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June 2014
V2 N3

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Starting Line

by Bob Freudenberger

Taboo!

Regardless of the dangers and laws, street racing is still a fact of life.

If you're a fan of old movies, you might remember the 1956 film Friendly Persuasion. In it, Gary Cooper is the patriarch of a Quaker family who is torn between his credo of non-violence and the need to defend his family and community during the Civil War. But there's a humorous part, too. Quaker men lived according to very strict rules -- no drinking, gambling, or chasing women -- and adhered to high standards of propriety. Cooper's character falls down in the propriety department, however, because there's one thing he can't seem to control: his desire to have the fastest horse and buggy in his little village. He simply can't resist racing the other Quaker men on their way to Sunday meeting, which was a serious breach of decorum.

When I saw that movie many years ago, it made me think about the phenomenon of street racing. I'm not a psychologist or anthropologist, but it seems to me that wanting to be the fastest is a genetically-determined impulse. The ancient Greeks conferred crowns of laurel leaves on the "fleetest of foot," and Native American foot races were an important part of the culture. Perhaps even Neanderthals and Cro-Magnons raced each other when they co-existed (the former might have been gorilla-strong, but my money would be on the slimmer, longer-legged latter). It's certainly deeply-rooted in all human societies.

Decades ago when I was the editor of Speed Shop magazine, I answered a technical question involving street racing sent in by a reader. Trying to be a responsible journalist, I also warned him about the dangers of driving with slicks on public roadways. Well, no sooner had that issue been published than I got a furious and very poorly written letter from the NHRA saying that I was promoting carnage on the highways by recognizing that people will actually race anyplace but on sanctioned tracks. I was young, and that letter upset me. I remained chagrined until I talked about it to a friend, then auto editor of Popular Mechanics, who put the situation in perspective. The NHRA, he said, had a "head in the sand attitude." Sure, people (not just kids, either) will race when and where the opportunity arises.

Hell, I grew up in farm country and we street raced ("road" would be a better word) regularly. There were no drag strips nearby, and if you made the trip to one the crowds and the regulations were both obnoxious. Besides, there wasn't much else to do in the evenings after a hard day's work. The most popular venue was Oakerson Road, as I recall, a long, straight stretch of crowned pavement that ran through wide fields -- nothing much to hit if you got out of shape -- and no side roads. There was an old farm house on one side, and the hippie-types who occupied it weren't about to call the police. In fact, they used to sit on the porch and watch while smoking illicit substances.

I don't think there was ever an accident, or even a close call (no traffic in those days), although there were some thrown rods and blown gears and universals. Certainly, there have been tragedies elsewhere involving racing on public roads and streets, such as the one in Brooklyn, NY a few years ago that killed a new bride and groom who crossed the wrong street at the wrong time.

Nothing, of course, can justify risking such horrors. You see this more clearly after you become a parent. In my case, the impulse hasn't gone away entirely, however. On a relatively-tame four-cylinder level, I had a strong desire to drag my neighbor, who was way too proud of the performance of his turbo Passat. I just knew my Prelude Si, which I'd tweaked, would be way out on him by the time his engine's artificial respiration took hold, and he wouldn't catch up. We taunted each other about it, but we never found the time or a safe-enough road to actually do the deed. The possibility of big fines was another disincentive.

Regardless of the dangers and laws, street racing is still a fact of life. I'll go on record here as advising HRP readers against the practice -- the thrill just isn't worth the likely consequences. If you must, be sober about it, choose a deserted area, and realize that that blast of testosterone will cloud your judgment and cause you to take chances. ■

High-Performance Brake Upgrades, Part 3: Friction Material

So far we've looked at the components that supply the pinching force and the ones that spin off all that heat. Here we'll talk about the interesting subject of lining "recipes" and what you should choose for your hot car or truck.

by Bob Freudenberger

If you were around cars (or around at all) before the wholesale adoption of disc brakes in the mid-1960s, you might remember a couple of attempts at making drum brakes less apt to fade in heavy use. The first was sintered iron shoes (you could call them "full-mets"), which were used in some Corvettes, on highway police pursuit cars, and in racing. They handled heat quite well, but until they got warmed up you needed both feet on the pedal to stop at the end of your driveway. Then there were the expensive finned-aluminum drums with iron wear surfaces that appeared around 1960 on certain Buicks and Pontiacs. No amount of lining materials change or engineering, however, could overcome the basic drawback of the drum brake: It's not good at shedding heat. After all, if you need to keep something hot you could hardly do better than to put it in what's essentially a Dutch oven.

No, disc brakes represented the design departure that made safe deceleration from high speeds, especially repeatedly, a practical proposition. They had other advantages, too, such as much lower sensitivity to immersion in water, fewer pesky parts to deal with during a reline, and the pads in those heavy early multi-piston calipers seemed to last forever.

What's in your caliper? You can bet the big Brembos on this Ferrari are loaded with pads that bear lining material exactly matched to the job (courtesy Brembo).

The resistance to this technological shift in the service business and among tradition-bound auto experts was almost humorous. It was said, for example, that only dealerships would be able to work on these new-fangled decelerators -- independent garage "mechanics" simply couldn't deal with them. Well, we don't know about you, but we'll race you any day hanging pads while you install new shoes and fiddle with all those springs, star wheels, levers, and cables.

For 15 years or so, however, disc brakes used the same old asbestos for lining material. Then, two things happened. First, the dust from that fibrous mineral whether in brake-component factories or service shops was linked to serious lung disease. Second, as brakes were lightened and downsized in the quest for fuel efficiency, and cars got overdrive and were made more aerodynamic so that they didn't slow down as much when you took your foot off the gas, we needed a better material anyway to combat the dreaded fade.

Never-ending quest

The history of the quest for the ideal friction material has been sort of like a drawn-out version of Thomas Edison's search for a suitable light bulb filament. All kinds of things have been tried since the automotive era began 120 years or so ago. The spoon brakes used on the first cars usually had wooden blocks, but they were sometimes supplemented with a leather lining. External band-type brakes were either metal-to-metal, or used wood or leather, too. The earliest drum stoppers (invented by Louis Renault in 1903) had iron shoes against steel, then some strange materials were used, such as the walrus hide linings of the English Wolseley.

The credit for first taking a scientific approach to friction materials goes to an Englishman, Herbert Frood, and Ferodo, the company he started early in the 20th century, which is still going strong as part of Federal-Mogul. Using a water wheel-powered friction test machine, Frood experimented with numerous materials (even cotton!) and bonding agents in 1879 (no cars yet, but there were many potential industrial applications) . In 1902, he hit upon resin-impregnated woven asbestos reinforced with brass wire, and the era of safer stopping began.

We'd better get our terms straightened out before we go any further. In the brake business, asbestos linings were called "organic," which is really a misnomer since only something derived from living organisms fits the dictionary definition of the word. It's applied to asbestos because it occurs naturally. Now, with all kinds of unusual materials being used, organic has come to mean anything that's not metallic or ceramic.

Semi-mets were the first step. Basically, these are steel wool, iron powder, and other metal particles molded together with a phenolic resin binder. They're very good at handling heat, but early recipes had big problems with noise and tended to eat rotors and drums.

As a spokesman for one of the major aftermarket brake parts manufacturers says, "The early replacements for asbestos were very aggressive on rotors, very noisy, and very challenging." Those of us who were around then remember the distress all that caused very well.

Then came non-asbestos, non-semi-met linings, called "NAO" (Non-Asbestos Organic -- there's that term again). All kinds of mixtures containing such things as aramid/Kevlar, fiberglass, carbon fiber, nut shells, different kinds of metal wire and particles, etc. are used, the goals being long wear, good friction characteristics, preservation of rotors and drums, and quiet operation, which they accomplished to a greater or lesser extent.

What the heck is this all about? This '27 Model T rod looks like it has 1960-style Buick finned aluminum drums. But wait. There's a Wilwood caliper sticking through the backing plate, and you can see a disc if you look closely. So, the fins are just very cool window dressing (courtesy Richard Rossi & Wilwood).

If you're not exactly racing, but instead engaging in what the Brits call "sportive motoring" on challenging roadways such as the Tail of the Dragon in the Smoky Mountains, you'll still appreciate the sense of security and the great feel of high-performance linings. This Mini Cooper has EBC Redstuff pads, which did great in all the tight curves and steep downgrades (courtesy EBC).

In 1873, Englishman Herbert Frood was the first to take a scientific approach to developing brake friction material (courtesy Ferodo).

Then something most of us would've considered far-fetched appeared: ceramic friction material. When we first heard of this back in the 1980s, we visualized bricks or chunks of concrete against the poor rotors, and wearing them down fast and relentlessly. We quickly learned, however, that ceramics have lots of positive benefits, enough so that most linings on the road today are on this material basis. They're actually kind to rotors, very quiet, and make little dust to spoil the looks of those beautiful wheels. They contain a high percentage of ceramic fillers along with a non-ferrous metal, such as copper.

Now, regulations are appearing in Washington State and elsewhere that are forcing friction material makers to phase out copper and other metals -- it's said that they're dangerous to fish! The manufacturers are making adjustments to meet the regs, and some have been successful already.

Fade is the most dangerous among many other factors

While we discussed fade in the last installment, it bears repeating. Normally, it won't be a big issue in one instance of hard decel even with stock brakes. It can sure get scary, though, with more than that, or when trying to keep control on long downgrades, say in the mountains. When it occurs, even the strongest human leg muscles won't stop you.

"Out-gassing" from the evaporation of the chemicals in the resins that hold lining materials together was implicated in the past -- it made

Left: Frood's company, Ferodo, is still going strong making O.E.-quality and premium performance linings, such as the ones on this rally car in South Africa (courtesy Ferodo).

the linings “aquaplane” over the disc friction surface. That phenomenon, however, has been mitigated in modern high-performance pads from reputable manufacturers, and a proper “bedding-in” procedure (we’ll get to that a little later) also helps.

Still, you’ll be apt to experience less braking power and a pedal feel that doesn’t instill confidence if you’ve chosen linings that aren’t formulated for the kind of driving you’re doing, say road racing where rotor temps may exceed 1,000 deg. F. If you do manage to overheat your brakes, it can cause even high-quality, high-temp friction material to break down and “smear” onto the rotor

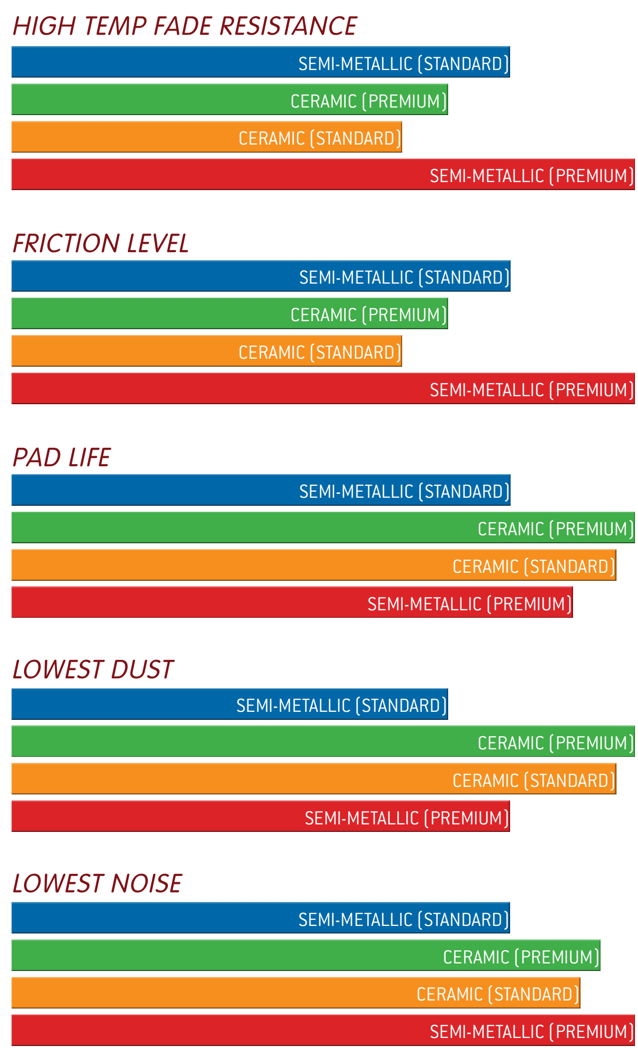
Boiling fluid is another likely cause of frightening fade during heavy-duty braking, as in pedal-to-the-floor fade. We have a feature planned on that topic for a future issue of HRP, so all we’ll say here is that you should change that hydraulic medium frequently.

Since boiling fluid caused by overheated brakes will cause a truly terrifying type of fade, as in pedal to the floor and no decel, you can switch to something like this 600 deg. F.-rated DOT 4, and change it regularly (courtesy Stop Tech).

Why? Because at less than 4% water, the boiling point of regular DOT 4 drops over 130 deg. F. That may sound like a lot of moisture, but we’ve taken samples out of cars that were 40% water.

And so to bed

Perhaps because in the old days linings were supplied “green,” or “raw,” there are still plenty of fallacious opinions out there about how new



Here’s one brake parts company’s comparison of semi-mets to ceramics, both standard and premium. Others may disagree, but you get the idea (courtesy cquenvce).

linings should be bedded in. As one aftermarket brake expert puts it, “It’s not unusual to see a perfectly good brake job ruined in the first five minutes by improper break-in.” Or, as Wilwood’s tech literature says, “Remember, the proper break-in of pads and rotors is extremely important. Not doing it properly can cause permanent damage to rotors and adversely affect overall brake performance. Pads and rotors interact with each other to provide efficient brake performance. The break-in or bed-in procedure is done to condition the pad/rotor interface. Depending on the pad being used, more or less pad material is uniformly transferred onto the disc as a thin film. The resins and bonding agents in some pads need to be heat cycled to work properly as well. By not properly bedding in pads, uneven pad material deposits can occur that may cause a vibration. Improper wear characteristics may also show up on either the pads, or rotors, or both.”

Some high-perf linings are “scorched” before delivery, meaning they get a super-heating process that forces any uncured bonding agents and impurities out of the friction material and pre-burnishes the pads to accelerate break-in and enhance consistent performance, cold or hot. Others are given special coatings that are supposed to do the same thing, but neither is justification for neglecting a sensible bedding-in procedure, to wit:

1. As long as it’s not deeply grooved and doesn’t have enough DTV (Disk Thickness Variation) to cause pulsation, a used rotor’s surface is the best thing to get new linings started on, believe it or not.
2. After installing the new pads, you do always pump the pedal a few times before moving the car, right?

3. Take it easy! Drive where there's no traffic, and do a series of light decels -- three to five seconds each, with maybe 10 seconds between -- to generate the initial heat. A dozen or more of these is good.
4. Follow that with numerous firm stops to continue heating the brakes. If you feel any fade, drive for a while at cruising speed without touching the pedal to cool things down.
5. Get 'er up to 60 mph or so, and brake hard down to 25. Speed back up to 60 and drive for at least 15 seconds before braking hard as above. Repeat this 10 times. Again, if you sense fade at any point, cruise for a few minutes.
6. Park it and leave it alone.

NOTE: DO NOT sit stopped with the pedal applied at any time during this process as it may cause "pad imprinting" wherein a thin layer of lining material is transposed onto the discs. This can result in pulsation.

