April 2014
V2 N2

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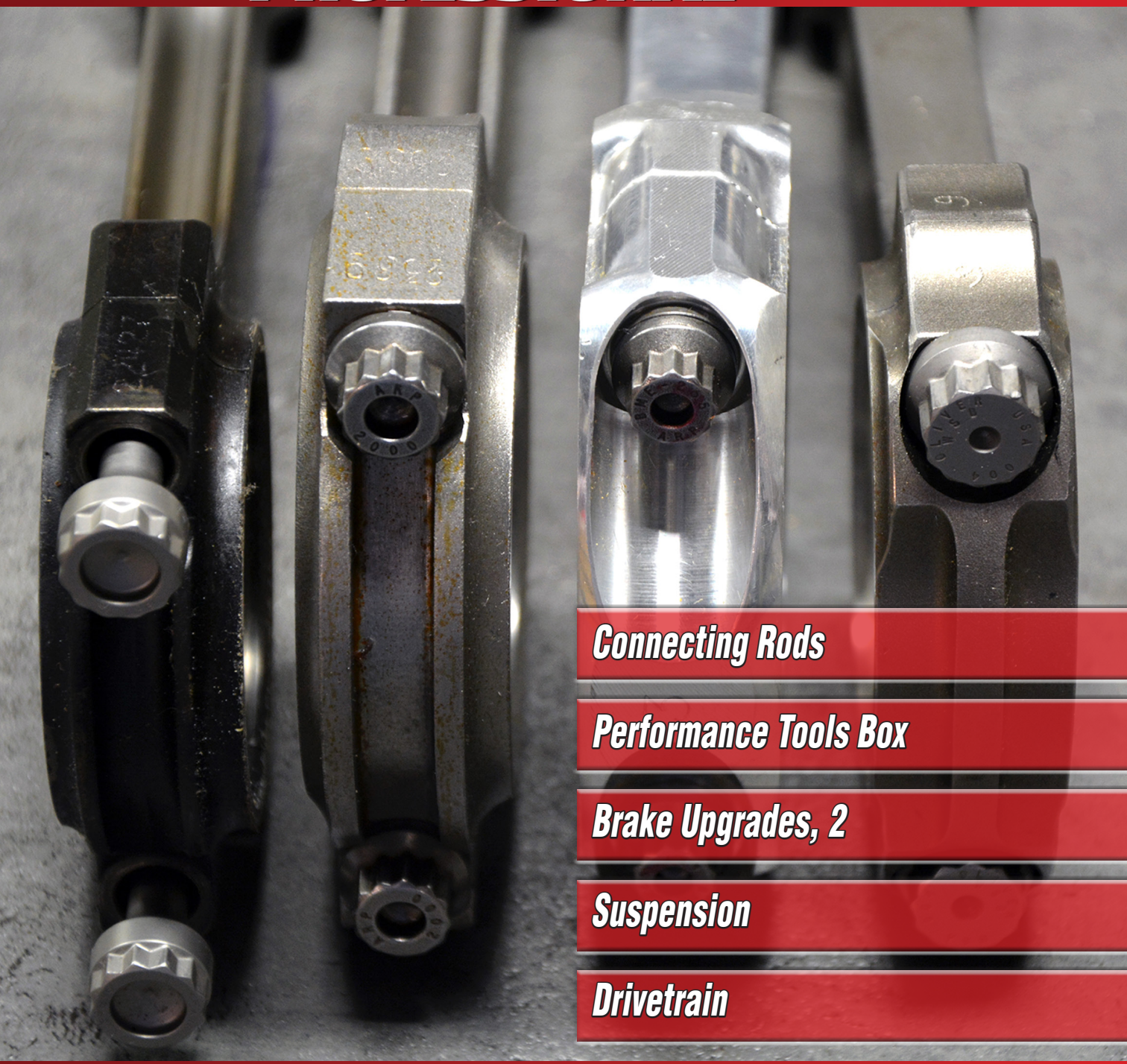

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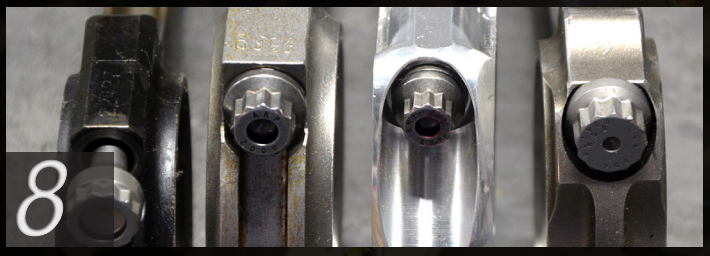
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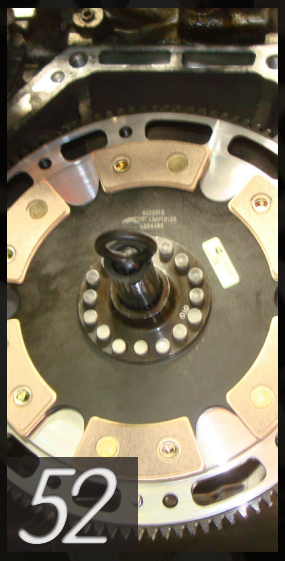
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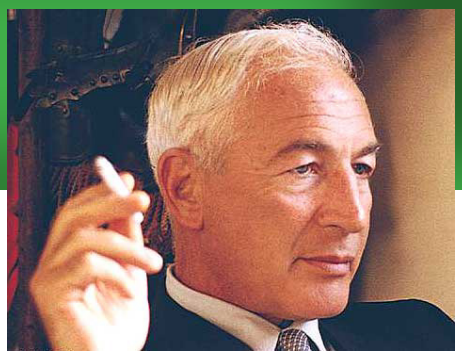
Starting Line

by Bob Freudenberger

Father of the Corvette



Zora Arkus Duntov, 1909 - 1996

Many years ago I had the honor of meeting Zora Arkus-Duntov at a cocktail reception put on by Chevrolet Public Relations as an adjunct to the introduction of some new models. Most of us were dressed in suits and ties, but he had the California-casual thing down, and was wearing an expensive tan cashmere sweater.

I had just become an auto mag tech writer and editor, so it hadn't been very long since I'd been working as a line techician (well, a mechanic back then) in a dealership. I didn't know who this nice-looking gentleman of about 65 was, but we immediately started talking about the technical and technological aspects of automobiles, particularly engines, not the lightweight "buff-book" stuff some of the other journalists present were discussing. We were into our second drink and plate of boiled shrimp by the time I realized with whom I was having this interesting and amiable conversation. When I did, all I could think of to blurt out was, "I've installed your cams!" Of course, I'd also admired and coveted the cars of which he was considered the father: Corvettes. I only saw him a couple of times thereafter, but he was always the same smiling, soft-spoken man with the pleasant accent.

I'm sure many HOT ROD Professional readers are too young to have had much to do with Ford flathead V8s, so you might not know that one of the big drawbacks of its design (introduced in 1932!) was that the exhaust had to exit through passages in the water jacket, which put a big load on the cooling system (two water pumps, 24 quarts of coolant, and a huge radiator were needed) and limited volumetric efficiency. There was an ingenious cure for this, though: Ardun heads, which gave you OHV hemi efficiency and a completely different path for the spent gases of combustion. Properly set up, flatheads so equipped could top 300 hp, believe it or not.

These excellent aluminum heads came up recently in a discussion with our esteemed contributor Henry Olsen, who had a vintage street rod in his shop with just such an engine, and I decided to research them. Well, duh, the name Ardun comes from Arkus-Duntov, a fact I had either forgotten, or never knew in the first place.

That led me to look into Mr. Arkus-Duntov's life. And quite an adventurous, interesting, and successful life it was, far more so than can be adequately described in a short editorial. So, I'll just mention the salient points, if that's not too disrespectful to the man's memory.

Born in Belgium on Christmas Day of 1909 to Russian parents (his father was a mining engineer, and his mother a medical student), Zora showed an enterprising streak while still a boy. There's even a story about him smuggling gold from France into Belgium in the chassis of a Mercedes at 16. The family moved to Leningrad (inexplicably given the horrors of the Russian revolution), then to Berlin in 1927 (how did they get away from Stalin?), where Zora

graduated from a top-tier engineering school in 1934. He also began racing motorcycles and cars, and wrote engineering papers for German automotive publications.

Zora's family was Jewish, so it's no surprise that when Nazi intentions toward that group became apparent that they moved to Paris, where he married a beautiful German girl, Elfi Wolff, who danced with the Folies Bergère (the marriage lasted 57 years until his death in 1996). About the same time, he joined the French air force and became a pilot.

When France surrendered, Zora somehow arranged for his whole family to escape to Portugal. According to the movie script-like Wikipedia description, "Elfi, who was still living in Paris at the time, made a dramatic dash to Bordeaux in her MG just ahead of the advancing Nazi troops." She joined the rest of the family, and they sailed for New York.

Zora became a U.S. citizen, and with his brother Yura formed Ardun Mechanical in Manhattan for the manufacture of munitions, but it became much more famous for the cylinder heads mentioned above. The company eventually employed 300 people.

But he remained passionate about racing, and shortly after the war he twice tried to qualify his own Talbot-Lago car for the Indy 500. He didn't succeed, but that's a pretty stiff venue. Next, he went to England to help develop the Allard, a light sports car powered by either a Ford flathead, or a Cadillac V8, one of which he drove at the 1952 24 Hours of Le Mans race.

At a New York car show in 1953, he was dazzled by the looks of the just-introduced Chevrolet Corvette, only to be disappointed when he saw that it was powered by a "Blue-Flame" inline six -- just a couple of minor steps up from the plebian "stove bolt" that had powered Chevy sedans and pickups since 1929. So, he wrote to GM president Ed Cole saying he would love the opportunity to help develop the car. Cole was impressed, and Zora started as a Chevrolet staff engineer shortly thereafter.

There's no way I can do justice here to the corporate wrangling that went on between Arkus-Duntov and the big company's top designers and upper management during the evolution of the Corvette. Suffice it to say that it was a battle between executives who believed that style was the key to selling cars, and Zora who believed in the substantive engineering that provided world-class performance. He stated his vision for Chevrolet's future in a memo entitled, "Thoughts Pertaining to Youth, Hot Rodders and Chevrolet," which helped transform the company's philosophy from conservative to "Heartbeat of America" exciting.

A few of Zora's early 'Vette accomplishments include the installation of the small-block 265 V8 in 1955, the winning of the Pikes Peak trophy and the setting of the 150 mph record for a production car at Daytona Beach in '56, and the introduction of the Rochester mechanical fuel injection system, which he helped design, in '57 (this made the magic "one horsepower per cubic inch" 283 legendary). Then came the first four-wheel discs on an American car, independent rear suspension, and many more innovations. Throughout all this, he found time to develop the famous Duntov high-lift cam that found its way into thousands of shade-tree hot rods.

In his obituary, famous columnist George Will wrote, "If you do not mourn his passing, you are not a good American." His ashes are enshrined in the National Corvette Museum, Bowling Green, KY.

If you'd like to read more about the man who did so much to shape American automotive culture, there are several good biographies available, and hundreds of articles on the Internet. ■

Performance Tool Box for Carbureted Engines

by Henry P. Olsen

One of the questions we always ponder: Is tuning an engine for maximum performance and/or fuel efficiency an art or a science? The answer appears to be that it is a combination of both. Back in the early days of hot rodding most of the fastest cars were set up by a highly-experienced tuner who could look at a spark plug to see if the air/fuel mixture was correct, and if the engine needed more spark advance.

But the changes in the formulation of today's unleaded gasoline and the many advances in engine technology have made it almost impossible to come to any meaningful conclusion from reading a spark plug, unless the air/fuel mixture or the ignition spark advance is way out of whack. This may seem like bad news, but the computer age has made tuning tools, formerly only used by factory engineers, now relatively affordable for virtually anyone with the need for speed and performance.

The basic tools that every tuner should have in his tool box include:

- Compression gauge
- Cylinder leak-down tester
- Fuel pressure gauge
- Vacuum gauge
- Manual vacuum pump
- Volt meter.

These allow you to check the condition of the engine and be sure there is enough fuel pressure and fuel volume, and to verify that the operating voltage is correct for any electrical systems in the vehicle you are testing. You will also need a few specialty tools that can make it possible for almost any motorhead to become a tuning hero. These include:

- Ignition scopes and timing lights
- Gasoline test equipment
- Tools for checking the air/fuel mixture
- Exhaust gas analyzers
- Digital air/fuel meters
- Tools for checking ambient conditions

Left: Having the right tools in your tool box makes it possible to unlock all the power and driveability that was built into the engine you are tuning.

Ignition Scopes & Timing Lights

An ignition scope can be very valuable in diagnosing the ignition system. It allows you to check the electrical output of the ignition system, look for open plug wires, or fouled spark plugs, plus it provides secondary pattern diagnosis. This is one key to analyzing air/fuel ratios, stuck or burned valves, and other mechanical conditions that can alter combustion. Many ignition scopes also have a cylinder-kill function that can allow the user to check cylinder balance to be sure all cylinders are functioning equally.

A cylinder leak-down tester will help you check the mechanical condition of the engine.

In an ideal world, every shop would have a distributor machine, and every engine would have a degreed harmonic balancer. But distributor machines are not as common as they once were, and most engines don't have degreed balancers. It would be best to check the distributor mechanical and vacuum advance curves in a distributor test stand, but a dial-back timing light is a good second choice. It allows you to determine how much total advance

Right: Compression testing may be old-fashioned, but it establishes an essential baseline.

The Robert Bosch MTS 5200 Analyzer is a high-quality ignition scope, plus it can also allow the user to diagnose the health of an engine by looking at the vacuum signal created by each cylinder.

A distributor test stand is the best way to check the spark advance curve...

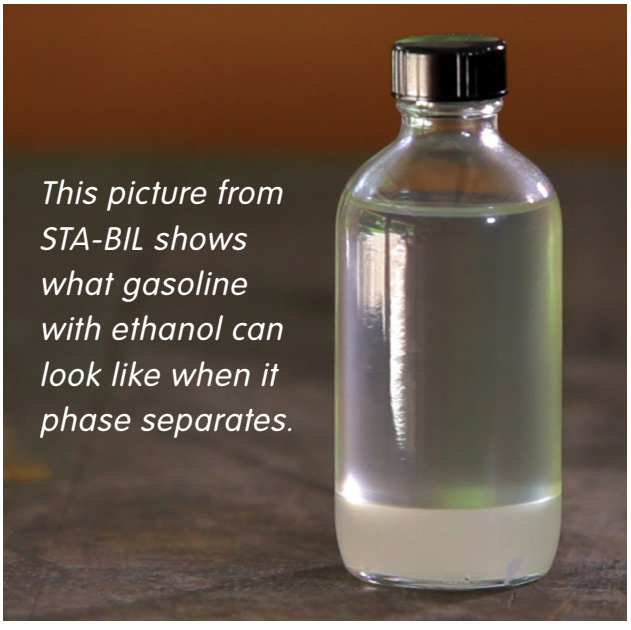
an engine has so you can be sure its spark advance curve is correct.

Reformulated Gasoline and Gasoline Test Equipment

Gasoline quality is a real concern when you are diagnosing drivability problems, especially now that most of the gasoline sold in the United States contains ethanol. The addition of ethanol is causing corrosion and swelling problems with many fuel system components of carburetor-equipped vehicles not designed with ethanol in mind. Ethanol can act as a solvent that will attack any component made with plastic or rubber compounds, such as fuel hoses. It can also attack components made from brass, copper, and aluminum that can become corroded over time if they are not given proper surface treatments.

The most common gasoline quality problems we test for are phase separation, high ethanol content, and low volatility. Phase separation can happen if the ethanol in the gasoline is exposed to enough moisture to cause it to separate from the fuel. This phase-separated ethanol

and water mixture is very corrosive to most of the components in a carburetor-equipped vehicle's fuel system. Both Driven Racing Oil and Sta-Bil offer fuel additives that will help extend the life of gasoline and prevent the corrosion problems that can happen using gasoline that contains ethanol. The OTC #7670 Gasoline Quality test kit can be used to test for water in the gasoline, fuel vapor pressure, and ethanol content. The Kent Moore/OTC #J-44175-A Flexible Fuel Tester provides a digital reading of gasoline's ethanol content.



This picture from STA-BIL shows what gasoline with ethanol can look like when it phase separates.

Tools for Checking the Air/Fuel Mixture

The biggest advancement in tuning tools has been in those that read an engine's air/fuel mixture. The digital age has reduced the size and price of five-gas exhaust analyzers, and brought us very affordable digital air/fuel meter systems. The readings from a five-gas

...but a dial-back timing light can also be used to get a profile of both the mechanical and vacuum advance systems' curves.

This gasoline quality test kit from OTC is used to check for water in the gasoline, the fuel vapor pressure, and the ethanol content.

This Kent-Moore Fuel Composition Tester gives you an electronic readout of the ethanol content of a gasoline sample.

analyzer are comprehensive and accurate, and the readings can help determine what air/fuel mixture the engine needs for maximum efficiency. The reaction time is slow, however -- six to 10 seconds. The readings from a wide-band oxygen sensor-based digital air/fuel meter are basically in real time, but users need to know what air/fuel mixture readings they are tuning for, and the unit can give false readings caused by an exhaust leak or engine misfire problems.

Exhaust Gas Analyzers

A five-gas exhaust gas analyzer provides readings that give information needed to determine the air/fuel ratio, misfire rate, and combustion efficiency. Plus, the readings can be used to see if the engine has any detonation issues. These readings can allow an experienced tuner to determine what air/fuel mixture an engine needs for maximum engine efficiency, and can help in the tuning of the ignition spark advance systems. The exhaust gas analyzer looks at:

- The CO (carbon monoxide) reading is determined by the air/fuel ratio. A low

The digital age has reduced the size and price of five-gas exhaust analyzers, and has ushered in an age of very affordable digital air/fuel meter systems.

The OTC/SPX performance exhaust gas analyzer module mounts on the back of the company's Genisys scan tool.

reading indicates a lean air/fuel mixture and a high reading indicate a rich air/fuel mixture.

- The HC (hydrocarbons) reading shows the amount of unburned fuel in the exhaust, normally caused as the engine misfires. The ideal air/fuel mixture and the ideal spark advance setting will provide the lowest HC reading, as long as the fuel is fully vaporized
- CO2 (carbon dioxide) is a product of complete combustion. The best air/fuel mixture and the best spark advance setting will give the highest CO2 reading.
- A high O2 (oxygen) reading -- excess oxygen in the exhaust -- indicates a lean mixture, an exhaust leak, an engine misfire problem, or an engine with a high-overlap camshaft at low engine speeds.
- NOx (oxides of nitrogen) is created by excessive combustion chamber heat. In many cases, a high reading may be related to excessive ignition timing advance, creating detonation, or an engine with an insufficient cooling system, and can result in engine damage.

