



**As Fast As Lightning Strikes...
Automotive Technology Changes.**

**LBT-100
HYBRID SYSTEMS
UPDATE**



WE ENCOURAGE
PROFESSIONALISM



THROUGH TECHNICIAN
CERTIFICATION

"Before everything else, getting ready is the secret of success."

- Henry Ford

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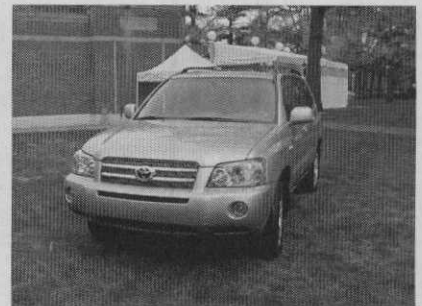
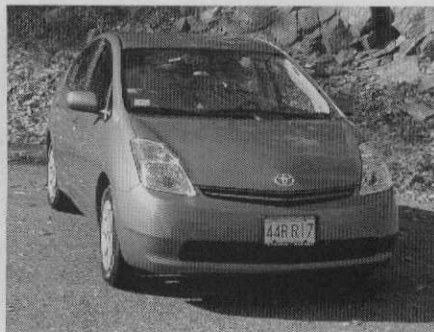


Understanding Hybrid Vehicle Service and Technology

Toyota Prius 2001-2006
Toyota Highlander 2006
Lexus RX400h 2006
Honda Insight 2000-2006
Honda Civic Hybrid 2003-2006
Honda Accord Hybrid 2005 -2006
Ford Escape Hybrid 2005 -2006
Mercury Mariner Hybrid 2006
Chevy Silverado 2004 -2006
GMC Sierra 2004 -2006



Written by Craig Van Batenburg



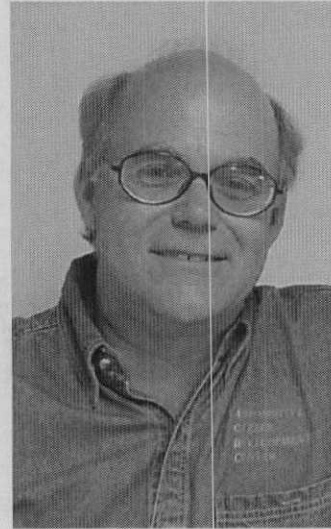
Last Update January 3, 2006

Dear Reader,

This manual was written for technicians, service writers and those interested in hybrid technology. Various technical classes are also available from the author. You will gain many insights (no pun intended) on how to service these vehicles, what to stay away from, safety issues, general maintenance, and much more.

ICE means internal combustion engine. EM means electric motor. NiMH is code for Nickel Metal Hydride, High Voltage = HV. New Technology, new lingo.

This is an easy read and the only manuscript like this anywhere. This does not take the place of in depth training. Please note: using this information without further training may result in injury or death due to the high voltage systems on these vehicles.



A handwritten signature in cursive script that reads "Craig Van Batenburg".

Craig Van Batenburg, AAM, CMAT, L1

Craig Van Batenburg was the owner of Van Batenburg's Garage Inc. for over 26 years and lead technician. Prior to that it was dealerships, both automotive and motorcycles, where he practiced his trade. His specialty is Honda and Acura, with a deep background in Asian technology.

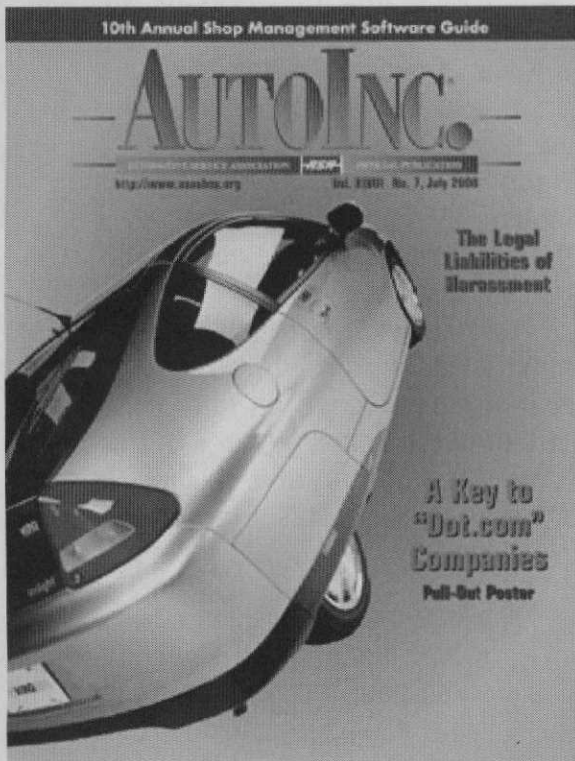
Today Craig delivers management and technical seminars nationwide. He is owner of the Automotive Career Development Center www.auto-careers.org. Craig delivers training nationally and develops new classes yearly. ACDC is certified with Massachusetts, Rhode Island, and New York for their I/M emission programs. He also contributes articles, both technical and management related, to MotorAge, Auto Inc., Automotive Journal, and ACtion magazines.

He has received many awards, including "Import Car Magazine Top Ten Shop" of the year for 1999, receives over 150 hours of training annually to stay current with the changes in automotive technology, and is a leader in electric / hybrid technical training. Craig is also a keynote speaker and has hosted call-in automotive radio shows. He works with state government on air quality issues, is a certified AMI (Automotive Management Institute) instructor and graduate (AAM - 1996) as well as ATTS trained as a technical instructor. He is a member of CAAT, ASA, IMPA, and other trade related associations. Past President and founder of ASA Mass/R.I., is past Vice President for NESSARA (New England Service Station and Automotive Repair Association). He is an ASE Certified Master Technician with advanced level (L1) skills. He is also a darn good tech.

Recently Craig has been touring the US teaching his hybrid and management classes to packed rooms. If you would like Craig to come to your area, call him.

When not busy doing something else, he impersonates Elton John and helps foster children get a permanent home. He started a non-profit organization in 1991 called Worcester Shines that has grown to be a major player in his town helping the less fortunate. Craig enjoys playing the trombone, motorcycling and attending open wheel races. Craig is also a husband and father to two boys, Mike and Will, age 14 and 20.

One sad statistic: Over 25,000 US kids age out of foster care each year at age 18 and hit the streets without a family. They were removed from their biological families for their own safety and not one American family gave them a home. Most of these kids can make it, if they get adopted into a family that doesn't know the word quit. Mike and Will are two living and loving examples.



One way to improve your customer base is to service hybrids. Don't wait as more are being built everyday. It also shows your customers and potential customers that you are keeping up to date.

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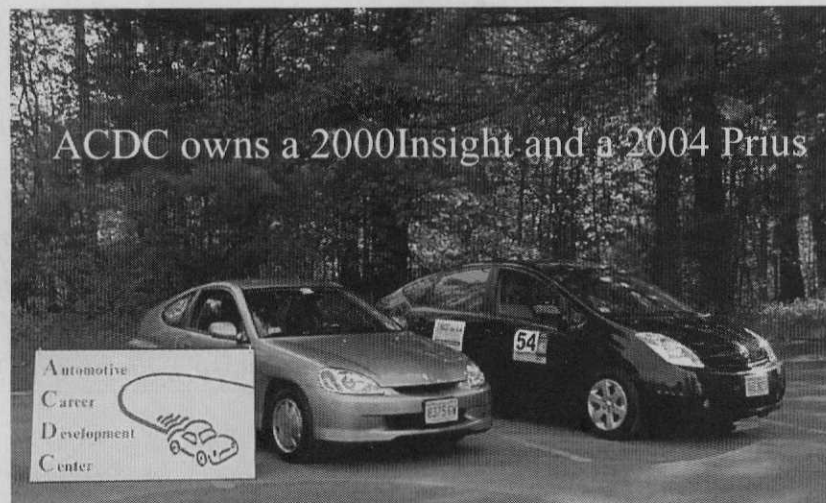
Fax 508 856-9280

Web site

www.auto-careers.org

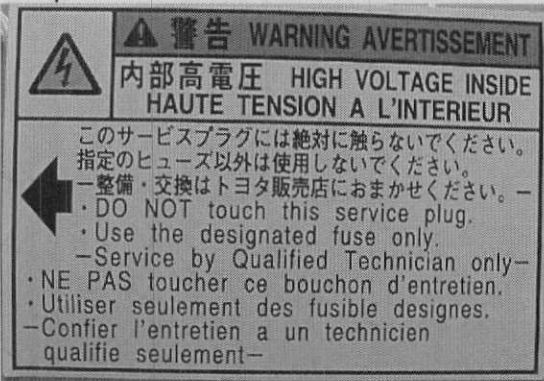
E mail at

Craig@auto-careers.org



Safety

A lot has been written and so far no one has died. How seriously should we take the warnings? When I first bought my Honda Insight I knew a little bit about the system. I ordered two Honda manuals when I bought the car in 1999. When the Insight showed up at my local dealership, they hid it out back and I found out it was in from my brother. He has a friend that empties trash and had noticed a weird car next to the dumpster. I called to



see if my car was in. It was but the dealership didn't want me to take it as it was their only one. This was January of 2000. I picked up the silver 5 speed on February 16th. Within 2 weeks it had been disassembled. Any label that said "Caution! You will die" had been ignored and this was all without any training or manuals. Was I cautious? Of course, but a lot was

going on behind the scene that keep me safe as I discovered later on. I worked without protective gloves (what did I know?). Some pictures in this manual came from that initial first step. I don't recommend that you follow my lead. It only takes minutes to be safe so why not. This manual will show you how.

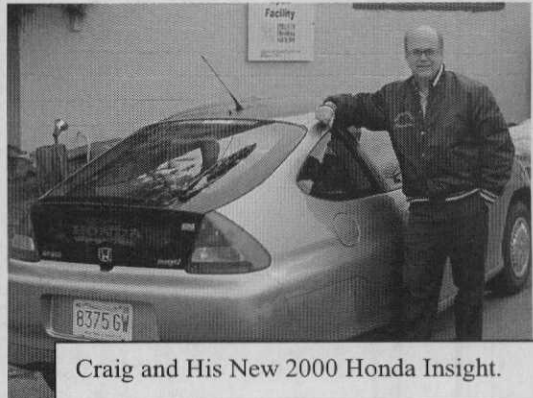


When working treat all HV parts as if they have HV until you have tested them with a CATIII rated DVOM and are sure they are at zero or close to zero volts. Use rubber gloves (1000v minimum rating) with no path through your heart (hand in pocket is a good idea when possible). Only have proven properly trained techs work on these cars.

Remember, 60v at 1 amp is lethal if it finds a path through your heart!!!

Outline

- How did hybrids come about?
- What is a hybrid Series vs. Parallel
- Advances in the technology that made this possible
- History of Hybrids, including the Insight and Prius
- What is the same and different about these cars?
- What can we service with limited tools and knowledge?
- What should we gear up for?
- Honda specific information
- Toyota / Lexus specific information, both old and new version
- Ford / Mercury specific information
- GM Specific Information
- The future of Hybrids



Craig and His New 2000 Honda Insight.

V6 IMA MID
DUALNOTE

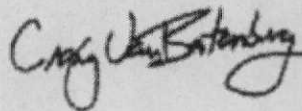


How it all started

The **first patent for a hybrid electric vehicle (HEV)** was **filed in 1905**. Some were built but cheap gasoline soon made them an oddity. The technology was looked at again in the mid 70's after our first oil embargo. All cars built during this period were experimental. Cost was a large factor because of a lack of mass production. With oil prices and environmental concerns two Japanese companies, Honda and Toyota, went head to head with their R & D programs, pride and money. The winner was the environment. For those of you that follow auto racing, CART series races have been a **Honda**, Toyota and Ford shoot-out for years, with Honda coming out on top from 1996 to 2001. Toyota won in 2002. Now Honda and Toyota are racing in the IRL series. It is interesting to note that the next manufacturer to introduce a hybrid was **Ford**. Because Honda and Toyota are extremely competitive, have deep pockets and are concerned about the environment as much as any car manufacturer could be, the Honda and Toyota Hybrids exist. It is certainly not for immediate profit as it was estimated that **Toyota** lost about \$10,000.00 per Prius and Honda over \$15,000.00 per Insight the first 2 years. The cost to build these cars was very expensive. This has gone away somewhat with volume sales. The Civic Hybrid makes Honda a small profit. The new **Ford Escape Hybrid** went on sale September 27 of 2004, and the **Nissan Altima Hybrid** (due out as a 2008 model) is a Toyota hybrid design.

This manual is a result of my research, interviews with Honda, Ford and Toyota, the internet, SAE training events, lots of reading, visiting dealership technicians, teaching many hybrid technology classes, writing numerous articles, owning an Insight since the **first hybrid came to Massachusetts** (Production date is December 1999) VIN # 0000157, taking these cars apart, driving with scan tools and scopes in my lap, visiting recycling yards (wrecked hybrids), my ministers Prius and the loan from Toyota of a Prius, IMPA test days, Reading SAE papers, attending numerous Hybrid SAE classes, buying a '04 Prius, and many other road tests and several Prius rentals. Plus having lots of questions asked of me almost daily. In fact ACDC has trained well over 4,500 techs with our first class in the spring of 2000.

Hopefully this small work will answer most (I know not all) of your questions, remove any **fears** you may have about service and repairs, and get you on your way to say YES when a customer asks "**Can you service my Hybrid?**" If you have a question I cannot answer post it on **www.IATN.net** under technical discussion. I will answer it. Send me a private E-mail so I know the post is there. My E-mail is craig@auto-careers.org



Hybrid Series and Parallel designs

Just as in your electrical class we have series and parallel circuits. A simple way of thinking about hybrids is that two power sources are sending power to the drive wheels. An internal combustion engine (ICE) is great at some jobs but fails at others. More low-end torque can be produced in an electric motor than an ICE. By supplementing the power at high load conditions with an electric motor, the ICE can be smaller and/or tuned for economy and lower emissions. If you reduce weight, add idle stop, have better aero dynamics, reduce friction, and take away some driver control, the mpgs and emissions just keep going in the right directions. We need to use less fuel to help control pollution, reduce greenhouse gasses, and our dependence on foreign oil. Hybrids are our best technological choice at this time.

A) Series hybrid

The engine drives a generator, and an electric motor uses this generated electricity to drive the wheels. This is called a series hybrid system because the power flows to the wheels in series, i.e., the engine power and the motor power are in series. A series hybrid system can run a small-output engine in the efficient operating region relatively steadily, generate and supply electricity to the electric motor and efficiently charge the battery. It has two motors—a generator (which has the same structure as an electric motor) and an electric motor. This is the system used on diesel / electric trains. It may be used in Fuel Cell Cars.

B) Parallel hybrid system

In a parallel hybrid system, both the engine and the electric motor drive the wheels, and the drive power from these two sources can be utilized according to the prevailing conditions. This is called a parallel hybrid system because the power flows to the wheels in parallel. In this system, the battery is charged by switching the electric motor to act as a generator, and the electricity from the battery is used to drive the wheels. Although it has a simple structure, the parallel hybrid system cannot drive the wheels from the electric motor while simultaneously charging the battery since the system has only one motor. The ICE is assisted by the EM. This is the system used by Honda.

C) Series/parallel hybrid system

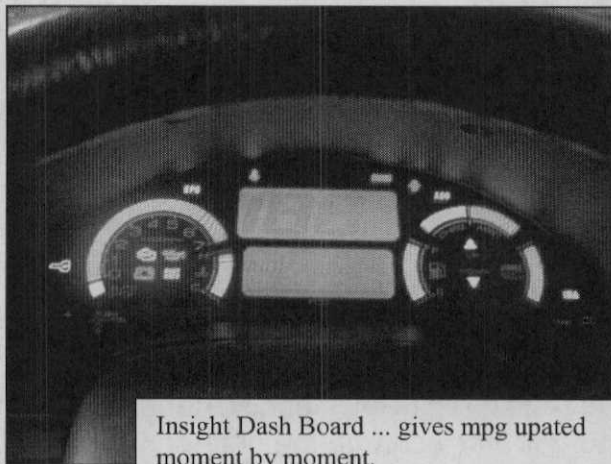
This system combines the series hybrid system with the parallel hybrid system in order to maximize the benefits of both systems. It has two motors, and depending on the driving conditions, uses only the electric motor or the driving power from both the electric motor and the engine (ICE), in order to achieve the highest efficiency level. Furthermore, when necessary, the system drives the wheels while simultaneously generating electricity using a generator. This is the system used by Toyota and Ford.

Toyota helped with this page of information.

Many more versions of hybrids are planned and some will be in production soon. This is list of commonly used types.

- Mini-hybrid or Micro-hybrid is usually a stop & start system 12 -36 volts - GM
- Mild-hybrid is what most refer to as Honda's system - IMA
- Full-hybrid (series / parallel) is the Toyota or Ford design

Note: the new 2006 Civic is considered a "Full" hybrid



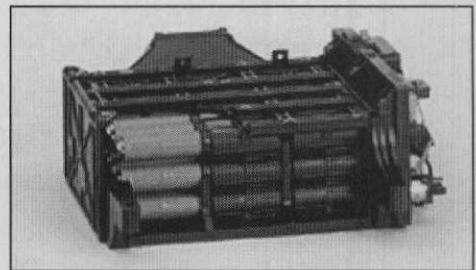
Insight Dash Board ... gives mpg updated moment by moment.



This Ford concept was shown at the NYC auto show in March of 2005. It is a diesel hybrid. Not in production.

Advances in Technology in the 90's that led to modern hybrids...without these breakthroughs, a hybrid as we know them would not have been possible

- Lean Burn / V-TEC / LAF sensor (Honda related)
- Computer speed and hybrid software
- Nickel Metal Hydride Battery
- More powerful DC and AC induction electric motors
- Stronger magnets
- NOx absorption catalytic converters
- HC traps in converters
- Rubber bladder in gas tank
- Aluminum metallurgy and production



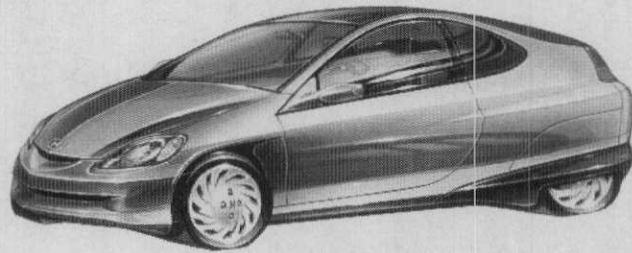
144Volt Battery Pack 2001 Insight



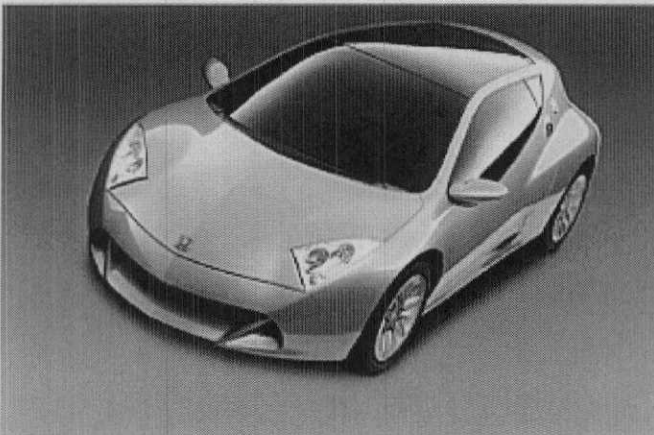
Toyota Hyjet Hybrid

Insight History

The Insight prototype, by another name, was first shown to the public at the Tokyo Auto show in 1997. It was a 2-passenger sports coupe. It had been in development for about 3 years prior to that. The Insight, code named the V V, was seen again a couple years later in the U.S., at another auto show. In the summer of 1999, it was named the Insight and Honda released the details. The first Insight was delivered in December of 1999. Prior to that a few Insights were available to reporters and politicians for road testing. As a member of IMPA I had a drive in a pre-production Insight in October of 1999.

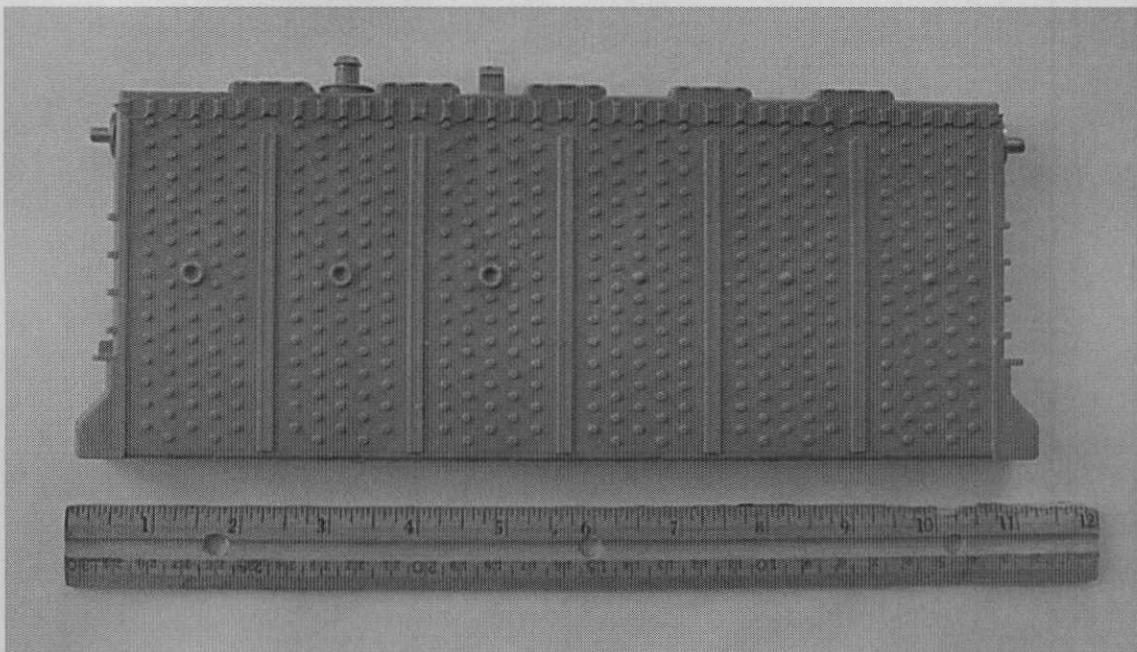


First year sales were limited to less than 6,000 due to lack of production ability. Insights are made in Japan in the same small factory that builds the NSX and the S2000. It has an all aluminum chassis and is very high tech in chassis, aerodynamics, engine, hybrid software and electronics.



Hondas first use of the Integrated Motor Assist (IMA) system was for F1 racing in the late 1980's. This was to add more torque to the ICE coming out of the corners when rpm's are low and torque is not enough to get maximum traction. It never saw a race.

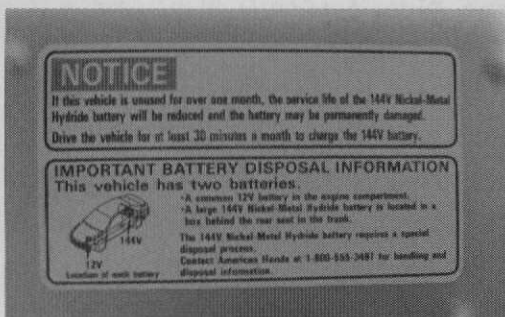
Insights sell in very small numbers, as the Civic is at the same price point. My wife, Deb, drives the ACDC Insight daily. It has been trouble free. ACDC may be the first company in the USA that bought a hybrid as their company car!



HV Battery Concerns

Above photo is a 01-03 Prius NiMH Module

The big fear is that the expensive nickel metal hydride (NiMH) battery pack will fail after the warranty is up and all the fuel saving will not be realized. It is wildly reported that that fear keeps people away. Here is what I know; the HV battery pack in my 6+ year old Insight is as good as new. Not a single NiMH cell (see above) has ever failed. Not one. Toyota has had a handful of warranty battery pack replacements that were not cell related. Honda had some Insights that sat too long and the cells degraded. They were warranted and now a warning label (see photo left) is under the hood. My scan tool tells me that the ACDC HV battery is fine.



If you are going to store a hybrid, here is what to do. Get the SOC as high as possible, then you can store the car for up to 3 months without a problem. The 12 v battery may need a battery tender on it while in storage. Over that time period the NiMH (High Voltage) battery pack could start to lose its charge. If the NiMH drops below 20% SOC (state of charge), it could cause some long term battery life issues. SOC is measured with a factory scan tool. There lies the dilemma.

Honda hybrid cars will need to be started and run for 30 minutes every 3 months.

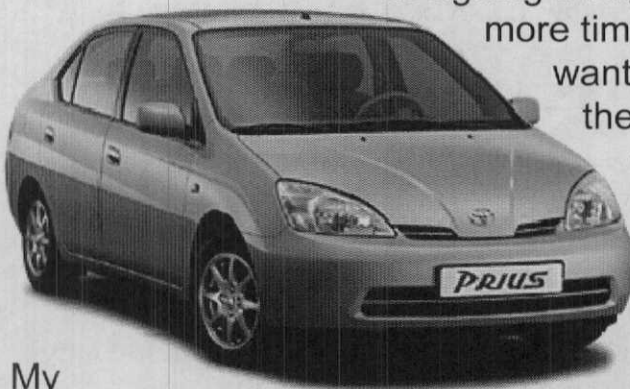
Toyota / Lexus have a HV charger but not available yet and pricy. So follow the Honda suggestion. ACDC is getting one ready for market.

Fords HV battery can be charged in this way. Hook a trickle charger to the 12 volt Lead Acid under the hood. Every month, switch the onboard HV charger switch on 2X. It is located on the left kick panel. Owners manual will point it out.

Prius History

The Toyota Prius was developed about the same time as the Insight, but was put on a fast track to go to market in Japan. The first Prius was sold in Japan in December, 1997. It was a hit, but Toyota never took Honda seriously with their small two-passenger hybrid. When it was announced that Honda had their Insight ready to go in mid 1999, Toyota management asked the R & D team to convert the Prius to left drive and beat Honda to the punch. Toyota had already sold over 35,000 Priuses in Japan and the technology was working fine. Soon a problem was sent back to Toyota management from R & D. They couldn't just move the steering wheel from right to left without re-

designing a large part of the car. It would take more time than Toyota had if they wanted to be the first hybrid sold in the USA. After a few pink slips went out (my assumption) the car was redesigned for the U.S. It was much quieter, faster, better appointed but the Prius had lost some mpgs.



thanks to Stan Stephenson

My from ARI, as he was able to get me a test drive a Japanese version, right-hand drive Prius, in the fall of 1999. The U.S. Prius was made available to the public, only through the Internet, in the summer of 2000, with a very limited supply. They sold as fast as a dealership could get them and still do.

The new Prius for 2004 has made the Hybrid more mainstream. It has many levels of trim. It is faster, bigger, carries more cargo, has a flip down rear seat, and is a 4-door hatchback. More on this car later on in this manual. To distinguish between the 01-03 Prius and the 04-05 we will call the 01-03 the Classic Prius.



Ever heard the sound a stoplight makes?

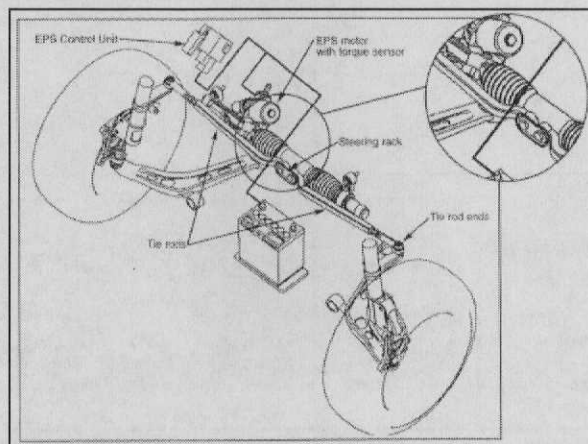
Producing a breakthrough in automotive technology from Toyota, Prius, the world's first production car to combine a fuel-efficient gas engine with an electric motor that never needs to be recharged, is a powerful solution between gas, electric or a combination of both. In addition to being the most efficient car to drive the streets, Prius is also one of the quietest cars on the road. The result is a car that's quiet, smooth and easy to drive.

Starting at \$19,999. Delivery, processing and handling fee apply. Taxes, license and other fees extra. Visit the new Prius at www.toyota.com/prius or call 800-90-TOYOTA.

TOYOTA PRIUS | gash

What is the same about the Honda, Ford, and Toyota (Lexus) systems?

- All use a gas engine with an electric motor(s) to provide power
- All use nickel-metal hydride batteries Ni-MH
- All use an idle stop feature that shuts off the ICE at idle under most conditions
- All are ULEV, SULEV or AT-PZEV vehicles
- All use kinetic energy (forward momentum), braking, and the ICE to charge the HV batteries while you drive
- None of these cars can be plugged into an 110v outlet to recharge, nor do they need to.
- All of these cars use a powerful electric motor as starters. They spin at about 1,000 rpm at start-up silently.
- All have electric power steering (EPS)



What are the major differences?

- **Insight has an all aluminum body, all other hybrids are conventional steel**
- **Honda uses one Electric Motor – Toyota and Ford have two EM's.**
- **Insight uses low weight and aero-dynamics to their fullest**
- **Insight is a two seater, all others are 4 doors.**
- **Prius and Civic are more conventional and more popular**
- **Honda is a simple design – Ford / Toyota is more complicated**
- **Ford / Toyota can be driven slowly with electric only**
- **Lexus and Accord are more about performance than fuel economy**
- **Insight can be dyno tested (no traction control)**
- **Prius can be dyno tested using a special procedure – no special tool required, but not recommended**

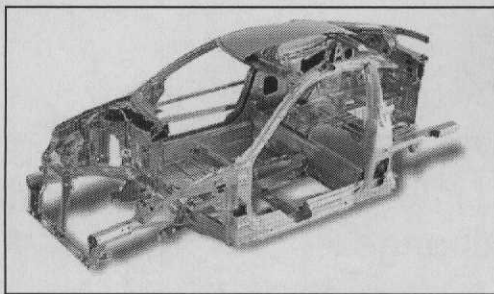
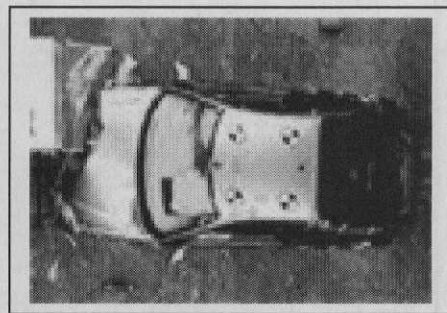
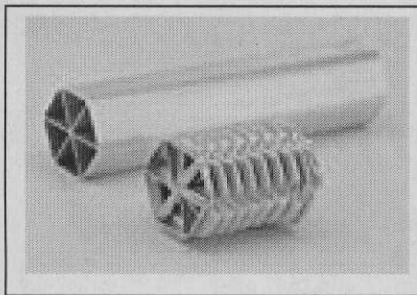
HYBRID
GASOLINE-ELECTRIC

What can we service with limited tools and knowledge?

- All ICE (internal combustion engine) repairs and servicing
- All brake work (except electronic parts on Prius/Escape as it is very high tech). This can be done with OEM scan tools. See caution on Ford brakes in Ford section.
- Normal tires, exhaust, bulbs, shocks, struts, tires, suspension


What is best to stay away from?

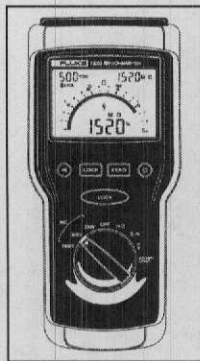
- Major Hybrid service work (but you can do it)
- Bodywork on Insight (aluminum, unless properly equipped)



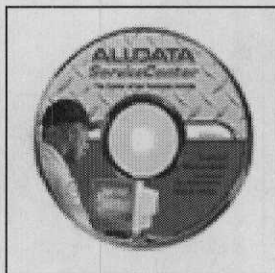
These pictures are from Honda. Insight crash protection.

Tools required

- Vetronix scan tool, Mastertech, is OEM for both Honda and Toyota. Cartridges are available. Separate for Honda and Toyota. About 900.00 each. 
- Ford requires both NGS and WDS scanners
- Teradyne Corporation supplies the 04' and up scan tool to Honda. This scan tool goes back to earlier years.
- Fluke 1520 MegOhm meter - testing H V insulation



- Good information available on All Data and Mitchell.



- The OEM's also have their own web sites. Go to www.nastf.org to check pricing and web address. Honda and Toyota has good info. Ford info is Motorcraft and poor at best. That may change.

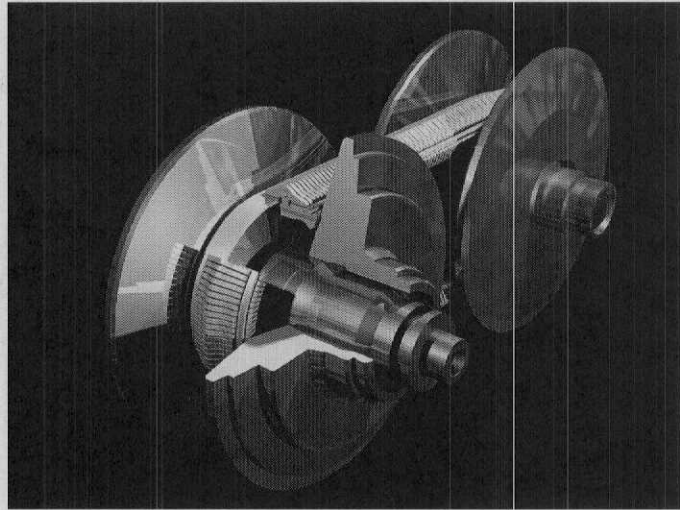
Safety concerns

- Avoid orange colored cables, wires, and connectors. Any orange cable can have a lethal amount of voltage.
- Do not exceed a set temperature, 140 degrees F. maximum, if baking paint in an oven. Check the manual. H.V. NiMH batteries can be damaged from too much heat.
- Learn how to de-power hybrid battery and capacitors and test for low voltage before getting near the high voltage system
- Engine will start and stop on its own while servicing car. This can mess up an oil change, so know what you are doing!
- If you have a pacemaker or metal in your body that is magnetic, stay away from the drive motor magnets
- Do not wear watches, jewelry or any metal near drive motor magnets



What should you gear up for?

- Learn as much as you can about today's computer systems, lean-burn technology, ac voltage systems, induction motors, CVT technology, Honda V-TEC design, and more.



- If you want to work on Toyota and Honda hybrids consider a Vetronix Mastertech scan tool.

- Special tools required to remove Honda HV Battery, Rotor on Electric Motor.



- OEM shop manuals are expensive

- Use the OEM websites



Teradyne Pocket Tester has been discontinued.

TIME'S UP

With hybrids moving to out-of-warranty service, the moment is right for independents to gain some market share.

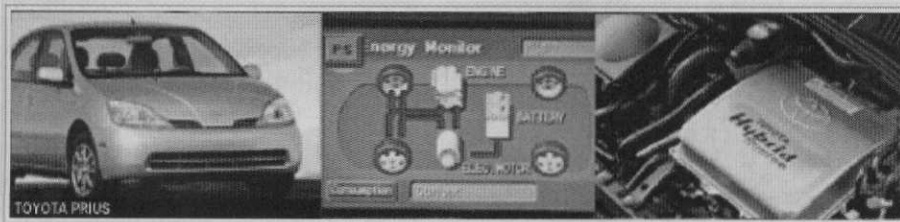
Most of you haven't worked on a hybrid yet, but more than 150,000 have been sold worldwide. Many thousands more are in the pipeline for next year: Automakers Ford and Nissan have even made arrangements with Toyota to use the Prius' design next year.

You will need to get ready for the inevitable service these half-electric/half-gasoline autos will require. Maybe you have taken a hybrid class, maybe not. But one thing is for sure: Hybrids are here to stay. These weird-operating gas/electric cars are advancing automotive technology, but which design will win the hybrid war? Will it be Honda's Integrated Motor Assist (IMA) or the Toyota Hybrid System (THS)? The battle is already waging. Remember VHS vs. BETA? The battle for home-entertainment supremacy was a shoot-out back then, and people were betting on both sides. This contest looks as if it's even closer. Let's see how it is going in "Hybrid Land."



A quick history

The Honda Insight arrived in December 1999, which makes this car almost four-years-old and already out of warranty. Some people really do drive 60,000 miles per year, so high-mileage Insights are common.



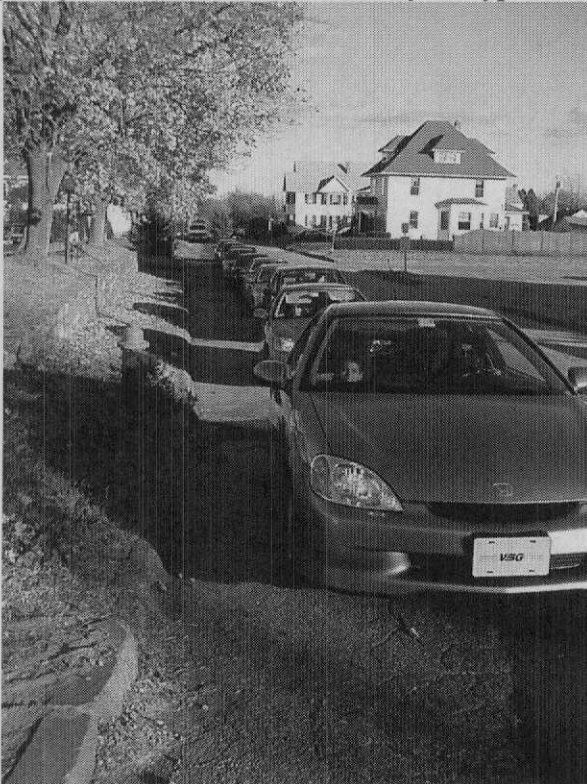
The Prius was the world's first mass-produced hybrid, sold in Japan in 1997. Here in the United States, the Prius was sold in small numbers during 2000 as a 2001 model car, but now dealers sell all they can get. In 2002, Honda introduced their Civic version of the hybrid, but it hurt the Insight sales. As production capabilities are increased, both Toyota

and Honda will be ready for hundreds of thousands of worldwide sales by the end of 2004, if the demand is there. Currently, these hybrids sell for around \$21,000 and average 50 mpg (with the Insight much higher), but they are still largely unknown to many consumers and techs. As long as gasoline is relatively cheap, hybrids may stay anonymous, but we all know too well that gas prices skyrocketed this past summer and can go up again at anytime.

Much has been written about gas/electric hybrid cars, but there's not been much information that will help you with the practical side of real problems in real bays. Here is your first installment. Let's take a close look at the Prius. Will this be the hybrid technology of the future? Is THS synonymous with VHS? It's a good possibility.

In this corner ...

Introducing the Toyota Prius: Weighing in at 2,765 pounds and using a conventional steel body, this smallish sedan has room for four adults (Toyota says five) and their stuff. Behind the wheel, you'll find the Prius' power is good. It handles fine, has a nice ride and gets great gas mileage. It is the size of a Corolla, has the feel of a Camry and has plenty of creature comforts and your typical Toyota construction.



Your average customer might buy one, as these cars perform like normal internal combustion (IC) engine cars. If you are afraid to service these new hybrids, don't be. It is only the high voltage that you need to have a lot of respect for. Anyone who has worked on 110-volt (V) or 220V systems knows to be careful and to de-power the system before you take any wires off.

The Prius has 274 volts, which is a lethal amount; but we'll address how to stay out of trouble later in this article. This Toyota comes with a 100,000-mile/eight-year hybrid component warranty and three-year/36,000-mile warranty for the rest of the car. Toyota also offers a

complimentary first five scheduled maintenances up to 37,500 miles of ownership, and many of these vehicles are just at that point. So, don't be surprised if a hybrid finds its way to your shop this year.

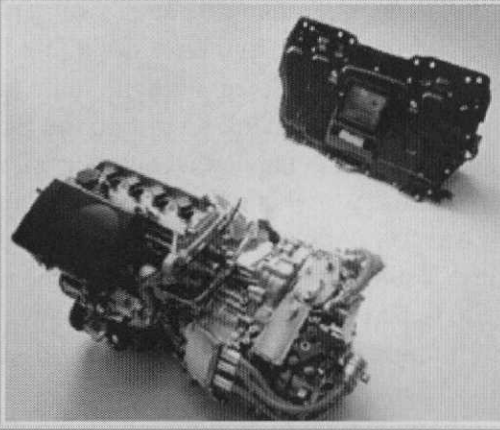
So what do you need to know about servicing the Toyota Prius? First you need to know that orange cables mean high voltage (HV), and you need to know how to de-power the HV system. If you are not near the orange cables, then you are fine, unless of course the car has been in an accident. Fluke makes a HV tester, known as a meg-ohm meter, P/N1520. A HV test tool is required to make sure an accident job is repaired properly and none of the insulating properties of the HV cables have deteriorated.

You will need proper training to safely handle the 274 volts that a Prius stores in its battery pack. To keep from getting a potentially lethal shock, you first need to open the trunk and remove the liner at the left front corner and find the service plug. It is a small handle that you raise and remove. Toyota says to use a rubber glove when removing the



Plugging along: With a potentially lethal 274 volts in its battery pack (above), you must first drain down the capacitors before attempting any service. Raise and remove the battery pack's service plug (below) and wait at least five minutes before checking voltage.

(Photos: C. Van Batenburg; Toyota)



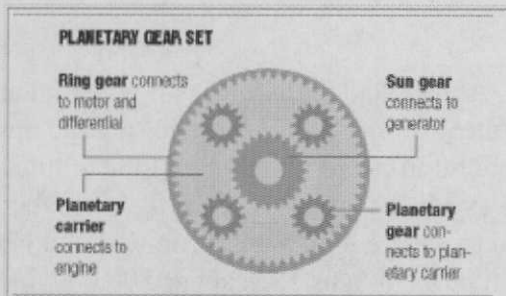
plug. The Toyota manual also tells you to keep the plug with you; I imagine they know about the pranks that some techs will play on one another. This high voltage is no kid's stuff, so pay attention and be extremely careful. Any voltage over 60 volts can be lethal.

After you have removed this plug, wait five minutes and test for low voltage – close to zero – at the orange cables. It is the three large capacitors that can hurt you, and this process drains down the capacitors so they are safe. If they are under 12 volts, all is clear. Don't forget that the 274-volt battery pack always has the potential for supplying you with a lethal charge, so handle this battery pack with care.

Until you are thoroughly trained to work on these types of vehicles, just be careful and do only work that you are qualified to do. All the body electrics are 12-volt, and Vetronix makes the scan tool software. The Vetronix scan tool is OEM for Toyota and provides a fair amount of information. Most of the service and repairs are the same as any other car. The IC engine is a 1.5L four-cylinder, similar to the Echo, and requires the same preventive maintenance that any normal Toyota does. Brakes are conventional at the wheel end, but power boosters are history. The Prius has a marvel of electronics that takes over all the braking. The brakes are designed to take advantage of the regenerative braking that hybrids use to recharge the main battery pack. It incorporates ABS and traction control, which are tied into the hybrid control system.



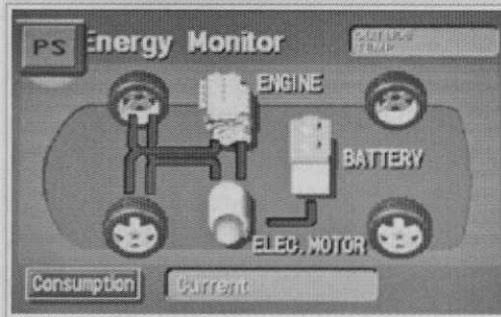
Understand that regenerative brakes do not mean electric brakes. Decelerating, braking or descending hills supplies alternating current (AC) energy that is converted into direct current (DC) and stored in the nickel metal hydride (NiMH) batteries instead of being wasted heat (friction). When descending a hill in "D," or low gear "B" if you want more engine braking, the electric motor is computer-controlled to offer resistance, much like a dyno does on the drive wheels. It uses that energy to produce AC energy. A digital processor then converts the AC to DC so it can be saved in the battery pack. The amount of electricity needed, along with the Vehicle Speed Sensor (VSS) and other inputs will determine how fast the car will slow down and how much force will be applied to the drive wheels.



Gearing Up: The Prius CVT's planetary gear (above) set uses one electric motor connected to the sun gear.

The dash readout display (right) includes driver-friendly information about what's happening under the hood and in the battery pack.

(Graphic source: HowStuffWorks.com; Photo: Toyota)



If the regenerative brakes aren't slowing the car down fast enough, it is human nature to press down further and harder on the brake pedal. As you do, the on-board computer will apply the conventional brakes that then come in contact with the rotors and drums and the car now has both systems operating. There are times when the regenerative brakes will not turn on, such as instances when you are almost stopped or ABS is being used. The PCM and other computers are very busy keeping an eye on lots of inputs. The system works so well you hardly know it is operating.

The NiMH battery pack, manufactured by Panasonic, consists of 234 batteries arranged in cells. At 1.2 volts per battery, the pack has 274 volts ready for electric-assist and stealth mode. Also onboard is a DC-to-DC converter that is used to supply the 12-volt system with a constant 14-volts. An AC-to-DC and DC-to-AC processor is used to allow an AC motor to work off of the DC system. Seven years ago, this car would not have been possible because computers were too slow. The amount of memory and speed required for a hybrid to work is mind-boggling.

One interesting note: A lead-acid battery loses its potential as the temperature of the battery drops. NiMH batteries are the opposite: As they get colder, they build in power. If they get too hot, they lose their strength. Air-cooling systems are used to keep the main battery pack from overheating and to ensure long battery life. One study shows the NiMH battery life can be as long as 15 years or 200,000 miles.

The Prius is a series/parallel design. This means that the IC engine can power the car independent of the electric motor and vice-versa. Both power sources also can work together. The trick here is a cleverly designed CVT transmission.

This CVT automatic transmission is like no other. It is simple in design, brilliant in use and suited perfect for a hybrid car. The planetary gear set uses one electric motor connected to the sun gear. This motor starts and shuts down the IC engine; it also can generate power to recharge the main batteries. In addition, it has a very important second function: It keeps the IC engine speed low. The sun gear (starter motor/generator) is used to control the speed of the planetary carrier (IC engine) by raising the speed, stopping completely or reversing direction. It is simple but amazing. By using this CVT transmission, the driver has little effect on rpm because he or she can't shift it. This allows the computer to do what they do better than humans, make decisions quickly to provide power, lower emissions and have the feel of a "normal" car.

The second electric motor is used for power to the wheels and for reverse. It is connected to the ring gear. The IC engine is connected to the planetary carrier, and the IC engine can be off while the car moves forward with the drive motor only. Reverse gear is the main electric motor running backwards; the IC engine does not play into the reverse function.

The transmission of power to the front wheels is what allows a lot of other things to happen. A standard shift is not available, nor would it work. By keeping the engine speed fairly constant, Toyota can control tailpipe emissions. Ignition timing stays within a 5-degree window most of the time.

While watching the dash readout, the driving experience can easily mislead you. See Figure 4. Toyota has put together a customer-friendly information center, with an optional GPS navigation, sound system controls, and a couple of displays that tell the driver what is going on under the hood and the back seat. The "energy monitor" display shows

a picture of the engine, NiMH battery, front wheels and the electric drive motor. For your own knowledge, the owner's manual will help you understand the dash readouts more than the shop manual.

If you follow the arrows and color changes of each component, you are led to believe the engine is off when indeed it is still on. Some magazines have reported that the car uses its electric motor as its main power source and the gas engine is a backup; however, it isn't so. The design gets you going on electric only, but unless you keep your foot at 25 degrees or less of TPS (my estimate), the gas engine is right there with you. Under normal driving the IC engine starts and runs at about 7 mph. It is possible to keep it in stealth mode (electric only), but you must work at it by creeping along or going downhill.

There is another myth circulating that you can use an outside source to charge the batteries – not so. There is a normal-sized 12-volt battery in the left corner of the trunk, but it is far from “normal.” Study glass matte batteries before you even try to charge this one up. Toyota is having more than their share of trouble with this 12-volt battery. Watch for TSBs about this in the near future. A pulse charger is used, but my studies show the car itself is the best charger to use. That is true for the main battery pack as well.

The 2004 Prius was shown at the New York Auto Show last spring, and I was allowed access under the hood and around the car. Stay tuned to Motor Age for an update on what looks like a huge leap forward in hybrid design for the 2004 model. By comparison, the 2001 to 2003 Prius is in some ways old technology.

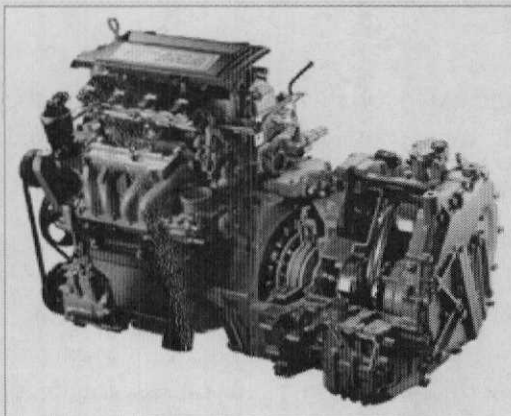
And in this corner ...

Enter the 2003 Honda Civic Hybrid. The IMA technology is now proven, and the second-generation IMA is more powerful, less complicated, more compact, lighter weight and integrated more compactly into the Civic Hybrid. What is revolutionary about the Civic Hybrid is that the same Civic body you can buy in a gasoline version is used for the hybrid model.

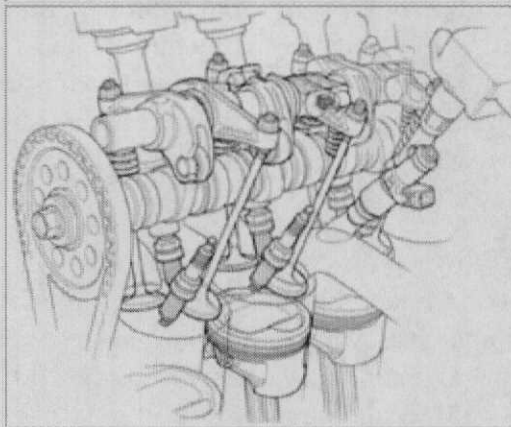
Honda is using the same unibody with some small changes up front in motor mount locations. If the IMA system can be used this way in the Civic, then Honda could offer an IMA system with your choice of a CVT, regular automatic transmission or a standard transmission in every car and truck within two years. That is, every car, truck, van, sports car, you name it, in a hybrid version. Officially, Honda says they have no plans to do so, but think about the implications if the Middle East has more problems in the future. Is Honda, once again, ready to lead the pack like they did in 1973 with the Civic 1200 and in 1975 with the CVCC engine? Don't count them out.

Let's take a close look at the Civic and Honda's IMA approach to hybrids.

Automotive engineers know that if you want good fuel economy and low emissions, there are only a few places to look for a solution. Start with the combustion chamber. Isn't that where most of the emission problems come from? If we can combine all the hydrocarbons and oxygen and leave the nitrogen alone, we are left with carbon dioxide (CO₂) and water. Water is good for the environment, but CO₂ is not. If you burn less fuel, you have less CO₂. Did you know that a good working catalytic converter adds about 1 percent more CO₂ to the exhaust stream than what the engine produces? Honda has spent a lot of time and money inside a four-stroke engine, and its hybrid system was no exception. Much like the Insight, the Civic hybrid uses a 144-volt battery pack, which is half the size of the Prius's counterpart. The Civic also incorporates many computers and sensors and a flywheel-mounted electric motor to keep it all going.



Versatility: Honda's IMA system (above) required only minor changes to the Civic's body, and opens up the chance of the automaker offering hybrid versions of all its vehicles. To recharge the batteries faster in stop-and-go traffic, the V-Tec (left) disconnects the two-piece rockers and lets three cylinders freewheel.



What size IC engine should go into a Civic hybrid? Answer: The most fuel-efficient one you can that will still give enough power to be attractive to the average consumer. The size of the IC engine then is determined by the size of the electric motor, battery pack, weight of the car, aerodynamics, rolling resistance, internal friction of driveline components and performance desired. Both hybrid Hondas have their own hybrid-specific engine. The Civic uses a specially built 1.3L, four-cylinder with a chain-driven cam, V-Tec and OBD II.

What is unique is that the V-Tec valvetrain technology – which Honda has been using for well over 10 years on their fleet – has a new twist: Instead of going with a different cam profile, they went for no cam profile at all. This means that the hybrid IC engine makes things harder for electric regenerative braking because of compression braking.

