

Panacea-BOCAF On-Line University



www.panacea-bocaf.org
www.panaceauniversity.org

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Hydroxy Course

Overview.....

Description.....

Installation and safety.....

Diesel engines and trucks.....

EFIE construction and installation guide.....

Open source DIY EFIE circuits.....

Faculty information on the EFIE and oxygen sensor.....

Alternatives to the EFIE.....

Brute force DC hydroxy booster designs.....

Faculty information.....

Patents and related information

Emissions tests and law related.....

Newbie FAQ guide and general hydroxy information.....

Beginner's FAQ

Booster supplies.....

Links.....

Technical support groups.....

Over View



Panacea's diesel installation using [Praveen's open source booster](#)

Quote- I really hope that this helps others from having to spend a lot of time and money like I have had to in order to out these internet theories. Yes it's hard not to hoard the

information I've discovered at my personal expense, however I'm looking to set an example. We have to be unselfish in these global matters.

What one has to realize is that if we don't work together on these projects then we will scare off the newbie's that may one day solve the issue of water cars. Yes, it would stink to think that a newbie may make billions of dollars off the royalties due to our hard work, but we will not have to worry about our children and our children's children surviving, long after we are gone.

The world is headed for disaster the way we are going. Fossil fuels will deplete. If we don't help secure our future by unselfishly sharing knowledge then there is nothing to stop our self destruction. If that is the case, however, then we deserve what's coming to us. Open source hydroxy engineer – end quote.

Before commencing reading, first it is important to understand that for any person who is inexperienced in experimenting with this technology, **hydroxy is potentially VERY dangerous to YOU.** Hydroxy is a highly explosive gas, it certainly isn't for people who like to blow up balloons, and it certainly is not for the beginner. It commands RESPECT and caution. Permanent ear damage is possible from the ignition of the gas from balloons. Explosions and a harmful shock wave can also result from unintentional combustion. Those who do not handle with care are posing a SERIOUS health risk to them self's and others.

If you cannot go along with this, then you are CERTAIN to in danger yourself and others. We must therefore state an obvious warning and disclaimer. If you are a beginner, PLEASE seek technical advice from professionals; do not experiment with it by yourself. Hydroxy gas IS dangerous to the inexperienced and to those who do not handle with care; **however, hydroxy technology is manageable for safe operation.**

Beware of fraudulent claims on cells; always stick to the open source forums listed in this document to check the credentials of cells. NEVER TRY AND STORE THE GAS.

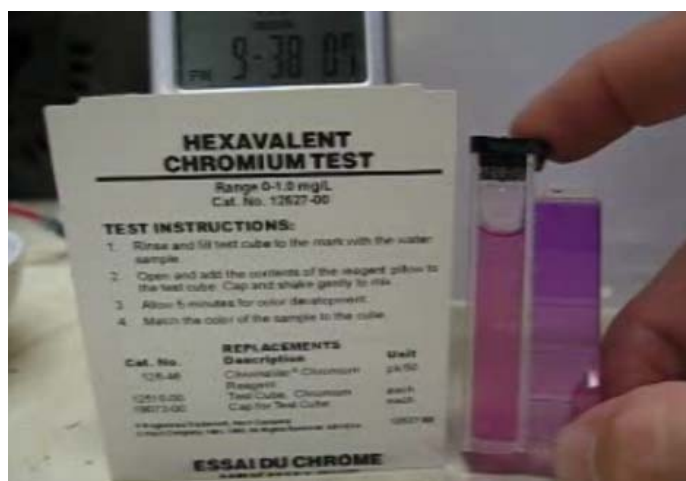
Authorities identify man killed in Simi Valley explosion; death ruled accidental -
http://www.vcstar.com/photos/galleries/2010/jun/18/simi-explosion-kills-man/12196/#section_header

Stick to the EXACT guide lines listed and damage is preventable. **Change these rules in ANY way**, and you may not be back to read how to do it properly the next time. **Please read the disclaimer before commencing any projects on the Panacea university site.**

There are regulations by the EPA related to the safe disposal of any toxic byproducts that result from electrolysis using stainless steel electrodes. There is currently a concern that Stainless steel boosters produce Hexavalent chromium in the left over electrolyte.

Even if the plates are prepared using the Bob Boyce plate cleansing method (Listed in the faculty section) you should check that is not producing small amounts over time.

Bob states: A properly designed and operated booster using quality stainless steel does not have an issue with hexavalent chromium production. Boilermakers and steaming behemoths (poor designed cells) cells may, but they are not properly designed boosters –end. Please stick to the design parameters listed in this document.



Screen shot taken from the [video of a Hex test](#) with electrolyte

DO NOT DUMP YOUR USED ELECTROLYTE. The Brown Muck left over is *Chromium Hexavalent* Mark it with the chemical name of the electrolyte {Example NaOH & Cr (VI)} and take it to your local Hazard collection center. Left over electrolyte must be tested and disposed of appropriately under the guide lines listed by the EPA. Hexavalent chromium is a carcinogen and will pollute the water ways.

More information and breaking down Hex testing has been posted in the faculty section. Recently specially coated Ti/MMO (mixed metal oxides) plate electrodes have appeared and have been reported to eliminate this possible by product. However, there is concern that the MMO/Ti plates with iridium and ruthenium oxides may not be compatible with Naoh or KOH electrolyte. Further testing reports on SS and Ti/MMO electrodes will be added to the faculty section as we are able to get data in.

Bob Boyce states *“Well, despite claims to the contrary, MMO/Ti does not make better gas than stainless steel. If that stainless steel has been prepared correctly and operated within acceptable parameters. But the same can be said about MMO/Ti, as it also has to be applied properly and operated within acceptable parameters. The only advantage that MMO/Ti has is the low chromium and iron content, but for me the disadvantages outweigh the advantages. There are other metals that also have low chromium and iron content, and work so much better due to the lower potential–end.*

Please check under the header "Bob Boyce method of preventing Hex" in the faculty section of this document. Currently more tests need to surface from both parties. The [Smacks](#) and [hydroelectric](#) sites both produce Ti/MMO and Ti coated electrodes as opposed to stainless steel ones. More data will be posted on them in the faculty section as it comes in.



Smack's Cell

There are 2 classes of hydroxy cells, the "dry cell" and the "wet cell" design. **Dry cells are now known to be more efficient.** The reasons for this are described in detail in the faculty section of this document. A wet cell is described as having the electrodes emerged (wet) in the electrolyte solution.



Wet Cell

A "Dry Cell" has minimum contact with the electrolyte and circulates it through the cell and back to the cell.



Smack Dry cell

The science described in this document is very old, in the 1800's water was turned into hydrogen and oxygen, using a battery. In 1805 the first car with an internal combustion engine burned hydrogen from water. Jules Verne wrote in 1875 that WATER would be the fuel of the future. [Reference](#)

As we are all aware, engines that run on gasoline won out over Electric, Hydrogen and Steam Technologies and in 1888 the first production automobiles were made by Karl Benz in Germany. But through the centuries interest has remained in hydrogen and Electric Technologies because of its sustainability.

Note , the current debate is , whether Ti/MMO plates last the distance, and an important point to get out here is all SS boosters must be passivated using the Bob Boyce procedure listed in the faculty section f this document, Some simple statements about the word "Passivation" for clarity.

The definition is: To seal or cause something to become inactive or inert to a given condition or material. Passivation comes in many flavors. The process we use is called "consumptive processing." It "consumes" the material we wish to remove thus leaving a more desirable surface. The surface we want is very free of iron or organic contaminants that will react with the electrolyte and make the surface less efficient for the desired process. As the surface is "cleaned and coated" it becomes more efficient for our process. This is not chemical "polishing" which is a stripping process which makes

a micro smooth surface but one that is wide open to any process that will react to the iron in the SS material. It is also not chemical "sealing" or over coating.

That material addition often is a much different "sheet resistivity" than the base material. It doesn't have to be, and can be designed to reduce the resistivity. A ton of variables in the highly technical field of electro- or electrodes plating.

Advice from someone who worked with plating processes "goblins" for many years: Do it Bob's way and save all the headaches which he has already research to exhaustion. The reasons for doing things this way have 40 years of "PROOF!"

In the 1820 British scientist introduced the concept of renewable hydrogen in his paper, Science and the Future, by proposing that "there will be great power stations where during windy weather the surplus power will be used for the electrolytic decomposition of water into oxygen and hydrogen." Today Iceland is become energy independent by moving to a Hydrogen economy using their thermal energy to do exactly this. [See Video](#)

In fact as far back as 1918; Charles H. Frazer received the first patent for a "hydro-booster". Charles's research found that his hydro booster design worked the best with low grade fuels-[Reference](#).

UNITED STATES PATENT OFFICE.
CHARLES H. FRAZER, OF COLUMBUS, OHIO.
HYDRO-OXYGEN GENERATOR.
1,962,034. Patented Apr. 9, 1918.
Application filed June 30, 1916. Serial No. 126,287.

To all whom it may concern:
Be it known that I, CHARLES H. FRAZER, a citizen of the United States, residing at Columbus, in the county of Franklin and State of Ohio, have invented certain new and useful Improvements in Hydro-Oxygen Generators, of which the following is a specification.

This invention relates to hydro-oxygen generators for use with internal combustion engines. The attachment is designed particularly to increase the efficiency of internal combustion engines, in that an additional quantity of oxygen is supplied where- 10 by complete combustion of the volatile hydrocarbons is insured. By the use of my attachment, the heavy carbon deposited upon the cylinder and its cooperating parts is also eliminated in that the carbon is completely burned by the use of the additional supply of oxygen.

The main object of my invention resides in the provision of a tank wherein a pair of electrodes are provided for decomposing 15 water into its constituent parts, together with conduits leading from the tank to the intake manifold, whereby the generated gases are permitted to enter the engine cylinder.

Still a further object of the present invention resides in a controlling or throttling structure whereby the generated gases, as well as the hydrocarbon fuel may be simultaneously throttled.

The preferred embodiment of my invention is shown in the accompanying sheet of drawings, in which similar characters of reference designate corresponding parts, and in which:

Figure 1 is a view in side elevation of an internal combustion engine showing my generator mounted in position.

Fig. 2 is a vertical section on an enlarged scale of the generator shown in Fig. 1.

Fig. 3 is a transverse section taken on line 3-3 of Fig. 2, and

Fig. 4 is a section through one of the controlling valves used in regulating the supply of gas to the intake manifold.

In Fig. 1, the internal combustion engine is represented by the reference numeral 1 and is shown as being provided with a T-shaped intake manifold 2, which latter is in communication with a carburetor 3. The generator itself comprises a circular tank 4 whose upper portion is divided by means of a transverse wall 5 to form compartments 6 and 7. The upper and lower ends of the generator tank are closed and located in the lower wall 8 thereof are a pair of electrodes, the anode being designated by the reference numeral 9 and the cathode by the reference numeral 10. Both these electrodes are located centrally with respect to their respective chambers 6 and 7. These electrodes are mounted in the customary manner by being insulated from each other, as is shown and they are further adjustable up and down by means of the adjusting nuts shown at 11. The lower portion of the tank 4 is in communication with a source of water supply (not shown) by means of the supply pipe 12, flow through which is governed by means of the valve 13. The water level is normally maintained constant by operating the valve 13 through the medium of a float 14. This float is pivotally attached as shown at 15 to a lever 16 which lever is also pivotally attached intermediate its ends as shown at 17 to the tank 4. The outside end of the lever 16 pivotally connects to a link 18 which latter forms a direct connection with the valve arm shown at 19. Thus, when the water level in the tank 4 rises, the valve will be closed through the elevation of one end of the lever 16. When the current is turned on, the water which, of course, contains a certain per cent of impurities to render it either acid or alkaline to serve as an electrolyte, will be decomposed into its constituent hydrogen and oxygen. These generated gases will bubble to the surface of the water within the generator and collect in the compartments 6 and 7, hydrogen being generated at the cathode and oxygen at the anode. These gases may then be conducted to the intake through the medium of pipes or conduits 20 and 21 leading out of the top of the compartments 6 and 7 respectively. Each conduit is provided with a valve shown in cross section in Fig. 4 and comprising a body portion 22 having aligning passages 23. A plug 24 operates within the body portion and is bored transversely as shown at 25, whereby when the passages 23 and 25 are all in alignment, free flow of the gases from the tanks 6 and 7 is permitted. The flow of these gases may also be throttled by partially closing the valves and the operation of these is preferably made simultaneous with the throttle 26 of the carburetor 3. In order to provide this arrange-

Add to this, CH Garrett's (and his Dad's) 1935 electrolytic carburetor technology. It has been known for some time (since a 1974 paper by the Jet Propulsion Lab of the

California Institute of Technology) that the addition of hydrogen to fossil fuels, burned in internal combustion engines, will increase the efficiency of that engine.

This study has been validated by a number of papers published by the Society of Automotive Engineers (SAE) .The hydroxy boost process is effective with any fossil fuel (diesel, gasoline, propane, natural gas) or bio-fuel (biodiesel, ethanol) though it is most effective in diesel engines. Among other, more subtle effects, the presence of the hydrogen alters the initial stages of the unfolding combustion dynamic, altering the kinetic chemical pathway which the combustion follows. The net effect is to alter the time at which heat energy is released relative to the power cycle. The end result is to increase the adiabatic efficiency of the engine, which, in turn, means decreased fuel consumption, decreased emissions, improved horsepower and torque and decreased maintenance expenses.

The following video presentation has put together by open source hydroxy engineer Jacob Wall

[Video presentation of successful hydrogen supplementation](#)

Currently Panacea's affiliated open source engineers Jake Wall and Dustin need funding to progress this research. Jake is planning to pursue a PhD degree in mechanical engineering. Dustin is planning on helping with the grant proposals to include need gas quality studies and combustion research. Both Jakes and Dustin's grant proposal can be forwarded on request please [Contact Panacea](#).

There have since surfaced MANY scientific tests, patents and designs which prove this technologies worth and benefits. **Yet car makers are not making hydroxy boosters in a standard model to save fuel and prevent unneeded harmful emissions-** [Reference](#). Why have hydroxy boosters since been ignored? Why are they suppressed? Using [Occam Razor's logic](#), the simplistic answer is following the money. The answers are contained in what hydroxy boosters can do NOW, and in what their advanced designs WILL lead to.

Hydroxy system uses only water and electricity to produce the Hydrogen and Oxygen gases from water, testing shows greatly reduced or totally eliminated emissions, removal of engine and exhaust carbon deposits, improved torque and power, and increased fuel economy due to the complete burning of the vehicles existing fuel. The hydroxy booster extracts separated Hydrogen and Oxygen gases from distilled water in a stainless steel container installed in a vehicle. The unit uses a little of the vehicles excess energy to produce just the right amount of Hydrogen catalyst to blend with the existing fuel source, enhancing the combustion of fuel.

The reason we are getting a benefit from hydroxy injection is simply because hydroxy is having a higher flash point than petrol its self-igniting temperature is 550 degrees Celsius. Petrol ignites from 280 degrees onwards depending on the grade. This causes a

complete burn of all the fuel in the combustion chamber. So therefore there is minimal pollution out the exhaust. There is a greater reduction of carbon build up in the combustion chamber therefore your oil stays cleaner longer. Your engine will run smoother and cooler. You will then be able to pass any emission testing that is in your state. **Note depending on your amount of injection, some vehicles may need to have their timing slightly retarded.**

Not only does this technology improve MPG (miles per gallon), **SIGNIFICANTLY CUT EMISSIONS down to a healthier level** plus allow many more benefits. **This technology also opens the door scientifically for 100% water based oxyhydrogen fuel systems for vehicles.** This is an obvious threat to the multi trillion dollar OIL industry. Hydroxy technology has even shown to be effective at [reduction of radioactivity](#).

Hydroxy technologies also show that hydrogen power can be stored safely by being perfectly inert in water. As a result, hydrogen can be produced on DEMAND from water. This eliminates the need for dangerous hydrogen storage tanks on board cars and in any communities wishing to use hydrogen for power.

Quote - "*Hydrogen-on-demand does not need costly infrastructure and makes cars safer*" *Hydrogen-on-demand would not only remove the need for costly hydrogen pipelines and distribution infrastructure, it would also make hydrogen vehicles safer. "The theoretical advantage of on-board generation is that you don't have to muck about with hydrogen storage," says Mike Millikin, who monitors developments in alternative fuels for the Green Car Congress website. A car that doesn't need to carry tanks of flammable, volatile liquid or compressed gas would be much less vulnerable in an accident. "It also potentially offsets the requirements for building up a massive hydrogen production and distribution infrastructure," Millikin says*-End quote Mike Millikin.

Quote- *Hydrogen-on-demand, whether from water or another source, could address two of the big problems still holding back the wider use of hydrogen as a vehicle fuel: how to store the flammable gas, and how to transport it safely. Today's hydrogen-fuelled cars rely on stocks of gas produced in centralized plants and distributed via refueling stations in either liquefied or compressed form. Neither is ideal. The liquefaction process eats up to 40 per cent of the energy content of the stored hydrogen; while the energy density of the gas, even when compressed, is so low it is hard to see how it can ever be used to fuel a normal car.*-End quote new scientist magazine.

This also shows that water can be used as a fuel. The public need not to be fooled into thinking that a hydrogen economy needs to be assimilated by the usage of the now redundant production of dangerous hydrogen storage in tanks, and or produced by none renewable methods. Add to this suppressive fallacy; **there have since surfaced HIGHER efficient ways of producing hydroxy technology since 1918.**

A typical hydroxy booster operates by "brute force" DC electrolysis. This process functions in accordance with Faraday's laws of electrolysis. This is what the mainstream curricula attribute to ALL methods of possible hydrogen production from water. **However unknown to the mainstream faculties there are OTHER more efficient ways of achieving the extraction of hydrogen from water.** This is done by using pulsed DC under certain resonant conditions to create an open system which is able to extract [additional \(non thermal\) energy](#) from the environment.



Zigouras racing 100% hydroxy powered unit

The mainstream faculties have not yet explored, validated and or disproved this more efficient method in question. The Pulsed DC method under certain resonant conditions is by far the most efficient electrolysis process. [References](#) to this process accompanied with validated Panacea tests proving this will be provided later in this document and on the Panacea university site.



Paul Zigouras WORKING 100% hydroxy powered test engine

There have since recently emerged stories in the main stream media showing 100% water fuel powered cars, This is more solid proof that the Water fuel cars science is not going to be ignored now.

Japanese company [invents car that runs on water](#)



Japanese company Genepax presents its eco-friendly car that runs on nothing but water. The car has an energy generator that extracts hydrogen from water that is poured into the car's tank. The generator then releases electrons that produce electric power to run the car. Genepax, the company that invented the technology, aims to collaborate with Japanese manufacturers to mass produce it. Kiyoshi Hirasawa, CEO, Genepax. - [Source](#)

With this in mind it is therefore important to state, that the DC brute force method used in hydroxy boosters is not the most efficient and or only method in the science of extracting monatomic hydrogen out of water. **It is however a very practical method which is critically needed implementation and application mean time until the higher more efficient pulsed DC resonant systems can be developed to capacity.**

Recently political legislation came in regarding new fuel standards. This legislation is an energy bill which calls to raise the fuel standard to 35 miles to the Gallon by 2020. This is hypocrisy, as hydroxy boosters not to mention the [EV-1 electric car](#), can produce these results right NOW. Also despite many others already having 100% water powered systems and suppressed like Meyers, Xogen and Steven Ryan – [reference](#).

Hydroxy technology can be used NOW as a bench mark towards managing harmful emissions and improving fuel economy toward more ecologically friendly technologies for such sectors as public and private transportation.

Currently the Ronn Motor Company proposes to use hydroxyl hybrid technology in an expensive sports car.



The SCORPION, a mid engine, hydrogen fuel injected hybrid-[Source](#)

The system provides Hydrogen on demand, which is injected directly into the motor. This alternative fuel approach allows an increase fuel mileage between 20-40 % and reduces toxic emissions. **But this approach can be implemented NOW on EVERY car, and not limited to an expensive sports car.**

Even today a 40 year old Corvair gets better mileage than a good portion of mid-sized passenger cars made in the last 10 years. We have come so far in refinement of technology – you cannot justify that is not possible for mainstream manufacturers to push 80MPG or better. Instead of concentrating on efficiency for mileage, companies have concentrated on efficiency so they can make a heavier vehicle with more power. And we bought them in droves. So it's kind of our own fault as consumers. Leadership and DOE should have known better. That is what taxes are supposed to pay them for.

The warnings were there, but those making the decisions ignored those warnings for the most part. It's time the world takes a new philosophy to transportation and manufacturing. We could have avoided this whole global problem decades ago. If only gas were more expensive 50 years ago - we would have already gone through these growing pains and would be cruising on electric/hydrogen today. The GM EV-1 disaster is an almost forgotten example of our ability but unwillingness to address the core problems we now face. Don't let low oil prices lull you into a false sense of security.

What remains unknown to most of the world and those who do not know how to cut their carbon foot print and save energy is that [David King the Police Chief of the Honea Path Police Department discovered how to use hydroxy to increase the gas mileage of his department's fleet of vehicles](#) while saving the local taxpayers thousands of dollars every month.-[Source](#) Only one police department (a government agency) is actively using hydroxy gas enrichment and reporting positive results and no complications. **All government bodies can employ this technology to save the tax payer money and reduce the carbon foot print. Yet why are they not using it?**

As an emission cutting device and power savings device alone, hydroxy booster technology justifies (and needs) law for its mandatory implementation. Material which

can be used towards helping make this emission cutting device mandatory [can be found on this page](#). Panacea has also done a video production with these related political themes which can be found on the page mentioned. **Note for those with modern cars which have an electronic control module (ECM), it is also advised that you check your state laws prior to asking your mechanic to install a hydroxy booster, as currently she/he could be breaking state and federal law.**

This is because modern cars have to have an additional circuit called an "EFIE" or electronic fuel injection enhancer installed to make sure the on board ECM does not inject more fuel due to the new oxygen content passing the oxygen sensor. It is illegal to tamper with the cars emission management systems. It can be proven that hydroxy cuts emissions down, so technically this is not having a negative effect on the ECM's ability to manage the cars emissions. **However politicians are not aware of this.**

Currently the Volo [FS2-HHO Edition](#) Chip is being experimented with successful results. Although Bob Boyce states that it may not be operational on LPG cars



Volo chip

Also the EFIE has been exclusively created by open source engineers and **gives varied results**. What is required is that we perform a dyno and emission test with the EFIE to prove its ability to stop pollution. **Then this is used to pressure politicians to work in conjunction with car makers to produce software which can re program the cars computer to work with hydroxy efficiently to help cut the carbon foot print.**

After market computers and the OBD II system are recommended. The only **other solution available at this time is to use designs that separate the hydrogen and oxygen, this requires no EFIE**. The leader in this field who also has CARB approval for his design is www.hydroelectricpower.com/ .



[HH2 system](#) donated to Panacea for testing

Another up and coming gas separation system is being done by <http://www.youtube.com/user/Electrocell>

Currently One of Panacea's most respected open source engineers Bill Williams has achieved prolific ground work on an open source dry cell separation unit design.



Bill William's 5X5 CDGSC gas splitter cell

The Bill William's 5X5 CDGSC Dry cell gas splitter design has been posted in the cell design section of this document. Bill has also completed AC Inventor Animation file on the The GSC Dual Gas Electrolyzer which can be found on his YouTube Channel "[vipond50](#)"

Hydroxy technology can be proven to decrease or eliminate exhaust emissions, lowering the carbon footprint. There is a great deal of benefits and income that can be generated by carbon credits. For both a legal and practical public solution to address this, please consult the Panacea University's fuel saving vehicle modification document below.

[Panacea University's fuel saving vehicle modification document- Click HERE to download](#)

For Engineers

<http://www.panaceauniversity.org/Hydrogen%20Enriched%20Hydrocarbon%20Combustion.pdf>

With regard to the optimum amount of hydroxy needed for optimum mileage improvement. Almost without exception the best results were obtained when the amount of hydroxy supplied varied between $\frac{1}{4}$ and $\frac{1}{2}$ a liter per minute of hydroxy for each 1000cc of your engine. This is also the exact same amount that is prescribed by Bob Boyce for optimal mileage. Also retarding your timing to usually 8 degrees is required.

[ICE Operation](#) -with Hydroxy

[Tuning Fuel injected vehicle with Hydrogen Generator and Delivery System](#)

Others are also experimenting with using [hydroxy gas for home heating](#). The Nonprofit organization Panacea-BOCAF intends to support open source engineers working with hydroxy and other suppressed clean energy technologies. These engineers require grants, resources, faculty recognition and security. All this can be created in [Panacea's proposed granted research and development center](#). Please consider helping the open source engineer's research in ANY way if you have found this document useful. For those able to help this effort, please [Contact us](#).

This document will cover open source hydroxy booster designs which are considered very practical given their out puts, material costs and construction requirements. The order will range from the most recent validated designs to those currently being presented "as is" or described as a result of **third party reports**. Information will also be provided for those not able to construct boosters and who simply wish to purchase a readymade unit.

Warning- PLEASE NOTE! DO NOT USE THE WATER4GAS BOOSTER OR ANY THING SIMILAR - THIS BOOSTER NOT ONLY IS AN IN EFFICIENT DESIGN BUT ALSO WILL PRODUCE TOXIC GAS!

A glass jar containing wires wrapped around pieces of plastic, and filled with baking soda is DANGEROUS electrolyzer!



Dangerous booster designs- [Courtesy of this website](#)

Below is the end result of using one of these jar/wire/Baking Soda units as an electrolyzer



Baking soda boosters are toxic-[Courtesy of this website](#)

Please note before choosing a design- With a 50A alternator you cannot run your booster higher than 25A, in fact 20A is already pushing it. As soon as you have a rainy day or have to use your headlights the whole day/night, it will draw too much power and your battery will get flat. If you go higher than 25A you may need a higher amp alternator.

It does take power to spin the alt. and the more you draw off the more power it takes to keep it spinning. If you draw 1600 watts from the alt you have expended only 2 horse power! [Look up to confirm the real numbers if you want to be precise. 860 watts = 1HP] At 13.8 volts, how many amps is that? 115. Most standard alternators never will consume more than 1/2 HP under any conditions! That's for all the electrical needs included. They are sized for the motor to keep from taking too much power.

It is important to note that modern cars fitted with an ECU may need SPECIFIC alterations and circuits installed in order for their hydroxy booster to function properly. For example an: "EFIE" device (electronic fuel injection enhancer). The EFIE and other options will be covered in more detail below. Some boosters can be made to produce

“orthohydrogen” which does not require modification into the vehicles sensors. More detail on them will be posted on the faculty section as it comes in.

All in all, hydrogen and hydroxy are pretty safe as far as engine longevity go, BUT when you change mixtures, you must monitor EGT, CHT etc. or you will destroy valves. EFIEs need monitoring until you are sure it is right. If you get too lean, the engine will go full rich and your gas mileage will plummet. If you don't go lean enough, you will see no additional gain. It is a fine line and it requires some skills many do not have.

It is important to note that although the benefits of hydrogen boost technology are well proven, at this time mileage gains from boosters are variable. One size and gain to fit all is not possible, you must take into account each type of engine, whether running diesel (huger gains are usually possible to high compression) or gasoline which is two very different situations when adding hydroxy.

Currently each vehicle is a unique case. Factors affecting the final result include the driving habits, whether it's a modern car with an on board ECM and how much hydroxy your injecting into the engine compared to its size.

HOWEVER anyone using a booster is assured of cutting pollution! At this time a popular experimental method is to match the hydroxy booster output in liters per minute, to the liter engine size capacity for a “good boost”.

For example- If you drive a 2 liter engine, you could use the tubular water fuel for all standard booster which is estimated to give out 2LPM at 20 amps. You do not need a lot of hydroxy to obtain mileage improvement by improving the burn. The theory is that you can add too much hydroxy, so that it becomes a fuel rather than a combustion improver, and that when you do that, you start to need extensive alteration to the timing, or the early burn will oppose the rising piston and work against you. More details on this is address in the faculty section below. For the first time hydroxy booster enthusiast please read the FAQ's in this document.

Description



One of Panacea's boosters -"Eletrik's" original
open source "Smacks Booster"

Energy losses occur in an [internal combustion engine](#) (ICE) due to the incomplete conversion of combustion energy (chemical energy) into mechanical energy. The overall engine efficiency is about 25% for a diesel cycle, and even lower for a gasoline engine. The ICE conversion from the air / fuel mixture of chemical energy into useful mechanical energy **wastes around 75% of potential energy**. This wasted energy results in **harmful emissions** and is expelled as a mixture of gases and **heat losses** evacuated through the engines exhaust.

Hydrocarbon fuelled engines produce carbon dioxide (CO₂), carbon monoxide (CO) and water vapor (H₂O) as byproducts of the combustion process. **Carbon monoxide (CO) is poisonous to humans at certain concentrations and is considered a major contributor of environmental pollution**. Also the compression ratios typically encountered with internal combustion engines coupled with elevated temperatures caused by the combustion process means the production of oxides of nitrogen (NO_x). Hydrocarbons attack the liver and also cause cancer.

These toxic smog producing compounds are major contributors to pollution in heavily populated areas of the world. There is growing public concern about global warming and the buildup of toxic and smog producing gasses produced by internal combustion engines. Hydrogen in combinations with other electrolyzed gases (H+H+O or Brown's gas) can be produced by a hydroxy booster and introduced into the intake manifold of an ICE. This will accelerate the flame spread during combustion and allow more of the vaporized fuel to combust during the initial part of the power stroke.

The hydrogen-oxygen mix brings the fuel to a temperature that allows more of the injected fuel to vaporize, preparing it for combustion. Hydroxy gas thus allows a more

complete combustion of the gasoline in the combustion chamber due to a faster flame propagation and higher combustion temp. This will result in a COOLER and a cleaner burn.

As a result there will be an *increase in horsepower and gas mileage from the better combustion of the gasoline or diesel*. This **reduces your engine's need for total fuel and also reduces exhaust emissions**. Normally, any UN burnt fuel coming out of an engine is burnt in a catalytic converter. Hydroxy gas improves the burn quality to such a degree that a catalytic converter is no longer needed. Although there is no UN burnt fuel reaching the catalytic converter, it is left in place and cannot wear out due to it not being used. The by-product of the Hydroxy Gas being burned is Oxygen. Instead of leaving harmful Carbon monoxide from the burning of gasoline (exhaust) you are now helping the environment by adding more Oxygen to the air.

If we go from burning 62% of the fuel to burning 90%, we actually need to feed less fuel into the engine to obtain the same power output literally- more bang for your buck. **This is ideal and critically needed "corrective surgery" to the ICE.** Gasoline ignites before TDC (top dead center). Top dead center refers to the point where the piston is at the highest point of its motion. Exploding fuel before top dead center will not be very efficient due to the explosion of the gas fumes pushing the piston down and out of sequence. This is way too early so will go a bit in reverse. Combustion will occur much closer to TDC with a hydroxy boost and translates to mechanical torque as each piston transfers more energy during its combustion cycle. More efficient combustion will mean less fuel consumed and more work being done for the fuel being used.

The Term "Hydroxy" refers to a mixture of gases that are produced as a result of an electrical current being passed through stainless steel electrodes which are housed in water.



Pictured in the right container are stainless steel plates used as electrodes, above them is

(white) hydroxy gas being produced in the water

This process is usually achieved with the addition of an electrolyte added into the water housed in a PVC plastic container. This combination is what is coined as the "Hydroxy booster".



A generic booster design - [source](#)

In a typical case the electrical system of the vehicle (battery + alternator) is used to generate the gas from the booster. Typically 10, 20 and even 30+ amps can be used and replenished by the cars alternator system to generate hydroxy gas and give **up to 50%+ better millage. Again the emphasis should be on the emission cutting attributes of the booster.** Current reports have stated that hydroxy boosters can clean out carbon deposits in the engine, as well as improve the fuel economy and remove harmful emissions.

Further in depth analysis and discussion of the process will be included in the faculty and FAQ sections below.

Introductory Information

[Hydroxy Energy Talk - Coast to Coast AM](#)

[Facts That Every Citizen Should Know about Hydrogen](#)

[Richard Harris article](#)

Installation and Safety

A good example of a dry cell installation -

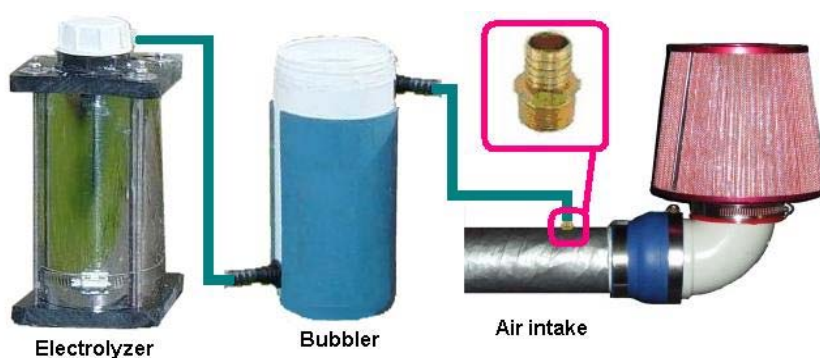
<http://www.youtube.com/watch?v=Dv9Ee3pgwvY>

Peter's great open source site - <http://www.myhydrogencar.webs.com/>

Please note- Only use the following advice as **guidance** in the installation of a motor bike or vehicle. The typical installation procedure described herein this document should be handled with ease by any professional mechanic or mechanically inclined individual with the appropriate tools and knowledge of engines.

Pre preparation-For the DIY person, do not commence construction and installation on your chosen booster design, BEFORE being aware of certain safety guidelines and modifications **which must be in place prior to operating a booster on your vehicle.**

IMPORTANT NOTE: The hydroxy gas produced in your booster is highly **flammable (explosive)** and can only be ignited safely inside the engine. You must insure that the gas is being feed only into the intake manifold ("upstream") before the butter fly. **We recommend the AIR FILTER BOX.**



The mounting of the booster's safety bubbler (explained below) is needs to be done as close to the carburetor or throttle body. This will allow a short length of piping to be used to connect the booster's bubbler to the intake of the engine. This connection should be installed into the air box which houses the filter, or put into the intake tube- **The closer to the butterfly valve the better. You want to tap into the ductwork just before the "Throttle Body" ALWAYS as close to the butterfly as you can get. THE CLOSER TO YOUR THROTTLE BODY THE BETTER YOU DON'T WANT Hydroxy HANGING OUT IN THE AIR BOX.**

It is preferred to add in the hydroxy before the air filter and only second choice after the air filter. The reason for this is pretty simple really. The by allowing diffusion of the hydroxy gas evenly into the intake air ensures thorough mixing for even boost into ALL cylinders. The air filter aids in this diffusion. If you send it into an engine via closer points (or intake vacuum ports for that matter) this will ensure that some cylinders receive more boost than others. Not good for your engine. In the following video, Bob Boyce explains this in great details. [-Bob Boyce Cell pt.5](#)



Taken from the Video showing the Hydroxy line installed into the inlet in the air filter

Turbo

Regarding a turbo, Bob has said that you need to make sure that you inject the hydrogen before the air filter, as this helps minimizing risk and also reduces the parts per million of hydrogen contained. All of this helps maintain the safety in working with a turbo car. The following is by David G. LeVine. The turbo housing temperature is nowhere near the intake air temperature. You really want to be injecting hydroxy close to the intake valves, so you have a cooler charge. Even one spark in an intercooler full of hydroxy is unhealthy for your wallet. If you put two one-way valves in place, one for turbo pressure to feed the electrolyzer and one to prevent back feeding through the bubbler, you can reduce the lag.

Air or "refill" supply =====>====[ELECTROLYZER]=====>====[BUBBLER]====...

Where =>= is a one-way valve. Let's assume your system generates 1.2 LPM and that looks like 0.02 LPS, and your "dead space" in the system is 0.04 L, you will have a two second lag between the turbo spooling up and the engine seeing hydroxyl again. This is not desirable.

If you pressurize the cell with cooled turbo gasses, the production is still lagging, but the hydroxy feed does not need to be refilled by the system before the engine sees hydroxy.

In the "faculty information" section of this document, timing and engine adjustments will be discussed further in greater detail. Remember to check the engine's ignition system and make sure it doesn't have a waste spark. If it does have a waste spark it must be disabled, for a waste spark fires when both valves are open to burn any remaining fuel in the piston. The EPA had that put in place to help with smog and green house gases, and that was the industries answer to the problem.

The booster must be installed with a circuit that will ensure that the current from your battery will only reach the booster when your engine is running. This circuit does not have a manually switched on and off circuit. A manual switch cannot insure against human error. This circuit will have the electrical supply connection to the booster through your engines ignition circuit. This will ensure that the booster will not produce any hydroxy gas unless the motor is turned on.

You must use electrical wires that are rated slightly above the amperage your booster draws. For example, if using a Smacks booster, the amperage draw is at around 20amps at 13+Volts DC. You will need wires rated to handle 30amps. **ANY wires which are being connected to your booster MUST be soldered not crimped and need to have tight quality connectors.** The slightest possible HEAT leakage from poor connections or as a result of crimping could lead to combustion of explosive hydroxy gas. **Please check your wires and connectors regularly.**

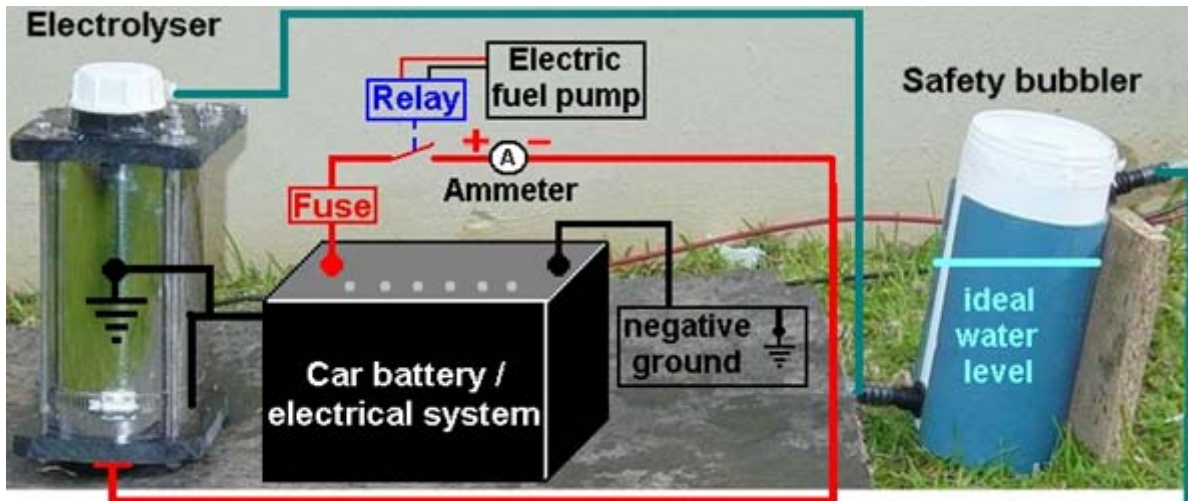
The Smacks installation guide recommends using 10g wire with soldered and shring wrapped terminals. This has been tried and tested by Eletrik (Smack) to run reliably. This has also been reported to work well to prevent any terminal heating or voltage drops. **Before connecting the booster to your ignition switch, your ignition circuit must be protected from extra amperage draw, which will be in place now as a result of the booster..**

Option one is to make use of a 30A relay which will be connected across your electric fuel pump. You will also need to use a 30A fuse between the battery and relay in case of any short circuit.

You can install a relay like this one: [12V SPDT 30 AMP AUTOMOTIVE RELAY | AllElectronics.com](#)

They also sell a relay socket: [SOCKET FOR AUTOMOTIVE RELAY | AllElectronics.com](#)

Never use brass or copper fittings on these cells.



Please note- It has been described above and in other guides to wire the relay by putting a fuse spade tap into the fuse slot for your fuel pump. This will make it where it is only is on when your key is turned to the run position. This is portrayed as being the only "Safe" way to wire it.

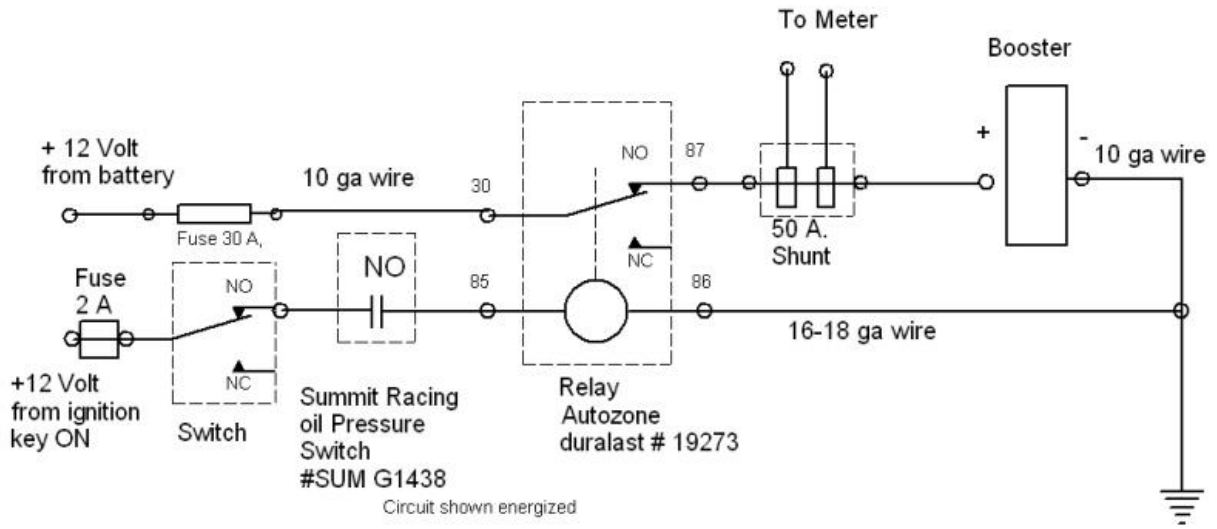
It is possible that this is not a safe method. When the ignition key is turned on, before the starter is engaged, the fuel pump is already turned on. If the engine is not started, hydroxy is building up with no place to go. The fuel pump line is ok, but it should enable an on/off switch or go through a normally open pressure switch in the oil line. These are only details, but need to be referenced early on to avoid problems. With both fuel pump line and oil pressure switch, it comes on with the key and oil pressure, and goes off if either is interrupted. Both are here included because the oil pressure may take time to bleed off and you want the booster to go off with the key.

If you use the fuel pump line to close the booster relay, it will NOT turn off if the engine stops. A secondary relay from oil pressure or RPM or some computer controlled point that actually changes when the motor stops must be used. The oil pressure is the least effective of these as it often takes considerable time for the pressure to leak off. Note the delay before the idiot light comes on or the pressure gauge reaches under 5PSI. For safety you must provide positive disabling of the booster in an accident. Agreed it has small potential for a problem, but this is the kind of issue that will prompt governments to impose restrictions or outright prohibitions. Considering these things ahead of time will give us more credibility. Only one control point is needed, but it must be only "on" if the motor is running.

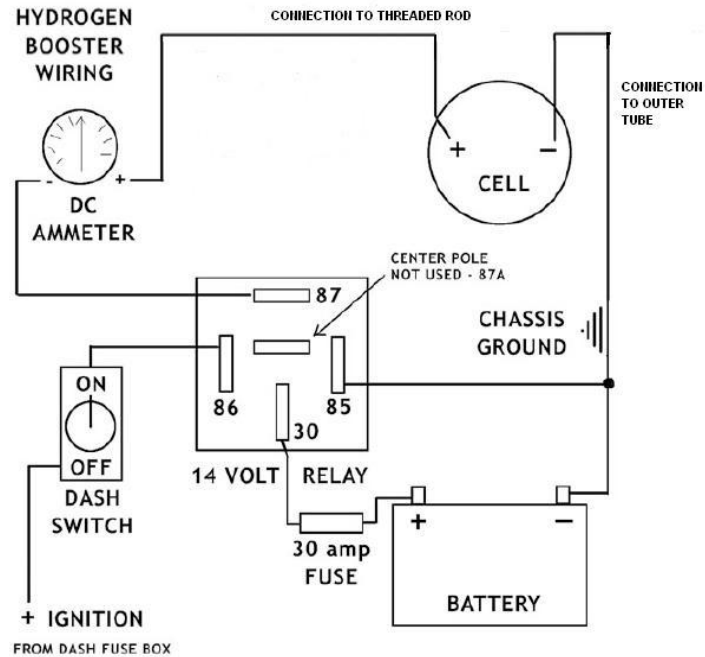
NEVER EVER hook it up to any engine vacuum. The Fuel pump relay is the only way to power on your cell. IF there is no fuel pump relay (like some Toyota) use the oil presser sender. The wires going to the plates inside the electrolyser will always need to be connected well below the surface of the water and electrolyte mix. This needs to be

done in order to prevent a possible loose working connection with any vibration of the vehicle. This situation can cause a spark in the hydroxy gas production area above the surface of the liquid. Always keep this volume as low as possible.

An alternate option has been supplied By open source engineer:
maxanthonybruce



Another option provided by Wouter from the WaterFuelFor All design.



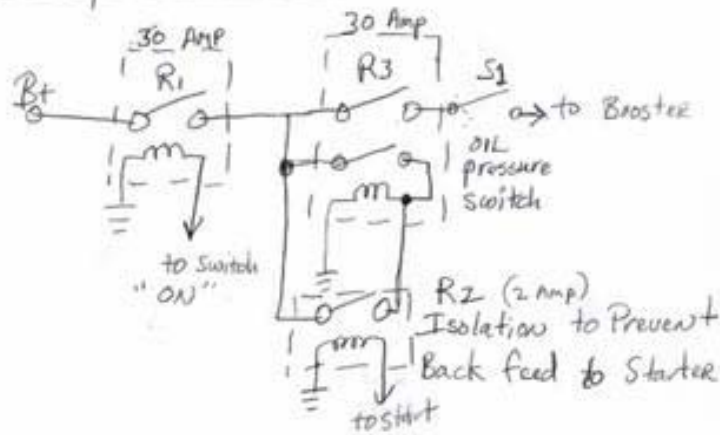
On the Relay Wiring, the trigger input just says "Ignition On" Make sure it is tapped into a component that only cuts on with the "Ignition On and Not Accessory" like the Fuel Pump fuse.

Mike Angerstein -How a booster can be shut off via an oil line sensor

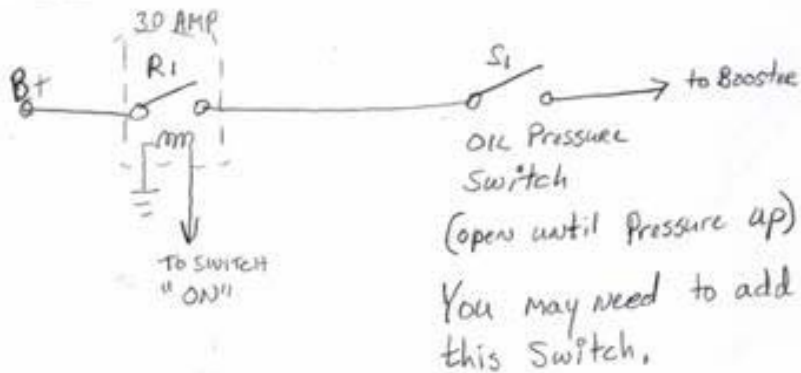
The relay method can be used if you can't get an oil line sensor installed. [Must be normally open, without oil pressure] If you can, use that alone and no hydroxy will be generated until oil pressure is "Up." This will shut off the system in a few seconds if the engine stalls.

Mike ANGERSTEIN

Relay Method:

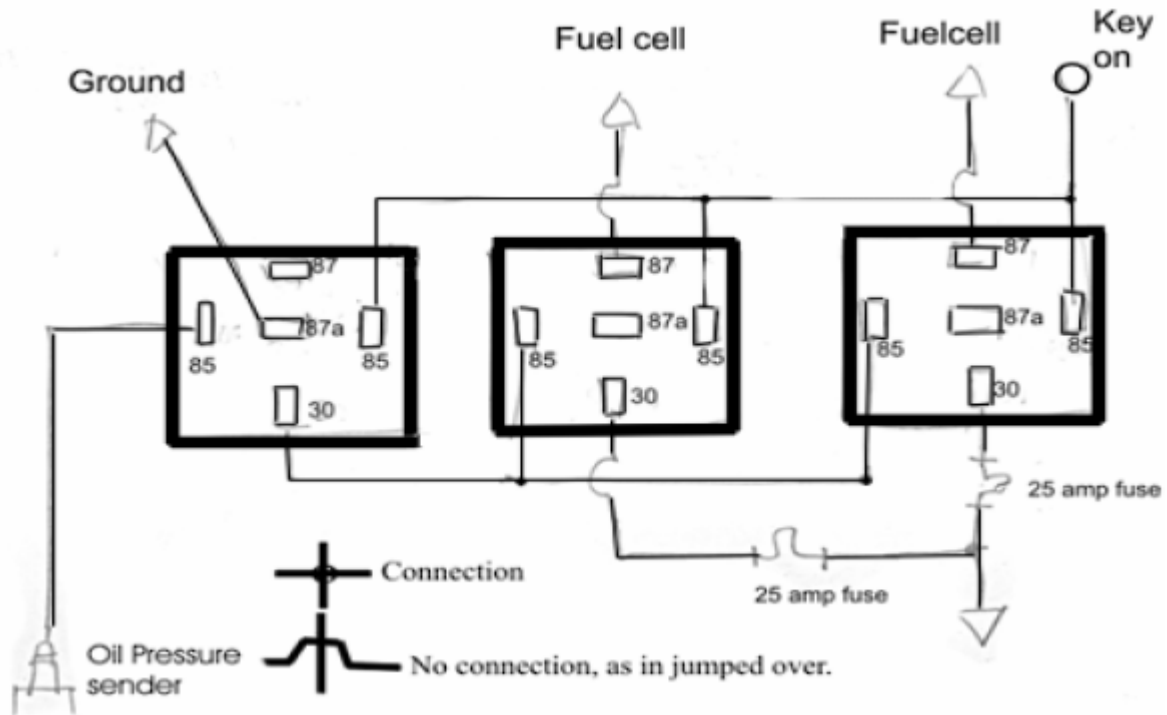


Better:



For any who try the relays, the isolation relay, R2 is required to keep from back feeding the starter and trashing the teeth on the starter or flywheel. If you are not proficient in electrical devices, get help. Individual cars and trucks may have hidden problems when adding things to the starter wiring.

Richard Coyle- How to use an oil pressure sender to do a booster shut-off



Relay one controls the coil power to relay two and three by their grounds. The contact are: 85 (2) are the control coil lugs, this coil controls the relay and #30 is the B+ lug with 87 and 87a being the out puts or switched contacts. Relay one must have normally open and closed contacts, that is: with no power one contact will connect to terminal 30 it will most likely be 87a and the other will not. Check with a ohm meter: if one connects and the other one does not: you're got a good relay, if both do not make a contact find a relay that does. It works like this, key on and all coils are getting the B+ power, but with no path to ground for relays 2 & 3, it being held open by relay one they do not connect, and relay one IS powered by having its ground connecting thought the oil pressure sender.

This is the tricky part, relay one controls the ground for the two power relays by holding the contact open for them to ground, so you want their ground connections on relays #30 lug and the ground hook up on the contact that is OPEN when relay one is powered up and to be connected when relay one's power is cut, or the normally closed contact (normally is at rest or unpowered). Starting the motor causes the oil pressure sender to open or come off ground, this cuts the ground connection to relay one letting it shut down and thus CLOSE the OPEN connection now letting relay 2&3 power up and they close their contacts and power the fuel cell. This will insure the fuel cell only runs when the motor runs making it safe.-Richard Coyle

Before the booster can be connected to the intake manifold, the booster needs protection from a potential "flash back" or back fire explosion. This is done by using what is called a "flash back arrestor" or a "safety bubbler(s)".



Above is a safety bubbler, it is advised you use two of them

If your engine produced a “backfire”, the bubbler will block the flame from passing back through the hose pipe and igniting the gas being produced in the booster.

Boosters must be constructed with a tight fitted screw on lid. A tighter lid will mask or soften the explosion. A large volume of water will be used in the bubbler to help mask and stop any flashback from reaching the electrolyser.

For an example of the cap coming off from an induced flash back please consult these videos:

[YouTube - Poor man's bubbler testing](#)

[YouTube-hydroxy fuel cell explosion](#)

[YouTube-hydroxy - Bubblers and safety](#)

If using an additional water trap, Wouter has provided the following explanation. The hose coming from the water trap is connected to the air intake **before the air breather**, so that the gases introduced into the intake are first filtered by the air filter. We are not interested in a vacuum because the manifold has greatest vacuum at the wrong time, and no vacuum at the worse time. Also, we want the hydroxy gas filtered of any mist, which may carry traces of electrolyte. As an additional benefit, the air filter serves as a first line of defense protecting against a back flash coming from the engine.

The reason why it is recommend connecting the hose coming from the water trap to the air intake before the air breather, is so that the gases introduced into the intake are first filtered by the air filter. We are not interested in a vacuum because the manifold has greatest vacuum at the wrong time and no vacuum at the worse time. Also, we want the hydroxy gas filtered of any mist, which may carry traces of electrolyte. As an additional benefit, the air filter serves as a first line of defense protecting against a flash back coming from the engine.

The reason why a check valve is needed between the bubbler and on the design like the Smack's booster (detailed in the brute force hydroxyl design section below) is

because the Smack is not designed to withstand the force of a flashback on its own and relies on the bubbler to protect it. Thus, to protect the booster, the bubbler must remain filled with water at all time to serve as a protection mechanism and the one way check valve is suppose to keep the water in the bubbler from siphoning back into the booster.

On the other hand, the WouterfuellForAll booster outer side-wall is constructed from 1.5mm (0.06") thick stainless steel, thus much stronger than many other commercially available boosters. So, the WFA booster can easily withstand a flashback on its own, even if there is no bubbler present. For that reason the WFA comes standard with a water trap where the purpose of the water trap is mainly to catch water carrying electrolyte that might spill over from the booster while driving. In this way we prevent electrolyte from being sucked into the engine. For this exact reason we do not connect the gas hose to any place that draws a vacuum, but rater connect the gas hose to the air filter box so that the hydroxy exits BEFORE the air filter. In this way, the air filter serves as additional protection against a possible engine backfire and the air filter also assist in filtering out any traces of electrolyte in the hydroxy gas. Note that the water trap has also been tested to act as an effective protection mechanism against a flashback. Should a flashback happen, the plastic cap of the water trap will simply shoot off or one of the rubber seal connectors will pop out. (Also note that the plastic cap is made of very light and soft HDPE plastic so there is no risk of shrapnel as with some other commercially available boosters!) So it is clear that on its own, this setup is both safe and easy to implement.

Replacing the water trap with a heavy duty bubbler adds even more safety to the installation and the idea is to keep the bubbler at least half full of water at a time. In this way, the water in the bubbler serves as an additional protection against a flashback and also serves as an additional filtering mechanism to filter out traces of electrolyte from the hydroxy gas. Unless a one-way valve is fitted in-between the booster and the bubbler, some of the water in the bubbler may siphon back into the booster when the booster cools down and for that reason you should only fill the bubbler with distilled water or water that has been filtered by a Brita filter. While fitting a one-way valve inbetween the booster and the bubbler prevents water from siphoning back into the booster, the bubbler will not be able to act as a water trap and thus more care has to be taken not to overfill the booster when refilling with water. Obviously nothing prevents you from having both a water trap and heavy duty bubbler which will give you the best of both worlds!

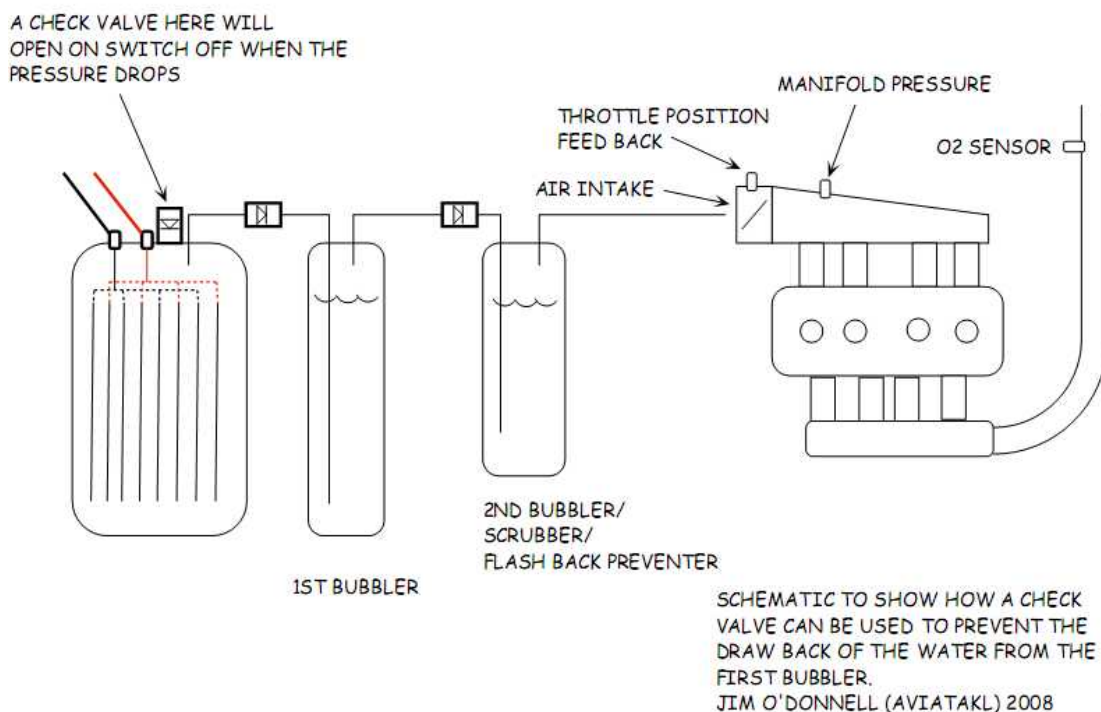
As a rule of thumb, for systems generating less than 2 liters per minute (that implies a current draw $\leq 20A$), the water trap on its own is sufficient, but we recommend the heavy duty bubbler for systems generating more than 2 liters per minute hydroxy (i.e. max current draw $>20A$).

Cheap Bubblers

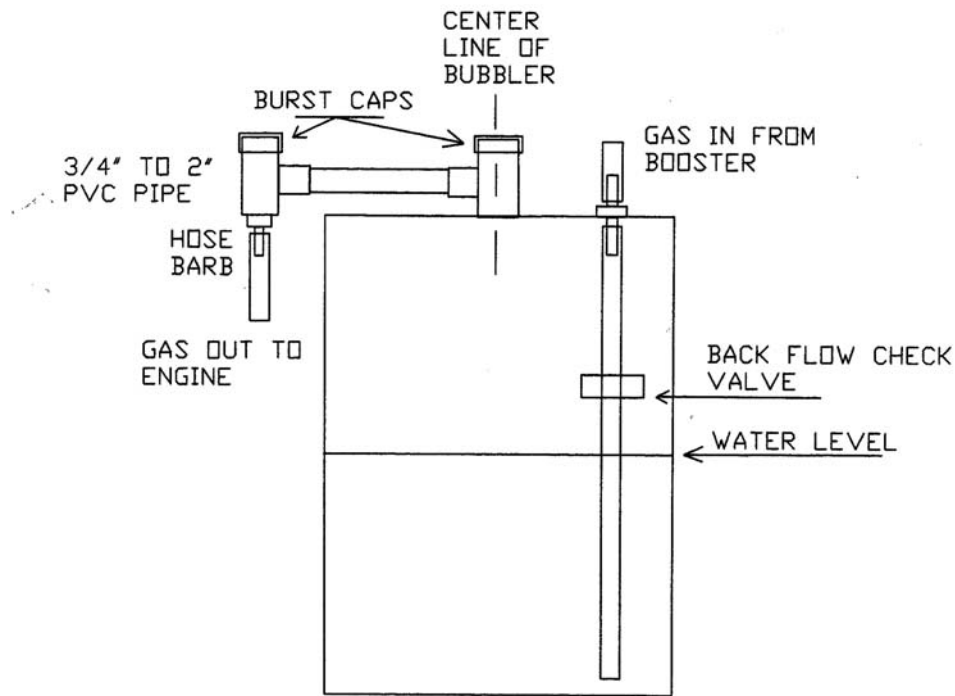
All you have to do is get a piece of 2" or 3" PVC drain pipe (not pressure pipe) from any plumbers supply, cut to length and glue an end cap on each end. Drill and tap a 1/2" BSP hole through the side of the each end cap so that the distance from the edge of the threaded hole to the face of the end cap is about 1/2" or 13mm. That is, the distance from the face of the end cap to the centre of the threaded hole is about 1" or 25mm.

Get a 1/2" BSP polypipe hoesetail (not easy to get 3/8") from the plumbers or a garden irrigation centre, Bunnings or similar store and dip the end of the 3/8 plastic pipe into some hot water and it should push onto the 1/2" hoesetail OK.

Jim's complete safety system with a check valve



Mike Angerstein Bubbler



BUBBLER

MIKE ANGERSTEIN

This is a bubbler design with 2 T sections to use as blast diverters to minimize pressures in the bubbler. No bubbler dimensions are given, as the important factor is semetry. The T leading into the bubbler should be in the center of the bubbler. Minimal gas space is assumed and a good quality back flow check valve capable of withstanding at least 150 PSI is required. The tube can be 1" tygon with a 1" barb fitting on the T. That makes the area of the burst diaphragm almost equal to the area of the top of the bubbler using 1" fittings. Not expensive and very effective design. The addition of a "blade style" micro switch will also turn off your booster if the diaphragm is burst. You will need a micro switch on each diaphragm with the normally open contacts wired in series to insure the booster will be shut off. This arrangement was in my design of 18 months ago and was mentioned here with no responders I can recall. It followed a long discussion about forces in the flash back in which Bob Boyce carefully outlined all these same points about shock wave pressures and their destructive results. -End

Never install any hydroxy unit or contraption IE, any booster or any bubbler near or inside the passenger compartment. Only suitable places are the engine compartment. **If you are thinking about the boot or trunk where is the gas going to escape if there is a leak?** Some commercial boosters like the Magdrive mention

luggage space as being a considered place to put a hydroxy generator. Of a valid concern here is anyone placing a hydroxy generator in a luggage compartment is taking a big risk should their unit develop a leak. High priority warnings should be made available to everyone in case someone manages to ignite one and spoils it for the rest of us.

Common sense dictates doing things with safety at the fore. Should a hydroxy booster in a car boot leak and an explosion occur, it would have dire consequences for the cause. Lawmakers would verily swoop on an event like that and very likely write in a new law banning hydroxy generators, not just for luggage compartments, they could go further, "in the interests of public safety".

Absolutely NO pipe containing gas should run through any part of the passenger area. The bubbler on the side of the unit should be filled about 1/3 to 1/2 full of water. The other option is to have another bubbler connect as a water trap. Beware of any systems that call for lots of chemical, (KOH, NaOH (lye)) **use double bubblers to help catch any before going to your motor.** Do not use tap water if you're choosing to use the Smack's booster design. **You must ensure that the bubbler level is maintained at all times. ANY Failure to do so WILL result in backfire explosion. Never perform electrolysis where the gas can escape freely, hydroxy can ignite very easily. Always keep the hydroxy gas held at the top of each cell to a minimum.**

For safety reasons, ideally you want to reduce the volume of hydroxy gas hanging around in the intake system so use short hose connections. Also to limit the amount of any unprotected hydroxy gas. One option is to drill and tap a 1/4" (6 mm) NPT fitting into the plastic inlet tubing with a barbed end for connecting the 1/4" (6 mm) hose. It is better to have as short a run of tubing as possible to the air ductwork of the engine.

If your length of tube is 3 feet / 1 meter or above, then include another bubbler at the end of the tube for extra protection. Use a larger diameter outlet hose, for example 3/8" or 5/16" (10 mm or 12 mm).

Also you must protect your engine from other damage by using a one way valve. This one way valve can be placed in the pipe between the booster and the bubbler. This is to prevent any water from being drawn into the booster when the booster is off and has cooled down. This will also "filter" the electrolyte vapor out of the hydroxy gas when on its way into the engine. It is advised you do this to remove any traces of electrolyte fumes from the gas before it is drawn into the engine.

Always position your booster in the best ventilated area of your engine. This will also help keep the booster cool when operating for long periods of time. Most prefer to install the booster behind the front bumper between the radiator (always facing upright). The booster's weight can be supported by being housed in bracket with two

hose clamps to secure the unit, one close to the top and one around the bottom. Please consult the recommended installation guides included later for further examples.

Always use your booster with distilled water. Tap water, salt water or rainwater will have impurities in them and will clog and cause damage to your booster and affect your health! **Always use KOH (potassium hydroxide) as an electrolyte. Never use table salt or baking soda!** This will permanently damage the booster more information why is provided in the faculty section.

While working with the electrolyte solution, use latex or rubber gloves and eye protection as well as a surgical or painter's breathing mask. If you ever have a substance on your skin that feels slippery, it is probably this solution. Wash it off with plenty of water and some vinegar or citrus juice. These are weak acids and will neutralize the base.

Caution, when mixing electrolyte with water, the solution will generate lots of heat. Add the electrolyte to the water a little at a time, stirring and giving the solution time to cool so it doesn't overheat. Do not breathe the fumes of this solution. Work in a well ventilated area and wear the surgical or painter's breathing mask. Both KOH and NaOH are bad for aluminum car parts. They are used in the gas generator and should NEVER get to the engine parts. That is what bubblers, filters, etc. are supposed to prevent.

It will depend on what booster design you use plus how frequently you use your car or bike as to how often the water and electrolyte mix will need topping up. If you want to stick to the Smacks low cost design and drive longer, you will need to use the Smack Gen III. More info on this is mention in the design section below. If you use your car for an hour a day using this first Smack design, typically you may only have to top it up (not completely refill) about once per week. **ALWAYS MONITOR THIS! The filling from a bubbler can be recovered and is to replenish so any electrolyte filtered from the gas can be reclaimed.**

When adding distilled water check your current draw. It is normal to observe a drop in current after a few refills. **It is also necessary to install an ammeter to monitor the current draw as you operate your booster.**

For those who have cars which have an ECU (electronic control unit) on board, you must add in a specific circuit which will enable the car to accept the hydroxy booster. All modern cars have a fuel computer (ECU) and this circuit is needed to adjust the sensor signal fed to the computer from the oxygen sensor built into the exhaust. If we don't do this the car's ECU will inject more fuel due to less emissions coming out of your exhaust.

Please refer to the EFIE section below. Also depending on your LPM (liters per minute) output of your chosen design, certain timing and adjustments need to be considered

for your car in order to achieve the best performance. This will be discussed in the faculty section below. Various designs of boosters will be covered shortly. Also Links to ready built boosters for sale are included below.

Auto Refill designs

Both the Bill Williams and karma booster designs listed in the booster section below have auto re fill systems

<http://smacksboosters.110mb.com/smactanium.htm>

[Les Blanki -Kit form](#)

Diesel Engines

The benefits of hydrogen and oxygen being fed into diesel engines have been scientifically proven, researched and documented by the U.S. Government, universities and research facilities globally.

*SAE Technical Paper 2000-01-2791:"A Before Treatment Method for Reduction of Emissions in Diesel Engines",
by S.O. Bade Shrestha, University of Calgary, International Fall Fuels and Lubricants Meeting and Exposition, Baltimore, Maryland, October 2000."Through an addition of a small amount of hydrogen to the main fuel, the combustion process can be considerably enhanced in internal combustion engines producing significantly lower levels of exhaust emissions.*

This improvement in combustion can be mainly attributed to the faster and cleaner burning characteristics of hydrogen in comparison to conventional liquid and gaseous fuels. An oxygen-enrichment of a fuel-air mixture also improves thermal efficiency and reduces especially particulate, carbon monoxide and unburned hydrocarbon emissions in exhaust."In comparison to the baseline diesel operation, the reduction, especially on PM and NOx emissions are attractive considering the simplicity and low cost of hydrogen generating systems used. The maximum reductions of PM, CO and NOx emissions are up to 60%, 30% and 19% respectively in comparison to the corresponding baseline diesel operation for the experiment considered." -end

Diesel is used in a high-compression engine. Air is compressed until it is heated above the auto ignition temperature of diesel (210° C). Then the fuel is injected as a high pressure spray. At normal temperature and pressure, it is estimated that hydroxy can burn when it is between 4% and 94% hydrogen by volume.

Diesel engines do not operate by using spark plugs hence there are no timing alterations which will need to be done to them in order to operate with a booster. With using large volumes of hydroxy gas, the diesel engine is set to tick over on diesel and

hydroxy gas is then added to "rev" the engine up and provide the power. The amount of hydroxy gas should not exceed four times the amount of diesel as engine overheating will occur if it does.

If there is too much hydroxy, timing will be impacted, and since hydroxy/diesel burns faster than pure diesel, the effect is to have over advanced the ignition. **You could get an EGT pyrometer and watch that exhaust gas temperature. If you run above about 1,300° you will do things like melting heads and pistons. Do a run without hydroxy and then with very slowly increasing the hydroxy, when the temperature rises, you will need to find out why.** This could be due to pre ignition or an increased fuel burn rate. Open source engineer Bob Boyce has also stated that diesel will run on 80% Hydroxy and 20% Diesel. In Bob's data he states that you can only replace 80% of the diesel before having too little lube on the top end. That means you are running on 20%. That is way up there in milage.

Glow Plugs

These should not have a negative effect and or cause a flash back. From logic: glow plugs don't pre ignite diesel. It takes both compression and the glow plug to have ignition on manifold injection [where fuel is present during compression].

LONG ANSWER: Question: ignition temp for each fuel. [gas: 280°C] diesel: 210°C [many references] hydrogen: 585°C <http://www.hse.gov.uk/research/rrpdf/rr615.pdf>.

Hydroxy: unknown [probably somewhat lower than hydrogen, but way higher than diesel]. Major problem: "hot spots" [see Ford article] These are hydrocarbon deposits that are "fanned into flame" by the inrush of the "charging" of the cylinder with air/fuel mix during intake cycle. If the spot is above the ignition temp it will ignite the fuel/air charge and cause backfire if the valve is still open, or "pre ignition knock" if during compression cycle. After the engine has been run with hydroxy boost for some time the hydrocarbon is "cleaned" off the walls and piston face and the probability greatly reduced.

The more common point of ignition is the sparkplug in gas [made worse if platinum because of intentional high retained heat at the tip] or the glow plug in diesel engines. On engines where the glow plug is left on, there are few deposits at the plug, but where it is turned off, the deposits are the "glow" needed for best timing on "manifold" or port injection. If direct injected, no fuel until injection and ignition is at the point of injection from "boundary temps" [the heat caused by friction between fuel at high pressure and hot air] as well as compression.

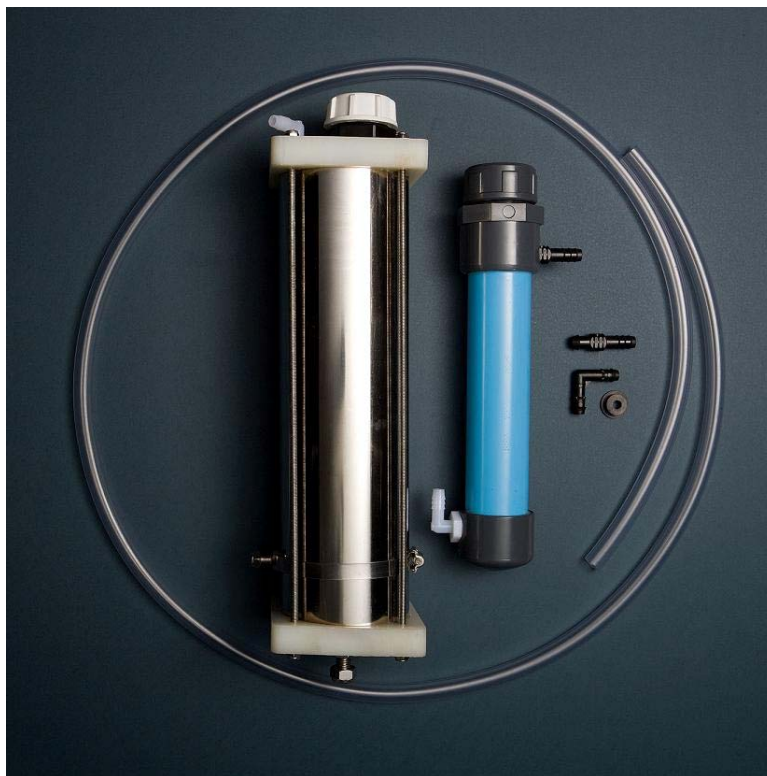
SHORT ANSWER: no. many examples of success with diesel and all have glow plugs. For a good article on ice hydrogen use see [ford doc]

<http://www.fsec.ucf.edu/en/consumer/hydrogen/basics/utilization-ice.htm>

In most diesels the glow plugs are on for a timed interval at startup. On these engines, the presence of hydrocarbon hot spots is likely. As these are "burning" at combustion temp, preignition of hydroxy is likely. In most engines, both gas and diesel, a low level of hydroxy injection for a cleaning phase seems indicated. No papers found to indicate this has been investigated.

Diesel and other trucks

The benefits of hydroxyl on trucks and in reducing their emissions is already well reported in the environmental testing laboratory in California, for this reference and more related papers, please consult the Law and emissions section below. Trucks will require a high hydroxy boost to get a significant gain. There are allot of retail units out there which are ridiculously priced given their output and material cost. The open source engineers have made the lowest cost designs. These designs are listed in this document. **PLEASE NOTE, WHEN USING BOOSTERS ON TRUCKS; YOU WILL NEED AT LEAST TWO HEAVY DUTY SAFTEY BUBBLERS, CHECK VALVE PLUS A WATER TRAP.** The reason being, **you are producing a HIGH concentration (up to 10LPM) of hydroxy, therefore safety must not be compromised.**



The Water Fuel for all Super Deluxe booster

An example of one heavy duty safety bubbler (right). This is the Wouter fuel for all super deluxe trucking booster (center) next to the water trap (right). **So far this is the lowest cost, reliable and compact retail booster.** The average price for a 7LPM Wouter fuel for

all system is around 1500\$. Similar systems (not even made of solid stainless steel) which produce high out puts currently go for up to 10,000 USD!

For trucks – it is recommend two bubblers where the first bubbler is empty and merely serves the purpose as a water trap while the second bubbler is filled with water. In-between the two bubblers we fit a one way check valve as to prevent the water in the second bubbler from siphoning back to the booster.

Note that you will be installing 2 bubblers per system with a one way check valve in between the two bubblers. The first bubbler is empty and the second bubbler will always be filled with water. Each truck installation can typically have between 1-3 boosters, but still only 2 bubblers are needed. Long distance truck installations MUST have a current limiter!!

Do not forget that it is preferred to add in the hydroxy **before the air filter and only second choice after the air filter**. The reason for this is pretty simple really. The by allowing diffusion of the hydroxy gas evenly into the intake air ensures thorough mixing for even boost into ALL cylinders. The air filter aids in this diffusion. If you want to connect your gas hose **AFTER** the air cleaner, then you **MUST** have a second bubbler filled with water. This is because we can no more rely on the air cleaner to filter out trace elements of lye and thus we must have a bubbler filled with water to catch any remaining lye. So, for this purpose we recommend this setup: Booster > water trap > one way check valve > bubbler(s).



An example of housings for boosters



Enclosure

In the following installation Panacea installed the water fuel for all "super deluxe" truck booster on a 1988 Toyota Dyna Pantec Engine – 2446 cc 4 cylinder diesel. Panacea applied the ratio of 1LPM (one liter per minute of hydroxy) per liter of engine size. In this case it worked out to be around 3 liter per minute of hydroxy for a 2.4 liter engine.



1988 Toyota Dyna Pantec Engine – 2446 cc 4 cylinder diesel

The wiring was done so that we take power for the relay from the oil pressure sender which only gives power when the engine is actually running.(see the Smacks Booster wiring diagram).When you turn on the ignition there is no power to the booster relay until the engine actually starts running. Much safer. Conversely, the booster shuts down when the engine stops since it loses oil pressure and the oil pressure sender cuts the power to the relay even though the ignition can still be on.



Amp gauge

The above unit can also have an EFIE and or a current limiter added into it.



Find a suitable place inside the car to mount the gauge



Booster installed with a water trap and safety bubbler

Panacea put the one way check valve in-between the water trap and bubbler.



One way valve used

One bubbler is going to be the water trap and will be empty and then you will fit the one way check valve in between the first and second bubbler which is filled with water. The water trap comes after the booster and is empty. The second one is full of water and is the bubbler. The non-return valve goes between the water trap and the bubbler.

That is to stop water siphoning back into the booster, however it does not solve the problem of too much vacuum pulling the water and electrolyte through the system and into the air cleaner. It may be corrected by introducing the hydroxy into the air inlet pipe coming into the air cleaner housing before it gets to the filter element. Since Panacea changed the hydroxy connection to the inlet pipe coming into the air cleaner it seemed to solve the problem of water and electrolyte getting sucked into the air cleaner. Probably because there is less vacuum at this point than after the air cleaner, which of course is closer to the inlet manifold and hence higher vacuum.



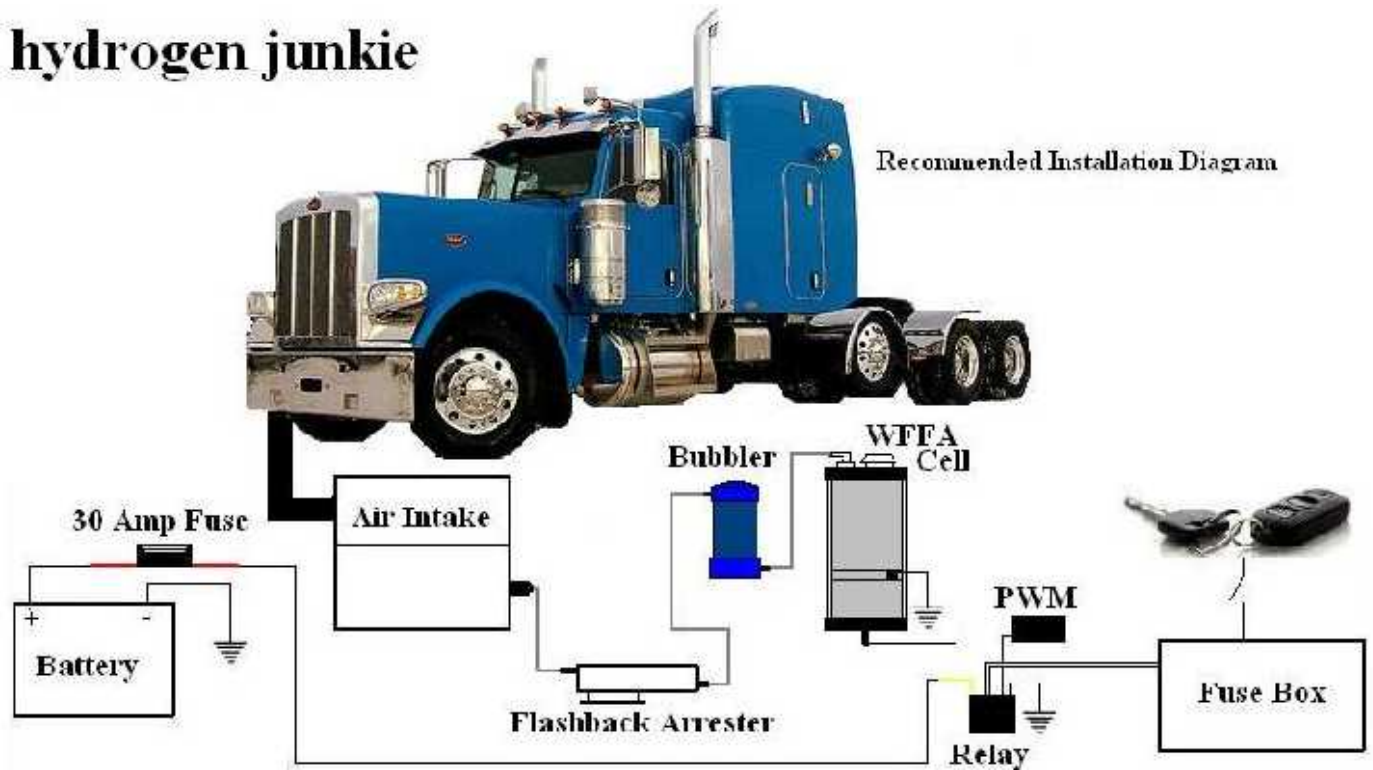
Hydroxy line feed into the air filter box



Relay installed on the left

The following is another option provided by the hydrogen junkie.

hydrogen junkie



There are many vehicle configurations in the market place; therefore the following can only be a general guide line which presents a typical installation. Although this may seem like a relatively simple process it should be handled by a professional mechanic or mechanically-inclined individual with the appropriate tools.

First you must find an appropriate location to house your electrolyser. This can be mounted at the back of a tractor cab, or the bed of your pickup, not inside the cargo bay of a truck. Then determine a path for your hydroxy hoses and electrical wire from the electrolyser to the engine compartment. Keep in mind that you will most likely want to run the hoses and wire together along a frame member or other similar under vehicle location where you can attach wire or plastic ties to hold them in place. **You MUST keep both hydroxy hoses and electrical wire at least 12" from the exhaust pipes and exhaust manifold to prevent them from burning, shorting, or melting.**

For inside- engine compartment, in-trunk, in-truck-bed. Note never the in-commercial-cargo-bay: combustible gases not allowed in-commercial-cargo-bay

After the location where you wish to install your electrolyser then find a place where you can drill 2- 11/16" holes & 3- 1/4" holes within 2" of each other (a circular pattern works well). Drill through the floor to the underside of the vehicle. **You must stay clear of the fuel tank, brake lines, and any other obstructions which would make it difficult for you to push or pull your hydroxy hoses and electrical wires through the holes you have drilled.**

Then either push or pull the 2 hydroxy hoses through the two 1 1/16" holes you drilled, providing enough slack near the electrolyser to allow you to position it conveniently when you want to fill/re-fill the electrolyte in the generating cells. Then secure the hoses on the two hose barbs extending from the electrolyser, using the hose clamps.

Then push or pull the two large red and green wires through two of the 1/4" holes, inserting each wire through separate 1/4" holes you previously drilled. Then push or pull both of the two smaller red and green wires through the last 1/4" hole. Wrap all the electrical wires with electrical tape where they may rub against the side of the drilled holes to protect them from wear. You can bundle the hoses and wires together to make it easier to tie them up to and secure them along a frame member in the direction of the engine compartment.

In the engine compartment of your vehicle use your electrical circuit checker/probe to locate a 12 Volt hot wire that will switch on/off when you switch your ignition on/off. Attaching the 2 small solenoid activation wires to a switched source will prevent the device from continuing to generate hydrogen and oxygen when your ignition key is switched off.

Cut the ignition wire in a convenient location and strip the 2 ends back about 3/8". Splice one end of the small red electrical wire onto the hot/power side of the ignition circuit. **Turn the ignition off while working on that circuit.** Then attach one end of the small green wire extending from the electrolyser to the other end of the wire you cut and are splicing into, to re-constitute the original circuit after the switched current has passed through the solenoid within the electrolyser. You can use two crimp-on butt connectors (see photos below) provided to effect the splice connections.

Now locate an area on your air-intake cowling as near the air-intake termination at the throttle throat as you can conveniently access. Drill 2- 7/16" holes about 2" apart. (Remove the air-intake, or move it to a position where the drilling debris won't fall into the throttle throat or intake manifold.) Re-attach the air-intake cowling and screw the 1/4 NPT x 3/8" hose barbs (2 fittings) into the 7/16" holes you drilled in the air-intake. There is no need to over-tighten the fittings. If you strip the threads or have trouble satisfactorily affixing the fittings into the air-intake cowling, you can clean the area around the holes and use any good plastic glue, such as PVC cement, airplane glue, Gorilla Glue, to secure the hose barbs.

Attach both vacuum hoses to the 2 hose barbs you attached to your air-intake cowling using 2 of the hose clamps. Double check to be sure you have chosen a path that will avoid the hot exhaust manifold and exhaust pipes as well as avoiding any moving mechanisms that would entangle or wear the hoses. It's a good idea to follow the same path as the electrical wires so the 2 hoses and the wires can be bundled with electrical tape as you attach and support them with plastic ties and/or mechanics wire as they

traverse along the vehicle framework between the location of the electrolyser and the engine compartment.

Attach a brass 3 circuit clip connector to each of the positive and negative battery posts. (see photo 1). On top mount battery posts, loosen each of the battery clamp nuts and slide one of the 3 circuit clip connectors between each of the 2 nuts and the 2 battery clamps, then re-tighten each of the nuts to hold the 2 circuit clips in place. On side mount batteries, loosen the 2 cable bolts and slide a circuit clip over each of the cable bolts between the battery and the cable connector, then re-tighten both of the bolts to hold the clips in place.



Photo 1



Photo 2



Photo 3

Attach (crimp) a 1/4" yellow female push-on connector (see 2) to the battery end of each of the large red and green battery wires. Then push the female push-on connector on the red wire onto one of the male prongs of the circuit clip you previously attached to the positive post of the battery. Then do the same with the green wire, attaching it to one of the male prongs of the circuit clip you previously attached to the negative post of the battery.

[Installation example on a Diesel Truck](#)

Turbo Diesel

The following has not been tested and verified thus is experimental. Seek out and or make a port just BEFORE the blades of the turbine, where the strongest vacuum would be. This helps produce more Hydroxy. Care must be taken so any particles can be sucked into the blades and possibly damage them.

If no turbo:



Do not use brass or copper fittings on the booster, the electrolyte will eat them. The next port option is to add a nipple onto the air filter box (preferably after the filter) or into the air duct itself. It may not matter where as long as the hydroxy finds its way into the intake. It may not be necessary unlike gasoline engines for two connections. One should do. It is unclear if leaning the mixture is desirable or beneficial once you introduce Hydroxy. Experiment first without changing anything else - just add Hydroxy. Then configure or alter the mixture to see if it improves mileage without causing power loss and/or overheating. Do it a little bit at a time.

Original Smack's Design on a Diesel

One experimenter who experimented with several different variations of the Smack's design reported his figures averaged closer to 1 LPM @20 amps. In his replication (not representative of all) over heating temperatures amounting to 170 degrees produced lot of steam. Stick to the Smack's recommendations with his design and allow for run time conditioning. However if this does occur. The Smack can be used at the 0.5 LPM @ 10 amps level, in order to keep the heat from building too fast making the unit unusable, especially for diesel engines. **Also it is advised to use multiple stages of bubblers and filters, just to make sure nearly all moisture has been taken out before released into the intake of ANY diesel. You cannot allow water to enter your Diesel engine!**

Smack's install videos

Optional installation extra's can be reference from our very own genius Eletrik in his Smack's Mobile.

