FUEL FOR THOUGHT ....

STRAIGHT TALK ON GASOLINE:
PUMP GAS, RACE FUEL AND OCTANE BOOSTERS

By: WBH

One thing all bikes have in common is that they run on gas. But there are a lot of myths circulating, regarding race gas, aviation fuel and octane boosters. So what's the answer? Is pump gas OK? Do octane boosters work? And what about racing gas? How can you tell one racing gas from another? To get some straight answers, I talked with Bruce Conrad, owner of F & L Fuels and Lubricants. Bruce makes Pro-Gas and knows what works. He owns a bunch of bikes, including a flawless Vincent Black Shadow, and rides a new Beemer on the street. **WE ASK QUESTIONS AND GET ANSWERS Q:** How are racing fuels made? **A:** All gasoline contains the same general family of hydrocarbons; low test, high test, racing gas and aviation gas. General refiners are set up to make a large volume of gasoline, hundreds of thousands of gallons per day to satisfy their retail market.

Making a racing gas goes like this: you start with a blending stock of gas, then you add your own additives to end up with whatever octane level you're after. A blending gas is a raw, basic gasoline, with no additives or detergents. Iso-octane is an example of one that can be used. You have to calculate what you want in a racing gas before you start adding things to a blending stock, or even what kind of blending stock you start with.

For example, for the fuel that we make, we want to end up with an octane of approximately 108 research method, with a motor octane that will blend back to about right at 103-104 RM-over2. That's an average of research and motor methods of testing octane and is the most commonly accepted rating. We add lead, lead scavengers, various aromatics, napthanics and light-end hydrocarbons to get the correct Read Vapor Pressure to control vapor lock. You have to change gasoline from a liquid to a vapor to get it into a proper state for an air/fuel mixture ratio, so the spark plug can ignite it. A carburetor does this job of turning the liquid into a vapor. **Q:** We see ads all the time, this gas has 102 octane, this gas has 115 octane, or another with 118. What do we need? Let's say you have an engine with 8.5 to 1 compression ratio. How much octane does it require? **A:** That's a tough question. It has a lot to do with the combustion chamber shape, location of the spark plug, condition of the combustion chamber, the air/fuel ratio you enter into it, a huge number of factors including the air temperature and the load the engine is put under. What we're talking about is trying to defeat detonation; that's the real problem.

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I can give you some approximate guidelines. If you're using a 10 to 1 engine and over, you need racing fuel. On a 9:1 engine, you're probably in the 98 octane area, and there are a lot of good strong 9 to 1 engines out there. There is no real linear type of relationship between compression ratio and the octane requirements.

You can have an engine with extremely high compression and really have a low octane requirement. I know people who have had engines in the 13, 14 or 15 to 1 compression ratio range and have used 103 to 104 octane fuel with no problems. **GOOD GAS/BAD GAS: MAKING IT HAPPEN Q:** What makes a good racing gasoline? Any secrets you'd like to give away? **A:** We buy a blending stock from two different companies? There are two different stocks and we co-mingle those. Now this is important: these stocks are sold by an ASTM specification and it means they'll be the same quality and molecular weight each time.

We try to control the variables as tightly as possible, by buying the same group of chemicals, time after time, with the same chemical characteristics. What we end up doing is giving you a base fuel that you can tune with and use, and it doesn't change. It has the same chemical components, the same chemical characteristics, the same specific gravity and all of this is very important for consistency. A racer doesn't want to change the variables. And fuel is one of them.

We've done our own testing, and without naming names, I can tell you some startling facts. We've sent samples of certain racing fuels to the lab for testing, and one time it's 114 octane, and a month later the same brand of fuel tests out to be 108. It's got a specific gravity of .76 one time and the next batch tests out at .73. You splash it in the motor one time and it runs great.

The next time, the specific gravity of the fuel is different and it flows differently. Different specific gravity fuels flow through the carburetor jets at different flow rates. By just changing the fuel, you can richen or lean your engine out. Let's say a major refiner wants to make an 86 octane fuel and they want it blended as economically as possible.

The building blocks used to make a higher octane fuel are expensive! The benzenes, toluenes, xylene complexes - or the BTX complexes - they want to use as little of these as possible. That's why lead was always so effective; because they could splash a lot of lead in it and bring the octane way up, and do it really cheap. These major refineries are only making a cent, two cents or three cents a gallon profit once the smoke clears. They have to keep production costs down.