The Toyota has no engine braking to speak of based on their CVT design, but the IMA system does. On Honda's design, the electric motor (EM) is in-line with the crankshaft, so slowing down under compression limits the amount of regenerative braking that you can capture. Honda solved that problem by deactivating three-cylinders, and in this case, it works. When the Civic starts to slow down, three of the four cylinders have a V-Tec-type system that disconnects the two-piece rockers and lets three cylinders free-wheel – no air in, no compression. This recharges the batteries faster in stop-and-go traffic.

The IC engine also runs very clean and has a horsepower and torque curve that complements the updated EM. The IC engine is at it's worse down low, and that is where an EM will shine. This is a great time for a powerful EM to take some work away from the IC engine. The electric motor is thin, mounts up easily and leaves plenty of room for your typical transmission. As all hybrids do, the ICE shuts off at idle and automatically starts again when you are ready to move. The Civic hybrid is available in a five-speed or CVT version.

The Civic Hybrid is about the same size as a Toyota Prius. It sells for about the same money, gets approximately the same mileage and has a good reputation. No tricks are needed to make this Civic a hybrid other than electric power steering, which is now standard on the non-hybrid Civic hatchback; a sensor that detects low vacuum in the brake booster; and the usual IMA controls. The body is steel and the suspension is the same. It's a bit more aerodynamic, but not much different than the gas-powered Civic. One side note: we've heard that the Insight will not continue in production after next year.

Are you ready?

Don't think that hybrid service is 'just too weird' to really be a part of your career choice. I hate to be the one to tell you, but this stuff isn't going away.

More than 60 percent of our gasoline is imported. Even if we started drilling today on our own land, it still takes 10 years from when the drill bit hits the ground to the time gasoline is in our tanks. If CO2 emissions are regulated, there are only three ways to reduce them: Use less fuel, drive fewer miles or burn something other than a carbon-based fuel. Add in predictions that the world's oil supply is dwindling, and we could have a hybrid war going on – possibly in 2005 or sooner.

What about fuel cells as an answer? Most automakers say “not in the near future.” We will wait and see. One thing is for sure: Honda and Toyota are ready today if gas prices shoot up, if fuel supplies become limited, or both.

Hybrid service will be a part of your future. As soon as it is economically feasible for consumers, more of these new fangled half-and-half vehicles will be driving to your shop. You might as well jump on-board: Both Ford and GM will be launching hybrid vehicles within the next 12 months. More are sure to follow.

So what should you do as a tech to prepare? Learn more about brushless DC and AC motors, make sure Ohm's law and you are friends. Keep using those lab scopes and current probes, and be up to speed on the current 12-volt cars so the bridge between what is coming and what you know is as short as possible.

Re Printed with permission Author: Craig Van Batenburg

Further Reading

If you are hungry to learn more about hybrid technology, here are some references:

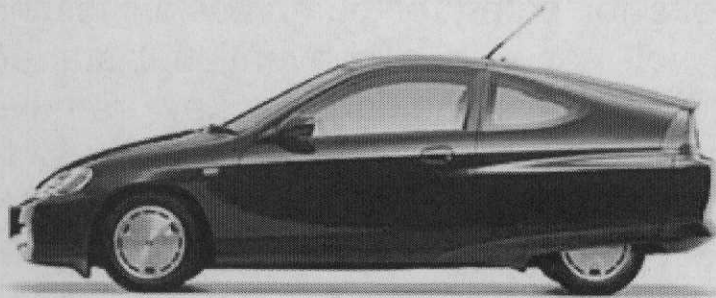
■ **Motor Age**, September 2000 issue, page 56, “2000 Honda Insight.”

■ The “Cutting Edge” section of the www.howstuffworks.com's automotive area offers an overview of hybrid technology and discussions of specific hybrid vehicles.

■ **One Prius owner** has documented his own personal experience with his vehicle online at www.John1701a.com. The Prius' scheduled maintenance, as well as his vehicle's own maintenance history, are available for viewing.

■ www.insightcentral.net is a Web site created by and for Insight owners and enthusiasts. The site includes information on TSBs and recalls, maintenance schedules and common problems and “non-problems.” In addition, the site houses an “Interactive Encyclopedia” with reference information about the Insight.

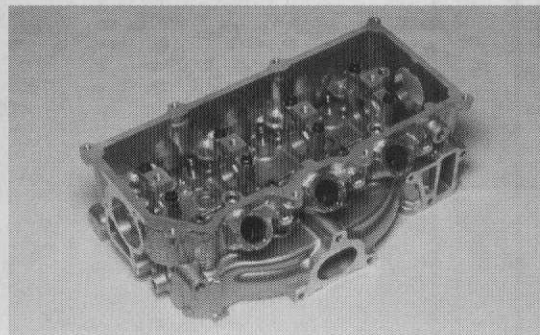
Honda Insight 2000-2006 section



This is only an introduction. This information is designed for the technician that wants to be able to say YES when a customer asks for service.

- Valve clearance adjustment required. All adjustments are screw type. Done on cold engine.
- Use OEM parts or very good quality
- No Timing belt - uses a chain
- Clutch is hydraulic
- Engine is 1.0 3-cylinder
- Check TSB's before diagnosis
- The cylinder head has a cast-in exhaust manifold to keep the engine hot when off at idle

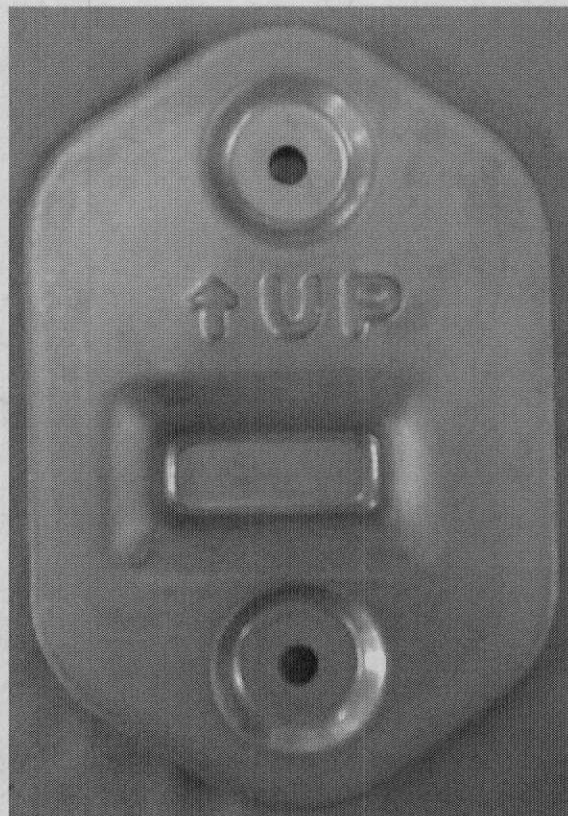
HONDA
IMA
INTEGRATED MOTOR ASSIST



For Safety.. How to de power the HV System

To turn off the 144 volts for safety or compression testing (now the car is a 12 volt car with a conventional starter, slower cranking speed), remove the ignition key, remove rear deck carpet; remove a small access panel – the only one with two bolts – in the center of the top aluminum plate. Remove red switch cover and turn the switch off. The HV capacitors should be drained of HV. Wait 5 minutes, check orange cables for low voltage with a voltmeter, and if it is at 12-volts or less the car is now safe to work on.

DO NOT PIERCE ORANGE INSULATION!!

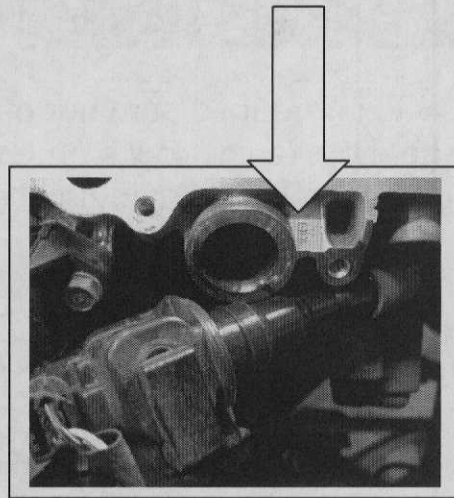


Use the 12V mode (see previous page) for compression tests or any time you want to have the engine crank at low rpm's. The Insight has a conventional starter and small 12V battery as a back up in case the Integrated Motor Assist (IMA) system fails or the 144V battery pack goes dead. The Insight can be jump-started but NOT push started with a dead battery. Note: when in 12-volt mode the 12V battery is NOT being charged by the alternator (EM).

An IMA light will light up on the dash if an IMA problem exists. It will also set the MIL lamp and a code. IMA problems affect emissions. POA__ is a hybrid code.



Match up the plug to the mark on the head. In this case it is a "B"



COPIII tester from Mac Van deBrink works great for testing the Honda COP system. Can be used on any COP system. Go to www.auto-careers.org for purchase information.

High-pressured tires. Size 165/65R14 79S
38 PSI front
35 PSI rear

Some owners raise the pressure higher for better fuel economy.
Honda uses stick on weights to balance tires.
Civic 13" rims will fit for snow tire use. Size -175/70 x 13



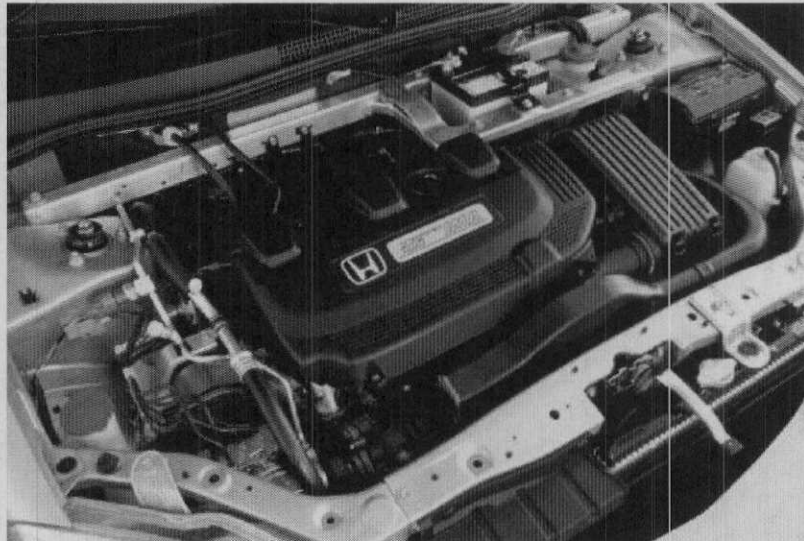
Special Honda Oil 0/20 w and filter.
2.5 qts with filter change.

Special Honda standard
transmission fluid - MTF
1.6 qts capacity

All aluminum bodies, special bolts
with a coating. Many single use
bolts in frame and body.

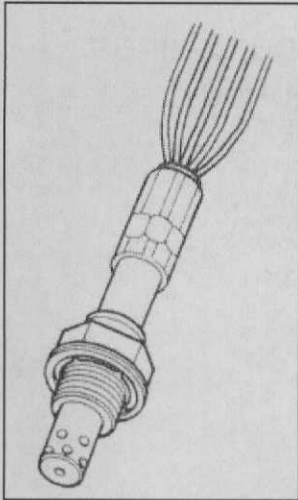
A/T (CVT) introduced summer of 2001. Uses special Honda fluid. -
rear wheel brake line-locks on CVT until engine starts and builds up
pressure in CVT. The fluid has been re designed and is better.

Vetronix
Mastertech Honda
aftermarket
software will give
you IMA codes,
SRS, ABS but not
Immobilizer. 00'-03
models only. For
04'-05' new tester
required.



DLC is located
right of center
console near heater core. No cover, just look hard. It is just under the
trim lip, 4 inches from the floor.

Honda uses their 5-wire LAF sensor (a special type O2 sensor) LAF = Lean Air Fuel sensor only on the 5 speed model.



This LAF sensor is really two O2 sensors in one. It was first used on F.I. systems in the 1992 Civic VX. It is used so that a 23-1 mixture can be used when at cruise under light load conditions. It can be tested but not in a traditional way. The sensor will set a code when it is slow to react to a command from the PCM. My experience has been that when a code is set for this sensor (not the sensor circuit or a lean / rich condition) it is the sensor that has failed. John Thorton does a great job in explaining this sensor in his classes. You can also go to www.motorage.com and do a search for articles.

NGK Spark Plugs only ILZFR5A-11 – they are indexed. The ground electrode is positioned for good intake flow.

There are 4 standard plugs, check cylinder head for mark stamped onto head, either A-B-C-D, near spark plug. Install proper plug per hole as the tip of the plug is indexed. Spark plugs have an A-B-C-D stamped on the top of each plug.

Iridium tipped plugs. 100K life per Honda. We will see!

Gap 0.40" Careful as iridium is very soft.

USE OEM PCV Valves (MAP sensor will be off calibration)

Timing set at Red mark 12 deg. BTDC +/- 2 deg.

Firing order 1-3-2

Compression test 130 PSI (Honda's # - may be higher)

Valve clearance adjustments are done cold

Int 0.007" - 0.009"

Exh 0.008"– 0.010" ACDC suggest an adjustment every 30K

New for Honda are quick connectors on fuel pump lines
(somewhat Ford like). No special tools required.

Fuel pump pressure 40 – 47 PSI

Fuel filter in tank (along with the pump)

A/C R 134a Capacity 17.6 – 19.4 oz.

Cooling system capacity 2 - 3 qts.

Electric Power Steering. Scan tool data will give trouble
codes through the DLC, again with Vetronix Mastertech.

ABS Scan tool again... you guessed it, Mastertech



Climate control
and heater
have trouble
codes. No
special tools
needed.

Holding down heater control buttons will flash codes. See
manual for help.

SRS.. trouble codes. Vetronix again



Mike Van Batenburg and a couple Insights

Preventive maintenance that works

- Replace the drive belt at 60k ..remember NO timing belt
- Remove spark plugs at 60k and lube threads.
Note: spark plugs are specific per cylinder for electrode line-up.
- Replace Thermostat every 60k
- Service calipers (aluminum) once a year in area with road salt / humidity
- Check / Re-adjust valve clearance every 30k
- Power steering is all electronic
- Use only OEM fluids
- Torque Lug Nuts to proper specs to avoid warped rotor
- Honda Insight has high pressure tires - Check specs

Parts Info

- Oil Filter 15400-PFB-004 - special to the Insight
- Special Honda Engine Oil 0/20 weight - Special CVT Fluid
- Many Seatbelts have lifetime warranty

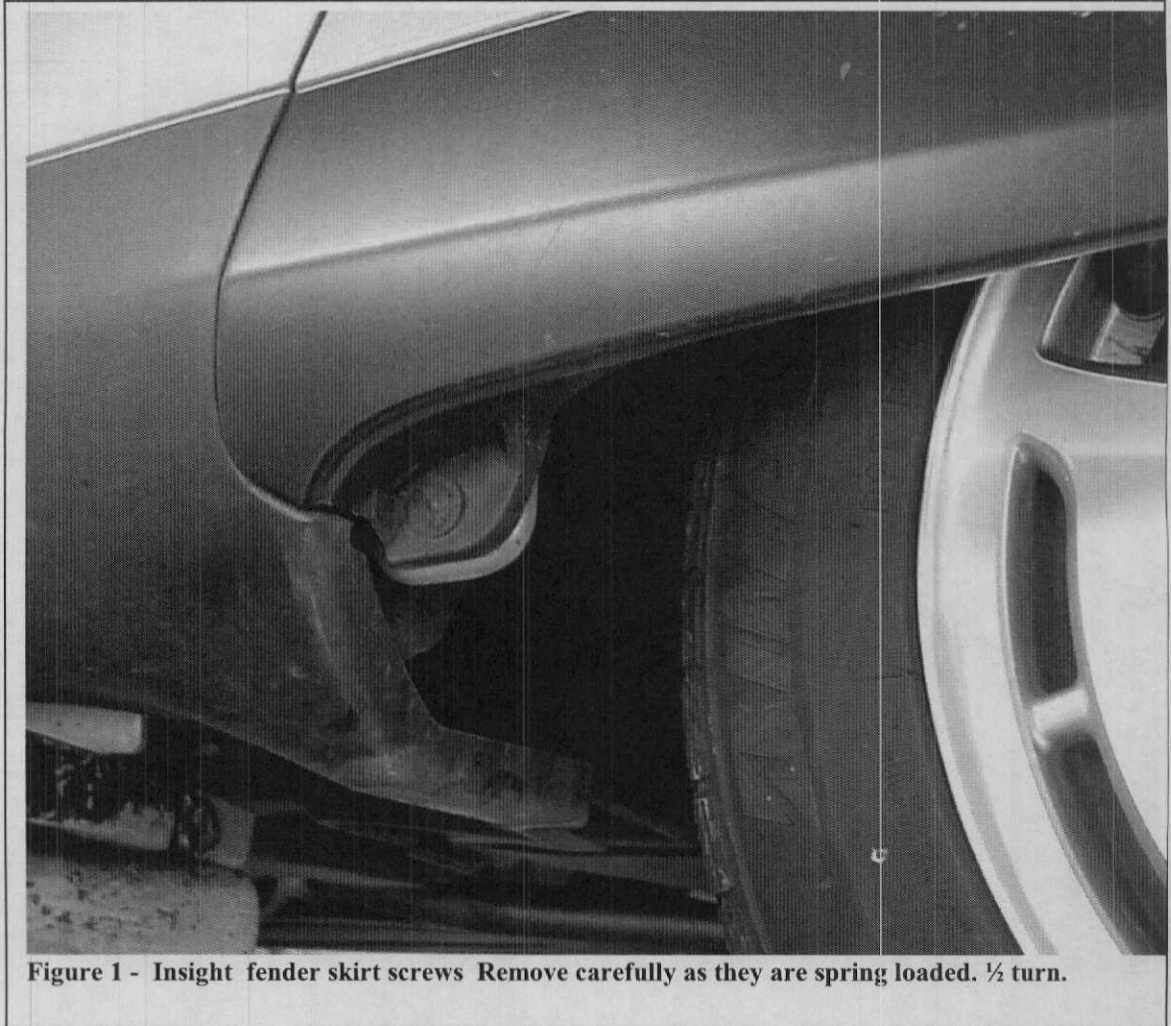


Figure 1 - Insight fender skirt screws Remove carefully as they are spring loaded. ½ turn.

Honda Insight uses a speed density fuel injection system to calculate air flow
Tight valves will cause a rich mixture
To force the system lean unplug an injector

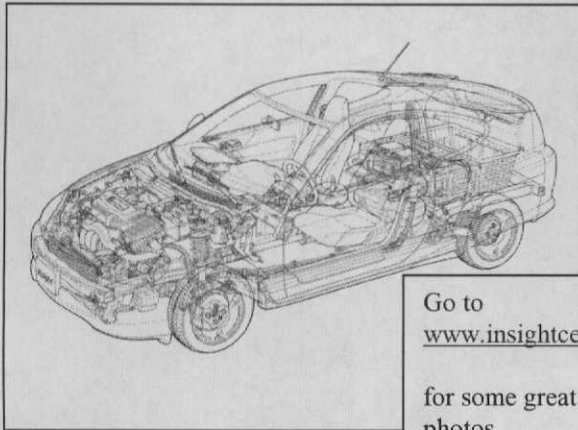
Retrieve codes:

OBD 11 Connector is found at passenger area, behind center console, down low near carpet. No cover.

Mastertech scanner has Asian software that is almost OEM. Vetronix is OEM for Honda/ Acura. (Also Toyota, Lexus, Isuzu, Suzuki and Kia)

Tell customers:

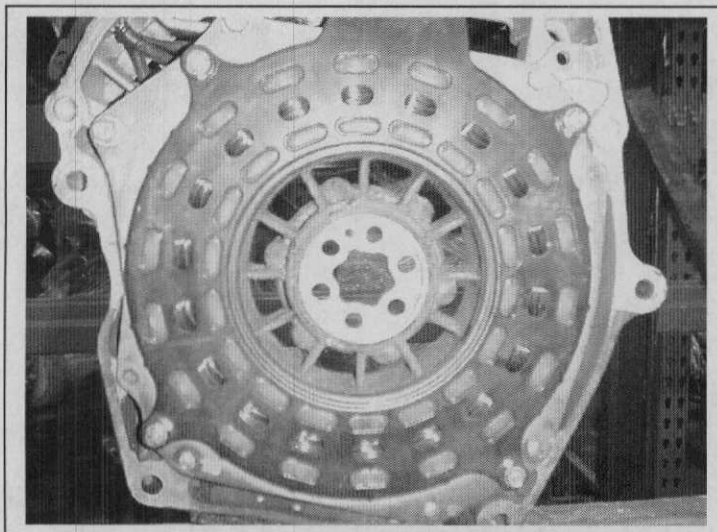
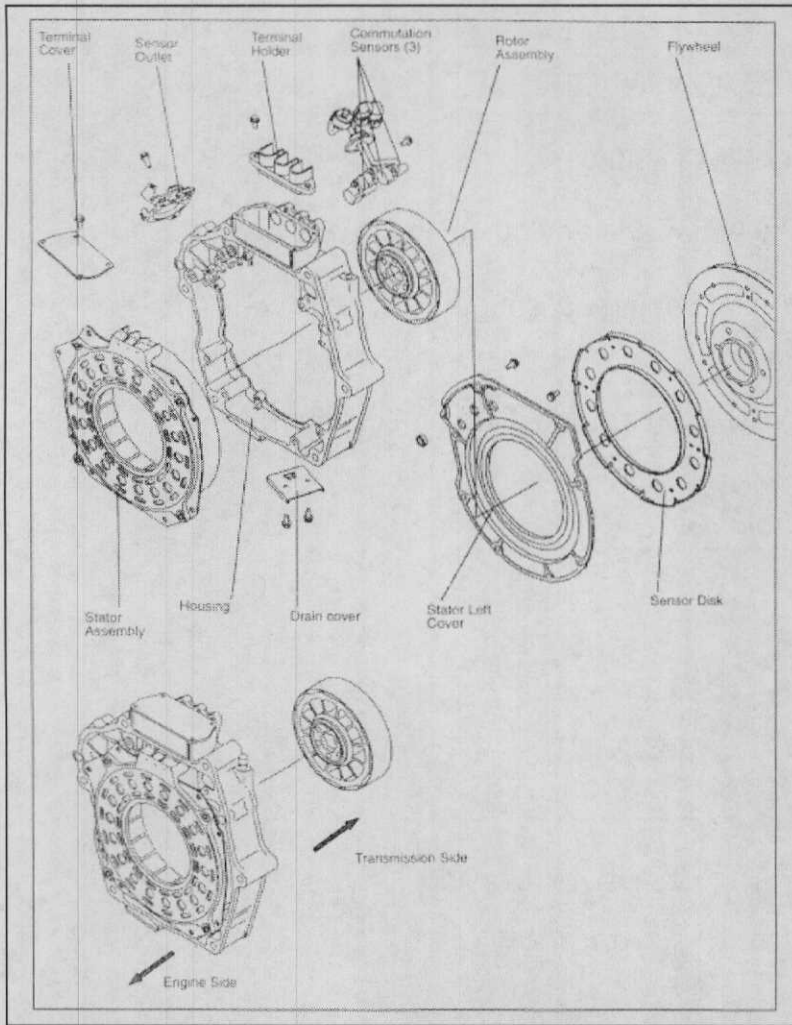
- Tire pressure is very important.
- Drive easy for best mileage.
- Service ICE like you would any other Honda engine.
- Do NOT block vent behind passenger seat. This vent is for the HV batteries.
- Careful with Wheel Lug Torque. Lots of aluminum.



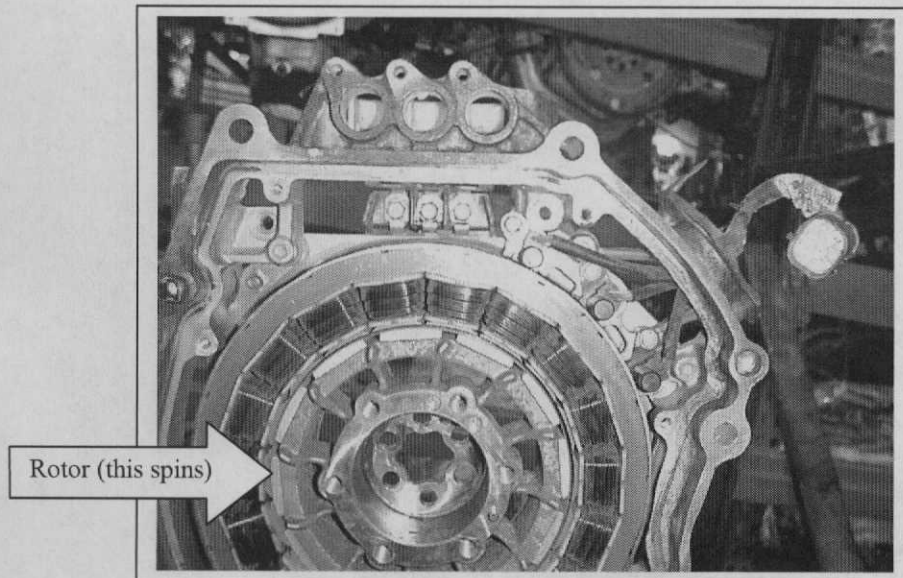
Go to
www.insightcentral.net
for some great info and
photos

Random Thoughts

- Most Honda Insight owners can be very loyal customers.
- Honda makes the cleanest fleet and has the best CAFE ratings of any major carmaker.
- Honda is a leader in advanced pollution controls
- The Sierra Club gave Honda an award for the 2000 Insight.
- The CART championship has been won 6 years in a row by Honda engines. 1996 – 2001. Indy 500 and IRL Champions in 2004.



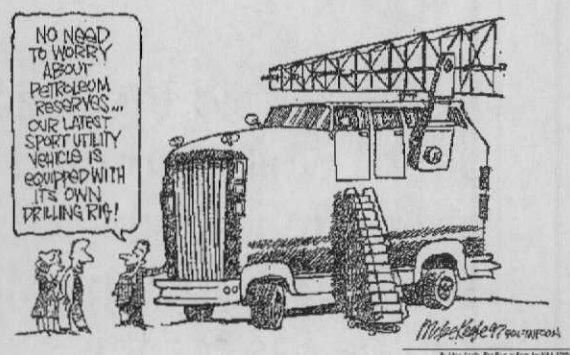
This is the IMA assembly after unbolting from ICE. Backside.

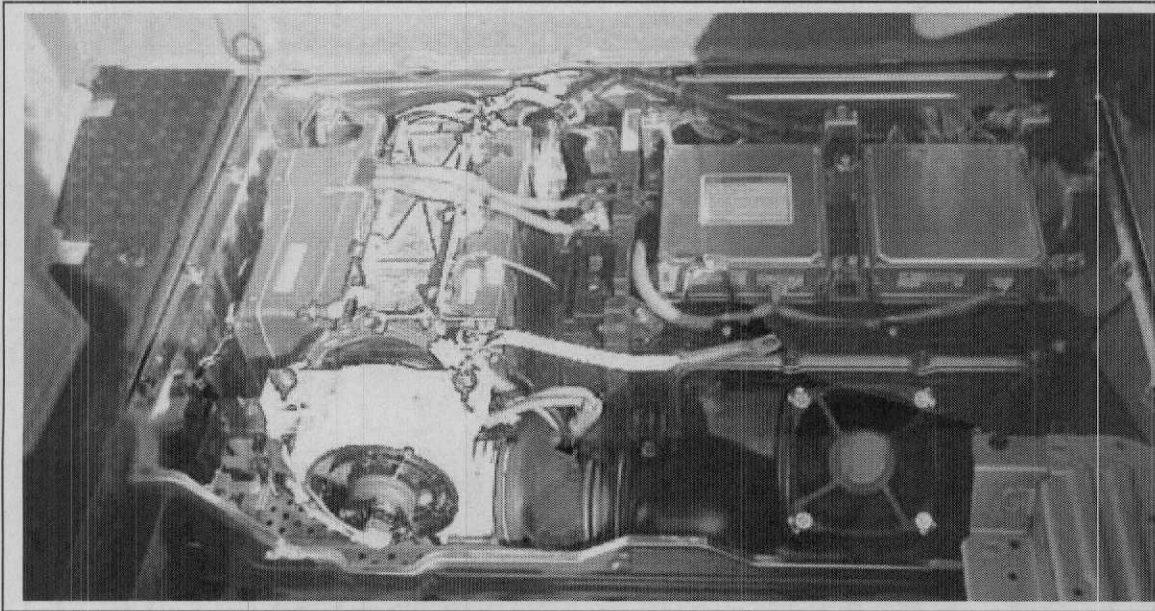


This is the IMA assembly from the transmission side. Rotor is in place after being unbolted from the crankshaft.

Customer complaint is “144V Battery seems to die overnight”

The Dash 144v Battery Indicator can be misleading. It averages the battery state-of-charge. You can see ½ charge on your digital readout and then after a restart it will show close to zero. A couple things to keep in mind here, when the dash shows zero bars, the 144v battery is about 20% charged. At certain times, criteria unknown, the battery readout will re-set itself and that is why the battery seems to be loosing charge rapidly while the car is off. This is not the case as the computer is re-setting its internal calculations. If the 12 volt battery goes dead or 12v battery is disconnected, the dash read out for main HV battery will read zero bars, just drive the car a few miles and the PCM and BCM (battery control module) will re-set dash readouts. No scan tool necessary.



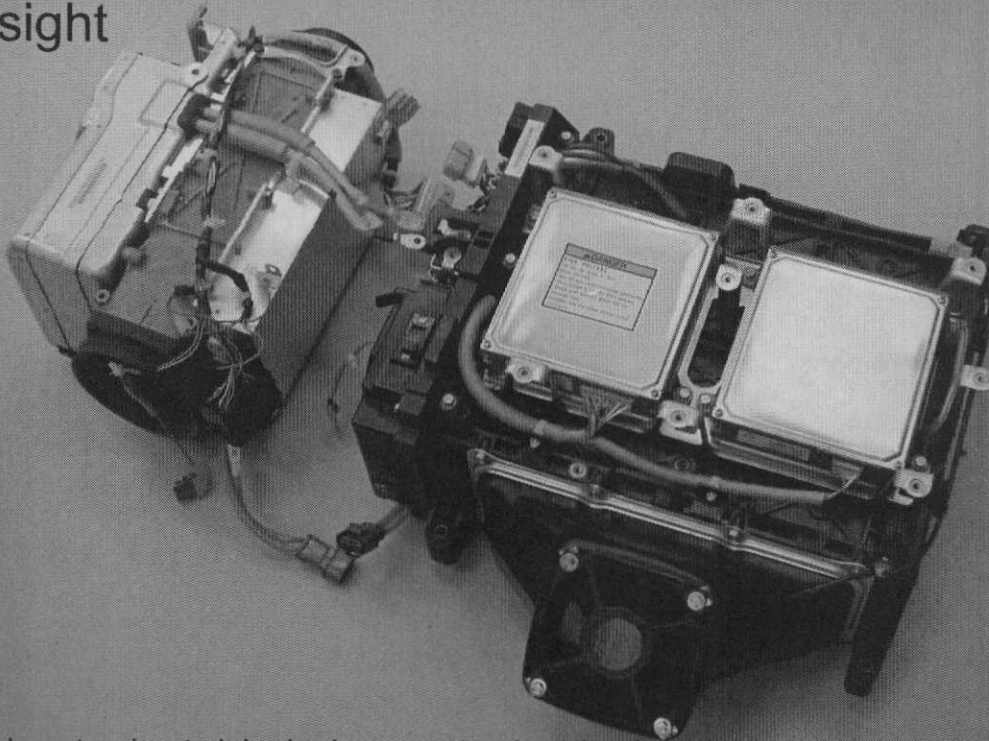


This is what the rear cargo area looks like with the cover removed. For a very good explanation of each component go to www.insightcentral.net and learn more.

How to re-set maintenance required light?

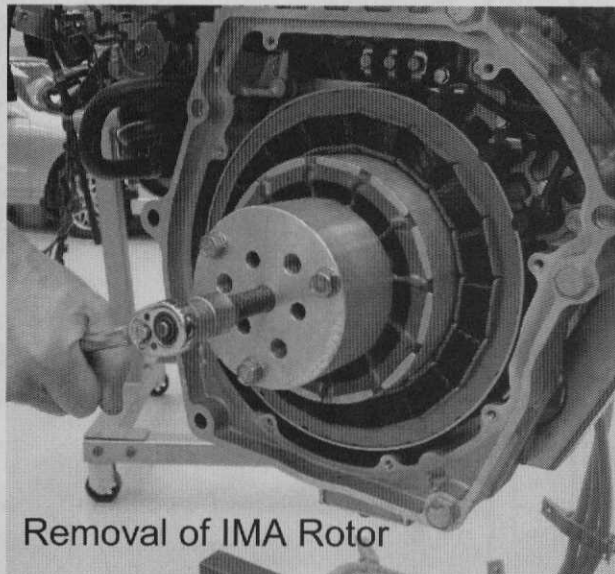
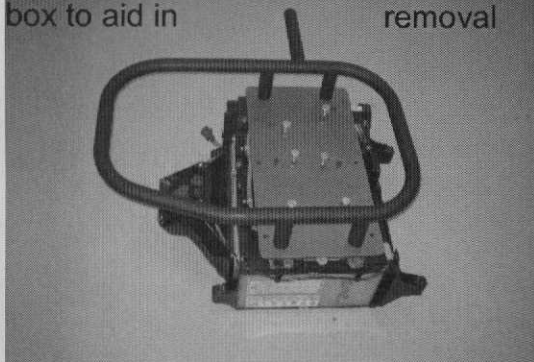
Key off..hold trip button in (right side of dash) while turning key on. Keep the trip button in until the light goes out. Wait for 10 seconds and light will go off. You will need two hands for this.

This is the hybrid system removed from the Insight



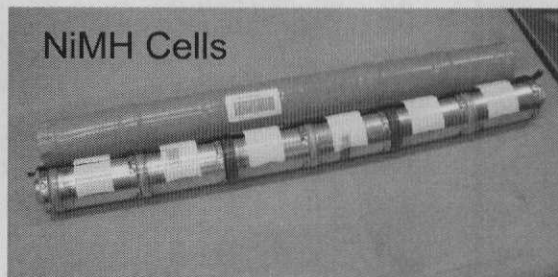
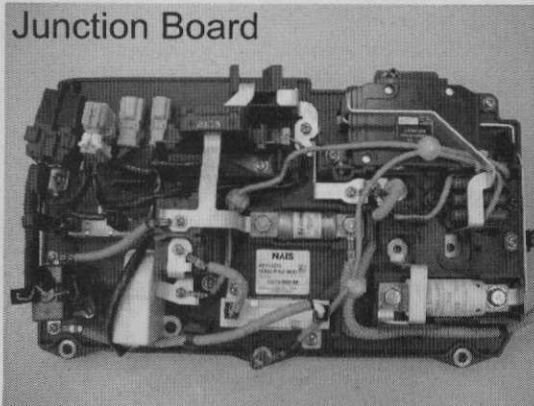
(l-r) inverter, heat sink, dc-dc converter, junction board, HV switch, battery box with ECU's on top.

Special tool mounted on HV battery box to aid in removal



Removal of IMA Rotor

Junction Board



NiMH Cells

Written by Craig Van Batenburg, AAM

Part II

Hybrid Safety

Important Tips That Could Save Your Life

Terms

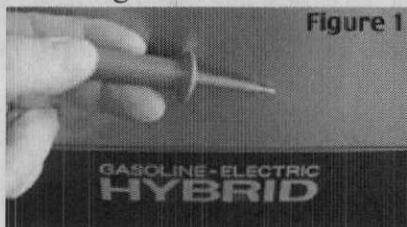
EV - Electric only vehicle
Hybrid - Gas and electric vehicle
ICE - Internal Combustion Engine
HV - High Voltage
HV battery pack - a series of Nickel-Metal Hydride (Ni-MH) batteries
Ni-MH - Nickel-Metal Hydride

Some of you have taken my gas and electric vehicles (hybrids) class, but most haven't. Safety is a big part of the course. The Toyota Prius and Honda Insight and Civic gas hybrids are out there. They will have accidents and you will be asked to fix them. Collision shops are usually the first to experience the difference.

So far we have not lost a technician to any electric-only vehicle (EV) repairs, but these techs are typically trained for one week on high-voltage systems. I sure hope the average tech prepares very well before he or she starts to work on a hybrid car. A large spark that would sometimes make a tech jump and a co-worker laugh may not seem so funny if the technician is hurt or, worse yet, dead. The safety issues are real. Read this carefully and pass it on to each associate in your shop.

The threshold for voltage that can be fatal, as in dead, is about 60 volts. For some people, it's as little as 50 volts. Hybrids use a dual voltage system: 12 volts for most of the car and high voltage (HV) for the drive motor(s) and related systems. The HV is what you need to respect. Electricians who have worked on 110v or 220v know to be careful and de-power the wires before working on the system. Well-trained electricians wear safety gloves, work in teams and know how to read a meter. The Toyota Prius is 276 volts, a lethal amount; and both Honda hybrids come equipped with 144 volts as standard equipment. Always wear safety gloves during the process of de-powering and powering the system back up again.

Most digital volt/ohm meters will read up to 600 volts. Just make sure you are using probes that have safety finger positioners and are rated for high voltage (Figure 1).



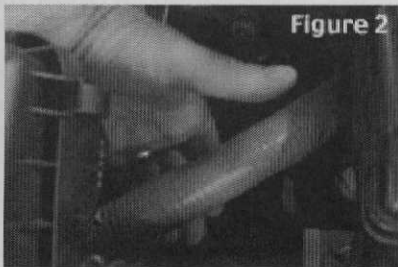
For the safety of passengers and emergency medical technicians, once an airbag is deployed the HV system is shut down. These cars have a lot of safety built into them.

The Civic hybrid is rated with five stars on crash tests.

Until you are trained to work on hybrids, just be careful and do the work that you can. Keep reading so you know how to stay out of trouble.

As in any new technology, play it safe! Read the warning labels (I know we are not prone to do that), get the proper equipment and wear those safety gloves. One note on safety

gloves; before you use them, each and every time, inflate them and make sure they do not have even a pinhole.



So what do you need to know about these cars? First, you need to know that orange cables mean high voltage, and you need to know how to de-power the HV system. If you are not near the orange cables (Figure 2), then you are fine, unless of course the car has been in an accident.

Fluke makes a HV ohm tester (part No. 1520) for about \$700. That megohm meter (Figure 3) is required to ensure that the insulating properties of the orange cables are still intact after an accident. You don't want to be the tech starting up a hybrid after a major collision and find out that the HV cables are shorted to ground.



Figure 3

Proper training will get you started in the safe handling of the HV systems. Once you have determined that you will be near an orange cable or junction, you will need to de-power the capacitors and disconnect the HV battery back.

Prius Safety

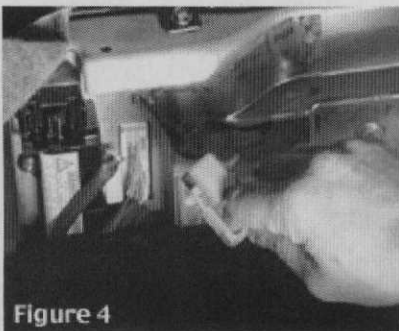


Figure 4

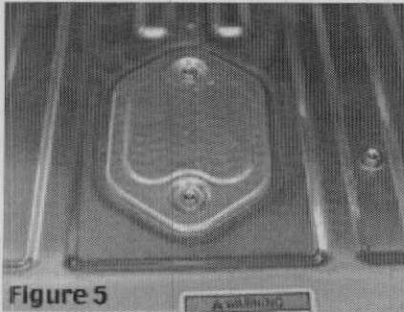
On the Prius, to keep from getting a potentially lethal shock you first need to open the trunk and remove the liner of the left front corner and find the service plug (Figure 4). It is a small orange handle that you raise and remove by pulling straight back. The Toyota manual tells you to keep the plug with you (I imagine they know about the pranks that some techs will play on another). This high voltage is no kid's stuff, so pay attention and don't make mistakes.

After you have removed this plug, wait 5 minutes and test for low volts (close to zero) at the orange cables you are close to. If they are under 12 volts, all is clear. Tape up any cable ends and bare metal. Don't forget that the 276-volt battery pack always has the potential for supplying you with a lethal charge, so handle this battery pack with care. Also, keep in mind that Mitchell and ALLDATA have good information on this car.

Insight Safety

On the Insight, open the hatch and remove the carpeting with storage box cover, as it is one piece. You will see a small aluminum cover (Figure 5). Remove the two bolts and the cover, and a switch (much like a wall switch) will be looking at you. Remove a red plastic

safety lock and turn the switch to off. Place the safety lock back on the switch in the other direction to hold the switch in the off position.



After you have switched it to off, wait 5 minutes and test for low volts (close to zero) at the orange cables or connectors. If they are under 12 volts, all is clear. Don't forget that the 144-volt battery pack is always hot. Once a cable has been disconnected, tape it up for safety reasons. Once again, Mitchell and ALLDATA can help you.

Civic Hybrid Safety

The Honda Civic hybrid is the new kid on the block, so Mitchell and ALLDATA will not help you. To de-power this hybrid, remove the rear seat upright cushion. You will see a small cover with two screws, an arrow pointing up and the word "up" on the cover. You guessed it! Remove the two screws and the cover, and turn the switch off. Place the safety lock back on in the other direction to hold the switch in the off position. After you have switched it off, wait 5 minutes and test for low volts (close to zero) at the orange cables or connectors. If they are under 12 volts, all is clear. Don't forget, the 144-volt battery pack is hot. Once a cable has been disconnected, remember to tape it up.

After your work is done on the hybrid car, tighten the connections very well. A loose HV connection is trouble. Turn the switches on or plug in the plug, wait for the capacitors to recharge and off we go.

I want to see you in class some day, so don't be foolish. If you have any doubts about your ability to perform these safety steps, then leave this for someone else.

Safety in the Oven

For collision shops, don't bake these hybrids at temperatures over 150 degrees F. Those nickel-metal hydride (Ni-MH) batteries really don't like extreme heat. Cook a battery pack in a Prius and you are out almost \$5,000 and that is only for parts.

Editor's note: To read more about hybrids, check out Craig Van Batenburg's mechanical feature in the March 2002 issue of AutoInc., and Roger Larsen's collision feature in the April 2002 issue.

Van Batenburg taught his hybrid class at ASA's Congress of Automotive Repair and Service (CARS) in 2001 to great reviews. Van Batenburg is available to conduct hybrid classes for your group or association. Call him at the Automotive Career Development Center (ACDC), (800) 939-7909, or send e-mail to vbgin@ix.netcom.com. ACDC's Web site is www.auto-careers.org.

2003-2005 Honda Civic Hybrid



Glossary

IMA – Integrated Motor Assist
IPM – Intelligent Power Module
MPI – Motor Power Inverter

0 – 20 oil same as Insight

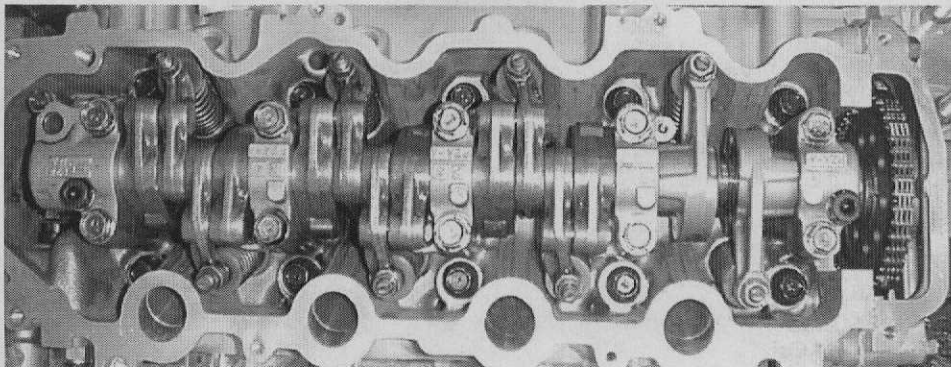
Oil Filter - 15400-PLM-AO1 same as 2001 Civic

Iridium Spark Plugs .. not indexed

Fuel Pressure 40 – 47 psi

Engine removed with cradle from under the car or out the top

V-Tec system disconnects all valve lift on cylinders 2, 3 & 4



Idle Re-learn Procedure

Hold at 3,000 RPM in park or neutral until fans come on. Note: No loads turned on. Then let idle with throttle fully closed for 5 minutes, again with no loads.

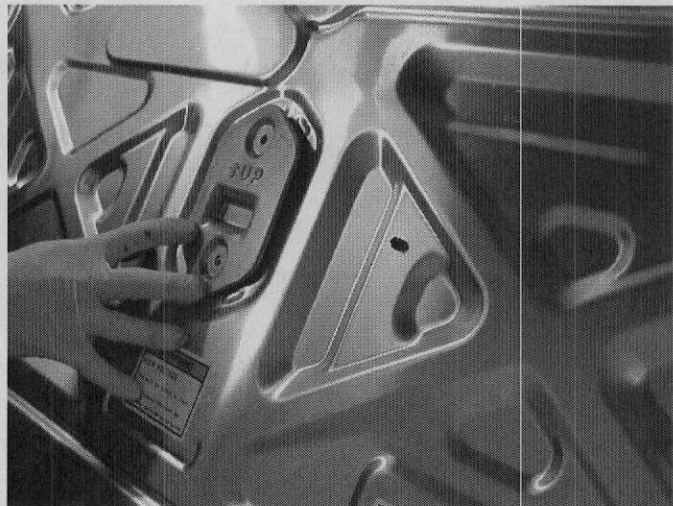
Fuel pump & filter come out hole under rear seat – gas tank stays in place. Easy to remove.

How to de-power 144 Volt system

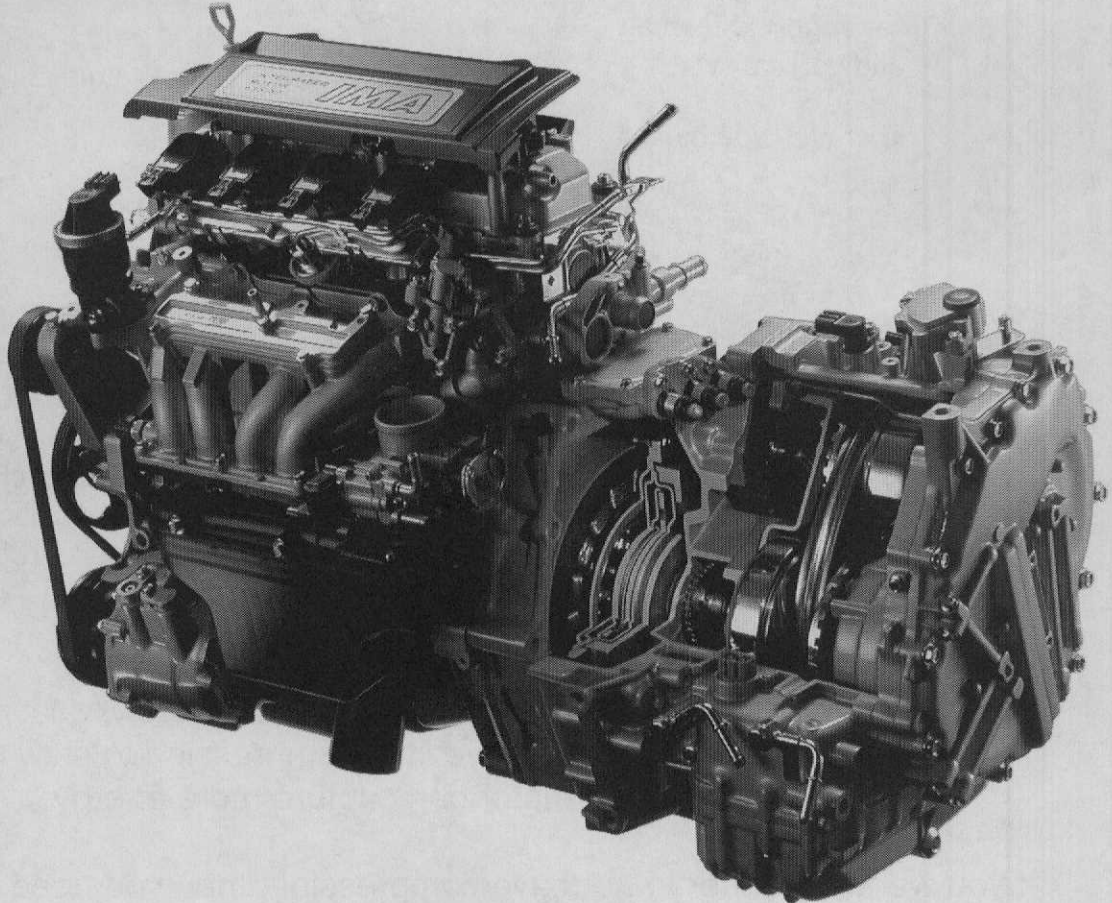
Remove back seat upper cushion.
Remove 2 bolts on cover with arrow & up marked on it. Flip switch to off. Wait 5 minutes. Voltage at orange cables should now be under 12 volts. Test before touching high voltage cables. See photos below.

