the calibration spring. It goes without saying that this is one spring you DO NOT want to take to bind! Two or three readings across the range will tell you if your tester is still in calibration. I sort springs individually and take them to an arbitrary height, then lock the travel on the

The entire spring package.

Seats are part of the installed height.



Buxton calibration spring.

ram to attain the same height each time and record the pressures. I then put the lower outers with the higher inners and try to get the entire batch within plus or minus 10 lbs. In this example, we are plus or minus seven lbs. across 16 springs. You'll note that I'm holding a couple of different kinds of spring locators or spring seats, an inexpensive stamped piece and a CNC machined part from Manley. I'm not a fan of the stamped seats for any real performance work.

The Buxton is best for spring sorting and balancing.

Precision gauge makes balancing easy.

The spring seat on aluminum heads.

Spring layout graph plus or minus seven pounds.

out there willing to mentor me and set me straight on my process, I'll just say "thank you" in advance. I'm a work in progress and I appreciate and accept all the help I can get.

I start with a physical inspection when the parts arrive, checking for nicks, scratches, and any signs of rust. Then, I cycle the springs five times to solid (bind) and take note of the pressures after the last cycle. I know that binding the spring lowers the pressure but I want that spring stabilized to the extent that I can get it stabilized. I don't care if the pressure drops a bit -- I can shim it to get it where I need it to be. In fact, installed heights as supplied by the manufacturers are only suggestions. As long as you've got the room, you can make the installed height whatever you need it to be to get the seat pressures you're looking for. Ideally, you would like to see the spring fully compressed at full lift with just .030-.060 in. clearance from bind because approaching bind helps dampen spring oscillation and surge for the same reason that you can't dance in a crowed elevator -- no room to wiggle!

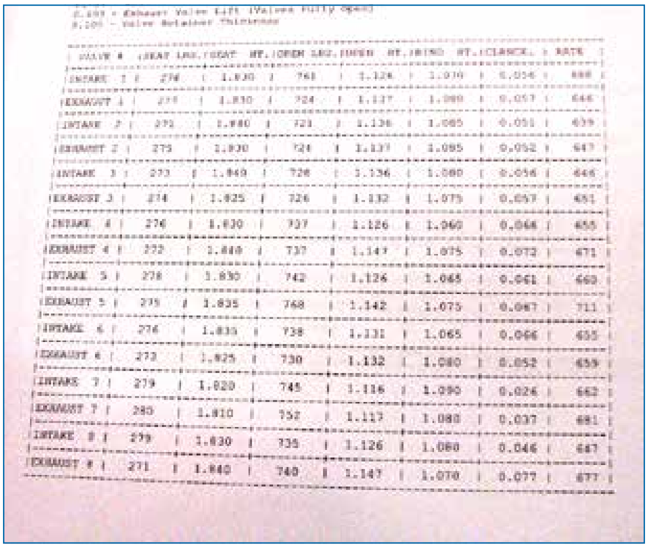
Next, I deburr the ends because I don't want them to dig into the retainer or spring seat and remove bits of metal that circulate in the engine, especially titanium from the retainers, which is non-magnetic and much harder than the cylinder wall and crankshaft, thus prone to causing galling with dissimilar materials.

I then chamfer the inside of the top and bottom coils for stress relief. The flat ends are ground onto the spring leaving a relatively sharp inner edge. I use a chamfering cone to break that sharp edge. Next comes 24 hours in a vibratory polisher with walnut shells and a metal polishing compound to polish and

(Continued on p.37)

Don't make setup hard -- transfer measurement with a height micrometer.

Once you measure the maximum installed height on your height micrometer, you can transfer the measurement to your spring tester just by moving the spring seat (or locator, if you prefer that nomenclature), spring, and retainer over to the tester platens and setting your zero. Compress to the installed height, lock down the ram stop, and run the set of 16, recording position as you go. Then, lower the ram to the maximum lift point, lock the ram, and run the springs again to capture seat and open pressures. You must use the retainer when you test the springs -- the inner coils are shorter than the outers and you need the steps in the retainer so that the coils all load up simultaneously. You also need to have the seat in place. The lower platen represents the machined seat area on the head. If you put a seat or shim against that surface it has to be in place during spring testing. On the Compu-spring system, you can enter the retainer thickness so it will correct for that thickness in its computations, but it has no way to know if there is a spring seat used with the spring under test. You must test with it sitting under the spring, against the lower platen.


[illegible] - Exhaust Valve Lift (Valves Fully Open)
0.100 - Valve Retainer Thickness

VALVE #	SEAT LBS.	SEAT HT.	OPEN LBS.	OPEN HT.	BIND HT.	CLEARNCE.	RATE
INTAKE 1	278	1.830	761	1.126	1.070	0.056	688
EXHAUST 1	275	1.830	724	1.127	1.080	0.057	646
INTAKE 2	271	1.840	721	1.136	1.085	0.051	639
EXHAUST 2	275	1.830	724	1.137	1.085	0.052	647
INTAKE 3	273	1.840	728	1.136	1.080	0.056	646
EXHAUST 3	274	1.825	726	1.132	1.075	0.057	651
INTAKE 4	276	1.830	737	1.126	1.060	0.066	655
EXHAUST 4	272	1.840	737	1.147	1.075	0.072	671
INTAKE 5	278	1.830	742	1.126	1.065	0.061	660
EXHAUST 5	275	1.835	768	1.142	1.075	0.067	711
INTAKE 6	276	1.835	738	1.131	1.065	0.066	655
EXHAUST 6	272	1.825	730	1.132	1.080	0.052	659
INTAKE 7	279	1.820	745	1.116	1.090	0.026	662
EXHAUST 7	280	1.810	752	1.117	1.080	0.037	681
INTAKE 8	279	1.830	735	1.126	1.080	0.046	647
EXHAUST 8	271	1.840	740	1.147	1.070	0.077	677

Compuspring makes hard work easy.

Cannot check springs without the retainer.

With the Compuspring, you have a permanent record.

provide a little stress relief. After a thorough cleaning in mineral spirits (you do NOT need walnut shells in the engine -- check the ends where the tight wrap forms the flat top and bottom for remnants stuck between coils) I lubricate the springs with oil and set them aside for a second inspection.

I carefully and thoroughly inspect each spring a second time for nicks, pits, or scratches. The surface of spring wire is harder than Chinese arithmetic and it will fracture through any nick present. Next, I pressure check the inner and outer springs separately and sorted them -- the highest and lowest are mated up and prepared for the final pressure check on the Compu-Spring tester. I swap the springs around as needed to arrive at installed pressures as close as possible across all springs.

Once installed and run, how often should you check springs? At least after each racing weekend, more if the event lasts several days. You should use an on-car spring checker that reads seat pressure, and you must inspect for rust and signs of end coil failures that might not affect engine performance very much. As a general rule, you should replace springs when you see your initial seat pressures drop by 10%. I wish I could tell you how long a prepped race spring will last, but I can't. It seems that they either fail almost immediately (caused, I believe, by unseen stresses introduced into the wire during manufacturing), or they function quite a while, slowly losing pressure over sometimes as long as two or three seasons (on a 1,000+ hp Sportsman class racer).

Because they're expensive and labor-intensive to prepare, getting a little extra life out of them saves time and money, so here are a few suggestions. Between race

(Continued on p.40)

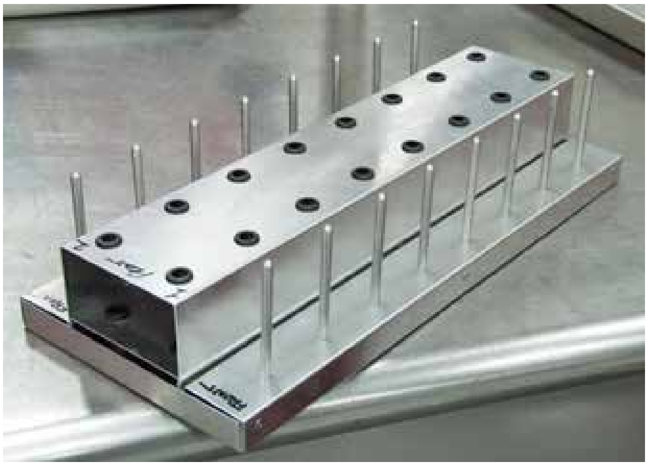
Buxton compression in operation.

There are many compressors, but Buxton is by far the best.

Use lube to prevent galling at retainer and spring seat.

When it's time to put it all together (after you've determined the best installed height, seat pressures, and coil bind distances), you should have a good way to control your assembly process. I use the tray shown (available at CVS Racing Products) as I build and as I tear down to keep track of everything. Once the new parts are assigned a position, I mark them and put them on the tray in the correct location. The springs are sitting on the seats and shims and the valve guide seals are inside the spring. Once it's all laid out, it's time to build. I use Ultra Gel on the seats and retainers, as well as under the lash caps during the build. It really seems to do a great job reducing start-up wear. If it's in the valve train and metal touches metal, it gets a dab of Ultra Gel. Don't forget those lash caps if you are running titanium valves without hardened inserts. The steel roller in the rocker must run against steel at the valve tip. Another Buxton tool has found a home in my toolbox: a spring compressor. It's the best all-around spring compressor I've ever used, and like all the company's stuff, it's top quality. You might not like it the day you buy it, but you sure will every time you get it out to use it on a valve spring that looks like a mis-labeled chassis spring.

Images continue on next page...



Valves springs, seats, shims, retainers, and locks storage.

Loaded spring and valve tray.

Titanium retainer and lash cap in place.

Have to use steel lash caps if there are no hardened inserts at valve tip.

With titanium-coated valves we're talking real money.

weekends, use a spring oil spray like Comp's #106 product and replace any spring that rusts because those tiny pits are the starting points for most failures. Keeping your race car in a climate-controlled shop is the best practice, but keeping the spring lubed may be your only option. I've also heard of racers rolling the engine over by hand periodically or releasing the valve train in the off season, but I've got no way to evaluate the efficacy of that practice. We tear down every year for inspection, so for us that's not an issue.