Part 1-<http://www.youtube.com/watch?v=osWBMrEkuks>

Part 2- <http://www.youtube.com/watch?v=P6hbAy4gGOM>

Installation examples

[Panacea-BOCAF - Hydroxy Booster Installation](#) of the [Water fuel for all](#) booster

Recommended- [Smacks installation guide](#)

<http://myhydrogenracer.webs.com/hydrogentoolbox.htm>

http://www.ehow.com/how_4559962_hod-system-gasoline-powered-vehicle.html

Video- [How to build a HHO Generator for Auto Installation](#)

[HOH Cells - Mileage increased by over 50%](#)

Video- [Alternative PWM installation on your car](#)

Video- [GOLDEN AGE TECHNOLOGY Oxyhydrogen Gas:A Do-It-](#)

Safety links

[Car Care Basics](#)

Trouble shooting

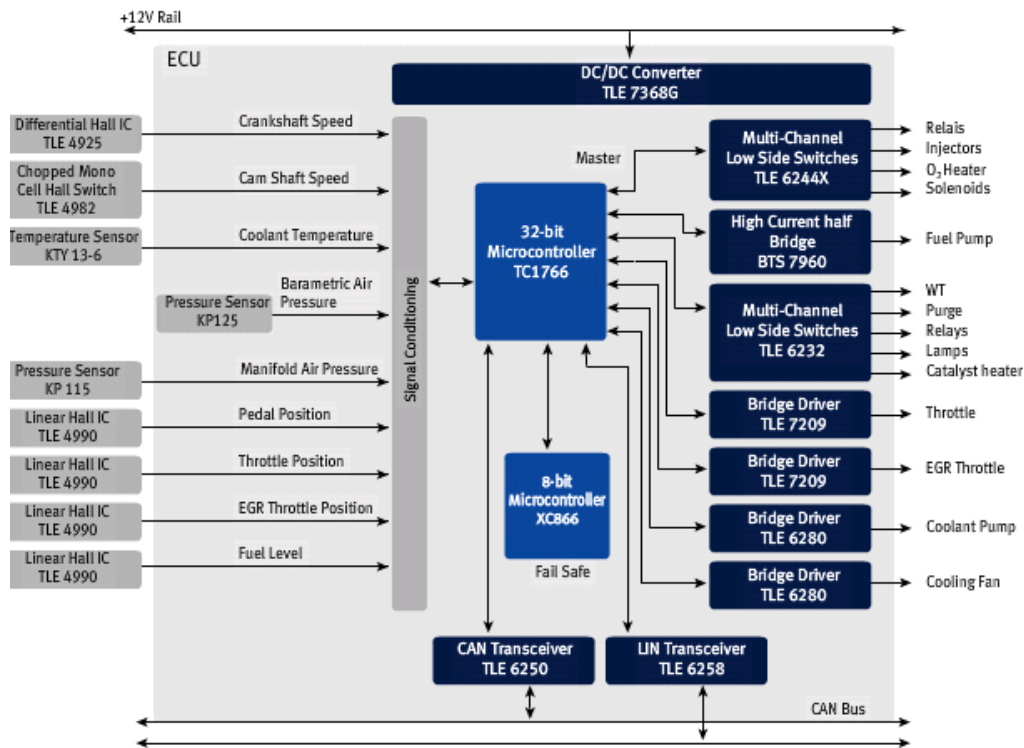
Every now and then we get a rash of people who are not getting any mileage increases. It usually turns out to be one of a few things.

1. The Hydroxy isn't getting to the engine because their connections are leaking.
2. They need an Effie or some computer control that works with their ECU.
3. The quality of the gas they are producing is inferior due to not following some of Bob Boyce directions.
4. They are using the wrong electrolyte or too little of it.
5. Their electrolyte is polluted with something (Most "liquid plumbers" of various brands have surfactants that make it not work well; some have aluminum bits in them). Even if you sift the aluminum bits there seems to be molecular aluminum left behind that craps things up.

Don't give up until you know that you have built it right, conditioned it right, genuine 100% KOH or NaOH in the right amount, no leaks in the system anywhere, the ECU is adjusted properly for Hydroxy, and timing is set properly for the amount of Hydroxy you are using.

EFIE construction and installation guide

Before we even get started please note - It is in most states a crime to alter, change, modify or disable any engine devices or emissions systems. Repeat offenses are very severe. Please check your local laws. We suggest getting an emissions test done first to then justify the use of these boosters and the needed alteration of your on board ECU.



ECU in a gasoline engine- [Source](#)

Oxygen sensors started after 99 for most vehicles. When a fuel burns it is only the fuel vapor which will burn. Liquid fuel droplets do not combust therefore will not contribute to powering the engine. Modern carburetor and EFI systems thus cannot provide efficient fuel vaporization. What they do is 'accurately' meter the fuel, and much of the fuel is still in the form of small droplets during combustion. The heat vaporizes this liquid which can then ignite at some time later, late in the power stroke and even continuing during the exhaust stroke. **This is obviously not very efficient and nearly all of the high mileage devices today and throughout history have been based on improving the fuel vaporization prior to the initial combustion.**

The liquid fuel which is vaporizing during combustion is quenching the flame, extracting heat to boil off and thus cooling the flame. When it does eventually burn completely, the final temperature that is achieved will be less than you would think because of the expansion and work output during the power stroke.

The scientific results detailing the benefits of boosters which can fix this problem have been established for over 80 years. Car makers have known long enough how to give us better fuel economy and how to take care of emissions. There is no excuse given the years old patent applications, scientific tests and recorded FACTS. Before we make the following points lets engage into some introspection.

First of all, if car makers know the science of boosters, then are they not an advantage in knowing how to make it difficult to install them encase somehow they did catch on?. **Also if it is known what a booster can do, can they not substitute something in its place to prevent boosters giving better fuel economy, and can this substitution appear to do benefits in its place?** This is the end of contemplation and the start of practical issues. The EFI was made [according to Wikipedia](#)

Quote: *Objectives-The functional objectives for fuel injection systems can vary. All share the central task of supplying fuel to the combustion process, but it is a design decision how a particular system will be optimized. There are several competing objectives such as:*

** power output * fuel efficiency* **emissions performance*** **ability to accommodate alternative fuels*** reliability* drivability and smooth operation* initial cost* maintenance cost* diagnostic capability* **range of environmental operation** Certain combinations of these goals are conflicting, and it is impractical for a single engine control system to fully optimize all criteria simultaneously. In practice, automotive engineers strive to best satisfy a customer's needs competitively. The modern digital electronic fuel injection system is far more capable at optimizing these competing objectives than a carburetor*
Wikipedia.-end Quote

First of all, to resolve our introspection, comparing the points of the invention of the EFI to enhance:

** power output * fuel efficiency * emissions performance*

The EFI's capacity to improve these is far surpassed by the substitution of a hydroxy booster in its place. This is an outright hypocrisy, how can oil and car makers justify a product which gets rid of the carburetor (making it additional laborious and complicated to install a booster) when it is already well know that a hydroxy booster can achieve MORE benefits then those mentioned above. What is the excuse now?

You can answer that by your own logic, and we all better do more than just think about it, we have had this problem (energy suppression) since the time of Nikola Tesla as far back in the 1800's. Those who are active towards helping assimilate a practical solution can support the nonprofit organization Panacea-BOCAF In any way possible.

Practical issues to deal in the mean time are to now do the best we can with what we have until the next best thing is achieved. For those with a modern cars which has an EFI on board, you will need to install an additional circuit called an "EFIE" (electronic fuel injection enhancer) to allow you motor to function much the same as the old carburetor cars(could/did) to "accept" the booster. There are other substitutions to the "EFIE" which have recently come to light, these will be covered also.

If your car is OBDII-Compliant (1996 and newer) Vehicles, currently the most popular method that's in circulation at this time is the [volvo chip](#).



Others are experimenting with [different injection position of the hydroxy](#).

What must be tested is the capacity to separate the gases and not need to fool the oxygen sensor. These gas splitter designs are posted in this document.

EFI engines use an oxygen sensor to infer the air/fuel ratio of the engine. The reason why modern cars equip with an ECU are not able to operate with a hydroxy booster is simply because the hydroxy booster will increase the combustion efficiency of an engine which then will increase the exhaust oxygen percentage.

As a result the electronic control unit's oxygen sensor will think there is not enough fuel and **will inject more fuel into the mix**. This will then make the car fitted with a booster achieve **worse** fuel economy. In the introduction one of the key claims is that an EFI achieves is the acceptance of alternative fuels. **This is hardly an invention which enables the acceptance of alternative fuels.**

It is the understanding that the O2 sensor actually performs a comparison between the oxygen content of the exhaust gas, and the oxygen content of air in the vicinity of the sensor (i.e. outside the combustion chamber, but under the hood). The ECM infers an

air/fuel ratio from that value. The problem is that the algorithm it uses for that inference is calibrated in development trials in test engines which do not have hydroxyl combustion improvement.

The logical way to address the problem is to reprogram the ECM, to correct the algorithm or match the new air fuel ratio. This requires specialist equipment, expertise and some trials in the vehicle, so not possible for all. Robert Kupra who invented the [fire storm spark plugs](#) (not manufactured yet due to suppression) reported that he achieved a 44% MPG increase and reduced the emission by the same percentage. He had a new air fuel ratio and had to do this by using ALDL (Assembly Line Diagnostic Link) and changed the air-fuel mixture.

There are two types of oxygen sensors (Narrow band and wideband), the next best solution is the LM-1 route, which will give the same sort of result, but only applies to engines which use narrowband sensors. No-one has yet succeeded in engines which use wideband (aka > AFR) sensors. That is not to say it cannot be done. The LM-1 uses software to generate a controllable synthetic narrowband output response. What would be needed would be a controllable synthetic wideband response - perfectly feasible, just needs development.

Once it is done, the engine must continue to be supplied with hydroxy. It doesn't have a convenient interface (like a switch) to revert to stock settings - you have to use a PC. If someone wants to develop the universal device, it requires both narrowband and wideband output, and an electrical interface to the hydroxy generator relay. Panacea has included two EFIE's (one of them called the VMU2) which can handle both wideband and narrow band below.

You are needed to forward this information to your local politician to create public pressure for them to work with the car companies for a re programming software, the merit is based on the pollution cutting attributes of the hydroxyl booster, not just the savings in fuel.

Mean time The Electronic Fuel Injection Enhancer (EFIE) circuit is intended to offset the voltage coming from the oxygen sensor, so your vehicle's computer is configured to be completely unaware that the oxygen content of the exhaust has increased. The intent of the EFIE device is to take the original O2 signal and add a very small additional voltage to the incoming signal to read back to the ECU. This will make the ECU think it is running rich so it leans the mixture accordingly. It also will allow you to keep the original signal level without leaning out the mixture.

This EFIE circuit and the installation of it is relatively is simple. You are also able to purchase a readymade EFIE if you're not able to build this circuit yourself. **Fine tuning MAY take some time and effort depending on each individual's car anatomy.** Some have had NO problems with the operation of the EFIE to fool their oxygen sensor. Some

find they need to adjust the lean mixture setting (explanation below) and ratio's based on empirical performance. A qualified mechanic can do this for you if you're not able. **Do NOT do this if you do not know what you're doing as adjusting the sensor too much could do PERMANENT DAMAGE your engine!**

It is advised that those without experience install an EGT gauge; you will see a dramatic rise in EGT a minute or more before any damage can occur. An EGT [Exhaust Gas Temperature] gauge [Pyrometer] is an inexpensive way to safeguard your engine from expensive repairs due to excessive EGT.

This section will cover DIY (do it yourself) EFIE designs circuits, the science behind them, links to technical advice, video installations and readymade ones for purchase. **After the EFIE installation it is advised that you take your car and get a dyno test done to indicate any bone fide MPG improvement and reduced emissions.** You must understand WHY and HOW to ADJUST the EFIE circuit to find the sweet spots. **If you're not experienced in adjusting your fuel air ratios please do not attempt it, go to a qualified mechanic or please check the link sections below for more information. Modern mechanics need to get up to scratch with these benefits and accommodate motorist accordingly. You can only help this by forwarding this information on this web page to them. Please participate!**

The EFIE circuit board needs to be added in order to appropriately configure the sensor signal of the computer into producing better suited air/fuel mixes for the hydroxy booster operation.

This is a relatively new and experimental area which needs careful study, planning and further testing. Panacea intends to get relative data on individual models through dyno and emissions test and report these results here. This will be updated into this document, **so please check back for updates.**

A lean burning engine is a hot burning engine All racers know this simple fact - Just ask one. Anything you do, can potentially harm your engine. Everyone needs to pay attention to this point (another point also proven by the racing crowd - who are well aware of this fact). If your engine is running rough (it can be harmful to your engine), If your engine is running too rich (gasoline can get into the crankcase), if it is too lean the combustion temps in the cylinders can have detrimental effect on the valves and pistons (which is why racing engines are built with high strength Stainless Steel Valves, and hi tech aluminum alloy components).

BUT if you are leaning out the fuel going into the engine and making up the difference with Hydroxy - then you are not "leaning out" your engine (you are optimizing its efficiency).

As for the knock sensors. Think about it If you are in fact optimizing your fuel mixture by supplementing Hydroxy Gas (not just leaning out the fuel/air mixture) then you should not have a serious knock issue. In proper proportions and replacing the removed fuel with Hydroxy gas, you are not in effect actually leaning out the engine (you are just using less gasoline). The ideal Fuel/Air Mixture for gasoline is like 1:14.7 (air : Gasoline), for "pure" hydrogen it is like 1: 39. So, if you are only using 10% Hydrogen, you conceivably are displacing over 20% of the gasoline -right? As for engine knocking - this is only a problem when you push the envelope of reality too far. But just because anything you do can harm your engine is only an excuse for not doing it.

Note - We are "Not" Technically running our vehicles Lean with hydroxy boosters. We are "Leaning" out the Fossil Fuel from the Ignition Process. The Hydroxy is capable of filling that void of missing fossil fuels and still have energy left over. So we will not have leaner car emissions.

Bob Boyce has stated:

1. Instant MPG gauges are typically available only in ECU equipped vehicles.
2. When boosters are added to ECU equipped vehicles, it takes time for the ECU to adapt to the changes and stabilize.
3. When O2 sensor modifiers are added to ECU equipped vehicles, it takes time for the ECU to adapt to the changes and stabilize.
4. It can take hundreds of miles of driving for ECU adapting to stabilize.
5. Sometimes O2 sensor changes can affect the instant MPG readings of the ECU, as most ECU systems use more than just distance driven and total injector pulse width to calculate estimated fuel consumed per hour and MPG. This accuracy is GREATLY affected if MAP, MAF, air, or engine temperature sensor readings are altered.

This EFIE as stated earlier is an acronym standing for "electronic fuel injector enhancer (EFIE). There are various EFIE's around for available for sale. Only the open source ones have been included here. These surprise, surprise are the best. Initially before the open source engineers started doing research, the most popular was the made and sold by Eagle Research. This link is included in the readymade EFIE's links section below. Eagle researches EFIE has been listed as being compatible with all oxygen sensors.

Individuals who used the George Wiseman's EFIE from eagle-research should be aware that **it uses an NE555 oscillator which generates the output voltage level from the timing control of the oscillator alone and is not related to the operation of the sensor at all.** Therefore it is suggested that you set the EFIE to its highest/ richest level and drive away, and when the engine has reached its normal operating temperature; then turn the EFIE

down very slowly until the engine starts to notice what you are doing. Then set it slightly above that point. The O2 sensor needs to heat up to "Operating" Temp as It does not calibrate only according to the temp of the exhaust.

Panacea will also include alternative ENHANCED circuits which are is designed to do the same thing, these will relate directly to the sensor signal and are there to adjust to the actual engine load conditions. The eagle research unit generates a small voltage by using a 555 timer chip as an oscillator and then rectifies the output to give a small adjustable voltage which is then added to whatever voltage is generated by the oxygen sensor. This voltage is adjusted at installation time and is then left permanently at that setting.

Is ever single EFIE's the same? NO, they all intend to do the same thing, but all of them do not function the same way. By design you will find that some are more efficient than others. It is important to look at the components used in the circuit. The EFIE circuits which include the 555 timer or a coil are NOT very good at all. These circuits will intercept the O2 sensor signal and then sends out 1 set voltage. This is not practical as the engine load changes so do its delivered A/F Ratio requirements.

Oxygen Sensor Q & A

How many oxygen sensors are on today's engines?

It depends on the model year and type of engine. On most four and straight six cylinder engines, there is usually a single oxygen sensor mounted in the exhaust manifold. On V6, V8 and V10 engines, there are usually two oxygen sensors, one in each exhaust manifold. This allows the computer to monitor the air/fuel mixture from each bank of cylinders. When displayed on a scan tool, the right and left oxygen sensors are typically labeled Bank 1, Sensor 1 and Bank 2, Sensor 1.

On later model vehicles with OBD II (some 1993 and '94 models, and all 1995 and newer models), one or two additional oxygen sensors are also mounted in or behind the catalytic converter to monitor converter efficiency. These are referred to as the downstream O2 sensors, and there will be one for each converter if the engine has dual exhausts with separate converters.

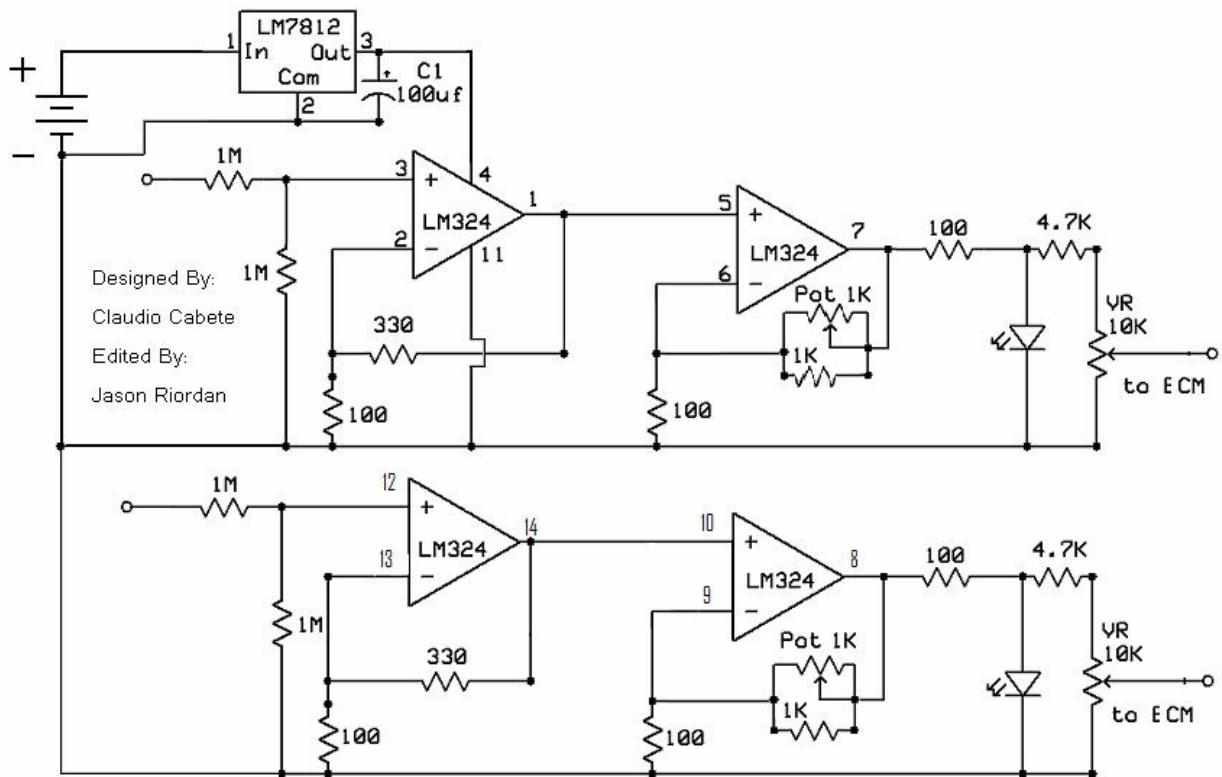
On a scan tool, the downstream sensor on a four or straight six cylinder engine with single exhaust is typically labeled Bank 1, Sensor 2. On a V6, V8 or V10 engine, the downstream O2 sensor might be labeled Bank 1 or Bank 2, Sensor 2. If a V6, V8 or V10 engine has dual exhausts with dual converters, the downstream O2 sensors would be labeled Bank 1, Sensor 2 and Bank 2, Sensor 2. Or, the downstream oxygen sensor might be labeled Bank 1 Sensor 3 if the engine has two upstream oxygen sensors in the exhaust manifold (some do to more accurately monitor emissions).

It's important to know how the O2 sensors are identified because a diagnostic trouble code that indicates a faulty O2 sensor requires that sensor to be replaced. Bank 1 is usually the front bank of cylinders on a transverse mounted V6 engine. But on a longitudinal V6, V8 or V10 it could be either the right or left bank. It may therefore be necessary to refer to the vehicle service literature to determine how the cylinder banks and oxygen sensors are labeled.

Open source DIY EFIE and PWM circuits

Dual O2 sensor for monitor control by Claudio Cabete

Please always [check here for updated versions](#). This EFIE provides a progressive voltage add to the source with a limit of 1 volt output. It allows you to adjust to run leaner or richer. It uses a POT to adjust how lean or how rich you want to run. Claudio has his set to Max Lean so when the O2 sensor sends .2 volts, it sends 1 volt to the computer.



To install a device such as this; use a factory certified connector to link the device to the oxygen sensor. Connect the certified connectors to the input and outputs of the device and wire power, +12 to the voltage in and ground to ground. Cutting the signal wire is a viable alternative, but is not recommended by Covert Auto Engineering as

doing so may break the laws of the EPA. For more information regarding EPA laws please visit www.EPA.gov

This is the schematic for a single unit, for a double unit just build the amplifier section twice. Pot 1 is your rich/lean pot. The pot right before the ECU is a voltage limiter, this should be tuned by supplying a 1v input signal and adjust that pot until there is $<$ or $=$ to 1 volt at the output. This is to restrict any voltages over 1 volt from ever reaching your vehicles computer, if a signal greater than 1 volt gets to the computer it will trigger your check engine light and will become a hassle.

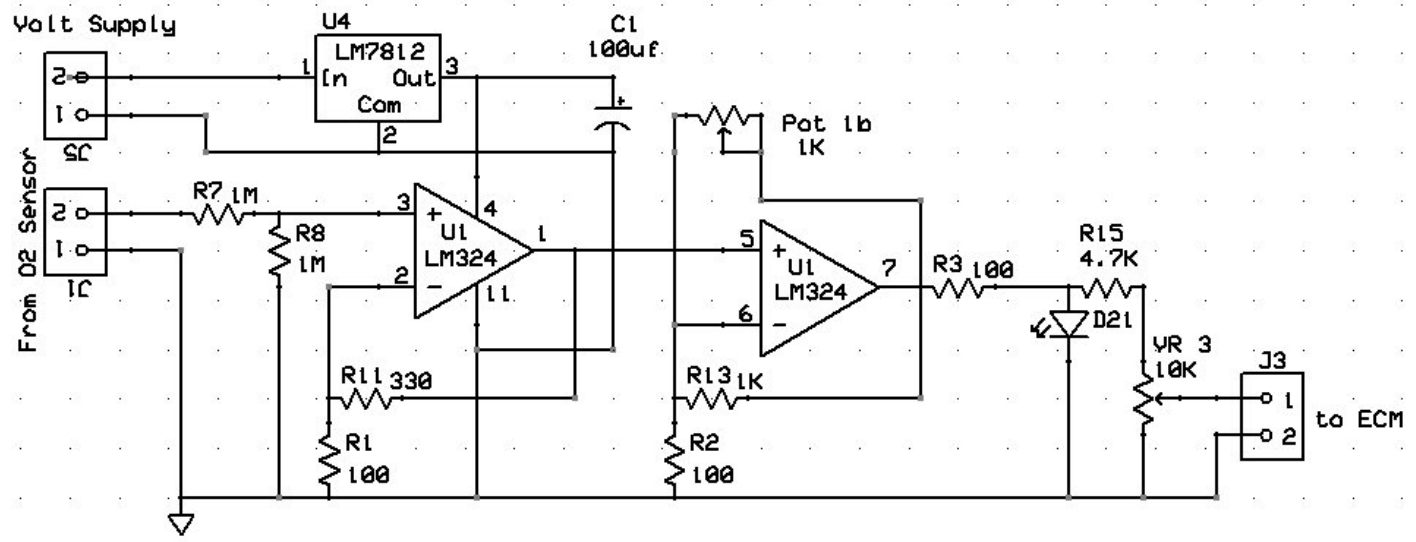
Parts List

3x 100 ohm resistors
2x 1meg ohm resistors
1x 330 ohm resistor
1x 1k ohm variable resistor
1x 10k ohm trim variable resistor
1x 4.7k ohm resistor
1x 1k ohm resistor
1x 100uf capacitor
[1 x 7812 12 volt voltage regulator](#)
[1x lm324 quad operational amplifier](#)
1x LED

O2 sensor circuit by Claudio and Jason

[Jason Riordan](#) is an open source engineer and has recently received permission from Claudio Cabete (aka, electrojolt, Circuit designer) to build the circuit for all at a small charge. For those not able to construct it, he makes this device cheaper than Eagle research and will send it handmade and hand tuned by himself. Jason can construct both a single and Dual Oxygen Sensor Controller. His oxygen Sensor Controller uses the signal coming from the oxygen sensor and amplifies it so the computer sees the actual signal. Eagle Research's device almost replaces the sensor altogether. Eagle research also charges for their plans, these plans are open source and free to you. [on his website](#)

This circuit amplifies the signal coming from the sensor and trimpot at the end of the circuit acts as a voltage regulator. You tune this potentiometer on the bench so at no time will a signal greater than one volt will be transmitted to the ECU. All the EFIE circuits out there are analog because the sensor gives an analog signal not a digital one. This circuit works because it just makes the signal bigger so instead of a signal that reaches only .6v it makes the signal larger and the ECU sees .8 or .9. The benefit of this circuit over adding a straight voltage is the circuitry at the end of the schematic. If you tune it right there will NEVER be a signal over 1v sent to the ECU.



Parts List

- 3x 100 ohm resistors
- 2x 1meg ohm resistors
- 1x 330 ohm resistor
- 1x 1k ohm variable resistor
- 1x 10k ohm trim variable resistor
- 1x 4.7k ohm resistor
- 1x 1k ohm resistor
- 1x 100uf capacitor
- 1x 7812 voltage regulator
- 1x lm324 quad operational amplifier
- 1x LED



To install, simply cut the wire coming out of your oxygen sensor and tie it to the input of the device. Next tie the other side of the wire you just cut to the output of the device.

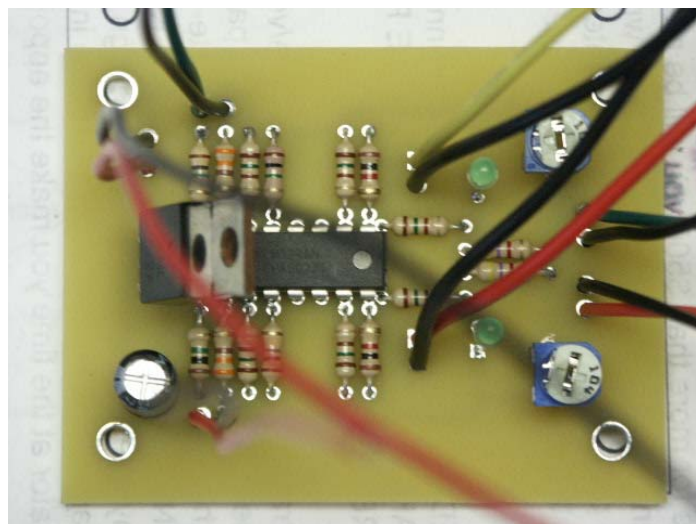
Next add power from a source in your vehicles electrics that is only on when the car is running, key turned to "on." Such a place is a MAF sensors power or a MAP sensors power. Run a wire from the "-" terminal or "ground" terminal to a spot on your vehicles engine block or a grounding node on the chassis of your vehicle. Once this is complete your circuit should work as intended.

This is the schematic for a single unit, for a double unit just build the amplifier section twice. Pot 1 is your rich/lean pot. The pot right before the ECU is a voltage limiter, this should be tuned by supplying a 1v input signal and adjust that pot until there is \leq 1 volt at the output. This is to restrict any voltages over 1 volt from ever reaching your vehicles computer, if a signal greater than 1 volt gets to the computer it will trigger your check engine light and will become a hassle. There is a switch that you can control whether the unit sends a modified or unmodified signal. The device we offer amplifies the existing signal instead of replacing it like the Eagle Research EFIE does.

Tune the 10k pot so \leq 1v is the output. The LED may flash when in operation because of the alternating voltage signal remember it goes from 0 to 1v in a sinusoidal fashion, well at the point where its 0v, the LED isn't going to turn on, the LED isn't a display really, it's more for limiting the output voltage.

Put your leads one at the input one at the output on a volt meter. Take a volt meter, put one lead on the input one on the output, and turn the knob until there is no difference in voltage until it reads 0 or pretty close and then you can lean it from there setting the voltages equal like that is basically bypassing the circuit meaning not lean and not rich The spot where it will most likely be equal is nearer to the rich side. You can only richen it a tiny bit with the EFIE.

That's how you should set it to run the car like it was stock, and a starting point before you lean it out listen to the car if it pings or knocks richen it a hair and your good.



Snap courtesy of Claudio

Thanks to Claudio for his dedicated open source work!

PLEASE NOTE DO NOT PURCHASE THIS CIRCUIT FROM <http://hhogear.com/> AS THIS GUY IS USING CLAUDIO'S INTELLECTIOAL PROPERTY AND REFUSES TO GIVE BACK TO THE OPEN SOURCE COMMUNITY

The simple way to explain Claudio's circuit: The ECM will try to keep the O2 sensor voltage somewhere between 0.45 and 0.55 volts. So when you add hydroxy, the extra Oxygen will cause the O2 sensor to generate less voltage making the ECM think that the Mixture is too lean, the ECM then adds more fuel.

This circuit amplifies the O2 sensor voltage, so when you the O2 sensor is generating a lower voltage due to the extra Oxygen, the circuit will send higher voltage to the ECM preventing it from adding more fuel. The One Volt limit is to prevent a check engine light.

<http://hydrogengarage.com/DIY/DIYinstructions.html>

Dustin (Smack) has since done an educational video and bench test of this circuit. In this video Smack explains how to adjust an EFIE unit to get the most out of your hydroxy booster.

[Smack's -How an EFIE works](#)

[Mark Lowing Install done By Panacea taking you through the tuning](#)

[Web page guide for Installation of this EFIE](#)

[Legality of the EFIE done by Smack](#)

How to Adjust the Dual O2 Sensor Control circuit

It is very important that you follow the following steps to adjust the circuit so it will not trigger your check engine light. Once you have the circuit built: Apply one VOLT to the O2 sensor input "J1" Adjust Pot 1b so you have MAX voltage on Output to ECM "J3" Also the LED should light up bright. Adjust VR3 so you have no more than one volt at J3. That is it for this side of the circuit. Now perform the same steps for J2 and J4 and Pot 1a. Note: Pot 1a and Pot 1b is the Mixture adjustment and should be dual Potentiometer just like the ones used for Stereo volume control.

Back ground on this circuit compared to others

In comparison to the Eagle Research EFIE and the COSM line of products: Firstly, using an oscillator as an EFIE device seems like an over-engineered solution to me. There is a lot of extra expensive parts used in the EFIE that are not needed. If you replace the

signal of the O2 sensor with an oscillator circuit you're negating the point of the sensor. If there is a problem with your exhaust and your sensor is replaced by a device like this you will never know there is a problem until you're getting an inspection.

The circuit mentioned that uses the dot/bar IC is also a bad idea as you're basically getting the same result. If you select an output for your signal and the signal isn't a high enough voltage you will be sending a constant 0v to the computer, who wants to do that? That is begging for a rich/open loop mixture. The simplest solution in my point of view is an amplifier circuit. Such as this one mentioned.

If you use an amplifier circuit like the one above you are using the signal coming from the sensor, not replacing it. If you change the amplification factor you're changing the fuel mixture. The circuit above also has a voltage limiter; the LED is part of this circuit. 1 volt zener diodes are tough to come by, and the voltage divider allows you to limit the output. (Output ≤ 1.00 volts.) Sure these devices work the same but you really should put each to the extremes for tests. If there is truly a problem with the sensor with an amplifier circuit you will know it. E.g. If the sensor is bad, slow reaction or constant voltage, you will see a slow reaction or a constant voltage at the computer. With an EFIE or COSM how will you see a bad sensor? You probably won't.

If you have a very lean signal to start with (.2v) with the dot/bar EFIE you may never get a high on the output. (The way the device works, it gives a 0 or 1 and the duty cycle determines the average the computer sees).

Tips -Two of those wires (most likely the red and black wires) are 12 volts to warm up the oxygen sensor, and the other two wires (most likely the yellow wires) are the O2 sensor signal.

Disconnect the oxygen sensor from your car (and make sure it's in an accessible place you can easily get to when the engine is warm), warm up the engine, and then test the voltages coming out of the sensor while it's disconnected. You should see roughly 0.5 volts across two of the wires. If you can trace these two wires back to the ECU inside the car and splice them there - even better as you want to minimize the cable runs inside the engine bay (ideal for mechanics to be able to work on the engine if they ever need to). Reconnect the oxygen sensor; check the ~0.5 volts inside the car where the ECU is.

PWM circuits

More are listed in the series cell design section below. Note In order to try to clarify why different "control designs" are right for a given purpose the following points:

1. ALL "linear" control systems, including "pass transistors" or FETs control the VOLTAGE to limit the output current. [except as "shut off over current devices"]
2. A PWM controls the AVERAGE CURRENT without changing the voltage!

So, why is this such a big deal? If you are controlling a device that will run fine on 9 to 15 volts, you can reduce the applied volts to control the current. If you are working with some device like our electrolyzers that are very voltage sensitive to remain efficient, you MUST control the current without changing the output voltage. This is best done with a PWM [Pulse Width Modulator]

For those who are new to these terms, the following may help.

Modulation = varying something to get a desired effect, as modulating a radio signal to impose an audio component to give information.

Pulse Width = the length of time a voltage is applied to a circuit. In DC circuits, it is the time from turning on the switch to the turn off point. It can be short or long. In faster times, usually when the "on time" is less than one second, the on time is described as a "pulse."

If the "switching" circuit turns the device on and off at a steady rate, it is described in "cycles per second." 1CPS is on and off once each second. If it is faster, say 10,000 times in one second, it is 10,000 CPS or Hertz, the term for CPS. It is abbreviated 10KHz, K for thousands and Hz for Hertz.

If the pulse widths are not the same for on and off times, the pulse width is said to be modulated, or controlled. It can be fixed or variable.

So a PWM is a device that controls the on/off times to change the applied power without changing the applied voltage. This means the AVERAGE current is what is controlled by varying the pulse width.

For electrolysis, the applied voltage to each cell gap in a system must remain the same to get the best results. By using a PWM you can change the gas production rate by changing the applied power [watts] by changing the available amps. The cell resistance, determined by electrolyte concentration will still determine the current draw at a given instant in time. The PWM just controls the average current drawn from the power source. If a very low concentration of electrolyte is used, the high resistance of the bath will self limit the current draw according to $I = E/R$. Amps = volts / resistance [ohms]. If a more efficient process is desired, the concentration of electrolyte is increased to lower the resistance of the bath, and therefore the losses to heat, and the average current is controlled by varying the pulse width, and there is the advantage of "Pulse Width Modulation." Courtesy of Mike Angerstein

Zero Fossil Fuel PWM

[The new PWM v2.1](#)

Alternative PWM circuits

[PWM Control for "Hydrogen Generators](#)

Other DIY EFIE circuit sources and guides

<http://better-mileage.com/memberadx.html>

http://www.mkiv.com/techarticles/oxygen_sensor_simulator/

<http://zerofossilfuel.angelfire.com/efie.html>

[Chapter 10 from the practical guide to free energy device](#)

Installation and informational you- tube videos

Videos- EFIE related

[How To Make a EFIE - PART 1 - Electronic Fuel Injection](#)

[How To Make a EFIE - PART 2 - Electronic Fuel Injection](#)

[Electronic Fuel Injection Enhancer](#)

[How to build a Hydroxy Generator for Auto](#)

[Hydrogen HHO Zero Cell EFIE CALIBRATION](#)

[EFIE Installation](#)

VMU2 controller

[Hydroxy VMU Computer](#)- The VMU detects the signals at the O2 and Map/Maf, then adds corrections to them with already predetermined voltages, as per required, at all stages of operation. You can manually control these settings, or go "full auto". It will automatically control the PWM as well, using temp and time to keep it all running sweet. Nobody else makes a controller like this. You can buy a special USB from Alexis, to input any updated settings and operating functions as they become available. These uploads are free to anyone who buys a VMU.

With traffic laws being what they are, any analogue controller is not practical, due to the need to manipulate it at all times, in varying conditions. The VMU takes this "hand on" stuff completely out of the equation. An eye on the road is the only way to go, for safety is the most important factor that any law maker will consider.

You only need to keep an eye on the 2 temp gauges on the VMU screen if you choose to, just to keep an eye on it. Watching gauges isn't illegal. This approach will easily

appease any law maker, and will only aid in allowing hydroxy to be operated on public roads without restriction, by any motorist.

If you come back in a month or so and the gains they get have disappeared. It has to do with not altering the MAF along with the O2 sensor. The cars ECU is designed to function from all its sensors. When the o2 sensor reads that the mixture is too rich from the Effie it may eventually disregard this due to the high air flow from the map/f sensor and injector pulse width. The car knows how much fuel it is injecting (about) by the injector and if not both sensors are somewhere close to each other it may not work.

90% of the Sensors that you will encounter the VMU S2 will work with. the only ones that are still under development are the Wideband O2 sensors that use a Floating amperage (the 0-5V voltage based wideband sensors will work) and the only other Air flow sensor that the VMU will not work with (that we know of) is the MAF sensor on newer ford vehicles.

The whole idea behind the MAF/P controller on the VMU is resistance or Lowering of supply voltage. so if the sensor that you want to use it on, what you call a "air flow sensor" Some are your standard Mass Air Flow Sensor. There are two ways to offset this sensor with the VMU. the first is if the sensor is a 5V supply (typically this is a MAP sensor) then you simply lower the supply voltage by disconnecting the sensor supply line from the ECU and replacing it with the supply from the VMU then lowering the supply voltage therefore allowing the sensor to do its job but everything to the ECU looks smaller (less air) sue to a lower supply voltage from the VMU (adjustable of course) the second is for MAF sensors that are frequency based.

This is typically your "heat wire sensor" where the required duty cycle of power to the little filament in the sensor required maintaining a consistent temperature determines the mass flow of air through the sensor. How we alter this with the VMU is by replacing the Ground to the sensor with the ground supplied by the MAP/F connection through the VMU and adding an adjustable resistance to the ground of the sensor (where the electricity has to flow to complete the circuit) .

The reason why this is a problem with the fords (my understanding of it anyhow so don't take it for cash) is that the signal ground completes the circuit in the vehicles ECU as opposed to the chassis ground like most sensors so the resistance has to be in series with the signal ground for the sensor and not simply for the sensors ground to the vehicle like in all other sensors. To put it in a nutshell, yeah it should work just fine unless it's a Ford newer than 95ish.

Note the VMU2 is designed to run the "Alexis Cell", Panacea has tested this cell and the VMU2 and does not recommend it due to it failing and not being robust. Here is the information on the Alexis cell.

This cell designed for is 3.45 V per cell at 13.8V. 5 plates = 4 Cells in the electrolyzer. $13.8 / 4 \text{ cells} = 3.45 \text{ V per cell}$, correct. Since anything more will produce heat, this cell is prone to overheating unless a temperature sensor and controller is used with it, however this will limit your gas production and thus gains.

It is recommended that you shoot for around 1.7 V per cell then there should be 8 cells, or nine plates. Alex found that the 5 plate setup worked well producing enough heat to stabilize around 20A with heating from a 10A cold start. This is also why he has a Temperature sensor that attaches to the VMU to lower the PWM Duty cycle based on the cells temperature.

There will be some steam produced, in any cell there will be some amount of steam produced. In this cell Alex suggests a 10A start. Personally we think your probably better off with a 6-8A start. it also makes a big difference if you are running the OBD2 version or not as the cell does not heat up as quickly with that version due to the significantly lowered PWM settings at low RPM. if you're not running the cell on a vehicle that is not using the VMU your better off to start around 8A.

VMU2 install videos

Part 1- <http://hk.youtube.com/watch?v=l6DI13AgxPA>

Part 2- <http://hk.youtube.com/watch?v=WzdFrXbckY>

Videos- Oxygen Sensor

[Smack EFIE testing](#)

[Oxygen Sensor Voltage Boost](#)

[Removing Oxygen Sensor \(O2\)](#)

[HHO Hydrogen fuel cell - O2 sensor voltage adder](#)

[O2 sensor + MAP Enhancer -Part 1](#)

[2 O2 sensor + MAP enhancer -Part 2](#)

[HHO Hydrogen fuel cell - O2 sensor voltage adder in operation](#)

[O2 sensor Bench Test](#)

Fuel enhancing and readymade EFIE links

<http://www.better-mileage.com/>

<http://www.fuelsaver-mpg.com/>

http://www.mkiv.com/techarticles/oxygen_sensor_simulator/

<http://www.pwmpower.com/efie.html> -> The EFIE information from PWM power may not be useful. First, the EFIE referenced here:

<http://www.youtube.com/watch?v=lw8MtfTx2cU> is incomplete. He never did follow up and finish the instructions. Second, he never did post the schematic or file for making the pcb. Third, and most important, a third party report stated that an engineer bought a completed EFIE from him and it was totally useless. Yes, it did add voltage to the O2 signal. However, when placed on an oscilloscope, it could be easily seen that it added so much noise to the signal that it caused a "out of range" error that threw a code from the ECU. Unless someone else has had a completely different experience, I would say that PWMpower's EFIE is totally useless.

Without being self-serving, the engineer in question stated that this experience inspired him to seek out alternatives to current EFIE thinking and design. All the EFIEs he was aware of are analog. That presents a problem. Simply adding voltage to the O2 sensor's signal means that it is possible that at the upper range, you are adding so much voltage that you send the out of range voltage. ECU expects to see 0-1.0v. If you are sending an offset of .2, and the actual signal is .9v, then the ECU sees 1.1v and may throw a code.

At the same time, if the actual signal is .1v, the ECU sees .3v. I believe the ECU is programmed to expect to see .2 or lower. If you add too much v. to the signal, the ECU will never see .2v and this may also trigger a code. A friend who is a master mechanic told me that the turning points to lean or richen the AFR is .2 and .8v. If you never see, or far exceed these numbers, you will get a code and the ECU will trigger open loop. This may be why a lot of people experience poor results, even when using an EFIE.

<http://www.thehydrogenshop.com/Hydrogen%20Products.html>

Devices which can monitor fuel economy and the oxygen sensor

[Scangaugell](#) - Note In the comments section under their You-tube video they explained that they had their generator wired so that it would turn on when they flipped the switch to the MAP sensor enhancer. Yes, they have that vehicle mapped. So, their sudden increase in mileage must have to do with the MAP readings being altered. An engineer did the same thing in his Saturn. He set the MAP enhancer to show 65 MPG, up from his normal 36ish. To his surprise the next fill-up showed a ZERO increase in mileage. The Scangaugell can lie in that regard. He even posted a question under their video asking them whether they filled up at the pump to verify. No response yet.

[OBD-II vehicles](#)

[MEMOSCAN](#)

[Megasquirt](#)

[The AFR meters and wide band controllers](#)

[Off Board Programming Harness – software to “hack” your EFIE](#)

Video- [Basic Enginuity/RomRaider Datalogging How-To](#)

This video is geared towards beginners who have never logged their own vehicles. Specifically subaru vehicles which are supported by the efforts of the OpenECU and RomRaider projects.

www.openecu.org

www.romraider.com

Here is a simple circuit if you want to see what the O2 sensor is actually reading

[DIY Air / Fuel Ratio Meter](#)

Supplier of electronic components

www.mouser.com

[Electronic and Electro-Mechanical Parts and Supplies at Discount Prices](#)

O2 Sensor Harness

[Casper's Electronics, Inc.: Honda](#)

This would be used to make an EFIE plug and play without cutting any of the vehicles wiring. This is extremely useful on lease vehicles. Get the extension, cut in half, wire it to the EFIE, and you have a lean very reliable install! The link refers to a Honda but just look in the column to the left. If your vehicle isn't listed, just look at your O2 sensor Plug (right before the sensor) and remember what it looks like. Then just browse through all the connectors on their site. You should find a match because there are pretty much only a few different types used by all Manufacturers for the Narrow Band O2.

Related Tuning information and Forums

<http://www.pgmfi.org/>

A great source for information about doing tuning and fuel maps yourself and also a decent forum

Faculty information on the EFIE and oxygen sensor

Introduction courtesy of Colin Lyon

The basic job of the o2 sensor is to measure the amount of "emissions" (oxygen and un-burned fuel) in the exhaust. This is sent to the vehicles computer, and in any type of Fuel injected and some carbureted vehicles, adjusts the air to fuel ratio accordingly. If there are not enough emissions coming out of the exhaust pipe to indicate the proper air to fuel ratio the vehicle richens the mixture. If there is an excess of emissions the vehicle leans out the mixture. There are two different types of O2 sensors, Narrow-band and Wide-band. Though they do the same job, they go about it differently.

Narrow-band

Narrow band sensors operate on a principle of fluctuation and operate from 0- ~1V with the average being .7VDC. The computer will lean out the mixture until the o2 sensor indicates a "lean state" then the computer will richen the mixture until the o2 sensor indicates a "rich state" and will lean the mixture again and so on. Overall optimum mixture is attained by the computers attempt to minimize the time between too rich and too lean. So, if you have a monitoring device such as a scanguage or something similar and you notice that the signal from the O2 sensor is constantly going up and down, don't worry this is completely normal. In fact you should only be concerned when your signal does not change. If you are not using the Alexis VMU unit, EFIE devices that replace the signal from the O2 sensor should be avoided. What you want is an EFIE device that simply adds an adjustable amount of voltage to the signal that comes from the sensor itself.

Wide-band

The wide-band o2 sensor is a newer type of oxygen sensor that essentially does the same job but does it differently. Wide band sensors are easily identifiable by having 5 or more wires and measure the air to fuel mixture by taking two separate readings, Unburned Fuel AND Oxygen. They operate not from 0-1VDC but from 0 to around 4 or 5 VDC . I have read on a number of different Sites of people who have had success with EFIE devices on Wide-band sensors. I cannot personally attest to this fact as i have not as of yet had the opportunity to play with one myself. My personal recommendation dealing with wide-band sensors would still be to use a wideband controller of some sort such as the one below but if you have had any experience, success or otherwise, with EFIE devices and wide-band O2 sensors please feel free to post on the hydroxy forums. More info on Wide- band sensors - <http://www.fuelsaver-mpg.com/doc/WhatNeedToKnow.html>

Though O₂ sensors have an effect on fuel mixture they are more of a fine tuning method for your car. The Base fuel mixture for different RPM's and engine loads are programmed into your vehicles computer as a non alterable baseline that is slightly modified by the various sensors that "fine tune" your Air to Fuel mixture according to the engines demands under changing conditions such as temperature, load and in some newer vehicles Altitude (less oxygen in the air at higher altitudes). To learn about the other sensors that fine tune Air to Fuel mixture please see the "Air Fuel Mixture" forum.

When altering the signal from the sensor to the computer thus changing the air to fuel ratio, please remember that the aim is not to lean out the mixture, but to prevent the vehicle from over richening the fuel to compensate for the more complete burn. Overshooting the settings for the O₂ sensor and MAP/MAF sensor can do more harm than good. When you over lean the air fuel ratio of your vehicle you can start to cause things like pre-ignition (the ignition of the fuel in the cylinder prior to the intake valve being completely closed, which can be indicated by a ticking noise predominately under load) and excessive heat that will eventually burn out your valve seals. This can cause the upper portion of your engine (the Head) to seep oil into the cylinder through the valve stem passage and make your car smoke thus decreasing its overall efficiency. Negative incidences such as those described in this paragraph will not so much be the outcome of the O₂ sensor offset as that of MAP/MAF sensor which provides the mixture adjustment in open loop situations (warming up and under load). I cannot speak on behalf of Hydroxy Technologies Corporation but I believe this is why their VMU limits the maximum MAP/MAF modification to 20%, in turn not providing the user with the opportunity to get over zealous with fuel savings and damage the engine.

EFI function

The EFI function is done by comparing the amount O₂ in the exhaust with the O₂ in the atmosphere. The part of the sensor exposed to ambient air (outside O₂) is compared to the exhaust stream O₂ content with the zirconia ceramic and platinum sensor piece in between them (general design). Since there will always be more oxygen on the ambient side compared to the exhaust side of a running engine, this produces a varying current flow in one direction because the higher oxygen content on the ambient side tries to balance out with the exhaust side to reach equal parts oxygen, but ends up giving up electrons through the sensor/barrier.

Thus, when you hold a sensor up in the air, it has equal parts oxygen on both sides of the catalyst and won't produce voltage. When an O₂ sensor is at operating temperature and there is *any* difference in O₂ content on either side of the sensor, such as when an engine is running and using up or combining oxygen into other chemicals through combustion, there will be an increasing voltage.

If you have ever looked at an O₂ sensor, and specifically the part of the housing that is external to the exhaust pipe, you will see the holes or slots where air can go in. The standard O₂ sensor is actually a little current generator. It does this by chemical pressure. Yes, the chemical oxygen content difference between outside air to exhaust oxygen leads to them wanting to equalize, thus the free oxygen from the atmosphere will flow current (electrons) in conjunction with the catalyst (the platinum in the sensor) at different rates according to the comparison of oxygen and its electrons in the exhaust stream.

A 'lean' mixture leads to misfire which, at the early stages, cannot be felt by you as a driver - any misfire results in a huge amount of oxygen going down the exhaust pipe (as well as a ton of hydrocarbons – un burnt fuel) and so the computer senses this and richens up the mixture. Thus, it is the oxygen level that is being sensed, NOT the amount of un burnt fuel in the exhaust!

The stoichiometric ratio of 14.7 to 1 for gasoline is a 'best overall' number (coincidentally? the same as atmospheric pressure at sea level - 14.7 lbs per sq in.) for power, fuel mileage, and emissions. For gasoline, this is also a measurement of pounds, thus - 14.7 pounds (not parts per) of air to 1 pound of gasoline. Any malfunction of the O₂ sensor system where it will read lean (low voltage), air leaks upstream of the sensor, or misfire, is going to result in the computer richening the mixture = higher fuel usage, lower MPG. You can see why lean is low voltage because as the oxygen content of the exhaust goes up, approaching what is in the atmosphere, there would be less current generated (less potential difference between outside to inside oxygen), thus the opposite, a rich mixture has very little oxygen, causing a much higher electron flow (read in voltage by the computer).

O₂ sensors in conjunction with the 'magic' 14.7 ratio are not primarily there to prevent pre-ignition damage from lean mixtures but rather for the best overall (read: lowest common denominator) power, fuel economy, and emissions: Emphasis on emissions. Again, O₂ sensors do not sense anything to do with the 'richness' in relation to the fuel content in the exhaust - they read oxygen levels in comparison to atmospheric oxygen content only.

Devices to bypass O₂ sensors have existed for as long as there has been electronic fuel injection - the aftermarket propane and natural gas system manufacturers needed to do this to shut off the engine light that resulted from the different exhaust content of propane and natural gas conversions (from gasoline). However, this was a totally different situation than adding devices to the gasoline engines that still ran on gasoline like we're discussing. With the propane and NG, the engine was often set up with a gas analyzer for optimum running (while on the alternate fuel, since many were running dual fuel - gasoline and the alternate) on the alternate fuel and so the electronic box

would just generate a typical rich/lean swing to the computer to make it think all was well in exhaust land. If we were to play with the O₂ sensor while STILL running on gasoline, it must be a more complicated device for the engine to run anywhere near right. There is a hierarchy system in the computer to still have a vehicle run, even with a totally malfunctioning O₂ sensor, but it would have problems. As mentioned above, the lean/rich swing of the standard O₂ sensors (there are other designs as well) does not actually affect the actual content of the exhaust very much - it is a very minimal swing.

Though the O₂ sensor system plays around with some so-called magical 14.7:1 ratio of air to fuel - what is its real purpose?? Answer: The next component in the exhaust system - the catalytic converter. The swing about stoichiometric (simply means the optimum 14.7:1 ratio for gasoline) is to facilitate the function of the Cat. What is the purpose of the Cat? To 'burn' or oxidize un-burnt fuel? Nope. Semantics maybe, but its main purpose is to store oxygen. Yes, during the lean swing of the burn cycle, excess oxygen goes downstream and is stored in the converter to facilitate the burning of un-burnt fuel during the rich swing.

This is actually done over a very small range of values in the literal content of O₂ and Hydrocarbons. If you looked at this with a gas analyzer, you would see very little, if any, change in the values displayed. So the computer purposely adjusts the swing of lean to rich to lean to give this pulse of oxygen to be stored in the Cat to help burn HCs. This is just the oxidization side of the Cat. Virtually all cars also have a Reduction side to deal with the Nox as well. The whole science behind O₂ sensors and Catalytic converters is amazingly complex from a chemistry/engineering side.

Installation data

The O₂ sensor really measures hydrocarbons. Here's why. The sensors bi metal is very sensitive to hydrocarbon fuels. The reason the O₂ sensor needs to be heated is to get the reaction between the bi metals to occur and produce electricity, the new sensors have little toaster elements in them that heat them up during cold starts so they "come online" faster. They are referred to as H₂O₂ sensors, meaning heated oxygen sensors. You may put this sensor in a vacuum and heat it up and see no voltage output. Take the same sensor and heat it up with atmospheric pressure and no voltage. Take same sensor and put in pressure cooker and little to no volts output. Take the same sensor and heat it up in hydrocarbons and see the voltage spike up!

Thus, what the oil and car manufacturers have done is fool you into thinking it measures oxygen when in fact it really measures the amount of hydrocarbons (un-burnt fuel) mixed in the exhaust stream. The manufacturer already knows how much air is entering the engine and exiting the exhaust but needs to regulate the amount of fuel, not air, into the exhaust. If you want to pump hydroxy into the engine you will increase the

amount of oxygen in the exhaust stream, thus to fool the computer you will need to add voltage (not resistance) to the signal that the computer is seeing.

One approach is to start with a volt and work up. You will need to increase the voltage with increased hydroxy used. Here's a simple method. Monitor the exhaust sensors output at idle without the hydroxy used. Take notes of HI and low voltage. Turn your unit on and now measure. Take instant reading (don't wait too long because computer will see drop in voltage and raise the injector pulse on-time to compensate and your voltage will go back up!) Let's say you note a 1 volt difference. Simply add 1 volt to the wire while using hydroxy, this way the computer will think nothing has changed.

How to determine O2 sensor lean operating limit voltage

Restart the engine. Observe the swaying needle indicating an operational O2 sensor. Introduce a vacuum leak into the intake manifold by disconnecting a vacuum line. I pulled the EVAP canister line and held my thumb over the tube so I could start and stop the leak and observe the O2 sensor's behavior. The vacuum leak causes a leaner mixture to occur. You will also notice an increase in engine RPM.

If you introduce the leak slowly you will be able to observe the LOW voltage reading DECREASE until the mixture becomes too lean for the sensor. (Don't go too slowly or the ECM will be able to compensate) At some point the swaying will stop and a constant LOW voltage reading will be displayed until the ECM enriches the mixture. Then the O2 reading will rise and hold steady at close to its high voltage limit and eventually start varying again. Stop the leak and the O2 will then swing back to the high voltage limit and remain there until the ECM can reverse its prior correction and lean the mixture back to what it was at the start of the test. The O2 voltage will begin to vary normally once that point is reached.

Narrowband O2 sensor and ECM operating characteristics while inducing a lean AF mixture.

Idle Air Control motor disconnected to prevent ECM from adjusting Engine RPM. Lean mixture induced by venting a large vacuum line which is connected to the engine throttle body to atmosphere. O2 Sensor monitored with analog gauge as test progressed. ECM parameters recorded using Launch CRECORDER. Note that the recording device takes readings in 4 second intervals. The test was done twice. Each test is denoted by a lighter colored boxed area in the graph below.



Tips by Fidel Rivera

I will also share some tips on how to change signals to the ECM to benefit from. Let me start by saying, even with the new systems coming out each year we still have the same job to do. First you must focus on the job being done. Then look at the system being used to do the job. The parts may look different from one manufacture to another. But it is all the same. I have been taught to fix the problem in my mind before I move my hands. It's a lot cheaper this way. I hope that what I share with you will save you some time and money. So let's begin.

Ok we need three things to start a fire; Oxygen, Fuel, and heat. To make the engine run we have add timing (when we start the fire. Then to get the best production, we must have the right balance of mix, heat, and timing. Let's go back to the basic system. First we look at air. Atmospheric pressure is described as a force or weight applied to a given area. We use pounds per square inch and bars as common means to measure

Atmospheric Pressure. At sea level AP is 14.7 or 1 bar. It takes two inches of vacuum to overcome one pound of pressure. Normal engine vacuum is 17 to 22 inches. Therefore normal engine vacuum cannot pull more than the atmosphere can push. Next we must understand that what we use from the incoming air is the O₂ only. Air is made up of 21% oxygen, 78% nitrogen, 2% what ever.

Atmospheric pressure is also the first reading the ECM takes to calculate engine control. The older systems worked the same way, without electricity. As the air passed through the carburetor it created a pressure indifference or lower pressure than the atmosphere. Then Atmosphere pushed the fuel out of the float bowl by way of jets into the engine. We are told normal mixture is 14.7 (1 bar) parts of air (21% O₂) to one part of Gasoline. At this mix you would have water coming out your tail pipe. More fuel gave us more power and higher emission. Less fuel gave us less power and less emission.

The Ignition system used vacuum advance to change timing. Again we must not think that engine vacuum is pull , rather atmosphere is pushing. This timing change is called load timing. There is also speed timing that will be covered later. Next I will take you back to the mid 70's to early 80's Cat Converter and ECM. I wish all will have a wonderful day. Fidel

Tips By Brian

First My name is Bryan and I specialize in Standalone ECU programming. 1. Heat is caused by amps and electricity. How do we keep heat under control. I've seen several designs come out. Water circulation addresses the heat issue to a certain degree however over time heat will destroy a good system.

2. One thing I have noticed is people are not building large enough cells and what I mean is the cell should be at the bottom of your container and have plenty of water above it. You can submerge a cell three feet under water if you wanted too and your still going to get the Same Hydroxy output.

3. I do not think any cell should be located under the hood. There is too much heat under the hood of the car.

4. What creates the most heat when operating a cell?. The answer is the bolts.

5. Always submerge your bolts well below the water line. In my cells the bolts go as low as possible in the unit.

6. Use good wire and always solder. Get good Rosin core solder not your cheap radio shack stuff. Good rosin core solder is essential to any cell. Always heat shrink your connections. Protect your connection rings. Keep your wires inside your cell as short as possible. Keep everything below the water line. This provides cooling.

7. My latest cell runs off 6 amps of electricity optimally. The cell holds two and half gallons of water and the water temps never go above 101 degree's Fahrenheit.
8. Switch to potassium Carbonate. I've found production is higher and it's not caustic. I've done extensive testing with potassium carbonate and I believe it's the best electrolyte all the way around. I mix three tablespoons per gallon of distilled water.
9. Always make sure you get quality distilled water. All these companies use different processes make sure you get the best.
10. I defer to Bob Boyce at this point. it is essential to hatch your plates using a belt sander.
11. Mr Boyce is right never handle your plates without gloves but I have found that the people who make the plates tend to handle them alot which kind of defeats the purpose. I feel if you want a super high end system then by all means spend the money and get some of these guys who are pro's to get you started.
12. However I feel this is unrealistic for the common man. I think safety is the number one priority. My feelings are if you're not going to do it right get a professional builder to make your system.
13. In each system I build I use a three bubbler setup right off the device. Clear PVC works ideal for this. At the very least incorporate a rubber cork into your bubbler's at the top so if you do get flashback the cork will pop out and relieve the pressure in the bubblier rapidly.
14. There are a lot of one way valves on the market. Make sure your one way valve selection allow free flowing of gas to prevent a lot of pressure building up in your lines.
15. Always use reinforced hose. It's a little bit more at the hardware store but will last a lot longer and holds pressure nicely.
16. Always use a relay in your system and find a spot on the fuse box under the hood and take a test light and make sure that when the cars off the system is off. Make sure the car has to be cranked to start gas production.
17. I am incorporating three blubbers and six one way valves into each system. Some may say this is overkill but you can never be too safe.
18. Steam if you have steam you have a problem. I also feel there is no need for recirculation tanks for the average guy. If the wiring is done correctly and you submerse your bolts you reduce the risk of steam.

19. I've found for a system made for the beginner that getting rid of the heat and keeping the amps low will allow you to enjoy your system a lot longer.

20. Clear acrylic boxes. I am against them not because I don't like how they look but over time epoxy and other sealants will break down and it's a potential safety risk for leaks. I do however like clear PVC tube.

21. I incorporate two 40 amp relays into each system as well as a switch under the dash. Here is how this works. you crank the car one relay is cut on. Next the second relay is activated then you flip the switch inside the car and now you start Hydroxy production. This gives you three electrical safety features and if one item fails the other relay and the switch are there as backups.

22. Always incorporate at least two 30 amp fuses into your system. I prefer making a fuse block myself and will line up 4 30 amp fuses. I also put fuses throughout the system.

23. Always do clean wiring do not leave loose wires exposed.

24. Tie all wires together using wire ties to make it neat and tidy and then protect them with wire looms or heat shrink them together.

25. Even though the gas mixture dissipates rapidly into the air. NO SMOKING AROUND Hydroxy

26. Check your amps daily for the first week then periodically. Wiring in series will help in keeping the amps low.

27. Be aware of flaky electronics being sold on eBay. If you're going to incorporate an EFI and Pulse width modulator buy quality electronics or have your own board made and use proper heat sinks preferably made of copper with fan cooling.

28. I'm working on ECU modification and eventually a cost effective Standalone ECU option or incorporating things like Apexi air fuel controllers. Power cards. E-manage ECT. New cars require engine management for Hydroxy production to benefit the automobile. Especially since the introduction of electronic fuel control.

29. Lastly it may be useful to go to a local automotive performance shop and run your car on the dyno. You can get a good idea of your increase and usually they can dial the car in at the facility.

30. Feel free to contact me about engine management AF retarding timing. N.C members are welcome to use my DYNO for tuning at no charge. I don't sell any items and have no desire to do so. I can dial in any car with standalone engine management and other new and developing technologies.

I hope this guide helps the beginners and I program standalone automotive ECU. I'm sharing these thoughts and information for free to the group. Please feel free to distribute how you would like too. This guide is not for resale and is If you use someone else's idea make sure you site them as the source. Nobody respects others taking information that they didn't come up with. A lot of people may have similar ideas however These are the things I've discovered in my own systems. copyrighted@ Bryan Martin ,2008

Another perspective on installation

First of all you need to monitor your O2 sensors reaction to having hydroxy gas added to your engine. THE ENGINE MUST be up to temp. I took some reading at idle and at cruising speed. Write them all down. In this example the engineer monitored his engine stock to get his O2 voltages to CPU. Using a CANOBDII monitor. This gives live data like rpm, coolant temp, etc. including O2 sensor voltages.

Then do it with Booster running. In this case stock = 470mV booster on= 230mV, that told him that he needed to add ~200mV back to the O2 sensor going to the CPU. When he got the circuit board he plugged it into a battery (14V drill) on the bench and turned it on. WATCH YOUR POLARITY!!! Then he tweaked the two pots to get to a 200mV output. It takes a while because of the capacitors in the circuit. He made a change then walked off for at least 10 minutes, then after he got it set let it run all night to make sure. He used an analog (needle type) VOM as his load while testing

Mike has very good instructions on his site. Follow them. The engineer then installed it in the vehicle. He used bullet connectors on the O2 sensor wires so that if in the case where he took it out of the circuit he could just plug them back together. Then he road tested it verifying that it fluctuated above and below 450-500mV. That is what your CPU wants to see.

Open loop vs closed loop By Bernie

The ECU, sensors, and injectors form what is known in the trade as a "Process Control System". This is a system that can accept inputs (MAP, BAP, O2, TPS, MAF, RPM, etc) to control an output (Injector pulse width).

Most of the inputs provide positive feedback, ie; the output increases if the input signal increases, but the O2 sensor provides negative feedback, the output decreases as the input signal increases. Since the goal of the entire system is to maintain a fixed A/F ratio, and that's what the O2 sensor measures directly, it becomes the primary sensor with the most control of the pulse duration. IOW, the pulse duration is mainly determined by the output of the O2 sensor. All the rest of the sensors have considerably less affect, and simply serve to reduce or increase the affect of the O2 sensor. For example, the TPS,

which is the driver/machine interface which allows us to control acceleration, only provides a moderate change to the output.

The effect of each individual sensor is known as the loop gain, and a specific gain is designed into the system for each sensor, based on how much affect each one should have on the output. In normal operation, the ECU will operate in closed loop, which simply means that the calculated output pulse duration is within the range that the O2 sensor can handle. If something occurs that causes the ECU to not be able to adjust the pulse duration sufficiently to bring the mixture back within the design range, an open loop condition occurs. I suspect that this condition might occur more often than most people think, but the duration of the condition is most likely key in generating error codes, and forcing the ECU to go to into a mode where it simply ignores the O2 sensor, as it has decided that the sensor is defective. In this mode the operating parameters are set so that the mixture is rich to avoid damage to the engine.

Types of O2 sensors

One of the most common types of oxygen sensors is the zirconium dioxide oxygen sensor. The O2 sensing component uses a solid-state electrolyte made up of a zirconic ceramic material that acts like a galvanic battery electrolyte under certain conditions. When the sensing element is cold, the zirconia material behaves similar to an insulator. At elevated temperatures, the zirconia material performs more like a semiconductor, and can generate a characteristic voltage output on the sensor connections.

In construction of the zirconia sensing element, a porous platinum electrode material covers the inner and outer surfaces of the zirconia solid-state electrolyte. The inner surface of the sensing element is exposed to an outside air reference, while hot gases in the exhaust stream surround the sensor's outer portion. Oxygen content of outside air is approximately 21 percent, while exhaust gases have much lower oxygen content - between 1 percent and 3 percent.

Differences in the two oxygen levels, and the electrolytic properties existing between the two platinum electrodes, allow ion transfer to take place and generate a small electrical charge. Oxygen ions are electrically charged particles that flow through the zirconia sensing element when there is a disparity in oxygen levels. The greater the ion flow, the higher the voltage produced. Once the zirconia sensor element reaches an operating temperature of 572 degrees Fahrenheit to 680 degrees Fahrenheit, signal voltage output can range from near zero to 1 volt - depending on the oxygen content of the exhaust gases.

Basically, the zirconium O2 sensor compares the oxygen content of exhaust gases with oxygen from outside air. Voltage produced by the O2 sensor depends on the amount of oxygen in the exhaust. If exhaust oxygen content is low, such as a rich air/fuel ratio,

the voltage output from the sensor may be as high as 1 volt. A lean air/fuel ratio increases the exhaust oxygen content, resulting in a low voltage from the sensor.

In normal operation, O₂ signal voltage is routinely varying from almost zero to 1 volt. An O₂ sensor signal voltage above approximately 0.45 volts is recognized by the PCM as a rich exhaust; below 0.45 volts as a lean exhaust. The goal of the PCM is to keep O₂ voltage moving across the 0.45 volt rich/lean switch point for optimum fuel efficiency and emissions.

So with this being said, If the cleaner more efficient burning air /fuel ratio mixture was in fact using up more of the oxygen then just exactly how do you suppose the computer sees this as a lean condition and increases the fuel ratio? This is why the extra voltage needs to be supplied to the CPU to counter the effects of the left over oxygen in the stream.

EFIE for wideband o₂ sensors by Ian

It's a problem. Engineers have researched allot and there are no reports of success with EFIEs for REAL wideband sensors. The reason the engineer who made this report states REAL, is because there are some vehicles with narrowband sensors which operate about 5V dc, and these get called wideband, although they are not.

The problem with wideband is that it functions very differently to narrowband. With wideband, the ECM supplies current to the sensor, and gets its measurement from the voltage it needs to apply to keep the current constant. This means that the voltage generation and measurement is internal to the ECM, and cannot be accessed to be modified by an EFIE. If there is a successful technique to achieve this, I have not been able to find it.

Our understanding on the wideband sensors is that they operate between 0 and 5 volts VS. 0 and 1 volt on the narrow band. Also they operate in reverse when comparing with the narrow band.

Narrow band:

Low volts (less than .4) = lean

High volts (over .6) = rich

Wide band:

Low volts = Rich

High Volts = Lean

Here is [a web site advertising a Digital O2 Sensor Electronic Fuel Injection EFIE Adjuster - 5-Wire Wideband.](#)

[JAW: Just another Wideband](#)

[JAW forum list of useful components](#)

[Tech Edge Wideband AFR Meters](#)

[Wide-band EFIE Google search](#)

Also the VMU2 is designed for narrowband sensors, and no actual experimentation by HTC has been done on the Wideband sensor modification. The buzz that you hear on the VMU2 working with wideband sensors is derived from claims that some people have made the vmu2 work with wideband sensors by reversing the way the VMU's interface between the sensor and ECU to remove voltage to the ECU which in the closed loop situation increases the amperage to maintain the same overall wattage balance between the two signal lines. Mr Sardo has released instructions on how to allow the user of the VMU to offset the voltage by up to 2 Volts by editing the software

Related paper on the ECU by tuning for better Mileage

So you installed the Acme Fuel Miser, the Presto Mileage Maestro, Sparky plugs, and a few other devices all claiming up to a 30% increase in mileage, but you are only seeing maybe a 10% gain. There are many devices and technologies on the market and the internet that are based on sound science that can't seem to deliver the goods.

It has become painfully obvious by observing my apprentices on the mpg Research Forum that a comprehensive Guide to Tuning is desperately needed. Simply making combustion more efficient these days isn't enough. The factory ECU is programmed for the factory hardware. Once you deviate from that basic recipe, the ECU is no longer able to deliver optimal results. The fix? Tuning! Tuning a stock vehicle usually won't deliver much of an increase in mileage. Up to 20% gains have been reported, but typically fall into the 10% or less range. Once you add something to improve combustion efficiency, much larger gains are common. In fact, I've been seeing over 100 MPG regularly with Browns Gas, fuel heaters, vaporizers, ozone, and other devices, almost always in combination.

Lets break the tuning process down into bite-sized steps. A logical format makes the tuning process more like science and less like a mystical black art.

- 1- Verify the vehicle is in good working condition
- 2- Install your mileage device(s)
- 3- Lower your lean-out limits

- 4- Adjust your air/fuel mixture
- 5- Adjust your ignition timing
- 6- Readjust your air/fuel mixture

Verify Vehicle Condition - A common cause of vehicles fighting mileage gains is a hidden problem with the vehicle itself. Tired oxygen sensors, clogged EGR circuits, carboned throttle bodies, ignition components that are not up to par, partially clogged catalytic converters, defective sensors, and a whole host of other problems have been found. Usually the vehicle runs perfectly fine, no codes are set, and the stock mileage is typical for that type of vehicle. The owner assumes that the vehicle is in top operating condition because he/she has no reason not to.

When the proper tuning procedure is followed and mileage gains just won't come, go back and start nit-picking the vehicle apart. Check everything. You might even consider planning on a complete tune-up at this time. In fact, this would be a good time to upgrade to Pulstar Plugs, MPG Plus ignition wires, Blue Streak or Neihoff cap and rotor. Clean out your throttle body and PCV system. Install new filters and oxygen sensor. Make sure the basics are in order.

Install Mileage Device -The next step is to install your mileage device(s). Many people like to install upgrades one at a time to determine the overall effect each addition yields. Some like to just toss several on at a time. Usually finances dictate the one-at-a-time method. Be sure to install the device(s) properly. If it is a product you have purchased, follow the manufacturer's instructions to the letter. If it is a device you have built from plans, perhaps from the internet, again, follow the instructions implicitly.

Any other modifications called for in the instruction manual should also be done at this time. Some devices require other changes in order to be effective. Without the other changes, the inventor cannot guarantee the results you seek. Short cuts usually short-cut your results.

Lower Lean-Out Limits -The ECU has parameters that it will not go beyond. The parameters that are correct for your modified vehicle almost always fall outside the range the ECU is prepared to operate. Combustion efficiency enhancing technologies will easily take your maximized operating conditions beyond what the ECU will tolerate. The solution is to change the parameters.

The ECU works similarly to our brains. It uses multiple inputs and controls multiple outputs. We have our 5 senses: hearing, sight, smell, taste, and touch. Within each of these senses there are a range of different inputs possible. The ECU has its senses as well: MAP, TPS, MAF, ECT, IAT, Tach, O2 and other inputs.

If the MAP (Manifold Absolute Pressure) sensor sees a given load, the TPS (Throttle Position Sensor) sees a corresponding throttle angle, the CTS (Coolant Temp Sensor) sees a normal operating temperature, and the O2 (Oxygen) sensor is saying the engine is too rich, the ECU will comply to a point. When the ECU has leaned out the AFR (Air/Fuel Ratio) beyond what the programming claims is an acceptable range, the ECU will go into Open Loop and ignore the O2 sensor. It then reverts to Look-Up tables for its source of information. At this point, mileage will invariably go down, and often a trouble code is set.

Consider the conditions needed for the ECU to accept lean fuel commands. If the engine is warmer than it actually is, the ECU will accept leaner. If the engine is under less of a load, the ECU will want to deliver less fuel. If the incoming air is hotter, the ECU will accept lean commands more readily. If MAF (Mass Air Flow) sensor equipped, less air entering the engine will require less fuel.

Last week we laid out the basic foundation for what is involved with tuning. Now let's look at the particulars. Next week will feature the final part of the series.

CTS -One of the easiest ways to lower lean-out limits is to install a resistor across the CTS and IAT sensors in parallel with the sensor. A parallel circuit offers 2 paths of travel for the voltage. A cold CTS will have very high internal resistance. As it warms up, the resistance goes down. Adding a parallel resistor nets a lower total resistance value, thus sending a hotter temperature signal to the ECU. It should be noted that this trick applied to the IAT sensor will retard ignition timing in addition to lowering the lean-out limits.

Most of the world uses similar resistance values to equate a given temperature. The Ford based systems (including Mazda, Infiniti, and Jaguar) use much higher resistance values. This is important to know when selecting resistors.

If you have a scan tool available to you, use it. Monitor the CTS temperature that the ECU sees. With your engine at operating temperature, check to see that the temp reading is close to the thermostat rating. If it is, proceed. If it isn't, check your cooling system for contamination or stuck thermostat. You may need to do a coolant flush or repair before proceeding. Assuming you are getting reasonable numbers, try different resistors across the CTS to raise the temp reading about 10* F (for example, from 195* to 205*). Even though higher numbers will work, you will most likely run into cold start issues beyond the 10* offset. The average vehicle will use something like a 3.9K ohm resistor. Fords may like a 5K ohm or larger value.

If your cooling fan runs continuously with your setting, add more resistance to lower the temp reading. Any mileage gains from the hotter engine signal will be more than offset

by the additional load on the alternator. If you have a rear-wheel-drive with a belt driven fan, you can still add too much temperature offset. The ECU has an internal cooling mode. After the engine overheats to a point, the ECU starts dumping copious amounts of fuel. The excess fuel will evaporate, thus cooling the engine from the inside. However, at this point your mileage literally tanks.

IAT -The IAT is less sensitive to cold start issues. You can add more temp to this signal than you can to the CTS. Just keep in mind that you are not only lowering your lean-out limits, you are also retarding your ignition timing. If you put a timing light on the engine as you adjust IAT values, you won't see the timing change. The timing changes under load. Hotter air is more prone to detonation. This is why the ECU retards the timing.

If you are tuning on the hottest day of the year, you may find out just how high of a signal you can generate before setting codes. Typically it is in the 240* F range. If you are tuning in the middle of February, then you can offset the signal from your base cold reading and things will be fine for now. Come June or August, this setting may be high enough to trip codes. Allow for this when tuning.

MAP -It is important to address your load sensing system in order to keep your mileage gains. Often times addressing only a few of the ECU's inputs will allow you to tune for a mileage gain, only to have the adaptive memory take it away as time goes on. The load sensing devices give the ECU a clue as to what you are up to, and it won't tolerate it. By generating a lower voltage signal from the MAP sensor, harmony is restored, and your mileage gains are for keeps.

There are 2 types of MAP sensors on the market. Most of the world uses a version that has a 5 volt VREF, ground, and DC signal wire. The MAP is a type of potentiometer; like a radio volume knob. Instead of turning the knob with your hand, the knob is turned as the vacuum in the engine changes. A high vacuum reading will give a low voltage signal. A low vacuum reading will give a high voltage signal. Low vacuum means the engine is under load and needs lots of fuel. Look at it this way, low signal voltage, low fuel requirements. High signal voltage, high fuel requirements.

If you raise the VREF, then the signal will be higher. If you lower the VREF, then the signal will be lower. A lower signal tells the ECU lower load. A relatively simple method of lowering the VREF is with an LM317T adjustable voltage regulator. If you are somewhat capable with electronics, you can build one for about \$10 to \$15. The parts you will need are:

- LM317T adjustable voltage regulator
- 220 ohm resistor (1/4 watt is sufficient)

- 1K ohm multi-turn potentiometer
- Small heat sink for the LM317T
- 3 different colors of 18 gauge wire
- Enclosure (box)

The LM317T comes in a TO-220 case. Looking at it from the front with the mounting tab at the top and the 3 pins at the bottom, solder the 220 ohm resistor across the 2 left pins. Run a jumper wire from the left pin to the center of your 1K pot. Run a ground wire to one of the outside legs of the pot. If you use one side, then clockwise will raise the voltage. If you use the other side, then counter-clockwise will raise the voltage. Bench test your unit to know which way it will work.

Run the right leg to a Key-On/Crank battery voltage source. It is important that you have voltage when the key is on AND when cranking. If you don't have voltage when cranking, the ECU will not see a MAP signal and usually won't start at all. Drill 2 holes in your enclosure; one for the wires and one to access the pot.

With your unit on the bench, apply battery voltage to the battery and ground leads. Check the voltage output. Adjust it to 5.0 volts to start with. To install it on your vehicle, cut the VREF wire going to the MAP. **DO NOT TAP THE VREF WIRE COMING OUT OF THE ECU!** This will affect all sensors using the same 5 volt signal and will deliver disastrous results. After you cut the wire, connect your adjusted voltage wire to the MAP sensor and tuck and tape the other end of the cut wire back into the harness. It is best to solder connections and seal with heat-shrink tubing.

Lowering the VREF voltage will lower your lean limits, but will also advance ignition timing. Less load equals more timing advance. More load equals less timing advance. Remember this when we get to step 5.

The other type of MAP sensor used almost exclusively on the Ford based systems is frequency based. It has a 5 volt VREF, ground, and frequency signal output. The method of dealing with the frequency based MAP sensors is different than that used for the DC voltage based MAPs. Simply cut the ground wire going to the sensor, and then add a small amount of resistance. A good starting point is about 10 ohms. Your upper limits will be between 15 and 20 ohms, depending on the ECUs calibration. The more resistance, the more offset. Notice I didn't say 10K ohms. It takes very little resistance to accomplish the job. You may find an Ohm Ranger or small value potentiometer helpful here.

MAF -There are a couple different styles of MAF sensors that have been employed over the years. Early versions were called Vane Air Flow (VAF) sensors. They had a spring

loaded door that controlled a wiper arm across a resistive pad. There is a black plastic cover that, once removed, will allow access to this resistive circuit. Raising spring pressure will lower lean-out limits. You can shift the wiper arm to a clean spot on the resistive circuit to extend the life of your MAF while you're in there.

Some of the MAF sensors work like the typical MAP sensors in that they have a DC voltage IN, and a DC voltage signal OUT. They can be dealt with the same as the typical MAP sensor.

Most of the modern MAF sensors have a ground, battery voltage input, and frequency based output. These aren't that difficult to tune. I've seen complicated and expensive products that aren't much better than this trick. Just like the frequency based MAP sensors, cut the ground wire and install a small amount of resistance. Again, no more than 30 ohms, with averages in the 10 to 15 ohm range.

Once you have set the stage by lowering your lean-out limits, you can now adjust the AFR for better mileage. The exact method will depend on the type of O2 sensor your vehicle uses. There are 4 types currently on the market: old style oxygen sensor, AFR sensor, titania sensor, and wide-band sensor. Each requires its own unique approach. Some vehicles may have 2 bank sensors. You'll have to address both equally. Don't worry about the downstream sensors (the ones after the cat) as they only tell the ECU that the converter is working.

To do your adjustment, you want to monitor your Loop Status. If your ECU pops into Open Loop, any adjustments you make are irrelevant. You have to stay in Closed Loop. If you pop into Open Loop, your lean-out limits are still too high (or your oxygen sensor is bad). If you can install a scan tool to monitor Loop Status, do it. This is the easy way. If you have an older vehicle that doesn't have data stream information, then hook a digital volt meter to the O2 signal wire. As long as the voltage is jumping around, you're probably in Closed Loop. If the voltage goes steady, you probably are in Open Loop.

As you begin to lean out the mixture you will probably feel an increase in power. There will be a peak in the power, and then it will gradually taper off. After so much leaning out, it will be like you just fell off a cliff. There will be a dramatic loss in power, it will want to hesitate and stall. I try to tune about $\hat{A}^{1/2}$ way between peak and cliff.

Old Style O2 Sensor -The oxygen sensor was introduced in mass back in 1981 on GM vehicles. It has an operating range of 0-1 volt. The higher the voltage the richer the detected AFR. The lower the voltage, the leaner the AFR. A rich mixture is a lean command. A lean mixture is a rich command. It is commonly called a Narrow-Band sensor because it is only accurate within a narrow range of AFR operation. Right at the 14.7:1 AFR, a small change in AFR yields a large change in voltage. As the engine goes

leaner or richer from the 14.7:1, the voltage changes get smaller and smaller.

A device that has been used for several years is the Electronic Fuel Injection Enhancer (EFIE) developed by George Wiseman of Eagle Research. The principle is to create a small amount of voltage offset that is electrically isolated from chassis ground. It is like a free-floating battery installed inline with the signal wire. This raises the voltage to the ECU indicating a richer-than-actual AFR.

If you have an older vehicle with loose parameters, you may be able to add as much as 0.450 volts to the O2 signal. If you have a newer vehicle with tight parameters, you may not be able to get away with more than about 0.280 volts. Experimentation will dictate what your ECU will tolerate. The old single wire sensors are easy to spot the signal wire, since it is the only one. There have been 2-, 3-, and 4-wire sensors used over the years. You may have to use a manual to determine which wire is the signal wire. Usually on a 4-wire sensor, you have 2 white wires for the heating element, a grey wire that is ground, and a black wire for your signal out.

Another method that I have not personally tried, but comes with good recommendations is to drill out a spark plug anti-fouler for the mid-70s Ford products with the 18 mm plug. Install the modified anti-fouler into the exhaust where the O2 sensor normally goes, then screw the O2 sensor into the anti-fouler. This pulls the sensor out of the exhaust stream and allows for leaning out the AFR. Since I haven't tried it, I cannot guarantee results.

Wide Band Sensors -Good news! You can use the same EFIE on the signal wire of a wide band. The one wide band that I modified used the blue wire for the signal. Wide bands will have 5 wires. That's the dead give-away. They have been used widely on VWs and Mazdas.

AFR Sensors -AFR sensors operate under a totally different set of rules. The same sensor is used in 2 different ways by various OEMs. One method involves putting a fixed voltage on the reference wire (white) and varying the current to maintain a fixed voltage on the signal wire (blue). Another method is to apply a fixed voltage and current to the reference wire, and monitor the voltage coming out. Either way, they are current devices, not voltage devices.

To alter an AFR sensor, cut the blue signal wire and install low value resistors. The range will be 30 ohms or less. Most of the vehicles I've modified have liked the 7 to 18 ohm range. I've never needed over 20 ohms as of yet. Again, an Ohm Ranger or low value pot will be helpful in your tuning. You will be able to feel 1 ohm resistance change.

Titania Sensors -They work similarly to the traditional O2 sensors, but backwards. I haven't yet had the opportunity to deal with these, so I can only give you guesses on what will work. One possibility is to install an EFIE backwards so you are lowering the signal voltage. Another way might be to add resistance to the signal wire. The spark plug anti-fouler may also work. Fortunately, they were only used for about 3 years and only on select vehicles.

Adjust Ignition Timing -If you have a distributor, the solution is simple. Loosen the hold-down clamp and turn the distributor. If you have DIS, COP, or a distributor that doesn't affect timing, then you have to play with the MAP and IAT signals to dial in the spark.

To adjust with the distributor, grab a vacuum gauge, timing light, and distributor wrench. Drive the vehicle down a relatively flat section of road at cruise speed. Watch your vacuum gauge. Pull over and either advance or retard the timing by about 4 degrees. If you increased the power and vacuum, adjust again by about 2 degrees. If you lost power and vacuum, crank it the other way about 8 degrees and test again. You want the least amount of timing advance needed to maintain maximum power at cruise. Any more advance than that will increase the possibility of detonation, and will fight the piston on the compression stroke.

If you have the DIS or COP, adjust the IAT sensor reading by 10* F increments for maximum power. If you start high on your reading (smaller value resistor), start adding resistance to advance timing. If you have a near ambient reading (no or large value resistor), reduce parallel resistance to retard timing.

As stated earlier, adjusting the MAP VREF will alter timing. A lower VREF will advance timing. A higher VREF will retard timing. There is a balance between finding the right lean-out limit, and maximizing the timing.

