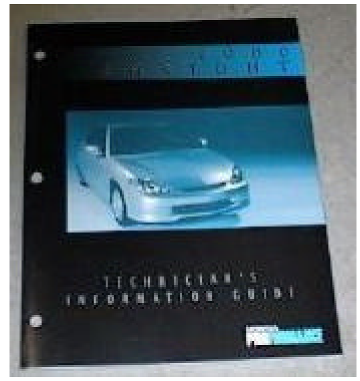
HONDA Insight

GENERAL INFORMATION

ABOUT THIS ENCYCLOPEDIA

This encyclopedia is provided so that you can learn more about the Insight and how it works. While every effort has been made to insure its accuracy, this information shouldn't be used as the basis for repairs or modifications to your Insight. If you wish to do any work with your insight, a Service Manual, Electrical Troubleshooting Manual and Body Repair Manual are all available from your Honda dealer.



Information contained in this encyclopedia is a compilation from a number sources. One of the major sources of information has been the Honda Insight Technician's Information Guide. Honda grants permission to reproduce this material for educational purposes only. As such, you are not permitted to use this encyclopedia, in whole or in part, for purposes other than personal education. Another major source of information was the Honda Insight Press Kit.

VEHICULE IDENTIFICATION NUMBER (VIN)

The Insight's VIN can be found many places on the car. The easiest and most visible location is through a small window at the bottom driver's side corner of the windshield:

An Insight VIN is broken into fields as follows:

JHM ZE1 3 7 - 1 T 000001

Where each field can be decoded as follows:

JHM	Manufacturer / make / vehicle type	JHM:	Honda Motor Co Ltd / Honda / Passenger Car
ZE1	Model / engine	ZE1:	Insight / ECA1
3	Body / transmission	3:	2-door hatchback / 5-speed manual
7	Vehicle grade (series)	5:	Base
		7:	With factory A/C
-	Check digit		
1	Model year	Y:	2000
		1:	2001
T	Factory	T:	Tochigi Factory in Japan
000001	Region & serial number	000001-	U.S.A. (KA)
		200001-	Germany
		800001-	Canada (KC)

FEATURES AND SPECIFICATIONS

Overview	
Vehicle type	Subcompact, two-seater, front-wheel drive, gasoline-electric hybrid
Standard features	*Major features:* • 5-speed manual transmission • Anti-lock brakes • Electric power steering • Dual air bags (SRS) • Alloy wheels • Digital instrument panel • AM/FM stereo cassette w/clock • Power windows • Power mirrors • Power door locks with keyless entry • Anti-theft "immobilizer" system (engine won't start without code transmitted from the key) • Automatic climate control with micro-filtration system (air conditioning optional) • Electronic instrument display with fuel mileage computer and shift indicator *Other features:* • Body-colored mirrors & bumpers • Heat-rejecting green-tinted glass • 2-speed/intermittent windshield wipers • Rear wiper/washer • Rear window defroster with timer • Roof-mounted antenna • Beverage holders • Reclining high-back bucket seats • Passenger seatback pocket • Rear-center net pocket • Lockable glove compartment • Driver's storage compartment • Hidden rear storage well • Cargo hooks • Cargo area light • Remote fuel filler door release • Map lights • Driver's vanity mirror

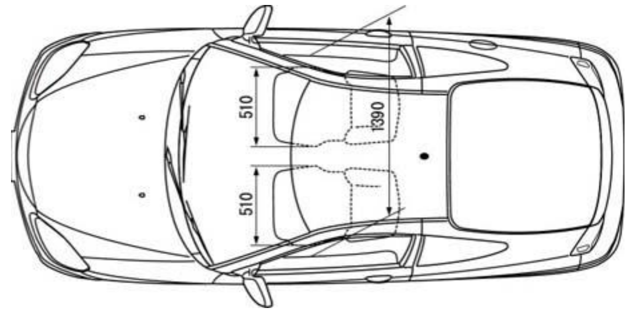
Drivetrain	
Engine & Motor	
Engine type	Lean-burn inline 3 cylinder
Fuel system	Multiport electronic fuel injection
Ignition system	Electronic
Materials	Aluminum-alloy head and block Lightweight magnesium oil pan

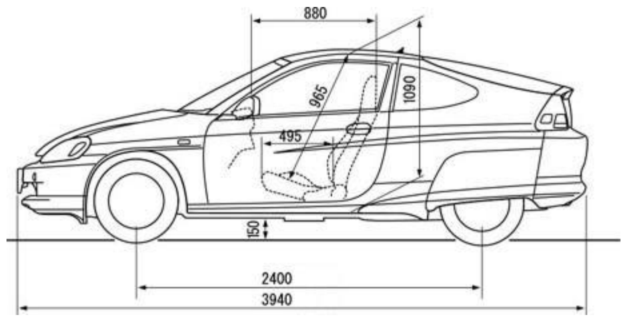
Valve train	12 valve SOHC VTEC-E variable valve timing and lift technology	
Bore x stroke	72 mm x 81.5 mm	
Displacement	0.995 liter	
Compression ratio	10.8:1	
Tune-up interval	170,000 km (105,000 mi)	
Engine weight	56 kg (124 lbs.)	
Electric motor	10 kW permanent magnet DC brushless motor	
Size	60 mm (2.4") thick	
Output	*Without assist*	*With assist*
Max. power	50 kW (68 hp) @ 5700 rpm	56 kW (76 hp) @ 5700 rpm
Max. torque	91 Nm (67 lb-ft) @ 4800 rpm	113 Nm (83 lb-ft) @ 1500 rpm
Transmission	5-speed manual transaxle *(see also:* Gear ratio graph*)*	
1st gear ratio	3.461	
2nd gear ratio	1.750	
3rd gear ratio	1.096	
4th gear ratio	0.857	
5th gear ratio	0.710	
Reverse gear ratio	3.230	
Final drive ratio	3.208	
Electrical		
IMA battery pack	144 volt NiMH (nickel metal-hydride) battery, consisting of 120 cells providing 1.2 V each	
Rated capacity	6.5 Ah	
Alternator	DC-DC converter, 75 A / 14.3 V (Provides power to 12 V accessory battery)	
Suspension, Steering, Brakes and Wheels		
Suspension & Steering		
Front suspension	MacPherson strut with aluminum-forged knuckle, aluminum lower arm	
Front stabilizer bar	17.3 mm (2/3")	
Rear suspension	Twist-beam and trailing arms	
Steering	Rack and pinion with variable electric power assistance	
Turning diameter, curb-to-curb	9.57 m (31.4 ft)	
Brakes	Four wheel anti-lock (ABS)	
Front	Discs, 231 mm	
Rear	Drums, 180 mm	
Handbrake	Mechanical, acting on rear wheels	

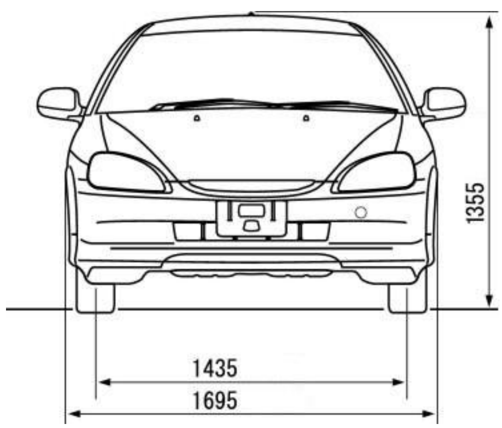
Wheels & Tires	
Wheels	14 x 5.5J Cast aluminum
Tires	Bridgestone Potenza RE92 165/65R14 78S Treadwear 260 Traction A Temperature B Tubeless Steel Belted Radial M+S
Body Construction	
Type	Aluminum monocoque
Materials	All structural components and most body panels are extruded or die-cast aluminum Front fenders & rear fender skirts are a recyclable ABS/nylon composite
Dimensions and Weight	
(see also Scale Drawings)	
Length	3945 mm (155 1/8")
Height (excluding antenna)	1355 mm (53 1/3")
Wheelbase	2400 mm (94½")
Front track	1435 mm (56½")
Rear track	1325 mm (52")
Ground clearance	150 mm (5.9")
Headroom	986 mm (38.8")
Legroom	1090 mm (42.9")
Shoulder room	1283 mm (50.5")
Hiproom	1237 mm (48.7")
Passenger volume	1342 liters (47.4 cu ft)
Cargo volume (Honda's figure)	462 liters (16.3 cu ft)
Main cargo area (by EU standards)	139 liters (5 cu ft)
Below-floor storage area	48 liters (1.5 cu ft)
Fuel tank capacity	40 liters (10.6 gal.)
Curb weight	
without air conditioning	834 kg (1,847 lbs.)
with air conditioning	848 kg (1,878 lbs.)
Weight distribution (F:R)	
fully loaded	57:43 (approx 600 kg front, 450 kg rear)
dry	60:40
Performance	
Top speed	180 km/h (112 mph)
Acceleration, 0-60mph	12.0 seconds (Honda's estimate) 10.6 seconds (Car & Driver)
Range	Over 1125 km (over 700 miles)

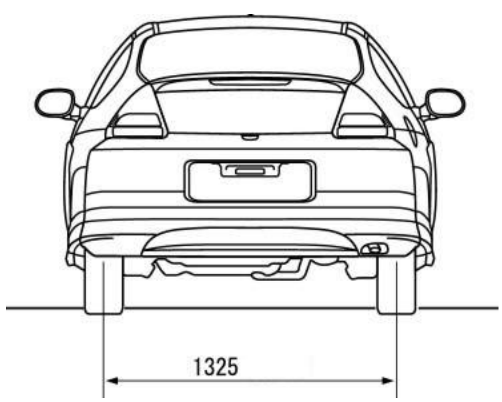
Fuel Consumption & Emissions	
Fuel consumption	3.4 l/100km (EUDC) 61 mpg city / 70 mpg highway (EPA)
CO_2 emissions	80 g/km
California emission standards compliance	ULEV