Other considerations

Other often-overlooked factors are the operation of the cam drive and the harmonic damper. Belt drives aren't just for quick adjustment at the track (is there ever something "quick" at the track after you drop half the parts in the grass or roast your hand on a hot header? Factoring in search time and the drive to the hospital, you're better off with good prep at the shop).

Belt drives absorb a lot of the violent snapping energy stored in the crankshaft as each power pulse hits, and it's the same with the harmonic damper. Dampening the snap of the crank so that it doesn't vary cam speed smoothes valve train operation and removes one more excitation force that can set up resonance.

Surface plate and stainless steel valves.

Left Column: Controlling the valve is all about mass, preload, good components, good preparation, and proper assembly. If you're running high dollar, small-diameter coated-stem titanium valves like the one shown, or big old heavy 3/8-stem stainless steel valves, you've got to size the support parts appropriately if you're to have any hope of getting the valves to follow the cam lobes. Making power is all about precision and good design.

On the output end of the crankshaft you've got quite a bit of mass in either a flywheel and clutch assembly or torque converter, but on the forward end you've only got the damper, plus maybe a drive for an alternator, vacuum pump, and dry sump oil pump. The cam belt drive and damper are key components in stabilizing valve train action and producing smooth and repeatable valve motion on any cam-in-block "V" engine.

Resources:

PAC racing springs: www.racingsprings.com/
PSI springs: www.psisprings.com/
Isky homepage: www.iskycams.com/
Lunati: www.lunatipower.com
Comp Cams: www.compcams.com
Ferrea: www.ferrea.com/Valve-Springs/c7535
Manley: www.manleyperformance.com/
Crane: www.cranecams.com/
Spintron video showing high speed valve spring operation: www.youtube.com/watch?v=yfmb-tCo2yA

Tools, Tools and More Tools, Part 2

by Greg McConiga

Editor's Note: As an auto service professional, you're obviously more than a little familiar with the subject of tools, and, for many of you, collecting them is almost a passion. Fine, but what you use in your day-to-day career, no matter how high-quality, is necessarily different from what you need for high-performance work, in this case engine building. The following will help acquaint you with the types of tools you'll probably end up buying, as did Part 1in the October issue of HOT ROD Professional. To quote Greg from the introduction to that article, ". . . the more you learn about high-performance engine building, and the more you know how to do, the more tools you'll need to support your activities. . . . you'll have to allow for a savings and purchase model that will support your career trajectory."

Cam Lobe Checking Tool

The plunger of this tool is reversible, as is the body. There is a flat tappet end and a roller end on the plunger, and the body fits common GM and Ford lifter bore diameters. If I run into an application that this won't fit, I just use a lifter and a dial indicator to do the same job.

Combination Squares

These are must-have tools for layout, measurement, squaring things up, and setting ring depth while you're grinding and fitting piston rings. There are so many uses I can't even think of them all. I use them every day -- can't do without them.

Valve Spring Height Micrometers (Opposite Page)

Your spring testers will give you spring tension at all heights on the spring along with the bind length. Use the height micrometer to set the installed height for the seat pressure that you need. Simply install them between the spring seat insert and the retainer, screw them tightly in place, and read the distance between seat and retainer. Shims can then be used to adjust the installed heights to your specification.

Cast Iron and Aluminum Burrs

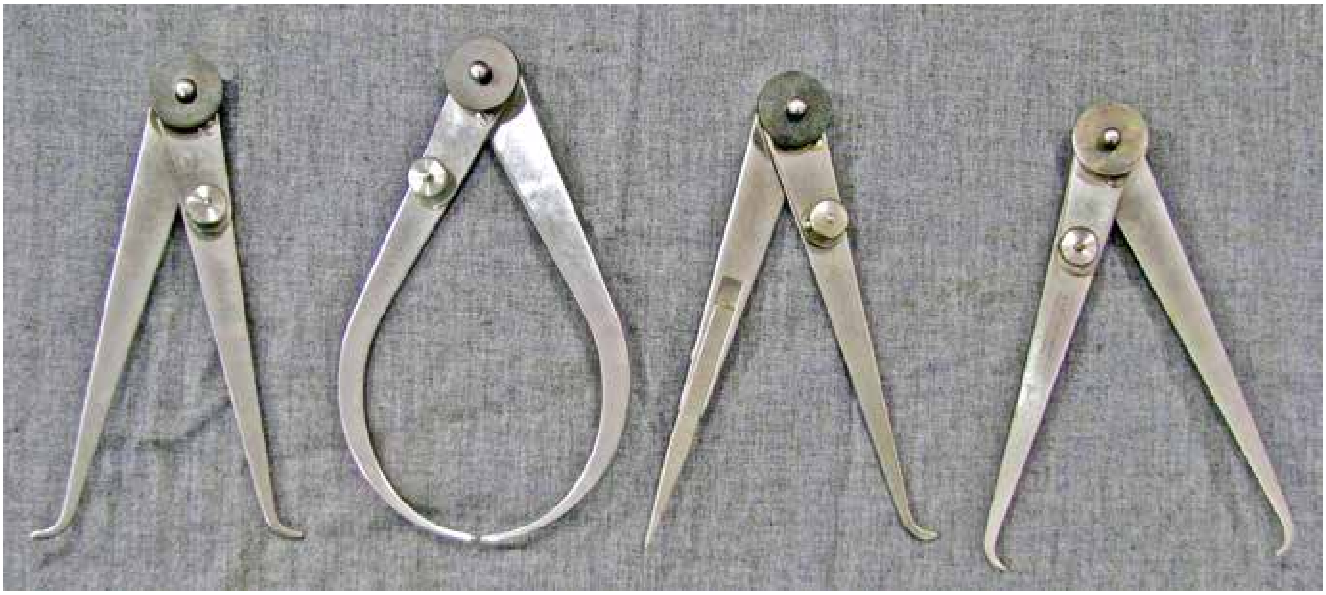
The narrow fluted burrs are for cast iron and the wide fluted burrs are for aluminum. In a pinch, you can spray the narrow fluted burrs with WD-40 and work slowly and they'll do aluminum. Just remember to keep them lubed because once they load up with aluminum they are miserable to clean.

Header Spark Plug Tools

No explanation needed. If you've ever tried to get plugs in and out from around a set of large tube headers, you'll know exactly what these are and why you need them.

Parts and Systems Trays

Cleanliness and organization. There's nothing else to say. Available through CV Products, they are something you should not try to do without.



Plain Calipers

Useful for transferring measurements or roughing in a piece on the mill or lathe, they are also good for checking material thickness. Pictured are outside wide clearance calipers, hermaphrodite calipers, inside calipers, and narrow clearance outside calipers. These Starret calipers have a very nice feature in that you can lock the reading and then release one leg so you can remove them and close them back to the exact opening and read the measurement. That's what that extra nut is for on the leg of the caliper. It releases one leg without changing the measurement.

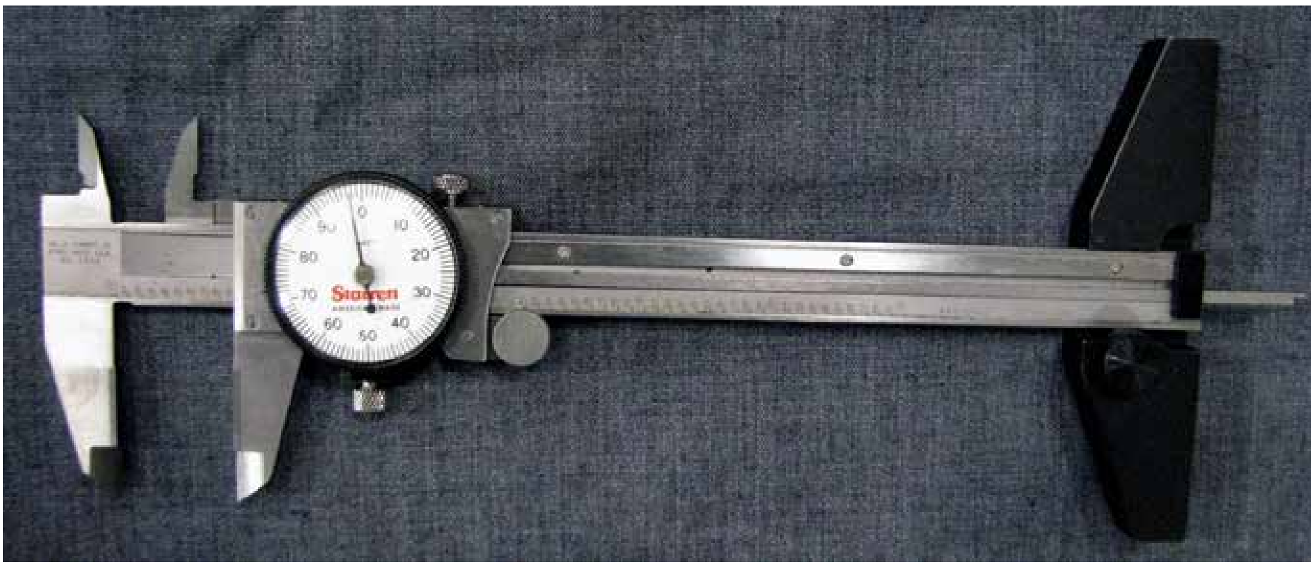
Bore Gauges

Investing in a full set of 1/10,000 in. reading dial bore gauges isn't for the faint of heart, but if you're going to check your guides, lifter bores, cam bores, cam bearings, main bores, main

bearings, rod bores, rod bearings, cylinder bores, or any other hole that needs to be round and straight, you're going to have to have them. Plasti-gage has no place in a professional engine builder's arsenal. Most of it has sat on the shelf for so long that it's not even usable -- you'll know when it's brittle and the color has bled out into the paper it comes in. It's junk.

Dial, Vernier, and Digital Calipers

Calipers come in three major configurations: dial, vernier, and digital. I've pictured just a few of the accessories that are available -- there are others. The dial type reads out each .100 directly and the body of the caliper shows the inch and tenth of an inch divisions. The digital versions are nice because they read out directly. The vernier scale reads like any other vernier in that the marks that line up represent the reading. In this case, 1.742 lines up best on the outside (lower) scale. Make sure you check the accuracy of your calipers periodically by using your gauge blocks as a standard. You can stack gauge blocks to get a longer calibration length.



