Understanding Specific Gravity

Specific gravity is the ratio of the mass of a liquid to the mass of an equal volume of distilled water at 64° F which is represented by 1.000 Specific Gravity on a fuel chart. Most fuel suppliers can offer the specific gravity number of a fuel. Should the fuel not match the specifications supplied, it might be contaminated fuel which could cause poor performance.

Specific gravity MUST always be referenced to a particular temperature reading. The specific gravity of a liquid decreases with a rise in temperature or increases when its temperature is lowered. Testing the specific gravity of a liquid will not identify its contents. it is only the measure of the weight of the fuel vs. distilled water. Methanol is commonly contaminated by water – which is heavier than the fuel. Checking the specific gravity allows the purity of the fuel to be referenced. When contaminated with a lighter or heavier specific gravity element, the final specific gravity reading will be lighter or heavier than the originally tested weight depending on the contamination of the fuel and the temperature reading.

WHY CHECK THE FUEL?

Combustion engines perform best at only one air-fuel ratio, and the ratio is determined by the weight of the air/fuel mixture. Since all carburetors and fuel injection systems meter fuel by volume, a jetting change must be made if the specific gravity of the fuel changes for any reason. This change will adjust the volume to keep the weight of the fuel going to the engine consistent. For instance, if the specific gravity of the fuel increases by 4%, then the volume of fuel put through the carb/injector system must be decreased by 4% to keep the net weight going into the engine consistent.

Many racing facilities and sanctioning bodies use the VP/Kinsler Fuel Analyzer Kit (sold by any VP distributor) to ensure the legality/accuracy of the fuel per any fuel rules the body might have. Alternative methods are available, but they can be cost prohibitive and time consuming.

OCTANE

Octane is a unit of measurement used to rate a fuels ability to resist detonation. Detonation (spark knock or "ping) is the tendency of the fuel to explode violently in the engine rather than burn smoothly at the precise moment when combustion occurs in the cylinder of the motor. If the fuel detonates, the pressure in the combustion chamber rises so fast and high that it is like beating on the top of the piston with a hammer – this is the primary cause of piston, rod, and bearing failures. The higher the octane rating, the higher the resistance of the fuel to detonate. Racing fuel is blended to provide additional octane rating, not necessarily more energy. In fact, all grades of fuel have about the same amount of energy per pound. Increasing the octane can help produce more power since more compression or spark advance is necessary to achieve the optimum performance level with that fuel. Too much octane, however, can slow the burn rate of the fuel causing a loss of power.

FUEL COMPARISONS

There is a big difference in specific gravity between various brands and grades of fuel, often even between two batches of the same brand. The typical range of premium automotive pump gas is .730 - .760 specific gravity rating. Aviation fuel is .680 - .720. Some unleaded racing fuel is as heavy as .790. Many blends of pump gas can often contain as much as 10% ethanol – measuring in a much heavier specific gravity range.

For Example:

Unocal 76 Unleaded Racing Fuel - .788 Specific Gravity @ 59° F.

Unocal 76 Leaded Racing Fuel - .728 Specific Gravity @ 59° F.

METHANOL (ALCOHOL)

The specific gravity of pure methanol is .792 @ 68° F. Methanol, methyl alcohol or wood alcohol (CH_3OH), is usually made from natural gas. It was first discovered in 1823 by the method of condensing hot gases from the burning of wood. It has been the fuel for Indy Cars since 1965. Methanol has the ability to absorb water, even right of the atmosphere. Keeping your fuel sealed will help prevent contamination. Adding water to alcohol will increase the specific gravity reading of the fuel. High levels of water contamination will cause the alcohol to get a cloudy haze in it. Loss of engine performance will typically occur before the contamination reaches these levels. Fuel should be checked with a hydrometer before using the fuel, possibly as you get you fuel from your supplier, just to avoid any problems. Methanol is extremely corrosive to aluminum and magnesium, so, great care should be taken to keep this reaction to a minimum. The fuel system components should be constructed of materials that do not react with methanol (stainless steel, brass, etc) or they should have a protective coating. Methanol also crystallizes when it dries and this dried material does not readily dissolve. The fuel system will need constant attention in this instance. When the methanol-burning vehicle is not in use, the fuel should be drained from the fuel system. Flushing or "pickling" with regular gasoline is a common practice to flush the system.

ETHANOL

The specific gravity of ethanol is .815 @ 68° F. Ethanol, ethyl alcohol or grain alcohol (CH_3CH_2OH), is a liquid derived from corn or other grain, other agricultural products or agricultural waste. Because ethanol is corrosive (due to oxidation), the same preventative maintenance as methanol must be utilized to protect the fuel system components.

