



STAGE 2

Building and Testing a Fuel Cell/System

FUEL CELL "GREEN MACHINE" PILOT PROGRAM[®] COMPETITION DECEMBER 4, 2006

FirstFuelCells.com

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Eastern Standard Time (Ohio)

Attachments included in this e-mail:

1. FUEL CELL "Green Machine" Stage 2
2. Green Machine Safety Guidelines
3. Visual photo of KIT box you're receiving from FedX
4. Media Release Form

Support Engineers, Contact Information:

Scott Leahy, Design Engineer
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TDM Fuel Cell Technology
Chuck Tanzola
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Procedures:

- ◆ e-mail Scott or Chuck at any time with questions, they will be happy to help you
- ◆ periodically frequently asked question sheet will be compiled and faxed to all the teams
- ◆ please leave your contact information for call backs

Happy Holidays from our team:

Diane, Chuck, Randy, Andrew, Tom,
Mark, Scott, Anji, Ben, Barb

Thank you!
My best, Diane Sadowski



BUILDING AND TESTING A FUEL CELL/SYSTEM**SAFETY: A****HYDROGEN SAFETY**

The following information and web site links are provided by Mr. Randy Avera, Consulting Engineer for FirstFuelCells.com. Mr. Avera is an Aerospace Engineer, Georgia Tech Class of 1977, and a prolific science writer on NASA science research programs and the future of the business of exploration of our Universe.

Mr. Avera worked for NASA at Kennedy Space Center, Florida from 1977 to 1991 as Lead Structures Systems Engineer for the Space Shuttle Orbiter vehicles. From 1991 to present he has worked for the Federal Aviation Administration Aircraft Certification Service certifying the design of transport and general aviation aircraft.

He is the author of “The Truth About Challenger” and “Memories of Columbia.” In 1979, Mr. Avera was the NASA structures engineer of the NASA/Rockwell International team which installed the first Hydrogen Fuel Cell into the Space Shuttle Columbia. The Space Shuttle Orbiters have three independent hydrogen fuel cells to supply 28-volt Direct Current for electrical power, and the by-product of water.

Disclaimer:

The following information is intended to provide students, robotic teams, and advisors with a variety of fundamental information and resources regarding working with hydrogen safely. This information was researched from The Department of Energy, NASA, The Bellona Foundation of Oslo, Norway, The National Fire Protection Association (NFPA), and the work experience of Mr. Randy Avera.

Working with any fuel exposes people and property to inherent hazards and risks due to the physics of the fuel, and the local environment where the fuel is being handled or used. FirstFuelCells.com and Mr. Avera advise students, robotic teams, and advisors to get proper training prior to handling any fuel, hydrogen included. Hydrogen fuel has been identified by many corporations, universities, governments, and organizations to be one of many needed solutions to providing alternate forms of energy. The safety and commercial aspects of hydrogen and fuel cells is currently undergoing very dynamic research and discovery. The students should realize that this introduction to hydrogen and fuel cells is the exciting beginning of an historic journey of science, engineering, and discovery. You have the opportunity to make great discoveries in the energy industry, provide excellent jobs for others, and relieve billions of people from the soaring cost of low-efficiency energy. Enjoy the journey and always follow the procedures which will result in “safe” operations.

- ◆ What does it mean for a system or component to be “SAFE?” A system is “SAFE” when it meets the specified constraints for Hazards, Risks, and Exposure to those hazards and risks. The design process used by engineers and scientist begins with a concept and development of design specifications, including Safety Analysis. Safety is not a one-time element of engineering. Safety and Safety Analysis are continuous work elements of design, development, test, and evaluation.
- ◆ The Department of Energy has published data that a Gasoline fire is more hazardous than a hydrogen fire. The hydrogen fire burns clean whereas the gasoline fire is heavy with hydrocarbons.
- ◆ Hydrogen is non-toxic, dissipates quickly in open spaces (14.4 times lighter than air), burns rapidly, emits 1/10th the radiant heat of a hydrocarbon fire, produces no smoke or emissions
- ◆ It is difficult to cause a mixture of air and hydrogen to explode because it requires a constrained volume. Hydrogen must be twice as rich as natural gas/air mixture, and four times as rich as gasoline/air mixture for combustion.
- ◆ The explosive power of hydrogen is 22 times weaker than the explosive power of gasoline vapor.
- ◆ In 1958, the Arthur D. Little company conducted detonation tests of 121 liters each of liquid hydrogen, propane, gasoline (petrol), and Jet Fuel JP-4). The combustion times for these fuels are as follows:
 - Liquid hydrogen – 27 seconds
 - Propane – 4 minutes
 - Petrol (gasoline) – 5 minutes
 - Jet Fuel (JP-4) – 7 minutes
- ◆ Hydrogen poses little if any threat to damage of the Earth’s environment.