That last note brings up the fact that almost all linings are "adherent," meaning they are formulated to transfer a layer of material evenly to the rotor's wear surface. This layer provides optimum braking performance, and anything that interferes with its formation should be avoided.

Suppose you install high-performance pads, but you never drive aggressively enough to get them up to their optimum operating temperature. The proper transfer of material won't occur and you'll end up with bumpy braking and poor performance. Once again, correct bedding in for the chosen material is the answer.

Practical points

So, what should you do? It all depends on the kind of driving you're actually going to do. Get over any delusions of grandeur you may have -- if you're not really going racing, you don't need (and shouldn't even want) true racing pads. If you put them on your car, you'll get a hard pedal, poor stopping when cold, and noise, and you'll eat up those rotors. Plus, you will have spent too much money.

That doesn't mean you shouldn't upgrade to high-perf street linings. They're great protection against fade, and you can live with them. They may do all you want without the need for a "big brake kit."

The best advice we can give here is to research, research, research. Go to the sites of all the best-known performance brake manufacturers and read their tech literature, paying special attention to what's suggested for the kind of use you intend for your vehicle -- realistically.

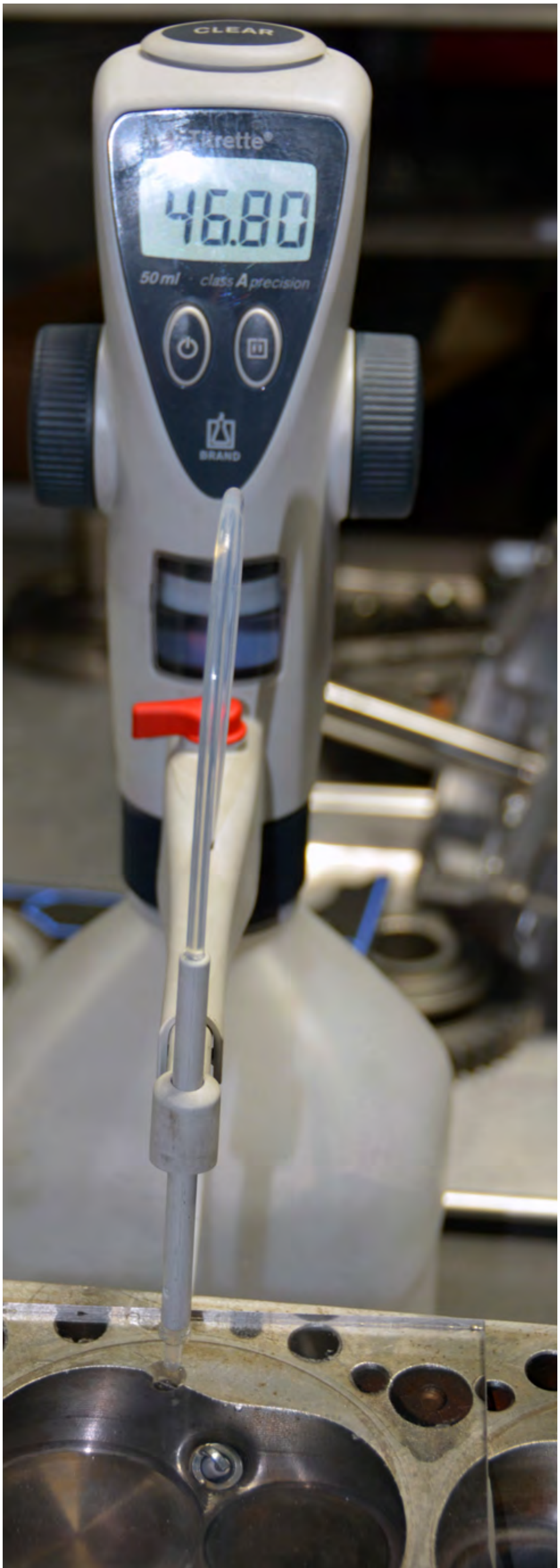
Reputation, reputation, reputation. If you choose high-performance pads from the selection offered by well-known and respected manufacturers, you'll know their characteristics beforehand. One big problem: counterfeiting. Be very sure of your suppliers (courtesy Hawk).

THE HOLIDAYS ARE COMING EARLY THIS YEAR....

CC Rider, Part 1

With apologies to Mitch Ryder, the Detroit Wheels and many, many others....

by Greg McConiga



With apologies to Mitch Ryder and the Detroit Wheels and many, many others, what we're talking about here is a bunch of "C" words -- cubic centimeters, combustion chambers, compression, and calculation.

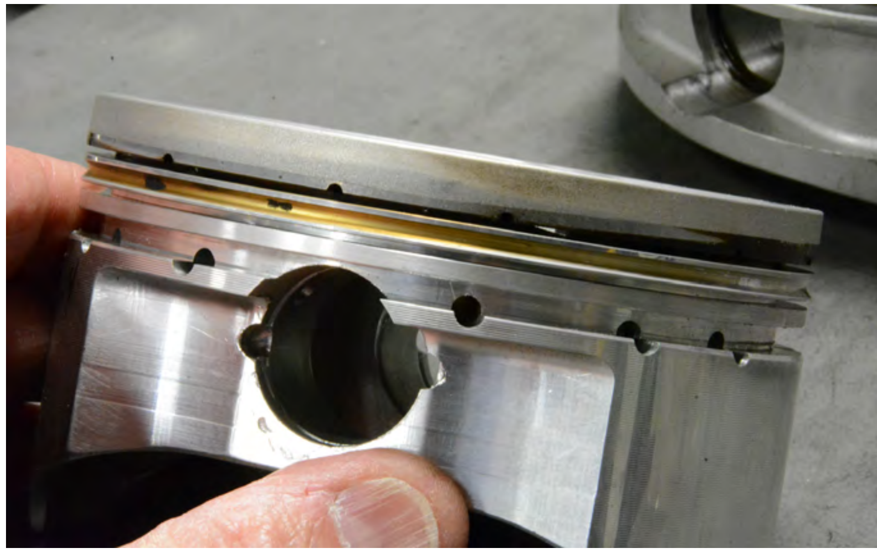
Professional engine building can be one of the most tedious occupations in which a person can find himself engaged. Because each combination tends to be unique based on the application, rules, and intended use of the completed project, every measurement, every bore, and every part has to be checked on every build. One of the most critical things to know involves volumes -- of intakes, of cylinder head runners, of exhaust runners, and, of course, the most critical of all, the total volume and clearance volume of the cylinders themselves, which is how we calculate the true mechanical compression ratio of an engine.

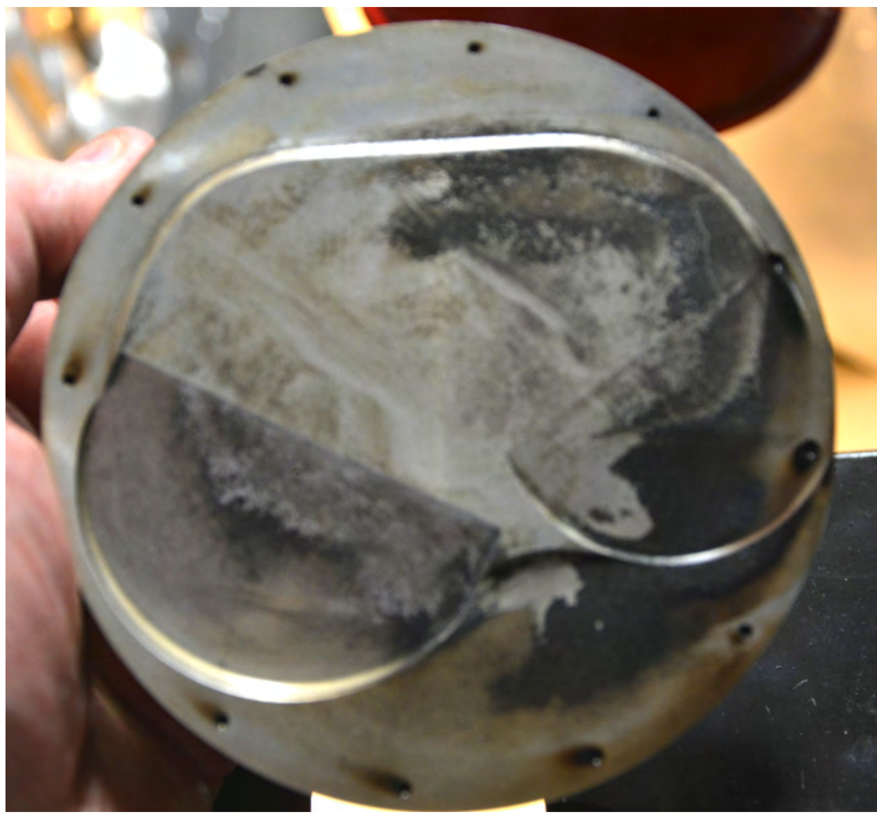
It Might Not Be What You Think

Have you ever heard someone say, "Oh yeah, she's really built -- I put 12.5:1 pop-ups in her"? But if you ask what the engine runs for compression, the guy really has no idea. It MUST be 12.5:1, right? Uh . . . not really. Compression ratio is more than just the configuration of the piston. It involves chamber volumes, valve relief notch volumes, swept volume, head gasket volume, and the volume above the ring. Your actual compression ratio could be a lot more and it could be a lot less! For example, in a recent build, a set of flat tops with valve reliefs ended

Left: These cast iron Air Flow Research heads are rolled and feature shallow combustion chambers. A typical small block Chevy runs in the 65-75 cc range where these run 46.8 cc's.

up being 11:1 on a 74 cc chamber... which is actually a pretty big chamber for today's engines. Sticking a set of "12.5:1 pop up's in her" would have been a disaster! This engine was designed to run on pump premium because the solid roller cam used ended up reducing the dynamic compression down to just under 8:1, the upper limit for 93 octane pump premium. More on that later . . .





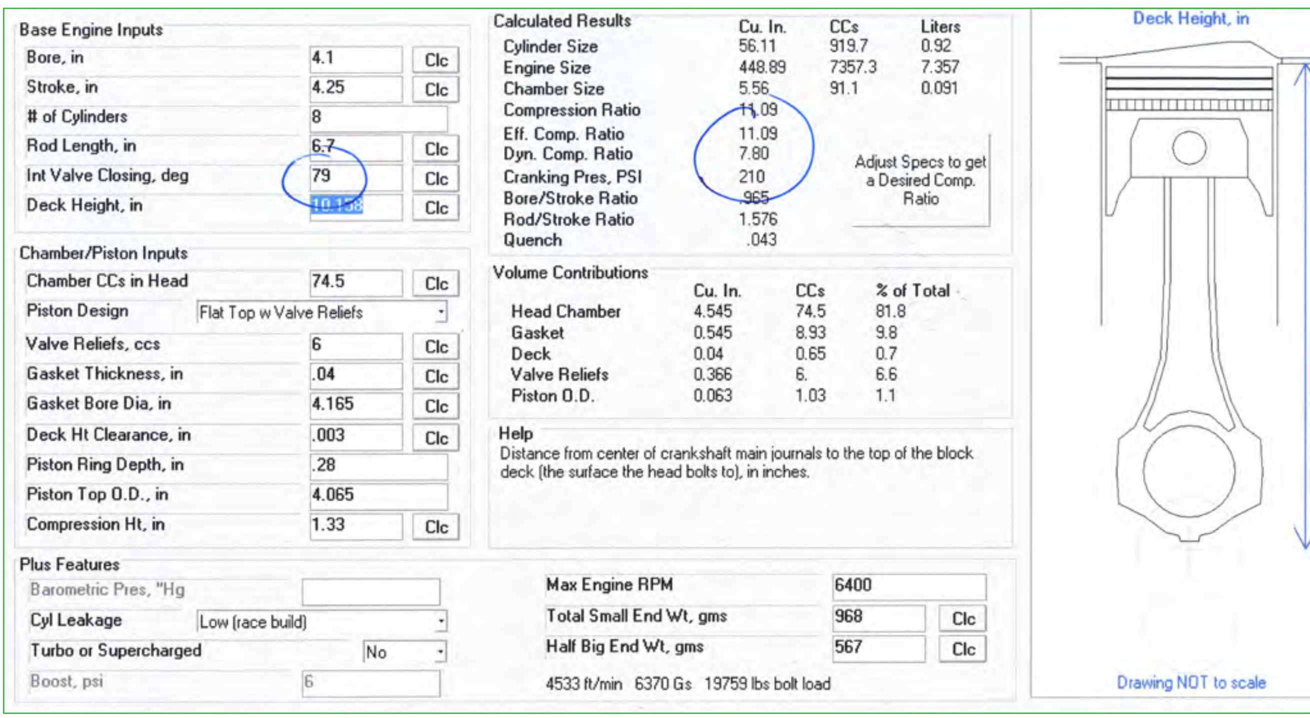
Two Kinds of Compression

First of all, we have to talk about the two kinds of compression. There is the mechanical compression ratio, the one we measure by simply dividing total volume (the cylinder volume measured when the piston is at BDC) by the clearance volume (the volume remaining after the piston is at TDC). Then there is dynamic compression ratio,

Building compression is all about sealing the cylinder. Gas porting is used to "advance" ring timing by pushing the ring out firmly against the bore earlier. Gas porting does not increase bore wear, it just seals the cylinder more quickly and efficiently. There are two ways to gas port: You can drill down from the top in behind the ring and you can drill in horizontally just above the top ring. The goal is to allow compression pressure a fast way into the backspace so that the ring seats more quickly. Vertical gas ports are more prone to carbon fouling than horizontal ones, but on drag race engines that are torn down for annual maintenance it's not really a consideration. If you're building duration engines, you might want to use horizontal gas ports.

which is the actual operating compression the reacting fuel and air mass sees once the intake valve goes completely closed. An engine cannot begin building compression until the cylinder seals and it's not sealed until the inlet valve is closed, and by closed we mean on its seat. To find the seat figure, you have to actually measure the valve at the retainer. Otherwise, you won't account for the effects of rocker ratio and pushrod geometry. Even with the valve on its seat, sealing is less than perfect since the piston rings aren't completely sealed until cylinder pressure builds enough to hold the ring firmly on the bottom of the land and the back space is pressurized to push the ring firmly against the cylinder wall.