Readjust AFR -Improving combustion efficiency usually requires less timing advance to get the job done. The fuel burns faster and more thorough. Thus, it takes less time to convert the chemical energy in the fuel into kinetic energy at the crank. On the flip side, as you lean out the AFR, it takes longer to burn across the leaner mixture. More timing advance is required. Sort of a catch-22. Once you have adjusted your ignition timing for maximum power, you may find that you can lean out your AFR a bit more. A leaner mixture requires more time for the flame to propagate across the cylinder. If you advanced your timing, try leaning out the AFR a bit more. If you retarded your timing, you might be able to slightly enrich the AFR and get better power and mileage.

Summary -Tuning was taught in tech schools up until about 30 years ago. As the vehicles became more complex, there was less tuning required for optimal

performance and mileage. Tech school grads coming into the work force these days are taught to follow flow charts, replace bad parts, and track down poor connections. For the younger generation, tuning is something they read about in magazines, but never get to experience. It isn't difficult, but requires a learning curve just like anything else. Don't get discouraged quickly. It may take a little time to get the hang of it, but you can do it. –End

From FORD

Heated Oxygen Sensor (HO2S)

The HO2S detects the presence of oxygen in the exhaust and produces available voltage according to the amount of total oxygen detected. A high concentration of oxygen (lean air/fuel ratio) in the exhaust produces a voltage signal less than 0.4 volt. A low concentration of oxygen (rich air/fuel ratio) produces a voltage signal greater than 0.6 volt. The HO2S provides feedback to the PCM indicating air/fuel ratio in order to achieve a near stoichiometric air/fuel ratio of 14.7:1 during closed loop engine operation. The HO2S generates a voltage between 0.0 and 1.1 volts.

The 14.7:1 stoichiometric ratio was mandated by the EPA in 1978. Rich air/fuel ratios indicate high hydrocarbon emissions. Lean air/fuel ratios indicate high nitrogen oxide emissions. NOx emissions increase logarithmically above 15:1.

Embedded with the sensing element is the HO2S heater. The heating element heats the sensor to a temperature of 800°C (1400°F). At approximately 300°C (600°F) the engine can enter closed loop operation. A voltage controlled circuit supplies voltage to the heater. The PCM will turn on the heater by providing the ground when the proper conditions occur. The heater allows the engine to enter closed loop operation sooner. The use of this heater requires the HO2S heater control to be duty cycled, to prevent damage to the heater.

If the oxygen sensors are warmed up and the PCM determines that the engine can operate near stoichiometric air/fuel ratio (14.7:1 for gasoline), The PCM enters closed loop fuel control mode. Since an oxygen sensor can only indicate rich or lean, the fuel control strategy continuously adjusts the desired air/fuel ratio between rich and lean causing the oxygen sensor to 'switch' or 'pulse' around the stoichiometric point. If the time between rich and lean switches is the same, then the system is actually operating at stoichiometric. The desired air/fuel control parameter is called short term fuel trim (SHRTFT 1 and 2)...Some calibrations will have determined time intervals between switches and short term fuel trim excursions that are not equal. These unequal excursions are used to run the system slightly lean or rich of stoichiometric. This practice is referred to as using bias. For example, the fuel system can be biased slightly rich during closed loop fuel to help reduce NOx.

Values for SHRFT 1 and 2 may change significantly as the engine is operated at different RPM and load points. Short term fuel trim values are not retained after the engine is turned off.

While the engine is operating in closed loop fuel control, the short term fuel trim corrections are learned by the PCM as LONGFT 1 and 2 corrections, these corrections are stored in memory fuel trim tables. Fuel trim tables are based on engine speed and load and by bank for engines with 2 HO₂S sensors forward of the catalytic converters. Learning the corrections in memory improves both open loop and closed loop air/fuel ratio control. Long term fuel trim corrections may change depending on the operating conditions of the engine (RPM and load), ambient air temperature and fuel quality (% alcohol, oxygenates). The values may change a great deal as the engine is operated at different RPM and load points.

From GM

An Oxygen sensor is a chemical generator (zirconium dioxide-platinum). It is constantly making a comparison between the Oxygen inside the exhaust manifold and air outside the engine. If this comparison shows little or no Oxygen in the exhaust manifold, a voltage is generated. The output of the sensor is usually between 0 and 1.1 volts. All spark combustion engines need the proper air fuel ratio to operate correctly. For gasoline this is 14.7 parts of air to one part of fuel. When the engine has more fuel than needed, all available Oxygen is consumed in the cylinder and gasses leaving through the exhaust contain almost no Oxygen.

This sends out a voltage greater than 0.45 volts. If the engine is running lean, all fuel is burned, and the extra Oxygen leaves the cylinder and flows into the exhaust. In this case, the sensor voltage goes lower than 0.45 volts. Usually the output range seen is 0.2 to 0.7 volts. The sensor does not begin to generate it's full output until it reaches about 600 degrees F. Prior to this time the sensor is not conductive. It is as if the circuit between the sensor and computer is not complete. The mid point is about 0.45 volts. This is neither rich nor lean.

A fully warm O₂ sensor *will not spend any time at 0.45 volts*. In many cars, the computer sends out a bias voltage of 0.45 through the O₂ sensor wire. If the sensor is not warm, or if the circuit is not complete, the computer picks up a steady 0.45 volts. Since the computer knows this is an "illegal" value, it judges the sensor to not be ready. It remains in open loop operation, and uses all sensors except the O₂ to determine fuel delivery. Any time an engine is operated in open loop, it runs somewhat rich and makes more exhaust emissions.

This translates into lost power, poor fuel economy and air pollution. The O₂ sensor is constantly in a state of transition between high and low voltage. Manufacturers call this crossing of the 0.45 volt mark O₂ cross counts. The higher the number of O₂ crosses

counts, the better the sensor and other parts of the computer control system are working. It is important to remember that the O2 sensor is comparing the amount of Oxygen inside and outside the engine. If the outside of the sensor should become blocked, or coated with oil, sound insulation, undercoating or antifreeze, (among other things), this comparison is not possible.

Tips

I think the first thing that needs to be done, is to learn all you can about your ECU and sensors. You need to know when it's in closed loop and when it's in open loop. Some are only in closed loop at cruising speed. To find out about your engine I recommend tacking a lead to the O2 sensor signal lead and running it into the cab and connect it to a digital voltmeter so you can keep an eye on the voltage under different driving conditions. Remember, this is the signal that the booster will mess with, so you want to know what it does under normal conditions - without the booster running, so you'll know what you want it to do after the booster is running. When the sensor signal stays at one voltage under differing driving conditions is when it's operating in closed loop.

Another thing that's relatively easy to monitor is injector pulse duty cycle. An analog voltmeter connected to one of the injector signal leads will work for this. It gives a fair indication of the rate of gas flow. The third device is a tachometer, which many cars already have. You can use these last two to get an indication of fuel flow at different RPM.

If you create a chart of these different parameters with the booster off, than when the booster is fired up you'll have a better idea of just what the ECU wants to see under different conditions. Of course, if you have a scan device to work with, it would be even better. However if your car is pre-OBD2 that's generally not available.

Changing the Air Fuel ratio

It is very simple to change the AFR if the vehicle is fitted with a "genuine" wideband sensor (aka AFR sensor), because that sensor is sensitive over a wide band of AFRs (that's why it's called wideband) If the vehicle has a narrowband sensor, it is not possible to alter the AFR by very much, because the sensor is not capable of giving a useful control signal other than in the very narrow band of values over which it is sensitive.

Genuine wideband (AFR) sensors are only found in vehicles with OBDII, which have the diagnostic interface to which a PC may be connected. Some of those vehicles have ECMs which can be re-programmed thru that interface. BUT, not all OBDII vehicles use AFRs; most do not. You have to know what you are dealing with. It is not cheap, but the way to harness this technology for vehicles with narrowband sensors is already available, and at least one person has reported using it with success. [LM-1: Digital Air/Fuel Ratio Meter](#)

The principal of Lean Burn Combustion and how it can improve engine efficiency by Franz Hofmann

Lean-burn combustion technology uses a concept of excess air. The main purpose of using excess air is to increase fuel consumption efficiency, but side benefits are:

Lowered combustion temperatures

Reduced NOx production

Reduced Carbon Monoxide

Lets review some combustion principals:

Ideally, during the combustion process, an engine ingests air, then supplies enough fuel to sufficiently burn the air in the cylinder. Most engines consume a fuel, such as gasoline, diesel, natural gas, propane, or mixtures of these fuels. Most of these fuels (with the exception of diesel) have an ideal air-to-fuel ratio, called the Stoichiometric Ratio. This ratio describes the ideal thermochemical process, where all of the air and all of the fuel is consumed during the combustion cycle, leaving no residual exhaust by-products.

Also realize that all internal combustion engines control the amount of power by controlling the amount of air that is ingested in the engine, then supplying enough fuel to burn efficiently. (Diesel engines allow for an unthrottled operation, and control the amount power by varying the amount of fuel metered in the cylinders. Here are some ideal combustion ratios:

Gasoline 14.7 to 1

Natural Gas 16.8 to 1

Propane 15.5 to 1

(These ratios are based upon the weight of air to fuel.)

Also, there is another number; the amount of air by displacement;

Gasoline, about 3.5% (0.75 to 7%)

Propane, about 6.5% (2.1 to 9.6%)

Natural Gas, about 10% (4 to 13%)

When a fuel is burned, its ideal Stoichiometric ratio is called the Lambda Ratio. With all fuels, the Stoich Ratio at Lambda is identified by the number " λ ". The Lambda ratio is symbolized by the Greek character "Lambda" or the " λ " sign. For example, gasoline with

its air to fuel ratio of 14.7 to 1 is called "Lambda 1", or " $\lambda=1$ ". If the air to fuel ratio is leaned by 10% to 16.17, the resulting Lambda would be " $\lambda=1.1$ ".

Notice that diesel is absent from this chart. Diesel fuel has a very wide combustibility range. That is one of the factors that makes diesel fuel ideal for a combustion ignition engine (CI). As an overview of a CI engine, these engines operate unthrottled, meaning that the incoming air is NOT controlled, just the amount of fuel.

Now, why don't we just use diesel for lean burn? Simple, we are! At idle, a diesel engine may operate at air to fuel ratios in the 40 to 60 to 1 range! At full load, this ratio drops to 12 to 1 (and the accompanying smoke in the process, indicating unburned fuel).

Emissions

As a fuel is burned in an engine, various exhaust emissions are produced:

Hydrocarbons, HC's, from unburned fuel. HC's are formed from a rich fuel mixture (or a lean fuel mixture where there is excess air, leading to a lean misfire).

Carbon Monoxide, CO, from a rich fuel mixture, and never from a lean fuel mixture.

Carbon Dioxide, CO₂, formed during any combustion process when oxygen and carbon are present in the primary combustion ingredients.

Oxygen, O₂, from a lean fuel mixture.

Oxides of Nitrogen (Nitrogen Oxide) NO_x. Nitrogen is present in the air we breath, and the engines air it consumes. Nitrogen displaces the air by approximately 75%. Nitrogen doesn't burn, but it can oxidize at temperatures over 2500 degrees F. NO_x is a health hazard and one of the EPA's primary emission problems.

One method of controlling NO_x is to reduce combustion temperatures. An EGR valve is the easiest device to use. It bleeds some inert exhaust gas into the incoming air stream, diluting the oxygen, and reducing combustion temperatures.

One other method of NO_x reduction is to run a richer fuel mixture. By adding more fuel, the amount of air is displaced, reducing NO_x. The leftover fuel is handled by the exhaust catalyst, converting the CO and HC into CO₂. With a liquid fuel engine, the addition of more fuel also lowers the combustion temperature by the condensing effect. Here the fuel is evaporating and absorbing combustion heat. With a vapor fuel, the reverse is true. If the engine is running lean (over $\lambda=1.2$), the exhaust actually begins to cool down, thus reducing exhaust and combustion temperatures. Now we understand the rationale of "Lean Burn"!

Engine Efficiency

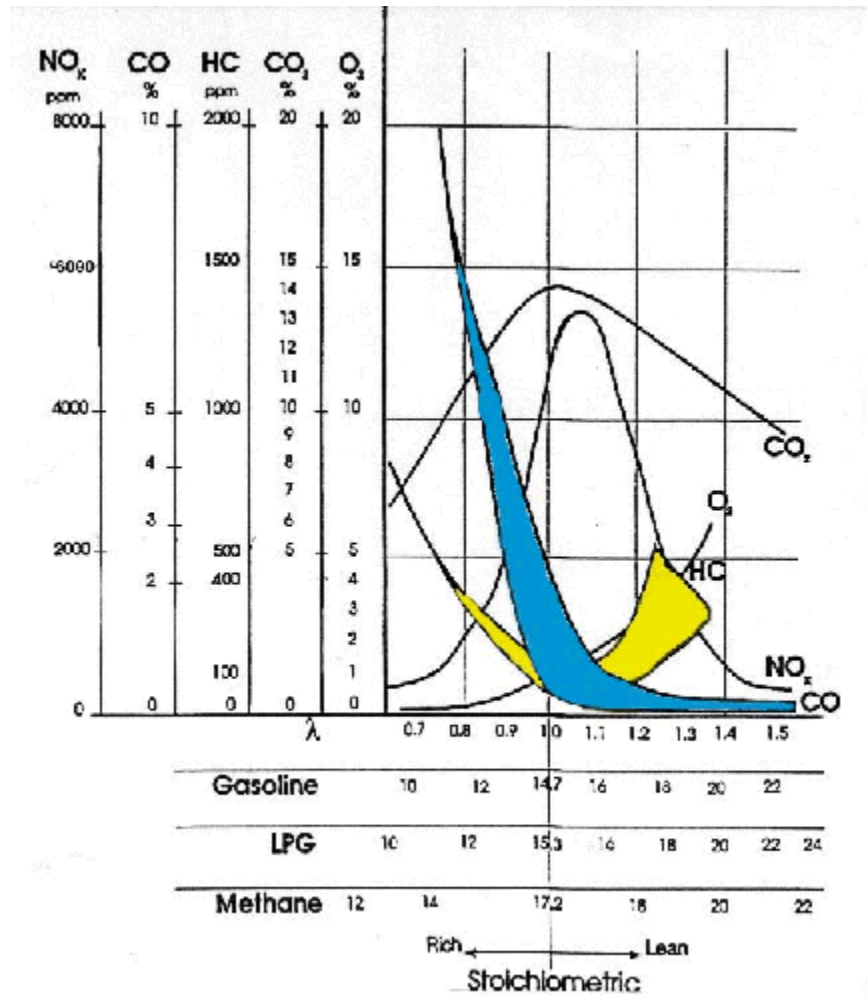
Conventional Otto cycle SI (Spark Ignited) engines have an efficiency ratio of approximately 29%. That means that for every calorie of fuel consumed, only 29% actually reaches the flywheel. The rest is lost during the combustion process, exhaust heat, internal friction, cooling system, cylinder block radiation, and so on. A significant amount of heat energy is lost in the thermochemical process itself! The single biggest robber of engine efficiency is the simple throttle! As an example, in a large 7 liter engine, each cylinder is almost one liter in size. With the throttle almost closed, (and with the engine intake manifold vacuum at 18" HG, or approximately 62% of absolute vacuum or zero psi absolute pressure) imagine trying to lift a plunger 4". You would be lifting 208 lbs.! (Assume a 4.25" bore, equating 14.17 square inches, times 14.7 lbs/sq/in air pressure at sea level.)

Take this one step further, and multiply it times the number of cylinders, and you have some kind of idea how much power it takes to just spin an engine over without any combustion process taking place!

Diesel Engines

Now the marvel of a diesel engine. No throttle! That means that the pumping losses are non-existent. You do have a higher compression, but that is a fraction of the pumping losses with a throttled engine. This factor alone can raise the efficiency of a diesel engine to 37%, but now add in the BTU of a diesel gallon (145,000) versus a gasoline BTU (117,000) or Propane (91,500) and you can have an engine with a combustion efficiency approaching 40%.

The Lean Burn concept takes this practice one step further. By pumping in more air than is necessary, (see the chart), HC's, CO, and NOx are reduced by going past the "NOx Curve".



This chart readily shows how the NOx levels drop once the Lambda ratio crosses the 1.1 range and goes leaner. Also note that the CO drops almost to nothing. Hydrocarbons are cleaned up with an oxidizing catalyst. What you have left is an engine that has very low NOx, low HC, low CO, and high levels of O2.

Easy? Not on your life! Anyone who has operated an engine that is starving for fuel can realize that you lose power quickly once you run out of fuel. So, how do we maintain the power levels with drastically reduced amounts of fuel?

We have to "help" the fuel and air into the engine. The only way to do that is with forced induction.

Now for some technical data on lean burn engines.

You **MUST** use a gaseous fuel for lean burn (or vaporize gasoline);

You **MUST** use a turbocharger or supercharger. If you attempt to operate a normally aspirated engine at elevated Lambda ratios, a severe loss of power will be noted, possibly accompanied by backfires.

Why can't we use a liquid fuel? The fuel micro-droplets are too far apart to support linkage combustion (where one droplet helps to ignite its neighbor). Even if the air mixture is compressed by using a supercharger or turbocharger, the fuel mixture now becomes a dense mass which has a difficult time supporting combustion. There is research using ultrasonic atomizers to assist with this fuel problem, but we go one step further, we use a fuel that is already a gaseous fuel, Propane or Natural Gas.

Fuel control strategy

Even with supercharging, there is no (or almost no) boost at engine idle speed, so the fuel mixture must be at $\lambda=1$ (at idle). As the power band is increased, the Lambda ratio may be increased. Hard acceleration, or snap throttle acceleration might invite a spectacular engine backfire, so a fuel enrichment to $\lambda=1$ or to $\lambda =.9$ would be used, until the engine reaches no more throttle movement (degrees per second rotation below a set limit). The real secret here is understanding the concept of boosting the intake pressure. At stoichiometry, there is an ideal mixture of air to fuel, with the fuel mixture evenly dispersed in the combustion chamber. As an engine operates in lean regions, the ratio of fuel to air decreases, reducing the relative amount of fuel in a cylinder. Air and fuel under boost, with excess air, increases the amount of fuel in the cylinder, approaching the previous stoichiometric ratio, albeit at elevated air ratios. This maintained fuel density allows for combustion.

Fuel injection is an ideal platform here, since there are electronic engine controllers available that would allow a tailorable fuel injector pulse-width algorithm, even while the engine is running.

The following parameters would be needed:

Fuel temperature;

Intake air temperature

Engine rpm

Exhaust Lambda ratio

Throttle position

Crankshaft position

Intake manifold pressure

This would be used to calculate the air mass density in preparation for developing the fuel injector tables. Why can't a mechanical carburetor be used?

It can, if a method of leaning the fuel mixture on high boost is used. One of the first laboratory engine experiments I ran used an Impco 200-A carburetor with a compensating pressure hose to the vaporizer. This combination allowed a Cummins 8.3 liter 6 cylinder to produce 330 bhp at 2750 rpm to reach λ -1.45 with exhaust temps after the turbo of 870° F. The exhaust did not require a catalyst to reach CARB standards (in 1995). A catalyst would be required today. I would NOT recommend a mechanical carburetor combination for an over the road Lean Burn engine. You MUST have some means of electronic controls, either with fuel injection, or an electronically controlled mechanical system.

Summary:

Lean burn is a fascinating concept. It will allow engine efficiency to almost reach diesel levels, with reasonably good performance. Lean burn has been used for years in stationary application, where there is no ramp loading or throttle position changes that would affect the air to fuel ratio.

(This page is in the process of being updated. This material was taken from a paper I wrote with the intention of incorporating it into a thesis.) -[Source](#)

Suggested faculty reading related to the oxygen sensor and EFIE

<http://www.asashop.org/autoinc/dec2002/mech.htm>

[Oxygen sensor - Wikipedia, the free encyclopedia](#)

[Hydrogen boost article on leaning out fuel](#)

<http://www.protiumfuelsystems.com/tips.html>

<http://www.fuelsaver-mpg.com/doc/TuningForMileage.html>

<http://www.osti.gov/bridge/servlets/purl/809114-OkfzRR/native/809114.pdf>

<http://www.greenfuelbooster.com/cng-ecuFrame.html>

<http://www.fuelsaver-mpg.com/documents.html>

To effectively boost OBDII-compliant cars one needs to understand the relationship between a few OBDII parameters, specifically Engine Speed (RPM), Engine Load (LOAD), Intake Manifold Pressure (MAP), Oxygen Sensor (O2). Without understanding this parameter relationship HHO boosting becomes a blind man's effort. Here are a few videos to at least get started.

<http://www.greenfuelbooster.com/videoFrame.html>

Alternatives to the EFIE

Hydroxy Systems on Older Honda's

The following information is intended for those who are using hydroxy systems on older Hondas. The open source engineer who has submitted this information did performance tuning. He states there are a few ways you can accomplish tuning on OBD0 and OBD1 Hondas. This method will allow you to completely remap the fuel curve and ignition timing if you choose to do so. The process requires you to "burn" bin data onto chips which you insert into a ZIF socket that is soldered into the ECU board. These were meant to be used on high performance engines but since you basically have complete control over the fuel and ignition curves you can pretty much use it for whatever tuning you need.

NOTE: This involves opening and soldering to your current ECU so make sure you're comfortable with that.

http://www.superhonda.com/tech/honda_ecu_programming.html - - This link gives some information on the socket you'll be soldering in and also mentions one of the few tuning software's out there to accomplish this.

Software:

Turboedit - OBD0 honda ecus - <http://www.turboedit.org/>

Crome - OBD1 honda ecus - <http://www.tunewithcrome.com/>

Uberdata - OBD1 honda ecus - <http://uberdata.pgmfi.org/> (seems to be down at the moment)

Hondata - <http://www.hondata.com/>

It is believed that they also allow data logging to help with the tuning process.

An Alternative to the above

Megasquirt is a good alternative if you're not comfortable with physically modifying your ECU. SDS is another one which allows generic tuning (not Honda specific) <http://sdsefi.com/>. The original author stated that he personally has never used SDS but had seen it run some very high performance motors (500hp+) hence believes it may work in an Hydroxy tuned atmosphere.

Further <http://www.xenocron.com/catalog/index.php> is a link to a place which the original poster used for chips. The actual ROM burner also has a bin library for base

maps although most of them enrich the mixture due to the fact that most people use these programs for turbocharged applications.

If you choose to look into the above products PLEASE do your research before jumping in to make sure it'll work with your application! This is only meant to be suggestions! Tuning is critical to engine performance and if you screw something up it could seriously damage your motor!.

914 Timing and Dwell, Adjustment-

http://www.pelicanparts.com/techarticles/914_timing/914_timing.htm

O2 Sensor modification using spark plug non-foulers

Thanks to Lee AKA Redmeanie and Aaron from the energetic forum dot com for this information. **This method is EXPERIMENTAL.** There has been some success with this method. A testimonial will be posted below. **This method is cheap and easy, it worked for some but definitely not "one size fits all.** The electronic way "EFIE" could be the only "reliable" way. The key is to find simple, reliable designs and incorporate both simple and reliable together.

Purpose: Non-foulers act as spacer to recede the O2 sensor probe out and away from the exhaust gases. By doing this, there will be less detectable oxygen at the sensor tricking the fuel computer into thinking it is more rich than it actually is. This manipulates the voltage from the O2 sensor going to the fuel computer to cause the injectors to pump less fuel leaning out the air/fuel mixture. This results in a reduction in fuel consumption.

If this is used by itself, it is possible to cause pinging, detonation, excess heat, et since the mixture may become too lean. It is recommended to only use this modification if you are using some type of fuel combustion enhancer that will actually allow a slightly leaner mixture to fully combust effectively such as various fuel additives like RXP or enhanced spark plugs like the Pulstar Plugs, water fuel "hydrogen booster" add-ons and other modification. Please [visit the forum for more info.](#)

[This document](#) is documentation of one attempt at using this modification; please note that no claims or guarantees are made. **If you do this modification without professional advice and destroy your engine, you are accepting full responsibility.** The actual discussion thread for this modification [can be found here.](#)

Original instructions:

1. First: Make sure there is enough room around the o2 Sensor to space it out, because the exhaust system moves around a lot.
2. Go to your local auto parts store and buy a pair of Non-Foulers (Anti-Foulers):

Motormite 42009 or Dorman equivalent. They are 18mm for Ford spark plugs. Be sure to get the Gasket Seat, not the Tapered Seat.

3. This may actually be a good time to buy a NEW o2 Sensor. Most o2 Sensors need to be replaced in the 60,000 to 100,000 range. Check and see what the recommendation is for your vehicle. When an o2 Sensor goes bad, the Computer goes into "Limp In" mode. Which means, the motor will still run, (although poorly) but the Computer will set all the operating parameters into "Very Safe" zones, which includes "Running RICH".

4. Disconnect the Battery while working on the o2 sensor to reset the computer and to prevent any electrical problems.

5. Put one non-fouler in a vice and drill through it with a 1/2" drill bit. A drill press is best. This makes room for the o2 sensor head and opens up the end.

6. Carefully unscrew and remove the old o2 sensor. If reusing the old Sensor, apply Anti-Seize to the threads and screw it into the drilled out anti-fouler. Now apply Anti-Seize to the threads of the Non-Fouler and reinstall into the exhaust pipe. Don't over tighten the Non-Fouler because the walls are pretty thin after drilling.

7. Some people will also add the second, undrilled non-fouler, between the exhaust pipe and the drilled non-fouler & o2 Sensor at this time. It's up to you. But I prefer to do it one step at a time. Be sure to use Anti-Seize on the threads.

REMEMBER: It may take 1 to 2 weeks for the Computer to relearn the system. DO NOT continue to drive if there is a lot of pre-ignition or detonation.

NOTE: Always use Anti-Seize on the threads. DO NOT Touch or get any Anti-Seize on the sensor head!!! It will ruin the Sensor. The o2 Sensor is actually a fairly delicate instrument.



The non-foulers were about \$5 at auto-zone. Anti-seize lubricant is about \$3. The 1/2" hole was drilled by placing one of the non-fouler spacers in a vice and drilling with a hand drill. It is much easier and more easily centered by using a drill press. No matter what, besides a few dollars, it just takes time to remove o2 sensor, attach to both non foulers and insert back into the exhaust manifold. Not counting the drilling time, removal and re-installation with spacers took about 10 minutes of time.

Aaron had to remove a heat shield from the exhaust manifold and the sensor which can be a tough nut to crack! With the anti-seize lubricant, everything should be a breeze. If you have a drill press, 1-5 minutes is all you need so this is a 15 minute project and about \$6-7 cost + time. There is enough anti-seize lubricant to do a couple dozen of these projects.



Aaron left the compressed stock washer on the base of the o2 sensor. I put on the modified non-fouler adapter without any new washer/gasket onto the o2 sensor. I added anti-seize lubricant to the o2 sensor threads. Be careful not to get that stuff on the sensor probe. I then put the unmodified non-fouler spacer on the modified one with lubricant and also no gasket/washer. Aaron DID use a gasket washer between the 2nd spacer and exhaust manifold and of course anti-seize lubricant on those threads going into the exhaust manifold.



Aaron hooked up all the wires again and then drove around a bit just to make sure nothing funky immediately happened and didn't really expect anything to. Some of the lubricant from exhaust heat smelled stopped. That will disappear over a bit of time.



Aaron used the old O2 sensor. A new one cost \$40 but with the RXP, it causes almost everything to burn since it links all the hydrocarbon molecules together causing more to burn as it absorbs infrared heat. So this sensor is in good shape and hardly had any carbon on it at all.



Notes on construction and operation

One suggestion is possibly trying to calibrate this via a hole size in the bottom plug and watching what happens via a system monitor. This would let us see what the computer is actually seeing and we could adjust the whole sizes to get our target A/F mixture. This would also be pretty close to universal (not perfect) for everyone to use.

One other advantage about this, is since we are not modifying electronics of the O2 sensor, when we start the vehicle it will run in the loop mode (factory A/F settings programmed into the ecm.) until the O2 sensor warms up to proper operating temp. This gives the "Booster" time to generate Hydrogen.

Also the size of the hole should be "tuned" and possibly sealed. One way in which this could be done is to make some discs out of stainless shim stock that would drop in the first Non Foulers. One will be with no hole and the rest with an index of sizes. Then to monitor the signal via a AF Mixture Gauge. That way you could calibrate your foulers to your vehicle and modifications.

Open loop is designed to just get the car running well until the O2 is warmed up, thus the heaters most O2 sensors have nowadays. They want to be in open-loop for as short a time as possible as this is programmed to be on the rich side, and high emissions. It is when the ECM observes the change in V at the O2 that at some point it goes into closed loop. This is important that any modifications take this into account, for if we were to modify something and have it stay in open loop - that would be much worse on MPG and emissions!

The O2 sensor needs to heat up to "operating" temp. It does not calibrate only according to the temp of the exhaust. So don't worry about the "Temp" with the spacers it will certainly get to its proper operating temp and function properly. It just won't see as much O2.

On adding the Non-Foulers it has been mentioned only adding to one Sensor. On a 1997 Ranger 4.0 L. V6 there are 2 more O2 Sensors right behind each Exhaust Manifold, one is very hard to find. You just need them on the upstream O2 sensors. The ones right off the exhaust manifold **it should just have 2 one for each side of the engine.**

Successful testimony

Taken from the energetic forum-Now I've settled on running the 2 front O2 Sensors with 2 Non-Foulers on each side. The first one next to the O2 Sensor with the ½ hole cut in it. The other Non-Fouler has the Factory size hole into the Exhaust. The back O2 Sensor next to the catalytic converter has only 1 Non-Fouler and it has a open ½" hole into the Exhaust. I'm getting better mpg at this point. I'm up to 6 to 7 mpg better than when I first started.

The Protium Oxyisolator

Please note- it is possible that the O2 sensor "isolators" CANNOT WORK! They do exactly opposite of what is claimed. The O2 sensor output would have to be RAISED in voltage to lean out the mix. Taking the sensor out of the exhaust stream lowers the temperature, which LOWERS the voltage and causes the ECU to richen up the fuel air mix ratio! It also can cause the sensors to foul prematurely.

The "[Protium Oxyisolator](#)" is an alternative to adding electronics. This device encases the existing oxygen sensor(s) in a spur fitting attached to the exhaust pipe. The device is designed to remove the sensor from the direct stream of exhaust gases, but allow it to operate as it heats up. By this function it can overcome the problem of the fuel computer pumping excess fuel. This experimental method has been found to work for some, where as others have found it in effective. It has been suggested that results depend on the particular vehicle and sensor involved.



The Protium connectors allow the oxygen sensor to be screwed into the outer connector piece which then itself will screw into the inner piece and takes the place of the existing sensor. The sensor will then be located in a T-junction spur off the main pipe.

The Circuit output signal modifier (COSMII) by "Mad scientist"

[The Mad Scientist research site](#) is a site describing research results on the COSMII. Video examples of his work [can be found here](#). Mad scientist is offering to build this circuit for those not able to reproduce it from his free plans, please consult his web site.



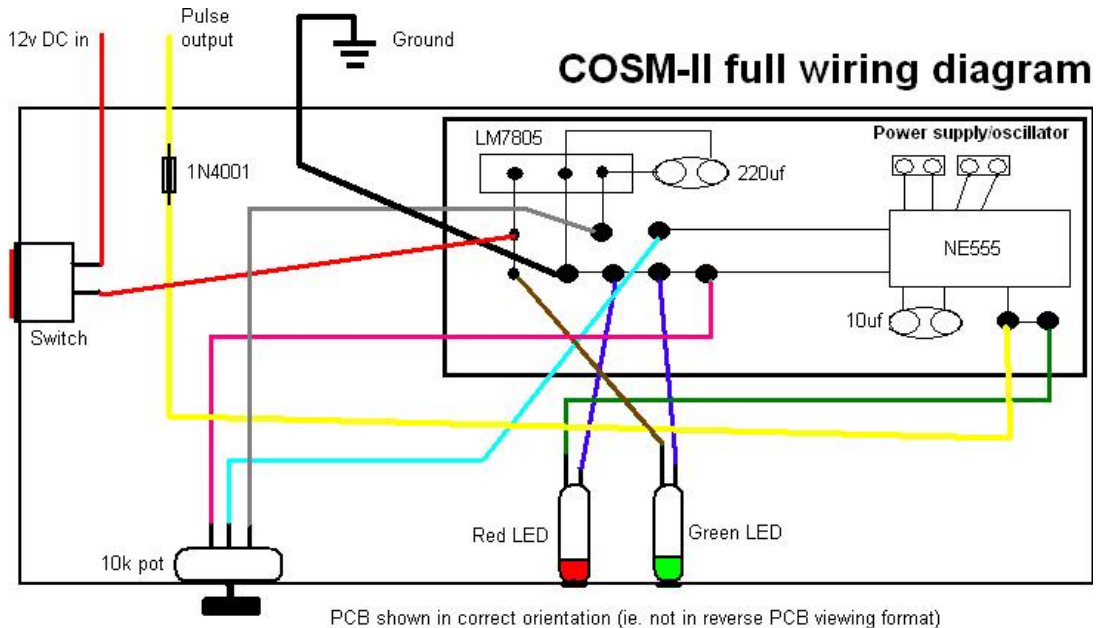
COSM-II

Bear in mind that the COSM-II is only for NARROW-band O2 sensors

It should be noted quote- "I've seen some forums around the Internet discussing the COSM/COSM-II, which in itself is very cool, but there is a little misinformation out there. There are folks who are saying that COSM works by replacing the O2 sensor completely, thereby causing you to lose its benefit in changing driving conditions. Nothing could be further from the truth and I wanted clarify that. The COSM is designed to work WITH the O2 sensor by adding its oscillated voltage to the oscillating voltage already being generated by the O2 sensor, to push the combined voltage to the threshold where the computer sees the command to lean-out the engine, so that your HHO generator is then taking up the slack from the reduced amount of gasoline no longer being pumped into the engine which in turn saves you hard earned cash by making the fuel you buy go further between fill-ups.

***The COSM could be used TEMPORARILY to completely replace your O2 sensor if, say, your sensor has gone bad and your computer is running open-loop.** In that event, the COSM's oscillated voltage would appear just like your O2 sensor's signal so your computer could run in closed-loop until you can replace the bad sensor. But this is just a side benefit of this device. Its primary function is to work WITH your O2 sensor by adding its voltage to what comes from your O2 sensor. It does not replace the O2 sensor, so you still always have the benefit of the sensor reacting to changing driving conditions. That also means when you power-off the COSM/COSM-II, you are back to just having O2 sensor voltage going to the computer. It's voltage is never replaced, just added to (hence the original name of the COSM, "Voltage Adder"). -End quote, mad scientist.*

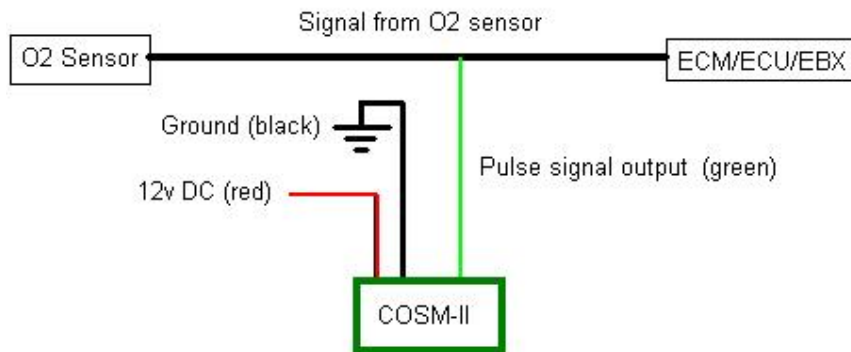
The following has been provided as a back up resource. Please visit his site and forum for updates.



LEGEND:		
RED: 12v DC input	BLUE: LED grounds (to ground-bus)	1N4001: Diode
YELLOW: Pulse signal output	GREEN: Red LED +	220uf 35v capacitor
BLACK: Ground (to ground-bus)	BROWN: Green LED +	10uf 35v capacitor
GRAY: POT-R (to LM7805 output)	NE555: Monolithic timer IC	
LT BLUE: POT-C (oscillator Vcc)	LM7805: voltage regulator	
PINK: POT-L (to ground-bus)		

COSM-II Vehicle connections

COSM-II Vehicle Connections



COSM-II is designed to have extra power available for driving multiple O2 sensors when such a need arises. The green pulse signal output wire may be split between the multiple O2 sensor wires, with care that the junction is protected from accidental shorting-to-ground.

The COSM-II is designed to add voltage to the existing O2 sensor signal, from either one O2 sensor or multiple pre-cat O2 sensors. An enhancement to the COSM-II will feature two output signal wires from the unit itself, negating the need to manually split the signal wire between multiple O2 sensor wires.

Faculty information on the COSM

What is the purpose of the oscillator and what does it do for the hydrogen intake. What is the difference between the COSM and the EFIE? If you hook a device that offsets the reading to the ECU, what does it do to the rest of the sensors? I have 2 oxygen sensors and a MAP sensor, how should the sensors be adjusted for a hydrogen booster?

[This web site](#) describes the EFIE and what it does. In practice, the EFIE and the COSM do the same thing: Add voltage to what the O2 sensor is providing, so as to "fool" the ECM/ECU into thinking the engine is running richer than it really is, causing it to reduce the amount of gasoline or diesel fuel being injected into the cylinders and force a lean condition. This is important because you want your engine to rely more on the HHO you are feeding it, without the computer fighting you by seeing more oxygen in the exhaust stream, thinking we are actually running LEANER than we really are, and pumping in even more gasoline or diesel to compensate.

The COSM was developed (and now COSM-II) to be a device that anybody could build because it does its job easily and is made in such a way that you could build it for just a few \$'s in parts. The EFIE typically runs around \$60. The COSM can be built for around \$10-20.

You only need to be concerned with the o2 sensor in the manifold. The one after the catalytic converter does not control the fuel supply on most cars. The post-cat sensors are only used to monitor effectiveness of the catalytic converter (and aren't used to maintain air/fuel mix ratios), you really only need a COSM-II on the pre-cat sensor(s). The pre-cat sensors are those near your exhaust manifold, usually visible somewhere under the hood (or bonnet) of your car.

The oscillator is what makes the COSM act like an O2 sensor by acting like an O2 sensor. If you put a meter on your O2 sensor signal wire, you'll see that the voltage constantly fluctuates from between .1 and around .45 or so (or higher if you're adding volts or you are legitimately running too rich). When you are adding voltage, you want to bear in mind that the computer expects to see the volts fluctuate. If you send too much constant (non-fluctuating) voltage for too long, your computer might assume something is wrong and kick itself into open-loop. But if you are adding voltage that oscillates just as it does from the O2 sensor itself, the computer doesn't know the difference and happily complies with the "command" it's getting to lean out the mixture. Some computers work fine with constant voltage, and some require the voltage to fluctuate in order to remain in closed-loop. **Bear in mind that the COSM-II is only for narrow-band O2 sensors.**

Wideband sensors don't oscillate. .45v is considered stoich (perfect). Low volts, like the .1v, means you're running lean and more gasoline is needed. When volts oscillate up

around .8 to 1 volt, it means you're running rich and the computer needs to reduce the amount of gasoline being pumped into the engine. EFIE and the COSM devices work by upping the volts enough that the computer sees oscillations at or above that threshold so that it thinks we're running too rich, thereby reducing fuel it pumps in. If you ground out your sensor, it will go from .1 volts to no volts and your computer will see no signal input and jump into open-loop, making your Accord run extra rich.

What you want to keep in mind is that .1v means that the mixture is too lean and to richen it whereas .8v or so means the mixture is too rich and to lean it out.

COSM or EFIE Installation

EFIE or COSM by doing the following: First, with the engine running and HHO cell OFF, power on the EFIE or COSM and start upping the voltage slowly. If you're using a meter to help with the tuning (which you really should), when you see your output volts oscillating up around .8v or so add volts from that point on VERY slowly in very small increments and then wait a few moments before adding more each time. When you hit the threshold where the ECM starts to see the "lean me out" command, the RPMS will begin to drop and the engine will start to run rough and probably sputter. At that point, then power on your HHO cell. If your cell has good output you should notice the roughness of the engine begin to subside and smooth out because your HHO gas is taking the place of the petroleum fuel that you previously leaned out of the engine.

Second, I would then do some fine-tuning by making the sure the engine is running smoothly and then VERY slowly back off on EFIE or COSM power again but again VERY slowly. Turn the pot just a tiny bit and then wait for the computer to react. When you feel the engine just start to run rough again (and the RPM's will probably begin to drop again), turn power back up just a very tiny bit until the roughness goes away. At that point, your engine is efficiently tuned to run very lean and utilizing HHO in place of the gasoline or diesel you were previously pumping in before. At this point, the engine should be tuned so well for your HHO generator that switching off your generator should cause the engine to begin running rough again in just a few moments because you'll be starving the engine for fuel again (because you're now running so lean).

The idea here is that you want to lean out the engine as much as you can so that the HHO from your generator is just enough to take the place of the gasoline or diesel fuel you were previously using. Of course, returning to normal operation with your petroleum based fuel is as simple as switching off your EFIE or COSM. Your computer will react in moments.

COSM Videos

[HHO fuel cell - COSM-IIA in-vehicle demonstration](#)

[HHO fuel cell - COSM-IIA READY!](#)

[HHO custom box installed](#)

Using a boosters which separate the hydrogen from the oxygen

A number of hydroxy boosters have surfaced which are designed to have their output to be 100% pure hydrogen (HOH) for the vehicles intake. What this will do to the engine is unknown, if you can find data on it and run time tests then please contact us and consider the first. Before you consider this option, it has been reported that Hydrogen is not as efficient as hydroxyl, so why reduce the benefit?

While gas separation does have the benefit of not interfering with the ECU it does reduce the amount of fuel economy improvement obtainable from a given watt hour of boosting power consumed. Now if you add the O₂ back to the intake airstream elsewhere, it does help restore some of that lost improvement. Systems that generate the gases separately are inherently less efficient by design



HT7 Pure Hydrogen generator

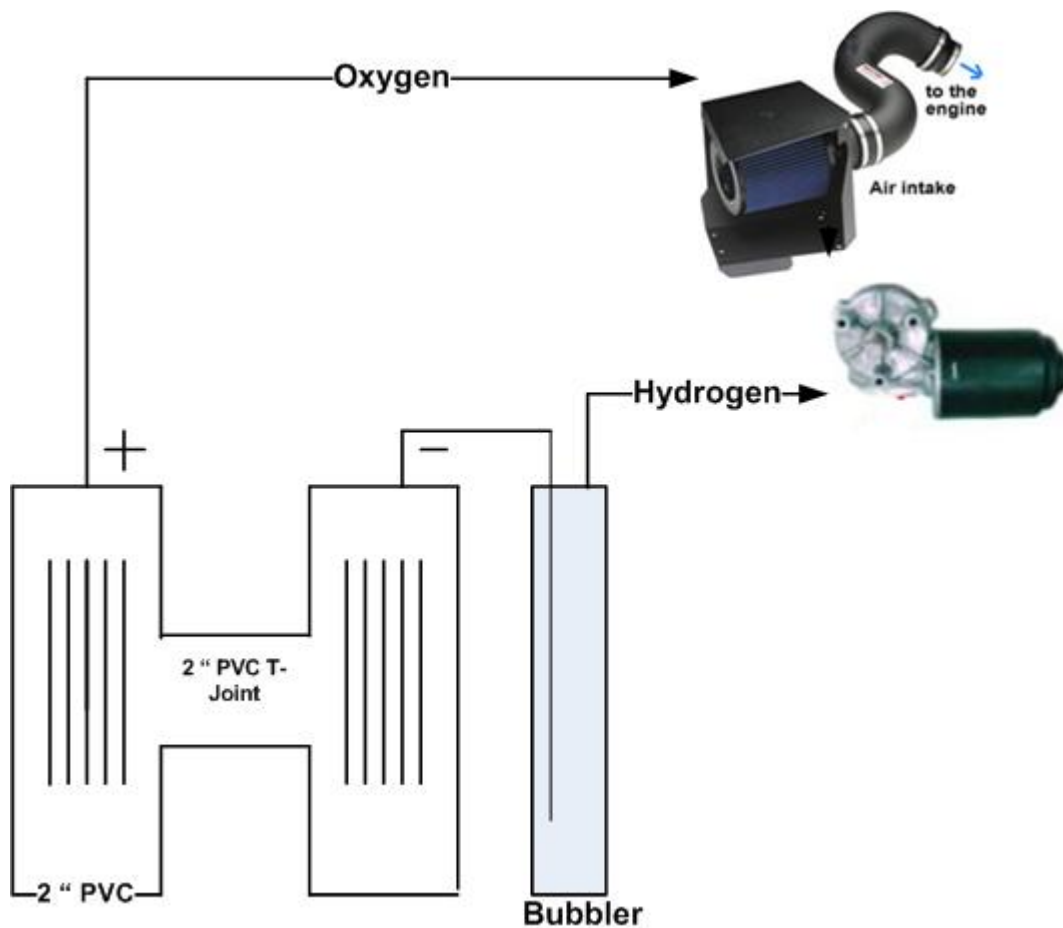
it is not known in the open source community how this process is accomplished at this time. There are commercial patented devices (listed in patents) which are designed to separate the hydrogen. Hydrogen and oxygen can be separated in another tank, either as gas or in distilled water such as a wet flame suppressor/bubbler, with strong electromagnets and permeable membranes such as [DuPont Nafion](#): Fuel cell in reverse.

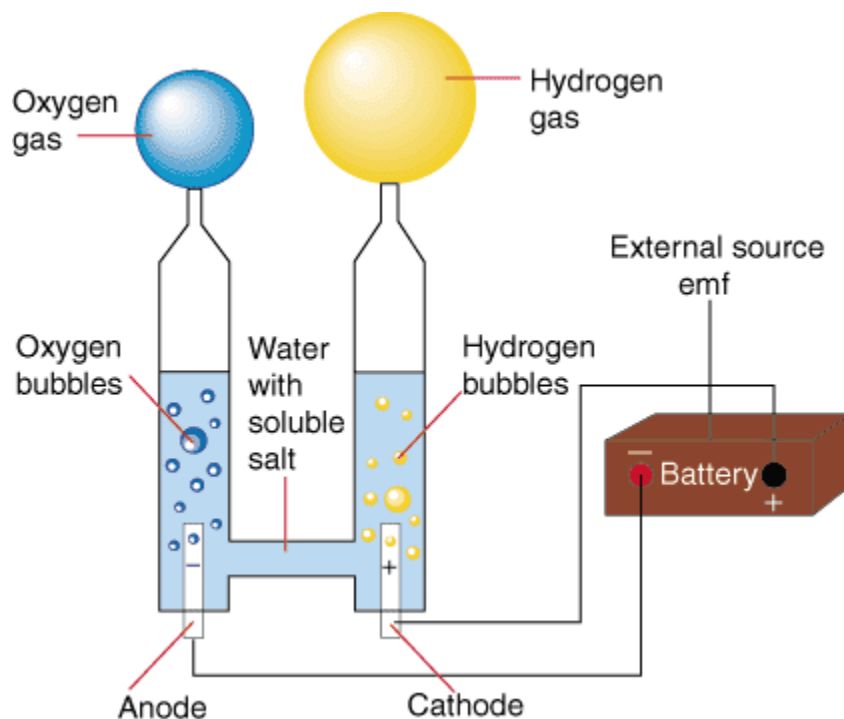
Sacrificial oxidizing metals such as aluminum, iron and zinc will also remove oxygen while allowing hydrogen to pass. Also there have been suggestions of hydrogen into the air intake and oxygen into the intake manifold. It is possible this will not make sense as one gas is added before the throttle and the other is after. Both go into the combustion cylinders. Adding oxygen into the intake manifold will reduce vacuum pressure which does rise idle due to the gas is unmetered like a vacuum leak.

[Membranes to spate hydrogen and oxygen](#)

The atmospheric air does a lot more than provide oxygen. It is a compressive / thermally expansive mass, and if enough is added – can prevent detonation damage to engine components! If you do not use atmospheric air in the combustion mix, an engine will not last very long. Straight hydroxy gas will destroy most good ICE engines in short order. Even the pressure and temperature caused by the compression stroke on a good tight engine can be enough to auto ignite pure hydroxy gas before TDC. That would put an end to an engine real quick. –Bob Boyce.

The following is an experimental design and idea found in the [Yahoo energy hydroxy group](#)





Please go to the group mentioned above for further technical discussion on this concept. The following information about separating hydrogen and oxygen from our cell output has been provided by Smack.

This is something that, unless I integrate a fuel cell, I will never do. The reason being, in the act of separating the constituents, you significantly reduce the BTU content. The reason for this is the hydrogen coming off the plates and exiting the cell has a net negative charge. Some of that hydrogen is monotomic. A larger portion of it is in the form of orthohydrogen. Orthohydrogen is unstable compared to its more stable form, parahydrogen. The reason for this is due to the charge and magnetic moment of the hydrogen molecule.

http://en.wikipedia.org/wiki/Spin_isomers_of_hydrogen

Parahydrogen is what one finds in a bottle, and contains less BTU content than orthohydrogen. Orthohydrogen tends to remain in this form until such time as it is allowed to come in contact with a conducting surface and release its charge, becoming parahydrogen. This is why we use non conducting plastics in our cells and delivery plumbing. The goal is to send the higher energy orthohydrogen into the combustion chamber before all of it has a chance to stabilize. This is a concept that Bob has explained many times and is a part of his latest video discussion at one of the FL events.

Hence I come to the reasoning of not separating the constituents. In the act of screening the gasses, the opportunity for ortho to decay to para presents itself, and as

a result the gas charge loses a significant portion of its energy content, reducing the savings effects normally seen in mileage.

Misconceptions on using alternatives to the EFIE

MAP -stands for, Manifold Absolute Pressure. MAF – stands for Mass Air Flow. One is a pressure transducer; one is an air volume transducer. They are different and do different jobs. First off the MAF stands for "Mass Air Flow". All this sensor does is measure air flow and air temp it has nothing to do with controlling the injector pulse width. It is an input sensor, and the injectors are an output device. The computer sets injector duty cycles base on a lot of input sensors, not just the MAF. Trying to adjust a pot on a MAF sensor wire will just be removed when the O2 sensors see the change. As soon as the O2 sees rich or lean, the computer will adjust the fuel to bring it back to normal. If you go too far, than yes the computer will turn on the check engine light and go into stored memory.(long term).**Forget about adjusting the MAF or MAP sensors, THEY WON'T WORK!**

Brute Force DC Hydroxy Booster Designs

NOTE- for those of you who commute for less than 2 hours a day, heating from the original Smacks booster design is not an issue. Smack has since upgraded his design more details are in his section below. For those that drive longer than two hours, a stainless steel tubular or plate cell design must be used.

As the open source free energy community consolidates more and more each day, a growing number of people are uncovering new ideas by doing R and D into improving hydroxy booster designs. **Please check back here for new additions or subscribe to our news letter for updates.** As far as the "booster" realm" is concerned, there are reports that allot of gas production is possible from the Archie Blue **type** of design, some prefer the Spiral Wassabe types of design, others swear by the tubular route. Bob Boyce's 7 plate cell is also considered an efficient design.

However none can argue that the "Smacks" booster design does not produce the most "bang for its buck", and further that it is not a perfect booster for a beginner. **For a beginner the Smacks booster is recommended.** To progress to a tubular or plate cell and others please study the faculty section below to understand plate cell booster dynamics. **Please read the FACULTY section detailing booster operation prior to construction to understand the fundamentals of boosters, this may also clear up allot of questions you have on designs.**

Tubular Cell designs

The advantages / disadvantages are as given below:

[Stainless steel resistant-Hydrogen boost explosion](#)

1. In tubular design the outer case is made of 4" SS pipe. So at the starting time it takes heat from the engine compartment and increases the efficiency of the booster. However when the water temp inside the booster is higher than it dissipates the heat to atmosphere from the 4" outer casing. With this effect the water temp inside the booster never cross beyond 60 deg centigrade.

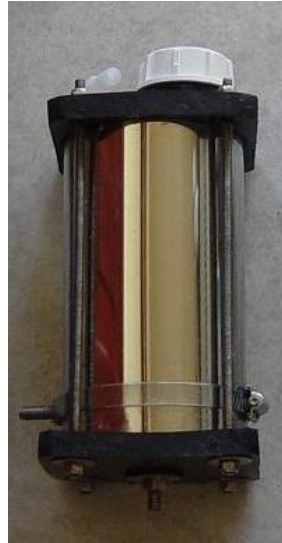
2. In a tubular design the space between each tube acts as separate compartment so there is not current leakage / energy loss.

3. You can provide a small hole at the bottom of the tube so that water gets leveled out. However with this you will be losing efficiency of the booster.

4. It is a compact design and can easily fit into the car engine compartment.

The major disadvantage of the system is unequal surface area from inner most tube to outer most tube. But the voltage drop difference is not very high from inner most cells to outer most cells and is well within 2 volts / cell in 6 cell design.

WaterFuel for All Booster



[Email](#)

[Website](#)

[Panacea coverage](#)

[Back ground Information](#)

This part of the document has been prepared by Panacea-BOCAF, a non-profit organization advocating clean energy. The information is a compilation of posts made by Wouter Oosthuizen on the forum www.waterfuelforall.com.

Wouter had received frequent mails from "Newbie's" asking advice about what would be a good and reliable booster to be used to improve fuel consumption. As a result, over the past months Wouter conducted his own (public disclosure) research in this regard. Wouter closely studied a number of commercially available boosters and evaluated their performance, strengths and weaknesses whilst trying to find a balance between optimal performance and reliability at an affordable price.

Quote- My goal is to provide the public with a reliable and efficient BUT also affordable electrolyzer. The majority of people out there, do not have the skill and/or specialized equipment to build a proper series cell with little current leakage.- Wouter End Quote



Open source engineer - Wouter Oosthuizen

Wouter wishes to give full credit of the design to Fran Giroux who has been using a similar design since 2001. While Wouter's design is similar to Fran's, it does have some subtle but important differences.

The most important difference is the usage of a stainless steel washer to connect the inner tube with the centre rod. This feature increases the total area of the centre electrode, so that the centre electrode consists of a rod and tube combined. Since the current flow in a tubular cell is limited to the surface area of the smallest electrode, this becomes crucial. By increasing the inner electrode surface area, we are decreasing the current density of the centre electrode, thereby leading to a centre electrode that will not overheat as quickly as a rod on its own.

Another subtle difference between the WaterFuelForAll (WFA) design and Fran's design includes the usage of s/steel rods to pull together and close of the cell with nylon blocks whereas Fran's design uses soft rubber seals. This change was made because it was found that the rods/nylon block combination is more robust than softer rubber seals and

the rigid nylon blocks also allow for the use of a rigid water opening and water cap for easier refill. The WFA booster also uses its own unique design for inner spacers for easy assembly and accurate spacing of the tubes. Another difference between the WFA booster is that Fran's design doesn't use equal spacing in between all the tubes, whereas the WFA booster does.

Wouter has made these boosters available already built at an affordable price in order to fiancé further open source hydroxy technology for all, please consider helping, more information can be found on the panacea coverage page.

Wouter has started with the manufacture of three models:

- 1) WaterfuelForall Standard max 25A, 20A continuous, 1.5-2.0 lpm @ 20A
- 2) WaterfuelForall Delux max 30A, 25A continuous, 1.9-2.5 lpm @ 25A
- 3) WaterfuelForall SuperDelux , rated 25A continuous, 13.8V and will be the preferred model for large trucks. Gas production will be +/-2.5lpm @ 25A

(gas production depends on whether booster is brand new or properly run in and is sustainable for 8+ hours continuously without overheating)



From left to right :

WaterfuelForAll Deluxe - Weight 4.1kg Height including cap 28cm (11") Width 11.5cm (4.5")

WaterfuelForAll Standard - Weight 3.3kg Height including cap 24cm (9.5") Width 11.5cm (4.5")

Heavy duty bubbler - Weight 0.8kg Height 27cm (10.5") Width excluding connectors 10cm (4")

Standard water trap/bubbler - Weight 0.18kg Height 20cm (8") Width excluding connectors 9cm (3.5")

Both models are a 6 series cell tubular design, with same efficiencies, and gas output just varying according to Amps. All tubes will be 316 grade (ISO certified) with wall thickness 1.5mm (0.06").

Spacing in between tubes is +-5mm (0.2") for maximum gas production. (Spacing less than 3mm inhibits the bubble flow at higher Amps) Plastics being used is Nylon, HDPE and polypropylene.

The standard model is 23cm (9") high and the Deluxe is 28cm (11") high, with both having a diameter of just over 10cm (4"). The Standard model is currently advertised at USD195, the Deluxe is USD 295 (excluding shipping). This price includes the electrolyzer, a standard water trap/bubbler and all necessary hoses.

A heavy duty bubbler is available at an additional USD30. AWG 8 cables with soldered connectors, a 30A relay, amp meter, in-line fuse and switch is available at an additional USD 50.

The tubes are already cross-hatch sanded on the outside as well as the larger ones on the inside.

All units are fully assembled and individually bench tested for a period of at least 2 hours, before leaving our workshop. So you can start using it right away, although the booster will only reach its peak gas production after about 30 hours of operation.

When receiving a brand new unit, all the seals are still settling. During fabrication one does not want to over-tighten the screws, so it is likely that some of the screws might need to be tightened a little bit more, once the unit had a chance to settle. The reason why all screws should be properly tightened (but NOT overly tight!) is because we want to make sure that all seals are 100% tight. Hydroxy has got the tendency to leak through places where nothing else will leak, and the mere fact that the booster does not leak water, is no guarantee that it does not leak hydroxy!

In fact, Wouter recommends that before you install the unit in a car, you should first run it standalone at full power e.g. +-20A and then put the complete unit in a bucket/bin of water to make sure that you do not see any small hydrogen bubbles escaping from any seal including the cap. With regard to the cap, you should also tighten it properly after a water refill, for the same reason mentioned above.

Wouter would like to emphasize that when comparing the quality and prices of various boosters, one must always compare apples with apples. The WaterfuelForAll boosters' tubes are made of 316 grade stainless steel (ISO certified) which is more expensive and more corrosive resistant than the cheaper 302/304 grades. The tubes have a 1.5mm wall thickness (0.06"), which is almost double the thickness than the electrodes of many other boosters. This also contributes to the fact that the boosters do not overheat. Note

a brand new cell with no conditioning should be able to produce at least 1.9 lpm @ 25A. **You should expect to see an improvement after 30 hours of use.**

The "small" Standard size booster keeps enough water to last for 8 hours at a time. So you have to check your water level at least every 6-8 hours of driving time. Thus, the typical commuter that drives +-1.5 hours per day, only needs to check his water level once every 5 days, e.g. while refilling with gas. The Deluxe and Super Deluxe unit keeps enough water to last 10-12 hours of driving time.

For trucks

On request, Wouter has expanded his range of boosters. Wouter has added an extra large Super DeLuxe model which will be 14.5" tall and 4.5" wide. It will be rated 25A continuous, 13.8V and will be the preferred model for large trucks. Gas production will be +-2.5lpm @ 25A. To operate this unit at 25A continuous, the unit must be installed in such a manner that it will receive a constant airflow while driving, as to assist with the cooling. The Super Deluxe booster will be priced at USD 395. (this price does not include the wiring and bubbler) Thus for less than \$1200, you can buy 3 Super Deluxe units and have a system that produces 7.5lpm @ 75A continuously without overheating!

Distributors wanted!

In order for Wouter to help finance the advancement of OPEN SOURCE hydroxy technology plus provide the public service of dissemination of these boosters at low cost, Wouter states: Dear Waterfuel Enthusiast - The past few days I have been approached by several people who wants to become a WaterfuelForAll booster agent so please forgive me for writing a general letter!



As you all know by this time, we have only very recently launched the WaterfuelForAll (WFA) booster. Whereas the design is the result of many months of research, the proof is in the real-time hydroxy gas production (with resulting fuel saving and emission benefits) and users quickly realized that the WFA booster is running circles around the competition.

I mention only the most important reasons:

- 1) The WFA booster does not overheat within 2 hours as many other commercially available boosters. (Thus makes it ideal for heavy duty use e.g. long distance trucks)
- 2) Having an outer casing made of 1.5mm (+-0.06") thick stainless steel, it is much stronger than most other booster designs and can even withstand a flashback without a bubbler, even though a bubbler could still be added for additional reassurance
- 3) With a maximum gas production of up to 1 liters per minute for every 10A @ 13.8V consumed, the design is extremely efficient and found a delicate balance between efficiency, robustness, reliability for implementation in an automobile
- 4) The booster is made of the more expensive 316 grade stainless steel electrodes with wall thickness of 1.5mm. Thus the electrodes are more corrosive resistant than the cheaper and less corrosive resistant 302/304 grade used by many other boosters.

Also the wall thickness of 1.5mm (+-0.06") is much thicker than the plate thickness of most other boosters, which is part of the reason why the booster does not overheat. In short, the WFA booster is built to last a lifetime.....
- 5) Despite the quality materials used, it is still priced competitively
- 6) It is a very compact design and even "looks" nicer than other boosters!

From the above it is clear the design has got the potential to become the standard for boosters and thus it comes as no surprise that people want to become agents! Also, it is our duty to ensure that this technology gets through to the man in the street as soon as possible.

Thus, over the last few days I sat down and evaluated different possibilities to offer potential agents. The first possibility would be for an agent to import the boosters in quantity at a reduced price and may then sell it at a price determined by them self. Yet this option would only be viable for agents that have got the facilities to service larger fleets of vehicles and it would also require a substantial cash flow upfront to pay for the boosters.

Most individuals might not be in the position to do this and thus I had to come up with another option.

I propose the following: Smaller agents can simply act as a marketer to generate new orders. These orders could either be placed on a web-site run by the agent himself or on our own web-site www.waterfuelforall.com

The order will be passed on to us with a reference as to identify the agent responsible for the order and we will execute the order by sending the unit directly to the customer.

For his effort, the agent will receive a 10% commission for each unit sold as a direct result of his marketing/referral efforts.

Thus, no upfront cash is needed although it would be expected from an agent to buy and install at least 1 unit for himself as to make sure that the agent fully understand what the WFA booster is all about.

We know that there are other schemes offering larger commissions, but it is clear that those units are made of inferior materials and are sold with a much larger markup for a start.

(If we were selling our product at twice the price, then we could also offer larger commissions to our agents) In this regard it must be remembered that our objective is not to have money making scheme, but rather to provide the public with a product that will last for years yet at an affordable price. In the long run people will realize that a booster like the WFA is money much better spend.....Well that's it!Should you be interested in becoming an agent just let me know!

Construction



NEVER touch these tubes with bare hands and ONLY use NaOH or KOH!

There have been various opinions about tubular cells on the internet. In many of these comments a lot of emphasis is placed on the fact that the voltage differential between tubular cells varies compared to square plate cells which have a constant voltage differential between plates. A common argument is that the uneven surface area from anode to cathode increases loss due to uneven current distribution. So the question is: How severe is this effect and what is the net effect on our overall efficiency?

In this regard we do not want to get involved in a debate with anyone. What we do want to do is provide none biased thinking and considerations. A majority of the people who criticizes the tubular cell design has never built one themselves and compared the real time performance with a square plate series cell. So let's not speculate in theory

and on paper, let's just look at the real time performance. By no means are we stating that this is a superior design over the plate cell, we are merely providing real data.

Facts: Bench Tests by Wouter have shown that the Waterfuelforall 6 series tubular cell generates 2lpm @ 20A, 13.8VDC without overheating. If the voltage differentials between cells were that much of an issue as is being portrayed by some, then how is it possible for the tubular cell to achieve such good efficiency figures without overheating!? Note that the following figures are achieved with constant spacing between the tubes:

$$2\text{lpm} \times 60 = 120\text{lph}$$

$$13.8\text{V} \times 20\text{A} = 276\text{Watt}$$

$$276/120 = 2.3 \text{ W/lph}$$

According to Faraday predictions, it should require 2.36 W/LPH of hydroxy gas production, when gas volume is measured at STP. At room temperature this figure changes to 2.16W/LPH. So the tubular 6 series cell performance converts to 93.9% Faraday efficiency. It is not claimed that the voltage differentials have no effect. What is being emphasized is that one can see by these results that the effect clearly has a minor impact on the overall performance of the tubular design.

In this regard one must remember that the voltage is the driving force behind the current. While the inner tubes does have a smaller total area, one does need a little bit more voltage to push through the same amount of current as with larger tubes, and this is exactly the case in a tubular cell, where the voltage differential between the inner tubes is slightly higher than between the outer tubes.

What people do not realize, is that if one was really that concerned about the voltage differential between the tubes, then you could simply have a larger space between the outer tubes and a smaller space between the inner tubes, and then the voltage differentials will be closer to equal everywhere.

E.g. instead of having equal spacing cells 1",1.5",2",2.5",3",3.5",4", you could have 1", 1.25", 1.5", 2", 2.5", 3", 4". Wouter has done a LOT of real-time testing in this regard and feels that it is unnecessary to complicate things. But this is merely to show that one could easily address the concern if it was really necessary. In this regard t as long as one makes sure that the surface area of the smallest tube is large enough, you will have NO problems!

An example:As a rule of thumb I aim for max 0.15A per square centimeter, because Wouter uses proper 316 grade tubes. (If you are using a stainless steel of a lesser quality I would not recommend going higher than 0.1A per square centimeter) So the length of the tubes will be determined by the maximum amount of amps that you want to run

your cell at. Obviously the inner tube will have the least area and thus you will be basing your calculations on the inner tube's area, e.g. if you plan to run your cell at max 25 A and we only want max 0.15A/cm², that imply we need a minimum electrode plate area of 167 cm² for each tube.

The area of the inner tube is calculated as $\pi \times \text{Diameter} \times \text{height}$. So for a 1" inner tube the required Height = $167 / (3.14 \times 2.5) = 21.3$ cm This will be the length of all the inner tubes and obviously the outer tube will be slightly longer.

Note that if we were trying to achieve resonance, then uneven voltage differentials between cells will have a greater effect and in such instance, Wouter does recommend people to go for a square plate series cell design. But since we are merely performing brute force electrolysis, it is not so much of an issue and we can take advantage of the benefits offered by a tubular design.

One of the biggest advantages of the tubular design compared to the sandwiched series cell design is the fact that the sandwiched series cell can be prone to leaking of water and hydrogen.

Wouter reports that after the 6 series cell design has been conditioned, the gas production has increased to +3 liters per minute @ 30 amps. The 6 series tubular design stabilizes at +-1 liter per minute gas for every 10 amps consumed, once the cell has been run in properly.

For a concentration of 6 teaspoons (30ml) of lye to 1 liter of water (distilled recommended), the typical temperatures and amp flow for the 6 series cell is:

Amp flow	Temperature	Gas production
Start	5A Cold	0.5 lpm
10 min	7.5A	0.75lpm
1/2 hour	10A	1.0 lpm
1 hour	12A 40 deg C	1.2 lpm
1 1/2 hour	15A 50 deg C	1.5 lpm
2 hours	16A 58 deg C	1.6 lpm
3 hours	17A 65 deg C	1.7 lpm
4 hours	18A 73 deg C	1.8 lpm
5 hours	18A 74 deg C	1.8 lpm

6 hours	18A	75 deg C	1.8 lpm
7 hours	18A	74 deg C	1.8 lpm
8 hours	18A	73 deg C	1.8 lpm

One can see that after 4 hours of continuous operation, the temperature stabilizes at +- 74 degrees Celsius which is ideal! Should the electrolyzer be used as a booster, then airflow will have a cooling effect on the cell and the booster should stabilize at a lower temperature.

The above figures is for a unit built from 7 tubes with diameters 4" / 3.5" / 3" / 2.5" / 2" / 1.5" / 1" and at least 20cm in length, measured with a water temperature not exceeding 75 degrees Celsius. Since gas production is directly related to the amount of amps, it follows that the formula for the expected gas production (once the cell has been run in) = 1 lpm for every 10A, 13.8V = 1 lpm hydroxy gas for every 138Watt.

Design considerations

This is a straight forward series cell design that uses tubes instead of plates. Since we are performing normal electrolysis (no resonance or anything fancy) Wouter's own testing indicated that tubes cells and plates gave pretty much the same amount of gas as plate cells, if used in a series cell configuration.

The Tubes design is chosen for practicality, efficiency (i.e. maximum gas production at lowest power consumption) and reliability (i.e. not overheating too soon). As a bonus, the shape nicely fits into any engine bay and is also a rather leak free design. An important advantage of the "WaterfuelForAll" tubular design (when compared to other series cell designs) is the fact that the electrolyzer can easily be disassembled should you at any later stage want to do maintenance. **It is not recommend a unit that is completely sealed and cannot be opened easily.**

The performance tubular 6 series cell is good enough to be used as a booster for someone that only commutes between 1-4 hours per day but cannot be used for an indefinite period.

When comparing operating temperatures it is also important to note the starting temperature and current after only a few minutes, because when evaluating operating temperature one must use relatively equal electrolyte solutions and one cannot compare a unit which starts of at 16A with a unit with much lower electrolyte concentration starting of at 8A for instance. Obviously the unit starting at 16A will pick up temperature faster and one must compare apples with apples!

So, if you want to run the tubular 6/7 series cell at a lower electrolyte concentration, you could start of with say 8A (instead of 16A) and then you could find that your booster is still well below 60 degrees Celsius after 4 hours.

Remember that the overall efficiency and speed at which your own cell will warm up will be a function of how precise you have built it and how much current leakage there is. If your tubes are not aligned properly or if you have lots of current leakage, do not expect a high performing cell and also don't be surprised if your cell overheats quickly.

The following is a discussion about the need for small water leveling holes. This implies that one is concerned that when filling up all the cells, it is not done evenly. In this regard, look at the following.



You will notice that at the top there is a flat polyprop disc with holes in it. Wouter's experience thus far showed that when he filled up with water, he did not even have to move his hand across all cells because this flat disc channels the water rather evenly to all the different cells. But adding some water leveling holes should not do too much harm as long as they are not aligned as to minimize current leakage.

However, in this regard you will have to do your own testing to see what works best for you. You will have to measure gas output as well as water temperature over time to find the best overall solution. The only electrical connection is to the inner most and outer most tubes. The outer tube is connected to negative and the centre tube is connected to positive. There are no connections between the tubes and they are isolated/seperated from each other with HDPE/polypropolene spacers.

The tubes have got polyprop spacers both at the bottom and at the top. At the bottom there is also a polyprop disc (with no holes in it as the top one) as to seal of the tubes from each other to prevent leakage of current and thereby delaying the rate at which the cell picks up heat. For ease of construction Wouter used a stainless steel clamp

around the outer tube to connect to the cathode. Alternatively, one could spot weld in a connection. The white discs and spacers inside is made of polypropylene which can withstand temperatures of up to 110 degrees Celsius.

To summarize, the unit is a 6 cell unit using 7 tubes (diameters 4" / 3.5" / 3" / 2.5" / 2" / 1.5" / 1") The outer tube is connected to negative and the centre tube is connected to positive. The centre 1" tube is connected to a 8mm (5/16") stainless steel threaded rod with a 1 inch s/steel washer so that the rod provide an easy and secure outside connection to positive.

The outer tube will be slightly longer than the inner tubes which are all the same length. The tricky part is to get the tubes to align properly and in Wouter's prototype he used polypropylene spacers cut to an accuracy of 0.1mm. This could be expensive if done in small quantities and for someone that is merely experimenting they might try to use some clear plastic tubing and simply insert it in between the tubes (or bent some pieces around the tube edges).

It will not look very professional, but if you are the only person that is going to see the inside of your booster it should do the trick and will be the cheapest! (However, if you go this route you must make VERY sure that the tubes are rock solid and won't move because you do not want to end up with tubes touching each other creating a spark!!)

Note -In a car it is recommended not to run it at more than 20A and at 20A (13.8V) the tubular cell generates 2lpm which is more than enough. With regard to the measurements, it is very easy.

If you have purchased a booster from Wouter and want to get exact specifications you can physically measure all outside measurements and simply deduct 3-4cm from the length of the outer tube to get to the length of the inner tubes.

Wouter states say 3-4cm because this length will be determined by how thick the plastic spacers are and how much space they will be taking up. (If the spacers are thin, then 3cm should be enough, but if the spacers are thick, then a 4cm longer outer tube would be appropriate) Inner rod is this length plus how far you want it to protrude at the bottom. For the Standard model Wouter is using 15cm long inner tubes and a 19cm long outer tube and for the Deluxe model He is using 20cm long inner tubes and the outer tube is 24cm in length.

If it is leaking a lot, then I would recommend that you open up the unit by simply unscrewing the 4 bolts at the top and then apply some epoxy glue around the perimeter of the white thread on the inside (bottom) of the black flat plastic square.

If your cell is leaking only very small bubbles rather slowly, then I would not worry too much, because you will probably lose about 10ml of gas in 1 minute which is nothing! If

you suspect gas leakage around the elbow, just remove the gas hose, clean the elbow nipple, smear some silicon (not too much) around the elbow nipple and refit gas hose with secure clamp! The original nylon elbow fitting specified is made of HDPE and may be a little too soft. Wouter has since replaced them so look for new Nylon ones which are harder and while the black plastic square is also Nylon will also glue better, thus less likely to leak.

With regard to the top spacer for the groove alternative refer. To ensure an extra good connection between the center rod and 1" inner tube, one can drill a 1" hole in the middle of the top spacer. Then place a stainless steel 1" dia. washer also on top of the 1" dia tube and fasten with a s/steel nut. To do this, the top spacer must be thick enough to accommodate the height of the nut. On top of the plastic spacer then comes another stainless steel washer with a diameter greater than 1" and finally a lock nut to keep everything together.

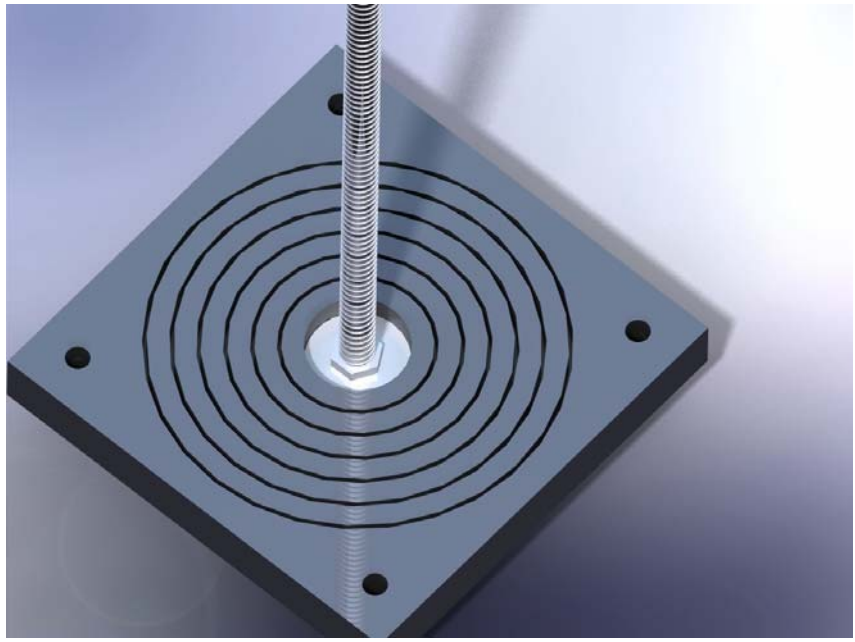
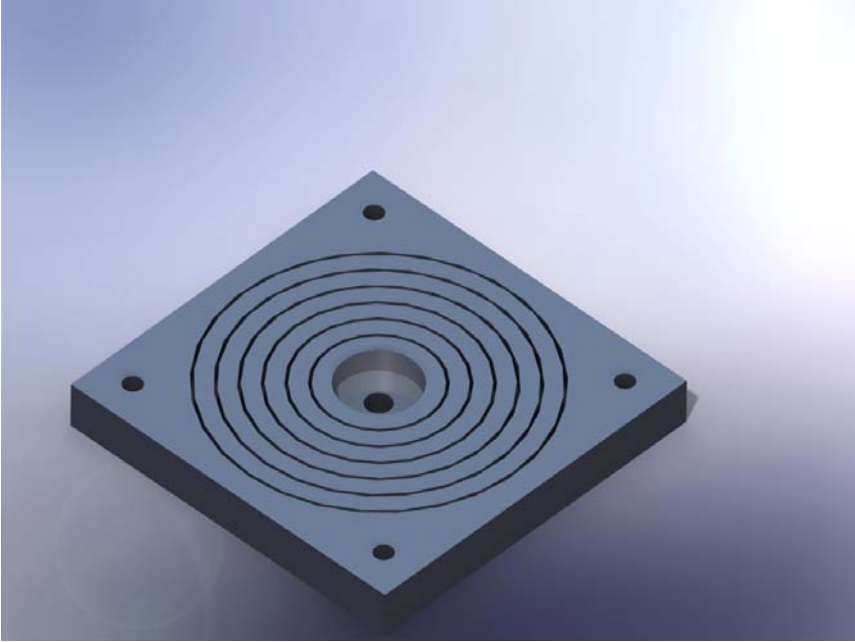
Additional water level indicator

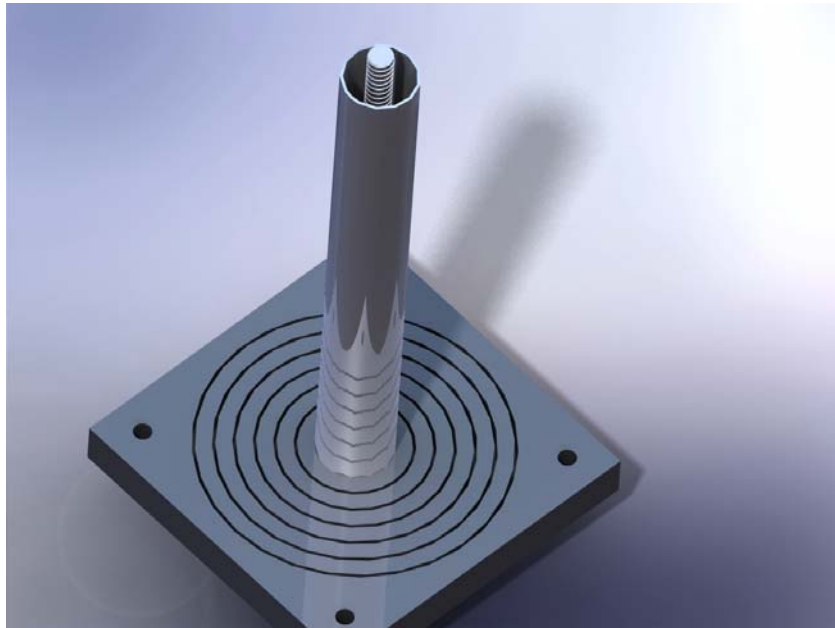
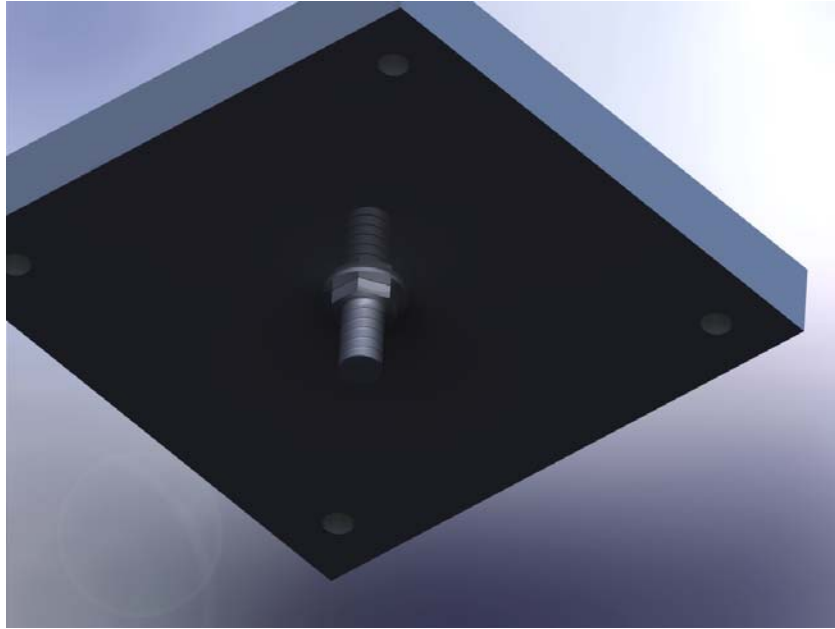
Just a few notes on a water level indicator: If the water indicator is connected to the bottom of the cell, then that will lead to current leakage and reduced efficiency. This means drilling a hole in the outer stainless steel tube and fitting/welding a small pipe/tube connection on the side of the cell.

Solid works and CAD drawings courtesy of Alex

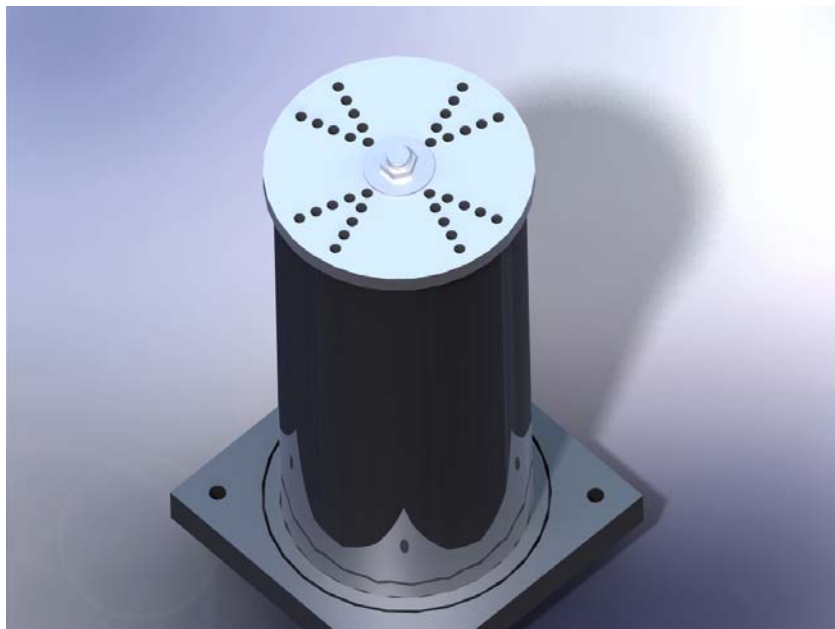
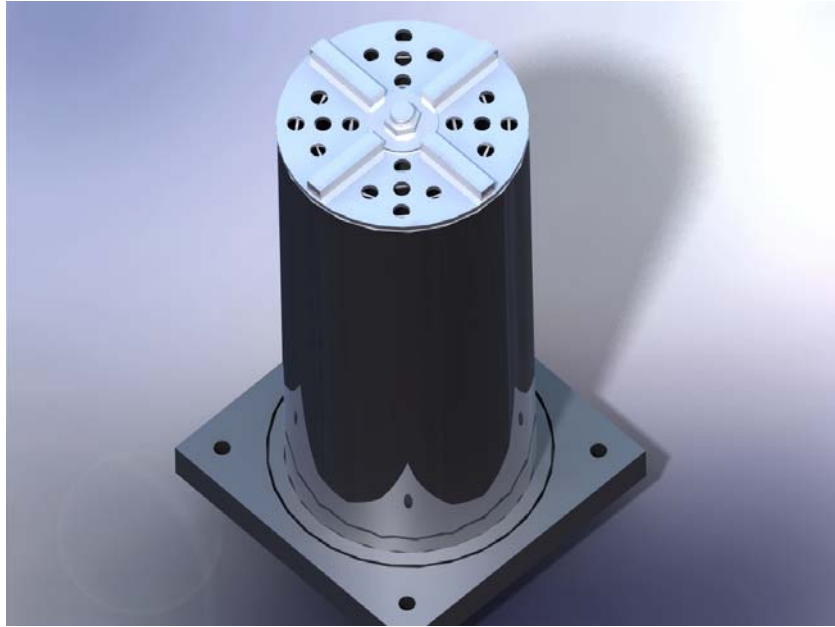
A special thanks and credit must go to Alex (Paradox user name on the energetic forum) for his precise and quality work on these drawings. These drawings are exceptional and he has done an extraordinary job in the detail. Wouter and Panacea would like to sincerely thank Alex for his work on these drawings you have him to thank for these!