This car was released in April of 2002. The IMA is similar to the Insight. Some of the unique features of this new car are:

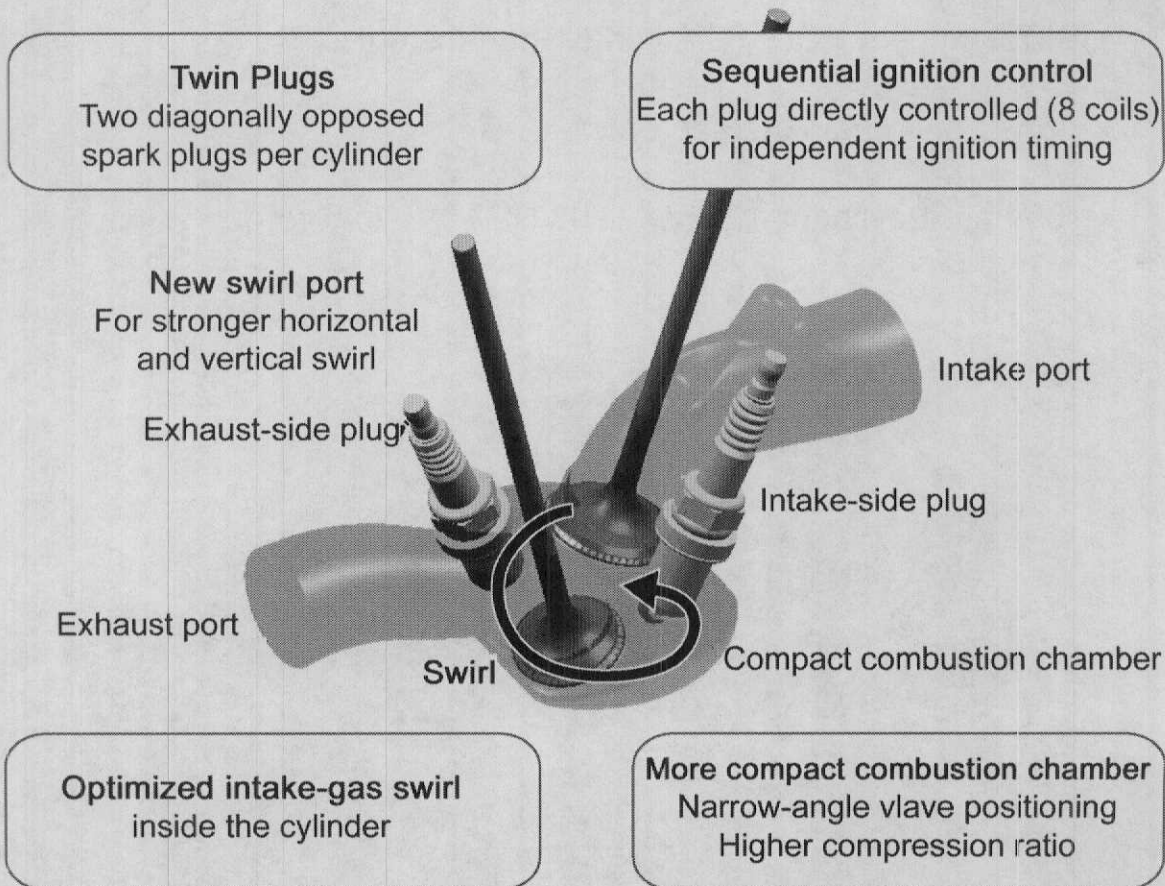
- Standard or CVT available 2,661 lbs. Std 2,732 lbs. CVT
- \$21,000 46/51 mpg with 5-speed 48/47 mpg with CVT
- 30% increase in Electric Motor output with same size motor



- 40% smaller PCU 30% lighter than Insight
- One cooling fan instead of two
- 85 hp. 4-cylinder 1.3 liter 93 HP / 116 lb-ft torque with electric assist

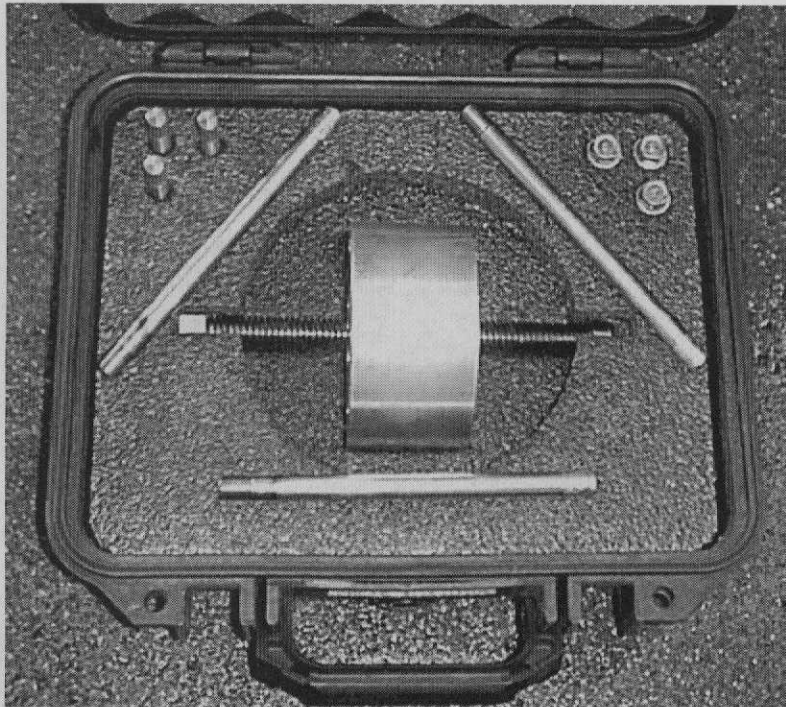


- COP - Direct (Dual) or sequential ignition
- Two plugs per cylinder - Independent control by PCM
- LAF / Lean burn system
- 3 of 4 cylinders are shut down during decel so that the IMA system can recover more electricity for re-charging



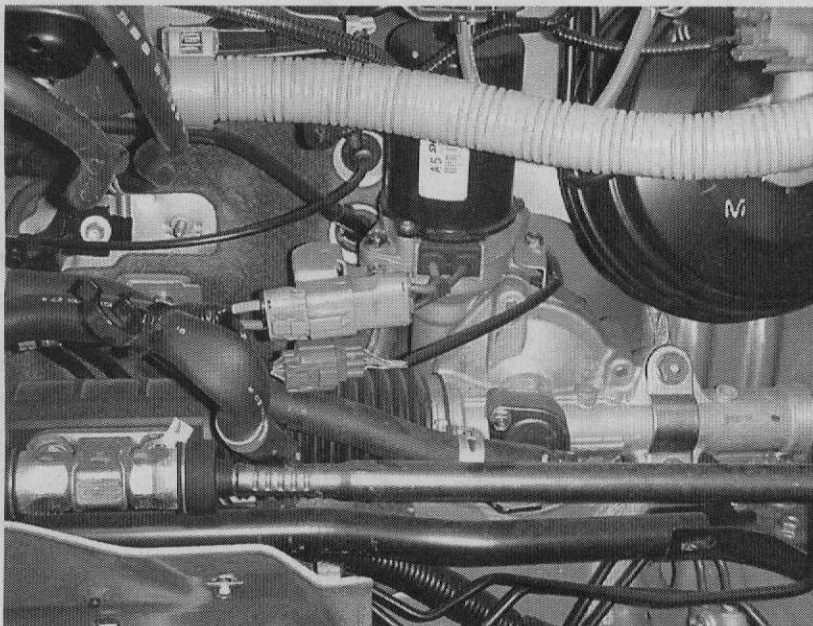
- V-tec type system lets valves stay shut completely, sealing off three cylinders. Now we have little compression to slow down the car so the electric motor can capture more energy.

If you want a cylinder to not have compression, than you need to stop it from acting as an air pump. The easiest way to do that is to use the V-Tec technology and make a two piece rocker arm. Then send oil pressure to those arms whenever you have the ability to recapture electricity through the IMA motor. That would include deceleration and braking, the same set of criteria for fuel cut. When cylinder idling is done, the IMA motor can capture more electricity to keep the main HV battery pack charged. It also saves some fuel in the process.



This tool can be rented from AHM (Honda). It is required to remove the rotor from the crankshaft. The magnets are so powerful you cannot do it any other way. It is also a lot safer. Honda has a patent on these new magnets.

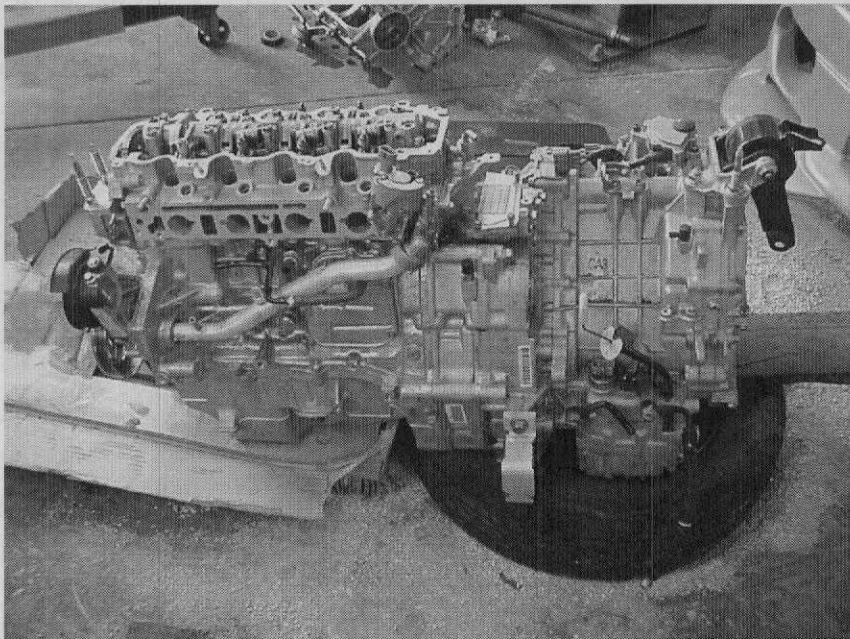
EPS = Electric Power Steering. The rack is typical of a non-power rack. A small electric motor (shown) is part of the rack. On some



designs the electric motor is on the steering column. There is no hydraulic fluid, pump or lines with this system. It helps save gas and it required for idle shut down. It runs on 12 volts.

When replacing the rack or steering column, a zero rest must be done so that the EPS CM knows where the electric motor and torque sensor are in relationship to center zero. A scan tool does this job.

This is a complete hybrid drive train. The car's owner had driven with no coolant (hole in radiator) and blew the ICE. A short block was replaced at an independent shop in Massachusetts.

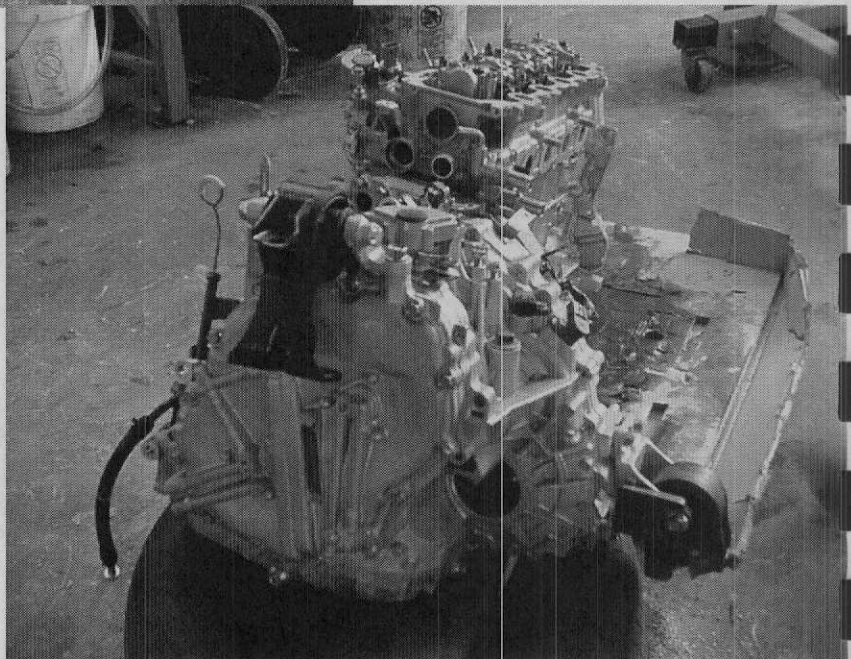


no coolant (hole in radiator) and blew the ICE. A short block was replaced at an independent shop in Massachusetts. They handled this repair as if it was any other. They had attended my Hybrid class.

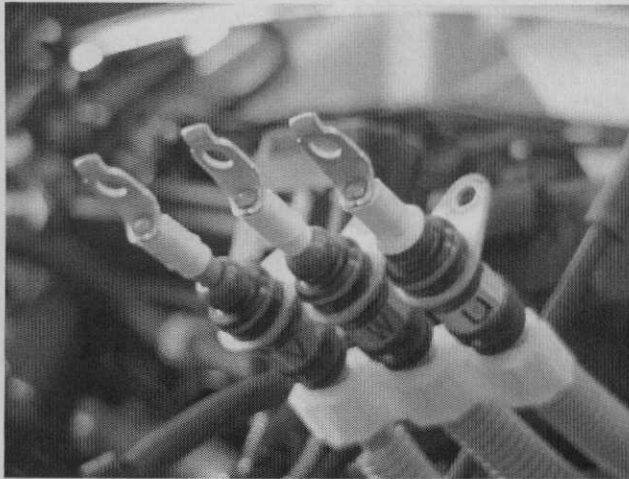
The motor and CVT were removed from the top. Lots of cables and wires. One special tool was required and was rented from AHM, American Honda Motor.

This is an example of an OEM, ACDC, and NASTF helping an independent shop stay in the game.

Don't think that hybrid owners will not seek out an

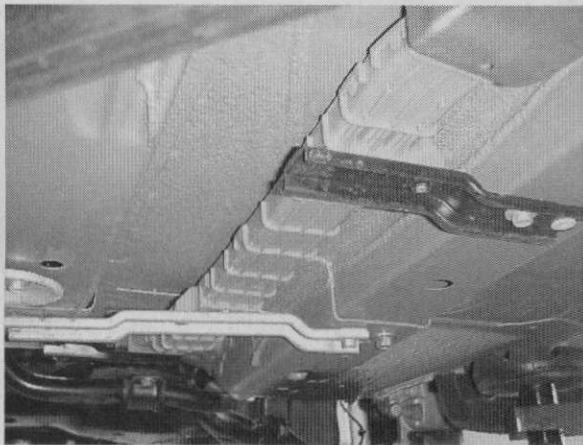


independent shop for repairs, as this happened in the fall of 2003! The Honda independent shops I know are doing hybrid work now. Once you get over the **hybrid hump** it is not as hard as you might think.



These are the orange cables you have heard about. They carry 144 volts at 6.5 amps maximum. 1 amp at 60 volts can be fatal! When these are disconnected don't forget to tape them up. Note this trio has a V -W -U on them. The inverter makes 3 phase ac current available to the IMA electric stator. Each cable has as much as 144v ac.

The orange cables run under the car on the inside of the frame rails. Watch the placement of your floor jack, as the cables are only protected by an aluminum tube, orange cable wrappings, and an orange plastic cover.

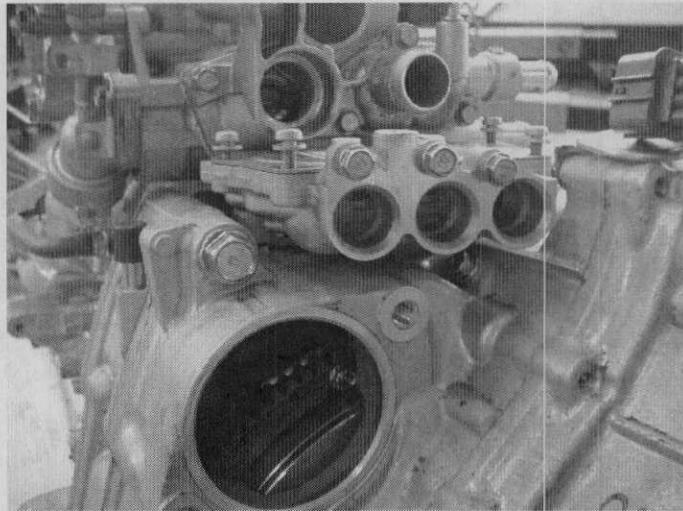


The IMA system does a self test every time you start the car, much like SRS. If a cable has been damaged the system will find a short to ground. Then the IMA light will stay on, the car may not (most likely won't) start (remember it has a 12 volt back up battery) and the main relays in the 144HV

battery box will not close. This prevents a HV shock to any passengers.

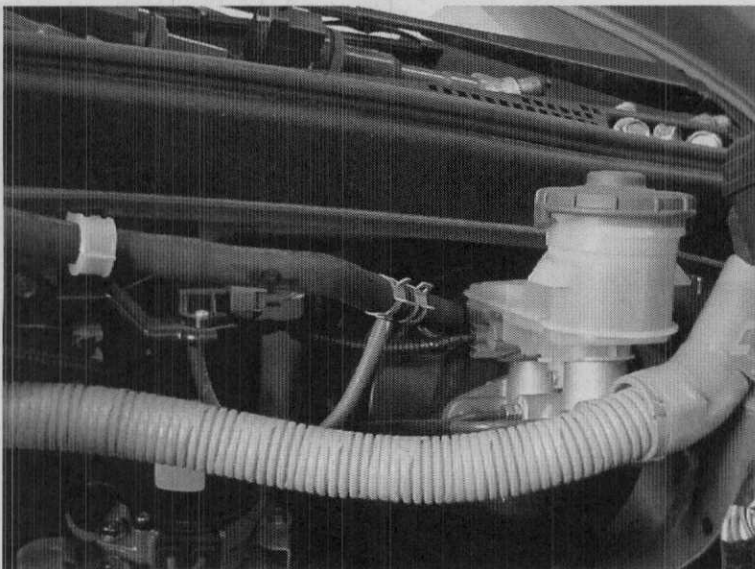
Creeping Aid System in the CVT.

For a Honda hybrid to feel like a conventional AT, some software strategies are in place. After the CVT (both Insight and Civic) Hybrid goes into idle shut down after coming to a stop, the hybrid



ECU issues one "idle shut down" per stop. Once you take your foot off the brake the ICE will restart so you have "creeping" that a normal AT does in the same situation. The ICE will then stay on until you accelerate past 19 (my estimate) mph and make another stop.

- 36,000 miles or 3-yr warranty / Battery and IMA system 8 years or 80K miles



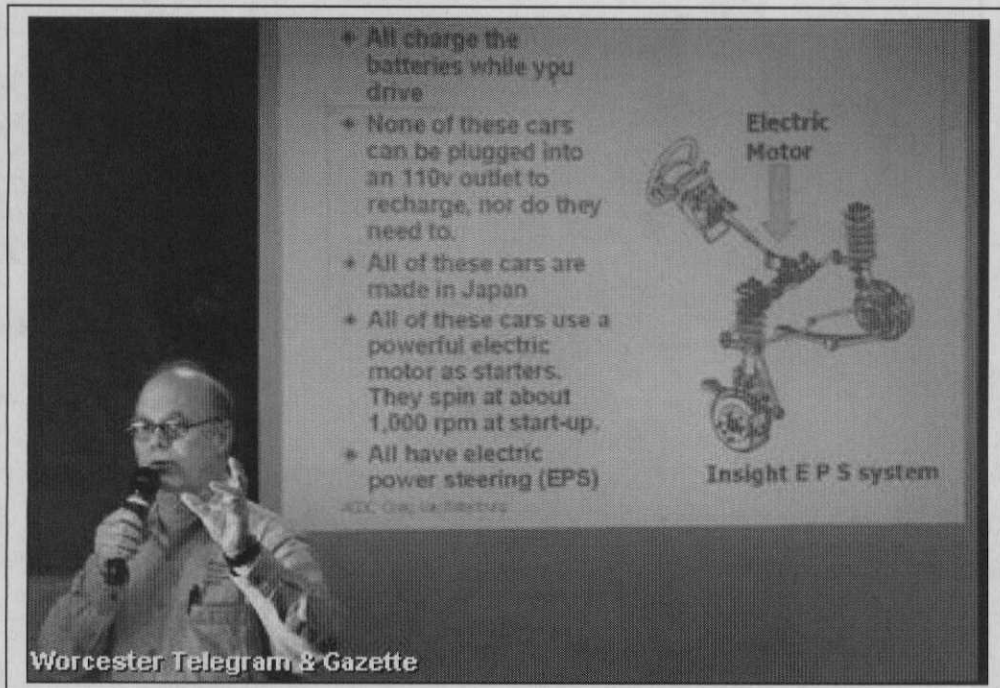
The power booster hose has a MAP sensor attached via a vacuum line to let the IMA system know if the ICE needs to be started when vacuum is low in the booster. This is part of the idle stop system. If you are stopped on a down hill section of road, the ICE may be off as you let gravity take over.

After a few stops the vacuum will be low and the ICE will restart automatically. This allows Honda to use a conventional braking system. As you will see the Full Hybrids use a more complex system for braking.

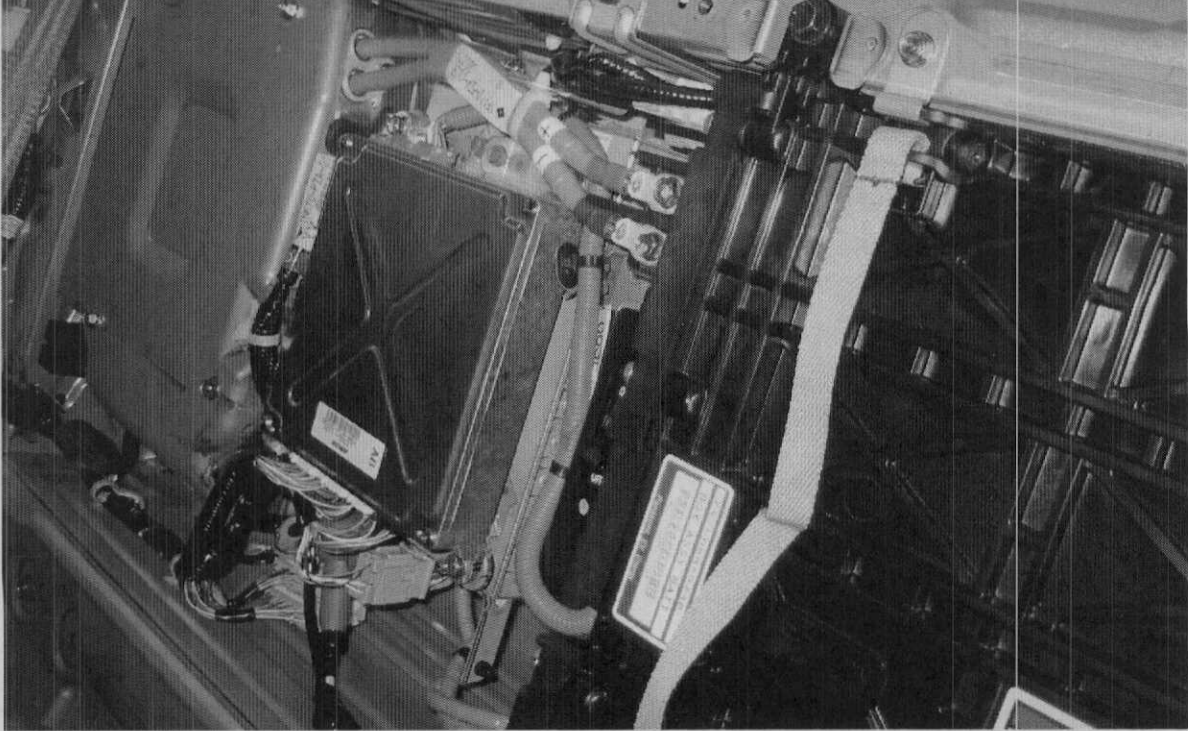
12 Battery concerns. Unlike a conventional car that uses the 12 volt battery to start the car, a Honda Hybrid uses the 12v battery to keep memory alive and run lights and accessories during idle stop, until it is extremely cold outside (approximately 0 degrees F.). At these cold temperatures the back up 12 volt starter is used. After a few years the 12 volt battery may not be up to the task of cranking the ICE. There will be no warning signs unlike a conventional system where you may hear a slower cranking speed. The hybrid will fail to start. Therefore, do not overlook a battery test at each service and replace the 12 volt when it is marginal, especially in the colder climates. The Honda Insight replacement batteries are a larger capacity than stock. These 12v batteries are conventional lead acid type, so any brand you like can be used.

Using the car as a battery charger (for the first time!) is now the recommended procedure. You cannot buy or use an external charge for the HV battery pack and the car does a great job charging the 12 volt battery as well.

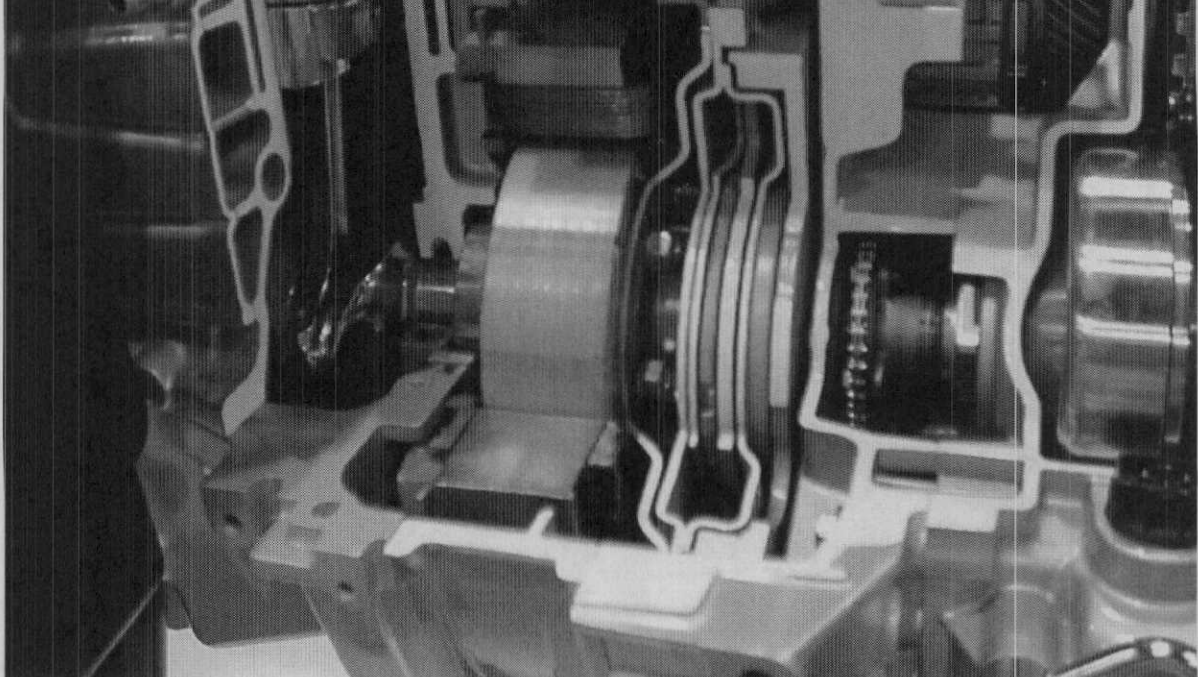
Craig is pictured below teaching one of his many award winning classes. This one is about hybrids of course.



Once the back seat is out, cover off, it is easy to get to connections and components



This cut away shows the IMA electric motor, part of the CVT, and one cylinder



hybridCARS.com

Greetings Hybrid Car Enthusiasts,

The response to the first newsletter was fantastic, so here comes newsletter number two. I receive a lot of email with technical questions about hybrid cars. It's not hard to stump me on these questions. I'm strictly an end-user. I love that drivers don't need to know the first thing about hybrid cars to enjoy the benefits of great fuel efficiency.

To help me answer your technical (and philosophical) questions about hybrids, I recently interviewed Craig Van Batenburg, a hybrid car fanatic, and apparently one of only three people in the country teaching independent auto technicians how to service hybrids. This extra long issue (about 7 pages) is dedicated to an excerpt of our conversation. (This may very well be the start of a series of conversations with the top-thinkers in the hybrid car field.) Please let me know if you like the longer, more conversational format.

~~ A Little About Craig ~~

Craig Van Batenburg grew up in Odgen, Utah, in the 1950s where his father had a used car lot and repair shop. Craig's earliest memories were sitting inside the cars in the back lot, turning steering wheels, and pushing and pulling on the levers and gears. When he was nine, he replaced the water pump on a 1956 Cadillac. At age sixteen, he began working at a motorcycle shop, where he learned about the holistic business and engineering principles of Honda founder Soichiro Honda. He was hooked.

At 22, he got a job at a Honda car dealership. Craig explains, "The oil embargo hit the same year, 1973. I bought a 1974 Honda Civic the second year it was introduced. It was a revolutionary car, front wheel drive, 30 - 35 miles to the gallon. I was politically inclined to think that we should be efficient anyway. I was in my early twenties. It became a political statement. The same reason I drive my Honda Insight today."

In 1977, Craig opened up Van Batenburg's Garage in Worcester, Mass. specializing in Honda and Toyota. The shop provided excellent service to a large loyal clientele for 27 years. (He closed his shop on January 16th of 2004.) In 1998, Craig achieved his long-held dream of opening a training center to teach auto technicians the fine arts of automotive repair, with a special emphasis on cutting-edge technologies. He is an ASE Master Certified Technician with advanced emissions skills. You can access his web site at www.auto-careers.org

~~ Hybrid Gas Pedals ~~

BB: You can get a manual (standard shift) Honda Insight of Civic Hybrid, but you can only get the CVT (Constantly Variable Transmission) or automatic version of the Prius. If you are comfortable driving a manual transmission, will you get an additional boost in fuel efficiency?

CVB: If you want a [hybrid] stick shift, the only option of course is Honda. If you look

at the fuel economy numbers on the Civic, the five-speed is higher than the CVT. That's correct, but to say that CVT is less fuel-efficient than a five-speed, technically you could get away with it, but the automatic transmissions are so sophisticated today, they can equal a stick shift.

BB: You're saying that stick-shift's are not necessarily more fuel efficient than automatics.

CVB: Not necessarily. Here's the other thing. A key point. The Prius does not allow the operator to do much except send signals to a computer. With rare exception, other than putting it in "B" you don't have a lot of control over anything. Toyota has taken the control away from the throttle, your foot. If you step on a gas pedal on a Prius, you're sending a signal to the computer with a sensor, a pedal position sensor. PPS.

You're sending a signal to a computer that then sends a signal to the throttle that opens it electrically. So you have no control. If you send a signal to the computer, for example in the Prius, while you're sitting in park in the driveway, and you want to floor the gas pedal, the computer will say "Why would it do that? It's in park." It will let you go to 1,800 rpm's, and that's as far as it will go.

So, the Toyota takes away your ability to operate the gas pedal. It takes your ability away from shifting the car. If you take that away from the consumer, you're going to get better fuel economy because you can't be an idiot, even if you are one. The computer won't let you be an idiot. You follow me?

People that drive stick shifts can do really stupid things. They can over-rev the engine, and go into what we call "fuel cut", where the computer starts taking over and backing off on how much fuel injector pulse width or how much fuel goes in. You can drive in the wrong gear. You can rev it up too much. You can slip the clutch. You can burn your clutch up. You can do all kinds of things in a five-speed to destroy your fuel economy.

BB: Does the Civic Hybrid also take away control from the gas pedal?

CVB: No. It doesn't as much. On the Honda's right now, it may change, the Civic and Insight, you can control the throttle with a cable. So, your foot is connected to the throttle opening. They're doing that to keep costs down. That's an expense thing.

And if you have a five-speed, you're shifting. Now, I'm controlling the shifting and the throttle with my five-speed Hondas, where I can't do either one of the things with the Prius.

~~ Maximizing Fuel-Efficiency ~~

BB: What hints do you have for people on how they can maximize their fuel efficiency?

CVB: Leave earlier. I'm serious. It's a lifestyle. I have a two-family house and I rent out the apartment upstairs. The woman who lives upstairs is always late for everything. She's a wonderful woman. She drives a Toyota Rav4. She must get horrible fuel economy because she runs downstairs, starts it up, throws that thing in gear, and wham down the highway she goes. She's not going to get fuel economy that way.

You leave early so you can drive slowly. Enjoy your ride. The difference in drag, wind resistance, between fifty miles per hour and seventy-five miles per hour is not like 25 percent more. It's like 100 percent more. You'd have to talk to somebody who knows physics to give you the exact numbers.

BB: When you think of the political or social impacts of how much gas we would be saving if people, without ever getting a hybrid, simply change their driving habits. It could make a huge difference.

CVB: [Sighs.] We'll never get this conversation done if we go down that road.
[Laughs.]

I got this number from Toyota. All the Prius's sold since the day they started in the United States have saved about 125 million gallons of fuel. They're comparing it to if people bought a comparable car, like a Corolla instead of a Prius. We would have used 125 million gallons more fuel in the last four to five years.

In the L.A. basin area, 33.5 million gallons of fuel are used every three days. In less than two weeks, just in L.A., they've consumed something like 125 million gallons of fuel.

BB: So you're saying that really the contribution that the Prius has made, and you could add the Civic Hybrid and the Insight, has been very small.

CVB: Infinitesimal when you look at our thirst. A buddy of mine was driving from Philadelphia to Worcester to attend a conference I was holding, and he got stuck in a traffic jam. He had his laptop. He spent the time computing how much fuel was used for all the cars idling in those eight miles of road. It was an astronomical number. If all of those cars were hybrids, Honda or Toyota, all of those engines would have theoretically been off. So just the amount of fuel consumed at idle is huge. And where you live do they have the tollbooths where you can drive through rather than stop to give money? Just getting the little transponder so you drive through instead of stopping, how much fuel does that save? A tremendous amount.

~~ Low Speed Driving ~~

BB: As a Civic Hybrid driver, sometimes when I stop, especially in the colder weather, I don't get the auto-stop (feature to go all electric at idle) to work. It seems like the Prius model of keeping more of the electric motor running at lower speeds is?

CVB: It's superior.

BB: What else do you have to say about the relative technologies as they relate to city versus highway driving?

CVB: If you know you're going to be in gridlock, buy a Prius. Couple of reasons why, especially with the 2004 model now. You're going to get into idle-start more often. You'll be able to creep along electric-only. And little nuances, like in the Prius, and unlike both of the Hondas, there's a small electric pump built into the heater system, and people need to understand how the heater system works, where we take antifreeze, and circulate it through heater hoses into a small radiator under the dashboard called a heater core, like a tiny radiator, and back out again. We put a fan behind it, and blow air across that. And that's how heat gets across to our cabin.

In a Prius, when you're stopped in the winter time, and the engine shuts off, the little electric motors continues to circulate the coolant, the antifreeze under the dashboard, so you continue to have heat. You don't have that in the Civic Hybrid or Insight.

So in the dead of winter when it's really cold outside, when your [Honda hybrid] car goes into idle-stop, which sometimes you can force it into, and you leave the heater on, you're going to start blowing cold air in thirty seconds. So the Prius is heads and shoulders above Honda's technology on the idle-stop feature for sure.

~~ Real versus Actual Miles Per Gallon ~~

BB: One of the big complaints that new hybrid drivers make is that they don't get the advertised gas mileage. Some people get a lot less. Obviously, they're going to be disappointed. On the other hand, some people seem to get super mileage. There's a lot of variance in terms of mileage. How do you explain that?

CVB: There are things we cannot control that have to do with fuel economy. Which way the wind is coming. I don't mean to say that in a silly way. Are you in a head wind or are you in a tail wind? Huge difference. The weather. Are we driving on snow? Are we driving on ice? Are we driving on asphalt?

The actual commute that you take. Are you in an area where you can never really get up to speed? Are you always accelerating and decelerating? Always.

BB: You're saying that it's not the manufacturing or construction of the car?

CVB: Not at all. With the Internet today, we know what the average person is getting on a hybrid vehicle. Beyond a shadow of a doubt. If you're not getting that, you better take a look at the way you drive, the conditions you drive in. Or take a look at the car. Not meaning that Honda made a defect. Here's an example. The Honda Insight when it gets a wheel alignment, what they call the toe adjustment, is set at zero. That's highly unusual. You never set the toe at zero on any car because it doesn't handle as well at zero. But, it gets better fuel economy at zero. So Honda made a trade-off. It won't give you great high-speed handling, but it'll give you better fuel economy.

Now, the customer goes in, drops the car off at a tire store. If that store isn't up to date on hybrids, there could be a problem. They buy some tires. The guy doesn't put high-pressure tires on, and he aligns the tires by using the Civic's specifications because he couldn't find it for the Insight. You've just lost ten to fifteen miles per gallon with the wrong tires and wheel alignment. Those things happen.

BB: So there are cases where it's not the fault of the manufacturer but because settings aren't observed?

CVB: After it was manufactured, somebody altered something. This could happen at a dealership as well. Get to know your service tech. A few days after the service, if you are happy, go back with a ten spot and drop it on the tech. You will get great service after that. Not too many people respect and thank their techs. And I mean talk to the tech directly, no one else.

~~ Hybrids, SUVs, and Safety ~~

BB: Some people stay away from hybrids, at least the current offerings, because they feel that they're not safe. They don't have a lot of metal around them, the way they might with a truck or SUV. Are hybrids less safe in any way?

CVB: No. Absolutely not. You look at the Star ratings. Somebody's going to drive what they're going to drive. If the fear factor is big, you'll put the biggest car you can around you. And you'll die at a higher rate, as you probably know. SUVs, in deaths per miles driven, is I think 2.5 times higher than passenger cars. Did you know it's that high?

BB: I know it's a lot higher.

CVB: It's huge. If that's their reason for not buying a hybrid, then they're just looking for a reason to justify their SUV because it's not a valid reason. If you're driving an SUV, you're probably under attack from time to time, so you're going to find as many reasons as you can latch on to. That's one of them.

~~ Hybrids in Cold Weather and Long Inclines ~~

BB: Probably the most common question I get relates to winter driving. Not only the cold temperatures, but also the snowy conditions and clearance.

CVB: I drive an Insight with full snow tires with steel rims in Massachusetts in bitter cold. I've had four winters now. I get about twenty to twenty-five percent less fuel economy than in summer. Partly due to the tires, and driving through the snow. I warm my car up. I start it up, warm it up, and go back, and hug my wife and have a cup of coffee, when it's really cold, like 20 degrees. And let it run for five or ten minutes before I get in it. That's hurting my fuel economy. [Laughs]. You know what I mean?

I can live with that. So I'm going to get between a 46 and 52 in winter, where I'm going to get between 52 and 65 in summer for average numbers. But they're perfectly fine. Hybrids are just as good as anything else. In some ways, when the electric motors kicks in, when you're going up a hill. It's all torque and no horsepower. So, it's great. When you're going in snow, you want to have torque. You don't want to spin the wheels. So you put it into low gear, and you nail the throttle, and your little LED lights light up, so that your 'assist' is on, and that sucker is perfect in the snow. I love it. It's lightweight, so you better not go fast. Nobody should go fast on ice.

BB: I got this question from somebody who lives in the Southwest. You mentioned before that the computer sets the batteries to always be charged at least twenty percent, and never more than eighty percent [to increase the batteries' longevity]. Is there any chance that the batteries could run all the way down if the assist is on for a long time?

CVB: No. Not unless something is wrong with the car.

BB: Could you reach a point where the assist is no longer working?

CVB: It's happened with me.

BB: At that point, you're 100 percent on gas?

CVB: Right. And then the car takes some of that gasoline power away from the car to charge the batteries back up again. So it even gets worse. It still has reasonable power.

BB: So there's no risk, for example, in damaging the car or having to replace the batteries? You're just going to remove the extra benefit of having the electric assist?

CVB: All of the sudden, your Insight turned into a Geo Metro. You'll say holy cow, 'I don't have any power.' You're still going, and doing sixty miles an hour. You just don't have any power because of that unusual and very unlikely situation you're in. It will correct itself very quickly.

~~ The Longevity of Hybrids ~~

BB: What are your thoughts about the lifetime of a hybrid. In terms of breaking the car in, I've heard that your mileage improves after a couple of thousand miles.

CVB: With any car.

BB: And what about the longevity of the car?

CVB: We've got an electric motor that's going to last forever. It's brushless. There's only one moving part. And the bearings that support that centerpiece, on the Honda it's the crankshaft of the engine, so unless you ruin the crank shift bearings inside your internal combustion engine, you don't have a problem. That's the bearing support, if you want, for the rotor assembly that is the inside of the electric motor on the Honda. On the Prius, all we have is five years of driving and lots of miles and no failures. But they're using a bearing that's just lubricated with transmission fluid. But so far, so good. It looks like they're fine.

BB: So they haven't been around long enough to be really proven, but you're saying that these cars should last as long as any cars.

CVB: If not longer. The battery packs, by the way, we're seeing maybe a three percent deterioration over a simulated 150,000 miles, where they cycle it back and forth, 20% to 80%, 80% to 20%. They've been doing battery simulations for a long time. There's a bunch of companies that do that. In fact, I met with some of these companies out in California. At the hybrid symposium, I had a wonderful conversation with a few battery manufacturers. So these Nickel Metal Hydride's, as long as they're protected, and all the systems work as planned and they are, these batteries can easily go 200,000 miles, maybe 300,000, maybe forever. You just don't replace them.

~~ Shopping Tips ~~

BB: That would lead to the question of a burgeoning used hybrid market. I look online, and I see that there are used Prius's out there. What should someone be concerned about when looking at a used hybrid?

CVB: The same thing as anybody buying any used cars. Has it been in an accident? Was it maintained? Was the gasoline engine maintained? Did they change the oil when they were supposed to? There's zero maintenance on the hybrid system. Zero. So there's no maintenance to do to make sure the hybrid system is okay. There's

nothing there. All of these cars, by the way, have a 12-volt battery, so when those get older, they need to be replaced like any 12-volt battery. The worst case is 150 bucks.

BB: Anybody's fear about having to do a major battery replacement?

CVB: Should be gone. It just doesn't happen.

BB: What do you think the most critical consideration is when shopping for a new hybrid?

CVB: You only have three choices. You have the Civic, the new Prius, and the Insight. The only three in production. The three are so distinctly different. People should be able to figure it out quickly. They're not going to buy the Insight, if they need a lot of room. They'll buy the Civic if they want a five speed. They'll buy the Prius if they like it. The Prius loaded is now \$27,000. It's gone up. You can still buy a \$21,000 one, but if you want all the bells and whistles that most people will want, you're going to want some trim level upgrades.

BB: And that's where the Civic Hybrid comes with a lot of that stuff.

CVB: I'll tell you quite honestly, right now, if I was out looking for one, and money wasn't an object, I'd buy a Prius in a heartbeat. (note: ACDC bought a 04 Prius in Jan. '05)

BB: Just to see that thing work on a daily basis.

You got to understand that my roots are with Honda. I don't feel like a traitor for saying that, but my roots are with Honda. Now, when that Accord V6 comes out, that may change my mind. I have a lot of respect for Toyota. I recently met with them in Southern California. They have a lot to be proud of.

~~ Newsletter Wrap-up ~~

That does it for newsletter number two. I know it was a long one, but it was hard to cut down on the interview. I only included a fraction of what we talked about. Thanks a million to Craig Van Batenburg for taking the time out of his busy schedule. I'll be adding some of his comments to hybridcars.com in the coming weeks. I hope his insights (no pun intended) will lead at least a few of you to arrange for a test drive.

<http://www.hybridcars.com/drive.html>

Until the next time, happy driving.

Brad Berman

<http://www.hybridcars.com>

hybridCARS.com

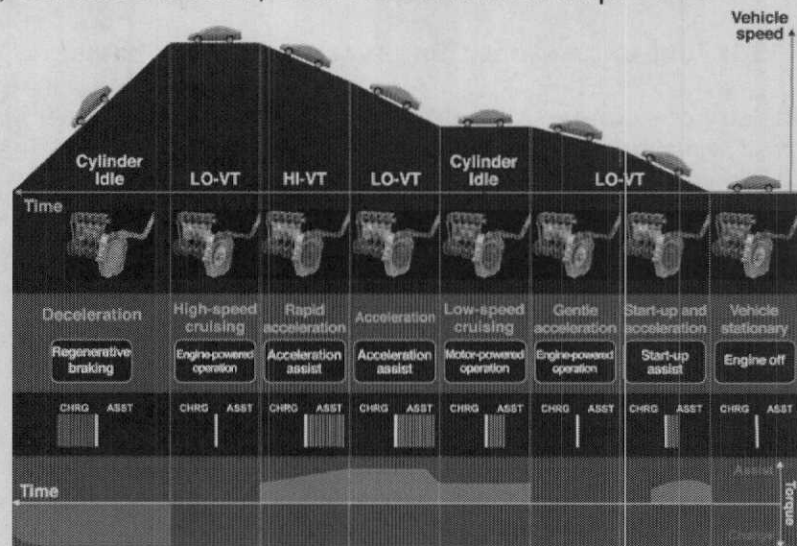
Honda Civic Hybrid 2006



This all new hybrid from Honda is an advancement that is not revolutionary but from the consumers mind it is a great leap. The car above is a pre production model that I had my hands on at the IMPA test days in

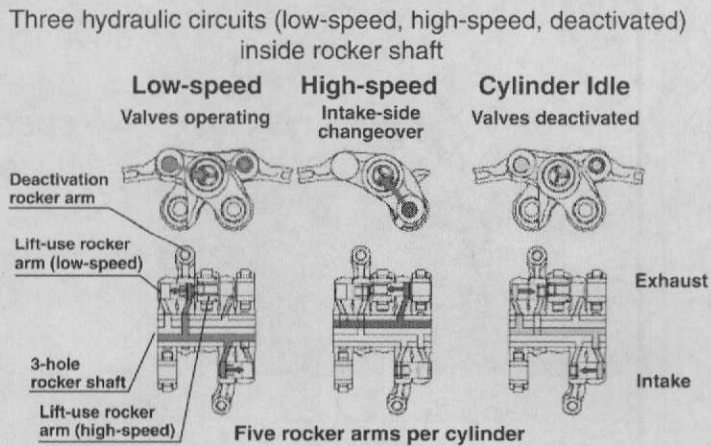
early September 2005. I fell in love with this car. It is better in almost every way, except it is no longer available in a standard shift, as the CVT is king. It is larger, handles better, and has a much improved braking system.

Honda suffers from NIH, "not invented here". Honda is always slow to get technology already introduced by another OEM to market (look at the PGM-FI system) but it is always better when they finally introduce it. This new "Brake-



by-Wire" system is very Prius like. The Honda OEM web site has little to offer on this system at this time. Other improvements are slighted higher voltages at 158 volts (a few more NiMH cells added), but what is most exciting is cylinder idling at low speed. This means that the new ***Civic Hybrid has an electric only mode***. This is a first for Honda, but it was easy to do as the IMA system pretty much stayed the same. The new IMA idles all cylinders rather than just three of them. At this time, the injectors are off, and the IMA HV electric motor is the only power producing source. The rotor for the IMA

system is bolted to the crankshaft so the ICE is still turning, it just isn't doing any work. This system is most likely buying time for Honda as they find a more Prius like system that they can call their own. For now it looks like Honda will sell all they can make. One other item worth noting; I ski, as do many others, and in both the Civic and Accord Hybrids the back seat does not go down or have a pass through. I feel this keeps some people out of these cars. The new 2004 Prius is more user friendly in this way, as is the Insight.

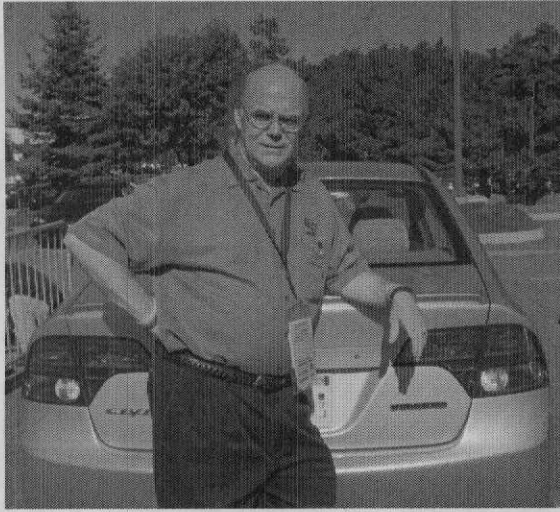


Valve operation	Motor operation	Driving condition
Deactivated	Regeneration	Deceleration
	Assist	Motor-powered
Low-to-mid engine speeds	Regeneration	Deceleration (When battery almost full)
	Inactive	Cruising
	Assist	Acceleration
	Inactive	Idling Stop
High engine speeds	Regeneration	Deceleration from high speed
	Inactive	Cruising
	Assist	Acceleration

The chart on the left shows how the new V-tec system is used to idle cylinders, but it also is used for increased performance. The rockers are now controlled on both sides with oil pressure and as in the past the cam has a street and race profile lobe for each cylinder. The new

Civic Hybrid is quick and gets 50 mpg. The Civic hybrid owners are Honda owners to begin with. Many need to be taught how to drive in order to get the best mileage. Consider having a hybrid open house at your shop to help owners get educated. It makes a big difference as to how you drive.





Craig Van Batenburg (who else) getting back from his first drive in the 2006 Civic Hybrid.

No special training of any significance, except on the new barking system, appears to be needed if you understand the earlier Civic Hybrid.

The dash lay-out is futuristic. A

couple new buttons to push. More on this car as I learn it. For now keep learning what you can and drive one as soon as possible. It will make a Honda hybrid believer out of you.



The IMA (Integrated Motor Assisted) system is a highly-efficient parallel hybrid drive system consisting of a main power unit (gasoline-fueled engine) and the assist unit (electric IMA motor).

The engine is an inline 4-cylinder, 8-valve power plant that has a displacement of 1,339 liters. To reduce fuel consumption, the IMA system is equipped with i-DSI, lean-burn control and valve pause system that reduces engine pumping loss and increases the regeneration of electric energy during deceleration.

The IMA motor, directly connected to the engine crankshaft, functions as a generator during deceleration, an engine starter, and a motor to assist the engine that drives the wheels.

The IMA system contains the DC 158 V battery and AC synchronous motor, control system, and related accessories. For safety, the intelligent power unit (IPU) is located behind the rear seat.

Idle stop

Idle stop will occur	<p>When the vehicle is driven above 7 mph (12 km/h) in D position, then decelerates with the brake pedal pressed (operation speed varies depending on the conditions).</p> <p>When the vehicle is driven above 7 mph (12 km/h) in D position after restart from auto idle stop condition, then decelerates with the brake pedal pressed, the engine will stop (two times only).</p>
Engine does not stop	<p>When the vehicle stops suddenly by sharp application of the brake pedal.</p> <p>When the engine coolant temperature is low.</p> <p>When the climate control unit prohibits the engine from stopping.*¹</p> <p>When the PCM (CVT system) prohibits the engine from stopping.*²</p> <p>When the IMA battery state of charge is low.</p> <p>When the IMA battery module temperature is low.</p> <p>When the electric load on the 12 V system is high.</p> <p>When the accelerator pedal is pressed.</p> <p>When the ignition switch is ON (II), just after starting the engine.</p> <p>When the windshield defrost button is on.</p> <p>When a fault is detected in a related system.*³</p> <p>When the A/C mode switch is</p>

*1: With the ambient temperature at 59 °F (-15 °C).

*2: When the CVTF temperature is low.

*3: PGM-FI system, IMA system, CVT system, A/C system, etc.

When the following engine restart conditions are met, the PCM restarts the engine by driving the IMA motor via the MCM and restarting fuel injection.

BMC

Battery Condition Monitor (BCM) Module

The BCM module computes the battery module state of charge (SOC) and controls the IPU module fan. The system's SOC computed by the BCM module using voltage, temperature, input current, and output current readings from the battery module.

Motor Control Module (MCM)

The MCM converts 158 V DC power into 3-phase AC power to run the electric motor during assist. During regeneration, the MCM converts AC voltage to DC.

The MCM module controls the DC/AC conversion (from the IMA battery's 158 V DC to the IMA motor's 3-phase AC and vice versa).

The MCM module is air cooled. The heat fed through the heat sink is exhausted to the trunk compartment and outside of vehicle by the IPU module fan.

The MCM controls the IMA motor to control the assist and regeneration.

IMA Motor

The IMA motor is a synchronous AC type that converts electrical energy into kinetic energy and vice versa, assists the engine during acceleration, and starts the engine.

The motor is located between the engine and the transmission. It consists of a 3-phase coil stator and a permanent magnet rotor that is directly connected to the engine crankshaft. A motor rotor position sensor is mounted on the back of the engine block to detect the position of the rotor.

Battery Module

A light-weight and compact Ni-MH (nickel-metal hydride) battery supplies energy to the IMA system.

The battery has 11 modules that are connected in series. Within each module are 12 1.2 V cells. Total battery voltage is a nominal 158 V, and maximum capacity is 5.5 Ah.

The battery module has 3 built-in thermistor-type temperature sensors, and a PTC (positive temperature coefficient)-type temperature sensor for each cell.

Junction board

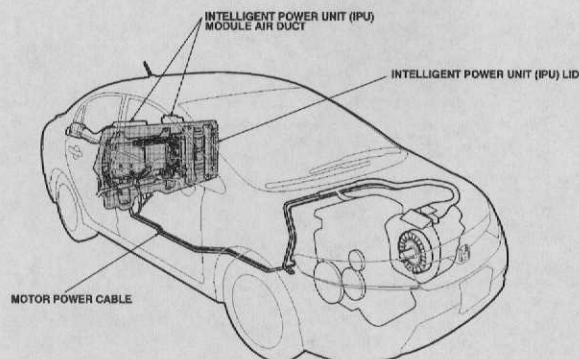
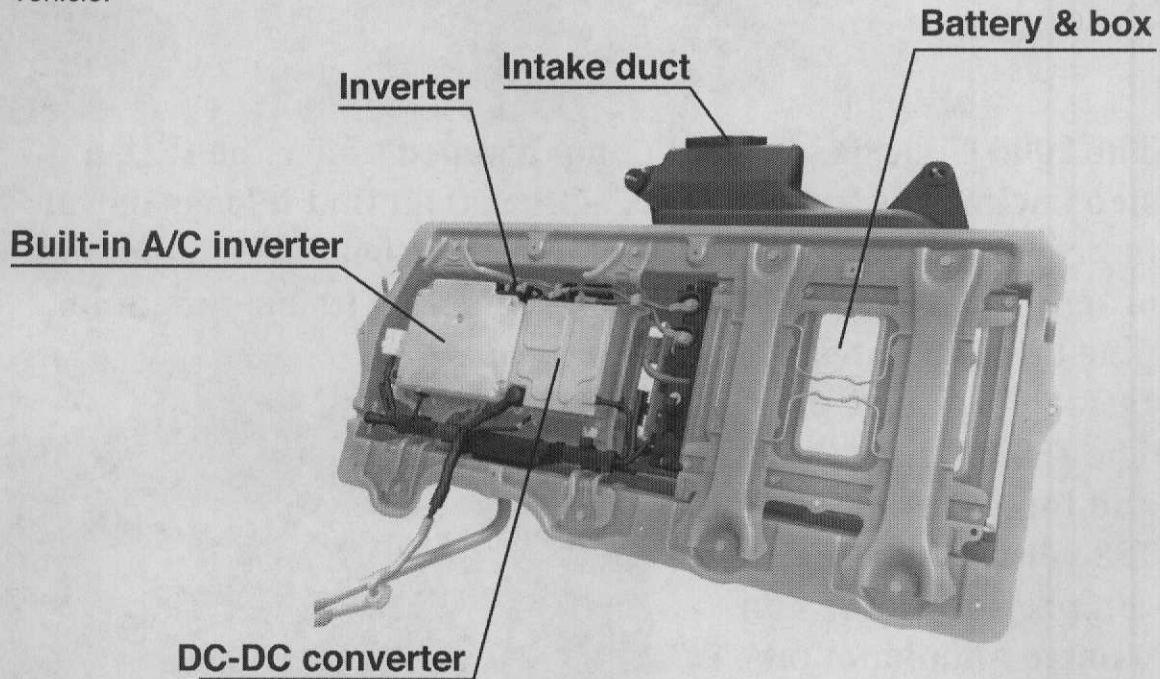
The junction board, mounted on the battery module, distributes high voltage energy to the IMA system. The contactors, bypass resistor, and the battery current sensor are all on the junction board.