This, by the way, is why you see gas ported pistons. The pressure is routed into the back clearance behind the ring earlier in the compression cycle, which seals the rings earlier. To dispel an old wives' tale, gas porting does not increase cylinder wear. The total pressure behind the ring will end up being the same; it just peaks earlier with gas ported pistons resulting in quicker and more positive ring sealing. Ring sealing timing accounts for the slight variations in the programs that calculate dynamic compression, and

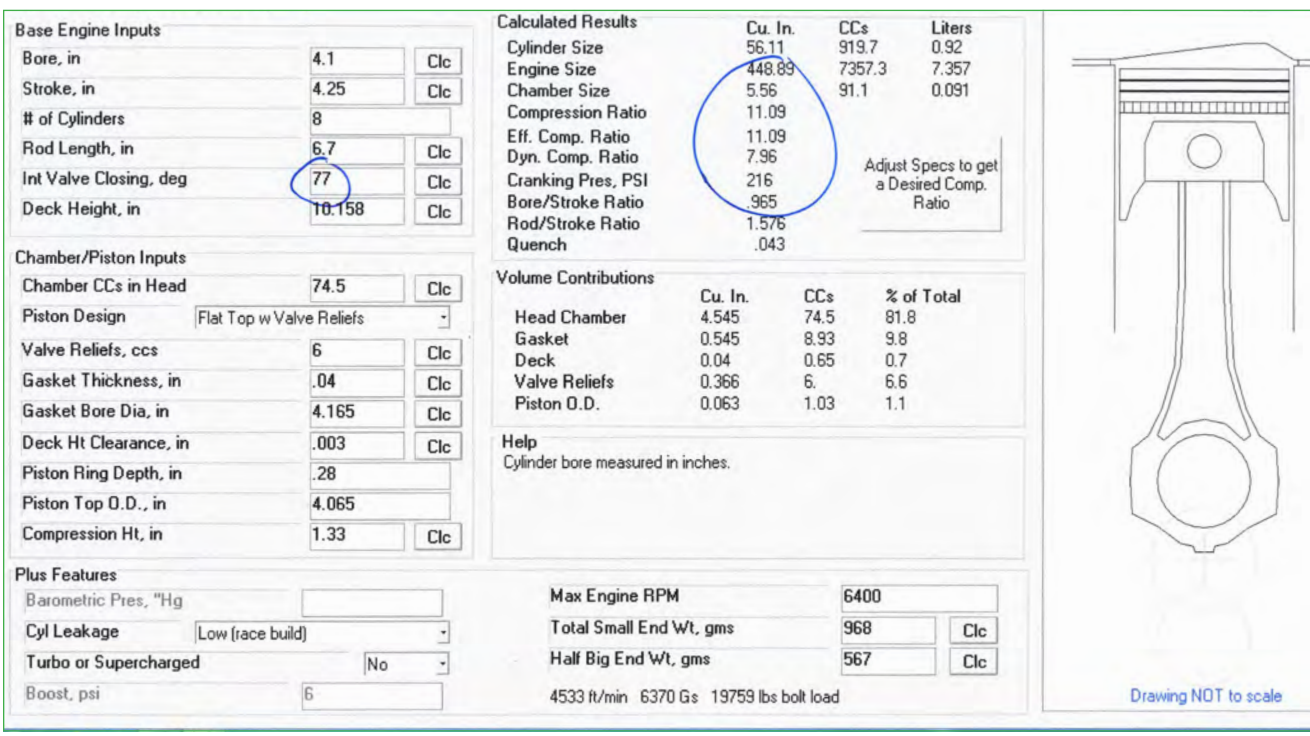


Cam timing - two degrees retarded: This compression program from Performance Trends is dead accurate IF you get the input data right. It will predict compression pressure within two or three pounds! What's nice about it is that it lets you run different iterations and see what effect your changes have. I just finished taking compression readings on a project and the program predicted compression readings of 198 psi -- and my actual readings were 195-202 across all cylinders. Static was 10.80:1 and dynamic was 7.50:1. Pretty impressive if you can get that close with a computer program! Here you see the effect of cam timing at two degrees retarded. Keep an eye on the dynamic ratio and the predicted cranking pressure as you advance the cam.

it's why you often see that the predicted compression pressure is just a bit less than the actual measured compression pressure. The accuracy of the computer-generated predicted compression pressure improves dramatically as the wall finish, ring selection and piston fit improves. On race engines, it tends to be right on the number, and on street applications the predicted pressure is usually slightly higher than actual, in perfect keeping with the difference in high-quality racing parts and good quality street parts. With the right kind of equipment, you can find a direct correlation between computer-predicted pressure, cylinder leak-down, and compression pressure as recorded on the compression gauge, but to get that correlation you'll spend at least a thousand dollars each on your cylinder leak-down tester and your compression gauge.

Despite What You Hear Too Much Isn't Just Right

So, how much dynamic can you run? Well, it varies (doesn't everything in a high performance application?), but in general you can run about 8:1 dynamic on the street, which will give you compression gauge readings of 190-205 pounds per square inch. Too much over that and you'll have to start looking at racing fuel or octane boosters. I can tell you that at 225 psi on an iron-head 1970 Chevy



Cam timing - As installed - No advance or retard: By moving the cam timing just two degrees, you can see the effect on dynamic compression and the cranking pressure. The dynamic moves nearly .2 of a point and pressure goes up to 216 psi. Not a big deal you say? It may be more than you would think: At 210 psi you're at the upper limit for premium pump gas, and at 216 you're moving into additive and race-fuel territory. There are other factors that will move the maximum allowable compression higher or lower, but you're in dangerous territory if you hope to run 93-94 octane pump gas.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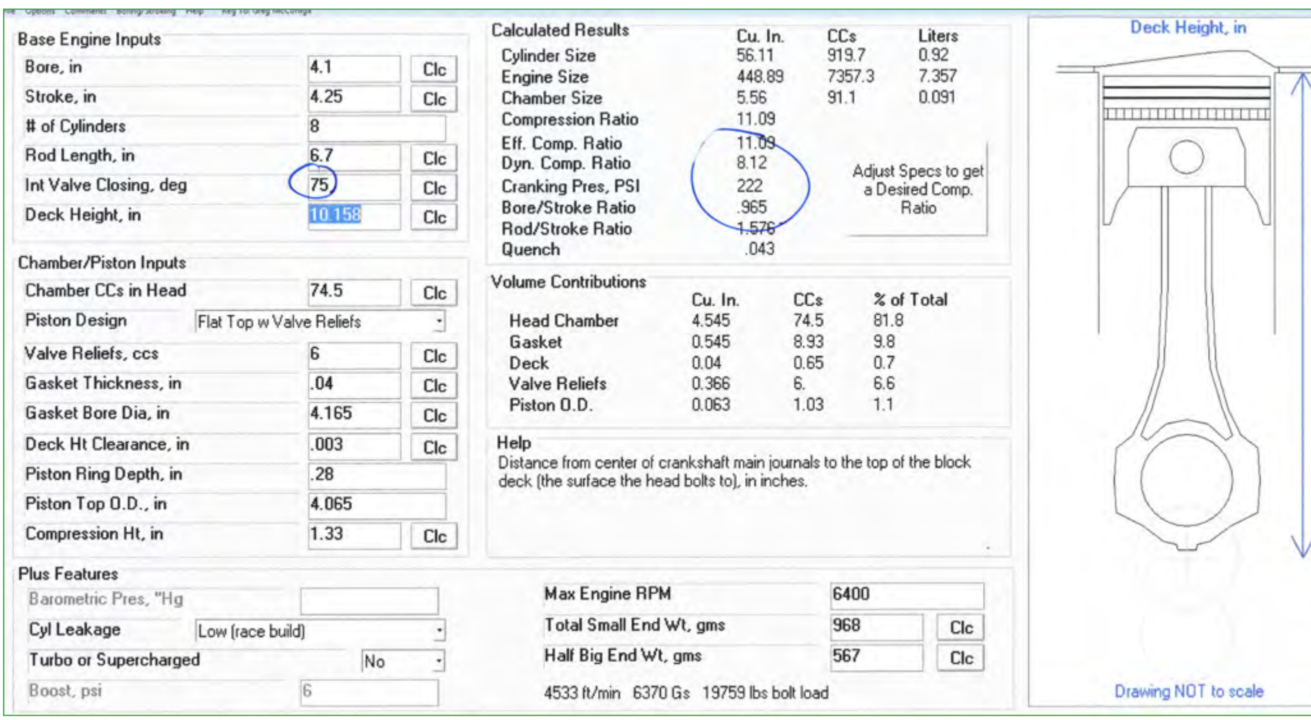
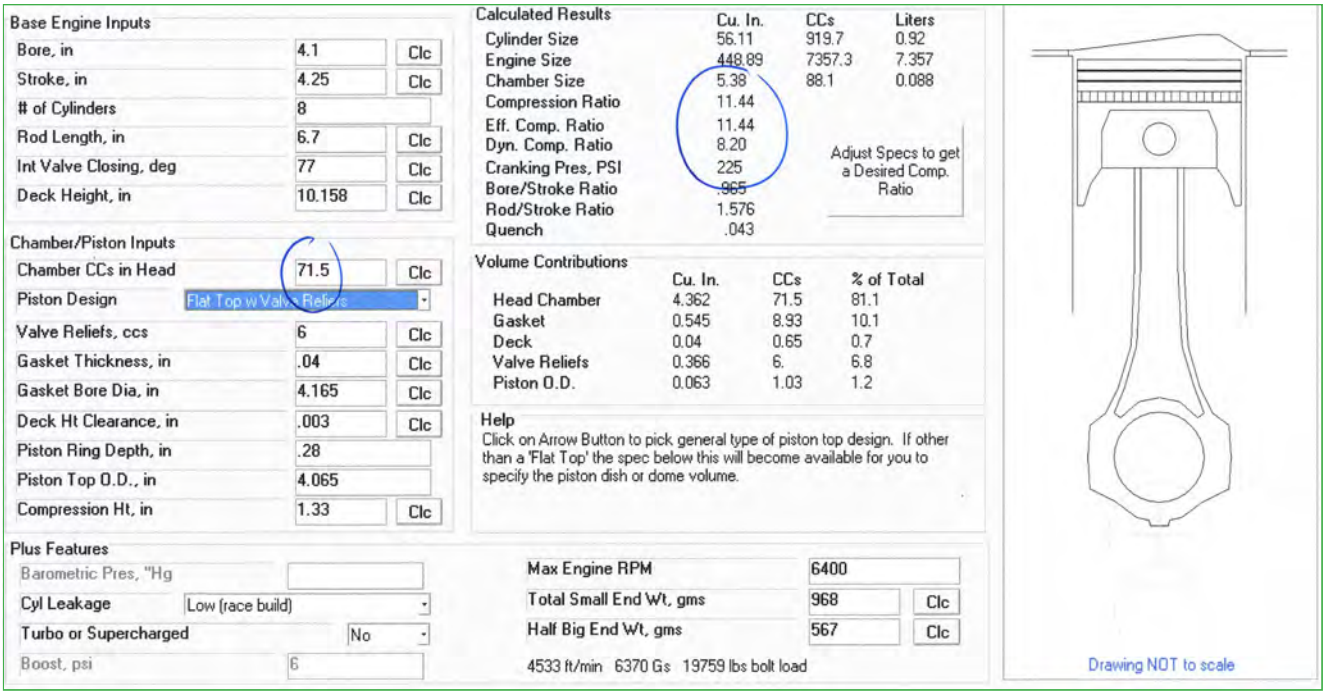
engine you will detonate hard on 93 octane pump gas.

For racing engines, again it varies. I generally see most engines at something between 9:1 and 9.5:1 dynamic, with cranking compression pressures at 225-290 psi. There are exceptions (really?). I've seen restrictor plate engines over 10:1 dynamic with compression pressures over 340 psi, but you'd better know what you're doing if you wander up into that territory!

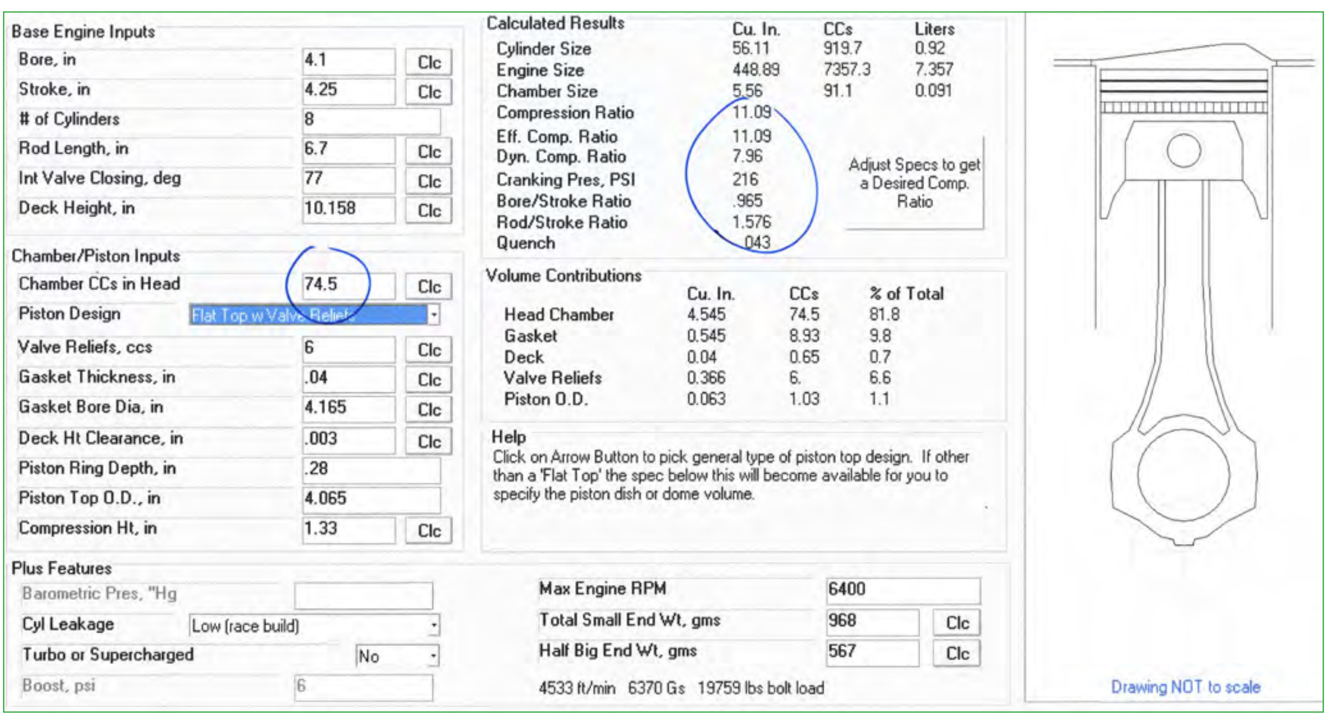
Programs like those written by Trend Performance will make your compression ratio calculations fast, accurate, and easy, and the screen shots shown will quickly explain all the variables you'll need to consider when calculating actual compression. The program calculates dynamic compression ratio, quench, rod-to-stroke, bore-to-stroke, and cranking pressure. It's amazingly accurate IF you get the data right! I've had several engines that I ran the program on and it got the cranking pressure within a couple of pounds. Take a second to look at the screen



Cam timing - Two degrees Advanced: Okay, now you're in the soup. Just another two degrees advanced and your dynamic is up to 8.12:1 and your compression pressure is at 222. I can tell you for a fact that an iron-head 350 Chevy 350 hp will detonate like crazy at 222 psi on pump premium, even with the timing trimmed back as far as possible while still maintaining reasonable torque. Aluminum heads, fast burn chambers, and a highly efficient cooling system can help control the detonation, but you're walking a fine line here if you're looking to fill up at the local gas station. Compression is good, but too much cranking pressure makes tuning a nightmare. Sometimes you will make better power with less cranking pressure and a more aggressive tune than you will with too much compression and a tune-up that covers up a poorly-thought-out build.