Digital Air/Fuel Meters

A wide-band oxygen or AFR (air/fuel ratio) sensor-based digital air/fuel meter can allow a technician to accurately read the mixture in real time, but the engine needs to be running efficiently if the readings are to be accurate. This type of meter uses a wide band oxygen sensor mounted in the exhaust system that tries to maintain a stoichiometric (14.6:1 by weight) air/fuel ratio in the sensor's detection chamber by sampling the engine's exhaust and by pumping oxygen in or out of the detection chamber. The sensor emits voltage that indicates relative oxygen content -- or lack of it -- in the detection chamber. It "looks" at the value of the pumping current the wide-band sensor requires to achieve a stoichiometric mixture, and compares this with the actual air/fuel mixture readings in real time.

The readings from such a meter are very accurate as long as the engine is properly burning the fully-vaporized air/fuel mixture in each cylinder. The readings will not be accurate if the sensor is exposed to a high level of unburned combustibles from an

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ignition or mechanical problem that would cause the mixture to not fully burn in each cylinder, or if the sensor is exposed to outside air from an exhaust leak. Any time the air/fuel mixture readings indicate that a major tuning change is needed, it would be wise to confirm the readings with an exhaust gas analyzer before major changes are made -- the oxygen sensor can easily misread the exhaust and supply false lean readings.

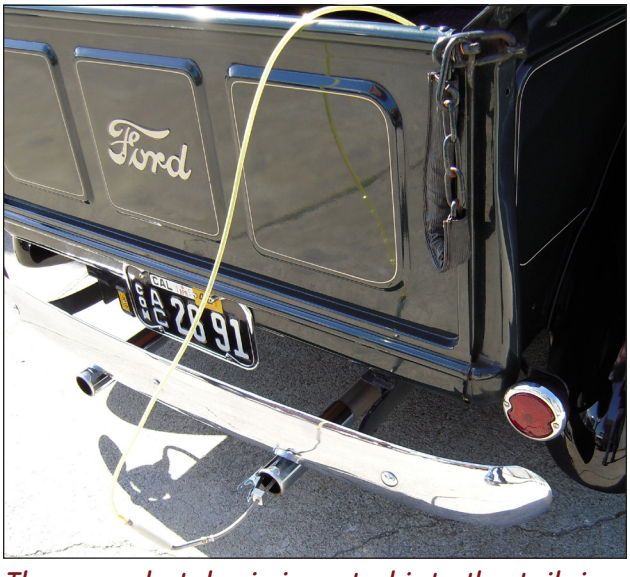
An example of a situation that could cause false readings from a digital air/fuel meter are incorrect ignition timing, the fuel not being fully vaporized (only vaporized fuel will burn), fouled spark plugs, a cylinder that is misfiring, or an engine with a high-overlap camshaft at low engine speeds. The sensor will "read" the unburned oxygen that is in the exhaust from the cylinders that misfired and assume that the oxygen is there because the air/fuel mixture is too lean, and will supply a false lean reading.

The Best of Both Worlds

Since both the five-gas analyzer and the digital air/fuel meter tuning methods have their advantages, we use the five-gas to tune both the air/fuel mixture and the ignition system, then we use the digital air/fuel meter for more advanced tuning during real-world operating conditions. If you're lucky enough to have a chassis or engine dynamometer available, use it to determine what air/fuel mixture the engine wants to make maximum power, then check to be sure the engine is getting the same air/fuel mixture readings when you are driving it on the road.

If the readings are different, check to ensure that the fuel pressure and fuel volume are adequate for the needs of the engine,

A five-gas exhaust analyzer samples the gases at the tailpipe to provide information on the air/fuel ratio, misfire rate, engine efficiency, and more.



The sample tube is inserted into the tailpipe so the tool can analyze the exhaust.

and be sure that the fuel tank vent system is operating properly -- you can only pump fuel from the fuel tank as quickly as the vent system allows air into the tank to replace the fuel being pumped out.

Air/Fuel Mixture Targets

If you are tuning a new or rebuilt engine, it would be wise to ask the engine builder what air/fuel mixtures you should be tuning for, as well as what ignition advance curve he or she suggests. If this data is not available, a good starting point for the air/fuel mixtures on a generic engine would be:

- An idle and cruise mixture of 14.1 to 13.4 to 1 air/fuel mixture (1% to 3% CO).
- A power mixture of about 12.0 to 1 (6.6% CO) with most early vintage carburetor-equipped engines, but if the engine is equipped with newer fast-burn cylinder heads it may use a slightly leaner power mixture of 13.0 to 1 (4% CO).
- The thing you need to know is that both the five-gas exhaust gas analyzer and the digital air/fuel meters supply the user with the average air/fuel mixture of all the cylinders that the tool is analyzing. It's more than likely that the air/fuel mixture will vary from cylinder to cylinder.

Many of the best performance tuners and engine builders use the data they get from multiple wide-band oxygen sensors, placed in the exhaust header tube of each cylinder, to determine the exact mixture of each cylinder so they can be sure each has the ideal blend for maximum power. This same tuning method can also be used to observe any fuel mixture changes that are caused by the G-forces that are seen during race conditions.

One example of this tuning method being used in actual race conditions is in NHRA

Don't let the small size fool you; a wide-band "oxygen" sensor based air/fuel meter is an essential tool that should be in your tool box.

Pro Stock. The data allows tuners to observe how much the air/fuel readings on the track changed from the readings they got when they were tuning the engine on the dynamometer. Many of the top carburetor-equipped engine race teams in both drag and oval track racing use these air/fuel mixture distribution readings as a guide when they are designing their intake manifolds so they can get maximum power.

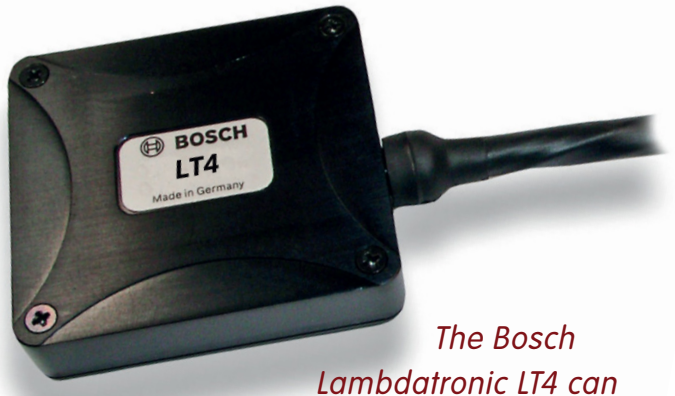
Checking the Weather

The tuning you've done may be correct for the density and altitude of the air -- this includes the air temperature, density, humidity, and barometric pressure -- at the moment the tuning was done. But whenever the density/altitude of the air changes, you may need to re-tune the engine for these new conditions. The computer of a modern fuel-injected engine uses the readings it gets from its various sensors to determine the density of the incoming air as part of the calculations it does to determine what commands it should send to the fuel injectors and what the ignition spark timing should be.

The computer then fine-tunes the mixture and the ignition spark advance for maximum efficiency. If you are tuning an engine for maximum power, it would be wise to consider using a weather station such as Computech's Race Air Pro so you can know what the weather conditions are and then tune the engine for ever-changing air density.

Burning the Fuel

Don't forget that the fuel must be fully vaporized in order for the engine to convert it into power. Most production carburetor-equipped engines use an exhaust passage across the bottom of the intake manifold to use heat to turn any liquid fuel into vapor. It has become very popular to block the exhaust crossover in the intake manifold, or to use an "air-gap" style manifold to keep the incoming air/fuel mixture cool. This may work quite well in hot-weather areas, but it will cause power and drivability problems when the ambient air turns cold. If there's not enough heat in the intake manifold to fully vaporize the fuel, the engine will often not idle properly, have poor throttle response, and may lack power at low rpm. So, with every part you buy, be sure it is designed to work properly with the expected driving conditions.



The Bosch Lambdatronic LT4 can tap into up to four AFR (air/fuel ratio) sensors at once. It's the unit many of the top engine builders for NASCAR, including Hendrick Motorsports, use in their engine test cells and at the track for mapping and tuning their fuel injection systems.

Getting It Right

Once you have spent the time to be sure the ignition system is doing its part to light the fire, and that the correct mixture of fully vaporized fuel is present, the engine you are tuning will provide all the power and fuel efficiency that was engineered into it. ■

-- Happy Tuning! --

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Basics Series:

Connecting Rods

Our esteemed tech editor shows us that there's a lot more to connecting rods than most of us have ever imagined.

by Greg McConiga

The connecting rod and its bolts are probably the most highly stressed components in the entire engine, absorbing the compressive stresses of compression and combustion and the tensile forces that occur as the pistons wheel over top dead center in an unloaded state with nothing to cushion or slow its movement during the end of the exhaust stroke.

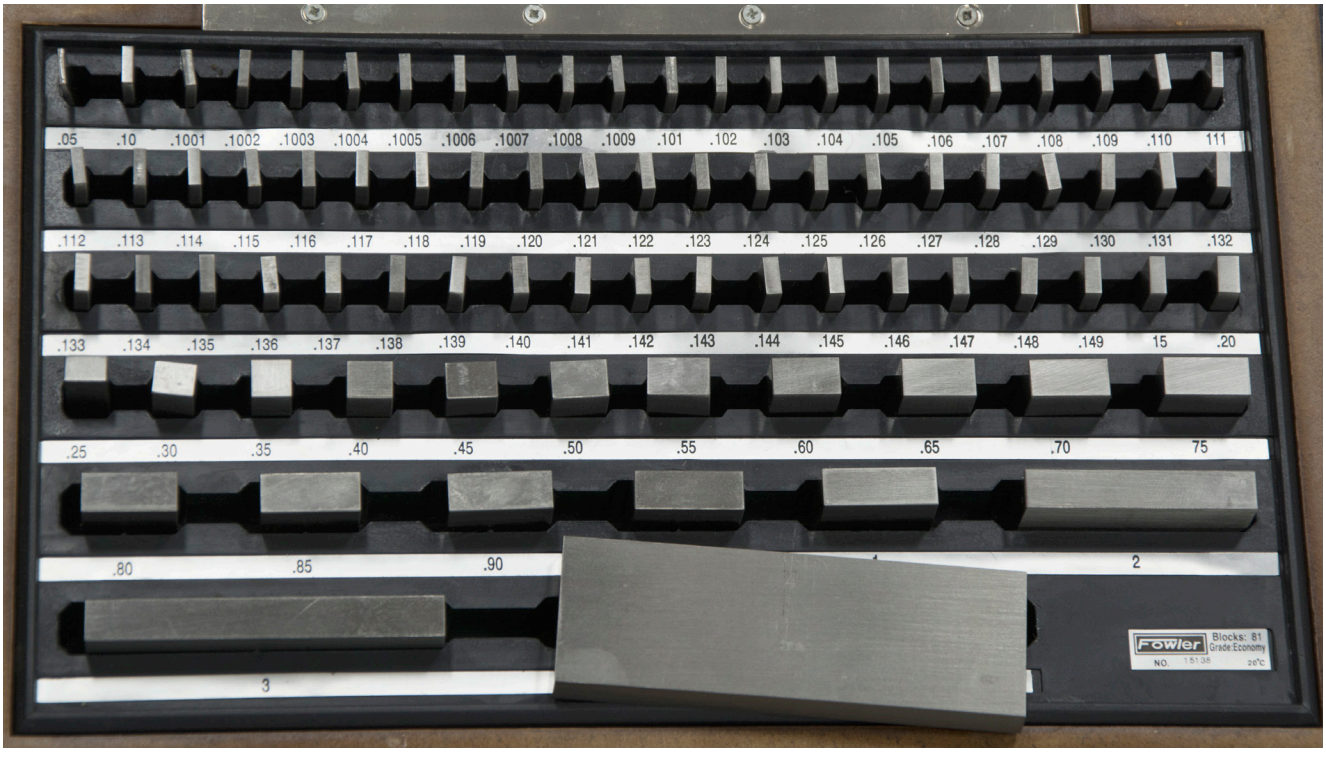
You've heard of the four-stroke engine cycle, but in truth there are seven cycles on a racing engine -- or any non-two-stroke or non-rotary engine, for that matter. There are three phases to the intake stroke. The first is exhaust-driven during overlap when the negative exhaust pulse pulls through the chamber creating negative pressures reaching over 100 inches of water. That vacuum reaches right through the opening intake port and jerk-starts cylinder fill, then is followed by the normal pumping induction that occurs as the piston falls, pulling mixture into the cylinder at something around 10-20 inches of water vacuum. Final cylinder filling continues even after the piston reaches BDC and begins its upward journey. This is due to inertial ramming caused by the weight of the inrushing air fuel mixture, often lasting for as long as 60-100 degrees ABDC. This can occur because piston dwell over BDC is longer than dwell over TDC for nearly all engines and you'll see this if you graph piston movement relative to crankshaft degrees.

Compression follows, then the power phase that lasts until the rate of expansion of the trapped mass becomes slower than the speed of the falling piston. At that point, the exhaust valve opens and the two phases of exhaust follow: blow down, which occurs due to residual pressure, and pump down, which occurs during upward piston motion. This completes our seven cycles and the whole exciting mess starts all over again.

Controlling all of this commotion is the lowly connecting rod, the link pin between the rotating crankshaft and the reciprocating piston. The conversion of linear reciprocating movement to rotary movement couldn't occur without this critical link in a piston engine. The forces battering the connecting rod alternate between compressive force (trying to shorten it) and tensile force (trying to pull it apart.)

As the piston rises on compression, it undergoes a relatively slow build-up of compressive strain, followed by the sharp spike of compression forces created when the cylinder fires and cylinder pressure rises rapidly. Forces are moderate over BDC on the power-to-exhaust transition, but shift rapidly to high tension over TDC at overlap since there's no compression to catch the piston and slow it down. Over TDC at overlap it's pure tensile stress... trying to yank the rod and rod bolts in two, and acting to distort the big end and small end as the piston moves from speeds of as much as 6,000 feet per second [Editor's Note: That's over 4,000 mph – Mach 5.2!], to a full stop to full acceleration away from TDC. It's a miracle we don't drive over thrown connecting rods more often than we do.

Left: Aluminum in tension tends to move or distort a bit more than steel resulting in a loss of radial bearing crush (all that normally retains a bearing in its bore). Aluminum rods use a dowel pin to locate and secure the lower (non-load) rod bearing so that if distortion occurs the bearing will not spin.



Gauge blocks like these, along with micrometer standards and pin gauges, are the only way to check your measurement equipment for accuracy. If you aren't measuring what you think you're measuring, you can't trust the results.

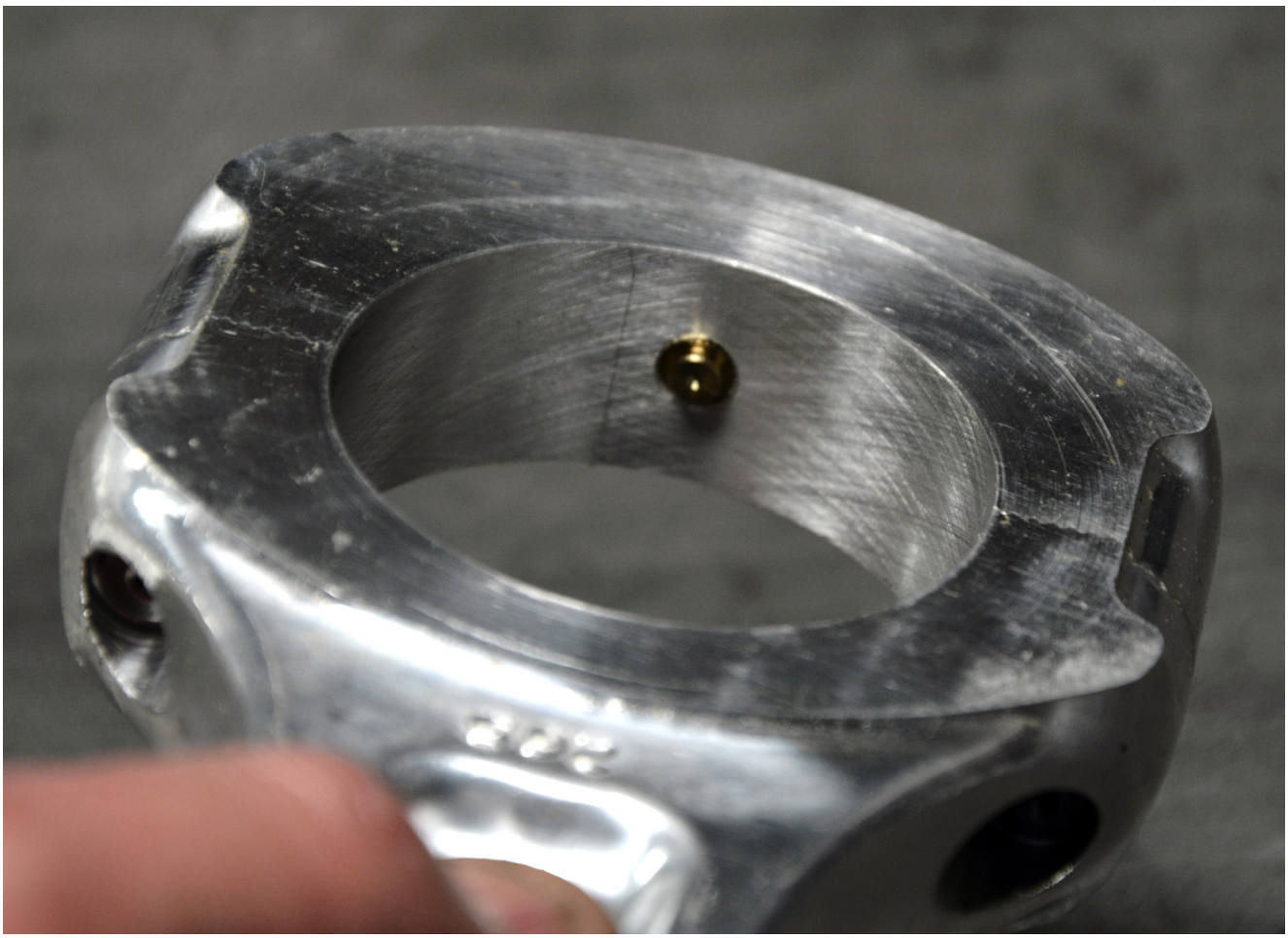
Right: This is the most expensive rod bolt I've ever held. It's a Carillo/Lentz, and they run about $50.00 – EACH! And to think I can remember using a whole connecting rod assembly that didn't cost that much. It's all about materials and manufacturing precision. Some bolts and fasteners are sensitive to the moisture in your skin and chlorine found in some brake cleaners and solvents. Make sure you know what you're handling and what precautions you must take or you can ruin a fifty dollar bolt just by holding it with sweaty bare hands. Once the bolt is oily, or if your hands are covered with motor oil, it may be safe to handle.