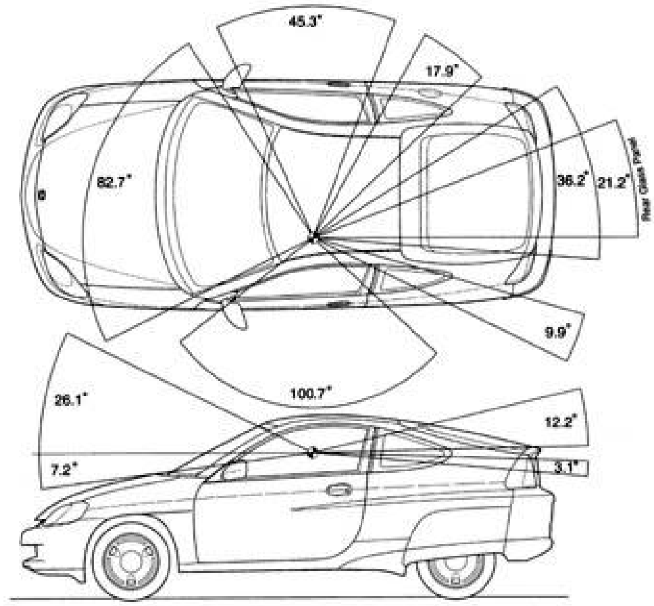
SCALE DRAWINGS



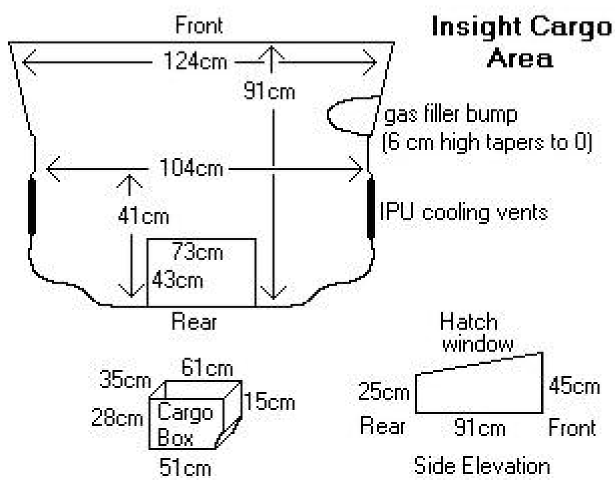








Non-Scale Drawing of Cargo Area
(Courtesy of John Johnson)



MAINTENANCE

SPECIAL MAINTENANCE CONSIDERATIONS

Engine Oil

The Insight uses an API SJ rated oil with an SAE 0W-20 viscosity.

For maximum fuel economy this oil should be used.

Washing

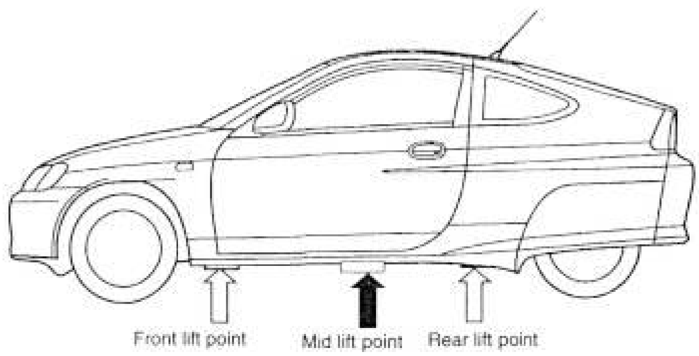
Remove the rear wheel skirts and the roof mounted antenna before driving in any automated car washes equipped with tire scrubbing type brushes. The rear wheel skirts can be removed by turning the two stud fasteners located at the front and rear of the skirt.

Vehicle Lift Points

The Insight's plastic and aluminum body parts can be easily damaged if it is not raised at the proper lift points. There are three reinforced lift points (Front, Mid and Rear) on the left and right rocker panels.

The Front and Rear lift points should be used when lifting the Insight with a frame hoist or when supporting it on safety stands. Space blocks must be used with any plate style lift to avoid damage to the rocker panels or rear strakes.

The Mid Center point is for use when lifting the Insight with a floor jack. In this case, a rubber pad should be positioned between the lift platform and support point.

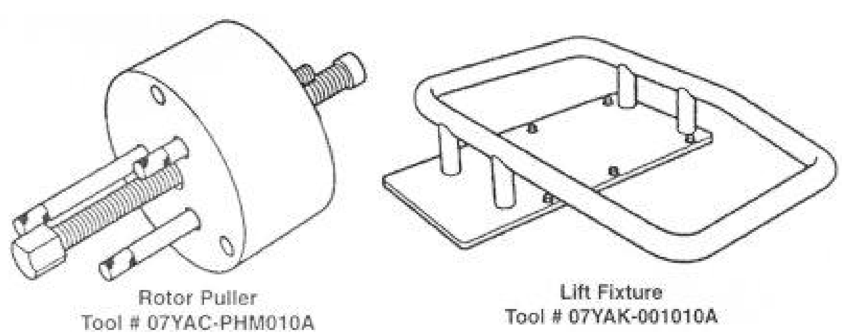


Special Tools

Honda has a "Rotor Puller" tool that is designed for removing the electric motor rotor from the motor.

Honda also has a lift fixture designed for lifting the IMA battery pack out of the car.

Both of these tools are made available to Honda dealers on a loan basis.



LONG-TERM STORAGE

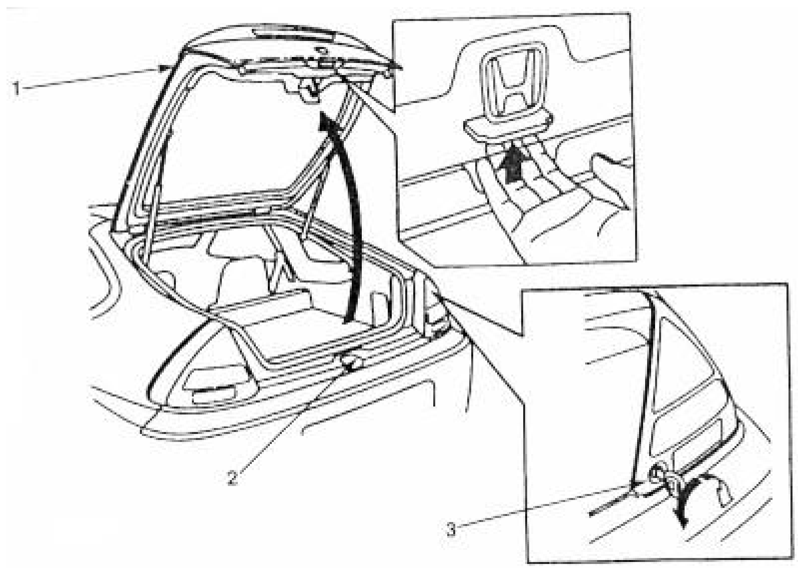
In addition to a conventional 12V battery, the Insight has a 144V IMA battery. When the vehicle is stored for a long period, the IMA battery will gradually discharge and must be charged periodically (ideally once every three months). To maintain the IMA battery, follow this procedure:

1. Remove the 40A EPS Fuse (No. 15) from the Under-Hood Fuse box in the engine compartment, then start the engine. The EPS warning light on the dashboard will illuminate because the EPS fuse is missing. This does not indicate a system fault. The warning light will go off when the EPS fuse is refitted.
2. Make sure the area around the vehicle is free of flammable items. Then, run the engine at 3500 rpm for 5-10 minutes. Monitor the IMA Battery Level Gauge for movement indicating its charging process.
3. The procedure is complete when the IMA Battery Level Gauge shows fully charged.
4. Reinstall the 40A EPS Fuse in its original position (No. 15).

HATCH ACCESS

The Insight rear hatch differs from many Honda models because there is no mechanical linkage between the hatch release on the outside of the vehicle and the actual latch. The exterior latch release is actually a switch that operates a hatch opener relay. A hatch release motor is operated by the relay. The hatch opener switch and hatch unlock (key) switch are both in series with the relay.

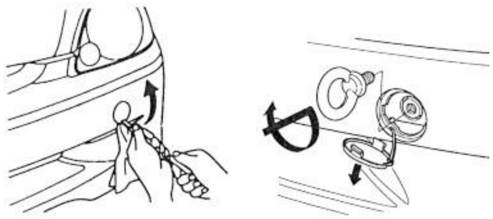
If the battery is discharged or disconnected, the hatch must be opened manually by use of turning the key release located in the right rear combination lamp all the way to the right.



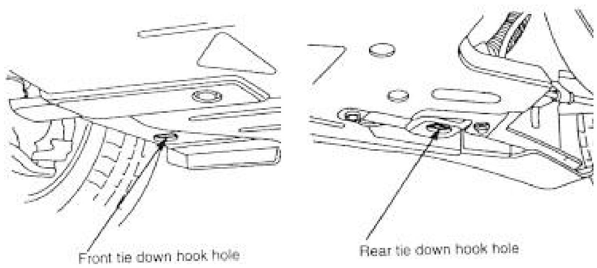
TOWING INFORMATION

To accommodate flat-bed towing equipment, the Insight is provided with a front towing hook, and front and rear tie down hook holes. The towing hook can be used with a winch to pull the Insight onto the truck, and the tie down holes can be used to secure the vehicle to the truck.

To install the towing hook, first wrap the flat end of the jack handle or screwdriver with a soft cloth to prevent damage to the painted bumper surface, and then pry the cover off. Next, screw the towing hook (stored with the spare tire) into the bolt hole and tighten it securely by hand.

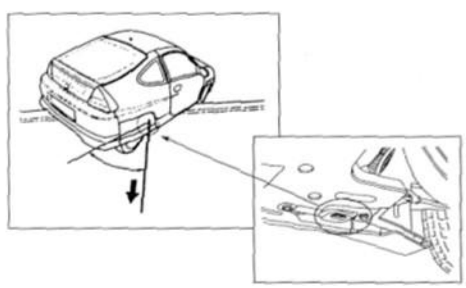


Once the Insight is on the truck, secure it by attaching hooks to the front and rear towing hook holes. Never attempt to pull or secure the Insight by any other means. Body or suspension damage could result.

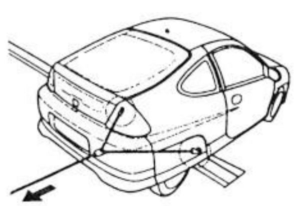


If the Insight must be pulled backward in order to free it, use only the rear tie down hook holes to attach a rope or cable. Attaching to any other point could result in body or suspension damage.

If it is necessary to pull the Insight backward by attaching a rope or cable to only one side, take care not to damage the rear strake.



Pulling the vehicle straight back to free it by using both rear tie down hook holes is the best method.



Service Safety Considerations

The Insight's IMA system employs high-voltage components and highly magnetic components, and so anyone working on the IMA system must exercise caution and follow Service Manual procedures carefully.

IMA Motor Rotor

The rotor of the IMA motor is highly magnetic. Consequently, all iron, magnetic and electronic materials must be kept away from the rotor if it is to be replaced.

The rotor should not be handled by people with a pacemaker or other similar medical device. Keep electronic devices away from the rotor as the magnetic field may damage watches, video tapes, floppy disks, or any other magnetic storage devices.

