Save Even MORE CASH Using Advanced Hydrogen On-Demand Gas Saving Secrets

Secrets "They" Don't Want You To Know

Age Old
Secrets
Finally
Reveld!

GAS4FREE
Water Hybrid Engine Technology

Study Manual

This Manual covers:

HHO & the Internal Combustion Engine

Tuning Options for EFI, Carb and Other Fuels like LPG and Diesel

Advanced Setup and Tuning

Tracking Your MPG Gains

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Acknowledgements

This book was made possible by the many that we would like to thank. In a world that almost truly seems to be driven by greed and fear, history has shown that the few can make a difference. All is not lost…

The price of gasoline WILL continue to RISE

Don’t get caught like a deer in the headlights. These people dedicated their lives to this technology. Some even lost their lives. We offer our condolences and many thanks…

Stanley Meyer	Yull Brown	Randy Udall
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And…

We would like to thank all of our staff for their continued hard work and drive toward improving life on Earth. Our team spent months perfecting this system so that you don't have too

But Most of All…

To all who has made an effort in pushing this technology forward & To you for joining our side of the fence towards an economical and emissions free tomorrow!

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This or any other form of hydrogen producing device maybe illegal in your town, city, state / province or country. It is your responsibility to inquire with your local DOT (Department of Transportation) about how to proceed. Vic was pulled over by state troopers in California and had no problems at all. But, the officer could have missed it.

Because this technology is experimental in the eyes of most of the United States, we are offering this information for closed track (Race Track) and off-road testing.

Gas4Free.com will NOT BE RESPONSIBLE for any mishaps that occur during the build, test and application phases of your construction. We are also not responsible for a partial or complete system that has problems or causes injury. You have all the information included in this manual to safely manage and handle your electrolyzer.

PLEASE READ THE ENTIRE MANUAL & ALL THE EBOOKS BEFORE DOING ANYTHING. THERE ARE TASKS AND TESTS TO BE DONE THROUGH OUT THIS BOOK

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Contents

Introduction to this book

As I have mentioned before, the anonymous bodies of power do NOT want you to posses the power of water or any other form of fuel that cannot be metered. How can anyone possibly charge you ridiculous prices for something that comes right out of the kitchen sink? The answer is they can't, so they keep the whole thing "hush hush" and try to sweep it all under the rug.

This is where book #2 comes in:

Save Even More Cash using Advanced Hydrogen On-Demand Gas Saving Secrets:

Secrets "They" Don't Want You To Know…

I am going to take you to the basics starting with the internal combustion engine itself as that is where the magic begins. But not a gasoline burning engine; a Hydrogen burning engine and I will explain how you are saving gas while increasing performance. I will also go over the functionality of the Gas4Free System again including vacuum routes for turbocharged and supercharged engines. Yes, the MAX cell too.

Sure enough, I will be explaining diesel, LPG and natural gas applications for those of you running you vehicle on the fuels just mentioned. I will save advanced tuning and MPG tracking for last. Makes sense, right? ☺

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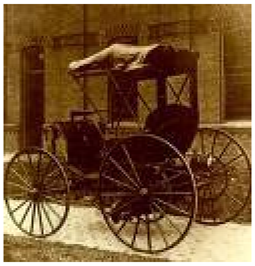
HHO & the Internal Combustion Engine

In this chapter, I am going to reveal, or uncloak if you will, the effects that hydrogen gas has on the internal combustion engine. Most of you already have the idea of how conventional gasoline engines work so this is good background towards understanding HOD (Hydrogen On Demand) fueled engines. But first, let's explain how a Hydrogen engine differs from gas.

Hydrogen Engines



The small number of vehicles using hydrogen internal combustion engines (HICE) makes it difficult to explain how will effect each engine ever made. Therefore, this section does not serve as a guide to all engines, but as an outline describing the operation of a hydrogen engine and its major components, its benefits, drawbacks and how components can be modified or redesigned to reduce the drawbacks.

In general, getting an internal combustion engine to run on hydrogen is not difficult. Getting an internal combustion engine to gain astronomical MPG gains, however, is more of a challenge. This section points out the key components and techniques required to make the difference between a hydrogen engine that just runs and one that runs well.

The earliest attempt at developing a hydrogen engine was reported by Reverend W. Cecil in 1820. Cecil presented his work before the Cambridge Philosophical Society in a paper entitled "On the Application of Hydrogen Gas to Produce Moving Power in Machinery."

The engine itself operated on the vacuum principle, in which atmospheric pressure drives a piston back against a vacuum to produce power. The vacuum is created by burning a hydrogen-air mixture, allowing it to expand and then cool. Although the engine ran satisfactorily, vacuum engines never became practical.

Please keep in mind that we are talking about engines that ONLY run on hydrogen at this point; not gas and HHO.

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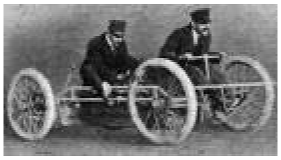
Sixty years later, during his work with combustion engines in the 1860s and 1870s, N. A. Otto (the inventor of the Otto cycle) reportedly used a synthetic producer gas for fuel, which probably had a hydrogen content of over 50%.

Otto also experimented with gasoline, but found it dangerous to work with, prompting him to return to using gaseous fuels. The development of the carburetor, however, initiated a new era in which gasoline could be used both practically and safely, and interest in other fuels subsided.



Hydrogen has since been used extensively in the space program since it has the best energy-to-weight ratio of any fuel. Liquid hydrogen is the fuel of choice for rocket engines, and has been utilized in the upper stages of launch vehicles on many space missions including the Apollo missions to the moon, Skylab, the Viking missions to Mars and the Voyager mission to Saturn.

In recent years, the concern for cleaner air, along with stricter air pollution regulation and the desire to reduce the dependency on fossil fuels have rekindled the interest in hydrogen as a vehicular fuel.

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Combustive Properties of Hydrogen

The properties that contribute to its use as a combustible fuel are its:

- Wide range of flammability
- Low ignition energy
- Small quenching distance
- High autoignition temperature
- High flame speed at stoichiometric ratios
- High diffusivity
- Very low density

Wide Range of Flammability

Hydrogen has a wide flammability range in comparison with all other fuels. As a result, hydrogen can be combusted in an internal combustion engine over a wide range of fuel-air mixtures.

A significant advantage of this is that hydrogen can run on a lean mixture. A lean mixture is one in which the amount of fuel is less than the theoretical, stoichiometric or chemically ideal amount needed for combustion with a given amount of air.

This is why it is fairly easy to get an engine to start on hydrogen. Generally, fuel economy is greater and the combustion reaction is more complete when a vehicle is run on a lean mixture.

Additionally, the final combustion temperature is generally lower, reducing the amount of pollutants, such as nitrogen oxides, emitted in the exhaust. There is a limit to how lean the engine can be run, as lean operation can significantly reduce the power output due to a reduction in the volumetric heating value of the air/fuel mixture.

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Low Ignition Energy

Hydrogen has very low ignition energy. The amount of energy needed to ignite hydrogen is about one order of magnitude less than that required for gasoline. This enables hydrogen engines to ignite lean mixtures and ensures prompt ignition.

Unfortunately, the low ignition energy means that hot gases and hot spots on the cylinder can serve as sources of ignition, creating problems of premature ignition and flashback.

Preventing this is one of the challenges associated with running an engine on hydrogen. The wide flammability range of hydrogen means that almost any mixture can be ignited by a hot spot. This, however, is not the case with a gas engine using a HOD system.

Small Quenching Distance

Hydrogen has a small quenching distance, smaller than gasoline. Consequently, hydrogen flames travel closer to the cylinder wall than other fuels before they extinguish. Thus, it is more difficult to quench a hydrogen flame than a gasoline flame.

The smaller quenching distance can also increase the tendency for backfire since the flame from a hydrogen-air mixture more readily passes a nearly closed intake valve, than a hydrocarbon-air flame.

However, because you are primarily using gas as oppose to a full blown hydrogen engine, this does not come into effect. This property of hydrogen ensures a “complete” burn when you ignite the air-gas-hho mixture.

High Autoignition Temperature

Hydrogen has a relatively high autoignition temperature. This has important implications when a hydrogen-air mixture is compressed. In fact, the autoignition temperature is an important factor in determining what

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compression ratio an engine can use, since the temperature rise during compression is related to the compression ratio.

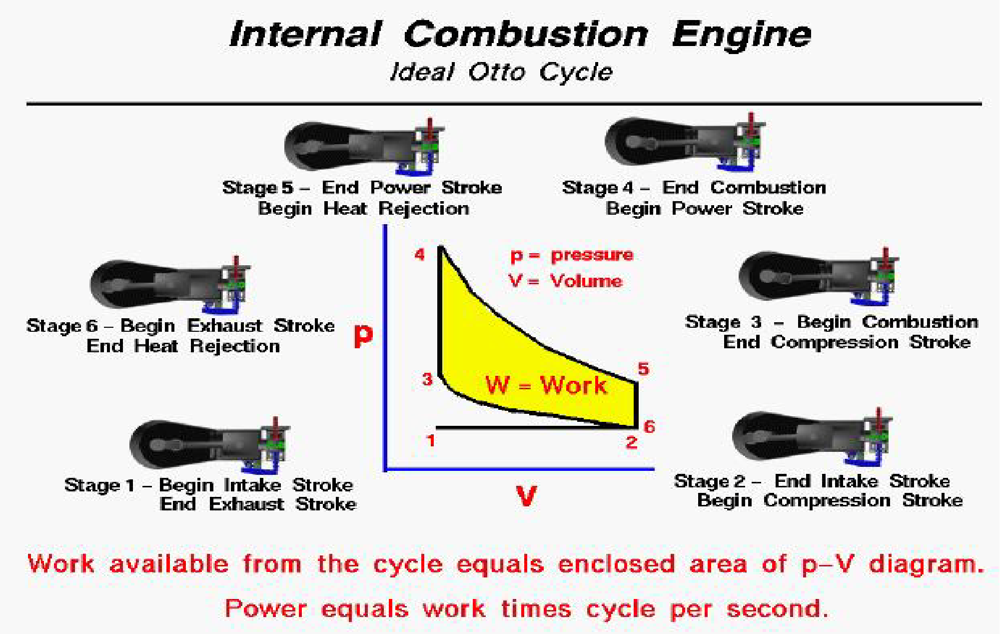
The temperature may not exceed hydrogen's autoignition temperature without causing premature ignition. Thus, the absolute final temperature limits the compression ratio. The high autoignition temperature of hydrogen allows larger compression ratios to be used in a hydrogen engine than in a hydrocarbon engine.

This higher compression ratio is important because it is related to the thermal efficiency of the system. On the other hand, hydrogen is difficult to ignite in a compression ignition or diesel configuration, because the temperatures needed for those types of ignition are relatively high.

Again, not the case with your application. Once your diesel engine is ignited, the HHO gas is also ignited and because of its ability to burn so fast and effectively, it will actually burn the diesel faster and more "complete." Remember, efficiency is the key to lowering emissions and improving mpg gain in all engines alike.

High Flame Speed

Hydrogen has high flame speed at stoichiometric ratios. Under these conditions, the hydrogen flame speed is nearly an order of magnitude higher (faster) than that of gasoline. This means that hydrogen engines can more closely approach the thermodynamically ideal engine cycle.



High Diffusivity

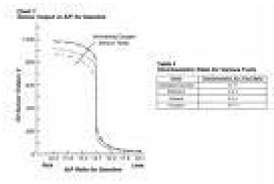
Hydrogen has very high diffusivity. This ability to disperse in air is considerably greater than gasoline and is advantageous for two main reasons. Firstly, it facilitates the formation of a uniform mixture of fuel and air.

Secondly, if a hydrogen leak develops, the hydrogen disperses rapidly. Thus, unsafe conditions can either be avoided or minimized.

Low Density

Hydrogen has very low density. This results in two problems when used in an internal combustion engine. Firstly, a very large volume is necessary to store enough hydrogen to give a vehicle an adequate driving range.

Secondly, the energy density of a hydrogen-air mixture, and hence the power output, is reduced.



Air/Fuel Ratio

The theoretical or stoichiometric combustion of hydrogen and oxygen is given as:

$2H_2 + O_2$ = $2H_2O$
Moles of H_2 for complete combustion = 2 moles
Moles of O_2 for complete combustion = 1 mole

Because air is used as the oxidizer instead oxygen, the nitrogen in the air needs to be included in the calculation:

Moles of N_2 in air = Moles of O_2 x (79% N_2 in air / 21% O_2 in air)
= 1 mole of O_2 x (79% N_2 in air / 21% O_2 in air)
= 3.762 moles N_2
Number of moles of air = Moles of O_2 + moles of N_2
= 1 + 3.762
= 4.762 moles of air
Weight of O_2 = 1 mole of O_2 x 32 g/mole
= 32 g
Weight of N_2 = 3.762 moles of N_2 x 28 g/mole
= 105.33 g
Weight of air = weight of O_2 + weight of N (1)
= 32g + 105.33 g
= 137.33 g
Weight of H_2 = 2 moles of H_2 x 2 g/mole
= 4 g

Stoichiometric air/fuel (A/F) ratio for hydrogen and air is:

A/F based on mass: = mass of air/mass of fuel
= 137.33 g / 4 g
= 34.33:1
A/F based on volume: = volume (moles) of air/volume (moles) of fuel
= 4.762 / 2
= 2.4:1

The percent of the combustion chamber occupied by hydro-gen for a stoichiometric mixture:

% H_2 = volume (moles) of H_2/total volume (2)
= volume H_2/(volume air + volume of H_2)
= 2 / (4.762 + 2)
= 29.6%

As these calculations show, the stoichiometric or chemically correct A/F ratio for the complete combustion of hydrogen in air is about 34:1 by mass. This means that for complete combustion, 34 pounds of air are required for every pound of hydrogen. This is much higher than the 14.7:1 A/F ratio required for gasoline.

Since hydrogen is a gaseous fuel at ambient conditions it displaces more of the combustion chamber than a liquid fuel. Consequently less of the combustion chamber can be occupied by air. At stoichiometric conditions, hydrogen displaces about 30% of the combustion chamber, compared to about 1 to 2% for gasoline.

Depending the method used to meter the hydrogen to the engine, the power output compared to a gasoline engine can be anywhere from 85% (intake manifold injection) to 120% (high pressure injection).