Chamber volume - 3 cc's smaller: Now let's look at what happens if we hold the cam timing steady and vary the chamber volume. If we reduce chamber volume by just three cc's, the static increases by nearly .35 of a point, the dynamic rises by .24 of a point, and the pressure increases from 216 to 225 PSI. The volume we're talking about here isn't much -- it's only about 60 drops of water! Drip 60 drops of water in your palm and see just how little that is.



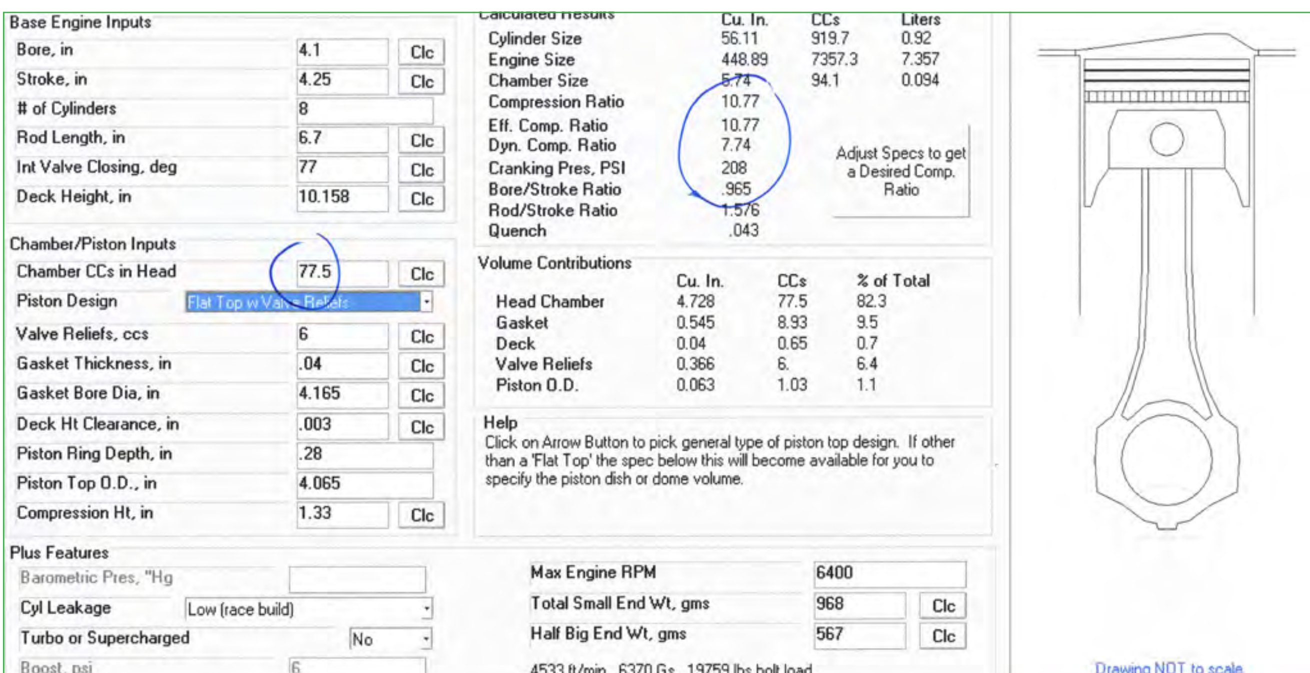
As Built - Actual Compression pressure 205#: Here are the as-built readings. Compression pressure came in a bit lower than predicted, but that's probably because of push rod geometry, which is affecting actual valve closing timing. I'll have to check net lift and net valve closing timing on the next angled pushrod engine I build.

shots and the data the program asks for. Also study the screen shots showing the effect of cam timing and chamber volume on static and dynamic compression. It doesn't take much to go from "okay" to "oh, no!" One cc is twenty drops, and six cc's will take you from good to bad, and that six cc's can be gained or lost anywhere in the clearance volume.

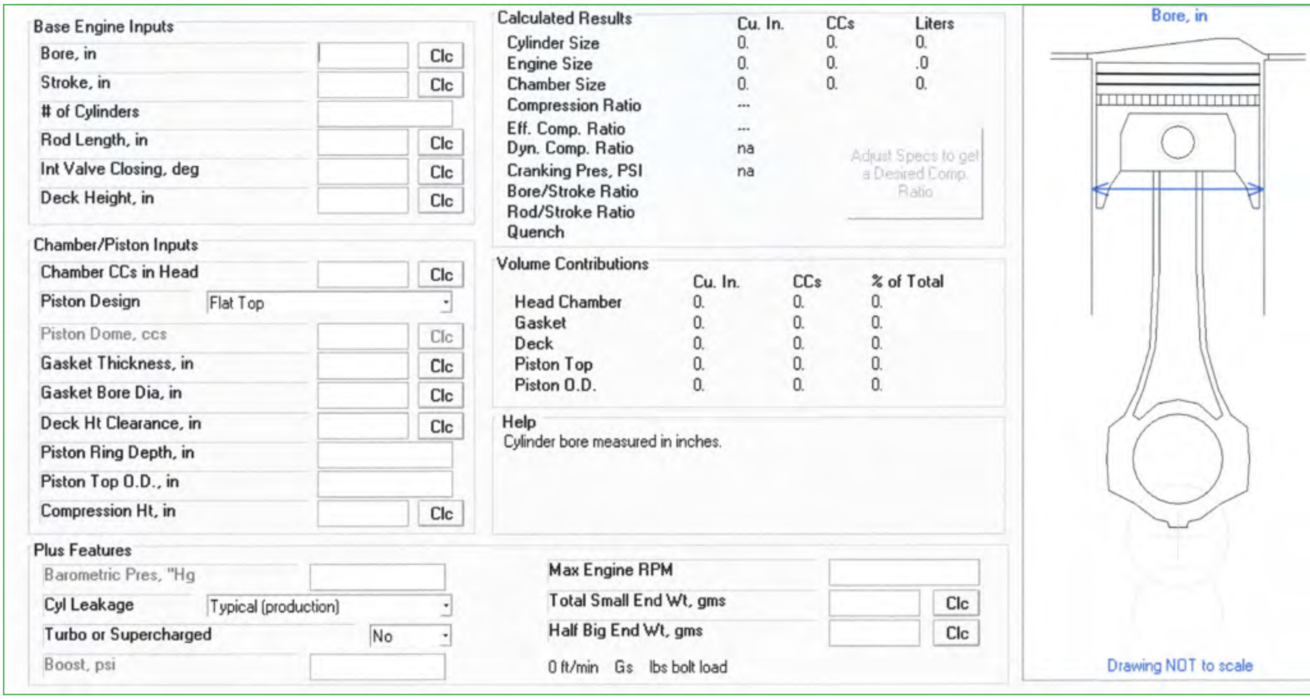
Static

What is static compression and why is it important to us? At what point in the design process do we need to begin thinking about compression ratio and compression pressure? Addressing the second question first, we have to begin thinking about compression ratio and pressures right from the first -- from the time pen touches paper in our design process. It is critical to engine power and it has a direct effect on engine component selection, including, but not limited to, cylinder heads and camshafts, which are the two parts most responsible for power and performance.

Compression ratio and pressures are also very application-specific. For example, if you're running an air-limited application such as a restrictor plate or a small carb on a big-displacement engine you can and should increase the compression ratio to make up for the intake vacuum created by an oversized air pump pulling against the undersized fuel mixer system. In cases where the engine is air-limited you may run compression up to as much as 18:1. You may also see extremely high compression ratios on engines operating at extreme rpm. If you're attempting to fill a cylinder and empty it at extreme rpm, closing the intake very, very late and initiating exhaust blow down very, very early works to your advantage.



Chamber volume - 3 cc's larger: Increasing chamber volume 3 cc's from as-built drops static to 10.77:1, dynamic to 7.74:1, and predicted cranking pressure to 208 psi. It doesn't take much, does it?



If you want to get accurate compression readings, you'll need all the readings you find in this screen shot of the compression program. To calculate dynamic compression, you'll need to calculate total cylinder volume at the time of intake valve closing and divide that figure by your clearance volume. You can do all this by hand -- it just takes a minute. It's changing all the variables and seeing what that does to your proposed build that takes all the time. Plus, you can make errors doing it by hand. The program is worth every penny in my opinion.

Notches, walls, dams, and domes -- tons of surfaces that pressure waves can reflect off of and coalesce against. It's amazing that we made the power we did with everything going on in this design. The "noisier" the chamber, the more attention needed for the tune-up and fuel curve. Definitely not a forgiving design.

What Was That Again?

Compression ratio is what we build and what we measure, but it's really the expansion ratio that most concerns us. The pressure decay curve on the expansion side during the power stroke is what dictates how much power can be extracted over what rpm range. A high compression ratio engine has a much steeper pressure decay rate during the power stroke, and therefore most of the work and more work can be extracted farther ahead of BDC. This in turn means that we can pop the exhaust valve open earlier, which then extends the blow-down period. This creates a higher pressure/velocity exhaust pulse, which improves exhaust-driven cylinder fill during overlap, which in turn reduces intake charge dilution, and that results in improved volumetric efficiency. It goes without saying that increasing the compression ratio also changes the cam valve overlap, lobe separation angle, and duration design parameters.

You can also see that as you increase compression ratio you are also able to decrease the size of the exhaust valve and increase the size of the intake because as the blow-down period increases with earlier exhaust valve openings, you can use a smaller valve to achieve the same gas exchange efficiency. Higher pressures for longer time periods drive higher flows through smaller openings. Increasing the size of the intake valve is ALWAYS a good thing (up to the bore limits) because the differential pressure across the intake is limited to the difference between the negative pressure above the falling piston during intake (typically only 10-30 inches of water) and atmospheric pressure (14.7 psi at sea level.)

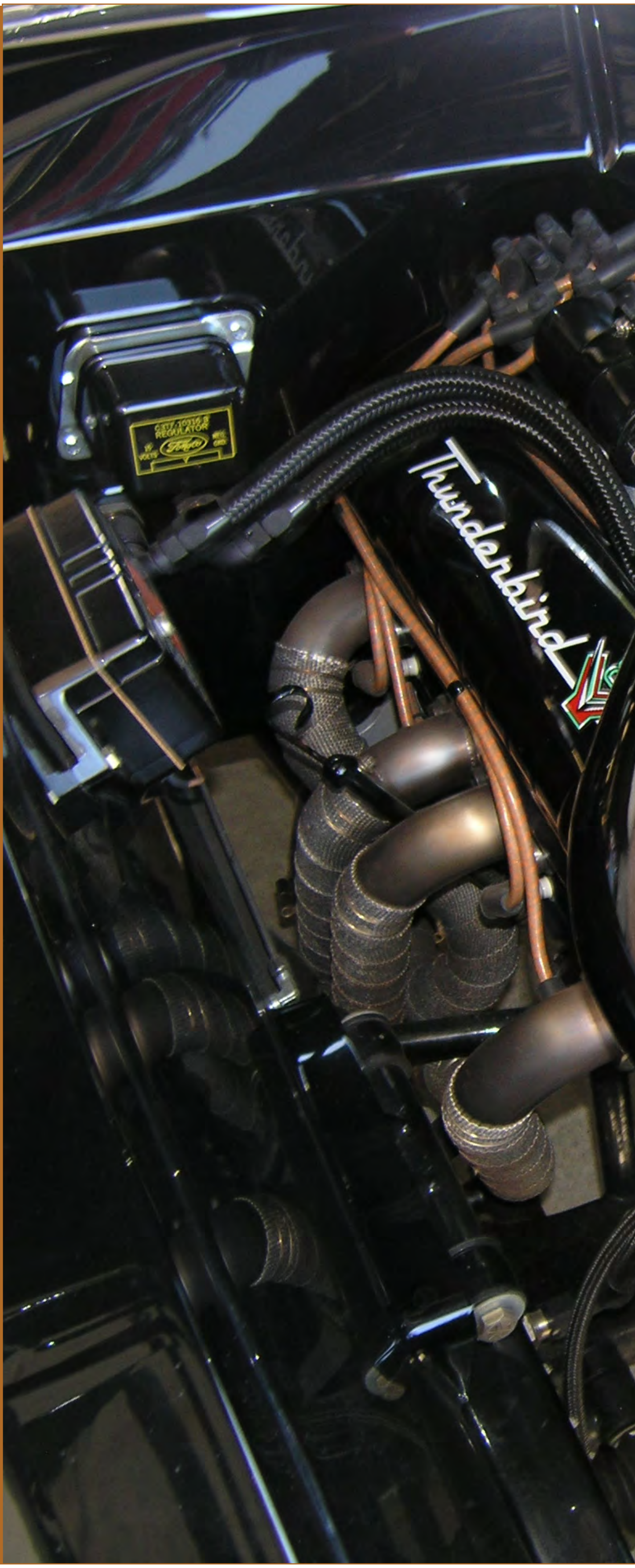
The intake side is always a bigger problem to make flow efficiently than the exhaust side because we may have 60-90 psi of pressure differential at exhaust valve opening versus a total of 16 psi difference across the intake valve. The exception to this pressure differential on the intake side occurs during overlap on a properly-designed and highly-tuned racing engine when the negative pressure created in a properly tuned exhaust system reaches as much as 120 inches of water, making total pressure differential across the inlet valve something on the order of 18-19 psi. Better, but still significantly less than the exhaust side. For any given bore diameter, you only have so much room to stuff two valves in a parallel- or stagger-valve engine (we aren't talking hemis here; they're a special case), so using higher compression to help increase intake valve diameters only makes sense. ■

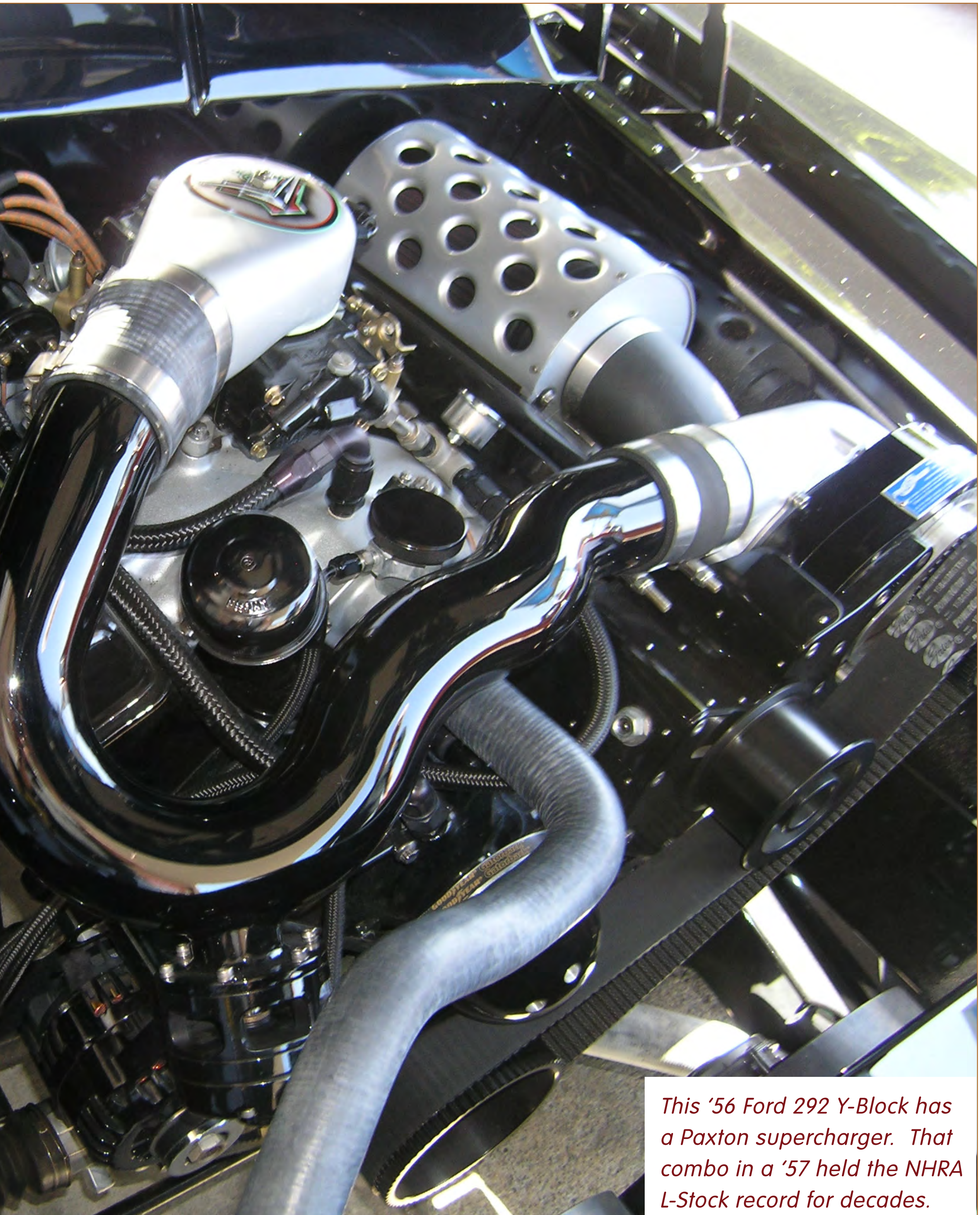
Here's an example of a piston used on shallow combustion chambers. If you can put a flat top in an engine, it will always produce the most consistent and uniform combustion process. Domes add complexity and one more variable you'll have to engineer around.