Connecting rods are made by a number of manufacturers; I've put the websites of some prominent suppliers at the end of this article for your convenience. What you buy and use is largely a matter of your personal preference and experience.

You need to know . . .

The key to keeping your reciprocating assembly alive is cleanliness, attention to detail, careful measurement, quality parts, and outstanding assembly techniques. Of primary importance is the selection, preparation, and technique used to install the rod bolts. In a nutshell, a rod bolt is nearly failure proof (assuming a lack of hidden defect) as long as it's properly installed and tightened and you don't stray outside of the design parameters by over-speeding the engine.

The only correct way to install rod bolts is by stretch. That is, measuring the change in the overall length of the bolt as it is



This state-of-the-art aluminum connecting rod is suitable for street use, according to the manufacturer. Made of forged aluminum it features ARP fasteners and uses a doweled lower bearing to positively control bearing retention and location. It is also extremely light compared to a comparable steel rod. The extreme clearance problems we used to see around the block skirt, bottom of the bore and cam have largely been fixed by better rod design, so using aluminum rods isn't the challenge is used to be.

preloaded. What we must do with a rod bolt is preload it to a higher load than the cyclic load to which it's exposed. If we do this, the bolt will not see the cycling load at all. The bolted joint becomes one piece – solid -- for that particular cyclic load. By preloading the fastener we force it to act more like a spring

This is a racing connecting rod for a Briggs & Stratton -- Okay, I'm kidding. This is an extreme example of a connecting rod from a seven and a half by seven inch Waukesha industrial engine. I've had it for years and I pulled it out just so I could show you another world of connecting rods. It measures 18 ½ inches from center to center, uses four rod bolts and it's gun drilled to provide lubrication up to the pin bushing and the piston oil spray nozzle.

Right: Setting fixtures are invaluable when you begin measuring down to the nearly 1/10,000th of an inch. By continuously checking during the measurement process, you can verify that you are aren't getting any "drift" due to temperature changes or tool bump.

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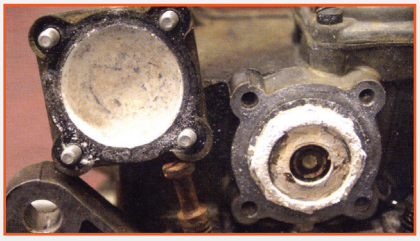

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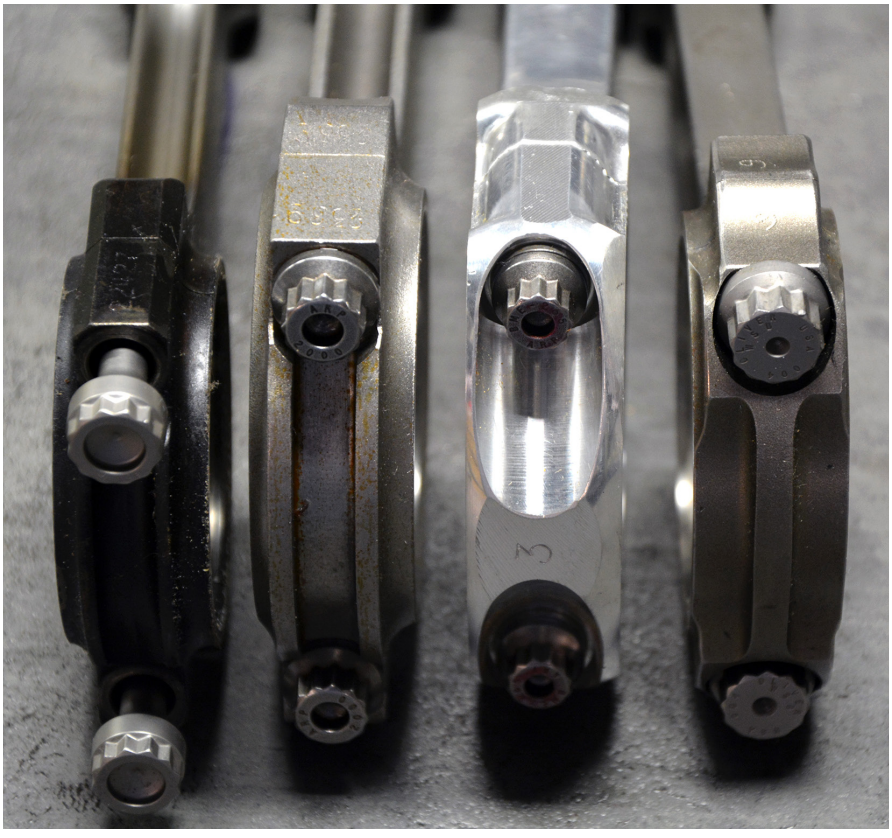
Right: Here are four examples I scrounged up from the shop. From the left there is a badly damaged Carillo H-beam rod, a Manley H-beam, a Bill Miller Engineering forged aluminum rod, and an Oliver Billet I-beam rod. If you slice across the beam and look at the cross section it will resemble either the letter "H" or the letter "I", hence the name. The "I" beam is generally heavier and stronger than the "H" beam.



Lubrication failures in racing engines are not a good thing. This Carillo was damaged when the dry sump oil pump drive belt was destroyed by track debris at 9,800 rpm. You can't lift fast enough at that engine speed to avoid the damage. At rpm like that the balance between component weight and strength are primary concerns. Pistons, pins, rods, and valves -- everything has to be light . . . and strong. The standard racer's parts weight check: If you throw it up in the air and it comes back down, it's too heavy!

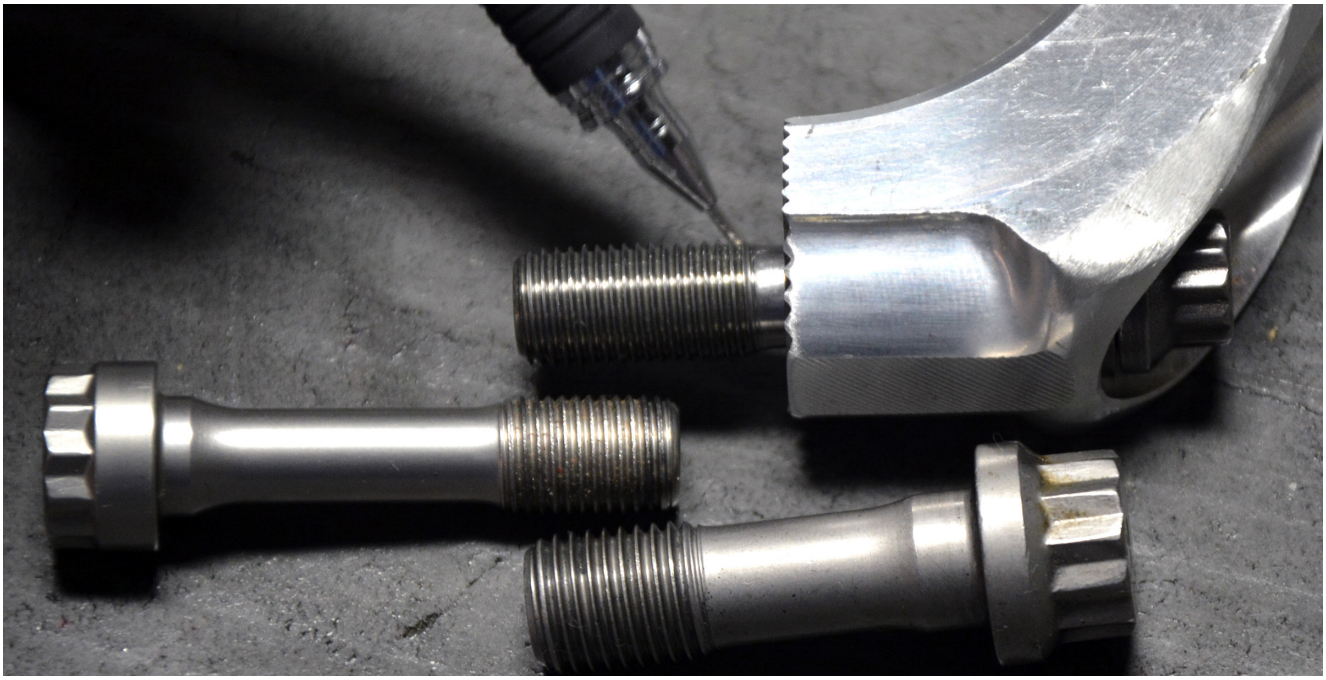
It's not uncommon to begin to see fretting and micro-welding occurring in high-horsepower applications. There are a lot of things moving and vibrating inside that engine under full load. Over three or four seasons you might notice small areas of fretting and micro-welding starting to appear. Eventually parts will have to be re-machined and bores trued.

Right: Liquid is essentially non-compressible (less than ¼ of 1% of its volume), to which this connecting rod bears testimony. A small coolant leak developed and suddenly we have a little lower compression ratio in one cylinder. Racing rods are tough and will often bend considerably before breaking.

than a solid object; the cap and beam of the rod appear to be one solid piece. This is not something that can be accurately done with a torque wrench, which is more affected by thread and bolt under-head friction than by actual fastener loading. As you increase torque, this actually gets worse.

Using high-tech, manufacturer-specified lubes helps attain consistent tightening and reduces preload scatter, but it doesn't eliminate it altogether. Most high-performance rod bolts have stretch specifications of something around .004 to .007 in. depending on the bolts and application. The stretch window is very small, sometimes as little as .0004 in.; that's 4/10,000ths of an inch. In one application I use, the window is .0052-.0057 in. Cheap tools, technique, dirt, even oil becomes a factor when reading that small a dimension, and every bolt in every application has a different specification. Don't guess. Go to the websites or make a call and get the exact specification for your application. Always use the lube the rod and bolt supplier specify

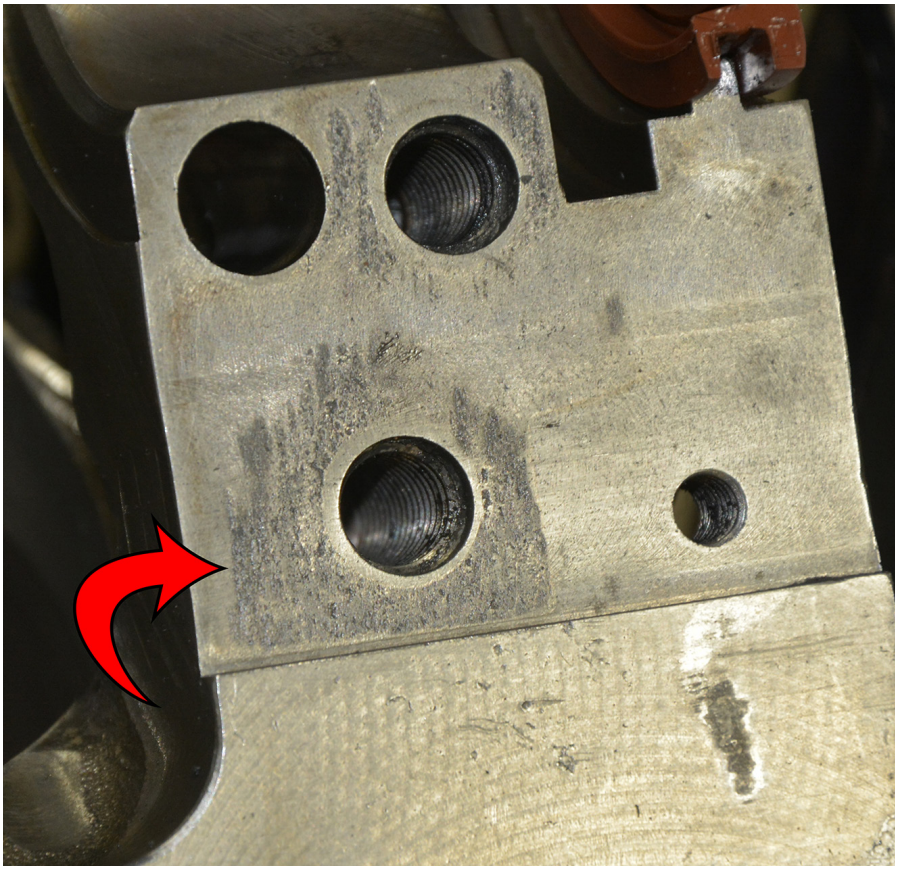
Right: Even though there is a plastic insulator built onto the shaft of the dial bore gauge, I'll often use leather work gloves to help keep the heat of my hands from affecting my readings, especially if I have to hold the tool for a while as I take a number of readings. It's amazing how much variation in readings you can get with changing tool temperature. When you are checking bearing clearances in 10,000ths of an inch it doesn't take a lot to go from good to not so good. The lesson? Always handle the tool by the insulator and wear gloves if you're going to be hanging onto it for a while.



Comparing the engaged thread length on these three rod bolts reveals something that seems logical: The aluminum rod uses a longer thread engagement. While the two examples used in steel rods have nearly identical thread lengths, the aluminum rod has almost double the thread engagement. If you're threading into a softer material, you'll need more thread engagement to hold the torque without stripping. Makes sense to me.

You can see how much bigger the rod big end is to accommodate the material strength and distortion characteristics of aluminum versus steel. You can also see how carefully shaped the upper shoulders of the rod are so these newer designs don't take near as much effort to install. Watch the clearance on the cam, bottom of the bores, and the block skirt areas.

because they have tested it on that bolt with that rod and they know that the torque or torque-plus-turns specification they give you to achieve preliminary stretch will work without overstretching the bolt. DO NOT experiment with home brews or cross-source lubes -- use what they tell you. They have ruined and tossed enough bolts finding the right combination that there's no point reinventing the wheel.

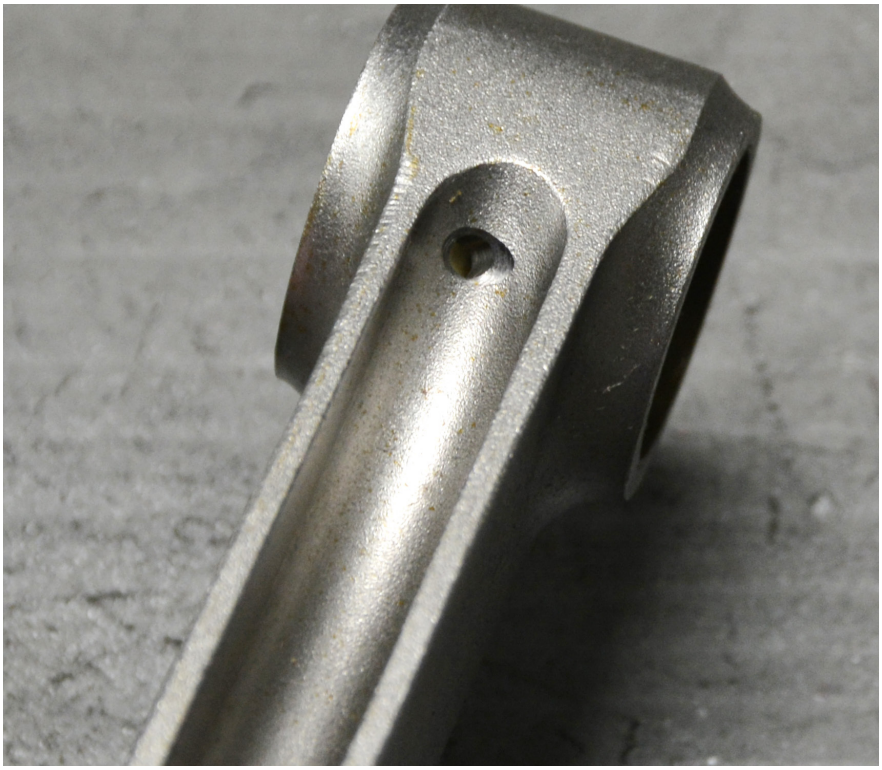


As the power levels go up, seeing this isn't completely unexpected. Even with billet caps, four-bolt mains and half-inch studs if you make enough power you're going to move things around. After three seasons this rear main cap shows what happens when you "shake things up a bit."

If you over tighten a rod bolt, you must relax it and re-measure it. If its relaxed length increases by as little as .0005 in., you may be required to discard it. In my experience, most bolts that are properly stretched will actually shrink in length when relaxed by about .0002-.0004 in., and I'm not sure I know why that is. I just know that I've got a modified ARP stretch gage that I've mated with an SPI dial indicator that will read to 5/100,000ths of an inch, and I've noted that nearly all rod bolts shrink slightly when properly stretched and cycled a few times. In the Navy, we called this PFM (Pure Freaking Magic), and while it's not a scientific term it can be used to explain all sorts of mysteries...

To correctly tighten a rod bolt, you must lube threads, under the head, and the face of the cap with the approved lubricant. Turn the bolt in one smooth motion -- do not stop -- measure, pull again, measure and so on, a technique I call "chasing the stretch." The reason is simple: Once you have pressure on the threads and on the interface between bolt head and cap, as you try to continue tightening the first thing you're doing is winding up the bolt shank before moving the threads, inducing the kind of stress that produces an early failure. If you undershoot the spec, back the bolt all the way off, relube the area under the head of the bolt, increase your torque reading or the degrees of turn, and start again.

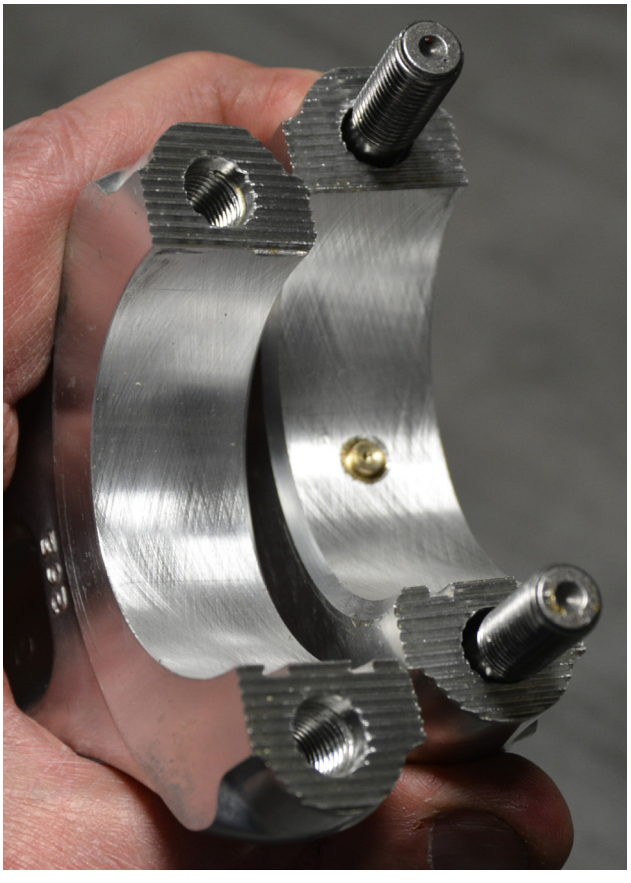
After opening up boxes and plastic bags, washing, and drying, the next step is inspection. Even the tiniest, slightest nick in a rod beam will create a stress riser that will eventually cause the rod to break. If you find something, you must use a stone to smooth and round the nick to eliminate the stress riser. Sharp edges are bad, but round smooth curves are good. Not just here, but everywhere inside your engine. Check that all surfaces appear to be in a "finished" state, check locating dowel, locating tabs, check that chamfers are correct, and that bores and overall lengths are what you ordered.