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Because of hydrogen's wide range of flammability, hydrogen engines can run on A/F ratios of anywhere from 34:1 (stoichiometric) to 180:1. The A/F ratio can also be expressed in terms of equivalence ratio, denoted by phi (Φ). Phi is equal to the stoichiometric A/F ratio divided by the actual A/F ratio. For a stoichiometric mixture, the actual A/F ratio is equal to the stoichiometric A/F ratio and thus the phi equals unity (one).

For lean A/F ratios, phi will be a value less than one. For example, a phi of 0.5 means that there is only enough fuel available in the mixture to oxidize with half of the air available. Another way of saying this is that there is twice as much air available for combustion than is theoretically required.

Air to fuel mixture: (Defined by Wikipedia)

Air-fuel ratio (AFR) is the mass ratio of air to fuel present during combustion. When all the fuel is combined with all the free oxygen, typically within a vehicle's combustion chamber, the mixture is chemically balanced and this AFR is called the stoichiometric mixture (often abbreviated to **stoich**). AFR is an important measure for anti-pollution and performance tuning reasons. Lambda (λ) is an alternative way to represent AFR.

In industrial fired heaters, power plant steam generators, and large gas-fired turbines, the more common term is **percent excess combustion air**. For example, excess combustion air of 15 percent means that 15 percent more than the required stoichiometric air is being used. A mixture is the working point that modern engine management systems employing fuel injection attempt to achieve in light load cruise situations. For gasoline fuel, the stoichiometric air/fuel mixture is approximately 14.7 times the mass of air to fuel. Any mixture less than 14.7 to 1 is considered to be a rich mixture, any more than 14.7 to 1 is a lean mixture - given perfect (ideal) "test" fuel (gasoline consisting of solely n-heptane and isooctane).

In reality, most fuels consist of a combination of heptane, octane, a handful of other alkanes, plus additives including detergents, and possibly oxygenators such as MTBE (methyltertbutyl ether) or ethanol/methanol. These compounds all alter the stoichiometric ratio, with most of the additives pushing the ratio downward (oxygenators bring extra oxygen to the combustion event in liquid form that is released at time of combustions; for MTBE-laden fuel, a stoichiometric ratio can be as low as 14.1:1).

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Pre-Ignition Problems and Solutions

The primary problem that has been encountered in the development of operational hydrogen engines is premature ignition. Premature ignition is a much greater problem in hydrogen fueled engines than in other IC engines, because of hydrogen's lower ignition energy, wider flammability range and shorter quenching distance.

Premature ignition occurs when the fuel mixture in the combustion chamber becomes ignited before ignition by the spark plug, and results in an inefficient, rough running engine. Backfire conditions can also develop if the premature ignition occurs near the fuel intake valve and the resultant flame travels back into the induction system.

A number of studies have been aimed at determining the cause of pre-ignition in hydrogen engines. Some of the results suggest that pre-ignition are caused by hot spots in the combustion chamber, such as on a spark plug or exhaust valve, or on carbon deposits. Other research has shown that backfire can occur when there is overlap between the openings of the intake and exhaust valves.

It is also believed that the pyrolysis (chemical decomposition brought about by heat) of oil suspended in the combustion chamber or in the crevices just above the top piston ring can contribute to pre-ignition. This pyrolysed oil can enter the combustion chamber through blow-by from the crankcase (i.e. past the piston rings), through seepage past the valve guide seals and/or from the positive crankcase ventilation system (i.e. through the intake manifold).

Keep in mind that this is true for 100% independently fueled hydrogen engines. Your gas, diesel, LPG or natural gas is only seeing a small amount of HHO gas so these conditions are deamplified greatly and will not affect your engine in this manner.

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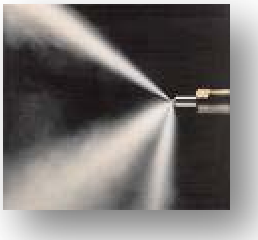

Fuel Delivery Systems

Adapting or re-designing the fuel delivery system can be effective in reducing or eliminating pre-ignition.

Hydrogen fuel delivery systems can be broken down into three main types:

- Central Injection (or "Carbureted")
- Port Injection
- Direct Injection.

Central and port fuel delivery systems injection form the fuel-air mixture during the intake stroke. In the case of central injection or a carburetor, the injection is at the inlet of the air intake manifold. In the case of port injection, it is injected at the inlet port of the cylinder head.

Direct cylinder injection is more technologically sophisticated and involves forming the fuel-air mixture inside the combustion cylinder after the air intake valve has closed.

Central Injection or Carbureted Systems

The simplest method of delivering fuel to a hydrogen engine is by way of a carburetor or central injection system. This system has advantages for a hydrogen engine. Firstly, central injection does not require the hydrogen supply pressure to be as high as for other methods.

Secondly, central injection or carburetors are used on gasoline engines, making it easy to convert a standard gasoline engine to a hydrogen or a gasoline/hydrogen engine like you are doing now.

The disadvantage of central injection is that it is more susceptible to irregular combustion due to pre-ignition and backfire. The greater amount of hydrogen/air mixture within the intake manifold compounds the effects of pre-ignition which does not apply to a HHO/gasoline hybrid.

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Port Injection Systems

The port injection fuel delivery system injects fuel directly into the intake manifold at each intake port, rather than drawing fuel in at a central point. Typically, the hydrogen is injected into the manifold after the beginning of the intake stroke. At this point conditions are much less severe and the probability for premature ignition is reduced.

In port injection, the air is injected separately at the beginning of the intake stroke to dilute the hot residual gases and cool any hot spots. Since less gas (hydrogen or air) is in the manifold at any one time, any pre-ignition is less severe. The inlet supply pressure for port injection tends to be higher than for carbureted or central injection systems, but less than for direct injection systems.

The constant volume injection (CVI) system uses a mechanical cam-operated device to time the injection of the hydrogen to each cylinder. The CVI block has one fuel line for each cylinder. The electronic fuel injection (EFI) system meters the hydrogen to each cylinder.

This system uses individual electronic fuel injectors (solenoid valves) for each cylinder and are plumbed to a common fuel rail located down the center of the intake manifold. Whereas the CVI system uses constant injection timing and variable fuel rail pressure, the EFI system uses variable injection timing and constant fuel rail pressure.

Direct Injection Systems

More sophisticated hydrogen engines use direct injection into the combustion cylinder during the compression stroke. In direct injection, the intake valve is closed when the fuel is injected, completely avoiding premature ignition during the intake stroke. Consequently the engine cannot backfire into the intake manifold.

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The power output of a direct injected hydrogen engine is 20% more than for a gasoline engine and 42% more than a hydrogen engine using a carburetor.

While direct injection solves the problem of pre-ignition in the intake manifold, it does not necessarily prevent pre-ignition within the combustion chamber.

In addition, due to the reduced mixing time of the air and fuel in a direct injection engine, the air/fuel mixture can be non-homogenous. Studies have suggested this can lead to higher NOx emissions than the non-direct injection systems. Direct injection systems require a higher fuel rail pressure than the other methods.

Thermal Dilution

Pre-ignition conditions can be curbed using thermal dilution techniques such as exhaust gas recirculation (EGR) or water injection.

As the name implies, an EGR system recirculates a portion of the exhaust gases back into the intake manifold. The introduction of exhaust gases helps to reduce the temperature of hot spots, reducing the possibility of pre-ignition. Almost all vehicles today have this system in place.

Additionally, recirculating exhaust gases reduce the peak combustion temperature, which reduces NOx emissions. Typically a 25 to 30% recirculation of exhaust gas is effective in eliminating backfire.

On the other hand, the power output of the engine is reduced when using EGR. The presence of exhaust gases reduces the amount of fuel mixture that can be drawn into the combustion chamber. Another technique for thermally diluting the fuel mixture is the injection of water.

Injecting water into the hydrogen stream prior to mixing with air has produced better results than injecting it into the hydrogen-air mixture within the intake manifold. A potential problem with this type of system is that water can get mixed with the oil, so care must be taken to ensure that seals do not leak.

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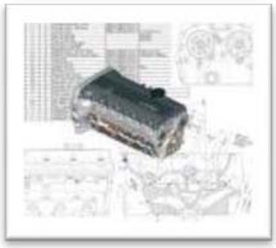
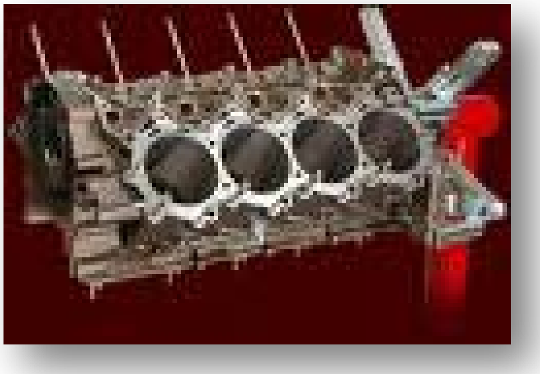


The method of water injection is viable in both performance and gains in fuel economy but I do not recommend it for the common folk.

Engine Design

The most effective means of controlling pre-ignition and knock is to redesign the engine for hydrogen use, specifically the combustion chamber and the cooling system. A disk-shaped combustion chamber (with a flat piston and chamber ceiling) can be used to reduce turbulence within the chamber.

The disk shape helps produce low radial and tangential velocity components and does not amplify inlet swirl during compression. Since unburned hydrocarbons are not a concern in hydrogen engines, a large bore-to-stroke ratio can be used with this engine.



To accommodate the wider range of flame speeds that occur over a greater range of equivalence ratios, two spark plugs are needed. The cooling system must be designed to provide uniform flow to all locations that need cooling.

Additional measures to decrease the probability of pre-ignition are the use of two small exhaust valves as opposed to a single large one, and the development of an effective scavenging system, that is, a means of displacing exhaust gas from the combustion chamber with fresh air.

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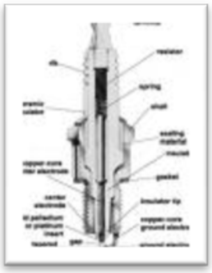
Ignition Systems

Due to hydrogen’s low ignition energy limit, igniting hydrogen is easy and gasoline ignition systems can be used. At very lean air/fuel ratios (130:1 to 180:1) the flame velocity is reduced considerably and the use of a dual spark plug system is preferred.

Ignition systems that use a waste spark system should not be used for hydrogen engines. These systems energize the spark each time the piston is at top dead center whether or not the piston is on the compression stroke or on its exhaust stroke.



For gasoline engines, waste spark systems work well and are less expensive than other systems. For hydrogen engines, the waste sparks are a source of pre-ignition.

Spark plugs for a hydrogen engine should have a cold rating tips. A cold-rated plug is one that transfers heat from the plug tip to the cylinder head quicker than a hot-rated spark plug. This means the chances of the spark plug tip igniting the air/fuel charge is reduced.

Hot-rated spark plugs are designed to maintain a certain amount of heat so that carbon deposits do not accumulate. Since hydrogen does not contain carbon, hot-rated spark plugs do not serve a useful function.

Your G4FREE system requires no change in ignition.

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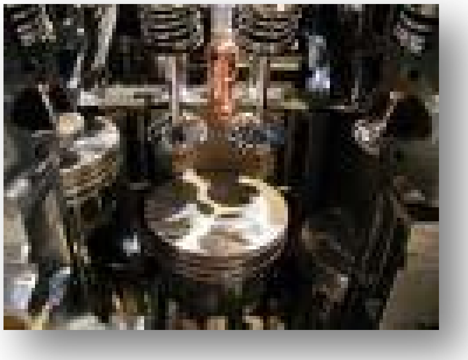

Some of the many things that can happen to your spark plugs

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Common spark plug conditions

NORMAL

Symptoms: Brown to grayish-tan color and slight electrode wear. Correct heat range for engine and operating conditions.

Recommendation: When new spark plugs are installed, replace with plugs of the same heat range.

WORN

CARBON DEPOSITS

ASH DEPOSITS

OIL DEPOSITS

GAP BRIDGING

TOO HOT

PREIGNITION

HIGH SPEED GLAZING

DETONATION

MECHANICAL DAMAGE

Crankcase Ventilation

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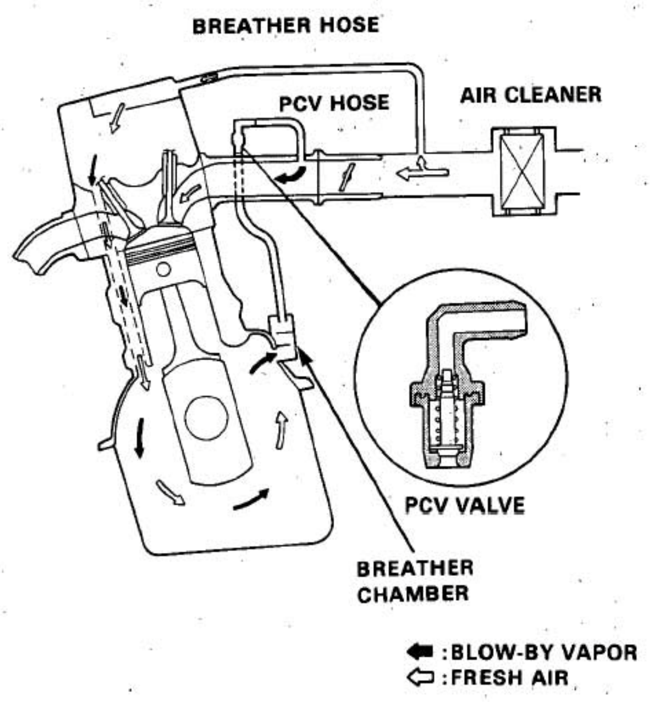
Crankcase ventilation is even more important for hydrogen engines than for gasoline engines. As with gasoline engines, unburnt fuel can seep by the piston rings and enter the crankcase.

Since hydrogen has a lower energy ignition limit than gasoline, any unburnt hydrogen entering the crankcase has a greater chance of igniting. Hydrogen should be prevented from accumulating through ventilation.

Ignition within the crankcase can be just a startling noise or result in engine fire. When hydrogen ignites within the crankcase, a sudden pressure rise occurs.

To relieve this pressure, a pressure relief valve must be installed on the valve cover. Exhaust gases can also seep by the piston rings into the crankcase.