Tuning a Carburetor-Equipped Supercharged Engine

Whenever people see a carburetor-equipped supercharged engine in a hot vehicle, they can't help noticing how impressive it looks, and they wonder how much power it produces. But they also see an engine they think is almost impossible to tune, is not very reliable, and will overheat at the drop of a hat. It doesn't have to be that way.

by Henry P. Olsen





This '56 Ford 292 Y-Block has a Paxton supercharger. That combo in a '57 held the NHRA L-Stock record for decades.

A supercharged engine doesn't have to be a temperamental powerhouse as long as the engine is built, and tuned, to work with the supercharger. A properly-built supercharged engine will withstand the extra load on bearings and other parts caused by all the power the engine yields, and will have a compression ratio designed to work with the boost pressure and the octane of the gasoline it will be burning. Careful attention to choices and upgrades in several areas can tame the beast almost to respectability. These include:

- Cooling system
- Ignition system and timing
- Carburetor or carburetors
- Fuel supply
- Air/fuel mixture

Cooling and ignition systems

The cooling system, for instance, will need to be upgraded to carry enough heat away from an engine that's producing a lot more power -- and generating a lot more heat -- than a non-supercharged engine. This may involve a more capable water pump, or even a larger radiator. The ignition system -- spark advance curve and spark output -- must be tuned for the unique demands of a supercharged engine. The system needs a lot more power output to fire the spark plug with, say, six psi of boost than is needed on a non-supercharged engine with a typical 9:1 compression ratio. Of course, as the boost pressure increases, the need for greater ignition spark output also increases.

This higher output will require upgraded spark plug wires, and the rest of the system must be up to the job of delivering all that extra energy to the spark plugs. Consult the supplier of the ignition system you are using to determine the recommended spark plug gap, and any other changes needed, for a supercharged engine. You probably will want to do some experimenting on your own to find the spark plug gap that works best for the needs of your particular engine.

A standard points-type ignition system with sufficient output to fire spark plugs with a gap

The supercharged Hemi in this '32 Ford runs just as great as it looks.

of 0.035 in. in a non-supercharged engine may need the spark plug gap to be as small as 0.018 in. when used with on a supercharged engine with six psi of boost. The ideal ignition curve for a supercharged engine advances the spark quicker, yet provides less total spark advance, than for an engine without a supercharger. This quicker advance helps give the engine better throttle response until the supercharger boost pressure kicks in, but because the supercharger increases the pressure in the cylinders the engine will need less total spark advance to avoid detonation problems.

A good starting point for a supercharged 350 small-block Chevrolet with an 8:1 compression ratio and six psi of boost is an initial setting of 18 degrees BTDC and a total of 30 degrees of advance achieved at 3,000 rpm. This ignition timing curve is just a beginning, and must be tailored to your engine package for best performance.

Spark retard can help

A spark retard system designed for a supercharged engine, such as MSD's Boost Timing Master, can be used to retard the timing as the boost pressure increases. This type of system allows for a more aggressive advance curve so the engine will have good initial throttle response before the supercharger boost comes in, but will retard the spark as the boost pressure increases to avoid detonation [see Greg McConiga's article on the dangers of detonation in the April issue of HOT ROD Professional]. This system can allow setting the total ignition timing at 36 degrees, with the system retarding the spark one to three degrees per pound of boost. Total spark timing can be retarded by as much as 20 degrees at one degree for each pound of boost pressure. Note: A supercharged engine should generally not rely on vacuum advance -- the extra spark advance it typically supplies can lead to engine damage.

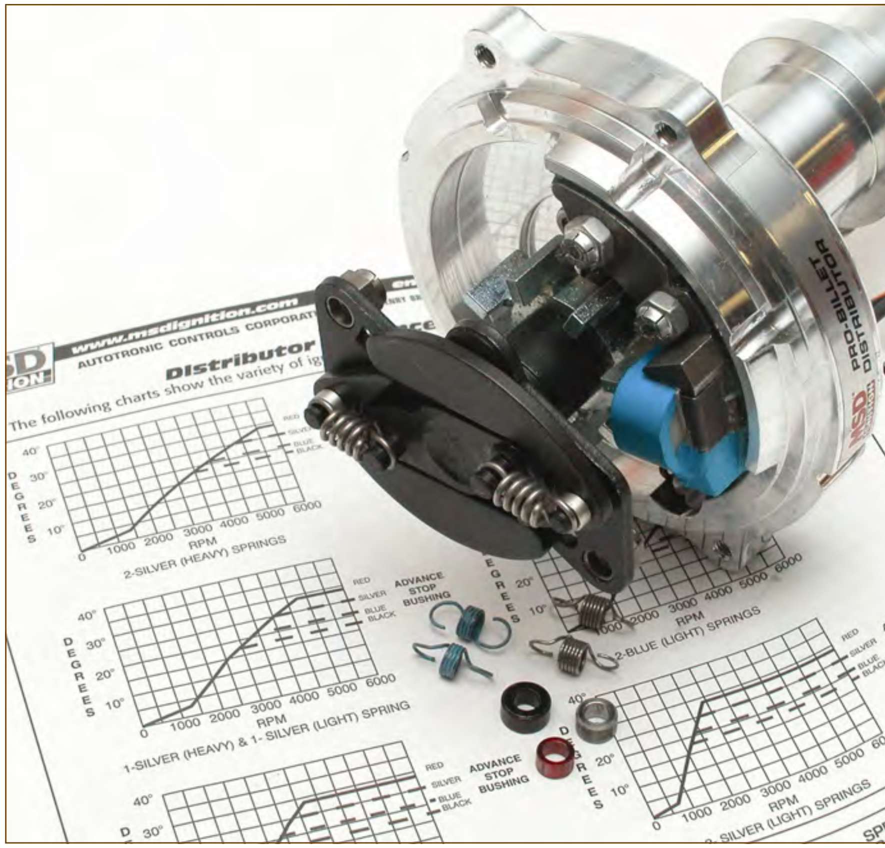
The MSD Boost Timing Master system allows you to retard the timing one to three degrees per pound of boost pressure.

The correct carburetor(s)

Selecting the correct carburetor(s) is one of the most important choices you can make in setting up a supercharged engine because all that extra horsepower means a lot more air. If the correct air/fuel mixture isn't available for all operating conditions, engine damage may result.

The most notable difference in a carburetor designed to be used with a supercharger is that the power valve includes a vacuum tube connection that mates with the boost pressure/vacuum signal in the intake manifold below the supercharger. This makes the power valve "boost referenced" -- the it will supply the richer air/fuel mixture the engine needs when the supercharger's boost pressure is creating more horsepower.

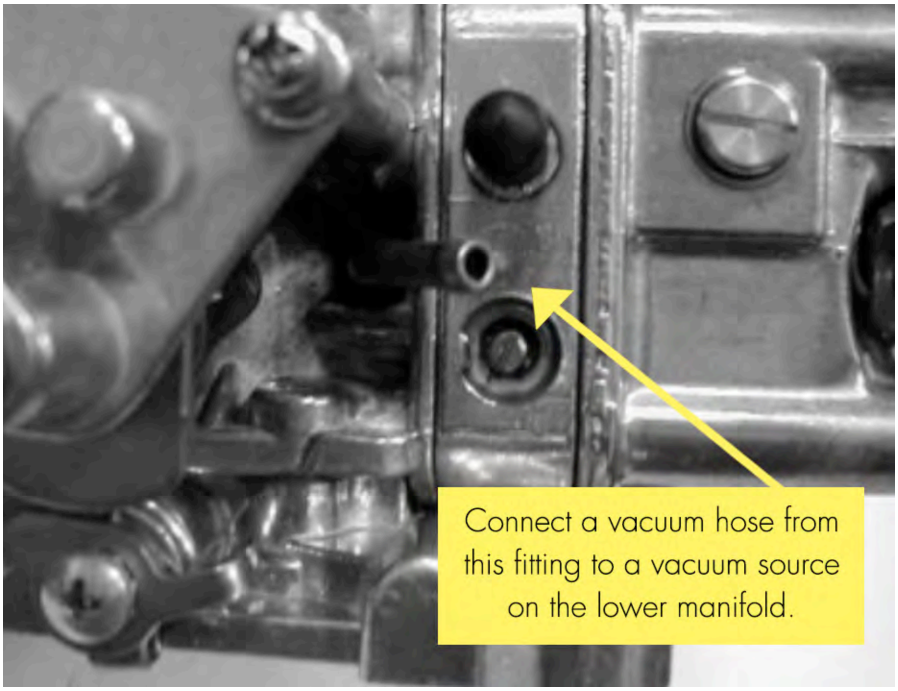
A standard performance carburetor's power valve reads the vacuum at the base plate of the carburetor. If this type of carburetor is used on a supercharged



If you expect your supercharged engine to perform as it should, the distributor advance curve will have to be tuned for the unique needs of "artificial respiration."

Right: The best way to check the advance curve is with a distributor test bench.

A dial-back timing light can also allow you to observe the spark advance.



Here's the boost-referenced vacuum port of a Holley carburetor designed for a supercharged engine.

engine, it will be reacting to the vacuum created by the supercharger instead of the vacuum or pressure that the supercharger is blowing into the engine. So, a power valve that is not boost-referenced will "see" a vacuum signal from the supercharger that is, in many cases, 10 in. Hg of vacuum higher than the actual engine vacuum. This will cause the power valve to stay closed because it is not reading the correct vacuum signal.

When the power valve does not open at the correct load conditions, the air/fuel mixture will be too lean, this can lead to internal engine damage.

If you must use a carburetor that does not have a boost-referenced power system, select a power valve or power piston spring that causes this carb circuit to open when the vacuum signal drops below 10 to 14 in. Hg. A properly-tuned supercharged engine with a boost-referenced power valve will work best, in most cases, with a power valve that opens at 4.5 in. Hg.

Selecting the correct air flow or cfm rating of the carburetor(s) is also very important if you expect the supercharged engine to supply maximum power and driveability. The first step in selecting the right carburetor(s) is to know how the vehicle will be driven most of the time. If the vehicle will be driven 90% of the time at part throttle, select a smaller carburetor(s) in the 500-650 cfm range. But if the engine will be operated at wide-open throttle 90% of the time, consider a larger cfm carburetor(s), knowing that low engine speed driveability may suffer.

The small amount of extra horsepower you will gain at higher rpm ranges by selecting a larger carburetor(s) may not be not be worth the driveability you will lose at part throttle!

A smaller carburetor can still generate good power

A supercharger can do a very good job of making a lot of horsepower even when the carburetor is on the small side. The Carter-designed AFB and AVS carburetors sold by Edelbrock, and the non-boost-referenced Holley-style carburetors can work well on a low-boost-pressure/mild blown engine. But when a carburetor does not have a boost-referenced power system, extreme care must be taken to avoid overly lean fuel mixtures, especially in off-idle and part-throttle driving conditions. The idle and off-idle systems on 500, 600 and 650-cfm Edelbrock carburetors can be modified to avoid an off-idle lean condition, so they can work well on a low-boost single or dual carburetor set-up. We tend to avoid the 750 and 800 cfm AFBs on street-driven blown engines, due to a lean part-throttle situation inherent in these carbs.

The fuel supply system must be capable of maintaining proper fuel pressure at all driving conditions. If the pressure drops, the air/fuel mixture will go too lean for the engine's needs. If this happens while the engine is under boost, the result can be damage to pistons and rings. The fuel pump, fuel line size, and fuel tank vent system must work together to supply the carburetor(s) with enough fuel to support all the power the supercharged engine is capable of making.

This picture shows the vacuum hose that connects to a port on the manifold below the supercharger that goes to the tube behind the choke on this Holley carburetor's boost-referenced power valve.

Tuning the air/fuel mixture on a supercharged engine

Modern technology has supplied the tools that make it possible, at an affordable cost, to properly tune the air/fuel mixture of a supercharged engine. One of the best methods for determining what the air/fuel mixture (jetting) is -- on any engine -- is the use of a portable five-gas infrared exhaust gas analyzer. This measures the critical gases in the exhaust, then supplies readings that can show combustion efficiency, misfire, air/fuel ratio, and excessive combustion chamber heat (detonation).

The CO reading from an exhaust gas analyzer is a very accurate indicator of the air/fuel mixture that the engine is getting. The HC reading indicates the amount of unburned fuel in the exhaust -- too much is an indicator of an engine misfire. The CO2 content in the exhaust is the product of complete combustion, so the best air/fuel mixture and the ideal ignition spark timing will create the highest CO2 reading. NOx content in the exhaust is created by excessive combustion chamber heat, and this gas can be seen as a precursor to detonation, and used as a warning. The O2 or oxygen reading can indicate a lean air/fuel mixture, an exhaust leak, that the engine has a "hot" cam -- or it could be the result of the supercharger "blow-through" effect.

Note: If O2 content readings in the exhaust are above two to three percent, the dilution of the exhaust gases being measured can cause the accuracy of all of the gas readings -- or wide-band oxygen sensor-based digital air/fuel ratio meter readings -- to be suspect.

Barry Grant Road Demon Jr. blower carbs use a connection on the base plate below the fuel bowls to supply the power valves with the correct vacuum signal for the needs of a supercharged engine.