Micrometer Stand

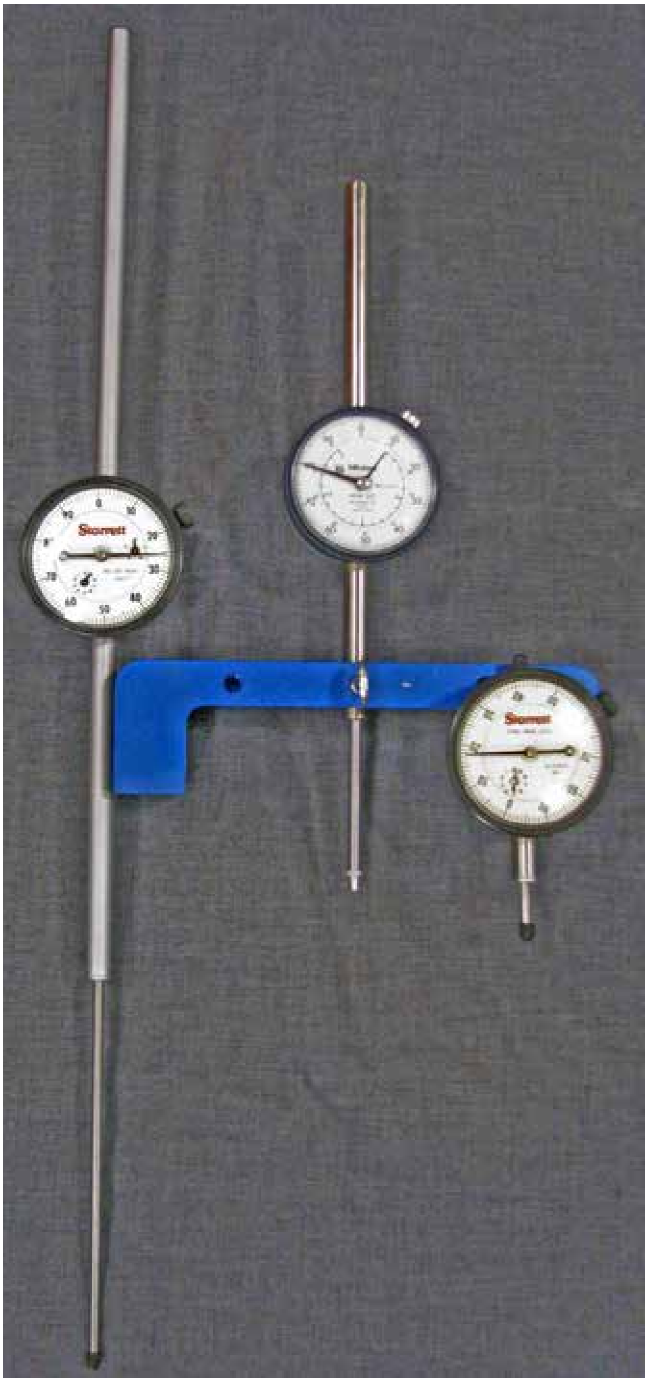
(Above) Another must-have. It keeps your body heat from affecting the accuracy of the micrometer and it's invaluable for setting up your dial bore gauges. It's a third hand that makes your life a lot easier.

Reading Tenths

(Below) The marks on the thimble and the barrel are the standard graduations you see on every micrometer. The additional lines that run lengthwise along the barrel make up a vernier scale that reads out in ten-thousandths of an inch. Carbide faces are the only way to go for long tool life.

Thread Micrometer

(Above) I mark each rod bolt with its location, measure each using this Mitutoyo thread micrometer, then record the overall length of each bolt prior to assembly. The pointed ends of the micrometer fit into the stretch measuring dimples of the bolt. If a bolt remains stretched after removal it's discarded. Rod bolts, valve springs, rings, bearings, spark plugs, engine oil, oil filters, gaskets, and seals are all consumable parts of a race engine.



Dial Indicators

Indicators come in a lot of types. There are lug back, direct, and indirect reading and a lot of face sizes to choose from. The two inch is mounted in the bridge flanked with a one inch and a six inch. If you've got a good eye, you can interpolate between the tics and come up with readings within a few ten thousandths of an inch.

Spring Cup and Washer Pickup Tools

Ever try to recover those washers or valve spring cups from an oily engine? The oil sticks the washer down as if it were glue. Rare earth magnets embedded in an aluminum handle make short work of it.

Piston Stuffers

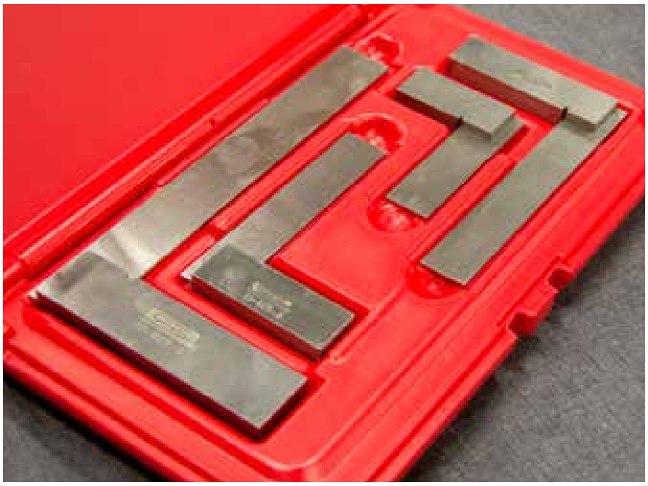
(Right) These aren't a lot of money individually, but at about $50 each they add up when you have to buy one for each engine bore size that you work on. They are the only way to load pistons and rings into a block.

High-Pressure Valve Spring Compressor

Another great tool by Buxton Engineering. This is without a doubt the best tool I've ever used for removing racing valve springs, and there is a bunch of adapters to fit nearly any application. Even valve springs that measure 450-500 lbs. seat pressure are easily removed. Yet another must-have.

High-Tech Compression Gauge

Compression gauges are another one of those tools that I've had several of over the years and accuracy has always been a question. This is a homemade unit, using bits from Snap-on and an Ashcroft 500 pound ¼ percent of scale accuracy gauge. Make sure if you try to replicate this that you spec the gauge correctly. It has to be tolerant of some pretty serious transient pressure surges. I was on a quest to verify my dynamic compression ratio software accuracy when I built this. The software is dead-on, by the way. That will become more important to you later when you're trying to build performance pump-gas engines and you're trying to find the upper compression limits you can run.

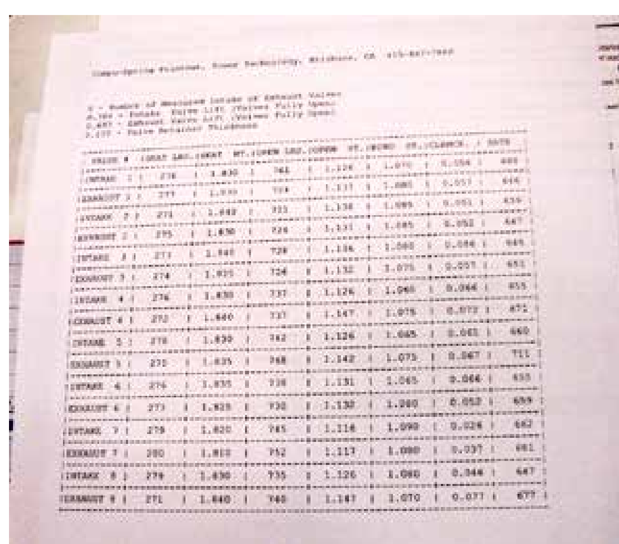


SPi Squares

(Left) There will be a number of times during a build that you'll need to confirm that parts are aligned or square with one another. A small machinist's square set like this is just the ticket.

Testing Valve Springs

Valve springs need a lot of love. They are some of the most highly stressed and failure prone parts of a performance engine. I use a Buxton for balancing the springs by measuring all the inners and outers and matching the lower reading inners with the higher reading outers. They are then tested on the Compuspring after cycling them through five or six bind cycles, then the spring output is printed. All the springs for this application were between 271 and 280 lbs. on the seat. The open pressures vary a bit more in part because this cam has different lift on the intake and exhaust and because the rate per inch varies a bit from spring to spring.



Testing Valve Springs (Cont.)

Modified ARP Bolt Stretch Gauge

Never torque rod bolts, always stretch them whenever you can. I have run into manufacturers who want you to torque their bolts, but in my mind that sounds like a no-confidence vote for their own product. Stretch must be accomplished in one pull -- never pull, measure, pull, measure, and so on as you'll only ruin the bolt. Don't forget to re-apply lube on the threads and under the bolt head before the next tightening attempt.

Scales

The big scale is handy for finding the assembled weight of your engine. You can measure over 150 lbs. by placing one end on a block the same thickness as the scale bed and the other end on the scale, and then swapping ends and adding the results together. The 3000 gram scale is used for weighing pistons, pins, rings, bearings and other small parts. Note the precision test standards that are used to calibrate the small scale.

LMS Valve Adjuster Tool

Makes adjusting the valves a snap. It's a calibrated clicker-style torque wrench that snaps over at twenty pounds-feet.

Ring Grinder and Switch Box

This variable speed unit uses a diamond grinding wheel and a flat turntable to mount the ring perfectly perpendicular to the grinding wheel. A dial indicator tells you exactly how much material you've got left to remove. I didn't like snapping the little toggle switch on this unit on and off, so I built a switch box to put in series with the grinder. If my switchbox fails, new parts are as close as the nearest big box hardware retailer.

Degree Wheel

(Right) A degree wheel and a good pointer is essential to finding TDC and degreeing in the cam. Every racing engine builder has one. The larger the diameter of the degree wheel the more accurate it is.