Since hydrogen exhaust is water vapor, water can condense in the crankcase when proper ventilation is not provided. The mixing of water into the crankcase oil reduces its lubrication ability, resulting in a higher degree of engine wear. Again, not the case with you gas4free system.



Thermal Efficiency

The theoretical thermodynamic efficiency of an Otto cycle engine is based on the compression ratio of the engine and the specific-heat ratio of the fuel as shown in the equation:

$$\mathbf{n}_{th} = 1 - \frac{1}{\left(\frac{V_1}{V_2}\right)} \; y_1$$

Where:

V_1/V_2 = the compression ratio
γ = ratio of specific heats

η_{th} = theoretical thermodynamic efficiency

The higher the compression ratio and/or the specific heat ratio, the higher the indicated thermodynamic efficiency of the engine. The compression ratio limit of an engine is based on the fuel’s resistance to knock.

A lean hydrogen mixture is less susceptible to knock than conventional gasoline and therefore can tolerate higher compression ratios.
The specific-heat ratio is related to the fuel’s molecular structure.

The less complex the molecular structure, the higher the specific-heat ratio.

Hydrogen ($\gamma = 1.4$) has a much simpler molecular structure than gasoline and therefore its specific-heat ratio is higher than that of conventional gasoline ($\gamma = 1.1$).

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Emissions

The combustion of hydrogen with oxygen produces water as its only product:

$2H_2 + O_2 = 2H_2O$

The combustion of hydrogen with air however can also produce oxides of nitrogen (NOx):

$H_2 + O_2 + N_2 = H_2O + N_2 + NO_x$

The oxides of nitrogen are created due to the high temperatures generated within the combustion chamber during combustion. This high temperature causes some of the nitrogen in the air to combine with the oxygen in the air. The amount of NOx formed depends on:

- The air/fuel ratio
- The engine compression ratio
- The engine speed
- The ignition timing
- Whether thermal dilution is utilized

In addition to oxides of nitrogen, traces of carbon monoxide and carbon dioxide can be present in the exhaust gas, due to seeped oil burning in the combustion chamber.

Depending on the condition of the engine (burning of oil) and the operating strategy used (a rich versus lean air/fuel ratio), a hydrogen engine can produce from almost zero emissions (as low as a few ppm) to high NOx and significant carbon monoxide emissions.

Figure E-1 illustrates a typically NOx curve relative to phi for a hydrogen engine. A similar graph including other emissions is shown in Figure E-2 for gasoline. (Shown in next page)

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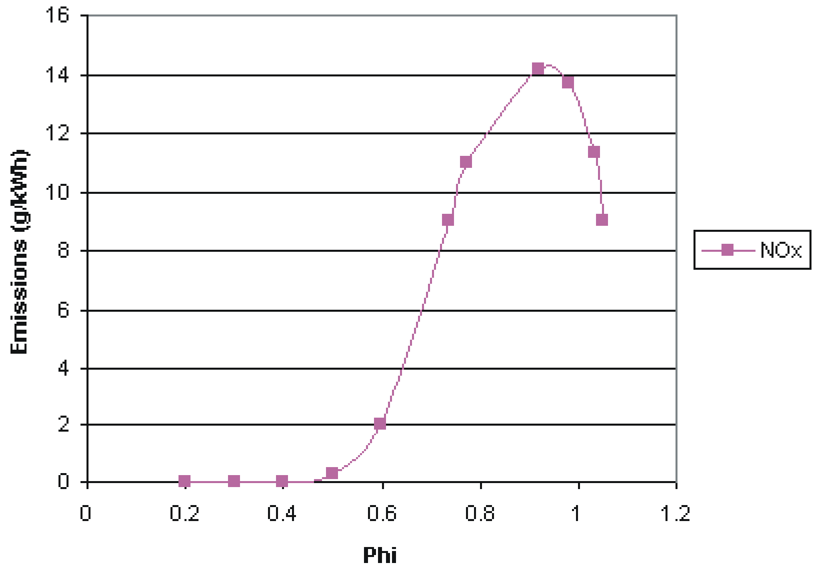

Figure E-1: Emissions for a Hydrogen Engine

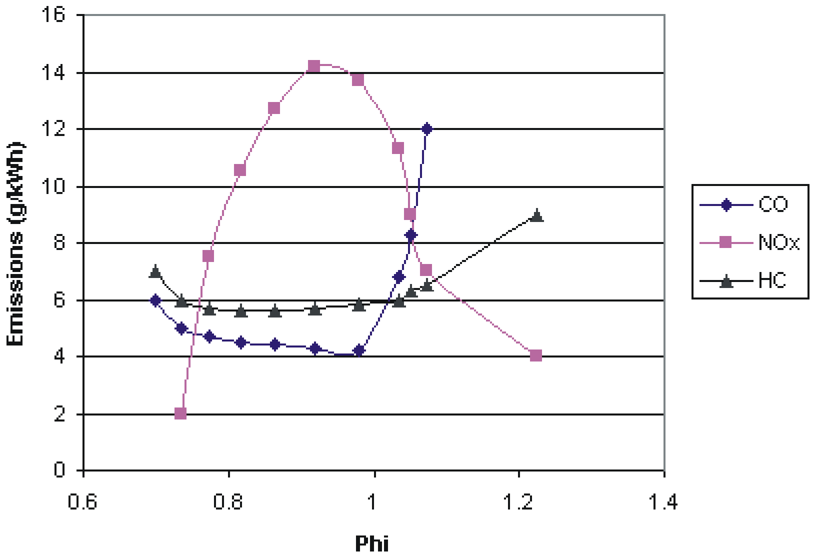

Figure E-2: Emissions for a Gasoline Engine

As Figure E-2 shows, the NOx for a gasoline engine is reduced as phi decreases (similar to a hydrogen engine). However, in a gasoline engine the reduction in NOx is compromised by an increase in carbon monoxide and hydrocarbons.

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Power Output

The theoretical maximum power output from a hydrogen engine depends on the air/fuel ratio and fuel injection method used. The stoichiometric air/fuel ratio for hydrogen is 34:1. At this air/fuel ratio, hydrogen will displace 29% of the combustion chamber leaving only 71% for the air.

As a result, the energy content of this mixture will be less than it would be if the fuel were gasoline (since gasoline is a liquid, it only occupies a very small volume of the combustion chamber, and thus allows more air to enter). Since both the carbureted and port injection methods mix the fuel and air prior to it entering the combustion chamber, these systems limit the maximum theoretical power obtain-able to approximately 85% of that of gasoline engines.

For direct injection systems, which mix the fuel with the air after the intake valve has closed (and thus the combustion chamber has 100% air), the maximum output of the engine can be approximately 15% higher than that for gasoline engines. Therefore, depending on how the fuel is metered, the maxi-mum output for a hydrogen engine can be either 15% higher or 15% less than that of gasoline if a stoichiometric air/fuel ratio is used.

However, at a stoichiometric air/fuel ratio, the combustion temperature is very high and as a result it will form a large amount of nitrogen oxides (NOx), which is a criteria pollutant. Since one of the reasons for using hydrogen is low exhaust emissions, hydrogen engines are not normally designed to run at a stoichiometric air/fuel ratio.

Typically hydrogen engines are designed to use about twice as much air as theoretically required for complete combustion. At this air/fuel ratio, the formation of NOx is reduced to near zero. Unfortunately, this also reduces the power out-put to about half that of a similarly sized gasoline engine.

To make up for the power loss, hydrogen engines are usually larger than gasoline engines, and/or are equipped with turbochargers or superchargers.

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Current Status

A few auto manufacturers have been doing some work in the development of hydrogen-powered vehicles (Ford has recently announced that they have developed a "production ready" hydrogen-powered vehicle using an ICE and BMW has completed a world tour displaying a dozen or so hydro-gen-powered 750i vehicles).

However, it is not likely that any hydrogen-powered vehicles will be available to the public until there is an adequate refueling infrastructure and trained technicians to repair and maintain these vehicles.

Like current gasoline-powered vehicles, the design of each hydrogen-powered vehicle will most likely vary from manufacturer to manufacturer and model to model.

One model may be simple in design and operation, for example, a lean-burning fuel metering strategy using no emission control systems such as EGR, catalytic converter, evaporate fuel canister, etc. Another model may be very sophisticated in design and operation, for example, using an EGR fuel metering strategy with a catalytic converter, multiple spark plugs, etc.

Until such time that a hydrogen infrastructure exists, hydrogen/natural gas fuel blends provide a logical transition to fully hydrogen-powered vehicles. These vehicles can operate on either fuel, depending on availability.

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HHO & GAS

The “Dynamic Duo” of MPG Gains?

You now have basic knowledge of how a hydrogen engine works. But you don’t have a hydrogen engine now do you? Now that you have some info under your belt, it’s time to tie HHO and Gas into a knot. It is not important to keep all that information on your mind, but rather use it to compare the dynamics of a gasoline internal combustion engine.

It’s time to show you…

- **What is happening in my engine**
- **How am I saving gas**
- **How am I increasing performance**
- **How am I helping the environment**

All of these questions will be answered simply by comparing. As you read through the different sections of the last chapter you noticed that a true 100% hydrogen burning engine inherent problems of its own, so I will go over some of those sections again. This time I will be explaining the dynamics of a gas engine with HHO gas supplement and paint you a mental picture for easy understanding.

Here are the sections we are going to tackle:

- Combustive Properties of HHO & Gas
- Air to Fuel Ratios
- Pre-ignition
- Fuel Delivery
- Thermal Dilution
- Engine Design
- Crankcase Ventilation
- Thermal Efficiency
- Emissions
- Power Output
- Hydrogen Gas Mixtures

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Combustive Properties of HHO & Gas

Overall, Gasoline has incredible results when supplemented with HHO gas. This relationship between HHO and gas is definitely the next big step in fueling our automotive need right now. After reading this book, you'll be glad you purchased this great resource. Let move on.

Again, I will go over each sub section:

- Wide range of flammability
- Low ignition energy
- Small quenching distance
- High autoignition temperature
- High flame speed at stoichiometric ratios
- High diffusivity
- Very low density

Wide Range of Flammability

Hydrogen has a wide flammability range in comparison with gas. This also means that it ignites sooner as well. Gas' air to fuel ratio is 14.7 to 1 or 14.7:1 but once you start veering off to ether the "Rich" or "Lean" ends of the scale you will begin to lose performance, increase hydrocarbon and NOx pollution and begin to add strain to the motor itself.

Hydrogen however, is fuel ratio friendly. For guys that wish to run that SBC (Small Block Chevrolet) or SBF (Small Block Ford) motor in their hotrods or muscle cars, they can still reap the rewards of this great technology. For the true "green car" running a lean burn system, this is not a problem.

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You already know that hydrogen can run on a lean mixture too. Fuel economy is greater and the combustion reaction is more complete when a vehicle is run on a lean mixture.

Low ignition energy

HHO has very low ignition energy. The amount of energy needed to ignite hydrogen is about one order of magnitude less than that required for gasoline. This enables hydrogen engines to ignite lean mixtures and ensures prompt ignition.

If you are thinking that a hot spot in the combustion chamber might pre-ignite the HHO gas, think again. Your engine is still a gas burning engine. You are only SUPPLIMENTING your engine will hydrogen.

So preventing this is one of challenge you need not bother.

Small Quenching Distance

Hydrogen has a small quenching distance, smaller than gasoline. Consequently, hydrogen flames travel closer to the cylinder wall than other fuels before they extinguish. Thus, it is more difficult to quench a hydrogen flame than a gasoline flame.

This is great for gas engines because it will help thoroughly burn the gas when ignited. This is how it starts to burn-off most of the unburnt fuel to increase its efficiency. It’s like have a blow-torch as a spark plug.

Again, because you are primarily using gas as oppose to a full blown hydrogen engine, this action ensures a “complete” burn when you ignite the air-gas-hho mixture.

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High Autoignition Temperature

Hydrogen has a relatively high autoignition temperature. This has important implications when a hydrogen-air mixture is compressed. In fact, the autoignition temperature is an important factor in determining what compression ratio an engine can use, since the temperature rise during compression is related to the compression ratio.

The temperature may not exceed hydrogen’s autoignition temperature without causing premature ignition. Thus, the absolute final temperature limits the compression ratio. But gasoline engines general can withstand a higher compression ratio. The mix of gas with HHO results in higher resistance to autoignition. So using HHO gas as a supplement yet again posses no interference.

Higher compression ratios are important because it is related to the thermal efficiency of the system.

High Flame Speed

Hydrogen has high flame speed at stoichiometric ratios. Under these conditions, the hydrogen flame speed is nearly an order of magnitude higher (faster) than that of gasoline. This means that hydrogen engines can more closely approach the thermodynamically ideal engine cycle. That means more time to burn the gas in your engine.

When your spark plug ignites the fuel mixture, the flame starts at the tip of the plug and works its way out. Using HHO gas speeds up the process which is one of the reasons you get a better burn.

High Diffusivity

Hydrogen has very high diffusivity. This ability to disperse in air is considerably greater than gasoline and is advantageous for two main reasons.

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Firstly, it facilitates the formation of a uniform mixture of fuel and air. This just means it mixes with air very well. This is important as an even amount of gas is spread throughout the combustion chamber.

Secondly, if a HHO gas leak develops, the hydrogen disperses rapidly. Thus, unsafe conditions can either be avoided or minimized. Another added safety bonus.

Low Density

Hydrogen has very low density. This results in two problems when not injecting it in high pressure.

Firstly, a very large volume is necessary to store enough hydrogen to give a vehicle an adequate driving range. But because you are making HHO gas from water, a compact state of HHO, the storage problem is solved and it is completely safe!

Secondly, the energy density of a hydrogen-air mixture, and hence the power output, is reduced. Gasoline is fed to the engine in liquid form (compact energy). HHO is in a gas state of matter and would require a greater volume area to reach its highest potential. You are using HHO gas not to only supplement gasoline you will be removing from the mix but to help gasoline surpass its limitations.

Gasoline and HHO gas were destined to be used together. There properties truly complement one another.