BUILDING AND TESTING A FUEL CELL/SYSTEM

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HYDROGEN SAFETY

- ◆ The Bellona Foundation (www.bellona.org) based in Oslo, Norway, stated in 2002, “Hydrogen is no more or less dangerous than any other energy carrier and has properties that in certain areas make it safer than other energy carriers.” In 2005, Bellona stated, “Hydrogen and fuel cells satisfy all requirements for an environmentally friendly vehicle with respect to emissions.”
- ◆ “Hydrogen can be produced, stored, and dispensed safely.” (U.S. Department of Energy)
- ◆ Like with any combustible fuel, following proven operations and safety methods are expected in order to BE safe. Failing to follow proven safety procedures introduces new Hazards and Risks to the SAFETY EQUATION of specified constraints for Hazards, Risks, and Exposure.
- ◆ Defective fuels (particularly gasoline, kerosene, natural gas, and propane) are usually caused by contamination which lowers the flashpoint of the fuel and the Hazard increases as the contaminated fuel deviates from the regulatory standard for production of the fuel. Hydrogen is no different; therefore storage system components are required to meet industry standards for storage of hydrogen.
- ◆ It is recommended practice to use hydrogen detectors to warn of any leakage of hydrogen from the storage system or in a vehicle.
- ◆ Negligence of safety rules and procedures is the cause of dangerous activity with any fuel, including hydrogen.
- ◆ Training from a qualified person or company is mandatory to know the facts about storing, handling, or using any fuel, hydrogen as well.
- ◆ Safety with hydrogen is a function of the technology, regulatory codes and standards dealing with the use of the fuel (hydrogen).
- ◆ Training information and programs are available with various corporations such as *Air Products*, headquartered in Allentown, Pennsylvania, USA. Such corporations typically include a safety services department for training classes, DVDs, PDF documents, etc. for learning how to use their gas and liquid products safely. Consult your local fire departments, colleges, and the Internet for a wide chose of safety training products and programs.
- ◆ The National Fire Protection Association (NFPA), www.nfpa.org, is loaded with excellent information for now, and for vision into the future, about working with hydrogen in all aspects. In January 2005, the NFPA gathered experts from industry and government to “define a research agenda and roadmap for hydrogen safety.” The group identified six priority areas: Hydrogen Code, Stationary Fuel Cell Siting, Vehicle Refueling Stations, Metal Hydride Storage Safety, Safety on Enclosed Parking Structures, Fire Service and AHJ Education. It is highly recommended to read the information titled, Stationary Fuel Cell Siting, found on the NFPA web site, NFPA Journal, Research, (www.nfpa.org/publicColumn.asp?categoryID=&itemID=29128&src=NFPAJournal.)
- ◆ The NFPA has published a catalog titled, NFPA 55: Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks, 2005 Edition. It is available for \$35 in book or PDF format, Item Number 5505.
- ◆ Consider *Hydrogen Safety, LLC*, for hydrogen safety training. The hydrogen safety Principle Instructor is Mr. Stephen Woods, a lead developer of the NASA Hydrogen Standard (NSS 1740.16) and author of the new International Standards Organization (ISO) report, ISO/PDTR 15916.
- ◆ The National Aeronautics and Space Administration (NASA) has decades of experience with gaseous and liquid hydrogen use. NASA Standard for Hydrogen and Hydrogen Systems (NSS 1740.16), 389 pages, is available in downloadable PDF format at www.hq.nasa.gov/office/codeq/doctree/canceled/871916.pdf. Although the document was cancelled for contract purposes in July 2005, the information remains useful. Be aware that any document on the topic of hydrogen safety may be revised on technical and legal purposes.



