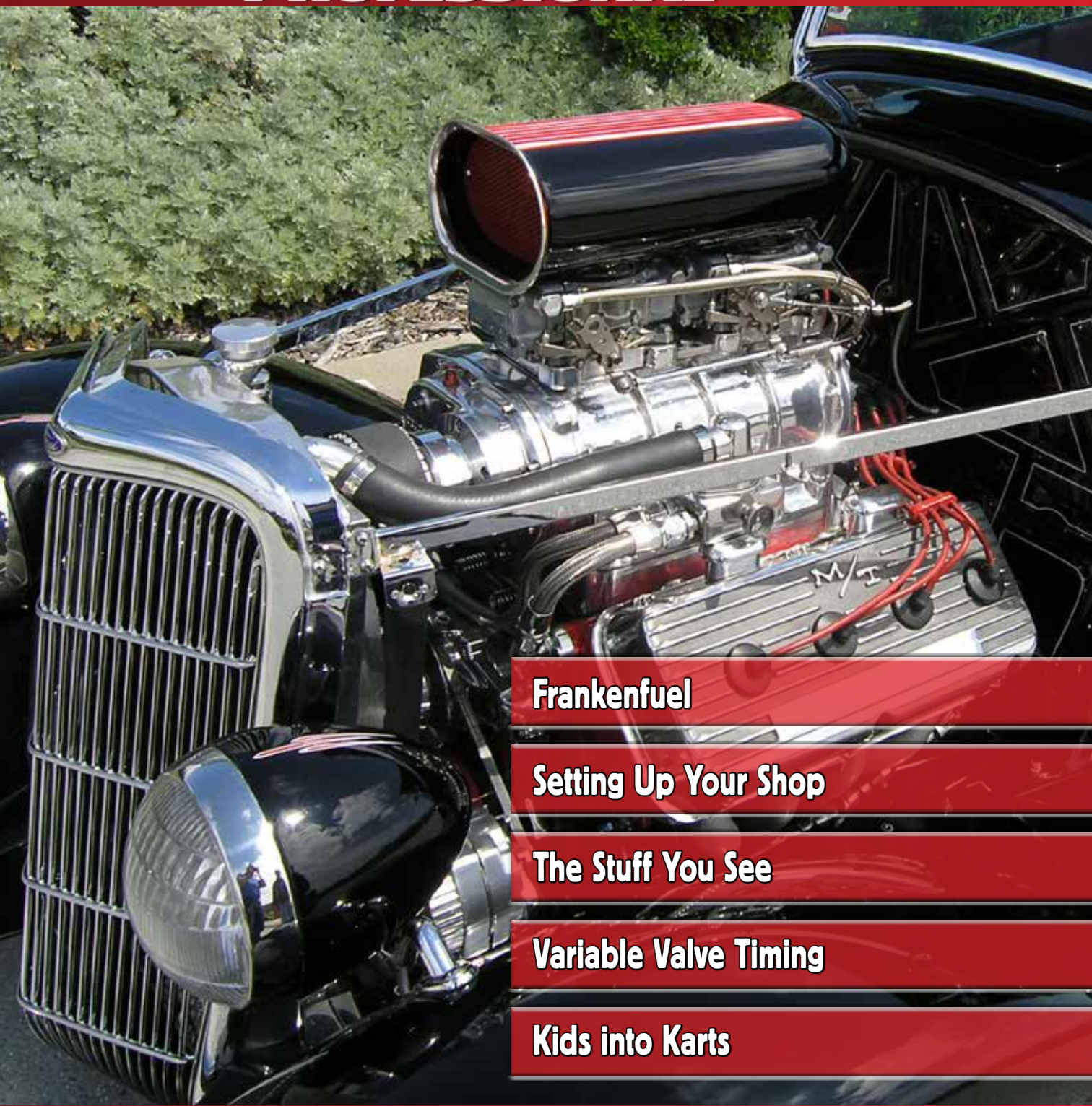
August 2013
V1 N1

HOT ROD PROFESSIONAL



Frankenfuel

Setting Up Your Shop

The Stuff You See

Variable Valve Timing

Kids into Karts

Performance Enhancement Knowledge for Service Technicians

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Starting Line

by Bob Freudenberger

. . . one of the things HRP is intended to do is alter our consciousness.

Welcome to the premier issue of HOT ROD Professional. That, of course, is a cliche that every new publication uses to greet its readers, but that doesn't make the sentiment any less heart-felt. I've been writing and editing articles, books, and training materials for professional automotive service technicians for decades, and there's no group of people for which I have more respect. The same, except perhaps for the length of experience, can be said for most of our contributors. What we all particularly admire about you, our readers, is your continual thirst for knowledge, your ability to apply scientific principles to sophisticated technology, and your can-do attitude no matter how knotty the problem may be, particularly in the area of diagnostics. We can't think of another profession where the learning and mental discipline are more intense.

That said, one of the things HRP is intended to do is alter our consciousness. In regular repair shops, the Holy Grail has always been producing the most billable hours in a given week. Sure, we all take pride in our craftsmanship, but time has always been of the essence.

In the world of high performance, we have to rise to another whole level of accuracy, careful procedures, mental projections of what might happen if something is assembled a certain way, and, again, the application of theory. There's no rushing this, unless you happen to be on a pit crew. You can't take anything for granted, either, such as having confidence that you can just bolt on that expensive new part. We have to learn to check, check, check.

Engines and their modifications are certainly the prime mover of high-performance pursuits, and our staff and contributors have a profound depth of knowledge on that subject -- we've built championship engines and tuned street rods for rock stars. We realize, however, that there's a whole lot more to the world of high performance (meaning modifications that take vehicles beyond the capabilities of what the carmakers provide, or the fabrication and refinement of dedicated race cars and karts) than just horsepower and torque. There's also getting all that twist to the pavement, avoiding spectacular breakage, stopping a ton or two of hurtling metal, keeping you on the track, enhancing the style of your ride, and generally having fun, so all those subjects and more are fair game for HRP.

What, exactly, makes us different from the venerable HOT ROD print magazine? Mostly, that we can raise the level of our content to appeal to people who already understand electronic engine management, the subtleties of multi-valves, the timing of intake, exhaust, and ignition events, swirl, flame propagation, turbocharging, angle torque, ABS, caster vs. camber, and any number of other concepts that you deal with every day in your work, but probably take for granted. Whether you know it or not, you're the Elite, and we'll never talk down to you. We will, however, try to challenge you with new, sophisticated knowledge that we hope you'll be able to integrate into your efforts in the high-performance field.

The technology involved in this pursuit has changed monumentally since I was the editor of Speed Shop magazine back in the days of Don Garlits, Grumpy Jenkins, Linda Vaughn ("Miss Hurst"), et al, and HRP gives me the opportunity to learn new, interesting science and technology every day, as much of which as possible I intend to pass on to you through the medium of our esteemed contributors. Regardless of our collective experience, however, we can't think of everything. So, I'd be much obliged if you'd help us make HRP interactive by suggesting topics and providing feedback, both positive and negative (email bfreud@hotrodprofessional.com – I'll forward to our contributors as necessary).

So, please dig into HOT ROD Professional and enjoy what we think is uniquely interesting reading. ■

The Stuff You See

by Greg McConiga

Our man Greg relates some egregious examples of the things that can be done wrong during the building of a high-performance engine. You'll learn a lot of interesting stuff here.

We see what we see and don't see what we don't see. Sounds pretty silly, right? A double tautology. But it's true nevertheless. How many times have you looked at something and decided it was good to go, only to look a second time and discover some fault or condition that you plainly overlooked the first time around? I know I've done it -- with embarrassingly regularity -- which is why I tend to look, walk away, and come back and look again.

Sociologists suggest that a lot of what we see and how we see it is due in part to our natural inclinations and due in part to the culture in which we are raised. For example, Americans tend to be very focused, seeing only the thing we are concentrating on, while our Asian cousins tend to see things in a broader context -- they see not only the thing, but those things that surround the thing. Perhaps learning a language that is very context-based teaches people to see beyond just the object being studied. I can only guess since that field of study is well above my pay grade.

Which brings us to the field of retail, or commercial, engine building; in this world, the parts are well known, the engineering is done, and the biggest parts of the job are keeping everything clean and making sure all the bolts get torqued. You don't really have to check and recheck every little detail because all the Legos come out of the same box. But in the world of high-performance engine building, everything gets different. You may be assembling parts from over 50 different vendors -- the cam from one guy, the lifters from another, the pistons, pins, rods, crankshaft, bearings, and rings all from different vendors -- which means that EVERYTHING has to be checked because NONE of the Legos come out of the same factory, let alone the same box.

I'll share a few stories with you about some engines I've worked on over the last couple of years just to show you what can happen. The people who brought these engines to me were very skilled commercial or retail engine builders. The vast majority of the steps they'd taken were done correctly. The problems they experienced were mainly due to our tendency to only see a part or problem as a single, stand-alone installation challenge instead of the entire context of what that part was designed to do. That, and a failure to understand that changing one part often necessitates changing several other parts to make the first part work correctly as part of the overall assembly. The owners of these engines have nothing to be ashamed of -- they didn't know what they didn't know, and didn't know they didn't know it! I've been there about a million times myself, and you will be too if you start building performance engines.

The First Victim

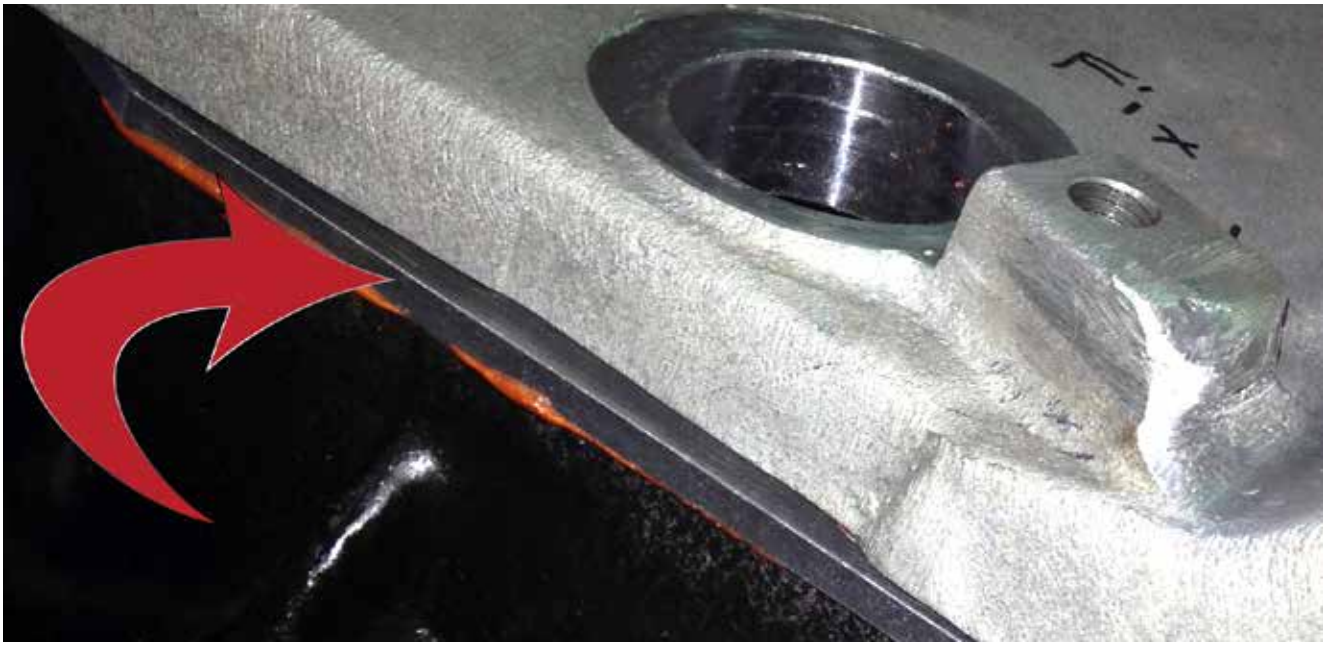
A 410 cubic-inch Ford stroker E85 street/strip engine.

The car owner had, over the course of a year or more, assembled the parts needed to build his latest bullet. He had found a commercially-built short block, a pair of aluminum cylinder heads, a custom-ground roller cam, and most of the parts needed to put it all together. I started by mocking everything up. Right from jump I had a problem: cc'ing the heads and block, I discovered that the predicted 11:1 compression ratio was more like 9.75:1. The "58 cc" heads were actually 62 cc. Can't trust anyone anymore.

His custom-ground cam had a pretty late intake closing, which meant that his dynamic compression was way, way low. Low enough that it was less than a lot of stock engines! I attempted to mount the heads and discovered that the trick aftermarket head dowels were too long and the heads wouldn't seat on the block... uh-oh. Got that squared away and found that the cylinder leakage test was sky high -- like over 30% on three cylinders. Needed to check that out. Installed the cam to check valve clearance and discovered a number of things. The cam retaining plate was too thick -- there was no end play at all. In fact, it was binding. The pushrods were the wrong length throwing the valve train geometry out of whack. There was too much piston recession in the block, and the head gaskets were too thick (not enough quench was the result of all that). While degreeing the cam during mockup, I discovered that the cam pin was installed in the wrong location, and that "straight up" was more like three degrees retarded -- on a cam with three degrees advance ground in!

About this time, I took it all the way down, and discovered that the ring gaps were running .032-.033 in. on both the top and second ring (explains the leakage...) and that the engine bearings were a street-only brand I'd never heard of. Checking the cylinder bores with a 1/10,000 in.-reading dial bore gauge, I discovered that the block obviously wasn't bored with torque plates. The bores were tapered, barreled, and out-of-round from top to bottom.

When I was done, it was 412 inches, the bores were round, the leakage was under 7%, the cam was degreed in correctly, the rocker geometry was correct, the compression was up to 11.9:1 (I wanted to go higher, but we ran out of money), and quench was set at .050 in. Now, he's all set to go out and lose his driver's license...



As you can see, a thin aluminum filler block is used to take up excess space between the china rail and the intake manifold. You can fill this gap with RTV, but why take the chance?

The Second Victim

A 599 cubic inch big-block Chevy-based wet sump racing engine.

A long-time racer arrived with a new combination that he wasn't entirely comfortable with. He reported that he had no oil pressure at the end of the quarter mile with a previous build and that even with an accumulator the engine bearings were always badly worn on tear down. He was also not getting the performance and reliability he had hoped for with his old combination and said he often spent most of his time at the race track fixing the car, so he replaced the pistons and the camshaft in hopes of finding the power he wanted. When he took it to his dyno operator for testing, the operator was unwilling to run the engine for him, saying that "he saw some things he didn't like and didn't want to break the engine on the dyno."

The first thing I spotted was that the intake wasn't entirely sealed at the china rails. The thick layer of RTV was just a little short and you could see daylight from one end of the intake to the other. It needed to have rail extenders installed.

I added on about a half of an inch to the mounting boss so the distributor could be properly tightened.

I also noted that the distributor could easily be turned by hand when the hold-down was fully tightened. While this was a crank-trigger engine, the distributor body

was the spark sorter, and if left this loose it would rotate against the torque of the high-volume oil pump in the wet sump and start cross-firing other cylinders resulting in catastrophe. The intake manifold distributor mounting pad was too short for the tang opposite the distributor to react against and hold the distributor from turning. So, I fired up the TIG, welded it up and shaped it so that it would lock the distributor in place against the resistance of the oil pump.

Further inspection revealed that the adjustable collar on the distributor body (an MSD billet piece) was not in the right spot, and the oil crossover channel at the back of the block sealed by the distributor body was nearly blocked off. Getting it in the right place (you have to remove the rear oil galley plug to visually center it) required that the distributor drive gear be machined a bit shorter and that the shoulder below the gear be reduced in diameter so it would drop deeper into the block. The block he was using was an aftermarket piece with a bulge that pushed over into the same place the distributor gear would normally occupy, and it was easier to modify the distributor gear than it was to modify the block.

On the preliminary inspection, I noted a slight catch in the engine as I rolled it over. When I pulled the heads, I found that the intake valves were hitting the pistons -- there was insufficient valve drop clearance AND radial clearance. The new pistons also arrived with too much dome on them to be used as supplied with his 12-degree aftermarket racing heads. The static compression calculated out to over 17:1 (diesel territory), and that, combined with the new cam's early intake closing, resulted in a dynamic compression of almost 12:1! Since the upper limit is

The lower arrow points to the rear oil galley cross-over slot that you see on all big- and small-block Chevy engines. You should center that slot in the oil gallery to ensure full flow to both sides of the engine. The upper arrow shows where I machined off the end of the gear so that the distributor could drop deeper into the block.

about 9.5:1 on racing gas, it's a good thing he never throttled it up. It would have been an aluminum-scorching machine for sure.

As I unloaded the rods and pistons, I used my rod bolt stretch tool to measure how much stretch was on the rod bolts. I was stunned to find several bolts that had relaxed

What do the **Chevrolet Camaro** and the **BMW M3** have in common?