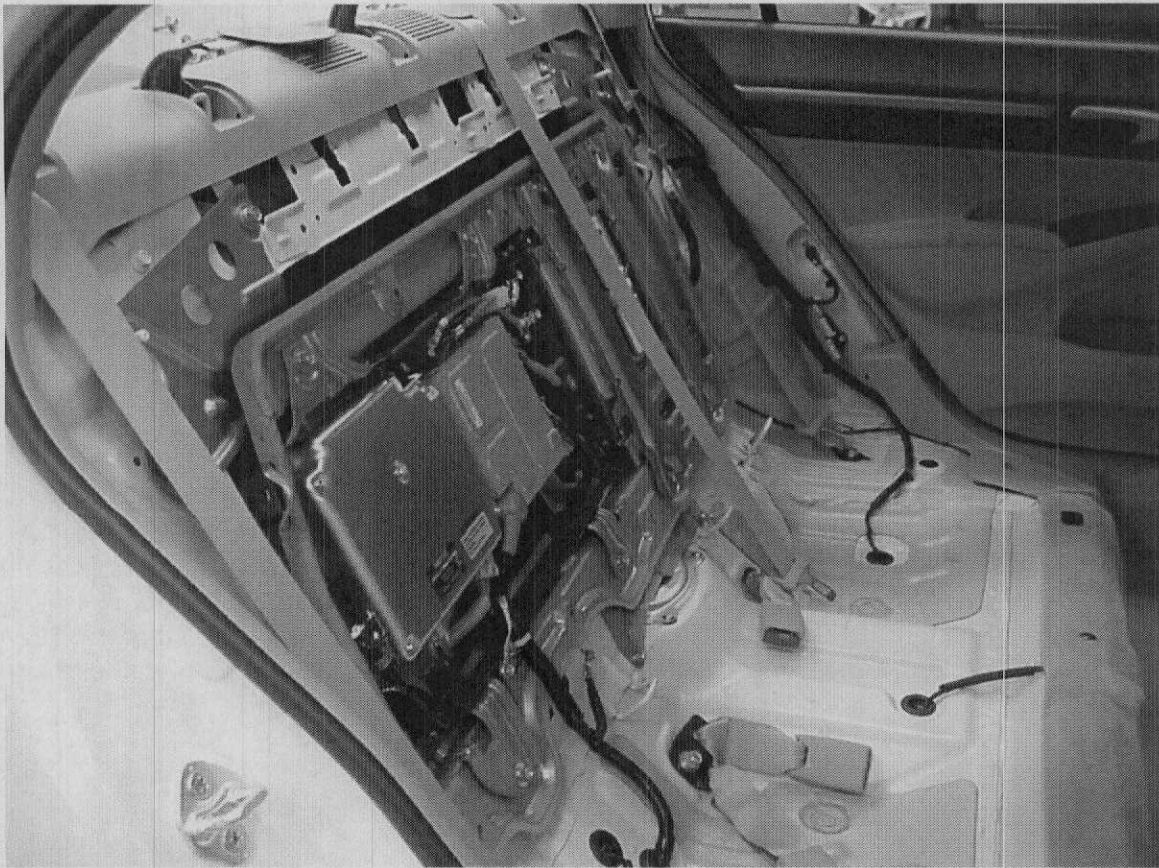
IPU Module Fan

The battery module, the MCM, the A/C compressor driver, and the DC-DC converter generate heat during assist/regeneration. The IPU is equipped with a fan to cool it down, assure proper battery performance, and protect the system. The fan has a control circuit and rotation sensor that are controlled by the BCM module. The cooling air is drawn into the battery module from the top of the rear tray, then it is exhausted into the trunk compartment and outside of vehicle through the MCM heat sink, the DC-DC converter and A/C compressor driver heat sink.

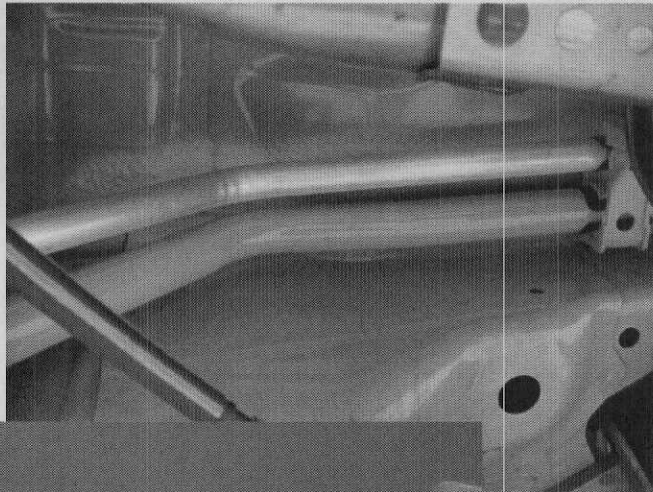
Power Cables

The IMA motor power cable connects the IMA motor and the motor control module (MCM). The cable goes through an aluminum pipe for damage protection and to prevent noise. Also, the A/C compressor power cable goes through the same aluminum pipe. The other aluminum pipe is parallel to the IMA motor/A/C compressor pipe that the 12 V power cable from the DC/DC converter goes through. These pipes are connected in one piece with the pipe clamp (orange), and attached under the vehicle.

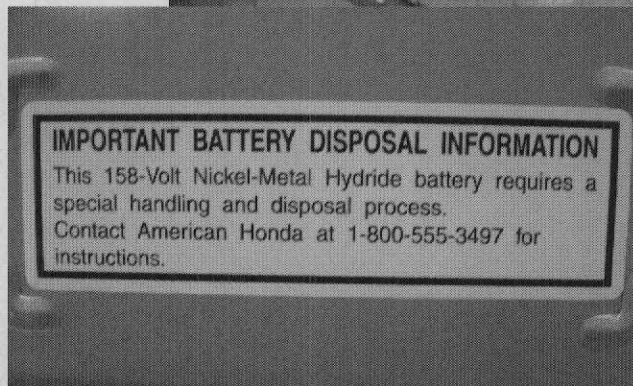




The 2006 Civic has the fuel pump trapped under the IPU, a step backwards from the 2005. Other than that it looks like an improvement in every way. In the picture below, note that the orange covered cables have been replaced with an aluminum pipe that is painted orange. Inside the orange pipe is The 158 volts for the IMA and three smaller wires of 158 volts for the A/C compressor. In the non painted aluminum tube is the 12-14 volt cable? (my guess).



**Who do you call?
Call ACDC as we
are looking for
used HV battery
packs.**



Honda Accord Hybrid 2005 -2006



Available only in a 4 door automatic for 2005 this car sells for just over 30K. It went on sale December 10, 2004. Sales were brisk, sold out immediately. It is different in concept to the Insight and Civic as it is performance based. It is fast at

255 hp. The AT is conventional in the sense it is not a CVT. No standard shift was available at introduction. I first saw this car at the IRL race in California, October of 2004. It uses the cylinder deactivation of the hybrid Civic but goes one step further in that it shuts down the rear bank for cruise as well as for more regenerative braking. VCM, variable cylinder management. This way

TECHNICAL FEATURES

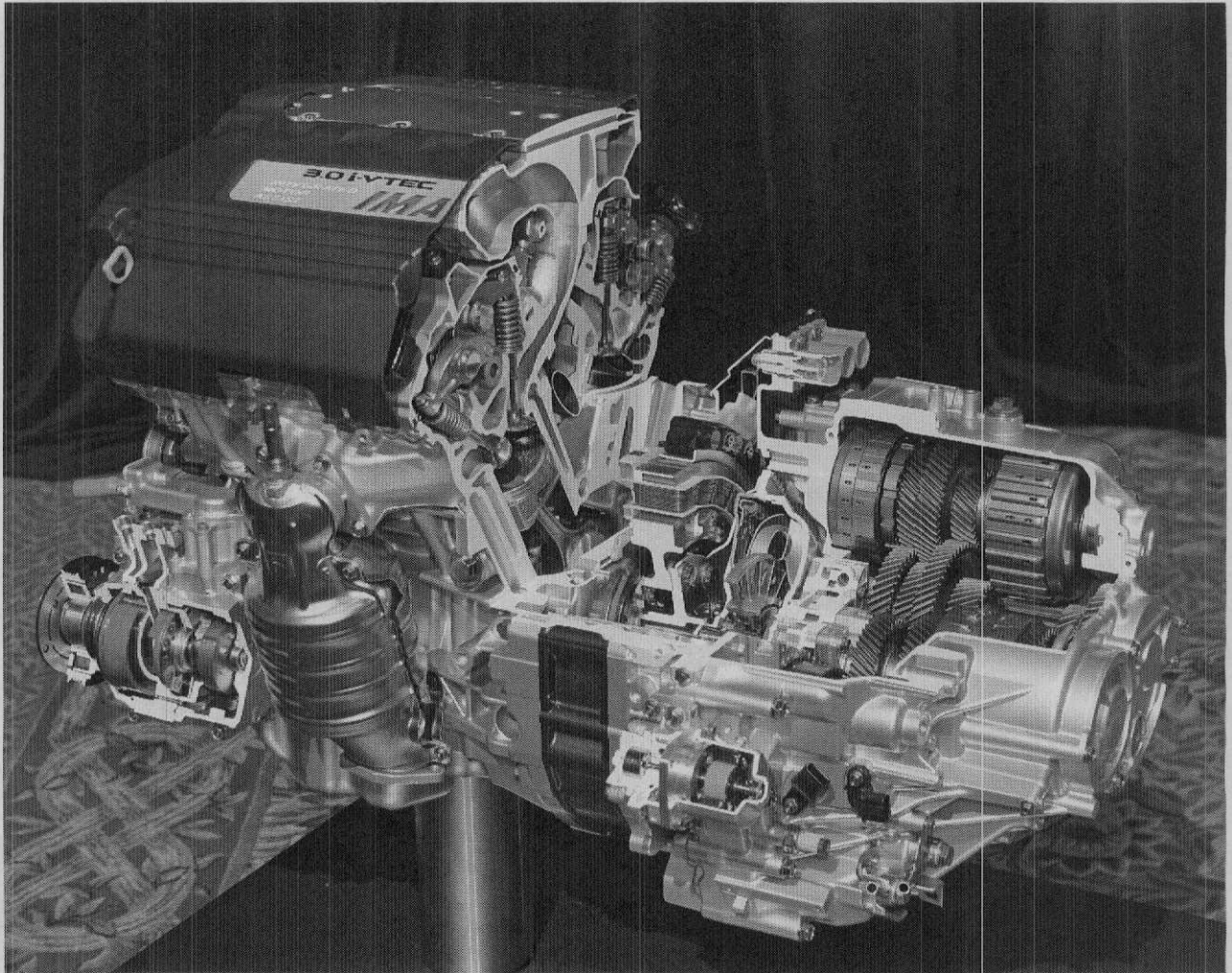
- 255hp 3.0 Liter SOHC 24-Valve i-VTEC V6 Engine with Variable Cylinder Management (VCM)
- IMA System
- CARB Ultra Low Emissions Vehicle Certified (ULEV)
- Compact 5-Speed Automatic Transmission
- Idle Stop Feature
- 4-Wheel Disc Brakes with Electronic Brake Distribution (EBD)
- Front and Rear Double Wishbone Suspension
- Front and Rear Stabilizer Bars
- Electric Power Assisted Rack and Pinion Steering (EPS)
- 105K Miles – No Scheduled Tune-ups (Under Normal Conditions)

INTERIOR FEATURES

- IMA Charge and Assist Indicators
- Available Honda Satellite Linked Navigation System with Voice Activation
- Leather-Trimmed Seating Surfaces
- Dual-Zone Automatic Climate Control
- Heated Front Seats
- AM/FM Stereo with 6-Disc In-Dash CD Changer, Anti-Theft Feature and 6 Speakers
- XM Satellite Radio
- Steering Wheel Audio Controls
- Driver's 8-Way Power Seat with Adjustable Lumbar Support
- Leather-Wrapped Steering Wheel
- Power Windows with Auto Up/Down Driver's Window
- Front Center Console with Sliding Armrest

Honda allows better fuel economy on the highway and when the V-tech system hooks all the cylinders back up again, the car has a lot of power. If power is what drivers want, then it looks alike Honda has a found a new use for the IMA system. But didn't Honda use this system in the old F1 days?

As you can see the Hybrid Accord drive train is an IMA system with the electric motor sandwiched between the ICE and transmission.

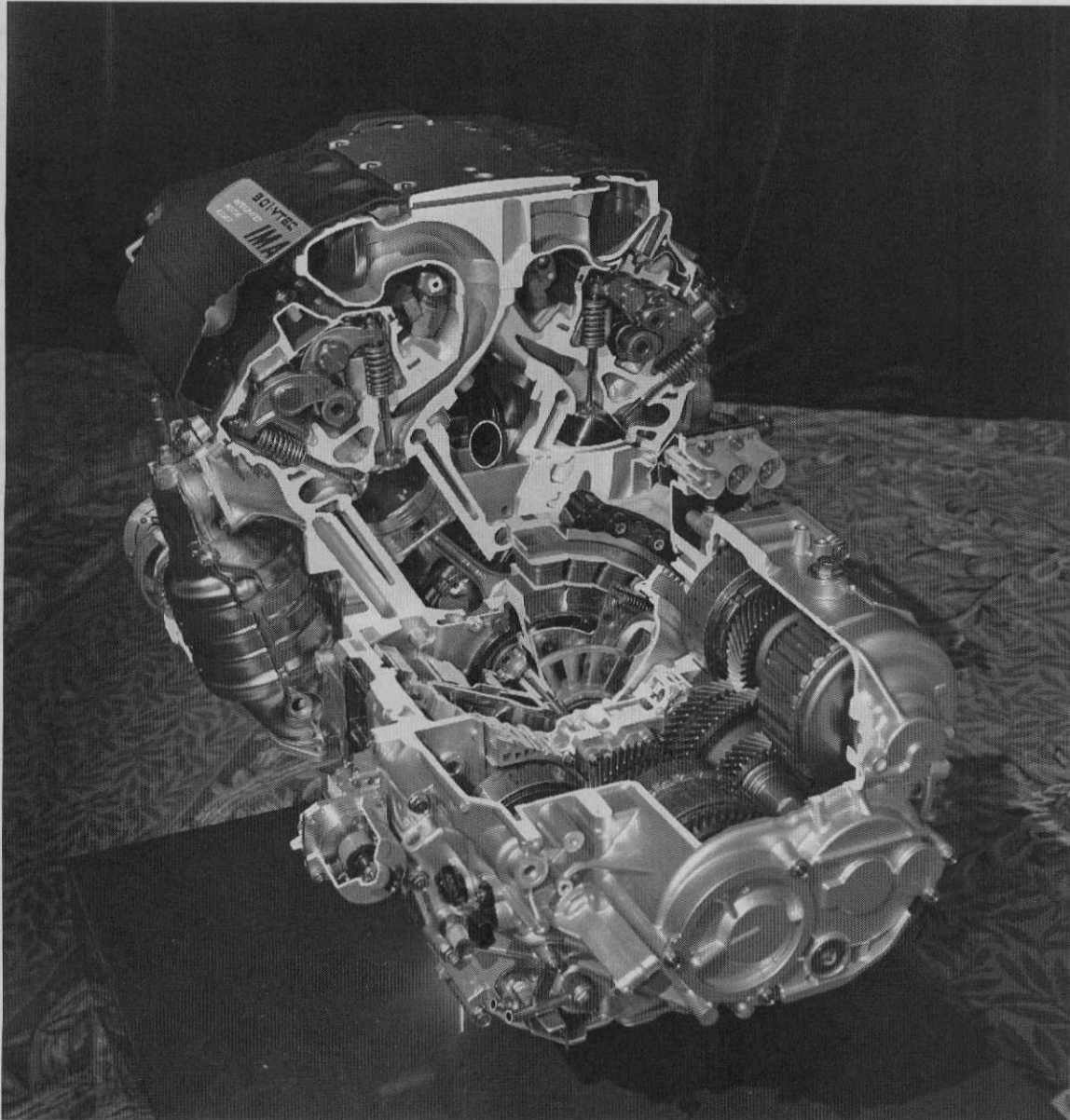


Note the electric pump used to keep the AT alive when in “Idle shut down” mode. Also note the A/C compressor is both belt and electric driven.



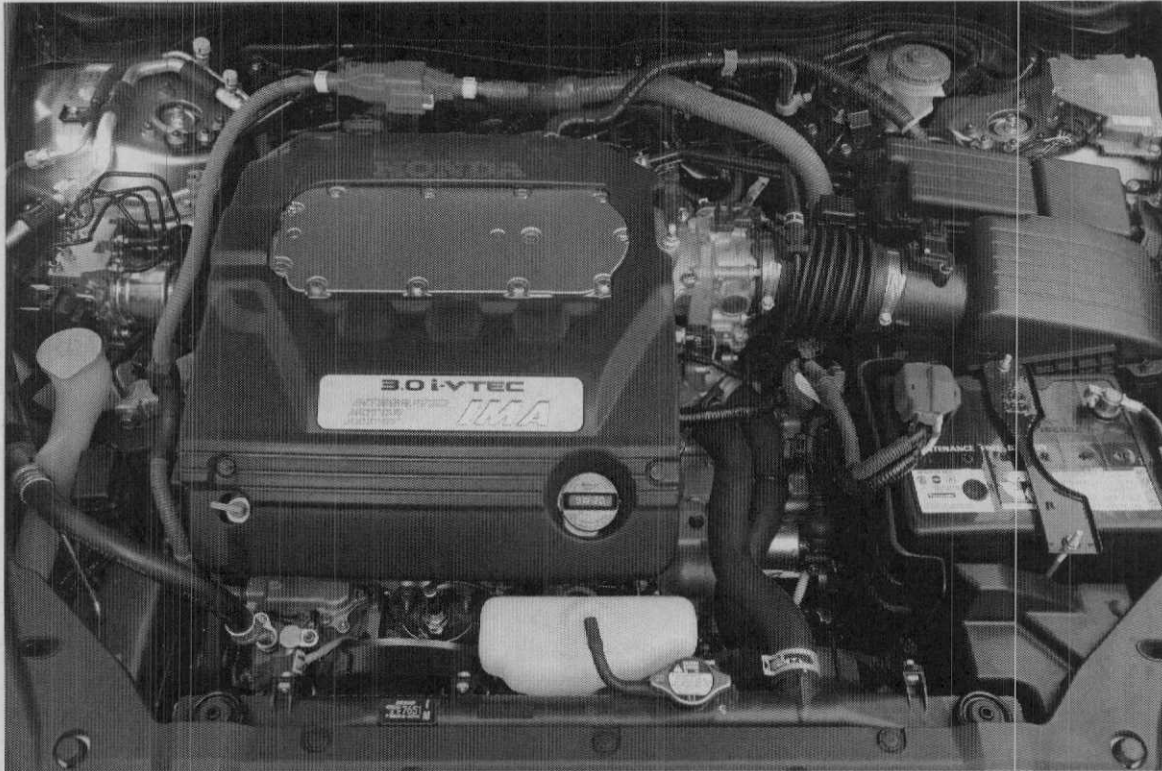
The compressor is two-in-one. The electric part is small and used for cool air while idle shut down mode. This allows for idle shut down with A/C on maximum settings. The belt driven part is conventional and provides max air. More improvements mean better mpg and lower emissions. At times both segments work together.

Hard to argue with that progress.

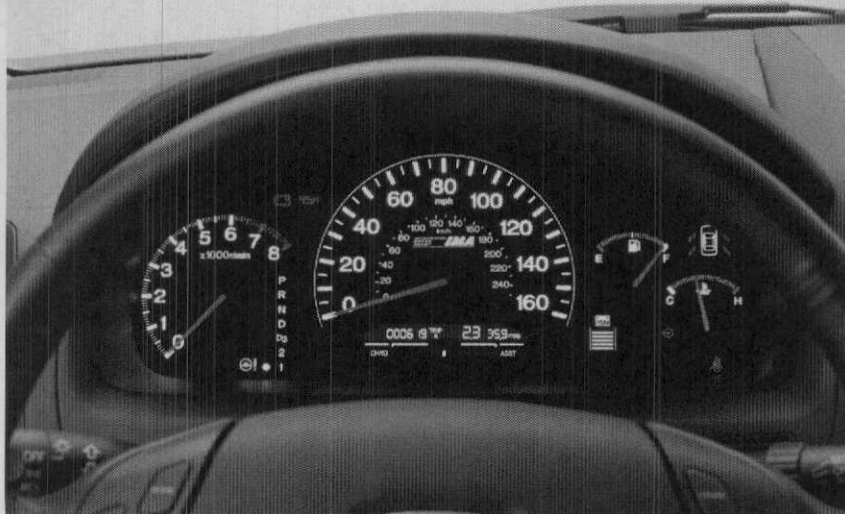


In this view the IMA is very easy to see. The conventional alternator is replaced by regenerative braking. The small 12 v starter is not shown.

The Accord is a BIG change as to how we see Hybrids. It is more about HP than MPG.



This shows the orange cable, new MAF with the MAP. The MAF is from OBDII monitoring. Note 5-20 oil, not the 0-20 of the Insight / Civic. Other changes for the Accord that do not share the Civic /



Insight strategies are horsepower over fuel economy. Luxury over utilitarian. Leather seats are standard; lots of hybrid owners are vegetarians. This is the first example of what

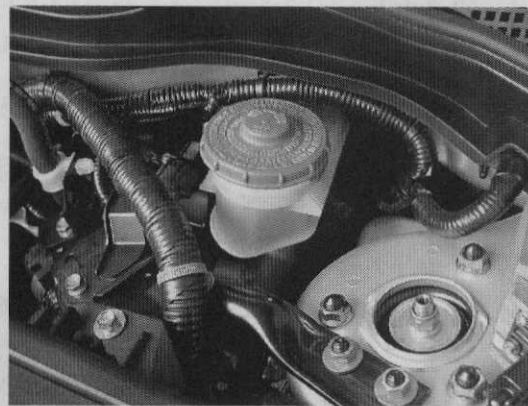
most hybrid owners (up to this point) have objected to in terms of their world views. So far all hybrids have been 3 or 4 cylinders, CVT or 5 speed. What does all this mean? Maybe Honda knows something about their customers. Time will tell.

The Accord Hybrid Dash uses more conventional gauges. Just below the speedo is the Charge / Assist LED's. To the right is the HV battery indicator, much like the Prius.

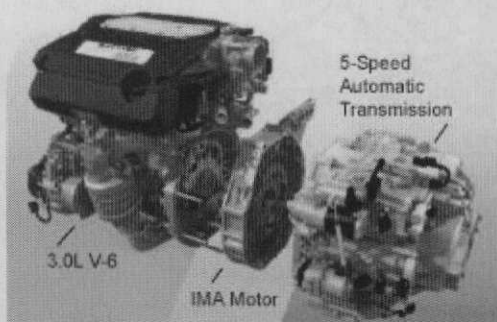
The MAP, PGM-FI, speed density system (call it what you like) has been changed. Honda has used the PGM-FI system in the US since 1985. Unless you had an Isuzu Honda (and that would be a shame!) you would not see any type of



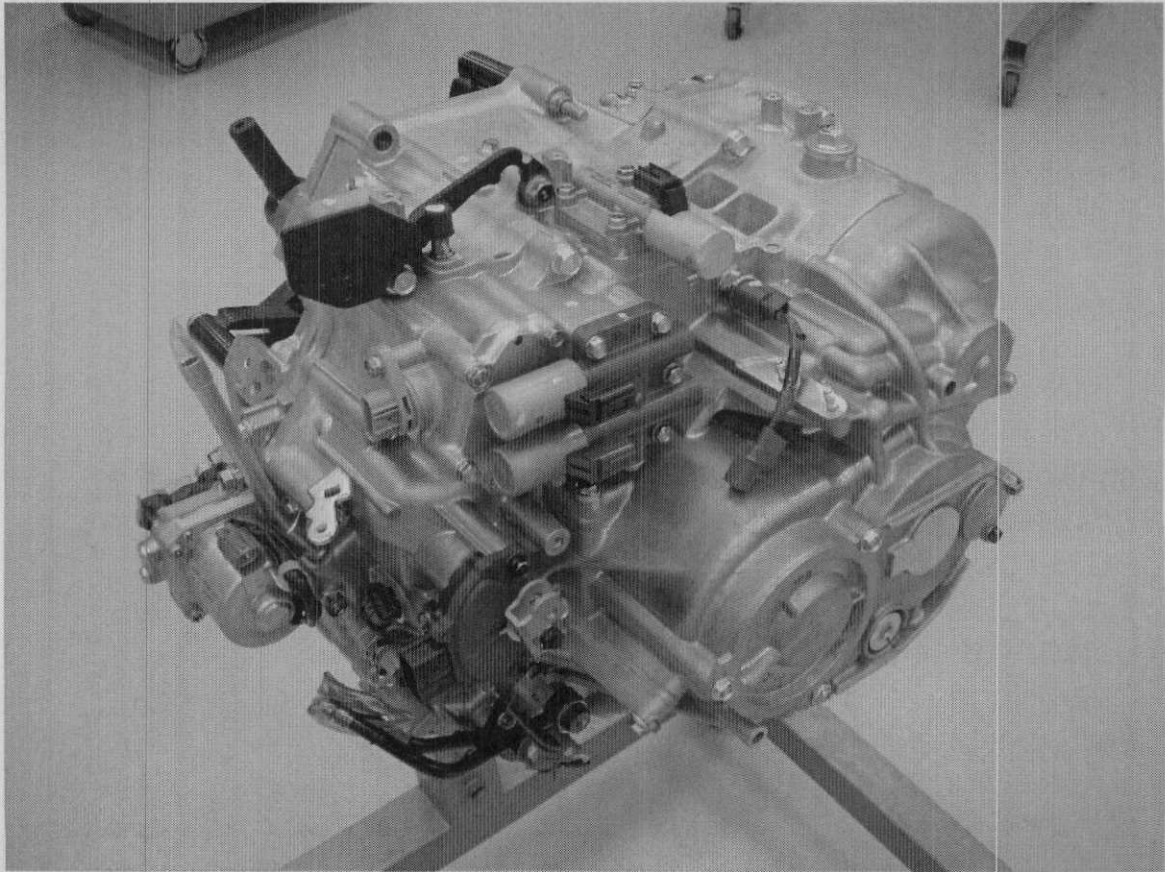
AFM. Air was always calculated. You may want to buy my Honda / Acura book as well. It is on my web site. If you look on the outlet of the air box you will see a MAF sensor. Honda says that the MAF is for OBDII monitors, not fuel trim. The MAP is in its usual place, just on top of the throttle body. Now air leaks might mean something more than before.



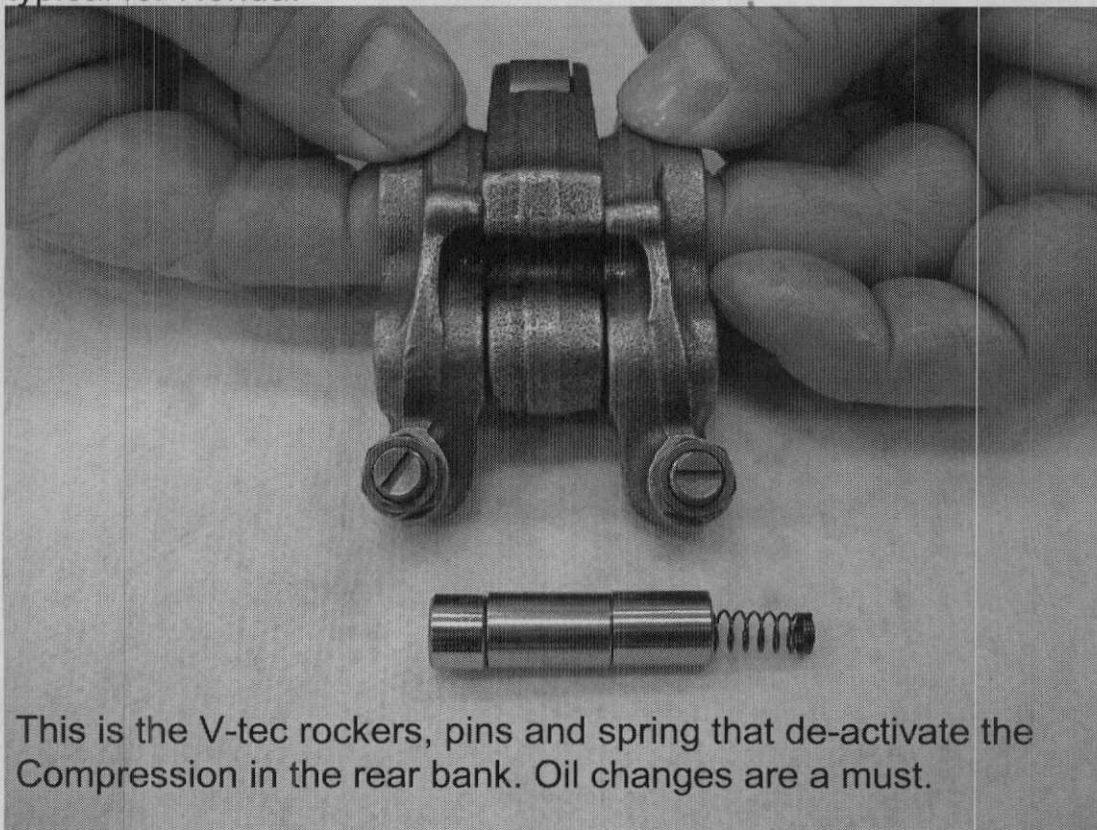
The braking system stays the same for the Hybrid Accord. An extra MAP sensor signals the hybrid ECU for low vacuum in the booster.



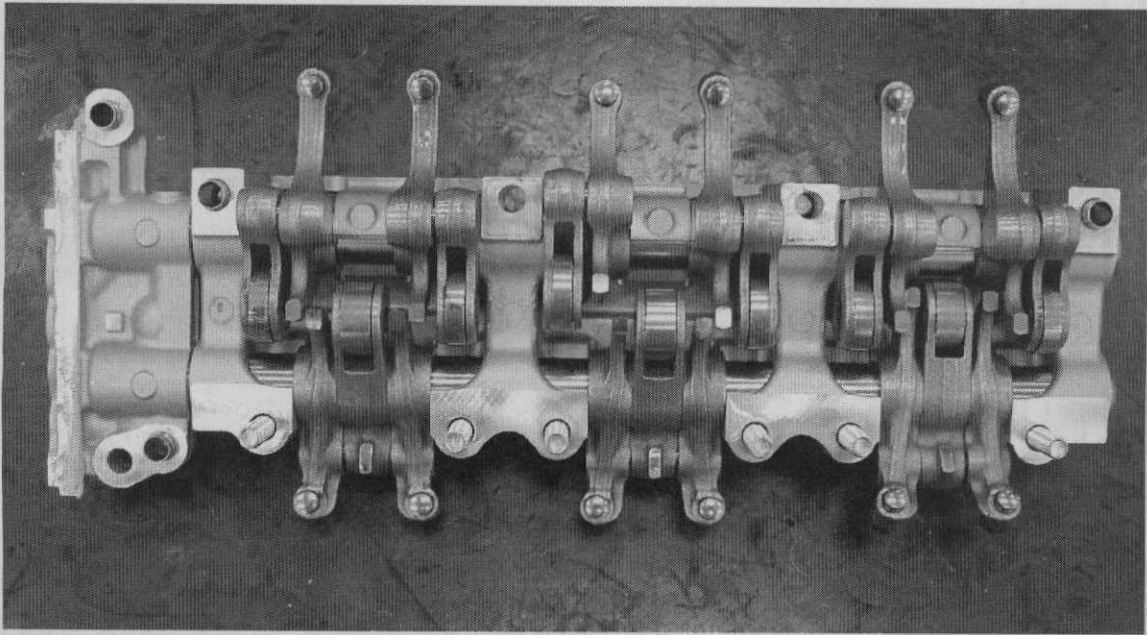
This picture makes it easy to see the Accord IMA system in three main parts. On a drivability problem, turn off the IMA and drive it. If the problem is gone, it is in the IMA system. If it is still there it is an ICE issue.



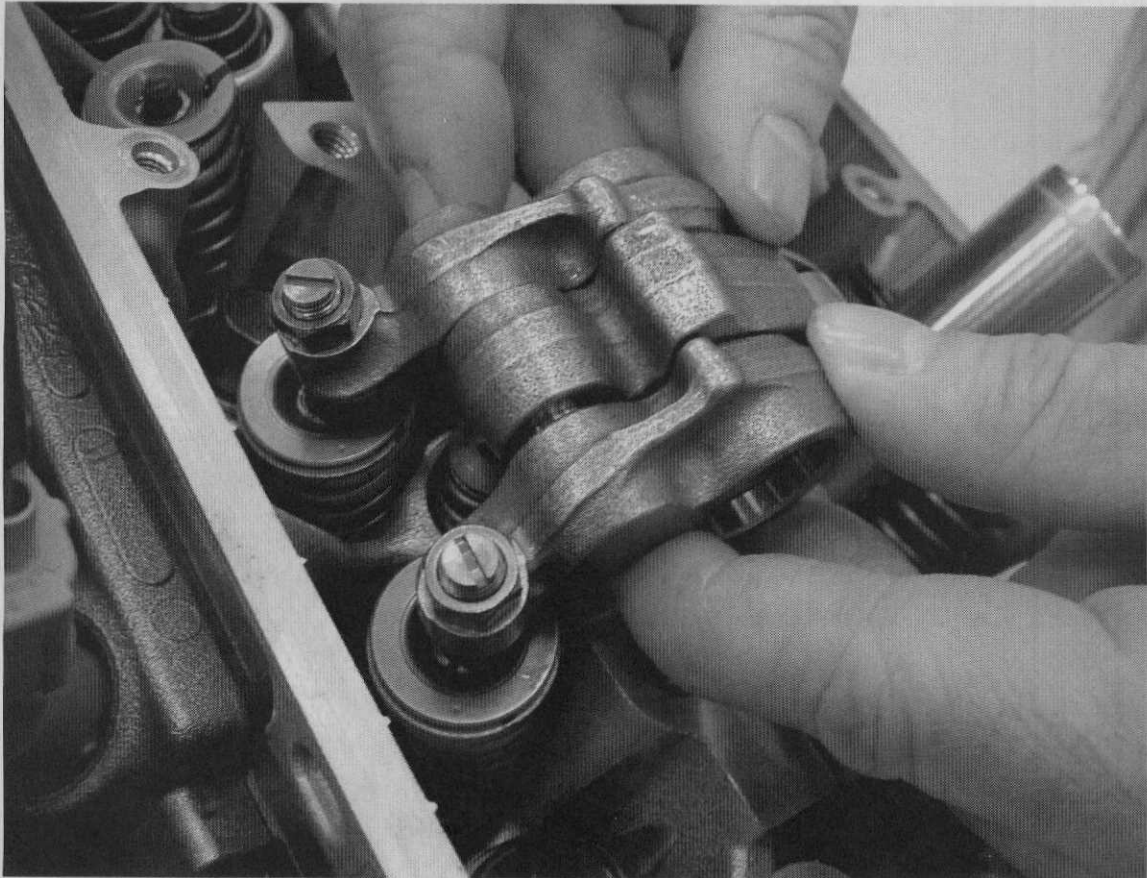
This transmission is straightforward. Electrical connections are many so pay attention to the electrical portion. No filter or pan as is typical for Honda.

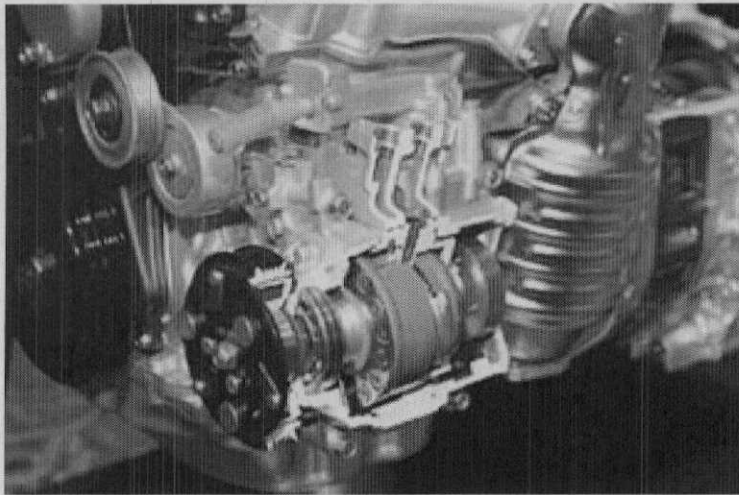


This is the V-tec rockers, pins and spring that de-activate the Compression in the rear bank. Oil changes are a must.



This rocker assembly is on the rear bank only, and the V-tec rocker pins are supplied engine oil at times when the compression of the cylinders would interfere with the IMA system being able to regenerate electricity. It also saves fuel when running on only 3 of 6 cylinders. Small springs keep the rockers busy when they are not pushing on valve stems.





The A/C Compressor has two modes of operation. In belt mode it is a typical compressor. In electric mode it pushes less cc of refrigerant and therefore is not as effective.

The Accord Hybrid's instrument panel incorporates an exclusive meter display that shows key operating indicators of the IMA system, including the state of the IMA battery charge, the level of IMA motor assist or charge, and a light to indicate Idle Stop mode. There is also an "ECO" light to indicate that the vehicle is achieving a high level of fuel economy and the VCM is operating in 3-cylinder mode.



IMA, VCM and Idle Shut down

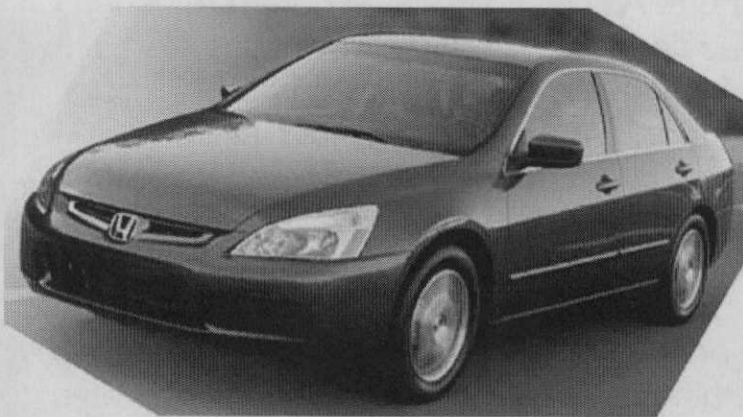
The IMA system's 12-kilowatt, high-output, electric motor contributes more than 100 lb.-ft. of torque to the Accord Hybrid's 3.0-liter V-6 engine during hard acceleration and recaptures kinetic energy generated during deceleration and braking for storage in the IMA system's NiMH nickel-metal hydride battery pack. When cruising at steady speeds where less engine power is required, the VCM system deactivates the V-6 engine's rear bank of cylinders, closing both the intake and exhaust valves for reduced fuel consumption. It shuts off

the rear injectors but continues to fire the spark plugs.

Under light acceleration from a cruising state, the IMA motor can provide power assistance to the engine in three-cylinder mode. When coming to a stop, the IMA system shuts off the vehicle's engine at speeds below 10mph to reduce fuel consumption and emissions. At the moment the driver releases the brake pedal, the IMA motor instantaneously restarts the gasoline engine. This allows for AT creep. New hybrid owners want their hybrid to act like their old car.



The Accord Hybrid makes use of a 3-liter V6 i-VTEC engine that is essentially the same as the engine used in the Accord EX. However, the aluminum-block has some additional brackets that permit mounting a magnesium composite head cover for the Variable Cylinder Management (VCM) system that's used for the hybrid, as well as for the Integrated Motor Assist (IMA) electric motor. The VCM is based on the i-VTEC (intelligent Variable Valve-Timing and Lift Electronic Control) system that's used on many Honda vehicles.



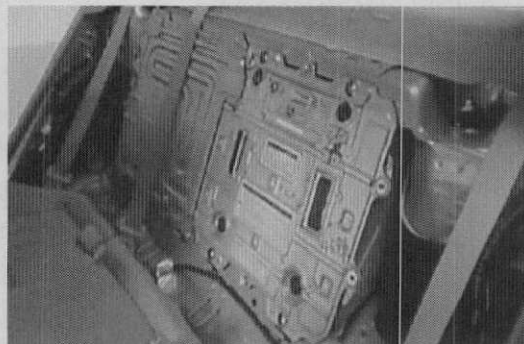
Ordinary i-VTEC operates at high RPM. In the case of the Accord Hybrid, the three cylinders on the rear bank of the engine are deactivated by a hydraulic circuit, even when operating at low RPMs. Among other things, the system

controls ignition timing and turns the torque converter lock-up on and off so that there isn't a jolt when switching between three- and six-cylinder operation. Because there are increased vibrations associated with shutting off a bank of cylinders, there is an Active Control Engine Mount (ACM) system that turns on actuators to move

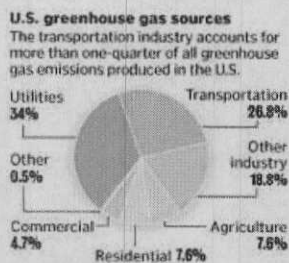
in synch with the vibration so as not to transmit vibrations to the vehicle occupants. **These electronic motor mounts operate on 24 volts.** Additionally, there is an Active Noise Control (ANC) system in the cabin that measures the booming noise from deactivation and emits via the audio system an opposite sound wave to cancel out the booming. To diagnose this system a CD is used in the CD player to talk you through a sequence of radio checks. The CD is a special tool.

The IMA is a 68-mm wide DC brushless motor that's located between the engine and the five-speed automatic transmission. The transmission is similar to that used for the Acura MDX SUV, but there are differences, like an integrated electric oil pump. This oil pump is important because there is an idle-stop feature of the car, which means that the gasoline engine is off at a stop light and other times. Consequently, the electric pump is used to pump oil through the transmission's torque converter.

The IMA also makes use of an intelligent power unit (IPU), which controls the electricity going to and from the electric motor. There is a bank of Sanyo NiMH batteries (consisting of 120 1.2-V units) that's located in a U-shaped module behind the rear seat; the

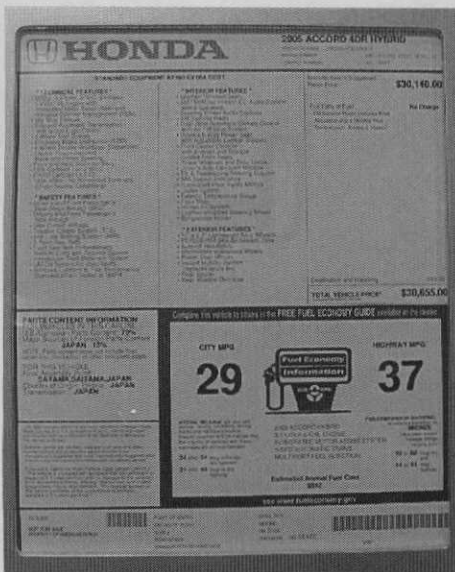


batteries are charged by the IMA, which acts as a generator when the vehicle is braking or decelerating. The IMA provides up to 16 hp and 100 lb-ft. of torque. Which brings the total to 255 hp (240 from the gas engine) and 232 lb-ft of torque at 5,000 rpm. Unlike the Toyota and Ford, the Honda system doesn't operate under electric motor power only. Honda insists their IMA is a full hybrid system, one that uses its electric motor for motive power, versus a mild system that uses its electric component for non-motive features, such as idle



stop or accessory power (read this GM). There is nothing inherently more efficient to systems that offer motor-only operation, like the Prius or Escape. Those systems require larger batteries, bigger and heavier motors, and more complex control systems all of which add weight, complexity and cost. This is Hondas take on it.

There are some other changes to the basic Accord. Aluminum is used for the hood, front and rear bumper beams, and rear suspension knuckle. The objective of these and similar changes (e.g., the magnesium engine head cover) was to reduce the weight of the vehicle because adding the hybrid system to the Accord, naturally, increases overall weight, which decreases efficiency. The engineers were able to reduce the weight of the vehicle by 176 lb. so that when the hybrid system was installed, the curbweight of the vehicle was up just 120 lb. (There are visible changes, too: a "Hybrid" badge; integrated rear spoiler; unique aluminum wheels; roof-mounted antenna for AM/FM and XM.)



The Accord Hybrid is being produced in Honda's Sayama, Japan, factory rather than Marysville, OH, where most of the Accords sold in America are built.

A few more interesting notes. Honda is feeling the pressure from Toyota as the Prius outsells all 3 Honda hybrids combined. On the Accord Hybrid they added a small electric pump to keep the anti-freeze mixture circulating so you have heat at idle stop. The 97' Prius had that feature. The electric pump on the

AT runs only at idle stop so that the transmission will not slip on take off.

I had a new Accord hybrid for 4 days and 400 miles. Great car, fast, handles very well, nice in every way. It wants you to step on the gas so mpg may be low for most people. It works best under 60 mph where the 3 cylinder mode kicks in. Over that speed the mileage drops from a real 36 mpg to 27 mpg. That is 3 cylinders vs. 6.

Let hybrids into the HOV lanes?

On Nov. 19, 2004 Rep. Brad Sherman (D-Sherman Oaks) introduced a bill to the U.S. House of Representatives that would allow solo drivers of hybrid cars to use the High Occupancy Vehicle (HOV) lanes. California passed a law in September allowing hybrids that get at least 45 miles per gallon unrestricted access to HOV

lanes, but because HOV lanes are built with federal funds, they are governed by federal regulations. Sherman's bill is a waiver of the passenger requirement that applies to all states. Even if the bill does pass, the Accord Hybrid's mpg's would keep it from qualifying; however, the Civic Hybrid and Toyota Prius would.



Photos: Honda.

2005 Honda Accord Hybrid Specs

Priced at: \$29,995 - \$32,510

Powertrain: 3.0-liter single overhead cam V-6 with variable-valve timing and lift and cylinder deactivation mode; 15-hp AC-motor; five-speed automatic transmission; front-wheel drive

Horsepower: 255 at 6,000 rpm

Torque: 232 pound-feet at 5,000 rpm

Curb weight: 3,513 pounds

O-60 mph: 6.7 seconds

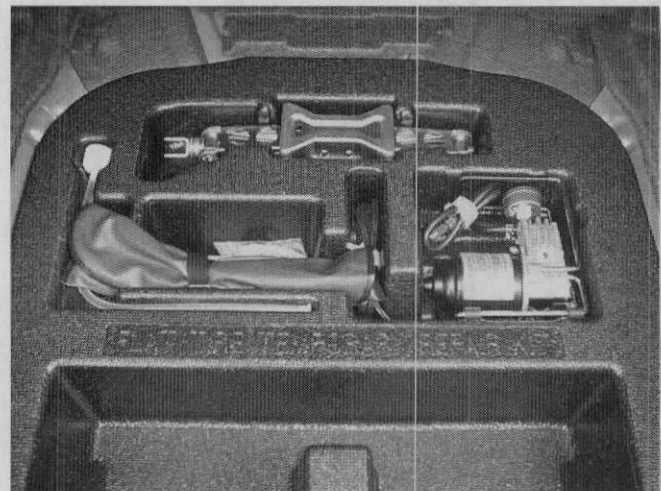
Wheelbase: 107.9 inches

Overall length: 189.5 inches

EPA fuel economy: 29 miles per gallon city, 37 highway



No spare tire, just a can of goo and a pump. A real spare will fit in the space.



Before we get into the Prius, let's look at the Electric Motors (EM) more carefully.

To do this John Wayland, an Insight owner, and engineer from the west coast has agreed to help me out. Here are some E mails we exchanged.

The Insight (same as Civic and Accord) type of motor is called a permanent-magnet-"brushless DC". It's a common type of motor found in a wide range of applications. Several EVs use this type of motor, too. Maybe John Wayland can comment.

Glad to join in the conversation

Nothing special to Honda and every electrical engineering student gets to learn about it along with DC, synchronous, asynchronous, servo and other motor concepts.

The DC in the name is confusing, though. It is actually a lot like a permanently excited synchronous AC motor. The key difference (if I remember correctly) is more in the drive than in the motor: AC usually uses sinusoidal current, while the brushless DC is rectangular.

The name is definitely confusing, because a brushless DC motor is in fact, an electronically commutated AC motor. A standard fare permanent magnet (PM) DC motor, like the tiny ones used in slot cars, or the ones used in cordless electric drills, are also AC motors....I'll explain. All motors spin by utilizing AC (alternating current) no matter if they are a series-wound DC motor like the starter motor in a car that gets it's power from a pure DC source via the car's 12v battery, or an AC induction motor as found in your everyday washing machine that gets its power from the AC line voltage coming from the wall socket.

The names 'DC motor' and 'AC motor' then are to describe the power source the motors run off of. Series wound, shunt wound, compound wound, and standard PM are all type of DC motors, and all of them have a wound armature (electromagnets) that spins and delivers the

hp and torque out its shaft. All of these DC motors also have fixed, none moving fields that interact with the electromagnets of the armature in an attraction/repulsion affair that cause the armature to rotate...this is how the motor 'works'. The fields in all but the PM motor, are wound types...PM motors usually have a magnetic ceramic 'ring' that surrounds the spinning armature. To get the motor action to take place, and since the wound fields are simply powered up to provide a none changing magnetic field (the permanent magnet fields of the standard permanent magnet motor also provide a none changing magnetic field) the armature's electromagnets need to be fed an AC voltage, not the DC voltage of the supply to the motor. Feeding an AC voltage into the armature causes the electromagnets to change their magnetic field from north to south with each reversal of the AC signal, and this causes the repulsion/attraction of magnetic fields that cause the armature to spin.

To get AC from the DC source, the power coming into the armature is 'commutated' via the commutator and brush rigging....in other words; the power is converted from DC to AC using an electromechanical device. The commutator is made up of smooth copper conduction bars that wrap around the motor shaft at one end and that have brushes that ride against them and make electrical contact. As the armature spins, the bars make and break contact with the brushes, and this then switches the DC current into AC current. Though this setup has worked for 100 years, it isn't the best way to go and it has it's problems:

- (1) In all of these DC motors, including the PM type, the windings of the armature get hot and need to be cooled, but being that they are located in the center of the motor and are spinning, this is hard to do.
- (2) Because of the windings and the com bars of the commutator, the armature is limited in how many rpm's it can turn before it flies apart from centrifugal forces.
- (3) Because the brushes need to always make good electrical contact with the com, they are pressed against it with pressure from springs, and this creates mechanical drag.
- (4) To have good electrical conduction and lubrication qualities, the

brushes are made from carbon. This material works well, but not perfect, and there is electrical resistance in the brushes.

(5) The motor's brushes are 'timed' for the best efficiency as a motor, but this ideal motor timing is the worse type for using the motor as a generator. If the brushes are instead, timed to act the best for a generator, then the generator makes a poor motor. It is not possible then, for a motor with properly timed brushes to act as an efficient generator, and it is not possible for a generator with properly timed brushes to act as an efficient motor.

(6) There electrical limitations in the com/brush configuration that limit the amount of current and voltage that can be fed to the motor without a resultant fireball from brush 'flash over'.

(7) The brushes and com are wear-out items that need maintenance, and as the brushes wear down over time, they create conductive brush dust that can lead to flash over and motor failure.

(8) Efficiency in the range of 87-90%.

What if we could rearrange things? Taking a PM type wound armature motor, let's take the magnets off from their field position, put them on the armature, and take the armature's windings and put them on the outside of the motor. While we're at it, let's throw away the commutator and brushes and replace them with transistors that can electronically switch the DC into AC. Now that there are no windings and no commutator, we won't be calling the spinning part of the motor the 'armature', but instead, it gets a new name, the 'rotor'. The rotor can be made as a solid chunk of magnetized parts, and without wires and com bars to fly apart, it can spin much faster than an armature....this makes for higher rpm hp! With the windings now mounted on the outer perimeter (as the fields of a shunt or series-wound motor are) of the motor, they can be easily cooled with heat sink fins, or liquid cooling. Since the commutator and brushes are gone, there are no longer these items to wear out, flash over and arc, and to cause mechanical drag and electrical resistance. Using modern electronics and stout transistors to do the work, this new kind of PM motor can be electronically commutated as the DC current is switched into AC and fed to the field coils on the outer perimeter of

the motor, and as this happens, the magnets in the rotor will try to follow the shifting magnetic field as the rotor spins...isn't this cool?