The « IPU » (Rear IMA Components) Compartment

Before working in the IPU Compartment, these are the safety steps that Honda recommends:

- Remove any jewelry.
- Turn off the ignition switch and remove the key.
- Turn off the Battery Module switch (located below the small cover in the middle of the rear cargo area floor, and replace the lock to secure the switch.
- Wait for 5 minutes before performing any maintenance procedures on the IMA system. This allows the 3 large capacitors inside the MDM to discharge.
- If the IPU cover has to be removed, there is a bolt inside the lid area. (It is impossible to remove this bolt if the Battery Module switch hasn't been turned off.)
- Before performing any maintenance procedures in the IPU, make sure that the junction board terminal voltage is at or near 0V.

Before switching on the Battery Module switch make sure:

- All high voltage terminals have been tightened to the specified torque
- No high voltage wires or terminals have been damaged
- To check for clearance between each high voltage terminal of the part you disassembled and the vehicle body

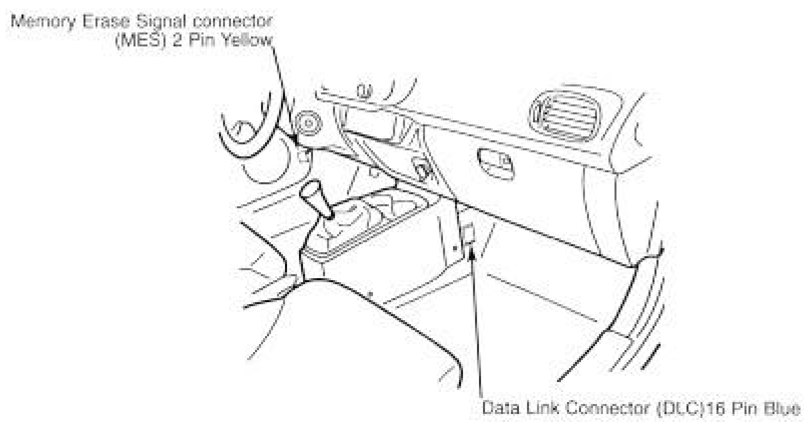
SERVICE CONNECTORS

The Insight uses an industry standard OBD-II onboard diagnostics system.

This system allows standard OBD-II diagnostic tools (including OBD-II software and connector cable available for Windows PCs; see below) to be connected to the Insight's engine control computer. This allows access to a wide range of real time performance and status information from the Insight. It also allows access to the log of any "DTC" codes that the computer records when the "Check Engine Light" (also referred to as MIL or Malfunction Indicator Lamp) is turned on.

There are three variations on the OBD-II system, all of which follow the same SAE J1979 command set standard, but with different electrical connection protocols. The Insight uses the ISO 9141 electrical connection standard, which is used by most European & Asian auto manufacturers, in addition to Chrysler in North America.

The location of the Insight's data link connector is shown in the diagram below.



ODB-II Scanner Software for PCs

ODB-II software is available, which can be installed on a laptop or other Window PC. With this software, together with a connector cable sold for use with this software, it is possible to access a wide range of performance, diagnostic and other information from the Insight's engine control computer (ECM).

Two sources we know of for such software are:

http://www.obd-2.com/- This is the cheaper alternative, written by Alex Peper, is available right now, and we can confirm that it *does* work with the Insight.

http://www.obdii.com/ - This scanner, called Autotap is not yet available for the ISO 9141 protocol used by the Insight.

BODY TECHNOLOGIES

AERODYNAMICS

Regardless of what power source a car is using, the less its aerodynamic drag, the less energy will be needed to travel at any given speed. A great deal of effort has gone into designing the Insight around the goal of achieving excellent aerodynamics, the end result being a drag coefficient of only 0.25, the lowest achieved by any mass produced car. In comparison, the Honda Civic Hatchback, with roughly the same 1.9 square-meter frontal area as the Insight, has a Cd of 0.36, and needs around 32 percent more power to operate at the same speed as the Insight.

Tapered Tear-Drop Shape

The Insight's body is tapered so that it narrows towards the back, creating a shape that approaches the optimal tear-drop shape. To allow the body to narrow, the rear wheel track places the rear wheels 4.3 inches closer together than the front wheels. The cargo area above the wheel wells is still narrower. The floor under the rear portion of the car actually slopes upwards, while the downward slop of the rear hatch window also contributes to an overall narrowing of the car at the rear.

At the very back of the Insight, the teardrop shape is abruptly cut off in what is called a Kamm back (a distinctive design feature also shared by the Honda CRX). The Kamm back takes advantage of the fact that beyond a certain point there is little aerodynamic advantage to be gained by rounding off or tapering and extending the tail section of an automobile, so one might as well abruptly truncate it at that point. The Kamm back is a design feature that has been incorporated into many high-performance automobiles and racing cars over the years.

Flat under-body Covers

Another important aerodynamic detail that greatly contributes to the Insight body's low coefficient of drag is the careful management of underbody airflow. The Insight body features a flat underbody design that smoothes airflow under the car, including three plastic resin underbody covers. Areas of the underside that must remain open to the air, such as the exhaust system and the area around the fuel tank, have separate fairings to smooth the airflow around them.

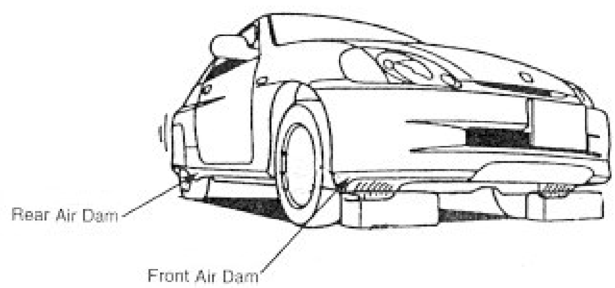
In order to minimize air leakage to the underside, the lower edges of the sides and the rear of the body form a strake that functions as an air dam. At the rear, the floor pan rises at a five-degree -angle toward the rear bumper, creating a gradual increase in underbody area that smoothly feeds underbody air into the low-pressure area at the rear of the vehicle.

Note that high voltage cables that are passed above the underbody covers, and so the covers must be replaced if removed for any reason.

Other Aerodynamic Features

- Other aerodynamic features includes:
- Optimally designed air intake shape, including shape of louvers
- Aerodynamically shaped nose
- Steeply raked windshield with edges that blend smoothly with the cabin roof, and with the aerodynamically shaped windshield posts
- Low hood-line
- Low height and small frontal area

- Low-drag door mirrors
- Rear wheel wells enclosed by fender skirts and disk-shaped wheels aluminum alloy wheels smooth airflow around the wheel openings
- Front fenders extend down below centerline of wheel
- To improve airflow over the exposed wheels, the aluminum wheels have a flat-faced design.
- The air dams are used in front of both front and rear wheels to improve aerodynamic characteristics. Since these spoilers extend lower than the rest of the body, when parking in front of concrete curb stops, you should be careful not to drive forward too far.
- The headlight assemblies blend smoothly into the contour of the fender, and the fenders have large-radius curves in order to minimally disturb the air flowing around them.



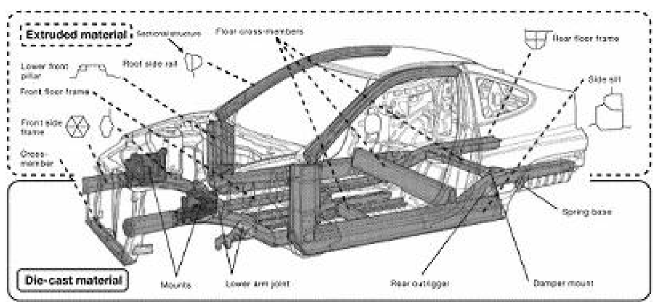
ALUMINUM CONSTRUCTION

The Honda Insight's body is made of aluminum, offering light weight and a high level of body rigidity to enhance overall fuel economy, handling and passenger safety.

Aluminum weighs only one-third as much as steel. In addition, aluminum alloy is highly versatile and readily lends itself to a wide variety of manufacturing techniques. Lastly, aluminum is extensively recycled, which helps lower its cost. The Insight's aluminum body in white (just the sheet metal: doors, hood, etc.) is roughly 40 percent lighter than a comparable steel body.

The basic structure is a new, lightweight aluminum monocoque, reinforced in key areas with aluminum extrusions joined at cast aluminum lugs. Stamped aluminum panels are welded on to this structure to form an extremely light and rigid platform for the drivetrain and suspension.

The resulting body structure has 13 percent more bending strength and an impressive 38 percent more torsional rigidity than a comparably-sized steel body, despite weighing 40 percent less. The unit-body part of the Insight's body uses stressed sheet-metal panels to absorb and distribute structural and suspension loads, much like an ordinary steel unit body.



From their experience building the Acura NSX - the world's most produced aluminum-bodied car - Honda engineers have gained extensive knowledge of aluminum. However, the Insight is designed for a very different purpose.

Market requirements dictated the development of new, more cost-effective techniques for manufacturing the Insight's aluminum body. In response to this challenge, Honda engineers developed the Insight's innovative unit-body/space-frame construction.

The unit-body part of the Insight's body uses stressed sheet-metal panels to absorb and distribute structural and suspension loads, much like an ordinary steel unit body. However, with the Insight's body all of these panels, including the roof, floor, front and rear wheel wells, rear quarter-panels, bulkhead, and even the doors and hood, are made of aluminum alloy. These stressed panels are reinforced in key areas by aluminum-alloy frame members.

It is these aluminum frame members and their cast-aluminum connecting joints that make the Insight's hybrid body so unique. In a steel unit body, frame members are formed by stamping in large presses and then joined to the body by welding. However, the Insight uses extruded frame members. Extrusions are drawn from a die in much the same way that tubing is made, and like tubing are of constant cross section. Once formed, extrusions can be easily made into complex three-dimensional pieces, such as a curved windshield frame. They also do not require any additional machining or finishing after they are formed.

On the Insight, each frame member's size and strength is optimized so that the frame is strong where it needs to be, and lighter in less critical areas. A variety of shapes are used, including hexagons, ovals, H-sections and reinforced box-sections. The door and windshield pillars, front and rear side-frame members, lower body sills, cross members and floor frame members are all formed in this manner.

In more highly loaded areas of the body (such as the front and rear sub frames), larger, internally ribbed, hexagonal aluminum frame members are used. These are joined to other frame members via rigid, die-cast aluminum joints. Die-castings are also used at engine and suspension mounting points. These die-castings offer versatility and cost savings, because they can be designed to suit specific size, space and strength requirements.

Thixotropic Die Casting

Some of the die-cast joints used in the Insight's aluminum body are made using a newly developed casting technology invented by Honda engineers, called Thixotropic Die Casting. Thixotropic Die Casting uses aluminum alloy that has been heated to a semi-solid condition, instead of the molten, liquid state normally used in die casting. Pieces made with molten aluminum must be more highly processed and refined before casting; however, Thixotropic Die Casting requires less energy for smelting (an important consideration since aluminum is more expensive than steel), and owes much of its strength to the controlled formation of discrete aluminum crystals within the metal casting.