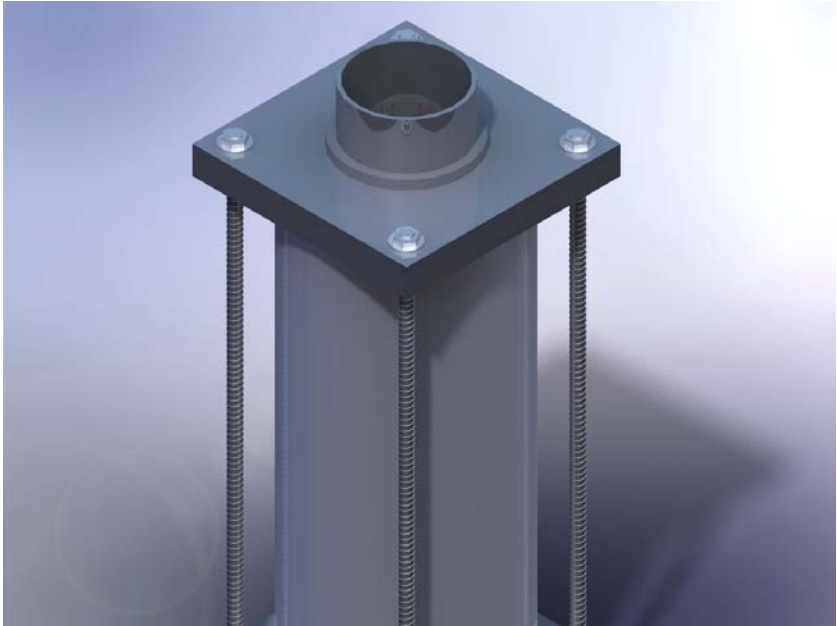
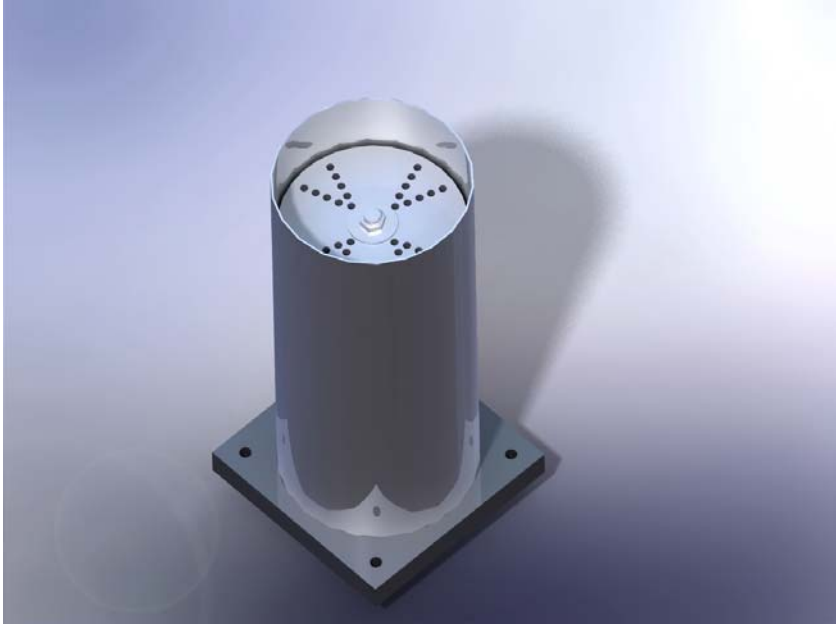
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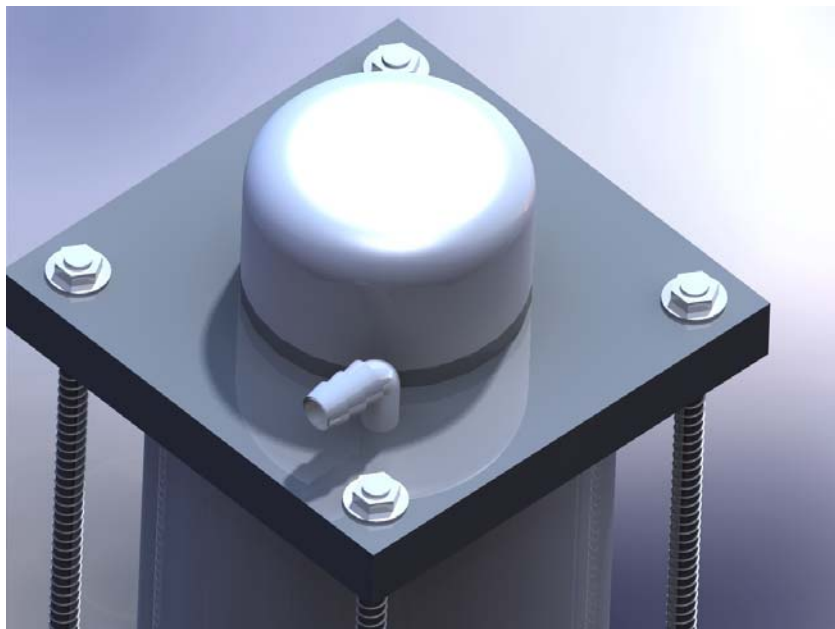
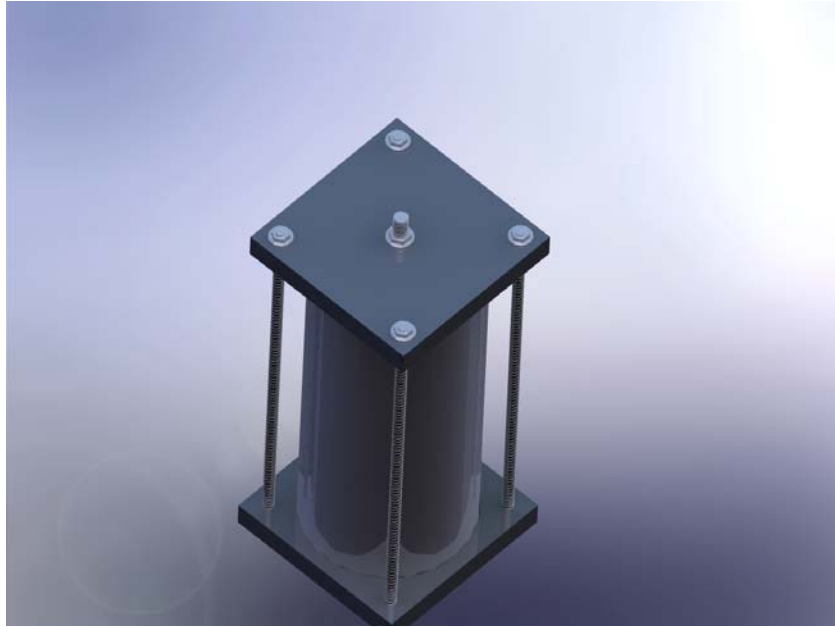


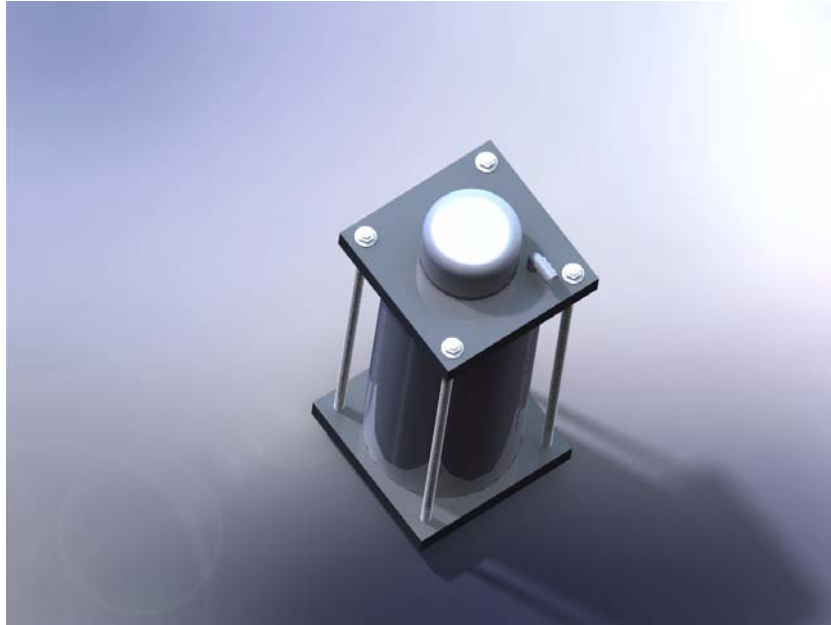












Lye Concentrations

For electrolyte, Wouter used NaOH (Lye) and for a 6 series cell you should not need more than 1 tablespoon for every liter of water. Wouter recommends add enough NaOH to start with a current draw of 10A (but no more) when the booster is cold. As the booster heats up the current draw will also increase.

The recommended amount of electrolyte to be used together with the typical resulting current flow is as follows. With regard to the amount of lye used, it must be noted that one cannot simply give a rule that is generally applicable, since the amount of lye used is a function of:

- 1) the number of cells (e.g. 6 or 7)
- 2) the size of the electrode surface area
- 3) the required starting/ending temperature required after a certain amount of time has elapsed

Below describes figures to use as a guide when operating a WaterfuelForAll 6 series tubular cell, where the inner tubes are +-20cm in length, with the smallest tube 1" and largest tube 4" in diameter (holding +- 1 liter of water without overflowing the upper rim of the inner tubes), and we do not want the amp flow to exceed 16A within the first 2 hours:

Add 1/8 cup (+-6 teaspoons or 30ml) of lye to 1 liter of water (distilled recommended)
Below is the typical temperatures and amp flow for the above concentration for the 6 series cell:

	Amp flow	Temperature	Gas production
Start	5A	Cold	0.5 lpm
10 min	7.5A		0.75lpm
1/2 hour	10A		1.0 lpm
1 hour	12A	40 deg C	1.2 lpm
1 1/2 hour	15A	50 deg C	1.5 lpm
2 hours	16A	58 deg C	1.6 lpm
3 hours	17A	65 deg C	1.7 lpm
4 hours	18A	73 deg C	1.8 lpm
5 hours	18A	74 deg C	1.8 lpm
6 hours	18A	75 deg C	1.8 lpm
7 hours	18A	74 deg C	1.8 lpm
8 hours	18A	73 deg C	1.8 lpm

One can see that after 4 hours of continuous operation, the temperature stabilizes at +- 74 degrees Celsius which is ideal! Note that the above temperatures were measured during bench-testing with an outside temperature of +-21 deg C. If the booster is installed in a car with sufficient air flow, this will have a cooling effect which could see that the booster stabilizes at a lower maximum temperature.

Once the booster has reached an operating temperature of between 60-75deg C, it consumes +-75ml water for every 1 hour of operation, so filling up with 1 liter, should last +- 13 hours of driving time. These figures are estimated to be ideal for the average car with engine capacity ranging between 1000-3000cc. 15A does not place too much of a burden on the alternator of the car, allowing maximum mileage gains.

Electrode spacing is another factor that influences the amount of electrolyte needed to allow a certain amount of amps. Note that in a series cell, spacing less than 3mm inhibits the bubble flow and resulting gas production at higher amps, because the electrolyte starts foaming and crawling up the tubes thereby reducing efficiency.

Also note that the amount of gas is NOT related to the amount of water left in the container (except when no water is left and no current is flowing!).

The amount of hydroxy gas produced is determined by the AMPS (e.g. 1lpm@10A, 2lpm@20A), so you could have peak gas production right until the last moment before your cell runs completely dry, where peak gas production would be determined by the amps at that time. Whether you have 100ml of water left or 900ml of water left makes does not determine the amount of gas although the temperature of the water determines the resistance of the electrolyte and thus also influences the amps that are flowing.

So with less water in the unit, the temperature is likely to be higher resulting in more amps flowing than with more water! For example, let's say you have only 100ml of water left in your booster with a given amount of lye, and let's say the water temperature is 70 degrees Celsius. For these parameters you might have 20A current flow resulting in 2liters per minute gas production.

Should we now add 900ml of ice cold water to reduce the water temperature to 40 degrees Celsius, you might find that your amps suddenly drop to 15A and thus only 1.5 liters per minute gas production. So in this case adding the water actually reduced the amount of gas produced. This is an extreme example but I use it to illustrate to you that the amount of water left is not the issue, rather the concentration of lye in the water (making the water more conductive) and the temperature of the water itself.

Faraday calculation

To exceed 100% Faraday efficiency you must go for a 7 series cell if you are using 13.8V. Most important reason was how long the 7 series cell takes to warm up to a temperature high enough to get decent gas production. When driving in a car we do not have the luxury of having the cell sitting on a bench and can wait for hours to reach decent gas production. User wants to have good gas production already after the first 10 minutes of driving!!

Another drawback of the 7 series cell is that it needs much more (+6 times more) electrolyte to pass the same current and as we know by now, the electrolyte is indeed being slowly consumed by the reaction. So the 7 series cell is much more sensitive to this and will have to be topped up with electrolyte much more frequently.

However, a 7 series cell would be ideal for powering a generator 24 hours a day, sitting at home. It is important to note that using the Faraday figure when gas volume is measured at STP, but most experimenters measure the gas at room temperature.

According to Faraday, it should require 2.36 W/lph of hydroxy gas production, when gas volume is measured at STP. (This is the figure Bob is using) BUT, at room temperature this figure changes to 2.16W/lph. So at room temperature the tubular 6 series cell performance of 2.3W/lph converts to 93.9% Faraday efficiency.

7 Series Cell design

A 7-series tubular cell will need up to 6-7 TIMES MORE NaOH than a 6 series cell booster. **This is not practical as the increased NaOH electrolyte concentrations are not user friendly.**

For a 6 series cell, one will typically see that 6 teaspoons of lye achieves a current flow of 5A at start-up, 12A after 1 hour and 16A after 2 hours. Wouter performed the exact

same test on a 7 series tubular cell of similar size and after adding 7/8 of a cup of lye (that is 42 teaspoons!) the amp flow was only 4A at startup.

More frustrating is the slow warm up period of the 7 series cell and after an hour the amp flow was only 5A and even after 2 hours, the amp flow was still only 6A! We need a decent amount of amps to generate a decent amount of gas, and after 2 hours the 6 series cell was generating 1.6 lpm compared to the 0.72lpm of the 7 series cell. So you can understand why Wouter say the 7 series cell is impractical for a car, apart **from the fact that a concentration of almost a cup of lye on 1 liter of water is certainly not very user friendly.**

The WouterFuelForAll booster is anyway so easy to take apart, that if you feel very strong about using 7 tubes (or maybe just want to experiment yourself), you could easily open up the booster and add an 8th tube to form 7 cells. Depending on the model, you might have to drill an additional circular groove. Then simply buy a tube with diameter 1.25" and of the same length than the inner tubes, and insert this tube in between the 1" and 1.5" tube! No other changes needed. Note - The number of active cells depends on power supply voltage. For a battery and a brute force operation, an 8 tube 7 cell works well with 13.2-13.6 volt battery supply, but more electrolyte is required thus more heat.

Series connections for higher LPM

It is suggested to use a 6 or 7 cell version. If you build our tubular design using 8 tubes, 1", 1.5", 2", 2.5",3",3.5",4",5" then you have a nice LARGE 7 series cell booster which should produce 3lpm @ 30A.

Alternatively you can use 7 tubes 1.5", 2", 2.5",3",3.5",4",5" and then you have a LARGE 6 series cell which should produce at least 2.2lpm @ 30A and will use less NaOH than the 7 series cell. Two tubular boosters should give you a good kind of gas production and you only have to unscrew two caps and refill two when refilling with water.

The length of the tubes will be determined by the maximum amount of amps that you want to run your cell at. Obviously the inner tube will have the least area and thus you will be basing your calculations on the inner tube's area, e.g. if you plan to run your call at max 25 A and we only want max 0.15A/cm² that imply we need a minimum electrode plate area of 167 cm² for each tube. The area of the inner tube is calculated as $\pi \cdot \text{Diameter} \cdot \text{height}$. So required Height = $167 / (3.14 \times 2.5) = 21.3$ cm This will be the length of all the inner tubes and obviously the outer tube will be slightly longer. The fluid level can be any level as long as the water does not overflow from one cell to another to allow current leakage.

You decide the lye concentration yourself upfront. Start with smaller amounts and if after an hour of operation the booster is still not at the desired amps, then add a little bit

of NaOH. In Wouters own testing the 7 series cell needed 6-7 times more NaOH than the 6 series cell, to allow the same amount of current to flow.

So for example: If you add two tablespoons of NaOH to 1 liter of water on a 6 series cell, depending on the size of the tubes, the booster might eventually stabilize at 10A after warm up. However, you have to use 12 tablespoons of NaOH just to get the same amount of current flowing when using the 7 series cell of the same size, indeed a very caustic solution and definitely not user friendly. Alternatively, to get the same gas production with a 7 cell unit, one would have to increase the electrode surface area a lot and therefore have to build a much larger unit. As we all know, space is a premium in an engine compartment not to mention the price of stainless steel.

Recommendations for New Cells

Here are some tips and recommendations for the new cells, based on some of our bench tests.

Before we get started, make VERY sure you do not have gas leaks!!!! Hold the whole booster and gas hose connections under water (while operating) to make sure. You need to also make sure you measure the voltage at a constant 13.8V.

Starting off with a new cell, start with a 1 liter of distilled water containing 4-5 teaspoons of sodium or potassium hydroxide, make sure they are not heaped too much. Make sure the electrolyte does not overflow the edges of the inner tubes. The idea is to get a cold booster starting off at 10 amps and stabilizing at 20A. If you're new booster does not do this with the recommended concentration of electrolyte, pour it into a suitable container and save it, mix up less so the current can stabilize.

It is always better to start off with less than more electrolyte concentration, you can always add more easily out of your pre mixed 1 liter container of water. If you went over 20 amps initially, say 25 don't worry Let it run a few hours and then let it stand overnight filled with electrolyte. The next day do the same test and after about 3-4 hours you should already see some increase in gas production.

Understand that since it is a new cell, the plates won't be fully conditioned. Before they can perform to capacity after a couple of runs they need to be prepared or conditioned properly. if done right, then you should see an increase in gas production after a few runs which may continue the conditioning process. It has been reported that they build up some catalytic layer, but this is a topic for another document.

Anyway, Wouter built a few tubular boosters and ran them for a few hours initially, no more than 8 hours. These were boosters that he tested at up to 30A and after 8 hours they would still only give the baseline 2.2-2.3 lpm @ 30A (which is same as 1.8-1.9lpm @ 25A). Wouter then put these boosters away in one of his store rooms. He left them filled

with a solution of electrolyte. One month later he retrieved these boosters and without changing anything, literally tested them as is, all of them then produced the desired 1lpm @ 10A!!!

So after he did some tests with this cell configuration he found that the conditioning / preparation of the stainless steel also have to do with TIME and not only number of hours it was operated.

So at the start of your new cell your production should be in line with a brand new cell: 13.8V @ 25A continuous, 1.9-2.5 lpm the production is expected to be at the bottom end of the range. It is recommended that the cell is run at least 30 hours before there is an expected increase in production. Whether it is some kind of aging / chemical change that gradually takes place within the stainless steel electrodes, regardless one should simply be patient as sometimes it is the TIME that does the trick. Still for 1.9LPM,, depending on your engine , most are still going to get a good boost right away.

Note please also refer to section 17 in the FAQ below for new cells.

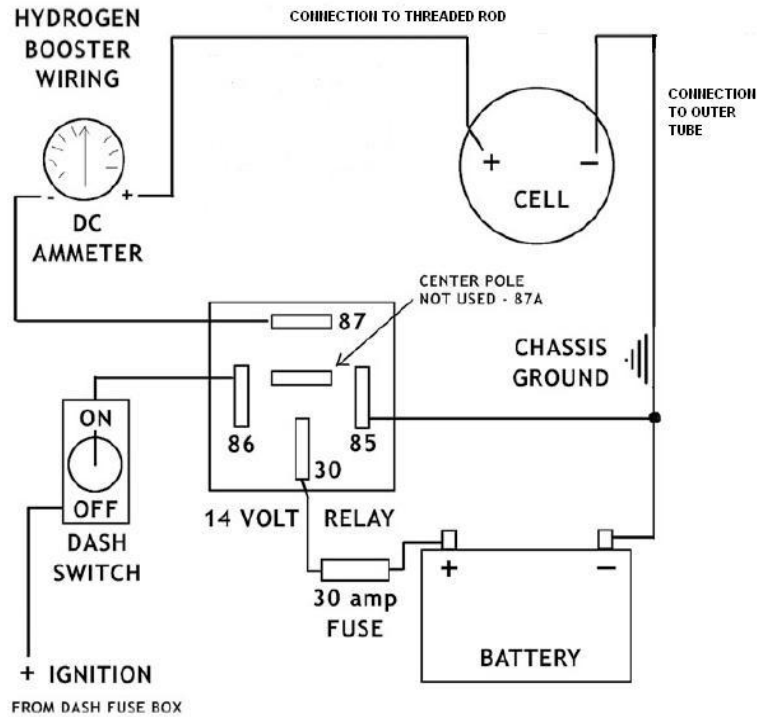
Note that one should not be fixated on getting exactly 2lpm @20A in the standard model design. If you get anything above 1.8lpm @ 20A, one should be happy and just start using it!! Also, when testing on the test vehicle, I suggest that one does two different tests:

- 1) Amps only varies between 5-12A max
- 2) Amps only varies between 10-20A max

We might find that one of the setups produce much better savings and it is not necessary going to be with the most hydroxy gas.

Car installation

Wouter recommends connecting the hose coming from the water trap to the air intake before the air breather, so that the gases introduced into the intake are first filtered by the air filter. We are not interested in a vacuum because the manifold has greatest vacuum at the wrong time, and no vacuum at the worse time. Also, we want the hydroxy gas filtered of any mist, which may carry traces of electrolyte. As an additional benefit, the air filter serves as a first line of defense protecting against a back flash coming from the engine.



On the Relay Wiring, the trigger input says "Ignition On" Make sure it is tapped into a component that only cuts on with the "Ignition On and Not Accessory" like the Fuel Pump fuse.

Water Fuel for All FAQ

1. How can the WaterfuelForAll booster improve my mileage? Will I still get the same power I have come to expect from my vehicle?

Adding a hydrogen-oxygen mix (also called hydroxy) to the fuel system of an internal combustion engine, increases the combustion of the gasoline (or diesel). This can be compared to putting a super high grade of gasoline in your engine. You get better overall performance, increased horsepower and gas mileage. The booster uses electrical power from the engine that is ultimately created by the fossil fuel, but the gain in efficiency of the engine exceeds the energy loss from generating the hydroxy mix.

The increase in horsepower and gas mileage comes from better combustion of the gasoline. Usually, only about 15% of the available energy in gasoline is converted to mechanical energy in an internal combustion engine. The addition of hydroxy results in better combustion which means more of the available energy in the gasoline is converted to mechanical energy and that has nothing to do with creating energy or violating any laws of thermodynamics.

2. Is the WaterfuelForAll booster a "true series cell"?

The 6 series cell tubular design is a "true series cell", since the cells are completely separated/isolated from each other so that water cannot flow from one cell to an adjacent cell. In this regard readers might be interested to know who really is the father of the- "true series cell". The credit must go to William Rhodes, see US Patent no. 3,310,483, (1967) who built the first series cell electrolyzer.

3. Which booster is the best?

There is no such thing as a booster that will always be the best under all circumstances. However, the two most important factors when comparing boosters are their efficiency, in other words, how much gas generated for a certain amount of power consumed, and also whether they overheat or not.

Some boosters, claim impressive amounts of liters per minute gas production, but they do not tell us at how many amps were used and at what water temperature the measurement was taken. Knowing how many amps is needed is important because it tells us both how efficient the cell is as well as whether the design is likely to have overheating problems.

The less efficient a cell is, the more there is current leakage and as a result the more generation of waste heat. (So for instance generating 3 lpm @ 35A is less energy efficient than generating 2 lpm @ 20A, and one should not just look at the lpm!). Knowing at what water temperature the reading was taken will tell us if the gas was a high quality gas or maybe contained a lot of water vapour.

As a rule of thumb, a series cell design is the most efficient design for straight forward brute force electrolysis. An open bath design will never be able to be as efficient as a series cell design such as the 6 series cell WaterfuelForAll design. (In a true series cell design, the individual cells are isolated from each other and water cannot move freely to adjacent cells, whereas with an open bath design, the cells are open and water can move freely in between the electrodes and from one cell to another.)

The biggest problem with an open bath design is that because of excessive current leakage, it usually overheats rapidly and typically gets to 90+ degrees Celsius within +/-2 hours. If an open bath design booster is not constructed from material that can handle those temperatures, you have a problem (e.g. PVC plastic which is only good for 60 degrees C)

Excessive heat also means energy is lost unnecessary with resulting lower efficiency. So a simple but very effective way to have a honest comparison between two boosters, is to put them next to each other and let them run at the same amps. To make an accurate efficiency comparison there should be no external water cooling device or mechanism present (e.g. heatsinks, cooling fans, radiators, siphons etc.). The booster that has the highest water temperature after two hours will always be the least efficient while the booster with the lowest water temperature will always be the more efficient design! It is actually the energy that is wasted that heats up the water, and hotter water simply means more energy is wasted which could have been used to generate more hydroxy. In this regard one must note that if a design needs some kind of external water cooling device or mechanism, this might actually disguise the inherent inefficiency of the design.

If you measure the gas production of an open bath cell while it is running at >85 degrees Celsius, it might look as if you are getting impressive gas production, but at those temperatures the gas contains a lot of water vapor, thus it is a lower quality of gas. So, be very careful when comparing the "claimed" gas production from various boosters. Make sure that you know at what operating temperature the claimed amount of gas was measured and make sure the claim can be verified!

Another important measure of the quality of the booster, is to look at the stainless steel being used.

Some boosters are constructed from cheaper stainless steel and not the more corrosive resistant 316 as is the case with the WaterfuelForAll booster.

Also the WaterfuelForAll booster only uses plastics (e.g. nylon, polyprop) which are capable of handling higher temperatures as PVC.

So the biggest advantage of the 6 series cell WaterfuelForAll booster is its efficiency, which is up to 2 liters per minute at 20A (13.8V) for the Standard model, and up to 2.5liters per minute at 25A for the Delux model, measured with a water temperature not exceeding 75 degrees Celsius. Even more important is the fact that it can run 8+ hours continuously without overheating.

4. What models are available and what is their pricing?

We manufacture two models:

WaterfuelForall Standard max 25A, 20A continuous, 1.5-2.0 lpm @ 20A - USD 195

WaterfuelForall Deluxe max 30A, 25A continuous, 1.9-2.5 lpm @ 25A - USD 295

WaterfuelForall Super Deluxe max 35A, 25A continuous, 1.9-2.5 lpm @ 25A - USD 395

This price includes the electrolyzer with a 1 liter HDPE water trap/bubbler and the necessary hoses.

A "heavy duty" bubbler is available at an additional cost of USD30. All units are fully assembled and individually bench tested for a period of at least 2 hours. AWG 8 cables with soldered connectors, a 30A relay, amp meter and in-line fuse is available at an additional USD 50.

5. Which shipping options are available?

Two shipping options are available:

	Americas	Asia, Canada, China,	Australia Europe	Delivery Time
Air mail USD	100	80	70	+/- 7-10 days
Surface mail USD	35	25	25	+/- 35 days

6. How do you manage such competitive prices?

We had several e-mails from individuals telling us that they cannot beat our price if they want to build it them self, and the reason is simple: we buy our materials in bulk and have designed a manufacturing process that is very cost efficient. Our goal is to provide the public with a reliable booster but at an affordable price so that it make more sense for someone to rather buy a professionally built unit from us, instead of trying to build a unit them self, with all the related problems.

7. Which unit do you recommended for my car?

If your car's engine size is larger than 2500cc, we recommend the Deluxe model otherwise the Standard model should be fine.

8. How difficult is it to install?

Detailed installation instructions goes with every unit sold, but the procedure is pretty straight forward and should not take longer than 1.5 hour to install, if so much.

9. Where must the booster be placed?

Anywhere in the engine compartment but preferably in a place where it will have a constant airflow (just like the radiator) so that it can benefit from the cooling effect of airflow.

10. How is the hydroxy injected into the engine?

The hose coming from the water trap is connected to the air intake before the air breather, so that the gases introduced into the intake are first filtered by the air filter. We

are not interested in a vacuum because the manifold has greatest vacuum at the wrong time and no vacuum at the worse time. Also, we want the hydroxy gas filtered of any mist, which may carry traces of electrolyte. As an additional benefit, the air filter serves as a first line of defense protecting against a back flash coming from the engine.

11. Where do you buy your tubes?

We are situated in South Africa, and are buying our tubes locally. All tubes are grade 316 ISO certified.

12. Do I need an EFIE?

If the vehicle has fuel injection, it is likely that you will have to use an EFIE together with your booster, before you will notice optimal mileage improvement.

Examples of EFIE circuits available on the internet is:

<http://www.fuelsaver-mpg.com/>

<http://www.madcosm.com/>

In cooperation with Panacea, a reputable alternative energy research organization in Australia

we will within the next few weeks be conducting in depth tests in this regard, using the WaterfuelForAll booster. Panacea will be testing various models of EFIE's as well to assist us in finding the best solution.

13a. What is the maximum amount of amps that my engine can handle for optimum mileage?

Every engine has a sweet spot where the net energy gain because of the addition of hydroxy is the biggest. If your booster is pulling too much amps, your engine may need more petrol just to supplement the drag from the alternator (just like an air conditioner causes higher fuel consumption). To answer this question, the following procedure is suggested:

Remove the hydroxy gas outlet from the intake and start your engine without the booster. Listen to the engine or watch the rpm's. Next turn on the booster, but do NOT feed the hydroxy gas into the intake. If you notice a change in engine pitch, then that is a sign that you are pulling too much amps. Next, turn off the booster, put the gas hose back into the air intake and turn on the booster again.

Listen to the engine pitch. If the rpm went down, then your booster is not offsetting the amps you are pulling, in other words, it is pulling too much amps and no/little mileage improvement is to be expected.

13B. How much Hydroxy is needed for optimum mileage improvement?

I do not have the answer yet, but Panacea, a reputable alternative energy research organization in Australia will within the next few weeks be conducting in depth tests in this regard, using the WaterfuelForAll booster. Hopefully these tests with advanced computer equipment will be able to answer all our questions in this regard.

14. How do I refill with water and how much?

The booster has a removable cap for easy refill. Just add the water until it wants to overflow the edges of the inner tubes. If you by accident fill up a little bit too much, then its not such a big problem.

Yes, there will be much more current leakage initially, but this will only last until that first bit of excess water has been used up, which should be rather quickly. If the water/electrolyte overflows, it will simply be caught by the bubbler/water trap.

15. What electrolyte should I use?

We recommend lye (also known as caustic soda, chemical symbol NaOH). You can also use KOH but it is usually more expensive than lye and not so easily obtainable. Do NOT use baking soda since it might damage the electrodes (tubes) which may lead to reduced gas production.

16. What kind of water should I use?

Distilled is recommended because tap water may cause sludge to build up and short the electrodes.

Should you decide to use tap water, you do so at your own risk and in such case we advise that you should regularly open up and clean out the electrolyzer, at least once every 3 months. If your water contains too much impurity, it may contaminate the electrodes which may lead to reduced gas production.

17A. How do I control the current draw (amps)?

Amps are controlled by how strong the electrolyte solution is, and to stabilize at between 15-18A you need to add +-30ml (6-8 teaspoons) of lye to 1 liter of water initially.

If you are driving less than 2 hours at a time, then you do not have to be too much concerned about the amps, and then you may add up to 50% more lye, and the current draw should not go above 30A within 2 hours. Thus, for usage less than 2 hours, you can start with 9-12 teaspoons of lye to 1 liter of water. Note that once you have reached the minimum required lye concentration (+6 teaspoons), the current draw increases very fast with every additional teaspoon of lye added. So rather start with too

little lye, than too much. You can always add another teaspoon of lye if you see that your booster does not get close to 25A within 2-3 hours, but if you have added too much lye initially, you may end up with the current draw increasing too quickly and after an hour you may be forced to switch off your booster.

17B. How do I prevent freezing in sub zero temperatures?

Electrolyte concentration needs to be high to prevent freezing. Alternatively you can put a heating/cooling coil around the unit (engine coolant driven) or wrap the booster with fiberglass foil backed insulation. NaOH (like KOH) at "moderate" (20%) concentration makes a reasonable anti-freeze. It will freeze at about -10 F. KOH at 28% will not freeze even in Norway. The bubblers can contain some antifreeze.

18. How do I / Should I condition my booster before using it?

Some successful commercial boosters do not recommend any specific conditioning procedure. On the other hand, Bob Boyce strictly prescribes the following procedure for electrode cleansing and conditioning:

Plate Cleansing - "During this stage, we are operating in submerged plate condition, where the liquid level is maintained just over the plates. Run this cell stack at full power for several hours at a time, which can be 4 amps or more. As the cell stack runs, the boiling action will loosen particulate from the pores and surfaces of the metal. Be sure to do this in a well vented area. Shut down and pour this solution into a container. Rinse the cells well with distilled water. Filter the dilute solution through paper towels or coffee filters to remove particulate. Pour the dilute solution back in and repeat this cleansing process. You may have to rinse and repeat many times until the cells stop putting out particulate matter into the solution. Optionally, you can use new solution each time you cleanse, but be forewarned, you can go through a lot of solution just in this cleansing stage. When cleansing is finished (typically 3 days of cleansing), do a final rinse with clean distilled water." (Not that Bob's system use a 101 plate cell, thus full power is only 4 amps. For the WaterfuelForAll booster, full power would imply 20-25A)

Plate Conditioning - "Using the same concentration of solution as in cleansing, now fill the cell stack with dilute solution. Monitor current draw. If current draw is fairly stable, continue with this conditioning phase straight for 2 to 3 days, adding distilled water to just replace what is consumed. If the solution turns color or skims over with crud, the cell stack needs more cleansing stages. After 2 to 3 days of run time, pour out the diluted solution and rinse well with distilled water."

My recommendation would be to try and stick as close as possible to the procedure prescribed by Bob, for best results. Best would be to connect your booster to a

regulated power supply during the break in period. (I'm using a PSU rated max 32A) But at the same time I have to confess that I have experienced little difference between different conditioning methods tested by myself. While we are not trying to achieve resonance (we are merely performing brute force electrolysis), and while we are using a good quality grade 316 stainless steel, I suspect that the exact method used for conditioning does not matter so much, as long as the plates are never touched by bare hands or any other chemicals than NaOH or KOH. I think the most important point is to stick to using distilled water and just know that your booster will not start out at maximum gas production, but gas production will gradually increase during the first +/- 30 hours of operation.

During assembly we only handle the tubes with rubber gloves, so you do not have to be worried about contamination for a start. For simple brute force electrolysis for purposes of boosting I will simplify Bob's procedure to: Connect your booster to a PSU and run at +/-20 amps for +/-24 hours before fitting to your vehicle. Interrupt the procedure every time when the cell gets to +/- half full of water and replace with new water & electrolyte. If you do not have a PSU, just borrow your friends! (I'm sure one of your friends will have one!)

19. Which are most efficient, tubes or plates?

A similar sized 7 plate series cell and 7 tube series cell should have similar efficiencies if built to the same precision. However, the biggest advantage of the tubular design compared to the sandwiched series design is the fact that the tubular design is less prone to leaking of hydroxy than the sandwiched series cell. This is because every seal between a sandwiched plate is a potential leaking spot at a later stage when the cell gets older (hydroxy has got the tendency to leak at places where nothing else will leak!)

20. Can I add a PWM to my booster and what would be the benefit?

Yes, you can add a Pulse Width Modulator (PWM) to your booster. Adding a PWM will allow you to manually control the amp flow as you like, but note that you will not have any improvement in efficiency. The gas production will merely increase/decrease as amp flow increase/decrease, for example, if your unit is drawing 25A and producing 2.5lpm hydroxy and you now add a PWM and adjust the PWM so that it limits the current to 15A, you will only get 1.5lpm A PWM is a necessity for boosters that quickly overheats.

While the WaterfuelForAll booster does not overheat (as long as you do not add too much lye!), a PWM is only is "nice to have" especially if you are only going to drive up to 3 hours at a time. However, if you are frequently going to drive for more than 3 hours

continuously, then adding a PWM will make your unit more users friendly since you would not have to worry about the lye concentration and can manually control the current flow.

21. Can we achieve resonance with a 6 series cell?

You need higher voltages to achieve the high resonance efficiencies that Bob Boyce is achieving.

That's why Bob's cell is typically running at 170VDC or higher. Bob said that at 13.8VDC he only achieved very little energy gain, typically in the 1.1 : 1 to 1.2 : 1 range. He specifically do not recommend low voltage systems, as the environmental energy gain is very low compared to the drive energy, and the cost is still high as far as the toroidal power system components is concerned.

Praveen's karma booster

Open source engineer Inventor: Praveen

[Email](#)

[Web site](#)

Back ground information

Quote- This booster is easy to construct and very economical. I don't think it should cost more than 70-80 USD. So let us save the oil and clean the world. –Praveen



Tubular design

In Hindu mythology the meaning of KARMA means the “WORK WE DO”. The following design although has been submitted by Praveen, was a creation from work done by all the open source hydroxy engineers. Hence Praveen rightfully decided to keep the name as KARMA BOOSTER. Since the beginning Praveen had been struggling for the best design which is compact, suitable for longer operation and cost effective etc. Praveen has found that the following “karma” booster has all these design parameters.



Praveen's compact and high efficient series cell

[New- How to by Praveen- This is a COMPLETE how to doc.](#)

[12 Volt Ultra compact systems - MB102](#)

[Auto Re Fill system](#)

<http://au.youtube.com/user/pvar06>

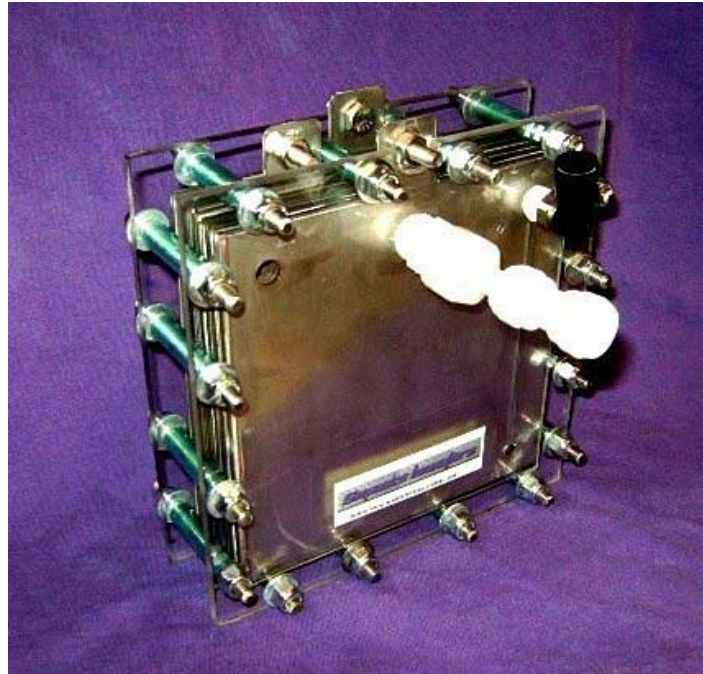
Eletrik's "Smacks Boosters"

Dustin (Smack) is the inventor of the open source Smacks booster. He is known on the yahoo energy group forums as "Eletrik". There are very few open source engineers out there as charismatic, aggressive (dedicated) and passionate as our own Dustin. **Note – if you find this information useful please consider helping Eletrik advance with his research. He has already proven his worth by disclosing this information FREE and intends to improve his designs and keep them all in the public domain.** To help Eletrik's EV-H2 hybrid R and D [please consult his web page](#), or contact Panacea for a tax deductible donation and please specify it is for Eletrik's research.

The original design is intended to operate only under 2 hours of driving time. If you run the original Smack Gen I design any longer than two hours will cause heating problems.

Smack has since upgraded his design to Smack Gen II (for longer trips) Smack Gen III and finally BB smack Gen IV.

Gen IV – The BB (Bob Boyce) Smack



The B.B. Smack Gen IV Dry Cell

Above is one [BB Smack cell design](#). Smack is up to Design V now. Recently has been experimenting with Ti/MMO coated plates. Please check his web site for updates. When Bob designed this kind of cell, he meant it to be completely isolated. The holes drilled in the plates take a pretty hard hit in efficiency - no matter how small they may look. It's tempting to make refill easier by just drilling that hole, but Bob has a refill design that keeps all the cells sealed. That design never got published, but there is a way to overcome this challenge and make this cell construction easy to fill while maintaining efficiency.

Overall dimensions: 7"x7"x3"

Plates: 22G 6"x6" 316L SS

Gasket material: soft clear PVC sheeting

All SS hardware.

Easy multiple mounting options

[How to build my B.B. Smack part 1](#)

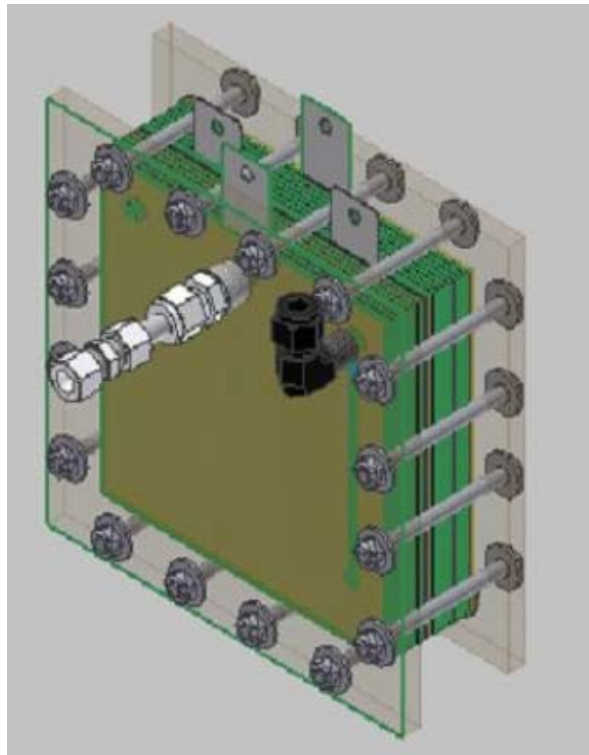
For those of you wondering how this refill tube works and how you build a cell with magnetic field alignment built in - here you go.

<http://www.youtube.com/watch?v=im0wJHYR93w>

<http://www.youtube.com/watch?v=IUzdG4YSNgY>

<http://www.youtube.com/watch?v=f1Is6rSX-nU>

BB (Bob Boyce) Smack – Courtesy of Bill Williams



[BB Smack Document](#)

Smack 7 Cell

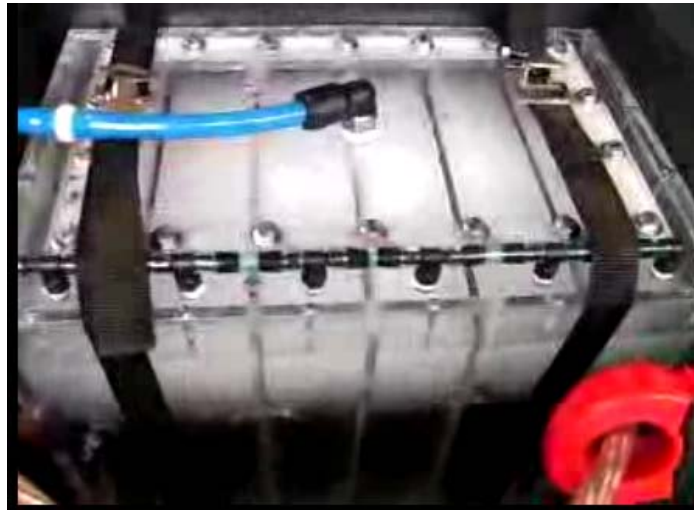
Those of us who understand the superior properties of a 7 cell design know that mixing the electrolyte to a higher initial current will allow the cell to yield more gas output than a 6 cell design over a given period of time. This is because while a 6 cell design is wasting time (and energy) heating up to reach maximum performance, a 7 cell unit is already there, and maintains that performance over a flatter output curve for longer durations. This means it works for short runs as well as long runs with no adjustments. To make a 6 cell unit perform consistently over varying durations, the operator would need to make concentration adjustments for every trip. Something I learned with my wet cell design, which varied over a large range do to the heating inefficiencies. A magnified

problem still observed with a 6 cell series design on a much smaller scale. So these constant adjustments are a real pain, and not often done. As a result – the mileage performance of a 6 cell unit is not as stable as a 7 cell design. Not to mention the fact that a 6 cell unit is not as efficient as a 7 cell design as I have proven already.

<http://www.youtube.com/watch?v=Q6lwal4L8xo&feature=channel>

Please check for updates on these issues from the Smack's site. Eletrik is in the process of patenting and trade marking the "Smacks booster". This does not mean that he does not intend to keep ALL his findings free and open source. This has been done to prevent bottom feeders and cheap knock-offs of his design emerging plus cashing in on his hard work. People are already selling Smack's booster plans on EBAY. This is an insult to Dustin who has put his hard work and time into keeping it free and disclosing it for everyone to enjoy FREE.

Smack Gen III



Smack Gen III- LOOK AT THAT GAS (Go Smack)

The GenIII, or "Smackzilla". This is one way to drop the applied voltage to a cell array efficiently. Inspired by the 6 Pack Smack, this new design completely eliminates parasitic current losses, dramatically increases plate surface area, cuts heating in half, and allows for huge current draws. It combines parallel and series configurations and takes the best characteristics of open and isolated bath designs. Kind of like a wet dry cell. Not as efficient as a dry cell thanks to magnetics, but keep in mind this is the first prototype and the bugs are being worked out. This is a series design in parallel with 6 compartments. Smack has detailed the background and open sourced how to get this cell operating. In his videos Smack describes how he came up with GenIII design and a little history on the step gap used.

[Youtube- Smack Gen III Back round](#)

Smack Gen I and II

The following is an overview and description of the Smack gen design. Smack's official site is listed below. The Smacks booster is designed to give the most gas for the least amount of materials needed **FOR LESS THAN 2 HOURS OF DRIVING ONLY. It is a compact design which is kept as cheap and effective as possible.** The Smacks booster is designed to give out from 1 to 1.7 liters' of hydroxy gas per minute at 20 amps. You will need to run your unit for a while in order to condition it to get the max gas output. This can also be paired together with another smacks for extra savings, these designs will be covered below.

This is suitable for most sized cars to eliminate their emissions and give the at least 20% better fuel economy for an average sized engine. The housing container size is comprised of 4-inch (100 mm) diameter PVC pipe. This design has a clear bubbler and a water level monitor attached to its side.

The PVC pipe has been converted to a container to house the booster from using PVC glue to attach an end-cap on the bottom, plus a screw-cap fitting on the top. The container then has the gas-supply pipe fitting attached to the cap, which is drilled with two holes to allow the connecting straps for the plate array to be bolted to the cap, as shown below.



The elbows connector joints on the bubbler measure half-inch in diameter which connects to the ends of the one-inch diameter bubbler tube. These have their threads pre coated with silicone before inserted into place. This is done as an added safety feature, as this will allow both of the connections to act as a pressure relief and muffle any flash back or "back fire".

The stainless steel electrodes used are made from standard electrical stainless steel wall switch covers. These stainless steel switch-cover plates's measure: 2.75 inch x 4.5 inch (70 mm x 115 mm) in size. You will need 16 of them as there are 2 pairs of 8 used. In the USA they can be sourced from the local hardware store. Note you can use 302 and 304 stainless steel. Spending extra on 316SS is not necessary for the Smacks booster's operation. Some people may confuse the need for 316L or 316 for the Smacks. This is only necessary for booster or hydroxy designs intended on achieving resonance and taking advantage of the chromium content of the SS with your isolated series cell - such as the work of Stan Meyers, Dave Lawton, or Bob Boyce.

Before the electrodes are used, they must be "conditioned" for the best gas production. Pre preparation of the plates involves the surfaces being scored in an X-pattern by using 36-grade coarse sandpaper. The idea is to create miniature sharp-crested bumps covering the entire surface of each of the plates. By creating this type of surface it will help the hydroxy bubbles to break away from the surface as soon as they are formed. It is estimated that this also increases the effective surface area of the plate by about 40%. **You must use rubber gloves when handling the plates. Never use your fingertips as it will reduce the working area on the plates.**



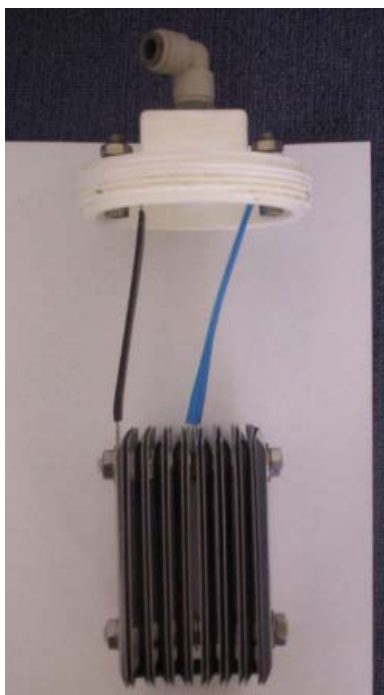
Sanded Stainless steel wall switch

After conditioning, the plates should look something like the above. Then their existing mounting holes are drilled out to 5/16 inch (8 mm) diameter. This is done so we can insert plastic bolts which will be used to hold the plates together and make an array.

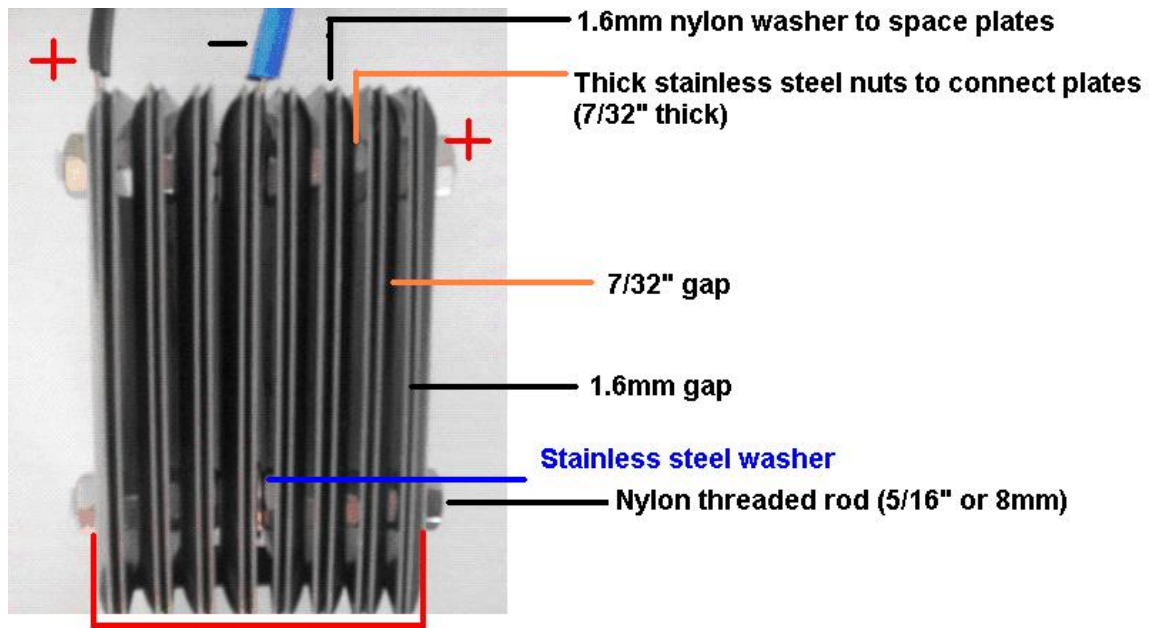
It is predicted that even after a year of continuous use, that these plates will remain shiny and will not be corroded in any way. The electrodes are attached to stainless steel connectors or steel straps. These are handles cut from food cutlery or cooking utensils.



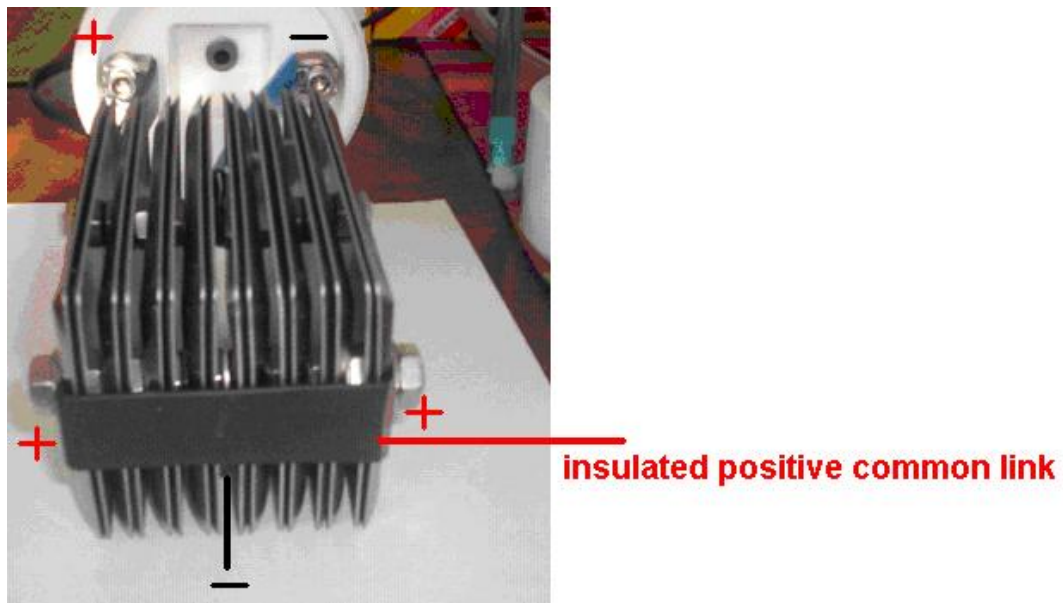
Above you can see how the stainless steel straps coming from the screw cap (right) are connected to the stainless steel electrodes (left). Eletrik has insulated these to prevent any current from leaking directly between them through the electrolyte. The preferred insulation is made from shrink-wrap. Another option can be McMaster Carr tool dip. You can also wrap the straps in electrical insulating tape however, the tape must be wrapped tightly around the straps and stretched slightly as it is wrapped.



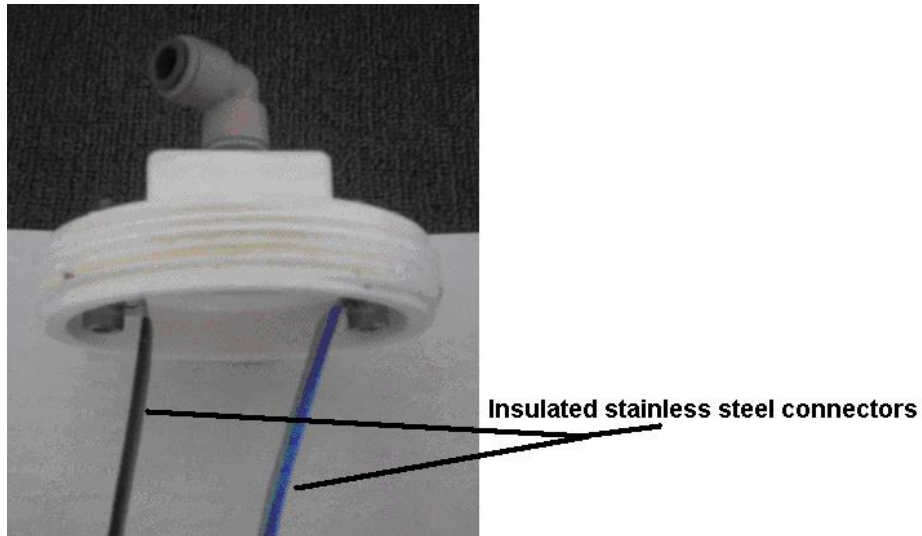
The plates will be held in position by two plastic bolts which run through the original mounting holes. These plates will have a small 1.6 mm gap between each of the eight pairs. These gaps will be produced from putting plastic washers on the plastic bolts between each pair of plates.



This cells efficiency relies on the 1.6 mm gap spacing used. This spacing is an optimum in the electrolysis process. Stainless steel nuts are used between each pair of plates; these will form the electrical connection between the adjacent plates.



This design of the plate array has been specifically chosen in order to be cheap, robust and easy to construct. **Note that when mounting the plate array, the section running underneath the plates is insulated before they are assembled.** The electrical straps are then bolted to the screw cap at the top of booster:



This both positions the plate array securely and provides an electrical connection in the bolts on the outside of the cap while maintaining an airtight seal for the holes in the cap.



Note some may perceive that by the way that the battery is connected that it should leave most of the plates unconnected. Specifically these plate pairs are called "floaters" and do produce gas in spite of looking as if they are not electrically connected at all. More Information and insights into this boosters operation will be covered in the Smacks faculty sections below.

The finished product should be close or like this:



Before adding wires and powering up your booster, stick to the installation guides and advice previously mentioned in description. As mentioned in the beginning you must use, the electrolyte which must be used has to be [KOH](#) or [NaOH](#)

Conditioning

Short version summary: You run the cell in the electrolyte solution at about 10 amps for 2 hours. Rinse them with distilled water. Pour the used electrolyte solution into another container through some coffee filters to filter out debris. Repeat this process for about 20 hours of run time total. Your plates should have a bronze color to them. Make sure you wear gloves! Please check Smacks PDF on his site for more detail.

Generally you get your electrolyzer finished, then add an appropriate amount of "**DISTILLED**" Water, add power to your cell. Then slowly add small amounts of KOH to the water until you get about 10-15 amps depending on what the total amperage you want to run at. You have to be real careful here because as the solution heats it will draw more amperage, this is why you want to add small amounts of KOH at a time so you don't over shoot your target final amperage of 20amps. You don't want a "RUN AWAY" amperage situation to occur. You can also preheat the water for a few minutes and that way as you drop the KOH in it will be pretty close to full operating temp.

To Begin, take the center electrode piece out and top the booster up with distilled water to about 2" from the top. Then start adding in a teaspoon of KOH or NaOH to the water. Then put the electrode piece inside but do not tighten the lid on, leave loose for now. Next connect up a 12V power supply to the leads and monitor the current draw of the unit. Since the booster is cold, you are aiming to get 16 amps flowing. The water will heat up over time, this should increase the current draw by about 4 amps to make

20 amps total. This is the reasoning why you are aiming to only draw 16 amps when the cell is cold.

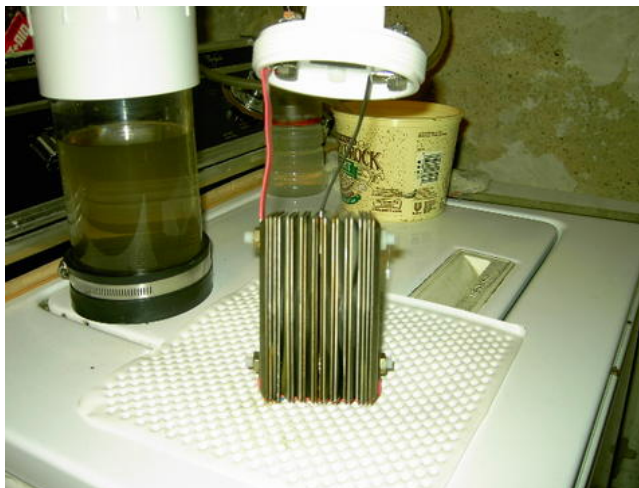
If you find that the current draw is too high, empty out some of the electrolyte (but save it in a suitable container) and re fill with only distilled water. If you find that then the current is too low, re add a small amount at a time of your electrolyte until the target of 16 amps is reached. If you cannot construct a Smacks booster yourself you can purchase one directly from Eletrik by going to his web site below. Smack also has also achieved advanced designs including the Smack gen II, III, IV and the 6 pack Smack. Eletrik intends on keeping these designs open source please consider helping him with his research if you have found this information useful, every tiny bit counts!

Smack Gen II



Taken from the video showing the shrink wrap

The Smack Gell has extra insulated shrink wrap. This cell is a 5 stack 2 series stack in parallel just like the old smacks except with one extra ell per side to reduce the cell voltage from 3 volts to 2 and a half volts which will also reduce heating for the same gas output.



Smack GenII

There is a link on E's site that gives the part numbers and quantities of the parts used in the design. Smack states that the design is still much the same as the GenI except that the plates are larger (3"x5") and precut/drilled. Same with the straps. No more spoons - though you replicators can still use them. The kits Smack is putting together have precut and drilled straps as well. More cells means less volts per cell which equates to less heating over time and more current control. This results in lower current and temperature delta's over a 4 hour test period. Higher starting current draw means more time making gas and less time ramping up.

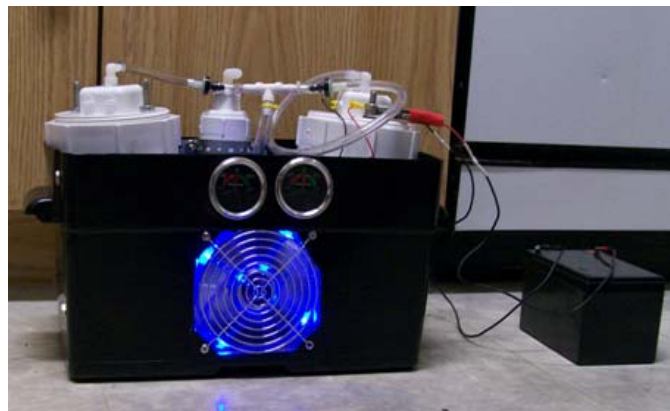
In short - 10 cells, each separated by a 7/32 SS nut. Each plate pair separated by a .8mm nylon washer. Plates are cross sanded with 36 grit. These plates are not pinged as testing shows there is not enough difference in output to justify the extra work. Smack is still running more tests to confirm this solidly, but for now it looks like the pinging of these larger 304 SS plates is not needed. This may also be due to the smaller .8mm gap which is similar to the bike unit. Output of the GenII is basically the same as the GenI.

Check the following Smacks videos where he shows how to add 2 more cells to the original design. Any 16 plate smack can be modified this way. Please note if you intending to modify an existing Smack design, The nylon rods are pretty much a onetime build. They cannot be re-used easily due to stretching/stripping. Also, you should not white knuckle the connections, as you will strip the threads. Remember, they are just plastic. Generally, if I have to break down a unit I use new rods.

[Mods to the Smack](#)

[Analyzing The GenII](#)

Double Smack



Testimony from a Smack's booster user details that he achieved a **49% increase in millage** by using two units which drew 20/30amps each.

6 Pack Smack

[The Six Pack Caddie Smack](#)

Smack Gen IV is the final and recommended design

[BB Smack Videos](#)

Smacks Gen I parts list – to order these direct please consult the Smacks web site.



Smack offers kits which include:

- 26 - 7/32" SS jam nuts.
- 16 - nylon 6/6 1.6MM washers
- 16 - 302 SS wallplates
- 3 - SS utensils for straps
- 7 - 5/16" SS washers
- 1 - 18" 5/8 shrink wrap
- 1 - 4" shrink wrap
- 2 - 4" 5/16" nylon rods
- 2 - 1.5" 5/16" SS cap bolts
- 2 - 5/16" rubber backed SS sealing washers
- 1 - 4" PVC female adapter
- 1 - 4" PVC plug
- 1 - 1/4" NPT 90 deg. swivel

- 1 - 1/8" NPT nylon fill port fitting
 - 1 - 1/4" rubber cap
 - 1 - 4" PVC end cap
- 1 - 8"x 4.5" O.D. x 3/16" CAST acrylic container tube
 - 1 - 8" x 1" O.D. extruded acrylic bubbler tube
 - 2 - 1/2" NPT bubbler end caps
 - 2 - 90 deg 1/4" elbows
 - 1 - 1/4" check valve

Smack Parts List (Modified)

Parts:

MCMASTER

<http://www.mcmaster.com/>

98831A030 - Nylon Threaded Rod 5/16-18

90295A160 – Nylon Flat Washer

94709A318 – Neoprene Bonded Sealing Washer

91841A030 – 18-8 Stainless Steel Machine Screw Nut

47245K27 – Diaphragm Check Valve

5233K578 – PVC Tubing 1/4"

5233K88 - PVC Tubing 3/4"

8486K577 – Clear Cast Acrylic Tubing (optional) 4" x 1'

2974K156 – 90 NPT Male for 1/4" x 1/2"

5923K73 – Acetal Quick-Disconnect w/valve (optional) 1/4" Barbed

5923K43 – Acetal Quick-Disconnect w/valve (optional) 1/4" Barbed

OPTIONAL FOR CAP MELTING PROBLEM

<http://www.rutland.com/index.php>

Rutland High Heat Silicon Sealant (under products/maintenance)

<http://www.pcepoxy.com/>

PC-Fahrenheit (under products)

RADIO SHACK

1 Voltmeter to check volts and amps (optional if you don't have one)

LOCAL HARDWARE STORE (minimum)

4" Schedule 40 PVC Pipe (12 inches)

1 4" End Cap

1 4" Plug (screw in cap)

1 4" Sleeve (to screw in the cap)

PVC Cleaner and Glue (comes in clear and purple)

GE Silicon II (clear)

Teflon Tape

1 Gasoline (on/off valve to act as vacuum valve when Smack cools down. You will have to open an

close this each time manually.) (alternatively add another check valve this placed between the bubb

and the booster)

1 T-Barbed Fitting to fit 1/4" PVC Tubing and connect into the on/off valve

5/16"-18-8 – 1.25 to 1.50" Stainless Steel Bolts (2 each)

stainless steel washers (4each) (More washers may be needed with cap melting problem)

16 Stainless Steel Gangs (light switch plates without the hole for the switch)(Also available at Hom

Depot or Lowe's)

2 each Stainless Steel Straps 3/4" x 12"

60 Grit Sandpaper

Rooto (Ace Hardware 100% Lye NaOH)

AUTO PARTS

30amp In line Fuse Holder

30amp Fuse

40amp Relay Switch and Relay Harness

30amp In-line Circuit Breaker (optional safety feature)

In-Line Circuit Breaker Holder

4 prong Emergency Flasher (Poorman's PWM – Optional-Testing this out)

1 on/off switch (wire into hot wire of auto radio)

10 and 14 gauge Wire for wiring (variable lengths as per vehicle)

EGT Gauge (Exhaust Temperature Guage – Optional for short term)

Ammeter Gauge

AFR Gauge (optional)

INSULATION FOR SMACK STACK

1 (for each stack) 2 ltr Pepsi, Coke, Sprite, Dr Pepper bottle

Smack parts in Canada

1. PVC Any good hardware or plumbing supply ie: Home Hardware, Home Depot
2. Switch Plates, Canadian Tire and Home Depot Lowes are a cheaper thinner version and found that they touch when used.
3. Fittings for tubes and bubbler TSC Tracter Supply Store
4. Stainless Nuts and Nylon Washers - Fastenal (best price and quality buy 200 at a time.
5. Nylon Rods, Fastenal carries 3/8 in stock but you would require changing nuts etc to fit. So I use plastic coat hangers.

McMaster-Carr will not ship to individuals in Canada anymore, but supply Fastenal with some of the parts.

Check valves - [web site](#)

<http://www.tscstores.com/>

[US Plastics](#)

Smack Links

Please always check the Smacks site for the updated version of his booster.

[Smacks own web site with design instructions and installations guide](#)

[Panacea's registered technology page on the Smack](#)

[Smack's explanation of the EFIE](#)

Series Plate Cell Designs

To single out the two most important points when choosing an electrolyzer design it would be:

- 1) Its efficiency, i.e. the ratio of liters per minute hydroxy versus the amount of power (amps) consumed
- 2) The reliability of the design, i.e. what material is being used and does the design has any overheating problems.

The "magic numbers" of just fewer than 7.5 MMW for hydrogen and just over 10 MMW for a single ducted system came into being. Using Faraday's numbers, and the minimum potential for electrolysis, these numbers fell into place.

MMW is milliliter per minute per watt which is easier for many to understand than the milliliter per joule number would be, even though the quantity of gas per unit of energy makes more sense.

Even though without doubt a series cell design is the most efficient, open bath electrolyzers are rather popular, mainly because they are easier to construct than the series cell designs. **The main difference between a series cell and open bath design is that in a series cell electrolyzer the cells are properly sealed off from each other so that water cannot freely flow from one cell to another.** With an open bath design, the water can freely flow in between adjacent cells/electrodes and as a result there is a lot of current leakage around the edges of the electrodes. This current leakage results in reduced efficiency and also the water heating up rapidly and eventually causing overheating problems.

Currently we cannot find an open bath design that will not heat up to more than 60 degrees Celsius after two hours of operating (while drawing 15 amps or more). This is however being worked on.

Therefore a properly built series cell or a tubular (design is covered below) is the best long term solution. **Also, beware of any web site electrolyzer manufacturer that cannot (or do not want to) tell you exactly what the operating temperature will be after 3-4 hours, when operating at a current draw of at least 20 amps. DO NOT TRUST THESE BOOSTERS!**

Obviously cost is also a consideration, people want to save money now and then they will build an open bath electrolyzer that will heat up to 90 degrees Celsius within 2 hours, yet they will be building the electrolyzer using materials like PVC that can only withstand 60 degrees Celsius, this electrolyzer is not going to last very long. Another short cut that people want to take is to use inferior quality stainless steel. For now they are saving a few dollars, but if they really took the time and did their calculations, **it would have been a much better investment for them to build their electrolyzer from materials that could last for years and not only a few months. After all, hydroxy is a highly explosive gas and you do not want to endanger your own life or the lives of your family.**

In the case of a 7-cell, isolated cell design, although there is a lot more involved in the construction and the cost is higher, it is predicted that around 38% of the power will go to heat up the electrolyte. **This effectively means that the gas-producing efficiency is doubled, meaning more gas for less amps and the wasted heat energy is halved.**

In straight brute force DC only electrolysis, the amount of current it will draw is determined by Ohms law. $I = E/R$ The amount of measured resistance of the total circuit divided into the total amount of DC voltage applied to the circuit will give you the total current the circuit will draw. For DC voltage, ie car voltage at 12 volts the ideal plate configuration is about 7 plates in series, this makes the system have 6 separated cells total in series. This divides the 12 volts by the 6 cells to get about 2 volts per cell. As for the amperage you want to maintain about 1/2 amp per square inch of cell. This means for a 10 inch by 10 inch cell you can apply enough electrolytes to draw 50 amps. Even though this is series, 6 cells total, the 50 amps will safely pass through each cell. The total amperage will be amps (50) X cells (6) = 300 amps of gas production.

For larger productions you can build 2 sets of cells then connect them in parallel or build a single larger surface area series cell. Keep in mind the power draw is volts X amps. 12 volts * 50 amps are 600 watts. This is within the limits of the car system as long as the car is running. You will find a dead battery quickly otherwise.

The most popular are a 6 or 7 isolated cell, a cell which has 7 isolated cells which will not get hot and produce at a good rate with 10% KOH by weight. This can only happen when you have created this cell in one container with a separate compartment for each set of cell. Then all the cells are connected in series to divide the voltage applied to the cell. Note - but it will be a cell in an open bath, but not act independently.

While 7 cell boosters are more efficient and can deliver more hydroxy gas per watt, they do take longer to warm up to pass higher current in larger engine boosting applications. For this reason, Bob Boyce has been recommending 6 cells for large volume application boosters that require fast warm-up times, and rely on control electronics to adjust current.

This is due to the fact that a 6 cell booster can pass more current at full NaOH concentration than a 7 cell booster when cold. The control electronics allow 6 cells to operate at very high efficiency for the desired amount of boost, from a cold start right up through warm-up. The 7 cell (and dual 7 cell) units are best for applications where hydroxy gas production efficiency is highest priority, and/or where operational time is long enough to allow the units to warm up. One way to look at it can be short trip vs long haul.

Experimental theory

You could try having an extra exterior connection to the first (or last) "neutral" plates, plus a switch, so that a 7 cell unit can be turned into a 6-cell when the needs demand. Running it at "6 cell" would also warm it up at which point it could be switched over to "7 cell" for more efficient operation earlier than pure 7-cell would provide. Adding layers of complexity for (perhaps) small gain, but my own "drive cycles" are short trips during the week (prefer a 6-cell) with long (2+ hours) on the weekends (a 7 cell).

This would turn

- n n n n n + n n n n n -

Into

- n n n n n + N + n n n n n -

With that last central "N" not really separating active cells, since it has the same potential (battery or PWM +) on both sides.

Bill William's 5X5 CDGSC Gas splitter dry cell



Special honorable thanks to Bill Williams for the donation of this design. Bill is one of Panacea's most respected open source engineers. Please familiarize your selves with the gasket material tutorial and proof of principle video's available at Bill's ["vipond50" Youtube channel](#).

This cell has been tested to run just like any good series cell does, so that being said .5 amps/ Square inch of exposed surface, that means 12.5 amps @ 13.5 volts brute force or a MMW of 5.6 to 7. So 1.2 litres/minute at that setting for a single stack adding both sides together (800ml of H & 400ml of O). Bill did test the volumes and it works out to be the 2:1 ratio as expect of the water molecule. The bench model produces that base line, so no losses due to its arrangement.

Bill has pushed this cell to 50 + amps or 4.5 litre/minute and the main thing he was after was to see if there was breaching of the membrane. The efficiency of the cell goes down at I push well above the design limit size.

The Oxygen side was clean of or clear hydrogen, would support combustion but no popping at all. The H side was pure H and burn lethargic , but needs further testing with special sensors. To test this Bill is building a spectrometer to look at the absorption & emission lines, this should reveal the total and true make up of the gases on outputs. Bill will be looking at emission in the angstroms or millionth of a wave length.

This is why Bill wrote the specification so tightly, if folks want this level of efficiency they must follow the spec as written, and deviation very likely will cause losses and changes of membrane if a looser weave is utilized will cause breaching. The key to this to allow only electron migration, so a wetted surface will accommodate this (tight weaves). All this being said folks are going to do what they think is right and some well be disappointed and some will be 100% successful.

NOTE WELL – historic PUBLIC RECORDS on William Rhodes and Yule Brown, as well as Bob Boyce's info on his first publication by Sterling Allen in 2002 shows that the following U tube video link of the is a plagiarized cell of this design.

<http://www.youtube.com/watch?v=BZO0knRAfwg>

Avoid this cell as copyright legal laws will apply to this cell. This is nothing more than an art drawing of the Bob Boyce series cell design with these "neutral plates", A copy the D9.pdf shows the original 2005 publication date and copyright, for references to Bob's and others prior art on series cells that use "neutral plates". Bob Boyce has dated emails from Bill Williams with files showing his flow-through design, and later his gas-splitting adaptation.

On July 26, 1966, William A. Rhodes filed for U.S. Patent 3,262,872 for an electrolysis production method for oxyhydrogen called, "Apparatus For The Electrolytic Production Of Hydrogen And Oxygen And For The Safe Consumption Thereof."

Eight years later, in 1974, Yull Brown of Australia would file a similar patent for what is known today as Brown's gas. Even though William A. Rhodes filed his patent 8 years earlier it was Brown who became more well-known for the invention and thus there has been much debate, controversy and even acrimony ever since.

. We all know W. Rhoades & Brown original patents, but Bob developed the first small or low E cell utilizing Neutral plates back 1982.

Regarding the cell in the <http://www.youtube.com/watch?v=BZO0knRAfwg> is all wrong. Sides plates, Adhesive, Membrane, Plate porting etc. The cell may sep most of the two gases, but breaching will going to happen at very low PSI due to the weave of the material, there should be no popping on the oxygen side of the cell, period! if there is then there is breaching of the membrane. Side plate material that he chose will break down and utilizing silicone WOW will create a hell of mess and coat the plates with goo.

Bill William's ran this bench cell at 50 amps + to try to create a breach and have not have a break down yet. The current cell was originally designed to operate at 12.5 amps, so you can see he has really pushed the envelope here.

Bill is also working on a Safe Procedure to capture the H component as well as the O so it could be bottled and use for cooking, heating welding etc.

The Common Duct Cell Gas Splitter design has evolved from the Light Industrial design listed in this document. Bill developed a panel-Gasket that would keep both gas separated during the electrolysis. He called this design out as Ver.1 and found it to

viable enough to continue work with it. Ver.2 an upgrade to that design in which Gas breaching was eliminate at tests up to 50+ amps.

5X5 Gas Splitter Cell Support Document

1. All Dimensions are in Inches

2. This drawing pack rresents a 1N6 Cell Stack. The Cell size can be increased by adding more cell stacks and configuring the Gas Separation panels accordingly to direct the component gas to their respect ports so NO gas mixing will occur.

Materials

1. All Stainless components are to be 316L.

2. All Fittings are speced out to be Nylon or Poly.

3. Side plates are speced out to be Acrylic or Perplex.

4. All Thru bolts and fasteners are speced out to 304 SS or Cadmium

Plate Steel.

5. In Multi Stack version of this design all Buss bars and fasteners are speced out to be Copper.

6. Thru Bolt Fasteners insulators are to Nylon tubing sized to just slide over thru bolt shank.

7. All Gaskets materials are spaced out to be 0.065 EDPM sheeting Note: No exceptions!

8. Panel Separation material is spaced out to 100% Rip Stop nylon. This means reinforcing threads as well as the blanket Note Most fabric vender carry this material, but the is MUST be the uncoated variety.

9. Panel construction adhesive used in this design is "Plumbers GOOP". I have noted NO contamination with this adhesive (DO NOT USE Silicon), is break down and cause leakage and contaminate to device. If these specs are followed or the construction method is altered the device may fail to separate the component gases. Also the operational life of the device will be shorted.

Bill posted video's relating to "Proof Of Concept Ver.2-6N3 002.avi" on 1/7/2008 and published it to YouTube on November 4, 2009. On 1/1/2008. He worked up two additional videos explaining the construction technique's of the panel to this cell. These videos were published to YouTube on 3/9/2010

[Bill William's 5X5 CDGSC Gas splitter dry cell 5X5 CDGSC & Support Doc](#)

Individual Link:

[Bill Williams 5X5 CDGSC Gas Splitter Dry Cell.pdf](#)

6N3 Series Gas splitter Cell

<http://www.youtube.com/watch?v=6C5jmTwJEV4>

Construction

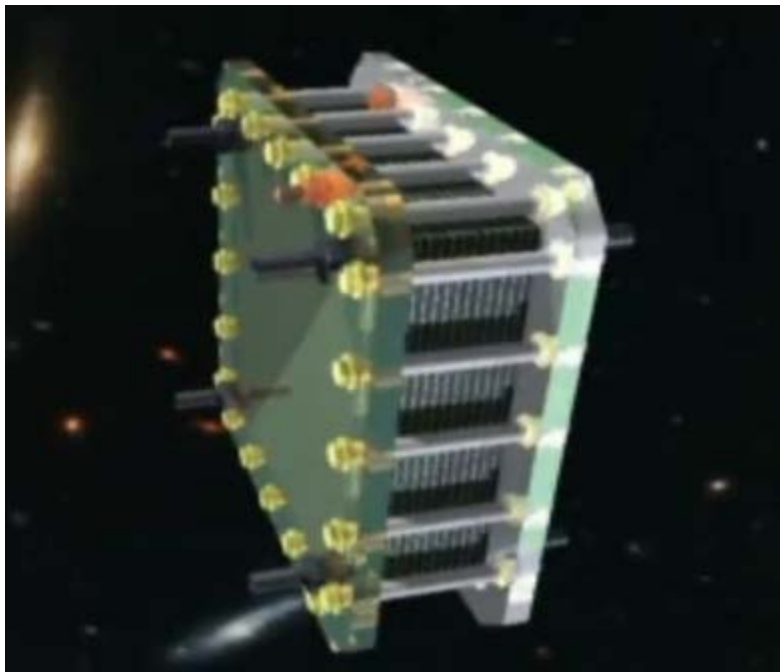
<http://www.youtube.com/watch?v=QGXT0hZnSYI>

<http://www.youtube.com/watch?v=Befd9VogkTw>

[Animation of partial exploded view of the GSC](#)

[5X5 Animation relating to GSC Bubbler](#)

[Bill Williams GSC Dual Gas Electrolyzer](#)



[The GSC Dual Gas Electrolyzer](#)

[8 X 8 GSC, 24 volt model, Single stack](#)

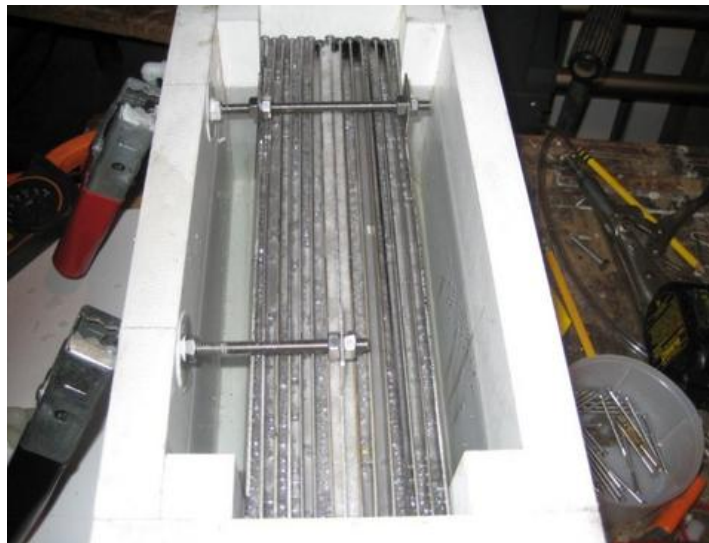
Dual Gas Splitter cell, 24 volt, Hydrogen - Oxygen separation series cell. Bill used with 100% success 1.9 oz Rip Stop Nylon (Uncoated) Down proof (when used in Pillow construction) Also the fabric needs to be bonded to the gaskets.... I used Plumber Goop (Blue colored tube) Note: whatever you do, **DO NOT USE SILICONE!!!!** Will gum up your cell.

The Gaskets are EDPM and can be had at RubberCal (RubberCal.com) Also use dual bottom feed ports... otherwise there will be gas mixing and another point is, if single port feeds are used the efficiencies of the cell will drop due parasitic current flows. Some folks have been working at this cell design and have made changes thinking that their ideas are better... consequently they have gas breaching (Mixing) ect
!!!! Follow the plans to the tee if you want successful working cells, then after that, build another with your own upgrades (Learning curve). The efficiencies should be just like a good designed series cell (Tero like based).that is close to Faraday.

15 and 29 plate Center tap designs

Scruffy Cell(s)

If you're looking for maximum brute force production, for example as would be needed in a truck application, it has been suggested by Bob Boyce that you use a double 7 cell booster with 15 plates. Connect negative to the center plate and positive to both ends. Normally Bob does not recommend this configuration due to slightly conflicting magnetic effects, but it will allow for higher hydroxy gas production than a single 7 cell unit. Conflicting magnetic is not as much an issue with low voltage boosters as they are with higher voltage systems.



Above is Jeff's (scuffy44) replication of this design

The absolute best and most efficient way to control current in most booster installations is to run the electrolyte at full concentration, and use an adjustable current regulator to set the desired output level. This means it will stay rock-solid at that current and hydroxy gas output level.

You may even be able to connect some current regulator installations to a throttle position sensor which can vary the hydroxy gas output according to instant engine demand. You would not want to try adding too many cells to a booster, as the more cells there are, the more voltage is required for the cell stack. As per cell voltage decreases, efficiency increases, but at a loss of current and hydroxy gas production per cell. Cell warm up takes longer. This may be ok for some installations, but for a big rig you would want to have good hydroxy gas production right away without having to wait for the cells to warm up.

Using +-----_-----+ setup. 6x12" plates laying on their side 6"high,12"long. He made the box out of [Azek PVC material](#) like you used on your EV car. 1" thick. 18' 1x8 was \$80. He tried on the first design to cut grooves for the plates but had too much current leakage. Jeff was in the local AutoZone store buying parts one day and stumbled on to a clear vinyl auto door protector edging. \$3.00 for 2 6" pieces. He bought a couple while there. They fit the edges of the 16 ga. stainless perfect and make a tight seal. After edging all 15 plates Jeff stacked them in the box (very snug fit). He then pressed them together on a row. The distance between plates ended up exactly 1/8" apart. Then clamped and glued blocks of Azek to keep them tightly in place. This left about 1 1/2 on each side for extra water. He filled one side with water to check for tightness. It took about 5 min for water to just start seeping to other side thru the plates. I felt that was good enough for a brute force box. The lid is also Azek 1" thick with a 1/2 barb for a gas outlet. The end plate and center plate have a tab above the cells where I used 1/4 stainless all thread rod to pass through the side of the box for electrical connections. The total box size is 14" long 9" high 8" deep (about the size of a car battery).

The plastic edging goes on the sides and bottom. There is a rubber gas that goes around the top between the box and the top to make the seal. Then the top is clamped down. Jeff made a metal frame bracket out of angle iron that fits around the top and bottom and is pulled down tight with all thread rods similar to Bob Boyces box.



He used two stainless screws through the side of the box at the level that he wanted to maintain the water level. He then hooked a relay to a wind shield washer pump to a separate water tank/bubbler for auto refill. The bubbler/res. tank was a 3 gallon marine gas tank. It fit perfect on the step box of the big rig. When full of water it leaves a very small area at the top of the tank for the gas outlet.

He further states he has tested the Azek to 180 degrees f. with no problems. One morning cold amp draw was 7.5 amps after 6 hours was at 10.9 amps. He has yet to report further but states he will check again at the end of the 10 hour run. If still at 10 amps and he may add a little more lye to get it to 14 amps. 14-15 seems to be best run temp for max production. He used 1" angle metal to make a frame for top and bottom of the box, welded two 5/16 tubes on front and back of frames than I ran 1/4 bolts thru to clamp the lid down on the gasket.

The box is made from a material can Azek. Can be purchased from lumber stores, It's actually a type of PVC plastic that comes in many sizes and thickness. This one is 1" thick 7 1/4 wide materials. Very easy to work with They have a special glue and screws for it. The glue melts the material together. I had the 316l stainless plates sheared at a metal shop 6x12". This is an innovation by using simple to craft Azek for the housing and off the shelf gasket material instead of precise machined slots to hold the plates. This is a very easy to duplicate that most anyone with basic skills can assemble. Jeff's work coupled with Bob's advice has produced a next generation brute force series cell.

Original specs for the clear plastic door protector strips were Autozone part#3800 is probably correct. they are clear strips (they also have in black) Most stores only carry two or three packs in stock at a time. (2 strips per pack).

Summery

7 cell booster with 15 plates

6x12" plates 6"high,12"long.

316L 16 gauge

Quarter " stainless all thread

12 stainless steel nutz

10 stainless steel spring washes

4 quarter inch large stainless steel washers

6" pieces.

PVC material, 1" thick.

Box dimension are 14" long

9" high

8" deep

Jeff states he that it takes two days to assemble. 1day to build box and let glue dry. 1 day to do plates.

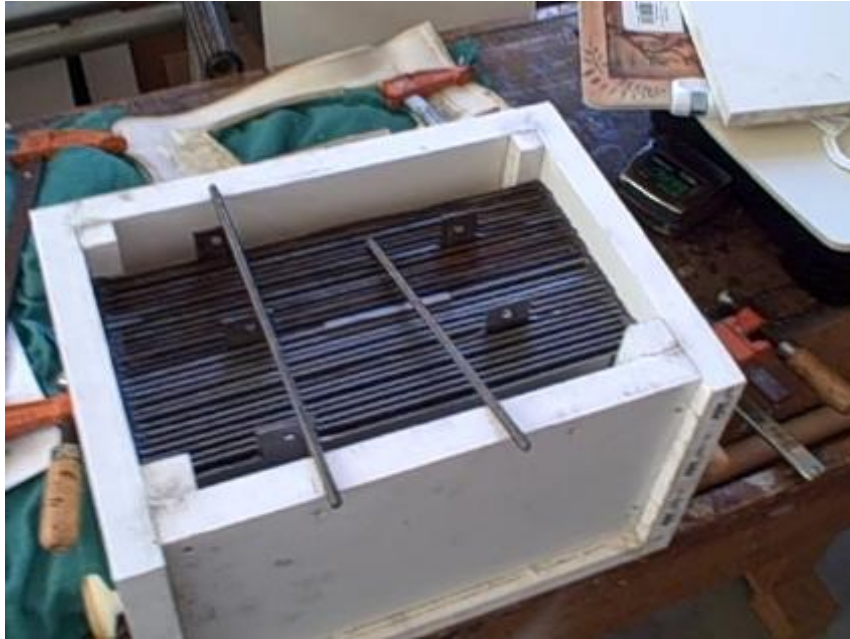
Jeff is hoping to get couple a 2 mile per gal gain which would be a 30-40% increase. If it does the next project will be to build the 61 plate like engineer Larry's (check the hydroxyl forums for this user name) to try for 100% increase close to what he got in the small box truck.