Here's what we end up with:

- (1) A PM motor with the parts reversed so that the PM's are in the rotor and the windings are in the fields.
- (2) A smooth and solid rotor instead of a wound and commutator equipped armature.
- (3) Mechanical commutation that can wear out and arc, replaced by a solid state motor controller.
- (4) A motor that never needs maintenance, which can spin up to very high rpm's without damage while providing a greater amount of power.
- (5) A motor that is always timed perfectly by the solid state controller that controls phase shift and commutation angle, so that this machine can be both a terrific motor AND a terrific generator.
- (6) Efficiency in the range of 95-98%!

Are there downsides? Not many. From a backyard EV builder's perspective, the cost for a high power BDC motor and its requisite 3 phase AC controller is way more than that of an off the shelf series-wound motor and DC controller. However, in the long run for OEM's, it is actually less expensive to design from scratch, a BDC motor and controller than it is for them to design and build big series-wound motors and controllers.

With the Insight, Honda engineers were very clever and they made the ICE's flywheel and the BDC's rotor one in the same. The ICE's flywheel has PM's in it, turning it into a rotor for the BDC.

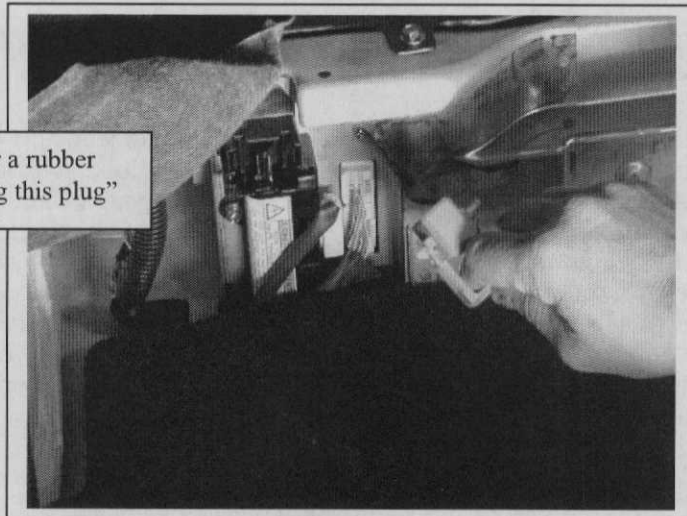
Hope this helps....John Wayland

Toyota Prius 2001-2003 Now known as the “Classic Prius”



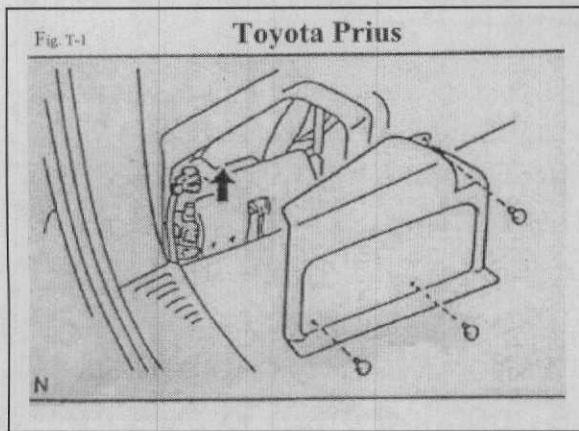
De Power HV : Open trunk. Remove trunk lining at left rear by seat. Wearing 1000v rated rubber gloves, find service plug (it is U-shaped) and remove it by folding small handle down and pulling it out. Wait 5 minutes and the High Voltage System should be safe. Test any high voltage cables (orange) with a voltmeter before handling them to be sure you have 12 volts or less, not 275 volts!

Toyota says “wear a rubber glove when pulling this plug”



12 Volt Battery

If the glass matte 12v battery is low or dead, it can be jumped like any other battery. It is stored away in the trunk, left side under a cover. Must use Toyota replacement battery or at least a glass matte battery that can be vented. Remember that batteries have fumes (it is vented with a hose to the atmosphere) and it is in the trunk with the HV batteries! Due to high parasitic draw Toyota has a higher capacity battery available. It was installed in some cars under warranty. Their 12 volt battery was their biggest customer concern.



A Quick Education into 12 V Glass Matte Batteries

(used with permission)

GETTING LONG LIFE FROM YOUR BATTERY: A sealed glass matte lead acid battery does not have a "memory" problem like NiCad's. Unfortunately, unlike NiCad's, lead acid batteries are easily damaged if they are left in a deep discharge condition, or if they are overcharged, so it is important to charge them up immediately after use & to use an approved charger designed for small lead acid batteries that current tapers the charge to zero, or cuts off at the correct Voltage & then pulse charges. The life expectancy of a sealed glass matte lead acid battery is a combination of how deeply it has been discharged, how long it stayed discharged before charging it back up & how many times it has been discharged. It's best not to completely drain the power from a sealed glass matte lead acid battery. **You will get more life from your battery if you only drain it to the half way point & charge it up immediately.**

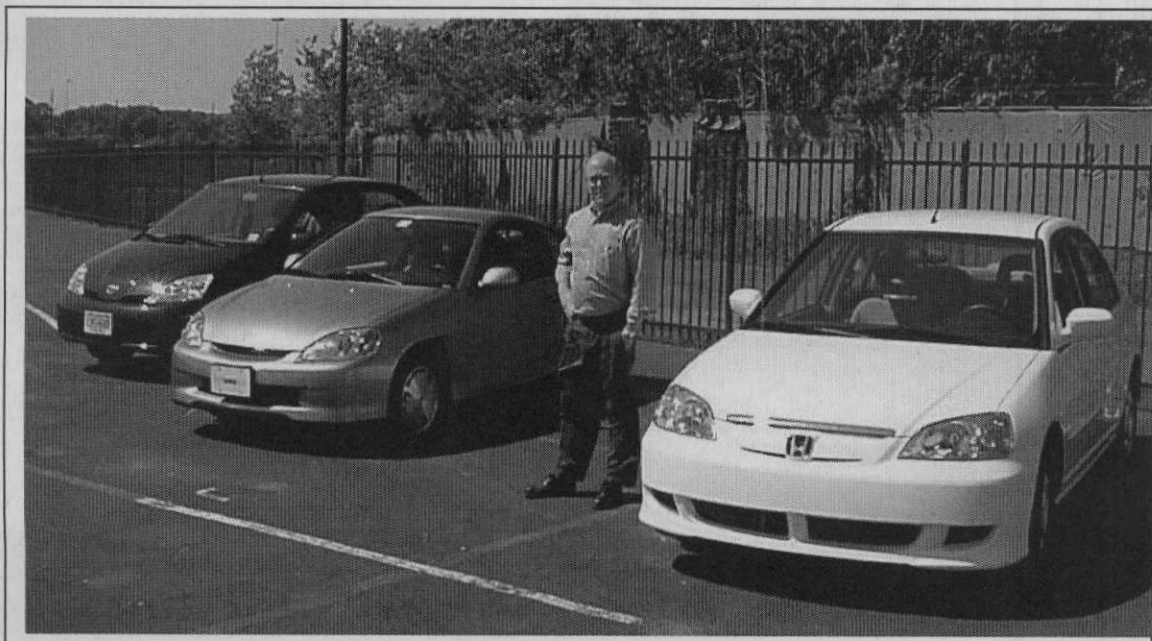
CHARGE/DISCHARGE RATE: A glass matte sealed lead acid battery accepts a **discharge / charge rate up to 40% or higher of its Amp/hour rating** until it gets to about the 80% charge level, then charges more slowly from 80-100%. A slightly warm battery during heavy discharge or charging is ok, but a really hot glass matte battery indicates that damage is being done to the battery. The maximum safe battery temperature is 125 degree F (52 degrees C).

Written by **Doug Hembruff** of Ontario Canada



This type of battery charger was designed for motorcycle applications. It is compatible with glass matte batteries. Low cost and available at most cycle shops. Charging time is at least 24 hours if not more.

Below Craig Van Batenburg is showing off the only 3 hybrids on the market in 2002 at the Tour De Sol in New Jersey. Stan Stephenson of ARI and Don Schnell from TFE were the other two driver/educators. The white Civic Hybrid was a pre production model.



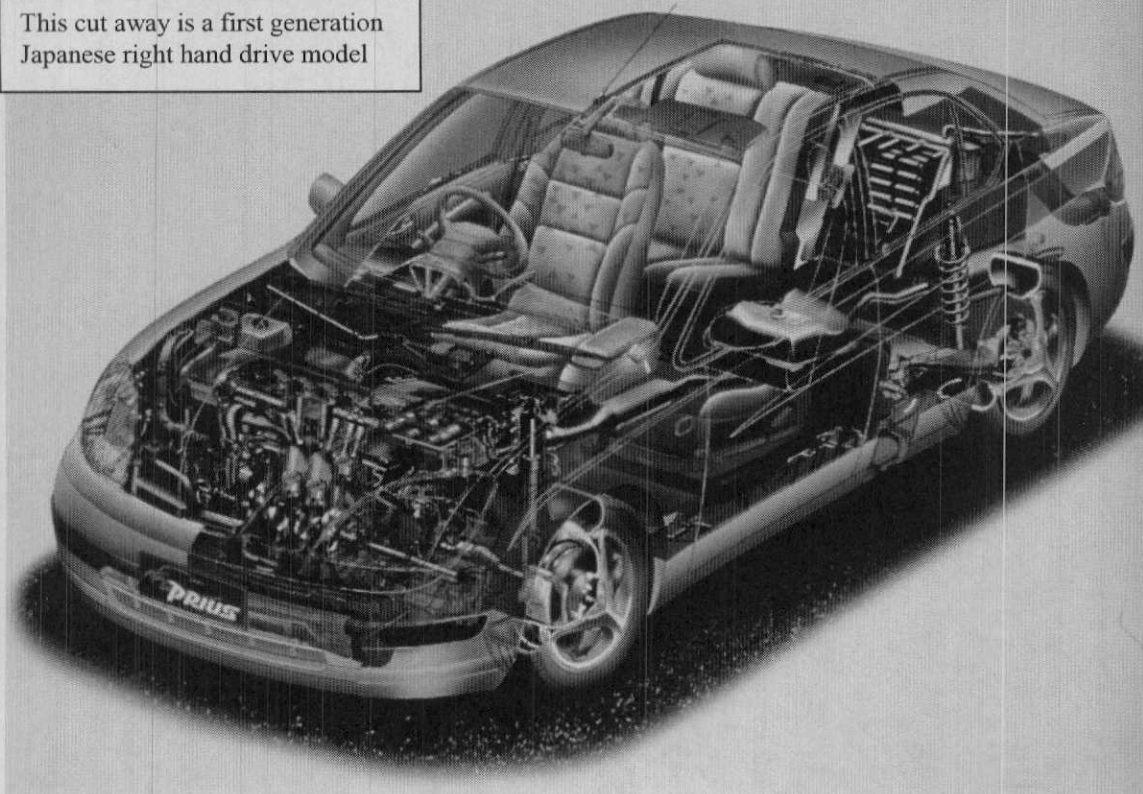
DLC is located at left of steering column, under dash and is very easy to find. All hybrid data is reported via the DLC to the scan tool. Remember a hybrid code is a P0A__ code and will be a reason for a state inspection emission failure.

Oil is 5/30. capacity is 4.0 quarts

The Classic Prius is a very popular car with their owners. There are many chat groups on Yahoo.com

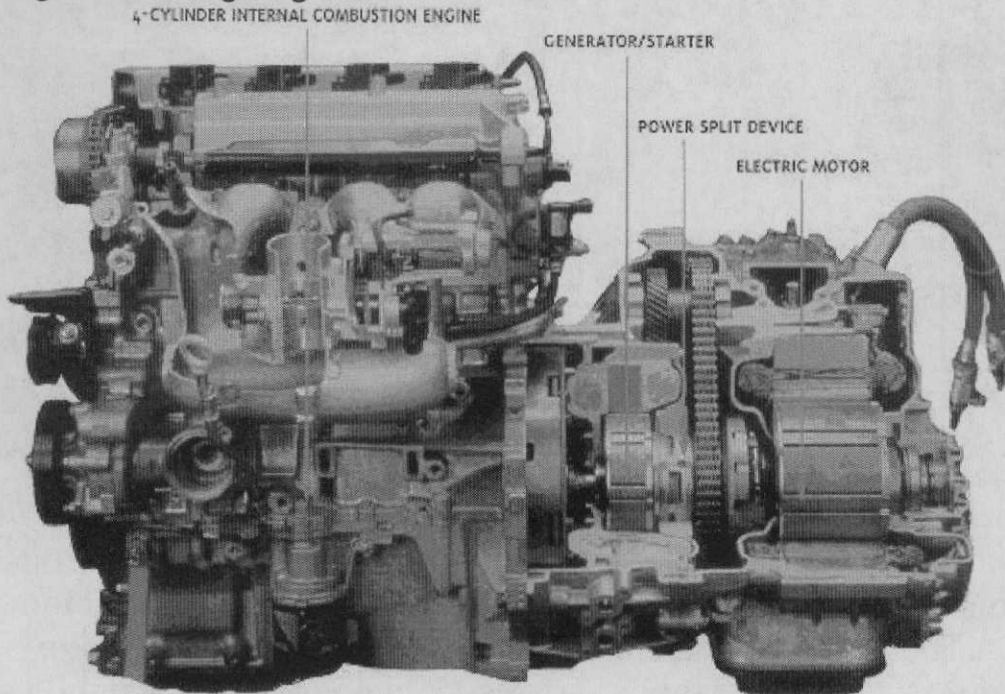
www.hybridcars.com has a \$10.00 book you can down load. It is loaded with interviews with Hybrid authorities, me included. Worth the 10 bucks for sure.

This cut away is a first generation Japanese right hand drive model



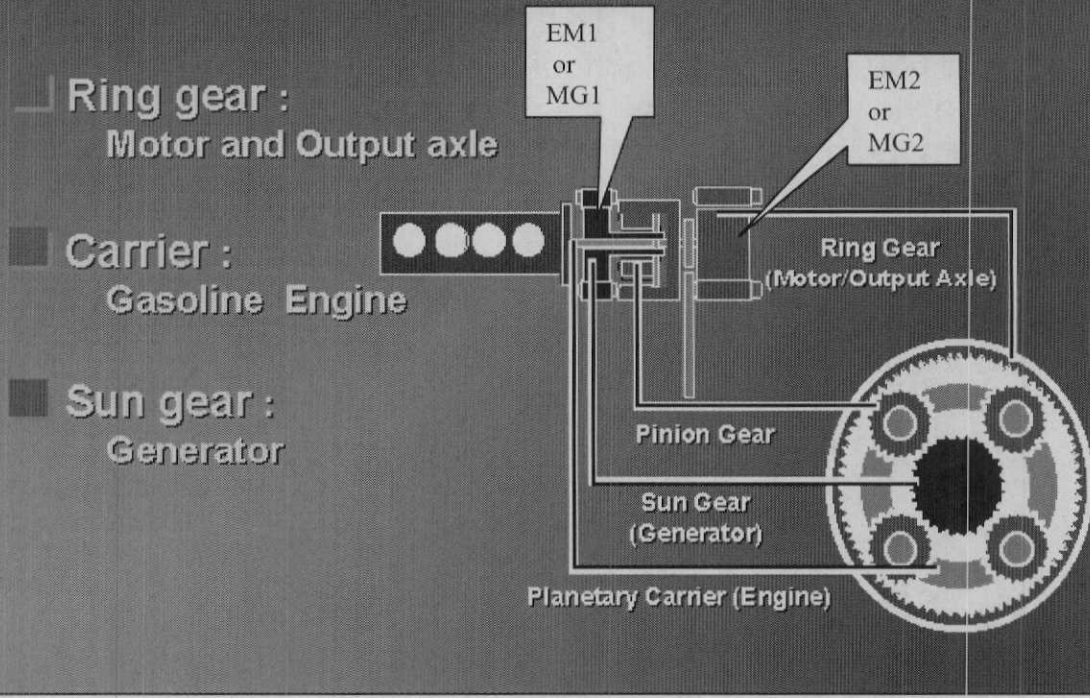
How the Prius CVT Transmission works.

One of the two electric motor (EM2 or MG2) is rated for 44 H.P at 1,000 to 5,600 rpm. It has 258 foot-pounds of torque at 400 RPM! This is the electric motor that can drive the car. It has enough power to get the car going without the ICE.



The CVT, continuously variable transmission, is not like any other. See figure below. The power split device (a planetary gear set) allows the Electric Motor (EM2) and the ICE to both power the wheels, either together or separately. Another electric motor (EM1 or MG1) is hooked up to the sun gear. EM1 is the starter for the ICE. EM1 also controls the speed of the engine and output of the transmission, thereby creating a continuously variable transmission. By speeding up EM1 or reversing the direction of EM1, the I.C.E.'s RPM's can be kept within a small window and still accelerate the car. Therefore the speed of the car and the ICE can be controlled. The EM2 is bolted to the ring gear, the crankshaft is bolted to the planetary carrier, and EM1 is connected to the Sun Gear. A chain connects the outer part of the ring gear to the differential, thereby driving the front wheels. The ICE can quickly get to a running RPM of about 1,600 to 2,400 rpm and stay there while the car accelerates

Planetary gear (power split device)



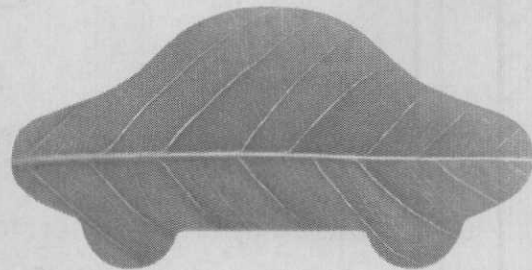
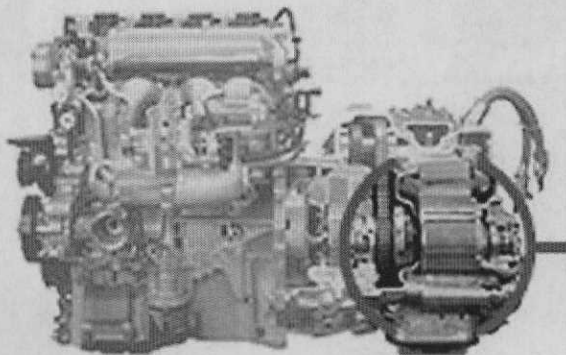
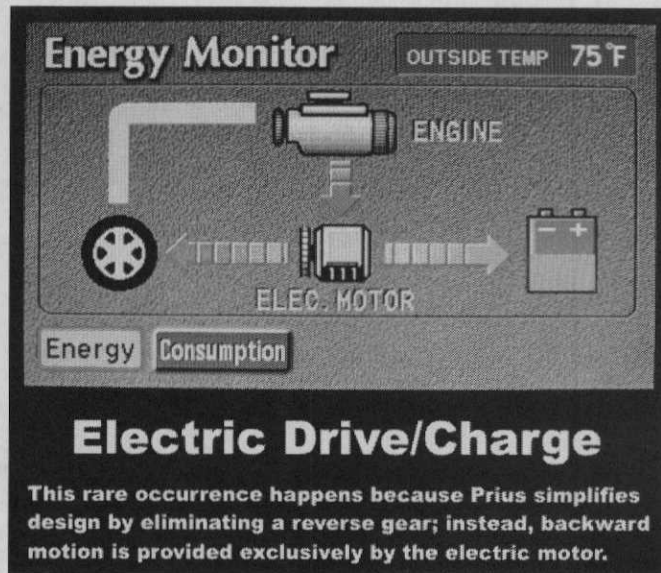
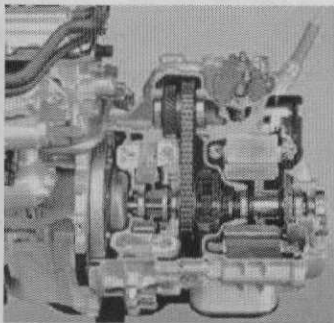
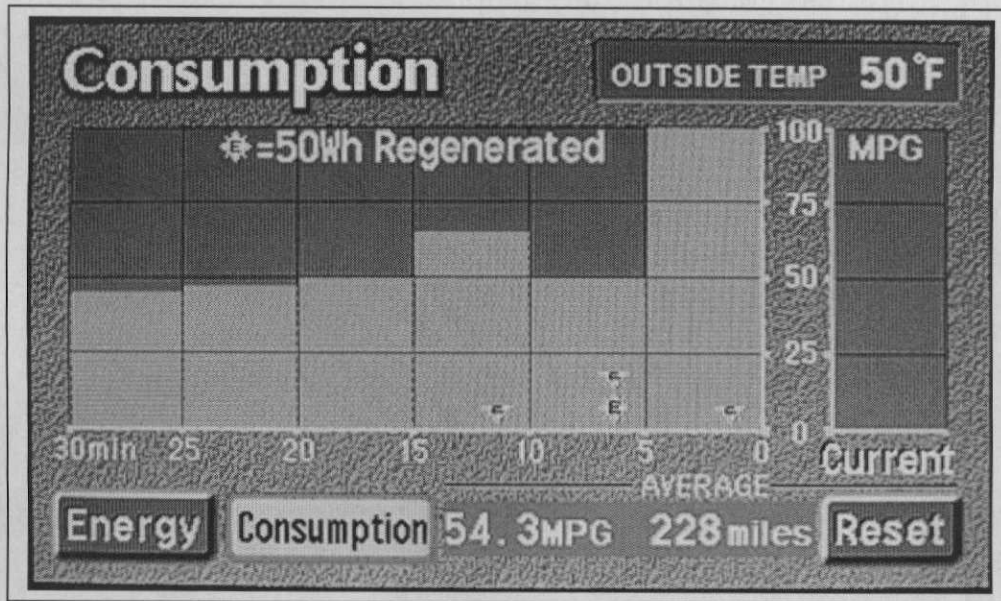
from 20 mph to over 100 mph. Most consumers are buying the Prius for gas mileage so they will drive it within the speed ranges that the ICE likes. The Prius is not a slow car. This transmission may take some more study of planetary gear sets to completely understand its operation. For a video of this CVT go to www.howstuffworks.com and search for hybrid cars. This site gives good visual explanations.

The CVT can be serviced by draining and refilling the CVT. A small black pan has a drain bolt. After a hot or warm drain, refill with about 5 quarts of Toyota T-IV fluid. There is no dip stick, although some manuals refer to one. That Japanese translation can mess you up at times!

Prius only come with a CVT transmission, as a standard shift will not work with the planetary gear set.

This chart below is an active screen on the dash display. It informs the driver of current gas mileage, energy recaptured and every 5 minutes updates the last 5 minutes of driving. It is a touch screen

system. Press energy and you will see a screen that shows the power flow from HV batteries to wheels and back.



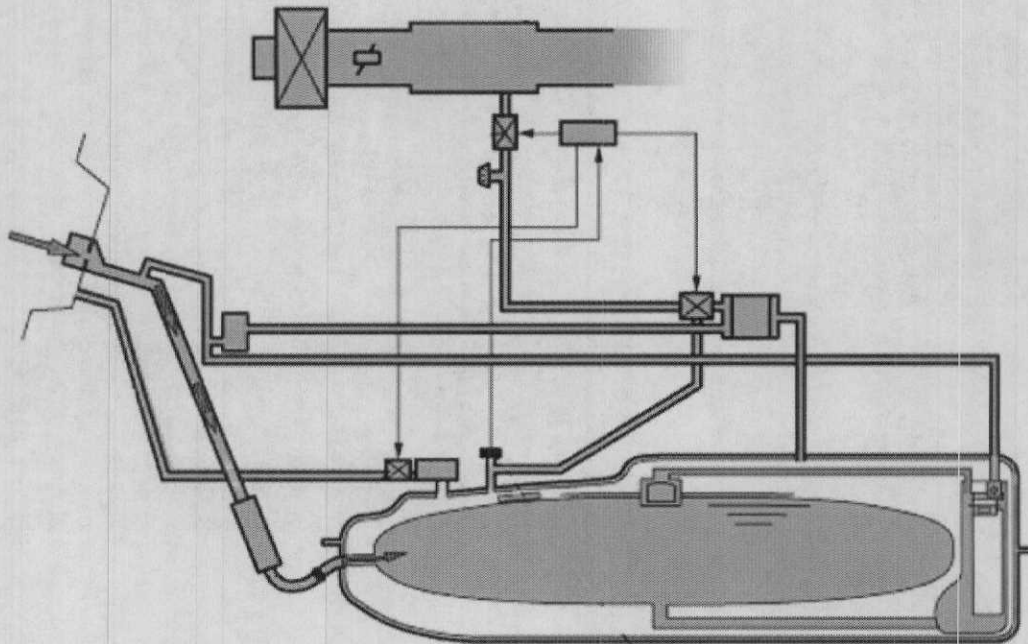
Use Oil Filter # 90115-YZZA2 same as a Tercel or Echo

Uses a Timing Chain, not a belt. Engine is very typical of Toyota.

Throttle by wire. At the accelerator pedal upper end you will see a Pedal Position Sensor. The throttle body uses a fast electric motor that is commanded by the PCM for acceleration and decel. It has an override that does not let you race the engine in park or neutral. The PPS is really two TPS, one that checks the other for safety reasons. Prius uses a MAF sensor.

Prius uses a similar quick disconnect at fuel lines, similar to the Insight and Ford.

Check this out! The steel gas tank has an expandable rubber bladder inside it to help control EVAP HC's. Gas refills will vary based on outside temperature.



Engine removal is out the bottom of the car.

Electric Power Steering.. scan tool data (Vetronix)

Valve adjustment is typical Toyota, Shims that are replaced when needed (usually OK for 200k miles)

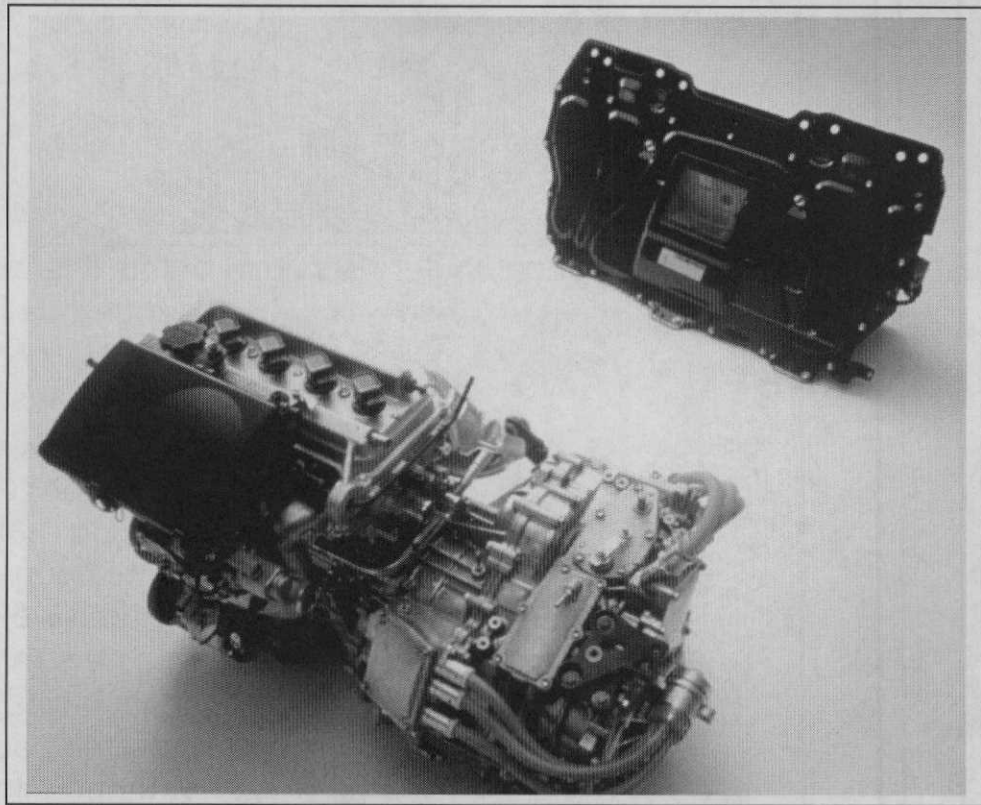
Specs Cold Intake 0.006" to 0.010"

Exhaust 0.010" to 0.014"

Compression specification at 250 rpm is 106 psi. The Vetronix tester has "cranking mode" capability that will reduce the cranking rpm from 1,000 rpm 250 rpm. The 106 is on the low side, you should see a much higher number.

Spark plug ND SK16R11 GAP 0.40" Coil over plug.

Set timing, use a Vetronix Mastertech with the new updated Toyota cartridge and use prompts to get engine ready for timing check, use a timing light as usual.



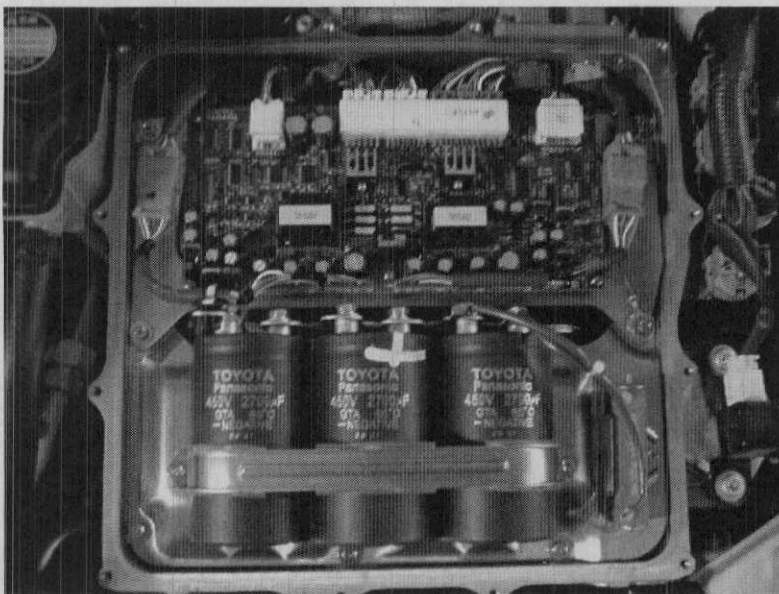
This is the original set up on the 1998 Prius

The inverter has its own cooling system, complete with reservoir tank, hoses, bleeders, water pump, thermostat, and radiator. The inverter sits on top of transaxle and has a cover that says "Toyota Hybrid" on it. This has the high voltage cables going to it. It gets very hot!

The inverters job is to change ac to dc and back again. It uses digital



technology and a very fast computer. Because of this it is more dangerous than the HV battery pack in some ways, other than a factory service procedure on early Prius to make sure some connection inside it were tight, it has no serviceable parts inside. Use extreme caution if you open it up. There are three capacitors rated at 450 v at



2700mf each. This is enough volts and amps to kill you.

For your safety. This next statement is true on all hybrids. When you turn off the ignition the capacitors are grounded and within 30 ms they are discharged. In the unlikely event that there is a problem with this event happening, one terminal on each capacitor is hard wired with a resistor to ground. That way it will slowly (five minutes or so) discharge even if the ignition system has a malfunction. This is why the shop manual tells you to wait 5 minutes after turning off the car and de powering the system.

An interesting note; the A/C system will be switched on automatically, if the driver does not select A/C, and the cabin temperature is too high (my guess is 85 deg. F or more). This enables the air duct for the HV battery to have cooler air than ambient to cool down the Ni-MH batteries on a hot day. This is true on all Toyota designs.

A general note about all the main H V battery packs in all hybrids

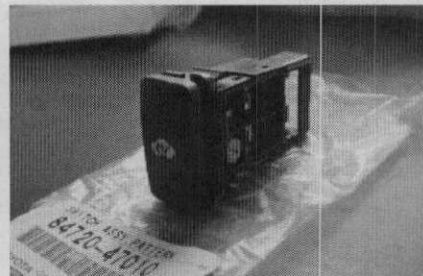
Nickel Metal Hydride, NiMH, was not used until 1990. It was invented in the USA. It is so new that a lot of durability issues were unknown when they went into the hybrid cars of today. Here is what we know now. They will last longer than we first thought. Because they have significantly higher power and energy density, NiMH batteries are much smaller, freeing up valuable space. They are safe and can be easily disposed of, without damaging the environment. For the first time NiMH batteries are being carefully monitored and protected.

Try this; buy a \$2,000.00 - \$3,000.00 battery charger and store your batteries in a compartment that is protected from the elements, monitor the heat and cool them when they get hot. Never let them overcharge or undercharge, and stop using them if you approach a limit that may be harmful. What do you think would be the result? What we have to compare these batteries to is lead acid or the NiMH batteries for our cell phone with its 40 buck charger. The other battery you have heard of is nickel cadmium that has an issue with memory. NiMH does not.

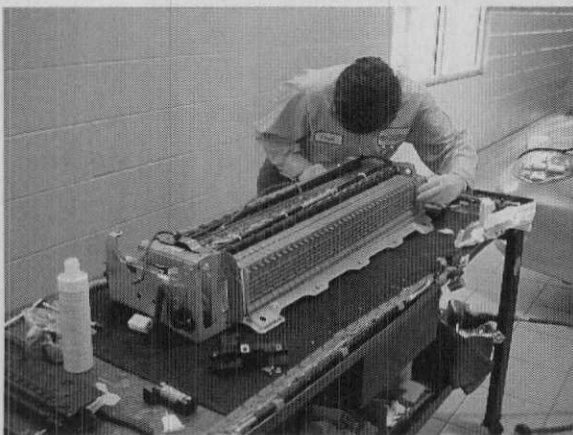
Safety Issue. Be careful when handling a leaking NiMH cell (this is rare). Use a pair of gloves as the electrolyte may cause some irritation. If you get the NiMH electrolyte on your skin flush with vinegar and water. I have never seen a leaking cell. This is more of an issue for EMT and Fire departments. Lead acid is worse.

Back to the Prius Classic

In Japan you have a switch on the Classic and new Prius that allows you to ask the PCM for “electric mode” only. That was left off when the Prius was Americanized. Why you ask? If the drivers and attorneys got together than possibly many HV packs may have had to be replaced because the driver would now have the ability to damage the HV battery from over use.

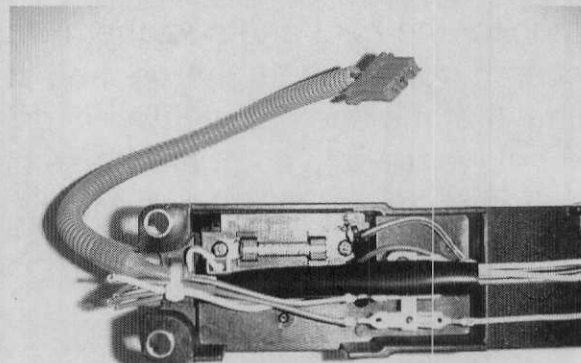


What do I do if the HV battery goes dead?



There are 5 or more Toyota HV battery chargers in the USA. They are kept by the Toyota Field Representatives and will charge up a dead HV battery pack. The dealership must request the service and it may take a few days to have the field rep show up. The chargers are not loaned or shipped. They are “Top Secret”

and have only Japanese lettering on them. There is a small round orange plug on the “Service Plug” end of the battery pack. This plug is removed with the battery pack still in the car and then a small connector fished out that has three wires in a small orange rectangular connector (see picture) and that is plugged into the HV battery charger. It



can then take up to 24 hours to raise the charge over 20% so the car can start. After that the on-board battery charger can take over.

ACDC is working with a company to produce a HV battery charger. If you are not on the ACDC e mail list, send us your e mail. ACDC sends out a Hybrid Newsletter 4 - 6 times per year.

There are two reasons why a Toyota HV battery can drop below 20%.

#1 - The car is left in neutral, key on and accessories are also on. In this condition the HV battery pack will continue to use the DC – DC converter to supply the 12 volts and there is no protection built into the BCM (battery control module) to stop this process.

#2 - The other reason is driving without fuel in the tank and repeatedly keep trying to restart the car.

If the HV battery pack is below 20% (actually more like 17%) charge, the HV battery will not have enough power to turn EM1 and it will not start the ICE. It is a tow at this time.

If you cannot get a dealership to help you, order a used battery pack and swap it out. This is about a two hour job at the most. Two people can handle the battery pack as it is about 120-130 lbs. Use caution when removing the HV battery pack. Be careful as the used battery pack may be degraded from just sitting around. NiMH has a poor shelf life unless it is trickle charged.

Toyota says "the battery cannot go dead!" This is incorrect.

In 2004 Toyota told me that out of 100,000 battery packs Toyota has had 7 problems, none of them due to a worn battery. My research agrees with that. It is poor and corroded connections in the HV battery pack. A verified defective cell was found in a 2001 Prius in October of 2005. Toyota warranted the entire battery pack even though it was out of warranty.

Running out of gas. If you run out of gas the car will run on electric only. Toyota says “do not run the car this way” It will die electrically after about two miles but will re-start (re-cycle) as many times as you want. This will eventually damage the batteries as they will drop below 20% charge. This fools the “Battery Protection” built into the BCM. When you try to start a ‘01-‘03 Prius that is out of gas it can fool you. It will crank for 30 seconds and it sounds exactly as if it is running. Remember it cranks at 1,000 rpm with a silent starter. After 30 seconds the ICE will shut down. You will think “bad fuel pump”.

Rubber Bladder in Fuel Tank A simple system that keeps hydrocarbons from evaporating is to install a collapsible rubber bladder in the gas tank. The tank will not hold as much fuel in cold weather as it does on hot days. Just a simple idea that works great and adds a safety barrier in accidents. How did Toyota get so creative all of a sudden? Did they hire some former Honda engineers? According to some accounts Toyota did hire a Brazilian engineer that worked at HPD, Honda Performance Development, in 2001 or so. “This system is on the updated 04’ Prius as well. The

down side? No replacement parts. Need a fuel pump, buy an assembly. Did I hear a remanufacturing opportunity knocking? Also the fuel level gauge is never accurate. There is no low fuel level warning light per say. Running out of gas is common.



The Dash It has a touch screen display. Warnings will display on this screen. A turtle will light up on the dash (above the screen to the right of the speedometer) if you have depleted the HV battery pack to 20%. Until the HV battery pack is recharged the electric motor will not assist the ICE. It just means you will not have a lot of power. A hybrid

failure will illuminate a caution sign on the touch screen and set a code. Codes are displayed on your scan tool as a P0A__.

The owner's manual is the best source of information for dash read outs.

If the 12 volt battery goes dead, the dash memory will also be dead. Don't worry about any lights, warning or readouts until the car has gone through two warm up cycles. Most read outs will return to normal. Make sure all else is OK before the road test.

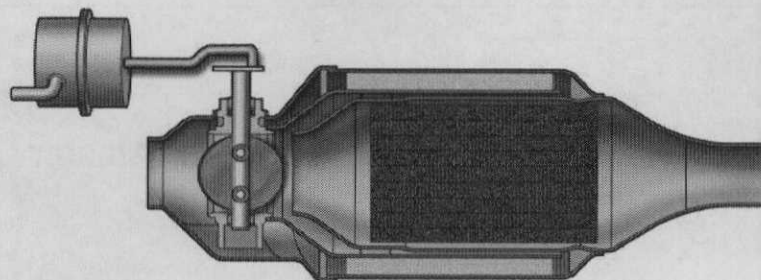
Take a long road test to get use to the dash readouts and study the owner's manual. You will need some familiarity with the "Classic Prius" to get you ready for the new Prius.

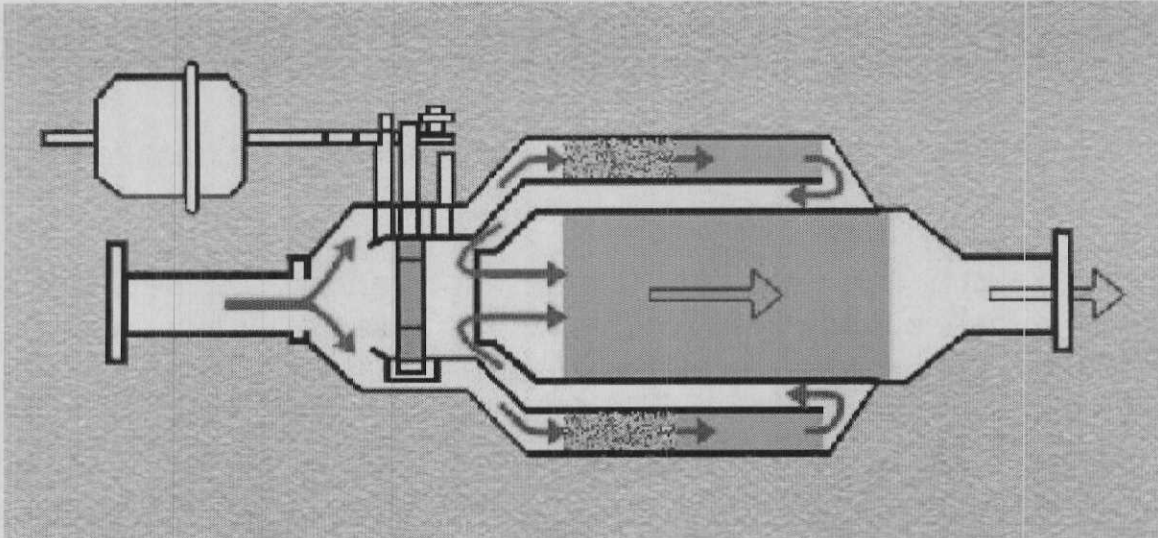


The READY symbol will light when the car is on, the ICE may be off but the car is ready to go. After the ICE is in closed loop the ICE will most likely shut down at idle. The 'B' next to the 'D' is equal to your understanding of 'L' on a normal AT.

iATN

If you are not a paying member of www.iATN.net, go to this web site and sign up. Great info, a way to help other techs and it is a bargain. Hi speed internet can really help your career. I have been a member for many years.





An HC trap is built into the catalytic converter. Problems with it will set codes. It is designed to trap HC when cold and release it for after treatment when it gets warm. It was discontinued on the new Prius. A simple vacuum valve is switched via the PCM.

New Brake-by-Wire system

The braking system on the Prius is a high tech wonder. Think of an ABS system that can not only provide ABS but will stop car as well with a signal from the driver's foot via computer. A Stroke Sensor, Stroke Simulator, 11 solenoids, a Pressure transducer and more are part of the system. The braking PCM applies the brakes, both hydraulic and electronic regenerative, using inputs from many sensors and the braking force as applied by the driver. The Brake PCM combines EM2 and conventional brakes as needed to slow the car. The hydraulic part is used more if the driver pushes further on the pedal. There is a conventional master cylinder, and if all fails, it converts back to conventional brakes, minus a power booster. A good article can be downloaded for free at www.motorage.com written by Jacques Gordon.



PRIUS
Master Cylinders

Tire specs High Pressure P175/65R14
Front 35 psi
Rear 33 psi

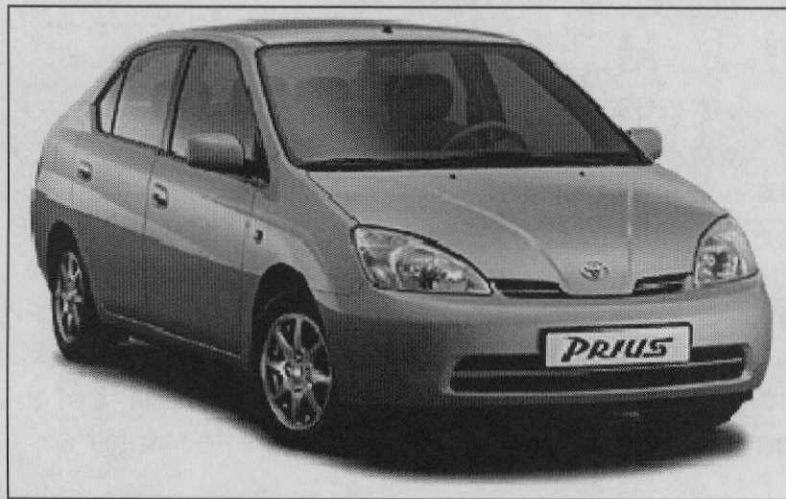
A/C system R 134a capacity 17.64 oz. +/- 1.76 oz.

Retrieve Codes:

The DTC is easy to find. Look under left edge of dash. No cover.
Vetronix makes Toyota's scan tools.

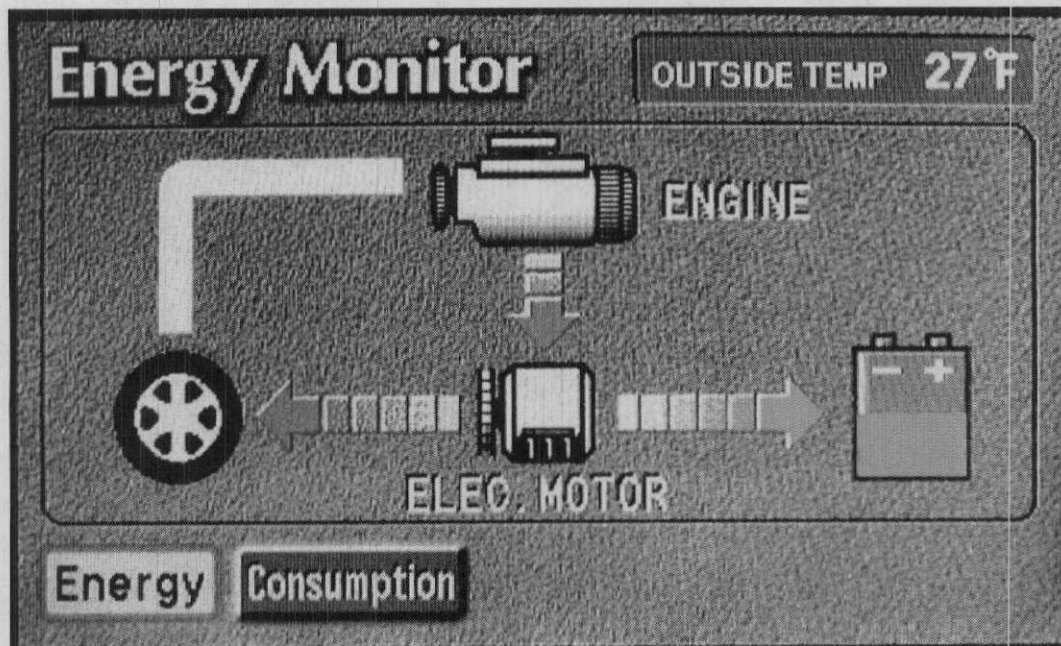
Tell customers:

- Tire pressure is very important.
- Drive easy for best mileage.
- Service ICE like you would any other Toyota engine.
- Do NOT spray water in side vent behind rear door. This HV air exhaust vent is for the HV batteries.
- Do NOT cover vents on rear parcel shelf. Inlets for air to H V Battery
- Watch out for kids in stealth mode as car is silent.



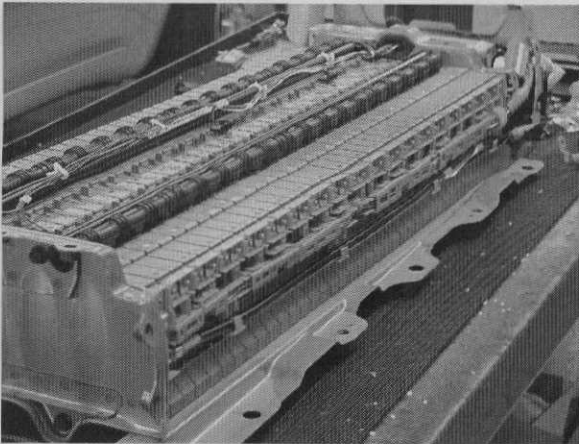
Random Thoughts:

- Toyota makes good cars so the Prius will probably not have a lot of problems.
- Toyota will have a hybridized version of all their Toyota models by 2010.
- Advertising for hybrid work will set you apart from your competition. Drive this car a lot so you are used to it.
- Use All Data and Mitchell for information, instead of buying the manuals.



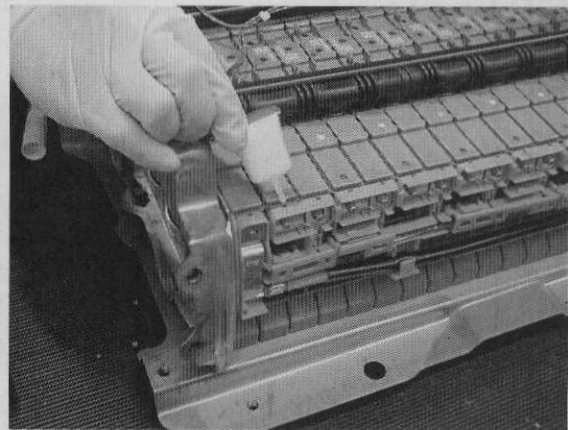
This energy monitor is showing the ICE powering EM1 while EM2 is driving the car. This is a slow speed situation where the HV battery is low on charge and both EM1, EM2 (both electric motors), and the ICE are in operation. Note how cold it is outside. Also the HV battery is about 1/2 charged. The monitor only shows one EM, but there are two. Your scan tool will give you much better information.

Major Recall on 01-03 HV battery packs.

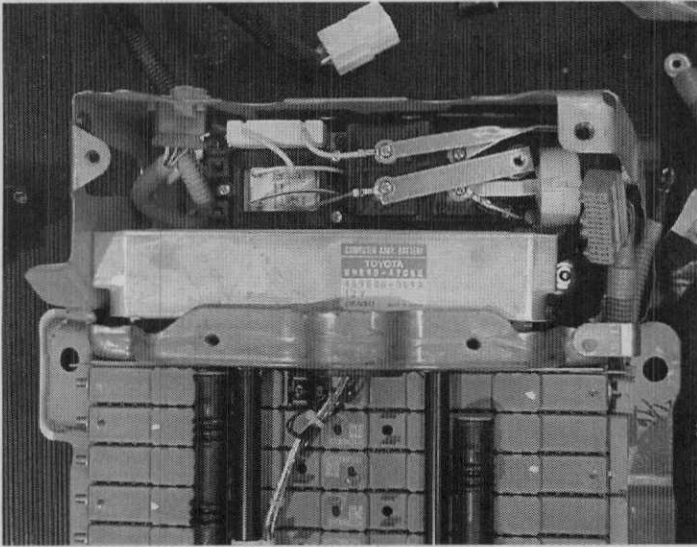


Starting in October of 2004, Toyota began a recall of all Classic Prius. The HV battery packs may develop some corrosion at the terminals where the individual NiMH cells bolt to the orange covered bars.

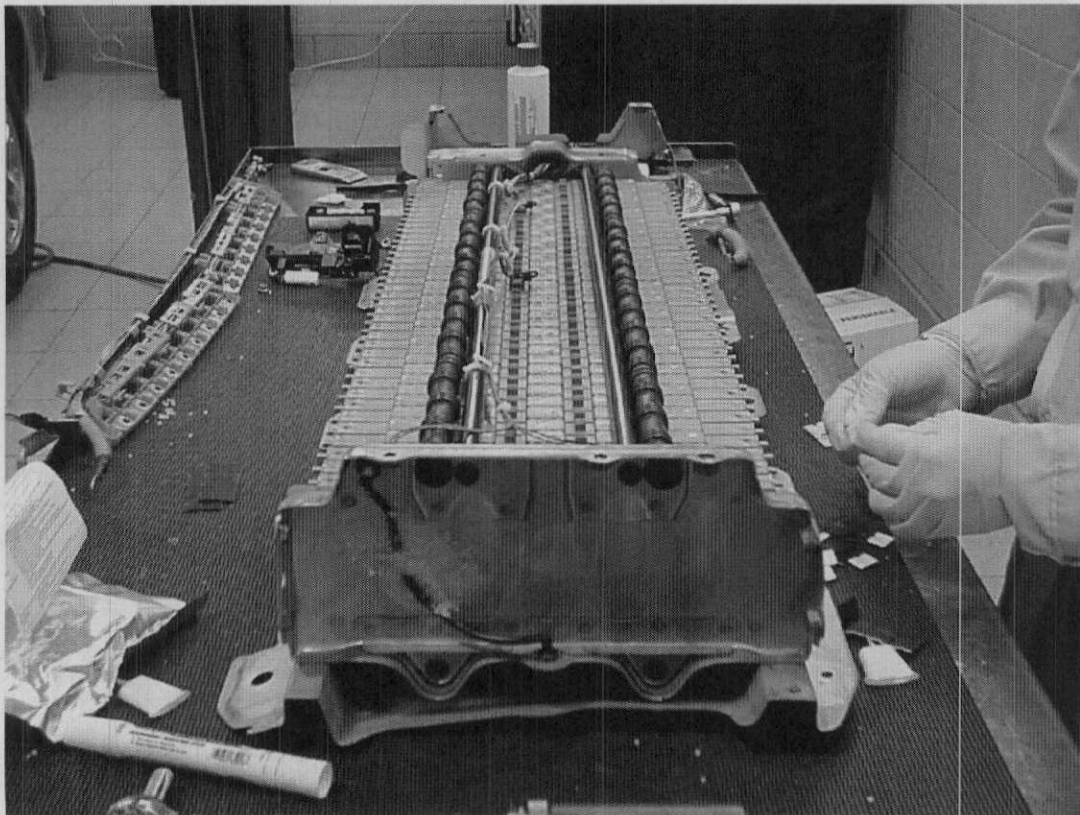
The recall is a 4.6 hour flat rate job that required the removal of the HV battery pack from the car. It can be done in one day and no customer problems have been reported. This is the first time that the HV technology has been tested at so many dealerships at one time. So far, so good. My thanks to Raj Ling, a Toyota tech in California, for spending time answering my questions and helping with these photographs.