Safety

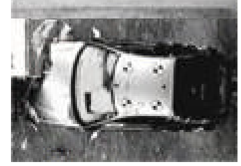
The Insight was designed to meet or exceed the latest U.S., European and Japanese safety standards. The interior is designed to meet the 2003 safety standards for side-impact and head-injury protection.

The Insight's aluminum body and frame are designed to meet the safety and impact-protection standards Honda engineers set for it. At the heart of this design is a newly developed Honda technology called G-Force Control Technology, or G-CON. G-CON optimizes each part of the Insight's aluminum body and frame to best absorb a specific type of impact. The cabin floor, for example, forms a strong and rigid foundation, designed to minimize deformation in an impact. Outside of this area, the surrounding aluminum frame members have been tailored to control impact forces.

G-CON
G-FORCE CONTROL TECHNOLOGY

Full-frontal and offset-frontal impacts are first absorbed by the large-section, hexagonal extrusions that serve as the front-side frame members. These hexagonal sections are made up of six individual equilateral triangles and are designed to progressively collapse like the bellows of an accordion in an impact. A die-cast aluminum joint connected to the rear of these extrusions transfers any additional impact energy rearward to an oval-shaped, curved hexagonal extrusion, which further absorbs energy by bending upward.

The aluminum extrusions that extend from the passenger compartment all the way back to the rear of the Insight on either side are also designed to progressively absorb rear-impact energy. In addition, the spare tire and wheel, and the Insight's aluminum suspension, including the tires and wheels, are designed to aid in rear-impact energy absorption.



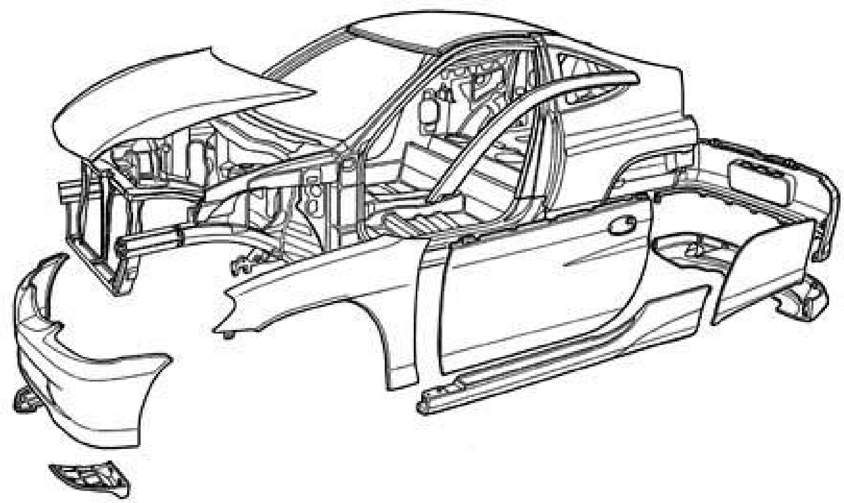
See also:

- Restraint System
- Body Panels

LIGHTWEIGHT BODY PANELS

The Honda Insight features lightweight plastic panels which are used extensively in non-structural applications. The front fenders, spoilers, under body cover and rear fender skirts are all made of plastic. Also, lightweight sound insulating materials are used throughout the Insight.

The bumper beams, steering hanger, roof, floor, front and rear wheel wells, rear quarter-panels, bulkhead, and even doors and hood, are made of aluminum alloy. These stressed panels are reinforced in key areas by the aluminum-alloy frame members.



BODY REPAIR INFORMATION

Dacro Coated Bolts

Bolts that make contact with the aluminum body or aluminum suspension components have a special Dacro coating to prevent corrosion between two dissimilar metals. If these bolts are removed, the Dacro coating is destroyed. Consequently, the Dacro coated bolts must be replaced once they are removed.

These bolts can be identified by the light green color of the Dacro coating.

Body Repair Techniques

Anyone performing service or repair of the aluminum body must be familiar with pertinent information in the Service Manual and Body Repair Manual. The information below is by no means complete repair procedures; it is simply provided to give you some of the key procedures that should be followed if you ever have someone carry out repairs on your Insight's body.

Welding

1. Wash and grind the welding zone.
2. Confirm welding conditions before welding, using a test piece.
3. Use A5356WY for the welding wire.
4. Use argon 100% for shielding gas.
5. Do not perform any type of brazing or acetylene welding.
6. Welding repairs should be done by MIG welding only.

Sheet Metal

1. Always **replace** any structural parts that have been damaged. Do not attempt to repair.
2. Do not solder mold any part.
3. Do not heat shrink any part.
4. Use only the repair tools specially designed for aluminum vehicles.

Grinding

1. Use only the repair tools specially designed for aluminum vehicles.
2. Use only wire brushes made of stainless steel.

Assembling

1. Use only the specified screws, bolts and nuts (Dacro coated and "torka" coated).

Inspection

1. After completion of any "drawing" or pulling, welding or panel replacement, conduct a fatigue crack inspection of all areas.
2. Perform measuring operations.

PLASTIC FUEL TANK

The Honda Insight uses a plastic fuel tank.

Use of a plastic fuel tank reduces weight. Also, since the plastic fuel tank will not corrode, it is far less susceptible to developing a leak whereby gasoline and/or gasoline vapours can escape into the environment.

Plastic fuel tanks have been used successfully on other vehicles for a number of years, particularly in Europe. Plastic is also used for transporting and storing gasoline in the form of the commonly seen red plastic "cans".

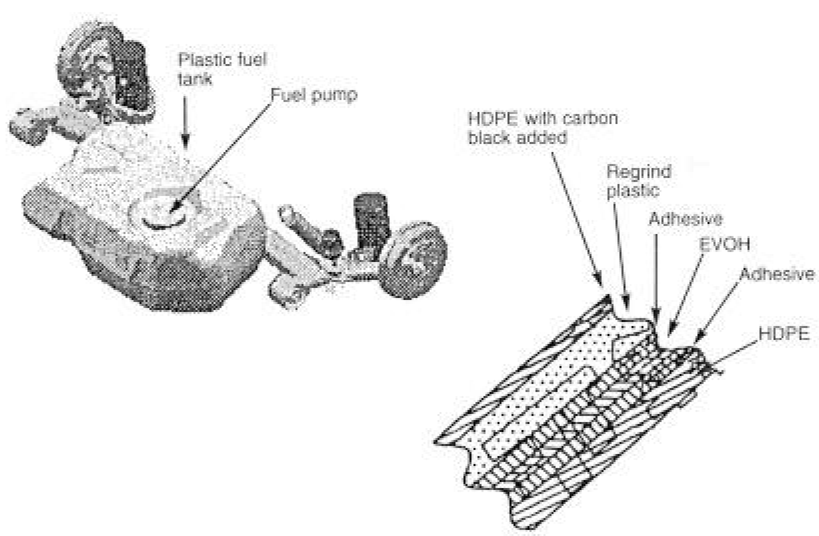
Construction

The Insight's plastic fuel tank is made up of six layers of four different materials:

- Ethyl Vinyl Alcohol (EVOH)
- High Density Polyethylene (HDPE)
- Regrind plastic (recycled polyethylene)
- Plastic adhesive

The EVOH is used because of its impermeability to hydrocarbons. IT ensures that the liquid fuel and vapors are sealed within the tank. The other materials provide structural stability.

The fuel pump is accessible from inside the car. The air intake for the IMA heat sink cooling fan covers the access hole. The rubber intake tube must be removed to gain access to the fuel pump.



See also:

- Refueling Vapor Recovery

STEERING / SUSPENSION / BRAKES

ELECTRIC POWER STEERING

The Honda Insight uses a variable-assist rack and pinion *electric power steering* (EPS) system rather than a typical hydraulic power steering system.

A typical hydraulic power steering system is continually placing a small load on the engine, even when no steering assist is required. Because the EPS system only needs to draw electric power when steering assist is required, no extra energy is needed when cruising, improving fuel efficiency.

Electric power steering (EPS) is mechanically simpler than a hydraulic system, meaning that it should be more reliable. The EPS system is also designed to provide good road feel and responsiveness. The Insight's EPS system shares parts with the Honda S2000 steering system.

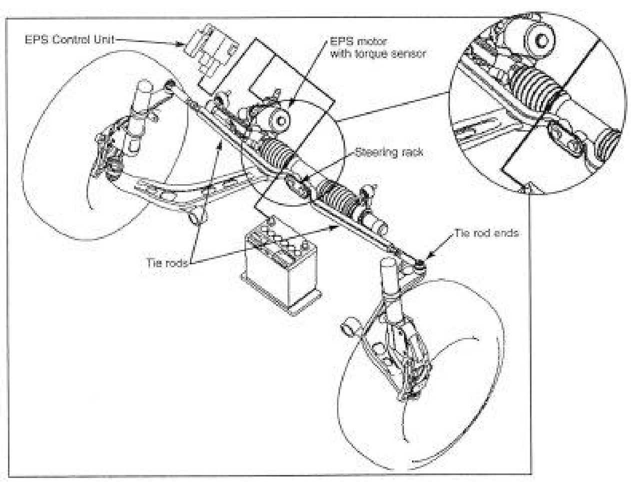
The system's compactness and simplicity offer more design freedom in terms of placement within the chassis. The steering rack, electric drive and forged-aluminum tie rods are all mounted high on the bulkhead, and steer the wheels via steering links on each front suspension strut. This location was chosen in order to achieve a more compact engine compartment, while improving safety.

The system is also smoother operating, more responsive to driver input, and has minimal steering kickback. The overall steering ratio is 16.4 to 1, and 3.32 turns lock-to-lock.

EPS Operation

The operating principle of the EPS is basically the same as hydraulic power steering except for the following:

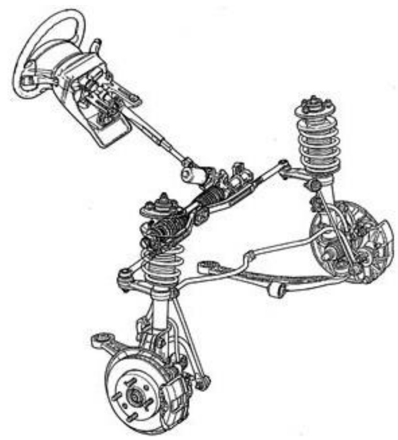
- A torque sensor is used in place of the valve body unit
- An electric assist motor is used in place of the hydraulic power cylinder
- An EPS control unit is added



Mechanical Construction

The rack is unusual in that it is mounted high on the rear engine bulkhead, and that the tie rods engage the rack in the center. The high mount location is used for crash safety, as it keeps these components out of the Insight's crumple zone.