Thread Chaser Kit

(Below) Every hole, every bolt, every threaded fastener must be checked. New block, old block, new part, or old part -- check them all. I promise you it'll save your hindparts one day. ■

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Running on Vapors and Mixing it up

Since the wholesale transition to EFI, some of us have forgotten about vapor lock and the subtleties of intake manifold design with carburetors, but many (most?) hot-rod and racing engines still breathe through the mechanical mixture maker.

by Henry P. Olsen

One of the most common complaints we hear from our friends and customers who own and drive carburetor-equipped vehicles is that their engines are often hard to start after they sit for 20 to 30 minutes subsequent to the vehicle having been driven on a warm day. The engine acts as if the carburetor has flooded and will only start if the throttle is held wide-open. This problem is most often referred to as vapor lock or fuel percolation, and is caused by gasoline boiling in the fuel lines and in the carburetor bowl from exposure to the heat from the engine. Hard starting occurs because the engine is loaded up with the raw gasoline and thick vapors that were boiled out of the carburetor bowl.

The heat radiating from the engine and exhaust system can cause underhood temperatures to reach 300+ deg. F during hot soak after shut-down. Gasoline is a mixture of hundreds of different hydrocarbons, which vaporize/boil at a wide range of temperatures. The lighter fractions will begin to vaporize at about 80 to 100 deg. F., and all portions of the fuel should be fully vaporized at about 400 deg. F. This wide range of vaporization temperatures of the gasoline are what makes it a very good fuel for an internal combustion engine. The downside is that when it is in a carburetor that is exposed to high underhood temperatures it will tend to boil, causing the troubles mentioned.

This open-element air cleaner may look very sporty, but it also allows hot air from the engine compartment into the intake, thus reducing the engine's power.

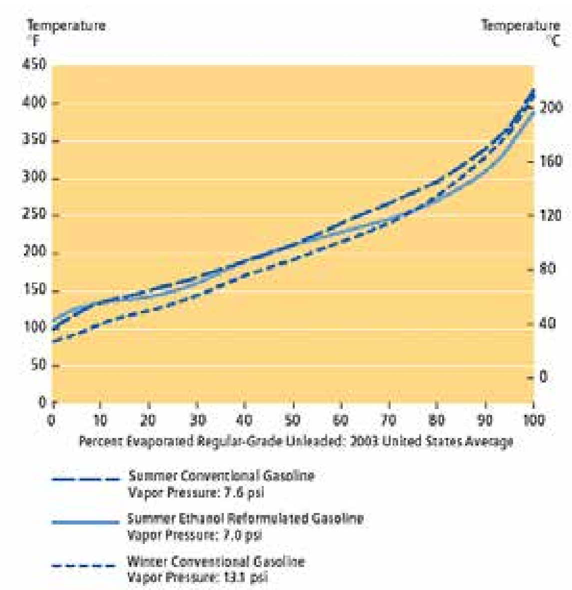
Left: The cold air induction air cleaner on this Mustang will help maximize engine power.

Vapor lock has always been a concern with carburetor-equipped vehicles (especially with an engine-mounted mechanical fuel pump), but it seems to have become more of an issue with today's reformulated gasoline. Modern fuel-injected engines have very few vapor lock-related problems mainly because the fuel pressure is higher and the gasoline is under pressure all the way from the tank-mounted pump to the injectors. A typical port injection system runs at a pressure of 40 psi or so, while most carburetors receive only about six psi. This higher pressure raises the boiling point of the gasoline -- a one psi increase equals about a 3 deg. F. increase in the boiling point.

New blends of unleaded gasoline in many parts of the country contain ethanol, which can often cause swelling issues with the rubber components that are used in the fuel systems of most vintage carburetor-equipped vehicles. Heat only makes this worse, and troublesome and dangerous leaks can result. As we said, when a carburetor is exposed to high temperatures, the fuel in it will vaporize/boil out into the intake manifold and out through the bowl vents, perhaps even dripping down onto the outside of the manifold in the engine compartment. This

This gasoline quality analyzer from OTC/SPX can be used to check how volatile the gasoline is.

unburned fuel will not only flood the engine, thus making it hard to start, but any that evaporates under the hood will also become a fire hazard that could be ignited by any flame source, such as natural gas- or propane-fired water heater in a garage.



This chart from Chevron shows the percentage of gasoline that evaporates as the temperature increases.

The amount of heat determines how quickly the rubber and plastic compounds used in the fuel system will degrade because the rate of this reaction doubles for every 50 deg. F. rise in temperature. It is always wise to insulate the fuel lines and route them as far away as possible from any heat source such as radiator hoses and the exhaust system to avoid heating the fuel.

Contrary to what you may think, liquid gasoline does not actually burn. It is only the vaporized portions of the gasoline or the vapors that are above a pool of gasoline that can catch fire. EFI engines use exhaust heat routed through the intake manifold to help turn the mist that is sprayed from the injectors into the vapors that the engine can turn into power. The fuel that comes out of a carburetor is in the form of bigger gasoline droplets that need to be changed into vapor so they can burn. The heat, vacuum, and turbulence inside the intake manifold all conspire to do that as the air/fuel mixture is directed to each of the engine's cylinders. The

This cutaway of an Edelbrock dual-plane intake manifold shows the exhaust crossover passage that's used to aid in fuel vaporization.

design of the intake manifold determines both how well the fuel will change from liquid into vapor, and the rpm range at which the manifold will operate best.

This Edelbrock Air-Gap intake manifold will help the engine make maximum power at high rpm operating conditions.

So, a carburetor-equipped engine needs enough heat in the intake manifold to convert the fuel droplets it gets into vapor form before the air/fuel mixture enters the cylinders. This need for heat is the reason most original-equipment intake manifolds are heated by the exhaust gasses being chanelled near the intake runners, but if the manifold gets too hot vapor lock problems may occur. There are intake manifolds, such as the Edelbrock AIR-GAP series, that are designed to reduce the heat in the ports, but if they get too cold the gasoline may not be fully vaporized at lower engine speeds.

Manifolds

The main job of an intake manifold is to direct the air/fuel charge from the carburetor equally to each cylinder. The intake manifold and the vacuum created by the engine also have the job of converting gasoline that is still in liquid form (droplets) into a vapor that the engine can properly burn. The factory designed the intake manifold to operate at a wide range of conditions -- the engine is expected to perform properly for very conservative driving, and also when maximum performance is required, resulting in compromises. This means that there may well be a fair amount of engine power that can be unlocked if you install a high-performance manifold.

There are quite a few options when it comes to selecting a single-carburetor intake manifold. First, do you want single-plane or dual plane? Then, you need to decide if you want a manifold with an exhaust crossover, or should you try a high performance manifold such as the afore-mentioned Edelbrock AIR-GAP? The dual-plane design is better for lower engine rpm operating conditions, but there are also dual-plane manifolds that are designed for higher rpm operating conditions. Most single-planes are designed for maximum power at high-rpm operating conditions. If maximum power is the goal, the AIR-GAP or equivalent design can offer a power advantage since it helps keep the incoming air charge cooler with the intake runners isolated from engine's heat. The plenum and runners can become so cool, however, that the gasoline

A dual-plane manifold is a good choice for power over a wide range of engine rpm.

certain amount of liquid gasoline, which will not burn properly, while other cylinders will get a charge that does not contain enough fuel, thus is too lean for the needs of the engine. Whenever an air/fuel mixture that is too rich or too lean, or if the fuel is not fully vaporized, the engine will not perform as it should and the exhaust emissions will be relatively high. When the fuel is not properly vaporized, it will not properly burn in the cylinders and it will

may not be fully vaporized at lower engine rpm and low-load operating conditions.

Vaporization

On the other hand, if the intake manifold to get too hot the engine may experience vapor lock problems, and the heat will also lower the density of the air, which will have a negative effect on the engine's power and efficiency at higher engine load. It is necessary to vaporize the fuel before it can be expected to burn, plus it is much easier for the intake manifold to properly distribute fully-vaporized gasoline than it is to distribute an air/fuel mixture that contains liquid or non-vaporized fuel. The equal cylinder-to-cylinder distribution of properly vaporized charge is essential for the engine to be able to provide the user with the best possible power, driveability, and fuel efficiency.

If an engine's air/fuel mixture is not fully vaporized, some of the cylinders may get a

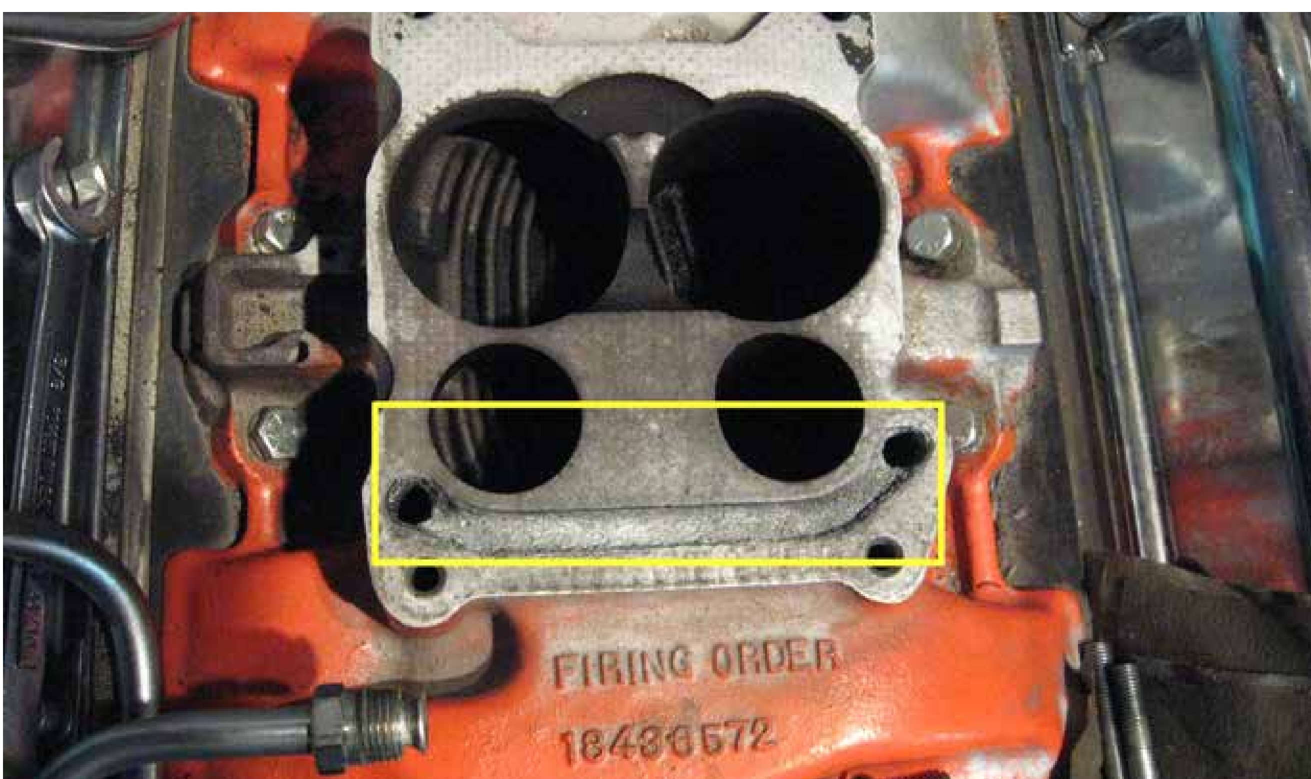
then go out through the exhaust system as wasted energy and air pollution (unburned hydrocarbons). The conditions that can cause the fuel not to be properly vaporized occur when the air/fuel mixture is traveling at low air velocity (low rpm), low manifold vacuum levels at low rpm (bogging the engine), an intake manifold with large runners (at low rpm operating conditions), a carburetor that is too large (CFMwise) for the operating conditions, or summer fuel blends used during winter conditions.