BUILDING AND TESTING A FUEL CELL/SYSTEM

SAFETY: B, INCLUDED IN YOUR FUEL CELL “GREEN MACHINE” KITS,

1. FUEL CELL “Green Machine” Safety Guidelines
2. Instructional CD (Putting together the Fuel Cell and Testing it
3. Fuel Cell Instructional Manual & Reference Information Booklet

SAFETY: C, OUTSIDE RESEARCH

1. Compress Gas Association: www.cga.org
2. National Teacher and Student Energy Training Programs: www.need.org
3. Coming soon check: FirstFuelCells.com web sight for BOOK LISTINGS
4. AIRPRODUCTS: www.airproducts.com
5. PRAXAIR: WWW.PRAXAIR.COM

KIT COMPONENT LIST

Description Qty.

10 Cell TekStak Kit, Air Breathing w/ cooling fins and high performance MEAs - 2
Extra graphite bipolar plate (air breathing w/ cooling fins, packed in one of kit boxes) - 1
#10-32 x 5.25" Socket Head Cap Screws for 20 cell stack - 8
1/8" diam x 6"L assembly dowels - 4
75 sL hydride canister, charged with H2 - 1
0-5 psig 2 stage regulator, brass - 1
10-32M x 10-32F check valve, brass - 1
10-32M x 10-32F inline 5 micron filter, brass - 1
M3 Male x 10-32F adapter fitting, SS - 2
10-32M x 1/4" OD tube adapter fitting, brass - 4
Nylon compression fitting, 1/4" OD tube x 1/8 MNPT - 2
1/4" OD high pressure tube, nylon 6 ft.
Blocking diode, 3 A, 100 V max. VRRM - 2
0-15 psig pressure gauge - 1
Tee fitting, 1/4" OD Tube x 1/4" OD Tube x 1/8 FNPT - 2
12 VDC Fan, 80 mm - 2
6 oz. bottle of Leak Detect Fluid - 1
Instruction/Safety Manual - 1

BOM for the 10 cell kits:

Description Qty.

Plastic Endplate - 2
Current Collector Plates - 2
Anode Endplate, graphite - 1
Cathode Endplate, graphite - 1
Finned bipolar plate, air breathing configuration, graphite - 9
MEA Bag Kit (includes 5 High Performanc MEAs inside of barrier bag) - 2
#6-32 x 1/4" Slotted Head Screw, Brass - 2
#6-32 Hex Nut, Brass - 2
#10-32 x 3.25" Socket Head Cap Screw, SS 18-8 - 8
#10 Flat Washer - 8
Tube fitting - 1/4" OD tube x 1/8" MNPT - 2
Plug for 1/4" OD tube fitting - 2
PTFE Gasket - 22
2-010 O-rings, Nitrile - 10
Assembly Dowels, 1/8" diam. x 4"- 4
Instruction Manual - 1
Instructional DVD - 1
Nitrile Glove - 2
5/32" L-shaped hex wrench (Allen Style) - 1
Vacuum formed tray, upper - 1
Vacuum formed tray, lower - 1



BUILDING AND TESTING A FUEL CELL/SYSTEM

ASSIGNMENT:

1. SET UP A SAFE PLACE TO WORK (Follow Lab Safety Rules)
2. Read all Safety Information
2. Build the FUEL CELL
3. Test the FUEL CELL
3. Build the FUEL CELL SYSTEM
4. Test the FUEL CELL SYSTEM
5. Calculate Energy Output
6. Add one battery
7. Calculate Output
8. Add two batteries
9. Calculate Output
10. Combine your findings to make a FUEL CELL Hybrid System
11. A FUEL CELL Hybrid System can also include:
 - ♦ Another innovative green solution that eliminates the use of the battery to reach your energy goal (ex. solar, wind, additional fuel cells)
 - ♦ You may add additional components, fuel cells, parts to make your design work.
12. Find a place to refill your hydrogen canister and document its location.
13. Test your invention in last years robot or a lab robot and power up, journal results and compare it to a total battery charged robot.
14. Calculate and document how much hydrogen you would need to run a FIRST Robot for a 2 min. 10 sec. match - using all hydrogen for its energy source.
16. Challenge: could you use your FUEL CELL SYSTEM as a recharging unit in your robot's cart? Show me how you would do that, in your journal report.