The tie rods are aluminum, and they connect to an ackerman arm that is mounted to the struts just below the spring seat.



Electronic Construction

The EPS control unit is mounted inside the car on the right side bulkhead, underneath the dash. It receives input from the vehicle speed sensor and torque sensor mounted on the steering pinion shaft.

The torque sensor is identical in construction to the unit on the S2000. The pinion shaft engages the pinion gear via a torsion bar, which twists slightly when there is a high amount of steering resistance. The amount of twist is in proportion to both the amount of resistance to wheel turning, and to the steering force applied. A pin on the torsion bar engages a diagonal slot in the sensor core, which moves up or down depending on the amount of torsion bar twist, and the direction of rotation. Two coils surrounding the core detect both the amount, and the direction of movement.

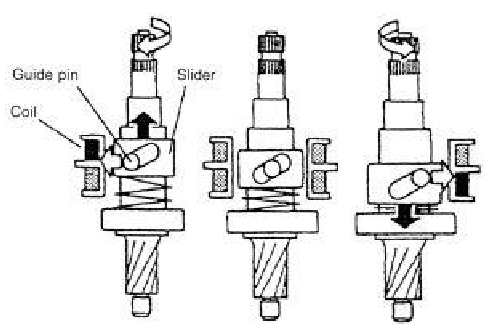
Using this information, the EPS control unit determines both the amount of steering assist required, and the direction. It then supplies current to the motor for steering assist. The amount of assist is also modified in proportion to vehicle speed to maintain good steering feel.

Torque Sensor

The torque sensor is a device to detect steering turning direction and read resistance. The sensing section of the torque sensor consists of two coils and a core (slider). The steering input shaft and pinion gear are connected via a torsion bar. The slider is engaged with the pinion gear in a way that it turns together with the pinion gear but can move vertically. A guide pin is provided on the input shaft and the pin is in a slant groove on the slider.

When road resistance is low, the steering input shaft, pinion gear and slider turn together without the slider's vertical movement.

When road resistance is high, the torsion bar twists and causes a difference of steering angle between the input shaft and pinion gear. In other words, the turning angle of the guide pin and slider differ, and the guide pin forces the slider to move upward or downward.



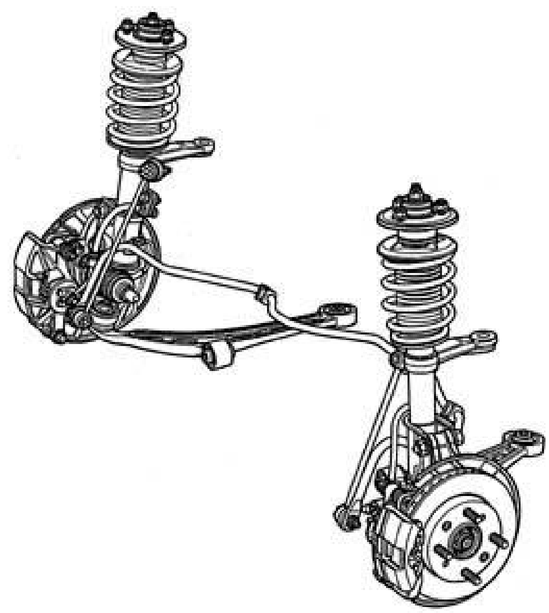
FRONT SUSPENSION

The Insight uses a Macpherson Strut type front suspension withstabilizer bars (0.66 inch). The front suspension geometry has been optimized to exhibit minimal changes in toe and camber throughout its travel, giving the Insight responsive handling, excellent stability and a smooth ride.

This differs from the typical Honda double wishbone design. In this design, the damper body is used as a suspension member, performing the function of an upper control arm. The top of the strut mounts to the body using a bearing so it can turn with the steering knuckle. The elimination of the upper control arm saves weight and also reduces intrusion into the engine compartment.

The system is also very compact-both of the lower arm's inner pickup points are connected to the same reinforced, cast-aluminum mounting.

At the lower end, the strut mounts solidly to the steering knuckle, locating it vertically. The lower end of the knuckle mounts to a lower control arm. On the Insight, the knuckle and lower control arm are aluminum forgings, providing maximum strength but minimizing unsprung weight. Weight is also saved by using a hollow front-struct damper rod.



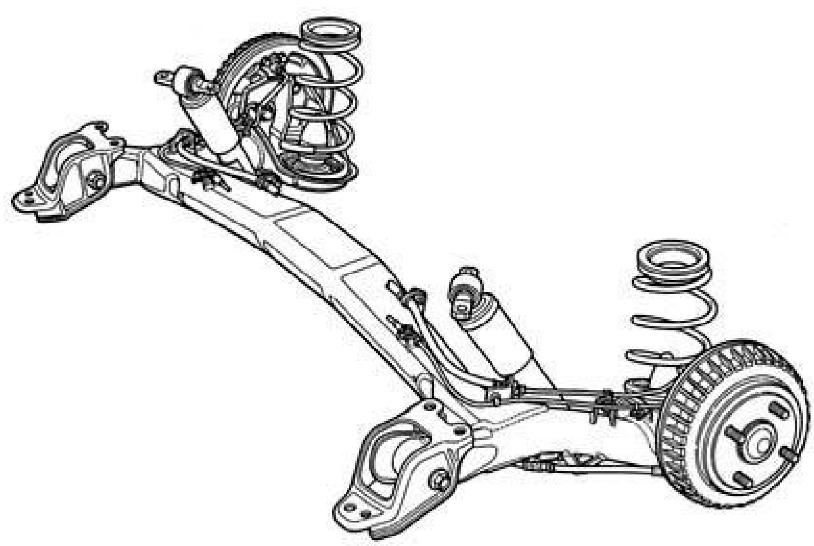
REAR SUSPENSION

The Insight's rear suspension uses trailing arms. These are connected midway along their length by a curved, H-section steel torsion beam that twists to allow a controlled level of independent suspension movement.

This arrangement works with very short springs and dampers which allow for a very low rear floor, while the suspension system still sits entirely below the floor. Coil springs are used, and the system's telescopic shock absorbers are mounted at a separate location, which also contributes to the Insight's flat cargo floor.

Other rear suspension features include:

- The rear track is narrower than the front track, which allows for a more aerodynamic body shape. This, in turn, helps to maximize fuel economy.
- The design gives a low rear roll center and high torsional rigidity. These factors contribute to handling stability.
- Large rubber bushings, built into the trailing arm privots, provide bump compliance, and are designed to minimize toe out on turns, also adding to handling stability.



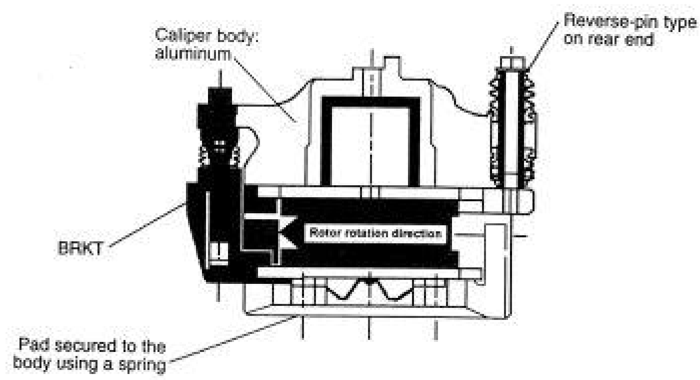
BRAKING SYSTEM

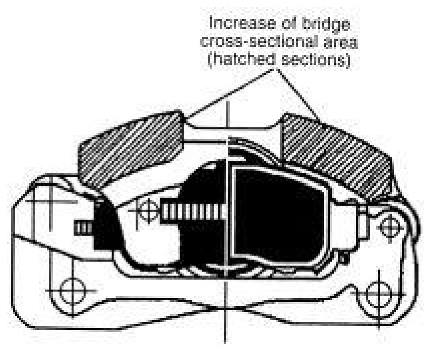
Front Disc Brakes

The front brake single piston calipers fitted to the Insight are made from aluminum. This helps to reduce the weight and drag of the components significantly without a loss of strength in the components.

There are many other new design features which include:

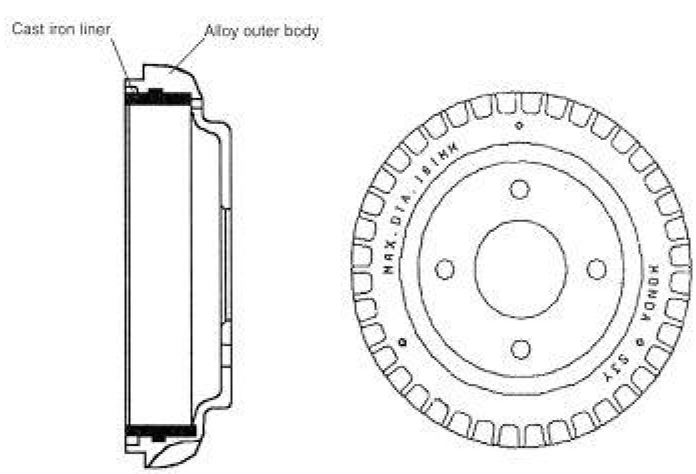
- Reduction of bracket size
- Revised pin design between caliper and bracket
- Increase of body cross-sectional area
- Even distribution of pad surface pressure
- Reduction of drag as pad is secured to the caliper body





Rear Drum Brakes

The Insight has a new two piece rear drum design with aluminum fins. The internal brake surface is made of conventional cast iron to help achieve a stable fraction, while the rest of the drum is made of aluminum which has large finning around the outer edge. This design has significantly reduced weight over a cast iron drum. The use of aluminum fins on the outside helps to assist with cooling.



While a typical cast iron drum might weigh 3.4 kg (7.5 lbs.), the Insight's aluminum/cast iron drum weighs 2.1 kg (4.6 lbs.). The drum's outside diameter is 181 mm.

Anti-Lock Braking System

The Insight is equipped with a compact and lightweight ABS modulator assembly. The modulator unit and ABS control unit are integrated into one component which also includes relays, wires and electrical couplers.

During ABS function the IMA cuts battery regeneration (charging) to ensure there is adequate voltage for ABS operation. After ABS operation has ceased, the IMA recommences battery regeneration (charging).

CABIN INTERIOR

CABIN INTERIOR

Interior Features

The interior of the Insight is well equipped, with automatic climate control, power windows, power mirrors and power door locks with keyless entry. An anti-theft system prevents the car from starting without receiving a unique code transmitted from the key. AM/FM stereo cassette is standard, with an optional CD changer being available through Honda dealers. Seats provide basic forward-back and seatback reclining positioning, and include integral head restraints.