Original testimony: I had a 90% increase with a small diesel box truck (3lpm) I Just installed my second one on a Peter built rig yesterday, it took its first 10 hour run today and I should have the results by Tuesday. The driver did call me the afternoon and told me at the start it was drawing 7 amps and after 5 hours was at 10 amps. The cell was made after Bob's recommendations. –End

The reason why there is a 2 x 7 series cell in parallel is to decrease the current density resulting in an increase in efficiency. They also do this because a single 7 series cell on its own, as we know by now uses 6-7 times more KOH than the 6 series cell equivalent and by placing 2 x 7 in parallel; one now can get double the amount of amps for the same electrolyte strength.

29 Plate variant

What I suggest is a series cell in the same box. +nnnnnn-nnnnnn+nnnnnn-nnnnnn+ with 6x12" plates would this be close to equal output of the Bob Boyce 61 plate box with 6x6" plates with brute force.



For the Quad 7 cell here are a couple modifications all might want to consider:

Use an inch thick clear acrylic lid to observe the reaction and replace the 1/4" threaded rod with 3/8" threaded rod as this cell is capable of carrying much more amperage with greater electrolyte concentration. It is a series cell as the liquid stays about 3/4 " below the top of the plates. Two series cells in parallel (I'm just completing a four 7 series cell, basically doubling the original.) After 10 hour run time temp runs from 85 degrees to 160 degrees. Increasing the size of the all thread to 3/8" would allow higher amp and a cooler cell. The original cell has been in use for about 4 months with no signs of any problems.



I use the azek glue that is made for product. There are also special azek ss screws for it to hold it together while the glue dries over night. The glue actually melts the material together. I would say it would hold up for years. Plate spacing is 1/8". The 3/8" is the all thread bolt size.

For spacers I order from autozone.com part# t3500. I think it is 2.99 for 2/30" pieces. I usually order 20 packs at a time. It is a medium soft vinyl with an adhesive made inside. The scuffy cell only seals on three sides (bottom and two sides The top is open to allow the gas to escape. The water level stays 1/2" below the top of the plates. I cut the edging for the bottom and two sides at 45 degree angles where it meets at the corner. After the plates with edging on I build the box around them using clamps to press the plates tightly together.

I build the back and bottom together first, place the plates in place, add the two sides with clamps glue and screw the sides. After this dries I add the front last by clamping and pressing the plates in place even tighter. The vinyl is fairly soft and not only acts as spacers but seals the plates together very nicely the tighter the better.

I ran mine for two weeks at 2 amps to condition the plates, then Increased solution to 25% to increase amps. I placed a siphon break on the side of the box to break the vacuum during cool down. This will stop the bubbler from siphoning back.

You tube Videos

[Scuffy cell -29 plate quad 7 booster cell](#)

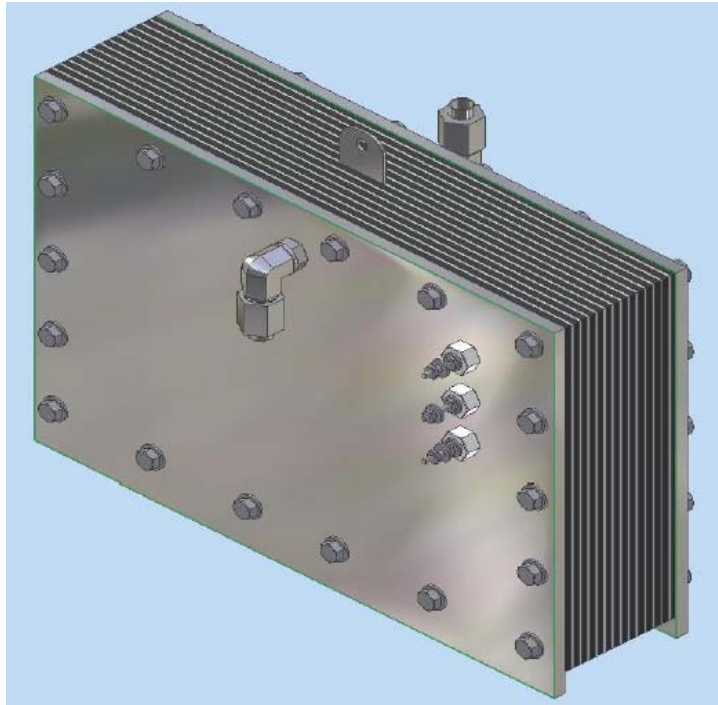
[29 plate scuffy cell testing](#)

The Scuffy III

<http://www.youtube.com/watch?v=DhDK05Kri84>

<http://www.youtube.com/watch?v=7nrKqFzJkD4>

Bill Williams Duplex Lite Industrial Electrolytic cell



[Duplex Lite Industrial Electrolytic cell - PDF](#)

14cell CT Sealed series cell By Dave



This is a Sealed Series Cell (corrected Boyce/TERO cell). Using 8x8 plates in a dual 7 cell design using common Neg center plate and separate self watering system per side. Only the top holes for PROPER Operation have been done. Tero didn't do this with his; he did not want to bother with a proper refill system, so he sacrificed efficiency for convenience.

This cell is NOT designed to be a wet bath or to circulate. When built right it will not have a HEAT problem. When first filling this, it is best to do it Before Install, you fill it with Electrolyte solution to the proper level (about 1" below the holes for Brute force and ~2" for resonant) to get the level even in ALL cells you tip it so the fluid goes through the Gas holes and equalizes. Once the Initial Electrolyte solution level is set and if the cell is working right the level will drop evenly in each cell so you monitor one of them for low / high level and use this to control the pump.

When re filling is required it is done through a water manifold (piece of plastic tubing with a hole drilled between EACH plate to fill the cell chamber) with Distilled water only. Make sure you have a one way check valve on the water inlet to the manifold so it doesn't try to push Hydroxy out and into your water reservoir. I have another method I am working on but it is still in the design stage. It uses the plastic tube from like WD40 and a check valve per cell with an external manifold.



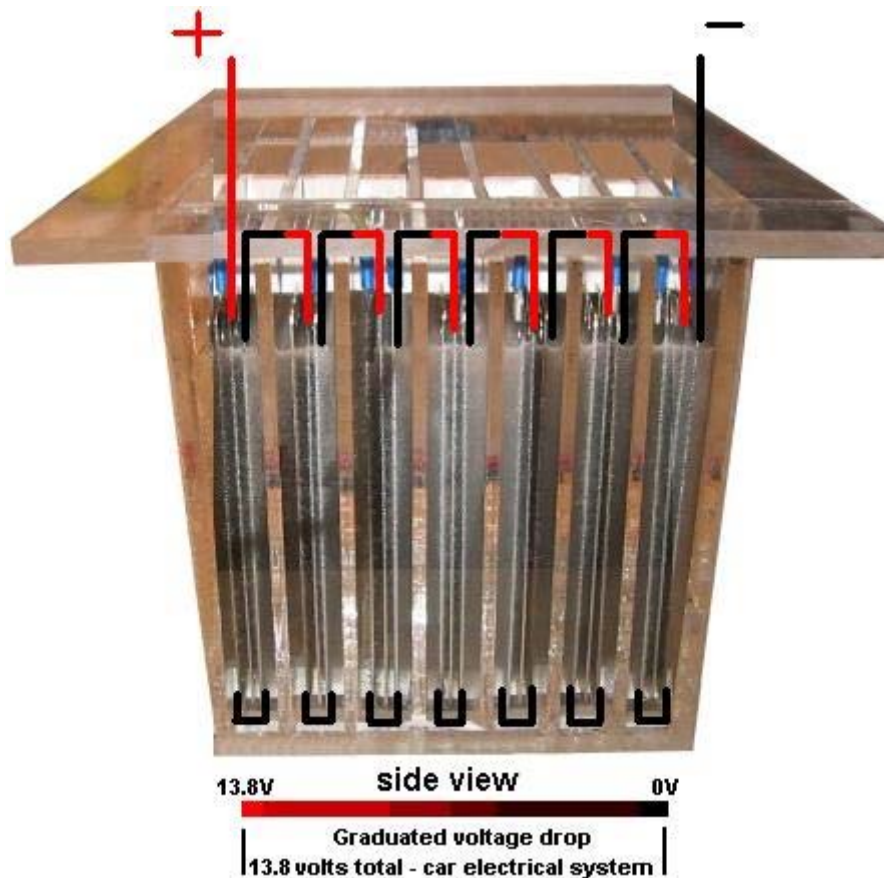






Generic 7 plate series cell design

This is a standard, 7-cell, series electrolyzer designed to have 2 volts across each cell when the engine is running.



Housing

You can make the housing out of plexi glass or acrylic. **Always check you material with the [compatibility site](#).** For example Lexan (=polycarbonate) does not like KOH! Some People are having great results with Acrylic Panels or Acrylic Castings (rated @ ~180°F) using interlocking panels with Capillary Bonding Glue such as Tenax R7 glue.

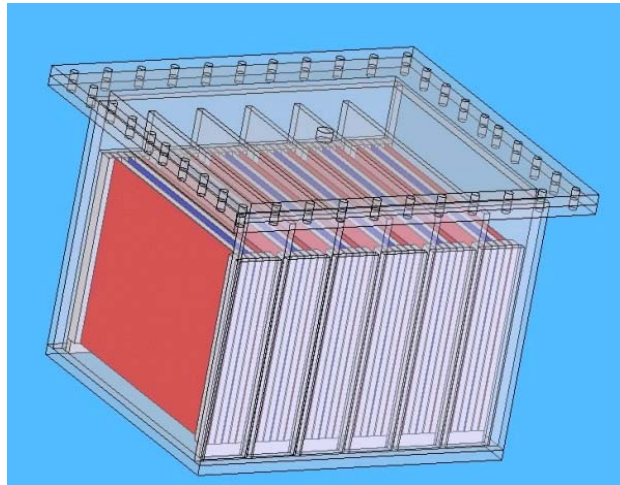
KOH is compatible with these plastics: LDPE = Low Density Polyethylene // HDPE = High Density Polyethylene // PP = Polypropylene // PA = Polyallomer // PVC = Polyvinyl Chloride // PSF = Polysulfone // PMP = Polymethylpentene // FEP - PFA = Teflon // ECTFE/ETFE = Halar/Tefzel // PS = Polystyrene // PVDF = Polyvinylidene Fluoride.

NaOH is compatible with this plastics : LDPE = Low Density Polyethylene // HDPE = High Density Polyethylene // PP = Polypropylene // PA = Polyallomer // PC = Polycarbonate, Lexan // PSF = Polysulfone // PMP = Polymethylpentene // FEP - PFA = Teflon // ECTFE/ETFE = Halar/Tefzel // PS = Polystyrene // PVDF = Polyvinylidene Fluoride.

Sodium hydroxide has a reactive affinity with aluminum and thus can corrode any aluminum parts like heads or pistons if it gets into the fuel line. This, however, is prevented by any simple bubbler, connected along the fuel line and by the design of the reactor chamber and gas storage buffer system. In a properly designed system, NO

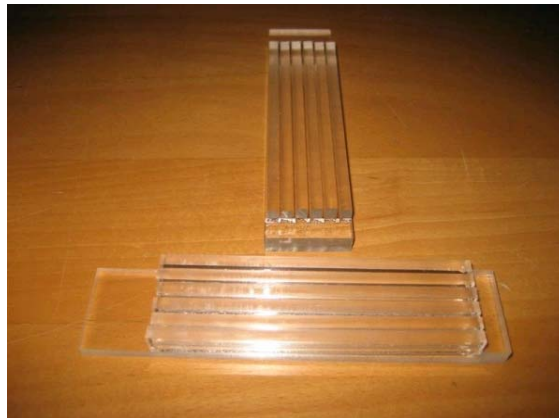
NaOH will get into your engine. In a generic 7 series design, you can make a standard box with pieces cut out for two sides, one base, and one lid. You must make sure you have no leaks. All the machining has to be accurate. Note- Acrylic will become brittle over time. Plexi Glass may be the best option.

Alternate housing designs

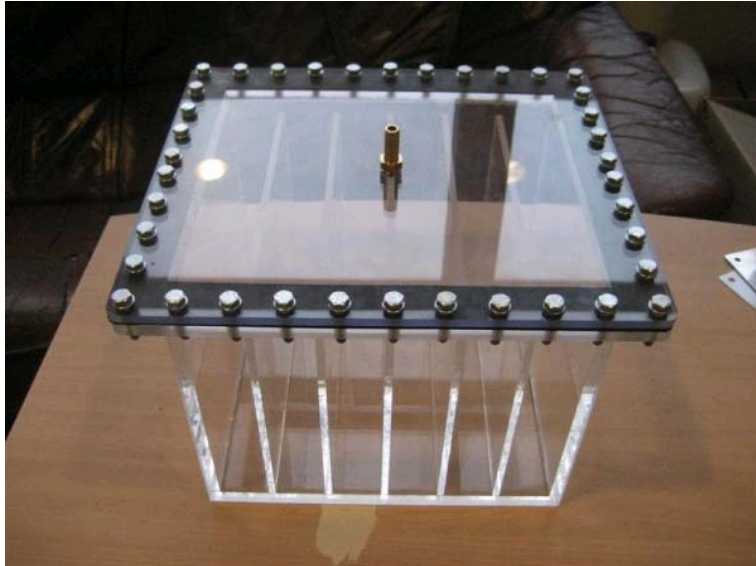


Designs courtesy of Jetijs

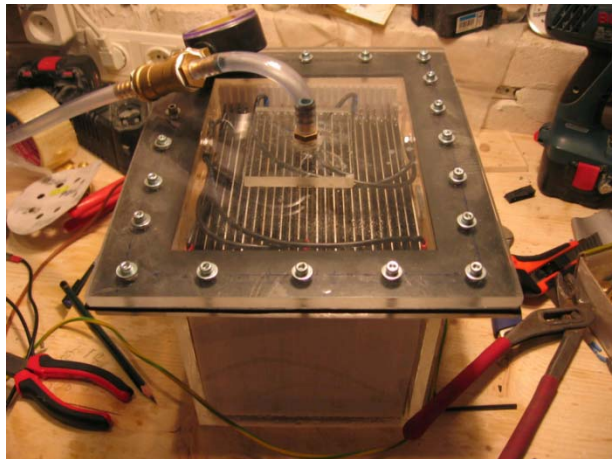
Shown below are simple plate spacers made from plexiglass. This way one can simply slide the plates in each compartment easily and the spacers hold them 3mm apart of each other and about 10mm from the bottom so that the water can flow around.







Completed unit



The plate size depends on the current you plan to use it at, and whether or not you are bothered by replacing plates every year or two. For long plate life, it is recommended to pick 2 to 4 square inches of working plate area per amp. With three 5" x 4" plates per cell, you could use 20 amps which could potentially produce 4 LPM. The plate array would be 7/16" thick (that is 3 x 1/16" for the plates, plus 2 x 1/8" for the gaps) so your cell width might be one inch. Overall case size might be about 8" x 6" x whatever height you want. This is the disadvantage of the design, it has a relatively large footprint and many vehicles would not have space for a case which has an 8" x 6" base.

By skipping the locking nuts and using a press-fit between the partitions, you could get it down to a 4" x 6" sized base, however you are then starting to lose one advantages,

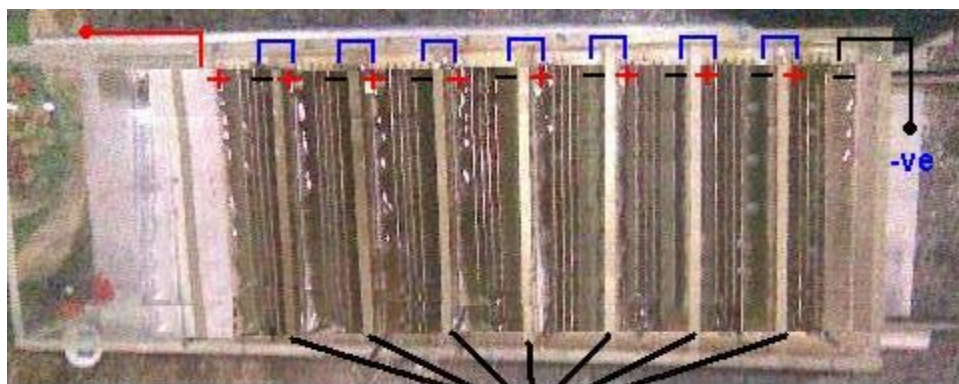
which is that it has no need to be a high-precision piece of construction - just a simple box with partitions (and a really good gasket between the lid and the sides).

For standard in this design, the plates will be 5" x 4" with 20 square inches of area on each face and should be held 3 mm (1/8 inch) apart for optimal gas-producing performance. This is done by using a plastic threaded rod and bolts positioned at each corner of the sheets. The sheets are spaced accurately by placing plastic washers on the threaded rod between the plates. The threaded rods need to be cut to just the right length so there can be a push-fit between the partitions that holds the plates securely in position inside the cell.

The methods of connecting the plates inside each compartment of this cell depend on the number of plates used in each set. A generic choice features two plates per compartment. With two plates facing each other, almost all the electrolysis will take place between the two active faces positioned close to each other. In an example where the plates are 5" x 4", this means that 20 sq. in. of plate area is available for effective electrolysis. Adding in a larger number of plates helps to prevent the bubbles forming on the plates from hindering the electrolysis by masking the part of the plate under the bubbles. It is also estimated that it will also extend the working life of the plates.

8 plate series cell variant of the design

Construction device details: Design of the 8 plate series cell (8th chamber is for current limiting / reduced gas output mode - switchable if needed or not. 8th chamber shorted out runs cell at full power across 7 chambers). Cell construction will look like:



Cell bath isolators

Series cell connection with isolated baths

Each water chamber is separate from the next. There are 8 chambers in this design, 2 of which are shown in the above drawing.

Bubbler

The bubbler for the plate cell can be built in and attached to the side of the housing compartment or housed separately.

Thanks to Jetijs, a bubbler design



The best electrolyte strength for 3mm gap series cell is 28 % (KOH) or 23% (NaOH). Leave at least 2 - 2.5 inch space between electrolytes to top cover. This is to cater for frothing (foam) which happens when electrolyte is cold.

Multi Stacked Larger cell designs

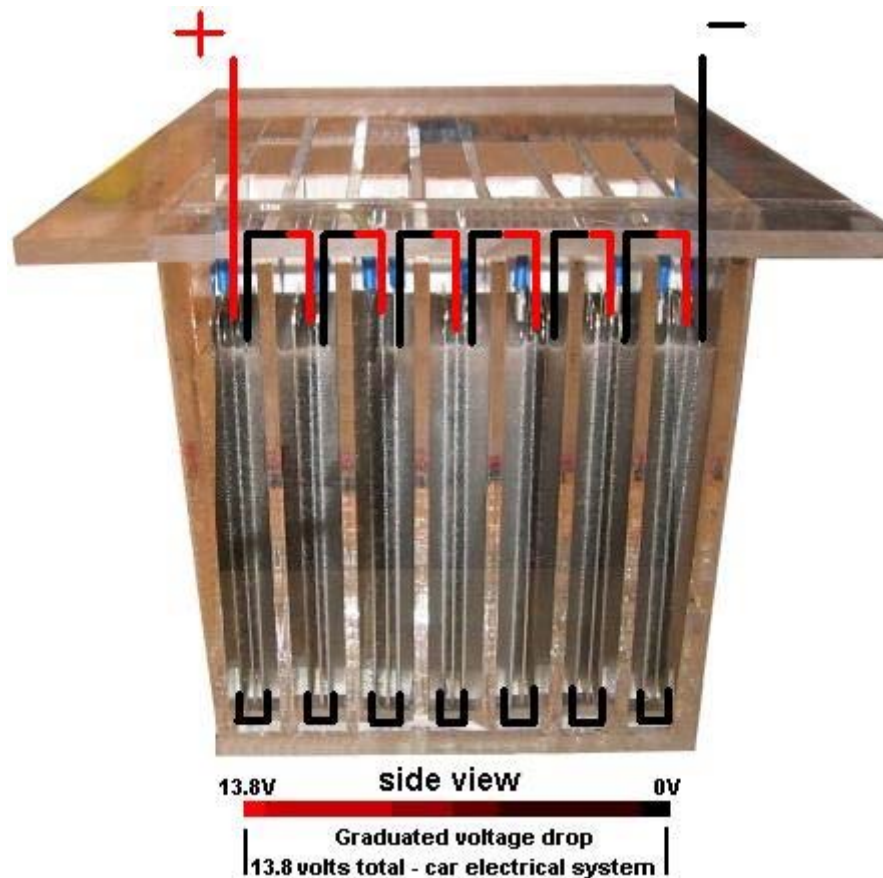
NOTE NEVER ATTEMPT TO STORE HYDROXY GAS- it can self combust between 10-15psi. If you construct a 21 plate (20 cell) unit with minimal leakage and fit it with a 1/2" output

tube, at 22 amps you will get approx. 14 lpm of gas out. As you raise the amperage to 30 the output will increase, of course. If you should get greedy and raise the amperage to around 40 amps it WILL explode. You don't have to believe it, construct it and find out for yourself! The reason for the explosion is the 1/2" outlet tube restricts the flow, builds up pressure and BOOM.

That is all I can say about that for now, except to say, it all depends on the quality of gas you are generating, but IT IS NOT a good idea to try storing Hydroxy gas or putting it under much pressure.

The 7 series cell designs which have been covered earlier are specifically designed to be compact. This was chosen in order to conserve space and manage the electrolyte concentration. You do not need to have a compact 7 isolated series cell if space and adding a larger volume of electrolyte is not a problem. **However it is a trade off, you do not want to have a dangerous caustic amount of electrolyte, and you do not need to build a fairly large unit to get a good boost.** There are many more different styles of cell. Larger cells which contain 61+ plates can be made for a higher gas output.

Additional larger plate cell designs will be covered below. The following tips should be considered. With a separation of the electrolyte between the cell compartments, this cell produces the following series electrical connection.



This is a standard arrangement connected electrically with the opposite sides of a single plate forming part of two adjacent cells. In the picture you can see how the relative electrical connection between those two cells.

1. If it's true series 7 cell, optimal electrolyte strength (28% KOH and 72% distil water). Don't use teaspoon measurement for electrolyte to get exact measurement. Example- To make 1 Kg of a 28% KOH solution by weight, add 280 grams of KOH to 720 cc of water. To make 1 Kg of a 20% KOH solution by weight, add 200 grams of KOH to 800 cc of water. To make 1 Kg of a 10% KOH solution by weight, add 100 grams of KOH to 900 cc of water. The total weight is always 1,000 grams containing whatever percentage of KOH that is wanted.

2. One option is to use double layer (3mm + 3mm) vinyl to increase cell spaces. This will not eliminate the foam (cold electrolyte) climbing to top but could lower the foam climbing height.

3. Parallel series cell design should eliminate foam climbing top problem totally because of larger cell spaces.

4. You need to measure the voltage across the cell and not from power source.

5. Properly conditioned cell should produce much better result.
6. Measure gas output after the electrolyte warmed up to get correct measurement.
7. For series cell conditioning, use less strength (< 10% KOH) electrolyte (< 3A) to conditioned the plate for 3 days. Pour out the electrolyte and fill up with new batch of electrolyte. Again power on for another 3 days and the process repeats until you see the color of electrolyte unchanged or minimal changes. First batch electrolyte will be very dark in color and becomes lighter and lighter in color on subsequent batches.
- 8. White smoking is gas with water vapor and KOH. That is why, Bob Boyce encourage using double bubblers. First is as scrubber and second is for safety**

when operating with brute force DC electrolysis operation all the gas production will be proportional to the current flowing through the cells. Using a standard 12 volt system, the current flow will be determined by the concentration of the electrolyte and its temperature.

When first starting your vehicle, the electrolysis will begin with at a low temperature. After an increased amount of run time the electrolysis raises the temperature of the electrolyte. The heat increase will increase the current flowing through the electrolyser which will create even more heat.

Therefore the gas production rate at start up is lower than the expected total capacity. Also after a considerable run time (4-8 hours for example) a temperature runaway effect can be created where the current gets out of hand. **ALWAYS BENCH TEST YOUR UNIT IN RUN TIMES FOR AT LEAST 5 HOURS AND MEASURE THE TEMPERATURE BEFORE INSTALLATION.**

After your individual cell has given you an indication of how hot it will get after a certain run time. You have some options to address the long run time heating issues. The first option to control current is to use a pulse width modulation circuit, sometimes referred to as a Mark/Space Ratio circuit.

This is a circuit which is designed to switch the power to the electrolyser ON and OFF many times each second. How it effecting gas production are discussed in the faculty section below.

The following design uses an ammeter to show the current, and a PWM Ratio control knob which will be mounted on the dashboard of the vehicle. This circuit will enable the driver to lower the current manually if it gets too high. You are also able to add in extra electrolysis cells (floater or "neural plates, discussed in the faculty section) which will serve both as a way of controlling the current and raising the efficiency of the gas production.

One option is to install extra cells with a heavy duty 12V switch across them. When the switch is closed, the cell is starved of current and effectively is not operational at all. Heavy duty switches of this kind are found in ship chandlers and used extensively in boating for switching engine and lighting circuits. Another alternative is to use a high powered semiconductor to replace the switch and use cheap, low power switches to control the semiconductors.

Ed Holgate Boyce 101 Plate cell Box



PDF - Ed Holgate Boyce 101 Plate cell Box

Open bath flooded cell - mistakenly called a "Dry cell" design

Note when ever referring to this design, please use the term open bath or isolated cell. None are dry! People seem to get confused when someone uses DRYCELL as a term. **DRYCELL is short for (sealed/closed/isolated series/parallel gasket separated plates not immersed in a bath of water where the outside is dry).**

They work better, are more efficient and have way less heat problems probably because the outside is DRY and the CELL is not getting current leakage from plate edges because it's DRY. Heat dissipates from the plate edges. Of course it is Wet on the inside. So I guess we could complicate even more by calling it A Dry outside, wet inside sealed/closed/isolated series/parallel gasket separated plates not immersed in a bath of water cell It just seems so much simpler to say Drycell , 95% of the Hydroxy world uses

and understands the term when it is used . It is recommended for the following to to use 1/8" for standard cells. Use 1/8" for everything with 18g plates.

Dry Cell Theory by Chuck

The theory is simple. We start with this truism. Plates are 3 dimensional they posses thickness. That means they have not 2 sides, but an edge as well, and that has to be factored in to the equation. In a wet bath cell, the entire plate is surrounded by electrolyte solution, and the *entire* surface of the plate is active. The large surfaces between adjacent plates are the "active" surfaces that we focus on but not the *only* active surface.

You see, electricity passes through the edges of the plates, too, and takes a circuitous path towards the next plate, etc. Since the gas is produced (with desirable efficiency) on only the large surface of the plate, the conclusion is that the edges are not useful parts and if possible should be eliminated, since they represent a parasitic loss.

But, how do you get rid of the edge? Someone came up with the idea to use *only* the middle part of the plate, and eliminate the edge from the active part of the cell, entirely. By a creative use of gasket material, he effectively removed the edge from the circuit. Thus was born the dry cell. A dry cell is actually, if you look at it, a series of discrete chambers which are individually flooded with electrolyte. The gaskets hold the electrolyte in the chamber and electrolysis can take place. With extremely tight tolerances, and small gaps, we can achieve very high efficiencies and with no parasitic edge losses. That's essentially how they work.

By Woodpecker

The following information has been donated to Panacea by Peter AKA "woodpecker". Thanks to peter for his effort and time, he has also made them [available in other languages](#) and completed a video walk through.



[PDF- Dry Cell by Woodpecker](#)

You Tube -[How to build a Dry cell electrolyzer English version](#)

<http://au.youtube.com/user/woodpecker1311>

Note -an alternative method for an alternate method for filling can be used that has two holes, one at each end at the same place on the plates. A second fitting on the back is attached to the "fill system" auto or manual that puts fluid in the back and out the front to a "Y" that returns to the reservoir.

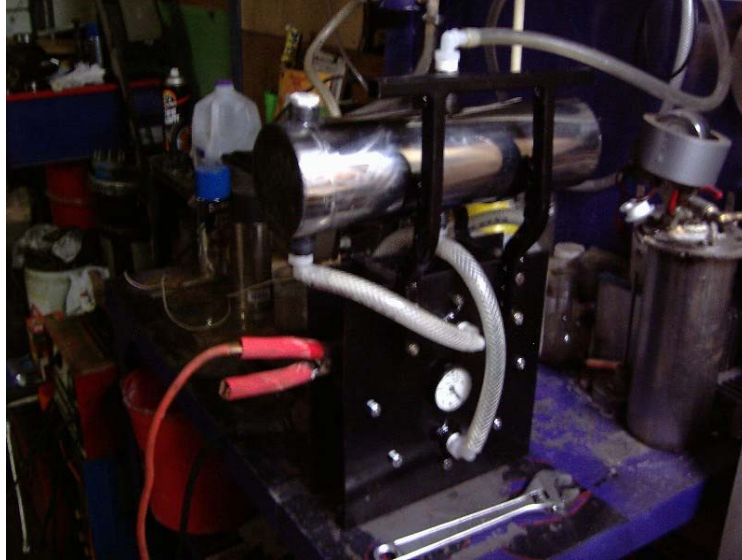
The reservoir will be pressurized and the level is below the booster. The fill will be up to the lip of the gas hole out until it drops below the hole height during use. If a sight glass is added to one end and the pump is run manually, the cell can be tipped to the side during filling and then turned straight after stopping the pump. This will provide the desired gap below the gas out holes.

Without the back fitting it is very difficult to get H₂O into the cell through the outlet fitting. I have managed it with a funnel with a 1/4" tube attached that I was able to extend some distance into the cell. Filling from back to front with the cell tipped will solve this problem. [Mine has a sight glass, but it also leaked so I am changing the clamping arrangement.

With these cell designs please keep in mind, you may have a high water vapor content as the level in the cells is not stable as it is in a constant flux between full flooded and isolated. This change will give very erratic voltage distribution and may also cause "lean" wetting currents. This is a condition where a very thin layer of fluid carries a current that changes the whole volume of the thin layer to water vapor or steam. This effect was used extensively in "flash boilers" in steam engines.

It would be necessary to run his output through a "chiller" and then calculate the volume of the condensate to determine if this effect is present. It would be simpler to just raise the tank higher than the cell to minimize this possibility. If the volume goes down when the tank is raised, it is a dead giveaway to steam content.

Bill William's flooded series design Duplex cell



Keep in mind that this cell has equalization holes and is a flooded series design. **If you get rid of the holes your MMW will improve. The gas output holes will not reduce efficiency as long as the level is not above the holes as well.**

Thanks to Bill for this efficient design. Bill's construction is essentially 2 x 6 series cells in parallel. This is expected to produce 3 liters @ 30 amp, 13.5V, We know that 30 lpm @ 30A, 13.8V = +-94%.

According to Faraday predictions, it should require 2.36 W/lph of hydroxy gas production, when gas volume is measured at STP. At room temperature this figure changes to 2.16W/lph. So 2.25 W/lph is equal to $2.16/2.25 = 96\%$ Faraday efficiency. Bill has bench tested these units and reports:

As far as the test the cells (duplex and single version) and all been tested with amperage setting 30 I and E settings of 14.5. These runs were continuous running of duration exceeding 90 day periods +. The operating temps run in at 110 degrees F. The only attention the units need was water. The electrolyte was set to 10% to 28% by weight (KOH). My water source was from my well(Borehole) and is extremely clean or clear of compounds usually associated, but do to varying waters throughout world I would recommend that others testers utilize Distilled version. The design has not presented itself with thermo runaway, it just stabilizes and keeps on producing Gas.

As far as cleaning the SS floaters and SS Anode I always do a mild Acid dip with HCL with a DC charge to open up the lattice of the SS. Then it's rinsed off with water and picked in NaOH or KOH solution. I have tested sanding the SS and this work very well, but I prefer to Acid dip which not only cleans the material of organics as well as opens up the lattices of the material.

The O ring material of the Single cell version is EDPM and the Oring of the Duplex is Nitrile. So far both have worked out in the long duration testing. Another nice aspect of this design is that the spacing between the plates can be control very simply by squeezing the Oring's more. I generally look for a 1/8 " crush for the typical setup. **In-addition when I first started working this concept I utilized plastic fittings but have changed over to Steel fitting due to heat growth issues.** Otherwise the fittings torque does not change as the device warms to is operating temperature, where as a plastic fitting growth rate is small and a leak could start.

[Bill Williams PDF - download](#)

[DuPlex cell v2.pdf](#)

[Simple Pump Controller Circuit.pdf](#)

Dry Cell Hydrolyzer



[Email](#)

[Web site](#)

Our new Patent Pending design is: EGG+NNNN-GIG+NNNN-GIG+NNNN-GGE using 4 or 3 or 2 or 1 or no neutrals E=End Cap. G=Normal Gasket I=Isolator Gasket +=positive - =Negative the Isolator gasket is a solid gasket with 1/4" holes, 3 at the top for gas exit, 1 at the bottom for electrolyte entry and return. The 1/4" holes are smaller than the GAS or ELECTROLYTE holes in the plates so it restricts the electricity from leaking to the next cell.

The Isolator gasket is sandwiched between 2 normal gaskets allowing that plate to be productive on both sides. This gives a balanced voltage and amperage to each cell and they all heat the same. No more hot spots in the cell center. Running a 4N you get 2 volts per plate. Also with the + amp; - in each cell you have a complete hydrolyzer cell in each stack so you do not end up with 3+ amp; 2- or visa versa. No more overheated unbalanced wires.

The isolator gasket splits the cell into each individual cell and each individual cell gets the same amperage. I have been testing this for weeks and am completely satisfied with the results and am incorporating the Isolators in each of our cells. The Hydroxy is produced in a smooth flow and not in burps and gushes as the old designs. Foam is still present but is much reduced quantities.

Links to other "dry cell" designs

<http://au.youtube.com/user/ebninc>

<http://greengasfuel.com/>

[Amoeba Cell with new no bottom hole reservoir](#)

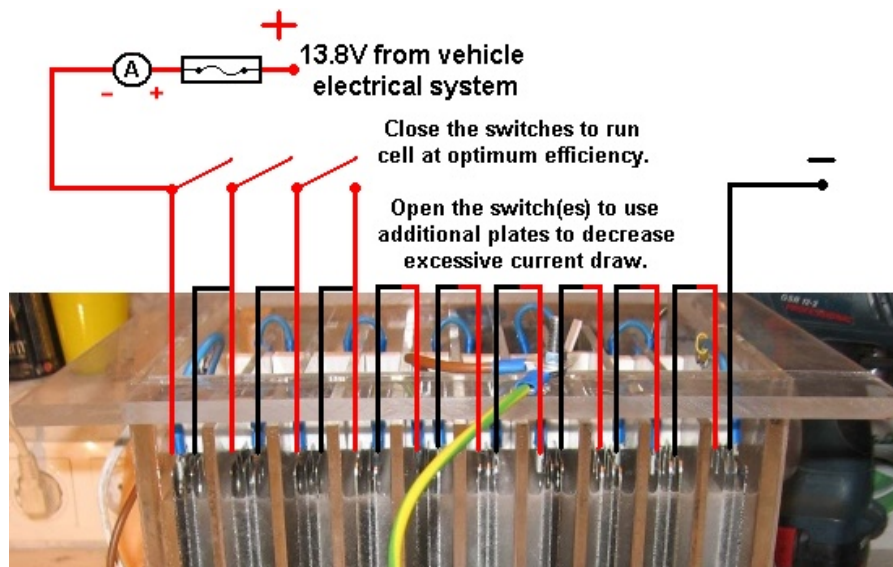
Sid cell how too

http://www.youtube.com/watch?v=s5z4tiW3BPE&feature=channel_page

A method of calculating MMW and factoring in temperature

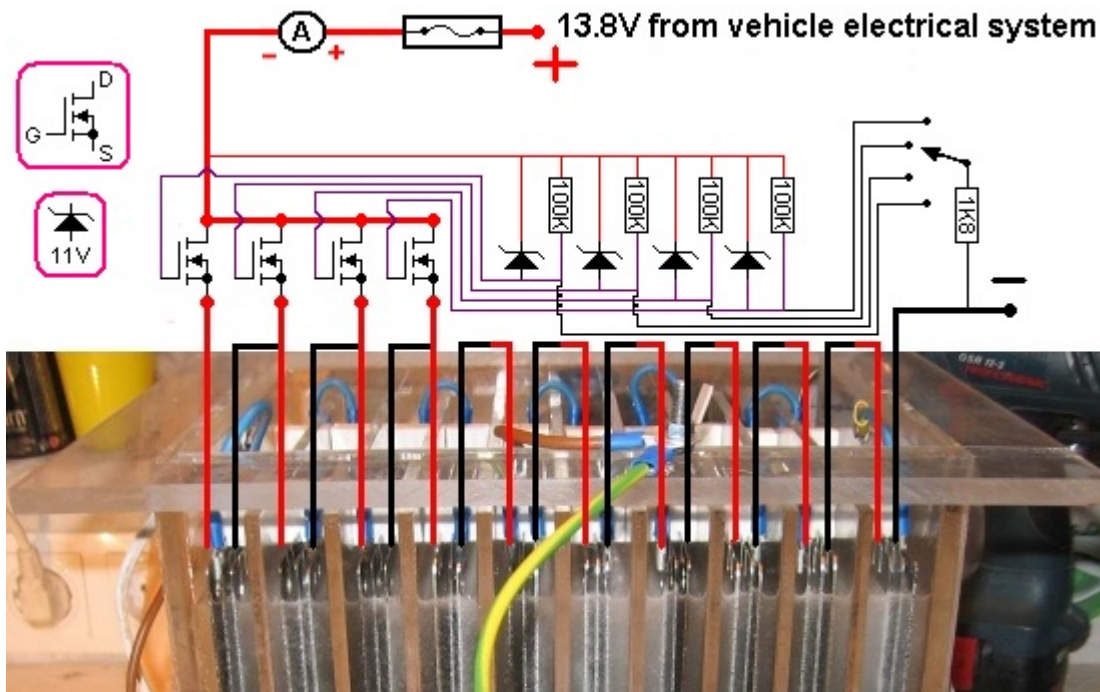
[File – Bob Campbell MMW Calc with Temp Compensation V4.1.4.xls](#)

Heavy duty switching for current control



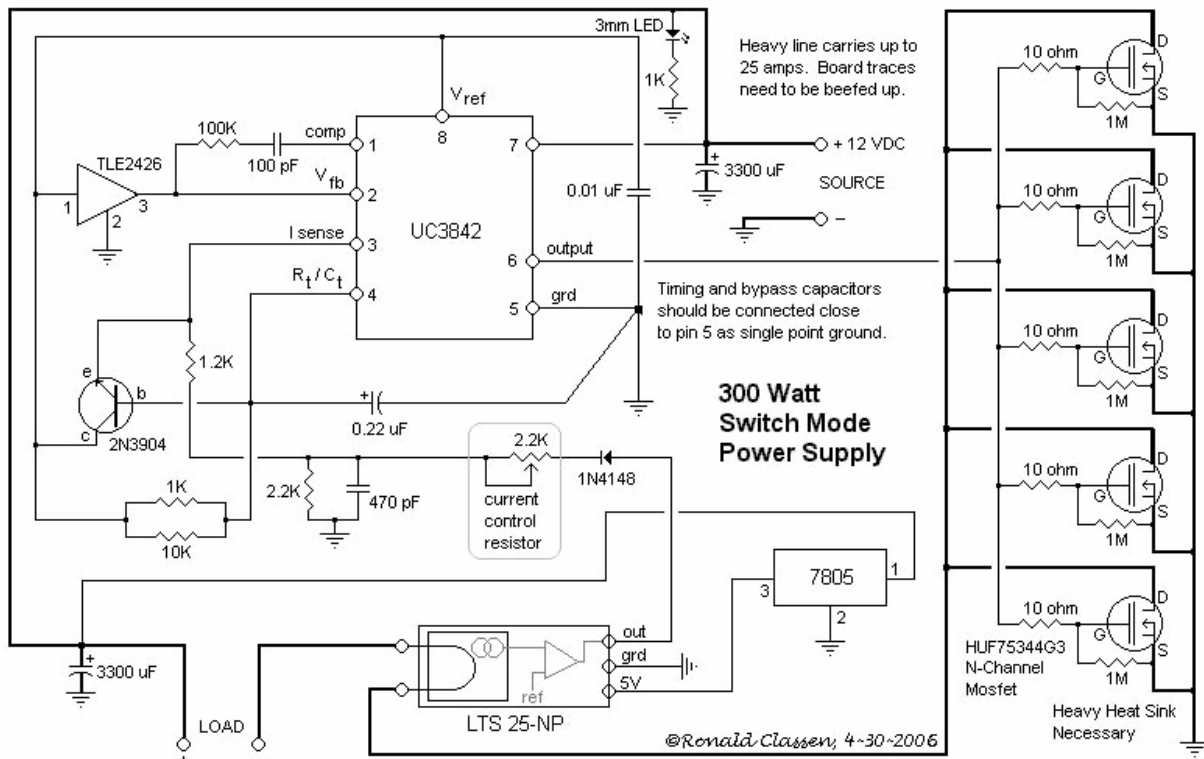
In the first schematic you have three switches and you are adding in three additional cells. This will have one switch per cell. In the second schematic, we will be using the same three switches and it will allow twice as many extra cells to be switched in or off. This switching arrangement is more complicated when driving along with one switch having to be opened and another having to be closed.

In the electronic switching version, the switch arrangement shows a single rotary switch mounted on the dashboard that is used to select the number of additional electrolysis cells to be used. Below a diagram will outline a configuration showing the switching for three additional cells. You can continue it for more cells if desired. There is a practical limit in the rotary switch; this is where twelve positions is the normal maximum for a standard wafer switch. This gives eleven additional cells, more than realistically needed in practice. **The three additional cells are adequate for a good boost.**

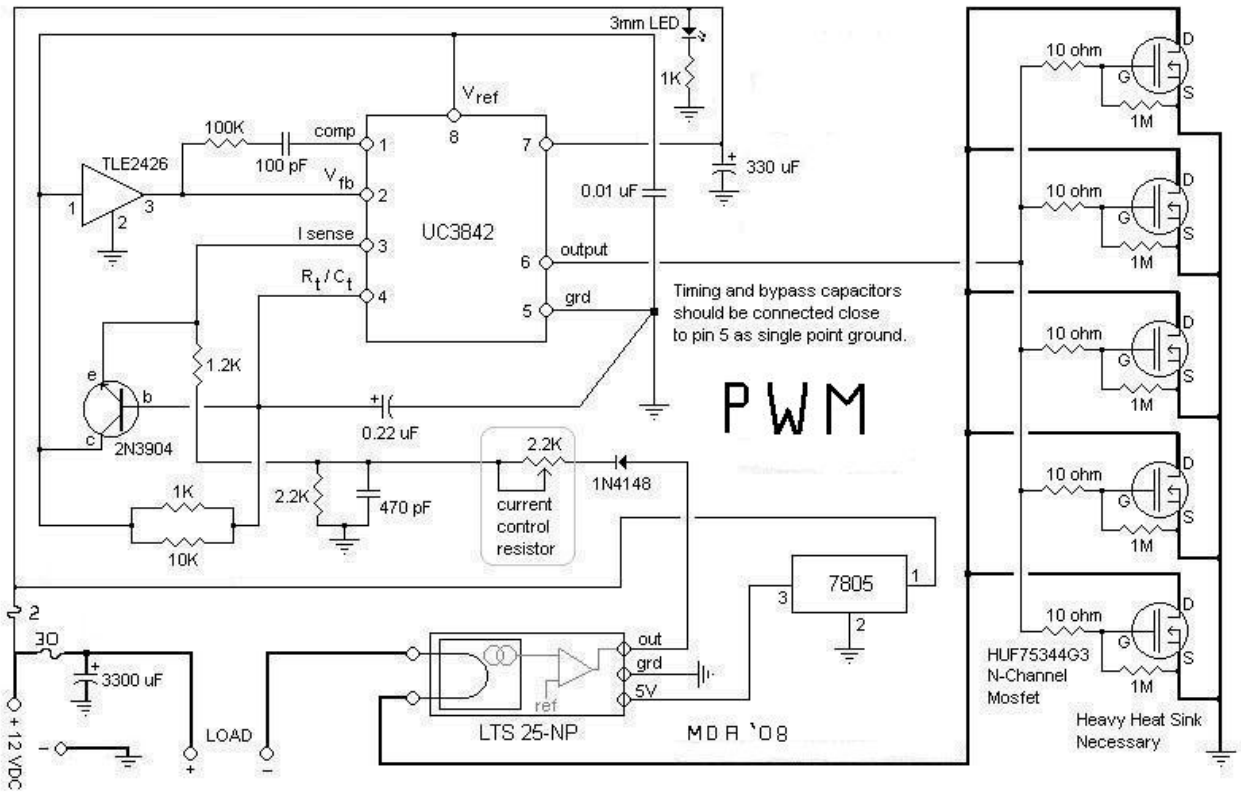


PWM control By Mike and Garret

The following PWM design has a true current control with industry standard parts. The first current device shown in the circuit uses traces on the board for the high current, not Mike's first choice. The following information gives an alternative device that mounts on the board, but monitors the current inductively by passing the high current output wire through the center. No high current through the board traces. You can cheat on the in board device by soldering large conductors to the pins and also take the current "off trace."



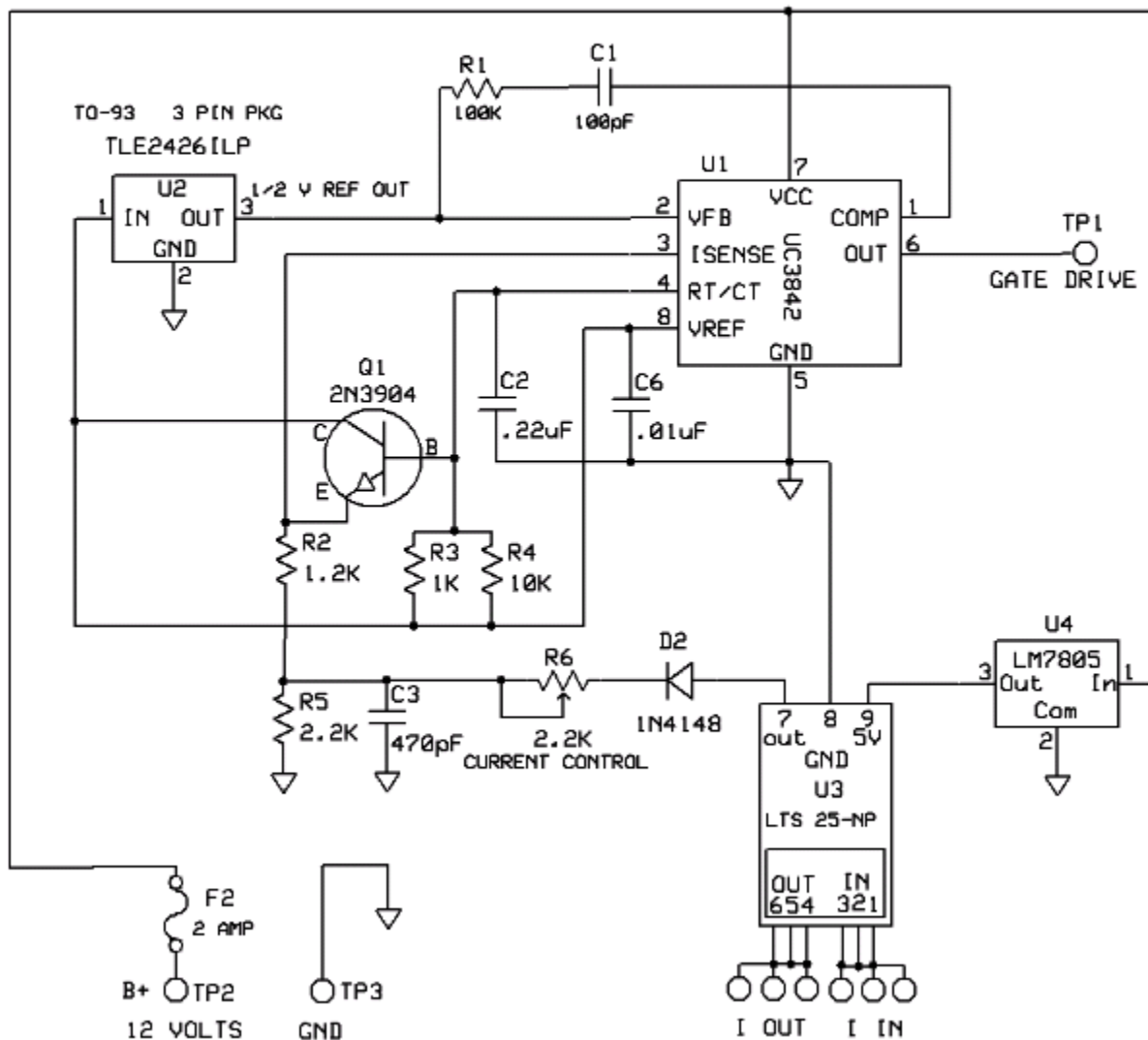
The current [Aug 1 '08] price on the LTS-25 NP is \$20.20 from Digi-Key. The limiting factor is it only goes to 25 amps and is only rated for 85C. This means ckt board in an enclosure and fan cooled, preferably not under the hood. An alternative is the LA 55-P which is only \$25 and does not carry the current in the circuit board. It should be easy to substitute in the circuit. It has the same temp limit but at 50+ amps.



[20Amp Version](#)

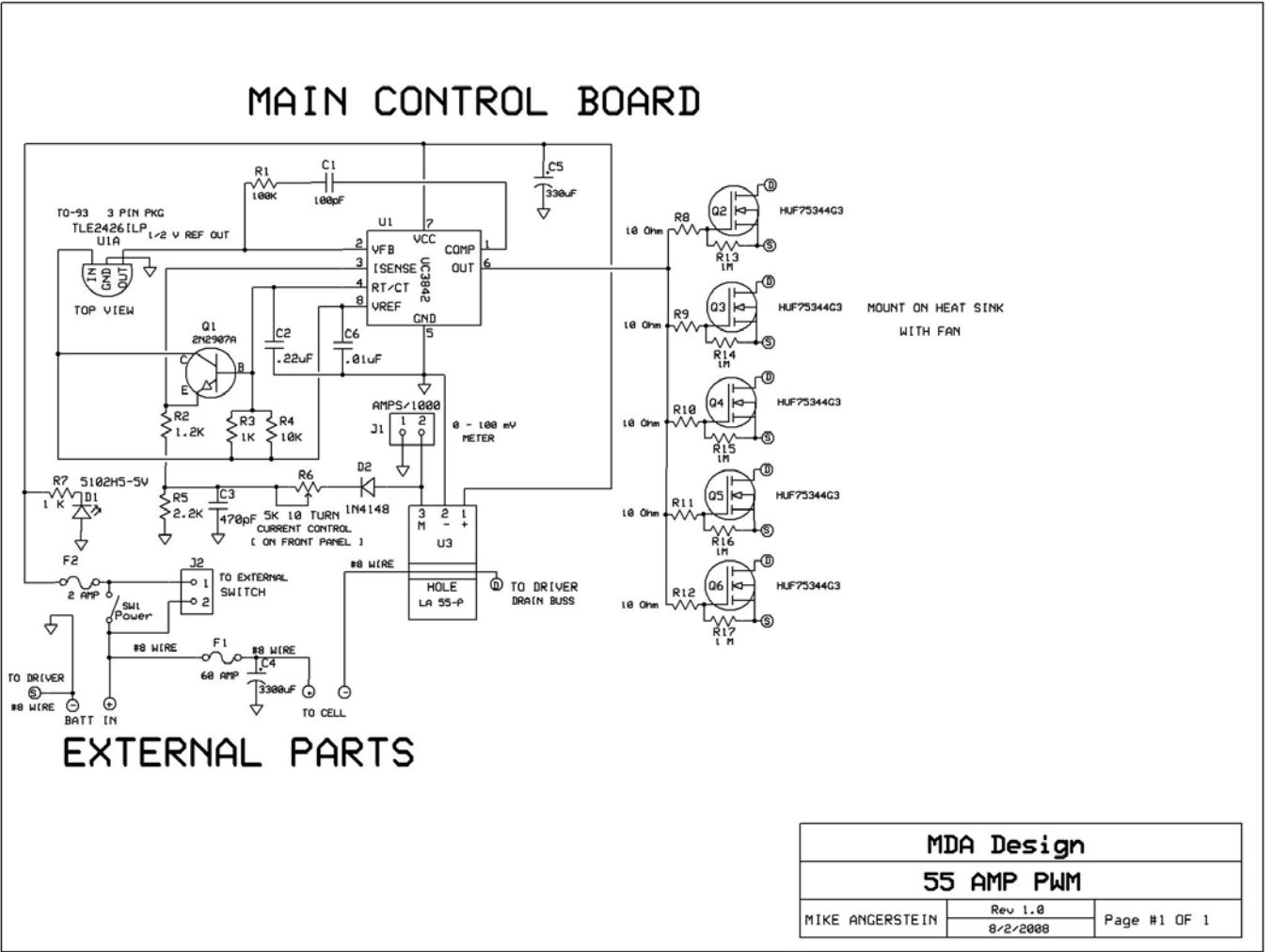
Here is the 40 amp version. Wiring is much easier as no high current traces on control board. The max current for the sensor is 55 amps at 70 deg C, 70 amps at a lower temp.

MAIN CONTROL BOARD



Here is a file with all parts values noted, divided into 3 areas, control board, driver board and external parts. The only expensive part is the current transformer. The 5 parts in the output are each rated at 55 amps, so no problem with heat if mounted on a fan assisted heat sink. Even under the hood!

[40amp version](#)



PWM current limiting from the "Terro Cell" PDF

The best way to limit the current is to use PWM or pulsed DC and to adjust the duty cycle to maintain the average current. A fairly straight forward way is to use a Hall effect current transducer (such as LEM LTS25-NP), which outputs a voltage proportional to the current and use this as a feedback to a PWM controller chip (TL494) to adjust the PWM duty cycle. For the switch FET IRFZ44 (N-channel 17.5mΩ 49A, placed between electrolyzer negative and ground, switched on with positive voltage) or IRF9Z34 (P-channel 140mΩ 18A, placed between electrolyzer positive and battery positive, switched on with negative voltage) may be used.

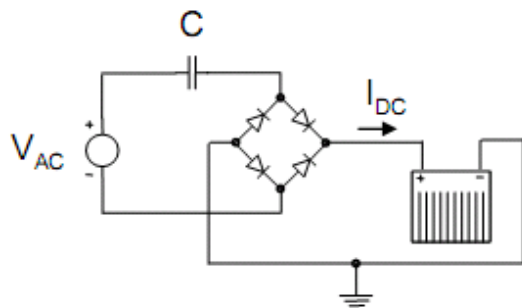
For the PWM controller a readymade DC motor speed control unit will do fine. It usually has a potentiometer to adjust the duty cycle, which can be replaced by circuitry to automatically adjust the duty cycle based on measured current draw. If automatic set-and-forget operation is not required, the PWM controller may be used to control the electrolyzer current draw manually.

For most accurate current limiting the RMS current value may be calculated with for example MX536A or AD536A True RMS-to-DC converter chips. For minimum parts count a microcontroller (e.g. Atmel AVR series) may be used with the Hall Effect transducer output routed to the AD converter input and the duty cycle adjustment and RMS current calculation performed in software. The switch FET may be directly driven with the microcontroller.

Capacitive current limiting

Capacitive current limiting may be used for electrolyzers powered by rectified AC. It is based on putting a capacitor in series between the AC source and the bridge rectifier. The reactance of the capacitor will limit the current to a certain value, but will not dissipate any power like a current limiting resistor.

The capacitor must be suitable for AC use (not an electrolytic capacitor). For mains-powered operation power-factor correction capacitors are the best. This is best suited for welders operating on mains power (no heavy transformer needed) or hydroboosters running on modified alternators (diodes removed). You can use any number of cells (even one), but you need to figure about 2.0V per cell minimum. For 230VAC 50Hz you need about 14uF for each Amp.



$$I_{DC} \approx \frac{V_{AC}}{X_C} = V_{AC} \cdot 2\pi f \cdot C$$

$$I_{DC} \approx V_{AC} \cdot 2\pi f \cdot C = 230V \cdot 2\pi \cdot 50Hz \cdot 100\mu F \approx 7.2A$$

Other current limiting ideas

There is a kit [available here](#) which could be easily modified by using a high current MosFet.



Water fuel for all universal current limiter

Background- There was a question on the Hydroxy forum about the tables with illustrative figures I used to demonstrate the difference between a PWM and a current limiter. Please note that these figures are ONLY illustrative and not an indication of the NaOH/KOH consumption of the WaterfuelForAll booster.

The question was asked how fast is NaOH/KOH consumed and some comment was given concerning current density. In this regard my own experience is that the ultimate factor that determines how fast/slow the NaOH/KOH is being consumed, is the actual water temperature. In this regard I provide below the comment I have given on the Hydroxy forum explaining the current density of the WaterfuelForAll Standard booster and its implications:

In the Tero_series_cell_v1.2.pdf document a good practical current density of around 0.5A/sqr inch is recommended. The main reason why 0.5A/sqr inch is recommended, is because higher current density will lead to hotter electrodes and resulting hotter water temperature. Thus many designs will quickly experience some overheating problems when a current density of higher than 0.5A/sqr inch is used.

In the case of the WaterfuelForAll tubular design, the outer tube serves as an heat exchanger and together with the fact that the design is a true series cell, it does not have the overheating problems experienced with some other designs. For that reason one can afford to run at a slightly higher current density.

If one looks at the current density of our smallest model, the WaterfuelForAll Standard, we have the following current density figures:

In a tubular cell the highest current density is experienced with the center electrode, while it has the smallest surface area. In the case of the WFA Standard the centre electrode consists of a 5/16" rod that is connected to a 1" diameter tube. This centre 1" tube is 6" in length, so the surface area is calculated as follow:

Total area of centre electrode = 6" length x 1" diameter x 3.14 = 18.84 sqr inch

Add area of centre rod = 6" x 0.3125" diameter x 3.14 = 5.888 sqr inch

Thus total area of centre electrode assembly = 24.728 sqr inch

The outer 4" tube is 7.5" in length, so the surface area is calculated as follow:

Total area for outer tube = 7.5" length x 4" diameter x 3.14 = 94.2 sqr inch

The WFA Standard is rated 20A continuous. Thus one can see that at the recommended 20A, the design has a current density of 0.81 A / sqr inch for the smallest electrode and an average current density of around $20 / ((24.728 + 94.2) / 2) = 0.34A / \text{sqr inch}$, taking into account that we have equal spacing between the intermediate tubes.

So the average current density of 0.34A / sq inch is even lower than the recommended 0.5A / sq inch.

(Also note that the wall thickness of the electrodes is 1.5mm (0.06") which is thicker than many other designs, so one should actually compare the volume of the electrodes as well, thus if we want to be 100% accurate in our calculations, we should look at cubic inch). More important than the current density on its own, is to measure the water temperature after several hours of operation.

In the case of the WFA Standard, when tested on a bench, the water temperature will stabilize at between 70-73 degrees Celsius, and can run so for many hours uninterrupted without overheating.

It is important to note that that is the stabilizing temperature when stationary with no air flow to aid with cooling. When the booster is properly installed, the stainless steel outer tube acts like a radiator and while the vehicle is moving the stabilizing temperature can be much lower than the 70-73 degrees Celsius. (Typically you will find that the WFA boosters run between 55-65 degrees Celsius during real time driving conditions.) As an additional benefit, the 1.5mm (0.06") thick stainless steel tube makes the WFA booster arguably one of the safest (if not the safest!) boosters on the market! In fact, the tubular design is so strong, it can even withstand a back-flash on its own if a bubbler is not present or has failed.

So one can see that in this case, the current density of 0.81A / sq inch for the smallest electrode and an average current density of 0.34A / sq inch is indeed not too high, which is proven by the water temperature stabilizing. Obviously, nothing prevents one from increasing the length of the tubes to bring the current density further down, but by the end of the day the grade 316 stainless steel is the most expensive material of the booster and while the water temperature stabilizes, we have found it overkill in the base model to use longer tubes.

Note that the WFA Deluxe and Super Deluxe models have indeed longer tubes, but are obviously more expensive.

So I have explained that the current density contributes to the water temperature and as long as the water temperature is not too high, we are ok! The water temperature after 4 hours of operation is a more reliable measure to ultimately determine if our current density is too high or not. One cannot only look at the current density because I know of several open bath booster designs that run at a current density of close to 0.5A / sq inch, yet they will overheat even after less than two hours of operation!

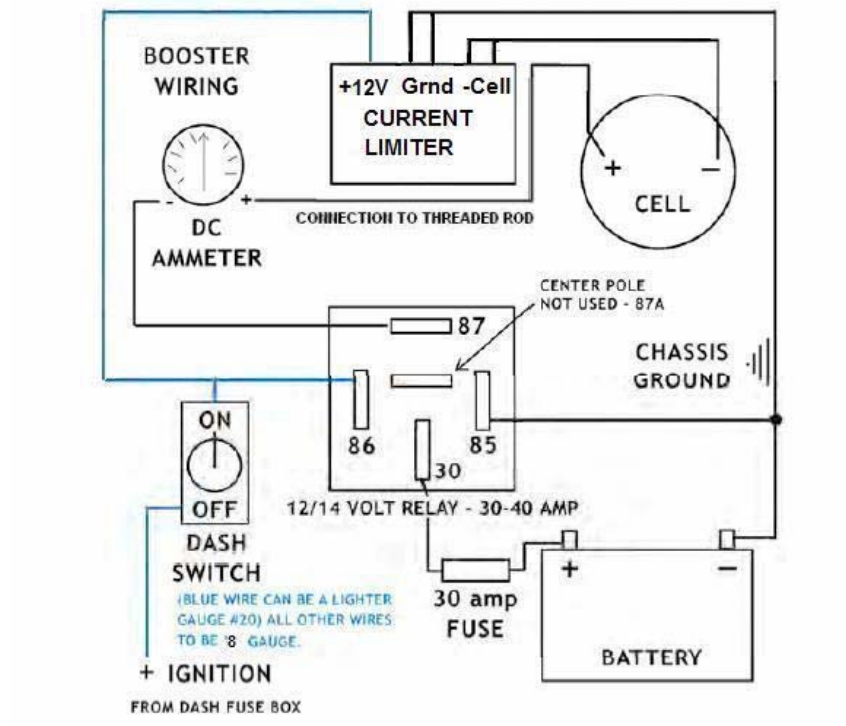
With regard to the consumption of NaOH/KOH, the higher the water temperature, the higher the NaOH/KOH consumption will be. In my own testing I have experienced exponentially increased consumption of NaOH/KOH if the water temperature goes above 75 degrees Celsius, so I would strongly recommend that one always choose a

design where the water will not rise higher than 75 degrees Celsius after 4 hours of operation.

Note that the figures that I listed above about the decreasing current because of the NaOH/KOH being consumed is only illustrative to show the difference between a current limiter and a PWM and these figures are NOT real-time figures for the WaterfuelForAll booster. Coming back to the current limiter and the reason why I am releasing this circuit.

It must be noted that the WaterfuelForAll tubular design is a true 6 series cell design and as such it does not have any overheating problems, thus it actually does not need a current limiter! In fact, while the outer tube is made of stainless steel that serves as a heat exchanger, the WFA standard can run for several hours continuous without overheating. In other words, the current limiter is a "nice to have" for the WFA booster, whereas it is almost a "must have" for open bath designs. The main reason why I am releasing the current limiter is for heavy duty applications, e.g. trucks, where the user wants to run his WFA booster day in and day out continuously. Then the addition of the current limiter makes the booster indeed much more user friendly.

Also, this current limiter is indeed UNIVERSAL. So the current limiter can typically help users of open bath designs to control their current and prevent overheating. So the current limiter can be used by ANY brute force booster.



Kits will be available at <http://waterfuelforall.com/orderform.htm>

Yikes Plate Cell

Please note the Yikes cell is not suitable for a beginner's cell. The "Yikes" cell is based on 2v current which we all want. He states a 1.24 voltage came from recombining h and o, therefore in a perfect world that should be the voltage needed to separate them. But it was found that an additional .47 volts was needed to kick start the action. (Personal note: I think that 1.73 will be the magic number when we find the system). At that voltage production is low but efficiencies are high. Hovering around 2 volts per cell is where production gets going.

Your car runs 14V from the alternator, if you put 8 plates in a row you will have 7 cells, (7x2V=14volts) lets call the 7 cells a group. You can add lots of groups, ie: +nnnnnn- nnnnnn+nn.... and so on. Each group needs electrical connections. 8 groups would be 57plates with 9 electrical connections. The biggest challenge is to seal the cells from each other, for true 2V operation.

The Yikes cell is described as a: series, using floating (or "neutral") plates, arranger in multiple sets in parallel. This can be illustrated by the following, take the Smacks booster cell as an example:



This is in fact two series cells ran in parallel. The plate configuration goes like this: + N N N N N N - - N N N N N N +. N being neutral. Now if say for instance you took 18 plates and did something like this: + N - - N + + N - - N + + N - - N +, then this would be in fact 6 individual cells using a neutral plate in each connected in parallel. So in other words for every instance of a + and - this is considered a cell. So if in the case of the Yikes configuration this is in fact six series cells in parallel.

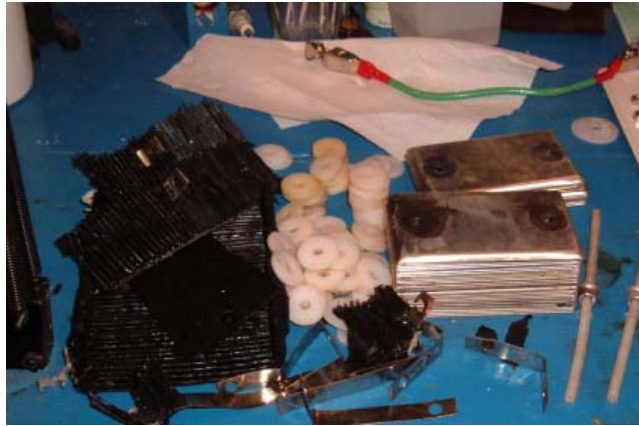


He states the plates are configured as follows:
 PnnnnnMnnnnnnPnnnnnnMnnnnnnPnnnnnnMnnnnnP with the p=positive, n= neutral, and m= negative. If the Yikes booster were in fact a true series cell then it would only have one positive and one negative connection i.e. Bob Boyce's series cells.

Original instructions

Those are SS electric blanking plates (kind of like switch plates but without the hole for the switch), Lowes \$1.63. The 1/4" plastic threaded rod is from graingers \$2.50 and 1/4" x 1.5mm nylon washers \$6.00/100. The straps are stove pipe clamps \$1.79 Menards. SS

nuts (4) and bolts (2). Also get sodium hydroxide which is red devil drain cleaner \$4.00. 1 tsp per gallon of distilled water to start. You will want a plastic box to put it in.



41 Plates, 7 stove pipe clamp straps (3 neg. and 4 pos.).

The electrical part is pretty straight forward. I spliced into a switched 12v wire to the window wipers, then I put in a switch by the driver so I could turn the booster on/off when I wanted. That wire then went to the engine compartment (run 2 or 3 wires while you are there, they may come in handy later) to a relay (a relay is an electrical switch used so that you don't have to have large wires running very far).

The relay has 4 connections (two for the small wire and 2 for the large wire. 1 small wire has 12v, 1 small wire goes to ground. 1 large wire has 12v coming from the battery, the other large wire goes to the booster. The large wire coming from the battery first goes to an ammeter (not necessary but nice to have) then to an ordinary house circuit breaker 30amp then to the relay. I use 4 gauge wires (overkill). You will need lugs for that wire to make connections.

The booster: here is the cute part of a series booster. Not all the plates are connected with wires. The water carries the current to most of the plates so that you don't have to. So the first plate is connected to the negative, the next 5 or 6 plates are not connected to anything, the next plate is connected to the positive. The next 5 or 6 plates are not connected to anything, and the next plate is connected to negative. You just continue like that. I say 5 or 6 neutrals because you have to make that call. 5 will give more liters per minute but will have heat issues. 6 will not heat up but will not be as productive. Here is how I put together a booster that put out 3 to 5 lpm at 17 amps.

P=positive M=negative N=neutral, no connection
PnnnnnMnnnnnnPnnnnnnMnnnnnnPnnnnnnMnnnnnP

Notice the 4 center stacks had 6 neutrals; the 2 outer stacks had 5 neutrals. The outer stacks created some heat but not too much. Overall is a good booster and the

inventor states he has never had a problem. It does not make any difference which (p or m) you start out with.

The build: cut two plastic rods a little longer than what you want. Put a SS nut on one end. On one rod put a strap (the pipe strap, you must drill a 1/4" hole on both ends, and measuring is a little tough. Drill through the strap into a piece of wood or the bit will grab the strap and WILL cut you. hmmm, how do I know that??) Then slide on a SS plate (you will have to drill out the hole to 1/4" and grind off the remaining lip), then 2 nylon washers on each rod,, this gives a 3 mm space, then put on the next plate and then 2 more washers per rod.

Keep going until you get to the plate that needs an electrical connection. You just put on a strap before you put on the plate, but the strap is on the other rod, so that you end up with all positive on one side and all negative on the other side (see pic). Keep going until you are done. I then seal all the plates (except the top of course) with 3M window weld (napa \$13). You must not have any water leaks (easy to say, tough to do the first time) Let it dry 2 days.

Put it in your box (put the bolts through the straps and through a 1/4" hole in your box sealed with plumbers goop (Lowes \$4). Washer and nut the bolt tight, put on your electric wire from the relay to the positive side and run a wire to ground on the other side. Fill with solution and turn it on. It will take 2 weeks for the booster to get up to it's potential and you will need to refill with water once a week,,,,but you will piddle with it daily so it's not a problem.

After 4 weeks your booster will become just a tool that you use and life will settle down again.

I use 3/8 nylon tubing and fittings Lowes \$1.50. Put a 90 degree angle fitting threaded into the box sealed with goop and barbed on the other end. Tubing goes to a bubbler. I use a 1" ID clear tubing about 8" long with bushing reducers 1" x 1/2" shoved into the ends Lowes \$.79. Nylon barbed to threaded fittings screw into the bushings. Tubing leaves the bubbler and goes to a fitting that is put into the rubber hose that is between the maf (mass air flow) sensor and the throttle body. We do not put it in after the butterfly in the throttle body because the vacuum there would take some of the HHO to the brake booster. Accumulations of HHO in the brake booster will eventually go bang.

This bubbler is extremely important. This is the only protection that will always work. There has not been a better method found. The bubbler is filled with plain water. HHO will come through the tubing and bubble through the water in the bubbler which cleans off the very small amount of NaOH which surrounds the HHO. Without the bubbler that NaOH would get into the metal in your engine and WILL attack any aluminum. If a backfire occurs the water will stop the flame from getting back to your box. That's

about it. I welcome questions to clarify any part of this quickly written outline. Original pictures are posted at : <http://s180.photobucket.com/albums/x171/mryikes/booster/>

The Terro Cell Design

Please note before starting this design – it has been reported that he did not care about power efficiency. He chose to push his test cell way over normal voltage and current for maximum production in minimum space, NOT for maximum efficiency. **He ended up doing modifications that sacrificed efficiency in return for convenience.** Reports given to us that the result was a lot of hydroxy gas, but also a lot of steam production, gasket failures, electrode erosion, all the stuff that the original design was designed to avoid. If you drill holes in the plates of series cell you are in danger of getting this result. **DO NOT DRILL HOLES IN THE PLATES OF SERIES CELLS! Be aware that making a hole at the bottom of the plate for water leveling is reducing the efficiency of the system.**

It has been suggested by some that the electrode erosion has nothing to do with the hole at the bottom of the plate but it is simply on the surface area of the plate to handle the applied current. Either way please be aware that efficiency is lost do to the holes that simplify the design. If someone is willing to lose efficiency to make something that is slightly easier to build that should be there choice as long as they know all the facts.

If you are going to make a series cell you should go the extra half mile and make it a true series instead of a leaky series.

In the Terro Ranta design, the electrodes can be cut geometrically perfect by guillotine shear. This leads to faster production and reduced cost, as there are many companies that will cut small quantities of electrodes with minimum lead time. Stud holes and gas holes will have to be made on a drill press.

This is the original text taken from the “Terro” document. We have since upgraded it with a better choice and stainless steal. The electrolyzer shown in Figure 1 is based on the common-duct series-cell electrolyzer concept originally developed and patented by William Rhodes, Ernest Spirig, Yull Brown and later refined by Bob Boyce, George Wiseman, etc. It uses an alkaline (NaOH, KOH) electrolyte to split distilled water into hydrogen and oxygen components very efficiently.

The produced hydrogen and oxygen gasses are not separated to separate containers, but kept mixed. The produced oxyhydrogen gas is a stoichiometric mixture of hydrogen (2 parts vol.) and oxygen (1 part vol.) and can be combusted in vacuum.

The combination of series-cell topology is very efficient, because it allows the cells to operate as close to their optimal cell voltage (1.47V) as possible. The electrolyzer runs fairly cool, at about 30-50 C depending on the current and electrolyte.

The electrolyzer shown in this report has about 80-90% total efficiency when all things are considered (ambient temperature, ambient pressure, accurate measurement of gas volume and current) when powered by straight DC. Pulsing (PWM) or modulation of the input voltage waveform could increase the performance further, as it is known that in the beginning of each pulse larger current flows than in the steady state condition, thus lowering the cell voltage needed to push thru a certain amount of current and increasing the efficiency slightly. There are also claims of various resonance phenomena (Boyce, Meyer, etc.) that supposedly dramatically increase the gas production rate vs. input current when the electrolyzer is driven with a certain type of PWM rich in harmonics. However, this author has not been able to replicate any resonance modes in any sort of electrolyzer.

The electrolyzer has 7 cells with a target input voltage of about 12.9-14.1Vdc depending on temperature. This makes the cell voltage about 1.85-2.0V.

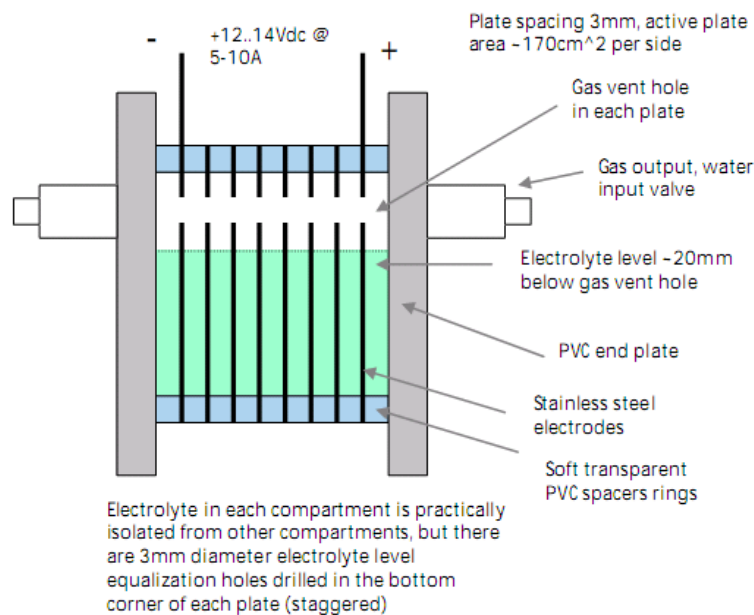


Figure 1. Series cell electrolyzer cross-section

The eight electrolyzer plates are about 0.8mm thick 160mm x 200 mm stainless steel (original stated 304 grades however it is recommended that you use 316L). A 10mm gas vent hole is drilled in each plate. The electrolyte level is always about 25mm below the gas vent hole. There are 3mm diameter liquid level equalization holes drilled in the bottom corner of each plate (not shown) in such a way that adjacent plates have holes in opposite corners. Staggering and using small holes minimizes any efficiency loss

due to current leakage between cells, but makes electrolyte refilling and level equalization significantly easier.

The two end plates have a small SS piece welded for electrical contact. After taking the picture the plates were sanded with an orbital sander to expose clear metal and then cross-hatch pattern was "engraved" on the plates with a rough file attached to a wooden block. This is to increase the active surface area of the plates and seems necessary for ultra high efficiency. Other methods to increase plate area exist as well.

Note on plate preparation given by Bob Boyce. Make sure you properly prepare the plate surfaces prior to assembly. And make absolutely sure not to contaminate the plates with any type of solvent or cleanser. The first several times that Tero assembled this design given to him by Bob Boyce, he made those mistakes. Instead of following Bob's instructions exactly, he thought that the plate preparation advice in George Wisemans book was better, so he used that. He met failure over and over, little to no hydroxy gas production. Of course, he did not tell me this for a long time, and he questioned the validity of Bob's design. It wasn't until after he told Bob he was using the George Wiseman book for plate prep instructions that Bob found out why it was failing. Bob told him to go back and read his instructions, and follow them "to the letter" this time. When he did, the unit began to work as it should. If you want something to work right, follow the right instructions. There is a reason why George Wiseman's units cannot even reach near Faraday efficiency!

Make sure that you do not follow Teros later experiments, which involved drilling staggered liquid equalization holes in the plates. That led to losses of efficiency that crippled the unit from ever breaking Faraday performance levels.

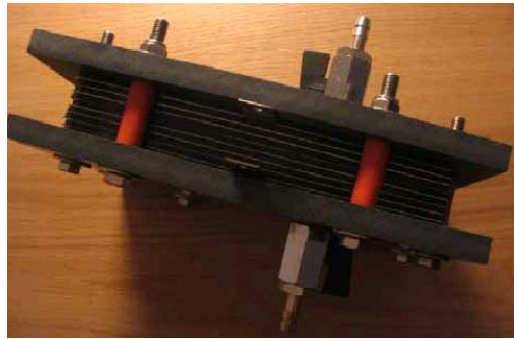
If you must store mixed electrolyte, store it in an airtight container. NaOH and KOH will absorb carbon (CO₂) from the air, which will poison the catalyst layers that form on the plates, lowering peak efficiency. Never vent your cell in a manner that will allow ambient air to enter.

Nine spacers were cut out of 3mm thick soft and transparent PVC sheet with a knife. The wall thickness is 12mm. The PVC sheet is originally designed for door material for large room-size refrigerators. The small square PVC blocks were meant to keep proper distance between SS plate centers, but they turned out to be unnecessary and were not used.

The end plates were cut out of 12mm thick PVC plate. The size of the plates was 200mm x 240mm. Eight 8mm holes were drilled for M8 size stainless steel through-bolts. A ¼" pipe thread was tapped in a 11.8mm gas vent hole. A valve and gas hose connector was epoxy glued to the ¼" tapped hole in both plates. Other thread sealants may not be compatible with the electrolyte so it's best to use epoxy or teflon tape. The valve was lined up with gas vent hole in SS plates. NOTE: When the electrolyzer stack is tightened

up the PVC end plates tend to bend and bulge. Some form of metallic bracing should be used to prevent bending or the end plates made out of thick stainless steel plate.

The finished electrolyzer is shown below. The two PVC end plates are clamped together with 70mm long M8 stainless steel bolts with Nyloc nuts. After initial tightening the electrolyzer was submerged in hot tap water (about 60 C) with the gas vent valves closed. This softened the PVC gaskets and allowed the stack to be tightened up even further to provide an excellent seal. Note that the 12mm PVC plates are quite soft and some bulging is visible. Two additional bolts would have been useful to equalize the bolt forces more evenly around the plates.



The finished electrolyzer equipped with a bubbler is shown below. The bubbler is absolutely essential to prevent backfires from blowing up the electrolyzer. The electrolyzer may be filled with slightly acidic water (use vinegar) to neutralize any residual NaOH vapors in the output gas. It would be wise to use a non-return valve between the electrolyzer and bubbler to prevent bubbler water being pushed back into the electrolyzer in case of backfire.



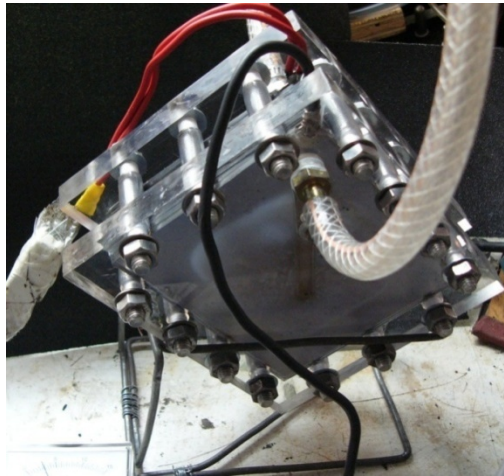
[Videos- Terro meets Bob Boyce](#)

Bro Andrew Plate cell design

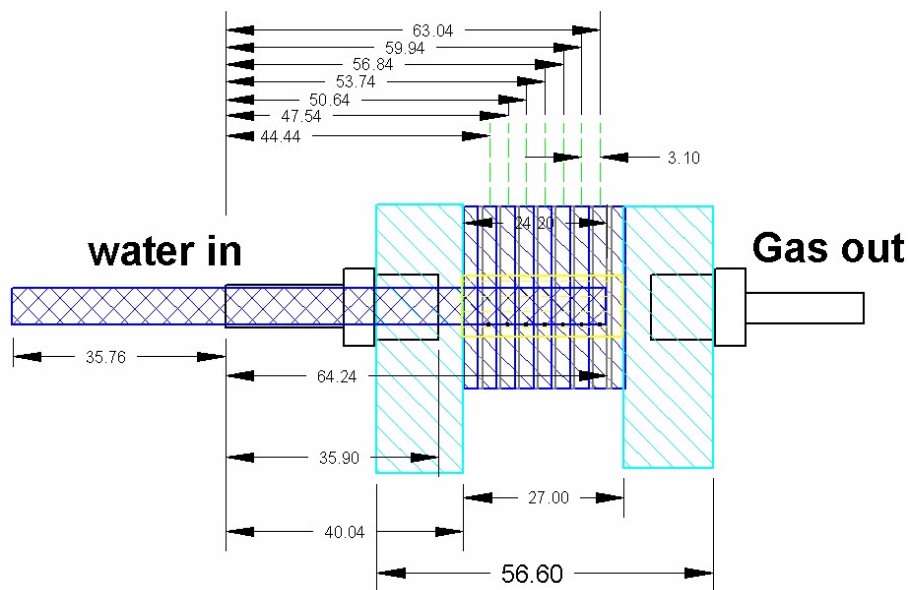
Quote-If you want to get away from any heat, go for lower voltage between the plates. 1.5 - 1.8 volts being ideal. – Bro Andrew.

The Bro Andrew design is a 9 plate cell (- n n n + n n n -) = 3 volts. Andrews plates are 2.5" x 6 = 15 sq. inches = 3.75 volts. I making a 11 plate cell (- n n n n + n n n n -) it will be 2.4 volts, I can fit 11 plates max. into a 4" ID cell tubing. Andrew mentions that he would like to go 13, but that will not fit at .125" spacing. 13 plates = (- n n n n n + n n n n n -) = 2 volts between the plates. 15 plates = (- n n n n n n + n n n n n n -) = 1.7 volts.

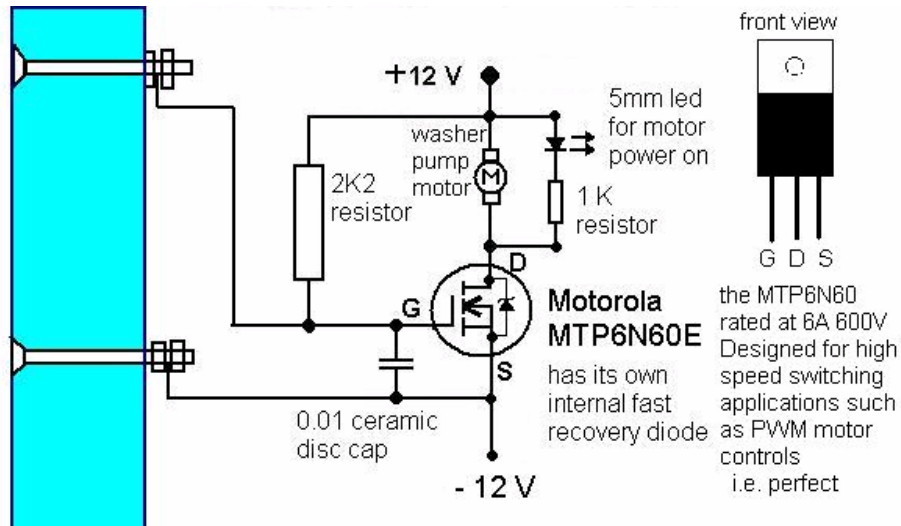
Baby Bob Boyce Cell by Peter



This is a 7 cell true series configuration (no water equalization holes) with outside perspex dimensions of 130mm by 155mm by 57mm. It involves a drilled plastic tube, in this case 6mm dia nylon. Peter first measured everything on the cell - ie the thickness of the end plates and the SS/ gasket stack, and then created it in a CAD program.



Pump driven water fill in the left via a check valve. Screen print from the measurements in CAD



The control circuit for the pump motor. The FET came out of an old 14" monitor with its own heat sink.

MTP6N60E-D Is the power FET device used for pump control, there is no pin out diagram in the datasheet so peter included the pin diagram in the washer control diagram. It was an easy matter to transfer the measurements to the tube which he inserted in the back of the cell (gas coming out the front).