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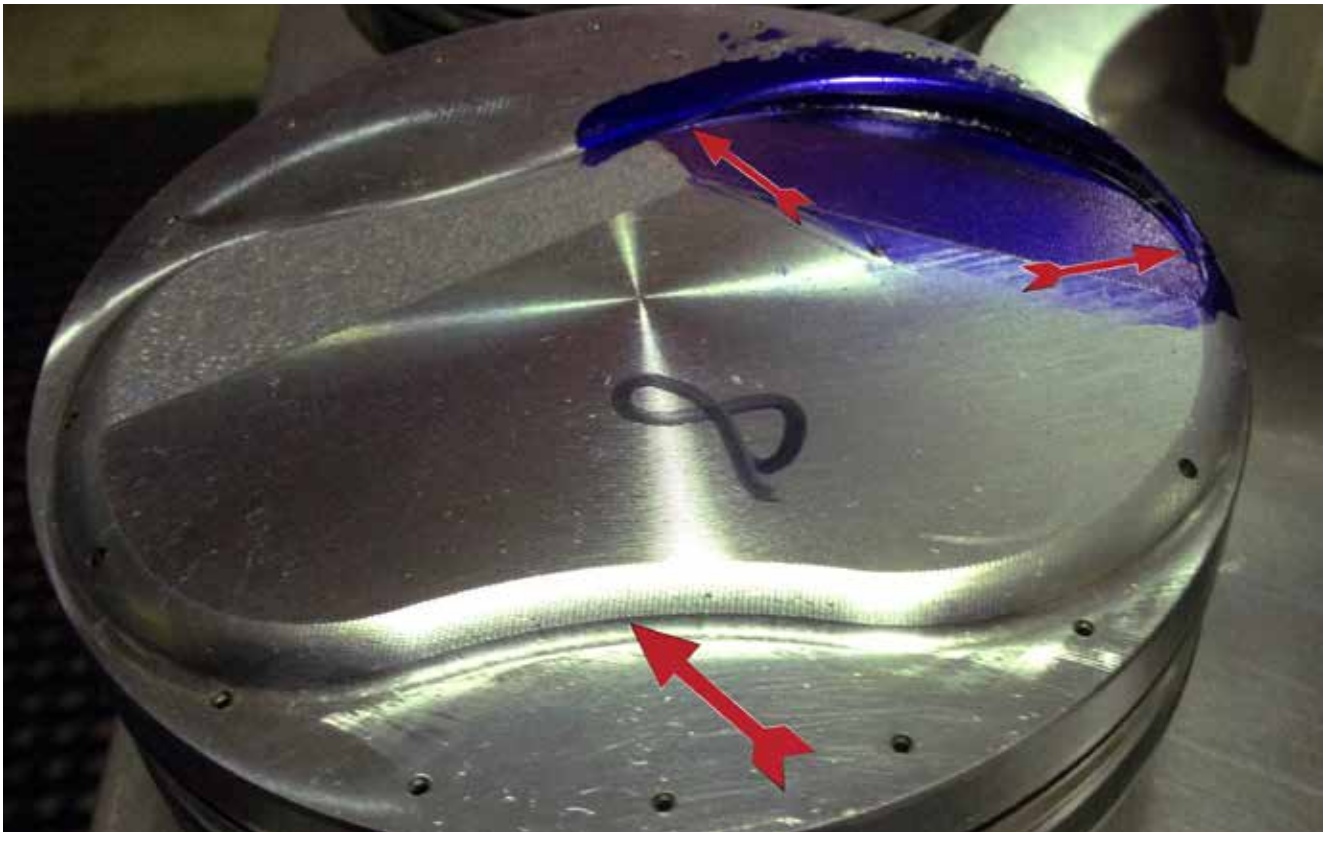


The new piston arrived with way too much compression and not nearly enough valve clearance. The space between the arrows in the valve pocket show where the valve was making contact.

A little Dy-chem and a lot of patience is all it takes.

Rod bolts run $15 to over $50 each, but even at that they are cheap insurance. Never chase the stretch or you'll have to replace them all.

This engine uses a vacuum pump which tends to pull oil away from the wrist pins, so the owner specified pins coated with diamond-like coating (also known as Casidium or DLC). We were able to run these again, but they were too tight to start with. The arrows point to damage to the coating on the right and "faceting" on the left E damage like this is a sure sign of too ittle clearance.

You must measure the pan depth from rail to sump bottom and pickup depth from rail to bottom of pickup. 3/8 in. is the preferred specification.

by .007-.009 in! The spec for the bolts was .0054-.0058 in. Turns out the owner "chased the stretch" as he tightened the rod bolts... a fairly common error it seems because I've heard of others doing this as well.

When you stretch bolts, you must lube them, turn them one time all the way to the final reading, and measure. If they don't reach stretch you must loosen them all the way, re-lube the area under the head, verify that they have not taken a permanent stretch and then stretch them again in one motion, and measure them again. You must NEVER tighten them, take a reading, then tighten them some more, and read them again and so on. All you'll end up doing is "chasing the stretch" and ruining the bolts. Plus, once over 75 ft. lbs. or so the head of the bolt and the shank above the threads winds up ahead of any thread movement and you'll introduce all kinds of stress into the bolt doing it that way. The best way I've found to tighten racing rod bolts is the "torque and turn" method used on a lot of late model car fasteners. I tossed the old bolts and bought new ones.

As I continued, I discovered that the DLC pins (Diamond-Like Coating -- the black finish you see in the picture) was marred. It turned out that the pin clearance was much too tight. If you look closely at the lower pin, you'll see that it is "faceted" from being overly tight in the bore. Both the rods and the pistons were resized to correct the condition.

In my search for the low oil pressure problem, I discovered one thing early on: The oil pump pickup was damn near sitting on the floor of the oil pan. It was literally off the floor by just the thickness of the oil pan gasket, roughly .060 in. The oil pickup was modified to raise it up to just over 3/8 in.

The results? He's been out with the car and he's running about 177 mph through the traps -- about 10 mph better than he'd done previously, and it was all done with his old combination. Now, he's holding 70 psi of oil pressure all the way. I didn't even have to use his new pistons or new camshaft to get him there.

The Third Victim

A 1970 Corvette, 350/350 horsepower, 11:1, recent rebuild, upfitted with a big thumping hydraulic roller cam

This classic arrived a very unhappy car. The owner reported that it wouldn't idle below 1,300-1,400 rpm, it was using oil, there was some upper engine ticking, and it didn't like it if you dropped the initial timing back to anything under about 25 deg. BTDC. The first thing I did was I stare at it a while. It certainly had a cam in it... diagnosis was complicated by how choppily the engine ran. So, first things first, I checked the original damper. It had slipped, but only by about five degrees (so far!). I popped the valve covers off and noted that on one cylinder there was a lot of thread showing above the aftermarket stainless steel rocker arm. Not a good sign. Flipping the aftermarket valve covers over, I noted that there wasn't a baffle in sight over the PCV valve. Also, I had noticed when I drove it into the shop that it was running about 70 psi of oil pressure when it was hot. Hmmm.... I'm betting a high-volume oil pump right about now. The plugs were oil fouled even though it had only been a few thousand miles since the overhaul. I could see the positive-style valve guide seals through the springs, which made that path into the fire unlikely. So, I pulled the PCV hose off and -- surprise! -- it was full of oil.

Always double check old rubber mounted dampers on older cars. A lot of them have slipped over the years. Remove your degree wheel without moving the crankshaft and verify TDC is correct.

The compression test told me I was in trouble -- I had about 40 psi more down one side of the engine than the other! Now I'm in "what the hell is going on here?" mode. So, I called the customer for permission to pull the engine out for a better look.

The pictures tell most of the tale. They had bored the block, installed the cam, roller lifters, stainless steel roller rockers and put it back together. Nothing fancy going on here... just gaskets and a few parts. It was originally an 11:1 engine, and that's just how it went back together. If you look closely, you'll see the original piston recession numbers on the pistons and the new recession numbers on the deck of the block (after I had it decked to fix it). This thing went from .019 to .027 in.

The numbers written on the pistons are how far down the bore the pistons were before we machined the deck. The numbers on the deck indicate where we ended up after machining - quite a difference! (Top: Driver's side; Bottom: Passenger's side.)

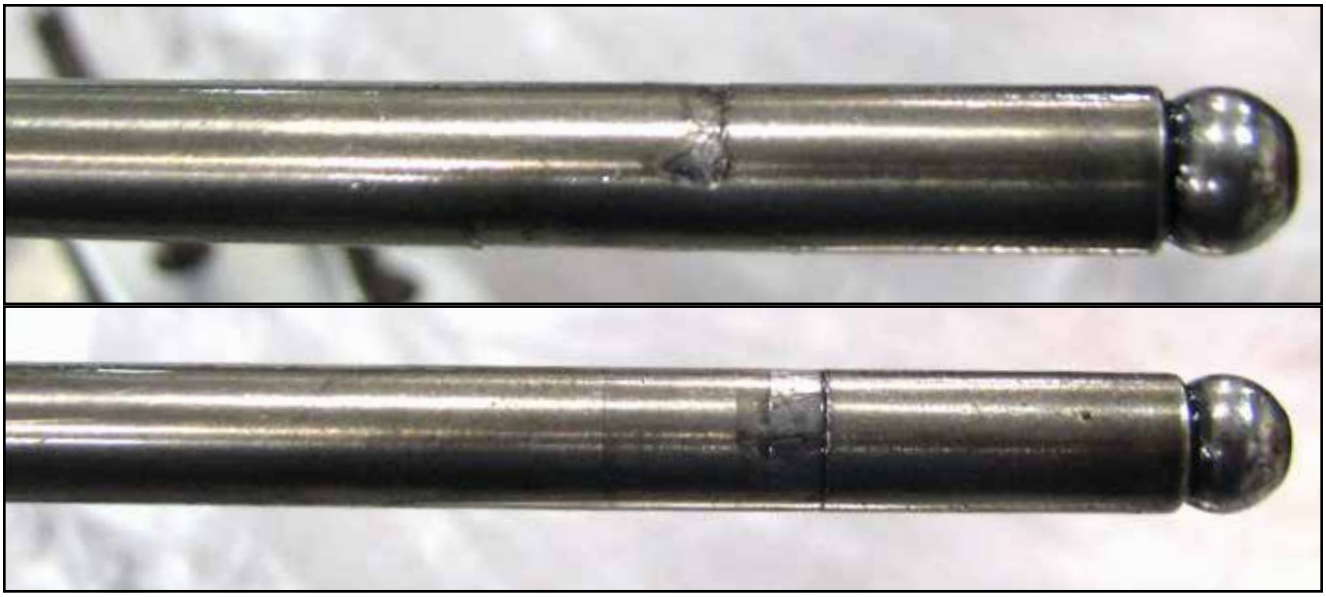
The valves were all sunk to about the same degree, so I just had the head with the larger combustion chambers machined to make both sides equal. It was the most elegant solution to the problem.

from back to front on the driver's side, and from .034 to .039 on the passenger side. The deck was tapered on one side, plus I had .020 in. difference in the piston-to-deck measurement. To make matters worse, the side with the sunken pistons had the cylinder head with the bigger combustion chambers -- something like three ccs bigger. I had one side of the engine at about 9.8:1, and the other side at about 10.4:1. Okay, combine that with a big old lumpy camshaft and I guess it might not run so well. The thing that struck me was that all of this mess had to come from the factory this way! The engine was original and had only been freshened up this one time. Good old days indeed...

It had a high-volume oil pump, which I replaced with the original high-pressure pump. I wanted to try to keep some oil out of the valve covers. I also fabricated baffles to divert the oil away from the PCV valve. I discovered that a couple of pushrods were trying to shove their way out of the pocket in the rocker arms because the guide plates weren't clearanced for the additional lift of the new cam. I also found one lifter fully collapsed and stuck down. He said he had a hard time getting one to quiet down and he had to keep adjusting it. Sigh.

It's easy to forget that you must baffle the valve cover to keep oil mist from being sucked up into the PCV system.

Another thing I found was that the customer had removed and rebuilt the distributor, and didn't get the gear on right. If you look at an old stock small-block Chevy, you'll see a drill mark on the gear (check the picture) that must align with the tang on the rotor. Not a big deal, but still... There are 13 teeth on that gear, and you'll throw your rotor register off if you mount the gear backwards.



These were the worst, but virtually all of the pushrods were damaged and had to be replaced and the guide plates ground out for clearance. The pushrods move in and out as the rocker travels in an arc. More lift means more movement.

For those engines that don't use guide plates it doesn't mean you're out of the woods when it comes to pushrod contact with its neighbors. Here you can see gear marking compound that has transferred from the pushrod to the clearance notch in the intake runner.

If you look closely you can see that the lifter is stuck down. I freed it up and tried to run it, but it stuck again and had to be replaced.

I also found that the owner picked the wrong intake gasket. It wasn't leaking that I could tell, but it looked to me like it was only one good cold morning backfire away from whistling. There was also a cam button installed to keep the cam from walking in and out of the block and it was jammed up against the front cover so hard it was trying to bore its way through. A little lathe work to shorten it up and I set the end play at about .006 in. and it was good to go.

Most of the assembly looked pretty good -- the rings, bearings and pistons were fine -- and it looked like they did a good job keeping everything clean during the build. Once it was back together, it actually ran much better than I thought it would. It ended up back up to a true 11:1 compression ratio, and with 230 pounds of compression on all cylinders it does need racing fuel to run, but it will drop right down to 750 rpm and 10 degrees of initial timing, and just pop them off with just enough chop to remind you of why you love those dirty old cars. The oil consumption dropped to next to nothing and the old girl ran out pretty strong when you got on her. As an added bonus, my machine shop gave me the award for "Most Screwed Up Stock Block We've Ever Seen." The wife and kids are so proud...

Myriad Ways to Mess Up

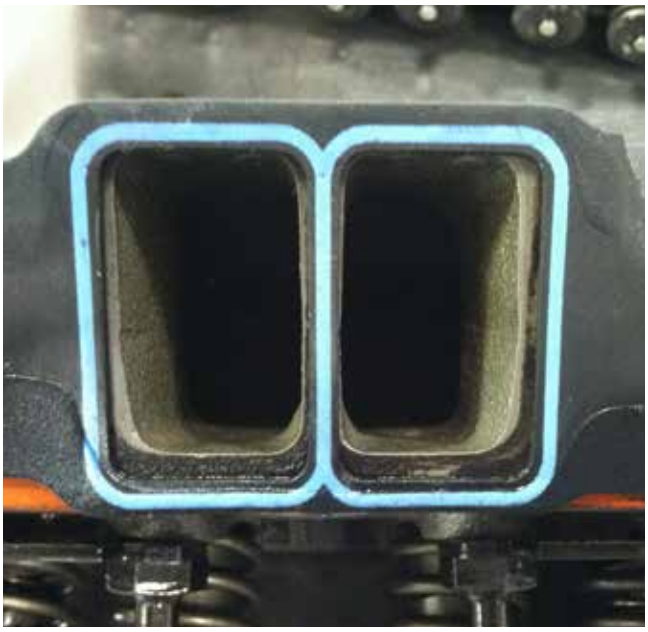
There are a hundred things to consider when doing this work, from parts that aren't made right, to cleaning, and learning good measurement techniques. If you need an example of parts that cost a lot of money, but aren't made quite right just look at the picture of the piston and ring. You can see that the ring stands proud of the ring groove... not enough back clearance. Oh, it'll fit into the bore, but if you miss a problem like

The top tang is facing away from drill spot on the gear. This gear is on backwards. You can see the center tang sticking up, but the rotor tang that directs spark to the cap insert is pointing away in this picture.

this on inspection, as soon as the engine starts and the ring heats up it'll grab the cylinder wall and stall the engine... and then restart, stall, restart, stall, restart, and stall over and over until you finally find it. Install bolts that are too long in the water pump of some engines and you'll shove the cylinder wall over into the piston. Fail to check your fasteners for proper minimum thread engagement and risk total failure. Or, fail to clean all threads on all fasteners and in all holes and risk false torque readings that leave a critical component so loose it'll fall off halfway through the race. It's all part of the many, many things you have to keep track of as you build performance engines.

The best part about this job is that there are always, always, always new things to learn every day. I learn something new on every engine, every time on every project... and that's what keeps it fun. ■

If you use a roller cam you have to use something to keep the cam from walking in and out of the block. Just make sure you've got end play on the cam after installation.



You can see the impression where the intake sealed on the gasket. Not much to hold on to!

Look closely -- you can see the ring stands proud of the groove. Minimum safe back clearance is 0.005 in.

Setting Up Your Shop

Organization is a virtue and a frustration - and money - saver

by John Galt

For every person who wants to start building race cars, there is a different style of getting the job done. We've seen work areas that look like a surgical theater and folks working in their back yard rolling the parts around in the grass. We're not going to tell you which is better, but we will share with you what we've done ourselves. And, we'll cheerfully tell you that we'll be doing it differently in two months because, just like you, we're still learning and improving. You'll never hear us tell you that that we've got all the answers, because we don't. In fact, sometimes we don't even know the damn question. With that, let's explore some of the things we've learned and you can sort through them and see if any of them will work for you in your shop.

To a large degree, the amount of space you have will determine how you end up working because your floor plan will dictate work flow. If you have a one-car garage to work out of, you will have to work differently from someone with a two-car, three-car, or big dedicated work shop. Workbenches and storage systems are critical, but the number of linear feet of bench, or the size and type of storage is set in part by the size of the work area. If you're in a small space, your organization, cleaning, and preparation skills have to be highly refined and follow a logically-designed flow path that will let you accomplish the most in the least space and in the shortest time.