Left: Oil feed into the rod bushing may be done from above or below the pin boss. Some rods have a hole drilled on top with a chamfer to collect oil, others drill into the four or six o'clock position on the boss and rely on splash to force oil into the pin bushing. Either way works as long as the holes are drilled all the way through and the bushing hasn't rotated to close off the hole (something to check during each seasonal overhaul).

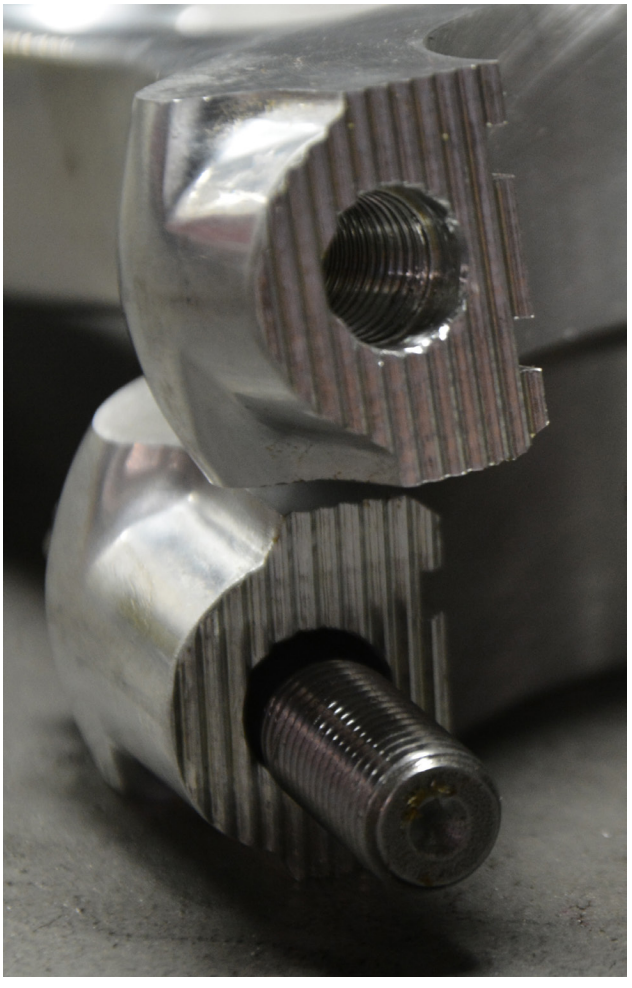
Types, advantages and cautions

There are three materials that I'm aware of that are used to make connecting rods: steel, aluminum, and titanium. Most of us will end up using either steel or aluminum as titanium is generally considered cost-prohibitive. Steel has the advantage of strength, relative affordability, and durability. The disadvantages are the finished weight of the connecting rods and the fact that they are stiff enough to transmit everything happening in the combustion chamber right into the crank, and ultimately into the valve train.



Connecting rods try to collapse inward at the parting line under tension, so keeping the parting lines solidly locked together is critical. Steel rods most often use dowels, but more interlocking surface area is engaged if you have precision machined serrations like these.

Titanium is light and strong, but it's expensive as hell and it galls easily, so lubrication must be spot on and the oiling system must be superb at stripping entrained air. Aluminum rods are light, strong (when increased in cross section), and absorb and soften combustion energy, which makes them perfect for blown alcohol, fuel and wild nitrous combinations. On the other hand, they have to be replaced



Here's a close-up of those serrations on a Bill Miller connecting rod. Very pretty work and very effective at keeping the softer aluminum rods from pulling in when the rod is under tension. If the sides pull in, they form a squeegee that wipes the oil from the journal resulting in rod bearing failure from lack of lubrication.

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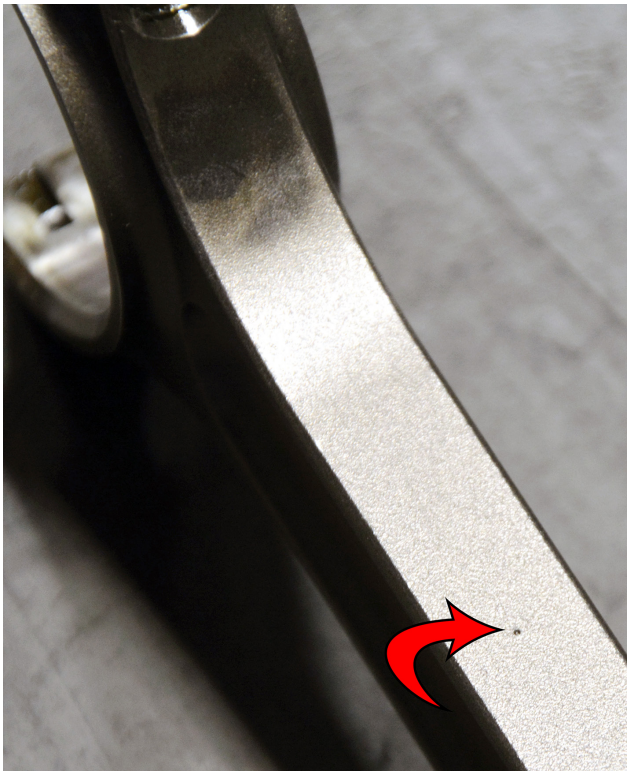
How big do connecting rods get? A LOT bigger than this one! Shipboard recip engines measure their bore and stroke in feet! This Waukesha rod measures about 18 ½ inches center to center and it's a good example of an "I" beam rod. It's a doozy… the engine it came out of was for power generation in an apartment complex and it ran at around 800 rpm.

much more frequently than steel or titanium, which increases operating costs.

Your choice of material, length, and sizes are determined by your application. Connecting rod selection isn't something you just go grab and then try to make everything else fit. Think deck height, compression height, stroke, fuel, application (drag or duration), blown or naturally aspirated (you can go with a lighter rod with a blower since intake pressure cushions the reciprocating assembly over TDC overlap) and rpm before you land on the rod you should use.

Prep and checks

Whenever new parts arrive, always decant them and count. Got everything? Two bolts per rod? One pin per piston? Thirty-two Spirolox of the right thickness? Check them in and look them over for shipping damage. Wash and inspect for nicks, dents, dings and anomalies and check that the bearing offset chamfer is machined in. Clamp two rods in a vise next to each other as they will be on



The only acceptable marks on a connecting rod beam will be the tiny dent you see here, left behind by a hardness tester used to check the Rockwell hardness of the finished product. Any mark, nick, or dent on the beam edge will certainly cause rod failure.

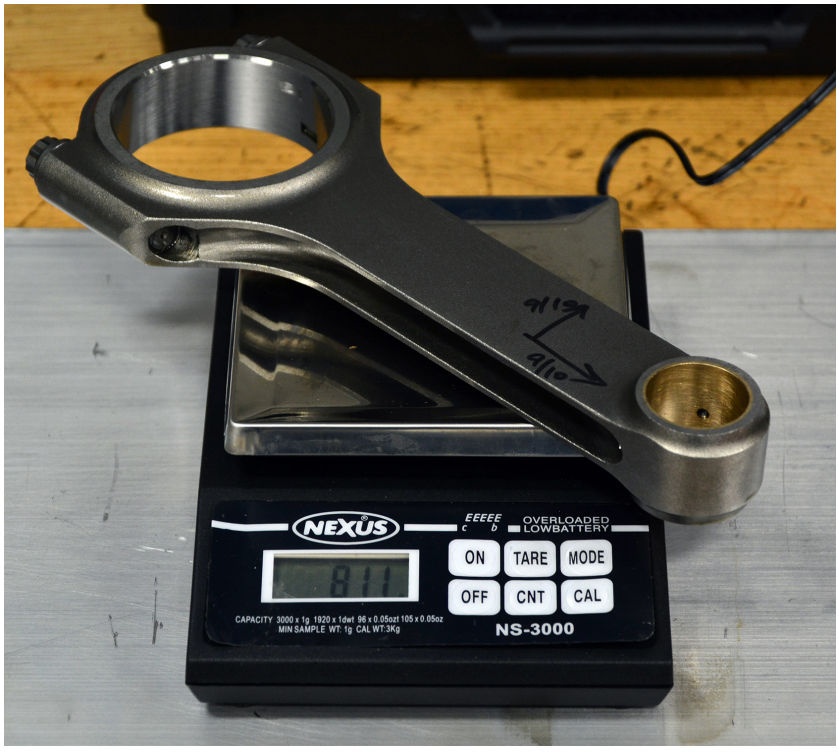
Before there were affordable connecting rod options, this was the treatment most often used to increase the reliability of stock connecting rods. This is a stock forged connecting rod that has been side polished to remove any stress risers formed along the forging parting line and shot peened to relieve stress. It also has been upgraded with ARP rod bolts. Although time-consuming, it was effective: This engine has been running for over ten years and regularly hits 6,000 rpm with a 4-1/4 in. stroke.

In a side-by-side comparison, the additional material used in the aluminum rod is apparent. The beam is thicker and the material around the crankpin and piston pin bores is thicker as well. Even so, it is much lighter than its steel counterpart.

the journal, measure overall width of the two big ends, and check to see that this is .010-.020 in. less than the crankpin length as a preliminary side clearance check. Inspect the pin end and make sure the bushing oiling hole is drilled and lined up. Take a look at the parting lines on the cap and rod -- dowels in place? Is the through hole in the cap relieved to clear the rod bolt radius? Everything final machined, straight, and smooth? Bores show hone marks as they should? Verify that the rod bolts are at full torque and measure the big end and pin end bores for dimension and concentricity, and calculate pin clearance for your application (more power means more clearance since you're trying to compensate for bending forces.) Verify that both bores are round. There ARE exceptions to this. There

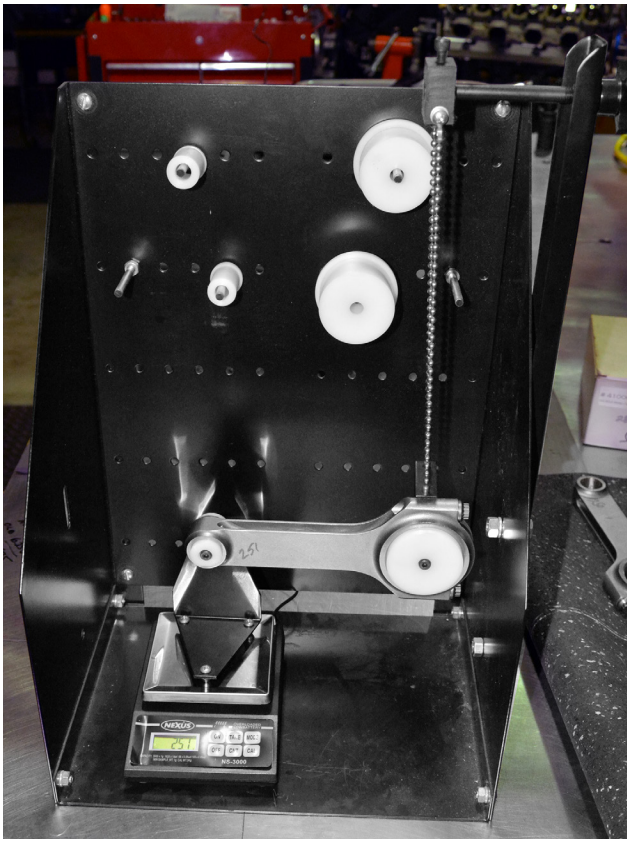
are some very, very exotic high-end rods out there that may not have perfectly round bores, but unless you're running Pro Stock, F-1, or NASCAR, you're not likely to run into those exceptions.

Mark rod bolts by location. I mark them 1 and 1L, 2 and 2L and so on for rod one opposite bearing locator tab slots and 1L for the bolt on the same side as the locator tab slots. Measure the overall length of the bolts and record that measurement. I set up my ARP stretch gauge with gauge blocks and record how much over or under my bolts are from that standard. Normally I use a 1.0000 and a 7.5000 standard for a total of 1.7500 inches and then record the over/under deviation for all my bolts. I've tried using micrometers, thread micrometers and height gauges, but nothing I've tried is as accurate as this method.



The total rod weight will be the same as the total of the small end and big end weights. That's how you double check your balance figures.

Inspect rod bolts for proper radii under the bolt head, properly-formed threads, and make sure bolts are completely free of nicks or dings. Cycle rod bolts five to seven times using the recommended lube at 70% torque to polish the thread ramp and the under-head-to-rod cap interface. It's extra time and some say that with the new lubes it's not needed, but my experience tells me otherwise. I get a much more consistent final



Right: Using a balancing fixture to measure each end of the connecting rod. Adding the weights together should equal the total rod weight.

stretch when I prep the bolts like this. Finally, run the bolts up to full stretch, loosen them and recheck overall length. Discard any bolt that remains .0005-.001 in. longer than your original measurement. You DID buy two extra "insurance" rod bolts, didn't you? Nothing worse than being in the middle of your build with a bolt that failed first stretch and no

Left: The nice part about big parts is that it's easy to see things. Here you can see the annular groove in the pin bushing that directs the oil into two oil slots on the top, or load side, of the pin bushing. The groove also directs oil up to a sprayer nozzle that sprayed oil up onto bottom side of the piston head for cooling. Big and strong… built to last long.

I replaced the mechanical .0005 inch-reading dial indicator that came stock with my ARP stretch fixture with an electronic SPI dial indicator that reads to 5/100,000ths of an inch. I can test it for accuracy with the gauge blocks shown elsewhere by simply zeroing it at one length, adding or removing gauge blocks of a known thickness and checking that the dial indicator reads the difference accurately. If you're trying to hit a .0004-in. window, your tooling must be accurate enough to do the job and you have to be able to prove that your tooling works as it should.

spares . . . it doesn't happen often today, but it can happen. In fact, that's something else to remember: Not every bolt is exactly the same, and they don't all stretch to exactly the same spec at the same amount of rotation. Start conservative and work your way up. Better to stretch them a couple of times and sneak up on it than to overshoot and ruin a bolt.

And In Summation . . .

Detonation, loss of lubrication, improper oil clearance, improper bolt preload, and over-speeding are the Big Five causes of rod failure, with 80% probably belonging to a loss of lubrication. You might see a product defect once in a blue moon, but it's not likely. With good inspection and

It is possible to set a dial bore gauge with a micrometer, but it is a pain and it takes time. A checking and setting fixture like this really speeds the process. The vertical fixture holds a combination of gauge blocks equal to the diameter you want to measure, and you set up your dial bore gauge by measuring between the lower and upper pad. You can also check micrometers with gauge blocks, or use them to space parts during mockup.

Below: As painful as it might be, good tools aren't cheap and cheap tools aren't good. We use a torque wrench to turn rod bolts, but the actual torque reading isn't as important as using the wrench to get the end result, which is proper stretch. This electronic Snap-on is extremely accurate and features a built-in angle meter that allows me to accurately record how much I turn a fastener. It records final torque, but that's not as important as being able to turn a fastener incrementally more until correct stretch is attained. I record final torque, but only as part of the documentation process. You have to have tools calibrated periodically -- you can see the last calibration sticker on the body of the wrench.

prep, you can race a lot of seasons and never see a rod failure -- and that's a good thing! It's certainly not what we dealt with in the bad old days.

The next time you're stuffing rods and pistons into a block, just take a minute and think about the job that 800-gram chunk of steel does -- from dead stop to full velocity

Tracking rod bolt overall length is the only way to know if the bolt has been stretched or worked beyond its design limits and measuring them accurately has always been a pain. After trying granite blocks and height gages, thread micrometers (with pointed anvils to fit the dimples machined into the rod bolt ends) and other methods I finally landed on this method and it has proven to be dead repeatable. First I updated my ARP gage with a tenth reading dial indicator. Since stretch is measured in tenths and the window is often less than a half thousandth this only made sense. Next I use a pair of precision gage blocks that are roughly equal to the bolt length to set an arbitrary zero on my stretch gage. I can use those same blocks to check my calibration before, during and after each measuring session if I think I've bumped something, the temperature has changed or if the indicator has drifted for any reason. Always use fresh batteries in your indicator.

to dead stop over and over. A thankless job performed in millions of engines the world over day after day after day. It's a wondrous little link pin that makes ground transportation and racing possible.

Resources

This list is far from comprehensive. There are many niche manufacturers out there for motorsport, motorcycle, watersports, and Asian or European specialists that make parts for a narrow range of clientele. I suggest that you perform your own search for rod and rod bolt manufacturers when you begin your project. ■

A-1 Technologies (bolt and stud manufacturer, no website located.)

www.arp-bolts.com/

www.spstech.com/home/

www.bmeltd.com/

www.cp-carrillo.com/Downloads/Catalogs/tabid/82/Default.aspx

www.arrowprecision.com/content/category/9-fully-machined-forged-connecting-rods-h-beam-rods-i-beam

www.howardscams.com/connecting-rods

www.crower.com/

www.dyersrods.com/index.html

www.eaglerod.com/index.php?option=com_frontpage&Itemid=1

www.grpconrods.com/

www.manleyperformance.com/

www.mgpconnectingrods.com/

www.oliverracingparts.com/

www.rrconnectingrods.com/

http://scatenterprises.com/

http://pauter.com/parts/rods/

After calibrating to my gage blocks and getting my zero I measure each bolt and record the deviation from that zero for all bolts. I measure them brand new, after my break-in sequence (running them up to 70% of torque a number of times) and after at least one full run up to full stretch. Don't be surprised to note that the bolts actually shrink a couple of ten-thousandths after fully tightened! Once I have final dimensions I can track that bolts changes as its run. Discard if you see any bolt change length by .001". They should stretch to specification and return to original length every time. If they lengthen, toss them.