In the 1950s and 1960s, General Motors designed many of its V8 intake manifolds with exhaust gasses that passed across the base of the carburetor to prevent carburetor icing and to help vaporize the fuel, but since today's gasoline is designed mainly for fuel-injected engines, it may be advisable to consider blocking off the exhaust passages that pass by the base plate of a carburetor, and, in some cases, reduce the exhaust flow thru the intake manifold's exhaust crossover. Blocking the exhaust crossover of an intake manifold, or the use of an AIR-GAP-style manifold can cause engine warm-up problems and reduce the fuel's vaporization during chilly weather conditions, which can reduce an engine's driveability, thus making the vehicle miserable to live with.

Chrysler, Ford, and GM all started using thicker base gaskets and/or heat shields under the carburetor to help reduce the fuel temperature on their carburetor-equipped engines starting in the late 1960s. The use of a plastic or phenolic carburetor spacers to help keep the carburetor cool is also a good idea to consider as long as you have the hood clearance to allow it. Carburetors spacers can also be used as a tuning aid to move the torque and powerband down to where it is more usable. A four-hole carburetor spacer (four individual holes -- one under each barrel) will increase your throttle response and acceleration because it will allow more time for the fuel to mix with the air before it has to make the turn toward each cylinder's intake runner. The use of this kind of spacer in most cases will improve the engine's torque and power in the lower rpm ranges. An open carburetor spacer (one big hole under the carburetor) will move the torque and power-band up in the rpm range by increasing the plenum area of the intake manifold.

Density

The density of the air is a very important factor in both how much power an engine will make and the jetting package an engine will need to perform at its best. The computer or PCM of a modern fuel-injected engine uses the data it gets from the air temperature and mass air flow sensors to calculate the density of the air, then it goes to its look-up



General Motors used exhaust gases to aid in fuel vaporization, but this tended to overheat the carburetor and led to vapor lock problems.

tables to determine what ignition timing and fuel injector pulse-width command should be used for the engine load and rpm at which the engine is being operated. Serious racers or tuners of carbureted engines should have a competition weather station such as the Computech Race Air Pro to help them tune engines for changes in temperature, humidity, altitude, and air density. Most carbureted engines get their air from under the hood, but those air temperatures are not ideal for maximum engine power and efficiency because the air has been heated as it passes through the radiator and over the hot engine components. A typical engine will experience a 1% loss in engine power for every 11 deg. F. the intake temperature increases.

The larger the carburetor venturi size, or the larger the size of the intake manifold runners, the lower the velocity of the air/fuel mixture. This can cause a loss of engine power because the fuel will not be fully atomized/vaporized and/or properly mixed with the air charge as it enters the cylinder heads and combustion chambers at lower rpm operating conditions. High performance (long duration) camshafts and cylinder heads with large runners (race heads) will also add to the problem.

Driving an engine on the street that has been built for maximum power at high rpm is not for everyone -- the engine may stumble and stall when driven "normally," plus it will most likely lack power at lower rpm, but will have tons of power in the higher rpm band. When you select or build an engine for the way it will be driven most of the time, the vehicle's driver will be a lot happier than he or she would be if the engine only ran good at wide-open throttle! ■

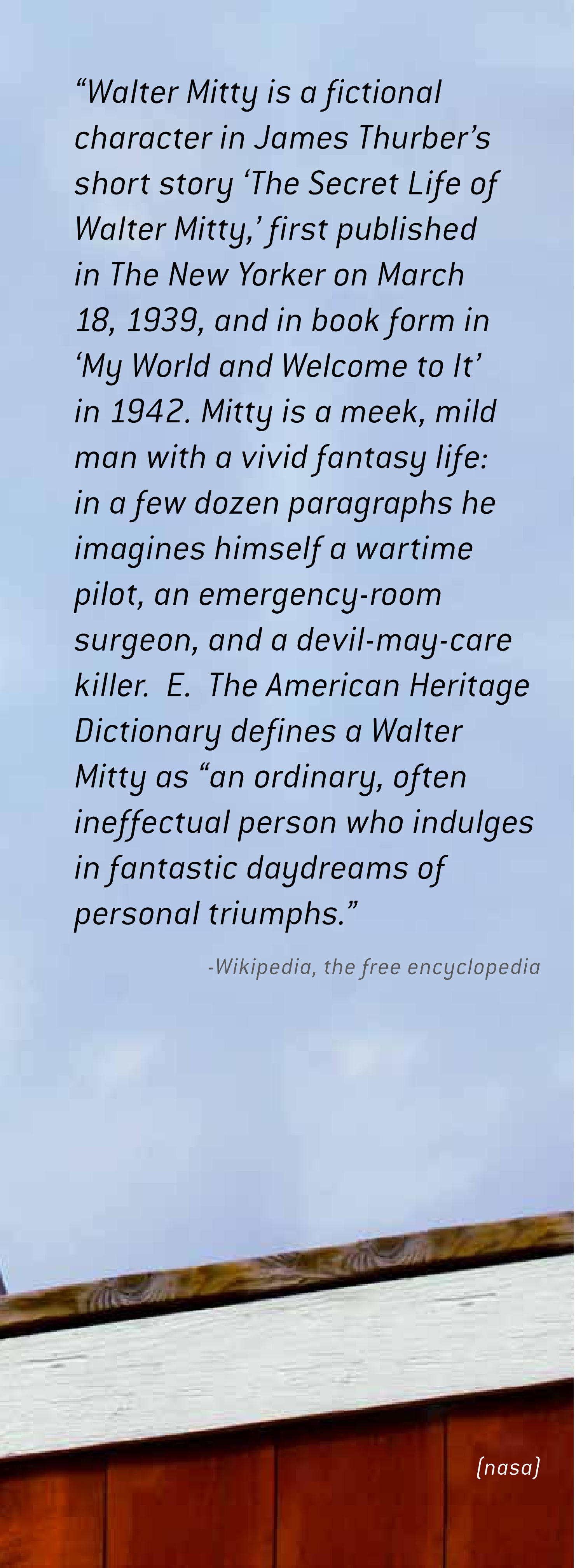
A phenolic spacer can be used to help keep a carburetor cool and thus reduce vapor lock problems.

So You Want to Drive on a Race Track?

Surprise!

...It's easier than you think

by Glen Quagmire



"Walter Mitty is a fictional character in James Thurber's short story 'The Secret Life of Walter Mitty,' first published in The New Yorker on March 18, 1939, and in book form in 'My World and Welcome to It' in 1942. Mitty is a meek, mild man with a vivid fantasy life: in a few dozen paragraphs he imagines himself a wartime pilot, an emergency-room surgeon, and a devil-may-care killer. E. The American Heritage Dictionary defines a Walter Mitty as "an ordinary, often ineffectual person who indulges in fantastic daydreams of personal triumphs."

-Wikipedia, the free encyclopedia

(nasa)

Truth be told, there's surely some of Walter Mitty in all of us. Rare is the person who has not imagined himself or herself heroically saving a person, a family, or even a city. And who among us has not watched a John Wayne war movie and pictured ourselves in an aerial dogfight against a faceless pilot in an enemy war plane? It's just part of our DNA to want to be a hero or to live out a fantasy.

While many of our fantasies are destined to remain just that -- fantasies -- others often make it onto our personal "bucket lists" in the hope that we can actually fulfill them before we ultimately assume room temperature.

There's little question that, for most of us "car people," driving a race car at speed on a race track is something we'd like to do at some point. Some in our profession are fortunate enough to already be participating in some level of motorsports. Some are into drag racing, others run oval track cars on dirt or paving, others may race go-karts or motorcycles, and still others may prefer road racing of some sort. And many in our business play a supporting role, helping to prepare race cars and serving as pit crew members. But, for most of us, auto racing is just another item on our wish list.

Bit it doesn't have to be that way. In fact, it's much easier to drive, at speed, on a race track, than you might think.

What's the Deal?

In the quest for added revenue, many race track owners and managers across the country continue to explore ways to generate more business from their facilities, that typically stand quiet except for fair-weather weekends when competitive racing is taking place. What they're finding, in increasing numbers, is that there is a growing interest in driving fast, thanks in no small part to the dramatic growth of interest in NASCAR racing.

The result, in many cases, is that track owners and managers are making their facilities available to folks who have never driven in competition, or even at speed, let alone on a race track. So, increasingly, track owners are scheduling "track days" which afford an opportunity to drive at speed, in our own cars, for those who may never have done so.