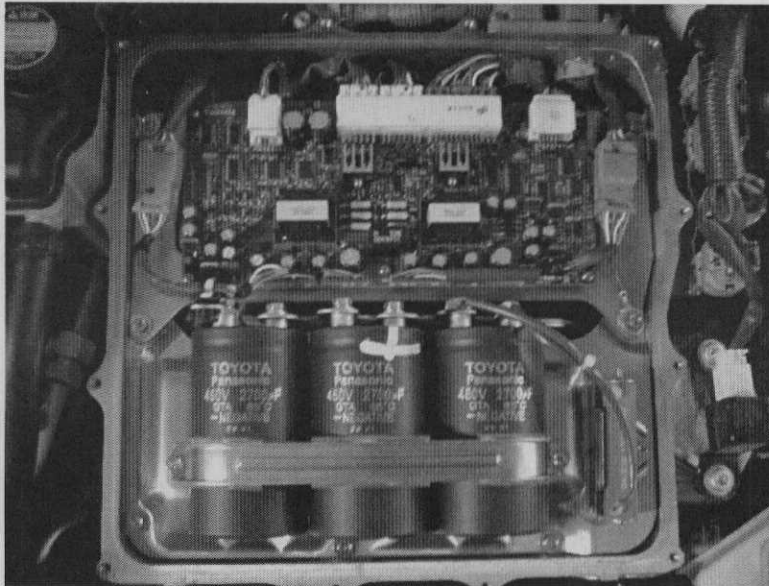


The battery pack is user friendly, time consuming but not difficult to access. Using a careful step-by-step procedure, any tech doing this for the first time would find it easier than they would have assumed.



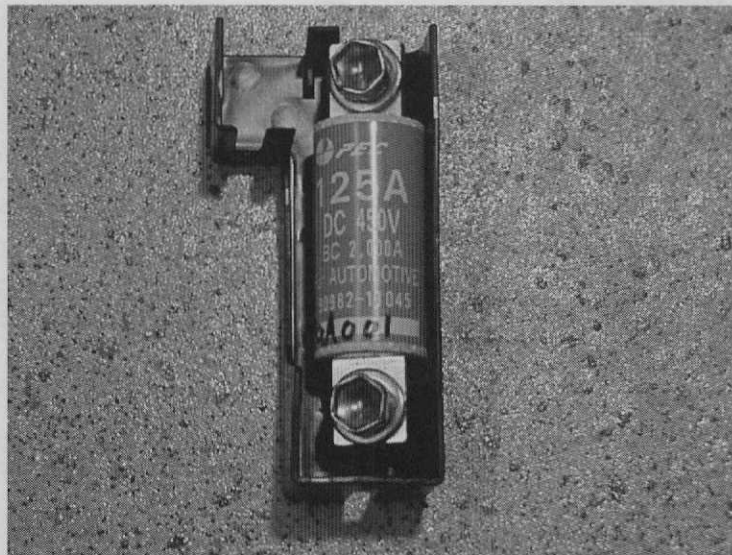
The recall is to replace the long orange bars with new ones and seal the posts of the small NiMH cells to the bars. Most batteries that have been done have small amounts of corrosion. Over time this would have been a problem. Toyota was smart in doing this now instead of waiting.



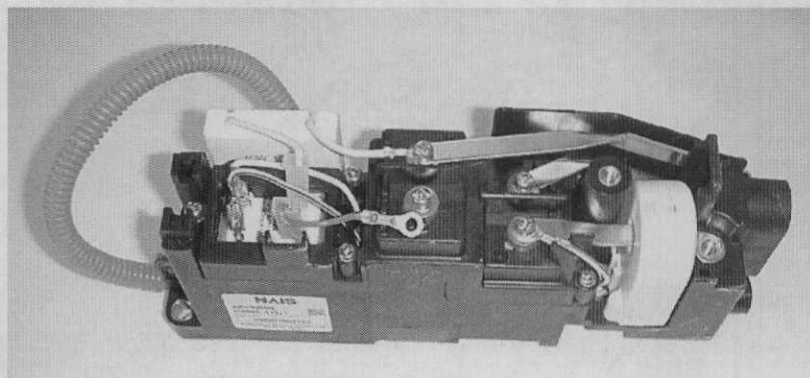


The pictures here are the inverter with three capacitors. The cover was removed for the picture. The removal of this cover is not needed in most cases.

This is the master fuse and is located in the battery case. It is rated at 125 amps and 450 volts. Please use caution if you ever get near this item. It is 1/2 the physical size of any fuse you would find made in the USA for its capacity.

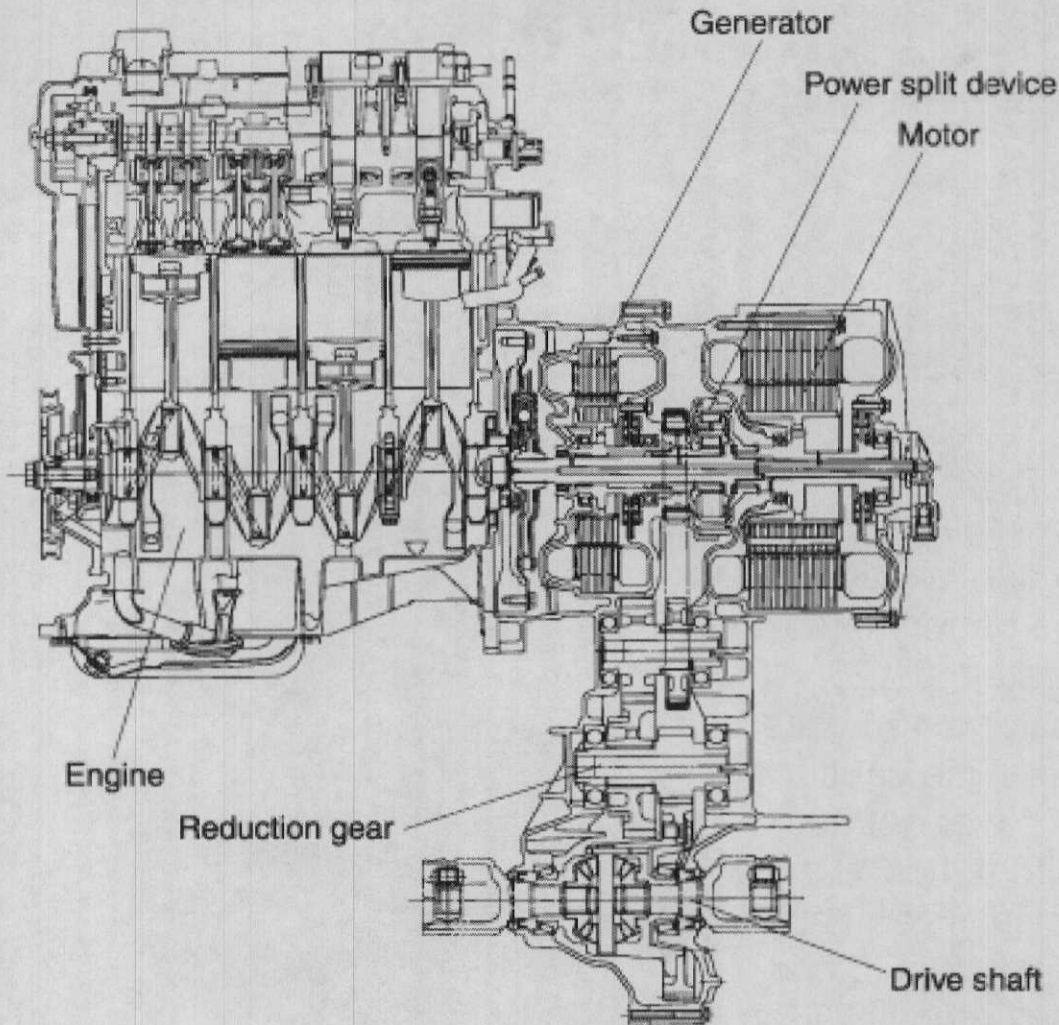


The picture is the contactor set, amp sensor, resistor and HV battery charging lead (orange cable).



Toyota calls this the SMR, system main relay. This is also located in the HV battery box.

Cross-sectional view



Cut away of the Classic Prius Drive Train

```

BATT BLOCK V1.....15.55V
BATT BLOCK V2.....15.50V
BATT BLOCK V3.....15.44V
BATT BLOCK V4.....15.50V
BATT BLOCK V5.....15.45V
BATT BLOCK V6.....15.49V
BATT BLOCK V7.....15.49V
BATT BLOCK V8.....15.46V
BATT BLOCK V9.....15.48V
BATT BLOCK V10.....15.46V
BATT BLOCK V11.....15.50V
BATT BLOCK V12.....15.49V
BATT BLOCK V13.....15.50V
BATT BLOCK V14.....15.48V
BATT BLOCK V15.....15.50V
    
```

Sample: 0.00sec

27 November 2004 19:42:41

MTS 3100 Mastertech © Vetronix Corporation

```

BATT BLOCK V16.....15.50V
BATT BLOCK V17.....15.52V
BATT BLOCK V18.....15.51V
BATT BLOCK V19.....15.47V
INSIDE RESIST1.....0.021ohm
INSIDE RESIST2.....0.021ohm
INSIDE RESIST3.....0.021ohm
INSIDE RESIST4.....0.021ohm
INSIDE RESIST5.....0.021ohm
INSIDE RESIST6.....0.021ohm
INSIDE RESIST7.....0.021ohm
INSIDE RESIST8.....0.021ohm
INSIDE RESIST9.....0.021ohm
INSIDE RESIST10.....0.021ohm
INSIDE RESIST11.....0.022ohm
    
```

Sample: 0.00sec

27 November 2004 19:43:56

MTS 3100 Mastertech © Vetronix Corporation

```

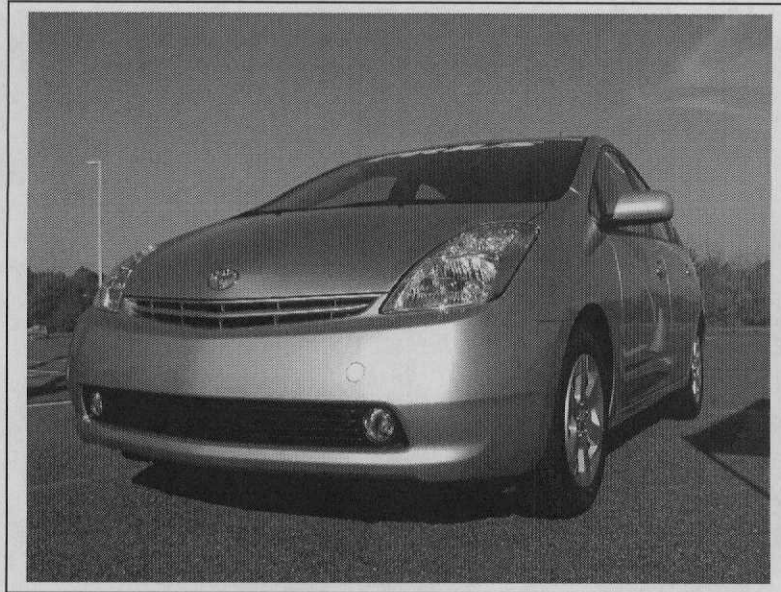
BATTERY LO TIME.....0times
DC INHIBIT TIME.....0times
BATTERY TOO HI#.....0times
IG OFF HOUR.....6Hr
IG ON HOUR.....0.19Hr
DTC.....0
ECU CODE.....47030A
.....
BATTERY SOC.....60.0%
WIN.....-20.0KW
WOUT.....21.0KW
DELTA SOC.....20.0%
IB MAIN BATTERY.....3.43A
BAT BLOCK MIN U.....15.44V
MIN BAT BLOCK #.....3#
    
```

Sample: 0.00sec

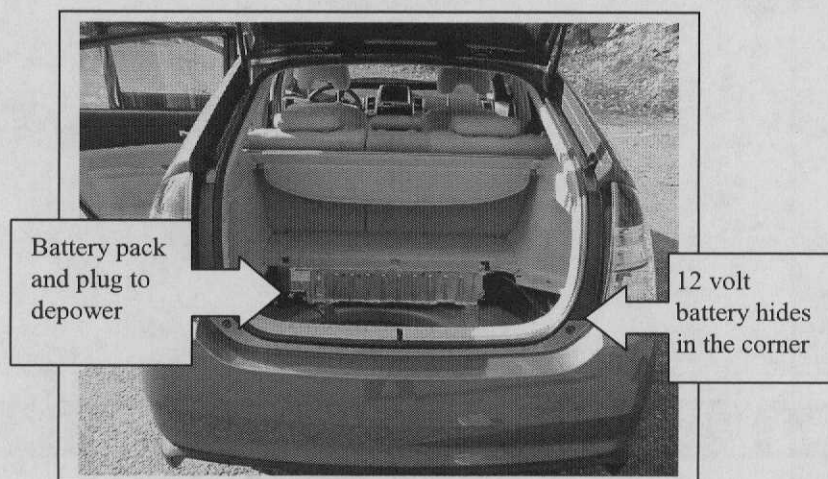
27 November 2004 19:45:33

MTS 3100 Mastertech © Vetronix Corporation

2004 - 06 Prius



This car now uses a 201v battery pack. The electronics can ramp up the voltage progressively (step-up transformer) and the EM can end up with as much as 500 volts three phase ac. This means a faster



car, more stealth mode and better mpg. The air conditioner uses 201v ac to power the air conditioner compressor. This allows the new Prius to go into idle stop with the A/C on maximum air. This newer Prius put hybrids in the USA on the map. ACDC bought a used 2004 Prius after a month of renting one in California thanks to ASC. This is the best all around hybrid on the market for the average driver and it is also the most popular. Get to know this car.

ENGINE

I.C.E. Specs

04' Prius

Gasoline Engine Type	4-cylinder aluminum double overhead cam (DOHC) 16-valve VVT-i
Bore and Stroke	2.95 x 3.33 inches
Displacement	1,497 cc
Expansion Ratio	13.0:1
Valve Train	4-valve/cylinder with VVT-i
Horsepower (SAE Net)	76 horsepower
Torque	82 lb-ft @ 4,200 rpm
Recommended Fuel	87-octane unleaded
Emission Control	SULEV (with AT-PZEV)

ELECTRIC MOTOR/GENERATOR/POWER STORAGE

Motor Type	Permanent Magnet Synchronous Motor
Electric Motor Power Output	50 kW/1,200 –1,540 RPM
Torque	295 lb.-ft. @ 0-1,200 RPM
Battery Type	Nickel-Metal Hydride
Nominal Voltage	201.6 V (168 1.2V cells)
Transmission	Electronically continuously variable transmission
Capacity	6.5 amperehour
Battery Peak Horsepower Rating	28
System Voltage	500 volts maximum

SUSPENSION

Front	Independent MacPherson strut suspension with stabilizer bar
Rear	Torsion Beam with stabilizer bar

BRAKES

Front	Ventilated front disc (hydraulic with power assist) with standard Anti-Lock Brake (ABS) system and integrated regenerative brake system
Front Diameter	10.0 inch Rotor 8.1 inch braking pitch diameter
Rear	Drum (hydraulic with power assist) with standard Anti-lock Brake System (ABS) and integrated regenerative brake system
Rear Diameter	7.87 inches
Parking	Pedal brake

STEERING

Type	Electric power-assist rack-and-pinion
Turning circle	34.1 Feet curb-to-curb

TIRES AND WHEELS

Wheel size	6JJ x 15 inches
Type and Material	Aluminum Alloy
Tire Size	P185/65R15
Tire Type	All-Season
Spare	Temporary

CAPACITIES

Fuel Tank	11.9 gallons
-----------	--------------

EXTERIOR DIMENSIONS (inches)

Wheelbase	106.3
Overall Length	175.0
Overall Width	67.9
Overall Height	58.1
Tread Width	59.3/58.3 Front/Rear
Minimum Ground Clearance	5.9
Coefficient of Drag	0.26

INTERIOR DIMENSIONS (inches)

Headroom (front/rear)	39.1/37.1
-----------------------	-----------

Legroom (front/rear)	41.9/38.6
Shoulder Room (front/rear)	55.3/53.0
Hip Room (front/rear)	51.0/51.6
EPA Passenger Volume	96.2 cubic feet
EPA Cargo Volume	16.1 cubic feet

PRELIMINARY EPA ESTIMATED FUEL ECONOMY (mpg)

City/highway/combined (target)
60/51/55

VEHICLE MASS (lbs)

Curb Weight	2,890
-------------	-------

SAFETY AND SECURITY FEATURES

Driver and front passenger airbags SRS*; Available front driver and passenger side-impact airbags SRS*

3-year/36,000-mile Roadside Assistance Coverage

Side-impact door beams

Front and rear energy-absorbing crumple zones

Three-point front seatbelts with pretensioners and force limiters, ALR/ELR retractors on all passenger seatbelts, three-point seatbelts in all five seating positions

Anti-Lock Brakes (ABS)

Standard regenerative Anti-lock Brake System

Rear seat CRS top tether anchor brackets and lower anchor point attachments

Adjustable front seatbelt shoulder anchors

Child-protector rear door locks

Internal trunk-release handle

BASIC LIMITED WARRANTY COVERAGE

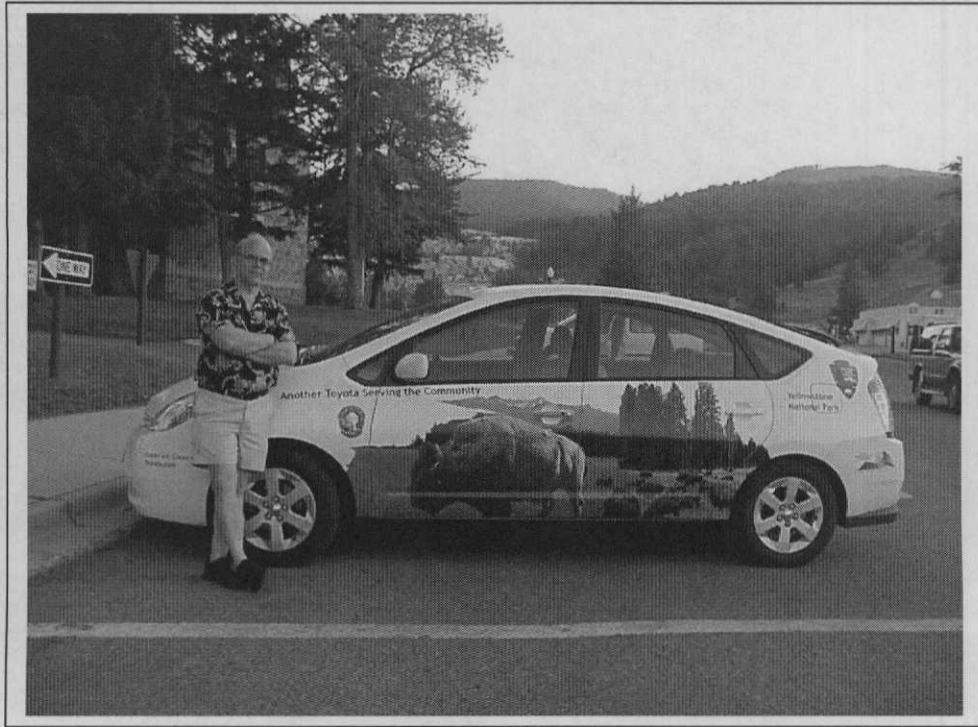
3-year/36,000-mile Comprehensive

5-year/60,000-mile Powertrain

5-year/unlimited-mileage Corrosion Perforation

8-year/100,000-mile Hybrid-related Component Coverage

Craig Van Batenburg and Yellowstone's 2004 Prius.



These pictures help explain why the 04' Prius was so popular. The 05' went on sale in September 04'. Toyota allowed a discount to those that ordered a 04' by April 04' but had to wait for a 05' to get their car. If only the other car companies had such problems.





How to start a new generation Prius (04-06)

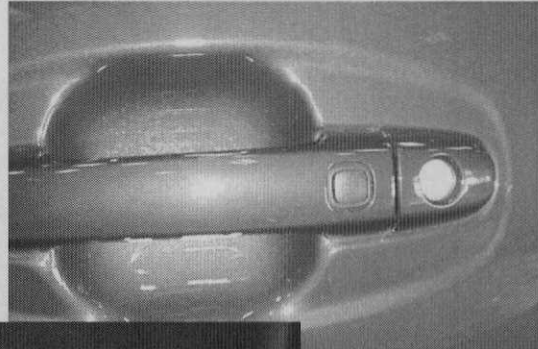
If you have a low end Prius take the key fob (it is the electronic key) and inset it into the slot just below the "Power" button. Then put your foot on the brake and push the Power button once. The ICE will start if it has cooled down and the READY light will illuminate. You are now ready to go. If you have the high end Prius the key fob can stay in your pocket as the PCM will pick up its transponder and allow you to start the car. This takes a little getting used to.

To turn on accessory position; push power button once **without** your foot on the brake, or twice to get to the "on" position.

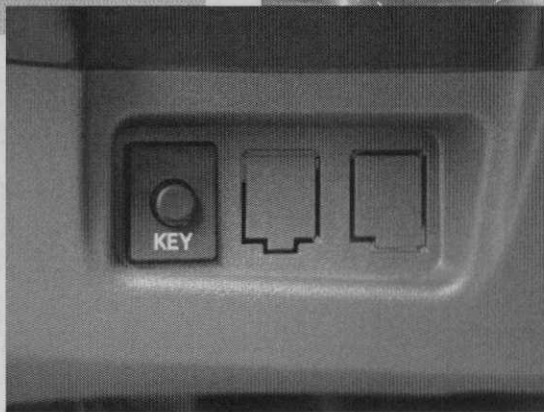
If you have a high end Prius you may have the **smart key system**. Disable that function for your own safety. Read owner's manual and push a small button under the steering column. Smart key allows the car to start without the transponder in the key slot. You can tell a smart key by the black button on the outside door handle. If you don't disable the smart key, another worker could start the car accidentally while you are working on it. Taking the key out doesn't matter.

Shifting the new Prius. The shifter is a dented lever that always returns to Neutral after each shift. To put into Park, push the park button. To remove the key, the car must be in Park with foot on the brake. Push the Power button once. The Prius has a foot brake operated emergency brake system that is conventional in design.

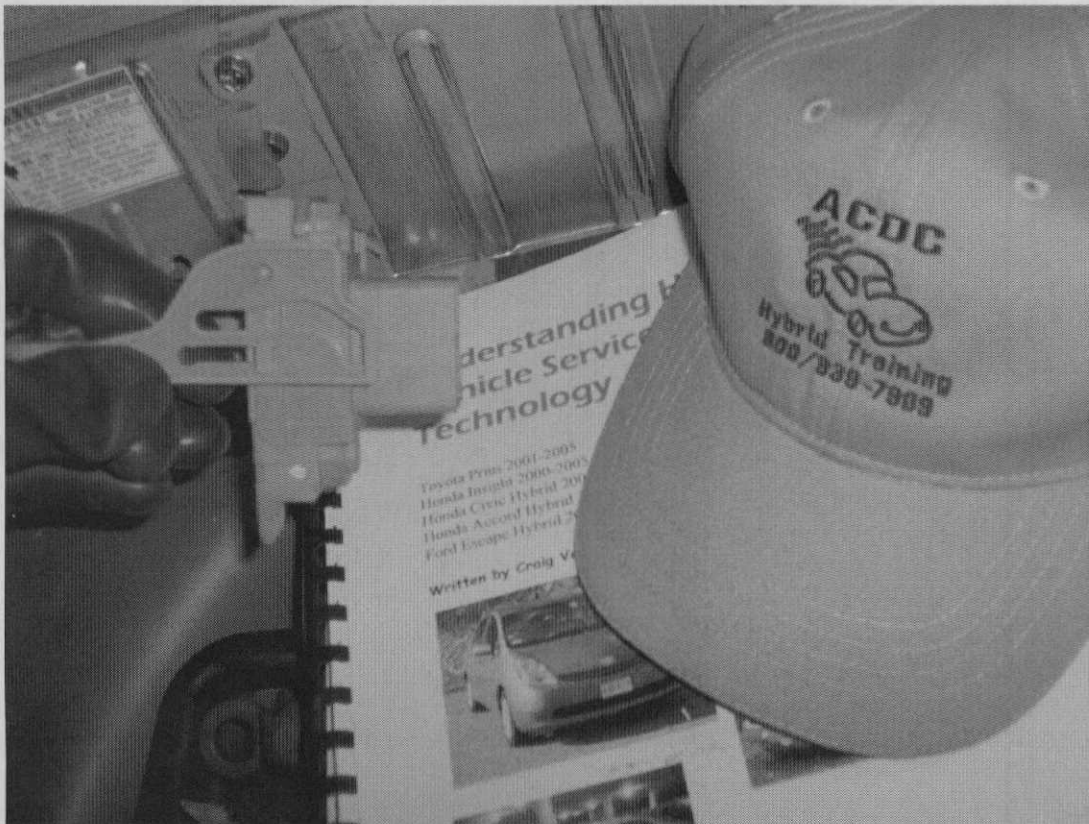
"Smart Key" fob with hidden key to gain access to the car if the 12 v battery goes dead. Door handles with black button indicate you have a "smart key" system Prius. The KEY button is depressed to deactivate the smart key system. The car can still be started but the key fob must be in the slot on the dash to do so.



ACDC Hybrid Hats
make you smarter



This KEY
button is
located under
the steering
column.

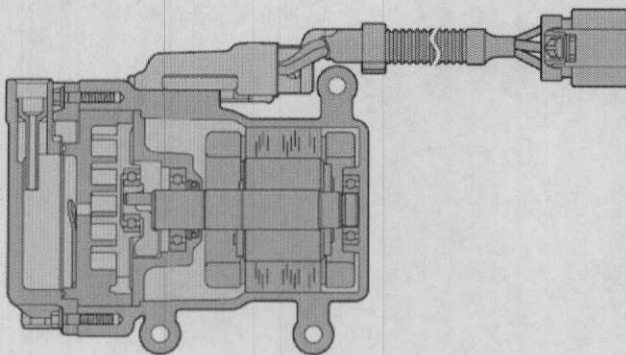


In case the 12 volt battery goes dead, Remove the hidden metal key in the key fob control. Open the left front door, the only lock on the car, then open the hood (cable operated) and then open the under hood fuse box on the left side. You will see a red positive battery type cover, open it. You will now see a metal stud, this is battery positive. Jump this connection and use the frame for ground. You can now use the remote to open the trunk. Toyota did consider this possibility as this is an all electronic system.

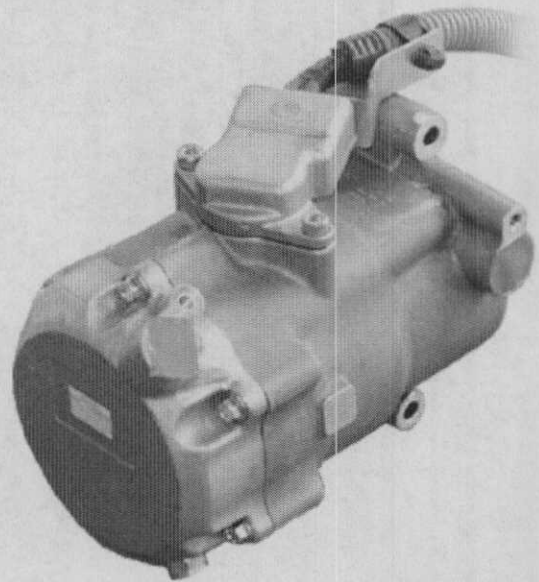
Air Conditioning

The A/C is conventional in all regards except the compressor is electric. It runs on 201 volts ac and can vary in speed. This allows for idle stop (although not for long, about 6 minutes on max A/C hot day, as it really eats into the HV power supply) and no compressor clutch is needed. What seems odd to me is that the location of the compressor is standard so that

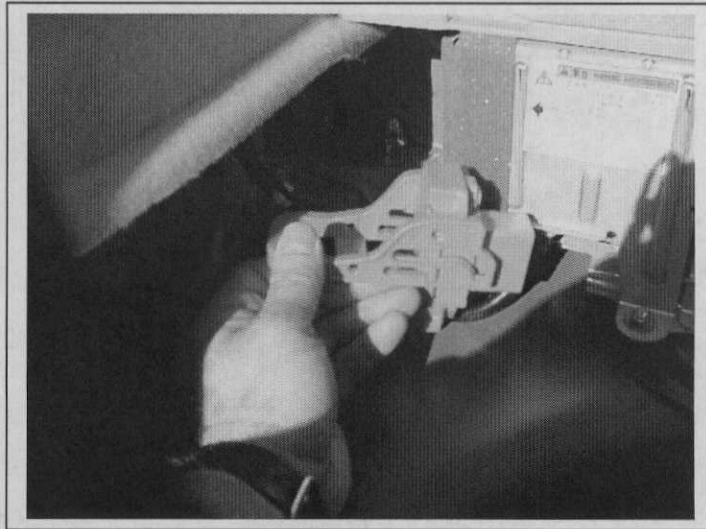
flexible hoses are still needed. It could have been frame mounted and have used solid lines throughout. Denso told me it was a vibration problem. Maybe next generation!



Running out of gas. You will only have 3 tries to re-start and then a scan tool is required. This is to prevent HV battery problems. See 01-03 for more info earlier in this book.

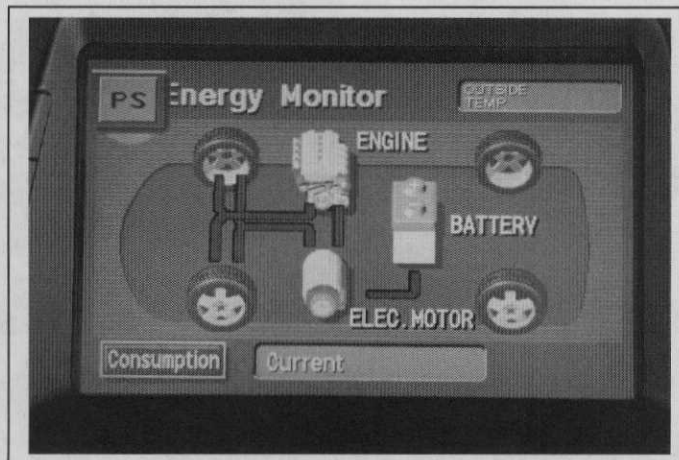


The Main battery pack is in the trunk, same place as first generation. To de-power the HV system, remove the plug in the left rear quarter.



Note: If you de-power a new Prius, you may need a factory scan tool to erase codes and turn off a warning on the dash. This is a CAN system. As of this date Vetronix is the only tool company that can do this. Try this before pulling the service plug; disconnect 12 volt battery negative, then the plug. This way the PCM's don't know what you are doing. If you are reading this too late, drive the car through two complete drive cycles and the warning light will turn itself off.

The engine compartment is just as tight as the earlier version.



The dash will let you know what is going on under the hood. There is an energy monitor (above) and consumption. They are touch screen operated.



The Glass Matte 12 v battery is tucked into the right rear quarter of the trunk. The small black box in front of the 12 Volt is another 12v power supply, full of small capacitors) as a back-up for the brake-by-wire system. This was added in 2004.

BETTER performance!

HIGHER mileage!

60 mpg city/51 mpg hwy*

LOWER emissions!

SAME MSRP as 2003!**

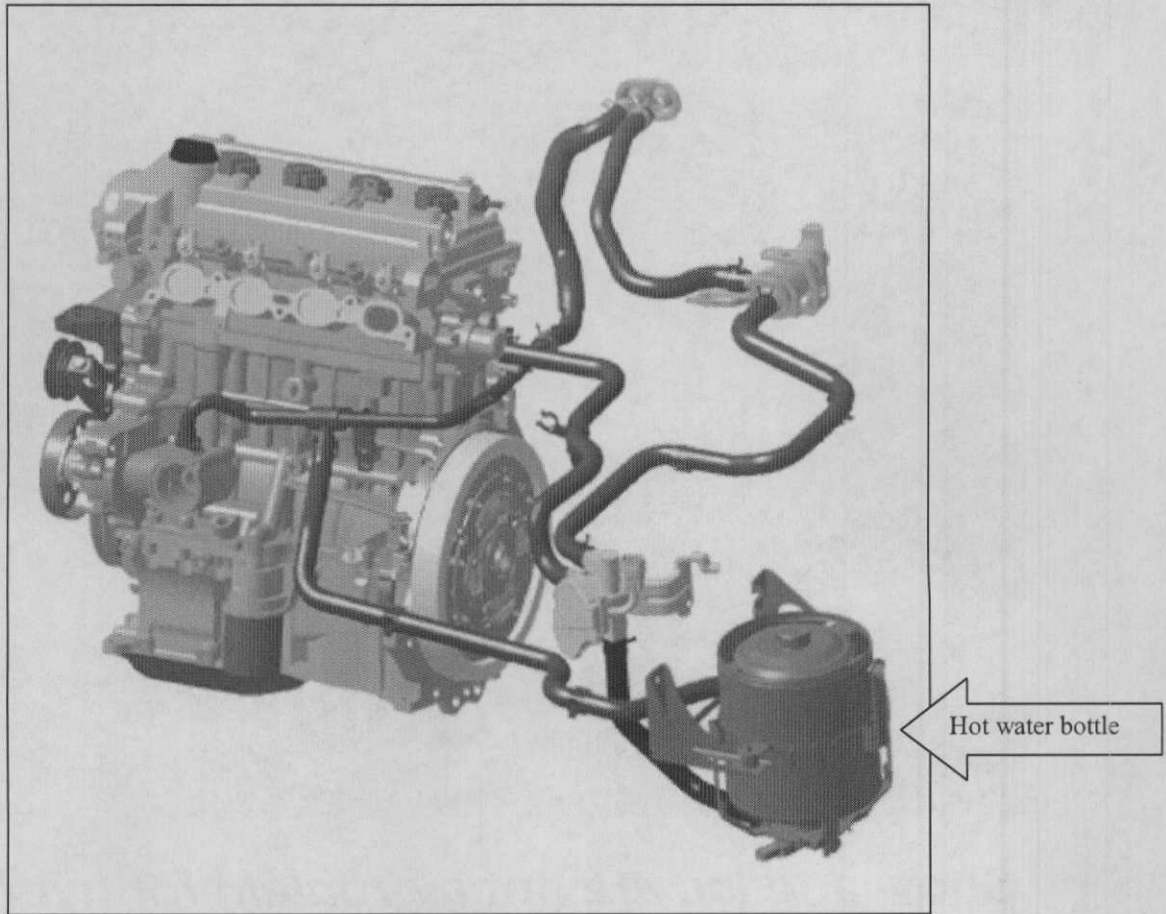
How often do you get to make a difference **without** making a sacrifice?

That's how the next generation Prius goes beyond expectations!

The key to Prius' remarkable achievement is its **combination** of innovative features.



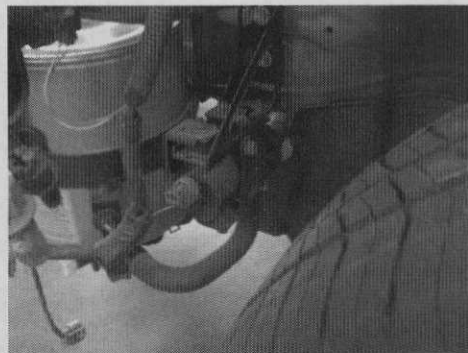
"Triangular Monoform" styling creates a sleek gas-saving 0.26 coefficient of drag.



Another way to recapture wasted energy is to keep some hot coolant ready. To do this Toyota came up with another simple but effective design. Whenever we shut off our engines and allow them to cool down, we have to heat them up again. Those in Minnesota know all too well how that works! Hot coolant is stored in a hot water thermos and recycled into the cylinder head every 5 hours, keeping the head warm and the engine ready to go into closed loop operation faster. The above schematic shows this simple system.

Tech tip: Disconnect the pump when working on the cooling system.

My thanks to Toyota Motor Corporation for help, photos and their time.



The pump is round and mounted to the back of the hot water tank. Two wire 12 volt.



***Snow and Ice are not a problem for hybrids.
This is ACDC's newest addition. Jan. 2005***

Prius hold land speed record at Salt Flats

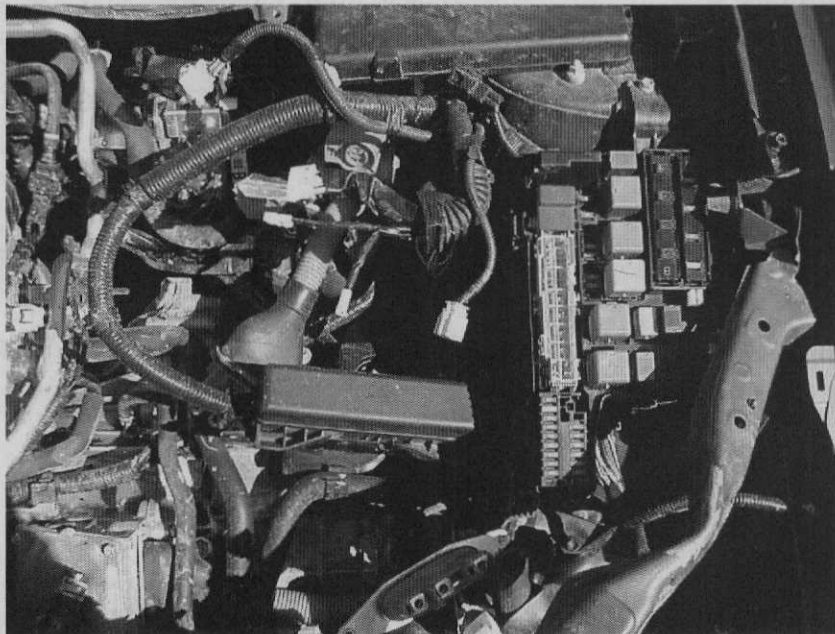




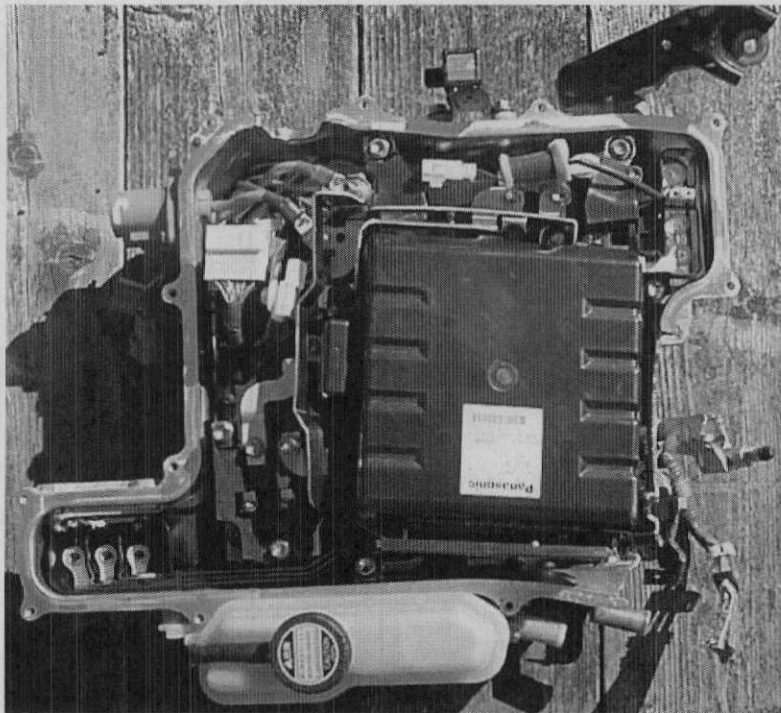
This Prius was hit in front. The inverter was hit. A sensor on the side of the inverter is there in case of impact and in milliseconds the capacitors are drained and the HV

battery pack is cut off from the transaxle. No one hurt. The

picture below shows the inverter removed with orange cable disconnected. It was also parked in a puddle. Note red square cover in under hood fuse box. This is a contact for



jumping the 12 volt battery which is in the trunk. A tow truck driver was never in any danger due to the redundant safety disconnects that keep the HV cables from being live. The air bags did not deploy (not needed). If they had the same safety disconnects would have been triggered.

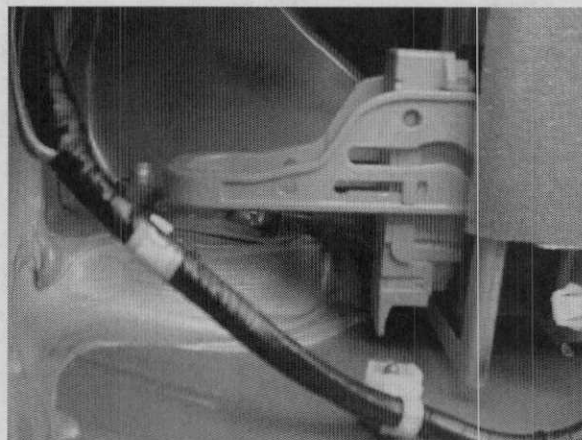


This inverter was hit and the cover was removed. You are looking at the capacitors in the square black box. The orange plug in the upper left corner is the 201 volts dc from the HV battery. The three contacts in the bottom left are 3 phase 201 ac

volts leading out of the inverter. Coolant tank is show. The small black box outside top is the sensor that triggers a HV shut down upon impact. It survived. Under the black box are the inverters. They get very hot so coolant is circulated under a hear sink attached to the inverters. This assembly is over \$3,700 retail. No rebuilds yet but the APRA, Auto Parts Rebuilders Association, have hired me to assist them in determining what needs to be done to offer rebuilt hybrid parts. There will be a market at some time in the future.

HV Battery removal

This job is easier than you may think. I removed a '04 battery assemble in under 1 hour the first time around. #1 Disable smart key if equipped, turn off car. #2 Remove HV safety





plug (see photo) using a 1000v rubber glove. #3 Start removing the lower trim in the hatch area, spare tire, jack, etc. Rear seat cushion completely and uprights enough to get it out of the way. #4 Remove small brackets

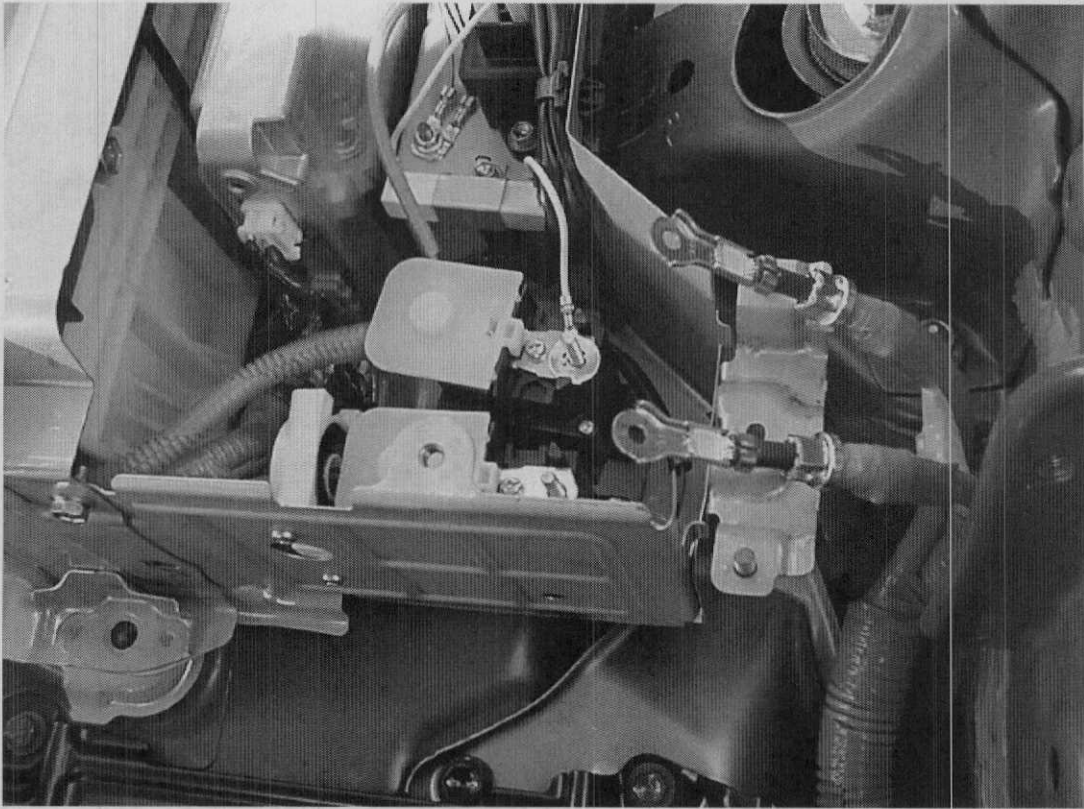
at either end of battery case, fan blower duct work (black). #5. Remove small metal cover that will expose the open ends of the two HV cables (covered in orange). #5 Test with safety gloves and a CATIII DVOM for voltage at the bolts holding the HV cables to the HV battery. If zero, remove gloves and go to work. After



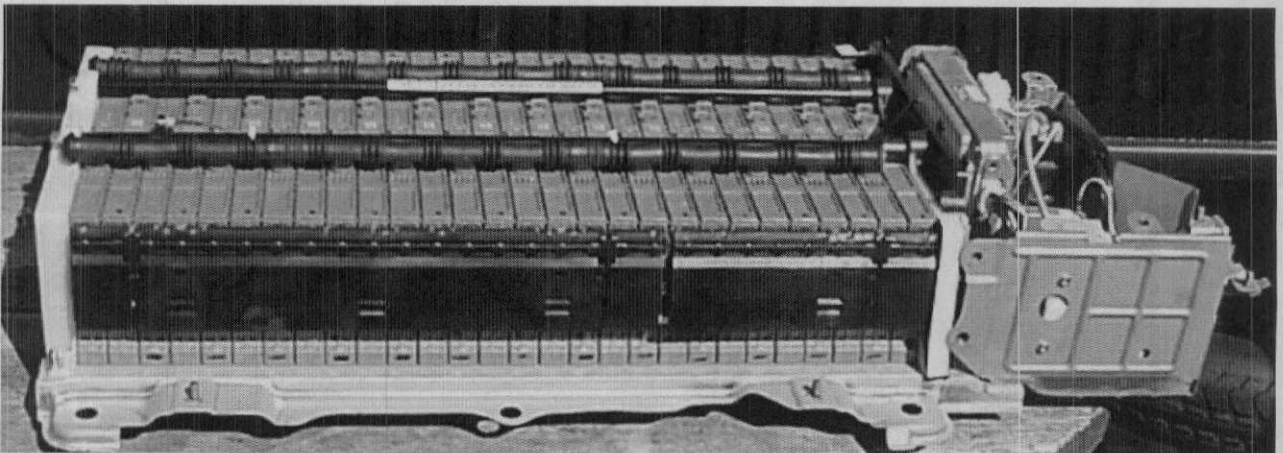
the HV cables are loose tape up the open ends and tuck out of the way. Remove mounting bolts at HV battery case #6. Get help and lift battery onto a rubber covered or wooden bench.



Most hybrid OEM's don't want the aftermarket to work on their cars and SUV's



as they are worried some tech will kill themselves. Don't be careless at this point. You are now at a point where once the battery is out. When you remove the covers there is no more built in protection. You are on your own. Toyota is the only OEM that has designed their battery box to be rebuilt. I know that won't stop any of you aftermarket techs to give it a try. If



you do, get the 1000 v gloves back on, test connections frequently so you know where you are and make sure your life insurance bill is paid up. Seriously, this is the part of the job that is unforgiving.