You're not under that restriction with racing fuel, because these fuels usually cost three dollars a gallon or more and the profit potential is greater, at least on a per-gallon basis. With this in mind, you should be able to make a good fuel, with repeatable characteristics, time after time. This is the single most important thing to look for in a racing fuel, I feel. **Q:** More important than high octane numbers? **A:** Absolutely! Look, if you had a bike where you used a dozen pipes during testing, and all of them were different, you wouldn't know where you were at! You couldn't time the motor... you couldn't jet it.

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Take a drag racer, for example. He might go through three or four sets of pistons in a race. If each piston had a different compression ratio, how would they know what to do? They'd be lost. So the important thing in any racing situation, is to have the same kind of fuel, day after day, time after time, year after year.

WHY DOES RACE GAS COST SO MUCH? Q: So the real expense for racing fuel is in the quality control, the assurance that it's consistent all the time. Why can't this be done with pump gas? **A:** For a major refiner to make racing fuel is out of the question; he's not going to touch it. It's a pain in the butt to make; there's a lot of quality control that has to be done and there has to be a level of cleanliness you're not going to find in volume production. **Q:** How can we, the consumers, tell a good racing fuel from one of lesser quality? **A:** Given that they all can provide you with an octane, say 103, it may be just window dressing.

A lot of people think that by buying a higher octane, it'll make your bike get to the finish line quicker and you may do better. As to usability in a motor, ultra-high numbers are questionable. Octane will make up for some sins that an engine builder might have built into the motor, but an engine only needs what it needs... not a bit more.

What makes a fuel better? Our fuel has been identical for 15 years ... same specific gravity, same Read Vapor Pressure, same octane, whether it be research or motor method of rating. Some people advertise outrageously high octane readings, which makes it particularly attractive to people who don't understand what they need.

TOO MUCH OCTANE CAN BE BAD! Right now in the racing fuel business, there's a race to market the highest octane fuel that you can make. People relate the highest octane to "my motor is making more power." That couldn't be further from the truth. One of the downsides to building a fuel with ultra-high octane is adding components that really slow down the flame front in the combustion process. You can get the flame front so slow, that the engine is now running in a too-rich condition. This takes away horsepower. So here you are, slowing down the flame front and getting rid of detonation, at the expense of losing horsepower.

I see this all the time at the track. I see engines running "heavy"; they're trying to tune it to lean it out, when actually the flame front is causing the problem. **Q:** Are there good ways to get the good octane numbers and are there bad ways? I guess our question is, are there shortcuts? **A:** I've seen some fuels with compositions of 25 to 30 percent aromatic content. Aromatics are a reliable, correct way to build octane, but people tend to think that if a little bit is good, then more ought to be better and a whole lot is just great!

If you run reliable lab tests on octane and incrementally increase the aromatic content, most lab people feel that if you get up above the 10 to 15 percent aromatic content, your octane falls off. What the engine does is start making more heat, which requires more octane, which makes more heat: a real vicious cycle. It's like a dog chasing its own tail. The bottom line is this: let's say your motor needs 92 octane to run correctly and you fill up with 125 octane wonder gas. You will not run any faster. In fact, you might end up running slower because of a radically slowed flame front.

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MIXING THE GOOD STUFF WITH THE BAD STUFF **Q:** Let's say that we have a racer on a budget. He's got a lightly modified engine and would like to run racing gas, but can't afford it. Can he mix race gas with pump gas and, if so, what ratios? **A:** On a stock motor, I don't think the racer would need to run racing gas, except during the summer when it's very hot. Here, you stand a very real chance of vapor lock with pump gas. I'd recommend that the racer start out with a good stock major brand gasoline of at least 92 octane rating, then go out and test. If the engine runs fine and doesn't ping or detonate, that's fine. You can use that gas. Just make sure you buy it at a very busy corner with a high volume turnover.

This way you stand a better chance of getting fresh gas, and no substitute gas. If you do have some pinging and detonation, try one gallon of racing fuel to three gallons of pump gas. In a stock motor, this should do it. Test it again under the same circumstances to check it out. You're going to have to check this regularly, because the variables in the street gasoline WILL CHANGE, while the variables in a good racing fuel will not.

The combination of 92 octane street gas and 103 octane racing gas will kick up the actual octane two or three points. There's no real chart you can draw... it's not a linear thing. But that's all it might take to make the motor happy. Here's something startling, and I almost hesitate to say it.