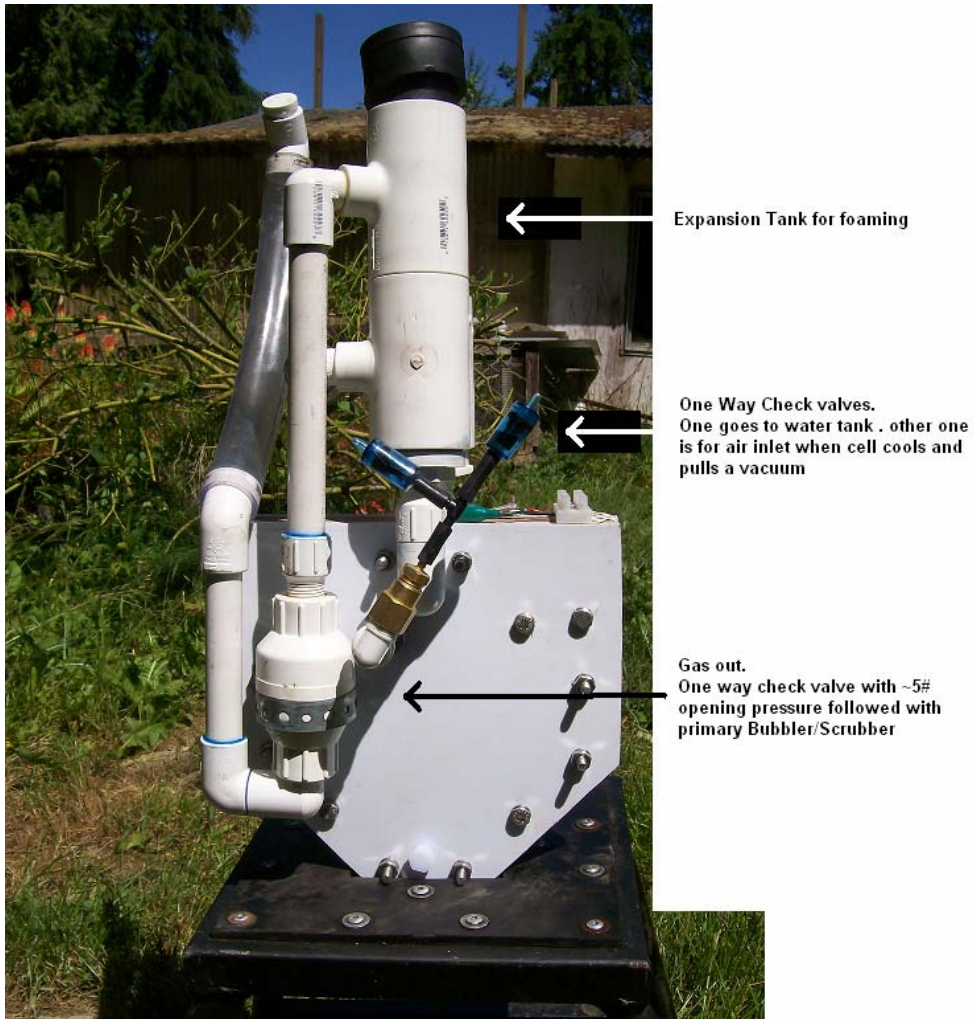
Plate size is 100mm by 125mm, with a gasket width of 10mm. One plate wetted area is 73sq cm to give a total area of 1022 sq cm, hence the "baby bob" name. Ambient temp was 25C max temp recorded on the center plate was 51C after 2hrs amps was 3.8A voltage 13.47 V (recorded across the cell).This gave consistent 400ml per minute or 0.4lpm over three tests and was sufficient to give a 25mm flame on an unmodified 21gauge hypo needle.

Electrolyte he is using is caustic soda flake 22% by weight (30grams to 136CC's) which peter then filtered before pouring in the cell. Plates were conditioned as per Bob Boyce recommendations 3days cleanse 3days condition with 5% solution and been running it only a day with the 22% solution, voltages were within 0.05V of each other. Wiring was looped through a drilled 3mm hole on the corner of the plate and soldered.

Total run time is about 7 days, it started out at 1.5A and had steadily risen to 2.9A with the weaker solution, now occasionally touching the 4A mark with the stronger stuff. Actual voltages are from pos side 1.93V-1.88V-1.88V-1.87V-1.88V-1.88V-1.90V with 13.27V across the pos and neg.

Also with tightening the stack when hot caused overall dimension to reduce from 32mm at the start to 27mm after 3 tightening sequences, usually a 1/4 turn to take up the slack. Peter is guessing the vinyl spacers didn't all compress equally which might account for some discrepancies.

Here is a photo supplied by open source engineer Dave which makes use of a clever auto re fill design



The Bob Boyce Brute Force DC 101 Plate cell



Bob's Prius modification

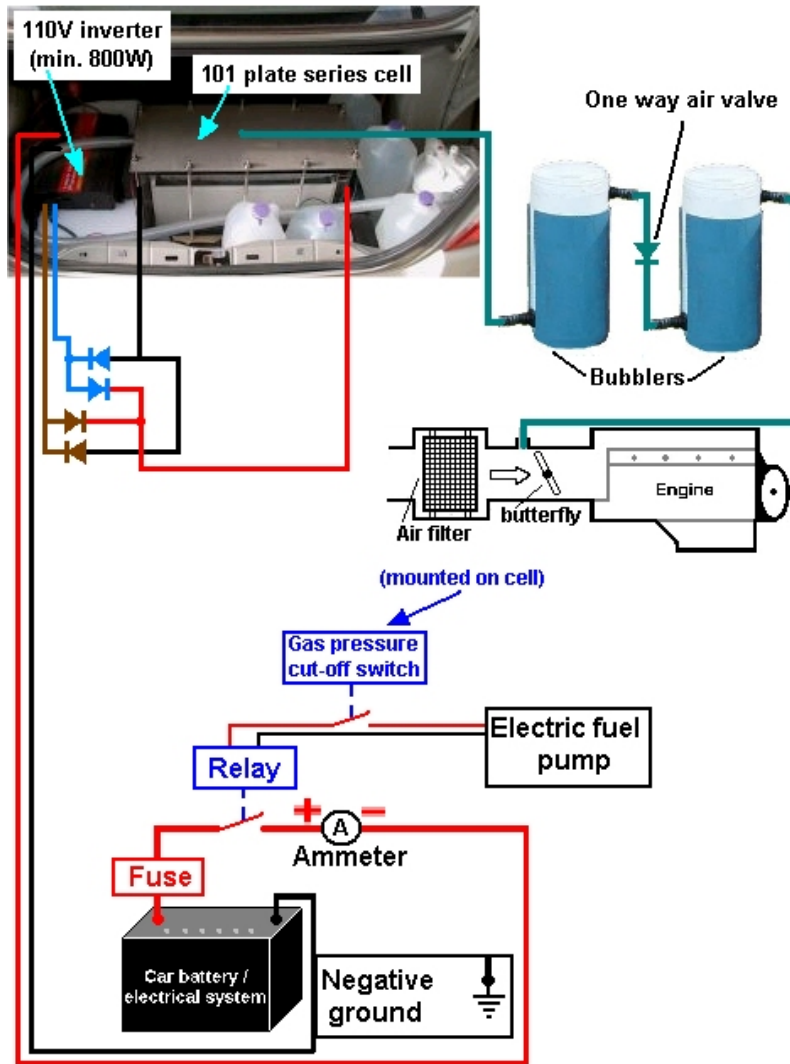
This cell makes use of 101 plates. Bob has found that to attain the highest efficiency pulsing, the best performance was in the application of 1.5 volts DC with 316L grade stainless-steel electrode plates. This works out as the following: $1.5 \times 100 = 150$ volts DC to attain the maximum pulsed output.

To get this higher voltage, we will need to use a 60 hertz 110 Volt inverter. The inverter will use a 12 Volt DC input and generate a 110 Volt AC output. The alternating Current will be converted to pulsing Direct Current by passing the output through four diodes called a 'Diode Bridge'. This unit has 101 metal plates and 100 separate bodies of electrolyte. The spacing between the plates is 3 mm (1/8 inch) and the plate thickness is 16 gauges (1/16 inch).

The width of a 100-cell electrolyser is about 20 inches. If you're using this cell in a Ute and have a large amount of space then the plate size may be selected by allowing from two to four square inches of area on both sides of each plate, per amp of current. Each side of every plate is in a different electrolysis cell so a 6-inch by 6-inch plate will have 36 square inches on each face and so would carry between $36 / 4 = 9$ to 18 amps of current. The electrolyzer and bubbler must never be installed in the passenger area of the vehicle. The bubbler must have pop-off caps are provided and a second protective outer housing is provided, as the shock-wave is so fast that permanent hearing damage would be a serious possibility.

This system uses straight DC electrolysis where the battery is connected directly across the electrolyser. The choice of the amount of applied current is up to the builder; bare in mind this will have to be matched by the inverter size and cost, also it will be limited by the allowable current which is able to be generated by the battery and replenished by the cars alternator system. Bob is using a 6" x 6" plate size.

The inverter also needs to be mounted securely; one suggestion is to have it in the stream of air drawn in to cool the radiator. We will be Using a diode "bridge" of four diodes to convert the stepped up AC output of the inverter back into pulsing DC and produce this electrical arrangement.



The following mains voltage is quoted is an average figure ("root-mean-square") which has a peak voltage of 41% more than that. This will mean that the pulsing DC has a voltage peak of just over 150 volts for the nominal 110 volt AC output from the inverter. You must have a one-way valve as shown between the two bubblers, this is to prevent the water in the bubbler mounted beside the electrolyser, being driven into the electrolyser incase of an explosion in the bubbler mounted beside the engine.

For the voltage on a large AC powered unit, you must calculate using the rectified and filtered DC voltage, not the nominal AC voltage. A nominal 120 VAC power source, when rectified and filtered, is typically 150 to 160 VDC.

Video's

[Bob Boyce hydroxy cell - Brasov - Romania](#)

[14 LPM hydroxy cell Bob Boyce design](#)

[14 LPM hydroxy cell running small engine](#)

The Bob Boyce 61 Plate cell by Larry



An example of a 61 plate cell done by Larry

Video's

[Bob Boyce Cell pt.1](#)

[Bob Boyce Cell pt.2](#)

"The Cell" By Bob Boyce



Bob Boyce has since released a commercial cell call "[The cell](#)" Details can be found in the video links below. It is not known at this time what the cell configuration is. In the following video Bob talks about an advanced way of using the throttle position sensor to regulate gas production and trying to match gas production to engine requirements.

<http://energyshowandtell.wetpaint.com/page/Bob+Boyce?t=anon>

<http://au.youtube.com/user/premelters>

<http://au.youtube.com/user/hydroalternation>

Spiral Electrodes Designs



[AntDavison's](#) spiral electrolyzer based on the Shigeta Hasebe design

Should you decide to try these spiral electrolyzer designs the following walk through provided by Ant Davison may be useful in constructing the electrodes. **A detailed back round on construction of this project and current results can be found on [Ant's OU forum project page](#).**

Other web sites detailing cell designs

http://waterfuel.t35.com/own_electrolyser.html

<http://www.oupower.com/>

<http://www3.telus.net/chemelec/Projects/Hydrogen/Hydrogen.htm>

Advanced resonant pulsed DC hydroxy booster designs, including Ravi's/ Daves Lawton and Bob Boyce are covered in separate documentation on the Panacea university site.

Faculty information

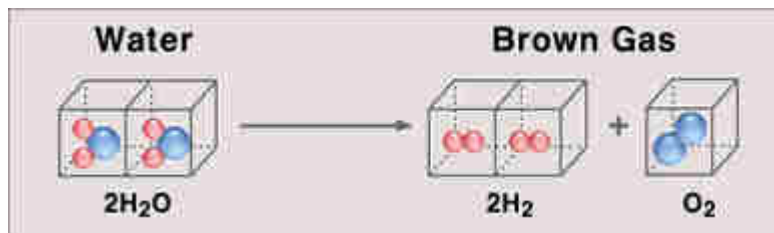
Hydroxy associated Names - Stabilized hydrogen / Brown gas / Rhode's gas / Oxy hydrogen / Hydrogen oxygen / HHO / di-hydroxy / hydroxy / green gas / aquygen / watergas / Klein gas (HHO gas or Klein gas is another oxyhydrogen mixture made by water electrolysis, which has been trademarked by Aquygen) - It is also compared to

what inventor Santilli claims to have developed, being novel fuels he calls MagneGas and MagneHydrogen. Note all respective trademarks belong to their respective owners, For the purpose of this write up, the trademarked "HHO gas" will not be used to describe the process. In place will be the abbreviations of the atoms as "H H O" with spaces HOH or hydroxy.

Hydrogen is the chemical element with atomic number 1. It is represented by the symbol H. At standard temperature and pressure, hydrogen is a colorless, odorless, nonmetallic, tasteless, highly flammable diatomic gas with the molecular formula H₂.

Antoine Lavoisier gave hydrogen its name, which was derived from the Greek words - "hydro" and "genes," meaning "water" and "born of." In 1800 the English scientists William Nicholson and Sir Anthony Carlisle discovered that applying electric current to water produced hydrogen and oxygen gases. This process was later termed "electrolysis." 1807 - Yes 1807 Francois Isaac de Rivaz of Switzerland invented a first internal combustion engine to be used in an automobile he designed. It used a mixture of hydrogen and oxygen for fuel.

Hydroxy gas sometimes referred to as "Brown's Gas" is one of the various forms of hydrogen. Hydrogen (H) on its own is "**monatomic**" hydrogen and if given the right conditions, will join up with another H atom to form H₂ called "diatomic" hydrogen. The same is for the case for oxygen atoms.



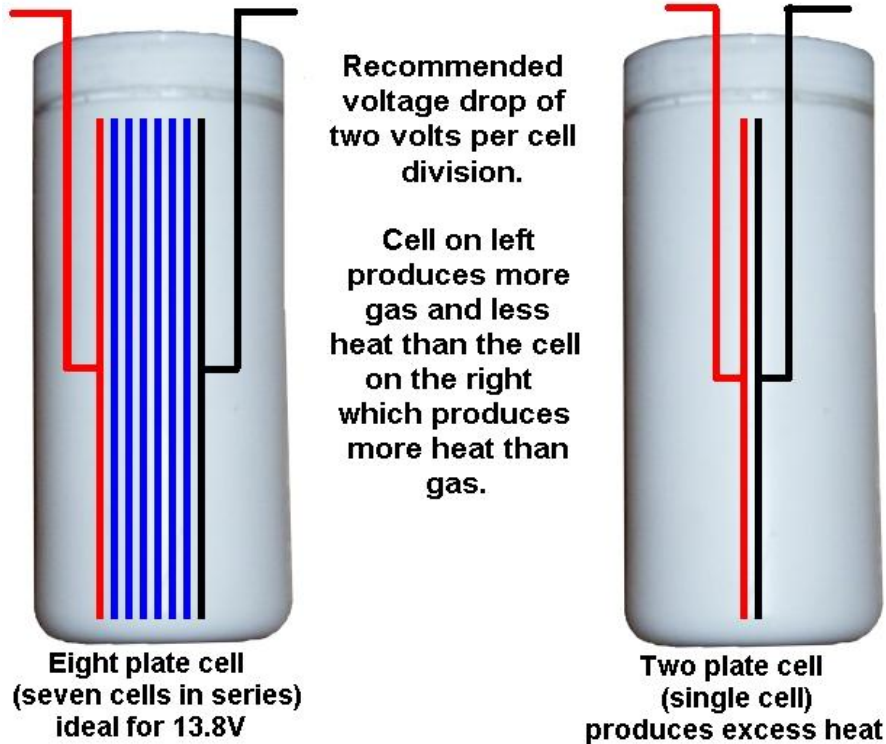
Hydroxy gas is a mon-atomic hydrogen (H) and mon-atomic oxygen (O) flame, this means we don't have to add any energy because the molecules are already in their simplest and highest energy atomic form. This means that a "perfect" hydroxy flame can have 3.8 times the possible 'heat' energy that an "ordinary" H₂ and O₂ flame has (442.4 Kcal/115.7 Kcal). Hydroxy gas production in a brute force DC electrolyser is reliant on current flow through the "conditioned" plates.

The conditioning of the electrode plates will be discussed in more detail below. This current flow will then break the bonding of the water molecules and convert the H₂O into hydrogen H and oxygen O. When an increased amount of current is applied to the electrolyser there will result an increased amount of gas production. The principle aim is to produce this current efficiently and to control it as accurately as possible. In a hydroxy booster, the concentration of electrolyte is used in order to help regulate or "control" the current.

When power is first applied to an electrolyser, it will begin operation with a low temperature. After a longer run time the electrolysis will increase the temperature of the electrolyte. As a result of a temperature increase, an increase in the current will flow through the electrolyser which will further heat up the electrolyte even more.

The dynamics of a cells operation as it pertains to being used in an automotive system will be illustrated by the following. In this case, potassium hydroxide (KOH) is used with distilled water inside an electrolysis cell. After a voltage is applied, current will flow through the water and electrolyte mix moving from one electrode to the next. If our applied voltage across the plates goes over 1.24 volts, this will produce no increase in the rate of gas production. Any extra voltage above 1.24 volts on each "plate" will go on to be wasted and heat the electrolyte. Red oxidized sludge will also result from "cooking" the electrodes with a voltage higher than 3 volts. This has nothing to do with the electrolyte or water quality. IE-using KOH or NaOH as an electrolyte with distilled water has nothing to do with sludge production.

There are various construction designs and ways of connecting hydroxy cells. In an example of using a hydroxy cell in a car which is drawing 10 amps of current and using 1.24 volts through the cell, $10 \text{ amps} \times 1.24 \text{ volts}$ equals to 12.4 watts. Whilst the engine is running typically the voltage at the battery is at about 13.8 or 14 volts. The alternator provides this extra voltage to drive current into the battery. This extra voltage applied to the cell is calculated to be around 1.24 less than 13.8, which equals about 12.5 volts. Therefore there is excess power heating up the electrolyte at about $12.5 \text{ volts} \times 10 \text{ amps} = 125 \text{ watts}$. This is a very inefficient process which shows that we are wasting around ten times the power being used to produce gas.



There will also result a voltage drop across the plates, therefore it will be necessary to **apply about 2 volts to the plates on each side of the cell**. In the case where the car is running off 12 volts, 6 cells connected in a row across the battery will produce the highest possible efficiency. **In the case where an engine is running and providing almost 13.8+ volts, 7 series cells will produce the highest possible efficiency.**

The voltage that's applied in an automotive system is at a relatively fixed value, plus the plate area of the electrolyser is fixed. It is therefore necessary to regulate the current flow to the cell by various concentrations of KOH in the electrolyte and the plate area.

So far empirical tests have shown that gas production improves until the KOH concentrations reaches 28% (by weight). Above this density, increasing the concentration will result in a reduction in the rate of gas production. Thus a low concentration of KOH is ideal, and optimum concentration can best be found by trial. Note the electrolyte of choice is ONLY KOH and NaOH. The reasoning for this is discussed in further detail below.

The most common designs of boosters are the open bath design, IE- The Smack's booster step gap design, a series cell and a tubular design. There tubular series connected cell, series cell and step gap which will be discussed later. From empirical testing it has shown that a properly built series cell (e.g. with 6 or 7 plates) is more efficient than an open bath design, in other words, for the same amount of amps consumed a series cell will ALWAYS produce more gas than an open bath cell. A series

cell is less likely to overheat because it has less current leakage and it is the current leakage that causes overheating.

An independent researcher has recently done a very thorough test on a Smack's open bath design and found that the booster reached a temperature of 90 degrees in less than 2 hours. This does not take anything away from the Smacks booster; it is an efficient and cost effective design that's suitable for 1-2 hour trips. The reason why people would consider construction of an open bath is because it does require more skill to build a proper series cell.

Researchers have recently done some comparisons between a series cell and the open bath design. If you study the results you will see that the Smack's type cell will only produce 45.23% of the expected Faraday output, whereas the proper 7 series cell design's produce between 89-99% efficiency.

The following results we conducted and published on the [misfit Jackie web site](#).

Configuration	W/LPH	Perc of expected Faraday output	Voltage	Amperage	Amps/SqIn	Litres/Min
Step-gap config (2P4S) Smack-type	6.06	45.23%	13.8	20	0.667	0.76
Series perspex cell with 1mm holes	4.99	54.45%	13.8	20	0.667	0.92
Series Gladwrapped cell	2.92	99.68%	13.8	4	0.133	0.32
Series perspex cell holes blocked	2.88	96.49%	13.8	11	0.367	0.88
Series perspex cell holes blocked	2.88	89.03%	13.8	15	0.500	1.11

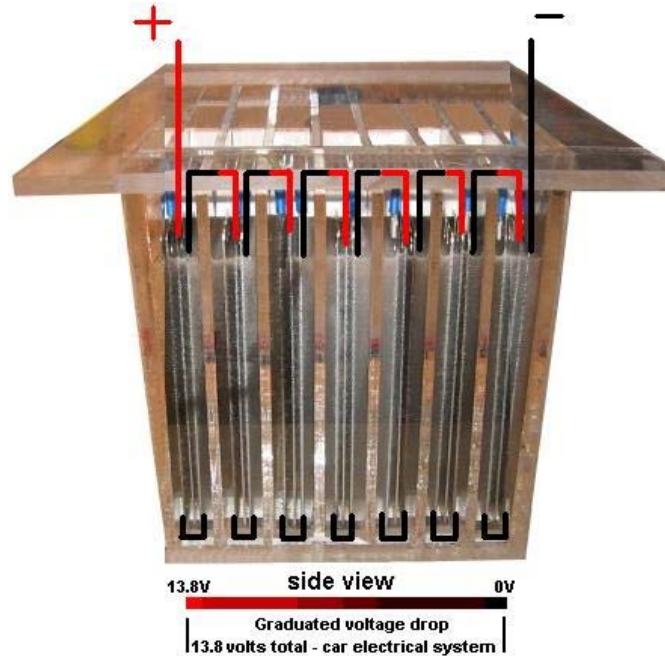
Most are content to concentrate on a series cell as the science of boosters dictate that it is the most efficient. There are R and D efforts in effect to identify a series cell design that is easier and more cost efficient to build than an open bath. The idea is to assimilate the best of both worlds, i.e. the most efficient and reliable cell which is least likely to overheat after several hours of operation, while still not too expensive or difficult to construct. Currently a good alternative to a 7 series cell for 4 hour operation have been obtained by using a tubular cylindrical design which is detailed with all designs in the booster design section.

Further differences in cells which are connected either in a series or parallel can be explained as the following. Basic electronics can explain this. A series circuit has all its components in line, like a train, one behind the other. Current is equal through all series components. Voltages across each component add and equal the applied voltage of the circuit.

Parallel circuits are kind of opposite. All voltages in a parallel circuit are equal to the applied voltage. Current on the other hand is divided amongst the components and when added up equal the total current of the circuit. Instead of a train, now you have a 2 or more lane highway. $V=IR$ is the formula used to determine the values. The formulas specific to each circuit are derived from this formula.

As explained earlier anything over 2V will create waste heat, hence series cells are desirable as they cut the voltage down by the number of cells used. Parallel cells are easy to make, but unless you have a low voltage power supply, they are very inefficient. The Smack's design uses both series and Parallel concepts together.

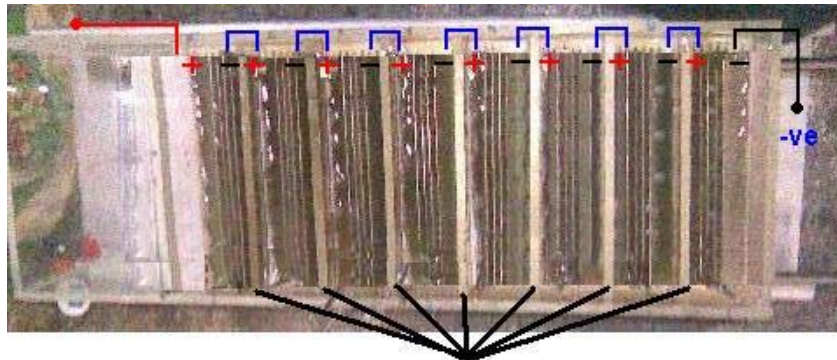
Consider the following configuration:



Above is a 7 plate series ISOLATED cell. Note the pockets of electrolyte are isolated from each other. In this 7 plate series connection all of the current flows through all of the seven set of plates. This produces a gas output between each one of those sets of plates. The open bath electrolyser design like the Smack's Booster, gives the current the option of bypassing the central plates and "skipping" direct to the final plate.

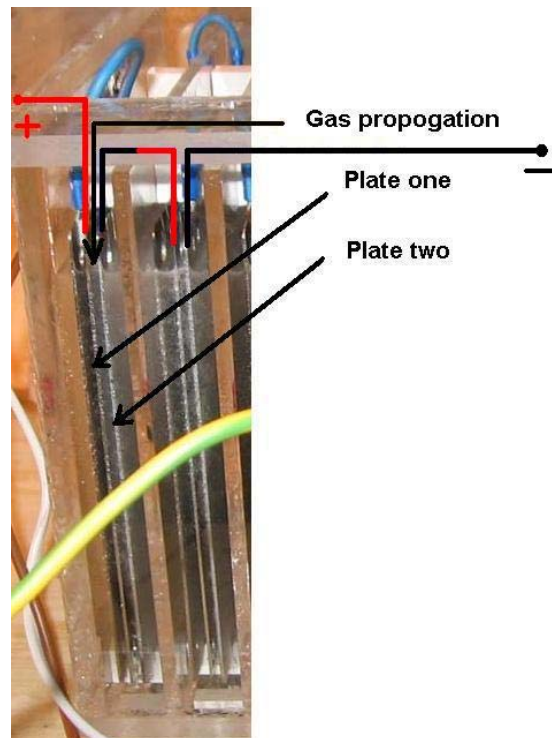
This will not produce allot of gas production; this "step gap" is large which means there will be only one resulting area where gas generation is possible. In this design there will be 7 separate gas producing areas from all plates. The Smack's Booster design (not including Smack Gen II) has only four pairs of plates, it is calculated that an estimated 65% of the power in (20A) will heat the electrolyte. More Faculty information on Smacks booster operation will be included further below.

In the case of a 7 plate isolated cell design, it's calculated that 38% of the power can go to heat the electrolyte. The gas flow and efficiency in a series 7 plate cell can be shown by Panacea's series cell. In the first example we will begin by a simple two plate arrangement.

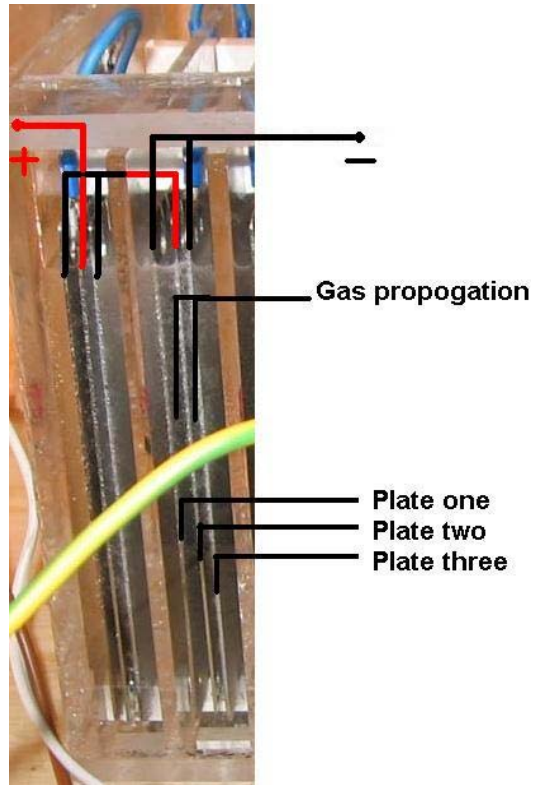


Cell bath isolators
Series cell connection with isolated baths

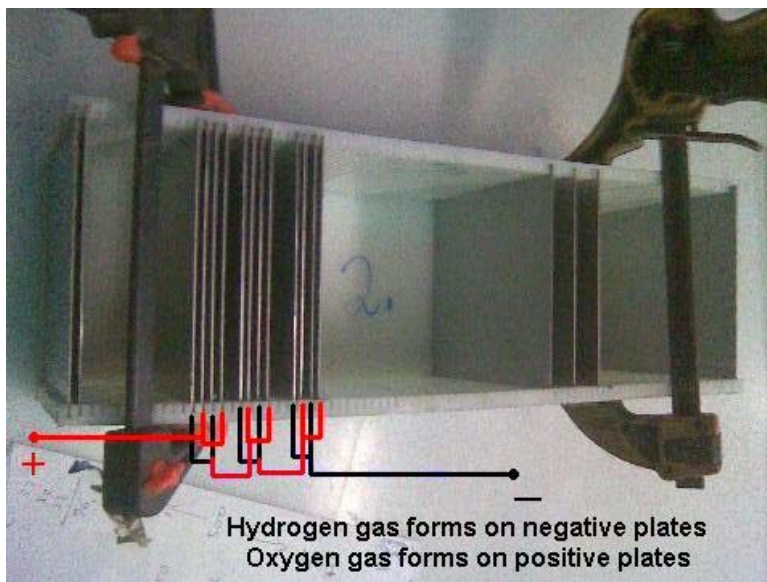
In straight brute force DC only electrolysis, the amount of current it will draw is determined by Ohms law. $I = E/R$ The amount of measured resistance of the total circuit divided into the total amount of DC voltage applied to the circuit will give you the total current the circuit will draw. **The above examples is using 5" x 4" (20 inches) plates which are spaced 3 mm (1/8 inch) apart in order for the best gas-producing performance.** Electrolysis will take place in the gaps between the plates, in the following two plate area there is just one area of electrolysis.



A plate which affords 20 square inches of area on each face, will allow up to 10 amps of current in the electrolysis area. In the three plates section of the cell, there are two inter plate spaces, so the hydroxy electrolysis will take place on both sides of the central plate in each isolated compartment.



With the three plates the electrolysis area in this cell will amount to 40 square inches, so this will allow a current of up to 20 amps through the electrolyser. In the case of four plates in cell, there are three inter plates spaces so the electrolysis will be taking place on both faces of the two inner plates in isolated compartment.



The electrolysis area of the electrode plates adds up to 60 square inches; this will allow up to 30 amps to be passed through the cell. With the two plates in the cell facing

each other, just about all the electrolysis takes place between the two active faces positioned close to each other.

In summary, the cell plates are 5" x 4" meaning that 20 square inches of plate area will be available for effective electrolysis. With three plates in this cell, there are two of these active gaps, one between each of the outer plates and the inner middle plate. Both sides of the inner plate will have active working surfaces. Working plate area is 40 square inches. With four plates of the Panacea cell, there are two inner middle plates, and we are using both sides of each plate. There are three gas producing working gaps (plate 1 to plate 2, plate 2 to plate 3, plate 3 to plate 4) and the working plate area is 60 square inches. **In a true series cell, the applied voltage is evenly divided between the cells because the surface area is even. In the Panacea case we are dealing with 13.8 or 14 volts produced by the cars alternator.**

Overheating and electrode corrosion will come from to a high a voltage per cell. Use seven cells in a single row, each with 2 volts across them. This design will give a decent amount of gas and no significant heating.

Series cell and Smack's step gap summary. **The significant difference between the above 7 series cell example and the Smacks open bath design is that in a true series cell electrolyzer, the cells are properly sealed off from each other so that electrolyte cannot freely flow from one cell to another.** In the open bath design, the electrolyte can freely flow in between adjacent electrodes. This will result in a significant current leakage around the edges of the electrodes. This current leakage results in reduced efficiency and also the water heating up rapidly and eventually overheating problems.

High amperage with seven cells isolated in series will have little heating of the electrolyte and allow a stable operation. **Heating will always occur unless each and every pocket of electrolyte in each and every cell is fully electrically isolated from one another, at all times that power is applied there will be heating of the liquid from I*R losses in leakage current flows.**

On top of this, even if there are zero leakage current flows, there will always be some electrolyte heating from the I*R losses within each cell. This is an undeniable fact of physics. The solution is to minimize these losses. The best solution is a true series cell design that has near zero leakage current, electrolyte conductivity adjusted to peak of conduction (lowest I*R losses), and the cell count set to exactly match the supply voltage at the desired per-cell voltage. When this is not possible due to space or cost constraints, then alternatives are sought.

In the case of the Smack Booster, while not a true series cell, it does use a clever stepped-gap design that when coupled with a lower than normal electrolyte concentration, it produces reduced leakage and current losses. It relies upon the higher I*R losses of a more dilute electrolyte mix, and the increased spacing at key points, to

minimize leakage current heating losses. The tradeoff is higher I^2R losses in the desired current flow paths. This has been partially offset by closer cell spacing in the desired cells, which concentrates most operational current in those locations.

A flat plate has the same area on each face. Referencing the area of just one of those faces:

A plate of 5" x 4" will have a face area of 20 square inches and can carry 5 to 10 amps

A plate 6" x 5" has a face area of 30 sq. in. and can carry 7.5 to 15 amps

A plate 6" x 6" has a face area of 36 sq. in. and can carry 9 to 18 amps

A plate 9" x 6" has a face area of 54 sq. in. and can carry 13.5 to 27 amps

A plate 12" x 12" has an area of 144 sq. in. and can carry 36 to 72 amps

These currents are for the least plate wear and can be exceeded if you choose to do so. That 1/4 amp per square inch figure come from Bob Boyce. He states it is a point in the bell curve of applied power vs power efficiency. Above that, the power efficiency of stainless steel electrodes begins to drop rapidly, requiring more and more voltage to meet the water / metal potential loss. Another other limit he also mentioned, 1/2 amp per square inch, is the point above which stainless steel electrodes begin to measurably deteriorate during electrolysis.

Recently further test to surface area were conducted on the hydroxy forum. An engineer intended to experiment with voltage and sizes of hydroxy generators. The following test was conducted to reinforce his ideas plus expound further to include the high voltage information.

To start out he did multiple tests. All tests are done with the same 5 plate generator (+nnn-) the KOH concentration varied but only to set a constant amp setting of 30 amps due to (foreshadowing)the FACT that gas production is absolutely and completely relative to amps. Note the "nnn" are floater plates or "neutral" and are explained below in more detail.

1st -12volt car charger powered on the 40 amp setting which puts out @15v and 30 amps, i produced 1/2 gallon a minute.

2nd -12volt vehicle ran which tests at 13.5v @ 25 amps and only produced a little over a liter per minute. Which lead him to believe that the wattage was the determining factor. He since proved himself wrong with further tests.

3rd- 24volts @ 30 amps = 1/2 gallon per minute.

4th -56volts @ 30 amps = 1/2 gallon per minute.

5th- 120volts @ 30 amps = 1/2 gallon per minute.

6th- 240volts @ 30 amps = 1/2 gallon per minute.

In conclusion, Amps = production. Also if you're even thinking about running higher voltage please consider the following.

12v @ 30amps @ 1/2 gal = 98 degrees temp from ambient temp

24v @ 30amps @ 1/2 gal = 108 degrees

56v @ 30amps @ 1/2 gal = 120 degrees

120 @ 30amps @ 1/2 gal = 132 degrees

240 @ 30 amps @ 1/2 gal = a whopping 168 degrees

All of these tests were at one minute. So voltage = waste and heat flashes.

In Conclusion to this Bob Boyce has stated that it is very good data collection, and it confirms what he has been saying all along, that it is much better to use less voltage and higher concentration electrolyte to decrease losses that manifest as waste heat.

However, the report still insists that surface area is not important. Yet this test model is not correct for measuring the factor of surface area upon overall power efficiency. In order to measure this the easiest, you should run the cells with the voltage / current right on the edge of endothermic / exothermic, and the electrolyte at maximum concentration, for maximum efficiency. The IR losses of dilute electrolyte, and excess voltage, makes it so much harder to tell the difference in metal / liquid voltage drop at the electrode surfaces.

We are talking about variance of tenths or even hundredths of a volt per cell, very hard to read sometimes in poor efficiency units of low cell count, but much easier in high efficiency high cell count units. Now, why would this be important if it is such a tiny amount? Using a highly accurate DVM, start varying voltage on a running cell stack with high concentration electrolyte, and watch how much current can swing with just a tenth of a volt of change!

Look at it this way, since a quick calculation shows that from this reported figures it is running that unit at a high of almost 37% efficiency, it would be very hard for you to even see a 5% change in efficiency, as it would only be a 1.85% overall change. But if you were running a 200% efficient series cell stack, that same 5% change in efficiency is a 10% change, a little more apparent.

The application of ohms law takes further distinctions to get to the base facts. In a cell there are multiple parts that must be diagnosed independently. To say voltage is the

driving force is correct only when viewing the cell from the battery terminals. The Load is both simple resistance, from wires and plate material, and a very complex "electrochemical" impedance that has many parts. Those parts, when in perfect balance, produce almost no heat for a given current density below about .75 amps per square inch. Go higher and the reaction within the chemistry produces a lot of heat. It also produces a decrease in impedance within the liquid. To the outside world, the current and voltage are simple ohms law. Within the cell, chemistry, thermal dynamics, and fluid dynamics produce the overall effect.

Cell resistance

Your cell has an apparent total resistance, computed by $R = E/I$.

12 volts at 12 amps = 1 ohm; [1,000 miliohms or 1,000,000 microohms!]

12 volts at 20 amps = $12/20 = .6$ ohm

The resistances quoted have been at various powers of 10 dependants on whether it was expressed per cm, mm, or METER of distance makes a huge difference. The resistance for each material, after removing the confusing powers of 10 [minus at that], are in micro ohms total for all 7 plates in a 6 cell arrangement! The ratio of bath resistance to plate resistance is about 100: 1! If you cut the resistance to 1/10 within the plate, it only affects 1% of the total [round numbers for SS]. The Lion's Share of improvement is in controlling the bath, not the plate resistance.

It is a valid ACCIDEMIC QUESTION ONLY! What really counts in all this is what happens in the bath. Is there enough ions to carry the current through the bath with a reasonable resistance? Is the fluid dynamics of bubble creation and then motion helped or hindered by the design? Is the current density [amps per square inch] within a reasonable range to make the conversion of ions happen at the plate to fluid interface? These are the important design questions. They hold 99% sway over efficiency for every cell. It is a continual tradeoff of these parameters that is the reason for cell design at all. If it was only one parameter, we would have a very simple time of design.

Water vapor tests

If a cell is producing mostly water vapor and not steam, the cell will be between 50°C and 80°C. At 10 amps and 4.4 volts per cell it must be a lot of vapor. The only way to tell is by the "water usage per hour." If he can detect a decrease in water level in an 8 hour test at 10 amps, it is a lot of vapor. In that size container, it should use less than a fluid ounce per 30 hours of test. [ball park] A good cell at 2 to 3 LPM will use 2 FI OZ per 500 miles. at 20 amps over 36 to 50 sq in of plate. **A productive design keeps the water temperature to most productive zone of 50-60 deg centigrade.**

Revision of important factors

The recommended target is .5 amps per sq in. As you exceed this target, the resistance in the plate and liquid become a larger factor in heat production, which is a loss in efficiency. With 24 sq inch plate area [counting one plate of one cell] it should be only 12 amps. [Note: The .5 number is midline in the min of .25 and max of 1] As you get above 2 amps per sq in you are wasting a lot of the drive voltage and will begin moving a lot of metal as well as current. It takes a lot of work to get the surface texture right for good gas production and you will tear off all those points you carefully sanded on the plates with a noticeable decrease in efficiency. If you test your cell at 6 amps for gas out and then at 12 amps you will see that 12 is not twice as much as 6.

All of this is to say that 2 cells in parallel is more efficient than one at twice the current if they are the same size plates, i.e. same square inch.

1. Plates as thin as possible for the durability of the material chosen (given a caustic solution) in order to minimize plate resistance (properly crosshatched, **cleaned and conditioned see the faculty section below on plate preparation and conditioning**).

2. Plates sized for target amperage @ 2 sqinch / 1 amp (ie; for a 10 amp system, plates should = ~ 20 sqin / <1> platesides = 20 sq / side = <5"W x 4"H>). For surface area calculations, you only count 1 surface of 1 electrode, because the same current passes through ALL active electrode surfaces in a series cell. If you count both surfaces of an electrode for surface area, you must also count the current flowing through both surfaces, i.e. double your current figure of a single surface. Also, at a current density of 1/2 amp per square inch, you are not leaving yourself any safety margin to prevent erosion, especially if there are any undesired "hot spots" in a cell(s). Cell height should not be taller than the width, as it can greatly increase the bubble occlusion factor, severely in an extreme over-square layout

3. For SS that corrected break even (zero current flow) voltage would be 1.47 to 1.48 V per cell depending upon the actual alloy used. To pass usable current, the voltage must exceed that figure. 2.4 volts is rather the maximum single cell voltage that will be useful without producing too much water vapor. This is a 6 isolated cell booster. The reaction voltage [voltage within the liquid] is 1.24V. The additional required voltage is to overcome the resistance in the plates and "kick start" the reaction. If you have about 1.1 volts, the recombination rate is almost equal to the production rate.

At 1.6 volts the reacting gasses will begin to "cluster" forming large bubbles quickly, which retards recombination. I use 1.9 to 2 volts per cell to make the system produce well and have a minimum of heat. That is 7 isolated cells.

4. Distance between plates of 1/8" (to allow for bubble dislodgment).

5. Isolated bath (the electrolyte held in each plate-gap-plate physically isolated).
6. Electrolyte at maximum concentration (for KOH that is probably around 28% by weight)

To include, of course, the ever-present proper safety precautions (for both man & machine) such as (but not limited to) full coverage clothing, hearing and eye protection while experimenting as well as bubbler(s preferably 2), pop-offs, line dryers, solid soldered & insulated connections and safety switches.

In your electrolyser, there are four things which resist current flow:

1. The wiring to the electrolyser and between cells.
2. The resistance of the electrode plates to current flow through them.
3. The resistance to current flow between the plates and the electrolyte.
4. The resistance of the electrolyte to current flow through it.

Looking at these in order: 1. The wiring to the electrolyser needs to be thick copper wire, otherwise there will be a serious voltage drop along the wire, starving the electrolyser of its operating voltage, which is about 14 volts.

The wiring between the cells and the plates inside the cells has to be stainless steel; otherwise there will be heavy erosion of the wires or plates due to them acting as a battery.

Stainless steel is a poor conductor of electricity, so those wires need to be thick, otherwise, there will be a serious voltage drop across these links, starving the cells of the voltage they need across them to work properly. The connections at the ends of the wires are critical and these connections need to be high-quality, very low resistance connections whether they are welded or bolted. If, when the electrolyser is fully assembled and operating, the voltage across each cell should be a constant, more than a few millivolts difference between cells indicates a constructional problem.

2. There is nothing much we can do about the resistance of the plates themselves, other than to provide 2 to 4 square inches of plate area per amp of current. The plate resistance is pretty much fixed by choosing 316L-grade stainless steel and that choice is based on years of experience of testing various plate materials. So, we have to accept the plate resistance as an unavoidable resistance to current flow.

3. The resistance caused by the interfaces between the plates and the electrolyte is often overlooked but is very important the material with the lowest resistance here is 317L-grade stainless steel but it generally costs too much to be used and 316L-grade is the next best material. This resistance is reduced dramatically by building up a

bronze-colored catalytic layer on the surface of the plates. To achieve this coating, the plates need to go through a lengthy process of cleansing, rinsing, cleansing again, etc. and then a conditioning process which builds up the catalytic layer. That catalytic layer produces a dramatic difference to the cell performance.

4. The resistance to current flow through the electrolyte alters dramatically with the concentration of the electrolyte. For sodium hydroxide (NaOH, "lye" or "caustic soda") the optimum mix is 20% by weight, where 200 grams of pure sodium hydroxide is added to 800 cc of water, for potassium hydroxide (KOH or "caustic potash") the optimum concentration is 28% by weight where 280 grams of KOH is added to 720 cc of water, taking the safety precautions for mixing.

These concentrations should give you too much current flow through your electrolyser and normally, the current needs to be kept down by using a PWM circuit or a Constant-current circuit. The fact that you are not getting enough current through your electrolyser indicates a problem with one of the items described above. The wiring connections are high on the list of possibilities, so if you can connect your 14-volt power supply to just six cells, it should give an indication if voltage starvation is the problem and the wiring needs attention. It may well be that your NaOH is far from pure and that it is causing weak-electrolyte problems.

Simple rule: Cells in parallel: [all cells connected to the same voltage] = all same voltage, each draws its own amps, so total amps is the sum of all the cells amps. Each cell need not have the same amps or amps per square in. Cells in series: [all cells connected in a string]= all cells have the same current passing through so only one value for current. The voltage from the supply is divided between each cell according to the "resistance" of the cell. This is why the voltage does not divide exactly between series cells. The small differences in electrolyte concentration or plate material will cause changes in "resistance."

Neutral or "floating" plates

The term neutral is confusing in this application. A better term would be "floating" meaning **not connected directly to that input voltage**. Physically they are neutral since there is no "direct" electrical connection from the source (although the electrolyte makes them electrically conductive) made to those plates. Your positive plates are connected to a positive power source and the negative plates are connected to the negative side of the power source. The neutral plates are not directly connected to either hence the term neutral. When those neutral plates are submerged in an electrolyte solution they DO conduct electricity over those plates and a voltage can be read off those plates so electrically they are no longer neutral.

So to keep it simple, "neutral" in our case simply means there are no direct electrical connections from the source to those plates. The purpose of these plates is to divide the

input voltage to get closer to 2 volts per "plate pair" which is the more accurate term for a "cell." Common terminology tends to reference the whole device as a cell. If you have 8 plates in a row with the voltage only applied to the ends, you have 7 cells with the voltage divided between the cells, or about 2 volts each for 14 volts applied.

This looks like this + n n n n n n - [F for floater instead of n for neutral is far more appropriate] each gap between a pair of plates is a cell. All the plates have voltage on them because it will be distributed across all gaps depending on how close the distances match. It is like a string of resistors connected end to end. The voltage is distributed according to the individual resistances and the current is determined by the total resistance and current is the same for all points in the string. If the gaps are not the same, the resistance [figuratively and actually] will be different and therefore the voltage also different.

This is the most likely reason for unequal gas production within a device. The reason for the plate pairs with a shorting "jam nut" between is to help isolate the pairs with the insulating spacer, nylon washers, from each other. The narrow gapped, insulated pairs are the cells. The Smack cell, or set of cells better called a cell system, uses 2 groups of cells, each 4 cells in series, to get the job done. If room was not an issue, each cell would be in a separate bath or container.

In a 12 volt plate configuration it will produce 12 volts between each plates. Connecting 12 volts up to a plate arrangement such as: - n n n n + n n n n -will produce about 2-3 volts between the plates or tubes. "n" = neutral plates, these are not connected to anything and are just in the way of the real anode and cathode plates or tubes. **The neutral plates are voltage dividers or absorbers; they resist the voltage and split up the 12 volts IN. This is a principle factor in running a cool cell rather than a steam producing cell.** An interesting experiment has also shown how the neutral plates generate hydroxy gas.

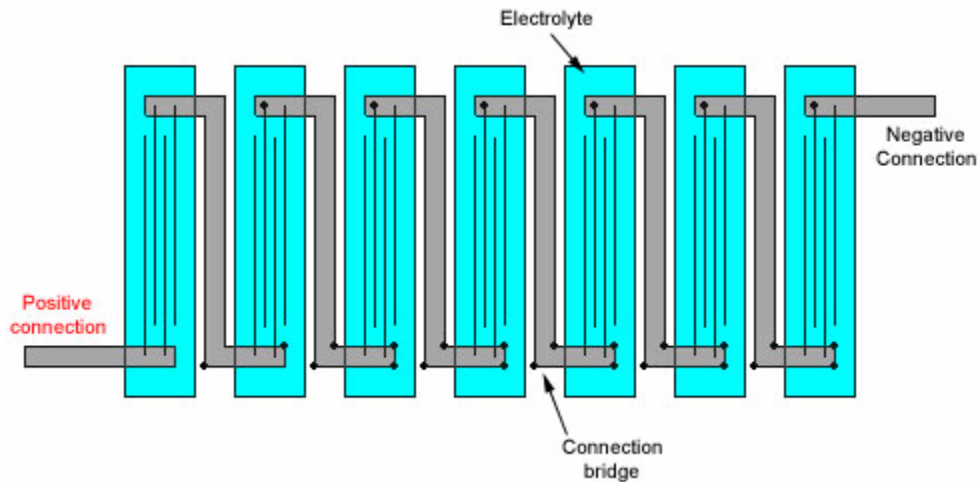
[Neutral plate hydroxy production video](#)

Note with the term "neutral plates", every plate in a series cell is active, not neutral. The conductivity of the plate is desired, as that is what carries the charge from one cell to the next. Where the + and - come into play, is that they are charges relative to the next plate over in each direction. So while the entire plate is at one potential, one side is + in relation to the next plate closer to the - connection, and the other side is - in relation to the next plate over in the other direction, towards the + connection.

Each cell (plate pair) is a dipole, and has a + pole (plate) and a - pole(plate). The plates are just shared poles in this string of series dipoles. When edges are exposed, that means that current can leak from one cell to the next, bypassing the plates in between. Running "pure" straight voltage (Brute Force Electrolysis) through it at say 14V, the

neutral plates will eat up amperage, produce more gas and help control temperature of the electrolyte.

If you use neutral plates, then you should not separate the plates with a cell divider.



Neutral plates won't work unless the space between the plates is isolated from the next space. If you have neutral plate's just wide open in a tank of liquid they won't work, then you will have a plus plate and a minus plate separated by a wide distance with a bunch of metal in between. The electricity is mostly going to go around the neutral plates. They need to be separate cells to be effective, just think of a stack of batteries, the plus connects to the minus of the next one and so on, they are in series.

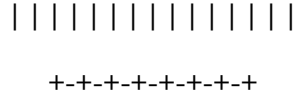
To make the neutral plate's work you need to have the plates go all the way to the side of the housing and seal each compartment of water off from the next, then the current is forced to go through the neutral plates and then they become actually active plates. So if you have 6 compartments of water between a bunch of plates and the positive on one end and the negative on the other then each cell gets 2 volts, then you get more cells with the same current draw and more gas output. So if you don't isolate each plate space from the other then neutral cells are counterproductive.

An example using neutral with a series cell design

Positive power-----

Negative power-----

Where positive power and negative power are connected to the two Volt supply and -- is wiring and == are plates. The seven plates can be put in any topology, the above ONLY describes the interconnection. For example,:



This describes a 15 cell electrolyzer with an all parallel connection. Both sides of the plates are used, but it will only be efficient at below 2 Volts.



Above is a seven plate electrolyzer which will be more efficient below 14 Volts and won't work well below 9 Volts.

"Neutral" or floating plates in tubular or cylindrical designs

With cylindrical electrodes the system works close to the true series cell design (you must ensure there is not much leakage from top and bottom edge of the cylinder). Although In a true series cell, voltage is evenly divided between the cells because surface area is even. This does not completely happen with tubular electrodes. The smaller inner tubes have less surface area so current density is higher; hence voltage and waste heating effects are higher. This reduces as you go outwards to the outer tubes. The net effect is that you have a fairly large difference in voltage distribution from inner cells to outer cells.

However so far it has proved to be minimal and still an effective solution. So on the tubular case, it can not be considered as a neutral plate as these in between tubes also takes part in gas production. The concept of neutral plates is there in open bath system. In such a system these plates are connected in series to break the voltage in range of 2 volt per cell.

In a tube design, if the spacing is the same, the voltage will be close to the same. If the electrolyte is isolated from tube to tube, you have a true series cell, If not you have leakage losses, however slight. The differences in cells voltage is a function of the differences in area of the tubes, as this varies the impedance of the tube to tube cells. The one quote recently posted showed 1.5 volts on the outside and 2 volts at the inside [check to see this is not backwards]. The difference is totally dependent on tube area so each design will be different.

This is minimized by using the largest inside tube practical in the space used and the least gap between tubes. If each cell is the same area and therefore the same voltage each gap will produce the same gas. **The likelihood of this in a tube design is slight.** In a plate design it is built in by design but will only be equal if no leakage currents. The tubes, like the plates in a smack or other open bath design are not neutral, just floating between the parts that have power directly attached. For an open bath arrangement,

the neutral tube does not produce as much as gas when compared with the 1st and last tube. In isolated flat plate cells, the gas is produced most equally in each cell.

In Summary -The neutral plates are more or less just that they do not get a connection to power if in the case of an open bath type design these plates will produce gas if spaced properly and the basic concept is that of a series cell design wherein the power travels from one plate into the one next to it and then to the next and so on until it reaches the other side of the cell stack. This reduces the effective voltage of each of the sets of plates and you would have to use the proper number of plates for a given input voltage and type of design you are building.

The Open bath flooded cell design

Often this design is attributed to and called a "Dry Cell" which is a total misused term. It is a "limited communicating, open bath, flooded cell. This primarily because when they say dry cell it is not dry but the bulk of the electrolyte is in a separate container same as [the Ameba cell](#).

The lack of efficiency is not a mystery. This is a flooded cell, meaning there is minimum communication between individual plate pairs, but there is still enough to limit efficiency. It is a variety of open bath that tries to minimize the cross currents. It is a "Tero" cell (listed in the design section) with the "leveling" holes AND an external tank for a separator/bubbler. It is not a bad design; it is just less efficient than the Tero WITHOUT the extra holes.

The "flooded" Tero cell is a "full up" design that is actually a common bath cell. It will pass both gas and fluid up the tube and "suck" liquid back in the return on the back if the tank level is below the booster. It WILL have heat like any other common bath design. [not new]. The top one brings electrolyte and hydroxy to a reservoir and a second line goes from the reservoir to the cell. It circulates electrolyte and the reservoir acts as a bubbler. So the cell does not get immersed in water. The following are some examples.

[Dry Cell](#)

[Tubular drycell design](#)

Summary of designs

As for actual Cell Design terminology:

- 1) There is the SEALED Cell in that EACH Cell is physically Sealed from each other with its own water chamber(Plate Spacing).
- 2) There is the OPEN Bath in which ALL Cells SHARE the SAME common bath.

3) There is a SERIES Plate Arrangement that works as a Voltage Divider sharing the same Current (Amps)

+ nnnn -

4) There is the PARALLEL Plate arrangement that Divides the Current and shares the Voltage.

+--+--+--+--+ .

The actual Electrolyzer can be a combination of any of these but the wrong combos will result in terrible performance. Other combos work great, as in the Stepped Gap "Smacks Booster" an excellent compromise between Series performance and open bath convenience.

For a Series cell you have a Higher Voltage Lower Amp arrangement you can build the cell for whatever V you need by adding or subtracting plates so you have ~2v per cell IE: 8 plates = 7 cells = 14v (Standard in Most Automobiles when running). A Parallel plate arrangement is a little different as it does not matter how many plates you have in it will only require 2v and the more plates you have the More AMPS it needs. So if you were to use a parallel plate arrangement in a 12v situation you would need to have 6 separate parallel units connected in series to bring the V into a usable range.

Either Series or Parallel can be used in either a sealed cell or open bath but the Current in a Series cell will basically Bypass the neutral plates in an open bath arrangement rendering about useless.

Note on "dry cells". There is nothing DRY about a cell stack filled with electrolyte/water that is producing hydroxy gas from water! Hopefully, all cells are wet inside, and dry outside! Ok, so there are some out there that leak solution un-intestinally.

A "dry cell" is a type of electrochemical cell that is used for generating electricity from chemical reactions, not a device for generating hydroxy gas. Just as a "fuel cell" is a device that is used for making electricity from hydrogen and oxygen feedstocks, not a device for generating hydroxy gas.

Equalization holes blow efficiency

Here is a pair of back to back tests that show beyond a shadow of a doubt that holes screw up dry cell efficiency. The cell being tested is completely green and not even cleaned yet. The water is dirty from cleansing and my MMW baseline is lower than the usual 7.5MMW it is capable of. That being said, the test is not about high numbers, but the delta between fully isolated and not fully isolated.

<http://www.youtube.com/watch?v=LADZTmV9msw>

Back ground on stainless steel boosters producing Hexavalent chromium

Why you should not use stainless steel electrodes for electrolysis: Many people using the electrolysis method for hydrogen production swear by stainless steel, stating (incorrectly) that it's not consumed, stays clean and seems safe. Stainless steel is indeed consumed when used in the electrolysis process, although slowly. The main problem with using it is the hazardous waste it produces.

Stainless steel contains chromium. The electrodes, and thus the chromium are consumed, and you end up with poisonous chromates in your electrolyte. Dumping these on the ground or down the drain is illegal. The compounds can cause severe skin problems and ultimately, cancer. Hexavalent chromate is poisonous. These compounds are not excused from hazardous waste regulations where household wastes are.

Does your electrolyte turn yellow? That's a sign of chromates.

If you have been using stainless steel for the anodes (positive electrodes), wear rubber gloves when working with or near the liquids. If you need to dispose of it, allow it to evaporate into powders and dispose of the powders in sealed containers during your local "hazardous waste clean-up days".

Best bet - don't use stainless steel no matter how tempting it is.

Q: What should I do with waste electrolyte?

A: Stainless steel leaches hexavalent chromium into the solution. VERY HAZARDOUS MATERIAL! If you've never seen it, watch the movie Erin Brockavich. NEVER dump it down the drain, onto the ground, into a stream or the ocean. The dangers are absorption through the skin from regular skin contact or ingestion through ground water contamination. Precautions one should take are to:

- 1) Handle carefully wearing latex gloves.
- 2) Collect waste electrolyte in empty plastic milk containers.
- 3) Label the containers with the contents - Cr+6 or Cr(VI) and your electrolyte, KOH, NaOH, NaHCO₃.
- 4) Dispose of through hazmat collection points.
- 5) If grinding stainless, wear a respirator.

Reducing Hexavalent Chromium in Waste Water

It is illegal to dump the electrolyte in your locality as it is hazardous to health, life and the environment and may contain hexavalent

chromium in addition to other hazardous substances. Treat it just as you would the electrolyte in your car battery - you wouldn't dump that in your kitchen sink would you?. Contact your local Hazardous waste handling facilities.

DO NOT pour your used electrolyte down the drain or onto the ground -What do do:

(1) Wear protective clothing (latex gloves, face shields) when cleaning or changing out used electrolyte solutions. Make every effort to avoid exposure to this known carcinogen.

(2) Do NOT dump used solutions on the ground.

(3) The small volumes of used solutions that the typical "experimenter" will encounter can generally be easily stored in a plastic milk jug or two. Many municipalities provide opportunities for free annual or semi-annual delivery of toxic waste materials to the landfill or recycling center. Take advantage of those opportunities to dispose of your stored waste byproducts.

Don't just be safe for yourself, but also be a moral and environmentally safe, responsible citizen for a green world.

Order - [Chromium Test Kit, Color Cube, 0.2-1.0 mg/L, 50 tests](#)

Hatch Test kit

Contents: 50 tests.

Your cost: \$37.22

(add \$9.95 S&H)

(click the image to order)



Gadgetman's Hexavalent Chromium Catalyst

All you do is adding one ounce (pre-packaged) of these crystals to one gallon of contaminated solution. Shake vigorously. The Hexavalent Chromium will solidify and drop to the bottom of your container. This catalyst is safe to handle, but do us both a favor and keep it out of the reach of children!



Click the image above to order. -WHAT TO EXPECT: The contaminated solution will discolor as these crystals begin to work. This is normal. Following the good shake, allow it to sit for 10 minutes and run another test. If the test kit indicates more CrVI, add another packet and repeat the procedure.

What you'll find are some brown crystals formed at the bottom. This is the converted Hexavalent Chromium, now Trivalent Chromium, a NON-HAZARDOUS waste product. Your cost: \$1.67 a treatment, 15 treatments to a package Total: **\$25.00** (\$3.50 Shipping)

The following comes courtesy of the [Adventures in Hydroxy Gas Blog](#)

The dangers of Hexavalent Chromium in the waste water of Hydroxy experiments is very real. This made me concerned about what it was I was doing, but the warning only told me to watch the movie "Erin Brokovich" to see how bad it was. Oh, and don't throw away the water.

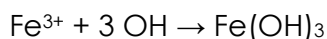
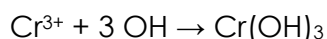
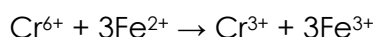
Well, rather than rely on a movie I decide to find out what [OSHA](#) had to say about it. Essentially **Hexavalent Chromium, Cr(VI) is a known carcinogen which causes cancer over long periods of exposure.** It also causes cell necrosis in the lungs when inhaled. More reading indicates that the acceptable levels of exposure are set pretty low. This is unlike Trivalent Chromium, Cr(III) which is an essential trace element.

Now that I know what kind of problem I'm dealing with, I decided to see if there is an industry solution out there. Thus the digging begins and about 2 days later the result I'm looking for pops out at me and the rest can be pieced together pretty quickly. Namely,

that Fe(II) can be used to reduce Cr(VI) to Cr(III). Way cool! Now what does that mean to me?

More digging reveals this adobe file. [Tertiary Treatment Chemical Treatment](#). The third paragraph, titled "*Removal of Hexavalent Chromium*" contained everything I needed to know about the subject, namely to reduce Cr(VI) I need to add Ferrous Sulfate and Lime to the water and let it sit awhile. It also recommended making sure 5 or 6 atoms of Fe(II) to one atom of Cr(VI) will allow the reduction to occur in timely fashion.

The chemical process is described thus:



So in reading this I see that for every Chromium atom I need 6 Ferrous atoms, and I need three lime molecules for each Fe & Cr. The rough recipe then is $1\text{Cr} + 6\text{FeSO}_4 + 21\text{CaOH}$. This means for each 1/4 teaspoon of FeSO_4 I also need to estimate about 1 teaspoon of lime for the mix. This is a slightly more lime than needed, but that should be fine. The estimate doesn't take into account any side reactions with the electrolyte itself.

From knowledge comes planning and from planning comes action. More to my line of thinking. So I know what the problem is (Cr(VI) is bad), and I know what the plan is (reduce it to Cr(III)). What's left? I need to buy the Ferrous Sulfate and Calcium Hydroxide and begin treating my waste water with it.

To solve this problem, I did some more digging and found The San Jose Scientific web site which sells lab grade [ferrus sulfate](#) in 100 gram and 500 gram increments for \$8.95 or \$21.50 plus shipping.

And here's a site to get the lime: [hvchemical.com](#). Lastly the [MSDS sheet](#) for the lime sold at hvchemical.com. I've begun Cr(VI) reduction studies on my waste water and subsequent articles record what I've done to date. Also apparently ascorbic acid (vitamin c) reduces Cr(VI) to Cr(III) but needs testing.

Tips From Bruno(Yes Bruno! ☺)

1) IS there a Chrome 6 problem at all? Because there would be no need if there ain't no problem.

2) IF there is Cr⁶ in spent electrolyte solution, (as I said before) you don't need to buy lab grade Ferrosulfate, and that count for lime too. Fe_2SO_4 , ferrosulfate, cheap and sufficient technical quality, can be bought in any garden center as an anti moss product. The same goes for the lime or Calcium Hydroxide, you find that too in garden centers and agri supplies, it is used on lawns and veggie gardens, and fields as a means to up the pH of the soil.

3) You even don't need the lime, because, the digged up manual to neutralize Cr⁶ probably started from Acid Chrome baths, then you need to neutralize the acidity, can make the pH above 7, with e.g. Lime; BUT our electrolyte has always a high pH, so lime would be a useless addition, only the iron sulfate will do.

4) Vitamin C is indeed a strong anti-oxidant, means 'Reductant' and must be able to shift Chrome from 6 to 3. BUT Your KOH or NaOH is a strong alkali and your vitamin is a weak acid, so you'll need to first neutralize the pH, make it neutral or slightly acidic before Ascorbic acid (your vitamin C) can do its reduction trick on Chrome 6, it can be done with a serious overdose of your vitamin C (wastefully expensive), or cheaper by adding vinegar (not on hot electrolyte solutions, the neutralization of the alkali with an acid is already exothermic !)

Back to point 1)

Is there Chrome 6? I don't know out of my head, or from what I've read up till now, but SS contains about 49% iron; AND under the caustic as well as voltage as the oxidative situation, (on the oxygen producing electrode versus a reductive environment on the other electrode!) It's very unlikely that chrome even enters the bath, because Iron is lower on the list of metals. So Iron will dissolve first (aka brown muck) and Chrome will stay till the last.

AND IF,IF Chrome ever is electrically pushed out of the plates as Chrome ions (3 or 6) it will react with the electrolyte (like iron does) to form insoluble Chrome Hydroxide, black muck. AND it may only form Cr⁶ at the oxygen electrode and for sure to Cr³ near the hydrogen electrode; because there is a reductive environment were NO (very oxidized) Cr⁶ can form. [AND Chrome 6 Oxide, CrO_3 is on its own a rather acidic Oxide while Chrome 3 Oxide Cr_2O_3 is amphoteric (more neutral). So there is an extra tendency in a high pH solution for Chrome oxides to shift to the Cr³ form. Here I'm talking about OX-ides not HYDR-oxides, but oxides can be formed too, then further go to hydroxides depending on the situation)]

So my tips and in between conclusions:

- You don't need the lime for caustic electrolyte neutralization.

- Iron sulfate from a garden center is the cheapest solution (IF there is any Cr6 to be neutralized)

- BUT: We need to first test :! S there A N Y Chrome in the spent solution or in a precipitate (muck) ???

A N D I F there is chrome in the spent solution I S I T CHROME 6 ?? Before we scare hydroxy enthusiasts and the general public in make them believe our beloved cells are devilish cancer causing devices. [And since we have in an operating cell a Oxidative AND a Reductive environment IF Chromes comes out of the plates it can go kind of both ways, to Chrome 3 and to Chrome 6] So real life testing is necessary to see IF Chrome is found in spend solutions; AND if it is, then we need to verify if it is in the Chrome 6 state .

About welding stainless steel

Report- I work as an environmental health and safety officer in construction. The gases released during welding of stainless 'Chromium Hexavalent' are toxic and you should protect yourself accordingly.

[Hexavalent Chromium - NIOSH Topic Page](#)

[You tube -Hexavalent Chromium Initial Test](#)

[YouTube- Myth or Truth, is Hexavalent Chromium in the Electrolyte](#)

[Hexavalent Chromium WARNING!!!! \(READ THIS\)](#)

[Safety tip on the safe handling of waste electrolyte if it contains hexavalent chromium starting 4:02](#)

[OSHA Training - Hexavalent Chromium Safety DEMO](#)

Disposal-Waste, scrap or other debris that are contaminated with hexavalent chromium and are destined for disposal should be collected and disposed of in sealed, impermeable bags or other closed, impermeable containers that are labelled in accordance with the OSHA Hazard Communication Standard, 1910.1200. -[Source](#)

Smack testing his electrolyte for Hex Chrome

Part 1-<http://www.youtube.com/profile?user=EletrikRide#p/u/9/j8DSZxtWVIs>

Part 2-<http://www.youtube.com/profile?user=EletrikRide#p/u/8/3PSzxi30E4E>

Part 3-http://www.youtube.com/profile?user=EletrikRide#p/u/7/_b6SJ16kV70

Bob Boyce method of preventing Hex

According to Bob Boyce after a careful conditioning and break of the Boyce cells to his specifications the cell will not leach Hex Chrome 6 which is the bad stuff. Only the NaOH from the break in period should have any Hex Chrome 6 in it. If it is then run at specifications there should be no Hex Chrome 6 problem.

When the cleanse process is done properly (after a thorough and deep crosshatch sanding of course), the high iron content in solution from the beginning of the cleanse, combined with the NaOH of the cleanse solution, will not allow any possible Cr6 to remain as Cr6.

Before totally trusting a Cr6 test kit for confirmation, I would want to know from the mfr how the presence of other compounds from the iron, NaOH, and Cr3, amongst others, is going to affect the accuracy of the results.

Adding lime is not required due to the presence of NaOH during this process. One issue discovered through R&D is that when KOH is substituted for NaOH during this cleanse process, the chromium on the electrode surfaces is better preserved, and hence much of it remains. We do not want this for obvious reasons; any chromium remaining will become a problem for us later by affecting the gas produced and adding chromium to the electrolyte. Thus the reason that I specify in my procedure that NaOH must be used instead, if we are to remove that chromium during the cleanse.

We use a high current density during this cleanse process. As long as operational current density is kept in its normal low range (the proper operational parameters that I specified), then there is no significant further removal of material from the electrode surfaces during normal operation. If these preparation and cleanse procedures, and subsequent operational parameters, are not followed to the letter, then many things can go wrong that can impact proper operation.

Othorhydrogen producing Cells by Bob Boyce

Booster systems that generate hydroxy gas with high percentages of orthohydrogen, do not REQUIRE engine management system changes in order to realize these benefits. There are times when it may be beneficial, but that is usually for fleet applications where truck drivers will use the extra power and efficiency to drive harder and faster, which can negate the savings. But this is a driving habit issue, not a technology issue.

In the Ti/MMO case (more info below) In this application, some of the oxygen produced binds with the titanium of the substrate, producing titanium dioxide. Because it is titanium instead of aluminium, each atom of titanium can bind 2 oxygen atoms instead of one, therefore the breakdown reaction of the titanium is slower than that of aluminium. Regardless of the slower breakdown speed, this breakdown still occurs, and eventually the substrate can no longer support the surface coatings. This bound oxygen

portion changes the mixture to non-stoichiometric, therefore reducing the amount of free oxygen in the hydroxy gas. Less oxygen means less sensor impact.

When adding stoichiometric H₂ and O₂, it is the reactivity of the applied boost gases, and how sensors react, that will determine how an engine ECU will respond. This is why a high quality hydroxy gas with a very high percentage of orthohydrogen will produce a much greater combustion improvement, than higher volumes of a lesser quality hydroxy gas. It is this reactivity that performs the useful work on the fuel charge, not the raw BTU content of the boost gases. When the boost gases are low in reactivity, then little gains are seen in combustion, and the ECU response to those boost gases is usually not favourable. This accounts for why some booster designs perform so much better than others, litre for litre.

Adding H₂ alone, or H₂ with much less than stoichiometric O₂, will cause a leaning effect because it consumes some of the oxygen that the fuel would normally be consuming. The ECU then leans out the engine a little, at the expense of some horsepower. Despite the percentages being numerically low as compared to the total intake air charge, they do have a measurable effect. This has been measured on a dyno.

Just ask dzup1234 of HH2 what improvement on horsepower was had by re-introducing the separated oxygen at another point in the intake airstream. **Unless the electrodes are of a good quality grade of stainless steel that have been crosshatch sanded properly, cleansed properly to remove the iron and excess chromium from the surface, conditioned to build up the catalytic layers, and operated at recommended specifications, then the hydroxy gas produced will be of low reactivity. Good quality hydroxy gas does not take a lot of energy to produce, it takes good booster design, construction, and proper operating practices. This is not to say that other metals cannot be used, as nickel/molybdenum electrodes would be most ideal. But most of us cannot afford the cost of exotic materials, so we have to make do with the next best thing... stainless steel, preferable 316L or 317L.**

Remember, chromium oxide is a catalyst that converts orthohydrogen to parahydrogen quite efficiently, releasing 6 joules of energy as heat per gram of H₂ converted. We want to get rid of as much iron and chromium as possible from the surfaces during the intense cleansing phase, and leave as much nickel and molybdenum as possible for catalytic operation. We want a booster that runs as cool as possible, and uses as little power as possible, while performing as desired.

There has been much lab work done, at great expense I might add, to determine the composition of the gases, and determine any possible contaminants in those gases. The detailed lab results are the properties of those that have paid to have these tests performed. But as I had mentioned before, it is only the highly reactive orthohydrogen

that is effective in the catalytic cracking of hydrocarbon fuels. I cannot elaborate more due to confidentiality, but any design that does not optimize orthohydrogen production, while minimizing parahydrogen and/or other contaminants, can expect to have poorer results. This is why the results obtained from boosters can be all over the place.

Depending on design and operational parameters, the quality of the gas can vary greatly. Booster systems that generate hydroxy gas with high percentages of orthohydrogen, do not REQUIRE engine management system changes in order to realize these benefits. There are times when it may be beneficial, but that is usually for fleet applications where truck drivers will use the extra power and efficiency to drive harder and faster, which can negate the savings. But this is a driving habit issue, not a technology issue.

The one advantage that the MMO/Ti electrodes can have is that there is no chromium oxide layer on the electrode surfaces, as chromium oxide is a catalyst that converts orthohydrogen to parahydrogen, releasing 6 joules of energy as heat for every gram of orthohydrogen converted. Does this mean that stainless steel is a poor electrode choice? Well, it can be, IF it is not properly selected AND prepared. The procedures that I outlined for proper preparation and cleansing of stainless steel electrodes, will remove not only the free iron, but also this detrimental chromium oxide from the electrode surfaces. This technique has been well published, and can be applied to any cell design. Use good quality stainless steel, and use it right, and you can produce good results. Use poor quality stainless steel, and/or use it wrong, and you will have mixed results.

Electro polishing stainless steel is not proper surface preparation, and will result in electrode contamination, and the chromium oxide to remain. My biggest concern with MMO/Ti electrodes is that they were not designed to be operated in NaOH or KOH solution environments. The normally protective Ti oxide layers are constantly being stripped off by the electrolyte, which DOES cause erosion through the pores that WILL undermine the coatings, despite the amazing claims made to the contrary. Just ask the manufacturers that make these electrodes! They will confirm every word I have said

Ti/MMO electrode Plates by Bob Boyce

The MMO coating is full of pores and imperfections that allow the electrolyte to directly contact the Ti substrate.

Ti/MMO electrodes are thought to be able to produce orthohydrogen, however My biggest concern with MMO/Ti electrodes is that they were not designed to be operated in NaOH or KOH solution environments. The normally protective Ti oxide layers are constantly being stripped off by the electrolyte, which DOES cause erosion through the pores that WILL undermine the coatings".

Normal cell operation does not provide the right conditions to form Cr6+. The heavy abundance of iron precludes the formation of Cr6+ during the cleansing phase, the only time that a cell should be run even remotely hot. That is still nowhere near hot enough to form Cr6+ in any abundance, as the electrolyte would boil away long before this could occur. The half-truth pseudo-science used to scare the uneducated away from stainless steel electrodes fails to address exactly what conditions for each grade of stainless steel are required in order to form Cr6+. Any materials test can be rigged to fail by exposing the material to conditions outside of the intended application range.

The same half-truth pseudo-science can be applied to MMO/Ti electrodes, as there are blends that are just not suitable for drinking water applications due to the toxic heavy metal oxides contained in the coatings. Just because a particular blend is suitable for water purification does not automatically mean that blend is suitable for use in even a dilute KOH solution. Similar to KOH + aluminum, KOH will remove the titanium oxides formed from the Ti exposed in the pores, exposing more Ti to oxidize. The claimed 60 years of experience is an outright untruth, as that 60 years of experience has absolutely nothing to do with using the product for hydroxy gas generation.

Just so everyone knows, I have no issue with MMO/Ti electrodes in general. I can only say that the ones tested by me did not live up to the extraordinary claims. **A properly designed and operated booster using quality stainless steel does not have an issue with hexavalent chromium production, and you of all people should know that! Boilermakers and steaming behemoths may, but they are not properly designed boosters.**

The fact is, it takes fairly high temperature operation to liberate Cr6+ from high quality stainless steel, even in an alkaline bath. The majority of chromium liberated is in the form of Cr3+. In fact, much government sponsored studies on the long term health effects of stainless steel have shown that the trace amounts of Cr6+ that can come from the interaction with food or medical grade stainless steel are metabolized into Cr3+.

One would have to directly drink the electrolyte from a hot run boilermaker or steaming behemoth in order to get enough Cr6+ to even come close to a dangerous dose. The hydroxides are more harmful in comparison. When cleansing and conditioning cells, we now filter the solution and re-use it, as it is the best solution available for cell conditioning and operation. There is so much test data already collected on the use of MMO/Ti plates. They were designed for use in water processing, NOT for use in an alkaline solution for electrolysis. Their lifespan in such an application is much more limited, and you are correct, the heavy metal content is a very big issue in such an application.

Forget all you have learned because these MMO/Ti plates have magically changed the laws of physics. Like how much voltage is required for electrolysis. Like how the

resistance of metal is decreased by using less of it, applied to PARALLEL SURFACES. Anyone with half a brain knows that as you reduce surface area in contact with water, coupling goes down and resistance GOES UP, ie more voltage is required. Sure, the coatings have a lot of surface area that is what they were designed for. But the material used has such a high resistance that it requires more voltage to overcome this resistance. This results in MORE heat generated per watt applied, not less. My testing of MMO/Ti electrodes proved this. It takes more resistive material in parallel to reduce resistance, not less! Oh, and the claim of how a MMO surface coating protects the Ti substrate from KOH in the solution. There is no such thing as a perfect surface when it comes to MMO, no matter what method of application is used. There will always be pores and defects in the surface that is how it gets the higher surface area per square inch!

. Testing was performed using this cell as a booster in my associate's vehicle, exactly as instructed. The electrode surfaces were examined using a microscope at various intervals during this testing, and some degradation was observed early on. After 4 months of booster operation, small pieces of the surface coating began to break loose from the Ti substrate. The booster is still in use, and the electrodes continue to degrade.

Ionic attraction by Bob Boyce

The involvement of the power of ionic attraction in a cells operation can be explained as the following. If you seal only the end plate cells, then the ionic attraction of the end to end of the next 2 cells from the end is still way stronger then the ionic attraction of the cell to cell path, still due to the barrier voltages of each plate surface in the path.

If there is a leakage path, even between a couple of cells, the ionic attraction through that leakage path is stronger than the direct path through the plates. Once you factor in the barrier voltages of each and every plate, it makes it clear that it is not as simple of a voltage divider as everyone assumes. With stainless steel, that barrier voltage is about 1.48 VDC for each and every "neutral" plate in the cell, or about 0.74 VDC per surface. If 2 VDC per cell is applied (brute force), this means about 0.52 VDC of potential for ionic attraction between the plates of that cell.

Now open a single hole or leakage path somewhere, say to the next cell, and that 0.52 VDC has to compete with another stronger potential. Now, you have 4 VDC between plates of 2 adjacent cells -minus the single surface of one plate in each of those 2 cells - 1.48 VDC added up. $4 \text{ VDC} - 1.48 \text{ VDC}$ means there is 1.52 VDC of potential pulling on those ions to coax it through the leakage path, as compared to the 0.52 VDC potential to pull ions to the "neutral" plate in between. At this point, it does behave as a current divider, with some ions flowing to or from the "neutral" plate, and some ions zooming through the leakage path. Only the physical friction of the solution limits how many ions

can bypass the "neutral" plate(s), creating unwanted heat in the solution while doing so.

The result is the "neutral" plate(s) work and bubble less, and the leakage path make the other path surfaces bubble more. Measuring voltage drop across multiple leaking cells will show a variation in divided voltage due to the uneven current distribution. Leakage across 3 cells (6 VDC applied) will have an ionic attraction potential of $6 \text{ VDC} - 1.48 \text{ VDC} = 4.52 \text{ VDC}$. Across 4 cells that ionic attraction is 6.52 VDC, and so on. Multiply it times the number of leakage paths, and you will see that a multi cell series cell with a lot of leakage becomes very inefficient. This is because it is the current flow that makes the gas in brute force. Any current leaking past the plates will only make gas once, typically at or near the ends, not multiple times at each and every cell.

This is why a Smacks booster, while dealing with the leakages by increasing distance between undesired leakage points, and moving desired ion paths really close together, works as well as it does, at the cost of total efficiency. By diluting the electrolyte, resistance is increased to the point that it tips the scale of the current divider to favor the desired path, even though there are multiple paths of leakage. A little too strong electrolyte concentration and the balance is lost, which is why it must be built and run as close as possible to the design or it fails to deliver expected results.

This can be done in a series cell with intentional leakage paths and diluted electrolyte, as is described in the booster designs section in the example of the "Tero cell". In this sealed cells by drilling holes in the plates. But the increased $I \cdot R$ losses associated with higher resistance in the electrolyte solution is not desirable for high efficiency hydroxy gas production.

Peak efficiency should always be sought in design construction and any leakage should not be an acceptable design consideration. What is preferable is to design a cell in order to get the most amount of hydroxy gas for the least amount of energy cost possible.

Monoatomic hydrogen By Bob Boyce

Monoatomic hydrogen and negatively ionized monoatomic contain no neutrons, and only differ in the electron count. The major difference is that the former cannot exist for very long in nature when there are other atoms around that it can bond with, while the latter will resist bonding until it decays, or enough activation energy is applied to cause an immediate reaction.

As for desirability, negatively ionized monoatomic hydrogen releases more combustion energy than either orthohydrogen or parahydrogen. It takes less than 1% monoatomic hydrogen in air to equal the combustion energy of 4% parahydrogen in air. This means that it takes slightly less than 1/4th the LPM volume of monoatomic hydrogen to run an

engine as compared to parahydrogen. Adding neutrons to hydrogen has a similar effect, but is a lot more dangerous due to the risk of tritium production.

If one has to expend the energy required to pump up the hydrogen to the negatively ionized monoatomic state, then it's not much of a bargain, as the losses are higher than the gains. But on the other hand, if the power source is "excess electron rich" like the TPS is, then those otherwise wasted surplus electrons are giving a free boost to performance.

<http://s160.photobucket.com/albums/t167/watkykjy1/?action=view¤t=M2U00305.flv>

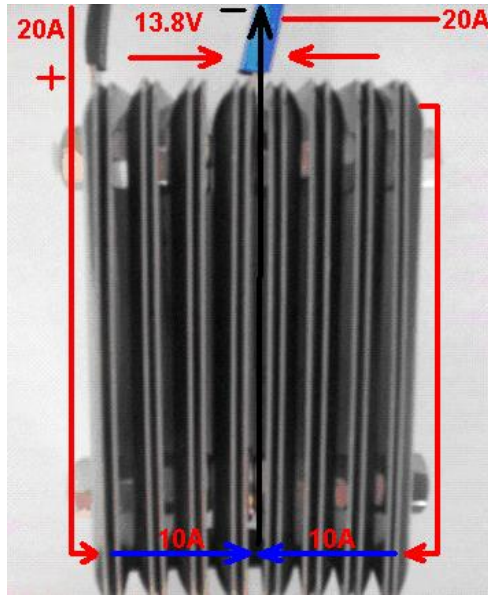
Here is an example of a TPS in operation. The excess electron production (regeneration) is connected to a switched output, which this replicator switches on and off. This is to demonstrate the difference between normal discharge state where the circuit is drawing power, and charge state where the circuit still draws power but the excess electrons are recycled back into the same battery it is running from. It shows the battery voltage rising as the TPS self-charges its own source battery. This is the exact same that TPS is used in the resonance drive system. -Bob Boyce

Faculty information on the Smack's Step gap

The Smacks booster is a series cell connected in parallel. This compacted design sits in a single container (open bath). This design uses a step gap. The benefits of using a step gap means that the additional electrode plates which are not connected electrically are closely spaced and are done so in order to provide an extra gas output.

All this was discovered by Elektrik through trial and error. All the plate spaces and sizes were bench tested to find the best gas production. Elektrik eventually settled on using four plate pairs. This produced the best efficiency and had a draw of about 3.45 volts across each pair of plates.

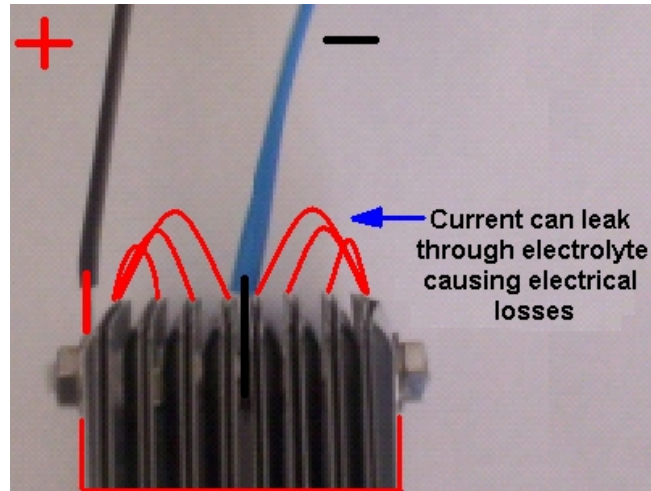
The Smacks booster uses a single-bath design (single container not isolated from each other), this is a specific case and 3.5 volts was tested to be the best setting. Smack has added a second set of an identical number of plates to increase the plate area.



Smack's arrangement employs two sets of identical plate sizes. Their relative identical position will determine where the current flows. This will be shown with one half of the circuit.



Above shows one half of the circuit, these plates are series connected. The edges of the plates are closed off to prevent any possible current paths passing through the electrolyte. The intent of doing this is to direct the current to only flow through the electrodes. This is not totally possible in this open bathed design. Elekrik will then try and direct this current flow by the spacing of the plates.



All the wasted leakage current will not produce gas. There will be some useful current. The flow gap of 1.6mm in the Smack's design will put the wastage current path as long as possible. This step gap is made specifically as large as possible.

A typical cars electrical system is about 13.8 volts. The amount of 4 plates is to divide the voltage evenly. This will be at about 3.45 volts across each of the electrode pairs. There are four pairs of 2 sets of plates. There are two of these making a total of 16 plates. Although they allocated back to back, each of them will be functioning independently. There will be a current leak from one set of 4 plates to the next tho. This series stack connected in parallel will have a steady voltage drop across the plates.



The voltage drop is the same as a normal series resistor circuit. Each plate pair has a negative electrical connection on one plate and a positive connection on the other.

Dustin's (Smack) Analogy

Dustin (Smacks booster inventor) has done his own tests to validate how he perceives hydroxy booster technology. Temperature: Looking at the cell some may claim that that one cannot quantify the volume of gas output due to the possible introduction of steam from boiling water. It can be shown that water does not boil at 60C, or in the cell. This is shown in the following video

[Temperature test](#)

In Dustin's video it is clearly shown that that the water in the Smacks design does not boil. Granted that some evaporation must occur since the water is in fact heated, but the water is not boiling. Next is the plate issue. Smack has proven the use of SS beyond any question of a doubt by running 303/304 SS plates in his own personal unit for well

over a year, putting 13,000 miles on the unit with ZERO plate degradation. There are dozens and dozens of replicators out there observing the same longevity.

Also, anyone who knows anything about this technology knows series isolated baths is more efficient than open cell designs. They are also more expensive and harder to construct. **The Smack Booster is the perfect compromise between cost and efficiency.** It was NOT designed to be the best performing device! It was designed to be the best performing device for the dollar. It is also granted that PVC is not the best container, but it is easily available. That was one of the most important design aspects. The unit had to be affordable and easy to build with easy to get parts.

End

Heating issues and tests

The following test has been done by open source engineer Praveen. Praveen's tests were based on his tubular cell design called the "Karma Booster" which is covered in the cell design section.

Assumption: Electrolyzer quantity - 1.5 liters

Initial temperature - 28 Deg centigrade

Voltage applied - 13.8 volts

Current applied - 10 Amps

Cell type - True series cell i.e. no current leakage.

Case - I

Number of cells - 6 (7 plate)

Voltage per cell - 1.97 volts

Excess voltage over 2 volt - 0

Excess power to heat the water - 0 Watt

Operation time - 60 minute

In the case of the above example the water should not heated up at all because there is no excess power available to heat up the water. But this is not the fact; in this case the water temperature will go up by around 10 deg centigrade in 60 minutes because of following reasons:

a. Unequal gap between the plate so unequal distribution of voltage.

b. Absorption of heat from ambient.

c. When the cell temp goes up the voltage required to break the water molecules goes down slowly up to 1.24 volts. In this case the excess voltage will be available in the cell to heat the water.

d. At the same time with increase in water temperature the current will rise. Hence it will have double effect i.e. excess voltage with more current. Because of this reason the Terro cell runs cool and reaches to maximum 50 deg centigrade.