Typically these track days are offered on road courses, with lefts and rights, and ups and downs. Such courses offer a more interesting driving experience for first-timers than oval tracks.

So What's It Like?

Track days are perfect for first-timers. They typically start with some classroom instruction, followed by the opportunity to drive on the track. The classroom time will cover a variety of subjects, most important of which will be safety

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(nasa) Photos courtesy Chris Schulze - Finish Line Productions *www.finishlineprod.net*

The National Auto Sport Association (nasa) offers a wide range of motorsports activities nationwide, including their High Performance Driving Experience (HPDE) which provides on-track and classroom instruction for first-timers who want to experience the thrill of driving at speed on race tracks. www.nasaracing.net


(nasa)


(nasa)


(nasa)

rules, regulations and measures. They'll cover the agenda for the day, strict rules about speeds and passing, and procedures for following the instructions of corner workers and safety personnel.

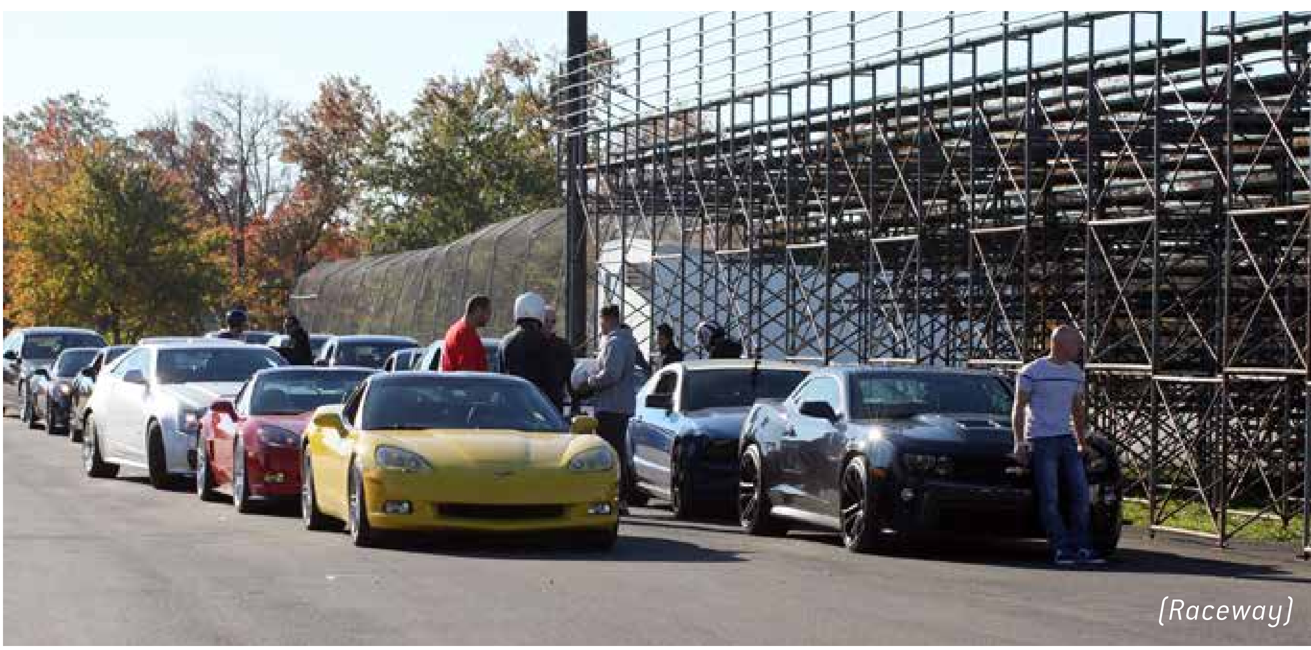
Typically corner workers will be on hand to display flags of different colors and designs to alert you of conditions on the track, which may include yellow flags indicating that caution is needed for some reason, a blue flag to indicate that you're being followed closely, a red flag which, while rarely shown, is an "all stop where you are" signal for some important reason, or the dreaded black flag, which, when pointed at you, means, "Please come into the pits; we'd like to have a talk with you about something you did, usually not to compliment you..." Of course the green flag means "go," the checkered flag means the session has ended, and a white flag may mean there's one lap to go, or, when displayed with a yellow flag, may mean there's an emergency vehicle like a tow truck on-track.

The classroom session will also cover proper driving skills, such as when to slow the car in braking zones, where best to cut an apex of a corner, and where to begin accelerating out of a turn. It may also provide instruction on how to give hand signals to other drivers, such as a raised hand to indicate you are slowing or your car is disabled for some reason, or how to provide a "point-by" to indicate which side of your car an overtaking car should take if/when passing is permitted. Display of your middle finger to show displeasure is not usually recommended....

It's common for speed to be regulated by a pace car, with a strict "no passing" rule in effect, at least early on. Individual instruction may or may not be offered, depending on the venue. Sometimes there will be several instructors who will ride along with each participant on a rotating basis. Other times personalized instruction may be offered at an additional cost.

A typical track day may involve a morning classroom session, followed by several on-track sessions of, perhaps, 20-30 minute duration each. Then a lunch break and perhaps further instruction or critique, and then perhaps three afternoon sessions. Normally each session will be at a speed a bit faster than the previous session, and it is common, in sessions later in the day, to allow passing, but typically only on straightaways.

The number of cars allowed on-track at any given time is commonly limited to, maybe, 8-10 cars, in order to allow instructors and observers the opportunity to watch and evaluate all of the drivers. If the sponsors accept more cars and drivers than that, they



(Raceway) Photos courtesy of Martin Pelta, www.martyphoto.net

Track Day instructors often come from the ranks of professional and semi-professional race car drivers. Chief Instructor for the road course at Raceway Park in Englishtown, NJ is Chris Winter, part-time driver in the NASCAR Camping World Truck series, who certainly knows his way around a race track. On-track instruction is an important part of the road course program there, and sessions are offered nearly year-round as weather conditions permit. www.etownraceway.com may likely establish several groups of cars, based on drivers' experience levels along with the speed capabilities of their vehicles.

What Kind of Car Can I Drive?

For the most part, participants in track days drive their own car. This often includes sports cars or sporty cars -- BMWs, Honda's, Camaro's, Mustangs, Corvettes, Porsches, and the like. But many facilities will let you participate in the family sedan, and sometimes even in SUVs. But vans and SUVs may not be permitted because they're top-heavy and are more inclined to turn turtle at speed.

They'll ask you to remove all loose objects from the cabin and trunk areas, and they'll insist on vehicles having lap belts and shoulder harnesses. Normally factory-installed belt systems are just fine; racing belts and harnesses are not usually necessary. Convertibles are usually only permitted if they have a roll bar installed, although many targa-type roof structures are considered acceptable. Instructors may perform a reasonable tech inspection of your vehicle to be sure it's safe.

What Does the Driver Need?

Usually nothing more than a valid driver's license and a check book. Advance registration is usually required, and drivers will have to wear a helmet while on-track. Loaner helmets are often available at the track, but its always preferable to bring your own whenever possible.

When you register at the beginning of the day you'll most likely be asked to sign a waiver form to release the sponsors and managers from liability should anything bad happen. This is standard practice for virtually all such events and while there's certainly an element of risk involved when driving at speed, track days are considered very safe, incidents are rare, and injuries almost unheard-of.

How Fast Can I Drive, and What Else Can I Expect?

Speeds will depend on a variety of factors -- track configuration, types of vehicles, drivers' experience levels, and, most important, the judgment of the instructors as to what they consider safe speeds based on their observations of you and the other drivers. That being said, with sufficient straightaways and vehicle capabilities, you might well reach speeds of 100 miles per hour or even more.

First-timers are both welcomed and encouraged to participate. But you'll likely also find those who take track days more seriously. It's not uncommon for track day regulars to show up with a dedicated track-only car on a trailer. Others may show up in daily-driver sports or sporty cars with an extra set of wheels and tires for use on the track. Instructors will be careful to group cars and drivers so you won't have to worry about getting dive-bombed by a Mario Andretti wannabe in a Porsche or Corvette if you're driving a Honda or Toyota.

What Does It Cost, and How Can I Find Out More?

Entry fees for track days often run in the $200-250 range per day, and much of this goes toward track rental and liability insurance for the track, as you might expect. It's also common for track days to be offered in two or even three-day packages, since many folks travel some distance to get to a suitable track, and may stay overnight in order to make a weekend of it. If you're fortunate enough to have a race track within reasonable driving distance, you're among the lucky ones.

You can find more information from race tracks' web sites, or by calling the track directly. The track may be able to provide schedule information, although the track day events are typically run by a club or racing sanctioning body. You may find that track

(Raceway)

(Raceway)

days are being held by enthusiast clubs of owners of BMWs, Porsches, Corvettes, and other marques. Very often they'll allow "newbies" and owners of other kinds of cars to participate in order to increase car count and revenue, since track rental is not a cheap undertaking.

Track days offer an inexpensive and newbie-friendly way to find out if driving at speed is something you'd like to pursue. If you'd like to take this to the next level, you might consider a professional driving school, offered at many/most of the major road courses in the country. Such schools offer more intensive personal instruction, more track time, and often include the use of a school-provided race-prepared car, which may be a sporty car or even open-wheeled formula cars. Your race track web site or manager will be able to provide you with all the details. ■

(Raceway)

Ford Reveals 2015 Mustang GT

The sleek 50th Anniversary Edition will feature a new look, improved engines, better handling and more technology touches.

Ford has given Mustang fans a peek at the future of the Pony Car with simultaneous unveilings of the 2015 Mustang GT around the globe in six cities on four continents. HOT ROD Professional.com attended the festivities in Dearborn, Michigan – home of the Ford Motor Company.

To the surprise of no one, the vehicle is being met with rave reviews. The combination of beautiful exterior styling, advanced powertrain, upgraded interior touches, and improved handling and suspension will ensure that loyal Mustang fans and new buyers alike are anxious to sit their bottoms in the driver's seat of their very own 2015 Mustang GT.