Outward visibility, sightlines and control placement are designed to enhance driver concentration and ease of movement. Honda designers have also designed the Insight's interior to be comfortable and relaxing. The high-backed bucket seats are highly supportive to help minimize fatigue during long periods of driving.

The interior is fully carpeted and upholstered, and a variety of patterns and textures are used to create a high-tech but comfortable look. The instrument panel has a two-tone, black-and-gray finish.

The door inserts are fabric-upholstered and incorporate armrests, passenger-assist grips, speakers and power door-lock controls. The padded, three-spoke steering wheel is the same design used on the Honda S2000 sports car.

Cargo / Storage Facilities

The Insight provides the following area for cargo and storage:

- Main cargo area, behind the seats
- 1.5 cu ft (48 liter) hidden cargo bin, located below the floor
- 274 cubic inch passenger side glove compartment
- Driver side storage compartment
- Seat back pocket and centrally located net pocket

Depending on the seat position, the spaces immediately behind the seats and the spaces below the seats could also be used for storage. If this is done, care must be taken not to block the battery cooling air inlet behind the passenger seat, nor the wires that run between the seatbelt and the floor.



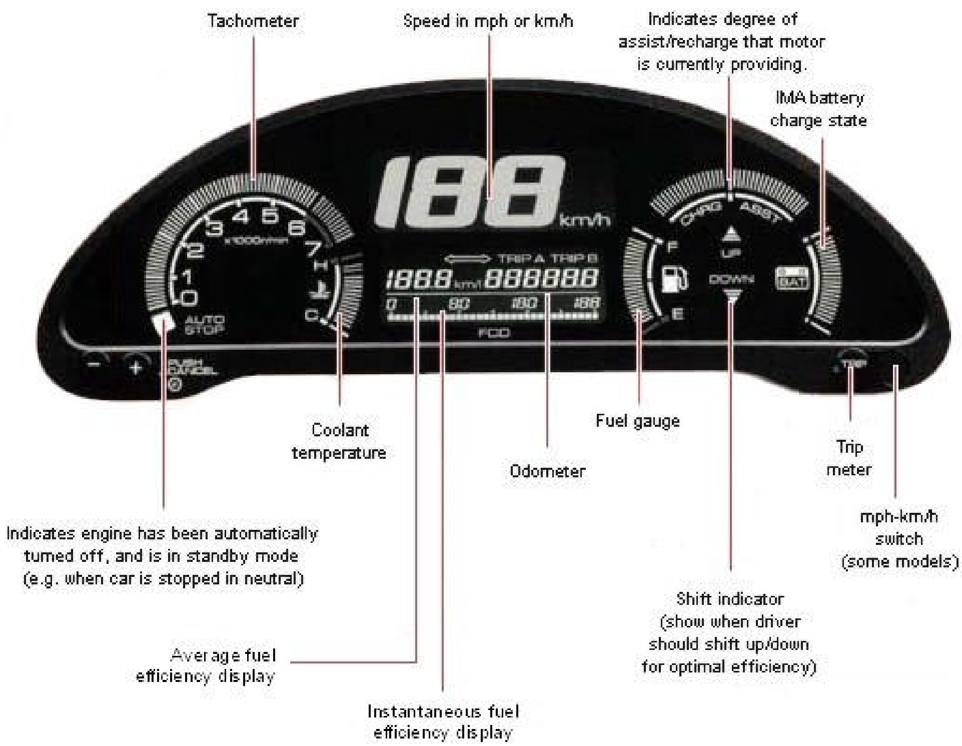
To assist in holding cargo in place, the cargo area is equipped with D-rings in four corners to which a cargo net or cargo bag may be hooked.


For more information on the cabin interior, see:

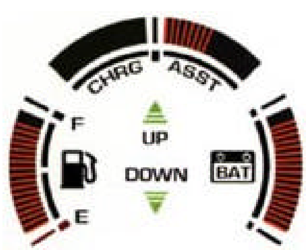
- Electronic Instrument Display
- Passenger Restraint System
- Heating, Cooling & Ventilation
- Micron Air Filtration

ELECTRONIC INSTRUMENT DISPLAY

Housed in a hooded central pod directly in front of the driver, the Insight's Electronic Instrument Display is a combination analog and digital readout that shows all important information about the Insight's Integrated Motor Assist (IMA) system and its effect on vehicle performance. This information is presented in a manner that encourages the driver to take an interest in improving the vehicle's fuel economy. Conventional information about engine and vehicle performance is presented in an easy to read digital or bar graph format.



Energy Use Meter



Assist/Charge indicator display indicates the operational status of the Integrated Motor Assist (IMA) system. There are three modes:

- **Motor Assist**: The IMA is using battery power to help propel the car, the amount of assist is indicated by the illumination of amber colored bars on the right side of the display. When more bars are illuminated, more assist is being used.

- **Battery charging**: The IMA is recharging the battery pack, using energy from vehicle momentum / the gasoline engine. The amount of recharge is indicated by the illumination of green colored bars on the left side of the display. When more bars are illuminated, the battery is being recharged at a higher rate.
- **Inactive**: No bars illuminated. Note that since the IMA motor/generator will generate electricity whenever it is turning, slow charging can take place even when no bars are illuminated. The rate of charging will depend on how many other accessories are turned on.

The battery State of Charge bar graph display represents the current state of IMA battery charge. The indicator is operated by the Battery Condition Monitor module (BCM), which constantly calculates the battery state of charge.

The BCM maintains the IMA battery state of charge in a range of 20% to 80%, which optimizes battery life. It never allows the battery to reach 100% charge or 100% discharge. When the BCM has determined that the battery should not be charged any more, the display shows full charge. When the BCM will not let the IMA battery discharge any further, the display indicates a zero charge. The display provides the driver information about the amount of electrical assist available at any time.

The display is not linear. As with many fuel level gauges, the top half of the display range covers considerably more than half the capacity range.

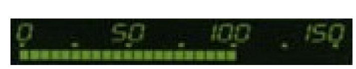
The upshift indicator will illuminate when better fuel economy can be achieved by shifting up to a higher gear.

The downshift indicator will illuminate when the Insight is unable to maintain the current speed, even with full assist. This light will sometimes illuminate when climbing steep hills at highway speeds. When driving in less hilly areas, this light may never illuminate at all.

Odometer / Trip Meter / Fuel Efficiency Meter

In the center of the instrument display, below the digital speedometer display, is the combination odometer / fuel economy meter.

At the left side of this display, average fuel economy is shown. This average is updated once per minute. To the right of this average, is the odometer / trip distance display. The driver can select the lifetime odometer for the vehicle, or switch between three resettable trip meters: "Trip A", "Trip B" or "segment". The average mileage display always shows the average for the distance that is selected. That is, if trip meter A is selected, the average mileage is shown for that trip. "Segment" mode is toggled on and off by touching the FCD button. The current segment is reset by pressing and holding the FCD button while in "Segment" mode. The normal mode display can be switched between the odometer and the two trip meters by pressing the Trip button.



At the lower portion of the display, a bar graph shows the instantaneous fuel economy, which changes in real time based on the amount of fuel that the fuel injectors are currently delivering, and based on the current speed.

When the speedometer is set to mph, odometer / trip meter distances are displayed in miles, and fuel efficiency is displayed in miles per gallon. When the speedometer is set to km/h, odometer / trip meter distances are displayed in kilometers, and fuel efficiency is displayed in liters per 100km.

Both the instantaneous bar graph and the average fuel efficiency number can be turned off at the driver's discretion. To turn off the bar graph, press and hold the FCD button until the bar & legend disappear. To also turn off the numerical average, press and hold the FCD button again, until that disappears.

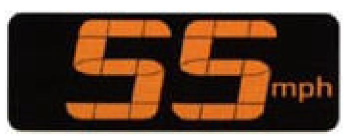
Engine Status Meter

The right circle on the dashboard shows information on the gasoline engine status, including gasoline engine warning lights, coolant temperature, tachometer and idle stop indicator:

When the Insight goes into Auto Idle Stop mode, a green "Auto Stop" LED at the base of the tachometer illuminates to indicate that the engine is not moving at all, but to remind the driver that the car is still in the "on" mode.

If the engine cannot be restarted because the clutch is not entirely depressed, the Auto Stop LED will blink. The LED will also blink and a buzzer will sound if the driver's door is opened when the car is in Auto Stop mode, so that the driver cannot easily mistake this condition for key OFF and leave the car.

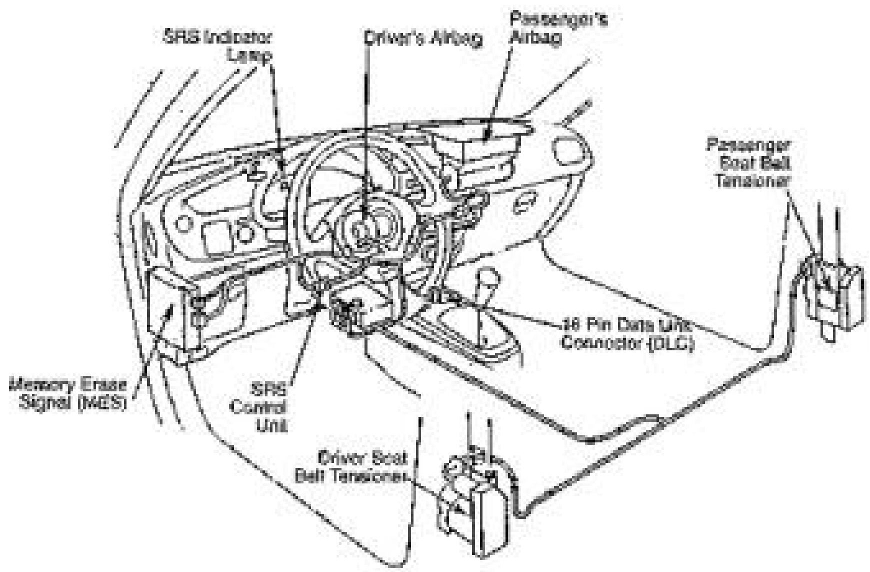
Speedometer



The speedometer reads the current speed in either kilometers per hour or miles per hour. Speed is displayed both when the car is moving forward and backwards. Speed as slow as 1 mph / 1 km/h will register on the speedometer.