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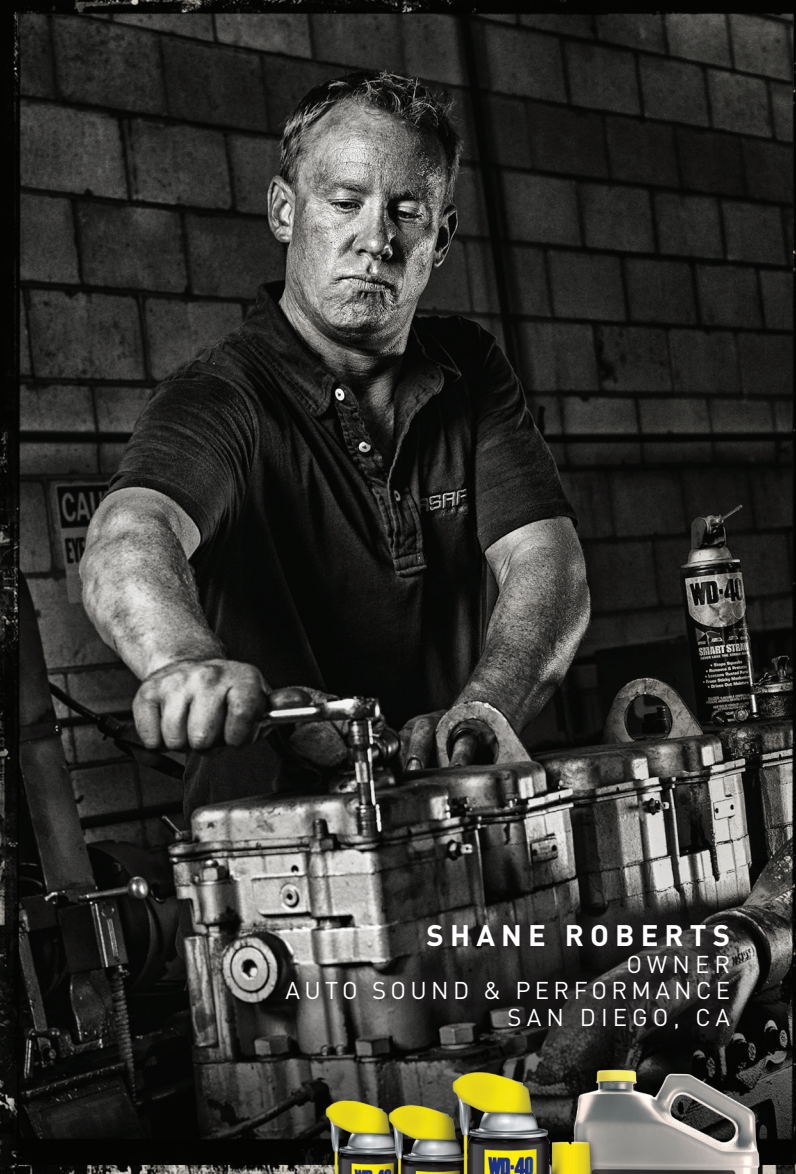

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High-Performance Brake Upgrades, Part 2: Rotorama

Last time, we looked at the parts that provide the pinch, but the components that spin off all that thermal energy are more interesting from a scientific, technological standpoint.

by Bob Freudenberger

Maybe you remember the old Firestone Tire advertising slogan, "Where the rubber meets the road." While it doesn't have quite the ring to it, saying that brake discs are "where kinetic energy is converted into heat" is somewhat similar -- it's the crux of the matter. Transforming the inertia present in a couple of tons of hurtling metal into huge numbers of Btus safely, smoothly, quietly, and repeatedly, then dissipating them into the atmosphere has required a great deal of engineering and materials development.

Numero uno

It seems logical to begin this story with the First Law of Thermodynamics, also known as the Law of Conservation of Energy, which states that energy cannot be created nor destroyed; it can only be converted from one form to another. Did you ever give any thought to where the potential chemical energy stored in all that gasoline you just burned to get up to speed goes? Well, first it's changed into the heat energy that expands the charge and pushes the pistons down, which action rotates the crankshaft transforming it into mechanical energy (a certain percentage at least -- the rest finds its way into the atmosphere by means of the exhaust and cooling systems). This performs the useful work of propelling your vehicle.

Gotta stop? Leaving the hydraulics out of it, the friction between the linings and the rotors converts most of the inertia of a hurtling mass of metal into, once again, thermal energy (deceleration is aided to some extent by air resistance and tire deformation), and that just disappears into the atmosphere and thus wasted (that's what makes the regenerative-braking feature of hybrids and electrics attractive). The amount of heat discs have to throw off can be terrific -- the temperature numbers we've been quoted for Formula 1 racing, for instance, are so high we have trouble believing them. Think maybe 1,000 deg. F. (540 deg. C). We've seen various equations that you can use to calculate how hot your brakes will get, which all require that you plug in weight, speed, time, swept area, rotor mass, etc. Sounds like too many variables to us, sort of like the computer models for climate change. Look them up if you want to practice your math, but the results won't be as practical in choosing parts as the recommendations of reputable manufacturers.

What we hope you'll gather from that little bit of physics is that, as a spokesman for a prominent high-performance brake maker tells HRP, "The total brake system is all about managing heat." So, everything has to be appropriate to the specific application -- calipers, fluid, friction material, and, our subject here, rotors.

Fade to . . . Yikes!

To put upgrades over stock systems into perspective, premium discs won't really have much effect on stopping distance in one or two instances of hard deceleration. Their superior characteristics where heat dissipation is concerned, however, will go a long way to insure that you never have to experience that scary phenomenon known as fade following multiple panic stops, prolonged

Opposite Page: Several of the major aftermarket manufacturers offer "big-brake" kits. When it comes right down to it, what you're getting is an integrally-engineered heat-management system. Note the unusual slotting pattern on this integral rotor (courtesy Hawk).

downhill braking, or road-racing conditions. You can expect other minor improvements, too, subtleties we'll get to later.

We don't care if you're a Tour de France bicyclist, your legs aren't strong enough to stop a car after fade sets in. We've felt it happening on race tracks and mountain driving, and we can say it gets your attention to a shocking degree.

Several factors are involved here. The resins that hold the friction material together can begin to vaporize at high temperatures ("out-gassing"), which results in a gaseous layer that separates the linings from the rotor -- it's similar to hydroplaning on your tires in wet weather. Modern friction recipes, however, aren't nearly as prone to this as those from the past.

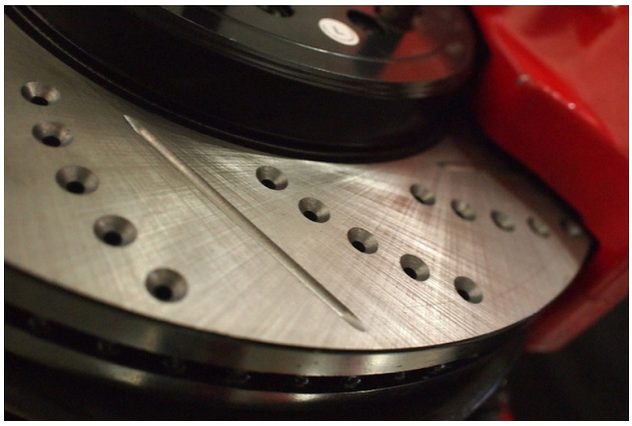
Bubbles

So, why do we still get fade during heavy braking with today's excellent lining formulations? Again, it's all about managing heat. If the Btus in the disc exceed what it can spin out and "pump" into the air stream, they have to go somewhere. Unfortunately, the main path for the excess is through the pads and into the caliper, although a small amount may travel into the wheel bearings and thence the spindle. Even the most high-tech brake fluid still has a boiling point. When that's reached, bubbles start to form. As you should know, fluids are incompressible for all intents and purposes, so a solid liquid column can transmit force almost perfectly. Bubbles are a different story. They can easily be squeezed down into a smaller volume. So, stepping on the brake pedal when this unfortunate situation obtains compresses the bubbles instead of pushing the pads against the rotor.

Water is another matter. When the discs go over 212 deg. F. (100 deg. C), which doesn't take much sporty driving, steam can form in the friction interface and cause a similar situation to the "hydroplaning" already

The temperatures we've been told Formula 1 brakes reach are so astronomical we can't believe them. So, we're not quoting any numbers until we get sufficient verification.

mentioned. True, any disc brake is a whole lot better at scraping of H2O than drums were, but there are design features in many high-performance rotors that give it a better escape path.



You can upgrade to cross-drilled or slotted discs, or a combination of the two as shown here (courtesy Stop Tech).

The new Corvette ZO6 with the ZO7 option package stops via Brembo brakes that feature floating two-piece rotors made of carbon composite material (CCM) (courtesy Brembo).

If fade is our main enemy (there are others, but none so dangerous), what can be done to insure against it? The first step typically mentioned is to upgrade to bigger discs -- size is one of the most crucial factors in heat absorption capacity and dissipation efficiency. The bigger diameter also increases the brake's mechanical advantage as the pads are farther away from the axis of rotation.

Especially if you've been running aggressive linings and your rotors are pretty much shot anyway, this makes a cost-effective modification. Many "big brake" kits are available for accomplishing this. Just make sure you choose one from a company that does serious testing and has a good reputation.

Holes and slots

The installation of cross-drilled discs another possibility, although that's what's commonly included in the kits just mentioned. In the days of out-gassing friction formulas, the precisely-formed holes allowed the vapors to escape into the moving air that's being thrown out around the circumference. Today, that action simply aids ventilation, thus cooling.

An additional thing the drillings accomplish is constant refreshment of the pads' friction surfaces. They keep them nice and clean and deglazed for better feel and perhaps even shorter stopping. You might assume that this accelerates lining wear, but by all accounts it doesn't.

The drawback to holey rotors is that cracks tend to develop around the drillings in extreme use. We've heard people say that they'd never use them because they fear complete breakage and loss of stopping ability. We did some

research into this, and found that this just about never happens with brand-name discs.

Then there are slotted discs, which look pretty cool. They help somewhat with shedding heat, but their main purpose is the refreshment of the lining surfaces, especially when very aggressive racing pads are used. Depending on the way the slots are made, they can accelerate lining wear, perhaps to unacceptable levels for a street vehicle. A benefit that those of us who actually work on cars will appreciate is that they act as visual wear indicators.

Centrifugal air pumps

Perhaps you're old enough to remember that some marginally-successful cars, such as the Chevette, used non-ventilated, solid rotors. Certainly, that is the cheap route, but it gives up at least half of the heat-radiating potential of the vented type. Not only do the latter have all that additional surface area inside, but they are designed as centrifugal pumps, picking up air near the hub and throwing it out of the vents.

Quality brake makers expend a lot of effort on the internal design to maximize this function -- we've seen several photos of discs sliced lengthwise to reveal the configuration of the vents. They may be plain, straight radial channels, or have curved vanes that enhance the pumping action, although this makes it necessary to designate right- and left-side part numbers. Brembo, for one, has patented a "pillar vane" design that moves air almost as well, yet can be used on either side.

Another step up is the floating disc, in which the iron wear surface is joined to an billet-aluminum hub hat. Only available for certain high-performance models, these offer a big advantage in unsprung weight, and they can help mitigate the runout that results in DTV (Disc Thickness Variation, the real cause of pedal pulsation) -- the mounting system is engineered to permit a greater degree of both radial and axial float. The look great, too.

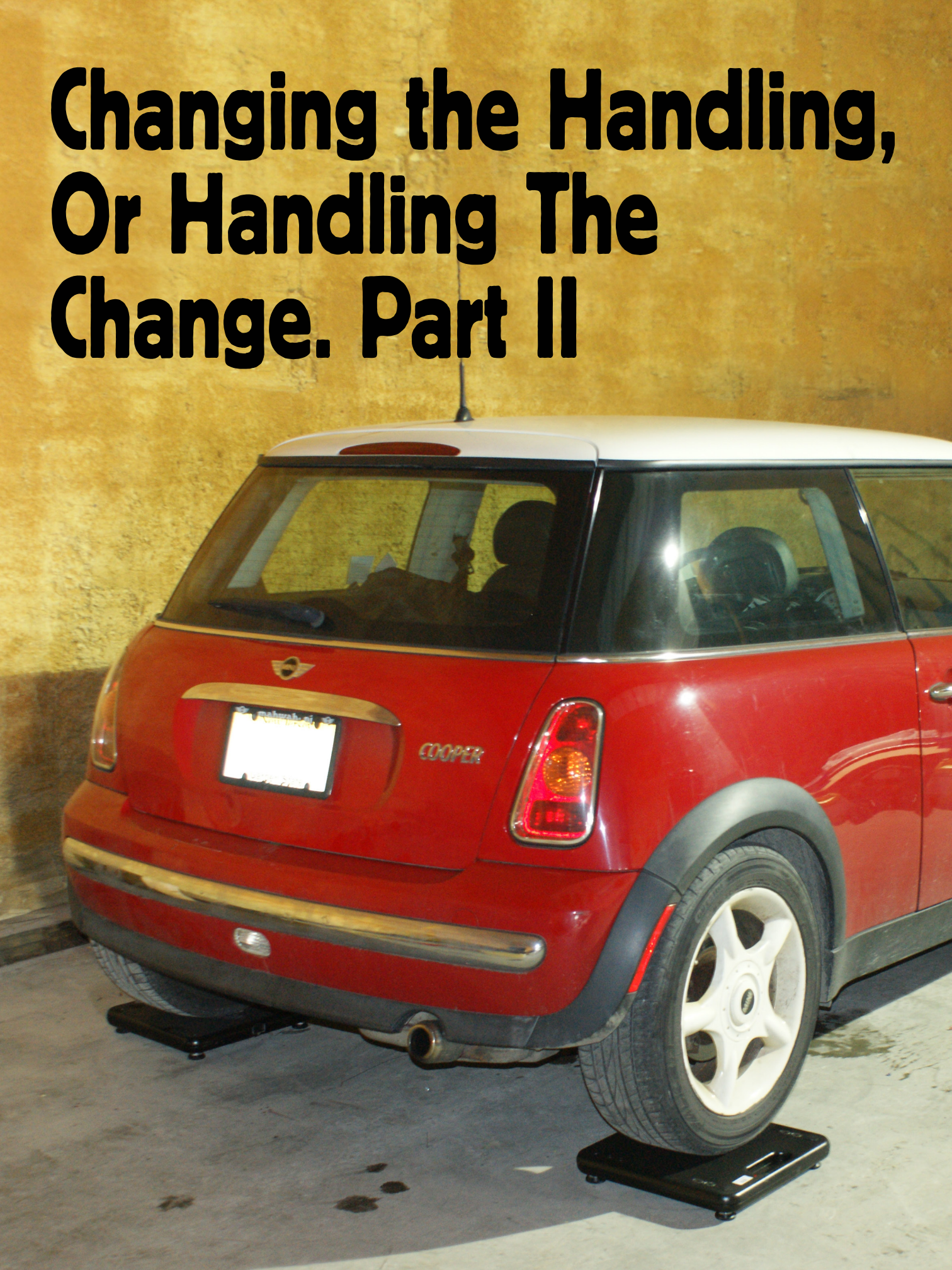
Mercedes-Benz, which has always prided itself on its "Bremsen" (brakes auf Deutsch), tries to head off the need for upgrades by offering high-performance discs in the first place. Check out the weight difference between the McClaren fiber-reinforced ceramic and the AMG cross-drilled iron integral rotor (courtesy Mercedes-Benz).

The End of the Iron Age?

Beyond that, we get into the actual material the disc is made out of. Most are high-carbon cast iron, with perhaps molybdenum or other metals added to help handle heat and cut warpage. Some manufacturers subject the castings to special processes. Centric, for example, chills them to -300 deg. F. (-185 deg. C), then allows them to slowly return to room temperature. This deep cryogenic treatment is supposed to permanently and dramatically affect the metallurgical structure, which inhibits internal oxidation and increases thermal fatigue resistance. The company claims that this can result in up to three times the longevity of ordinary rotors.

Believe it or not, carbon ceramic, or fiber-reinforced ceramic, discs were first used by racing teams back in the late 1970s. They've been available in the aftermarket for years, but have only recently found their way into production cars. Advantages? How about saving 28 lbs. (12.7kG) on a Z28 Camaro? Or, consider that the very large composite discs on a Mercedes-Benz McClaren weigh only 14 lbs. (6.4kG) each, whereas the iron units on the company's SL55 AMG are a comparatively-ponderous 34 lbs. (15.6kG). If you understand why reducing unsprung weight is a good thing for handling (less mass to change direction during jounce and rebound, hence faster movement and more consistent contact between the tire tread and the road), you'll see why this is a big deal. That these high-tech discs are also much better at handling heat and much more resistant to warpage are important additional benefits.You can upgrade to cross-drilled or slotted discs, or a combination of the two as shown here (courtesy Stop Tech). ■

Changing the Handling, Or Handling The Change. Part II



Here we have the car up on our race car scales, which give the individual corner weights, plus the total weight of the car. We are going to need this information to perform our calculations.

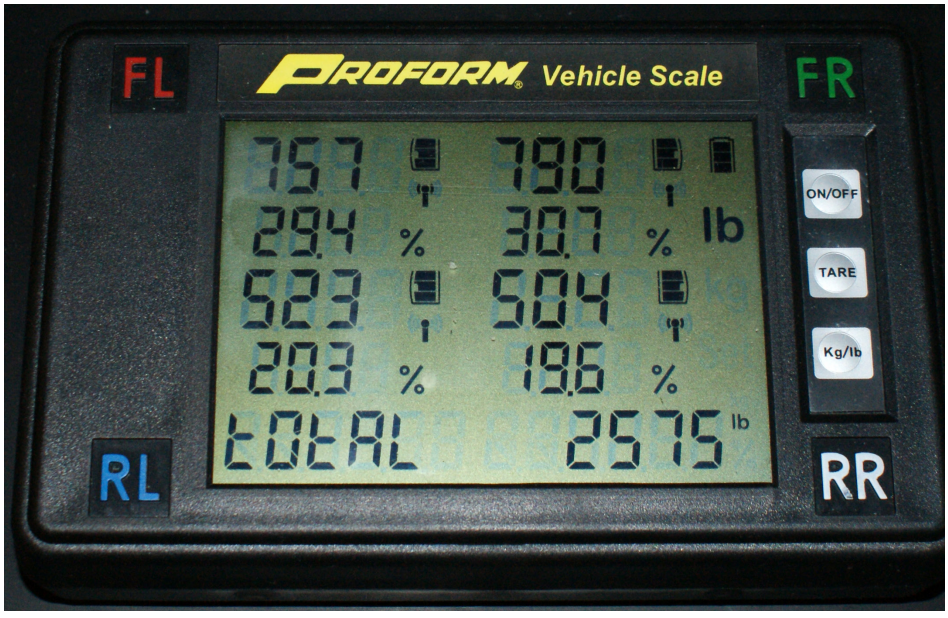
In part I we covered the benefits of track width, lowering your center of gravity and adjusting your corner weights. In part II we will show you how. You don't need to know chassis dynamics to enjoy a spirited drive down the road. But if you're on a track and being timed then you may want to know the changes you can make to drop that .1 of a second.