You don't get any increase in the performance with racing fuel. Not a bit. Not any racing gas. Good racing fuel allows you to run your timing more radical, to extract more horsepower out of what you've got. I can take any racing fuel made - including ours - and make the engine hammer and detonate by have the timing set too far out. Timing lead is critical.

You want to make the engine ping? Easy, just add too much lead. Conversely, running the timing closer to top dead center will cool things down. Remember the TT bikes of ten years ago? They ran so much lead, they could not be kick started. They had to be push started. **HOW TO KNOW WHAT YOU'RE GETTING** I would not buy any racing gas, or pump gas, with alcohol in it. That's the first thing I'd ask ... "Does it have any alcohol?" It's not that you can't use alcohol. Ethyl alcohol is a good additive; it can be used up to ten percent in most cars.

Alcohol really offers a different fuel/air ratio than gasoline. Racers who do run alcohol have to use enormous jets and really drink the stuff through the carb.

Make sure that the **fuel does not have MTBE** in it. It's a very effective new additive, but it may be illegal in your organization, as it is in many.

It's an oxygen or nitrogen bearing com-pound. Probably the single best option is to test with a hydrometer several containers of the racing gas you're considering buying.

This will give you the specific gravity of the fuel, and if it varies from container to container, it will tell you a very sad story about quality control. You can buy a gas testing hydrometer for about four or five bucks.

All savvy tuners test with them BEFORE they start tuning, or if they cannot use their regular gas. **AVIATION GAS: MYTHS AND FACTS** **Q:** What about using AV, or aviation, gas? **A:** There's an old wives' tale about AV gas out of World

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War II and I don't know who started this, but it says that if you put AV gas in your car, you'll burn the valves.
There's no doubt that aviation fuel can be used in any internal combustion engine that's driven up and down the highway at cruising speeds. It doesn't make much sense to use it for that since it goes for something like $1.75 or $1.85 in this area, and is not easily obtainable.
A motorcycle and an airplane really live in two different environments. An airplane generally takes off, climbs to its altitude and the general outside temperature is at or below zero. Even in the summertime, it maxes out at 10 or 20 degrees above. And an air-plane does not turn high rpm. A typical prop job loafs along at two to three thousand rpm.
Of course, there are some high perfor-mance exceptions. The engine just drones along at low power settings, except for take-offs. PUMP GAS, RACE FUEL AND OCTANE BOOSTERS

PUMP GAS: IT'S NOT WHAT IT WAS A FEW YEARS AGO Everyone complains about the new generation pump gasoline we burn in our cars, trucks and bikes. You know what! They're right! Take a gallon of leaded regular gas, for example. In the good old days, a gallon of decent regular leaded gas contained about two and one-half grams of tetraethyl lead. Today, you can't find leaded pump gas. Old-fashioned high-test (premium leaded) gas used to come with about 4.27 grams of lead per gallon. Hot stuff!
So we now have to deal with a future of unleaded gasoline. This wouldn't be so bad, except that the new gasolines suffer from more than just the removal of lead. Among other things, modern gas does the following: * Builds up varnish and deposits much faster than "good gas." * Won't tolerate high-compression engines. *** Stores poorly. * Reacts poorly to the presence of oil, as in a two-stroke pre- mix situation.**

OCTANE: WHAT DO THE NUMBERS MEAN? The octane rating of a gasoline is the measure of the anti-knock quality of the fuel. Knock is just that...a hammering sound inside your engine. When a charge of fuel is introduced into an engine and ignited, the flame spreads out from the spark plug to the cylinder wall. If this happens all at once, you get detonation, or knock.
A steady, even, slow burn is desirable. **Octane (or an increase in the octane level) will not increase your horsepower**, no matter what your buddy tells you. However, insufficient octane can cause an engine to lose horsepower. All the octane you need is what your engine demands to keep from detonating.
Some theory is needed here.
Without getting into upper trig, you can assume that the higher the compression ratio of an engine, the higher its octane requirement. The mechanics behind compression ratios is simple, and creates problems for high-performance engines. The smaller the space you try to squeeze the burning fuel into, the more power you'll develop...all other things being equal.

READING THE PUMPS

The number you see on the gas pump is supposed to tell the octane reading of the gasoline. It's not quite as simple as that. Here's how it all adds up.