Case - II

Number of cells - 5 (6 plate)

Voltage per cell - 2.76 volts

Excess voltage over 2 volt - $(2.76-2) = 0.76$ Volts

Excess power to heat the water - $(2.76-2)*4*10$ Amps = 31 Watts

Operation time - 60 minute

Considering no current leakage then the temperature of water after 60 minutes can be calculated by using following formula:

Excess power = Qty of water $\times 4.184 \times (T_2 - T_1) \times 1000$ / Time in Seconds

31 Watts = 1.5 liter $\times 4.184 \times (T_2 - 28) \times 1000$ / (60 \times 60)

$T_2 = 45.78 \sim 46$ deg centigrade

So with so much excess voltage the water temperature is reached only up to 46 deg centigrade from 28 deg centigrade i.e. 18 deg centigrade rise in 60 minutes. But in open bath system the water temperature rise in one hour would be around 40 deg centigrade. Anything over 18 Deg centigrade in case II comes from the current leakage. However as mentioned in point (d) above the increase in temperature will have multiplying effect i.e. more and more energy loss and more and more temperature rise.

Somebody may ask-"WHY IS IT THAT NORMALLY TEMPERATURE DOES NOT GO BEYOND 90-95 DEG CENTIGRATE AND WHY THE TEMPERATURE RISE GET SLOW DOWN ABOVE 80 DEG CENTIGRATE"?

This is mainly due to the higher temperature difference with ambient temperature. So the booster eliminates the waste full heat to atmosphere at faster rate. But in any case we should not allow it go up to that level.

Conclusion is that the heating of the water is mainly because of the current loss in the system. Of course anything above 2 volts also has an impact on heating but the main is current loss or parasitic current. This can be seen by building Tero design with 6 plates i.e. 5 cells. With this you will have 2.76 volts per cell. Run this booster for 4 hours and measure the temperature. You will not get too much heat even at 2.76 volts. In second trail, build a open bath system either step gap or with neutral plate. Keep the 7 number of cells to get around 1.97 volts per cell. Again operate this booster for 4 hours and measure the temperature. You will see significant heat in spite of the voltage being lower than 2 volt.

In third trail, make a parallel plate arrangement and apply 3.3 volts to the cell with around 8-10 Amps. Again operate it for 4 hours. In this case also you will not get much heat. This testimony is not based on THEORY, but reported results based on tests which were conducted.

Sealing the plates is not going to control the heat in the open bath system. Current is not a thing which can be hold using some stuff like plastic wrap, coca bottle etc etc. One must decide the usage parameter before making the booster. The main usage parameter would be time of operation, ambient temperature, space in car engine compartment etc etc. then select the device and build it. One must understand the technology before making a booster.

Plate conditioning

The actual purpose of the surface prep is to create "low resistance current sites" that greatly improve the efficiency of the electrolyte to plate interface. Sanding in a cross hatch pattern will produce points, while sand blasting produces "micro divets." These divits improve surface area but do not have as big an effect on the electrolyte to plate efficiency. If these sites are done in the size created by 30 to 60 grit sandpaper, they will have a positive effect. If this same "micro current bunching" is enlarged to the size of "thread edge" of a screw or sharp edges on a plate in open bath boosters, the effect is too much current bunching and the result is water and electrolyte vapor production. In the extreme you will also get steam if the cell voltage is over 2 volts.

The Stainless steel electrodes plates are "conditioned" to prevent the bubbles of gas "sticking" or remaining on the surface of the electrodes and impeding the electrolysis process. The importance of bubble propagation and release must not be underestimated. Sharp edges = more bubble formation and easier release into the electrolyte. Enough bubbles being present on an electrode can prevent it from "touching" the electrolyte and stop electrolysis altogether. **The preferred electrode plates to use are made from 16 gauge 316L-grade stainless steel.** It is advised that there is to be between 2 and 4 square inches of plate area on every face of every electrode for each amp of current passing through the cell.

Various experimental methods to aid electrolysis and prevent the bubbles from remaining include the use of an ultrasonic transducer underneath the plates to vibrate the bubbles off the plate surfaces. Other open source engineers configure the engine suck its input air through the electrolyser in order for the air drawn through the electrolyte to dislodge the bubbles. Other methods include the use of piezo electric crystals attached to the plates to vibrate the plates and shake the bubbles free. Also magnetic fields, usually from permanent magnets have been suggested.

The following information has been originally provided by open source engineer Bob Boyce. Plate conditioning needs to be done in order to "condition" your cell to produce the most gas out put. When using brand stainless steel, the new shiny surface cannot be used in an electrolyser; this will need to receive careful treatment and preparation before it can produce a peak level of gas output.

The surfaces need to be cross-scored with coarse sandpaper before the cleansing and conditioning process is started. **At no time are the plates to be handled with bare hands. Use clean rubber gloves to handle the plates.** You must not to contaminate the plates with any type of solvent or cleanser.

Store conditioned plates in clean distilled water, protecting the surfaces from scratches. Allowing them to dry can cause some catalytic layers to crack. The reason for this, not everyone conditions at low enough current, so the catalytic layers may not be as well adhered to the base metal as they should be. If conditioning is done very slowly, and at low current, it will be finer and better bonded to the base metal, and it should be able to survive being dried out without damage.

If you must store mixed electrolyte, store it in an airtight container. NaOH and KOH will absorb carbon (CO₂) from the air, which will poison the catalyst layers that form on the plates, lowering peak efficiency. Never vent your cell in a manner that will allow ambient air to enter.

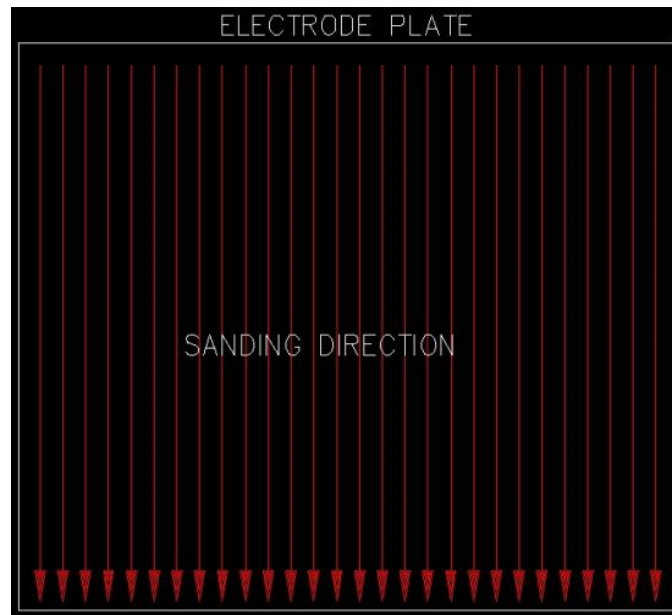
The aim here is to treat both surfaces of every plate in order to encourage the gas bubbles to "break away" from the surface of the plate. The first option is to do this by grit blasting, care must be taken that the grit used does not contaminate the plates. There is the possibility that your stainless steel plates can be rendered useless as far as electrolysis is concerned. Sandblasting or using an orbital sander will NOT work the same as hand sanding. This sanding is typically done by hand or on a belt sander using 60 or 80 grit sandpaper. Reports state that using a 6-inch x 48-inch belt sander is great for preparing the plates with 60 or 80 grit. Always wear rubber gloves when handling the plates to avoid getting finger marks on the plates. Wearing these gloves is very important as the plates must be kept as clean and as grease-free as possible, ready for the next stages of their preparation.

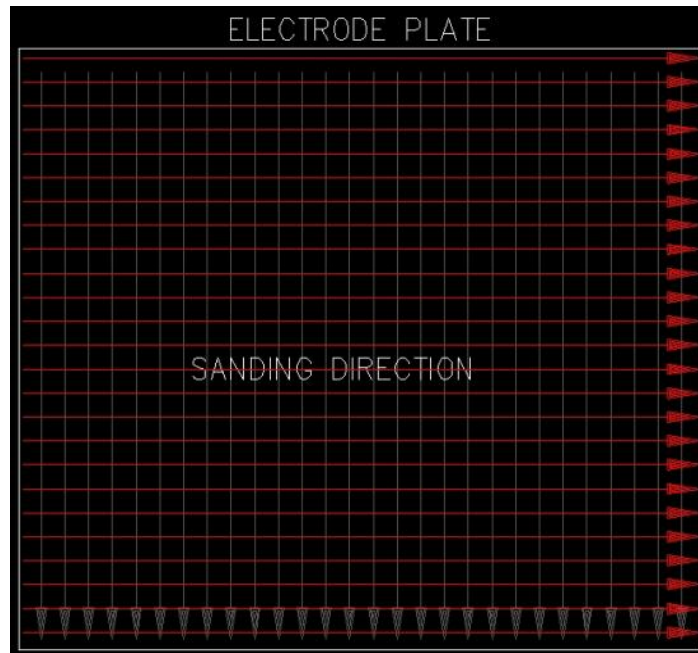
Any particles created by the sanding process should now be washed off the plates. **This can be done with clean tap water (not city water though, due to all the chlorine and other chemicals added), but only use distilled water for the final rinse.**

The safe way is to score the plate surface with coarse sandpaper in two different directions to produce a cross-hatch X pattern. This is done to produce microscopic "sharp peaks" and "valleys" on the surface of the plates. Sharp points and ridges are ideal for helping bubbles to form and break free off the plates.

Diagrams courtesy of <http://aquauto.com>

First sand from left to right from side to side -on the side- Then from top to bottom downwards.





1. Plate Preparation

First, you must deeply crosshatch the plates in an X pattern. Rinse the plates clean of particulate matter. **Acids or other cleansing chemicals are never to be used on the plates. The only chemicals that should EVER touch these plates are sodium hydroxide.** Clean water (not city water though due to all the chlorine and other chemicals added) may be used to rinse, but distilled water only is to be used for final rinse.

2. Cell Assembly

Assemble the plates into the series cell container. Mix up a dilute solution (5% to 10% by weight) of *sodium hydroxide* in distilled water. Pour this solution into the series cell container until the solution is just covering the plates totally.

3. Plate Cleansing

During this stage, we are operating in submerged plate condition, where the liquid level is maintained just over the plates. Run this cell stack at full power for several hours at a time, which can be 4 amps or more. As the cell stack runs, the boiling action will loosen particulate from the pores and surfaces of the metal. **Be sure to do this in a well vented area.** Shut down and pour this solution into a container. Rinse the cells well with distilled water. Filter the dilute solution through paper towels or coffee filters to remove particulate.

Pour the dilute solution back in and repeat this cleansing process. You may have to rinse and repeat many times until the cells stop putting out particulate matter into the solution. Optionally, you can use new solution each time you cleanse, but be forewarned, you can go through a lot of solution just in this cleansing stage. When you're cleansing is finished (typically 3 days of cleansing), do a final rinse with clean distilled water.

4. Plate Conditioning

Using the same concentration of solution as in cleansing, now fill the cell stack with dilute solution. Monitor current draw. If current draw is fairly stable, continue with this conditioning phase straight for 2 to 3 days, adding distilled water to just replace what is consumed. If the solution turns color or skims over with crud, the cell stack needs more cleansing stages. After 2 to 3 days of run time, pour out the diluted solution and rinse well with distilled water.

In Summary, the following is essential to get the most gas production out of your cells, do not expect to get any significant gas flow if you do ensure the following:

1. **Good solid series cell design with no bypass leakage.**
2. **Good preparation;**
 - a) **Cleanliness (wear gloves when handling electrodes).**
 - b) **Thorough, uniform, and deep crosshatch sanding.**
 - c) **No contamination (no cleaning chemicals used on electrodes).**
 - d) **Thorough electrode rinsing with clean (distilled best) water.**
 - e) **Follow thorough cleansing (base passivation) procedure.**
 - f) **Follow thorough conditioning (catalytic layer build) procedure.**
3. **Operate unit within recommended electrolyte type/concentration.**
4. **Operate unit within recommended current density specifications for catalytic operation**

Bob Boyce plate cleansing

Bob has recently stated that plate cleansing and conditioning HAS to be done with sodium hydroxide (NaOH) and can't be done with potassium hydroxide (KOH). Plate cleansing and conditioning is done with a NaOH solution from 5% to 10% in strength. A 5% solution ("by weight") is 50 grams of NaOH in 950 cc of water. A 10% ("by weight") solution is 100 grams of KOH in 900 cc of water.

Walk through conditioning by <http://aquauto.com>

Electrode "plates" are the most common type of electrode so when you read "plates" below, I am just referring to the electrolyzers electrodes. Why do this?

This process can be somewhat of a pain and take several days to do (if done properly). So why you do you want to spend the time to do this? This process will make your booster much more efficient and will help it perform the best it can. Before Starting

[Bob Boyce](#) states in numerous places around the internet (see the yahoo group "hydroxy") that you should not EVER touch your plates with your hands. This will add oil's to the plates and will decrease their efficiency.

Scoring

Scoring is the simplest part of "preparation" process. In short, all it involves is sanding the plates vertically, then horizontally using 60-80 grit sand paper. This can be done by hand or with a belt sander. Don't use an orbital sander or sandblast the plates, they do not work the same.

This will help produce very small grooves on the surface of the steel allowing more bubbles to form and makes it easier for them to break away from the surface. After sanding the plates, rinse them with clean water. Don't use tap water as it contains chemicals and can affect the ability of the plates to produce hydroxy. Finally make sure that your "last" rinse is with distilled water.

Plate Cleansing

To clean the plates of grease, fingerprints, etc... Thoroughly rub the plates with rubbing alcohol. Be sure to use gloves when you do this so you don't get more prints on the plates. Assemble the plates in series and place them in a container. Mix up some sodium hydroxide (NaOH) in distilled water, 5% to 10% by weight. Pour the NaOH solution in to the container until the plates are totally covered.

Apply voltage to the plates of at least 2 volts per cell, but not over 2.5 volts. Also, start out pulling about 4-5 amps

Temperature is more important than amps here; your system should run at 120-140 deg F for the cleansing process

Shutdown the system and pour the solution into a separate container.

Rinse the cells thoroughly with distilled water.

Filter the previously used solution through paper towels or coffee filters to remove any particulate

Pour the solution back in too the first container and repeat step 4.

Repeat steps 4 through 8 until the cell stops leaving particulate matter into the solution.

When cleansing is finished (this can take unto 3 days) do a final rinse with distilled water.

Safety: Only do this in a well ventilated area (such as the outdoors). The cell will be producing hydroxy gas which is explosive and can get trapped in ceilings.

Note: you can use new solution every time you cleanse, but you will go through A LOT of solution.

Explanation

As the cell stack runs, the boiling action will loosen particulate from the pores and surfaces of the metal. This will help the electrolyzer to produce at its peak.

[Step by Step PDF of conditioning by Andre Shori](#)

The physics of it is this. When electrons stream off the cathodes, the electron velocity is directly proportional to the applied potential (voltage). If the electron velocity is too high, they bounce around between water molecules until they slow down, causing excessive wasteful water molecule motion (ie friction). This friction creates heat, not gas. The Bob Boyce efficient series cell designs make less heat because the electrons are slowed down by the lower applied potential per cell.

Proper surface preparation and the catalytic materials used in Bob's designs, allows the voltage to be reduced and still be able to flow a higher current per square inch of electrode surface area. It does this without electrodeposition taking place, as long as rated current limits are observed. Do not have your electrodes electropolished or passivated! Common electro polishing or passivation is done with acids, which removes the WRONG metals from electrode surfaces and exposes more chromium. This raises the potential required to push a given current, as compared to the surface preparation procedure Bob has outlined which exposes more nickel and molybdenum. PTI uses Bob's method process in The Cell systems, and they are so efficient that thermostatically controlled heaters are added to bring electrolyte temperature up to 90F as quickly as possible.

Bob does not use acids for the normal cleansing / passivation / electro polishing phase. The only time acid use is acceptable for these systems, and only as a last resort, is if the plates have become extremely contaminated somehow. Then muriatic acid can be used to soak the plates in for a while. Then you must rinse well, and then neutralize the acid with a sodium hydroxide soak prior to beginning the process all over again.

Choice of what "grade" of water to use in a booster

Rainwater, spring water, or tap water contains impurities. A typical analysis will show minerals, suspended solids and more contained in these varieties. These impurities will precipitate out of the water when subjected to electrolysis. These appear in the form of brown, black and green scum in water or any discoloration of the water itself. These impurities has a solid mass which in turn will clog up the electrodes and further impede the operation of the cell overall. Of further concern is the fact that these solids accompany known gases which mix with the hydroxy to go on to create unknown chemical reactions which are toxic to the environment. **Therefore ONLY DISTILLED WATER MUST BE USED FOR THIS TASK.**

Electrolyte and mixing

There are many different electrolytes that CAN work in an electrolysis process, but does that mean they are suitable? **NO.** Some common ones considered for hydroxy boost application include:

KOH- Potassium Hydroxide- Used in soap making

NaOH- Sodium Hydroxide- Lye- Used to open drains

NaCl- Sodium chloride- Table Salt- Raises blood pressure – DO NOT USE!

NaHCO- Baking Soda- Makes bubbles and poisonous gas– DO NOT USE!

H₂SO₄- Sulfuric acid- Car battery acid- Makes bad gases and burns! – DO NOT USE!

Vinegar (5 to 10% solution of acetic acid) – DO NOT USE!

Sodium sulphate - DO NOT USE!

There are many other electrolytes in the acid, base and salt families, but generally these are the common off the shelf ones considered for use in most hydroxy electrolyzers.

The best choice of electrolyte is judged by its ability to remain unchanged as the reaction takes place. Note first understand what is a catalyst? An electrolyte such as he KOH acts as an ionizer for conduction of the electricity, whereas the nickel in stainless steel acts as the catalyst (hence the finish on the surface of the plates after iron is leached out). Other papers refer to nickel as a catalyst in this electrolysis process. The better the flow of electricity the better the splitting of water to a point, current is the generator of heat. Once most of the free iron has been cleansed from the cells, the KOH or NaOH combines with the nickel (and molybdenum in 316L) to form the catalytic layers. The anode and cathode each take on a slightly different characteristic patina and chemistry.

KOH is a even strong base and also a bit more conductive then NaOH, so it was clearly not the way to lower amps and or reducing the heat problem.

By using distilled water it must be understood that this water cannot conduct electricity on its own, therefore a catalyst is required in order to aid electrolysis. **The ideal catalyst is a substance that enables the reaction to take place without becoming a part of that reaction.**

From empirical testing, it has been found that Potassium hydroxide (KOH) and sodium hydroxide (NaOH) are two substances that catalyze efficiently. Tests have shown that when combining distilled water with one of these two catalysts that a cleaner cell bath and more homogeneous hydroxy mix results. This results in a more efficiently operating unit thus an in improved mileage gains, performance and less emissions.

Therefore KOH is what you want to use. It is the most stable, and it is not consumed during the electrolysis. So once you have your cell working at the target amperage you just need to add distilled water as the water is consumed, no more KOH. About once a month you want to use the water from your primary bubbler to replenish your cell. This will put back any of the KOH that may have been carried by pressure or steam to your primary bubbler back into your cell.

Every couple of months you need to check your amp draw to confirm you haven't had any MAJOR Changes. About every 6 months it is a good idea to drain your cell and refill with fresh electrolyte. This is because as you run your booster it should get more efficient and require less KOH to get the same result.

Warning- Potassium hydroxide also known as "caustic potash" is highly caustic. This needs to be handled carefully and kept away from ANY contact with skin, and even more importantly your eyes. If any splashes come in contact with you, by adding water on the affected area will cause it to react and heat up, the use of vinegar will neutralize the burning, then wash it off with allot of rinsing.

Always store it in a sturdy, air-tight container which is clearly labeled "DANGER! - Potassium Hydroxide". **Keep the container in a safe place where it can't be reached by children, pets or people who won't take any notice of the label. When working with dry KOH flakes or granules, wear safety goggles, rubber gloves, a long sleeved shirt, socks and long trousers.** Additionally wear a face mask which covers your mouth and nose.

If you are mixing solid KOH with water, always add the KOH to the water, and not the other way round, and use a plastic container for the mixing, preferably one which has double the capacity of the finished mixture. The mixing should be done in a well-ventilated area which is not draughty as air currents can blow the dry KOH around.

When mixing the electrolyte, never use warm water. There results a chemical reaction between the water and the KOH which generates allot of heat. By placing the mixing container in a larger container filled with cold water will help to keep the temperature down, and also prevent any spillage if your mixture should "boil over". **Add only a small**

amount of KOH (table spoon) at a time, stirring continuously, and if you stop stirring for any reason, put the lids back on you storage container.

Electrolyte concentration DOES have a direct impact upon maximum obtainable efficiency. If the electrolyte concentration is run at below peak conductivity, it is just like inserting resistance in series with a cell. Current flow is limited by the increased resistance of the solution. This causes less power to flow, BUT, more of the power that does flow, is wasted as heat. Therefore, if one wishes to achieve peak efficiency, even at brute force DC, one would want to run the electrolyte concentration at peak conduction, and use another means to control current, such as a current regulator.

Note that this cannot be applied to a Smacks Booster. This design actually uses the increased resistance of more dilute electrolyte to obtain it's step-gap current differential. Since his design has these criteria, it cannot be improved in efficiency by increasing electrolyte concentration to peak conductivity.

KOH is added into distil water to bring conductivity. Without KOH / NaOH the current does not pass through the water from +Ve to -Ve. With the quantity of KOH / NaOH we control the current draw by the booster. That means if you add more KOH then more conductivity and less resistance hence more current and more gas production for applied voltage and vice versa. Hence the concentration of KOH is directly related to the current draw / gas production.

10% KOH concentration (by weight) is so far reported and understood to be the optimum. NaOH weighs 1.829 g/cm³. If you can find out how many cm³ in a teaspoon this will be very useful. KOH it weighs 11 grams per heaping teaspoon. The following is based on an engineer's empirical example. This was based on using a Smacks booster where it took @ 3liters of water to which 1 TEASPOONFUL of KOH was added. The amperage reading on startup was @ 20 AMPS which is too high. Recommended starting amperage draw for a cold booster is @ 16 amps per the instructions.

Adjust concentration based on amperage draw. He removed 1 liter of the electrolyte and replenished with distilled water and my starting amperage is now @ 15 amps. This is close enough as the normal loss of water due to use will gradually increase the concentration and subsequent amperage draw as it runs.

Example- To make 1 Kg of a 28% KOH solution by weight, add 280 grams of KOH to 720 cc of water. To make 1 Kg of a 20% KOH solution by weight, add 200 grams of KOH to 800 cc of water. To make 1 Kg of a 10% KOH solution by weight, add 100 grams of KOH to 900 cc of water. The total weight is always 1,000 grams containing whatever percentage of KOH that is wanted.

Using NaOH

If using off the shelf NaOH (drain cleaner or "caustic soda" you must check that there are no other impurities in it. [Warning about Drain Cleaners for use in Hydroxy Production](#)

How much NaOH is 28% in a u.s gal of h2o?

roughly $280 \times 4 \times .95 = 1064$ grams = 2.35 pounds (280 grams per liter * 4 liters * .95 liter per quart) but an even more interesting question is "what's the concentration -now-?" after you've been running a while. For that you can use a battery hydrometer .One of those "baster-like bulb with glass tube with calibrated float in it" car battery testers. Such as: <http://www.sjdiscounttools.com/ezrsp101.html>

Or <http://www.buyhardwaresupplies.com/?t=5&m=g1&itemNumber=80530> (you want one that shows -numbers-, not just "good/poor") A 28% solution of NaOH has a specific gravity (density) of 1.3064 A 28% solution of KOH has a density of 1.2609 (source: <http://www.handymath.com/cgi-bin/spcgrv.cgi> And <http://www.handymath.com/cgi-bin/spcgrvkoh.cgi>.)

[PDF-NaOH Hand book](#)

[PDF-KOH Hand book](#)

Using Baking soda as an electrolyte

Empirical tests have shown that using baking soda as an electrolyte gives a false sense of security. Baking soda will not only remain baking soda in use, but also cause permanent damage to the electrode surfaces during its transition into sodium hydroxide. Note Baking Soda is very dangerous to use.

Empirical tests have shown that after the gas was analyzed, there is hydrogen, some CO₂, also enough CO to be lethal. There is NO oxygen produced until ALL of the carbon has been reacted from solution. It is not suitable to state that the gas produced is to be burned and not inhaled. Many experimenters who use baking soda are burning the gas when they are doing their experiments. Most are venting the gas into the air in the room they are in, and even those that DO burn the gas in an engine often-times have leaks in their systems.

Baking soda it will permanently damage the surface structure of stainless steel. That is why it has to be sanded or ground off, and then the cleansing and conditioning started all over again.

Baking soda does not lose potency; it decomposes as a part of the reaction during electrolysis. Some carbon binds with the electrodes and causes damage to the surface structure, the rest of the carbon binds with oxygen to produce other products of reaction during electrolysis. While it is still baking soda, it does not produce hydroxy gas, it produces a blend of hydrogen (H₂), carbon monoxide (CO), and carbon dioxide

(CO₂). As this occurs, the baking soda is transformed into NaOH, sodium hydroxide. This is why it keeps on working, but as the carbon is consumed, the way the gas burns (it changes from bingo fuel gas into hydroxy gas), and the way it effects hydrocarbon fuel combustion during boosting.

A reliable and repeatable performance increase is not going to happen during the decomposition phase of baking soda. It will eventually stabilize, but not until all of the carbon is consumed. If your looking to "escape" the usage of caustics by substitution of baking soda.

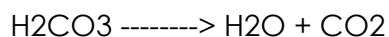
Baking soda decomposes into NaOH during electrolysis; you end up with a caustic. And the worst part of this is, the end users are lulled into a false sense of security, thinking that it remains safe baking soda. So they are unlikely to take proper safety precautions. And worst of all, if you have expensive SS electrodes, they become damaged as the carbon will also poison the catalytic capabilities of stainless steel. Salt is also unsuitable as is battery acid. To recover them would require a real good sanding to get rid of the surface damage and start over. **DO NOT USE BAKING SODA PERIOD END OF STORY!**

Further you would have to add 84 grams of baking soda (NaHCO₃) to obtain the same amount of sodium as you would for 40 grams of Sodium Hydroxide (NaOH). This is relevant because it is the Sodium that is driving the electrolysis process.

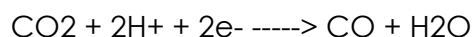
On electrolysis of NaHCO₃, the Na⁺ ion will rush to the cathode and you will get:-



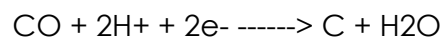
Also



Also



Also



Conclusion: On adding NaHCO₃ a whole range of chemical processes can take place but due to the nature of alkali metals, the one sure conclusion is that Hydroxides will be formed. DO NOT BE DECIVED into thinking that if you make a completely safe electrolytic solution using NaHCO₃ or other carbonates that you end up with a completely safe electrolytic solution after use. If one takes pH readings of the electrolytic solution over time, one can access the progress of the carbonate solution (pH will increase with increasing Alkalinity), but my advice is play it safe, where PPE.

But when someone intentionally publishes that using baking soda is safe and does not put out carbon monoxide, sure, there is hydrogen, and sure, there is some CO₂, but there is also enough CO to be lethal. There is NO oxygen produced until ALL of the carbon has been reacted from solution. The argument that the gas is to be burned and not inhaled does not mean it is safe. How many of these people that use baking soda actually is burning the gas when they are doing their experiments?

Most are venting the gas into the air in the room they are in, and even those that DO burn the gas in an engine often-times have leaks in their systems. If calculations are correct, then a concentration of just 0.0667 % in the atmosphere you are breathing is enough to bind with 50 % of your Hemoglobin, this is a life threatening situation! For non chemistry people who wish to get a grasp of the toxicity of Carbon Monoxide, a good rule of thumb is, when you think Carbon Monoxide, think Cyanide! [Reference](#)

A glass jar containing wires wrapped around pieces of plastic, and filled with baking soda is NOT a suitable Hydrogen Electrolyzer! Reference the picture of the result of a baking soda booster shown in the overview to remind you!

Bob Boyce has also done tests with baking soda, it has been found to also release CO₂! The results were that the percentage of CO to CO₂ was directly related to the temperature of the electrolyte solution. Even at room temperature (78 F) there was enough CO produced to be lethal if inhaled directly. As temperature rises, the percentage of CO to CO₂ increases dramatically. At temperatures above 125 F, there was no measurable CO₂ production, only CO.

The reason given was the carbon reaction is more endothermic than electrolysis, and absorbing heat energy from exothermic electrolysis alters the results of that carbon reaction.

Using Vinegar

A common person may reason that Vinegar (a 5 to 10% solution of acetic acid) is a suitable electrolyte for DC Electrolysis to make Hydroxy. Why not? It's cheap, sometimes cheaper than bottled water, everybody can buy it around the corner, and it is very safe you can drink it. **WRONG.**

It's not a good electrolyte, and you can NOT count on its stability. One of the reasons is that is not a solid with an high boiling point like the preferred KOH or NaOH, but pure Acetic Acid is a liquid, with a certain vapor pressure (you cannot smell cold KOH, while sniffing on a bottle of cold Acetic acid may let your nose fall off, it stinks pretty strong); and it has a boiling point not much higher than water.

(Water = 100°C, Acetic Acid = 118°C). And because many Cells and Boosters are run on elevated temperatures, some above 90°C, you can imagine that besides your

Hydroxy gas, allot of water vapor (steam) AND also allot of acetic acid vapors will escape such a Cells. Thus you are loosing your electrolyte if you use Vinegar, not so with NaOH and KOH.

Further See : http://en.wikipedia.org/wiki/Kolbe_electrolysis The Kolbe electrolysis From Wikipedia, the free encyclopedia reaction is an organic reaction named after Adolph Wilhelm Hermann Kolbe. The Kolbe reaction is formally a decarboxylative dimerisation and proceeds by a radical reaction mechanism.

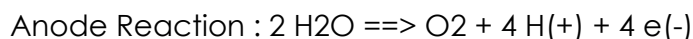
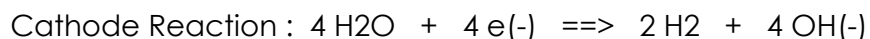
As an example, electrolysis of acetic acid yields ethane and carbon dioxide:



Acetic Acid gives Ethane gas + Carbon dioxide gas So you get an un-useful gas CO₂ (it extinguish flames not promotes explosions) and Ethane gas which is a flammable gas that will behave as a fuel. Your electrolyte is also by the electrolysis process itself falling apart and vanishes trough your engine, you'll be left with plain water, without electrolyte, resistance goes up, amps go down, gas production goes down, and your possible gain in MPG is pretty fast back to zero.

Using Sodium Sulphate (Glauber's salt)

The electrolysis of an aqueous solution of sodium sulphate using inert electrodes produces hydrogen at the cathode and oxygen at the anode and a neutral solution of sodium sulphate remains unaltered by the electrolysis.



BUT sodium sulphate is much weaker than lye, so you would need much more electrolyte and WORSE: it quickly turns your water into a brown/red substance. Though it does not damage your electrodes, it really does not look good!! So the bottom line is that after all my experimentation I simply decided to stick to lye. Yes it is a drain cleaner and thus caustic, but just like any object or substance that can be potentially dangerous in the wrong hands (e.g. scissors, medicine etc. etc.) you simply need to be responsible and keep it out of the reach of your children. Lye (NaOH) or KOH, when used as electrolyte, is clean and will never damage your electrodes.

Using Ammonia

Ammonia is consumed in the process which means you would have to continuously add more Ammonia instead of distilled water in the case of NaOH. Also Nitrogen is being produced instead of oxygen again in the NaOH case. So what you end up with

is no oxygen (good stuff) and nitrogen (good fertilizer but it won't burn but occupies space in the combustion chamber therefore bad in this application.) **This is probably why it is not used.**

Pulse width modulation on brute force DC booster technology

Pulse Width Modifier (PWM) -The issue of using pulse width modulation with existing brute force DC designed boosters is considered to address the issue of heating problems. Usually "step gap" designed boosters have heating issues after a certain amount of run time. The PWM should be used in open bath to control the supply /modulated supply so that the heating can be reduced **at the cost of less gas**. Note an isolated-cell 7-cell series-connected booster will not have heating problems as it has a much higher electrical efficiency and far less of the current goes in heating the electrolyte.

This electronic device is basically a DC motor controller. It takes a Direct Current (DC) Voltage and pulse's it at a steady preset rate. The frequency and pulse width is adjusted by the variable (adjustable) resistor and the capacitors used in the Circuit. This is currently being experimented with in a "Booster" to control current from a "Run away" situation, common in a "Brute Force" direct current cells. The run away current is caused by your electrolyte heating and therefore allowing more current to flow through your cell.

The "Pulse-Width Modulator" or PWM circuit is a circuit which switches the power to, the booster ON and OFF thousands of times per second. By adjusting the duty cycle setting of the circuit, you alter the ON time to OFF time ratio and so control the average power fed to the booster. As the booster is fully ON or fully OFF nearly all the time, not very much power is wasted in the switching circuit.

It is understood that a pulse width modulator (PWM) in a brute force DC design will not increase the amount of gas produced. It will in fact produce less gas as the current will be limited by the duty cycles on and off times. However experiments where the duty cycle fluctuates between 50%-70% and 100% can be experimented with to give an "averaged out" practical result.

The usefulness and merit of using a PWM is sometimes confused with the benefits of using a PWM in pulsed DC resonant circuits. These configurations produce a unique "resonant tuned waveform" that allows more gas for LESS current. These systems include Stan Meyer's, Bob Boyce's, Dave Lawton's, and RAVI's. This is where the pulsing is sharp and at resonance with the cell. Typically you do not get this operation with just an ordinary PWM circuit in a brute force DC operation.

While a PWM can be "the quick way" to solve any overheating problems on a booster, one must also remember that most PWM's have large heat sinks to get rid of a lot of heat and that heat is simply energy that is lost. So, although the PWM can solve the cell

overheating problem your overall gas production could be lower compared to without the PWM.

This you will need to verify with out put and heat tests. A Pulse-Width Modulator circuit can be installed with a control knob mounted on the dashboard beside an ammeter. As an engine load and RPM's increase, the quantity of hydroxy gas that benefits combustion increases as well. So if at idle the booster is always running at full power, the excess hydroxy gas produced does nothing to offset the excess high load of the alternator caused by the booster.

This has been the bane of poor quality boosters that consume way too much power for the amount of hydroxy gas consumed. The units in question typically do not produce enough hydroxy gas output to benefit combustion enough during times of high demand.

A PWM power control board tied into the throttle position sensor could help, but only if the booster is efficient enough to make enough hydroxy gas at full boost to assist in high demand applications. This could also help with excessively low startup output by increasing cold booster current, and solve long operating time booster overheat issues by cutting back on hot booster current. This is a perfect fit for a Smacks or series cell type of booster, both which is capable of higher hydroxy gas output levels. The boilermakers and steaming behemoths just don't put out enough hydroxy gas per amp of power consumed to make this very feasible.

For example take the scenario a booster power control is fitted. The driver of the example in question drives a Prius in low demand applications, the gen-set engine cycles on and off to meet net power demand, and the traction battery unit powers the electric drive. He states In this setting, I would turn the booster control off. Once on the highway at speeds over 50 MPH, the gen-set would typically stay running, so I would adjust the control to peak MPG as displayed on my instant MPG indicator. The only time I would set for maximum boost was for climbing hills or any other situation that required full throttle operation. The Prius is one example where a throttle position sensor on the throttle pedal would not work, as the system is "fly by wire" with no direct link from the throttle pedal to the gen-set engine throttle. The onboard computers manage the gen-set throttle position based on instant power requirements. Please note, a Prius hybrid is a completely different motor operation to the ICE.

PWM facts design and use By Mike.

1 PWMs come in many flavors, grouped into two types: A "OPEN LOOP" control, ie no feedback either internally or externally from the load [cell] being controlled. B "CLOSED LOOP" CONTROL, ie with feedback from the load [cell] that changes the control point.

2 ALL PWMs DECREASE the "duty cycle" to control the output. This means that at 100%

on time [which none will do] the current in the load is the same as with no PWM.

3. ALL PWMs are rated for amps at a specific ambient temp. Above this the max current is "de-rated" by some amount listed in amps / degree C. The output devices, usually a FET or several FETs in parallel are mounted on heat sinks to help control the heat. The heat sink is also rated for an ambient temp and it too has a "de-rating" for higher temps.

The cheaper PWMs like the MC12 are open loop controllers. The adjustment only sets the "duty cycle," which is the % of "ON TIME." If you set the control for 50%, the AVERAGE current is 50% of the uncontrolled DC value. The "PEAK CURRENT" is only determined by the load [cell] resistance.

This is not all bad. It just changes how you set the device. WHY? If you set the duty cycle, and therefore the current when the cell is cold, to say 7 amps, that only applies to the temp. As the bath heats up the resistance goes down. Let's do the math. $I = E/R$
 I =current in amps, E =voltage, and R =resistance in OHMS

$$I[7] = E[14] / R [2] \text{ COLD}$$

When the cell gets hot the resistance goes down and the current goes up. If the resistance goes down to 1 OHM [a reasonable number for a common bath] the math is: $I = 14 / 1 = 14 \text{ AMPS}$ Still OK!

Now: if you start at 18 amps you are in big trouble.

$$18 = 14 / R$$

$$R = 14 / 18 = .77 \text{ OHMS}$$

If the rise in temp changes this to .5 ohms you have:

$I = 14 / .5 = 28 \text{ amps}$ on a 20 amp device already likely to be running at way over its designed temp!

Is this a stopper? NO, you just have to set the current when HOT!

SET YOUR CURRENT TO A LOW VALUE FIRST AND THEN ADJUST AFTER THE CELL HAS WARMED UP. REMEMBER IT WILL HEAT UP MORE AFTER YOU READJUST IT SO DON'T GO TO 20 AMPS ON THE MC12. TRY 14 AMPS AND SEE HOW THE TEMP DOES.

All this requires you to have an amp meter in the circuit to monitor the current. If it is easy to adjust from the drivers position, you can adjust the current for the length of the trip. After some use you will

see how fast the current changes and set the start accordingly. NOW, IS THERE A BETTER WAY?

The trade off is price. A better, and likely more costly PWM will have some feedback from the load [cell] that controls the output. The best ones have current sensing within the controller. That means the setting is maintained regardless of load resistance. These PWMs can be set to the desired amps and as the cell changes; the PWM will control the current to the set amount. HOW WELL WILL THIS WORK IN AN OPEN BATH CELL?

The big difference in open bath is the change in efficiency with temp. As the temp goes up, the % of applied power making gas [hydroxy] goes down. The stray current increases as the bath temp goes up. The result is more power wasted making "steam." [actually water vapor mostly] This is a large part of the trade off to get an inexpensive booster that is easy to build. It is often just as practical for the user to control the max amps by adjusting the concentration of electrolyte. This process also takes patience. You must add electrolyte slowly to get a low amp draw and then watch where the amps go when it gets hot. I recommend starting with 6 to 8 amps cold until you see where it goes when hot.

EVERY CELL WILL BE DIFFERENT. ANY ONE CELL WILL BE DIFFERENT IN DIFFERENT OUTSIDE TEMPS. THIS PROCESS IS NOT MAINTENANCE FREE! I do not generally recommend a PWM on open bath boosters because of all the increase in temp. It is a reasonable compromise if it remains simple to use and maintain. Like all the other factors, trade off are the choice of the user.

Measuring hydroxy by Bob Boyce

No lab test that Bob is aware of has the ability to detect monoatomic hydrogen production in real time. True monoatomic hydrogen is very short-lived once it leaves highly negatively charged environment. If measuring combustion energy, they may be confusing orthohydrogen for monoatomic hydrogen. When combusted, orthohydrogen yields twice the energy of parahydrogen of the same volume. When combusted, monoatomic hydrogen also yields twice the energy of parahydrogen of the same volume.

There are only two "easy" ways to tell the difference. The first is to measure by weight, as monoatomic hydrogen weighs about half that of orthohydrogen or parahydrogen of the same volume. The second is to measure the volume of hydroxy gas generated, and compare that against the amount of water consumed. Monoatomic hydrogen occupies twice the space of diatomic hydrogen, so this is also a good way to measure for it.

Both tests require drying the gas before measurements. The reason Bob mentions this is that regular electrolysis will produce hydroxy gas that contains hydrogen in the ratio of

about 70% orthohydrogen to 30% parahydrogen. This figure falls dead center of your 60% to 80% figure. It leads me to think that your cell is making a 70%/30% ratio blend of ortho/para diatomic hydrogen.

Measuring your MPG gains with a hydroxy Booster

As you diminish the number of miles driven and the gallons used, the statistical error goes up to an unusable %. If the test is repeated for 500 miles instead of under 50, the % probable error will be 1/10 as much. That becomes a "statistically significant test." With Bob's trip, note the average was 63MPG but the short run peaks of level driving was 100MPG! Small sample error will kill the creditability of results.

That is why so many members ask for a 5 fill up average before getting too excited about numbers. Note how E does the smack tests over long miles and multiple fill ups. Caution is advised to not rely on an instant MPG gauge. It's lying to you. There is only one correct way to measure fuel consumption. **Actual distance traveled divided by actual volume consumed.** And it takes a few tank fills to average out all the errors. Also, you need a real amp meter. Like a fluke DMM.

Suggested "HHO" driving test protocols

Backed up here taken from - <http://holysmoke.org/temp/proposed-protocols.htm>

Here is what I suggest for a driving test, with the caveat that **driving tests are a poor way to measure fuel economy** (which is why *the EPA doesn't allow automobile manufacturers to claim fuel economy figures based on driving tests*). There are a few additional protocols required but they are "blinded," so I will not list them here; "blinded" protocols are used to prevent bias on the part of the people performing the test, and explaining those protocols would defeat the purpose of them being "blinded."

- A) Video tape the trip indicator being zeroed before each test run.
- B) Put masking tape over the trip indicator after it has been zeroed each time so that the driver cannot see elapsed distance. [\(1\)](#)
- C) Put masking tape over the clock and battery status meter. [\(2\)](#)
- D) The driver's lunch and drinking water should be in the car for all tests. The driver should do her or his best to not go potty until after all testing is completed. [\(3\)](#)
- E) Before the test, measure PSI in all four tires.

F) After the test, measure PSI in all four tires.

1a) Obtain a vehicle that the seller and/or promoter of "HHO" devices will certify, in writing, that the "HHO" device is functioning properly and that the "HHO" device is responsible for an increased miles-per-gallon fuel economy. [\(4\)](#)

1b) Obtain in writing a statement from the seller or promoter of the device that states test conditions and protocols are acceptable.

2) Obtain a one-gallon gasoline can, and a five-gallon gasoline can.

3) Obtain eight gallons of gasoline. [\(5\)](#)

4) Manufacture a one-gallon external fuel tank out of PVC, with a flexible fuel line attached to the bottom. The top cap must have a small hole drilled into it as a vacuum break. Conversely, obtain a fuel tank off of a large lawn mower or large gasoline-powered water pump.

5) Disconnect and seal the automobile's fuel line from the fuel injection body, and run the automobile until the engine quits.

6) Attach the external fuel tank to the automobile's fuel injection body.

7) Hang the external fuel tank above the engine compartment so that the vehicle operator can still drive, and also so that the fuel from the external tank will completely enter the engine. [\(6\)](#)

8) Fill the one-gallon gasoline can all the way to the edge of the lid, let the fuel over-flow the lip a little, and then carefully pour the one-gallon into the external fuel tank.

For each test (device on, device off), everyone must keep away from the automobile by twenty feet or more except the person turning the device on or off, and the automobile operator. Tests are to be rendered a failure if the seller or promoter steps closer than 20 feet; tests are to be rendered invalid if anyone else steps within 20 feet.

The seller or promoter of the "HHO" device may cancel all future test runs by walking up and touching the automobile. At that point, all testing will cease.

9) One person should toss a coin: "Heads," turn the device off, "Tails," turn the device on. The result is kept secret from everyone else. The person who tossed the coin and turned the device on or off will leave the area

during the test. **The device shall be turned on or off at the device by disconnecting its (-) power lead.**

10 Zero the car's trip indicator.

11) Drive the vehicle in a wide circle **at 50 miles per hour** until all the fuel is gone. Cruise control would be ideal. On a large parking lot, hold the steering wheel to the left or right, then set the cruise control. If the vehicle does not have cruise control, the operator must strive to keep a steady speed until the fuel runs out.

THE SAME AVERAGE SPEED MUST BE MAINTAINED FOR EVERY TEST PERFORMED.

12) Note how long the fuel lasts, with a stop watch.

13) Note trip indicator value.

14) Repeat steps 9,10, 11, 12, and 13 ***TWICE*** more.

15) Toss the coin.

16) If the first three tests had the device always off or always on, ignore the result of step 14 and turn the device on or off, the converse of the state it had been in.

17) Follow steps 11, 12, and 13.

18) Reveal the results of all four tests only after all four tests have been completed.

19) Publish the trip indicator values (miles per gallon) and the time required to consume the one gallon of fuel (time over distance) for each test.

20) Any test results where the average speed differed significantly from 50 miles per hour will be discarded, and a new test run performed in its place.

NOTES:

(1) If the driver testing the vehicle is alone, she must be trusted to not look under the tape: **this is a major flaw in this protocol: place an observer in the passenger seat for all tests.**

Also note that operators can also zero the trip indicator after a few miles have been driven, which will have the appearance of lowering fuel economy: observers should be in the car preventing this, or observers should be in a place where they can keep track of distance themselves---
- such as in a chase car, or counting laps around a track.

(2) "HHO" on-demand under-the-hood devices draw current which can be readily seen on most automobile's dash board battery condition meters.

(3) While the weight is negligible, all effort should be made to limit the number of excuses available to the promoters and defenders of the "HHO" devices when the test shows they fail to increase fuel economy.

(4) Do not test a vehicle that the seller or promoter of the "HHO" device has not claimed is getting increased fuel economy from the device. Do not test a device that you or the seller or promoter has installed in your car without first getting a statement, in writing, that the device is working and producing better fuel economy.

(5) Use the same fuel source, from the same day and time, for each test, acquired at one time.

(6) Modern automobile engines have reliable fuel pumps, so placement of the external fuel tank is not critical as long as all fuel is pumped out of it during tests.

(7) If the "HHO" device has a switch installed to turn it off or on, disable the switch; if one cannot disable the switch, use masking tape to cover the switch so that it cannot be turned on or off. **If the switch can be accessed by the driver, do not trust the driver: place an observer in the passenger seat for all tests.**

(8) Never allow the seller or promoter of the "HHO" device come closer than 20 feet to the automobile.

(9) Agree on the number of tests and the test fuel volume before tests start, and perform every test: no fewer, no greater.

(10) Results, video, and images taken of the tests are the property of the people taking the video and images, to be used as the property owners see fit.

(11) The possible testing states are:

On: 1 time
Off: 3 times

On: 2 times
Off: 2 times

On: 3 times
Off: 1 time

(12) It is important to note the time it takes for the fuel to be consumed, as well as the distance traveled, for every test run. These figures will provide time-over-distance: that is, average speed.

(13) All expenses for testing will be paid by the "HHO" seller / promoter, as the burden of proof rests completely upon them to meet.

Hydroxy Engine timing and adjustments

Timing is everything!

What do we mean when we talk about this "timing" concept? We need to understand "timing" as related to the fuel burning pressure wave being applied to the piston. Engine timing is an attempt to ignite the fuel to optimize the piston position with the arrival of the burned fuel pressure wave. That's why it is called "ignition timing". Burning regular gasoline. The piston is on the upstroke approaching top dead center (TDC) and is compressing the air/fuel mixture above the piston. The ideal gas law ($PV = NRT$) tells us that the pressure is increasing. Increasing the pressure requires work and consumes energy.

The spark plug fires and ignites the fuel. The fuel burns, the temperature increases tremendously and the pressure increases – that ideal gas law thing again. This is not instantaneous -it takes time for the pressure/force wave from the burning gas to reach the piston. If the spark occurs too soon in the cycle, the force wave arrives too soon the majority of the force will be exerted on the piston before it reaches TDC, attempting to

push the crank in the opposite direction desired. Net power turning the engine in the correct rotation is lost.

If the spark occurs too late in the cycle, the force wave arrives after TDC, the piston is on the down stroke, the volume in the cylinder is rapidly increasing and, again according to the ideal gas law, the pressure is dropping. The pressure gained from burning the fuel is being lost from the increased volume of the down stroke. We also lose time to burn the gas between the ignition and the exhaust stroke of the engine so net power is lost with unburned fuel.

Now let's say we change the fuel to Premium gasoline. Premium gasoline burns slower than Regular gasoline. This means we need to advance the timing (ignite the fuel sooner) since it will take longer to reach the piston surface. Now let's go the opposite direction – hydroxygas. This is an extremely fast burning fuel when compared to gasoline. It is far easier for the hydrogen and oxygen to combine with hydroxygas burning than for the oxygen to combine with complex (large) organic molecules to form carbon dioxide when burning petroleum products. Because the burn rate, and therefore the velocity of the pressure/force wave reaching the piston, is so much faster with 100% hydroxygas you must retard the ignition timing. Otherwise the pressure wave will reach the piston so early that it will attempt to drive the engine backwards.

There are several examples on the www of lawnmower engines running on hydroxygas and the biggest challenge for most was to retard the ignition. Reports of automobile engines running on 100% hydroxygas have all stated that they run with the ignition timing set after TDC. So what happens when we blend hydroxygas and gasoline?

Small additions don't seem to cause much of an issue with the ignition timing. This may be because the percent of hydroxygas is not sufficiently high for the effect to be major as far as the majority of the force/pressure wave arrival at the piston. That is to say, the petroleum fuel weakens or delays the effect, either due to the higher percentage of petroleum fuel or, perhaps the petroleum fuel just interferes with the hydroxygas ignition.

We do know however that the petroleum fuel burns more efficiently. So much so that with increasing hydroxygas concentrations modern automotive systems will add more fuel based on higher exhaust Oxygen Sensor readings – compensated by in some systems with an EFIE. Continued increases in hydroxygas fuel augmentation have generated a lot of reports of engines running “tight” and other issues which I believe are primarily related to ignition timing and power/force wave generation from a faster burning fuel. The hydroxy gas is going to burn faster and set up a faster initial pressure wave.

It is also plausible that with a more intimate mixture of the two fuels with increased hydroxy gas concentrations, the hydroxy gas spreads the flame through the petroleum

fuel faster than it would normally go across the cylinder. Almost like the spark plug ignites the fuel blend but the hydroxy gas ignition travels quickly across the cylinder and, in effect, ignites the petroleum fuel at numerous sites instead of just from the spark plug and then across the cylinder as seen in non-hydroxy gas augmented systems.

Note for boosters that produce over 3 LPM, you must expect to have to adjust EVERYTHING including, Fuel mix, timing, etc. Hydroxy gas is not gasoline, and the more you add, the more of an effect its superior properties will have over your engine. This is why you may see mileage and performance tank, parts fail, catastrophic engine failure and the like. Hydroxy gas has no lubricating qualities, a faster flame front, and different burn temps than gasoline.

One needs to also adjust timing. This is especially prevalent when using over 3 LPM. Also, for MPFI vehicles, the AFR readings must be altered to compensate for the cleaner burn. This is magnified the more gas you add. If you do NOT make the proper adjustments, your mileage will in fact peak and then drop off. This is not some mystical science or flaw in the technology. This is due to improper engine management.

It is of the utmost importance that all researchers continue to strive towards more hydroxy output. The more gas you add, the better your mileage. You have reached your goal when you are using no gasoline at all. But until that time, all of you must be aware that adjustments to the engine management system MUST be made. The higher the percentage of hydroxy gas added the more important and sensitive these parameters are.

If you are using fuel additives, HHO, Hydrogen, PulseStar Plugs, or anything else that increases flame spread speed, **then you need to be sure that your timing is retarded to at, or just after, top-dead-center. According to Roy McAlister**, we should be sure that the timing for the firing of our spark plugs needs to be only at, or just after the piston reaches top-dead-center of the cylinder; otherwise, we will be increasing engine wear, while decreasing engine horse power or mpg. The timing should be after top dead center not before which means retarded not advanced.

Video- [Hydrogen Fuel - Engine Fundamentals #3](#)

The first step most of us will take is to add a booster to an unmodified engine in order to get an initial gain as quickly and easily as possible, so understanding the limits of such a configuration is indeed valuable, even if not optimal. As we gain experience and confidence with using hydroxy, those with the proper skills can experiment with more elaborate engine control modifications.

It has already been mentioned in the overview that modern fuel injected cars need the "EFIE". However note Just because you have a carbureted car doesn't mean that there is not an O2 sensor. There are plenty of feedback carbs out there that are

computer controlled and will have the same reaction as EFI systems, for example a 86 Toyota Trecel with a feedback carb.

As far as spark timing, it can be advanced a little since hydroxy kicks out high octane. In most cases you loosen the distributor and give it a little turn to increase rpm. A little is good, but a lot is not better.

2 main things you must do:

1) Adjust timing, it has to be retarded to achieve maximum efficiency; this is best done by a qualified mechanic.

2) you should not physically have to lean out the fuel at all, with a carbureted car it is already tuned and if you lean it (by say putting a smaller main jet in) it can cause serious damage, its basically adding more fuel and a perfect fuel at that (already has a oxidizing agent so no air has to be added) so its completely automatic, it means you don't have to use as much pedal to achieve the same result (= less fuel used),

On most carburetors you adjust the air fuel mixture with the needle valves which are controlled by screws in the base of the carb. This is not the same as a throttle body which has injector in the top of the unit. Different carbs will have the brand and modification number of the carb is, we cannot not give the exact details of the adjustments needed (1, 2, or 4 barrel carb etc.)

Air fuel mix is controlled by these needle valves and the opening of the butterfly type flaps on the air intake of the carb. Timing is another issue. As you are only boosting you probably will not need much timing adjustment, (from 0.5 to 3Liters per minute of hydroxy is not needed) however **you may get some improvement by advancing the timing a few degrees depending on how much boost you are doing.**

On carbureted vehicles this is almost always done by rotating the distributor while observing timing light attached to the no. 1 plug wire. Your standard timing may be around 6 degrees before top dead center (TDC) moving it closer to TDC may prevent back flashes and give performance improvements, however the % of hydroxy you are adding to the fuel mix will determine how much advance will help. You may just have to go by the sound of the motor, and how it does when you press the accelerator. If you are going to change your timing, It is recommended you have a cylinder head temp gauge and keep a close watch on the temp.

Timing depends on several factors:

1. Distributor ignition. Advance timing until the engine revs increase slightly. Retard until engine pings, then set in the middle of that range. Then over the course of several tanks of gas, play with it to get optimum performance. Unless, of course you happen to have a \$3000 snap on scanner, then you can read emissions with it.

2. Electronic units, advance timing 2 degrees per tank until you get optimum performance.

There are too many variables to give a set number, such as booster output, tumble velocity of your HHO, air temperature, engine compression and vacuum to name a few.

Hydroxy engine calculations related to timing

Why do boosters work? The boost comes from the more efficient burn of the gasoline not the hydroxy. When a spark ignites gasoline the heat causes the hydrogen carbon bond to break, the hydrogen combines with oxygen releasing their energy and forming water vapor. The carbon also bonds with oxygen forming carbon dioxide and carbon monoxide etc. etc. if the heat is too high nitrogen also bonds with oxygen making nitrous oxide. This process takes time and is the reason gas engines need to have timing advance, to allow the fuel time to burn.

When hydroxy is well mixed in the charge it ignites instantly throughout the cylinder, igniting the gasoline in many places at once rather than just at the spark plug. if you put in just enough hydroxy to make the process efficient you will see extra power and mileage. More is better? NO, remember you never get back what you put in so any more will LOWER your mileage.

The focus should be to make the booster work as efficiently as possible, it should be off at idle, you don't need it if you're not going anywhere. Boost should be highest when accelerating or going uphill and level off for cruising, one way to do this is to monitor manifold vacuum and adjust the booster accordingly. High vacuum, boost low, low vacuum, boost high. One can look for a vacuum sensor that will give a resistance proportional to manifold vacuum. One idea is so this can then be used to control a PWM hooked to the booster, the control for the PWM could be physically connected to the throttle linkage with the same effect.

It is **ESTIMATED** that when using a hydroxy booster, any hydroxy volume from 0.5 LPM (liters per minute) upwards will give an improved gasoline burn. Amounts of 1.5 to 3.0 LPM will give excellent pollution free operation, increased torque, smoother running and cleaning out of any old carbon deposits inside the engine, which increases the engine life. There are no issues of the engine rusting or hydrogen embrittlement reported so far, more detail on this is included below. It is also reasoned that water does not enter the engine go through the exhaust. Steam may be produced, but upon exit of the exhaust where it can cool and is where the water will surface.

At volumes of 1.5 to 3.0 LPM, no timing adjustment is needed. As the volume increases beyond 3LPM, the hydroxy ceases to be just an enhancer of the gasoline burn and starts to take part as an additional fuel in its own right, needing a progressive retarding

of the spark as the ratio of hydroxy increases. In this situation where the fuel is hydroxy and the gasoline is just an additive, the spark timing will be about 8 degrees after TDC (Top dead center) as hydroxy burns enormously faster than gasoline droplets do.

If you use hydrogen on your car to aid gasoline combustion or just plain hydrogen without retarding timing, then this of course will shorten the engine life, because hydrogen does increase the burn speed of fuel mix and if the timing is too advanced, the piston will still be in the fuel compression phase when the hydrogen aided fuel mixture already explodes and starts to push back. So it is possible that without changing the timing, the faster fuel burn rate can damage the engine. In most vehicles it is also quite possible that the cam timing has been set ten degrees retarded.

When calculating how much hydroxy is needed for your particular size engine. Larger engines will need much larger amounts of hydroxy for a boost. The ICE is by far out dated and impractical. It is reasoned that in the mean time before having technology and or EV (electric cars) are mainstream, that a booster is in fact productive to stop pollution and save fuel. However some wish to also run on 100% hydroxy. There are various designs predicted to be able to do this these will be mentioned on the Panacea university site. To run 100% on hydroxy alone it is estimated that the volume needed is about 4% of the amount of fuel/air mix entering the engine.

With hydrogen, LOWER compression ratios are better. Gasoline atomizes very poorly, mostly because it's in liquid form. Hydrogen mixes with the air perfectly, and will run in as low 4:1 compression. Extra compression will only strain the engine. In this case, hydroxy will burn completely with no compression whatsoever, as long as it is in a sealed chamber.

In example: A 5 liter capacity, four-stroke engine running at 2000 rpm, the full engine capacity is drawn in during two revs, so the total intake amount is $5 \times 2000 / 2 = 5,000$ LPM. If 4% (or 1/25th) of that amount is hydroxy, then the hydroxy required would be $5,000 / 25 = 200$ LPM which is a large amount.

When running at 3,000 rpm. The amount would be 300 LPM. For this reason, it is far more practical to pick a smaller capacity engine of 2 liters or less for a conversion. A 2 liter engine running at 3000 rpm will need $3000 / 25 = 120$ LPM of hydroxy gas to run 100%. A Geo Metro 1 liter, 3-cylinder car at 3,000 rpm would only need 60 LPM. This is far more feasible to generate. Also a 1.6 liter is practical. In India, they have launched a 4-door, 5-seat car with a 650 cc engine giving 33 horsepower, selling new for \$2,500.

More examples: A 1,600 cc engine running at 2,500 rpm. To calculate what volume is likely to be required: The 1.6 liter engine capacity is drawn into the engine when two revolutions are completed. 1.6 liters will be taken 1,250 times per minute. That is exactly 2,000 LPM. But only 4% of that volume needs to be hydroxy gas and the remaining 96%

can be air. Hence the amount of hydroxy gas needed per minute is $2,000 / 25$ which is 80 LPM of hydroxy. **These figures are based on third party reports.**

Automotive experts have calculated that an engine running at speed, only succeeds in replacing, typically, 85% of the cylinder contents on the exhaust and intake strokes. Then only 85% of that 80 LPM will be needed to run a 1,600 cc engine. This works out to be 68 LPM, which may not be a small amount of hydroxy gas but is possible. Please keep in mind that these volume calculations should only be used as a ball point figure and may not be accurate in real life. Engine capacity can vary enormously in the amount of power needed to make them run.

The following is provided courtesy of Eletrik inventor of the "Smacks booster". Common calculation mistakes results from the incorrect assumptions on the following:

ALL the CFM requirement of the engine must be met by hydroxy production. This is not the case. Further that you cannot add any air to the hydroxy mix. This is not the case, the hydroxy is metered into the engine and mixed with air similar to the way propane or natural gas is. Next is failing to convert the liquid volume of water into a vapor volume. The water is split first and resulting gasses are what combust. Also miscalculations result from basing them on using hydrogen properties instead of hydroxy (monatomic) properties to perform their calculations.

Hydrogen - oxygen mix in its monatomic form has more energy in it than a similar volume of propane. A typical propane company work vehicle consumes .3 liquid liters per Km of propane, at an expansion rate of 270:1 that's 81 L/Km gaseous propane. Travelling at a very normal speed of 100 Km/hr, that's a consumption rate of 135 LPM gaseous propane. [Reference](#)

Propane gas has an energy density of 2.3K BTU/ft³ at 1 atm. Hydrogen gas has an energy density of 270 BTU/ft³ at 1 atm. That means the same vehicle would need 8.5 times the propane fuel rate, or 1147.5 LPM H₂ gas. Remember this number you will see it come up again in close proximity later in this post. [Reference](#)

There are plenty of hydrogen powered ICE cars out there. Here is a hydrogen powered Cobra built to break a land speed record. [Reference](#)

Note the tank on this car holds 590 standard cubic feet of H₂, and it empties in 5 min while doing a run. That's 118cfm, or 3342 LPM. This would seem to support some of those outrageous claims. But this is not your typical engine. First of all, that is what was consumed at WOT during a land speed attempt. Secondly, it's a huge bored and stroked 527CI. There is no air metering (no throttle plates, engine speed determines airflow, not throttle position) and they engineered the engine to run at a crazy fuel ratio of 80:1 in order to eliminate the Nox emissions we have been talking about. Not many of us are going to try and build our

engines like this. Most of us will be using air metering devices, running an A/F closer to 34:1, and closer to the 350CI range or smaller. My Olds motor is less than 1/2 the size of this beast, so if I wanted to set it up with this configuration (which I wouldn't) I would be using around 1400 LPM H₂ gas. Put some throttle plates on it and drive it normally and I'd be closer to 1000 LPM. There is that number range again.... On that note - look at this next H₂ car:

The BMW hydrogen car uses 17.6 lbs, or $17.6 \text{ lbs} / (4.432 \text{ lbs/ft}^3) = 3.97 \text{ ft}^3 = 112 \text{ L}$ of liquid H₂ to go over 125 miles (201.2Km) = .56L/Km. [Reference](#)

Hydrogen has an expansion rate of 1:848 which means the car uses 472L/Km H₂ gas. Assume a nice speed of 100KPH, and you get a fuel demand of 787 LPM. Somewhere in the ballpark of what I predicted for the olds and calculated for the propane rig above. Now take into account that hydroxy is NOT H₂. Here is where we all need to sit up straight in our chairs:

One researcher calculated via experimental data hydroxy gas contains 60,000 KJ/m³ of energy at 1 atm. Now there have been varied reports up to ten times this value - but this is the lowest one I could find so I chose it for the worst case scenario. Keep in mind our ongoing discussions about the mysterious "soup" some of our cells generate. [Reference](#)

Compare this to hydrogen gas which contains 10,000 KJ/m³ at 1 atm. That's 1/6th the energy of hydroxy! With that observation, let us substitute hydroxy into the previous calculations:

The propane powered rig would need 190 LPM hydroxy gas. The Cobra would need 560 LPM hydroxy gas. My Olds would need 170 LPM hydroxy gas based on the comparison to the Cobra. The BMW would need 130 LPM hydroxy gas.

Let's talk about the Olds some more. My Olds gets about 23 MPG at 60 MPH, or .165 LPM liquid gas. Gasoline has an energy density of 31,150,000 BTU/m³ liquid compared to 8,491,000 BTU/m³ liquid H₂. This would mean that almost 4 times the amount of liquid hydrogen would be needed, or .66 LPM. With an expansion ratio 848, that's 560 LPM gaseous H₂. Now, I calculated that hydroxy has at least 6 times the energy of H₂, so the projected demand for my Olds is 93 LPM based on my observed gasoline mileage and the conservative reported BTU's of hydroxy.

Notice how this calculation supports my previous statement concerning the comparison with that bad ass Cobra. Even that beast could be designed to run on less fuel. Frank Roberts has made a claim of 20 - 30 LPM with his Taurus which is not that far from my own Olds estimate and certainly no where near to being close to 3000 LPM. Perhaps with the proper tuning, correct hydroxy mix and good driving habits I could get

into the 30 LPM range like Frank did, an order of 2 magnitudes less than other's estimates. That brings the technology right back into the realm of possible!

Running internal combustion engines on oxyhydrogen By Terro

The amount of oxyhydrogen needed to run an internal combustion engine is spectacular. Idling a small engine (e.g. 5hp) would require 500-1000 LPH (liters per hour), while idling a car engine would probably consume about 3000LPH of oxyhydrogen. Driving down the highway would probably consume 20000-30000 LPH of oxyhydrogen. The electrolyzer shown in this report produced approximately 57LPH at 11A, which is not enough to idle even the smallest 4-stroke engine (at least 300-400LPH would be required to idle a small 1hp brush cutter 4-stroke).

One liter of gasoline contains approximately 30MJ of energy, while oxyhydrogen gas would contain approximately 7-8kJ per liter. This means that you would need approximately 4000 liters oxyhydrogen for each liter of gasoline your engine currently uses, assuming the engine efficiencies are approximately the same on oxyhydrogen than on gasoline.

Thus if your car uses 6 liters of gasoline per hour while driving down the highway, prepare for 24000 LPH oxyhydrogen consumption. Assuming a super-efficient series cell electrolyzer (2.5 W per LPH) you would need 60kW of electrical energy to run the electrolyzer. This corresponds to about 80hp, which is significantly more than the amount of engine power used at highway speeds (~20hp). Figuring in the alternator efficiency (~50%) you would actually need 160hp on the engine shaft to produce 24000LPH of oxyhydrogen gas.

How about a 100cc scooter powered by a 60-cell series electrolyzer running off an 120V inverter and bridge rectifier powered by the 12V battery? Estimated gasoline consumption while riding at 70km/h would be about 1LPH gasoline, which would convert to about 4000LPH of oxyhydrogen consumption. Idling the same scooter would probably take 500-1000LPH. The 60-cell electrolyzer would produce about 40 LPH per Amp measured at room temperature. Thus you would need 100Amps thru the 60-cell to produce 4000LPH. Because the electrolyzer has 60 cells, you need to power it with about 120Vdc (assuming 2.0V cell voltage) from the inverter. Assuming 100% efficient inverter, it would draw 1000 Amps from the 12V battery to produce 120Vdc 100A. If the scooter had a fully charged 5Ah battery it would last for 18 seconds at 1000A until it would run out. The scooter's "alternator" would produce probably about 5A maximum.

A common misconception is to think that you can dilute oxyhydrogen gas with air and run the engine with very small amounts of gas. Oxyhydrogen gas is in itself a perfectly proportioned mixture of hydrogen and oxygen gasses, which combusts perfectly leaving no hydrogen or oxygen but only water vapor and heat. Adding any air will make it combust imperfectly and release less energy for same volume of gas.

An often quoted air:fuel ratio for hydrogen combustion in air is 34:1, but this is a MASS ratio. This means that you need 34 grams (=27.76 liters) of air for each gram of hydrogen (=11.1 liters). Converted to VOLUME ratio this is 2.5:1, which makes perfect sense because air contains approximately 20% of oxygen by volume and you need 0.5 liters of oxygen for each liter of hydrogen. Thus you need 2.5 liters of air for each liter of hydrogen for perfect combustion (leaving nitrogen and other atmospheric trace elements).

Assuming the engine has 100% volumetric efficiency, a 2.0L auto engine running at 2500RPM would have a total air intake flow of 150000LPH. Running this engine fully unthrottled at 2500RPM to produce the maximum power would take about 43000LPH of hydrogen gas and 107000LPH of air for stoichiometric operation. The 43000LPH of hydrogen contains about $43\text{m}^3/\text{h} \times 2.8\text{kWh}/\text{m}^3 = \sim 120\text{kW}$ of power. Assuming 25% engine efficiency you would get about 30kW or 37hp shaft horsepower.

Below is shows the experimental setup that was used for idling a 6.5hp 200cc 4-stroke Honda copy on oxyhydrogen gas. The electrolyzer did not produce enough oxyhydrogen to run the engine continuously, but the oxyhydrogen gas was first collected in a balloon and then used to run the engine. The 7-cell unit was used, powered by a current limited welding transformer running at about 40A producing approximately 200 LPH of gas. The gas was collected for 1-2 minutes which later ran the engine for some 20 seconds. Approximately 600-800LPH of gas would have been needed to idle the engine continuously. The engine timing was not changed in any way. The electrolyzer gas output tube was routed to a propane adapter bolted at the intake of the carb. The oxyhydrogen was admitted thru a narrow (1-2mm) orifice to the intake of the carburetor. The engine ran fully choked, with no outside air used at all. The engine would not run without the narrow orifice or without being fully choked.



Figure 14. 6.5hp 200cc 4-stroke running on electrolytic gas

Additional reading on this subject can be found in the Arizona collage study "hydrogen use in internal combustion motors".

3 Modes of operation to achieve hydroxy production by Bob Boyce

There are 3 primary modes of operation on such a unit. The power in vs hydroxy gas out figures are different for each. The first, which is by far the easiest, is brute force electrolysis, which will typically deliver at or near Faraday efficiency. This is the mode that a brand new unit will operate in until it has been cleansed and conditioned well. The hydrogen content of the hydroxy gas produced is typically composed of about 25% orthohydrogen and 75% parahydrogen.

The second, which is a little harder to get to, is catalytic mode. This is where the electrode plates have been cleansed (base passivated) to remove free iron and other contaminants, then conditioned by operating the unit at very low power levels. This is done in order to form desirable catalytic coatings on the electrode plate surfaces. While still running from straight brute force DC, the formation of hydroxy gas is enhanced by the catalytic layers and cell magnetism's, while production efficiencies of up to twice that of Faraday have been obtained. In extreme cases, where power levels are kept low, this has resulted in measured efficiencies of up to 238%.

The hydrogen content of the hydroxy gas produced is typically composed of about 70% orthohydrogen and 30% parahydrogen. The third, which is much harder to obtain, is resonance drive mode. This is where the applied DC voltage is intentionally reduced to suppress electrolysis. In place of electrolysis, a specially constructed toroidal power system is connected that is tuned to produce high energy LEM standing waves in the cell cavities.

Construction accuracy and tuning are super-critical in order to obtain even distribution of these standing waves amongst all of the cells in the unit. The result is a highly negatively ionized form of hydroxy gas that contains a high concentration of monoatomic hydrogen and orthohydrogen. This highly energetic form of hydroxy gas is so potent that only about 25% of the volume is required to equal the combustion energy of normal stoichiometric parahydrogen / oxygen.

[PDF –Air fuel mixtures possible for Hydrogen introduction into ICE's](#)

Xcel files

Calculate the amount of Hydroxy required replacing 100% of gasoline to run your car. Hydroxy Volume Required Replacing Gasoline. Enter known mileage data about a car you intend to convert and calculate the volume of Hydroxy required to replace 100% of the gasoline. Hydroxy Volume required replacing Gasoline. Calculate the amount of Hydroxy required replacing 100% of gasoline to run your car.

[Hydroxy Volume Required to Replace Gasoline](#)

[Fuel required](#)

[Fuel Required version 1.1](#)

[Ratio as in water. 2 H₂ molecules for every O₂ molecule.](#)

Links to potentially excellent engine candidates for running on hydrogen or hydroxy

Mazda <http://www.hydrogencarsnow.com/mazda-rx8-renesis-re-hydrogen.htm>

MYT <http://www.youtube.com/watch?v=MBYg1NPzMY&NR=1>

Quasiturbine <http://quasiturbine.promci.qc.ca/ETypeHydrogen.htm>

Axial vector engine http://www.axialvectorengine.com/about_history.html#

NEVIS engine

<http://www.autobloggreen.com/2007/06/21/nevis-the-internal-combustion-engine-rei\vented/>

Papp engine (non-fuel)

<http://video.google.com/videoplay?docid=-2850891179207690407&g=documentary+p\hysics+duration:long>

Bourke engine <http://bourke-engine.com/ani.htm>

Hydrogen fusion engine http://nanodetonator.com/TECHNICAL_OVERVIEW.html

Free-Piston HCCI engine <http://www.greencarcongress.com/engines/index.html>

Linear Combustion engine

<http://www.iceproject.org/en/principle/functional-model.php>

ROTOBLOCK engine <http://www.rotoblock.com/howitworks.shtml>

Hilton Centrifugal engine <http://www.linux-host.org/energy/shilton.html>

Larsen RADAX Hydrogen ICE engine

<http://www.hydrogencarsnow.com/blog2/index.php/hydrogen-cars/larsen-radax-hydrog\en-internal-combustion-engine-video/>

Issue of hydroxy gas imploding in an engine

Calculations state that liquid water can be broken into a hydrogen and oxygen gas mixture some 1,850 times larger in volume than the water which was split. That same gas mix can then be ignited and it will convert back to water. If this conversion resulted in the form of water at the original temperature, then it would be exactly the original volume. But, in this case, the ignition causes a very high temperature which causes the resulting water to be in the form of a large volume of water vapor at high temperature.

Implosion will only occur if the surroundings are capable of bleeding off the temperature gain instantly. This can be seen in the example of lighting up a balloon with hydroxy gas inside. (Do not attempt this as you are liable to damage your hearing permanently). The balloon does not have the thermal capacity to perform this cooling, so an overall rapid expansion will take place (commonly called an explosion).

Because hydroxy gas does NOT implode, when burned in a normal reciprocating internal combustion engine the expansive media (air) expands, pushing the piston down. There is not enough time during engine cycles for burned hydroxy gas to implode, even IF it were run pure with no air. Atmospheric pressure is not enough to run an engine of this type, even if it were slowed down to a few RPM to give time for implosion to occur, and the heat of combustion could be drawn away fast enough to allow implosion to occur even at that low speed.

Therefore Hydroxy Implosion = urban legend. You will find that this is condensation, and only occurs when the burned torch flame output gas (water vapor) contacts a surface that is cool enough to cause condensation of the water vapor to occur. The definition of "implosion" is a RAPID and VIOLENT decrease in volume, similar to "explosion", which is a RAPID and VIOLENT increase in volume.

Condensation of the gas phase of water to the liquid phase can be rapid, but not rapid enough to be violent. Hence, it is properly called condensation. One can simply look at it this way, if hydrogen and oxygen were to implode immediately after combustion, then how can this be used as a rocket propellant? The space shuttle would be trying to suck itself backwards against the thrust of the solid rocket boosters, as it burns a mix of hydrogen and oxygen in the main engines. It certainly is cold enough at altitude to allow for rapid condensation. The answer is, it is rapid, but not as rapid as an implosion would be.-End

Could it both explode and implode. Here is an experiment to try see for yourself. Use a 600mL soft drink bottle as bubbler. Pour water into bubbler until bottle neck. Turn electrolyser power on and let the excess water spill off. Now set fire on torch tip and let the flashback happen until reach bubbler. The explosion cause back pressure to push the water into electrolyser.

Now the water level reduced in bubbler and more space between water level and bottle neck. Set fire again and check the impact on soft drink bottle. In one engineers

experiment, his electrolyser is able to produce about 2LPM hydroxy, the soft drink bottle shrinks after each explosion. Why this happens if hydroxy explodes? If the electrolyser could not produce much gas, he believe everybody still can simulate explode and implode using 600mL soft drink bottle. Just pour water 3/4 of the bottle and set fire. Happy testing.

An observation- What makes the most sense on the explosion and implosion is that the gas explodes and when it instantly turns back into water, that shrinkage of volume creates a vacuum effect (implosion) that quick follows the explosion.-End

There is a common misconception that when the engine runs on oxyhydrogen it operates by imploding the oxyhydrogen gas in the cylinders supposedly creating a vacuum that pulls the cylinders up, thus requiring altered engine timing. One mole of water (~18ml) turns into 33.6 liters of oxyhydrogen gas. Thus you get about 1860 liters of oxyhydrogen for each liter of water, and correspondingly one liter of oxyhydrogen turns into $1/1860 = 0.53$ milliliters of water.

But you only get a vacuum if the produced water vapor (steam) can condense, and you only get condensation if the combustion chamber is very cold. Steam will not condense on the hot cylinder walls of the engine and you won't get a vacuum in the cylinders as a result of oxyhydrogen combustion. One mole of water (~18ml) will turn into 33.6 liters of oxyhydrogen at 0 deg C, but when the oxyhydrogen is combusted it will turn into 100 deg C steam. Assuming the steam is at 1 atm pressure, it will occupy a volume of about 30.6 liters (one mole of 100 deg C steam). In reality the oxyhydrogen gas combusts in the engine just as any gas (even though the flame front proceeds quite fast), creating a rapid pressure/heat increase which then runs the engine.

Patents and related information

Recommended Patent reading

-Diesel applications- When the hydrogen enriched air is compressed, the diesel fuel is introduced with a resulting improvement in fuel efficiency and maximized combustion of the fuel. US4,573,435 (1986) Glen Shelton Apparatus and method for generating hydrogen gas for use as a fuel additive in diesel engines.

A 50% reduction in fuel consumption, at idle, was reported by numerically analyzing an on-board hydrogen reformer operating at 80% efficiency. G. Fontana, E Galloni, E. Jannelli and M. Minutillo (January 2002) " Performance and fuel Consumption Estimation of a Hydrogen Enriched Gasoline Engine at Part-Load Operation" SAE Technical Paper Series (2002-01-20196): p. 4-5.

Archie Blue. Patent # 4,124,463 applied on On Dec 29, 1976, now in the public domain. A carburetor which operates by drawing the intake air of an IC engine through

an electrolyzer composed of horizontal plates with holes in them. There is a compressed air source fed to the input so that the output will be at standard atmospheric pressure. This electrolyzer is operated from a heavy duty alternator driven by the IC engine.

Electronics World & Wireless World (January 1991) Dan Danforth: Molecular Dissociation of Water Water Fuel Cell News Release (Winter/Spring 87/88)

Water Fuel Cell R&D Format Infinite Energy 19: 50-51 (1998) Obituary Water-Powered Car Video <http://www.lonelantern.org/collection.html>

HFI system an [Efficient Canadian patent](#) for big trucks: [Web site](#) .

[Cornish patent](#)- Note the Cornish patent is well known, and like many others of its kind, is just another "burning" aluminum underwater technology. For every 1 KW worth of hydrogen you get out, you must oxidize a quantity of aluminum that required 5 KW to 8 KW of electricity to refine. On top of that, the aluminum oxide crud left over has to be dealt with. This is not very "green" technology, and should be avoided like the plague. We need clean and green technologies, not ones that waste way more energy than they can yield.

U S Pat 7378063 -Radio Frequency Hydrogen and Oxygen Generator and Method, dated May 27, 2008, it seems to me that that this patent describes a new approach to applying radio wave resonance to the process of splitting and utilizing water to generate Hydrogen and Oxygen" .

Enhance electrolysis by controlling spin states-APPARATUS FOR DECOMPOSITION OF AQUEOUS LIQUID by HASEBE SHIGETA -[Patent number US4105528](#)

USP # 4,936,961 ~ Method for the Production of a Fuel Gas

USP # 4,826,581 ~ Controlled Process for the Production of Thermal Energy from Gases.

USP # 4,798,661 ~ Gas Generator Voltage Control Circuit

USP # 4,613,304 ~ Gas Electrical Hydrogen Generator

USP # 4,465,455 ~ Start-up/Shut-down for a Hydrogen Gas Burner

USP # 4,421,474 ~ Hydrogen Gas Burner

USP # 4,389,981 ~ Hydrogen Gas Injector System for Internal Combustion Engine

Canadian Patent # 2,067,735 ~ Water Fuel Injection System

WO 92/07861 ~ Control & Driver Circuits for a Hydrogen Gas Fuel Producing Cell

USP Appln. 2005/0246059 ~ Hydroxyl Filling Station (Stephen Meyer)

Raum & Zeit 1 (6) 63-68 (1990) Patents Granted (@ 1990)

United States Patent 4,450,060 Gonzalez May 22, 1984 for a Bi polar electrolytic cell.

Roy McAlister patents

ELECTROLYZERS and FUEL CELLS; (Numerous pending patents) A family of inventions to provide efficient, long life, and dependable operation for production and utilization of hydrogen in applications ranging from distributed energy systems to transportation.

PRECISION SPARK INJECTOR; (SparkInjector) TECHNOLOGY (See U.S. Patents 5,394,852; 5,343,699; and 6,155,212) These inventions allow virtually any engine to utilize hydrogen to: produce more power, last longer, and clean the air that passes through the engine.

ENERGY STORAGE SYSTEM; (See U.S. Patent 6,015,065; numerous pending patents) This family of inventions allow hydrogen to be stored at energy densities comparable to gasoline and provide much greater safety than gasoline storage.

SOLAR ENERGY CONVERSION; (See U.S. Patent 5,899,071 and numerous pending patents) These inventions enable much higher annual delivery of power by technology that holds the world's record for converting solar energy into line-voltage electricity.

Links

Water fuel cell patents can be [sourced from here](#)

Patent search by number can be done at: [Link](#)

Other patent office search sites are:

Canada: [Link](#)

Main US: [Link](#)

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Papers

The Hydrogen Injection System

The technology of using hydrogen as a combustion enhancement in internal combustion engines has been researched and proven for many years. The benefits are

factual and well documented. Our own utilization of this technology. i.e. the CHEC HFI hydrogen injection system, has also been tested and proven both by institutions and in hundreds of practical applications in road vehicles.

Here is a synopsis of a sampling of the research that has been done: In 1974 John Houseman and D.J./Cerini of the Jet Propulsion Lab, California Institute of Technology produced a report for the Society of Automotive Engineers entitled "On-Board Hydrogen Generator for a Partial Hydrogen Injection Internal Combustion Engine".

In 1974 F.W. Hoehn and M.W. Dowy of the Jet Propulsion Lab, prepared a report for the 9th Inter society Energy Conversion Engineering Conference, entitled "Feasibility Demonstration of a Road Vehicle Fueled with Hydrogen Enriched Gasoline."

In the early eighties George Vosper P. Eng., ex-professor of Dynamics and Canadian inventor, designed and patented a device to transform internal combustion engines to run on hydrogen. He later affirms: "A small amount of hydrogen added to the air intake of a gasoline engine would enhance the flame velocity and thus permit the engine to operate with leaner air to gasoline mixture than otherwise possible. The result, far less pollution with more power and better mileage." In 1995, Wagner, Jamal and Wyszynski, at the Birmingham, of University Engineering, Mechanical and Manufacturing>, demonstrated the advantages of "Fractional addition of hydrogen to internal combustion engines by exhaust gas fuel reforming." The process yielded benefits in improved combustion stability and reduced nitrogen oxides and hydrocarbon emissions.

Roy MacAlister, PE of the American Hydrogen Association states the "Use of mixtures of hydrogen in small quantities and conventional fuels offers significant reductions in exhaust emissions" and that "Using hydrogen as a combustion stimulant it is possible for other fuels to meet future requirements for lower exhaust emissions in California and an increasing number of additional states. Relatively small amounts of hydrogen can dramatically increase horsepower and reduce exhaust emissions."

At the HYPOTHESIS Conference, University of Cassino, Italy, June 26-29, 1995, a group of scientists from the University of Birmingham, UK, presented a study about hydrogen as a fraction of the fuel. In the abstract of that study it stated: "Hydrogen, when used as a fractional additive at extreme lean engine operation, yields benefits in improved combustion stability and reduced nitrogen oxides and hydrocarbon emissions."

In the Spring of 1997, at an international conference held by the University of Calgary, a team of scientists representing the Department of Energy Engineering, Zhejiang University, China, presented a mathematical model for the process of formation and restraint of toxic emissions in hydrogen-gasoline mixture fueled engines. Using the theory of chemical dynamics of combustion, the group elaborated an explanation of the mechanism of forming toxic emissions in spark ignition engines. The results of their

experimental investigation conclude that because of the characteristics of hydrogen, the mixture can rapidly burn in hydrogen-gasoline mixture fueled engines, thus toxic emissions are restrained. These studies and other research on hydrogen as a fuel supplement generated big efforts in trying to develop practical systems to enhance internal combustion engine performance. A few of them materialized in patented devices that didn't reach the level of performance, safety or feasibility that would allow them to reach marketing stages.

California Environmental Engineering (CEE) has tested this technology and found reduction on all exhaust emissions. They subsequently stated: "CEE feels that the result of this test verifies that this technology is a viable source for reducing emissions and fuel consumption on large diesel engines."

The American Hydrogen Association Test Lab tested this technology and proved that: "Emissions test results indicate that a decrease of toxic emissions was realized." Again, zero emissions were observed on CO. Northern Alberta Institute of Technology. Vehicle subjected to dynamometer loading in controlled conditions showed drastic reduction of emissions and improved horsepower.

Corrections Canada tested several systems and concluded, "The hydrogen system is a valuable tool in helping Corrections Canada meet the overall Green Plan by: reducing vehicle emissions down to an acceptable level and meeting the stringent emissions standard set out by California and British Columbia; reducing the amount of fuel consumed by increased mileage."

Additionally, their analysis pointed out that this solution is the most cost effective. For their research they granted the C.S.C. Environmental Award.

We also conducted extensive testing in our facility in order to prove reliability (MTBF, life expectancy, etc.) and determine safety and performance of the components and the entire system. As a result of these tests, we achieved important breakthroughs as far as the designs of the components were concerned. We have since increased the hydrogen/oxygen production significantly. This has resulted in increased effectiveness on engine performance.

The results of these tests were able to confirm the claims made about this technology: the emissions will be reduced, the horsepower will increase and the fuel consumption will be reduced. [Source](#)

End

Hydrogen boosters work. Here is how and why:

By George Vosper, P. Eng. June 1998. Hydrogen Injection -The technology of using hydrogen as a combustion enhancement in internal combustion engines has been

researched and proven for many years. The benefits are factual and well documented. Our own utilization of this technology, i.e. the hydrogen injection system, has also been tested and proven both by institutions and in hundreds of practical applications in road vehicles.

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The results of these tests were able to confirm the claims made about this technology: the emissions will be reduced, the horsepower will increase and the fuel consumption will be reduced. From researching the Internet we also found the following information To best describe how Hydrogen Enhanced Combustion works, we are providing this excerpt from a University Technical Report, written by Mr. George Vosper, P.Eng.; ...a Hydrogen Generating System (HGS) for trucks or cars has been on the market for some time. Mounted on a vehicle, it feeds small amounts of hydrogen and oxygen into the engine's air intake. Its makers claim savings in fuel, reduced noxious and greenhouse

gases and increased power. The auto industry is not devoid of hoaxes and as engineers are skeptics by training, it is no surprise that a few of them say the idea won't work. Such opinions, from engineers can't be dismissed without explaining why I think these Hydrogen Generating Systems do work and are not just another hoax.