Swarf

Working on race components means that you will inevitably be grinding, welding, or re-shaping parts, because "Race Car Parts" is Latin for "Almost Fits." You will find yourself resizing fasteners, removing or adding metal on blocks, heads, intakes, and header flanges. You'll have to manage the swarf floating

around from the abrasive or cutting tools you use, dirt that's resident in your shop, and dirt that's blown in when the door is up. Managing dirt will become an important part of your day if you're a successful builder.

It's not always possible, but ideally you would like to set up dirty-process areas, clean-up process areas, and an ultra-clean area for reassembly. But let's assume for now that you don't live in a perfect world and that you have to work in the same general area and bring the project from teardown to reassembly in the same few square feet. Let's start the conversation with storage and work benches.

Work surface

We like steel top, laminate wood, and stainless steel work surfaces. Given our druthers, we'll take stainless every time. It shows dirt, reflects light, cleans up with lacquer thinner or brake cleaner, and you can write notes all over it with an industrial Sharpie that you can clean off later with thinner. It doesn't rust, won't chip, or dent, or hold dirt. It does scratch, but over time the scratches all morph together into a "matte" surface that works just fine. It's a great surface, either as a work bench or an oversized Post-It note.

We salvaged a stainless steel sink section and mounted it on scaffolding wheels to make it mobile. The wheels lock in both the rolling and rotating planes and when locked up the bench is rock solid. Wheels are wonderful things ... everything you have should be on wheels. It makes

Kindred spirit and fellow performance junkie Mike G. is the most organized human alive. Look at what's packed in this two car garage!

There is a large upright air compressor, a flow bench, a cold tank, a valve grinder, a lift, a seat and head machine, a blast cabinet, a water cooled TIG welder, a custom work stand and dozens of tools, jigs and fixtures stuffed into every nook and cranny. No excuses! You can do it!

moving something outside easier (for cleaning, grinding, or welding), and it makes cleaning your shop a breeze. We use the built-in sink as a parts catcher. We put a plumber's test plug stopper in it, and we just toss everything we're discarding in there to hold until the project is done. Holding on to the old parts will save you sometimes if you need to compare new to old halfway through assembly. You can see in the photos that we also kept the pots and pans hooks and the carousel. Makes a nice place to clip instructions, or hang gaskets, caulk guns, or miscellaneous parts. The racks below hold all sorts of things you should throw away -- a man can't have enough "crap collectors" (shelves) in his shop. Speaking of which, shelving needs to be on wheels as well. The tall rack with the red canvas covering is holding tools and boxed items in our shop, but that rack (available from Omega Shelving... https://www.precisiontools.com/default.asp, for around $240) will hold 1,200 lbs., and you can store an entire engine on the five-shelf unit, including the block. We like the wire shelves because the dirt and dust falls right through to the floor. Roll it outside, blow it off and cleanup is done. That heavy red cover you see in the photo is another $250, but if you want to keep things under wraps and clean, it's a great addition.

If you are lucky enough to locate one, a salvaged sink section makes a great work area.

You can also see plastic tubs like they use for bussing tables in a restaurant, and full-sheet, half-sheet, and quarter-sheet baking pans, along with lots of magnetic trays. The bussing

Even in a large dedicated shop putting everything on wheels makes the space flexible and easy to clean.

A sink isn't wasted real estate... it makes a great holding tank for dirty parts.

tubs and sheet pans are available at any restaurant supply store, and the magnetic trays are available from the Mac or Snap-on man, or online at any number of tool warehouses. Buy all of the same type and brand of magnetic tray so all the magnets are of the same polarity and you can stick them together in a tall stack to take up less room. We've acquired a couple of off brands, and they repel the others and won't stack. You'll also see a few specialty trays -- piston and rod racks, valve train racks, V-blocks for holding cranks and cams, and valve and valve spring racks. They're worth their weight in gold and can be found at places like CV Products.

Bag it and tag it

We're "bag it and tag it" kind of guys. We've got day jobs and sometimes it takes a few days to get back into the shop, so given our age and state of deterioration, it's either organize or spend half our work day searching for something we misplaced when we were last in the shop (don't laugh, if you live long enough this will all make sense to you one day).

When a job arrives, we grab a handful of trays and start the teardown. We spread

One cart stores tools, the other stores parts for the project in process. This one measures 24" by 48" by 96". Go up to maximize storage with the smallest footprint.

If you have several projects running concurrently you just can't have enough magnetic trays.

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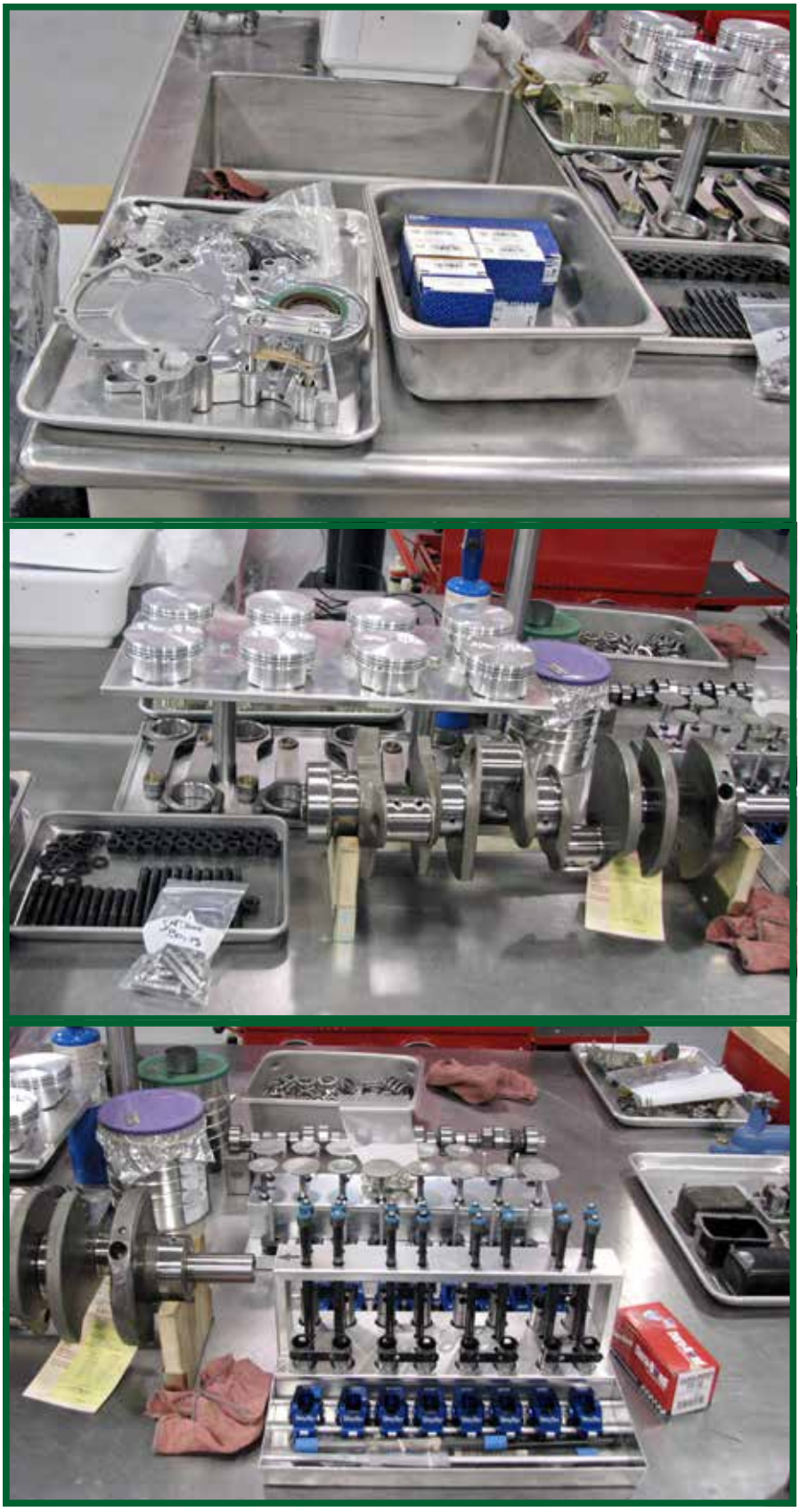
each system into its own tray or container and make notes in permanent marker on the tray (just love those industrial Sharpies). We'll put fasteners in magnetic trays to hold them fast and put everything associated with a given system on the sheet pans. Then, we'll wrap the whole thing in a cheap plastic trash bag, tie it off, and put it on a shelf. We've found that doing it this way ensures we won't lose parts and that the dirty bits stay in the bag until we remove them for cleaning and modifying, if needed. After everything is cleaned, modified, and inspected, we clean the tray, use a new trash bag and our freshly-cleaned parts stay clean until we're done fitting, grinding, and mocking up all the other parts that need work. If we're replacing parts, we'll remove the old parts from the tray and put the new ones in place of the old, tossing the old parts in our sink holding area, "just in case."

We like using anti-fatigue mats on the floors around the work bench area. Not for our comfort, but because sooner or later you'll drop something really, really expensive and those mats will save your hindparts. While we're



On build day, the clean parts are removed from the storage bags and organized into the various trays and parts organizers so that your time is spent building in quality and not looking for a misplaced part.

Putting the entire system and all the related parts on a single tray and bagging it all up helps inventory control.

Bag it and tag it.

talking about floors, we highly recommend that you seal them with an epoxy type floor product. Not only is it much easier to clean, but if you use a color like a light grey, it reflects light and makes spotting dropped parts a lot easier. We're not fans of the "sprinkles" that you top off some floor products with because a single color makes spotting things on the floor much easier. We also use rubber matting on the bench if we're working with large aluminum parts like heads. If you have the luxury of starting with a clean slate in your shop or work area, remember that you can never have enough light, enough pegboard or shelves, or enough air and electrical outlets.

Control freaks

A big part of this business is inventory control. Make sure you keep track of what you bought, when you bought it, and where you bought it. We've attached a sample inventory control sheet for your use. As parts arrive, we "decant" them, count them, record the information, clean them, tray them up, and cover them with a light film of oil before we put them in their respective plastic bags. While we're thinking about this, know what materials your parts are made of before you clean them. Certain materials are not compatible with some common solvents or cleaners (titanium and chlorinated solvents like brake cleaner come to mind -- never expose titanium to any chlorinated compound). Several of the exotic alloys used in race engines must never be exposed to any kind of moisture, including the oils and sweat on your hands and must be kept oiled. Some alloys that we're aware of that require special handling include L-19, H-11, Custom Age 625+, ARP 3.5, 300M, Aeromet 100, and Inconel 718. There are others, so read the directions!! We keep Sure Shot cans full of WD-40, Marvel Mystery Oil, lacquer thinner, and an alcohol/acetone-based brake cleaner on our bench for quick cleaning and lubrication needs.

As you bag and tag, try to keep systems together -- valves, springs, locks, retainers, pushrods, and rocker assemblies in one group. Pistons, rings, rods, locks, rod bearings, and rod bolts in another. Block plugs, cam bearings, oil pump, pickup, oil pump drive rod, crank and main bearings in yet another. Oil pan and windage tray in another, and so on. You can count on mocking up the engine three to five times, so don't get crazy with your final cleanup until everything has been installed and checked for clearance throughout the full range of at least two crankshaft revolutions.

Keeping all your assembly groups in nice, clean plastic bags will make your job as lot easier as you load, unload, modify, and reload the parts. Once you're good on clearance, all you're left with is removal from the storage bags, final clean up, and installation. If you mock up, measure, grind and fit, clean and bag, you end up just pulling clean parts out of clean bags and torqueing up the fasteners during the final assembly.

Look, I don't care how clean the shop looks or how many times a week you clean it. Even if you've got heat and air conditioning, you've still got dirt moving. Just lock the shop for a week and go back in and look at the dust lying around. You tell me, what could be worse than losing parts, or mixing clean and dirty parts during mockup? Other than working until midnight on the final assembly only to discover that you forgot to order something, or miscounted it, and you're one main stud short of a build. When it comes to engine building organization, cleanliness really is next to godliness. ■

Tracking your parts on a spreadsheet like this example will save you time and effort later. We record the manufacturer, the supplier if it's not manufacturer direct, who we talked to and the date and time ordered. Under "notes" we record the received date and the inventory count so we know that we have the parts that we need to complete the build. You can easily build your own customized spread sheet that fits your specific needs in a program like Excel.

Keeping the right cleaning products and lubricants close at hand and the wrong ones out of the shop altogether will keep you from making a bad mistake.

Stainless and aluminum pans and system trays are worth their weight in gold as you move from mock up to mock up. They are easy to clean and once the parts are placed they keep you from overlooking a misplaced part or component.

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Variable Valve Timing and Performance Applications

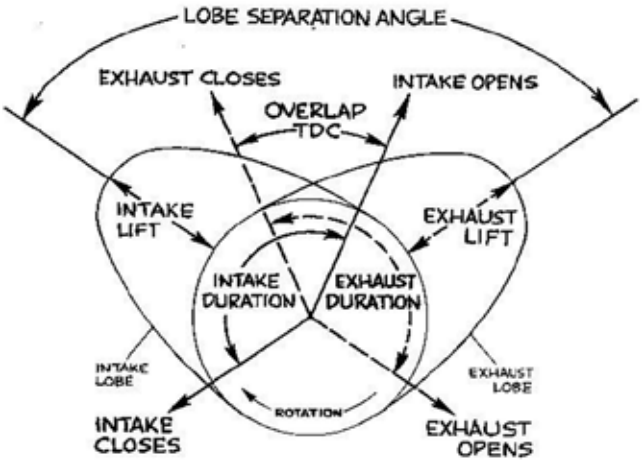
Part I: Cam Selection

Lots and lots of critical questions, and you'll need your sharpest wits and the advice of the cam grinders to answer them accurately

by Adam Smith

Considering all the underlying subtleties, camshaft design and selection is a complex topic indeed. It seems simple at first; when do you open the valves? When do you close them? How much overlap will work for your application? What kind of lobe separation angle (LSA) works best? Where do you want the lobe centers (LCA) for the intake and exhaust? And of course what duration and lift figures do we end up with? But none of these things can be considered without looking at all the underlying pieces that make up the reciprocating assembly, intake, and exhaust conduits.

An engine is a system and all the parts that make up that system must be considered when making a cam choice. When you consider the additional complications



While there are a whole lot of subtleties involved, this simple drawing gives you the basics. Keep it in mind.

Left: Everything that has anything to do with valve timing is referenced to the crank position, in degrees. An accurate degree wheel is an absolute necessity, made even more necessary when you're installing performance cams in VVT-equipped engines. Not knowing your valve position relative to the piston's location in the bore throughout the entire range of the VVT limits is a recipe for disaster.

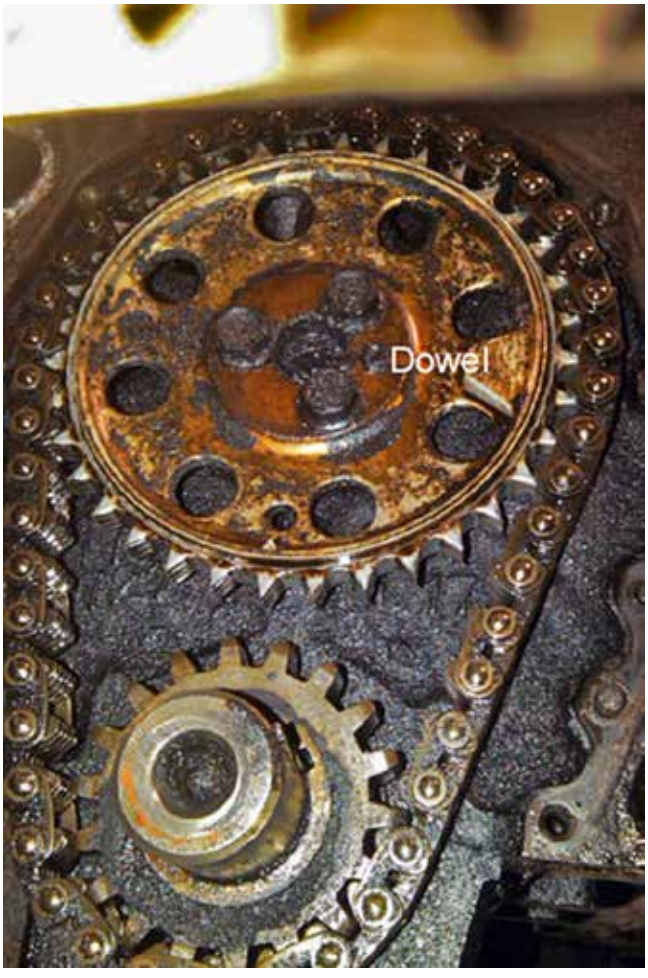
brought by variable valve timing or variable timing and lift systems, it can get really complicated... which is why you must utilize the tech resources that are available at the cam manufacturers if you hope to achieve the best possible result.

So why do we even need or want variable timing systems? Because with fixed timing systems the cam events are really only optimized for one specific, narrow, rpm band, sometimes only a few hundred rpm wide. Let's look at fixed systems first, then examine some of the variable timing and lift systems out there today along with some of the limitations that retaining these systems place on our engine build.