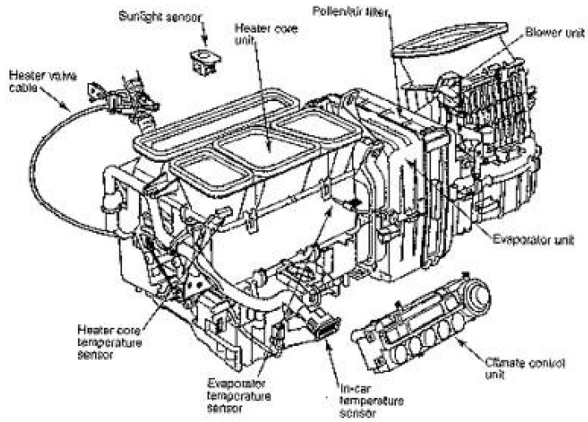
PASSENGER RESTRAINT SYSTEM

The Honda Insight Supplemental Restraint System consists of an SRS control unit with integral impact sensors, driver and passenger airbags, and seat belt tensioners. The seat belt pretensioner system also provides a load limiting function, where the seatbelts are released slightly when needed to limit the amount of force exerted on a passengers by the seatbelts during a collision. The driver's air bag is designed for the lightweight compact type steering wheel (similar to the S2000).



Heating, Cooling & Ventilation

The Honda Insight Heating and Air Conditioning (optional) achieves a balance between comfort for the passengers and fuel economy for the vehicle. This unique design allows the engine ECU and the IMA to control the auto(idle)-stop feature based upon various driving conditions and Heater and Air Conditioning climate control panel selections.



The climate control is thermostatically controlled. The driver simply selects the desired temperature, and the climate control system will automatically adjust the mixture of cold and hot air and fan speed to maintain this temperature. To do this, the climate control system makes use of an interior temperature sensor located below the stereo controls, and a sunlight sensor located on the dashboard at the base of the windshield.

Interaction with Idle Stop Mode

The driver can control whether air conditioning or idle stop mode should be given higher priority. When the climate control system is set in full-auto mode, idle stop will not take place if the system wishes to run the air conditioning compressor. When the climate control system is set to "Econ" mode, the system will function normally, except that idle stop will still take place if the cabin temperature has stabilized at the set temperature, possibly meaning that the air conditioning compressor to stop running for the duration of auto idle stop mode.

In addition to choosing between Econ and Auto mode, the driver can also leave the fan speed set to automatic mode, or set a specific fan speed. With automatic fan speed mode, the system will turn off the fan during idle stop mode. If a specific fan speed is set, the fan will continue to run at that speed during idle stop.

Rear Defroster

Heating grids for the rear defroster are installed in the main hatch window and the small vertical rear window. The rear defroster switch is located on the climate control panel. The system has two operating modes, automatic and manual:

- **Automatic activation**: If the outside temperature is below 0 C (32F), and the engine has not yet reached operating temperature, the heating grids will automatically activate. When automatically activated, the indicator lamp will not illuminate
- **Manual activation**: If manually activated, the timer will deactivate the grid after 25 minutes.

See also:

- Micron Air Filtration System

MICRON AIR FILTRATION

The Honda Insight is equipped with a cabin air filter located between the blower housing and the evaporator case. The purpose of the filter is to provide a comfortable and healthy environment for the vehicle's occupants. The filter will prevent the intrusion of small particles, such as pollen, diesel smoke and bacteria into the car's interior.

A secondary benefit of the micron air filter is reduction in dirt and dust buildup on the car's interior.

Replacement

The filter should be replaced every 15,000 miles (24,000 km) or 12 months, whichever comes first. This filter can be accessed below the dashboard from the passenger, near the center of the car. For additional information, refer to the Insight Service Manual or Owners Manual.

IMA HYBRID SYSTEM

IMA HYBRID SYSTEM

A hybrid power system for an automobile can have a series configuration or a parallel configuration. With a series system, an engine drives a generator, which in turn powers a motor, whose output propels the vehicle. With a parallel system, the engine and motor can both be used to propel the vehicle. The Insight employs a parallel system that is described by Honda as the Integrated Motor Assist (IMA) system.

The IMA system is one of the most technologically advanced parallel hybrid power systems in the world. By employing techniques such as brake-energy regeneration to maximize the efficiency with which energy is used, it combines low-pollution, low-cost operation with high levels of safety and running performance.

The main parts of the Insight's IMA system are:

- Gasoline Engine
- Motor / generator
- Battery Module (High-voltage battery)
- Battery Condition Monitor (BCM)
- 12v battery
- Motor Drive Module (MDM)
- DC-DC converter
- Motor Control Module

A thin design motor/generator is located between the 3-cylinder engine and the 5 speed manual transmission. A Ni-MH battery module is used for supplying electricity to the motor during assist mode and for storing regenerated power.

A DC-DC converter is used to produce 12v power required by the Insight's 12v system. All high voltage components of the IMA system are collectively located behind the seats in the IPU (Intelligent Power Unit) box.

See also:

- IMA System Modes of Operation

IMA Modes of Operation

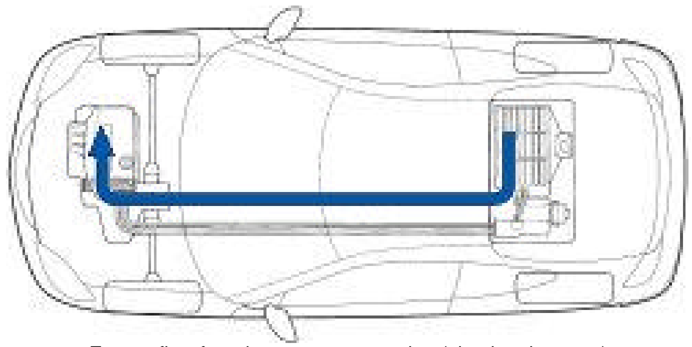
As the Insight's goes from being stationary to accelerating, cruising and then decelerating, the IMA hybrid system's mode of operation changes. In each mode of operation, the gasoline engine and IMA electric motor each play a different role. Click on the links below to learn more about a particular mode of operation.





<table>
<tr><td>Vehicle Operating Mode</td><td>Start-up</td><td>Acceleration</td><td>Cruising</td><td colspan="2">Deceleration</td><td>Stationary</td></tr>
<tr><td>Gasoline Engine Mode</td><td rowspan="2">Engine Start</td><td colspan="2">Vehicle Propulsion</td><td>Fuel Cut</td><td colspan="2">Auto Idle Stop</td></tr>
<tr><td>Electric Motor Mode</td><td>Assisting with Propulsion</td><td>Generation / Off</td><td>Regenerative Braking</td><td colspan="2">Off</td></tr>
<tr><td>Battery State of Charge
Full</td><td rowspan="3">Engine startup by IMA</td><td rowspan="2">Assist with partial load & wide open throttle</td><td>No generation</td><td>No Charging</td><td colspan="2" rowspan="3">Auto Stop System Enabled</td></tr>
<tr><td>High ↑</td><td>Generate for 12v system</td><td rowspan="3">Regeneration</td></tr>
<tr><td>Low</td><td>Wide open throttle assist</td><td rowspan="2">Generation for recharging</td></tr>
<tr><td>Zero</td><td>Startup by auxiliary Starter Motor</td><td>No assist</td><td colspan="2">Generation</td></tr>
<tr><td>IMA Contribution to Fuel Efficiency</td><td>Best fuel control when starting</td><td>Reduce engine load and fuel consumption by motor assist</td><td>Reduce unnecessary generation and load by efficient battery control</td><td>Recover and store energy, no fuel consumption</td><td colspan="2">No fuel consumption</td></tr>
</table>

STARTING / RESTARTING MODE



Energy flow from battery to gas engine (via electric motor)

Under most conditions, the Insight engine is started by the IMA motor, which instantly spins the engine to 1000 rpm.

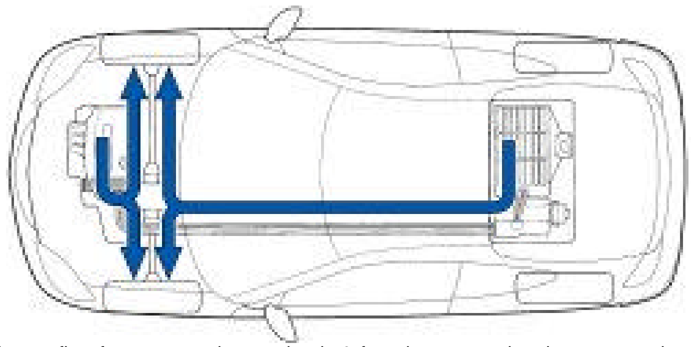
The Insight also has a conventional 12v auxiliary starter motor that is used in the following situations:

- The state of charge of the Battery Module is too low.
- The ambient temperature is too high or too low.
- There is a failure of the IMA system.

Because the Insight won't enter idle stop mode in any of the above situations, all engine starts other than the initial start will always be done using the IMA motor.

To test the 12v auxiliary starting system, first disable the IMA starting system by removing fuse #2 from the under-dash fusebox.

ACCELERATION / ASSIST MODE



Energy flow from gas engine to wheels & from battery to electric motor to wheels

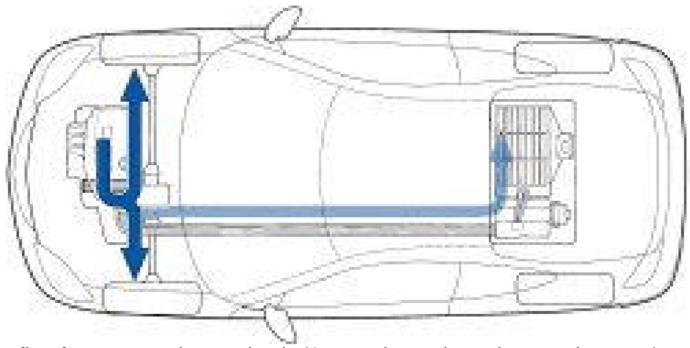
During acceleration and other high load conditions such as climbing a steep slope, current from the Battery Module is converted to AC by the MDM and supplied to the IMA Motor, which then functions as a motor. The IMA Motor's output is used together with the gasoline engine's output so that power available for acceleration is maximized.

The amount of electric motor assist will vary depending on the load and throttle position. Under light acceleration the electric motor only operates at partial assist, while under heavy acceleration the electric motor operates at its full capacity. The instrument display will indicate the degree of assist on the assist/charge gauge.

During acceleration the 12v electrical system is fed power from the Battery Module, via the DC-DC converter. The 12v battery is charged as necessary.

When the remaining battery State of Charge is very low, but not at the minimum level, assist will only be available during wide open throttle acceleration. When the remaining State of Charge is reduced to the minimum level, no assist will be provided. Instead, the IMA system will generate energy only to supply the vehicle's 12v system. This maximizes the gasoline engine output available for acceleration.