2006 Lexus RX400h / Highlander Hybrid. They are the same drivetrain.

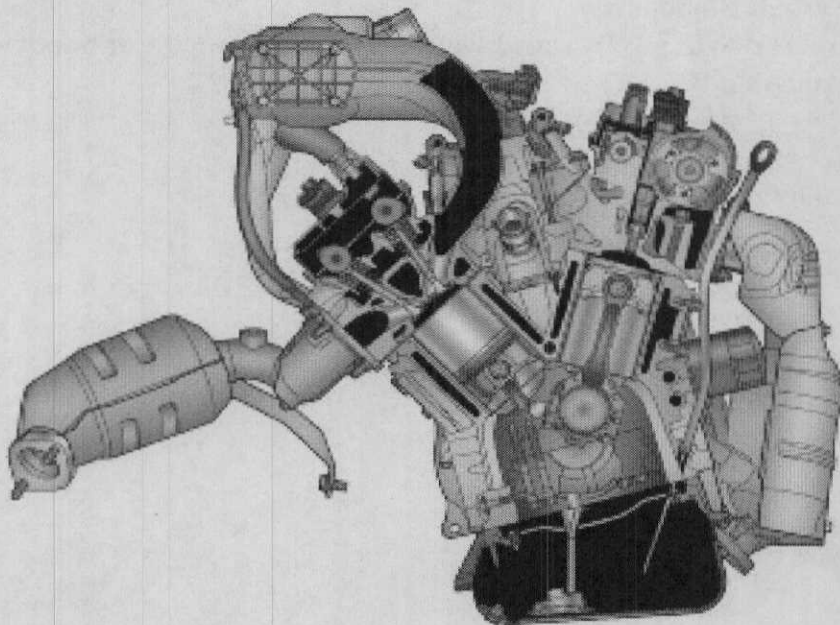


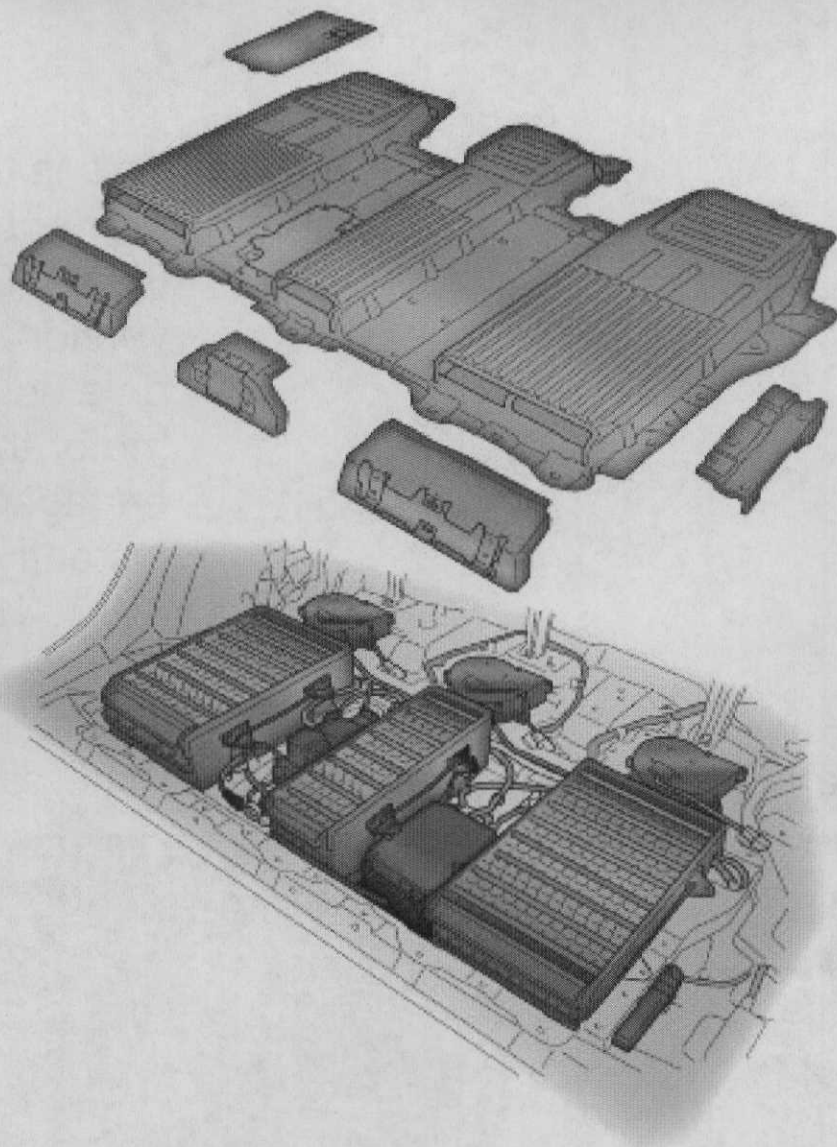
- 3.3 liter, 60° V6 engine. Certified Super Ultra-Low Emission Vehicle (SULEV)
- Four cam, four valves per cylinder, with continuously Variable Valve Timing with intelligence (VVT-I)
- 268-hp Total System Horsepower
- Part-time all-wheel drive (AWD) with Electronically-controlled Continuously Variable Transmission (ECVT)
- Vehicle Dynamics Integrated Management (VDIM), a traction management system that integrates the following:
 - Electronically Controlled Braking (ECB)
 - Electronic Power Steering (EPS)
 - Vehicle Stability Control (VSC)
 - Traction Control (TRAC)
 - Four-sensor, four-channel Anti-lock Braking System (ABS)
 - Electronic Brakeforce Distribution (EBD)
 - Brake Assist

***Lexus RX400h went on sale April 15, 2005
Highlander Hybrid started sales June 14,
2005***



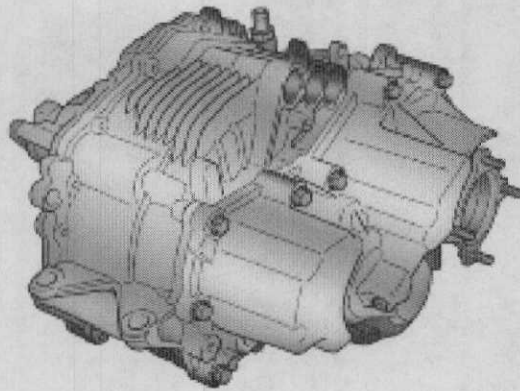
V-6 hybrid drive 650 ft. pounds torque at idle





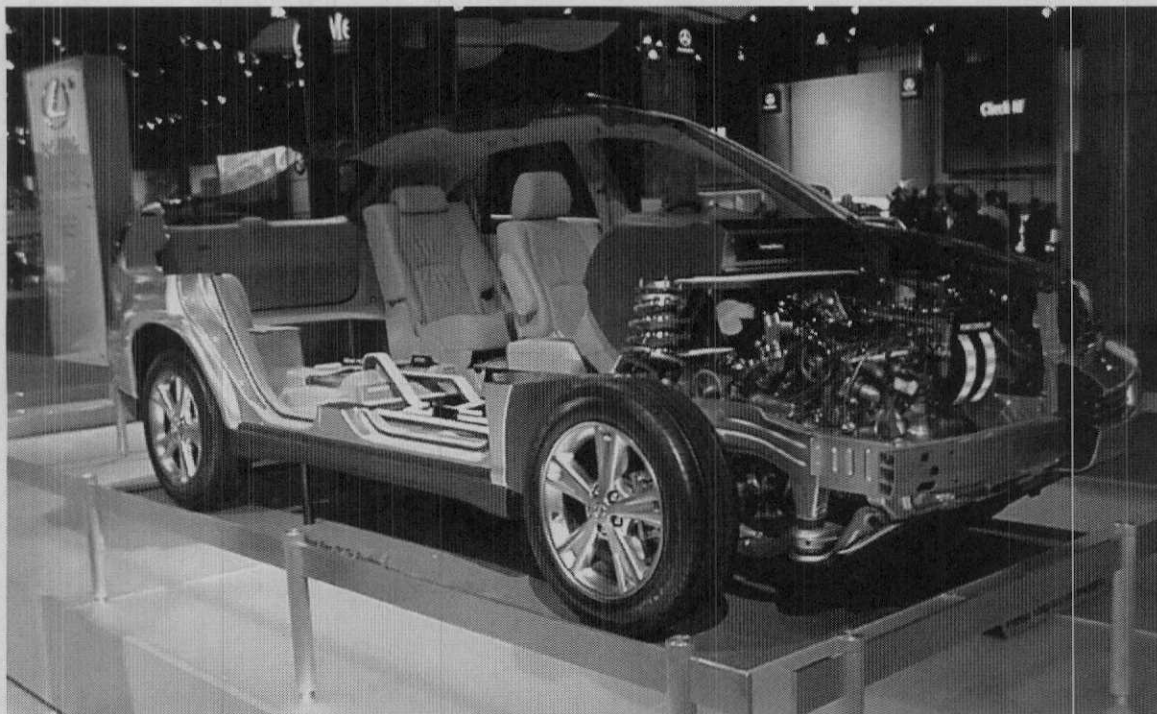
The Service Plug for disconnecting HV is on the left edge of the rear seat. The HV voltage battery pack is three separate modules, each with their own fan. This locates the battery in the most protected part of the SUV.

The location of Ford Escape HV battery is the most compromised part of the Ford design.

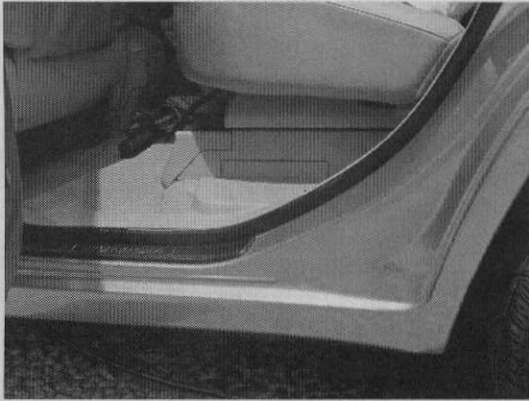


This is the rear end of the 4WD version. It has an electric motor that is engaged instantly for 4WD. Three orange cables replace the drive shaft. The EM is cooled by air and differential oil.

drive shaft. The EM is cooled by air and differential oil.



This cut away was at the NYC auto show. It shows the lay out of the hybrid components.



The service plug is behind the rectangular trim just below the center portion of the lower cushion. Under the hood is all the usually Toyota hybrid components. This new duo of SUV's will

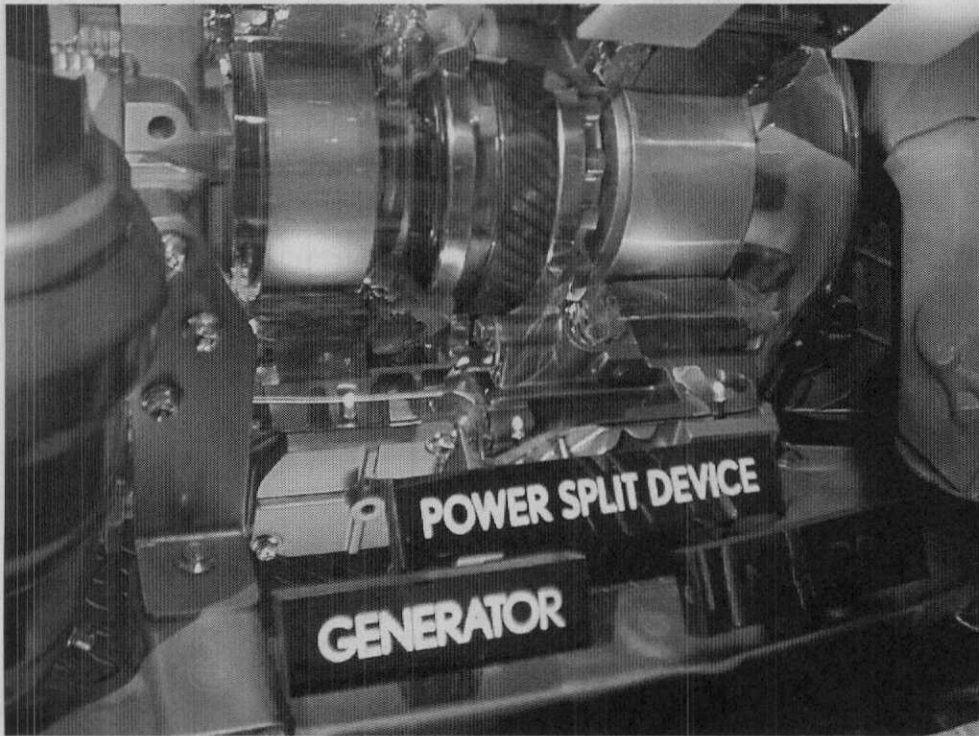
be easy to service. To spot one look for the Synergy Drive logo on the rear and a cut out in the front bumper for more air to the inverters. The transmission is still a CVT but with two planetary gear sets. As the SUV is much heavier than the Prius



a torque multiplier (the other planetary gear set) was required. More power with a 288 volt NiMH battery pack. Toyota is

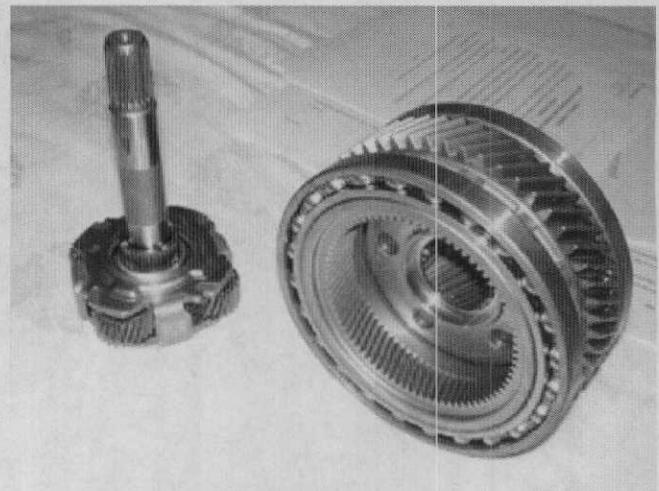
now ready to launch a minivan and pick up truck with a hybrid drivetrain.





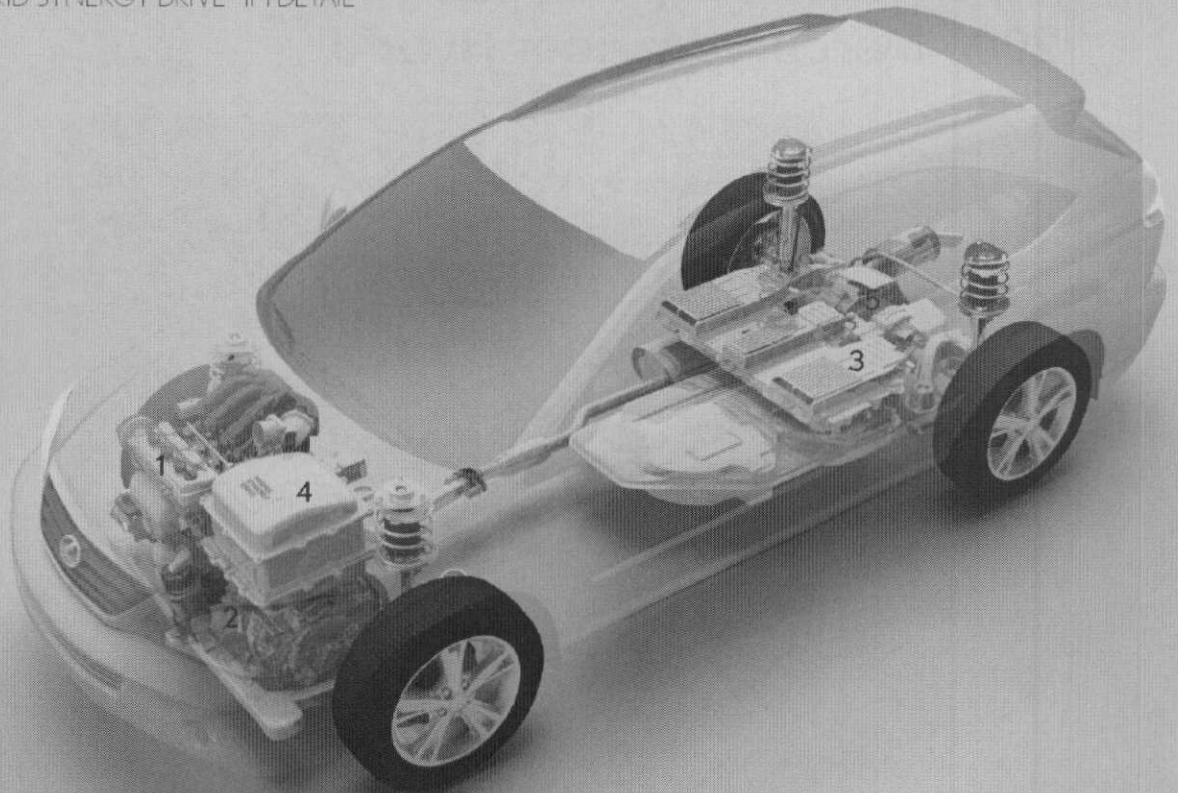
The power split device is the same as the Prius but with one more

planetary gear set so the gear ratio from the drive motor (EM2- MG1) has more torque. This cut away was at the NYC auto show in early 2005. Dave Hermance from Toyota was there and explained to me once again, how this



transmission functions. It takes a while to understand, so go to www.howstuffworks.com and type in hybrid. An animated CVT is there to look at. One thing is for sure, transmission work will never be the same.

HYBRID SYNERGY DRIVE® IM DETAIL



1. 3,3-Liter V6 Benzinmotor
2. Vordere Antriebseinheit (Vorderer Elektromotor, Generator, Planetengetriebe der Leistungsverzweigung, Planetengetriebe zur Reduzierung der Drehzahl des Elektromotors, E-CVT)
3. Hochspannungsbatterie
4. Energie-Management (Inverter, Spannungswandler, Gleichspannungswandler)
5. Hintere Antriebseinheit (Hinterer Elektromotor)

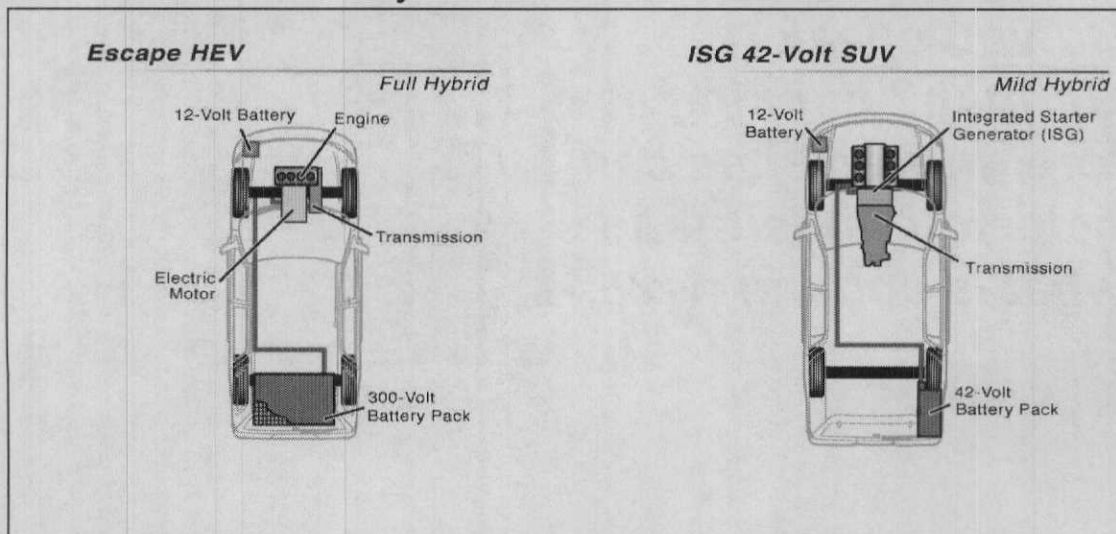
***Do you speak
German? Looking at
foreign web sites can
help you understand
what is coming next.***



2005 Ford Escape Hybrid 2006 Mercury Mariner Hybrid



Of all the two Domestic Car Manufactures (DaimlerChrysler is German) it is clear that Ford tries harder than GM when it comes to environmental issues. The ISG 42-volt below is the GM Silverado / Sierra hybrid. Most do not consider the GM hybrid a hybrid at all. I agree. ACDC will cover it in this book. It was sold in only 6 states in very low numbers from 2004-2005. The GM Micro hybrid is now available in 48 states.



Ford did not buy the hybrid system from Toyota as is widely reported. Here is the real story.

In 1986 a partnership between Toyota and Aisin (a Japanese transmission design and manufacturing company) started the development of a two motor hybrid AT design. The basic concept was thought up by an American engineer that in the mid 60s delivered an SAE paper

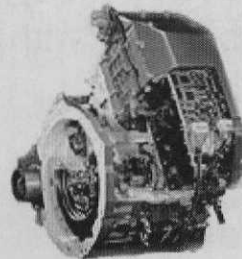


based on using a planetary gear set as a power split device. This

concept was a new use of the planetary gear set that Henry Ford used in his Model T. Henry Ford was the designer that first saw an automotive application for this simple device.

Toyota and Aisin stayed at this until 1992 when the contract expired and Toyota took the project in-house. Toyota makes their own transaxle for themselves. This left Aisin design and no partner.

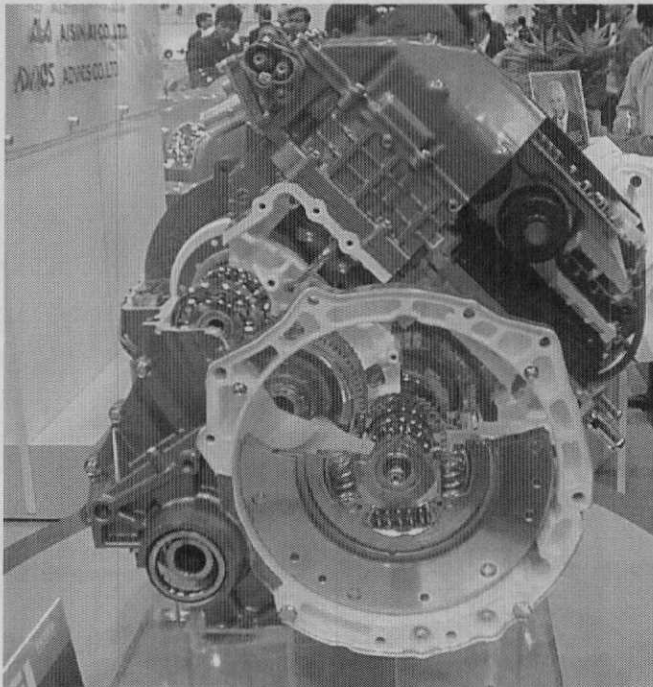
Volvo and together they development. Then Ford Volvo. Ford had done work of their own but this



design was much more advanced. Toyota had released the Prius in December of 1997, so you can be sure Ford had bought one and looked it over closely. After a press release (I have a copy) the hybrid design was now Fords. Ford has never given proper credit to Volvo. The power split design is similar in nature with what Toyota ended up with. Ford had originally said they would have the Escape Hybrid ready for sale in 2002. What happened was the software needed to merge the ICE and electric transaxle wasn't as easy as Ford had expected. It took almost two years longer than expected

their hybrid with an early Along came continued in 1999 bought some hybrid Volvo / Aisin

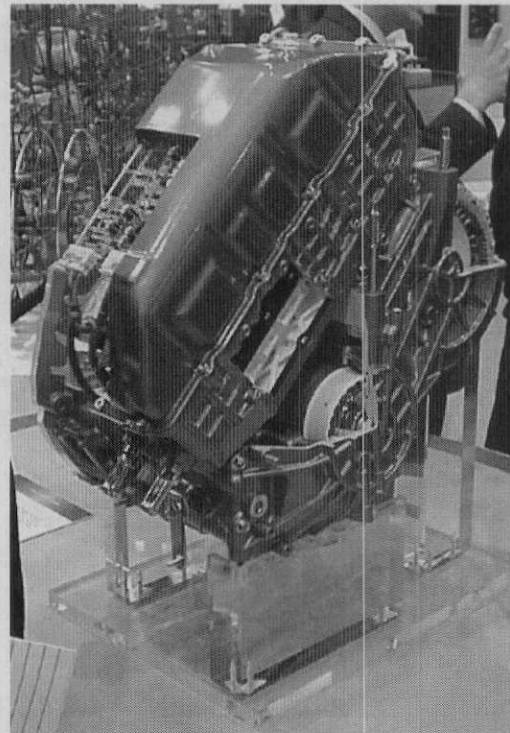
but Ford / Volvo / Aisin got the job done and Ford is now the third OEM with proven hybrid technology.



One more note: Before the Escape Hybrid was released all the US Toyota hybrid patents were looked at, some 151 of them, and it was agreed that some of the technology was so close that an agreement was reached that Toyota would swap some

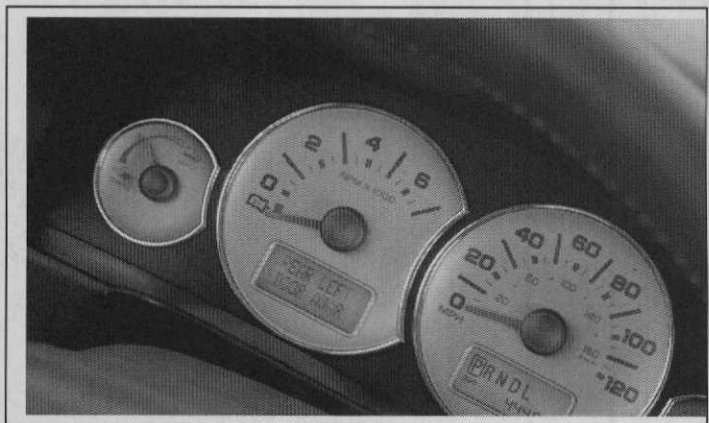
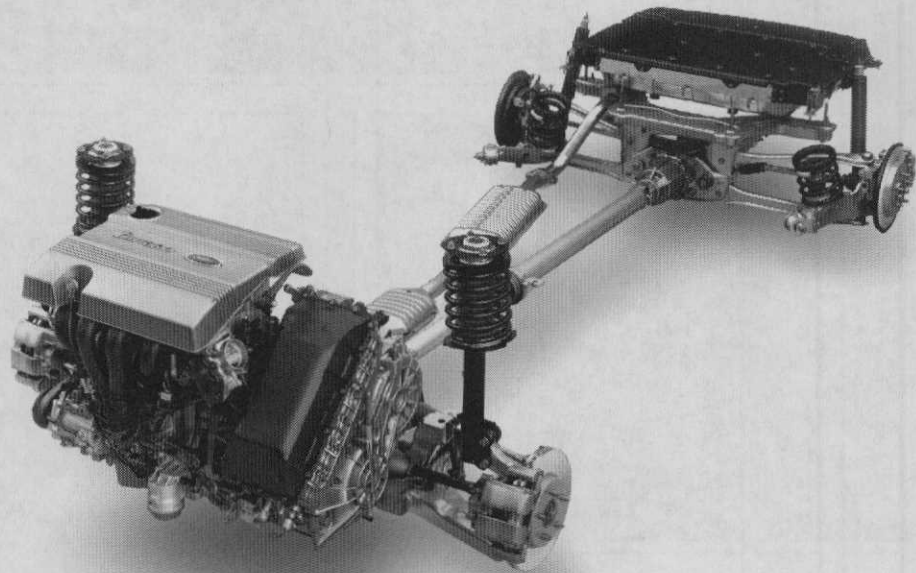
patents use for some Ford EVAP patents that Toyota could use. In the end Ford save face, learned a lot and really did (with the help of Volvo and Aisin) develop a great hybrid design. More power to Ford for sticking with it. If only GM would work as hard and have the vision that Bill Ford III has.

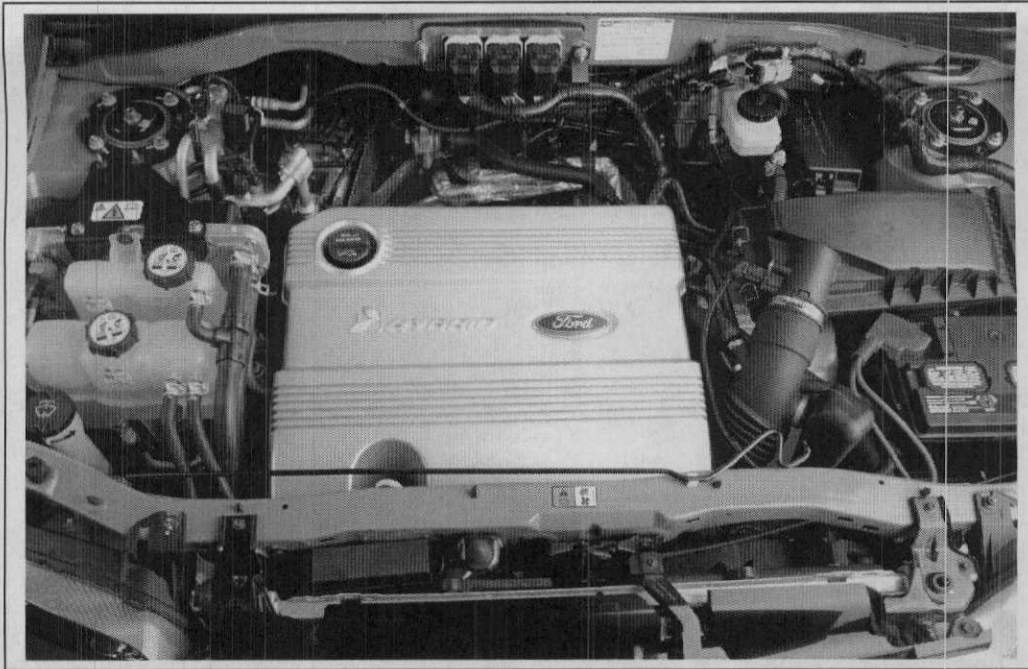
The transmission is the key to this type of hybrid design. If someone was clever enough this trans-axle has a system not used by Ford. If a larger battery pack was used it could be more electric. A one way clutch would allow EM1 to add power to EM2.



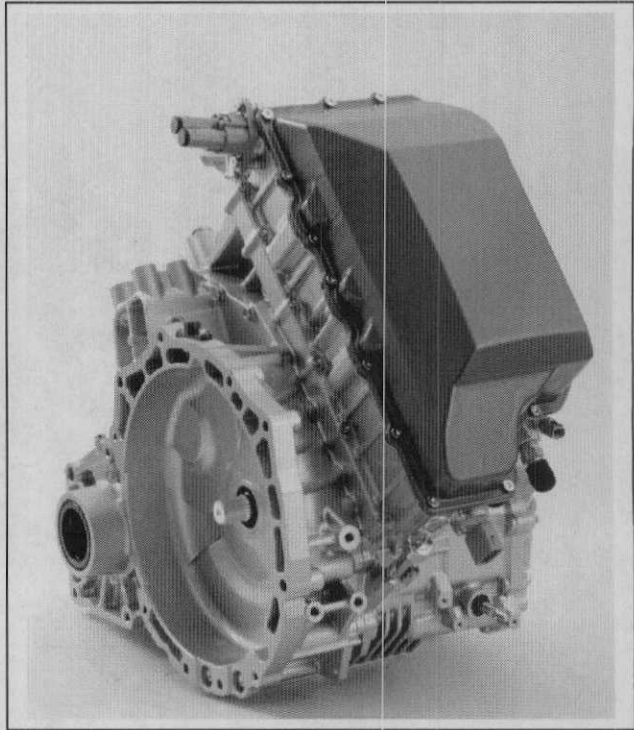
The Ford Escape was offered for sale in September of 2004. It was well received. Ford is very sensitive to their Escape being portrayed as a Prius, but the general design is very similar. No parts are interchangeable in the Ford system with Toyota. Back in 1965 Toyota sold a "Toyopet" with a Ford automatic that took type F Fluid. Now the tables are turned.

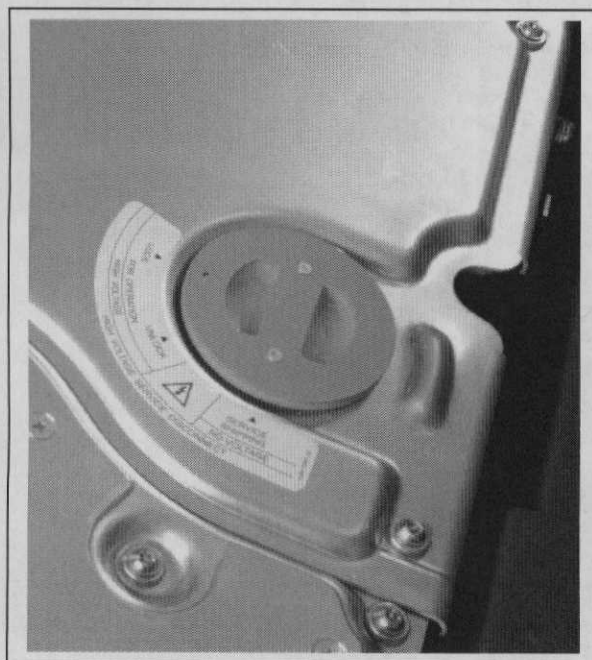
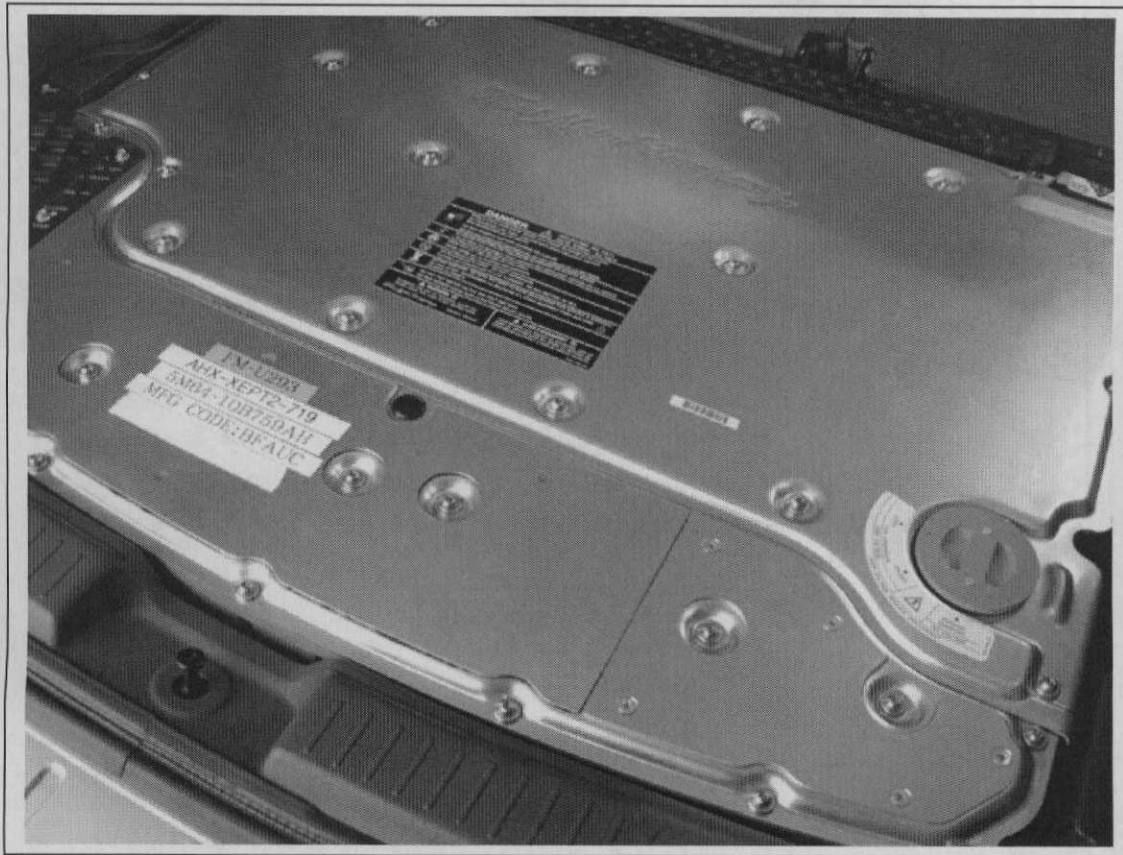
This layout has the same basics as a Prius. The CVT transmission is typical for a front drive that feeds the rear wheels. The Battery pack is a 330 volt NiMH. Note: Orange cables are not shown. 4 cylinder Ford engine with electronic controlled throttle. Below are the gauges, simple design. Left side is assist / regen gauge.





Top: Underhood. Looks like we can work on it. Right: CVT with inverter attached to top (in black cover). This is water cooled. Dash (above) is not too intimidating. Ford has done a nice job of putting this together.





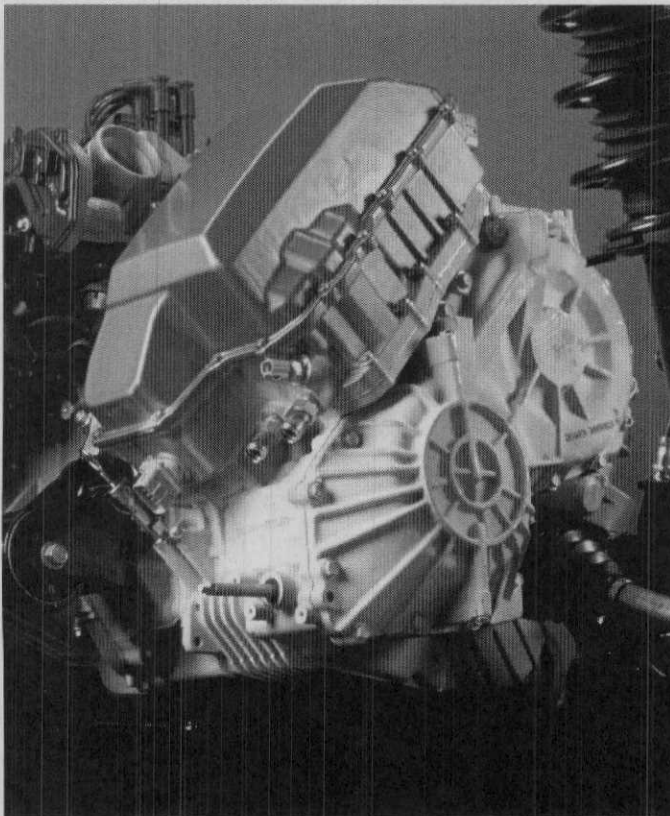
Before getting near the High Voltage System, the service switch (orange switch in picture) located on top of the HV battery pack in the rear of the car must be switched. It is turned to unlock and removed. Then put back into the shipping position. Get current Ford information for this process. The battery pack is cooled by the A/C system. Very clever. All hybrid components are made in Japan.

Ford Escape Hybrid Overview

The Ford Escape Hybrid was two year late. After talking to Tom Watson, a Ford engineer that has spent years on this project it is clear that it was not easy. Unlike Toyota and Honda this was not "get it done AT ANY EXPENSE". No, Ford was also trying to make this hybrid good but also keeping in mind the cost factors. It took about a couple years longer than expected. Because of this mandate, two key components were designed with a cost cutting mindset, and it looks like it was done well.

First the HV battery pack is "Chilled" using the climate control system and one more evaporator. This is not new, as two evaporators are on many Fords that use a rear A/C system. This is smart engineering as the components were already "on the shelve". Plus at 330 volts this was the most powerful HV battery to date. It also allows Ford to locate the HV battery pack where lots of air is not a requirement. The location of the battery pack is Pinto like. That is a problem in a rear end crash. Lexus / Toyota did it much better in this area.

The other clever move was to build the CVT in such a way that a separate PTO is used to make it 4WD. That way the Transaxle/ CVT is the same unit for both 2WD and 4WD.



The Ford Escape also boasts a nicely done electronic braking system, and by Federal law, has a master cylinder in place "just in case".

The main battery pack uses 250 flashlight size NiMH "D" size Cells made by Sanyo and grouped into cells containing 6 batteries. 2 briefcase sized packs make up the HV unit. They can produce up to 330 volts of 3 phase a/c current for

acceleration. A warning label appears on the HV battery case that warns about electrolyte. This label makes no sense at all, until you understand the U.S. Government, which is a lot like understanding women if you are male. The label is required on all batteries regardless of what type of battery it is. OK, now I know to ignore most of the warning labels I see. That will help a lot!

Traction control is limited to closing the throttle, as it is electric also.



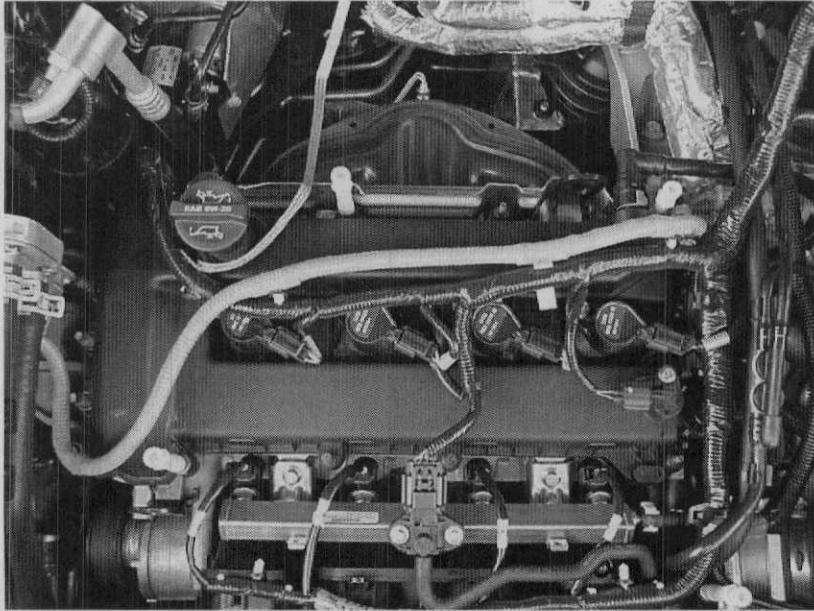
On deceleration the EM can make up to 395 volts of regenerated electricity. This has a lot to do with the weight of this SUV. More weight, more regenerated electrical power is possible. If the braking is under 1.5 g's the brakes will be front only and all regen. Think of re-gen as

compression braking. We use the EM (electric motor) instead of the ICE (internal combustion engine) to slow down the car. If over 1.5 g's the conventional brakes are added to the mix for stability and more braking. If the HV battery is full (about 80%) the re-gen will not function and the brakes will act conventionally. The brakes are all disk and all electronic. In case of a failure a master cylinder will take over.



The cooling system uses 2 radiators and the A/C condenser. The first one in line is for the transaxle, both EMs and inverter, as they get very hot. 2nd in

line is the A/C condenser and 3rd in line is for the ICE (internal combustion engine). A conventional water pump is used for the ICE along with an electric one for cycling coolant in the winter during idle stop to ensure enough heat. Lots of orange cables are near the inverter so watch out.



The orange cable on top of the valve cover is for the DC to DC converter. This steps down the high voltage to a useful 12 volts dc. 12 volts is what most of this little SUV runs on.

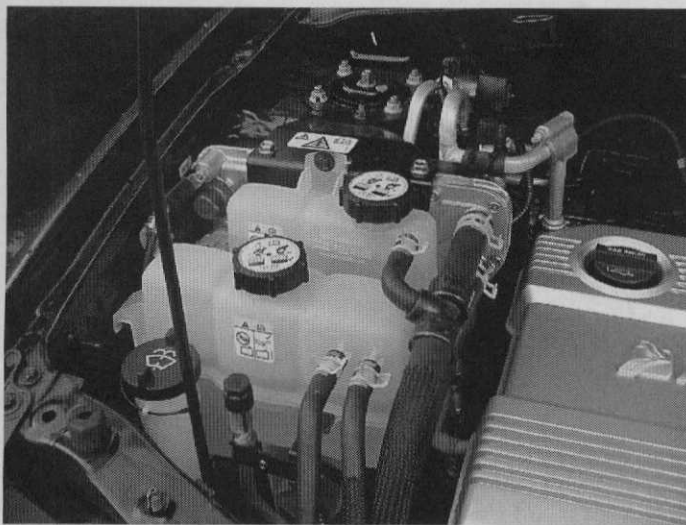
A small orange colored round rotating switch is used to de-power the system. It also has a location on it called "shipping". With 330 volts inside this used on the assembly line as the Ford Escape in made along side the 12 volt brother. Ford wants to keep the assembly line moving and shocking their workers is not their plan.

As Ford developed this hybrid, the planetary gear set is the focus of the CVT and it is extremely similar to the Toyota design. Ford insists that they were working on this design when Toyota was also developing their Prius. It was 7 years after Toyota sold their first Prius in Japan that Ford sold their first hybrid in America. Toyota has gone on record stating that they did not help Ford in anyway except to license the use of their patents for a large portion of this layout. Note; Honda's IMA (Integrated Motor Assist) is unique. I am happy that Ford has done their work, even if they leaned heavily on the Prius, and came out with their Hybrid system. More hybrids equal less pollution and less foreign oil. Hard to argue with that!

For those of you that many not be familiar, read up on the Prius CVT and you will have what you need for Ford's design. They are kissing cousins.

The capacitors are there to soak up any unwanted voltage spikes. They are not big enough to act as a battery in addition to the HV pack, but the

capacitors can be deadly. Know what you are doing if you get around them. They are on top of the transaxle. In the case of an accident there is a constant monitoring of the HV cables and other related parts. If the hybrid computer detects any leakage of voltage to ground, two contactors (aircraft quality relays) switches automatically open and in less than 200ms the capacitors are drained.

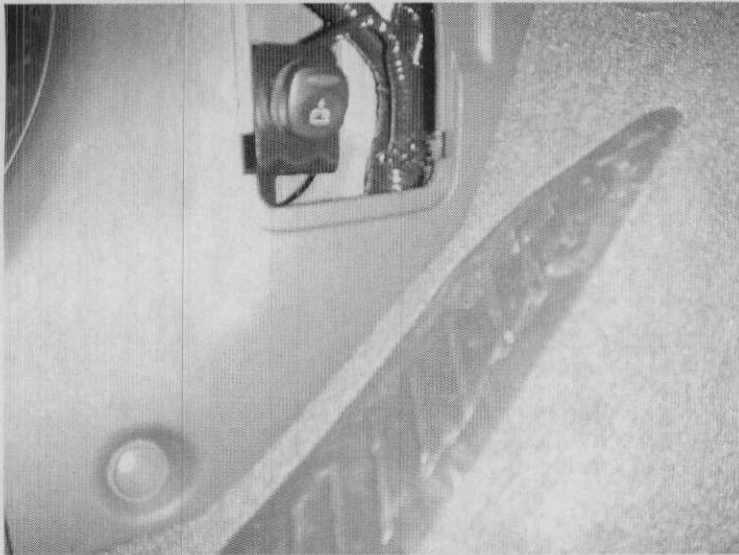


A small vent is installed for the natural cooling effect of the NiMH batteries at rest. A small vent will open that allows any heat or hydrogen (a safety issue) to escape from the HV battery box. The vent is located on the left side rear glass. Look closely and you will see a two pane glass. The inlet is on top and the exhaust is below. In cool

weather the HV batteries are air cooled, not chilled by the A/C system. If there is a problem with the A/C system, it will set the MIL lamp but will provide codes. If the HV batteries get too hot in an Escape with a failed A/C system, the on board computer may limit the power from the NiMH batteries. Simple, efficient, and the vent is out of the way.



One interesting note, since Ford has done their own work and they are state side, there is easier access to technical information. My thanks to Ford for being willing to answer questions.

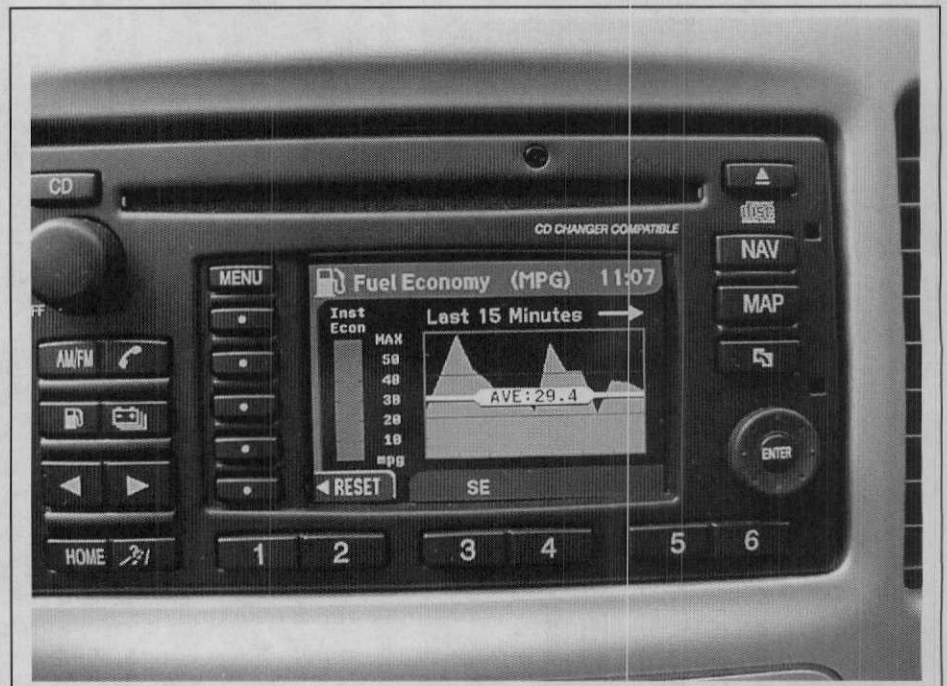


One more note: If the NiMH battery gets too low to start the ICE, locate a small switch on the left foot well inside kick panel under a cover. It can be switched on and the 12 battery will start to charge the HV battery pack. There is an 8 minute timer so the 12 volt battery won't go dead. It can be recycled on as

many times as you need to until the HV battery pack can start the SUV. Once it starts let the SUV run so that both batteries get recharged. Your scan tool will show you SOC. Use a charger on the 12 volt during this process. Great idea! Honda and especially Toyota need this feature.

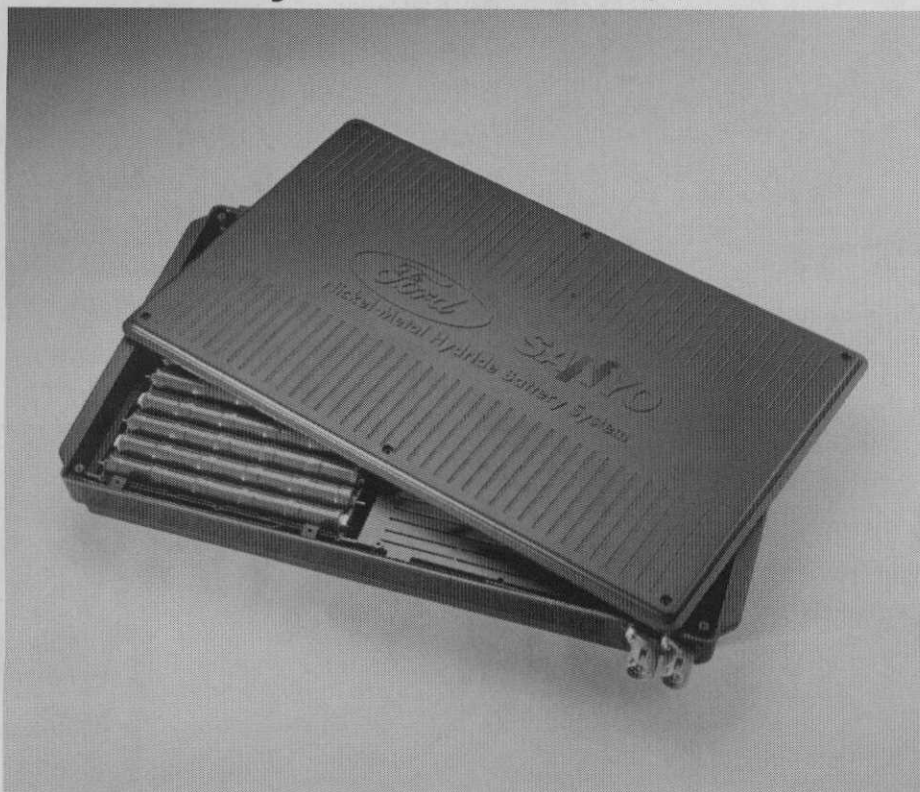
Note on left side of display two buttons. First one has gas pump. Push that for Fuel Economy screen. See Upper Picture. This screen is an option.

Push Battery button for lower screen. Power distribution. When there is orange around the EM the Escape is ready to drive. This is like the "READY" light on the Prius.





The Battery Pack. This Battery pack consists of 250 'D' size



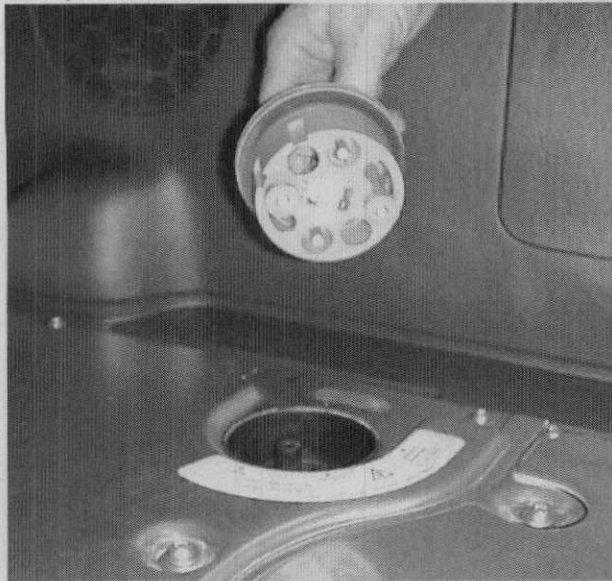
NiMH cells. The BCM, contactors (relays), blower, ducts, on-board HV battery charger, and wiring are all sealed in this case. At the present time Ford is not allowing any service in this

module. That may change as time goes on. My guess is that a RMD pack will be available as more Fords come on line. At the NYC auto

show a cut away was on display. Other than the poor location (vulnerable in a rear end accident) this is a very nice set up.

The orange service plug is removed (with a high voltage rubber glove) and

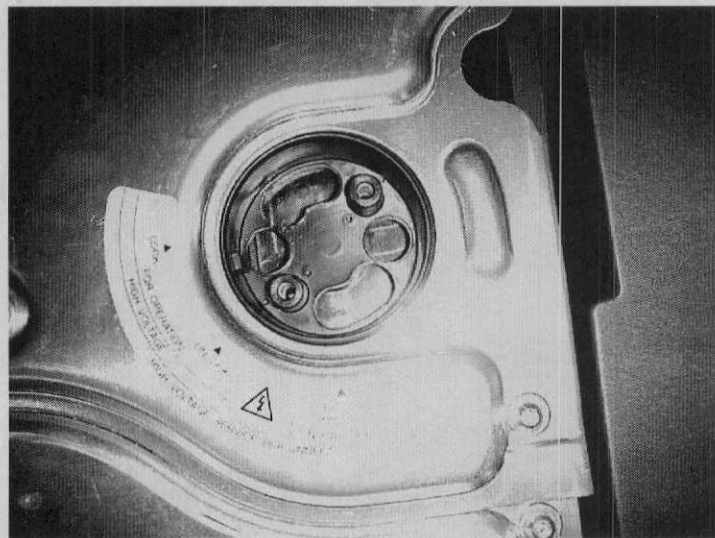
then placed back into the shipping position so that nothing falls into

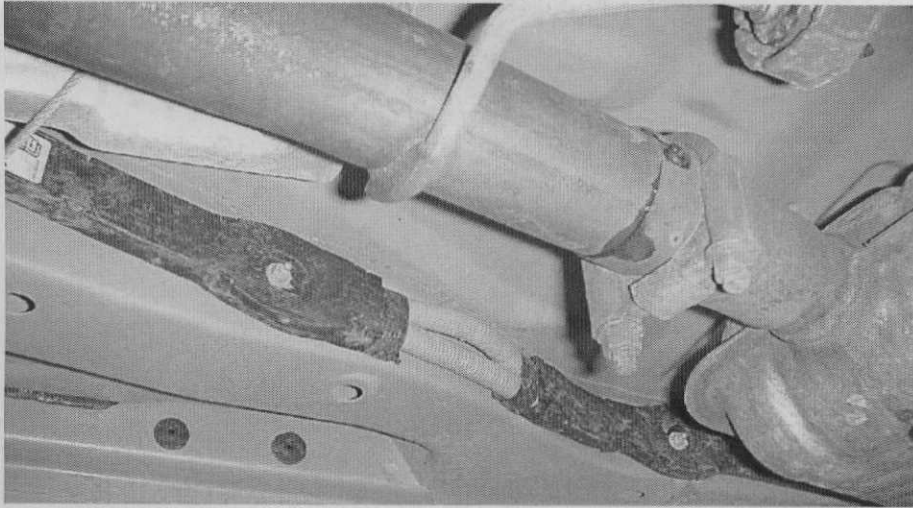


the hole. That would require removal of the battery pack and disassembly, and it also has 330 volts inside there so be careful.