It's An Air Pump...Sort Of

While an engine could be simply described as an air pump or compressor, it's a dynamic air pump that varies in efficiency and volume based on the physics of the cold and hot gas exchange cycles occurring during portions of the four stokes. To further complicate matters, these exchange cycles also have overlapping, shared events during which each affects the other. These cycles are also linked by common intake manifolding in most applications and by an exhaust system typically linked on at least half the engine... and the cycles are constantly varying in intensity due to changing rpm, throttle opening, intake pressure, exhaust pressure, pulsing, resonance, mixture, and timing.

Incoming air mass and density is affected by engine temperature, ambient temperature, humidity, and the fuel delivery system; a "wet throttle plate" fuel system that promotes evaporative cooling in the intake conduit charges the cylinder differently from a "dry throttle plate" system where fuel is injected either directly into the combustion chamber, or right at the back of the intake valve. The wet-intake evaporative cooling effect dramatically affects intake charge density, but the air volume – both the oxygen and the nitrogen (which acts as a buffer in combustion) – displaced by the fuel in a wet intake has to be considered. Charge density affects incoming charge inertia, which means that for any given bore, stroke, and rod length combination the intake valve may need to be open for a longer or shorter period to achieve maximum cylinder filling without going into intake reversion.



Old school: On traditional engines such as this 1967 Chevy 327, cam timing was determined once and for all by the position of the sprocket dowel.

Blow down, etc.

Then there's part two: A more fully-charged cylinder changes the optimum exhaust valve opening timing (the beginning of "blow-down"), the timing of which affects both blow-down pumping losses and the pressure and velocity of the exhaust gases in the port and header, which in turn affects scavenging efficiency at overlap. Properly done, the exiting exhaust gases create a low pressure that helps clear the cylinder for the next intake event -- it's sort of like blowing across the top of a straw in terms of how it works -- and the less residual exhaust left in the cylinder, the more room there is for fresh air and fuel to react in.

For minimum blow-down pumping losses, you'd like the exhaust to open as soon as possible and let the cylinder's residual pressure vent the cylinder all the way down to exhaust system back pressure so the rising piston has almost no work to do, but in doing so you won't extract the maximum work produced by the trapped expanding gases. While we always talk about "compression ratio," the mirror image of compression is the expansion ratio... and that's where the power is extracted. The main reason we measure compression ratio is because we can measure it and because it gives us a "mirror image" of the expansion ratio.

There are other considerations as well: What about the intake manifold? Is it variable in volume or length? Ported? Matched to the cylinder head to minimize turbulence in the intake conduit? Stock air cleaner and filter, or cold air system with a low-restriction/high-flow air filter?

Even something as simple as the installation of a low-restriction air filter has to be taken into consideration.

How about exhaust system efficiency? Are you running cast manifolds? How big is the exhaust system tubing if you're running a full length exhaust? Pre-cats and/or catalysts? Mufflers? "H" or "X" piped? Headers? Stepped primary tubes? Large primaries? Four-into-two-into-one, or just a four-into-one? Are you running a merge or non-merge collector? Is the collector length tuned to the application, or is it just what you got out of the box? What's the system backpressure at wide-open throttle at the top of each gear?

Then there's combustion chamber design and shape. Are you running a stock head, or is it an aftermarket rolled head with a shallow fast-burn design? Ported? How about material? Aluminum in most cases, of course, but what about a purist who keeps the stock cast iron heads on his old musclecar? What must he do to compensate for that heat retention? Cam and valve layouts come into play, of course. Single overhead, dual overhead, cam-in-block, cam-in-cam? Are you running a canted valve, straight valve, stock or larger-than-stock valve diameters? Are the valves shrouded by the cylinder wall? What about port shapes, flow rates, conduit volume, quench, or "squish," as it's sometimes called, tumble and swirl characteristics? (Tumble occurs when the air somersaults into the cylinder, swirl is when it rotates like a tornado.) What is the maximum designed engine speed and the application? All of the above may amount to question overload, but now you know why you need to talk to the experts when you select your camshaft. They'll ask you the same questions during the process.

So Many Options, So Little Space...

Variable valve timing comes in a number of different flavors, and the use of VVT is on the rise. There are discreet systems (think digital, only one or two states), continuously variable systems (analog!), single cam, dual cam, and variable lift systems. Plus, just about any combination that you can think of.

Cam phasing refers to a system that changes the installed lobe center of one or both cams and cam changing refers to

While not a brand that's typically hot-rodded, BMW was one of the early adopters of cam phasing. This is the single VANOS (a somewhat implausible abbreviation of the German variable Nockenwellensteuerung) unit, which operated on the intake camshaft only, and had just two phase-change points.

systems that change the lift and duration of the cam. The advantage of dynamically altering phase and cam profiles is that you can optimize the lift, duration, and phasing for nearly the entire operating range of the engine. By moving things around, the camshaft goes from best at a narrow rpm band to best over the whole operating range.

Each manufacturer has a different name and acronym for its particular system, but for our purposes here we'll just refer to them all as variable valve timing, or VVT. The first thing we have to consider is what each of these changes do and how each affects engine performance and output. With some cam changing systems, both lift and duration are controlled, as well as cam phasing. Other cam changing systems only control two or three steps of performance with two or three cam profiles (discreet system.)

As engine speed increases, the valve opening and closing timing events must occur earlier or later to optimize cylinder filling. Opening the exhaust earlier and the intake later moves the powerband up, improving high-speed torque and horsepower. This also changes overlap and cylinder scavenging efficiency, and by adding cam changing technology we can add additional control over mechanical duration and lift.

Duration changes are limited by the optimum valve opening and valve closing timing since duration is just the period between those events expressed as crankshaft degrees. Any increased overlap

The much more sophisticated Double Vanos not only dynamically adjusts the timing of both the intake and exhaust cams, but does so in an infinitely variable manner.

that would normally contribute to poor cylinder performance at low speed isn't an issue, since the cam changes only occur at engine speeds well above idle. Increasing lift is essentially "free" in terms of power production, past the considerations needed to get the lobe profile smooth enough that the valve train is able to follow it without float or exceeding valvetrain component load ratings that an excessive rate-of-lift might cause. Vaulting the valve farther open only makes more power, so long as the valve is controllable and valve train isn't damaged.

There are limits to this, of course. Once we get to lift points that are roughly 35-40% of the valve head diameter, the gains become so modest that more lift isn't worthwhile, ASSUMING that the conduit is stable up to that point. If the ports are unstable, if the flow is unsettled or turbulent, all bets are off. While being able to change the cam sounds like it would be the better all-around solution, it does come with additional expense and complication. With the right camshaft installed, cam phasing systems are very affective and are cheaper and simpler.

In general terms, advancing the camshaft opens the intake valve sooner, starts cylinder filling earlier, builds low rpm torque, decreases intake valve-to-piston clearance, and increases exhaust valve-to-piston clearance. Tightening the lobe separation angle will, in general, move the torque band down, increase peak torque, narrow the power band, increase cylinder pressure, lower the detonation threshold, increase cranking compression, reduce idle vacuum and idle stability, increase overlap during both open- and closed-valve events, increase internal EGR, and decrease valve-to-piston clearances.

For single cam applications, VVT acts as

a means to vary the cam installation point -- we can advance it for better low-end torque and retard it at high rpm for better high-speed torque and power. It's the same as being able to continuously degree-in the cam.

For dual-cam applications with the VVT on the exhaust cam only, changing the exhaust valve opening timing moves the torque band up and down. If we open the exhaust late, we get better part-load efficiency and more low-speed torque. At higher engine speed, opening the exhaust earlier improves high-speed torque and horsepower. Remember, horsepower is just (torque times rpm) divided by (5,252), so whatever you do to make the high-speed torque number better also nets you more horsepower.

With dual-cam engines with VVT on both the intake and exhaust cam, you get the advantages of being able to move the lobe separation angles, the exhaust valve opening timing, and adjusting both the open-valve and closed-valve overlap periods. Careful control of these parameters will allow smoother idle, lower emissions, a flatter and broader torque curve, and improved high-speed power. Adding cam changing just gives us more of the same, with the bonus of being able to finely tune low-, mid-, and high-speed performance and efficiency.

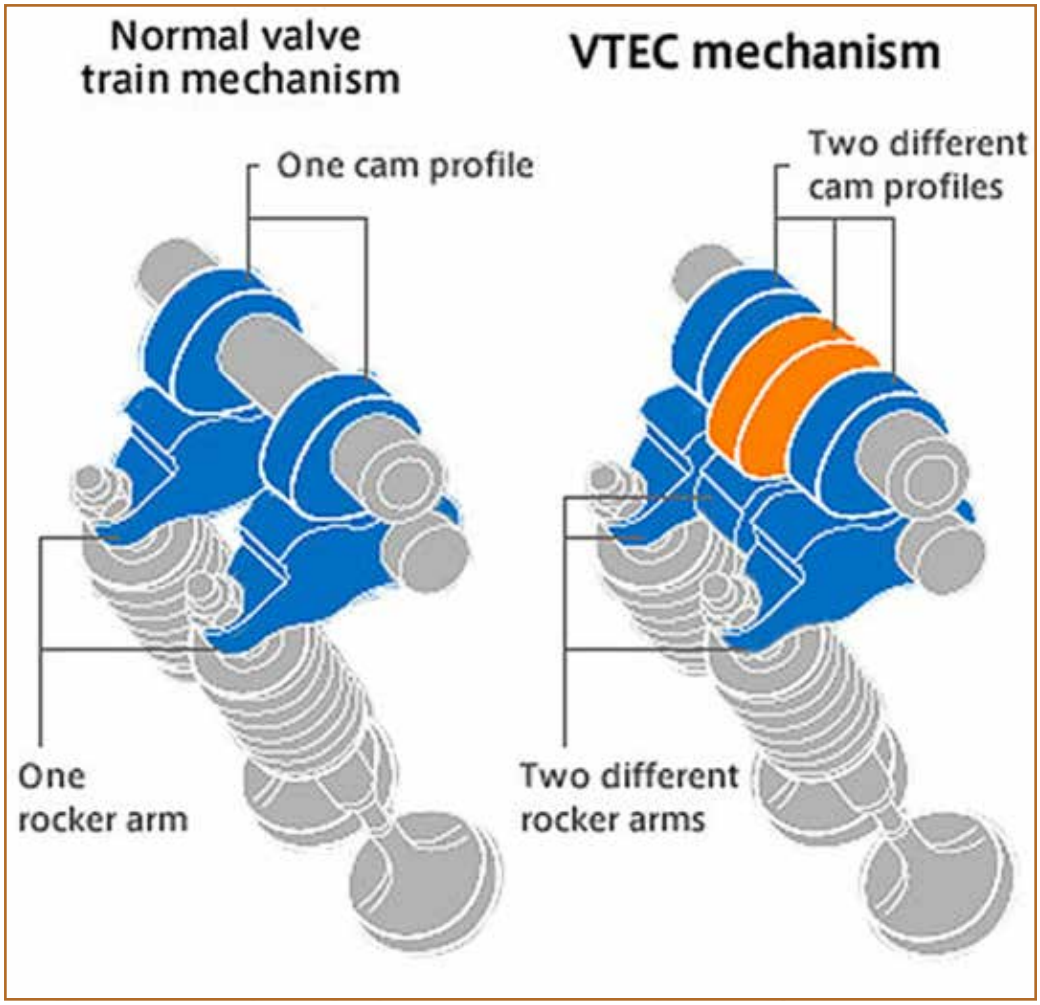
Going one better requires thought

It all sounds so great, it must be too good to be true. When it comes to enhancing the performance of these systems, there are some limitations you must be aware of. Obviously,

two things a performance grinder does nearly 100% of the time is increase lift and duration. If you're upfitting a VVT-equipped car or truck, you must be cognizant of some potential trouble spots. First of all, the factory VVT phasers may have as much as 60 degrees of cam control. Not a problem for a low-lift, moderate duration cam, but possibly disastrous with a "hot" cam -- you need to keep a safe distance between the valve and the piston, so you'll have to check to see if phaser control needs to be limited. In some cases, kits are available to limit total control to something around 20 crankshaft degrees. Or, you may have to purchase new phasers compatible with your cam selection. For radial installations phaser eliminators are available.

Two, if you purchase a cam that requires a valve spring with more open tension to control the valve you are limited to about 375-385 lbs. of open pressure with the stock VVT phasers. Past that and the spring pressure may overcome the VVT operation and you may lose the ability to accurately control the cam timing.

Installing performance cams on a VVT engine means checking all the things you normally check: coil bind, valve-to-valve clearance, valve-to-piston clearance, and installed lobe centers, or valve opening events to confirm installed advance or retard, plus rechecking everything with the phasers activated at full limit. You could take someone's word that everything will clear, or you could take the time to figure out how to check it and be sure because if it breaks, it's your mess to make right. You're the builder...



When Honda's VTEC concept debuted in 1989 on the Acura Integra XSi/RSi, we were wowed. It goes beyond variable valve timing with variable lift. A sliding pin actuated by oil pressure engages a "hot cam" lobe. It was the first production engine to generate 100 hp per liter (courtesy Honda).

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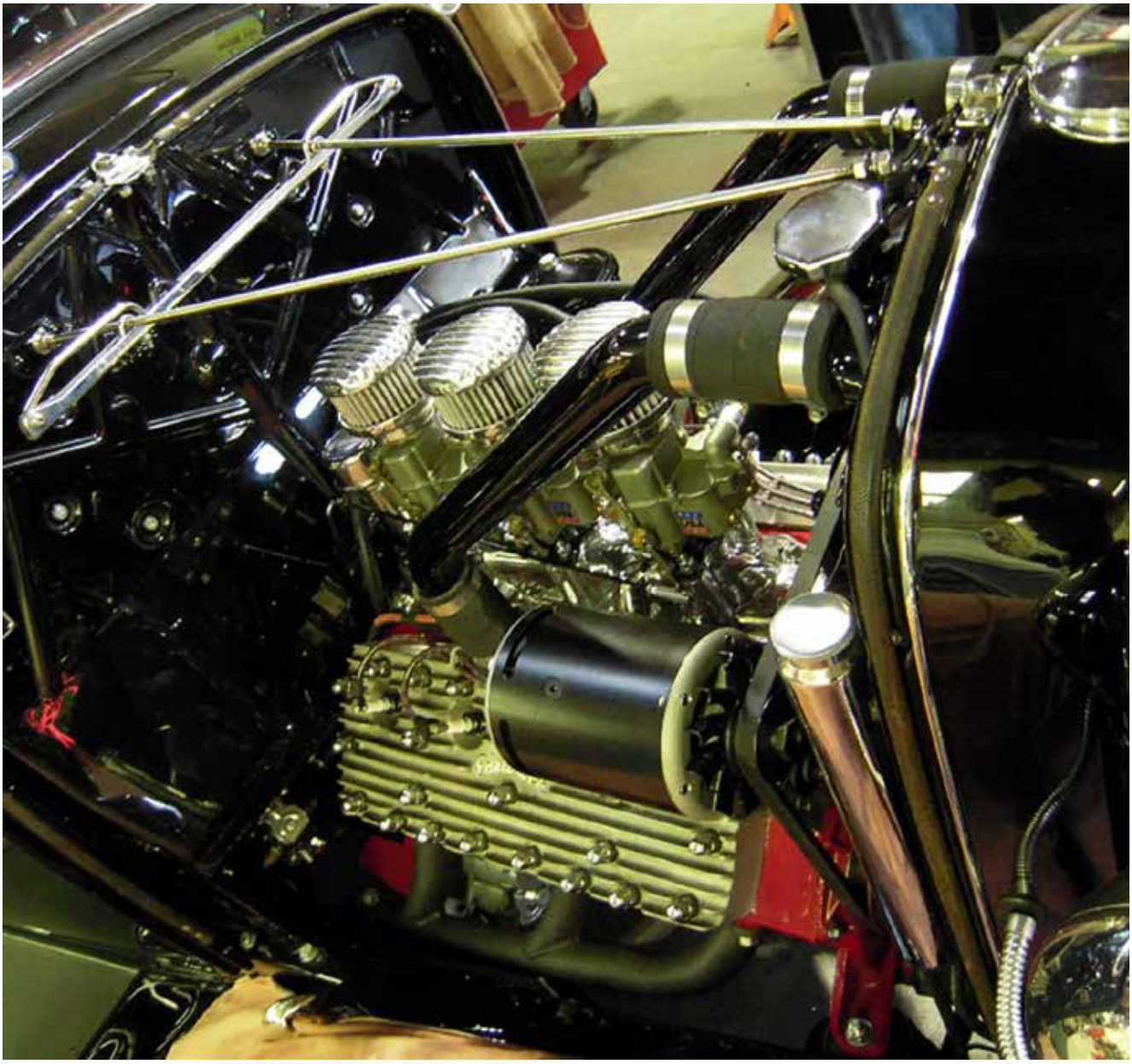
Reformulated Gasoline and Vintage Vehicles

by Henry Olsen

Gasoline ain't what it used to be, and it's only going to get worse. Here, Henry gives us an intro to a tuning topic that's often overlooked, with more installments to follow



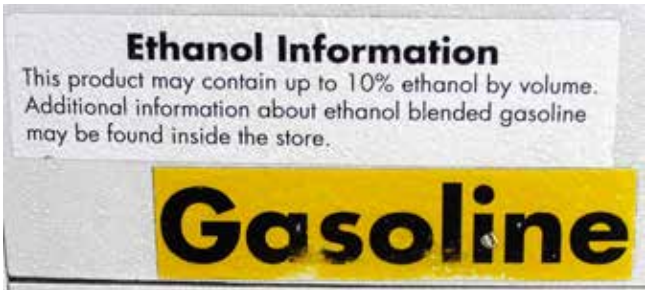
Vintage cars, trucks, and hot rods are becoming more desirable and valuable as both transportation and investments. These vehicles were designed and tuned to run very well with the leaded gasoline that was in use when they were built, but many of them lack performance and driveability with today's reformulated unleaded gasoline. Modern fuel-injected engines that are in the new cars of today have a computer that is continuously tuning the air/fuel mixture and ignition spark advance to adapt to changes in gasoline, air density, and engine load. Since a vintage carburetor-equipped engine can't adjust itself for the changes in gasoline, there is a market for a HOT ROD Professional who can make the necessary tuning adjustments for the owners of these vintage vehicles.