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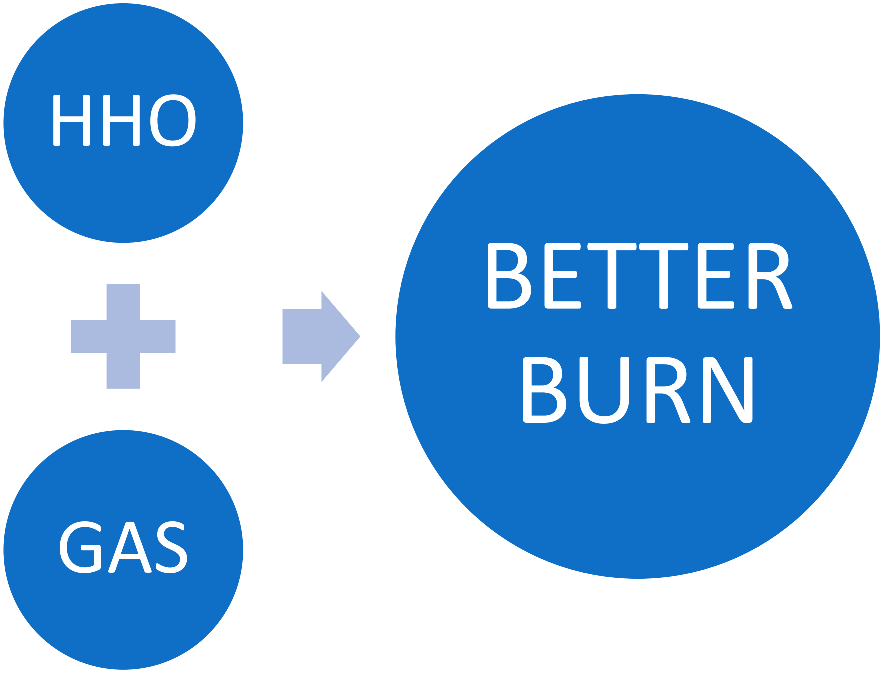
Air to Fuel Ratios

The stoichiometric or chemically correct A/F ratio for the complete combustion of hydrogen in air is about 34:1 by mass. This means that for complete combustion, 34 pounds of air are required for every pound of hydrogen. This is much higher than the 14.7:1 A/F ratio required for gasoline.

Gas' stoichiometric air to fuel ratio is 14.7 to 1 or 14.7 pounds of air to 1 pound of gasoline, but once you start veering off to ether the “Rich” or “Lean” ends of the scale you will begin to lose performance, increase hydrocarbon and NOx pollution and begin to add strain to the motor itself.

Since hydrogen is a gaseous fuel at ambient conditions it displaces more of the combustion chamber than a liquid fuel. Consequently less of the combustion chamber can be occupied by air. At stoichiometric conditions, hydrogen displaces about 30% of the combustion chamber, compared to about 1 to 2% for gasoline.

Again, gasoline is fed to the engine in liquid form (compact energy). HHO is in a gas state of matter and would require a greater volume area to reach its highest potential. You are using HHO gas not to only supplement the gasoline you will be removing from the mix but to help gasoline surpass its efficiency limitations.



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Pre-Ignition Problems and Solutions

The primary problem that has been encountered in the development of operational hydrogen engines is premature ignition. Premature ignition is a much greater problem in hydrogen fueled engines than in other IC engines, because of hydrogen's lower ignition energy, wider flammability range and shorter quenching distance.

Your water hybrid motor should not see this condition as long as the engine is not modified greatly. When I mean greatly, I mean you have installed higher compression heads, a very lumpy camshaft (High Lift + Long Duration), Advanced the timing and so on. Don't get me wrong, you can still use this system on an engine like that but it will require some tweaking.

Premature ignition occurs when the fuel mixture in the combustion chamber becomes ignited before ignition by the spark plug, and results in an inefficient, rough running engine. Backfire conditions can also develop if the premature ignition occurs near the fuel intake valve and the resultant flame travels back into the induction system.

Your engine was designed to run on gas and was tuned for it. So you may think "Well if hydrogen pre-ignites easier than gas, won't I get detonation?" Good Thinking! BUT NO! Remember when I said that hydrogen dissipates well? Well, because it does it becomes harder to ignite. It starts to thin-out which will resist pre-ignition. Out of the 10+ motors I have installed this system on, pre-ignition never occurred.

Keep in mind that this is true for 100% independently fueled hydrogen engines. Your gas, diesel, LPG or natural gas is only seeing a small amount of HHO gas so these conditions are deamplified greatly and will not affect your engine in this manner.

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Fuel Delivery Systems

Let go over the different fuel systems once again. If you are running on diesel, LPG or natural gas; this still applies to you.

Fuel delivery systems can be broken down into three main types:

- Central Injection (or “Carbureted”)
- Port Injection
- Direct Injection.

PLEASE NOTE: I am only explaining how the G4FREE system reacts with all 3 fuel delivery systems! The G4FREE system is a DRAW-BY-DEMAND system; when the engine revs higher, it sucks in more HHO.

Central and port fuel delivery systems inject the fuel-air mixture during the intake stroke. In the case of central injection or a carburetor, the injection is at the inlet of the air intake manifold. In the case of port injection, it is injected at the inlet port of the cylinder head.

Direct cylinder injection is more technologically sophisticated and involves forming the fuel-air mixture inside the combustion cylinder after the air intake valve has closed.

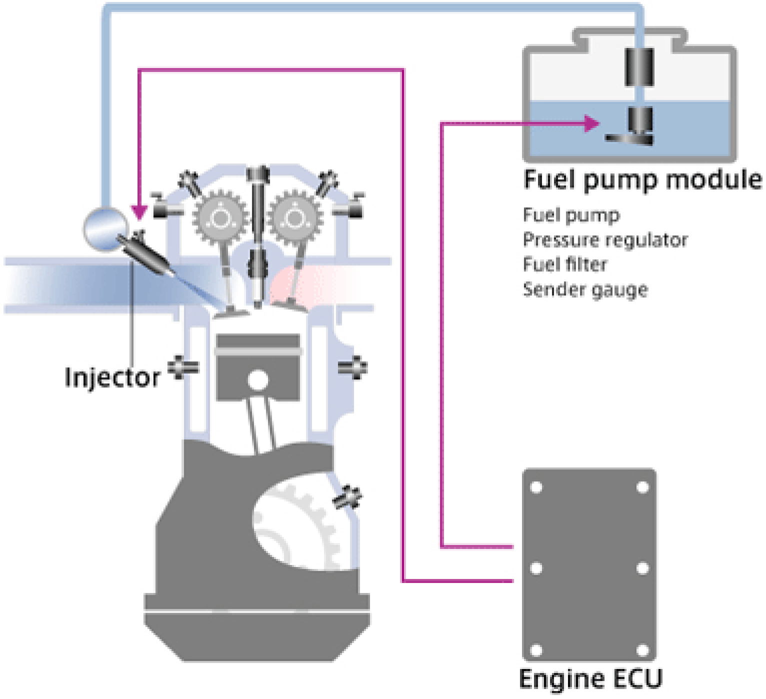
Central Injection or Carbureted Systems

The simplest method of delivering fuel to a engine is by way of a carburetor or central injection system. Central injection does not require a supply pressure to be as high as for other methods.

Central injection or carburetors are used on gasoline engines, making it easy to convert a standard gasoline engine to a gasoline/hydrogen hybrid engine like you are doing now. Because HHO is a gas, it will easily flow through the intake manifold along with the gasoline and enter the combustion chamber with no problems. You are going to change a couple of fuel delivery settings in order to MAXIMIZE gain.

Using a carburetor or throttle body injection system is sees no ill affects and is actually easier to tune.

Port Injection Systems



The port injection fuel delivery system injects fuel directly into the intake manifold at each intake port, rather than drawing fuel in at a central point. Typically, the gasoline is injected into the manifold after the beginning of the intake stroke. At this point conditions are much less severe and the probability for premature ignition is reduced.

In port injection, the air is injected separately at the beginning of the intake stroke to dilute the hot residual gases and cool any hot spots. Since less gas (or air) is in the manifold at any one time, any pre-ignition is less severe. The inlet supply pressure for port injection tends to be higher than for carbureted or central injection systems, but less than for direct injection systems.

The constant volume injection (CVI) system uses a mechanical cam-operated device to time the injection of the hydrogen to each cylinder. The CVI block has one fuel line for each cylinder. The electronic fuel injection (EFI) system meters the gasoline to each cylinder just like the hydrogen.

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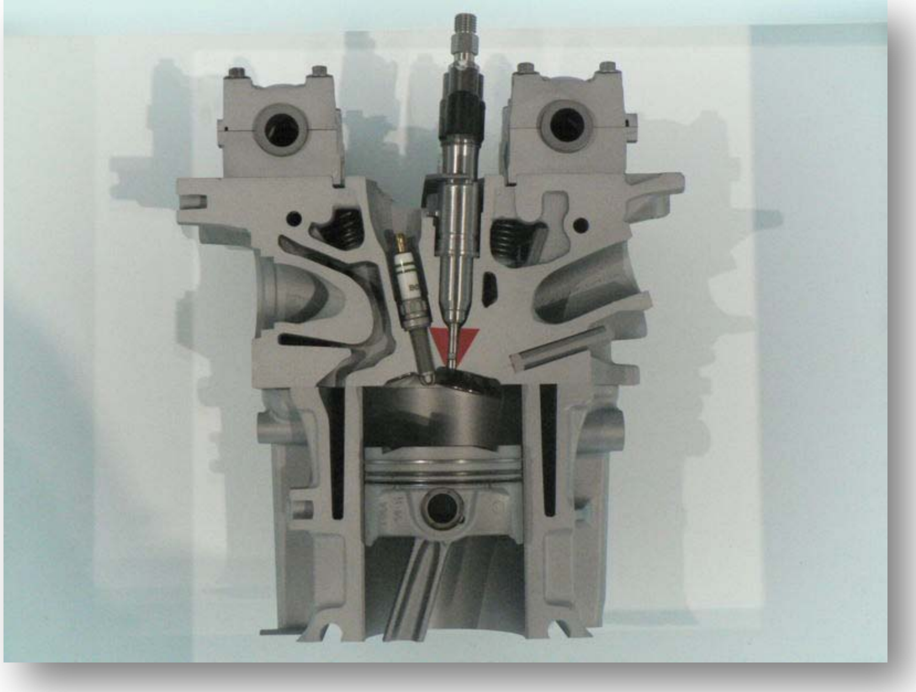
This system uses individual electronic fuel injectors (solenoid valves) for each cylinder and are plumbed to a common fuel rail located down the center of the intake manifold. Whereas the CVI system uses constant injection timing and variable fuel rail pressure, the EFI system uses variable injection timing and constant fuel rail pressure. Here, your G4FREE system still does not interfere with a port injection type system as air, itself a gas, still mixes with the fuel just fine.



Direct Injection Systems

More sophisticated engines use direct injection into the combustion cylinder during the compression stroke. In direct injection, the intake valve is closed when the fuel is injected, completely avoiding premature ignition during the intake stroke. Consequently the engine cannot backfire into the intake manifold.

The power output of a direct injected hydrogen engine is 20% more than for a gasoline engine and 42% more than a hydrogen engine using a carburetor.

In addition, due to the reduced mixing time of the air and fuel in a direct injection engine, the air/fuel mixture can again be non-homogenous. The HHO gas actually helps with emissions because of the faster burn rate. This leads to a lower hydrocarbon ppm count. Go Go HHO!

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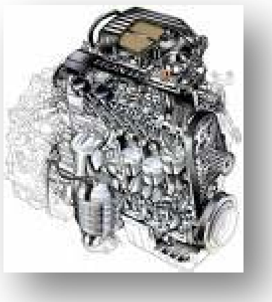
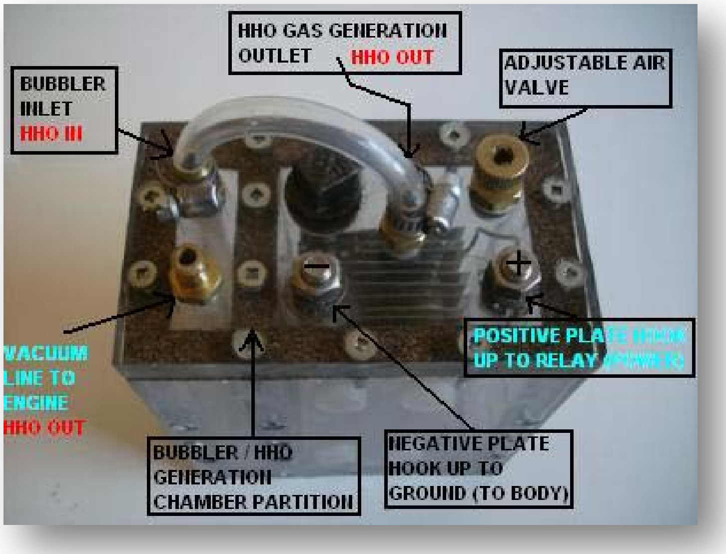


Engine Design

Again, your engine was not designed to run hydrogen alone. That does not mean it cannot work as a gas / HHO hybrid. I am basically trying to drill into your head that there are many people out there who claim to be something they are not. There are folks that say “hydrogen will hurt your motor” or “you are going to have to change your valves (in the cylinder head) to stainless steel valves”. This is just bull!

When you were watching my video where I had the Hydrolyzer running, it seemed like water was being sucked into the engine. That is not what is happening. Those ringlets of water are cause by a high water level (just filled) hydrolyzer in operation. This will stop after 50 miles or so.



The bubbler serves two purposes:

1. To prevent a backfire to the HHO chamber
2. To catch water vapor from entering the engine

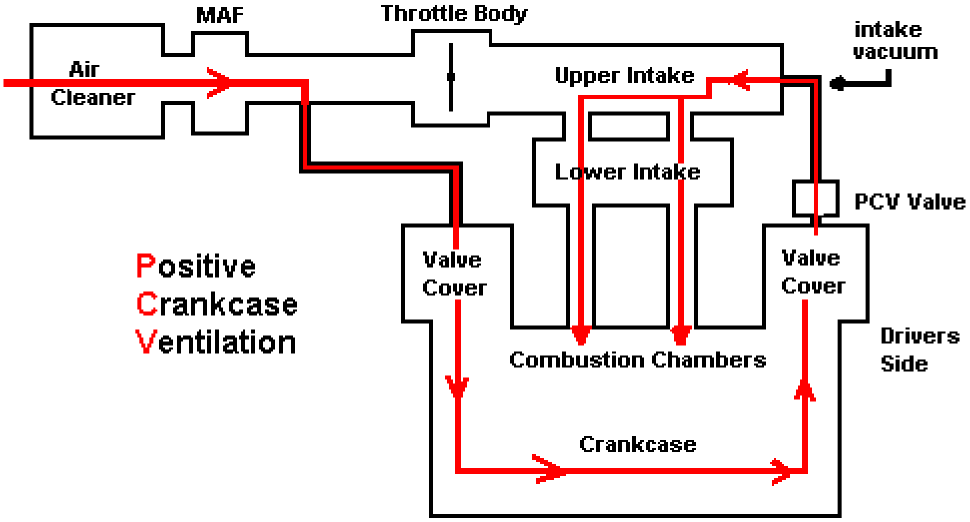
Your engine will work just fine. There is no need to modify it in any way. It doesn’t matter what fuels your engine, HHO gas can be used safely.