DEADLINE: Record your results and hand in, January 15, 2007

1. Photos and/or Video on Building the Fuel Cell
2. Photos and/or Video on Testing the Fuel Cell
3. Photos and/or Video Team Developments
(lab testing, recharging canisters, working with mentors etc)
3. Journal (findings, calculations, conclusions)
4. Signed Media Release & Team Photograph

Hand in Photos, Video and Journal: they may be done in "Power Point", "Quicktime", "Word" or "PDF" formats. (Mail in CD, DVD, MiniDV Tape SP Format on Sony tape Stock recommended by video director). **Deliver to us** by registered mail to: FirstFuelCells.com, 11163 Blossom Ave., Parma Hts., Oh 44130, postmarked by midnight deadline of **January 15, 2007**. We have 20 states in this competition, please label your work by state, high school, team name & number. With permission, include a **photograph(s) of your team** with small sign showing your school name, team name and number, and date. (team photo can consist of mentors, teachers, sponsors, students and all those who are helping out - **have fun!**)

THE FOLLOWING ARE CURRENT FUEL CELL "GREEN MACHINE" SPONSORS:
(Please present them proudly on promotional materials (robot, shirts, buttons, hats, newspaper releases, advertisements, banners, signs and/or other creative ways to say - Thank You)

FirstFuelCells.com
DLS Design Studio
TDM Fuel Cell Technology
Parker Hannifin
GrafTech

TheEliteTutor.com
Randolph Publishing
PGM Diversified
Kettering University
Ohio Fuel Cell Coalition

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NEWS SHEET:

SHIPPING UPDATE,

Boxes are shipped out of Parker Hannifin Corporation (Mass.), Parker Hannifin apologies for the shipping delays, they are tracking all packages, very strict guidelines through FedX regular ground delivery, hazard paperwork done, which has slowed up the process, please let me know if you have not received KIT by Friday. All shipping is paid for, if anyone is charged by the carrier please e-mail us for reimbursement. I also included a picture of the boxes so you know what to look for,
My best Diane



Answers to Frequently Asked Questions:

You will **not** be competing on the floor this year with the “green machine”, authorization for use of hydrogen on game floor has to be developed. We will be showing results from 20 states in Atlanta. Your fuel cell challenge ends Feb 1.

We are compiling a video presentation of the results. If time allows each state will get a copy of the video to show in their regional and/or their school.

I will be asking some teams to model their robot in Atlanta, either physically or photo or video. Some teams are very advanced.

Designing a fuel cell game, yes this is a pencil and paper challenge.

Installing and testing the fuel cell hybrid system - you can test in last years robot or this years - your chose

If your team builds a separate robot to play the game you designed we would be highly impressed, and would consider using the ideas for next years competition. (of course this is optional). This part of the challenge is pencil and paper. Please be creative. Instructions will follow for stage 3.

Your competition ends Feb. 1, judged starts and video assembly

Current in Developments:

Planning and logistics for a “**Hydrogen Fuel Cell “Green Machine” Game Floor**, looking for 6 model state sights in the USA, Ohio and South Carolina are stepping up to the plate.

Approaching **Hydrogen companies** for recharging student canisters, training classes and becoming sponsors

Just in time, automatic electronic application, order processing, product delivery, game release, customer service system currently being developed for next year

We are getting more sponsors, vendors and opportunities on a daily basis, locally and state wide

FirstFuelCells.com has submitted for the **Ohio Third Frontier Grant** for 2007 for further business development

The media has been contacting us: please let us know if your team is interested in being on TV, Feature Magazine, Newspaper, or interviewed for radio. Send in snapshot of team so we can show the media who you are.

Thank you, Diane Sadowski
FirstFuelCells.com