Neogas

Gasoline has changed quite a bit since the 1970s, including the removal of lead and major alterations in formulation to reduce both the evaporative and exhaust emissions of an engine. The federal government has recently mandated the oxygenation of gasoline with ethanol in an effort to further reduce exhaust emissions and our dependence on foreign oil, but adding ethanol often causes driveability and reliability problems when it is used in a vintage vehicle that was not designed to tolerate it, and not tuned for it.

Reformulated gasoline with ethanol is actually quite different from the leaded gasoline that a vintage carburetor-equipped engine was designed and tuned to use. The main differences between today's gasoline and the leaded fuel of days past are that the burn time is faster because of the removal of lead, and it is also not as easy for the spark plug to ignite the air/fuel charge as it was before the changes in formulation because they have reduced volatility to limit evaporative emissions. The current maximum ethanol content of pump gasoline is 10%, but it looks like new regulations will increase that to 15% or more in the future, which may lead to even more driveability problems with vintage carburetor-equipped engines and fuel injected vehicles built before about 2001.

A carbureted engine will most likely need to have its air/fuel mixture and ignition spark advance curves retuned for these new blends of reformulated gasoline. The addition of ethanol to the gasoline will cause the air/fuel mixture to shift leaner than the same gasoline without ethanol, which can cause a further loss in driveability and throttle response. A modern computer-controlled, fuel-injected vehicle should be okay with gasoline that contains up to 10%



Although the government touts the addition of ethanol to gasoline as a means of reducing both air pollution and our dependence on foreign oil, it can cause performance problems and deterioration of fuel system components, especially in older vehicles. Plus, ethanol hasn't got near the energy density of gasoline, so both fuel efficiency and power output are diminished.

Opposite page: This flathead V8 is in Vic Edelbrock, Jr.'s personal 1932 Ford street rod. It's equipped with three of Edelbrock's new Model 94 carburetors, which have made it very driveable, reliable, and fun even on today's gasoline.

ethanol, but many modern fuel-injected vehicles built before 2001 may experience fuel system problems and driveability issues if the ethanol level exceeds 10%.

Choices

There are several different options for making these vehicles both reliable and fun to drive. They vary from tuning the ignition spark advance and air/fuel mixtures of the original equipment engine package to replacing the powertrain with an engine package taken out of a newer vehicle, with a high-performance "crate" engine, or with one of the emissions-compliant E-Rod engine packages.

If you choose to go with the engine swap, you'll have to decide on some further options: Will you switch it to a carburetor, will you retain the O.E. computer-controlled fuel injection, or will you go with one of the many aftermarket fuel injection systems that are on the market?

In some areas of the country, ethanol-free gasoline is still available. Buy it whenever you can.

The modern fuel-injected engine package pulled from a modern vehicle can work very well, but you and your customer should be aware that this option is not always as simple as it appears. The engineers who programmed the engine-management computer spent hundreds of hours tuning the program that controls the ignition spark advance and the air/fuel mixture mixtures for

The supercharged 392 Hemi engine in this street rod is as reliable as it is powerful because both the ignition curve and the fuel mix have been tuned for modern gasoline.

This 1967 Camaro has a modern fuel-injected engine under the hood. Transplants usually require some re-engineering, however.

In the '67 Camaro shown above, the intake is picking up hot air from right over an exhaust manifold. This caused both performance and driveability problems.

the vehicle it was going into on the assembly line. In contrast, the new E-ROD engine packages that General Motors offers were designed to be put into vintage vehicles.

Out of range

You would think that an engine swap with a newer fuel-injected engine package out of a late-model car and going into a vintage vehicle should be fairly simple, but that is not always the case. The problems begin when the input data is outside of what the computer was programmed to see. The problems can range from "minor" performance and driveability issues to those that are safety-related. One example of a safety-related issue would be with an engine package that uses an electronic throttle control. An installation or programming error could cause unintended acceleration and perhaps a collision.

One of the problems we see the most often that will cause both performance and driveability issues is the location of the engine's air intake. The factory engineers would have programmed the computer for the "cool" air that comes through a duct from outside the engine compartment. On the other hand, if the air is instead taken from inside the engine compartment the inlet air temperature can range from 150 to 300 deg. F. The computer will see these high air temperatures as a problem because it is much higher than it was programmed to expect, therefore it will most likely retard the ignition timing and lean down the air/

This 1947 Suburban also has a modern fuel-injected engine, but the air box supplies cool outside air just as the engine management system likes it.

fuel mixtures, which will cause the engine's performance and driveability to suffer. In addition, it may set a trouble code and turn on the MIL (Malfunction Indicator Lamp, if you have included it in the swap).

Obviously, the O.E. engineers programmed the computer for a particular vehicle of a certain weight, with its own aerodynamic profile, and final drive ratio (overdrive transmission, tire diameter, and rear end gear ratio). This provides the engine with the baseline settings of what the spark timing and the air/fuel mixture should be, which are then electronically fine-tuned as the computer reads the inputs from an array of sensors. When you put such an engine package into a vintage vehicle, you can run into programming problems because those factors and others are going to be different.

Some of the most important inputs the computer looks at are intake air temperature, air density via the MAF, engine rpm and vacuum, throttle position, air/fuel mixture (oxygen or A/F ratio sensor), and coolant temperature. If these signals do not match up with what the computer was programmed to see, the engine will not perform as it should, and may even go into what's commonly called "Limp Home Mode," or "LOS" (Limited Operating Strategy).

Aftermarket Fuel Injection Systems

Aftermarket fuel injection systems can allow you to install something more modern and efficient than a carburetor on a vintage engine. Most of these systems are either self-tuning or programmable, but they require that the engine use a camshaft that is designed for feedback/closed-loop fuel injection so the oxygen sensors can accurately read and then adjust the air/fuel mixture. Also, remember that the inlet air temperatures must be in the range that the computer was programmed to expect. These systems do not come cheap, but if you are computer-savvy it is an option that is well worth considering.

Carburetion lives

The carburetor is still alive and well. There are quite a few new performance and reproduction vintage carburetors on the market, plus almost any original carburetor can be tuned for today's gasoline. You can keep the engine looking just like it did when it was new with all the original parts, or update the performance and appearance with aftermarket parts such as the carburetor, distributor, and air cleaner to dress up the look of the engine. To many people, a vintage vehicle just does not look right when the hood is open unless there is a carburetor on the top of the engine.

The downside of the carbureted option is that since there is no on-board computer to perform the tuning changes that are needed for today's ever-changing gasoline formulations, someone will need to tune the air/fuel mixture and ignition timing curves for the needs of the engine on the new fuel. The good news is this offers the experienced tuner with a challenge that, when properly performed, will make you a hero in the eyes of the vehicle's owner.

Steps

The first step in tuning is to customize the base or initial ignition timing, then the mechanical/rpm-based advance curve and the vacuum-based advance systems for the needs of the engine with the blend of gasoline that will be used. The total mechanical timing a typical vintage engine needs for maximum efficiency has not changed by very much even with the newest blends, but the initial timing and the amount of additional timing from the vacuum advance has changed due to the

removal of lead and other reformulation factors. This modern gasoline causes a typical vintage carburetor-equipped engine to respond favorably to more initial/base timing because the fuel is harder to ignite (it's slightly less volatile -- its Reid vapor pressure is lower). We set the initial timing of many engines at a point that would have had the engine fighting the starter when gas was gas, but if we set it back where we would have in the '60s and '70's we'd get hesitation when we tried to rev it. On the other hand, the engine needs less spark advance from the vacuum system is because the fuel burns somewhat faster. During our tests with a five-gas exhaust analyzer, we found that if you use a stock vacuum advance the misfire rate is quite high, but if you limit the vacuum advance to 10 to 12 degrees (instead of the 18 to 24 degrees of days past), the misfire rate drops.

The next step is to check and tune the air/fuel mixtures that the engine will see during idle, cruise/low load, power and acceleration, and cold starting conditions. The way most "mechanics" determined if an engine's air/fuel mixture was correct back in the 1960s and 1970s

A carburetor-equipped engine is still what most performance enthusiasts prefer.

Reformulated gasoline burns faster, but is harder to ignite than old-fashioned fuel. So, the ignition timing must be adjusted accordingly.

was to look at the color on the porcelain nose portion of the spark plugs. Today's reformulated gasoline, however, does not leave any color on the spark plug unless the mix is extremely rich. The best way to "read" what air/fuel ratio carbureted engine has is to use a exhaust gas analyzer, or a wide-band oxygen sensor-based digital air/fuel meter.

Good starting points would be:

- 13.41-14.1:1 air/fuel ratio at idle
- 14.0-14.2:1 at cruise
- 12.0:1 during power/acceleration
- Some high-performance engines with fast-burn cylinder heads may need a leaner power/acceleration ratio of 13.2:1.

Swelling, rotting, and corroding

It is also important that you update the fuel system including the rubber fuel lines so they can withstand the corrosive effects of gasoline that contains ethanol. The ethanol portion of today's gasoline can act as a solvent that will attack any fuel system component made with older plastic or rubber compounds. The combination of exposure of rubber and plastics to high heat conditions and today's gasoline greatly accelerate swelling and deterioration problems.

Ethanol also readily attracts water from its surroundings (such as the moisture in the air in the fuel tank), and it takes as little as one tablespoon of water per gallon of to cause the ethanol to phase-separate from the gasoline. This extremely corrosive mixture of ethanol and water will drop to the bottom of the tank. Not only will it be harmful to the components in the system, it can also cause major drivability problems.

The under-hood temperature of many vehicles can easily reach over 300 deg. F. during a hot soak (after the engine is shut off). Even though reformulated gasoline is less volatile than what we had in the old days (lower reed pressure), we are seeing more vapor lock issues recently. The high heat is obviously a factor, but there's also the theory that this is ethanol-related.

When it comes to racing gasoline, it's another whole story. According to one of our valued sources, a race fuel engineer, some of the newest blends of race gas have actually made more power than expected. We'll cover this interesting situation in a future HRP article

Speaking of future coverage, in upcoming issues of HOT ROD Professional, we will provide you with more in-depth articles on subjects such as tuning ignition advance and air/fuel ratios, mixture reading technology, changes in gasoline formulation, and much more. So, stay tuned (pun intended)!

Accurate and compact, a modern air/fuel ratio meter is a boon to the tuner.

Kids Into Karts

Getting Involved in Motorsports

by Steve Campbell

The love of motorsports starts early. With some kids, all it takes is the sight of a racing machine on the course. The grin gives them away. It happens with others the first time they take the driver's position in a motorized vehicle, even if it's just a bumper car at the county fair. But for some kids, it goes deeper. For some, the competitive fires burn too brightly to be fueled by mere child's play. And it's those kids for whom karting can be the beginning of an avocation or even a career.

Go-karts—now more commonly called simply karts—have been around since the late 1950s, and they are the least expensive way to get into true motorsports. Karting

A typical Yamaha Junior Sportsman set-up will cost anywhere from $4,500 to $5,900, depending on brand and options.

experiences can range from “arrive and drive” indoor or outdoor tracks, where everything is supplied and karts are rented on a per-session basis, to all-out shifter karts with multi-gear transmissions and top speeds in excess of 100 mph. Sanctioned racing can begin as early as age eight in World Karting Association competitions or even earlier in other venues. And karting is where some of the top names in motorsports today logged their first hot laps.

NASCAR stars Tony Stewart, Danica Patrick, Jeff Gordon and Juan Pablo Montoya started in karts. World champion Formula 1 drivers Ayrton Senna, Alain Prost, Michael Schumacher and Kimi Räikkönen started in karts. And Indy 500 veterans Scott Goodyear, Al Unser Jr. and Scott Pruett started in karts.

All those top motorsports pilots began in karting because karts—beginning with the novice ranks and moving through the

Younger drivers should look for features like this adjustable pedal set-up on the Margay Wildcat. These types of features allow for easy adjustments as the driver grows.

Margay’s Brava C1 Cadet features a built in steering lock to enable quicker and more precise steering alignments.

Many kart tracks will specify a brand and compound of tire for all competitors to run in order to provide more competitive and economical racing.

various classes—are real race cars. They teach a driver about vehicle balance, throttle control, selecting the proper line, cornering and optimizing vehicle setup through chassis stiffness, tire pressure, gearing and carburetor tuning.

They teach not only competition but also sportsmanship. Karting can bring families together and build a kid's self-worth and confidence. But a kart will also fit in the bed of a pickup, and a used entry-level kart can cost as little as a few hundred bucks. Like any form of racing, however, karting requires a time commitment, and it does take some money.

Getting Started

Spectating at an actual kart race may be the best way to gauge a kid's interest. Make

Well-respected engine builders are always a great source of local knowledge and can help get you up to speed quickly.

Braking systems are often overlooked when it comes to going fast. A quality system with readily available parts such as this made-in-the-USA MCP system offers reliable stopping power—one of the keys to going quick laps.

it a whole-family outing: tour the pits; ask questions; watch the drivers you saw in the pits go out to compete. Find out about your local track's rules, the types of karts and racing it accommodates, what the entry-level class requires. If you can lay your hands on a tech manual, pop for it to get more detail. If the kid shows interest, keep coming back, digging deeper with each visit.

The world of karting is diverse, ranging from short, paved oval tracks to dirt tracks to longer road-racing courses. The most common are sprint courses, which encompass both left and right turns and usually feature short races of up to 20 laps. Oval races—left turns only—may be run on full-size speedways or karting ovals and on pavement or dirt, and they may be indoor or outdoor, with some courses constructed as temporary facilities. The third type, road racing, is similar to sprint racing in that it features both left and right turns, but it involves much longer timed events at high speeds. In most cases, kids start out in sprints and progress through the ranks to higher classes and longer races.

A number of books have been published on karting, but not all of them are of recent vintage. Online sources such as Motorbooks.com and Amazon.com offer the latest and most complete releases, but pay attention to publication dates to get the most up-to-date information.

A scene repeated at tracks all over the country. Grandmothers and grandfathers, moms and dads, brothers and sisters load into vans, pickups, and trailers and hit the speedways to support the young racers. In Fort Wayne, IN, the local track, Baer Field Speedway, is rich in racing history with many well-known racers from NASCAR and Indy racing competing on one of its four tracks over the Speedway's 50 years. Names like Rusty Wallace, Bobby Allison, David Pearson, Buddy Baker, Darrell Waltrip, Benny Parsons, Joe Ruttman, Johnny Rutherford, and Gary Bettenhausen all competed here before and after moving up to "The Show."

Looking down two rows in the pits it becomes clear how vibrant and successful kart racing is in the midwest. Over 140 participants came from the surrounding area for a chance to win $1,000 on the 1/8th mile dirt oval in early May of this year.

When it comes time to get behind the wheel, an arrive-and-drive program may be the simplest way to get a taste of actual karting. For a reasonable fee, the youngster will be outfitted with requisite safety equipment, be checked out on a lower-power kart's operation and take part in a multi-lap session with other drivers of varying experience.

This first session—even the first few—shouldn't be viewed as competition. It will be a learning experience to get a feel for the kart's steering, throttle and brake controls as well as the sound and feel of being on the track with others. It can be intimidating, so the adults should be as supportive as possible of the first-timer's introduction to seat time.

Buying a Kart

Committing to the purchase of a kart should come only after significant research and a few sessions in a rental. The first criteria should be determining the style of racing and at the rules of the racing class. During your spectating visits, try to learn which brands and models of karts are most popular in the class(es) that seem most appropriate for youngsters. Take heed of which models win most frequently, since that's a pretty good gauge of quality.

Local tracks normally follow an easily accessed set of rules that include technical specifications. Ensure that you understand the requirements and that any kart you consider will qualify for the type of racing you or your child want to pursue. Then you'll have to decide on whether to buy new or used.

Most newcomers gravitate toward used setups for obvious cost reasons. And that can be a very good way to start, assuming that you can find a well-maintained, properly equipped and technologically up-to-date machine. On the other hand, buying new ensures that you don't wind up paying for somebody else's mistakes. At this stage, it's prudent to again seek advice from seasoned karters who can spot obvious flaws and steer you away from bad choices.

Avoid brands that are not well represented at the track. You'll want one that is relatively easy to find parts and service for. Again, ask around in the pits about the quality of the karts you're interested in and local shops that racers recommend for that brand and model.