By Kerry Jonsson

For the most part we all enjoy driving. If you didn't you probably wouldn't be reading this. Now going out for a Sunday drive you don't need to know what your lateral weight transfer is but you may simply want to learn what your car is doing while you are driving around a corner as you feel the 'g's. If you're on a race track and you are trying to drop lap times the more information you have about your car can lead you to make changes that may not feel right at the time but the stopwatch never lies. Keep in mind that you are probably the driver of the car you are setting up. You are going to feel the changes you make to the car. You will definitely need to make some adjustments to your driving style to take advantages of the changes you've made. So what do I need to know to calculate where my car setup is now?

Speed Cost Money, How Fast Do You Want To Go?

Generally on older V8 sedans the center of gravity is right around the level of the camshaft on an overhead valve V8 that has the camshaft in the V of the block. With modern engine designs, front wheel drive and modern chassis construction we can no longer assume this is true. So if you are tuning Asian or Euro cars you are going to need to take the measurement and perform the calculations. The first thing you need to know is the overall weight of the vehicle. You are also going to need the individual axle weights and individual corner weights. These weights in pounds will be put into equations to calculate the center of gravity. You will have to make a decision of how much time you want to invest in calculating your center of gravity. We covered in part I how the fuel weight drops throughout a race and depending on your racing series, can have an effect on handling as the center of gravity moves.



As you can see on our scale display, the overall weight of the car is 2,575 lbs. with a nearly-empty gas tank. You can also see that the individual corner weights are not as even as you might expect. We can use these numbers for calculating the front-to-rear weight bias.

My personal suggestion is to perform these steps with a fuel tank of fuel, a half a tank of fuel and with a totally empty tank. This is going to take time and effort and time is money but too much information never hurt anyone. It may be a tremendous benefit to know how much the center of gravity changes as you use up your fuel supply. If you think about it knowing how much the drop in fuel weight changes the center of gravity should affect your chassis set up. You may set up the car to handle better with a low level of fuel this way you can have a strong finish. You may want to set up the car with a heavy load of fuel on a tight and twisty track so you can have a strong start on tracks where it is difficult to pass. Either way you are in control of the situation.

Not the Two Step but Step Two

In part I we suggested the fuel cell be as close as possible to your center of gravity to minimize the effect of the change in fuel weight but the rules of your racing organization will probably have a greater effect on where your fuel cell is mounted. Now that we have the weight of the car on each corner on level

We need to establish the wheelbase of the car. Here, we measured approximately 81 in. from the centerline of the front axle to the centerline of the rear axle. With this figure, and lifting the car 24 ins., we can calculate the wheelbase off the ground to about 84.5 in. We can now plug in these numbers and calculate our CG (Center of Gravity).

ground you can move on to the next step. Before that you are also going to need to know the wheelbase of your vehicle. That is the distance from the center point of your front axle to the center point of your rear axle. It is difficult to measure in the wheelbase at the axles themselves and the more accurate you are the more precise the reading are going to be. You can drop a plumb from the center point of your axles and mark where they hit the ground. Use a tape measure to measure the distance in inches.

The next step is going to be jacking up one axle of the vehicle at a time while the car is on scales. I suggest you do this for both axles although calculating your center of gravity will be the same no matter which axle you pick. It is just a good way to double check your work. Now there is some difficulty in achieving accurate readings. Tire deflection and suspension deflection can change the weight load on one axle. Ideally you want to keep the suspension in the same position as the car was on the ground. This can be achieved by making blocks and resting on of the axles on the blocks to allow the suspension to settle on its weight. If you are well equipped you can fabricate straight bars in place of the suspension shocks or struts, but I think the block are much easier to use.

What Are We Looking For?

You need to jack up the vehicle at least 24 inches for an effective measurement. Jack up one end of the vehicle and rest the suspension on blocks at least 24 inches high. Look at the change in weight on the scales with the vehicle off the ground. The weight will increase once you have jacked up the car. Subtract the weight of the axle on level ground from the weight of the car while it is raised to get the weight transfer difference. You also need to measure the new wheelbase at ground level

and add that to the equation. You should have already measured the cars wheelbase while on level ground. Now you should have all 5 numbers you need to calculate the center of gravity. Multiply you level wheelbase by your raised wheelbase by the weight difference and you will divide that by the distance you raised the car multiplied by the overall weight of the vehicle. The equation looks like this:

$$\text{Center of Gravity Height} = \frac{\text{added weight} \times \text{level wheelbase} \times \text{raised wheelbase}}{\text{distance raised} \times \text{overall vehicle weight}}$$

As an example let's keep the math simple. If your car weighs 4000lbs and 1000lbs at each corner; let's also say the car has a 100 inch wheelbase. We can use the Pythagoras Theorem which states the square root of the side opposite the right angle is equal to the sum of the squares of the two other sides. With a 100 inch wheelbase and lifting the car 24 inches out raised wheelbase would end up being approximately 97 inches. If we plug all of these numbers into our equation we get

$$\text{C of G Height of 10.10in.} = \frac{100\text{lbs} \times 100\text{ in.} \times 97\text{ in.}}{24\text{ in.} \times 4000\text{lbs}} = \frac{970000}{96000}$$

We now know the center of gravity is just above 10 inches, which is pretty low on our theoretical vehicle. To calculate the front to rear weight bias you need to divide the weight of the rear of the car by the overall weight and multiply that by the wheelbase. The equation looks like this:

$$\text{Center of Gravity behind front wheels} = \frac{\text{weight of rear axle}}{\text{overall weight}} \times \text{wheelbase}$$

If we plug our measurements in we get:

$$\text{Center of Gravity from the front axles 50 inches} = \left(\frac{2000\text{lbs}}{4000\text{lbs}}\right) \times 100\text{in} = 0.5 \times 100\text{in}$$

I'll Bet You Wish You Paid Attention In Math Class.

So our center of gravity is the midpoint between the axles of 50 inches and the height is just over ten inches. If you want to calculate the center of gravity from one side of the vehicle to the other the formula is:

$$\text{Center of Gravity side to side} = \frac{\text{track width}}{2} - \left(\frac{\text{lighter side}}{\text{overall weight}} \times \text{track}\right)$$

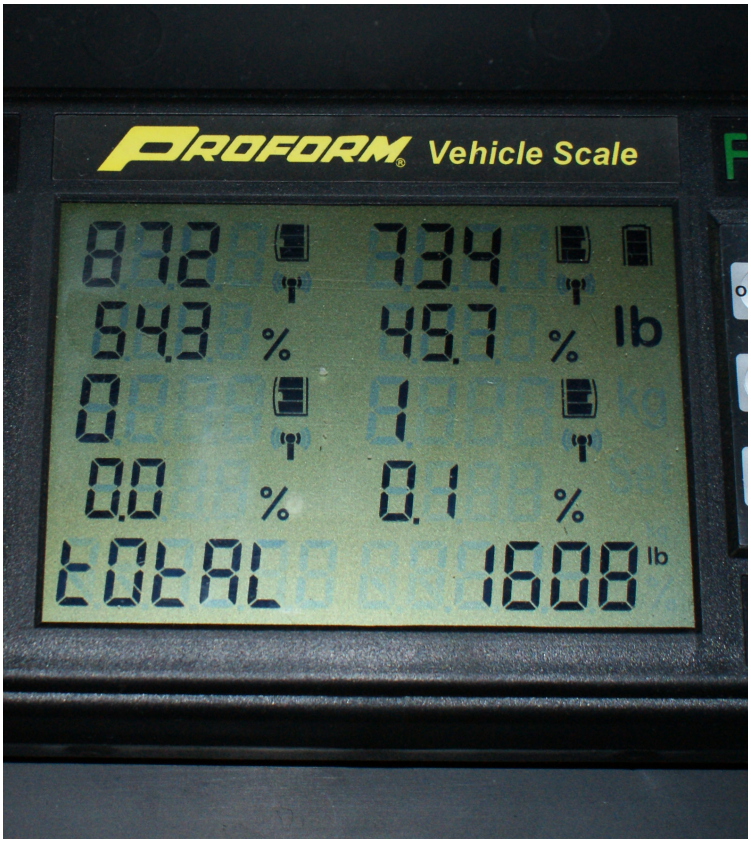
For the moment we are going to assume the track width is 75 inches. If we plug in our measurements we get:

$$\text{C of G side to side} = \frac{75\text{ in.}}{2} - \left(\frac{2000\text{lbs}}{4000\text{lbs}} \times 75\text{in}\right)$$

$$\text{C of G side to side} = 37.5\text{ in} - 0.5\text{lbs} \times 75\text{in} = 37.5 - 37.5 = 0\text{in off center}$$

Our theoretical vehicle's center of gravity has no offset one way or the other so we have a perfectly balance car from one side to the other which is great for road racing but not so good for circle tracks. In any event you should now be able to calculate your cars center of gravity for both front to rear and side to side. This gives us a three dimensional view of where it is located in the car. If you allowed to make modifications to the car you may want to move around something

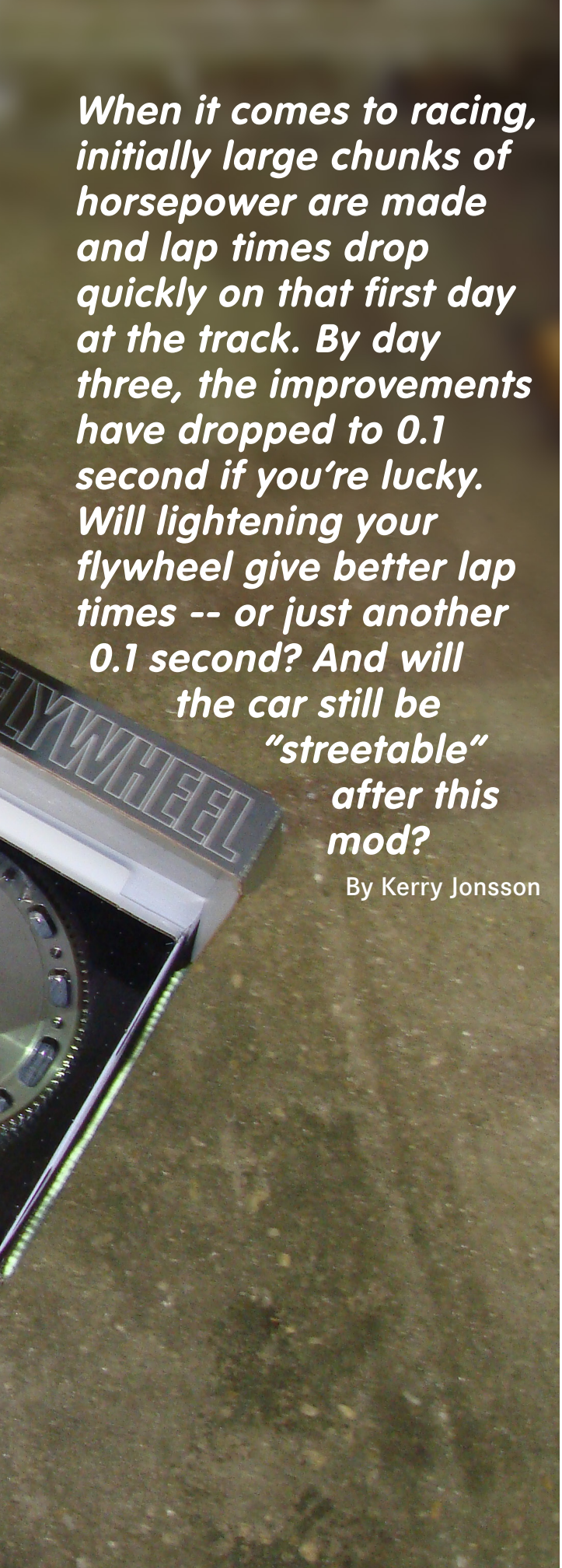
like the battery to help manage weight distribution. You can also add ballast at specific locations to control this as well. Knowledge is power. ■



Left: With the car up in the air, we can measure the weight on the axle that's on the ground, in this case 1,608 lbs. Our starting weight was 1,547 lbs., giving us a difference of 61 lbs. Plugging this into our equations for CG, we get 6.75 in. This is impressive, but not surprising for a Mini Cooper, a car renowned for having a low center of gravity and go-cart-like handling.

Lifting one end of the car 24 in. is no easy task with conventional equipment. Always be safe and use wheel chocks on the axle you are leaving on the ground, plus jack stands. We saw these blocks to 24 in. so we can rest the weight of the body of the car on the springs and not allow suspension droop to throw off our calculations.

Light Flywheels and High-Performance Clutches



When it comes to racing, initially large chunks of horsepower are made and lap times drop quickly on that first day at the track. By day three, the improvements have dropped to 0.1 second if you're lucky. Will lightening your flywheel give better lap times -- or just another 0.1 second? And will the car still be "streetable" after this mod?

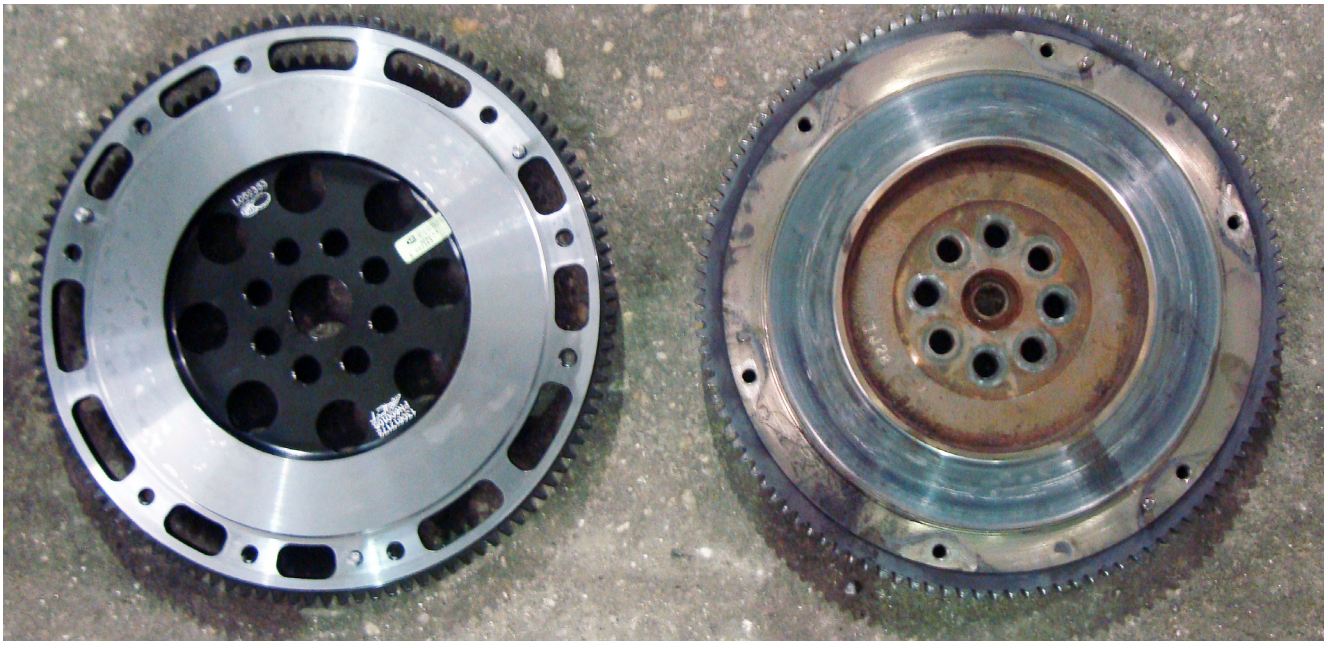
By Kerry Jonsson

You might be wondering what you can do next to your engine to pick up faster laps. You have already installed high-performance camshafts, and maybe free-flowing intake and exhaust to improve breathing. You may have even fitted high-ratio rockers with double and triple valve springs. Pretty exciting stuff, but how about putting that power into the driveline and on the ground?

Whatever you envision as your next step, we strongly recommend you make gradual improvements to the entire system, rather than wholesale individual changes, to avoid any unintended consequences that might not sit well with your all-important power plant.

Let's take a look at the engine when it's out of the car. Perhaps you're thinking the next modification is going to be the clutch and maybe the flywheel -- say, your clutch just went, and, besides, you just did the engine over. Whatever the reason, you're thinking about racing clutches with multiple "pucks," high-pressure pressure plates, and of course, a new throw-out bearing. Yes, it is important to apply all the horsepower the engine can make to the ground, and it has to pass through the driveline. Here, we'll look into getting the right clutch, and maybe lightening the flywheel.

You've done your research and settled on a high-performance clutch, but in your research you see you can also upgrade to a light-weight flywheel. What will that do for you? There are many myths spread around by people who just don't know the physics behind a high-performance engine and drive train. We will try here to dispel most of these myths, but you must keep in mind that a lot of what you feel as you drive your car is your own personal interpretation. What is "streetable" to you may be an awful commute in traffic for someone



Will the huge reduction in rotating mass represented by the installation of that high-performance flywheel have negative driveability consequenses? After all, the one on the left weighs about 75% less than the stock unit on the right.

else. So, we'll take a look at the pros and cons of these modifications.