The cost of the HV NiMH battery pack is very high (over \$7,000.00) and Ford requires a \$1,000.00 core charge. If the case has a dent, the \$1,000.00 is forfeited. I have consulted with insurance companies and this is a concern for

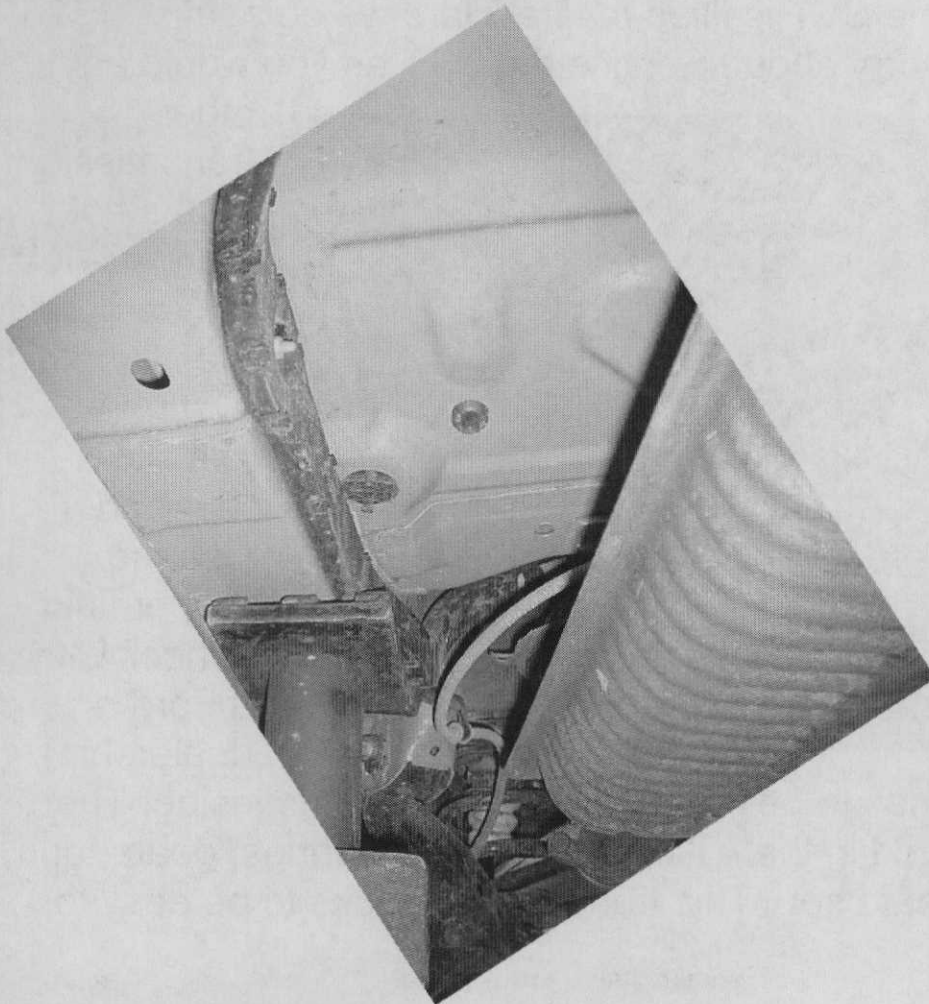
them. In some cases Ford has discounted the battery pack to satisfy an insurance company. Ford has no close ties with a NiMH battery company and relies on Sanyo in Japan for their supply. As more hybrids come on line, and these batteries are built in the US this situation should find a remedy.





The orange cables running under the SUV are held in place by a few black

covers. Watch these cables as I have seen some sagging. Also, if a wayward jack finds them, all h*ll will break loose.

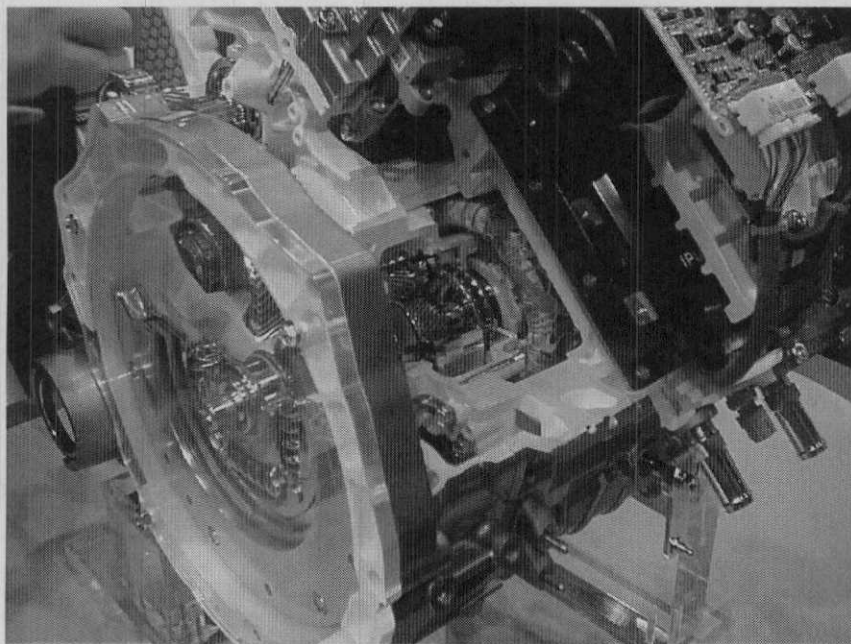




Servicing the CVT

After partially removing the splash shield, there will be one bolt that isn't worth going after just to check the fluid level, cut away a piece (it is a circle

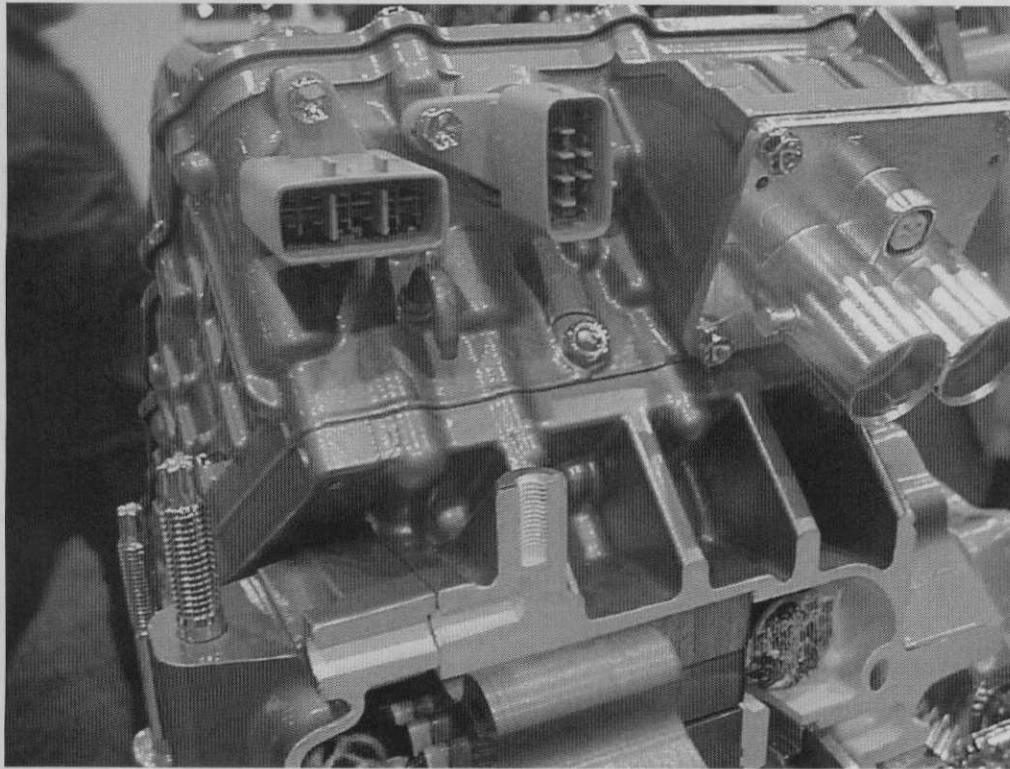
shape) and checking the CVT will be easier next time. Ford states that the CVT is filled for life. Here we go again, nothing to worry about! Service the CVT as you would any



other transmission. It gets hot, there are lots of gears, and the fill drain system is just like a rear end. Use the proper fluid (Check with a Ford dealership)

as the fluid has to be harmless to the HV parts inside. The EM are bathed in the AT fluid, as is the bearings, gears, and planetary gears set. This transmission looks to be easy to rebuild.

The chrome bolt just below the center electrical



connector is the air bleed for the inverter coolant. Use this to bleed off any air after



refilling the inverter radiator.

An ACDC
Ford Escape
Hybrid class
for a fleet.

05' Escape Specs

Gasoline Engine

Engine type	2.3L I4 engine Atkinson cycle
Engine electronics	Electronic engine controls
Displacement	2.3L (138 CID)
Horsepower (SAE net@rpm)	133@6,000
<u>Combined horsepower of gasoline engine and electric motor</u>	155 hp
Torque (lb.-ft.@rpm)	129@4,500
Compression ratio	12.3:1
Bore and stroke (in.)	3.44 x 3.70
Main bearings	5
Valve lifters	Direct-acting mechanical bucket
Fuel delivery	Sequential multi-port electronic fuel injection
Fuel	Regular unleaded
Fuel economy *	4x2 36 city/31 hwy. 4x4 33 city/29 hwy.
Transmission type	Electronically controlled continuously variable
Exhaust	Single with catalyst system

Electric Motor

Motor type	<u>Permanent magnet AC synchronous</u>
Power (rpm)	94 hp@3,000-5,000
Voltage	400-volt maximum

Chassis Specifications

Front suspension	Independent MacPherson struts supported by L-shaped lower control arms, coil springs and stabilizer bar
Rear suspension	Multi-link suspension with two lateral links and trailing arms
Front and rear brakes	Power-assisted, ventilated 4-wheel disc with standard ABS and integrated regenerative braking
Steering	Rack-and-pinion with electric power assist

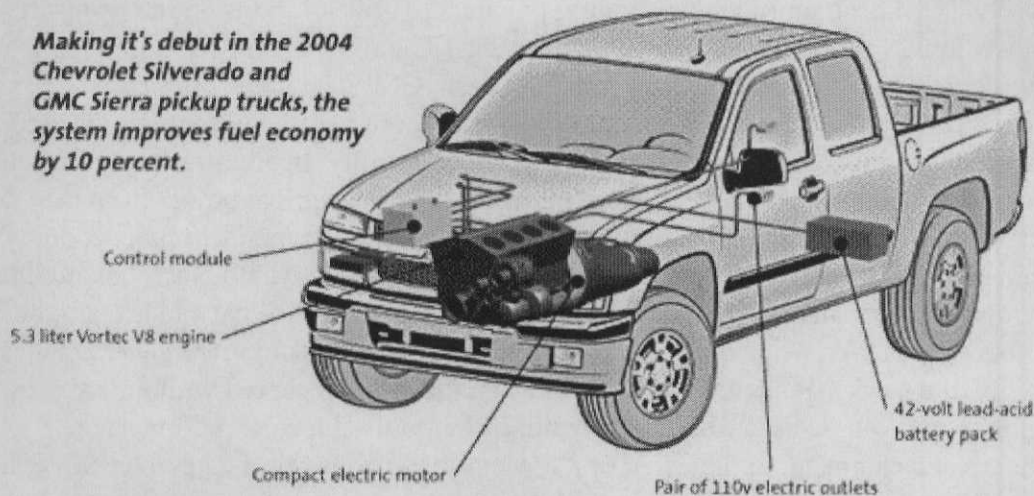
*** the real mpg will be around 30 combined. A lot depends on the driver. I drove both 2wd and 4wd and averaged about 30 mpg.**

Chevrolet Silverado Hybrid Pick-up Truck GMC Sierra Hybrid Pick-up Truck

GM Hybrid Pickup Truck

GM's Hybrid Truck uses a compact electric motor, integrated between the engine and transmission, instead of a conventional starter motor and alternator. Regenerative braking and early fuel cut off are part of the system. The gasoline engine shuts off at idle, while the 42-volt battery motor powers the accessories. The system also provides 110 volts to a pair of onboard electrical outlets, which can be used to run appliances at a campground or power tools at a construction site.

Making it's debut in the 2004 Chevrolet Silverado and GMC Sierra pickup trucks, the system improves fuel economy by 10 percent.



Source: General Motors

Vehicle Description

The 2004 - 2006 Sierra / Silverado Hybrid is a 1500 4wd extended cab truck. GM wanted to get into the hybrid game after they turned down a few offers back in the 80's and 90's. The hybrid system (GM is using the hybrid name loosely) was contracted by GM with Continental Teves, a German company, to help GM put a hybrid out ASAP. It has sold in very small numbers. Many dealerships will not sell it as it would require a level of commitment that doesn't make sense given the small numbers (under 1,000 nation wide). ACDC defines a hybrid as "A vehicle that has two forms of power to drive the wheels". This truck only has one, the V8 engine. A good start? YES. A hybrid? NO. It has three lead acid 12 volt batteries under the back seat in series, and a 12 volt under the hood for most systems. The chance of you working on one is very slim.

More info from GM follows: Factory options; power driver seat adjuster, cj2 dual zone air cond , auto c7h gvw rating - 6,400 lbs d13, osrv mirrors w/pwr fold & adj, heat & turn signal; electro-chromic dr-side mirror, 50-state emissions, gu6 rear axle - 3.42 ratio hp2 hybrid system, m33 4-spd automatic hybrid transmission, pdu light duty power package incl: vortec 5.3l 295hp iron blk v8, h.d. rear locking differential, h.d.trailerling

equipment r6j customer dialogue network 1sz ld power pkg savings - 3sa sle1 decor includes: electrochromic isrv mirror with compass & temp, electric rear window defogger, deep tinted glass, am/fm stereo w/cd player, cruise control, power locks & windows, remote keyless entry system, power heated exterior black mirrors, leather-wrapped steering wheel, chrome-styled steel wheels, bodyside moldings, autotrac transfer case.

The hybrid pickups feature GM's powerful 5300 Vortec V-8 and Hydra-Matic 4L60-E four-speed automatic transmission, coupled with a new hybrid technology that delivers 10 to 12 percent improved fuel economy over GM half-ton pickups, giving the hybrid Chevrolet Silverado and GMC Sierra the best highway fuel economy of any full-size truck on the market. The trucks also feature reduced emissions and unique accessory power capability, without any sacrifice in load-carrying, towing and grade-climbing capability. "GM is committed to providing practical hybrid solutions on the widest range of high-volume vehicles, including full-size trucks. Today's delivery shows GM is delivering on this commitment," said John Gaydash, GM Fleet and Commercial marketing director. "These hybrid pickups will save more fuel than gasoline-powered pickup trucks, with no compromise in performance or utility. In addition, you now have the flexibility and productivity of generating wall-quality electrical power from the GM pickup truck when in remote locations." In addition to improvements in fuel economy and emissions, the GM hybrid pickups feature four 120-volt, 20 amp electrical auxiliary power outlets under the rear seat of the cab and in the pickup bed that can accommodate up to four accessories while driving or when parked. With this auxiliary generator capability, the truck's generator can operate when the truck is parked without a key in the ignition and can be used to power anything from tools at a construction site to appliances at a campsite. In the event of a power outage, the hybrid Chevrolet Silverado and GMC Sierra pickups could power tools or appliances for up to 32 hours non-stop. This design shuts the engine down before the tank is emptied, leaving enough gas to drive to a station for refueling. All power supply circuits are protected by a ground fault detection system to prevent overloads and short circuits. The GM hybrid pickups are more efficient because of the engine start/stop function and regenerative braking, which turns the motor into a generator as the truck decelerates. Extra fuel savings come from quickly shutting off fuel any time the truck is coasting or braking, and using the electric motor to smooth out any resulting vibrations. Instead of a conventional starter motor and alternator, the hybrid truck features a compact electric motor that is integrated in a patented, space-efficient way between the engine and transmission. The electric motor provides fast, quiet starting power and the ability to generate up to 14,000 watts of continuous electric power. At a stoplight, the gasoline engine stops running, but the accessories continue working on stored electrical power. When the light turns green and the driver releases the brake, the gasoline engine kicks in again seamlessly, with little or no delay or disturbance. To ensure full accessory capability while the engine is temporarily stopped, an electrically driven hydraulic pump provides power steering, an electric pump continues to circulate hot water if cabin heat is needed in the winter, and cold, dry air is supplied in the summer for an extended period through control of the conventional air conditioning system.

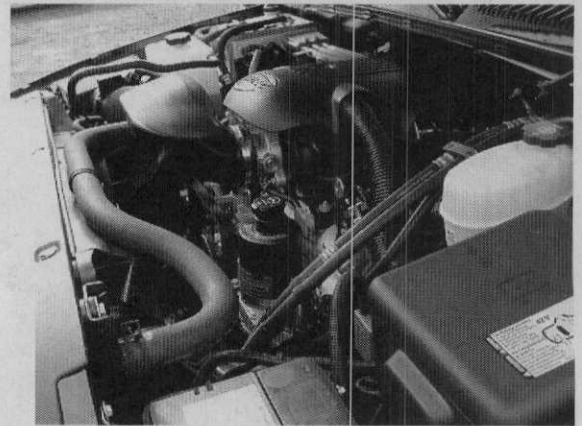
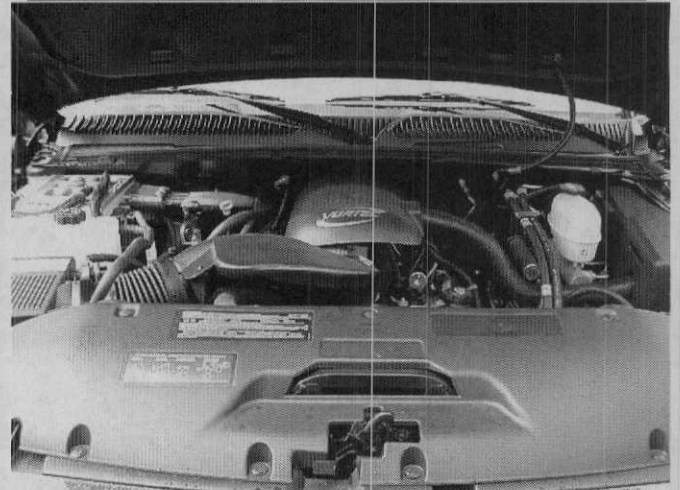
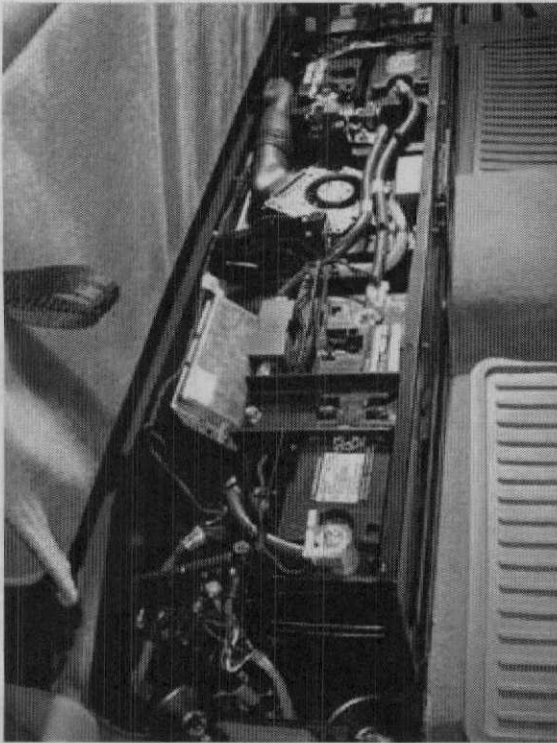
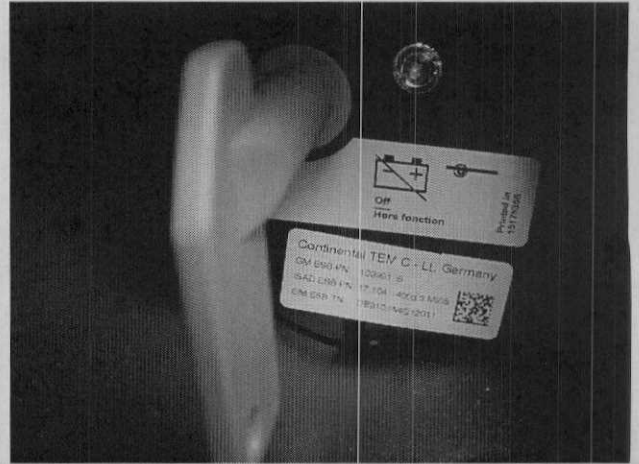
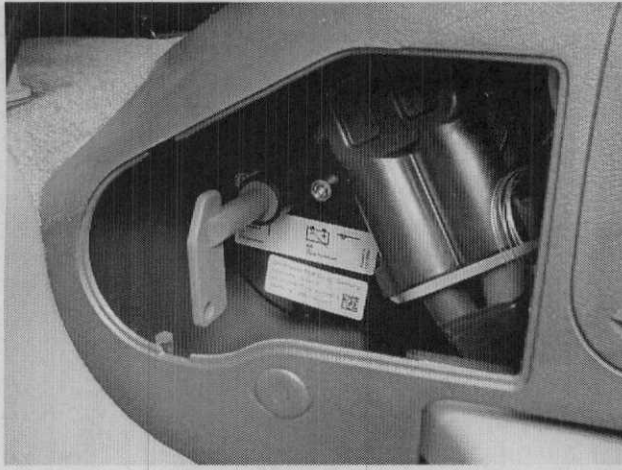


More info at <http://www.conti-online.com>

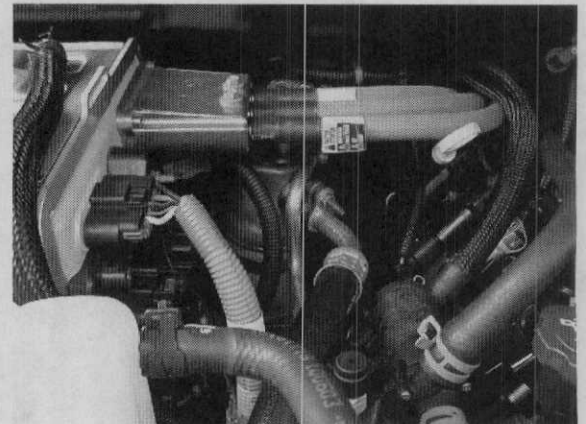
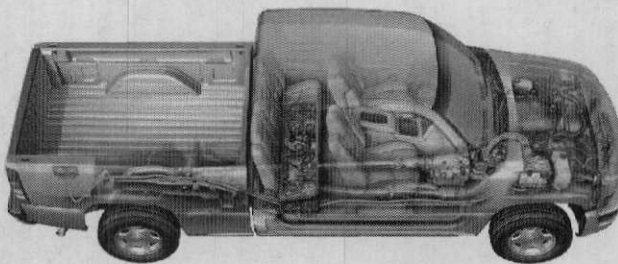


ACDC

Craig Van Batenburg



GM Parallel Hybrid Truck (PHT)



The future of Hybrids

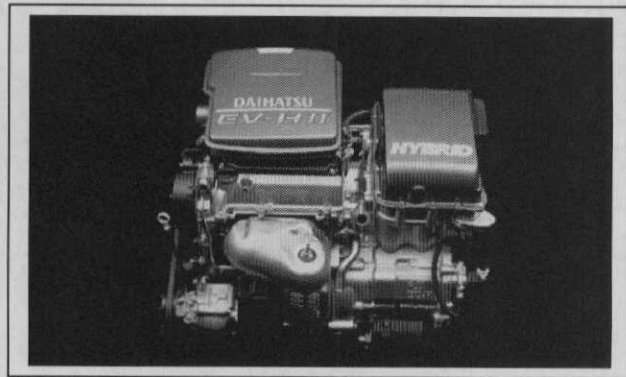
Honda now has three hybrids, Insight, Civic, and Accord. Toyota has updated their Prius, added the Highlander, and Lexus now has their RX400h. Ford has the Escape, Mercury their Mariner. GM is getting more serious. Toyota has a small mini-van, the Estima, sold in Japan that is a hybrid design with gas/ electric front drive and electric only rear drive, making it a 4-wheel drive system. Daihatsu (owned by Toyota) has a hybrid.

Very Mild Hybrids (VMH) are available from GM as the Hybrid Silverado and GMC Sierra Hybrid.

DaimlerChrysler just entered an agreement with GM, and BMW for sharing hybrid designs. Toyota has clearly taken the lead.



Daihatsu hybrid
above and at
right.



The car below is an Opel Diesel Hybrid prototype. More are in the works from every car and truck maker. John Deer is looking into hybrids.

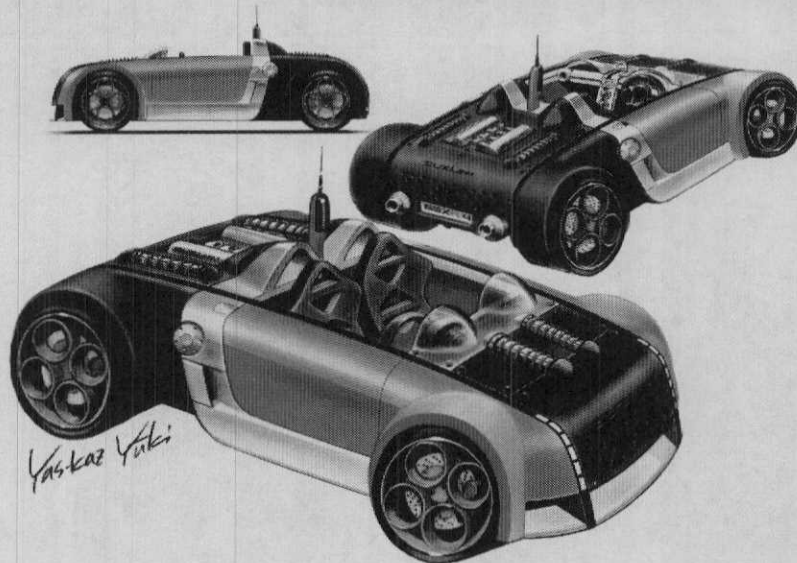
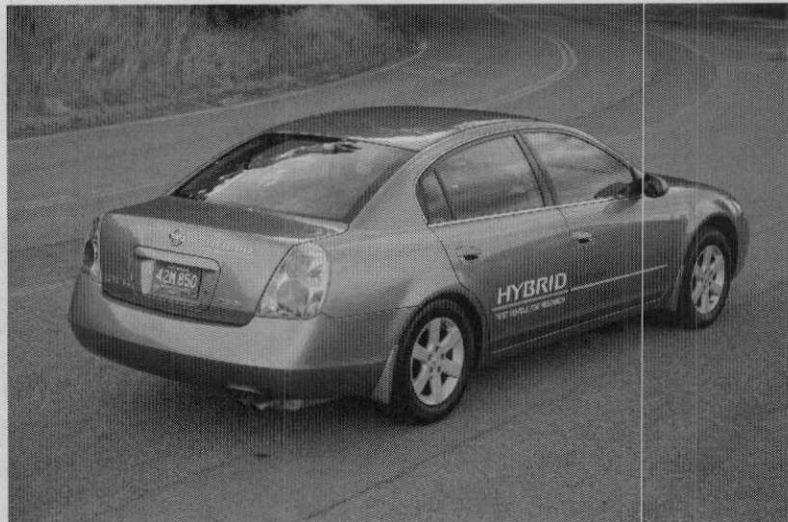


What is coming next?

2007 - Camry Hybrid
Nissan Altima Hybrid
Ford Fusion Hybrid

2008 - Hyundai Accent Hybrid
Chevy Malibu
Lexus IS
Lexus GS

The above models are almost certain. Other factors could be Porsche, Mitsubishi, GM and Ford may get more out sooner depending on gas prices and sales of their other cars, SUV, and trucks.





Craig takes the wheel of a new 2004 Prius. Summer 2004.

“The stone age didn’t end because they ran out of stones”

We don’t have to use up all the oil. Hybrids and life style decisions can lead us to alternate energy.

A Thank You

A thank you needs to go to Brian Pirie that gave me permission to use “what ever I needed” from his web site www.insightcentral.net. Bill Haas from ASA that asked me to put a hybrid class together for a national audience. John Wayland for E-mails, to Dave Hermance from Toyota for being helpful with a Prius and answers to my questions, to John Ball, Keith Johnson, and Tim Jones from Honda that helped with Honda questions. To the EPA for the use of their “Getting to Know Prius” guide. To Tom Watson from Ford Motor Company and their Environmental Dept. To Stan Stephenson for getting the early drives in pre-production cars, to Bill Cannon for asking me to write for Motor Age, to Auto, Inc. for their help in promoting hybrids, to Scott Bleau, who drove while I studied scan tool data, to Deb Van Batenburg my editor and wife and my sons, Mike who reminds me daily as to why I love this work. (Mike has asthma. He is fourteen years old) and Will who asks a lot of questions. All pictures and diagrams were used with permission.

Thanks for purchasing an ACDC product. Please remember there is no substitute for doing the basics, getting good information, and not cutting corners. Watch our Web site for classes and latest schedule. www.auto-careers.org

Hybrid help on the WEB or by phone

www.auto-careers.org **Automotive Career Development Center Craig Van Batenburg's web site**

www.identifix.com **Identifix hot line 1.800.288.6210**

www.iatn.net **tech help / forums**

www.honda.co.jp/ **Old /new Honda History.. Japanese site**

www.insightcentral.net **Independent Insight site..very good**

www.howstuffworks.com/hybrid **very good explanations**

www.John1701a.com **Prius independent site**

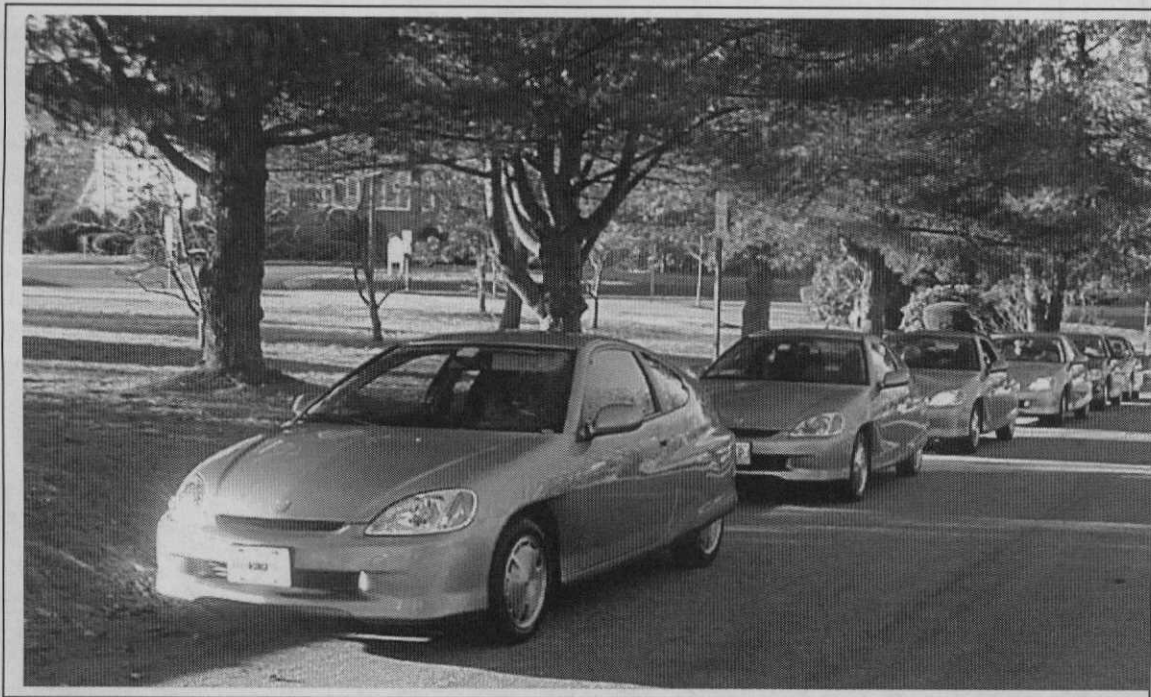
<http://autotech-elearning.com> **Grant Swain's Pay Honda Site**

www.nastf.org **link to all sites for oem's**

www.sae.org **former STS Tech Group**

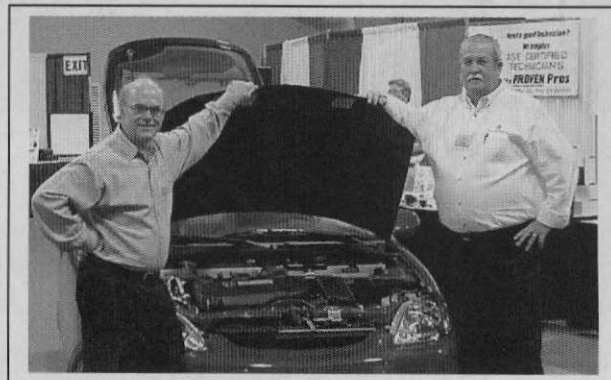
www.lindertech.com **Ask for Doug - Injectors 888 809-3835**

www.hybridcars.com **I do some of the technical part of this site. Good 10 buck book to download.**



Above pictures is what the world would look like if it was up to Craig.

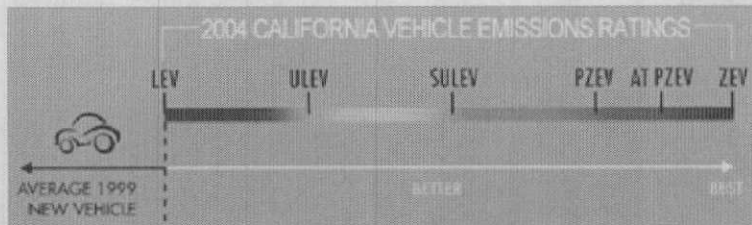
Right: Craig tries to get Jim Linder to buy a hybrid car. So far no luck!



What is all this ULEV, PZEV, STUFF?

DRIVECLEAN.CA.GOV

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*Special Note on Trucks, Vans & SUVs



ZEV

Zero Emission Vehicles have zero tailpipe emissions and are 98% cleaner than the average new 2003 model year vehicle.

AT PZEV

Advanced Technology PZEVs meet SULEV tailpipe emission standards, have a 15 year / 150,000 mile warranty, have zero evaporative emissions and include advanced technology components. For example, a plug-in hybrid or a compressed natural gas vehicle would qualify in this category.

PZEV

Partial Zero Emission Vehicles meet SULEV tailpipe emission standards, have a 15 year / 150,000 mile warranty and have zero evaporative emissions.

SULEV

Super Ultra Low Emission Vehicles are 90% cleaner than the average new 2003 model year vehicle.

ULEV

Ultra Low Emission Vehicles are 50% cleaner than the average new 2003 model year vehicle.

LEV

Low Emission Vehicles are the least stringent emission standard for all new cars sold in California in 2004 and beyond.

NOTE ON TRUCKS, VANS AND SUVs:

In 1998, the California Air Resources Board extended the passenger car emission standards to heavier sport utility vehicles and pickup trucks (with gross vehicle weight up to 8,500 pounds), which formerly had been regulated under less stringent emission standards (LEV I). The new regulations (LEV II) provide a transition period between 2004 and 2007 for manufacturers to meet the new standards for trucks, vans and SUVs. Consequently, a portion of the large vehicle fleet will meet less stringent emission standards (LEV I) until 2008.

For the consumer this means that until 2008, larger vehicles with, for example, a SULEV emissions rating could pollute up to ten times more than a passenger vehicle with that same rating.



Is GM really in the hybrid business? In one word... NO! The hybrid PU on sale now is a German design, with a hybrid badge. It is not a hybrid in the most common definition. Will GM really get into the business? Their future is at stake so I don't know how they can stay out of it. It may take Toyota to come to their rescue!

GLOSSARY of Hybrids with a slant toward the Prius

ABS	Anti-Lock Braking System
A/C	Air-Conditioning
ACDC	Automotive Career Development Center. The company that wrote this book.
AT-PZEV	Advanced Technology Partial Zero Emission Vehicle
"B" Gear	Engine Braking, (it isn't actually a gear) when you shift the transmission to this setting the engine will be used to slow down the car, it works similar to a "Jake Brake" used on the large semi-trucks.
C	Celsius, a measure of temperature, $(C * 1.8) + 32 = F$, $-25^{\circ}C = -13^{\circ}F$, $-15^{\circ}C = 5^{\circ}F$, $-5^{\circ}C = 23^{\circ}F$, $0^{\circ}C = 32^{\circ}F$, $5^{\circ}C = 41^{\circ}F$, $20^{\circ}C = 68^{\circ}F$, $25^{\circ}C = 77^{\circ}F$, $30^{\circ}C = 86^{\circ}F$
CARB	California Air Resources Board, an agency dictating emissions requirements for cars sold in California. (These are often more strict than Federal standards.)
CAT	Catalytic Converter, a vital component in the emissions system
Cat Warmer	A slang term used to identifying the thermal storage system designed to heat the intake manifold so emissions entering the catalytic converter will keep it warm enough to insure maximum exhaust cleansing is possible.
CC	Cruise Control
Cd	Coefficient of drag (0.29 for the classic Prius, 0.26 for the +2004 Prius, 0.25 for the Insight!)
CEL	Check Engine Light
Classic	The term used to identify the 2001, 2002, 2003 model years of Prius.
CVT	Continuously Variable Transmission, in Prius is a "planetary" design using a power-split device, other CVT vehicles use a belt & cones
DRL	Daytime Running Lights
DVD	Digital Versatile Disc, used for the Navigational system in Prius
ECU	Electronics Control Unit, the amazing computer that monitors and controls the two motor-generators, the gas engine, the motion of the planetary gear set, the battery pack power levels etc. to provide the Prius' smooth acceleration and speed control.
Engine	The common term used to refer to the power device which runs on gasoline.
EPA	Environmental Protection Agency, the group responsible for rating the emissions and gas mileage of vehicles sold in the United States.
EV	Electric Vehicle, powered exclusively by a battery-pack charged before use
F	Fahrenheit, a measure of temperature, $(F - 32) / 1.8 = C$, $-15^{\circ}F = -26.11^{\circ}C$, $0^{\circ}F = -17.78^{\circ}C$, $15^{\circ}F = -9.44^{\circ}C$, $32^{\circ}F = 0^{\circ}C$, $40^{\circ}F = 4.44^{\circ}C$, $60^{\circ}F = 15.56^{\circ}C$, $70^{\circ}F = 21.11^{\circ}C$, $80^{\circ}F = 26.67^{\circ}C$

FCHV	Fuel Cell Hybrid Vehicle, a fuel-cell vehicle that takes advantage of hybrid technology including the use of a battery-pack
GPS	Global Positioning System, this is the part of the Prius Navigation System that identifies your exact location on Earth.
HEV	Hybrid Electric Vehicle
HEV #	Hybrid Electric Vehicle, where # represents the distance in miles the vehicle can travel using only electricity. (Prius doesn't qualify as this since the engine will sometimes run briefly while driving in stealth.)
HID	High Intensity Discharge, bulbs used for headlights
HSD	Hybrid Synergy Drive (Toyota's modular hybrid design, currently implemented in the +2004 Prius with many more vehicles planned to also use it)
HOV	High Occupancy Vehicle (used to describe the restricted "diamond" lanes on highways)
HP	Horsepower, indicating a unit of power, a measurement different from torque
ICE	Internal Combustion Engine
IMA	Integrated Motor Assist (Honda's hybrid technology)
km	Kilometer, a measure of distance, 1 kilometer is equal to 0.6214 mile
kW	Kilowatt, an electrical measurement unit used when describing Prius power consumption & storage
LEV	Low Emission Vehicle
L/100km	Liters per 100 kilometers
LMPG	Lifetime Miles Per Gallon
LRR	Low Rolling Resistant (used to describe minimum friction tires)
M	Mile, a measure of distance, 1 mile = 1.6093 kilometers
MD	Multi-Display (the screen on the dashboard of the Prius)
MG	Motor Generator, an electric motor which can either provide motive power when electrically driven or generate electricity when mechanically driven.
EM1 MG1	This three-phase AC permanent-magnet synchronous motor/generator starts the ICE, controls the CVT, and generates the electricity (by using thrust from the ICE) to charge the HEV battery.
EM2 MG2	This three-phase AC permanent-magnet synchronous motor/generator drives the wheels, and generates electricity (from the regenerative braking, by recapturing the car's energy of motion) to charge the HEV battery.
Motor	The common term used to refer to the power device which runs on electricity.
MSRP	Manufacturer's Suggested Retail Price
MY2001	Model Year 2001 (which became available in the United States the summer of 2000)

NAV	DVD-based GPS Navigation System, used in Prius
NiMH	Nickel-Metal Hydride, the type of modules used in the Prius battery-pack
OEM	Original Equipment Manufacturer
OPEC	Organization of the Petroleum Exporting Countries
Original	The term used to identify the 1998, 1999, 2000 model years of Prius (which were only available in Japan).
Priustoric	All that transpired before the Prius
PSD	Power-Split Device, the planetary gear set which divides power between the ICE and the two electric motor-generators, also functions as the continuously-variable transmission.
PZEV	Partial Zero Emission Vehicle. (A manufacturer must eliminate evaporative emissions and ensure that the vehicle will run cleanly for its entire projected life. Even if the vehicle is just sitting in the driveway, it is still polluting. The source of this pollution is hydrocarbons emitted from the gas tank as gasoline slowly evaporates. To achieve PZEV certification, all evaporative emissions must be eliminated.)
R&D	Research & Development
SOC	State Of Charge (indicating the amount of stored electricity available in the battery-pack)
Stealth	Electric-Only driving (up to 42 MPH) without the engine running.
SRS	Supplemental Restraint System, better known as Airbags
SULEV	Super Ultra Low Emission Vehicle (only a few vehicles qualify for this clean rating category, Prius is among them)
THS	Toyota Hybrid System (Toyota's hybrid design for the classic Prius)
Torque	Measurement value indicating wheel turning force, a strength value different from horsepower
TRAC	Toyota Rent-A-Car, a program by which some have shortened the waiting time: when the demo/rental units reach a time/mileage it permits the dealer to sell them.
Turtle	Driving a Prius with the battery-pack extremely drained of electricity, in conditions too hot (typically above 105 F degrees), or conditions too cold (typically below -10 F degrees), so that an orange "turtle" icon displays near the speedometer. This warns the driver to avoid forceful acceleration.
ULEV	Ultra Low Emission Vehicle (as of the 2003 model-year there were 90 vehicle models in the United States that met the rating criteria)
V	Volt or Voltage, an electrical measurement unit used when describing attributes of Prius propulsion components.
Vaporware	A term from the computer industry used to describe claims made by a company about a product that was never delivered. It sounded great in concept, but for whatever reason was impractical in the end. In other words, don't believe it until you actually see the product available for consumers to purchase.

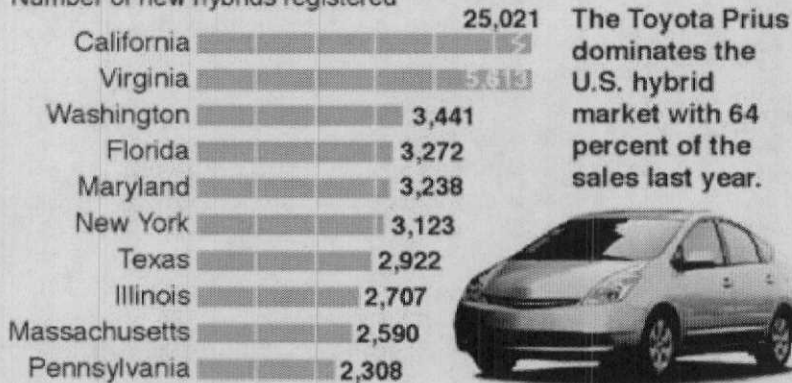
VSC	Vehicle Stability Control, a safety feature that automatically engages side-specific braking for you when it detects the vehicle wheels slip; stepping on the brake is not necessary for the feature to work
ZEV	Zero Emission Vehicle

Hybrid market sales nearly double

New hybrid vehicle registrations had an 81 percent increase over last year as gas prices soared and new models appeared.

Top 10 states for hybrid vehicle registrations, 2004

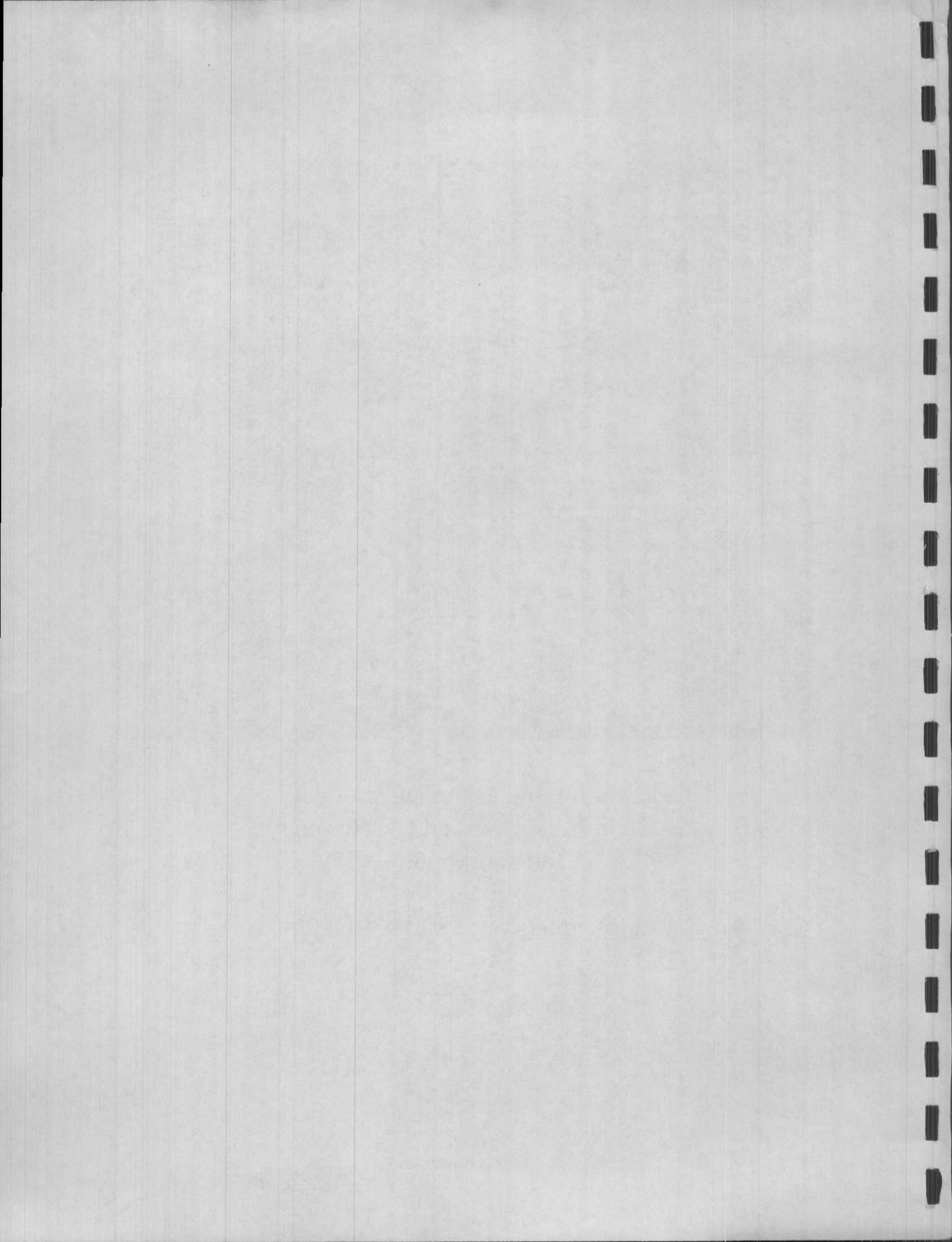
Number of new hybrids registered

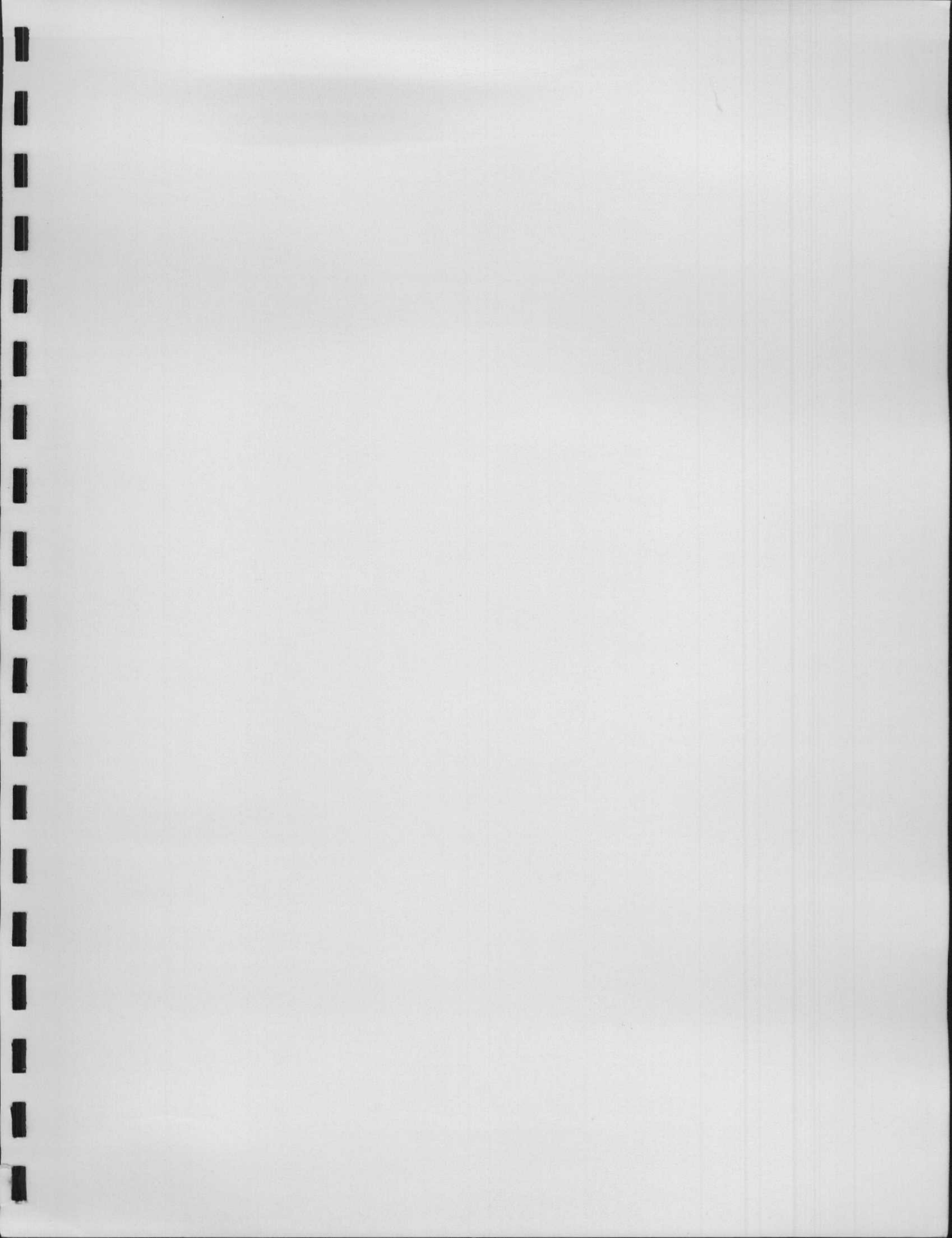


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