Ford says the all-new sophisticated design is inspired by 50 years of Mustang heritage that has evolved to attract wider array of customers and expand global market availability. "Ford Mustang inspires passion like no other car," said Raj Nair, Ford group vice president, global product development. "The visceral look, sound and performance of Mustang resonates with people, even if they've never driven one. Mustang is definitely more than just a car – it is the heart and soul of Ford." For the first time ever, Ford will bring Mustang to customers in key parts of Europe and Asia.

An All-New Shape, But Definitely a Mustang

Aggressive style was a key factor in redesigning the 2015 Mustang. "You only get one chance to make a first impression, and when you see this car you immediately see a Mustang strong and true," said Moray Callum, Ford executive director, design, The Americas. Several key design features define the all-new Mustang, including:

- A lower, wider stance with a reduction in roof height, and wider rear fenders and track.
- The return of the Mustang fastback with a sleeker profile enabled by a more steeply-sloped windshield and rear glass.
- Three-dimensional tri-bar tail lamps with sequential turn signals.
- Contemporary execution of the signature shark-bite front fascia and trapezoidal grille.

The Engine Lineup

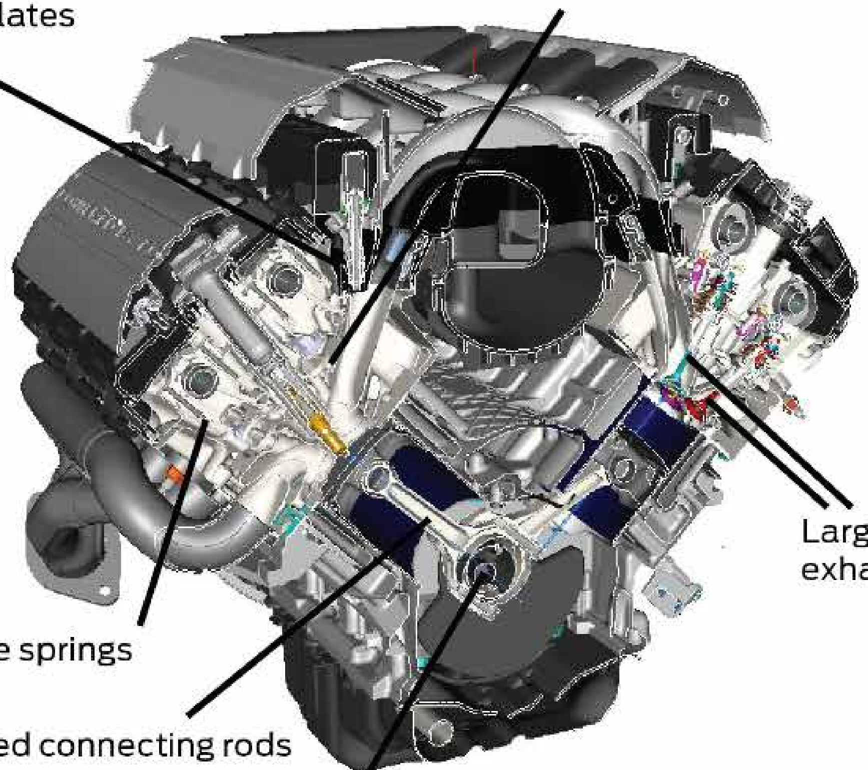
The 2015 Mustang will be available with three engines offering a broader choice of power: a more powerful 5.0-liter V8, a 3.7-liter V6 and an all-new fuel-efficient 2.3-liter EcoBoost 4-cylinder engine.

Mustang GT continues with the latest edition of the throaty 5.0-liter V8, now featuring an upgraded valvetrain and cylinder heads that yield more than 420 horsepower and 390 lb.-ft. of torque. A new intake manifold improves low-speed breathing for better fuel economy, idle stability and emissions.

With at least 300 horsepower and 270 lb.-ft. of torque on tap from the standard carryover 3.7-liter V6, even the most accessible Mustang delivers the performance customers expect.

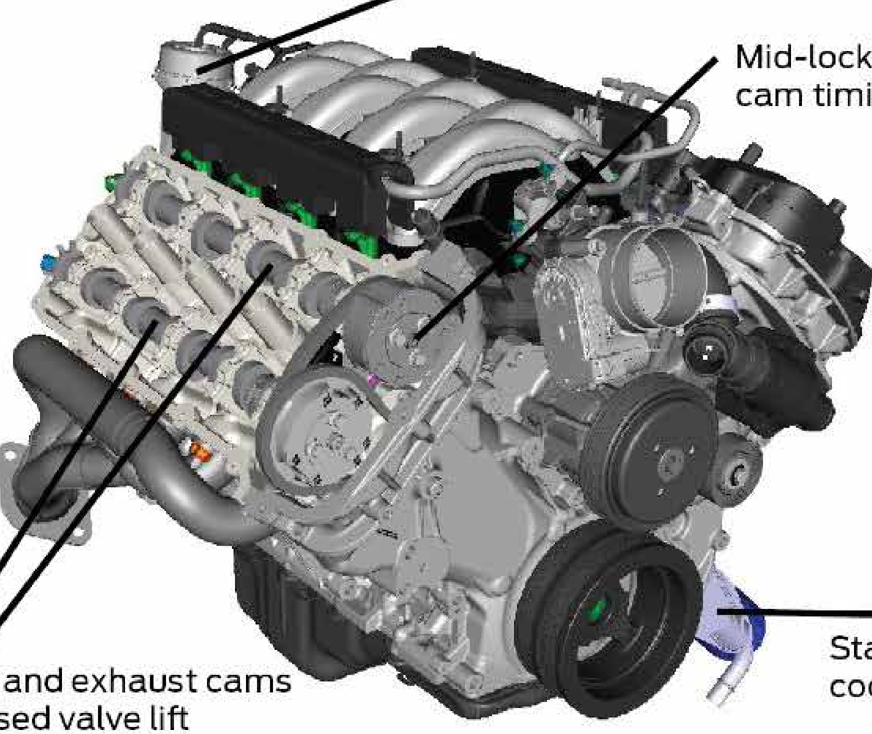
The new 2.3-liter EcoBoost engine uses direct injection, variable cam timing and turbocharging to deliver plenty of usable performance with improved fuel efficiency.

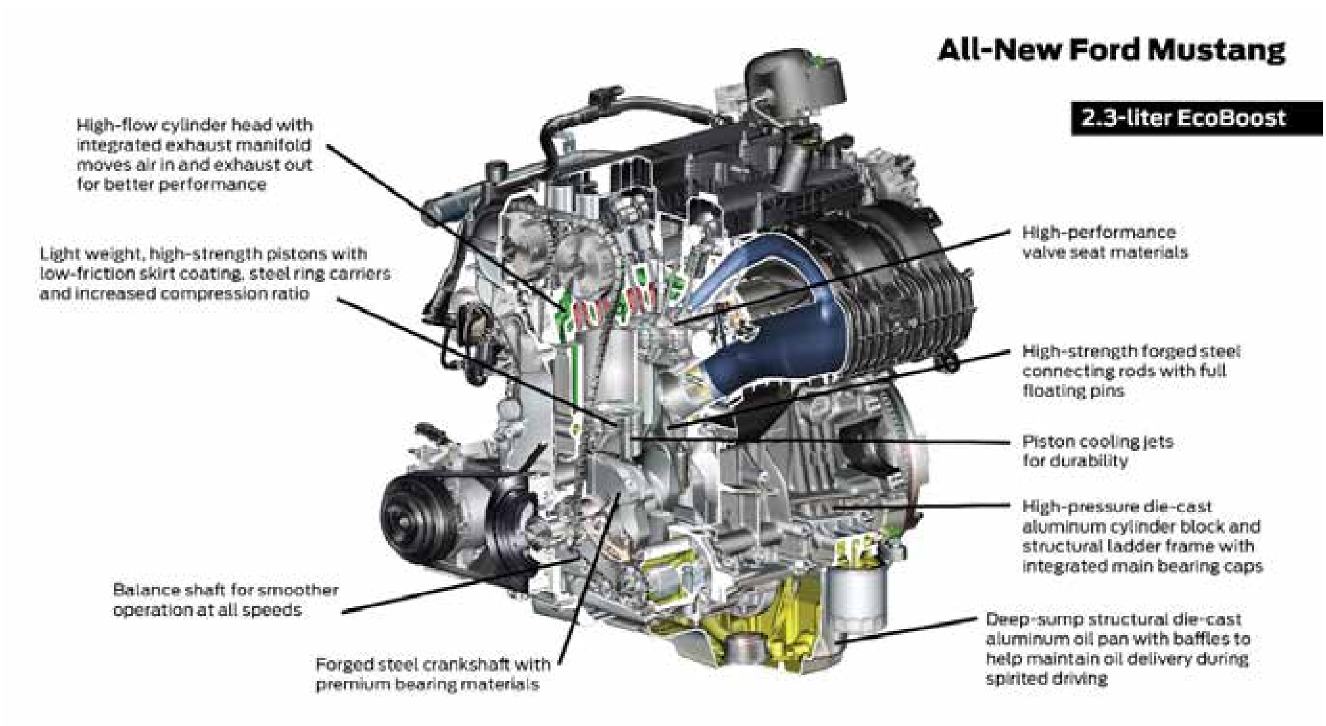
All-New Ford Mustang



5.0-liter V8

The 2015 Mustang's 5.0-liter V8 will deliver an increased 420 hp





The new 2.3-liter turbo engine will supply more than 305 horses while still being fuel efficient.

A unique intake manifold and turbocharger housing enable it to deliver the performance Mustang drivers expect with output projected at more than 305 horsepower and 300 lb.-ft. of torque.

Interior Improvements

The information and controls an active driver needs are all readily accessible in the aviation-inspired cockpit. Large, clear instrumentation puts vehicle information right in front of the driver in the roomier cabin, while improved ergonomics and tactile switches and knobs provide better control. The added width and a new rear suspension contribute to improved shoulder and hip room for passengers, and a more usefully-shaped trunk Ford says can accommodate two golf bags.