The air/fuel mixture can also be checked using a wide-band oxygen sensor-based digital air/fuel ratio meter. This method reads the oxygen/unburned combustibles content in the engine exhaust, then supplies an air/fuel mixture reading. The readings are normally very accurate, but this type of meter is subject to false readings created by the supercharger blow-through effect, exhaust leaks, engine misfire, or the valve overlap of a high-performance camshaft at low engine rpm and low-load conditions.

False lean readings

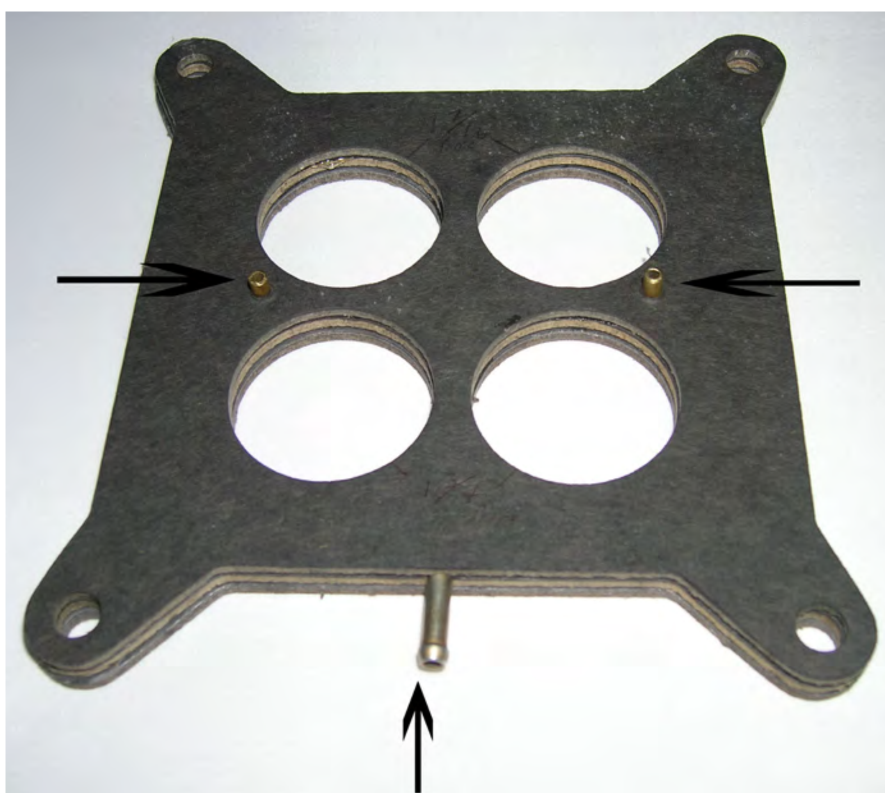
Any extra oxygen seen by the wide-band oxygen sensor as it looks at the exhaust will cause the meter to display a "false lean" reading. A digital air/fuel ratio meter is a very good, highly-portable, and low-cost method of determining what the air/fuel mixture is while the car is driven on the road at any condition from a light-load-cruise to a high-power, wide-open-throttle run down the race track.

A good power mixture for most low-boost engines is indicated by a CO reading of 6.6% -- 12:1 air/fuel ratio -- while a higher-boost supercharged engine might need a CO reading of 8.0% -- 11.5 to 1 air/fuel ratio -- or richer. This richer mixture can help control detonation created by the high boost pressure, but if it is too rich the engine will lose power. As mentioned earlier, a good starting place for power valve opening on a boost-referenced power system is 4.5 in. of vacuum -- this allows the carburetor to supply the richer power mixture needed by the engine when the driver opens the throttle.

Boost-referenced carburetors avoid lean air/fuel mixture

A typical big-block Chevrolet engine with a 6-71 supercharger in a street rod accelerating down the road may have a vacuum reading of 12 in. Hg of vacuum above the supercharger -- at the carburetor. But a vacuum reading below the supercharger where the boost-referenced power valve gets its reading -- in the intake manifold -- may be two to three in. Hg of vacuum. This would mean a boost-referenced power valve would be supplying the correct power mixture, but a non-boost-referenced power valve would supply a much leaner mixture, which could lead to detonation and/or engine overheating.

The target cruise mixture normally used on a mild-cam engine with low boost pressure would be 1.0% to 2.0% CO -- 14.1-13.8:1 air/fuel ratio -- but on a hot-cam, high-boost engine the target mixture we use is 3.0% CO, representing a 13.4:1 air/fuel ratio.



The vacuum tube on this prototype spacer would be used to supply the power system of a Carter-designed AFB or AVS carburetor with a boost-referenced vacuum signal.

Power, performance, and appearance -- some people prefer the old-school look of this '32 Ford, but if you prefer new-school you could always supercharge your late-model Corvette.

This flathead Ford has Ardun heads and a supercharger that breathes through two Stromberg 97 carburetors.

Fuel pressure is a concern with blow-through

The first concern for an engine using a blow-through supercharger -- where the carburetor is under boost -- is fuel pressure. A special regulator that is boost-referenced, along with a high pressure/high volume fuel pump, is mandatory. The regulator senses the amount of boost and keeps the fuel pressure at a set point above the boost pressure. The setting that we see most often is 5.5 to 6.5 psi over the boost pressure. For example, with six psi of boost, the fuel pressure would need to be set at 11.5 to 12.5

psi. The two methods of pressurizing or blowing through the carburetor are:

- the carburetor is in a pressurized box
- a "hat" is used on top of the carburetor in place of the air cleaner.

If a hat is used, the throttle shafts will need to have seals installed to keep the fuel from blowing out through the clearance between the shaft and its bore. Every carburetor we are aware of was designed to work with the air flow coming in evenly from all directions as it travels through the air cleaner. But when the air is blown through with a supercharger, it may not supply all of the emulsion bleeds in the carburetor with the same air pressure or flow patterns.

A marine-type flame arrester inside the air box or hat can help diffuse the air charge as it blows into the carburetor and its air bleeds -- if some method of diffusing the air-charge is not used, the air flow blowing from just one side of the carburetor across the air bleeds may cause air/fuel mixture curve problems, possibly leading to engine damage from an overly lean or rich mixture in one or more cylinders.

So that's the story -- you can drive an awesome, supercharged machine that scorches tires at the touch of the throttle, but that is relatively well behaved when you want it to be. Match the supercharged engine with the correct carburetor(s) properly tuned and well-supplied with fuel, and an ignition system with the right parts and spark curve, and you have built a supercharged driving experience that is both enjoyable and trouble-free. ■

Yes, you can have it all: power, performance, and that supercharged look. All it takes is the time to pick the correct parts and properly tune it for the special needs of a supercharged engine.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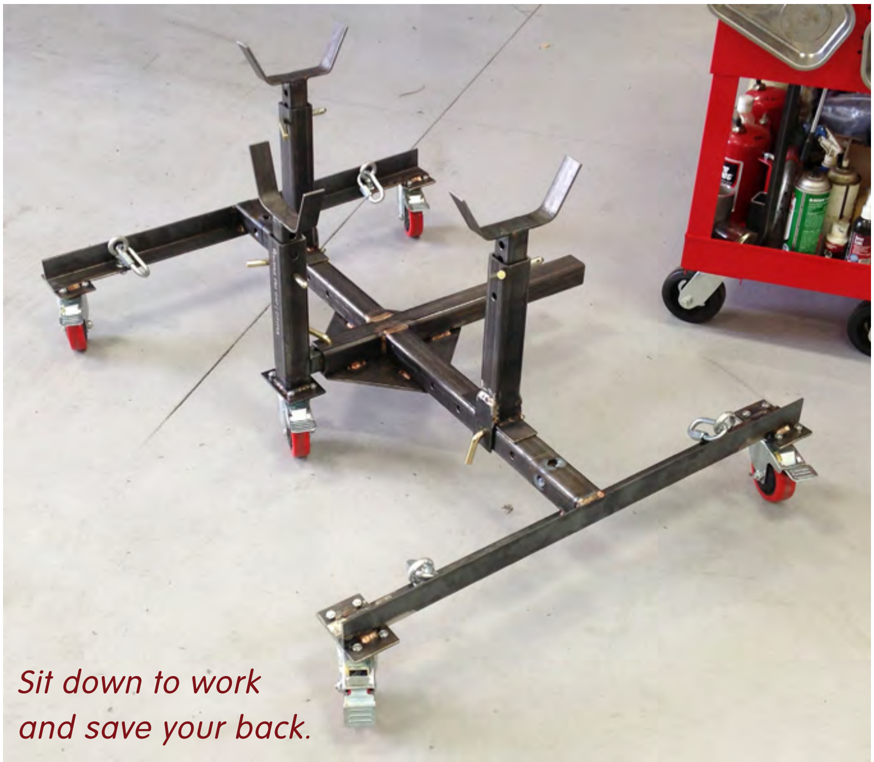
Torque Benders, Part 1:
Differential Basics

With RWD, you're making all that horsepower up front, but you've got to make it do a 90-degree turn to spin those tires. That's got to be hard on the mechanism -- downright brutal in any kind of racing. Here's how to get started putting the pieces back together, and a set-up shortcut, too.

Suppose you were an early vehicle inventor. What would your mechancal imaginings be? You might have started with a transversely-mounted engine and a chain to a sprocket on the rear axle. To think this out further, wouldn't an inline engine mounted longitudinally between the chassis rails be better? Then you could put a clutch and transmission behind it and route torque to the rear wheels by means of a driveshaft. The direction of rotation would be exactly wrong, though.

What would you use to turn that power 90 degrees so that it could forcibly rotate the wheels in the direction of forward progress? You might devise a simple pinion and crown wheel, as had been used for centuries in water- or wind-driven mills, and drive axles that went to both rear wheels. That wouldn't be too satisfactory, though, because in curves and turns the rear wheels would be traveling different distances. The car would want to keep driving straight ahead and would resist turning. If you forced the turn, the tires would scuff and complain. What about just driving one rear wheel? Not good, either -- that wheel would have to do all the work, its tire would wear out quickly, and it would tend to spin even when starting out straight ahead on a level road.

This is presumably the chain of reasoning that resulted in the invention of the ingenious device we call an automotive differential (the basic "averaging" concept had been around for centuries, though). With it, the rear wheels could turn at different speeds, yet all the torque could be used. Damned clever. Meanwhile, that leaves us to deal with a heavy, complex component.



Sit down to work and save your back.

Opposite Page: Whether you call it a Daimler or a Mercedes, this 1901 car is generally considered to be the first with a modern layout: radiator, fan, longitudinally-mounted engine, clutch, transmission, and 35 horsepower to the rear wheels. Looks low-slung and stable, too

Spiral bevel

The gears in the differential (rear end?) of modern cars and light trucks are of the spiral-bevel variety, although some people still refer to them incorrectly as hypoid gears, which are mostly found on heavy-duty trucks today. The spiral-bevel term came about because of the spiral shape of the teeth and the truncated-cone shape of the drive pinion. This design not only transmits power more efficiently than a true hypoid does, it's also quieter during driving and coasting transitions, and multiple teeth are always engaged.

The main problems a diff is likely to have involve noisy bearings and leaky, clunky pinion seals and shafts. That's in normal street use, however. When it comes to racing or high-performance driving of any kind, all bets are off -- there's no telling what you might see. Also, there's a good chance you'll want to change the ratio at some point, so you should know how to install a new ring and pinion set and have it live.

Spalling & brinelling

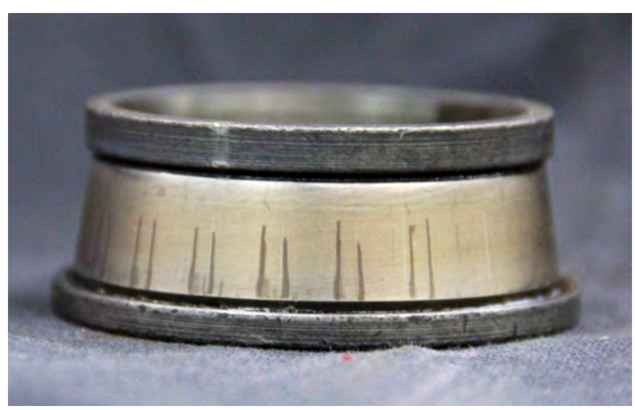
Typical bearing failures will be due to either spalling, or loss of lubrication. Spalling occurs when the surface of a bearing's inner or outer race begins to chip out or peel. It's mostly the result of work hardening, where the maximum shear stress occurs just below the surface of the race, loosening the bond with the surface so that the next passing roller shears the "spall" (a flake or chip) off. The ball or tapered roller of a bearing pushes a tiny wave of metal ahead of it as it rolls across the race, and the surface of the race eventually fails from metal fatigue. Spalling is characterized by irregular pits and chunks missing from the races and bearings. The type, level, and cleanliness of the lubricant, the amount of load, and the length of time in service type all help determine when this will happen.

Then there's brinelling (after Swedish engineer Johann Brinell who invented a hardness test), which is caused by impact from road shock, or faulty bearing installation. You'll see it as dents in the race the same length as the rollers, or that match the contact points of the balls. "False" brinelling looks similar, but is caused by "fretting," sometimes with corrosion. This occurs when the lube is squeezed out of a loaded area by repeated shocks, motion, or vibration.

Lethal lube lack

Normally, the rollers of a bearing are separated from the race by a layer of lubricant. If metal-to-metal contact ever actually occurs, catastrophic damage will happen immediately. As our esteemed tech editor Greg McConiga has said in the past, "Although the lubricant

Spalling is really a sympton of metal fatigue. The wear surface simply flakes or chips off.



True brinelling is dents in the surface. This "false" brinelling is due to fretting and corrosion.

appears to be fluid and not solid, under high pressure it acts like a solid and keeps the bearing and race separated. Think of it this way: A belly-flop into the pool from three feet up is fun, but try it from 2,000 feet and you'd be hard-pressed to figure out if you're landing on water or on the hood of a Buick. This looks-like-a-liquid-acts-like-a-solid principle is exactly the same for any roller, ball or insert bearing and any lubricant you've ever used on a motor vehicle, including crankshaft and cam bearings, rocker pivots and pistons. There is one immutable rule for bearings of all types: If it touches, it's toast." There's no improving on that explanation.

While we've used GM 10- and 12-bolt and a Ford 9-inch rears as our photographic examples here, the principles of setting up a differential properly are pretty much universal. Sure, shim locations and side bearing pre-load and backlash adjustment methods may vary, and pinion bearing pre-load procedures differ, but the fundamentals remain the same.

For instance, pre-loading the bearings to compensate for the force that's trying to push them apart must be observed. Next, the top of the pinion must be a specified distance from the centerline of the ring gear. Also, some backlash between the ring and pinion gears is required. Theoretically, backlash could be zero, but in the real world it must be allowed to prevent tooth interference and binding -- machining discrepancies and heat expansion have to be accounted for.