Crankcase Ventilation

Crankcase ventilation is even more important for hydrogen engines than for gasoline engines. As with gasoline engines, unburnt fuel can seep by the piston rings and enter the crankcase.

Since hydrogen has a lower energy ignition limit than gasoline, any unburnt hydrogen entering the crankcase has a greater chance of igniting. Hydrogen should be prevented from accumulating through ventilation.

Ignition within the crankcase can be just a startling noise or result in engine fire. When hydrogen ignites within the crankcase, a sudden pressure rise occurs.



Again, not the case with your gas4free system. You are only allowing a partial amount of HHO gas into the engine. The HHO gas will BURN UP and will not reach the crankcase as unburnt fuel. As for water vapor, most of it is burned as well. I have tested this using filters and by engine disassembly to examine the internal effects. No trace of water on an engine that ran 1 year straight with the G4FREE system attached.

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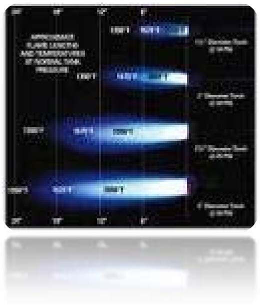

Thermal Efficiency

The theoretical thermodynamic efficiency of an Otto cycle engine is based on the compression ratio of the engine and the specific-heat ratio of the fuel.

You might be looking at all that from before and said “what the heck is all that? Do I need to know that?” The answer is no but for the diehards, myself included, it is what we want to know. I am going to make it easier.

The higher the compression ratio and / or the specific heat ratio; the higher the indicated thermodynamic efficiency of the engine. The compression ratio limit of an engine is based on the fuel’s resistance to knock.

A lean gasoline mixture is more susceptible to knock than hydrogen and therefore cannot handle higher compression ratios as well. The specific-heat ratio is related to the fuel’s molecular structure.

The less complex the molecular structure, the higher the specific-heat ratio.

Hydrogen (γ = 1.4) has a much simpler molecular structure than gasoline and therefore its specific-heat ratio is higher than that of conventional gasoline (γ = 1.1).

What that all means is hydrogen runs better with a high compression engine when it is leaned (less fuel) than gasoline. So again, GOOD NEWS! Your engine is still bound by its gasoline roots and will not differ because if it. This and other factors will change depending on how much HHO gas you intend on using.

Emissions

The combustion of hydrogen with oxygen produces water as its only product:

$2H_2 + O_2 = 2H_2O$

The combustion of hydrogen with air however can also produce oxides of nitrogen (NOx):

$H_2 + O_2 + N_2 = H_2O + N_2 + NO_x$

The oxides of nitrogen are created due to the high temperatures generated within the combustion chamber during combustion. This high temperature causes some of the nitrogen in the air to combine with the oxygen in the air. The amount of NOx formed depends on:

- The air/fuel ratio
- The engine compression ratio
- The engine speed
- The ignition timing
- Whether thermal dilution is utilized

In addition to oxides of nitrogen, traces of carbon monoxide and carbon dioxide can be present in the exhaust gas, due to seeped oil burning in the combustion chamber.

Depending on the condition of the engine (burning of oil) and the operating strategy used (a rich versus lean air/fuel ratio), a hydrogen engine can produce from almost zero emissions (as low as a few ppm) to high NOx and significant carbon monoxide emissions.

Now, with a gasoline motor you are introducing unburnt hydrocarbons and carbon monoxide into the environment. With the help of HHO gas, you can severely drop the levels of those to toxic elements from the very air we breathe. That's something to thing about!

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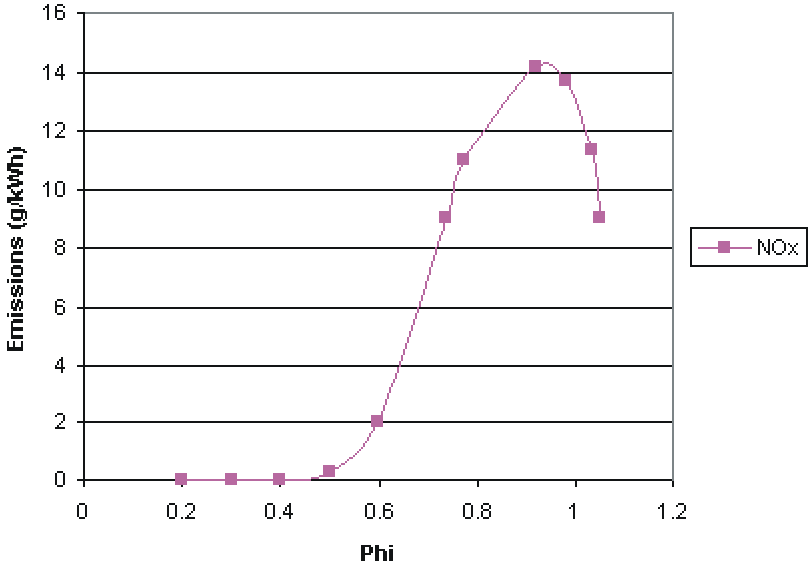

Figure E-1: Emissions for a Hydrogen Engine

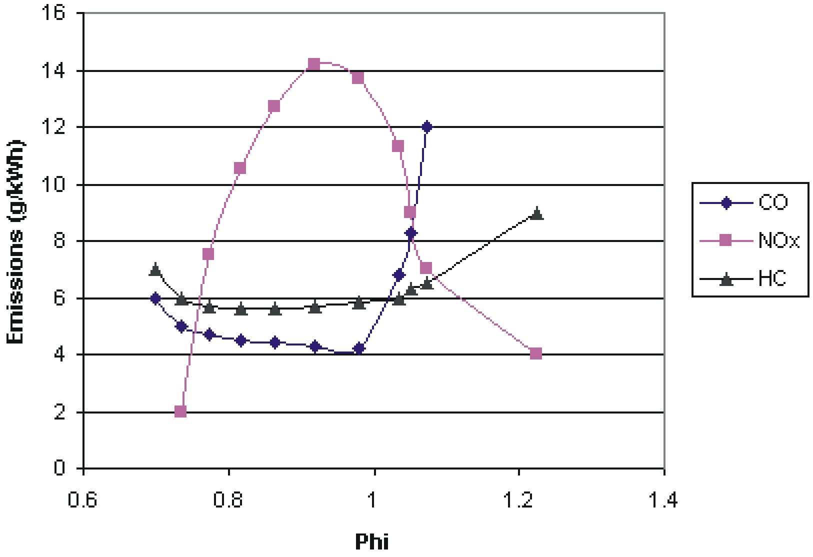

Figure E-2: Emissions for a Gasoline Engine

As Figure E-2 shows, the NOx for a gasoline engine is reduced as phi decreases (similar to a hydrogen engine). However, in a gasoline engine the reduction in NOx is compromised by an increase in carbon monoxide and hydrocarbons.

Expect to cut Figure E-2 by 30% just by installing the G4FREE system. But it doesn’t stop there. **With computer & engine tuning I was able to cut the emissions by 89%!**

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Power Output

The theoretical maximum power output from a hydrogen engine depends on the air/fuel ratio and fuel injection method used. The stoichiometric air/fuel ratio for hydrogen is 34:1. At this air/fuel ratio, hydrogen will displace 29% of the combustion chamber leaving only 71% for the air.

As a result, the energy content of this mixture will be less than it would be if the fuel were gasoline (since gasoline is a liquid, it only occupies a very small volume of the combustion chamber, and thus allows more air to enter). Since both the carbureted and port injection methods mix the fuel and air prior to it entering the combustion chamber, these systems limit the maximum theoretical power obtain-able to approximately 85% of that of gasoline engines.

For direct injection systems, which mix the fuel with the air after the intake valve has closed (and thus the combustion chamber has 100% air), the maximum output of the engine can be approximately 15% higher than that for gasoline engines. Therefore, depending on how the fuel is metered, the maxi-mum output for a hydrogen engine can be either 15% higher or 15% less than that of gasoline if a stoichiometric air/fuel ratio is used.

However, at a stoichiometric air/fuel ratio, the combustion temperature is very high and as a result it will form a large amount of nitrogen oxides (NOx), which is a criteria pollutant. Since one of the reasons for using

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hydrogen is low exhaust emissions, hydrogen engines are not normally designed to run at a stoichiometric air/fuel ratio.

Typically hydrogen engines are designed to use about twice as much air as theoretically required for complete combustion. At this air/fuel ratio, the formation of NOx is reduced to near zero. Unfortunately, this also reduces the power out-put to about half that of a similarly sized gasoline engine.

To make up for the power loss, hydrogen engines are usually larger than gasoline engines, and/or are equipped with turbochargers or superchargers.

The power output for your HHO hybrid will vary. There are far too many different makes, models and engines to possibly know how much you will gain. I will say that a typical install will see a gain of 4 to 10%. But this is all up to you as you are installing this system. You can tune for better economy and slightly less performance than your stock vehicle has.

STOCK VEHICLE:

Manufacture equipped; Unmodified.

I have gained up to 15% in terms of performance but it required a lot of time to work well. It is not something I would recommend to all but I’m sure some gearhead will take on that challenge.

Performance is great to have as a benefit but your sole reason of buying this ebooks is to save gas. And one of the best things you can do for free is change your driving habits. Check out the Hyper Mileing ebook. Great stuff there!

Another thing that will affect performance is how your particular engine burns fuel. If your engine has a design flaw where the fuel does not burn well from the factory, you will see a great improvement of performance as the HHO will help enormously.

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Hydrogen Gas Mixtures

Hydrogen can be used advantageously in internal combustion engines as an additive to a hydrocarbon fuel. Hydrogen is most commonly mixed with high pressure natural gas for this purpose since both gases can be stored in the same tank.

If hydrogen is blended with other fuels, it usually has to be stored separately and mixed in the gaseous state immediately before ignition.

In general, it is impractical to use hydrogen in conjunction with other fuels that also require bulky storage systems, such as propane. Gaseous hydrogen cannot be stored in the same vessel as a liquid fuel. Hydrogen’s low density will cause it to remain on top of the liquid and not mix. Furthermore, liquid fuels are stored at relatively low pressures so that very little hydrogen could be added to the vessel.

Liquid hydrogen cannot be stored in the same vessel as other fuels. Hydrogen’s low boiling point will freeze other fuels resulting in fuel “ice”!
Hydrogen can be used in conjunction with compact liquid fuels such as gasoline, alcohol or diesel provided each are stored separately. In these applications, the fuel tanks can be formed to fit into unused spaces on the vehicle. Existing vehicles of this type tend to operate using one fuel or the other but not both at the same time. One advantage of this strategy is that the vehicle can continue to operate if hydrogen is unavailable. But in your case it is!

One commercially available gas mixture known as Hythane contains 20% hydrogen and 80% natural gas. At this ratio, no modifications are required to a natural gas engine, and studies have shown that emissions are reduced by more than 20%. Mixtures of more than 20% hydrogen with

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natural gas can reduce emissions further but some engine modifications are required.

Lean operation of any internal combustion engine is advantageous in terms of oxides of nitrogen emissions and fuel economy. For hydrocarbon engines, lean operation also leads to lower emissions of carbon monoxide and unburned hydrocarbons.

As more oxygen is available than required to combust the fuel, the excess oxygen oxidizes more carbon monoxide into carbon dioxide, a less harmful emission. The excess oxygen also helps to complete the combustion, decreasing the amount of unburned hydrocarbons.

As with hydrogen, the drawback of lean operation with hydrocarbon fuels is a reduced power output. Lean operation of hydrocarbon engines has additional drawbacks. Lean mixtures are hard to ignite, despite the mixture being above the LFL of the fuel. This results in misfire, which increases unburned hydrocarbon emissions, reduces performance and wastes fuel. Another disadvantage is the reduced conversion efficiency of 3-way catalytic converters, resulting in more harmful emissions.

To some extent, mixing hydrogen with other hydrocarbon fuels reduces all of these drawbacks. Hydrogen's low ignition energy limit and high burning speed makes the hydro-gen/hydrocarbon mixture easier to ignite, reducing misfire and thereby improving emissions, performance and fuel economy.

Regarding power output, hydrogen augments the mixture's energy density at lean mixtures by increasing the hydrogen-to-carbon ratio, and thereby improves torque at wide-open throttle conditions.

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Questions Answered

From reading through all that info, you can see the four main questions are answered. But here is a sum-up again.

- **What is happening in my engine**

  The HHO gas is sucked from the G4FREE system in the air intake. From the air intake, it travels through the intake manifold, into the cylinder head and finally into the combustion chamber with the gasoline.

  The pistons then compress the HHO/Gas/Air mixture and ignite the mix. At that point, the explosion forces the pistons down and the exhaust stroke completes as the pistons come up as the last stroke.

  When HHO gas is burned, water is the natural bi-product of combustion. No, you will not have to upgrade you exhaust to stainless steel. Water is also a bi-product of combustion with propane, gasoline and other fuels as well so not to worry.

- **How am I saving gas**

  As you have slightly reduced the amount of gas your engine normally delivers, HHO gas takes its place but that is not the only way you save gas. More Importantly, It’s the burning process of that occurs.

  You are adopting a “Lean Burn” method of burning fuel. HHO is even more potent that hydrogen and will allow you to get the most of your gasoline. Because gasoline has limits to

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how well it burns, the extra burn adds more explosive punch to the pistons, forcing down harder to turn that engine.

The effect of gas savings will be determent on how much you tune you particular vehicle. Later on in this manual, I will be going over this in detail.