One of the advantages to buying used—assuming your can find a quality kart that hasn't been completely wrung out—is that it will come with some spares. It will also be substantially less expensive, since it will have depreciated the moment it left the new-kart dealership. On the other hand, a used kart will undoubtedly require investments of time and money to repair or refurbish into race condition.

If you decide to buy new, you'll need to do yet more research. You want to find a dealer with a top-notch reputation and the ability to provide parts and service when needed. Some dealers build their karts themselves, so you'll want to find one with seasoned, expert assemblers using quality components. Pre-assembled karts are typically put together with price in mind, so they may feature less-than-the-best parts and may require upgrades after the purchase.

Of course, you don't have to buy a complete kart. If you enjoy doing the work yourself,

Looking down the main straightaway on the asphalt side you can see the entrance to both turn ones, the near one for the 3/8 mile and the far one for the half mile oval. The entrance road angling off to the left has the kart scales set up on it and it's the main entrance onto the 1/10th mile asphalt karting track.

The 1/10th-mile karting track at Baer Field is busy all through the summer and early fall with kids as young as four finding the fast line around the track and racing wheel-to-wheel in various classes.

While it might not seem fast as you watch it, some of these karts can run the track wide-open on restricted engines. Going 30 mph with your rear end two or three inches off the pavement seems like 200 mph to a kid! There are a lot of smiles on the faces of these youngsters.

These are serious racing machines running methanol, restrictor plate engines, and slicks. Steering wheels are detachable, five point harnesses are mandatory, and there are both caged and uncaged classes. Most arrive with dedicated trailers, kart buggies, and "a pair and a spare" for those times when open wheels collide, or the karts get tangled up.

you can purchase the various assemblies and build your own kart. An Internet search will reveal a variety of parts sources for everything from engines and chassis to sprockets, tires and seats. And building the kart with your kid can be what we now call "teachable moments." Just be sure that what you build meets the rules for the track and class you plan to compete in.

Kart prices vary widely, depending upon the type of racing you're interested in and whether you buy new or used. You can get pre-owned karts very cheaply—a few hundred bucks, in some cases—but you'll get what you pay for. Base-level new karts that are designed specifically for youngsters starting at age 4 and up are equipped with small engines (usually 50cc) and simple mechanicals. New, entry-level, race-ready karts of this type start at about $2,500 and can go up to $5,000 and more for top-level equipment. By the time you progress to the shifter-kart level, prices escalate to $10,000 or more, but you'll have been involved in the sport for a significant period before you advance that far.

In addition to a kart, the racer will also need approved safety equipment that includes a helmet, a racing a jacket or suit, a neck collar and gloves at minimum. A rib protector and a head-and-neck device, while not usually required, are also recommended. Check with your track's tech specifications to determine what type and quality of safety gear is required.

You'll need a truck or trailer to haul the kart and its associated tools, spare parts, fuel, lubricants and miscellaneous equipment

such as a kart stand, which makes moving the kart easier and gets it up off the ground when you need to perform maintenance. You'll probably want some type of pit cover or tent to keep out of the sun or inclement weather, and you should also factor in the cost of entry fees and travel expenses (even if it's only the cost of gas to get to the track).

The costs can mount, but karting is still a lot less expensive than many other recreational activities. It also offers educational opportunities in a variety of disciplines that include not only vehicle dynamics and safe-driving techniques but also physics, mechanics and even a bit of chemistry. Best of all, though, is the time you'll spend with your kid. That will be priceless.

Running on dirt can be just as fast as running on asphalt once the dirt is "run in." The judicious application of water combined with the pressure of the slicks packs the dirt into a hard surface that the kart tires can hang onto. Dirt track racing is doubly challenging as conditions change with a drying track -- hot sunny days and wind can make the track go from good to bad in short order. Not only does traction change, but excessive dust can cause dangerous conditions when the drivers lose sight of each other.

KARTING SANCTIONING BODIES

World Karting Association

6051 Victory Ln.
Concord, NC 28027
704-455-1606
www.worldkarting.com

The largest organization in the United States. Sanctions oval, sprint and enduro competitions.

International Kart Federation

1609 South Grove Ave., Ste. 105
Ontario, CA 91761
909-923-4999
www.ikfkarting.com

Original sanctioning body for karting. Runs oval, sprint and enduro races.

Superkarts USA

P.O. Box 2161
Noblesville, IN 46061
317-774-7025
www.superkartsusa.com

Specifically for high-performance and shifter karts.

Commission Internationale de Karting-FIA (CIK-FIA)

2 Chemin de Blandonnet, CP 296,
CH-1215
Genève 15, Switzerland
+41 22 306 10 80
www.cikfia.com

World karting sanctioning body. Karting division of the Fédération Internationale de l'Automobile (FIA).

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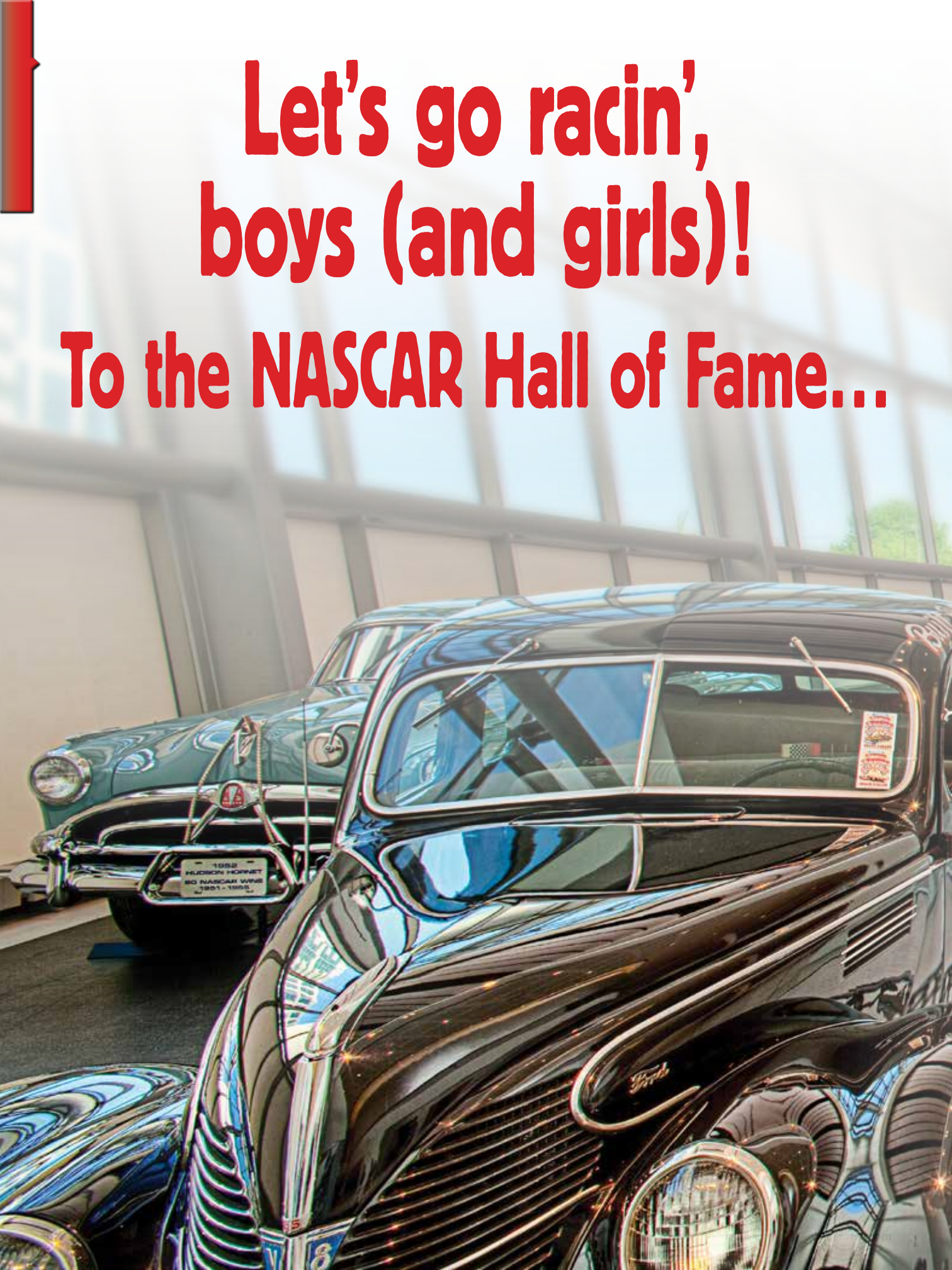
To the NASCAR Hall of Fame...



Greetings from NASCAR Universe!

by Glen Quagmire

(all photos courtesy NASCAR Hall of Fame)

www.NASCARhall.com

Let's face it. There are museums, and then there are museums. And then there are a handful of sites that are so much more than museums that they are actually their own little universe, focused on a particular subject, event, or sport.

The NASCAR Hall of Fame ain't no stinkin' museum; it's a virtual way of life.

Take a wild guess. Where would you expect a NASCAR Hall of Fame to be located?

New York City? Nah, too many museums there already.

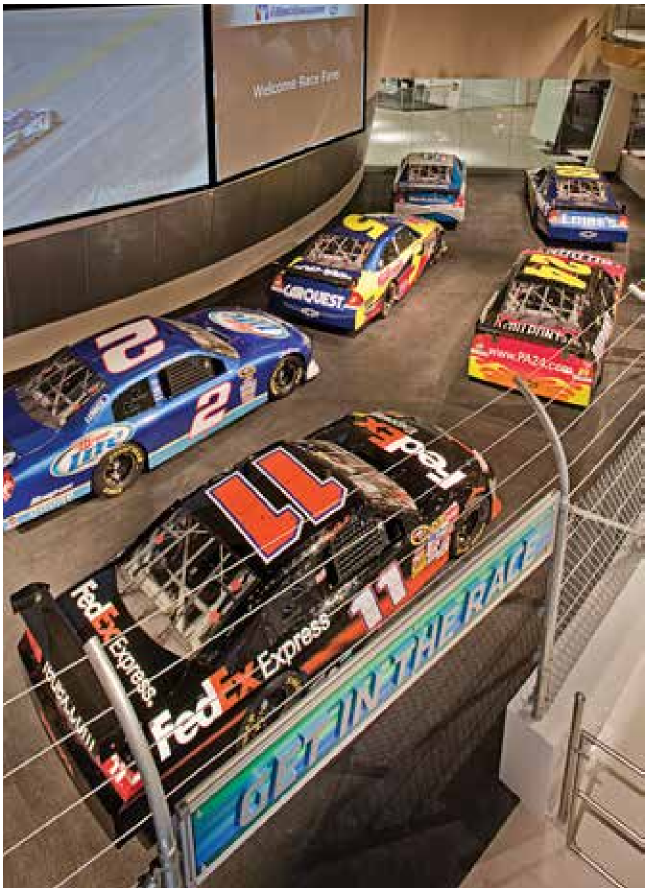
Las Vegas? Nope. Wayne Newton's got that one sewn up.

St. Louis? Negative. Too much Clydesdale poop.

Boise? Are you kidding? (Sorry, Idahoans...)

OK, you guessed it. Charlotte. Not even Mooresville. Beautiful downtown Charlotte. Smack dab in the middle of the NASCAR universe, just as you'd expect.

Opened in 2010, the NASCAR Hall of Fame is much more than a museum. Practically speaking, it's really like ten museums rolled into one. In all, the facility spans more than 150,000 square feet, which is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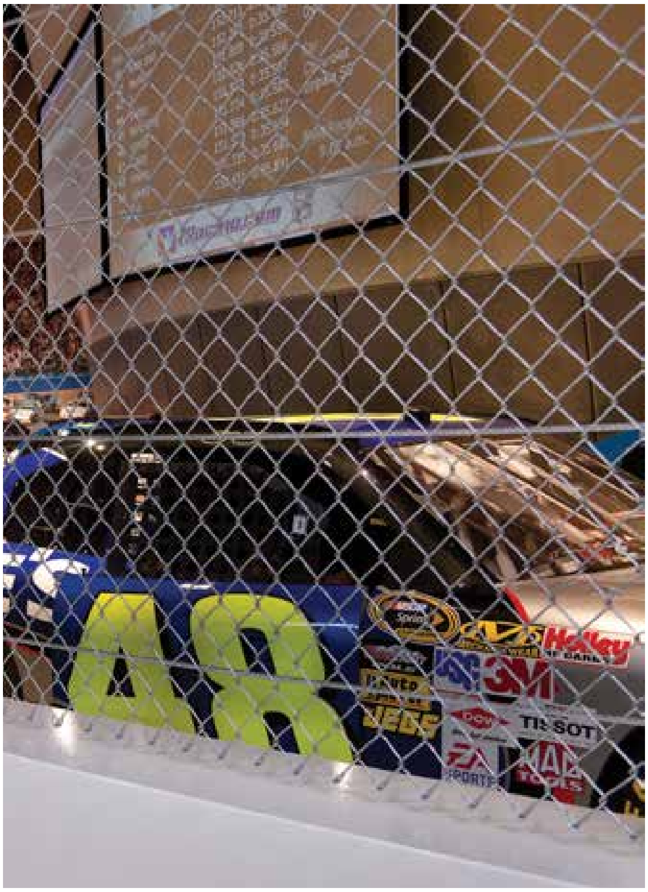
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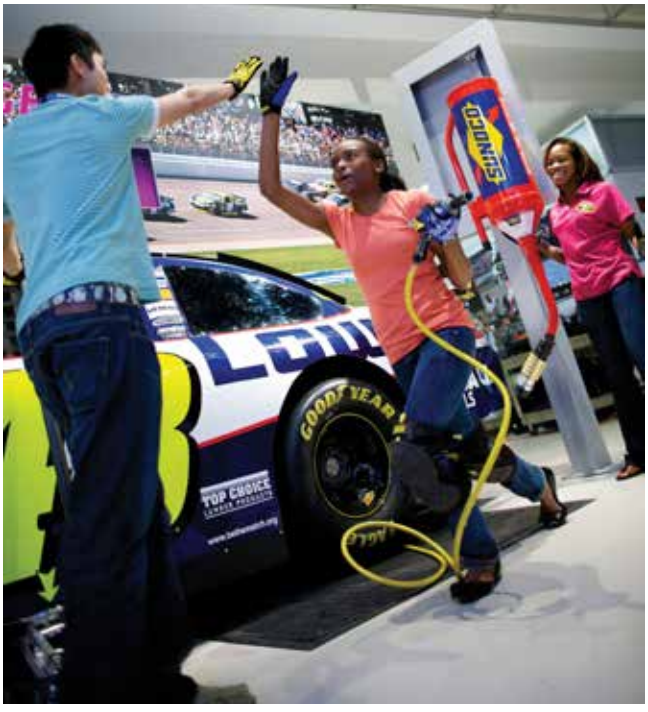


approximately the size of the entire infield at the Bristol, TN track. The Hall of Fame is strategically located right next to the Charlotte Convention Center, which provides great synergy for both venues. The Hall of Fame is a terrific diversion for folks attending various conventions and conferences next door. And having the convention center adjoining the Hall of Fame provides nearly unlimited room for expansion or overflow if a large function is being held at the Hall.

Taken all at once, the NASCAR experience could be overwhelming. But the NASCAR Hall of Fame is structured as a series of sub-museums, more than a half-dozen of them, each an attraction in its own right, plus shopping, dining, and meeting areas.

Collectively, the various areas represent all the key aspects of NASCAR racing – the cars, the drivers, the tracks, plus all of the rich history of stock car racing, which traces its roots to the moonshine-runners of the 1930s. Much of the facility is interactive, and all of it is family-friendly, in the true NASCAR tradition. And, in addition to the permanent displays, there are constantly-changing special exhibits, based on specific themes, that keep the tour fresh and interesting, for first-timers as well as repeat visitors.

A First Impression is a Lasting One

Your first view of the Hall is sure to impress. Sweeping architecture provides an immediate impression of motion and speed, and leaves no question but that you are about to have an experience that will leave you with the feeling that 20W-50 racing oil is coursing through your veins.


GREATEST FINISHES
32


18

The Ceremonial Plaza that greets you was cleverly designed using special brick pavers that lend an immediate impression of "The Brickyard" at the Indianapolis Motor Speedway, which, by the way, continues to feature brick paving at the start/finish line, even though the rest of the track itself, of course, is paved with much more appropriate asphalt. But the pavers in front of the Hall immediately set the tone for the experience soon to follow.

The Plaza is often used for various functions and ceremonial events, made all the more favorable by the usually-warm and comfortable Carolina climate.

But First, Some Background

You'll want to start your tour and experience with the proper perspective, so your first stop will be the Belk High Octane Theater, sponsored by the large southern chain of Belk Department Stores, a company with a long history of community involvement. In this 275-seat theater you'll view a film that will properly position NASCAR's history and posture for the tour to follow. It provides an important perspective, so you'll have an appreciation for the checkered history behind the current NASCAR phenomenon.

The film is both fun and informative, and the surround sound makes you feel like you're in the driver's seat of the cars spanning NASCAR's history, from the original beaches of Daytona to the current cars and circuits on the NASCAR schedule.