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The Research, or "R" Method, of rating octane is done on a standard test engine in a lab. The air temperature is controlled on this to a strict 125 degrees Fahrenheit. Mild loads are put on the engine, just about the loads you might put on your family car under normal driving conditions. This is called an F1 test.
The next rating test is called the Motor Method. Here, another engine is used on a dyno, but the air is introduced into the inlet at a hot 300 degrees Fahrenheit. Heavy loads, similar to full-throttle acceleration and passing on uphills, are dialed into the engine. The engineer notes ping and detonation at certain load conditions and the octane rating is determined by its ability to control the detonation. This is called the F2 test.
The number you see on the face of your gas pump is known as the Road Octane rating and is a combined average of the Motor and the Research Methods. In fact, if you take a close look near the posted octane number, you'll more than likely see: M0+R=92 OCTANE, or whatever the actual octane rating is of that particular gas. For example, if the F1 test showed 94 octane and the F2 test indicated 86, then the Road Octane rating would be 90.

MEXICAN GAS

For you folks who drive in Baja, here is the scoop. Pemex is the government-controlled gasoline, and it's not as bad as the stories would have you believe. However, the octane rating is in the low 80s and that's why most engines will ping and detonate badly when using it. In some parts of Baja, there's new high test gas available that's rated at 92 octane and it's quite good. Look for the red pumps.
Mexican gasoline feels very oily compared to United States stock. That's because its refining process is not as elaborate as ours and there are less light ends and volatilities than in the typical U.S. gas. Also, contamination and the presence of water is a very real problem.
If you buy Mexican gas in a busy city location, chances are it will be of decent quality, even though the octane rating is low. Buy your gas along the road at a small station, and you'll more than likely buy a fuel that's been stored for a considerable time and suffers from contamination. If you drive in Mexico, a good fuel filter is a must and it should be checked and cleaned regularly.
One last word of warning: the very low octane rating of Mexican gasoline can create a lean condition in an otherwise properly jetted carb. Consider going larger on the jetting, or even backing the ignition timing off if you must run this gas for any extended period of time in a high performance engine.

OCTANE BOOSTERS TO THE RESCUE

You've seen them on the shelves at your local bike shop and on the counter at Local Discount Auto Parts: cans of octane booster in every color of the rainbow, ranging in cost from a buck to five dollars.
Do they work? Sure! The good ones do. First, let's take a look at what a good octane booster will do to your gasoline. Please make note of that word "good," because there is a lot of trash out there on the market.
An ounce of an effective octane booster should raise your octane rating by 2-1/2 numbers. That is, if you start with 86- octane gasoline, one ounce of booster to a gallon will take it to 88-1/2 octane. One word of caution. Octane boosters decrease in effectiveness as their quantity increases. Just because one ounce gives you 2-1/2 numbers more, ten ounces will

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not give you 25 numbers. Here's a good scale of just about how decent octane boosters will work:
One ounce/per gallon ¼ 2-1/2 numbers increase
Two ounces/gallon ¼ 4-1/2 numbers increase
Three ounces/gallon ¼ 6 to 6 1/2 numbers increase
Four ounces/gallon ¼ 7 to 7 1/2 numbers increase
A good rule of thumb is that anything over three ounces per gallon is wasted. Some crazies dump in a whole can of booster, thinking they're going to get radical gains. Actually, they'll get a decrease in performance, as excessive ratios can cause the volatiles in the gas to deteriorate and excessive **aromatics** can make the engine run "heavy," or rich.

WHAT ARE OCTANE BOOSTERS MADE OF

There's no mystery here. Most octane boosters are **nitrogen** carriers. Common ingredients are methanol, isopropyl alcohol, naptha, xylene, toluene (tyline), benzine, hexane, nitro benzine and aniline. Available octane boosters do not have tetraethyl lead in them, as lead is very toxic.
There are lead substitutes for sale also, but very little substantiation and research is available on these.
Aniline is the best octane booster available and is the prime ingredient in the better boosters. Nitro benzine also works well, but is not as effective and costs a great deal. Aniline is made by Dow, and is a very poisonous liquid that can actually be absorbed into the skin on contact.
Nitro benzine smells like shoe polish and castor oil. Alone, it's not too effective, but used in conjunction with other additives, it can do a decent job. You'll also find it used as an additive in some of the more expensive castor bean oils for use in two-stroke engines.

WILL OCTANE BOOSTERS ADD HORSEPOWER?

No. This is a misconception. Octane in itself does not add power. However, an engine that's forced to run on fuel with a lower octane than what's needed will run hot, detonate, and eventually lose power. The proper octane level will let the engine run to its full potential, but won't transform it into something special.
When a combustion chamber gets a charge of fuel, the plug sparks, and the fuel is burned. With the right octane level, the burn is clean and even. With too little octane, the burn can be uneven and a hammering can result.