Magic shortcut nobody teaches you

Whenever you're confronted with shredded, noisy bearings, there's a basic principle that nobody seems to want to tell you. In almost every case, you can simply reuse the old pinion depth shim and the original cast factory side shims, and the depth, backlash and carrier preload will be on the money. Blasphemy! Don't we need to go step-by-step through our tech school training? Well, no. Even though the bearings may be wrecked, none of the critical dimensions of the housing have changed. The carrier, drive pinion, and ring are all in the same place, and with any high-quality bearing the inner race dimensions will be

Holy smokes! We got this much swarf just by swabbing the axle tubes. Wouldn't be good in the gears.

within .0005 in. (that's five ten thousandths) of the originals, which means that replacing them just puts you back at the starting point for that differential. Even if you replace a ring and pinion with high-performance parts, we can tell you that the factory-installed pinion depth shim will usually be pretty close to what you'll need with the new setup. At the very least, it's a great place to begin.

Nice and clean now

So, keep everything in strict order during disassembly. Clean that EP lube off the parts and identify them with an indelible marker, paying special attention to the side shims and carrier bearing housing caps.

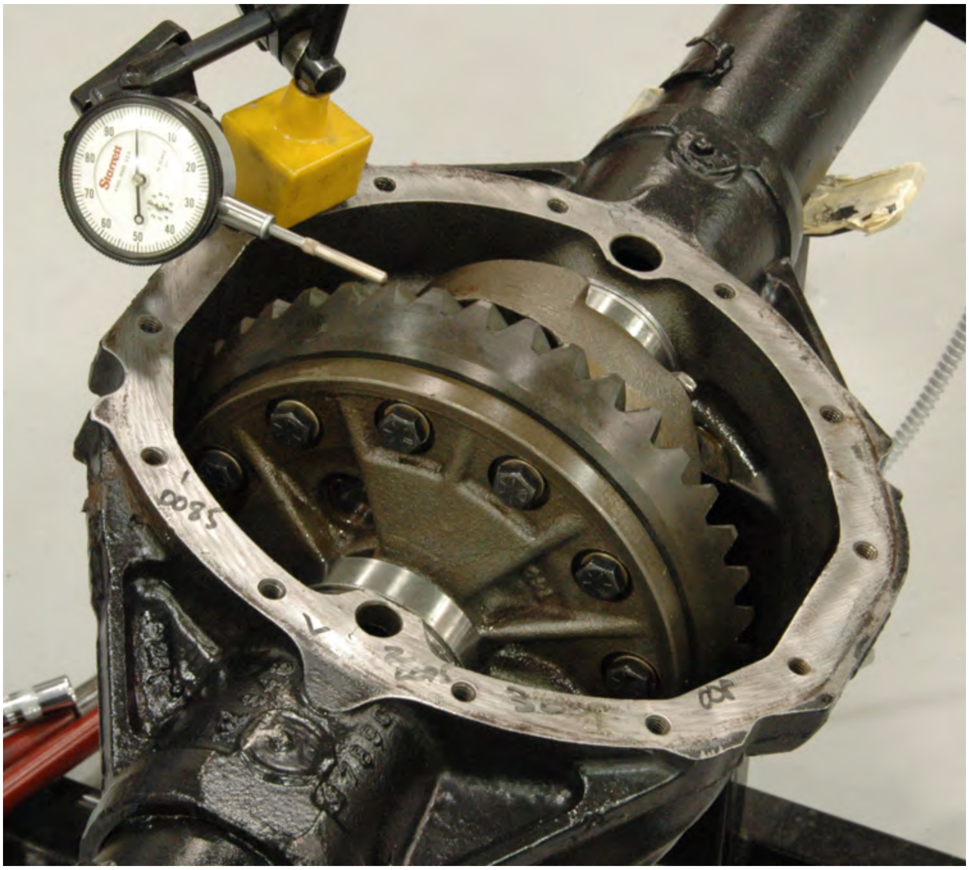
Once you're down to the housing, clean everything very thoroughly. We mean it. Going the extra mile here is well worth it in terms of the longevity of the job. That extends to swabbing out the axle tubes as you would a rifle barrel. You'll understand why cleanliness is important if you think about the damaging effects of metal particles circulating through the small clearances between the gear teeth.

If you're just putting bearings in, press the side bearings and the rear pinion bearing off, keeping track of the depth shim that's between the bearing inner race and the back of the head of the pinion. Solvent wash and air dry everything, then inspect the ring, pinion, side gears, differential pinions and pinion shaft for wear. If it all looks good, press a new pinion bearing onto the drive pinion – don't forget the shim! – and press new side bearings onto the carrier. Using a race driver, install both pinion bearing races and put the front bearing in behind the pinion seal and drive the seal home. Make sure to lube all bearings with gear oil before installation. Put a new crush sleeve on the pinion and slip the pinion through the front bearing. Install the flange, the washer and nut, and tighten to the correct preload.

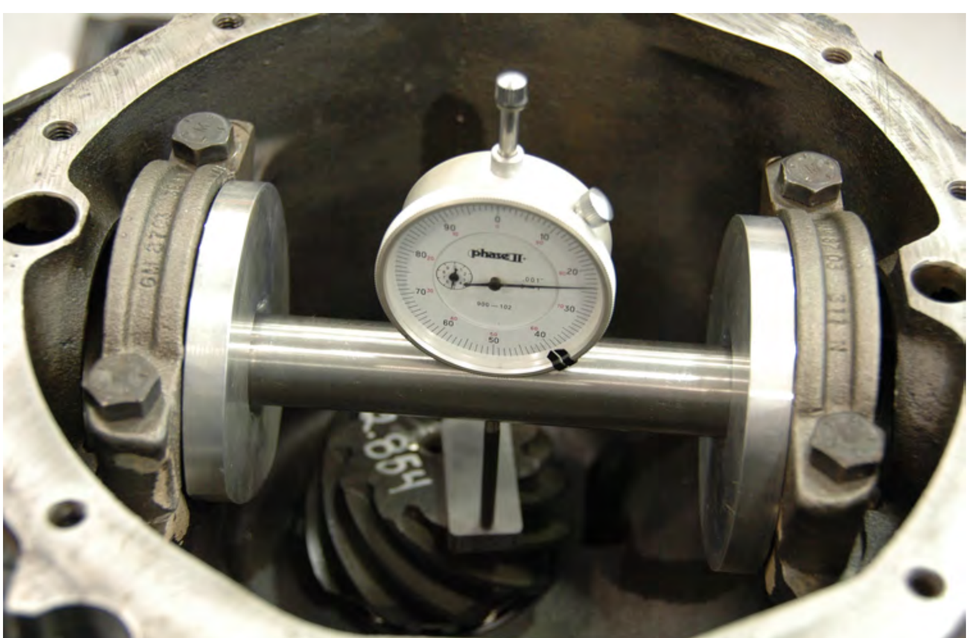
Verify

It makes sense to check and record the backlash before you take the differential apart. If you've got a set of depth micrometers, you can also check the distance between the ground, flat surface where the carrier bearing cap bolts to the housing and the drive pinion head before you loosen the drive

A proper pinion race tool is way better than a brass drift of a chunk of oak, and not all that expensive.



You might as well check and record backlash before you take anything apart. It'll amount to quality control after assembly.



It wouldn't hurt to check pinion depth, but bearing replacement really shouldn't have changed it.

pinion. Compare that measurement to what you've got after the new bearings are installed just to make sure that no major changes in pinion depth have occurred. In our experience, 98% of the time you won't see enough change in depth or backlash to make a difference.

Next, install the carrier with new bearings and races, keeping the side shims on the correct sides and tighten the bearing caps to specification. Check the backlash -- again, we've never seen a significant change with new bearings, but that doesn't mean it can't happen.

That's what it takes to freshen up a differential. Next time we'll look at the subtleties of setting one up from scratch. ■

Lift Safety: Always be Aware

Lifting a vehicle is the most dangerous part of your job, and you do it every day. Never forget that.

Few pieces of shop equipment can be as dangerous as the vehicle lift. You may have personal experiences or know of incidents involving lift failures or improper use. While most technicians are always in a hurry to get jobs completed, you must stop and think when using a lift. The consequences can be devastating if you don't properly lift the vehicle, work around the raised vehicle properly or pay attention while lowering the vehicle. Safety is Job One!

Most lift failures occur because the technician is rushed to get the job done, isn't focused, or doesn't know all the factors and practices of safely lifting vehicles. Let's try to look at some of the best practices and cautions to keep in mind when using a lift.

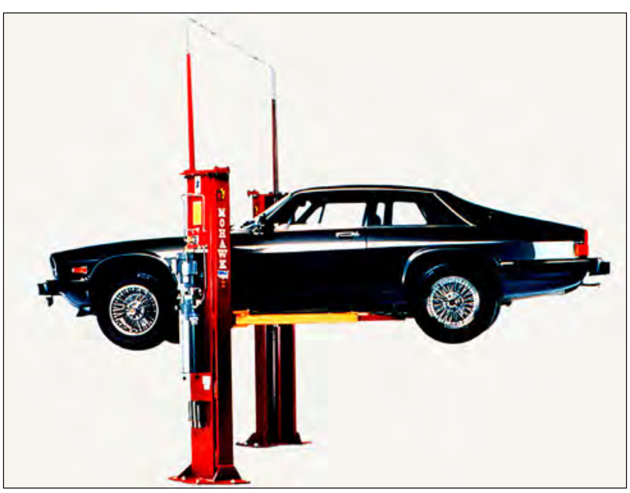
Plan Before You Lift

Like most procedures, preparation is the key. Stop and think about the vehicle's lifting points, what procedures you are going to perform, how the vehicle's weight and center of gravity might change if any heavy components are removed and how long the vehicle is going to be raised.

Using the correct lifting points cannot be overemphasized. This one thing is the most important factor in lifting safely and protecting yourself against injury.

Owner's manuals typically illustrate lifting points. If you're not familiar with the model, take the time to check the glove compartment. Using the manufacturer's designated lift points not only prevents vehicle damage, it ensures you get a balanced lift.

If the owner's manual is not available, check with quality service information. Vehicle manufacturer service information websites can be accessed for a minor fee or free by logging onto the National Automotive Service Task Force (NASTF) and clicking on "OEM Service Websites." Many other sources offer lifting point information, such as the Automotive Lift Institute, Inc. (ALI) and Alldata.



With its big engine, this Jag clearly illustrates that the middle of the vehicle may have nothing to do with its center of gravity (courtesy Mohawk).

Given the increasing weight of some newer pickups, make sure the lift is rated for the heavy lifting.

Here are some other points to consider before lifting a vehicle:

The weight of the vehicle, not the length of it, should be centered when using a two-post lift. This is referred to as the vehicle's "center of gravity." An inspection mirror on a stick and a flashlight will eliminate much of the kneeling and lying down required to inspect lifting points.

Before raising a four-poster drive-on or alignment lift always set a brake and wheel chocks.

Make sure the lift you're using is rated for the weight of today's larger trucks.

Inspect and confirm that the lift's saddles/contact points are centered on the vehicle's lifting points before you raise it all the way up. A lift with broken safety features probably hasn't been maintained. Don't use it until it's fixed, lubed, adjusted, etc.

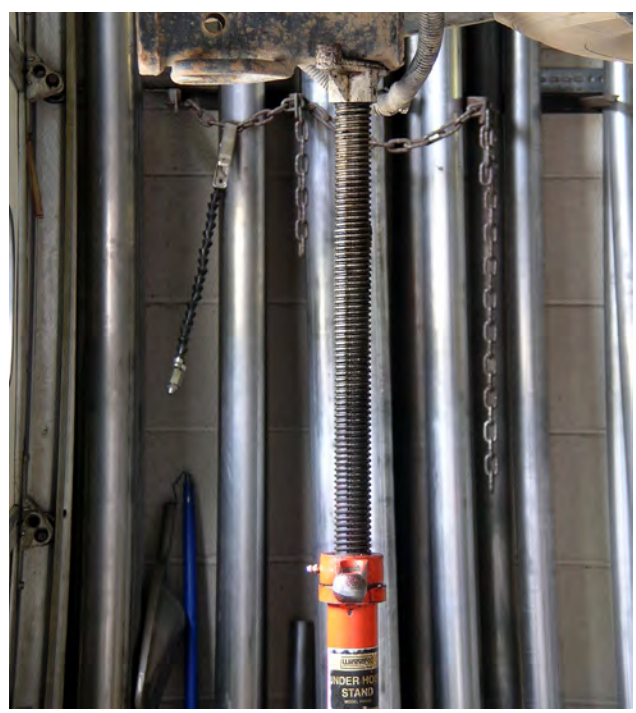
It doesn't get much more solid than this. You want to feel confident about every lift point.

A vehicle can become unbalanced if something heavy is removed, such as a rear differential. Use a screw jack at one or both ends of the chassis.

Safely servicing longer, wider, or lower vehicles may require investing in a new lift. Arms that can't reach factory lift points are a warning sign. A lift with arms too short to reach the manufacturer's recommended lifting points on extra-long trucks should warn you that you may not be able to properly balance the load on the lift. An unbalanced load can not only result in a dangerous tip-off, but may rip a lift out of the concrete.

Raising the Vehicle

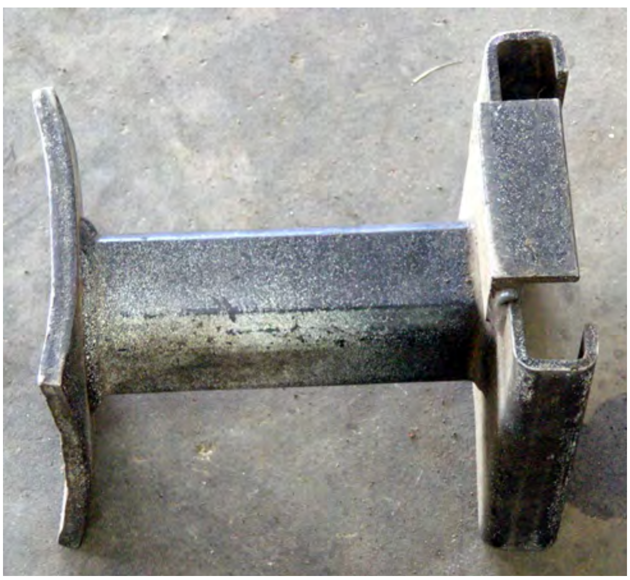
Once you have properly identified the correct lifting points and are ready to raise the vehicle, take a minute to make sure you've got



A screw jack at one end (on this trailer hitch, for example) will compensate for the removal of a heavy component, such as a rear axle.

a solid mounting. Rock the vehicle's bumper while the vehicle is only inches off the ground to determine if you've got a stable lift. As the vehicle's wheels approach waist height, shift your gaze to the ceiling /overhead safety bar to prevent damage.

Having to re-center a vehicle, or rolling it forward or backwards, even having to set it back down several times in order to obtain a good lift isn't a sign you're incompetent.



Do you have all the necessary attachments and adapters for safe lifting handy?

Instead, it says you're intelligent enough to take the time you need to avoid injury.

If you're interrupted before completing a lift, re-check the position of all four lift arms. Someone may have bumped one walking by, or while dragging a piece of equipment past it.

If you have to put a vehicle on and off a lift repeatedly, mark a chalk line on the floor where the front tire should be for fast relocation. Always lower the lift onto the safeties before getting underneath it.

Safely Working Under and Around a Raised Vehicle

While you are working under or around a raised vehicle, always be mindful that a multi-ton vehicle is above you. Any sudden change of balance can cause movement . Using a cheater bar can apply hundreds of pounds of force, and cause the vehicle to move. Take the time to consider in what direction it may move. If possible, lower the vehicle before you apply large forces, or use an impact gun.