- ## How am I increasing performance

It’s all about that extra burn! The unburnt gas that all engines experience is just potential power going to waste. In fact, these hydrocarbons are harmful to our environment as well.

With the burn properties of HHO, you are actually burn up most of the unburnt fuel, which in turn relates to more power from the engine.

Heat is the other element that contributes to more power. Thermal energy is what drives an engine in the first place. Most of the heat produced in the engine goes right out the tailpipe. Did you know that?

Because the events that occur in an engine happen so fast, anything to help increase heat in an engine without reducing fuel “going too lean” will result in more performance and MPG gains. Yes, you are leaning out the mixture but not by much.

- **How am I helping the environment**

The silent killers of our planet are hydrocarbons, carbon monoxide, carbon dioxide and nitrogen oxide. Because you are burning your fuel more efficiently, you are reducing the amount of these toxins per cycle. This also allows your catalytic converter to operate more efficiently too. Here is something people are unsure of when it comes to NOx:

Nitrogen Oxides (NO_x)

Several air-polluting gases composed of nitrogen and oxygen which play an important role in the formation of photochemical smog. Nitrogen oxides are collectively referred to as "NO_x", where "x" represents a changing proportion of oxygen to nitrogen.

Internal combustion engines are significant contributors to the worldwide nitrogen oxide emissions. For the purpose of emission regulations, NO_x is composed of colorless nitric oxide (NO), and the reddish-brown, very toxic and reactive nitrogen dioxide (NO_2).

Other nitrogen oxides, such as nitrous oxide N_2O (the anesthetic "laughing gas"), are not regulated emissions.

This should help you take some of the guesswork out of figuring what this system is really doing. You now truly see what is happening and continue on your strive to getting gas 4 free.

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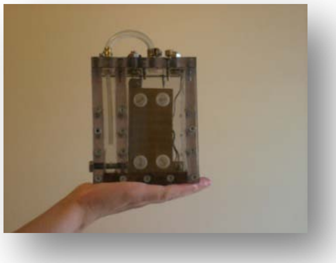


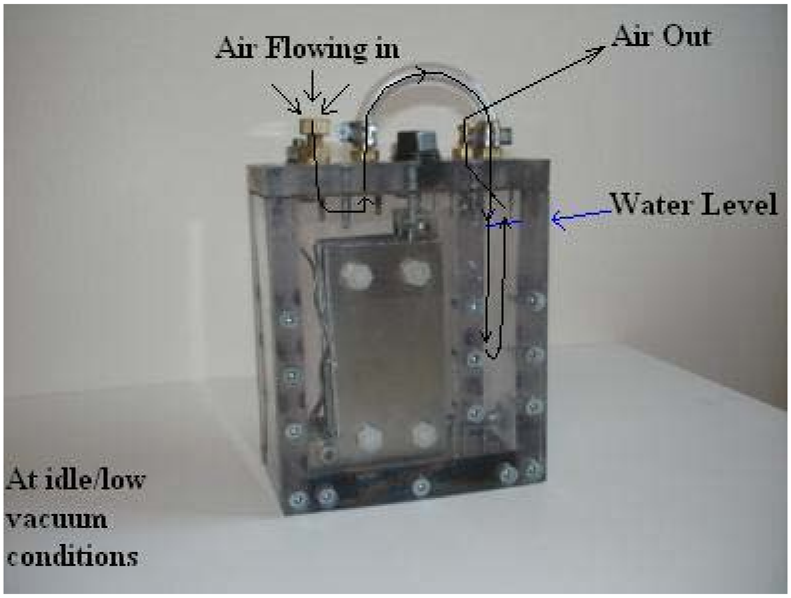
The G4FREE System

So lets get back to your water hybrid; the G4FREE system. In this chapter, I will discuss the following:

- The Vacuum Route
- The Max Cell

I would like to go over the air flow dynamics once again. Regurgitation helps.

Many of you have a hard time understanding engine vacuum and believe me, its not as simple as some may say so I will do my best in explaining it to you.



The first thought you have in your mind is “Won’t the water be sucked up the tube?”

That is a valid question to ask. The answer; NO! Take a close look at the picture. This is at low vacuum conditions. Here is what is happening when your idling or at the halfway point of deceleration. The air is flowing straight through with no problems. Now, this is also what would happen under high vacuum conditions as well IF the opening of the air valve was opened all the way.

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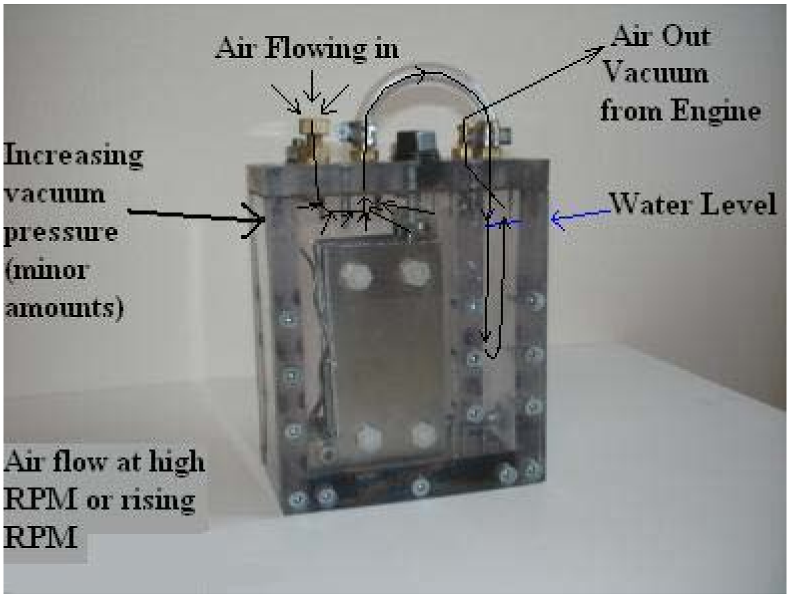
But because we set the air valve opening and restrict the flow slightly; and I mean slightly, as the vacuum pressure rises it will suck harder at the open walls and water. Here is where it gets tricky.

Please keep in mind that as the vacuum pressure rises at the Hydrolyzer & it also rises at the air filter because both at attached at the air duct leading to the throttle valve.



The air filter is designed to allow air in so that is why the air pressure can't shoot through the roof like you think. Remember when I said HHO intake increases with the RPM? This is what I was talking about. At idle, fuel economy is not a concern.

Its when you accelerate. As you step down further on the gas pedal, you are demanding the engine to rev higher. For fuel injection, the computer reads what you are doing and dumps in more fuel. For carb fed engines, the accelerator pump shoots a stream of fuel then the metering rods or power valve adds fuel accordingly. I will cover this subject in detail in Book #2.

At idle, the HHO gas being generated is sucked into the intake but at a slow rate. It begins to stack against itself and slowly through the bubbler and into the air intake duck.

Now, as you step on the gas, the vacuum pressure increases and begins to suck at the stacked HHO gas. This will also promote

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better HHO gas generation as pressurizing the chamber would slow the electrolyzing process. No, you will not get positive pressure to answer your question. Positive pressure is PSI (Pounds Per Square Inch).

When you blow up a balloon, you are using positive pressure. When you are taking a sip of water through a straw, you are using negative pressure measured in Hg-inch in our case (Please do search on Google).

As the RPM's increase, the engine begins to suck in more HHO gas. If you were to use a vacuum line off of manifold pressure (after the throttle valve) all the HHO gas would be lost at idle. You cannot see gains that way. Some of these so-called "experts" even tell you to tap both manifold vacuum and the vacuum before the throttle valve.

This applies to both naturally aspirated and forced induction.

A **naturally-aspirated engine** or **normally-aspirated engine** (or "N/A" - aspiration meaning breathing) refers to an internal combustion engine (normally petrol or diesel powered) that is neither turbocharged nor supercharged. Most automobile gasoline (petrol) engines are naturally-aspirated, although turbochargers and superchargers have enjoyed periods of success, particularly in the late 1980s and the current 2000s era.

Most road-going diesel-engined vehicles use turbochargers and intercoolers because naturally-aspirated diesels generally cannot offer power-to-weight ratios acceptable in the modern car market.

Air or air/fuel mixtures are forced into the cylinders by vacuum caused by piston movement, natural atmospheric pressure, and

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venturi effect upon opening of the inlet valve or valves. The pressure within the cylinder is lowered by the action of the piston moving away from the valves (so as to expand the volume available for incoming air). In some cases the lowering of the cylinder pressure is enhanced by a combination of the speed of the exhaust gases leaving the cylinder and the closing of the exhaust valve at the appropriate time.

A tuned exhaust can help with this but generally only works at a narrow range of engine speeds and hence is most useful in very high performance cars, aircraft, and helicopters.

Many N/A engines today make use of Variable Length Intake Manifolds to harness Helmholtz resonance, which has a mild forced-induction effect but is not considered true forced induction.

Cylinder head porting design is of premium importance in naturally aspirated engines. Camshafts usually will be more "aggressive", having greater lift and duration. Cylinder head gaskets will also be thinner, with the top of the piston rising up into the combustion chamber,= for high-performance N/A engines that benefit from higher compression.

Naturally-aspirated engines generally gives less power than either turbo or supercharged engines of the same engine displacement and development level but tend to be cheaper to produce. In drag racing naturally-aspirated vehicles are those that do not operate with a supercharger, a turbocharger, nor use nitrous oxide.

Many racing series specify N/A engines to limit power and speed. NASCAR, IndyCar, and Formula One are all in this category. Naturally-aspirated engines have been mandated in Formula One since 1989, in order to curb excessive power output and the high cost of engines with superchargers or turbochargers. The Indy Racing League mandated Naturally-aspirated engines in 1997.

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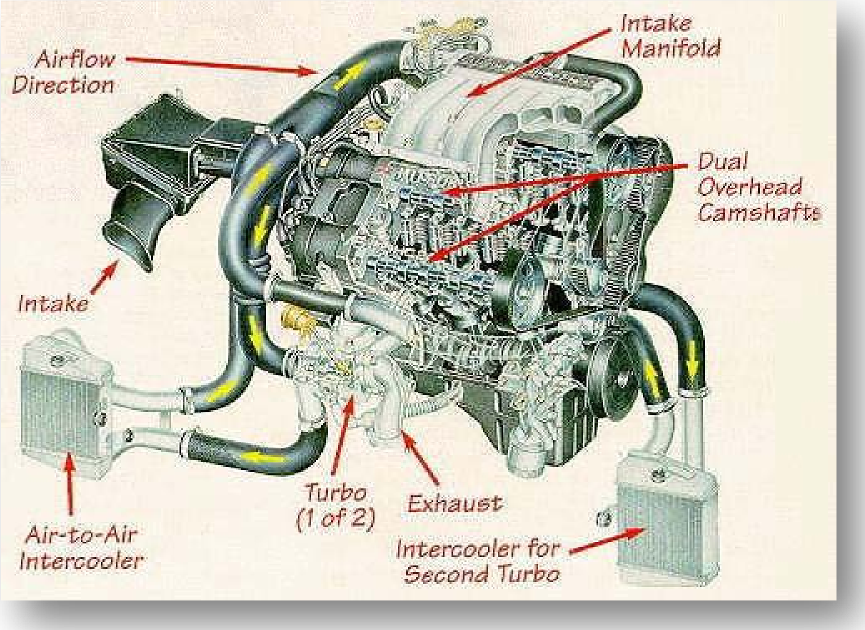
Forced induction can be used to improve the power, efficiency, emissions, or combinations of same, without much extra weight and minimal modifications to the engine architecture.

The two most common forms of forced induction are turbochargers and superchargers, which both compress the air entering the cylinders, but use different methods to obtain the requisite power. Functionally, they are much the same. Since only so much power can be had from a given amount of gasoline, the more gasoline can be burned in the cylinder, the more power can be produced.

However, simply adding more gas beyond the optimal air/fuel ratio (commonly called "running rich") does nothing for power. An engine can only take in so much when breathing air at atmospheric pressures, since the capacity and number of cylinders is non-variable.



Hence, the only way to get more air into the cylinder, and therefore produce more power, is to increase the pressure at the intake.

All we've considered up to now is increased power, so how does forced induction improve emissions or efficiency? One of the primary concerns in internal combustion emissions is a factor called the NOx fraction, or the amount of nitrogen/oxygen compounds the engine produces.

High combustion temperatures lead to a lower NOx fraction, and since gasses heat when compressed, the more gas is compressed in a given volume, the hotter it will get, and the lower the NOx fraction will be.

Since forced induction increases the amount of gas being compressed, it increases the heat generated when compression occurs. Since colder air is denser, it is most desirable, from a power standpoint, to have cold air coming in, but better from an emissions standpoint if the air is hot. In a perfect world, incoming air would be frigid, and the compression would be high enough to dramatically and rapidly increase cylinder temperatures, reducing emissions significantly.

Two of the commonly used forced induction technologies are turbochargers and superchargers. They differ primarily in the power source for the compressor. There is a difference between forced induction and power adders. A power adder is anything that improves an engine's power output, which does not necessarily mean increasing charge density.

Oxidizing technologies such as nitrous oxide injection systems provide improved power, but are not a form of forced induction.