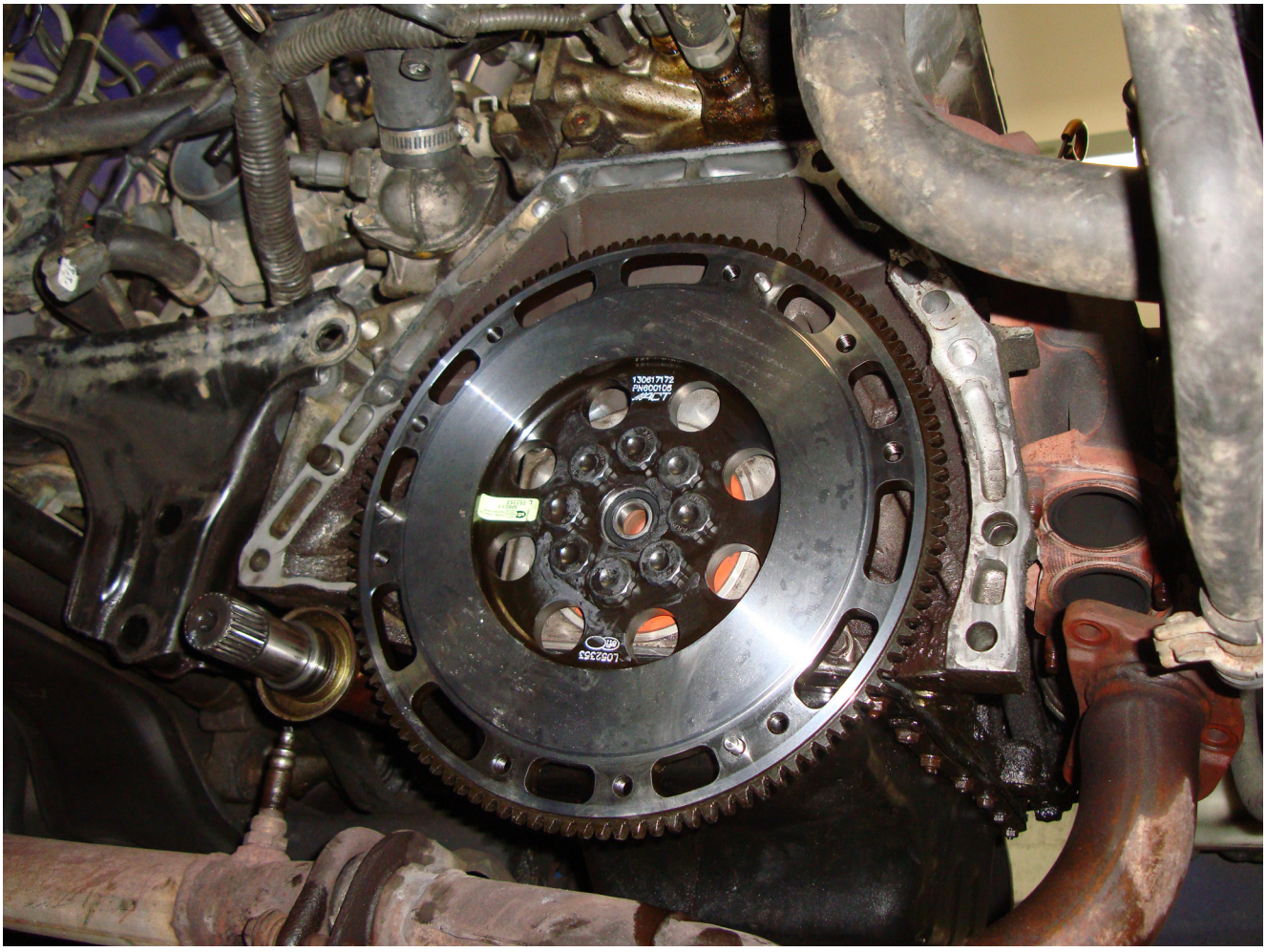
While researching a stronger clutch and possibly a light-weight flywheel, you've seen advertisements for Stage 1, Stage 2, and Stage 3 mods, maybe even a Stage 3+. Sounds alluring, but what are the realistic options for a light flywheel? You have probably read that this can increase horsepower, but can make the car very difficult to drive in traffic.

Light Flywheel Equals No Boost for Horsepower

Well, truth be told, a lighter flywheel will not increase horsepower -- we repeat, ***a lighter flywheel will not increase horsepower***! It may change your horsepower curve slightly, but the peak horsepower will remain the same.

Think of your engine as an air pump. The more air it can move through the cylinders, the more power it is capable of making. If you can keep air intake velocity up, get the ignition curve to match airflow, and get rid of the spent gases as fast as possible, you can produce large amounts of horsepower, but the weight of the rotating mass won't affect it as long as it's within reason.

Lightening the load, however, does have its advantages. A lighter crankshaft will contribute to quicker crankshaft acceleration, and also reduce the load put on the rear main bearing and seal. The job of a flywheel is to dampen pulses that occur between cylinder firings, and smoothness is a big concern with production engines. A robust crankshaft makes for smoother power delivery and smoother shifts in a vehicle equipped with an automatic transmission -- this is important to most commuters, but chances are if you're just commuting you're not reading this anyway.



Here, new ARP bolts are being used to secure the flywheel to the crankshaft. These should be torqued down to ARP specs. The company also supplies a thread lubricant to ensure proper torque. You also might notice the new rear crank seal hiding behind the flywheel (orange).

The weight of a stock flywheel is typically something like 36 pounds. There are outfits that will re-machine an existing flywheel to make it lighter, and you might want to consider this and save the expense of replacing it. We decided to see what would happen if we went to an ACT XACT Prolite light-weight flywheel that weighs only 8.7 pounds, roughly only 24 percent of the stock flywheel. Sounds like a drastic change, but if you calculate the weight of the entire rotating and reciprocating mass of crankshaft, connecting rods and pistons the percentage is smaller.

Allows Crankshaft to Spool Quickly

Lightening the load of our rotating mass will allow the crankshaft to spool up quicker, and this means you are going to notice the improvement mainly while under hard acceleration. Look at the type of driving you do and how much WOT you do. It can be argued that if it is drag racing, or just street performance driving, you are doing, this does not involve enough time accelerating to make lightening the flywheel a cost-effective performance improvement.

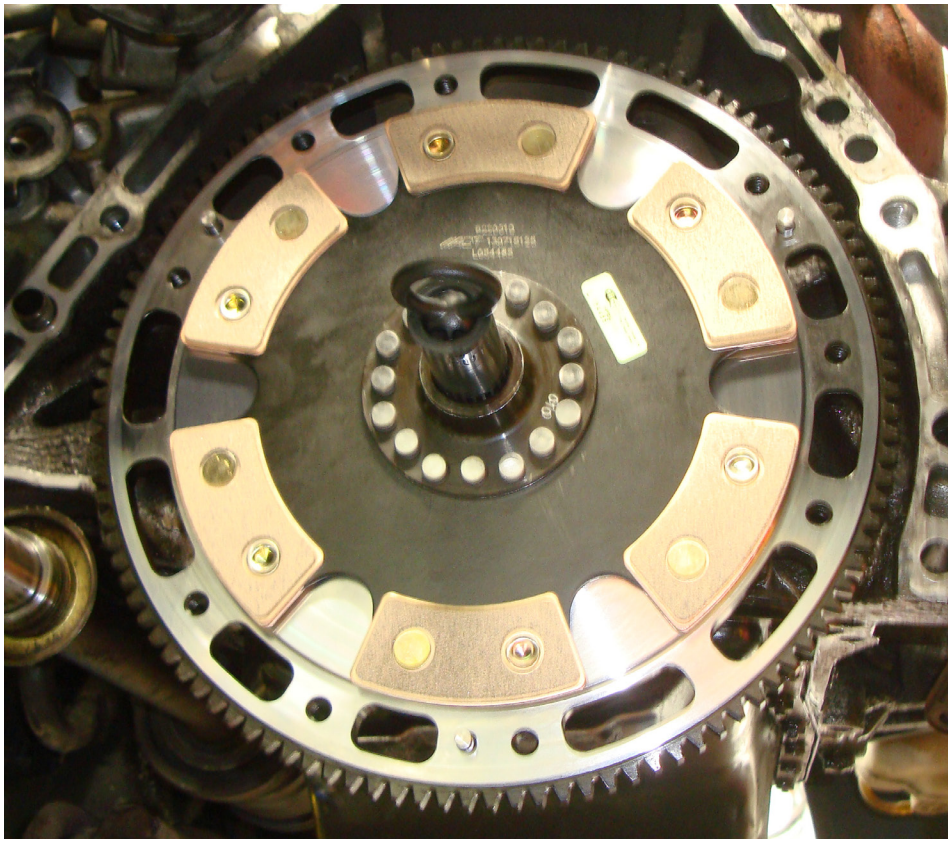
It will be difficult for all but the most dedicated racing enthusiasts to quantify the performance gained from a lighter flywheel. Conventional theory and common sense tell us there will be an improvement, but it is probably something you will only notice on a stop watch during timed laps at a racetrack. We're not saying it's a waste of money, we're just warning you that you may only notice a small change in performance. On a racetrack with many opportunities to accelerate out of a corner, for instance, the effect will be cumulative and you should be able to decrease lap times.

Mounting Bolts Distribute Shock Load

The stock flywheel uses only six mounting bolts to mount the clutch to the flywheel. The Prolite flywheel we installed upgrades this to nine mounting bolts. This helps distribute the shock load. We went with ARP high-grade bolt kits for both the flywheel and clutch to feel confident in the strength of our fasteners. ARP makes an eight-bolt kit for the flywheel and a nine-bolt kit just for the clutch upgrade. You can find new torque specs on the website.

The clutch kit purchased comes with everything but the Prolite flywheel. Make sure to install or press the pilot bearing all the way in until it is fully seated up against the lip of the new flywheel.

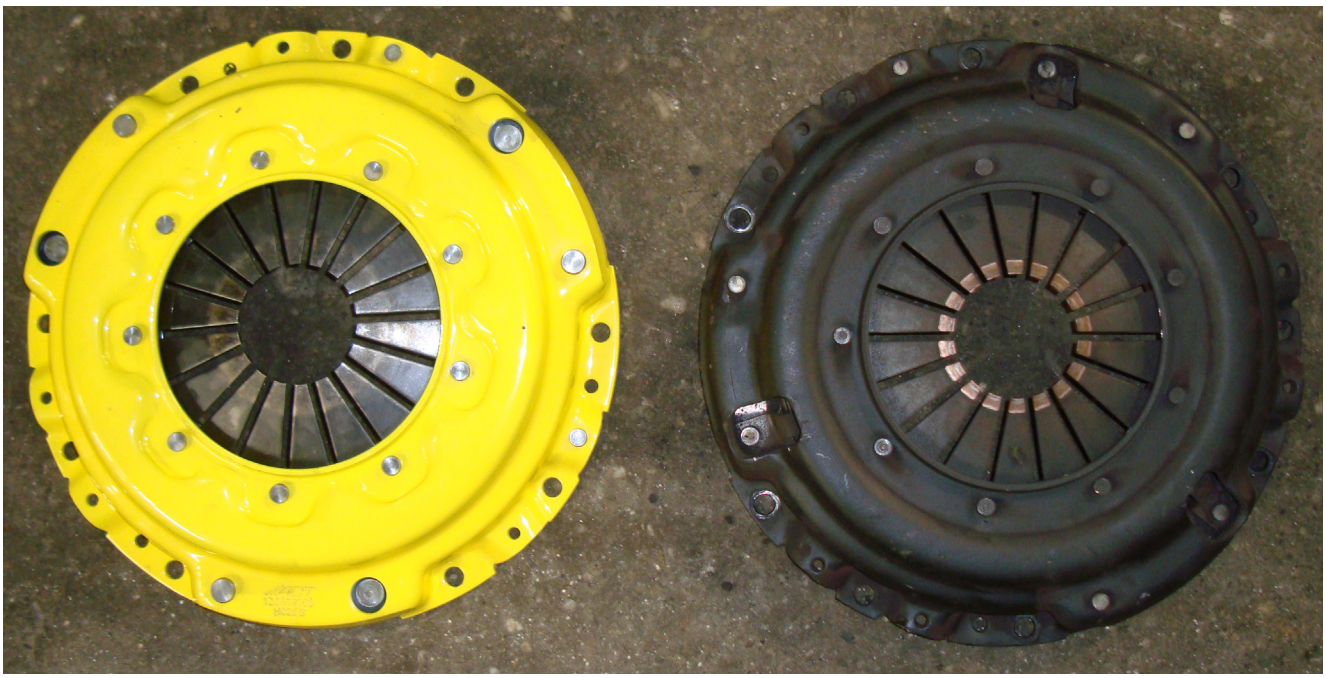
The kit comes with the tool to center the clutch ceramic element plate. The six ceramic pucks means this clutch is going to grab quickly and is not make to "slip" in. Make sure you have cleaned the metal surface of the flywheel before installing the clutch plate, then clean the surface of the pressure plate before you install it.



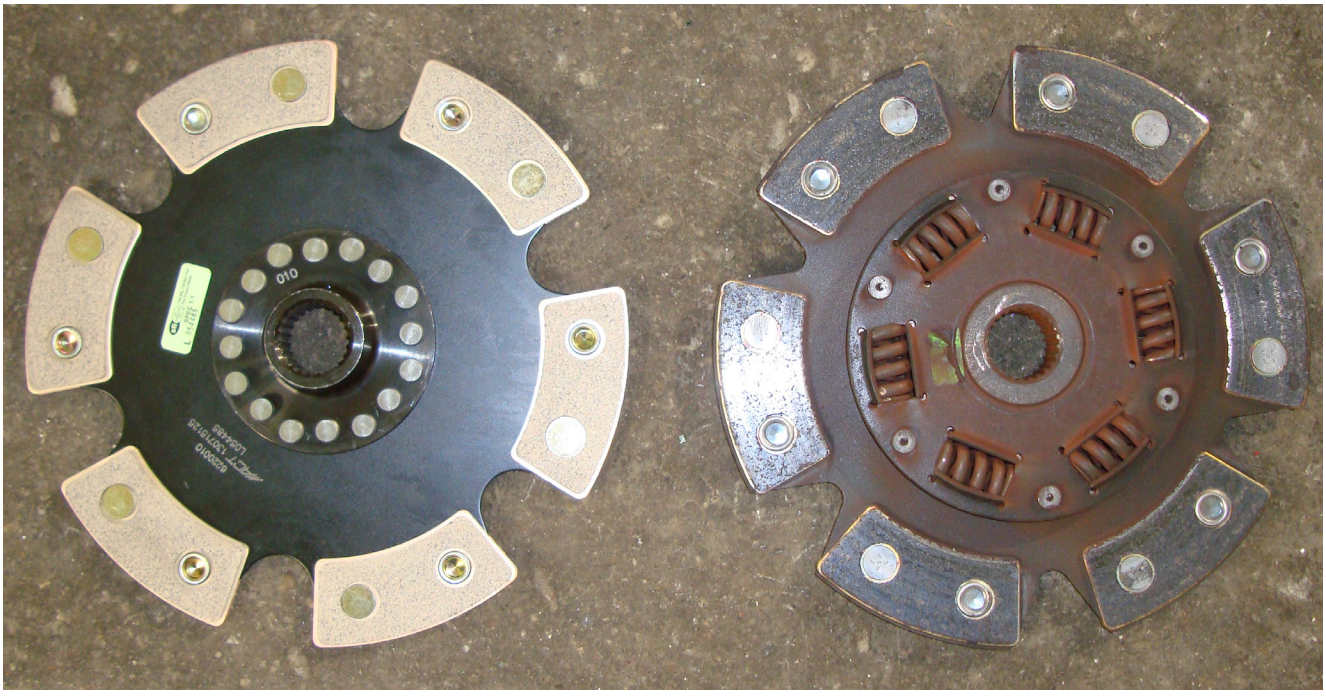
With our new flywheel, we of course installed a new pilot bearing. No sense having your input shaft wobbling around under hard acceleration stressing out the input shaft bearings. The pilot bearing is pressed into the flywheel, and make sure you have pressed it in all the way and it is fully seated up against the lip. Whether you are using a bearing driver kit or a hydraulic press make sure your tool is only applying pressure to the outside bearing race to avoid stressing the bearing.

We noticed no significant difference in drivability with the Prolite light flywheel during regular driving -- the clutch had a much bigger effect on drivability. Of course, we also upgraded the clutch at the same time we did the flywheel, opting for an ACT Sport/ Race Ridge six-puck unit with ceramic friction material. This may seem like overkill on what at this point is a fairly mild engine, but we are just starting to make powertrain upgrades and the car needed a clutch anyway.

ACT does not recommend using these rigid-ceramic-puck design clutch discs for spirited street driving. The engagement point, with a thinner design pedal, will feel lower and the ceramic pucks with a harder material will also be harsh -- this can definitely change your commute. Also, the rigid clutch does not have a spring set to protect the transmission input shaft from the shock of acceleration, and the entire driveline is going to absorb that shock. You can purchase a four- or six-puck ceramic friction clutch assembly with shock absorbing springs from the manufacturer to counter this.



This is what makes a clutch a clutch. The spring pressure provides the clamping force to transfer the power from the crankshaft to the gearbox input shaft. We opted for the rigid disc with a torque capacity of 280 ft. lbs., this for the moment is more than the engine produces. As far as weight goes, ACT states its clutch assembly weighs about the same as the stock unit.



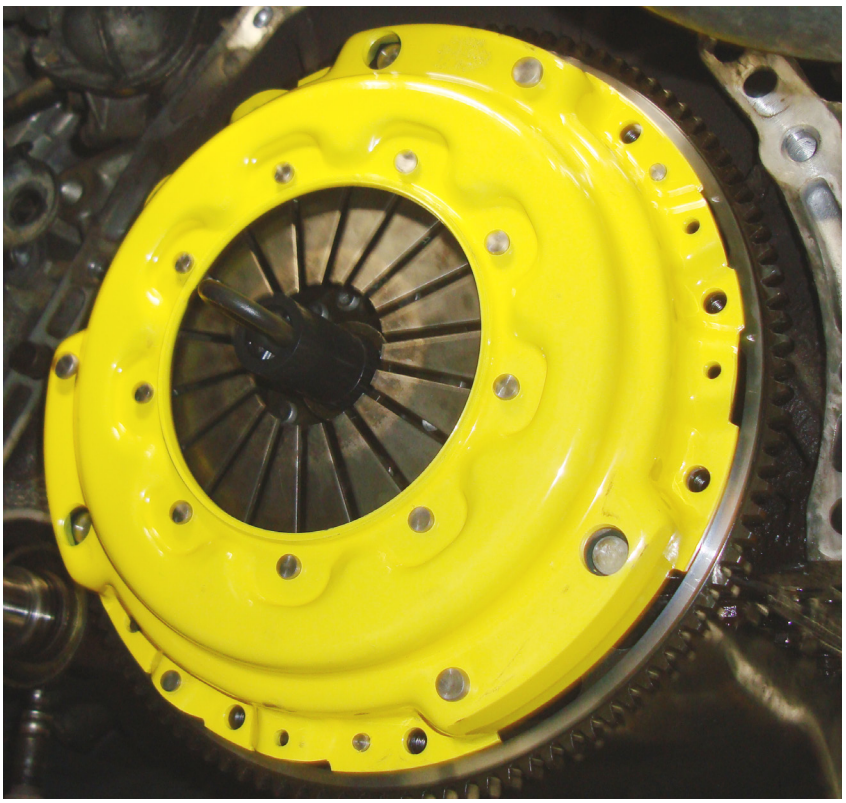
Although an upgraded six-puck clutch plate had been previously installed in the vehicle, we opted for the rigid design this time. The old clutch had springs to absorb some of the shock to the driveline when the clutch engages, which changes the weight of this part of the clutch assembly. This is more of a racing set up, and you will notice this during clutch engagement.

Pressure Plate Clamping Ability Crucial

Just as important as the friction clutch disc is the pressure plate. Most manufacturers supply a wide range of clamping abilities. ACT, for example, offers pressure plates with clamping forces that can handle anywhere from 175 to 1,010 ft. lbs. of torque for single plate clutch designs, and up to 1,500 ft. lbs. for dual-plate clutches. The one we installed here is the A14-SPRsix, which is rated for 280 ft. lbs., way more than we really need at this point in our engine's transformation. Remember, with a rigid clutch plate, engagement is going to be harsh to begin with, and the increased clamping force needed to handle more horsepower also requires more spring pressure and therefore increased pedal effort -- a clutch with clamping force capable of handling up to 1,500 ft. lbs. would be a bear to drive in traffic.