On to the Great Hall

Once inside the Great Hall, you'll find race cars and much, much more. The cars, presented in as-raced condition, span all

the glory years of NASCAR, and some of the most special are displayed on Glory Road, a simulated banked oval spiraling upward toward heaven . The priceless cars in this particular display area, featured older to newer, include a Richard Petty Plymouth and Pontiac, David Pearson's famous Purolator Mercury, and cars raced by the late Dale Earnhardt and current racer Jeff Gordon.

In addition to the Glory Road display, other race cars adorn the Great Hall, some on permanent display, and some rotate in and out of the Great Hall.

For instance, currently finishing up is a special display titled, "Wrecks! Dramatic Crashes of NASCAR," which features as-raced and as-wrecked cars from some of NASCAR's most spectacular crashes. Included are two particularly noteworthy cars that each flipped a record-holding nine times. Michael McDowell's car flipped nine times at Texas, and Phil Parsons' Pontiac went over nine times at Talladega. Neither driver was seriously injured. Other specially-themed exhibits appear throughout the year, including race viewing parties, open to the public, where you can experience races in real time in the Belk High Octane Theater.

But the Great Hall holds much more for visitors. There are countless items of memorabilia, including drivers' suits and helmets, engines and car parts, trophies, and even the actual moonshine still that led Junior Johnson to his career in racing.

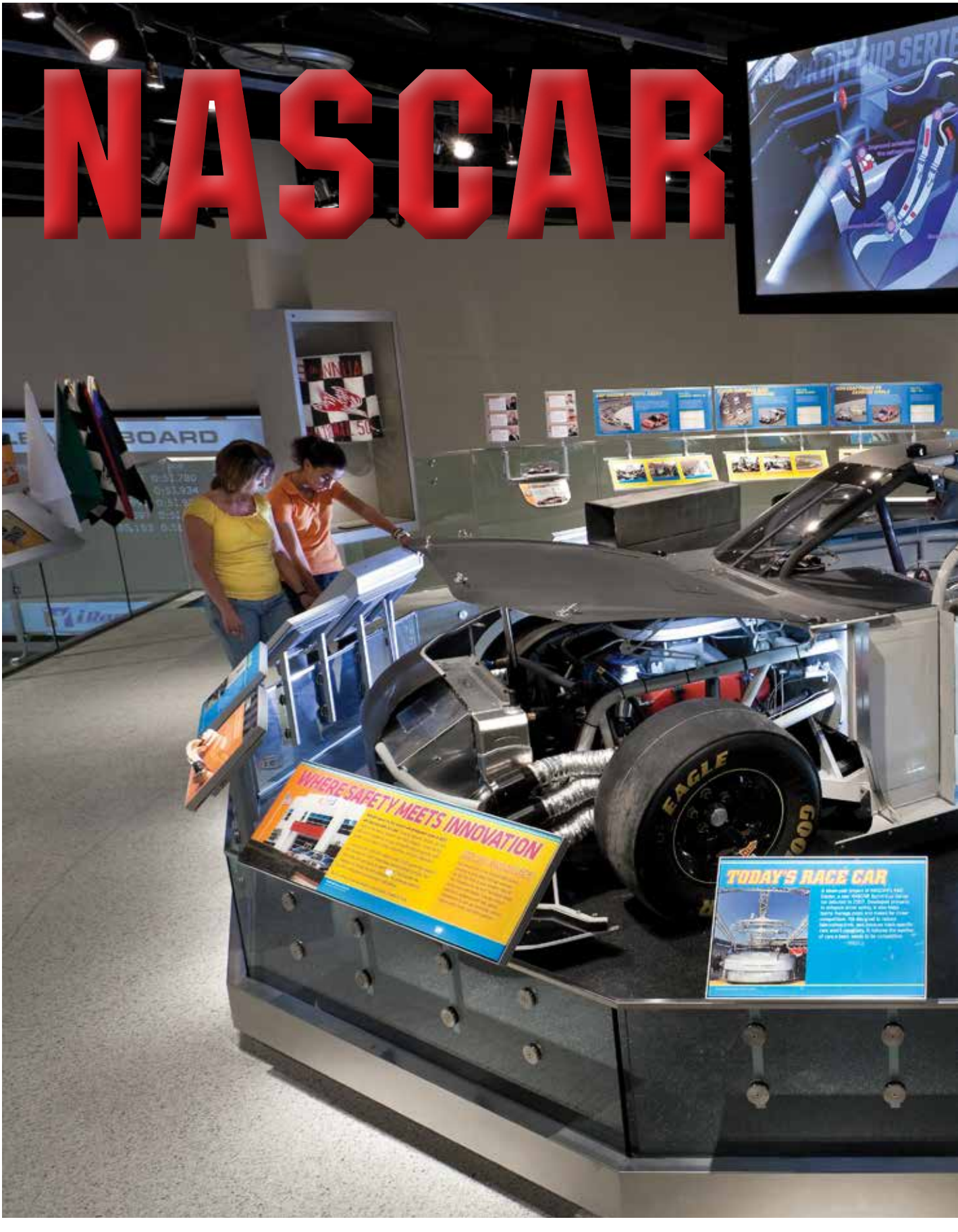
In the Great Hall, you don't just see, you also "do." The designers have done an extraordinary job of making much of the facility interactive, for "kids" of all ages. You can try your hand at driving on a true-to-life simulator, or see if you've got what it takes to speed your way through a 14-second pit stop. You can also walk through a real-life race team hauler to see the kind of spares, tools, and equipment it takes to support a high-end race effort.

All Hail, the Hall of Honor...

Since the Hall of Fame is really a Hall of Fame, a top priority is to honor those whose efforts have made NASCAR what it is today. To that end, each year since the NASCAR Hall of Fame was founded in 2010, five honorees are inducted. While mostly chosen from the ranks of successful and noteworthy drivers, as you would expect, nominees and inductees come from the ranks of crew chiefs, team owners, businessmen, and others who have contributed to the growth and success of the sport.

Of course, members of the Hall of Fame include the noteworthy drivers you'd expect, like Dale Earnhardt, Richard Petty,

NASCAR




SAFETY
SPRINT CUP SERIES CARS
GOODYEAR

and Junior Johnson. But also included are Bill France, Sr. and Bill France, Jr., both instrumental in developing the whole concept and posture of NASCAR. Other inductees include Glen and Leonard Wood of the famed Wood Brothers, who pioneered innovations in engine building and pit road strategies that form the basis today of virtually all successful NASCAR teams.

Each year's class includes just five inductees, making this a very exclusive club indeed. Selection is done by several groups of electors that include NASCAR industry leaders, manufacturer representatives, former competitors, the media and fans, who can vote on-line for the superstar of their choice. Other electors include media representatives, car manufacturer representatives, retired drivers, retired owners, retired crew chiefs, and other industry leaders

Just twenty-five nominees are considered each year. Nominees must meet certain criteria, including years of participation in NASCAR racing.

Your Own Private Race Week

You'll want to be sure to take in the Race Week area of the facility, as this affords a terrific look behind the scenes, depicting all the activity that goes into preparing for a NASCAR race. Just as a concert is the culmination of many practice sessions and dress rehearsals, so is the running of a NASCAR race. As in any endeavor, success in motorsports depends on thorough preparation, and Race Week provides a surprisingly realistic depiction of the work that's done during the week prior to a race. It gives you a taste of what teams must do to pass NASCAR's rigorous technical inspection, including body panel templates

to assure that the size and shape of each car conforms to precise standards.

Heritage Speedway

History buffs as well as anyone curious about the evolution of motorsports in general and NASCAR racing in particular can immerse themselves in archival materials of every description in the Heritage Speedway. Cars, parts, suits, helmets, literature, promotional materials, race track programs, and much more are available for close inspection. Most folks will marvel at the crudeness of early cars and safety equipment of the day. But remember that all such items are viewed through the prism of today's standards -- those that allow for drivers to walk away from horrendous crashes.

It's precisely this perspective that makes the NASCAR Hall of Fame so fascinating to all those who love motorsports, and even to many who don't share the love...

Track your visit with a "Hard Card." Your admission to the NASCAR Hall of Fame includes a NASCAR Hard Card, which is your ticket to all areas of the facility, and also allows you to record and track your progress through the facility and your success in driving racing simulators, participation in pit stops, and other interactive exhibits.

And when you've finally explored all the nooks and crannies of the vast hall, you can enjoy well-deserved rest and refreshment in the Pit Stop Café, and shop for souvenirs for yourself and others in the Gear Shop.

Whether you're intrigued by the personalities of the drivers, fascinated by the technology (or lack thereof...) in stock car racers over the years, or just interested in learning more about how NASCAR racing has become the powerhouse of competition and entertainment that it is, the NASCAR Hall of Fame belongs on your "must-do" list. ■

COMPANY SHOWCASE

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The Racer's Edge

So how did all this come about? The Joe Gibbs Racing Team started experimenting with various lubricants to find the best combinations that would give them a competitive edge on the track and, at the same time, protect their very expensive engines. Their goal was to find specific products for the team's needs. This is a factor that has remained constant as the company developed lubricants and products for other areas of engine performance.

As the Joe Gibbs Racing Team developed specific products for their needs, other teams and industry professionals began to ask for these products for their own individual requirements. And so was born Driven Racing Oils.

Soon, Driven Racing Oil was well-established with the American Engine Rebuilders Association (AERA) and the word began to spread to the motorsports industry. Today, the company still enjoys a close working relationship with the Gibbs Racing Team and its products are used throughout the performance world.

Strong Technical Support & Training

Another unique aspect of the company is that it informs you as to technical factors of oil formulations and usage, and the composition of its products, through several online training videos and articles.

The company doesn't just sell you oil; it strives to educate you as to the physical properties, wear factors, and specific applications of its products and how to select the best product for your vehicle. If it is a racing machine, street performance car, motorcycle, boat, or even a racing lawn mower, Driven Racing Oils has the right product for your needs.

Along with every product, the company offers strong technical support. The company website (www.drivenracingoil.com) has lots of training materials and articles to inform and educate the end user. If all else fails, the company offers online and telephone technical support.

Click to watch "Viscosity 101" video.

The chief technical expert for Driven Racing Oils is Certified Lubrication Specialist Lake Speed, Jr. Lake is a well-known expert in the field of performance lubrication and has spoken at many industry events. He has helped produce several video presentations for the company's website that educate and inform in an entertaining manner. Check out Lake's "Viscosity 101" video that accompanies this article!

Speed says, "Remember that different oils are needed for different applications. Use of a stock oil in a non-stock application can be a big problem." He adds, "All oil will lubricate, but how well and for how long?

We offer specific products for many performance applications, so you'll always be satisfied that you have the right product for your particular needs."

Driven Racing Oil can be purchased on the company's website, where you can also find the closest dealer. The company offers quantity discounts to groups and clubs.

If you will be attending the SEMA Show in Las Vegas in November, you can visit Driven Racing Oil at Booth 25117 in the Central Hall.

OE Performance News

Ford Racing Offers a Wider Selection of Engines & Components

Many racers and enthusiasts have long looked to Ford Racing Performance Parts to fulfill their need for speed. The 2013 Ford Racing catalog is stocked with new options for every budget and application. The updated lineup includes new four-cylinder and V6 EcoBoost® crate engines plus classic small-block, modular and contemporary Coyote V8s, along with wheels, suspension and brake parts.

Build Your Own Cobra Jet

Racers who couldn't get on the list for one of the limited-production 2013 Mustang Cobra Jets can now build their own with the Aluminator XS crate engine. The 5.0-liter Aluminator XS is based on the naturally aspirated engine that was offered in the 2013 Cobra Jet earlier this year. Anyone interested in building a fast 5.0-liter powered Ford vehicle for the track now has a ready-to-install option with more than 500 horsepower and the capability of 7,700 rpm.

Builders aiming for even greater heights from the Coyote V8 should consider the range of race-bred performance parts, including the new Coyote Motorsports block. This new block has been optimized by the Ford Racing engineering team for improved durability, even when subjected to the stress of high-output racing applications. A variety of other Coyote race-tuned parts include the Cobra Jet intake manifold, billet oil pump, high-rpm competition pulse ring and more.

Modern and Classic V8 Options

Fans of the Modular V8 also have a new build option in the Aluminator 46X Stroker short block. Stroked from 4.6 to 5.0 liters, this short block is assembled with top aftermarket components to provide a durable foundation for on- and off-road applications in both naturally aspirated and supercharged forms. The engine is compatible with any of the two, three, and four-valve cylinder heads used on the Modular V8.

Builders looking for V8 power in a compact and easy-to-service package should look no further than the two new flavors of the classic Ford pushrod small block crate engines joining the existing lineup.

Ford Racing's X302D crate engine.

With a displacement of 460 cubic inches, the Z460 is the largest small block engine ever offered by Ford. The Z460 builds on the long-running group of Ford small block crate engines, and is available with either a front- or rear-sump oil pan to fit the builder's needs. Just add an intake, carb and accessories, and the Z460 is ready to rock with more than 500 horsepower.

Enthusiasts looking for a true bolt-in small block solution will like the ready-to-run X302D crate engine. It comes out of the box equipped with an Edelbrock intake manifold, MSD distributor and a Holley Carburetor jetted to Ford Racing specifications. The engine provides affordable and reliable small block power for street rods, restored muscle cars, or kit cars.

EcoBoost Power for the Aftermarket

Ford's lineup of EcoBoost© engines has proved extremely popular in an ever-increasing number of vehicles ranging from the Focus to the F-150 thanks to outstanding power and torque delivery and exceptional fuel efficiency. Featuring the latest turbocharging, twin independent variable camshaft timing, and direct fuel injection technology, two of these engines are now available to customizers, racers and resto-mod builders.

With 365 horsepower and a remarkably flat torque curve peaking at 420 lb.-ft., the revolutionary twin-turbocharged 3.5-liter EcoBoost V6 packs V8 performance in an efficient package. The crate engine has proven its worth in both off-road truck racing and everyday work truck use. Off-roaders will appreciate the performance and ability to program custom calibrations to suit their vehicles.

Kit car builders, racers, and hot rodding enthusiasts of all types will love the 2.0-liter EcoBoost four-cylinder crate engine. This 255-horsepower package comes straight from the new Focus ST and has already proven to be a true performer is the US and Europe.

Engines are just the Beginning

Power is only useful if it can actually be put to use, so Ford Racing also offers a complete lineup of suspension, brake, and wheel kits and components to maximize the full performance potential of every Ford vehicle.

Owners of 2005-2013 Mustangs in search of improved grip can now get a fully-assembled handling pack. The kit includes a set of pre-assembled struts that DIYers can install in their garage without any specialized tools.

2011-2013 Mustang GT drivers can get a new shifter kit for the six-speed gearbox that provides 25% shorter throws and a crisper feel for enthusiastic driving.

While Mustang owners have nearly half a century of customizing history, Ford Racing is really ramping up support for Focus owners for 2013. A complete slate of bolt-on upgrades is now available to further sharpen the already impressive European-inspired dynamics of the Focus. Springs, dampers, and beefier brakes help keep the Focus on course while European RS-spec wheels provide a unique appearance.

Truck owners who want an improved exhaust sound can now get a premium stainless steel cat-back system. A collaboration between Ford Racing and exhaust specialist Borla, the system is manufactured from the highest quality Austentic stainless steel to ensure maximum resistance to corrosion. The systems are available for 2011-2013 F-150 pickups.

For more information on these products, check with your local Ford dealer, or visit www.fordracingparts.com.

Information Station

Snap-on Shallow Countersink Inverted Torx Sockets

Manufactured from special alloy steel and precision forged and heat treated for optimum strength and durability, the new Snap-on 3/8-inch Drive Shallow Countersink Inverted Torx Sockets (FLCE140, FLCE160, FLCE180) are a “must have” for every service technician looking to improve productivity and efficiency in the workplace.

The FLCE140 is ideal for connecting rod cap bolts on various Toyota and Scion vehicles, while the FLCE160 works perfectly on the cam sprocket of a 2.5L FB engine on 2011 and newer Subaru Forester vehicles, plus the camshaft timing gear assembly on various 2012 Toyota vehicles. The FLCE180 is the right choice when working on the spider gear of the rear differential on 2010 to current Chevrolet Camaro vehicles.

For more information, contact your Snap-on representative, visit www.snapon.com/handtools or by call 877-SNAPON-4 (877-762-7664).

Bosch Offers 15 Additional Reman Alternators and Starters

Robert Bosch LLC is celebrating its 100th anniversary of producing generators, alternators, and starters with 15 new additions to its line of remanufactured products. Designed for European vehicles in the aftermarket, these new part numbers cover Audi/VW, BMW, Mercedes, Mini, Porsche, Saab, and Volvo, and cover 1.45 million vehicles on the road in the United States and Canada.

All Bosch remanufactured alternators and starters are covered by Bosch’s industry-leading 2-year warranty, and also are covered by Bosch’s exclusive 2-year, free emergency roadside assistance program.

For more information, visit www.boschautoparts.com. To find Bosch Auto Parts on Facebook, visit www.facebook.com/boschautoparts

Penray Introduces Liquid Tune-Up

Penray has introduced a package of chemicals designed to work in harmony to restore vehicle engines to optimal performance and efficiency, which will help consumers to save money at the pump. Penray Plus Liquid Tune-Up is an integrated package containing specially-blended, made-in-the USA chemicals, and designed as a three-step process to fortify the three key fluids in today's vehicles – fuel, lubricating oil, and engine coolant.