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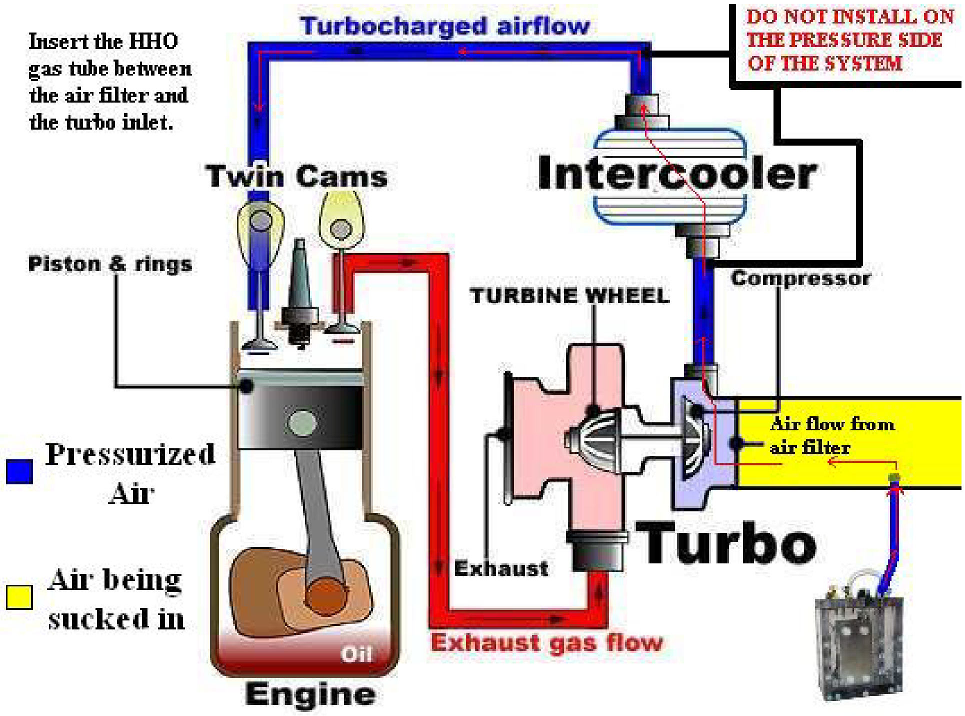
Now, this is how your system should be hooked up for a Naturally Aspirated engine:

You can see that a Naturally Aspirated engine will pull gas right off the intake ducting before the throttle body

Here is a diagram of a Turbocharged engine using the same hook-up:



Insert the HHO gas tube between the air filter and the turbo inlet.

DO NOT INSTALL ON THE PRESSURE SIDE OF THE SYSTEM

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The MAX Cell

This is the heart of the G4FREE system. The cell was designed to promote the most amount of HHO gas with the least amount of electrical draw from your system.

It was also designed to only uses 35 to 45% of the surface area to produce HHO gas. This accommodates for the water level dropping. I did this so you would not have to worry about keeping the system topped up all the time. You just drive and get a consistant gain.

That’s all nice and dandy, but how does it work? I’m sure most of you know already but here is for those who don’t. You know that electrical power is used to produce HHO gas. If you remember science class in high school, your teacher may have used an electrolisys machine to split water into hydrogen and oxygen. That machine is different in many ways compared to our hydrolyzer.

A sum up would be that 5 of the plates are negative and 6 are positive. Once you connect all the negative plates to a negative power source and the same with the positive, the electricity in the water (charged negative plates and positive plates) will want to travel from the positive plates to the negative plates. Because the water is now acting like a wire connecting the unlike plates, electricity flows through it causing the oxygen and hydrogen to unbond.

The “LOAD” or work being done is the water breaking down to oxygen and hydrogen. Water does conduct electricity but not very well. When you’re watching a movie and one of the characters through a hair dryer in a bathtub with someone in it, you see them

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getting electrocuted. This happens because of one factor; Voltage. Household and commercial wall outlets use 120 Volts of A/C electricity where cars use 12 D/C.

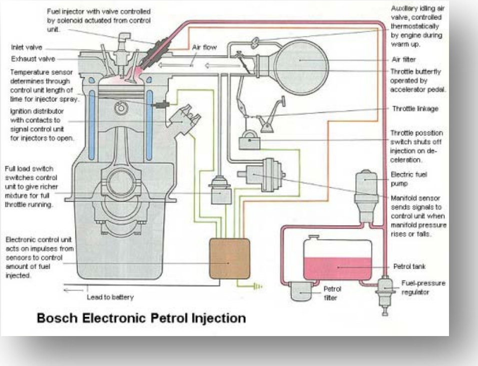
Voltage is electrical pressure. Anything can be penetrated depending on the amount of Voltage applied; even wood, air and stone. A 12 Volt system cannot harm you but the electric socket in your home can kill you. The funny thing is that it's not Voltage that kills you ether, its Amperage (Current flowing).

The water in the HHO generation chamber is the load because it has resistance. Here, once electricity is applied to the plates, the work being done is the hydrogen and oxygen splitting at the appropriate plate.

HYDROGEN = NEGATIVE PLATE
OXYGEN = POSITIVE PLATE

This should shed some more light on how plate (stack) designs work as appose to the wire design. Because splitting of the molecules occur at the surface of the plates, it proves that surface area optimizes HHO production.

These companies that state wire designs are great are full of BULL, PEIRIOD! It would take 6 to 8 of those useless mason jars to match one G4Free Hydrolyzer.



Tuning EFI Gasoline and Diesel Systems

So your ready to take the plunge and begin tuning your vehicle's EFI (Electronic Fuel Injection) system to maximize gain.

EFI systems are generally used to control the fuel delivery and timing of ignition. It uses multiple sensors to read what's going in and out of the engine so it can adjust as needed.

Lets get one thing out of the way. All auto makers will have different components in order to stay competitive but the general function is still the same. I cannot get into details about every system ever made. It is up to you to research your vehicles specific EFI system. But I will be covering the components they all share.

Since the late 80's to about 1995, all cars ran on a computer system known as OBD 1. From mid 1995 to present day, the switched to OBD 2. Lets discuss that further.

On-Board Diagnostics, or **OBD**, in an automotive context, is a generic term referring to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or a repair technician access to state of health information for various vehicle sub-systems.

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The amount of diagnostic information available via OBD has varied widely since the introduction in the early 1980s of on-board vehicle computers, which made OBD possible. Early instances of OBD would simply illuminate a malfunction indicator light, or MIL, if a problem were detected—but would not provide any information as to the nature of the problem.

Modern OBD implementations use a standardized fast digital communications port to provide realtime data in addition to a standardized series of diagnostic trouble codes, or DTCs, which allow one to rapidly identify and remedy malfunctions within the vehicle.

OBD 1

The regulatory intent of OBD-I was to encourage auto manufacturers to design reliable emission control systems that remain effective for the vehicle's "useful life".

The hope was that by forcing annual emissions testing for California, and denying registration to vehicles that did not pass, drivers would tend to purchase vehicles that would more reliably pass the test. Along these lines, OBD-I was largely unsuccessful—the means of reporting emissions-specific diagnostic information was not standardized.

Technical difficulties with obtaining standardized and reliable emissions information from all vehicles led to an inability to implement effectively the annual testing program.

OBD 2

OBD-II is an improvement over OBD-I in both capability and standardization. The OBD-II standard specifies the type of diagnostic connector and its pinout, the electrical signalling protocols available, and the messaging format.

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It also provides a candidate list of vehicle parameters to monitor along with how to encode the data for each. Finally, the OBD-II standard provides an extensible list of DTCs.

As a result of this standardization, a single device can query the on-board computer(s) in any vehicle. This OBD-II came in 2 models OBD-IIA and OBD-IIB

Your OBD or On-Board Diagnostics system in short is what turns on the "check engine soon" light on your dashboard. A solid light means that an emissions device or sensor itself in not reading correctly.

You might cause this light to come on if you tune you system too much. You must do things in small steps in order to

A. **See gains or losses**
B. **Return to last setting if the Check Engine light comes on**

If you get a check engine light, you will have to clear it. Your engine's computer system will run in a "limp mode" while your check engine light is on so don't think its ok.

To clear the codes or check engine light

For OBD1 : Undo negative cable from battery for 1 hour

For OBD2: Undo negative cable from battery for 8 hours

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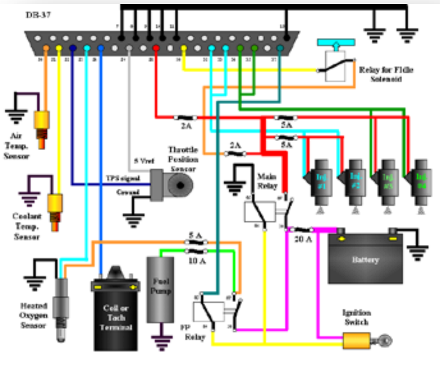


Components to Enhance your EFI System for HOD

There are 2 components that you can enhance to improve your MPG gains dramatically. If one were to manipulate the readings of these sensors to the vehicles engine management system, you would be able to tune for some great gains.

The 2 sensors are in question are:

- **MAP Sensor**
- **MAF sensor**

Your vehicle uses one or the other. NOT BOTH. There is an easy to build device to enhance the MAP sensor already. A recent addition, this enhancer worked well along with The O2 Sensor method.

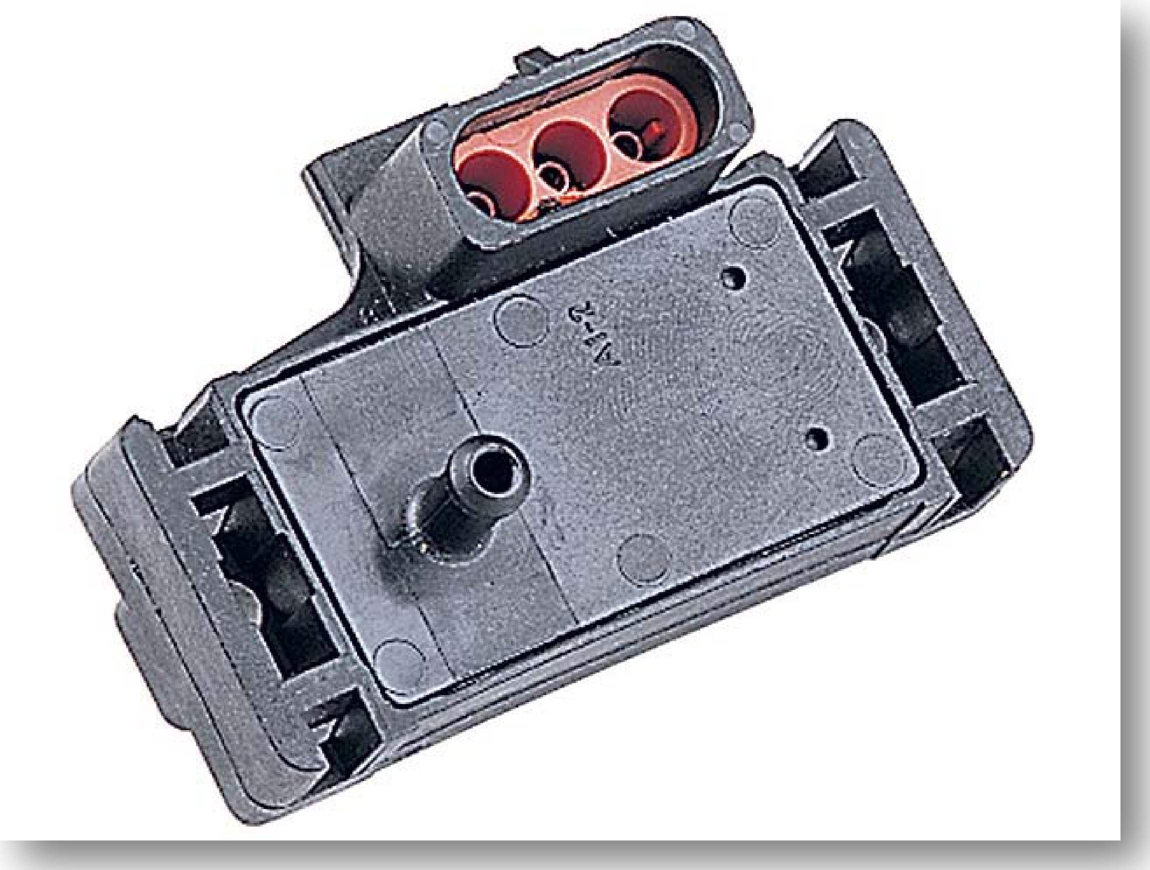
It has been reported to also work on OBD-I. I don't think it works well for MAF (Mass Air Flow) sensors or Oxygen sensors because those rely on frequencies while this is a direct current device. Now let's define some words. When we say the word “computer” in reference to the fuel and emulsions control system, we're generally referring to the ECU or Electronic Control Unit.

It is also sometimes called the PCM or other names. So we may be using the word computer and ECU interchangeably, although some cars have more than one computer. The ECU is what we're interested in when it comes to saving energy. OBD means On Board Diagnostics – basically the engine computer system and a dictated set of performance sensors that are mandatory on all cars since 1996. OBD-I is pre-1996. Now we have OBD-II.

They say it is mandatory for emissions control. I have come to realize that it's for the purpose of wasting gas. This “modern” system uses gasoline to cool down the engine and “control” the emissions, when patents and technology have been in existence for a century now to do all that without wasting energy (deteriorating the planet) and without building up sludge (aging your car real fast).

“Potentiometer” (or “pot”) simply means variable resistor. For a long while I've been hearing about the use of some “resistor” to lean out the mixture. I've heard it was being sold on eBay and thought it was too good to be true. Because if it is so simple, then why do we need EFIE or D17 (various electronic devices that change or “translate” the pulses of the O2 Sensors?)

I tried this simple device here in a vehicle running OBD-II and it worked better than expected. While driving at 55 MPH I have dialed the MPG gauge up by as much as 69% just by turning the knob way down. The latest test results have averaged 82%.



HOW DOES THE MAP SENSOR WORK?

The Manifold Absolute Pressure (MAP) sensor signal is electrically used in a similar way to the use of Mass Air Flow (MAF) sensor signal (although internally it is built differently). It takes a 5 volt signal from the computer, and returns a lower direct current signal in accordance with the vacuum in the engine.

A higher output voltage means lower engine vacuum, which is then calculated as “more fuel is needed”. Lower output signal indicates higher engine vacuum, which requires less fuel. It's not just fuel control though. The MAP senor signal gives the computer a dynamic indication of engine load.