Drivers will appreciate smoother shifts from the updated manual gearbox, while a reworked automatic transmission features new steering wheel-mounted shift paddles for drivers who want the choice between convenience and control.

Ride, Sally, Ride

It's all about the ride. If it doesn't ride comfortably and handle well, it's not going to satisfy Mustang purists. Ford says the all-new Mustang sets new handling benchmarks for the brand, delivering world-class dynamics and ride quality.

The 2015 edition features all-new front and rear suspension systems. At the front, a new perimeter subframe helps to stiffen the structure while reducing mass, providing a better foundation for more predictable wheel control that benefits handling, steering and ride.

The new double-ball-joint front MacPherson strut system also enables the use of larger, more powerful brakes. This is expected to be the best stopping Mustang yet, with three available brake packages.

Interior refinements include steering wheel and touch screen controls.

At the rear is an all-new integral-link independent rear suspension. The geometry, springs, dampers and bushings all have been specifically modified and tuned for this high-performance application. New aluminum rear knuckles help reduce unsprung mass for improved ride and handling.

Tech Touches

The new Mustang features a significant amount of innovative technologies providing drivers with enhanced information, control and connectivity when they want it. From Intelligent Access with push-button start to SYNC and MyKey, plus available Track Apps, MyColor gauges and new Shaker Pro audio system, drivers will be able to customize their time behind the wheel.

On a twisty back road or a weekend track day, the driver can tap the toggle switches on the console to quickly adjust steering effort, engine response, and transmission and electronic stability control settings using the available Selectable Drive Modes.

The advanced new stability control system is tuned to maximize dynamic capabilities. Another nice tech feature is launch control that enables drivers to achieve smooth, consistent starts every time.

Driver-assist features include Blind Spot Information System with cross-traffic alert and adaptive cruise control can help ease the load, while SYNC AppLink lets drivers control their smartphone apps to listen to their favorite form of entertainment.

While it's way too early to name the 2015 Mustang GT the "King of the Road" (especially as the Chevy Camaro has been selling like hot cakes), from initial responses, the new Stang will certainly make a great impression on Mustang loyalists and perhaps the rest of the buying public. Look for it on the streets in late 2014. ■

Information Station

2014 Chevrolet Performance Catalog

Chevrolet Performance is offering its all-new 180-page 2014 catalog featuring a broader range of high-performance parts for fifth-generation Camaros, a new six-speed manual transmission designed for LS engine installations in older vehicles, expanded Connect & Cruise crate powertrain offerings, a new line of performance parts for Sonic, and all-new exterior and interior accessories for Chevy vehicles.

There's also a new ZZ5 crate engine and revised versions of other classic small-block crate engines, which feature updated cylinder heads and new valvetrains, supporting greater high-rpm performance and durability. The catalog is available from Chevrolet dealers or can be downloaded at vwww.chevrolet.com.

Cold Weather Battery Charger

CTEK has introduced its new MUS 4.3 POLAR, a 12V, 4.3 battery charger specifically designed to offer excellent all-around charging with special cold weather performance. The POLAR mode is a special cold weather feature that delivers a higher 15V charge to ensure a 100 percent charge is achieved, even in the coldest conditions. It is available on the 0.8A, 4.3A and AGM Battery settings.

The charger comes with an extreme cold weather resistant cable to protect against cable breakage in cold weather. The company says it works in temperatures as low as -22°F (-30°C) and is approved for outdoor use.

For more information, visit www.smartercharger.com or phone 330-963-0981.

OBDII TPMS Decoder/Activator

For vehicles requiring an OBDII relearn, ATEQ's VT55 OBDII kit includes a universal OBD connector which interfaces with the vehicle's ECU via CAN bus or K-line. Service technicians only have to select the make of the vehicle, trigger the tire sensors and transfer the IDs.

In addition to all US-manufactured vehicles, the ATEQ VT55 OBDII reprograms Asian or European vehicles (including Toyota, Honda, Nissan, Hyundai, Kia, Subaru, etc.), which do not feature a TPMS "learn mode". It's just that easy and fast to accurately activate and decode TPMS sensors, and display data or any sensor faults.

Everything needed to get started and complete service is included in a convenient, heavy duty case: the VT 55 OBDII tool, USB cables, PC Driver, software and instruction booklet. For more information, visit www.ateqtpm.com.

Color Matching Spray Out Cards

Creative Autobody Solutions has introduced TruColor plastic spray out cards. These patented cards are used by professional automotive painters to better match the color of the plastic bumper to the adjacent steel body panel.

The cards are composed of the same OEM-quality material composition as automotive bumpers and motorcycle fairings, rather than commonly-used thin cardboard material or metal, so the final result on the bumper will more closely match the car. No more need to blend in adjacent body panels, or re-do the complete bumper if a customer is not satisfied.

The cards are available in black or gray and are available in a variety of quantities. Visit www.creativeautobodysolutions.com for more details.

Finish Line

Wandering Fulminations on High Performance:

...And the Saga Continues

"The older we get the faster our cars were."
-Attribution unknown

by Greg McConiga

As promised, the tale of the little Torino that could and the Ciera that couldn't continues -- please bear in mind that a lot of time and miles have passed since the events described herein, and some facts may be lost to the sands of time. The story, however, is as true as I can render it after forty years.

When we last left our hero -- that would be me -- he was stationed on the west coast near San Francisco at the Mare Island Naval Shipyard, bringing the U.S.S. Abraham Lincoln back from the dead. A complete refit of a nuclear powered fleet ballistic submarine takes several months, often stretching into a couple of years, and during that time I had earned enough leave to allow a road trip home to Indiana and back.

Reasonable and Proper

On my way out of California on I-80, I crossed over the California-Nevada border into the land of "Resume Reasonable and Proper Speed." This was pre-oil embargo Nevada, with the space -- and the state's permission -- to "let her fly" in the wide and vast western high desert. It was cold as hell that day, perfect for serious driving, and somewhere east of Sparks the road fell away from the high country and stretched out into a long ribbon of downhill, nearly new, straight-as-an-arrow asphalt.

I'd paid off the car and already started doing a few modifications to it, so naturally I thought I'd let it run out a touch, just to see what it would do.

As the needle passed right on by the end of the miles per hour marking on the speedometer it started bouncing off the trip odometer reset button, and shortly after that the tach needle was buried as well. The

engine was way past redline and was making a rather unnerving howl, while the car was meandering all over the road.

I was just about to lift -- when a Nevada trooper passed me going in the other direction. No problem! Reasonable and proper, right?

That phrase, as it turned out, was subject to interpretation.

I was way down the road, slowed to about 110 when I saw the lights coming up behind me like I was tied to a post. Holy crap, what kind of rocket-powered supercars do they drive out here? Now, being from Indiana, I'm thinking I'm about to spend a few nights in the Graybar Hotel -- back home if you're running something north of 120 and they pull you over, there is a real possibility you'll spend an evening or two getting to know the local law-breaking citizenry on a somewhat intimate level.

Instead, I got a chance to live a little longer, get a little smarter, and encounter the coolest police cruiser I'd ever seen in my life, up close and personal. Let me explain.

Strictly Professional

First, the lecture. The trooper was as professional as he could be -- at first. Asked for my license, registration, and proof of insurance, and I voluntarily handed him my military ID. You know, just for luck. And then he pulled me out of the car.

I'm trying to get a better look at his car. I can hear it idling and it sounds like it's running something a lot bigger than stock. It's a full-sized Plymouth or Dodge, like a Fury or Coronet, with one hell of a cam in it. Inside lights, no light bar, the grill is pushed forward, the bumper looks like it's been widened and frenched in, and the whole car is sitting low, like down on the road low. It's also got some

Courtesy Ford

serious looking possum-mashers on it, front and rear, no hubcaps, painted steel wheels, and the exhaust note was pitch-perfect -- deep, throaty with more than a little chop in it.

I'm trying to get back to look at his car as he starts in on me. He begins by telling me how stupid I am. I can see right away that we're going to be friends, because at this particular point in my life "stupid" wasn't so much the occasional lapse of reason as it was a lifestyle. He talks – yells -- at me about animals, road conditions, cross winds, blowing sand, tire design, and about how a 1972 Torino isn't designed to go that fast. Then we talked a bit about my sanity, or more correctly, my lack thereof.

No Mention of Heritage

I did not point out that I volunteered to serve on a ship designed to sink, powered by a whole-body ionizing radiation source. I thought it would not help make my case at this point. He never got around to my heritage, but I think he was working his way up to it.

He made me feel my tires, which were surprisingly hot given the fact that I was freezing my ass off, and finished up with the fact that I was getting a ticket, because 138 miles per hour was not reasonable and proper for a Ford Torino!

Well, hell, who knew?

Dreading the answer, I asked how much the ticket would be and was stunned to learn that all speeding tickets in Nevada at that time were $10, regardless of speed. Just mail it back in the convenient envelope. Okay, I can do $10, and didn't mention that I would have paid ten bucks just to see what this guy was driving, this unknown race car with radar that made a U-turn on a car running as fast as I was and then ran me down like a cheetah on a Chihuahua.

Specially Built, with Race-Prepped Big Block

Turns out it was a specially-built car, one of two or three that the Nevada patrol used to catch the rich punks with the European exotics coming out of California to test their top speed on the highways of neighboring Nevada. The car had a roll cage in it, a whole front seat full of VASCAR or whatever timing system might have pre-dated VASCAR, front and rear radar, and some kind of race-prepped Chrysler big block in it. The speedometer went to 220. I asked if it would make 220, and he kind of smirked and said, "Not quite."

I did get him to tell me that he hit 165 coming after me! No wonder I was taken aback by the closing speed. By now he had calmed down and we were just two car guys checking out his ride -- and that ride was one highly modified, seriously fast squad car. I even asked for a ride in it, but doing that required that I "be restrained," and I just don't look that good in handcuffs, so I respectfully declined.

Would've been fun though, wouldn't it?

Next month, a tale of married with two children, no money, and the most unlikely SCCA Solo II parking lot racer ever. Until then, make power and have fun.

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