When doing something that could cause the vehicle to lurch or bounce during service, use

If the arms won't reach, they won't reach. Face it.

screw jacks at both the front and rear of the chassis. Also, any time you've got an "iffy" lift, use screw jacks, tranny jacks, etc. to help stabilize and secure the vehicle.

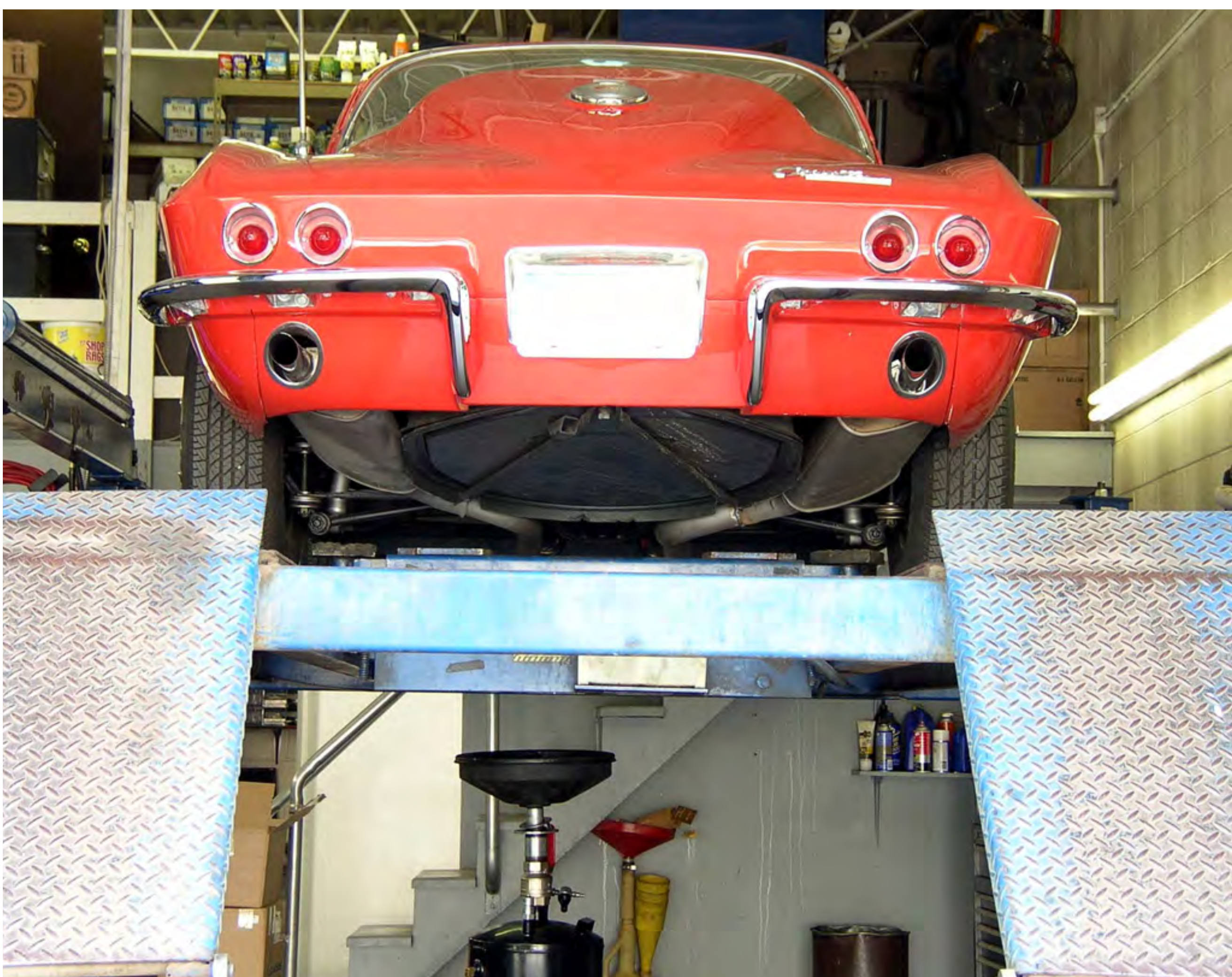
Hydraulic lifts can sag overnight. Don't leave things like oil drains or tool carts underneath or you could arrive in the morning to find a disaster. It's probably better to just lower the vehicle overnight.

Lowering Safety

When lowering a vehicle, keep an eye on it to make sure it remains level. If a safety doesn't disengage on one post, a vehicle can tilt sideways and fall over. Watch your feet when letting a vehicle down – keep them out from under lift arms. Steel toe boots won't help.

Don't be a Statistic

The old adage, "It's better to be safe than sorry" was never more true than when working around an automotive lift. ALWAYS be cognizant of safe practices when using a lift. There are training, safety and lift inspections available to help you stay healthy and well. Check out what's available from the manufacturer of your lift or the Automotive Lift Institute at www.autolift.org. ■

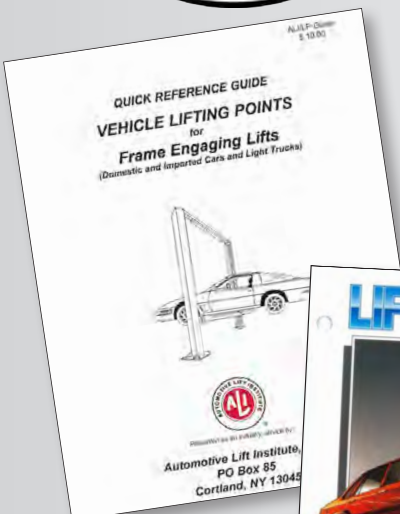


Leaving anything under any lift overnight is asking for trouble.

The Automotive Lift Institute

The Automotive Lift Institute, Inc. (ALI) is the trade association of automotive lift manufacturers and marketers. The association provides an independent, third party Certification Program that promotes the safe design, construction, installation, inspection, and use of automotive lift products. The top twenty manufacturers of high-quality lifts are members and adhere to these strict guidelines.

ALI certifies that lifts from its member companies meet the highest standards of quality and adhere to the most rigorous safety standards of the manufacturing industry and regulations.

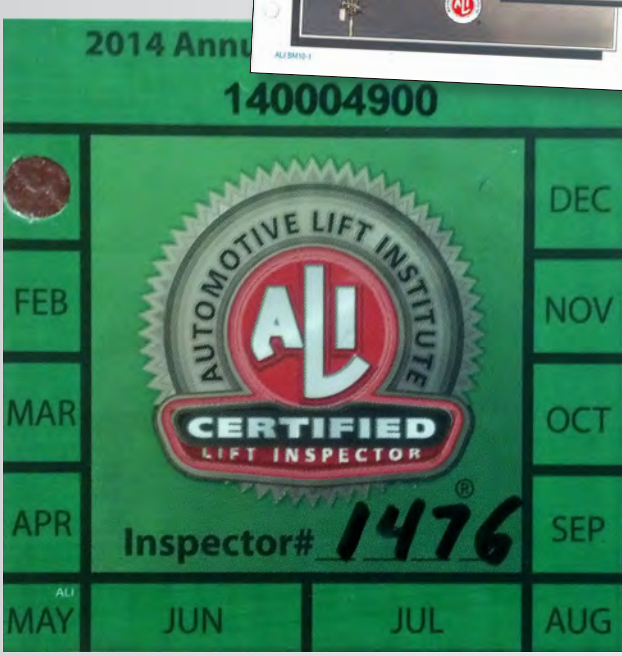


The ALI Vehicle Lifting Points booklet can be a valuable resource for safely and correctly lifting domestic and imported vehicles.

ALI offers lift safety training materials in the form of printed manuals, DVD kits or online.

ALI offers an inspection service for automotive lifts. Has your lift been inspected lately?

Check out the complete range of services materials from ALI at www.autolift.org. ■



Information Station

Dual-mass Flywheel Conversion Clutch Kits

Sachs has announced the introduction of two new dual-mass flywheel conversion clutch kits. The company says these solid flywheel conversion clutch kits offer a low cost, high quality alternative for customers needing to replace the dual-mass flywheel clutch system.

The new kits fit 2011-2005 Volkswagen Beetle, Golf, Jetta & Rabbit; 2005-1997 Audi A4 & AF Quattro & Volkswagen Passat. All key components are included in the kits. For more information, contact your Sachs distributor or visit www.zf.com/us/sachs.

Low Cost LED Lamps

Optronics Inc. has launched its new ONE Series single-diode 4-inch round and 6-inch oval LED stop, tail and turn lamps. The company says the lamps offer a lighting solution that looks like an incandescent lamp, costs about twice as much, but lasts 50 times longer.

The lamps meet all FMVSS 108 photometric requirements for visibility and safety. Each lamp comes with a lifetime warranty and lenses and housings are made of tough polycarbonate material that is sonically welded. The lamps employ a solid-state, surface-mount device design that protects their electronics against moisture, shock and vibration. For details, visit www.optronicsinc.com.

New Differential Locker

Auburn Gear's new MAX Lock Locker fits inside the original equipment's open differential case and automatically eliminates wheel slip in both two- and four-wheel-drive vehicles. The unit is engineered to match OE case specifications and is easy to install.

Fifty-four SKUs of the new locker will fit a broad range of popular vehicle makes and models reaching all the way back to 1955. For more information or to find a distributor, visit www.auburngear.com/aftermarket/distributors.aspx.

Tenneco Hosts Training at Technical Schools

The Monroe Ride & Drive seminar and Walker Emissions Control Diagnostics workshop are two popular training programs developed by Tenneco to help drive improved shop efficiency and improve the consumer experience. New this year, the program now provides a venue for industry parts professionals and technicians of the future to connect while learning about vital vehicle systems and repair diagnosis procedures. The 2014 schedule includes visits to technical schools like Universal Technical Institute, WyoTech, Lincoln Technical Institute and others.

For the program schedule, contact your Tenneco supplier, visit www.monroe.com/en-US/events/ for the Monroe Ride & Drive schedule and www.walkerexhaust.com/events for the Walker Emissions Control Diagnostics workshop schedule, or call 800-304-8878.

MONROE® RIDE & DRIVE

New Diesel Urea Filter

Bosch has introduced a new Urea filter for the Bosch 2.2 DENOX System for Class 4 – 8 vehicles. The company says an important feature of this filter is the high capacity media that traps and holds contaminants throughout the manufacturers' recommended change intervals.

Other features include an O-ring that provides a tight seal to prevent leaks, and an equalizing element that buffers the pressure within the pump by expanding and contracting to eliminate cracking on internal components. The package comes with an extraction tool to simplify filter removal. For more information visit: www.AASAKnowYourParts.org.

Finish Line

Whistling Syclone

by Greg McConiga

It was 1991 . . . and my first stint in a dealership after years of working as an independent shop mechanic or manager. I went to work for a local Olds and GMC franchise as a service manager. It was a good year.

GMC came out with the Syclone pickup and we got just one in on allocation. A local street racer decided to relive his mis-spent youth and stopped in to buy the only one we had (fewer than 3,000 were built in 1991, and only about dozen in 1992.)

If you don't remember those little rocket boxes, they were a job-shop-produced water intercooled turbocharged 4.3 V-6 powered all-wheel drive with great big sticky tires riding on a lowered S-10 pickup truck platform. The pistons, main caps, head gaskets, intakes, fuel system, and exhaust manifolds were unique to the application, and GMC borrowed the 350 throttle body and bolted her on the little race truck. It was rated at 280 horsepower and 360 foot pounds of torque, but they'd run the quarter at 13.6 at about a hundred miles an hour with zero to sixty times of 4.3 seconds at a rolling weight of 3,800 pounds (with a two hundred pound driver), so in truth they were probably making something like 325 horsepower and 400 foot pounds in stock trim.

Said reborn street racer bought the truck and promptly went out to lay waste to the other local street racers. He put the little rocket-powered country Cadillac in stealth mode by removing all the badging, and went hunting most Friday and Saturday nights for the first few weeks of the summer. He was doing pretty well . . . the truck was quick off the line, and since most street racing involves short distances he was making some pretty good beer money fooling the locals. Believe me, 400 foot pounds will move you along pretty smartly if you have AWD and no tire spin.

As he worked his way up the ladder, he got into some stiffer competition and his win/loss record looked like it might begin to suffer. So, he stopped in one day to see if there was anything I could do to get him a little more power.

Those were the dark days of electronic tuning. Performance chips were nearly unheard of and the few that were being produced mainly just advanced the hell out of the timing, over-fueled the engine, and shut off the detonation sensors. The results were sketchy at best. However, where there is a turbocharger there is a way...

I took a little time to study the plumbing and determined that the electronically-controlled waste gate valve was a simple spring-loaded shut/pressure opened solenoid-controlled bypass that dumped exhaust ahead of the turbine, thus regulating boost. And all it needed was a calibrated leak to delay opening the bypass to increase boost -- after all, if some boost is good, more is better, right? One problem: GMC had figured out that this might be the case, so had installed tamper-resistant hose clamps to secure the control plumbing to the waste gate. If modifications were made, they'd be evident and warranty claims could be denied. Hmmm. Thwarted again? Not hardly...

Pretty smart of GMC, but tamper-resistant is NOT the same as tamper-proof, if you know what I mean, especially in the face of a determined and dedicated "performance-enhancement specialist." I knew what I wanted to do: I was going to use a Holley main jet as the leak and just tee it in so I could tune right to the edge of the detonation sensor limits. My first guess wasn't even close -- that thing came up on boost, reared back and took off like a Saturn V launch vehicle . . . for about three seconds. Then it hit detonation, the det sensors grabbed it and the system shut down hard. I don't know what all was shut off, but it felt like everything. I've never felt anything quite like it since -- it was like you tossed out an anchor. It was so severe that it pinned you right up against the seat belt. I limped back for Round Two and began sneaking up on the limit. I trimmed the leak a couple more times (had a whole box of Holley jets, don't you know) and got it just right for the 94 octane gas he was running. I don't know how much more power it made, but it was a lot. It was significantly quicker and faster, and, as a side benefit, as it went to full boost the calibrated leak whistled like a tea pot at full boil under the hood. It was like more power and a warning system all in one!

Everything went swimmingly for nearly the entire summer. His winning record remained intact, and he stopped in on a regular basis to regale us with tales of terror. After one particularly-productive weekend, he shows up looking a little worried. Seems that over the course of the last evening spent on the asphalt the engine developed a persistent ticking sound, reminiscent of a lifter or valve guide. On closer exam it was determined that the noise was a little deeper, down in the crankcase, and the cadence was at crankshaft speed. Okay, this was officially "not good." With the customer's permission, I removed the oil pan and was stunned to find one connecting rod that was twisted slightly and shortened just enough so that the crank counterweight was ticking the bottom of the piston pin boss! That's about as close as you want to get! Just a little more and the counterweight would be serving double duty as a clearancing cutter.

A new rod and piston assembly was obtained and installed and the decision was made then and there to remove the calibrated leak since it was pretty obvious that GMC had done its homework in terms of reliability and distance from the edge of the proverbial cliff. Still, it was a summer to remember . . . and I'm sure there are those around here who still remember getting dusted by a middle-aged guy with a little black whistling pickup truck. ■

HOT ROD PROFESSIONAL

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