SIDE EFFECTS OF OCTANE BOOSTERS

Will attack plastics, rubbers and some fiberglass. Discolor and attack most paints. Foam filters will deteriorate if cleaned in a booster-carrying gasoline. So will the glues holding the filter together. Some oils are affected by octane boosters. Most normal oils are not bothered, but if you have any doubt about your favorite brand, check with the manufacturer, to play it safe. Two-stroke users have to pay particular attention to this. ***Can make an engine run rich. Rejetting*** may be necessary. Are toxic to the skin, and the fumes can make you sick. Exposure to air can cause a 50-percent breakdown in effectiveness. Ultraviolet rays - that's plain old sunlight- will make octane boosters deteriorate. Will attack gas tank sealants and could plug up your entire fuel system if used together. Cost a lot of money. NOW...***THE GOOD SIDE*** Don't let all of that scare you. Octane boosters have a real place in the world today. Here are some of the good things

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they can do: Better throttle response. You can actually feel it. Gets better mileage. Also, you can often lean out the carb slightly when using octane boosters, which will give improved mileage. Best performance possible from your engine, short of using race gas. Reduce detonation and pinging. Clean out deposits. A good booster will actually let the engine run cleaner and inhibit carbon build-up. Acts as a gasoline stabilizer when the machine is left to sit for a period. Gas stores longer with a good octane booster in the fuel. Lets you use whatever gas is available at the time. A good booster doubles as an emulsifier and can keep small amounts of water in suspension. Fuel system condensation is a very real problem, especially when the machine sits for long periods of time between use.

HOW TO TELL A GOOD OCTANE BOOSTER FROM A POOR ONE

At most any race track in the world, you'll see big drums of race gas. At around four bucks a gallon, it can still be a bargain if you have a highly modified engine. The market is loaded with octane additives. Here's one rule of thumb: if the product comes in a clear or transparent bottle, don't even consider it. Ultra violet rays cause deterioration.

There should be specific directions on the label, i.e., how much octane booster to use to how much gas. And, there should be a ***listing of how many numbers the octane will be raised per ounce of booster used to each gallon of gas***. ***A good octane booster will raise a gallon of gas by two-and-a-half numbers with one ounce added***. If the label isn't specific, don't bother with the product.

Consider the cost per ounce. You can get a good octane booster to add 2-1/2 numbers per ounce per gallon for around 30 cents per ounce. Some of the cheaper products might not be as efficient as the more expensive ones.

Make sure the label has a toxicity warning. If it isn't toxic, it isn't going to work. And if it is toxic and there's not a prominent warning, this borders on criminal negligence. Some of the ***better octane boosters are aniline, nitro benzine and toluene***. Additives like acetone and sulfurs can be very corrosive.

Better octane boosters also have metal deactivators in them. This lessens the corrosive action of the additive on brass. And, as you know, all of your jets are made of brass, as are a number of parts in the carb and fuel system. Traces of brass can destroy volatilities in the gas.

HOW MUCH OCTANE BOOSTER SHOULD YOU USE?

Ideally, you should only use what you need to stop pinging and detonation. An engine makes the most horsepower and has the best throttle response when there's just a light trace of pinging under a maximum load situation.

In air-cooled engines, play it safe and allow for heat build-up and potential detonation, as it does happen. A water-cooled engine is much more stable and can be jetted much leaner; a bit of pinging can be tolerated without harm to the engine.

You're better off starting with the best pump gasoline you can buy and then adding small amounts of octane booster, rather than getting low-octane gas and adding a lot of booster. Most gas stations have available unleaded premium in the 90- to 92-octane range. An ounce or two of a good octane booster added to this should be more than enough to handle the demands of a stock engine running hard.

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SUMMING IT ALL UP

Here's how the ORC staff goes about it. We normally run unleaded premium with the highest octane we can find. If there's a rattle in the engine under a load, we add a small amount of octane booster, as needed.

In high-performance bikes, one ounce of octane booster per gallon of 92-octane unleaded premium works well for us. Some of the highly modified bikes demand three ounces per gallon. If the temperature is high, or the bike is raced, we like to add one gallon of real race gas to three gallons of pump gas.

Naturally, top pro racers cannot afford to take any chances, and you'll see them using only pure racing gasoline. When your livelihood is on the line, you get rid of all the variables and only take chances on the track, not on what goes into your tank.

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