In the 1880's, Henry Ford built one of his first automobiles – the Quadricycle – and it was fueled with ethanol. Early Ford Model T's had a carburetor adjustment that could allow the vehicle to run ethanol fuel that was produced by local farmers. Ford's vision was reportedly to build a vehicle that was affordable to the working family and powered by a fuel that would boost the rural form economy. However, in the past, due to various reasons, any alternative fuels other than standard gasoline were suppressed. Today, we are seeing the return of alternative fuel vehicles.

NITROMETHANE

The specific gravity of pure nitromethane – nicknamed "nitro" is 1.139 @ 60-70° F and is chemically CH_3NO_2. The specific gravity of pure alcohol is .792 @ 68° F is obviously quite different from nitro. It is simple to determine the percentage of nitro in alcohol by measuring the specific gravity of the mixture. Adding nitro to alcohol will increase its specific gravity. A chart can be set up to show the percentage of nitro vs. specific gravity (as supplied with the fuel testing kit available from VP Racing.)

The procedure is only slightly complicated by the fact that temperature affects the specific gravity, since any fluid expands as it is warmed, and therefore has a lower specific gravity when warming occurs. For example, a 60% mixture of nitro and alcohol heated, we know that the mixture is still 60%, yet the specific gravity is decreased when this happens.

Some brands of nitro hydrometer kits are sold without a temperature correction table. Errors of up to 5% can be common if not temperature correction is used. For best engine performance, the nitro percent mixture should be kept within one or two percent of what the engine was specifically tuned for.

NOTE: Mixing nitromethane fuel with alcohol creates a mild endothermic reaction which absorbs heat from the mixture, thus, cooling the mixture (opposite of most reactions, which usually give off heat). The maximum affect is with about 50% mixture, which cools approximately 15° F.

DETERMINING JETTING CHANGES FOR DIFFERENT SPECIFIC GRAVITY READINGS

Since the specific gravity of a liquid decreases with a rise in temperature, specific gravity must always be referenced to a particular temperature. The accepted standard is 60° F.

However, since it is not always convenient to measure a liquid at 60° F in the field, a chart has been compiled to allow the specific gravity to be measured at any temperature, and then corrected to a 60° F reading. The chart is included when you purchase a fuel testing kit from VP Racing.

Example: at 90° F, the specific gravity reading of standard gasoline is .747. However, to compare it to the specific gravity reading at 60° F, the chart will indicate the number is .760. This is how you can read the chart to make sure your fuel readings are as accurate as possible.

Procedure for adjusting jetting from one type or batch of fuel to a new batch:

1. Measure the specific gravity of the "previous/old" fuel and note the jetting size that performed best with that fuel.

2. Measure the specific gravity of the new batch of fuel.
3. Calculate the percent difference between the previous fuel and the new fuel:
    a. If the new fuel checked at .712 and the previous fuel at .736, the difference is -3.26%.
4. Jetting correction for the new fuel

    a. Calculate the area of the old main jet and increase or decrease them by the same percentage found in the results above. Larger jets are richer than smaller ones.

i. [Old jet area = (old jet area x % from step 3 above] = new jet area required to obtain the same performance with the new fuel.

ii. Sign (+ or -) is the opposite of the sign found for the % in Step 3 above.

<u>PROCEDURE FOR OBTAINING SPECIFIC GRAVITY READINGS</u>

1. Hold the glass cylinder almost horizontal; place the hydrometer and thermometer into the glass. Slowly bring the cylinder to an upright position while jiggling both meters to allow them to fall to the bottom.

2. Fill the glass cylinder to within an inch of the top of the fuel sample. This will cause the hydrometer to project out of the top of the glass for easy positioning with your fingers.

3. Place the glass in a shady area. Wait a few minutes for the temperature to stabilize.

4. Carefully sight across the bottom of the meniscus and read the hydrometer. The hydrometer muse be floating freely when you read it – not in contact with the glass cylinder or your fingers.

5. Hold the thermometer up so that the bulb on the end is at about the middle of the part of the hydrometer that is submerged in the test fuel. Read the temperature.

6. Note that you now have observed the specific gravity of the test fuel. To find the true specific gravity of the fuel, you must use the temperature correction chart supplied with the fuel test kit. Go down the column that has the heading temperature that is closest to the one you observed until you come to the specific gravity you observed, and then read across the 60° F column on the chart to calculate the “true” specific gravity of the fuel you are testing.