We wanted the clutch kit to match the flywheel. Both the flywheel and the clutch are balanced and we felt we might be able to save a step and not need to have the clutch and flywheel balanced together. If you are mixing and matching clutch components, or just replacing the clutch disc, you should have everything balanced together -- especially if you are dealing with a small-displacement, high-rpm engine.

You don't need us to tell you that out of balance components will cause vibration and excessive wear, and could even lead to total failure. Installing a lightweight flywheel will be more noticeable on the track than in street performance driving. The type of clutch material and spring pressure (torque capacity) used will have a much greater effect on drivability, if you use your car both as a driver and an occasional strip/race machine. ■



Our new flywheel and clutch combination fits flawlessly, but something we did not anticipate is that the new flywheel and clutch use nine mounting bolts to hold it together, three sets of three 120 degrees apart. The stock set up used only six. You could use the six bolts and leave each middle bolt hole empty in the set of three to maintain the balance, but that is simply out of the question. The whole idea of staying with the same manufacturer was to save time and money on balancing the whole package together.

ARP makes the perfect bolt kit because most upgrades use nine bolts to secure the clutch pressure plate to the upgraded nine bolt flywheel. High-grade bolts will do a much better job of securing the clutch pressure plate under heavy acceleration.

Technician Health and Wellness Series

Don't Play with Fire

There's no such thing as a "minor fire" at an auto service shop. Beyond the obvious loss of property, equipment and business income, the threat to the safety of humans is paramount.

We've all heard the stories or know someone who has had it happen to them. Perhaps it has happened to you. A fire at an auto service shop can be devastating for everyone involved.

The shop owner faces a miserable loss of business income; the fact that everything on the property may not be covered by the insurance company; the decision to rebuild and get back into business; the interminable length of time it takes to get back up and running; claims from any customers who had a vehicle damaged in the fire; how to pay outstanding invoices for parts, services, utilities, taxes and such at the time of the fire. The list goes on and on.

Shop employees out of work due to a shop fire are also face the loss of income, and maybe the personal tool boxes they use make their living. However, the more important aspect of a fire can be the possible loss of life or injury to anyone in the shop at the time of an explosion or fire.

Safety is the Number One Priority

The National Fire Protect Protection Association estimates that a little over 5,000 fires a year occur at automobile service facilities. While that number may include gas stations with a greater risk of fire at the gas pump areas, it's safe to say that at least a portion of that number includes mechanical and collision service shops.

If you are a shop owner, you want to make sure that you run a safe place to work and protect your business, your employees, your personal health and your customers. If you are an employee, you make want sure you work in a safe environment. The fact is:

safety is everyone's responsibility. Even the best safety plan won't work if just one person refuses to follow the plan and observe the rules of safety.

Have a Fire Emergency Plan

The best thing to do is have a plan. That plan should not only address the steps to handle a fire emergency (both during and after), but also fire prevention.

First and foremost, everyone in the shop should know the emergency phone numbers for the local Fire and Police departments, or 911, if it is available in your area. Those numbers should be posted in several locations around the shop and everyone should have those numbers posted in their cell phones. That's the best way to ensure that help arrives quickly.

Next, everyone should be trained in when and how to exit the building and assemble in a designated area well away from the building. Remember, there are lots of flammable and explosive items in all auto service shops so don't make that assembly area right outside the office or anywhere close to the building.

Other phone numbers to record are the insurance agent, family members of all employees and surrounding businesses and homes to notify them of the dangerous situation. This list should not be kept only in the office as would most likely be unobtainable during a fire, or at least, too dangerous to retrieve.

This unfortunate shop might have been spared or saved if a fire emergency plan and preventive measures where implemented.

Fire alarms should be installed and monitored by an alarm company. While it costs to have a system installed, it can avoid serious damage and can become a business tax deduction. Most insurance companies offer lowered fire insurance rates if you have a fire alarms system installed.

Lower the Risk: Make a Prevention Checklist

To minimize the possibility of a shop fire, you should have a checklist of things to do and things to avoid. Many business insurance companies provide a fire prevention checklist for their customers, so check with your insurance agent for any possible suggestions. Share all information on the checklist with all employees to ensure they understand why it's important to follow the rules.

Blocking access to a fire extinguisher can spell disaster when the difference between putting out a small fire or letting the blaze get out of control may be mere seconds.

Here are some basic suggestions for a fire safety check list:

•Fire Extinguishers

Have the correct number and type of portable fire extinguishers placed at strategic locations. Train all employees in their use to stop small fires and when to call for the fire department if it gets out of control. Class ABC extinguishers are best for all around use. If you work on brake pads with magnesium content, you should have a Class D extinguisher placed at the bay where brake work is done. Do not block access to the fire extinguishers. All fire extinguishers should be in good physical shape, inspected and certified by a fire extinguisher service company annually. What good is a fire extinguisher if it doesn't work when needed?

•Enforce "NO SMOKING" rules within the building

If a smoking area is required, make it in a safe place, usually outside and away from any combustible materials. Always check that area for any possible burning materials prior to leaving the shop for the day. Many fires flare up into blazes after employees have left for the day.

•Practice Electrical Safety

Use electric fixtures and switches that are designed for use in explosive environments. Inspect all electrical equipment for wiring

that is broken, cracked or frayed that could be the source of sparks. Make sure that all equipment is properly grounded. Have building electrical system inspected at least every couple of years.

•Welding & Cutting Safety Issues

Welding and cutting should be performed in areas free of combustible materials. Gas tanks used for welding should be properly labeled. They should be stored away from heavy traffic areas, out of direct sunlight, in a ventilated area and should be chained securely to avoid damage or explosion from tipping over or falling. Never weld containers that have held flammable or combustible material until the container has been thoroughly cleaned. Be sure the welding cart includes a fire extinguisher. Make sure hoses are in good condition. Make sure that your employees are properly trained and have proper certification to perform cutting and welding.

•Storage of Flammable & Combustible Liquids

Flammable and combustible liquids should be kept in covered containers when not in use. Containers should be bonded and grounded when liquids are transferred from one container to another. A wire with alligator clips can be used to connect one container to another (bonding) and one container to an underground water pipe or electrical ground (grounding). Store flammable paints, thinners, and adhesives in approved fire-rated cabinets away from ignition sources. Obtain Material

Old, dirty fire extinguishers should be replaced with new ones.

New, clean fire extinguishers ensure they'll operate properly when needed.

Safety Data Sheets from manufacturers to be sure you are storing and using these materials in a safe manner. Proper equipment should be used to drain and fill gas tanks for removal. Establish maximum ventilation, disconnect the vehicle's battery, and store the empty tank outside.

•Practice Proper Painting Procedures

Spray painting should be done in a spray booth designed for that purpose. Keep portable lamps or any flame source out of the spray booth. Be sure that fire extinguishers and sprinklers in spray booths are operational. Check that spray booth ventilation is working as designed. Clean filters, ducts, and interior walls of the booth. Operate the ventilation system for a period of time after painting to remove residue vapors and paint. Do not use space heaters where spray painting or welding is done, or near oil or gas storage tanks.

•Good Housekeeping Prevents Problems

To limit the fire potential, stock rooms should be kept clean and orderly. Aisles providing access to fire exits should be clear. Service bays should be kept clean and should not be used to store combustible materials. Clean up spills immediately, especially flammables and oils and dispose of daily. Avoid the accumulation of cardboard cartons and packing/crating materials that would feed an accidental fire. Combustible waste materials placed outdoors for trash collection should be located away from the building. Trash dumpsters should be located so that fires will not spread to the building. Remove trash daily. Keep oily rags and clothing in a closed metal container until you dispose of or launder them.

•Know the Laws & Regulations

Be aware of the national (OSHA), state and local laws and regulations that affect your shop. If you are not incompliance, you could be subject to fines or penalties. Plus, it may be grounds for denial of claims by your insurance carrier. The vast majority of insurers will gladly work with you to provide a fire prevention plan and to help you meet applicable laws and regulations.

It's All about Safety

The whole point of this article is to get you thinking about fire safety – emergency plans and preventive measures. If you've ever been involved in a shop fire or known someone who has, you'll agree that the results can be devastating. Your personal safety should always be considered as the primary concern in safe shop operation. ■

Left: Used motor oil should be stored outside in closed tanks while waiting for recycle pick up.

2014 Detroit Autorama: A Little Ray of Sunshine

ot cars warm the heart and lift the spirits at Detroit Autorama.

If you're a Car Guy or Gal, one of the highlights of the winter season in the Midwest is attending the Detroit Autorama. Seeing all the hot rods, muscle cars, racing machines and custom vehicles is invigorating. In the depths of the snowiest of winters, gazing at all the brightly-colored paint jobs and tons of chrome brings hope and inspiration for the coming warm weather and the time for playing with our own cars.

This year's show, the 62nd Detroit Autorama, filled two floors of Cobo Hall and Convention Center, with cars, trucks, motorcycles, mopeds, bicycles, pedal cars, and vendors. Tens of thousands of gear heads and car freaks flocked to Autorama, bringing like-minded friends, spouses, children – and at least one camera each. They trudged around the spacious halls taking tons of photos, meeting other car aficionados and carrying bags of brochures, handouts and purchased goods.

Among the automakers were Ford, Mopar and Chevrolet, who had large arrays of their modern muscle cars, racing and restoration parts, and lots of interactive displays. Aftermarket companies included Edelbrock, Summit, Jeg's, Flaming River, Ididit, Painless Wiring and many others.

On hand were many celebrities for "Meet and Greet" and to sign autographs for fans, including Richard and Kyle Petty, WWE stars Chris Jericho and Shawn Michaels, plus many other TV and industry favorites.

Several seminars and training sessions were available to attendees and many schools offering automotive training programs had information and recruiting booths. Several high school automotive students came with their teachers to get their first look at the lure of car culture careers.

Over three days, thousands of car buffs visited the Detroit Autorama.

The Cars are the Stars

The central focus of Autorama is the cars – in every form; hot rods, customs, showroom stock, restored, rat rods, racers and tuners. More than four hundred cars were displayed. And, add to that the numerous displays of trucks, motorcycles, bicycles, boats, pedal cars, memorabilia, toys and models. There were company displays, club displays and individuals showing their special rides. Owners came from across the U.S. and Canada to be part of the prestigious event.

Right up in the front of the gigantic upper hall were the Ridler Award contenders. The Ridler Award is the prize for "Best in Show." For over 50 years, the Ridler has been the Holy Grail for car customizers; the recognition that a car, and its builder, stand atop the heap. Past winners include Chip Foose. Some of the 32 contenders put hundreds of thousands of dollars into their design and execution, and sit in custom-made displays with special lighting, mirrors and signage. Some even have their own websites and Facebook pages. Many past winners come back for adoring fans to take photos.

Most folks around Detroit suffer from an addiction to cars. Detroit was the home base of several automobile manufacturers and still boasts the "Big 3," as Michiganders call them, fully aware that domestic vehicles no longer rule the global market. That doesn't matter. Grandfathers came to Detroit to earn a living, fathers worked for automobile companies and suppliers. Many Midwesterners still do, or did, work in the automotive industry. It's just natural for them to love cars – especially the old cars that are the heritage of the industry and the area. Cars are their drug of choice.

The annual Detroit Autorama is a sign that the car culture is alive and well during the cold, snowy Midwest winter. Soon, flowers will pop out of the ground and favorite cruisers and hot rods will pop out of garages. All will be right with the world. ■

Several vendors showed their newest and shiniest products.

Several contenders for the coveted Ridler Award were decked out in lavish displays.

Some custom builders have put hundreds of thousands of dollars into their creations.

Beautiful paint jobs and shiny chrome draw Detroit Autorama attendees to snap photos of their favorites.

Information Station

Monroe Brakes Promotion

Monroe Brakes Trust the Pros promotion offers a $30 prepaid card to consumers who have two sets (front and rear) of qualifying Monroe Brakes Total Solution brake pads installed at a participating professional repair shop. Additional promotion details, including a complete list of qualifying products and downloadable promotion rebate forms, are available at www.MonroeBrakes.com.

VDO TPMS Sensor Catalog

VDO has released its new 2014 TPMS Replacement Parts Program catalog, which includes the latest applications for the REDI-Sensor. The catalog features an application section and an illustrated buyer's guide with individual listings for OE sensor assemblies, multi-application sensors, service kits, torque specifications, installation tips, service kit guide, make/model index, OE cross reference, REDI-Sensor cross reference, REDI-Sensor product information, and contact information. For more information, visit www.redi-sensor.com.

Mickey Thompson Tire & Wheel Promotion

Now through May 31, 2014 Mickey Thompson Performance Tires & Wheels is offering consumers up to $80 back on the purchase of select light truck tires and wheels.

Consumers who buy four new Baja STZ, Baja ATZ, Baja MTZ, Baja Claw TTC Radial, or Deegan 38 tires will receive an $80 Mickey Thompson Tires Prepaid Card by mail. Consumers who buy four new Classic III, Classic III Black, Classic Baja Lock, or Sidebiter II wheels will receive a $50 Mickey Thompson Tires Prepaid Card by mail. For details and official rules, visit www.mickeythompsontires.com/rebate.

MSD EFI Receives CARB Exemption Status

MSD Performance says its Atomic Fuel Injection System has been granted an exemption from the California Air Resources Board, making it the only aftermarket EFI system that is legal on 1987 and older GM vehicles in California.

Enthusiasts with an '87 and older GM car or truck can finally do away with their old carburetor and take advantage of the driveability benefits of a modern, self-learning EFI system such as quick starts, consistent idle and smooth power throughout all driving conditions. For more information, visit www.AtomicEFI.com or call 915-857-5200.

Walker Exhaust Promotion

Walker will help consumers save on emissions control products – including mufflers, welded assemblies and catalytic converters through its "Exhaust Extravaganza" spring promotion, which runs until May 31, 2014.

To earn a $100 prepaid card, consumers must purchase a qualifying Walker Quiet-Flow SS muffler or welded exhaust assembly and Walker direct-fit or CalCat direct-fit catalytic converter. The Walker promotion also offers a $50 prepaid card for either the purchase of a qualifying Walker direct-fit or CalCat direct-fit catalytic converter or a qualifying Walker Quiet-Flow SS muffler or welded assembly. To learn more about the offer or to download the rebate form, visit www.WalkerExhaust.com.

The Watch That Roared

by Greg McConiga

Just finished up two engines and sent a good friend off for another season of Super Comp and Super Gas racing. I have to admit I don't really get this kind of racing. It is, as another friend put it, like trying to hit the moon with a BB gun. Build a bunch of power, then shut it partially down, then back to wide-open throttle and try to hit an exact 8.900 or 9.900 with all the top speed you can muster so you can run the slow guy down from behind and catch him right at the finish line. And jump on the brakes near the finish if you think you'll break out. Sure seems like it was more fun to just build all the power you could and go like hell and whoever got there first was the winner.

This was the first year that I really got to do nearly all of both builds and I've got to tell you that it is one tedious task to build engines designed to make something in excess of a thousand horsepower that can withstand what is, essentially, a full quarter mile high-gear pull, while hot (if you're lucky or good enough to go until the rounds are running back to back) without detonating it so hard it shucks its guts. Everything in these engines is measured in "holy crap I think it's touching" clearances. In fact, in a lot of cases we DO catch the piston with the head and the valves with the pistons. You know it's serious when you machine the piston top to precisely match the valve angles not because you're maximizing clearance, but because you're counting on the valve to hit at one time or another and you want the angles to match so you don't bend the valve. The first time my mentor told me that's why we did it that way, I looked at him like he was growing an appendage out of his forehead. It isn't that some things are close, it's EVERYTHING that's close. Pushrods almost hit intakes, rods almost hit cams and windage trays, rockers almost hit retainers (and did hit the valve covers until we ground a bit off to let them clear). The first time I watched the piston and valve race through the ports I was cringing -- it looked to me like there was no way to avoid crashing parts. At these kinds of tolerances even a bit of extra rod bearing clearance turns zero piston-to-head clearance at 8,000 rpm into, "Oh, look . . . we touched!" Thank goodness for good parts, good tooling, and good machine shops.

I'm not saying it isn't fun and challenging. I'm not saying that I don't improve my processes every time and get better and better at my documentation. I'm saying that I've never built a big block watch before.

I have to say that I would never have been able to do this kind of work when I was young. I was too impatient and prone to losing my temper over trivial matters. It takes a certain mindset to put something together and take it apart and put it together and take it apart over and over. Mocking things up is just part of what has to be done now, both in the race shop and in the restoration shop I work at part time.

I'd like to tell you that I see the next generation lining up to do this work, but I'm not sure that kids raised to scream at a microwave because it takes too long are ever going to have the patience for it. Maybe my attitude about this is unreasonable. I am, after all, a senior citizen now and proud of it. I never thought I'd live long enough to claim the title! I know that as one ages one's memory fails. We were far more responsible, more dedicated, and capable than our offspring at the same relative points in life. We forget what loons we were. We become less liberal, more conservative and prone to talking about the good old days when we walked to school in three feet of snow -- and it was uphill both ways.

I do miss the rumble of the big healthy V8s and I'm glad to see the next generation of Mustangs, Camaros, Mopar Hemi's out thundering around the neighborhoods (I just wish I could afford one!). In my case, it's not the car so much as the tickets I'd collect. I DID lose my license a couple of times when I was a youngster for speeding and speed contests, and I'm not entirely sure that behind the wheel of a car like that I would demonstrate sufficient maturity to keep out of trouble. Of course, today you can get put in jail for street racing -- never done that before. Maybe it's more fun that it appears.

A couple of us senior locals were talking about that one day. On any given night in the old days you'd hear the rev-rev-rev and screech of tires all over town, especially after about 11:00 PM. Nowadays that would draw the law like ants to a picnic. And there certainly wasn't as much traffic in yesteryear. Street racing was, in retrospect, pretty stupid. But it sure was fun! Even if you weren't racing it was fun just watching.

While I appreciate the high technology that powers today's street cars, there's no sound like big displacement and lots of cam. It's like the music you listened to when you were in high school. It becomes the music you listen to all your life, even after you figure out that it really wasn't all that good to start with (and we all know how much more horsepower is coming out of the factory today compared to the sixties technology we remember so fondly).

I guess the best we can hope for is that the youngsters that are out there building the next generation of racers out of the Asians, Euros, and new American muscle cars learn to love the smell of exotic fuels and oils and learn the patience to become the next generation of watch builders. One can only hope . . . ■

HOT ROD PROFESSIONAL

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