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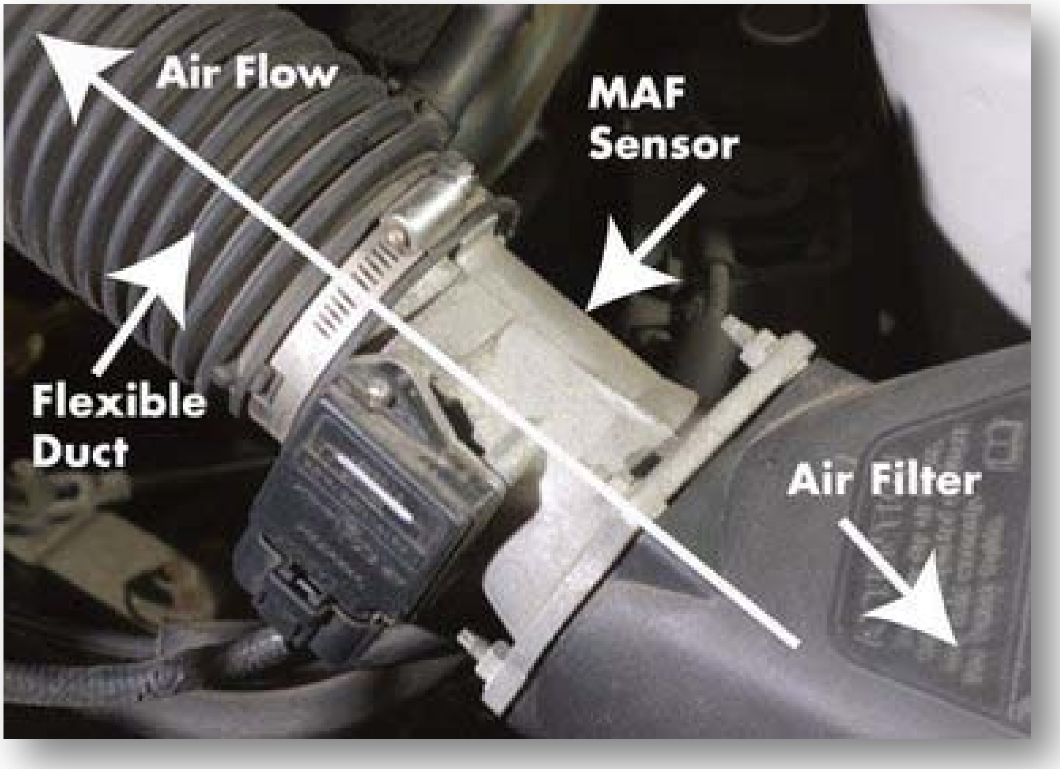
The computer then uses this data to control not only fuel injection, but also gear shift and cylinder ignition timing. In some cases it is even used to calculate changes in barometric pressure, to automatically adjust for different altitudes.



HOW DOES THE MAF SENSOR WORK?

The Mass Air Flow (MAF) sensor helps the computer to calculate the flow and mass of the air entering the engine. It does that by measuring the cooling effect of air flow over a heated wire element. The electronic circuit inside the sensor attempts to keep the sensor at a fixed temp.

When it is cooled more by an increased air flow, more current is needed to maintain a constant temperature. The increase in current is converted into a signal and that signal goes to the

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computer. In most cars this signal would be a high frequency signal. Not as high as a radio wave, but much faster changing than the (relatively) slow frequency of the Oxygen sensor.

During low air flow rates, such as at engine idle, the MAF sensor produces a lower frequency signal. During high air flow rates, such as at wide open throttle-road load, the MAF sensor increases the frequency. The control module then converts these frequencies into their corresponding Grams-Per-Second values. Yet again, some MAF sensors may work on a straight DC signal 0-5 Volts such as the typical MAP sensor.

This is the case in some older MAP Sensor designs that have a trap door with a potentiometer connected to its shaft. For better understanding of air flow sensors read this document: http://www.autoshop101.com/forms/h34.pdf I'm giving you these descriptions so you can understand how to apply the correct circuit to each sensor.

I don't think the pot arrangement can do if all you have is a MAF sensor or if the MAP sensor works with frequencies (very rare).

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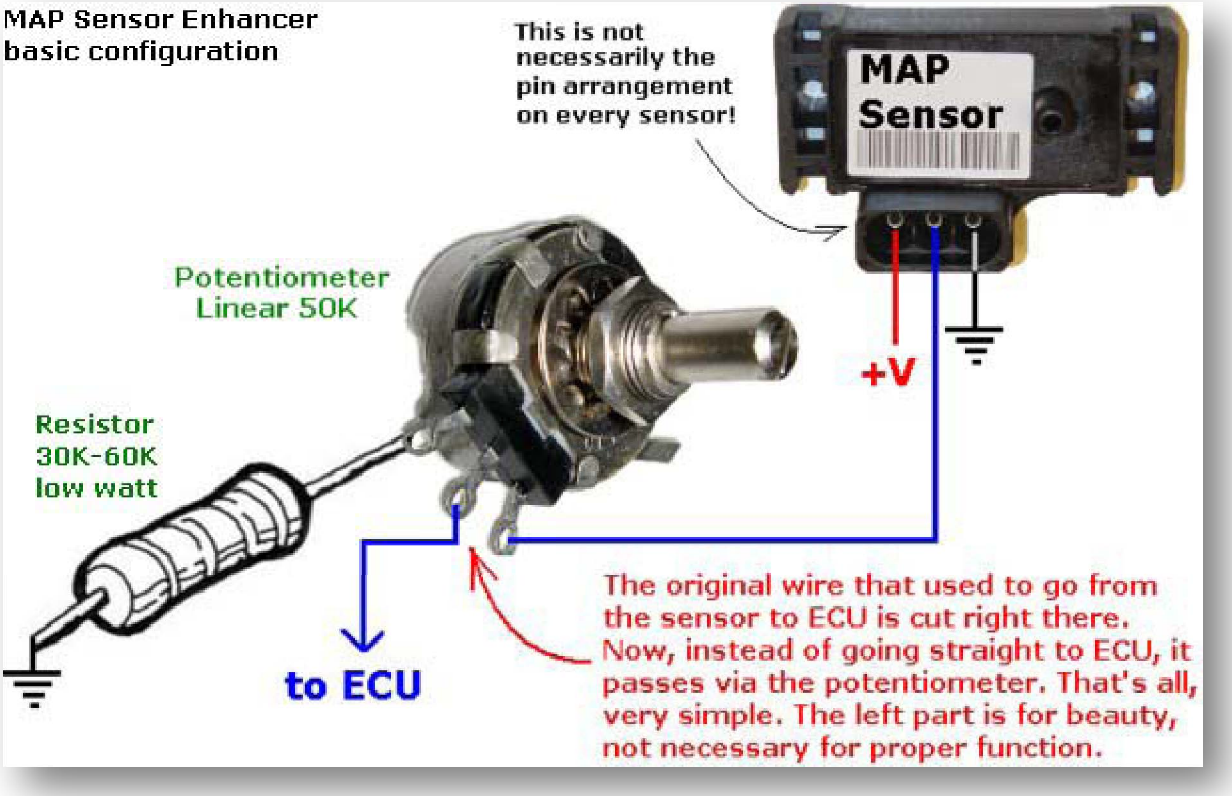

MAP Sensor Enhancer basic configuration

This is not necessarily the pin arrangement on every sensor!

The original wire that used to go from the sensor to ECU is cut right there. Now, instead of going straight to ECU, it passes via the potentiometer. That's all, very simple. The left part is for beauty, not necessary for proper function.

THE ENHANCER

The invention we're talking about here is a simple play with resistors. A resistor is a little piece of carbon that somewhat blocks electrical current. Higher value means it resists more. The potentiometer (“pot” for short) is a resistor, a variable resistor, which varies its value by turning the knob.

But it is still only a resistor. There is another resistor, a fixed value resistor, in series to the pot as shown in the diagram below. The MAP or Manifold Absolute Pressure Sensor is a little though expensive device installed in your intake manifold, or installed on the firewall and connected to the manifold with a thin hose. It has 5 Volts or 12 Volts coming in, and it simply senses the vacuum in the manifold and attenuates (reduces, weakens) this incoming voltage by a certain factor.

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In other words it reduces the supply voltage to a direct-current voltage in the range of 15% to 60% of the supply voltage (depending on the car's design these numbers will vary), and this varying but non-pulsing signal is then sent back to the computer. The arrangement of resistors simply takes this already attenuated (reduced, weakened) signal – and attenuates it further.

Too much attenuation kills the engine, it will simply shut off. Yet if you control it correctly you can lean down the mixture from the stoichiometric (a big word that simply means “balance of ingredients”) which is factory set at 14.7:1 (14.7 parts of air to 1 part gasoline)

This device is totally passive and will work just the same if the signal coming in is 12 volts, 5 volts, or whatever comes on the line. The diagram here is the SIMPLEST way of doing this. The line from the sensor to the ECU is cut, and you place a pot on the line as shown. Further below you will see the improved enhancer based on the same principle.

INSTALLATION AND TUNING ATTENTION:

The tuning procedure calls for clockwise and counter-clockwise rotation of the knob. In some of the drawings the shown connections will result in opposite rotation. The solution is to swap the connections of the SIDE wires going to the pot (not the wire in the middle). The last drawing in this chapter shows the “correct” connection on both pots.

By “correct” I mean it will have full rich in the counter clockwise end and full lean in the clockwise. The idea is that turning clockwise will “enhance” the more you turn. But it's up to you. The potentiometer can be installed on the dashboard. To eliminate the

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work and possible damage to the dashboard, and to enable me better control, you can build this into a small mobile box and place the box beside the driver seat. It makes tuning quite effortless.

(The markings “Highway” and “City” shown for example only)
Now locate the 3 wires connected to the MAP sensor. There will be one for the positive supply voltage, usually 5 or 12 volts but it does not matter. The signal will be the one with the WEAKER voltage, and will change with RPM if you start the engine. And there will be a ground wire.

You can solder or crimp electrical wire connectors, so you can always hook it back to factory setup. But I doubt if you'll ever want to go back! If you cannot locate the sensor or the wires, or you're not sure, you'd better get the car's manual. DO NOT IMPROVISE OR GUESS – you may damage your computer.

All I had to do at my (low) skill level was to walk into AutoZone and purchase the maintenance manual (Haynes) specific to the fuel injection system of my test car. Two users of this method have advised me that one should also disconnect the plug of the upstream oxygen sensor (i.e., the one closer to the engine).

The idea is that otherwise the computer will eventually lock in constant-rich mode again.

Now for actual tuning on the road.

1. Turn the knob all the way to “rich” (it should be fully counter clockwise if you hooked it as shown in the last photos of this chapter). This will be factory original.

2. Make sure your water device is operational. Warm up the engine and drive a while before messing with the knob.

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3. DO THE NEXT STEP WITH CARE – ON A SIDE ROAD - JUST IN CASE YOUR ENGINE STOPS UNEXPECTEDLY.

4. Now start turning the knob clockwise, the mixture will turn leaner and leaner until the car stalls or bucks as you drive. Back the knob off slightly after the bucking and chugging.

5. Keep the danger of overheating in mind. If your Water4Gas device is non operational temporarily, set the enhancer at or near original factory setting (rich).

6. Another thing I've noticed is that set points change from one gas station fuel to another, weather conditions, cold engine, etc. The differences are not large, but if you're on the edge then the car will buck or vibrate and you'll need to change the set point a bit. Remember that this is a simple device. There is no point in computerizing it, it will require a whole new programmable ECU which is a very costly thing for most drivers and countries.

7. NOTE: When this device turns on the "check engine light", and it WILL do that, you can turn off the light using a ScanGauge-II (1996 cars or newer).

HOW TO MAXIMIZE YOUR BENEFITS

One recent set of road tests (6-16-07) averaged 52.4% better mileage. But tests from a week earlier on the same car averaged only 24.5%. Actually 22% if you count out idling. WHY such great difference? The secret of the BIG DIFFERENCE between the two test groups: The later and more successful one got MORE THAN DOUBLE average gain, was because the MPG was not dialed to near choke point.

It was about ¼ turn closer to factory setting! On the earlier tests I was choking the engine half to death. It reminds me of the greedy guy slaying the gold laying hen to get all the gold right now...

Each and every MPH readout was obtained by ScanGauge-II after (and only if) the readout has STABILIZED.

My rules were strict: I wrote down a DEFINITE result only if there was a steady road condition where I could dial in a certain MPG on the enhancer (in enhanced mode), then switch back to original, back to SAME enhanced point (by an electric switch so I know it duplicates exactly), back to original.

I let the readout stabilize in EACH mode. If the road was flat enough or steady uphill enough AND I could do it back and forth and still got the same numbers, I'd write down one line of results, and the speed I was in. Cruise control, never touched the pedal. Windows up, no air conditioner, no radio, nothing else changed.

MARKINGS

The "city" side is identical to 'highway". There are several ways to use the device. For instance you can mark one side as "enhanced" and the other side would be marked "original" (in which case you leave that side at full-rich position) so now you can switch between enhanced mode and original factory setting.

Or mark them "hot engine" vs. "cold engine", or "bypass/uphill" vs. "flat road" - or whatever suits your use and driving conditions. Watch out for mixed-up wires. It is not a complicated device, but its structure must be duplicated exactly.
Especially note these points:

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1. The potentiometers are wired in such a way that turning it counter-clockwise will ENRICH the mixture and clockwise will LEAN the mixture. If you get anything else, check the wires per the diagram above. Also refer to the photos below.

2. The nature of this type of lever switch is that the right-hand pot is actually the “highway” adjustment, and the left-hand pot is the “city” adjustment. Observe the photo below - see how the wires are crossed to the switch? (Otherwise the knob/switch arrangement would be confusing).

3. Fixed resistors of 33K worked fine in my experiment. Your engine may be different. Any similar value will work, but the idea is that this resistor is calculated to enable a larger active range of the pot's movement. Call or email me if this is not clear. This diagram below demonstrates the reason and usage of the fixed resistor. You may want to trim the value of your (fixed) resistor to a different value if the control range you're getting is not optimal.

   NO FIXED RESISTOR FIXED RESISTOR ADDED

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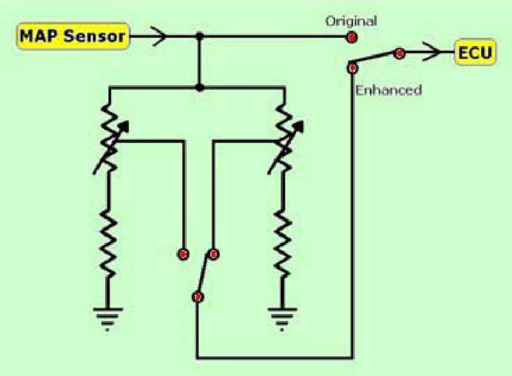
Duel Setting Enhancer

This may be going too far. Maybe not. But it is definitely a convenience to have TWO settings enhanced, and be able to switch back to original stock (factory settings) with a flip of a button. In the device shown below which is a variation of DEMSE, the lower switch moves up-down rather than left-right, and toggles between “Original” and “Enhanced” modes. In Enhanced mode the upper witch toggles between the two knobs. For instructions on how to replicate this design



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