The 2nd law of thermodynamics is a likely source of those doubts. Meaning the law - would lead you to believe that it will certainly take more power to produce this hydrogen than can be regained by burning it in the engine. i.e. the resulting energy balance should be negative. If the aim is to create hydrogen by electrolysis to be burned as a fuel, the concept is ridiculous. On the other hand, if hydrogen shortens the burn time of the main fuel-air mix, putting more pressure on the piston through a longer effective power stroke, and in doing so takes more work out, then this system does make sense.

Does it work? Independent studies, at different universities, using various fuels, have shown that flame speeds increase when small amounts of hydrogen are added to air-fuel mixes. A study by the California Institute of Technology, at its Jet Propulsion Lab Pasadena, in 1974 concluded: The J.P.L. concept has unquestionably demonstrated that the addition of small quantities of gaseous hydrogen to the primary gasoline significantly reduces CO and NOx exhaust emissions while improving engine thermal efficiency A recent study at the University of Calgary by G.A. Karim on the effect of adding hydrogen to a methane-fuelled engine says ... The addition of some hydrogen to the methane, speeds up the rates of initiation and subsequent propagation of flames over the whole combustible mixture range, including for very fast flowing mixtures.

This enhancement of flame initiation and subsequent flame propagation, reduces the Ignition delay and combustion period in both spark ignition and compression ignition engines which should lead to noticeable improvements in the combustion process and performance What happens inside the combustion chamber is still only a guess. In an earlier explanation I suggested that the extremely rapid flame speed of the added hydrogen oxygen interspersed through the main fuel air mix, gives the whole mix a much faster flame rate. Dr. Brant Peppley, Hydrogen Systems Group, Royal Military College, Kingston, has convinced me that insufficient hydrogen is produced to have much effect by just burning it. He feel's that the faster burn is most likely due to the presence of nascent (atomic)

hydrogen and nascent oxygen, which initiate a chain reaction. I now completely agree. Electrolysis produces "nascent" hydrogen, and oxygen, which may or may not reach the engine as nascent. It is more probable that high temperature in the combustion chamber breaks down the oxygen and hydrogen molecules into free radicals (i.e. nascent). The chain reaction initiated by those free radicals will cause a simultaneous ignition of all the primary fuel. As it all ignites at once, no flame front can exist and without it there is no pressure wave to create knock.

The results of tests at Corrections Canada's, Bowden Alberta Institution and other independent tests reinforce the belief that combustion is significantly accelerated. They found with the HGS on, unburned hydrocarbons, CO and NO, in the exhaust were either eliminated or drastically reduced and at the same R.P.M. the engine produced more torque from less fuel.

Recently I took part in the highway test of a vehicle driven twice over the same 200-kilometre course, on cruise control, at the same speed, once with the system off and once with it on. A temperature sensor from an accurate pyrometer kit had been inserted directly into the exhaust manifold, to eliminate thermal distortion from the catalytic converter. On average, the exhaust manifold temperature was 65°F lower during the second trip when the Hydrogen Generating System was switched on. The fuel consumption with the unit off was 5.13253 km/li. and 7.2481 km/li. with it on, giving a mileage increase of 41.2% and a fuel savings attributable to the unit of 29.18%

From the forgoing, the near absence of carbon monoxide and unburnt hydrocarbons confirms a very complete and much faster burn. Cooler exhaust temperatures show that more work is taken out during the power stroke. More torque from less fuel at the same R.P.M. verifies that higher pressure from a faster burn, acting through a longer effective power stroke, produces more torque and thus more work from less fuel. The considerable reduction in nitrous oxides (NO_x) was a surprise. I had assumed that the extreme temperatures from such a rapid intense burn would produce more NO_x. Time plus high temperature are both essential for nitrous oxides to form. As the extreme burn temperatures are of such short duration and temperature through the remainder of the power stroke and the entire exhaust stroke, will, on average, be much cooler. With this in mind, it is not so surprising that less NO_x is produced when the HGS is operating.

Assume a fuel-air mix is so lean as to normally take the entire power stroke (180°) to complete combustion. Educated estimates suggest the presence of nascent hydrogen and oxygen decreases the burn time of the entire mix by a factor of ten (10). If a spark advance of 4° is assumed, the burn would be complete at about 14° past top dead centre. Such a burn will be both rapid and intense. The piston would have moved less than 2% of its stroke by the end of the burn, allowing over 98% of its travel to extract work. The lower exhaust manifold temperatures observed when the Hydrogen Generating System was in use can be viewed as evidence for this occurrence.

Power consumed by this model of the electrolysis cell is about 100 watts. If an alternator efficiency of 60% is assumed, then 0.2233 horsepower will produce enough wattage. Even on a compact car, a unit would use less than ¼ % of its engine's output, or about what is used by the headlights. The energy regained from burning the hydrogen in the engine is so small that virtually all of the power to the electrolyser must be considered lost. That loss should not, however, exceed ¼%, so that any increase in the engine's thermal efficiency more than ¼ %, is a real gain.

An engineering classmate suggested a grass fire as a useful analogy to understand combustion within an engine. The flame front of a grass fire is distinct and its speed depends in part on the closeness of the individual blades. If grass is first sprayed with a small amount of gasoline to initiate combustion, then all blades will ignite almost in unison. In much the same way, small amounts of nascent oxygen and hydrogen present in the fuel-air mix will cause a chain reaction that ignites all the primary fuel molecules simultaneously. Faster more complete burns are the keys to improving efficiency in internal combustion engines. Power gained from increased thermal efficiency, less the power to the electrolysis unit, is the measure of real gain or loss. It follows from the foregoing paragraph that even a modest gain in thermal efficiency will be greater than the power used by an electrolysis unit. The net result should therefore be positive.

Thus onboard electrolysis systems supplying hydrogen and oxygen to internal combustion engines, fuelled by diesel, gasoline or propane, should substantially increase efficiencies. While the auto industry searches for the perfect means of eliminating harmful emissions, consideration should be given to what these systems can do now, since the HGS considers reduction of harmful emissions even as the engine ages. Almost all unburned hydrocarbons, CO and NO_x, are eliminated. Reducing hydrocarbons and CO causes a slight rise in the percentage of CO₂ in the exhaust, but as less fuel is used, the actual quantity of CO₂ produced is reduced by roughly the same ratio as the savings in fuel. In brief, noxious gas is almost eliminated and greenhouse gas is decreased in proportion to the reduction in fuel consumption. Nothing I have learned so far has lessened my belief that the benefits of using electrolysis units to supply hydrogen to most types of internal combustion engines are both real and considerable.

End

COMMON DUCT ELECTROLYTIC OXYHYDROGEN

Parameters & Variables by Dr. William A. Rhodes, Physicist

HISTORY-This concept was discovered in 1961 by request from a manufacturer for a new and novel means for producing torch flame temperatures beyond those of that era. Such system was conceived and developed involving electrolytic production of mixed hydrogen and oxygen. Prior to that time, literature on the subject focused exclusively on separation of such gases and conducting them out of the electrolyzer for tank storage. Using hydrogen and oxygen immediately when generated through a common duct was not found in the literature and it appeared to be a new technology.

The first patent -Apparatus For The Electrolytic Production of Hydrogen And Oxygen For The Safe Consumption patent # 3,262,872 issued July 26, 1966 dealt with intermixing the gases in an electrolyzer, issuing through a common duct for instant use in a torch. 9

claims in the patent read on;"an outlet for said generator to conduct a mixture of hydrogen and oxygen gases there from," as opposed to other electrolyzers using separate ducts for each gas. The patent contains the financing party as co-inventor. His contribution was limited to an additional small alcohol booster tank, entraining the vapor for a reducing flame.

The patent appears to establish my precedence in the art. Starting in 1962, the Henes Mfg., Company of Phoenix sold many thousands of their trademarked 'Water Welder' in several sizes, presently continuing under another name.

Immediately after launching the Henes venture, I began research on a large electrolyzer patented in March 1967 under the title, MULTICELL OXYHYDROGEN GENERATOR (3,310,483).It contained 60 iron plates, nickel plated on the oxygen generating side and iron on the hydrogen side. This patent claims use of loosely fitting grooves for holding the plates in tank 8"x8"x16"x3/4" Plexiglas. I previously discovered that current could not bypass such plates loosely fitting in grooves of proper design. The torch flame from that unit was 20 inches long, melting everything into blue-white puddles, including firebrick, ceramics and carbon (in argon atmosphere).

REFERENCE PROBLEMS- Of all elements, hydrogen and oxygen should hold no secrets. Yet, in this example they do and have been troublesome. Many experts in such gases contributed important knowledge hoping such would answer our questions. Their offerings were accurate for tank gases, but these were not tank gases and three major obstacles remained. * 1. flame propagation rate (burning velocity) was unusually high. * 2. Flame temperature is far greater than tank gases. * 3. Allowing the gases to mix at the moment of generation, and delivered in a common duct for immediate consumption should contain both molecular and atomic components. Until these were examined through experiment and observation, conjecture and theories were invalid.

FLAME PROPAGATION RATE DETERMINATION - SETUP: A phototransistor cell was attached to a Plexiglas base containing a groove to locate the start and finish marks on a known length of transparent plastic tubing. An ignition chamber with sparkplug was attached to a 2500 v transformer controlled with a button switch. The electrolyzer was attached to the input end of the spark chamber; a 22 ft length of tubing was attached to the output side of the chamber. The first marked tubing position was placed in the phototransistor groove, and the 20 ft mark was placed on top of the first tubing mark. Recording equipment included a dual pen strip-chart recorder with parallel connection to a memo-scope and audio tape recorder. NIST WWV clock ticks were coupled to all. With this setup we hoped to capture precision measurements of flame front velocity plus rise and fall time.

TESTS: Electrolyzer gas purged the tubing, and since the flame is in the UV, the electrolyzer was allowed to run until a trace of KOH allowed visual spectra to produce a

slight pink-white. Stripchart, memoscope and recorder running and standardized. Spark initiated. SIX SEQUENCES: Recorded timing for 10 feet of tubing was consistently 1.225 milliseconds = 10,000 ft in 1.226 seconds, or 8160 ft/sec div 1088 ft/sec (speed of sound not compensated for our 1150 ft above sea level) was mach 7.5.

Rise and fall pulse duration via memo-scope was .5 millisecond with a total baseline to baseline duration of .6 millisecond. With exception of the small error between sea level and 1150 ft above sea level, results of these tests appear reliable. This combination has MAXIMUM INSTABILITY. Any electrostatic discharge can trigger a very mild explosion compared with tank H₂ & O₂. The "ashes" from burning are of course pure water.

LUMPED FLAME RATE CONFIRMATION The previous rate was resolved from pip spacing's. These tests were made with the plastic tubing wound into a small donut with phototransistor mounted on the focal plane of a camera lens. A flat-black background behind the donut and floodlight illumination allowed the donut image to be adjusted to cover the active area of the phototransistor. The tubing beyond the measured marks was covered to prevent errors from their exposure.

Instrumentation and standardization was identical to the previous test. Recorded data of the previous were pips, marking the beginning and ending of the flash. This time, burn illumination produced a slightly rounded flat area with a baseline to baseline rise and fall of .6 milliseconds as before. (Previous test shots allowed strip chart recorder gain adjustment for approximately 3 cm reading. The flat tracing showed gradual rise and fall of about 2 mm from beginning to end of a sequence.)

Time measurements of six sequences were identical to the previous. The last test was made with the tubing exit clamped off, and gave readings identical with the others. No tubing rupture occurred and explosion sound was muffled. These should provide sufficient evidence of the flame propagation rate of such mixed gases.

FLAME TEMPERATURE -Flame tests in an argon atmosphere directed on several layers of carbon fiber fabric with its micron size filaments (Used on the stealth fighter & bomber.) melted carbon filaments into brilliant globules. This means carbon's melting temperature 3550C/6422F is exceeded, but its boiling point 4827C/8720F is not attained. Past that point no reference exists.

LIFTING POWER OF ELECTROLYZED MIXED GASES - First, be aware we are dealing with common-ducted gases, data being absent from NIST and the literature. There is also theory vs experimental evidence to contend with. From the CRC handbook: "Lifting power of 1 cu/ft hydrogen is about 0.075 lb at 760 mm pressure."

SETUP: Our test volume chosen was 1 liter single duct electro-lyzed gases. An igloo from a plastic pop bottle was cut to provide exactly 1000 ml volume between the flat igloo door top, and the upper dome. (1000 ml was from a standard 1000 ml flask, transferred

to the pop bottle, marking the door top, and extending the igloo another 2", where it was lathe cut and the doorway snipped out. It was located inverted on the pan of our Mettler milligram balance. An L shaped tube on lab stand extended through the doorway and bent upward ending near the dome top, leaving the balance completely free of interference.

The gas generator was purged of air 15 minutes. The balance was tare arbitrarily adjusted for 30 grams \pm 1 mg. The igloo was filled with pipe smoke; -6 mg deflection noted due to warmer air. The gas tube was attached and maximum weight reduction of 0.510 grams was attained, rounded off to the nearest mg. Gas input was allowed to flow for 30 minutes for accuracy. 5 minutes after gas cutoff, the balance returned to the pre-gas reading caused by rapid diffusion of electrolyzed gases into atmosphere. Comparing H₂ lifting power, 1 liter mixed gases multiplied to 1 cu/ft provided lifting power of 0.0311 lb. Or 41% that of H₂. Here we must consider single atoms of hydrogen 1 and oxygen 16 for lifting power against atmosphere (29+). Of course, if a stoichiometric mix of H₂ & O₂ were present, O₂ alone would have a molecular weight of 32, and such gases introduced in the igloo would show a slight weight increase as the combination spilled *downward* through the doorway.

TESTS FOR STATIC GAS CHANGES- Over the years many suggested if such gases were collected and remained unused, several kinds of re combinations would spontaneously occur regardless of temperature. Determining volumetric changes of stored electrolyzed gases was done with a calibrated 100 ml domed bell of 1/4" thick Plexiglas open at the bottom and sliding inside a closely fitting Plexiglas container, with an L shaped gas entry tube extending upward under the bell. The bell was held in place to prevent upward movement. 500 viscosity silicone oil was poured into the outer cylinder as air inside the bell was slowly exhausted, causing the oil to fill the bell completely, continuing to flow slowly into the plastic vacuum tubing, to eliminate all air. A cock on the metal L tube was turned off, and the plastic tube pulled from the L and cleared of oil.

Room temperature was adjusted for 80 F. When the temperature of the oil over the bell read 75 F, gas electrolysis began, allowing the plastic line to be purged of air, and then connected to the cock which was turned on. Gas filled the bell from top downward below the 100 ml mark. The cock was turned off, gas line pulled, and generator switched off. The cock was cracked to bleed gas down to the 100 ml level and turned off. At the end of 6 months, room temperature again increased oil temperature to 75F. Volume change was not measurable. The gas was then allowed to fill the inverted bell on the gram balance. Calculations gave the same answer as previous, comparing lifting ability as being 41% that of H₂. (Plus or minus 2% error.) To prevent any light activity, the system was covered with black polyethylene.

ADDITIONAL CONDITIONS - The only purpose of KOH is to create the lowest possible resistance eg, highest electrical conductivity. Being slowly depleted by mist generated during electrolysis, specific gravity must occasionally be corrected by addition of KOH. It is noted that any sharp metallic whisker in the storage atmosphere could cause an explosion, similar to the dangers of storing high percentage hydrogen peroxide, where the entire contents can burst into high pressure steam with disastrous results, just because somewhere in the interior someone forgot to round off a sharp edge.

On the other hand, these mixed gases were ignited repeatedly in a 4 liter container of 16 gage iron with flat ends and sparkplug. The only evidence of ignition was a sharp click, with no damage to the vessel. A recent report revealed one experimenter was wounded with shrapnel from such explosion. The only way this might happen is from accumulation in an unusually thin container, or one made from an easily fractured plastic. However, a duplication of the original multi cell unit was constructed of 3/4" Plexiglas with an interior volume of 8 liters. Half of this was filled with electrolyte leaving 4 liters for foam and gas accumulation, (identical to the volume of the iron container.

The multi cell had a 2.5" diameter returnable diaphragm of food grade Saran wrap. The unit was set on a stand in the open and ignited. The resultant pop splintered the case into many pieces which were all deposited within a radius of 5 feet around the stand. The diaphragm remained intact. Such indicated the sonic wave front was responsible instead of pressure which would have ruptured the diaphragm. These tests allowed us to design electrolyzer tanks of materials and thicknesses that could contain flashbacks. Viewing the permanent Plexiglas multi cell in operation, electrolyte foam rises upward, but at maximum elevation allows sufficient gas space above. Therefore no purpose is served with designs containing more gas than necessary for conduction out of the reservoir. Extrapolation of chart curves indicates a possible diesel type explosion as pressure approaches 400 psi. However, this is not conclusive. Generation of such single ducted gases appears to be an event not found in nature, unless lightning produces them.

FLASHBACK ARRESTERS - There are two types of arrester. For small units of one or two liters total tank capacity, two aquarium aerator stones are adequate. Over time they tend to clog with KOH vapor, but can be easily cleared by back flushing with 50% phosphoric acid. For larger units water filled U-tube is service free and best, since its inertia disallows flame movement through the water. An alternate to the U-tube is two tubes of different diameters. [INCOMPLETE]

FLAME PROPAGATION RATES OF SEVERAL GASES - Flame propagation rates refer to complete combustion mixtures to fill a measured length of tubing and after ignition, combustion speed is measured against standard time pulses from WWV transmissions from the National Institute of Standards and Technology. From the literature, the Butane rate is 60 ft/sec. Acetylene 330 ft/sec. Tank Hydrogen (H₂) 680 ft/sec. Since no literature

could be found for mixed atomic gas, burning velocity was precision measured in our lab.

ENERGY CONVERSION LIMITATIONS - Be aware of this: If a current i flows for a time t and reacts with water whose electrochemical equivalent is e , mass of the gases released is: $m=eit$. This means present chemistry is forever restricted by this equation. Direct current wave shapes, frequencies, half-waves, full-waves, nothing will allow gas delivery approaching unity. Some claim that under certain electrical manipulations, cells run cooler, or may produce more gas than before.

Yet, if precision measurement instruments are available, they will always show results exactly following this equation. Amperage readings made of rectified direct current by some hang-on ammeters produce enormous errors, leading the observer to believe cell efficiency has improved. This requires special attention to exhibit trustworthy data. Note: Data on gas species percentages are incomplete. No reference source exists for atomic gases.

W.A.Rhodes. 3-13-2000

Original OxyHyd discovery from 12/97/00

End

Related Links to Papers on Hydrogen

<http://mysite.du.edu/~jcalvert/phys/hydrogen.htm#Line>

http://waterfuel.100free.com/water_dissociation_1.html

[First images made of hydrogen burning in working internal combustion engine](#)

[Faraday electrolysis efficiency](#)

[Enriched Hydrocarbon Combustion](#)

Emissions tests and law related

Government bodies in Australia are talking about paying massive compensation to the coal burners if emission restrictions are put on power stations. Electricity prices will rise.

[Reference](#) **If just 1% of the billions in compensation payouts were put into the development hydroxy research, [GEET technology](#) and [others](#), then, the emission problems would disappear overnight as would carbon trading.** What is needed is grass roots activism and public appeal or pressure. Panacea is an organization with the tools which can be used towards this task. **Please forward this information and participate.**

There are currently rebates by government bodies in place in order to reduce emissions from fossil fuels. This can be seen in the example from rebates being available from the installation of various renewable energy technologies like solar power and others. **There is still no rebate available for GEET technology or hydroxy booster all which via easy an installation can ELIMINATE emissions in cars where it is needed the most.**

Given the critically needed nature of this technology and the difference it can make to the environment and in the prevention of disease, it is important to address a few issues which could play a role in preventing the technology from surfacing to capacity. **One must address the political side of the technology. Also one must address the very realistic issue of any possible hindrance in dissemination of the technology being created by over pricing retailers of the technology.**

Government rebates must be given to help consumer fit this technology to help cut the carbon foot print this will enable **every motorist to have one fitted in their car.** Add the fact that we need this technology on the diesel engines the most and it is the most overpriced. In one example of how they Police the smog laws in California relating to a diesel exhaust emission, maintenance and smoke output. One company was fined \$88,000. Hydroxy boosters can create 80% less emissions in diesel engines.

Booster implementation is now a survival issue, it does not fall into a category which lends its merit to being dependent on profit for dissemination. Resources must be managed in order to ensure stability and balance. Panacea endorses the open source engineer's LOW cost designs and has made them available. These designs are not only the most efficient and cost effective, but also any revenue raised form them goes back into more research and development into sustainable energy, something retailers in the energy business do not do.

Based on the capacity boosters and other fuel reforming technologies have. Laws must be mandated done TODAY to ensure a mandatory use of ANY fuel reforming technology being, hydroxy boosters, GEET or a vaporizer for both a health and environmental incentive. Grass roots activism is needed also!. Pressure must be applied from the public to make the politician work for us (sadly).

Boosters must be fitting by approved and qualified licensed installers, all components must be made to a standard, and a warning is stated against water4gas type boosters. These can ruin the whole hydroxy name entirely.

In law issues, in modern cars boosters require modification to be done to the ECU. It is against the law to add anything to an engine or mess with the ECU that is not approved first by ARB. This is because it is only understood that by messing with your ECU , that it would produce more emissions. **Adding a booster and configuring the ECU to accept its operation does NOT produce worse emissions; In fact it produces FEWER emissions.**

At this time it is logical for those who have had some success with the EFIE to present their findings to an official government body or city council. Start locally to influence your LOCAL members. The theme must be to demonstrate the POLLUTION CUTTING attributes and fuel savings in order to influence the LOCAL parliament members to work in conjunction with the CAR companies to work towards a diagnostic re programming route. In other words, get the car manufactures to produce software which can re program the air fuel ratio.

Show members of your local communities your EFIE car to influence the local communities to write to their local members to look at the emissions/Dyno fuel saving reports then get them to work with the manufactures to help implement this in an agreed voted emission standard. Start LOCAL.

In fact a booster will blow the emission standards out of the water (pun intended). These laws must extend to this acceptance based on the capacity hydroxy technology has to reduce emissions. A Certified mechanic can ensure that the ECU and booster operation are on par with the emission standards. A mechanic can inspect and stamp an approval which can be presented to the department of transport to meet their regulations. Here is an example of [various emission tests conducted](#) in different countries on hydroxy technology.

There are two major environmental regulatory and certification hurdles in the United States. The Federal Environmental Protection Agency and the California Air Resource Board. Federal emission standards are less stringent than C.A.R.B. Seven other states use California standards as well. Next year, Tier 3 standards will include eleven 'pollutants' including methane and carbon dioxide.

The European Union [EURO 4] and India [Bharat Stage III] emission standards are less stringent than either American standard, although a great deal of energy is being expended by the Continentals to include carbon dioxide. During combustion, not all H-H-O recombines to water vapor. Oxygen has a nasty habit of attaching to nitrogen and sulphur. NOx being of particular interest in California [smog].

Oxygen sensors will react to increase O levels in the exhaust by adding more fuel, ignition timing retardation and/or adding more exhaust gas recirculation. An EFIE that modifies emission data to the engine computer and management systems and are strictly forbidden by law.

There are currently products in trials with C.A.R.B. Certification can take more than 16 months and can cost more than \$100,000. The State of California has been aggressive promoting fuel cell and hydrogen technologies, as political campaign contributions come from primarily Japanese automotive manufacturers. An electrolyzer which separates oxygen from hydrogen before gas introduction would make sense and look good in a press release. Oxygen is too valuable during hydrocarbon combustion. EFIE

is required to lean fuel even more as well as modify O2 sensor signals. Electrolyzers and electronics are non-permanent installations for those living on the left coast. They have annual and bi-annual vehicle emission testing hence why they reinstall the catalytic converters, unplug the EGRs and MIL eliminators, retard ignition timing and whatever else they can undo the other 50 weeks of the year to extend MPG and improve performance.

Currently the EPA has emission regulations that cannot be exceeded for the particular year model vehicle being tested. If you modify your vehicle and it exceeds the maximum amounts, you fail the tests and need to remove or re-tweak your modifications and retest. If, however, your vehicle's engine modifications show low or ultra-low emissions, you pass the test and the inspector will want to know how you did it as all ICE's pollute to some extent(the EPA would then mandate your mods to all ICE's).

The OEM's with multi-million dollar labs spend tons of money trying to find ways of reducing the pollution (just take a tour of GM engine lab).If you could show and prove your modification reduces emissions(which hydroxy technology does) under all operating conditions, the OEM's should be beating a path to hydroxy technologies door.

HOWEVER where is the OEM's endorsement of the GEET technology or hydroxy technology? Why have they not taken into account numerous patented inventions, dating back to the early 20th century that reduced or eliminated exhaust pollution altogether?. HELLO?

Without the endorsement, participation and validation of these technologies it can only be reasoned that the OEMs have behaved like bed partners with the oil companies, because reduced emissions has meant lower fuel consumption, and they have always shown a reticence to promote such technologies. Instead, we have the wasteful re-burn of unused fuel in a catalytic converter, first promoted by a politician who was himself poised to manufacture them. **What a sad commentary on the human species!**

Further in the USA the NHTSA Introduced a Proposed Fuel Economy Targets for 2011-2015. The US Department of Transportation's (DOT) National Highway Traffic Safety Administration (NHTSA) has issued a notice of proposed rulemaking for new vehicle fuel economy standards that would bring the US average to about 31.6 miles per gallon in 2015 (35.7 mpg cars, 28.6 mpg trucks).

The Energy Independence and Security Act of 2007 (EISA), passed in December 2007 mandates the setting of separate attribute-based maximum feasible standards for passenger cars and for light trucks at levels sufficient to ensure that the average fuel economy of the combined fleet of all passenger cars and light trucks sold by all manufacturers in the US in model year (MY) 2020 equals or exceeds 35 mpg -[Reference](#).

Hydroxy technology can do better than this right now. Regulation is thus practical, public participation into pressure and even at a grass roots activism level. The MPG gains and pollution cutting facts and figures of the GEET and hydroxy technology speak for themselves. These CURRENT facts and figures must make their way into legislation.

[Panacea-BOCAF - Hydroxy Booster Installation Plus - Dyno and Emission Tests](#)



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These tests show conclusively:

At 80km/h the horsepower and torque increased with the boosters as follow:

With boosters

Horsepower 41.2hp 42.5hp

Torque 314lb 325lb

At 80 km/h, the emissions decreased as follow:

At idle

Hydrocarbons 797 ppm 364ppm -54.3%

Carbon monoxide 0.18% 0.12% -33.3%

At 80km/h

Hydrocarbons 125ppm 41ppm -67.2%

Carbon monoxide 1.82% 1.47% -19.2%

In the USA, the ARB must approve any devices installed on motor vehicles that may affect the emissions, ECU, catalytic converter, etc. Violators could have their car confiscated and crushed. Smog testing stations are under penalty of Law to report violators. **This legislation needs to extend to allowing hydroxy booster technology and even the mandatory implementation of it!** Further in the state California in the US only one business which has an overpriced unit which has approval for the IRS Section 535 TAX CREDITS to cover the cost of the unit(s). Obviously these need to extend to every state, not only that the rebates must be extend to other western countries. **Please lobby your local member or continue to pay for fuel and have UN needed smog.**

CO2 produced by using hydroxy booster technology

The following is a [very useful report](#). It shows that, for the same mechanical output (same performance), when you add hydrogen you use less fuel and release less CO₂. It also shows that the other pollutant levels drop, but not all initially. The CO and NO_x levels initially raise, then drop away.

However Using hydroxy results in more complete burning (oxidation) of the gasoline. With more complete oxidation, the percentage of CO₂ in the exhaust will rise, and the percentage of CO will reduce. CO₂ is a greenhouse gas, yes, but CO is a poison. And what counts is the amount (pounds mass) of CO₂ AND of CO per mile travelled. Those are the statistics to compare between vehicles with and without hydroxy.

The following has been provided by Dereck from WWW.HH2.US

To understand the CO₂ on a smog test, the higher the number (I.E. average is 14.7 CO₂, this means the amount of air present in the combustion of the fuel), this does not mean the CO₂ is bad, in fact it means the engine is running normally, if the number is higher, example 15.1 CO₂, that means the engine is running in a leaner condition, less fuel is being used and more air is in the combustion chamber.

We know down 99.9% of the greenhouse gases, No CO, No Nox, No O₂ etc. I looked at the old 2001 tests at CEE labs, the reason the Nox increases, Hydroxy pumps in combined Oxygen and Hydrogen and the extra oxygen plays havoc with combustion. Our system does the opposite. Hydrogen enters the system by itself and we input the Oxygen in at a near location.

The 51.1% reduction referred to by the Canadian guy, relates only to reductions of visible diesel smoke, it does not relate to actual greenhouse gas emissions being reduced, just the visible smoke. Again the higher the number in the air mix showing up as Co₂ the better burn is occurring, resulting in a LEAN condition (15.1 or 15.4 is great). The Co₂ mix is necessary for combustion and a higher number does not mean or show higher Co₂ output, in fact, the higher the better.

Sick engines will show lower Co2 ratios, the real key is reductions of all of the other toxic gases, resulting in totally clean exhaust discharge, you can actually inhale the exhaust from a vehicle that has the HH2 Hydrogen Clean Air System installed and working.

HH2 HOT HYDROGEN 07' CAMRY HYBRID RACING

Green Drag Race DEBUT HH2 Hydrogen Camry Hybrid 4 cyl, 146 HP 2.4L using the HH2 clean air Hydrogen from water system and pump gasoline. CARB legal Hydrogen proved to be a crowd pleaser as ate up the Taurus SHO hot V6, 2 mustang V8 GTs a Hot Masda and a few others on the 1/8th mile track, running mid 10s and 69mph in just 660 feet. Positive proof racing can be clean and green fun.

the hydrogen vapor is input into the air cleaner separately from the oxygen, the oxygen acts as a power boost completely burning all fuel in the combustion chamber resulting in NO toxic emissions. Fun, Fun, Fun and also it averaged 33 mpg while racing (9 runs total). website www.HH2.US

Hydrogen Injection by -Hydrogen boost dot com

Archived here in case the site ever goes down-The technology of using hydrogen as a combustion enhancement in internal combustion engines has been researched and proven for many years. The benefits are factual and well documented. Our own utilization of this technology. i.e. the hydrogen injection system, has also been tested and proven both by institutions and in hundreds of practical applications in road vehicles.

Here is a synopsis of a sampling of the research that has been done: In 1974 John Houseman and D.J/Cerini of the Jet Propulsion Lab, California Institute of Technology produced a report for the Society of Automotive Engineers entitled "On-Board Hydrogen Generator for a Partial Hydrogen Injection Internal Combustion Engine". In 1974 F.W. Hoehn and M.W. Dowy of the Jet Propulsion Lab, prepared a report for the 9th Inter society Energy Conversion Engineering Conference, entitled "Feasibility Demonstration of a Road Vehicle Fueled with Hydrogen Enriched Gasoline."

In the early eighties George Vosper P. Eng., ex-professor of Dynamics and Canadian inventor, designed and patented a device to transform internal combustion engines to run on hydrogen. He later affirms: "A small amount of hydrogen added to the air intake of a gasoline engine would enhance the flame velocity and thus permit the engine to operate with leaner air to gasoline mixture than otherwise possible. The result, far less pollution with more power and better mileage." In 1995, Wagner, Jamal and Wyszynski, at the Birmingham, of University Engineering, Mechanical and Manufacturing>, demonstrated the advantages of "Fractional addition of hydrogen to internal combustion engines by exhaust gas fuel reforming." The process yielded benefits in improved combustion stability and reduced nitrogen oxides and hydrocarbon

emissions.

Roy MacAlister, PE of the American Hydrogen Association states the "Use of mixtures of hydrogen in small quantities and conventional fuels offers significant reductions in exhaust emissions" and that "Using hydrogen as a combustion stimulant it is possible for other fuels to meet future requirements for lower exhaust emissions in California and an increasing number of additional states. Relatively small amounts of hydrogen can dramatically increase horsepower and reduce exhaust emissions."

At the HYPOTHESIS Conference, University of Cassino, Italy, June 26-29, 1995, a group of scientists from the University of Birmingham, UK, presented a study about hydrogen as a fraction of the fuel. In the abstract of that study it stated: "Hydrogen, when used as a fractional additive at extreme lean engine operation, yields benefits in improved combustion stability and reduced nitrogen oxides and hydrocarbon emissions."

In the Spring of 1997, at an international conference held by the University of Calgary, a team of scientists representing the Department of Energy Engineering, Zhejiang University, China, presented a mathematical model for the process of formation and restraint of toxic emissions in hydrogen-gasoline mixture fueled engines. Using the theory of chemical dynamics of combustion, the group elaborated an explanation of the mechanism of forming toxic emissions in spark ignition engines. The results of their experimental investigation conclude that because of the characteristics of hydrogen, the mixture can rapidly burn in hydrogen-gasoline mixture fueled engines, thus toxic emissions are restrained. These studies and other research on hydrogen as a fuel supplement generated big efforts in trying to develop practical systems to enhance internal combustion engine performance. A few of them materialized in patented devices that didn't reach the level of performance, safety or feasibility that would allow them to reach marketing stages.

California Environmental Engineering (CEE) has tested this technology and found reduction on all exhaust emissions. They subsequently stated: "CEE feels that the result of this test verifies that this technology is a viable source for reducing emissions and fuel consumption on large diesel engines."

The American Hydrogen Association Test Lab tested this technology and proved that: "Emissions test results indicate that a decrease of toxic emissions was realized." Again, zero emissions were observed on CO. Northern Alberta Institute of Technology. Vehicle subjected to dynamometer loading in controlled conditions showed drastic reduction of emissions and improved horsepower.

Corrections Canada tested several systems and concluded, "The hydrogen system is a

valuable tool in helping Corrections Canada meet the overall Green Plan by: reducing vehicle emissions down to an acceptable level and meeting the stringent emissions standard set out by California and British Columbia; reducing the amount of fuel consumed by increased mileage."

Additionally, their analysis pointed out that this solution is the most cost effective. For their research they granted the C.S.C. Environmental Award.

We also conducted extensive testing in order to prove reliability and determine safety and performance of the components and the entire system. As a result of these tests, we achieved important breakthroughs as far as the designs of the components were concerned. We have since increased the hydrogen/oxygen production significantly. This has resulted in increased effectiveness on engine performance.

The results of these tests were able to confirm the claims made about this technology: the emissions will be reduced, the horsepower will increase and the fuel consumption will be reduced. From researching the Internet we also found the following information:

To best describe how Hydrogen Enhanced Combustion works, we are providing this excerpt from a University Technical Report, written by Mr. George Vosper, P.Eng.; ...a Hydrogen Generating System (HGS) for trucks or cars has been on the market for some time. Mounted on a vehicle, it feeds small amounts of hydrogen and oxygen into the engine's air intake. Its makers claim savings in fuel, reduced noxious and greenhouse gases and increased power. The auto industry is not devoid of hoaxes and as engineers are sceptics by training, it is no surprise that a few of them say the idea won't work. Such opinions, from engineers can't be dismissed without explaining why I think these Hydrogen Generating Systems do work and are not just another hoax. The 2nd law of thermodynamics is a likely source of those doubts. Meaning ...the law -would lead you to believe that it will certainly take more power to produce this hydrogen than can be regained by burning it in the engine. i.e. the resulting energy balance should be negative. If the aim is to create hydrogen by electrolysis to be burned as a fuel, the concept is ridiculous. On the other hand, if hydrogen, shortens the burn time of the main fuel-air mix, putting more pressure on the piston through a longer effective power stroke, and in doing so takes more work out, then this system does make sense.

Does it work? Independent studies, at different universities, using various fuels, have shown that flame speeds increase when small amounts of hydrogen are added to air-fuel mixes. A study by the California Institute of Technology, at its Jet Propulsion Lab Pasadena, in 1974 concluded:

The J.P.L. concept has unquestionably demonstrated that the addition of small quantities of gaseous hydrogen to the primary gasoline significantly reduces CO and

NOx exhaust emissions while improving engine thermal efficiency A recent study at the University of Calgary by G.A. Karim on the effect of adding hydrogen to a methane-fuelled engine says ... The addition of some hydrogen to the methane, speeds up the rates of initiation and subsequent propagation of flames over the whole combustible mixture range, including for very fast flowing mixtures. This enhancement of flame initiation and subsequent flame propagation, reduces the Ignition delay and combustion period in both spark ignition and compression ignition engines which should lead to noticeable improvements in the combustion process and performance .

What happens inside the combustion chamber is still only a guess. In an earlier explanation I suggested that the extremely rapid flame speed of the added hydrogen oxygen interspersed through the main fuel air mix, gives the whole mix a much faster flame rate. Dr. Brant Peppley, Hydrogen Systems Group, Royal Military College, Kingston, has convinced me that insufficient hydrogen is produced to have much effect by just burning it. He feel's that the faster burn is most likely due to the presence of nascent (atomic) hydrogen and nascent oxygen, which initiate a chain reaction. I now completely agree. Electrolysis produces "nascent" hydrogen, and oxygen, which may or may not reach the engine as nascent. It is more probable that high temperature in the combustion chamber breaks down the oxygen and hydrogen molecules into free radicals (i.e. nascent). The chain reaction initiated by those free radicals will cause a simultaneous ignition of all the primary fuel. As it all ignites at once, no flame front can exist and without it there is no pressure wave to create knock.

The results of tests at Corrections Canada's, Bowden Alberta Institution and other independent tests reinforce the belief that combustion is significantly accelerated. They found with the HGS on, unburned hydrocarbons, CO and NO, in the exhaust were either eliminated or drastically reduced and at the same R.P.M. the engine produced more torque from less fuel.

Technical papers proving the benefits of hydroxy

[Effect of Hydrogen Rich Gas and Gasoline Mixed Combustion on Spark Ignition Engine](#)

Document Number: 2006-01-3379 Date Published: October 2006

Author(s): Teruo Suzuki - JOMO Technical Research Center

Yoshihito Sakurai - JOMO Technical Research Center

Abstract: Performances of gasoline engine fueled by gasoline into cylinder and pure hydrogen or simulated reformer gas (H₂, CO, CO₂, and CH₄) into intake manifold were evaluated in view of improvement of thermal efficiency of spark ignition engine. Commercial spark ignition direct injection gasoline engine was modified to install injection system of commercial CNG vehicle. Test engine can be controlled by

homogeneous and stratified charged combustion for gasoline. **Thermal efficiency of the engine operated with gasoline and hydrogen or reformer gas is much higher than that with gasoline under low- and mid-load conditions.** Especially the improvement of thermal efficiency with gasoline and hydrogen on lean burn condition is less than 40% than with gasoline on stoichiometric condition under low-load condition. The operating range of the engine operated with hydrogen is limited due to knocking, but the range is extended by the addition of gasoline. NO_x emission from the engine operated with gasoline and hydrogen or reformer gas is almost zero under low-load condition, but the emission sharply increases with increase in load. The combustion on gasoline homogeneous and hydrogen homogeneous is higher in NO_x emission and lower in thermal efficiency than that on gasoline stratified and hydrogen homogeneous.

[A Quasi-Dimensional Model for Estimating the Influence of Hydrogen- Rich Gas Addition on Turbulent Flame Speed and Flame Front Propagation in Ic-SI Engines](#)

Document Number: 2005-01-0232

Date Published: April 2005

Author(s):

Enrico Conte - ETH - Swiss Federal Institute of Technology

Konstantinos Boulouchos - ETH - Swiss Federal Institute of Technology

Abstract:

Addition of hydrogen-rich gas to gasoline in internal combustion engines is gaining increasing interest, as it seems suitable to reach near-zero emission combustion, able to easily meet future stringent regulations.

Bottled gas was used to simulate the output of an onboard reformer (21% H₂, 24% CO, 55% N₂). Measurements were carried out on a 4- stroke, 2-cylinder, 0.5-liter engine, with EGR, in order to calculate the heat release rate through a detailed two-zone model.

A quasi-dimensional model of the flame was developed: it consists of a geometrical estimate of the flame surface, which is then coupled with the heat release rate. The turbulent flame speed can then be inferred. The model was then applied to blends of gasoline with hydrogen-rich gas, showing the effect on the flame speed and transition from laminar to turbulent combustion.

Comparison between the quasi-dimensional model and the conventional Metgalchi-Keck + Damk\arhler model gave a general validation for gasoline operation and suggested a modification of the usual time-delay function for transition from laminar to turbulent flame.

Results give new insight in previous findings from the heat release calculation: the effect of hydrogen-rich gas addition on flame speed is predominant in the early phase of the flame propagation, and the effect of the high curvature of the flame at the onset of combustion, compensated by the high mass diffusivity of hydrogen, is believed to be the physical reason to such behavior.

[Combustion Optimization in a Hydrogen-Enhanced Lean Burn SI Engine](#)

Document Number: 2005-01-0251

Date Published: April 2005

Author(s):

Joshua Arlen Goldwitz

John B. Heywood - Massachusetts Institute of Technology

Abstract: As part of ongoing research on hydrogen-enhanced lean burn SI engines, this paper details an experimental combustion system optimization program. Experiments focused on three key areas: the ignition system, in-cylinder charge motion produced by changes in the inlet ports, and uniformity of fuel-air mixture preparation. Hydrogen enhancement is obtained with a H₂, CO, N₂ mixture produced by a fuel reformer such as the plasmatron. The ignition system tests compared a standard inductive coil scheme against high-energy discharge systems. Charge motion experiments focused on the impact of different flow and turbulence patterns generated within the cylinder by restrictor plates at the intake port entrance as well as novel inlet flow modification cones. The in-cylinder fluid motion generated by each configuration was characterized using swirl and tumble flow benches. Mixture preparation tests compared a standard single-hole pintle port fuel injector against a fine atomizing 12-hole injector.

Results indicate that optimizations of the combustion system in conjunction with hydrogen-enhancement can extend the relative air/fuel ratio λ at the lean limit of operation by roughly 25% compared against the baseline configuration. Nearly half of this improvement may be attributed to improvements in the combustion system. Furthermore, hydrogen-enhancement produces a nearly constant lean misfire limit improvement of λ 0.20 - 0.25 values, regardless of baseline combustion behavior. In contrast, the improvement of the amount of dilution with excess air at the point of peak engine efficiency decreases as engine operation becomes leaner, due to the inherently lengthening burn duration as λ increases.

["Onboard Plasmatron Hydrogen Production"](#)

Daniel R. Cohn

Massachusetts Institute of Technology

Heavy Vehicle Systems Review

Argonne National Laboratory
April 19, 2006

page 13: Electrical Energy consumption: 1 -3% of the combustion power of the reformat

page 27: about 15% efficiency improvement at A/F ratio of 1.8 Lambda (about 26.5:1) with 30% hydrogen bearing reformer gas from the onboard plasmatron with 1% of the NOx emission.

[Lean-Burn Characteristics of a Gasoline Engine Enriched With Hydrogen From a Plasmatron Fuel Reformer](#)

Document Number: 2003-01-0630

Date Published: March 2003

Author(s):

Edward J. Tully

John B. Heywood - Massachusetts Institute of Technology

Abstract: When hydrogen is added to a gasoline-fueled spark ignition engine the lean limit of the engine can be extended. Lean-running engines are inherently more efficient and have the potential for significantly lower NOx emissions. In the engine concept examined here, supplemental hydrogen is generated on-board the vehicle by diverting a fraction of the gasoline to a plasmatron where a partial oxidation reaction is initiated with an electrical discharge, producing a plasmatron gas containing primarily hydrogen, carbon monoxide, and nitrogen.

Two different gas mixtures were used to simulate the plasmatron output. An ideal plasmatron gas (H_2 , CO, and N_2) was used to represent the output of the theoretically best plasmatron. A typical plasmatron gas (H_2 , CO, N_2 , and CO_2) was used to represent the current output of the plasmatron. A series of hydrogen addition experiments were also performed to quantify the impact of the non-hydrogen components in the plasmatron gas. Various amounts of plasmatron gas were used, ranging from the equivalent of 10%-30% of the gasoline being reformed in the plasmatron.

All of the data was compared to a baseline case of the engine operating stoichiometrically on gasoline alone. It was found that the peak net indicated fuel conversion efficiency of the system was increased 12% over the baseline case. In addition, at this peak efficiency point the engine out NOx emissions decreased by 94% (165 ppm versus 2800 ppm) while the hydrocarbon emissions decreased by 6%.

In the data analysis, the relative air/fuel ratio was found to be an inadequate measure of mixture dilution. Two dilution parameters were defined and used. The Volumetric Dilution Parameter, VDP, represents the heating value per unit volume of the air/fuel mixture. Pumping work reductions due to mixture dilution correlate with VDP. The Thermal Dilution Parameter, TDP, represents the heating value per unit heat capacity of the air/fuel mixture. Combustion and emissions parameters correlate with TDP.

[Effects of Hydrogen Addition to SI Engine on Knock Behavior](#)

Document Number: 2004-01-1851

Date Published: June 2004

Author(s):

Tomohiro Shinagawa - Toyota Motor Corporation

Takeshi Okumura - Toyota Motor Corporation

Shigeo Furuno - Toyota Motor Corporation

Kyoung-Oh Kim - Toyota Motor Corporation

Abstract: In an SI engine, increasing the compression ratio could be one means of achieving higher thermal efficiency. However, when the compression ratio is increased, knock occurs and it prevents higher thermal efficiency. It is generally known that if the burning velocity is increased and the combustion period is shortened, the occurrence of knock may be suppressed. **Here, hydrogen was added to the gasoline engine as a means of increasing the burning velocity. As a result, it has been confirmed that the occurrence of knock could be controlled to some extent, and knock could be completely avoided depending on the conditions for the distribution of hydrogen.** Furthermore, it became clear that this result might have originated not only by the increase in the burning velocity but also by the hindrance of radical production by the hydrogen.

[Performance and Fuel Consumption Estimation of a Hydrogen Enriched Gasoline Engine At Part-Load Operation](#)

Document Number: 2002-01-2196

Date Published: July 2002

Author(s):

Gustavo Fontana - Universita di Cassino

Abstract: **Hydrogen and gasoline can be burned together in internal combustion engines in a wide range of mixtures. In fact, the addition of small hydrogen quantities increases the flame speed at all gasoline equivalence ratios, so the engine operation at**

very lean air-gasoline mixtures is possible. In this paper, the performance of a spark-ignition engine, fuelled by hydrogen-enriched gasoline, has been evaluated by using a numerical model. A hybrid combustion model for a dual fuel, according to two one-step overall reactions, has been implemented in the KIVA-3V code. The indicated mean pressure and the fuel consumption have been evaluated at part-load operating points of a S.I. engine designed for gasoline fuelling. In particular, the possibility of operating at wide-open throttle, varying the equivalence ratio of air-gasoline mixture at fixed quantities of the supplemented hydrogen, has been studied.

[Many more papers are presented in this thread](#)

Related links

[Legality of the EFIE done by Smack](#)

[Tests Done by Peter](#)

[EPA guide](#)

[Rancho SMOG](#)

[California Environmental Engineering](#)

[Hydrogen Injection](#)

<http://www.smogsite.com/>

Hydroxy Dyno and emission tests reports

EMISSIONS AND TOTAL ENERGY CONSUMPTION OF A MULTICYLINDER PISTON ENGINE RUNNING ON GASOLINE AND A HYDROGEN-GASOLINE MIXTURE Johz F. Cassidy Lewis Research Center Chehnd, Ohio 44135. [Download.](#)

[NASA Emission and Energy Test - Hydrogen-Gasoline Mixture](#)

<http://www.hydrogen-boost.com/September%202007.html>

[Hydrogen use in internal combustion engines – Collage of Alabama](#)

[Emissions And Total Energy Consumption Of A Multi cylinder Engine](#)

[Summary of emission tests](#)

[California environmental testing laboratory – Truck related](#)

IRS deduction

Following are excerpts from [IRS Publication 535](#). You are allowed a limited deduction for the cost of clean-fuel vehicle property and clean-fuel vehicle refueling property you place in service during the tax year. Clean-burning fuels. The following are clean-burning fuels.

1. Natural gas.
2. Liquefied natural gas.
3. Liquefied petroleum gas.
- 4. Hydrogen.**
5. Electricity.
6. Any other fuel that is at least 85% alcohol (any kind) or ether.

Deduction for Clean-Fuel Vehicle Property The deduction for this property may be claimed regardless of whether the property is used in a trade or business Clean-fuel vehicle property. Clean-fuel vehicle property is either of the following kinds of property. Any property installed on a motor vehicle (including installation costs) to enable it to be propelled by a clean-burning fuel.

The property is an engine (or modification of an engine) that can use a clean-burning fuel, or The property is used to store or deliver that fuel to the engine or to exhaust gases from the combustion of that fuel. For vehicles that may be propelled by both a clean-burning fuel and any other fuel, your deduction is generally the additional cost of permitting the use of the clean-burning fuel.

Related Links

<http://www.mimousa.com/hydrogen/tax-deduction.asp>

<http://www.savefuel.ca/oxy-hydrogen/>

Newbie FAQ Guide and General Hydroxy Information

NOTE – PLEASE READ ALL OF THIS SECTION PRIOR TO GOING TO ANY TECHNICAL SUPPORT FORUM AND ASKING A QUESTION. YOUR QUESTION HAS MOST LIKELY ALREADY BEEN ANSWERED HERE.

At least 80%! YES 80% of the questions can be answered in these guides simply by **READING** thoroughly. **Engineers on the forums are better off doing advanced research and development rather than spending their time answering obvious questions.** If you go on to a forum and ask obvious questions, you soon will be regarded as lazy and taking up UN necessary time. While the hydroxy forum engineers are all very happy to

answer any questions, you may save the time of having to wait for the answer by reading the files in the group's files section.

PLEASE USE THE GROUPS SEARCH FUNCTION FIRST.

If you are a beginner and eager to get started it is recommend to start with the Smacks booster. It is not intended to be a 100% water power system for your vehicle, but it is virtually guaranteed to improve your gas mileage. After you have successfully completed this project we suggest researching other systems in the files section, then moving straight on to theoretical 100% water powered car via the Bob Boyce's cell.

The water car forums are a group objective to work together in a friendly environment to develop systems of water as fuel technologies. **They are not interested in patenting and profiting off of their efforts; but actually freely giving away information as a gift to society.** The reason for this is that ALL who have attempted to do so in the past have had their technology suppressed via threats from entrenched institutions. The energy industry is one such institution. But there are others as well for example in the case of the suppression of medical devices and the banking cartels that have ties with the energy industries. Please keep this in mind when developing systems of your own and when participating on the forums. The Water car forums are not interested in the political discussion of the issue, but mainly on the technical side. [You can find more information on these political issues on this page.](#)

The water car forums are NOT for skeptics who have got 101 "scientific" reasons why Water fuel technologies won't work. Members of the water car group's work together in order to discover and resurrect water fuel as a viable alternative energy solution and are simply not interested to hear the opinion of anything otherwise.

If you do have a viable suggestion which can further improve the efficiency of proposed designs, then do not hesitate to share this with other members, but again, forums members do not have any time for people who are still questioning the viability of hydroxy technology.

However, if you are a newcomer to water fuel/hydroxy, or unknowingly has been indoctrinated by misinformation about water fuel, and are eager to learn the real facts, then you are most welcome to join the forums. You are request to respect the opinion of existing members the forums and communicate in an OBJECTIVE way, not emotional.

The principle aims of the hydroxy groups is to produce and use boosters with the goals of reducing and eliminating the need for fossil fuels, cleaning up pollution, creating an open source community and also improving the research. This movement is by no means limited to the internet forums.

In fact it is advisable to locally join with others to form an enthusiast group. It is quiet likely that other forum members could live locally to you. This can lead to training and the possibility of getting together for joint projects and to help each other out with your particular skills. The Panacea university site will have technical forums coming soon where you can register your area. Mean time you can ask on the forums about who is in your area.

All boosters make "gas." The major difference is what else they do. [or don't]

1. all boosters produce load on the engine.
2. all boosters do not have the same efficiency.
 - a. some produce 1 horsepower load for 1 LPM [relative numbers]
 - b. some produce 5 or more HP load for 1 LPM [computed by watts applied to produce 1 LPM]
3. all boosters produce heat, some low and some high.
 - a. low heat produces the least water vapor. [all have some]
 - b. high heat produces the most water vapor. [for the same design.

Water vapor SLOWS DOWN THE BURN!]

4. all boosters have different amps per sq in.
5. all boosters have different surface topography. [surface prep]
6. all boosters have different electrolyte concentrations.
7. all boosters have different external IR drops in the wiring.

This list only has some of the differences between boosters. It doesn't include the differences incountered in the ICE, which will be a much larger list.

The largest ICE parameter NEVER talked about is the "time spent at maxpressure" and the rod angles of this force. NONE of the burn pressure exerted after 120* ATDC converts to crank power. This is why there is such a big improvement in adding Hydroxy. If all the power from the gas is released before 45* ATDC, all the available power can be converted to angular motion in the crank. The ideal burn duration is from TDC to 45*. The next 80* exerts the maximum convertible torque on the crank.

When the exhaust valve opens, the conversion ends and if the gas is still burning, as is typical, all that energy from 120* ATDC to valve open is lost. The ICE will stand the pressure of causing all the fuel to burn by 15 to 30* ATDC and then all the energy is

recovered except for heat and friction. If the engine size is small, the 1 to 2 LPM will produce a larger % complete burn at an earlier crank angle and therefore a greater performance improvement. If the HP load is also reduced, IE less gas produced, again the small engine will have a bigger improvement on a small LPM. On a larger engine, there needs to be a larger amount of LPM to get the same burn improvement.

The Hydrogen blends with incoming outside air and acts as a catalyst with the existing fuel source, gas or diesel. The Hydrogen cleans up all of the carbon in the engine and exhaust system. The Hydrogen causes the fuel to be consumed completely and in that process incinerates all of the toxins and particulates resulting in lower emissions and clean air exhaust discharge. The Hydrogen then passes out the exhaust system cleaning the cat and muffler and tailpipe of carbon deposits and returns back into the air as Hydrogen to return back to the Planet.

Most see an average of 20+% increase in average mileage, of course it depends on the driver and driving habits, road conditions, weather conditions and hilly terrain, in any case no less than 5% improvement in MPG, and on several vehicles, especially small diesels the power and MPG improvements are really noticeable. Power increases are also noticeable as pickup and performance increases also.

Q-Why can't I use the term "HHO" on forums?

A-The term "HHO" refers to hydroxy and is a registered trademark, currently the owner of the "HHO" trademark is enforcing his copyright and is shutting down public forums who mention his trademark. Despite how much this doesn't make sense to you, **DO NOT REFER TO HYDROXY AS "HHO" on ANY public forums.** You may use the term "hydroxy", "HOH" or even "hho" in lower case.

Q-What is Hydroxy gas and how is it made?

A-The term "Hydroxy" is a word coined by open source engineer "Bob Boyce". It refers to monatomic hydrogen or "Browns gas" (there are other names associated with it) that has been created by separating H₂O into molecules by passing an electrical current through water. Hydroxy is usually attributed to the case where this monatomic hydrogen or "browns gas" is being created in order to boost and or power an engine or a generator.

There are two popular methods which are used for hydroxy creation. The first is to use straight DC using water mixed with electrolyte, this is coined as "Brute force DC". The second is by using pulsed DC under certain resonant conditions and is understood to be "water splitting" or water fractioning as first described by Stanley Meyers. In the individual case of the Bob Boyce unit, both electrolyte and Pulsed DC under resonant conditions are used in the process.

Hydroxy is extremely volatile, flammable and powerful. HYDROGEN, OXYGEN and the HOH mixture of the two obtained from electrolyzing water is EXTREMELY EXPLOSIVE and DANGEROUS gasses. This is experimental technology, and you do so at your own risk. Seek professional advice before experimenting for the first time. Your health, life and property insurance companies may not appreciate your experimentation and potential carelessness/recklessness, and could cancel or not honor your contracts of coverage (your policy).

DO your research and be confident about what you are doing before you attempt it. **Use common sense. Be organized, clean and systematic when experimenting.**

Do not's with hydroxy

Never use glass as a container for holding/creating/piping this gas. Hydroxy is very static sensitive and will ignite given the opportunity. Always handle it as if it is about to explode. Any spark will ignite Hydroxy; if electrodes are close enough to touch make sure they are always submerged in water.

Connect wires to the electrodes at the bottom of your container. **Do not use aluminum connectors to electrodes.** Always use stainless steel. DO NOT use galvanized, or zinc plated steel. They give off poisonous gasses when electrolyzed. Metals which are completely unsuitable include copper, aluminum and platinum.

Never operate a hydroxy unit without A BUBBLER. A pop off cap must always be used when producing Hydroxy. A bubbler is the most basic form of safety for you and your equipment. Engines are prone to backfiring at anytime. USE A BUBBLER ALWAYS.

Do not attempt to ignite the Hydroxy from the end of the output hose from the cell, it will detonate the bubbler. If no bubbler is used it will detonate the cell then YOU.

Do not attempt to add Hydroxy to a lawnmower engine (use a GEET instead; more GEET details are posted on the Panacea university site). They use a waste spark which is triggered when the intake valve is open. This will ignite the incoming hydrogen and detonate your bubbler. Other 1 cylinder engines for lawn care also use "waste sparks".

Do not use Baking soda for your electrolyte. More information as to WHY and on all these topics can be found in the faculty section above. Only use KOH (potassium hydroxide) and NaOH (sodium hydroxide). They are very caustic and so be very careful when using these electrolytes. **DO NOT use salt as an electrolyte as it will create poisonous chlorine gas that can kill you.**

ALWAYS wear proper safety gear when experimenting with hydroxy gas. Eye goggles, a face shield and protective clothing are highly recommended. If you can afford them, then use a 1" polycarbonate (plexiglass) blast shield to place between you and your experiment.

Do not use Rain water, spring water or tap water in your booster. **Only use Distilled water.** The reason for this is because of the impurities contained in them.

Do not connect your booster to an engine vacuum source. **ALWAYS connect your boosters output to the intake piping; this is located as close as possible to the butterfly valve.**

DO NOT EVER connect hydroxy to the inlet of the turbo. There is flammable gas with its own oxidizer just waiting for a stray spark from a faulty sensor to backfire, or metal to metal contact from turbine blades on casing and ignite the hydroxy. In the Case of adding a booster to turbo engines, this is done by connecting the hydroxy to as close as possible to the throttle plate, similarities can be seen in the example of the normal connection on an aspirated engine.

It is suggested to operate the booster 10PSI above max boost pressure. This will ensure you will have hydroxy production throughout the operating range. This can be done by restricting the output of the booster with a needle valve, and then connecting the booster power through a relay activated by a pressure switch to prevent over pressurization. Do not forget a pressure relief also - or a pop off device of some sort and a bubbler.

Do not under any circumstances hook your electrolyzer unit up to an engine vacuum source. There are three important reasons for this:

Exposing the surface of a body of water to pressure that is less than atmospheric results in a lower boiling temperature. This is due to the fact that the drop in pressure allows water molecules to escape their liquid confinement and be liberated into a vaporous state more easily. In small quantities, this can be desirable when attempting to improve the performance of an ICE. The problem is there is no easy way to monitor just how much and under what conditions this is maximized. Too much vapor/steam will dilute to hydroxy mix and render it useless by reducing its volatility.

This will nullify any fuel efficiency gains you may otherwise have had. In fact, too much steam and you may actually decrease your mileage. The way to utilize vaporous water is by mist injection where the process can be monitored and controlled. Those of you using engine vacuum now on your boosters probably have no idea how much and of what quality your cells output has. Now add this to the problem of already hot running cells and after a very short period of operation you basically have nothing but a big steam generator piped into your manifold vacuum. This can wreak havoc on sensors and components within your engine.

It is true that putting an electrolyzer unit under vacuum will increase its hydroxy output as long as the temperature of the bath remains below its new boiling point. So the temptation to do this is great - but there is a problem even more serious than boiling.

Think of how manifold vacuum works. For those of you that have a gage you know that vacuum is the highest when the throttle plate/s is/are closed. Vacuum is at its lowest value when the valve is wide open.

This is the exact opposite of what you desire. You want the unit to be outputting its maximum when the throttle is wide open, not fully closed. This will cause engine management problems and reduce the effectiveness of your fuel savings. If one wishes to use vacuum to increase production, one would need to use a vacuum pump that provided a consistent value. The problem with that - now you have a larger volume of flammable hydroxy gas prone to ignition and being pumped through a mechanical device which could fail and blow up.

Manifold vacuum is not stable. It pulses violently with every cycle, and surges with every movement of your right foot. This causes large fluctuations which cause bubblers and cells to be evacuated very quickly - almost instantly sometimes. So hook your cells output to the intake piping just before and as close as possible to the butterfly valve as you can. This minimizes the stored hydroxy volume while still avoiding the vacuum phenomenon.

DO NOT STORE HYDROXY GAS ANY WHERE, NEVER ATTEMPT TO STORE THE GAS!

Again - DO NOT STORE HYDROXY GAS ANY WHERE, NEVER ATTEMPT TO STORE THE GAS!

Storing hydroxy gas is very dangerous, **it can self combust between 10-15psi**. If you construct a 21 plate (20 cell) unit with minimal leakage and fit it with a 1/2" output tube, at 22 amps you will get approx. 14 lpm of gas out. As you raise the amperage to 30 the output will increase, of course. If you should get greedy and raise the amperage to around 40 amps it WILL explode. You don't have to believe it, construct it and find out for yourself! The reason for the explosion is the 1/2" outlet tube restricts the flow, builds up pressure and BOOM. That is all I can say about that for now, except to say, it all depends on the quality of gas you are generating, but **IT IS NOT a good idea to try storing Hydroxy gas or putting it under much pressure.**

You should not compare stoichiometric hydrogen oxygen to hydroxy gas for this criteria. You would be comparing stable parahydrogen to unstable orthohydrogen. The issue with pressurization comes from the fact that the orthohydrogen content of freshly generated / pure hydroxy gas will avalanche decay into parahydrogen at about 15 PSI. When that happens, an electrical discharge occurs within the gas, igniting it. BOOM!

We have demonstrated this repeatedly by operating a well designed cell unit into a blocked off output port and watch what happens as it gets to 15 PSI. I am not condoning this for everyone to try, but it is amusing to watch as long as the cell is designed to handle this sort of repeated abuse.

Q- Is it possible to make 100% water powered car driven by hydroxy gas?

YES. Typically gasoline is burned in your engine in order to convert chemical energy into mechanical energy to power your car. In the case of a hydroxy booster, when the engine turns the alternator mechanical energy is converted back into electrical energy and is stored in the battery as electricity. This electricity is then used to produce hydroxy gas inside an electrolyzer. This gas is burned in the engine just like gasoline and will improve the burn of the gasoline, therefore giving more MPG and less emissions.

With the physics of the typical booster, the engine needs more Hydroxy gas to run it than the electrolyzer can produce. Bruce force DC booster designs containing electrolyte cannot accomplish this job at this time. Other systems which include using use pulse DC under certain resonant conditions have been reported to be able to produce enough hydroxy gas to power a car 100%.

Most famous is the Stan Meyer system which first appeared on mainstream TV in the Mid 90's, this news report showed Stan's 100% water powered dune buggy. Stan patented his designed but was killed and suppressed. Later his brother formed the Xogen Company which attempted to resurrect the technology, this also ran into suppression. Before all this a person in the Philippians named Daniel Dingel had a 100% water powered car, he was unable to get support due to suppression. Next came Bio's fuel corporation headed by Steven Ryan, he had a 100% water powered motor bike. Now he only offers a 50% water system, so go figure. There are other designs which have been suppressed, it is understood that each design differs in operation but is still using hydroxy to power the vehicle. [Further research on this can be found on this page.](#)

The Meyer's system became popular again recently in 2004-2007. Two engineers re popularized the design by re producing similar results off the patent. However it did not produce the same efficiency but still proved that the principle is sound. At this time this current design is not suitable to power a vehicle on 100% water alone, **but is still an exceptional booster**. Further R and D can get it there based on the already promising results. [This design can be found on this page.](#)

There is another option proposed in the open source design by Bob Boyce. This has been reported by him to be able to produce 100 LPM of hydroxy at 350 watts. This could power an engine of up to 2 liter's or 4 cylinders on 100% hydroxy with out the need for fuel. More Information on this design can be found on the Panacea university site. **The Boyce cell is certainly not recommended for newcomers because of the complexity of achieving resonance and all the specialized and extensive work needed.** It is advised for those who are working on the open source Meyer's replication and or Bob Boyce design to **use a booster in the mean time**, or check for up dates on the Les Bank circuits.

So far open source engineers have researched water fuel systems through the patents which they appear in, third party replication reports, working demos that have been presented on TV and in theory. A list of these patents can be found on [Panacea patent's page](#) under "water car patents".

Q-How much water is needed on 100% hydroxy powered systems

A- "Unconventional" water electrolysis systems HHO gas production reports:

[Yull Brown](#) suggested that one gallon of water could propel an 8 cylinder car for 1000 miles, mixed with air from the car's breather, using only two car batteries and his electrolyzer. He didn't say what alternator(s) he used. His figures were the following: 1 US gallon of water = 1860 gallons of HHO gas, 1860 gallons x 4 liters / gallon = 7440 liters of gas.

[Dennis Klien, of Aquygen](#), says that his system takes 4 ounces of water to run a car 100 miles. With 128 ounces per gallon / 4 = 32 33,695 Watts per Gallon / 32 / 3 = 350 Watts of generator power is needed to operate this system. One average car alternator output would be needed with his system.

Stan Meyer suggested that his car required one gallon of water to drive 100 miles. [Xogen](#), a Stan Meyer spin-off company in Canada, provides home energy & heating & waste treatment.

Daniel Dingel stated that his system can drive a car one hour on a liter of water. Using one 12 Volt battery, a honeycomb plate electrolyser, & one solenoid on each spark plug.

He says his Hydroxy is six times more powerful than gasoline, because he regulates the H & O mix.

You tube Videos

[Daniel Dingel - Water Car](#)

[Car Using Water As Fuel 1](#)

[Car Using Water As Fuel 2](#)

Commonly people (who could be dis info agents) appear on the forums and throw around theories (and figures) as to why Water fuel cannot work. The same statements have been regurgitated for years, on several Internet sites. This is not so much in reference to brute force DC designs but to pulsed resonant designs like those mentioned above.

"It gets back to simple chemistry, how many BTU's or calorific values are needed to produce certain power and what are those characteristics for hydrogen and hydroxy."

This technology DOES NOT follow those "simple chemistry" rules! This has been REPEATEDLY explained by several people, including popular experimenter Bob Boyce. Most do not understand that we are referring to monatomic hydrogen rather than diatomic. Others do not understand the much touted Faraday prediction. Some class Faraday's law to be a method on how to measure "unity". The Faraday prediction never was, nor will it ever be a measure of "unity".

When dealing with efficiencies, keep in mind that according to Faraday predictions, it should require 2.34 W/h per L/h of hydroxy gas production. Power consumption below this could be considered above unity by many. Hydrogen in its lowest energy form requires 4% H₂ diluted in 96% air to achieve the same power as gasoline. Hydrogen in a high energy state can deliver the same power at just under 1% when diluted with about 99% air."

This is referring to the published ratio for parahydrogen, the low energy state of hydrogen. The kind of hydrogen that comes from a tank and has had the excess energy bled away. Even low pressure brute force electrolysis will typically produce hydroxy gas in which about 75% of the hydrogen exists in the orthohydrogen state, with about 2X more energy than that of parahydrogen. Resonant reaction created monohydrogen is in an even higher energy state, with about 4X the energy of parahydrogen. There are other states as well, such as deuterium and tritium (radioactive), but those are obtained through different processes.

There is much speculation on the amount of hydrogen or hydroxy gas required to run an engine. This is because not all hydrogen or hydroxy gases are equal. All of the published figures for calculating the amount of hydrogen gas it takes to run an engine are based on normal tank hydrogen, which is diatomic parahydrogen, the lowest energy form of hydrogen.

Freshly generated hydroxy from a resonance reaction contains 4 times the energy content. This is not just the hydrogen energy content, but the oxygen energy content as well. Even the hydroxy gas generated from straight DC electrolysis contains much more energy content than tank hydrogen, about twice as much."

When catalysts are involved, output can be brought to above Faraday efficiency. But all in all, Faraday efficiency is pretty much worthless to use in gauging anything. After all, Faraday did his research so long ago, and what he had to work with was very limited. We have so much better to work with nowadays. Any People clinging to ancient rules as if they were gospel will be the defining element that holds back progress.

Faraday does not apply to catalytic reactions, only to electrolysis. Electrolyte is used as the catalyst, but some other factors appear to be at work there. The limiting factor seems to be how fast the gas can get out of the way of the electrodes when in that mode of operation. It's as if the electrolyte is literally boiling from heat, while the electrolyte temperature actually drops from what it was at prior to the resonant reaction starting.

Q- What spark plugs can I use with hydroxy?

A- If you currently are using platinum plugs, replace them with standard copper core plugs such as Autolite. Iridium plugs are also acceptable. Platinum causes the H and O to recombine acting as a catalyst for that reaction and should be very detrimental to extracting energy from Hydroxy according to Bob Boyce. So, his recommendation is not to have any platinum touching the gases, including platinum plugs.

Q-Can I use a booster with a diesel engine?

Yes. There is a theoretical limit where there must be 20% of diesel fuel in the cylinder, but it would be nearly impossible to produce hydroxy gas fast enough to exceed this upper limit.

Q- Is modifying your car to have a booster illegal?

A-You must check with your state and federal emission laws and with the department of transport. At this time a unified effort is underway to present strict safety guide lines to follow for those wishing to boost their vehicle. You are needed to help these efforts. Any information and help can be sent to the non profit organization. [Contact us.](#)

Q-What about vacuum pressure?

A- when you have a vacuums, you increase the production of water vapor and steam, pressure slows the water vapor production down, maybe you think more hydroxy is being made, when its more water vapor.You should put your inlet connection before your air filter so you will completely mix up the hydroxy and incoming air before it enters the combustion chamber, so every piston gets the same charge, stay away from the vacuums on your car.

Vacuum does not increase production of hydroxy. It lowers the boiling point of water and thus your unit is making more steam. There are numerous posts concerning this and where to connect your output (not to a vacuum).

Beginner's FAQ

Q-What is a hydroxy booster?

A-The Term "hydroxy booster" describes an electrolyzer that is designed to be simple, compact and to produce hydroxy gas. Hydroxy gas is being produced in order to "boost" the vehicle or generator by improving MPG (miles per gallon) performance, improving the burn quality of the fuel thus reducing any unwanted emissions, produce more power and to clean out old carbon deposits inside the engine. This is done by booster being added to the air entering the engine.

Q-What is "brute force DC" and what is pulse DC under resonance?

A- Brute force DC refers using straight DC current to power a booster with electrolyte in it. All current boosters use brute force DC created from their cars battery in order to produce the hydroxy gas. Pulsed DC refers to using a pulse width modulator and resonance refers to using it under certain conditions, IE with no electrolyte and with additional circuitry like a "choke" (Bifilar coil) to limit current and produce resonance. The only exception is the Bob Boyce system which employs electrolyte and resonant conditions.

Q- Can I buy a readymade booster and who can I get to install it?

A-Currently there are a few open source engineers doing readymade boosters in order to help themselves finance their open source research and development. Please consider them before others. Not only are the open source designs better, but they are also cheaper. Currently as of mid 2008 the most respected booster is Wouter's and Praveens Tubular cells, Bob series cells and the "Smacks: booster. Other designs are on the way, you can keep up with these designs by checking the Panacea University site.

Booster materials

Q-What safety devices are needed?

A-It is essential to install TWO "bubblers" to prevent damage encase the engine backfires. Two bubblers also wash any traces of electrolyte vapor out of the gas being fed to the engine.

Q-How are bubblers made?

The generic bubbler is made from any tall plastic container with a tight lid. The pipe carrying the gas is inserted through the lid to near the bottom of the container, which is then filled to at least a 5-inch depth of water. The gas takeoff pipe is inserted through the lid for half an inch or so, and shielded from splashes.

Q- What is an electrolyzer?

A-An electrolyzer is a device made up of stainless steel and electrolyte intended to convert water to hydroxy gas. The Aim is to do this in considerable volumes and at the

minimum possible current. There are several designs which you could build which vary in efficiency.

Q-What is electrolyte?

An electrolyte is a catalyst chemical added to water to make water more conductive to current or to make electrolysis easier. The best one to use is evaluated by its ability to not be consumed during electrolysis. Both KOH and NaOH have been found to be the best.

Q-What current is needed?

Electrical current for boosters usually ranges from 10 to 35 amps, typically 20 amps and 15 amps. In the case of Bob Boyce's unit, 350 watts is needed. In the Dave Lawton circuit typically up to 4 amps of pulsed DC are desired.

Q- What is an electrode?

An electrode refers to a piece of metal which is placed in an electrolyte in order to allow electrical current to be passed through the electrolyte. The best electrode material to use is commonly agreed to be 316L-grade ("food-grade") stainless steel. You can also use 304 or 302 stainless steel in brute force DC boosters. These materials are selected in the brute force booster's case to be the best corrosive resistant materials; in the case of resonant hydroxy systems are 316L (Seamless not welded) is chosen

Q-How big should electrodes be?

Electrodes get eroded with use if the area of (one side of) the electrode is less than 2 square inches (1290 square mm) per amp of current carried. Erosion reduces and gas production is improved with increasing electrode area up to 4 square inches per amp. Above that, no noticeable improvement has been seen is seen.

Q-How thick should electrodes be?

There are a few things to consider, the first is how thin the electrode material is in comparison to how difficult it would be to hold it securely in place. It is usual for the gap between electrodes to be quite small, so 20 gauge or 22 gauges - say 1/16 inch is generally chosen. Thicker plates weigh more, cost more and take up more space.

Q-Do the electrodes wear out?

A-In a properly designed and operated electrolyzer, the plates will be in first-class condition after a year of use. The best shelf life reported so far is from using stainless steel, distilled water and KOH or NaOH for electrolyte.

Q- How much water will be used?

A-It is estimated that one liter of water produces about 1,850 liters of hydroxy gas. In the example of the Smacks booster which can produce 1.7 LPM (liters per minute) of hydroxy gas, this will use 1 liter of water in 1,090 "minutes" of running.

Q-Can I use any kind of water?

Use ONLY distilled or de-ionized water as other varieties like rain, spring and tap water leave residues behind when the water becomes gas.

Q-What happens if I forget to top the booster up with water?

The electrodes will become partially uncovered and the gas production will drop off, so you should keep an eye on the water level.

Q- Which is better Acrylic or PVC?

Experience with acrylic in other fabrication projects has shown that it doesn't like heat, vibration or many chemical substances especially in a prolonged exposed environment, for example a motor vehicles engine compartment. It gets brittle and will craze (small cracks) when exposed to many chemical or solvent compounds such as lacquer thinner, acetone and I think gasoline.

It also doesn't take impacts as well as PVC and when it does fail, shatters with sharp edges. From a practical building stand point PVC is a cheap preferred choice and easy to work with, materials and fittings readily available most anywhere, no special solvents to buy or try and deal with (Weldon-4 can be tricky), and usually much less costly.

Q-How can I measure gas output?

The cheap and easy way to measure hydroxy flow is to do what is called a displacement test. First fill a basin with water. Fill a plastic soda bottle with water and position it upside down with the neck under the water in the basin. Feed the tube from your bubbler up into the neck of the bottle, and measure the length of time taken to fill the bottle with gas. Example- If the bottle is 2 liters and it takes four minutes to fill it with gas, then the gas production rate is $2 \text{ liters} / 4 \text{ minutes} = 0.5 \text{ lpm}$.



Right is the electrolyser connected to a hose going into a bucket of water

Containing a 1 litre bottle of water.

To get more accurate, use a 1.5 liter plastic bottle, cut off the bottom, and unscrew the cap. Then place the whole bottle under water with the open mouth at the top and the open footend of the bottle at the bottom with the gas tube exiting for underneath inside the bottle.



Once the bottle is completely under water and filled with water, simply screw the cap on again, then you have a bottle that is 100% full of water at that moment. Obviously the gas bubbles coming out of the tube will immediately start replacing the water, but you started with a bottle that was filled 100% with water, thus making your reading very accurate.

Metric gas measurement



This open source hydroxy engineer cut the bottom off a 1/2 liter bottle, marked the 1/2 liter point at the bottom, and immersed it in water and routed output bubbles thru the bottom. If the mark moves up to the surface of the water as it fills with bubbles in 1/2 minute, then you are making 1 liter of gas per minute. You can figure out the math for other volumes/arrangements. Unscrew the cap to let the bottle go back down to reset the instrument. Leave the cap unscrewed when you are not measuring.

Alternative method



Alternatively if you have distilled water, and an electrolyte like KOH or NaOH, in a cell with clean SS plates, and you add a DC voltage to it, you'll get a stoichiometric mix of hydrogen and oxygen, = OxyHydrogen, aka Hydroxy, no other gases, except if by too high a voltage the temperatures run high, so you will (or can) also make a lot of steam. No need for a steam in hydroxy analyzer, run your output gas through a freezing cold empty bubbler and the water vapor will condense and can be measured.

Video -[Alternative Example of a flow meter connected](#)

Watts are measured in watt hours, so if you are using say 240 watts and produce 9 liters per minute you multiply the 9 liters by 60 (minutes) you get 540 liters per hour. Take the 240 watts and divide it by your 540 liters of gas and it will tell you watts/liter. In this case as an example it would be .44 watts per liter.

Watts are a base term. Power in watts is amps times volts. It is an instantaneous measurement. Watt seconds, watt hours, or more common Kilowatt hours is a time based sum of watts used.

If a device draws 20 amps at 12 volts and makes 3LPM then you are applying $20 \times 12 = 240$ watts to make 3LPM. That is simply $240 / 3 = 80$ watts per LPM. No great fuss.

Remember in DC work, the term is for the instantaneous power found by multiplying volts times amps. In this case you can also say you used 240 WM [watt minutes] DC for 3 LPM. Other efficiency measurements are about applied power divided by gas output to get watts per L.

To convert to watt hours and LPH [L per hor] both terms must be multiplied by 60. If 3 LPM is produced, then 180 LPH is produced. If 240 watts is the instantaneous power then 14,400 WH or 14.4 KWH is used. dividing the watts used by the gas produced is $14,400 /$

180 = 80 watts per L. No difference whether at 1 min or one hour. The gas production efficiency is 80watts per LPM.

When someone has less than 100 watts applied to get 3LPM, we all take note! When someone gets it down to 10 watts for 10LPM, we will be ready for Hydroxy only cars!

E gas temp sensor by Bill Williams

Here a simple little device that will assist in acquiring more accurate temps of the discharges gas from electrolyzers when relating to efficiency.

[E Gas Temp Sensor PDF](#)

Engine related

Q-How is a booster connected to a vehicle?

A-The hydroxy booster is first connected through two bubblers and then into the air filter.

Q-Does the engine timing need to be changed?

When using a booster which produces LESS than 3LPM there is no need to adjust any thing. At 3LPM the hydroxy gas ceases to be a fossil fuel enhancer and starts to become a second fuel in its own right. As the gas production rate increases further, the spark timing needs to be delayed ("retarded") gradually. The maximum delay is to a point some 12 degrees after Top Dead Center.

Q-Will my engine rusts from using a hydroxy booster?

No. Hydroxy gas is understood to be a very helpful additive and/or fuel. Hydrogen first burns inside the engine, then the by product is steam which then only becomes water as it condenses and cools OUT SIDE of the cars exhaust.

Q-what about [Hydrogen embrittlement](#)?

A-Reports have stated that hydrogen embrittlement does not occur. This is mainly a concern in storage tanks under high pressure. Iron has so much space between the atoms that hydrogen can seep right through it. In an engine all iron parts are covered with a thin film of oil which helps prevent the hydrogen from contacting the metal. Since gasoline is composed of about 500 different hydrogen carbon compounds, when it is heated the hydrogen is released to mix with oxygen from the air, a spark ignites it and the carbon is left inside the cylinder to foul the oil and accelerate wear of all the moving parts.

Storing hydrogen does not cause metal embrittlement. Hydrogen has been stored in pressure tanks like oxygen since WWI. And these tanks are still in use today. Some have been tested by Roy McAlister just for that purpose. And no embrittlement was found, or any special type of metal was used for the tanks. The point is that unless you are making pools of liquid metal, hydrogen embrittlement is unlikely to occur with the low concentration of hydrogen we are seeing. A common ICE generally doesn't run that hot, if it does, we have other major problems.

Q-Can I use a booster with a turbocharger?

This can be done by feeding the hydroxy gas to the low-pressure side of the turbocharger.

Q- Can a booster work on fuel injected cars and what is an EFIE?

A-EFIE is an acronym standing for "electronic fuel injection enhancer". It is required for all fuel injected cars to accept or use a booster. More reading on this is described above.

Q-what is the best booster to use?

A-Currently the best booster to use based on efficiency and cheap construction materials is the Smacks booster, however for those who do longer trips in their car, for example 2 Hour + trips , it is advised to use a "7 series plate cell" or a tubular cell design.

Q-What can I do to prevent freezing of the water ion my booster?

A- Electrolyte concentration needs to be high to prevent freezing. Alternatively you can put a heating/cooling coil around the unit (engine coolant driven) or wrap the booster with fiberglass foil backed insulation. NaOH (like KOH) at "moderate" (20%) concentration makes a reasonable anti-freeze. It will freeze at about -10 F. KOH at 28% will not freeze even in Norway. The bubblers can contain some antifreeze.

Q-what of Ozzie freedom's design advertised on the water for gas sites?

A-This uses both an in efficient design and the wrong electrolyte (Baking soda). This produces a TOXIC gas. The tiny amount of surface area is what is limiting current, at the cost of POWER! Surface area directly translates into how much VOLTAGE is required to push CURRENT. So while it is true that with electrolysis it is the amps that make the gas, it is also true that the more voltage you have to use to push those amps, the more POWER is consumed per liter of gas produced. The only reason the Ozzie Freedom design does not heat the water with the hugely poor efficiency of the device is because of the relatively low amount of power applied vs the volume of water contained. The poor efficiency means that it does not put out much gas.

It is also understood by some as NOT performing as a hydroxy gas booster, it is an intake air humidifier. It is not going to do anything but add water vapor to your intake, which will only help a little if you live in a dry, arid environment.

Q – *How do I mix the electrolyte and how do I know how much to add?*

A- http://www.youtube.com/view_play_list?p=AFE0C21ED792D60B has an index of the link for you to look at. If this hyperlink works it will take you directly to the video. How to set BB Smack electrolyte concentration.

Q-*What about other free energy devices?*

A-[Please visit this page](#) for introductory information and the Panacea university site for further technical details.

Booster supplies

Electrolyte

[NAOH, KOH](#)

<http://www.aaa-chemicals.com/>

Potassium Hydroxide [KOH] –

For supply of the KOH - try your local hydroponics supplies as an alternative to soap makers etc. It costs only \$3-6 per kg depending on quantity purchased.

Others use the Chemistry store.com Fast service, [usually about 2-3 days] price is about \$22.00 with shipping

[Saltcitysoapworks.com](http://saltcitysoapworks.com)

[Potassium Hydroxide](#)

Plastic Supplies

[Liquid/Gas Check Valves - US Plastic Corporation](#)

[AZEK adhesive](#)

[For Barbs, Check Values](#)

[For quick Disconnect Fittings, plus clear containers to hold plates](#)

[Stainless Steel Bolts](#)

Materials compatibility web site

http://www.flotronicpumps.co.uk/templates/page_01.php?cfp=page:0004S

MMW Calculator
Millilitres per Minute per Watt

<http://www.watervan.co.uk/tools.php>

Electronic Odds and Ends

[All Electronics](#)

<http://mouser.com/>

[Digital temp meter](#)

Gas flow metering videos

[Good Video on how to set up a gas measuring device](#)

[Example of a gas flow meter attached to the cell](#)

Miscellaneous

AEPC 2009 Hydroxy presentations:

<http://energyshowandtell.wetpaint.com/page/AEPC+2009>

<http://www.youtube.com/user/hydroalternation>

High Alternators - <http://www.excessiveamperage.com/>

[Alternator charging](#)

[Boat electric alternator charging](#)

[Pulse Plugs - 20,000X More Powerful Than Spark Plugs. Greater Horsepower, Fuel Efficiency, Torque.](#)

Links

Individual open source hydroxy project pages

<http://au.geocities.com/misfitjackie/>

<http://www.brianspdr.com/hydrogen-fuel-cell.html>

<http://members.shaw.ca/w.elliott/Club.html>

<http://www.alt-nrg.org/>

<http://www.ihhoi.org/>

<http://www.energybuilders.net/>

<http://h2science.blogspot.com/>

<http://www.hhoclub.com/>

<http://www.hhoforums.com/>

<http://hhoinfo.ning.com/>

<http://www.hhohub.com>

<http://www.hhocountry.com/>

You tube Users and Videos

[Bob Boyce interview](#)

[Hydrogen Fuel - Engine Fundamentals](#)

[How to assemble the HHO generator](#)

<http://www.youtube.com/daddyo44907>

[Tube cells and flat plate cell construction experimentation](#)

<http://www.youtube.com/user/crwebb>

<http://www.youtube.com/user/wwwbrianspdrcom>

<http://www.youtube.com/user/mdbreedi>

<http://www.youtube.com/watch?v=DL90PDiceQ8>

[Hydrogen gas made with variable capacitor](#)

<http://www.youtube.com/user/camster6>

<http://www.youtube.com/user/srawofni>

<http://www.youtube.com/user/kevlaunterprises>

<http://www.livevideo.com/byte312>

<http://www.youtube.com/user/wwwbrianspdrcom>

<http://www.youtube.com/user/delvis11>

[Roy Teaching Chem and Manufacture of H2 Part 1](#)

[Roy Teaching Chem and Manufacture of H2 Part 2](#)

<http://www.youtube.com/user/babyella07>

[Hydroxy Booster Presentation](#)

Technical support groups

Yahoo energy groups

[Hydroxy group](#)

[Water car group](#)

[Radiant Energy](#)

[WaterFuel Cell Research Group](#)

<http://www.mpgresearch.com/forum/>

<http://ecomodder.com/>

Credits

The Open source engineering community!

If you are able to contribute to this document in ANY way, IE- replication details, faculty info and or additional data please contact the non profit organization.

<http://www.panacea-bocaf.org>

<http://www.panaceauniversity.org>