Penray says optimizing the fuel, lubrication, and cooling systems will help extract the best performance and efficiency from your engine, while offering protection for vital systems that will impact service life and resale value.

For more information, check with your local Penray supplier or visit www.penray.com.

Lisle Offers Ford Camshaft Alignment Kit

The Lisle 37410 Camshaft Alignment Kit is designed for servicing the timing belt, chains, head gaskets or other valve train repairs on Ford, Mercury and Mazda vehicles.

The kit comes with an aluminum camshaft holding bar, plus one short Top Dead Center (TDC) timing pin and one long TDC timing pin. The camshaft bar and long TDC timing pin are used on 2.0L DOHC Zetec engines found in 1994-2003 Ford and Mercury vehicles. The camshaft bar and short TDC timing pin are used on 2004-2012 2.5L DOHC, 2.3L DOHC 4V and 2.0L DOHC engines that are found in Ford, Mercury, and Mazda vehicles. The camshaft alignment bar can also be used by itself on 2.0L DOHC engines in 1993-1994 Ford Probe.

For more information, call 712-542-5101 or visit www.lislecorp.com.

Maradyne Introduces High-Performing Fan

Maradyne High Performance Fans has released its new Texas Twister fan designed for weight-conscious drivers seeking to lower drag and improve engine performance. The new lightweight fans are constructed of a heavy-duty, flexible blend of glass-filled nylon and thermoplastic elastomer, making them one of the most cost-effective fans on the market.

The fans are available in 14, 15, 16, 17 and 18-inch diameters and are suited for any vehicle with a four-bolt water pump pulley. The fan has a maximum capacity of 8,000 rpms. The kit comes with mounting washers.

All Maradyne electrical fans come with a limited one year warranty with tech service available at 800-537-7444. www.maradyneHP.com for more information.

Autodata Launches Update to its 2013 Key and Remote Programming Manual

Autodata Publications has launched its latest and most comprehensive manual for guiding technicians through the correct procedures for programming and synchronizing vehicle keys, remote transmitters and alarm systems. These procedures match the recommended manufacturer practices so technicians can always ensure a service completely compliant with the OEM.

The updated US-specific manual covers even more domestic and import vehicles between 2003 and 2013, enabling technicians to complete time consuming tasks faster.

Autodata's new manual, which includes new chapters and, for the first time, models from Fiat.

To purchase please contact your automotive tool distributor, call Autodata directly at (800) 305-0338 or email ussales@autodata-group.com

QA1 Mustang Racing K-Members

QA1 now offers made in the USA K-members for Mustang racing applications. The K-members are manufactured in QA1's fabrication facility and provide the vehicle with performance race stance. They can be paired with the company's tubular control arms for even better results.

QA1 also offers an extensive line of control arms, anti-hop bars, K-member braces, panhard bars, strut tower braces, sub-frame connectors, sway bars, toe links, torque and trailing arms for motorsports performance.

Visit wwwQA1.net or call 800-721-7761 for a free catalog.


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Wandering Fulminations on Performance: Begin With the End in Mind

by Greg McConiga

If you're like a lot of mechanics I've known (*Editor's Note: Greg prefers "mechanic" to the more politically-correct "technician" for reasons we're sure he'll tell you about in a future column)*, you've probably circled the brave new world of performance engine and race car building like a shark at a shipwreck since first discovering internal combustion. Come on in... the water's fine!

Performance work is more than fixing what's broken or doing preventative maintenance. It's more than work-a-day, pedestrian repairs or color-by-numbers diagnostics. It's where design, engineering, preparation, and assembly converge and where every part and every step shows your skill -- or reveals your weaknesses.

Maybe you like the challenge of finding ways to reliably increase power and you listen to the sound of a finely tuned, high-output engine

like a musician listens to a favorite symphony. Perhaps you find the aroma of exotic fuels and oils a bit intoxicating. Maybe you've helped out on a project or two... did a few bolt-ons on your own ride or helped out the brother-in-law with his old-school muscle car build. Maybe you'd just like to learn more, or actually begin working in the world of high performance building. If so, then HOT ROD Professional is for you. Even if you've got quite a bit of

experience in the field, we hope you'll pick up some new tricks and tips that will help you in your quest for more torque and horsepower.

Our goal is to help you transition from commercial mechanic to performance builder. How far you go is strictly up to you and your willingness to spend your hard-earned money on the tools and equipment needed to build power, and how committed you are to a continuous, lifelong learning process. You need to get your arms around a couple of things right now: Good ain't cheap, and cheap ain't good, and that's true 100% of the time if you're talking about racing tools, racing parts, or race-quality engine machining. There might be people who will argue this point, but they won't be the same people you see in the winner's circle on a consistent basis.

From a learning standpoint, no racer who's every lived can tell you how deep that particular rabbit hole goes. Everyone is somewhere on the path and the guy who claims to know it all just hasn't figured out that there always have been and always will be a long list of "unknown unknowns." Beware of those with "all the answers" because that means they've stopped asking questions, and questions are the life's blood of learning! A good builder has to be prepared to learn or re-learn everything all the time. You should be constantly refining your tools and techniques. "Because we've always done it this way" is a recipe for disaster in racing.

The investment in frustration, time, and money isn't something you can ignore. You've got to love this to do this because, frankly, there's no way to get paid for every hour you'll spend on it. If a healthy return on your investment is your goal, this may not be your best use of time and resources. This is more about the personal challenges of bettering your last effort than it is about making a pocketful of cash. I'm not saying you can't

make a living at this, I'm just telling you that there are lots easier ways to earn money. Not many people will tell you that right up front.

There are a few basic rules; ignore them at your peril. First of all, "Race Car Parts" is a euphemism for "Almost Fits." You need to know that and you need to begin to develop the kind of skills it takes to "Make Them Fit." Learn how or re-learn how to use a lathe, a mill, a drill press, a grinder, and a TIG welder. Learn how to fabricate brackets, tools, fixtures and stands. For those cases where the job exceeds your talent, tools and availability of a good machinist or tool and die maker -- strike up a friendship because if you can't make them fit, you need someone who can make them fit. You're going to need a guy like that in your corner. I've worked with car owners who become very frustrated with "almost fits" and do everything they can to hurry the process, trying to cut corners or just stuff the part in place without fixing the problem. I always tell them, "That's okay with me, but remember that when you cut a tire down at 180 mph because you drove over your $3000 crankshaft!" I'm always amazed at how quickly people grow a "patience bone" once they let that statement soak in. I don't care how safe the car is, a wreck at any speed is just an uncontrolled experiment in kinetic energy.

Second, never trust anyone, and check everything. Twice; then once more just to be sure. Don't trust your machinist or your parts supplier. I don't care how much money you spend and I don't care if you think it ought to be right for that kind of money, don't trust them; check them. Twice. Maybe "trust" is the wrong word, but remember this: Everybody makes mistakes and every so often even incredibly expensive parts whittled out on tooling that holds tolerance to the millionths of an inch makes it past the QC inspector with a defect certain to turn your expensive pile of racing parts into scrap at a nickel a pound. I know, for three or four grand it ought to be right, but sometimes it's not.

There's a second benefit to checking the work of others. Are you familiar with the Law of Unintended Consequences? The law that says that the actions you take often yield a result other than the one you intended? As hard as it might be for you to believe it, if your suppliers and engine machinist know you're checking their work, the quality of their craftsmanship gets better! A bitter pill to swallow if you've been doing business with a guy for ten years only to find that what he or she has been delivering to you has

been commercial-quality work priced like custom work. I can say this with complete certainty: The only part that won't work will be the part you didn't personally check. I don't care if the heads come assembled, take them apart and double check everything. I don't care if your machinist told you the bores were round, check them anyway... and don't be surprised at what you find.

Three, invest in high-quality measuring tools and learn to use them. Buy tenth-reading carbide-faced gear whenever you can (reads to 1/10,000th of an inch.) Some of your suppliers and machinists will curse you for this and tell you you're a nit-picking knucklehead and that you don't know what the hell you're doing. That's because their tooling is worn out and they can't hold tolerance! On the other hand, there are superior people out there who can make round holes and they don't mind a bit when you check them in tenths because they measure in millionths.

Measure every hole, every dimension, and every part. Inspect everything for burrs, fit, lubrication holes, clearance, and quality. Learn to think in terms of static clearance and dynamic clearance. Checking things on the bench is one thing. Allowing for distortion or growth under load, pressure and heat is another. It's all part of checking racing parts. Twice. I did say twice, didn't I? Check every part in every position -- remember that most parts are not static and clearance must be checked throughout the part's entire range of motion. Twice.

Next, write it down (it's considered particularly good form if you write it down where you can actually find it later). Keep a loose-leaf binder on every project, or invest in an engine build log book program and keep track of everything you do. Keep part numbers, quantities, instructions, and every measurement you can think of. If the worst should happen, it will help you find the cause of failure during the post mortem. If the cause of failure wasn't a poor parts choice or the design, the parts list helps you re-create your little monster with a minimum of fuss.

Inventory all your parts on arrival, verify the count, and write that down. Measure everything and write that down. Learn brutal organization skills. Buy piston and parts trays, magnetic trays, and cheap trash bags to wrap everything up in so it can't migrate to the nearest floor drain. Wrapping it all up also keeps everything already cleaned clean until assembly. Buy anti-fatigue mats and put them all around your workbench because aluminum doesn't bounce -- don't ask me how

I know that. There are immutable rules that apply to a dropped tool or part: It will be the most expensive thing on the workbench; it will land in a way that causes maximum damage; it will roll to the exact geometric center of the nearest immovable object, just out of reach of your longest magnet, or it will drop through a drain grate measurable smaller than the smallest dimension of the aforementioned dropped object, directly over the drain hole to the sewer. You think I'm kidding, don't you?

Read every bit of the instructions that come with every part and use the tech resources sections online and in the catalogs. Even if you read them last time, read them again -- the one thing that doesn't change in the world of racing is the fact that things are always changing. Take advantage of all the online resources that the suppliers and manufacturers offer online. There's a ton of information out there for those willing to read.

Expect that your engines, transmissions, and differentials will break. All a race car is is a rolling test lab; you begin racing because it's fun and "affordable" (in the stock or near-stock classes). You decide to go in a little deeper, so you step up. Now you don't have enough power, so you redesign the engine. You can't hook it up so you build in more traction. You've got power and traction, so you smoke the transmission or clutch. You improve the transmission or clutch and the differential grenades. You upgrade the differential and now you're not making enough power again... and around and around you go.

Everything breaks sooner or later -- the failure rate for components that operate at the outer fringes of their design is 100%. Engines break valve springs, drop valves, pound out keyways and bearings, burn pistons, and snap crankshafts, and they'll break a lot more often without proper maintenance and inspection. If they don't break, it's because you're not making enough power or because you're smart enough to aggressively maintain them. Sometimes it's a part failure, sometimes it's a design or materials failure, and sometimes it's a driver/car owner failure. If they over-rev it in the water box, or shake the tires hard enough to break bones, you can expect to be replacing parts sooner rather than later. If your owner/driver picks up a drum of Uncle Bob's Racin' Gas from a trailer peddler at the track, or skips checking the valve springs or lash for the whole season, it's still broken all the same. And you'll have to figure out what went wrong and why.

Finally, begin every project with the end in mind. Understand that everything you do to the block and reciprocating assembly is for durability and must match the rpm and power output for the application. Everything you do for power is in the cylinder heads, cam, induction, and exhaust system. Before you start, know the class rules for what you're building. There are head, induction, carb, block, displacement, compression, oiling system type, chassis rules, and safety rules for everything. There are open classes, claimer classes, throttle stop classes and "run-what-ya-brung" classes. Know where you're going before you start.

Building a 9,500-rpm, 830 horsepower circle track car is not the same as building a stout street engine, is not the same as building a class-specific drag race engine. An engine is a system -- one part of an overall system -- and each part of the system must match the intended purpose. Don't skimp or cheat on the system unless you like other racers beating you with a jack handle for oiling down the track at the turn-in point for turn one or scattering shrapnel all the way

down the "fast lane" at a division or national meet. If you're buying "a pair and a spare" for every part on the car because that's just enough to get you through the weekend, you'd better rethink your program. And you damn sure better not let the wife find out!

Everybody knows a guy who said he bolted on an intake and headers, monkeyed with the fuel and timing, and made 500 rear-wheel horsepower. Don't believe it, even if he produces a dyno sheet to "prove" it. A creative dyno operator can make that number whatever you want it to be, but IF that number is legit, the next question is, "How long will it run at that output before you drive over engine parts?," which is an altogether different question, isn't it? "Not long" is the answer if you didn't build the rest of the engine to match that power level. Besides, we don't race dynos -- the engine is just one part of the whole system and if you don't design the chassis and powertrain to match the horsepower you make, all you've built is a bomb with a fuse of undetermined length. Making horsepower is one thing, controlling it is another. It's a system. As the power goes up, the parts get more expensive, lighter and tend to be made from more exotic materials, which makes scattering them all the more tragic. The tune up, cooling and lubrication systems all have to match design and performance level. You can't make a lot of power without an adequate cooling system to carry away the heat, and you can't rely on a wet sump when a dry sump is called for. You can't build one without building them all.

Don't get me wrong. There are classes where you can have a lot of fun without spending all your money, but the faster you go the more expensive it gets and the more power you make the more you spend per horsepower to move up the horsepower curve. Most new racers fail because they spend too little, not because they spend too much. Spend the money and spend the time when you design, build and prep and you'll spend more time racing and less time driving to the race track to work on your car, which I always thought was counterintuitive anyway. Why would I drive hundreds of miles to lie in the grass and mud to fix or finish something what could have been done in the comfort of the shop? Call me silly, but I thought we were here to race, not rebuild a race car in the worst possible conditions.

So, now that we've got this program primed, let's hit the starter, flip the ignition on, and get going.

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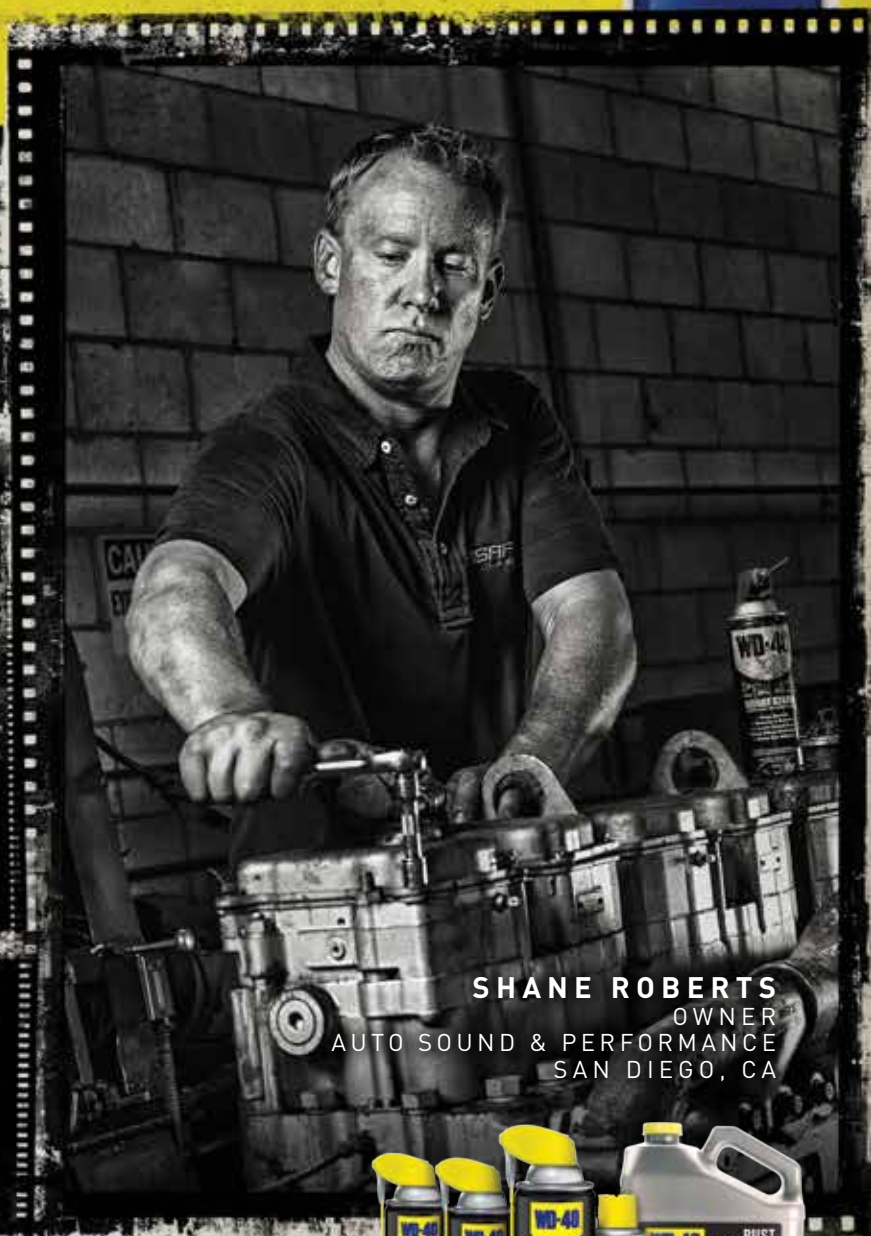

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