CRUISING MODE

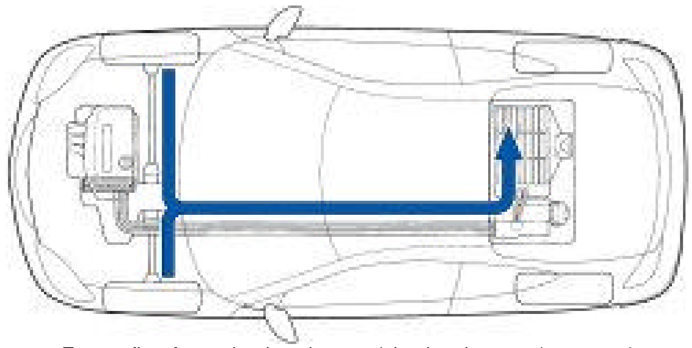


Energy flow from gas engine to wheels (& sometimes also to battery via motor/generator)

When the Insight is cruising at a constant speed and the Battery Module state of charge is relatively low, some engine output is used by the IMA motor/generator being operated in ***generation mode*** to charge the Battery Module. Some of this energy will be delivered to the Insight's 12v accessories, via the DC-DC converter, as necessary. In this state, the instrument display will show partial charging on the charge/assist gauge.

When the Insight is cruising and the high-voltage battery is sufficiently charged, the IMA motor/generator continues to turn but only a small amount of electricity is still generated. This electricity will be used to supply the 12v accessories, and any excess energy will be used to slowly charge the Battery Module. In this state, the instrument display will show no charging on the charge/assist gauge.

DECELERATION / REGENERATIVE BRAKING



Energy flow from wheels to battery (via electric motor/generator)

During deceleration, the gasoline engine is switched into fuel cut mode, and the IMA Motor/Generator is operated in generation mode. In this mode, the IMA Motor is driven by the wheels, generating electricity to be stored in the Battery Module, and slowing the Insight in the process. The amount that the IMA Motor slows the car is in proportion to the amount of regeneration being done. There are two deceleration modes:

- **Foot off throttle but not on brake pedal** - In this mode, the charge/assist gauge will show partial charge, and the vehicle will slow down gradually.
- **Foot on brake pedal** - In this mode, a higher amount of regeneration will be allowed, and the vehicle will slow more rapidly. During light brake pedal application, only the IMA Motor/Generator is slowing the car. With heavier brake pedal application, the conventional friction brakes also come into play.

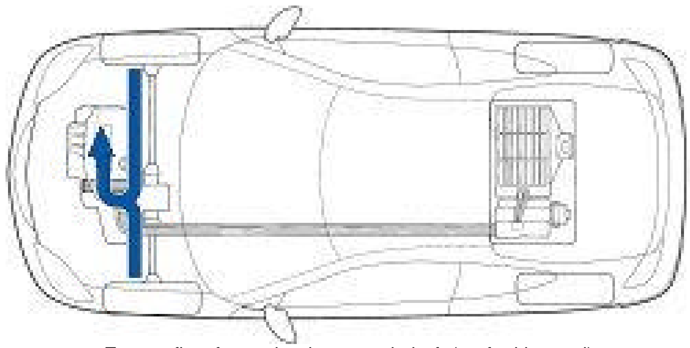
When decelerating, regeneration will continue until engine speed falls to about 1000 rpm. At this point, the driver will typically shift into neutral. In many cases the gasoline engine will now immediately enter auto idle stop mode. If vehicle speed is such that it isn't clear whether the driver will most likely come to a stop, the engine may idle for a few moments before entering idle stop. If the battery state of charge is very low, idle stop will not be entered at all, and instead the engine will continue to run at a fast idle to recharge the Battery Module.

During generation, the AC produced by the IMA Motor/Generator is converted by the MDM into DC, which is used to charge the Battery Module. The DC output of the MDM is also applied to the DC-DC Converter, which reduces the voltage to 12v. The DC-DC Converter's 12v DC output is supplied to the vehicle electrical system. It is also used to charge the 12v battery as necessary.

When the State of Charge of the Battery Module is at its maximum level, generated electricity is only delivered to the 12v accessory system.

When the ABS system is controlling wheel lock up, an 'ABS-busy' signal is sent to the MCM. This will immediately stop regeneration to prevent interference with the ABS system.

FUEL CUT MODE



Energy flow from wheels to crankshaft (no fuel burned)

Whenever the Insight is moving with the clutch engaged and the transmission in gear, the gasoline engine is mechanically connected to the wheels, and so it must continue to turn also. However, this doesn't necessarily mean that it is consuming any fuel.

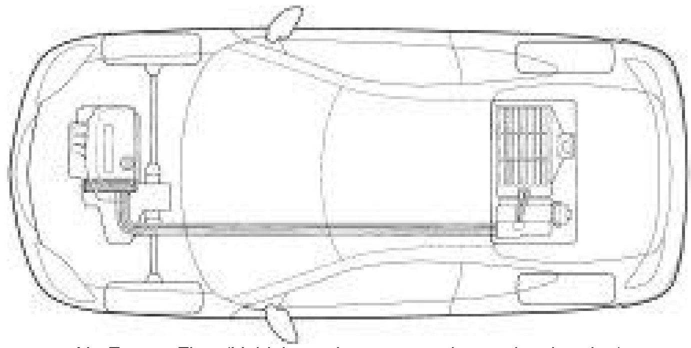
During deceleration, if the clutch is engaged and the transmission is in gear, the IMA will typically enter fuel cut mode. This is considered a separate mode from idle stop mode, as the engine (and by extension any engine-driven accessories such as the air conditioning compressor) is continuing to be turned by the wheels. In idle stop mode, the engine is not turning at all.

Fuel cut mode will take place at engine speeds above 1100 rpm. If the engine speed falls below 1100 rpm, fuel will be supplied to prevent the engine from stalling when the driver releases the clutch.

So, this is what takes place during a typical deceleration:

- When the driver releases the accelerator pedal, a low level of regenerative braking takes place, and the gasoline engine enters fuel cut mode.
- When the brake pedal is applied, a higher level of regenerative braking takes place. The engine is still in fuel cut mode, rotating but not burning any fuel.
- When the driver presses the clutch pedal, the car may now enter idle stop mode where the engine no longer turns at all. In this case, no fuel will be consumed from the time the driver began decelerating until the driver reaccelerates. If the conditions for idle stop are not satisfied when the driver releases the clutch pedal (for instance, battery level is too low), fuel cut mode will end, and fuel will be delivered to the engine to keep it running.

IDLE STOP MODE



No Energy Flow (Vehicle stationary, coasting or decelerating)

To prevent unnecessary fuel consumption and exhaust emissions, the Insight's gasoline engine is turned off when there is no need for propulsion or air conditioning. During typical deceleration, the regenerative braking and fuel cut mode begin as soon as the driver begins to decelerate. When the engine speed slows down to about 1000 rpm, regenerative braking will stop, and the driver will typically switch into neutral. At this point, the fuel may be needed if the IMA system determines that there is a need to keep the engine running (idling).

After the vehicle speed drops below 30 km/h (19 mph), idle stop mode will typically be triggered, and the gasoline engine will stop turning. The engine will typically remain off until the transmission is put into first to begin accelerating again. Restart is performed instantly and very quietly and smoothly using the IMA motor.

Conditions for Engine Shutdown

While reducing vehicle speed, the engine stops itself automatically under these conditions:

- The vehicle speed is less than 30 km/h and the the brake pedal is pressed, or vehicle speed is less than 5 km/h
- The transmission is in any gear, except 1st, before slowing down
- The clutch is disengaged or neutral position is now selected
- The engine speed is less than 1000 rpm

If the brake pedal is released while the Insight is slowing down, the engine starts again instantly, unless vehicle speed is below a certain speed. Even in this case, the engine will be restarted if a gear is selected or the gas pedal is touched.

Idle stop will not take place in any of the following conditions:

- The engine has not yet had time to warm up
- The transmission is in reverse gear
- The Battery Module is not charged sufficiently to restart the engine using the IMA Motor
- If the IMA-ECU detects stop-and-go traffic conditions (e.g. if the transmission has not been switch out of first since the car was last stopped).

Also, climate control mode will affect whether or not idle stop is performed. In Auto mode, the engine will be allowed to continue running to operate the air conditioning compressor. In Econ mode, idle stop may occur, possibly causing the air conditioning compressor to temporarily stop. See the climate control page for more information.

Conditions for Engine Restart

The engine is restarted when:

- A gear is selected with the clutch disengaged, or
- The brake pedal is release during deceleration, or
- The accelerator pedal is depressed with the clutch disengaged and/or the transmissions neutral position selected, or
- Master brake cylinder pressure becomes low, or
- Battery Module's remaining charge decreases to a certain level with the clutch disengaged and/or the transmission's neutral position selected.

IMA COMPONENT LOCATIONS

This view shows the contents of the "IPU" compartment, immediately behind the driver and passenger seats. This compartment contains the following components:

- Motor Control Module (MCM): This is the metal box located in the upper right corner, which controls when the motor operates in assist or regeneration mode, and controls the degree of assist/regeneration.
- Battery Condition Module (BCM): This it the metal box to the left of the MCM, just right of center. This tracks the battery state of charge and decides how much energy can be supplied to or delivered from the battery.
- Battery Module: Located below the MCM and BCM, this is the Insight's 144 volt primary battery pack.
- Battery Module cooling fan, located in the bottom right portion of the picture. This two speed fan draws air from the cabin, behind the right seat, and pulls it through the battery pack.
- Motor Drive Module (MDM): This is the component located in the upper left corner of the picture. The Motor Drive Module contains the switching electronics used to bidirectionally-directionally send power between the Battery Module and the IMA Motor, based on instructions provided to it by the Motor Control Module (MCM).
- Heat Sink: This is the duller colored component located next to the MDM, which absorbs and dissipates heat produced by the MDM and DC-DC Converter.
- DC-DC Converter: This is the component located to the right of the Heat Sink. The DC-DC Converter converts the 144 volt power supplied by the IMA motor and/or Battery Module into 12 volts to supply the Insight's conventional 12 volt accessories.
- Power Control Unit (PCU): The MDM, Heat Sink and DC-DC Converter are collectively known as the Power Control Unit.
- PCU Cooling Fan: This is located in front of the heat sink, and draws air through the heat sink to aid in cooling of the PCU.

- Junction Board: This is the black component, located to the right of the DC-DC Converter, and is actually part of the Battery Module assembly. The Junction Board contains the battery module switch, along with contactors that are used to connect the Battery Module to the electronics when the Insight is turned on.

Power is carried between the components in the "IPU" compartment behind the seats and the IMA electric motor under the hood by three orange cables than run below the floor, under the left seat.

See also:

- IMA Modes of Operation
- IMA Motor

IMA MOTOR / GENERATOR

Role

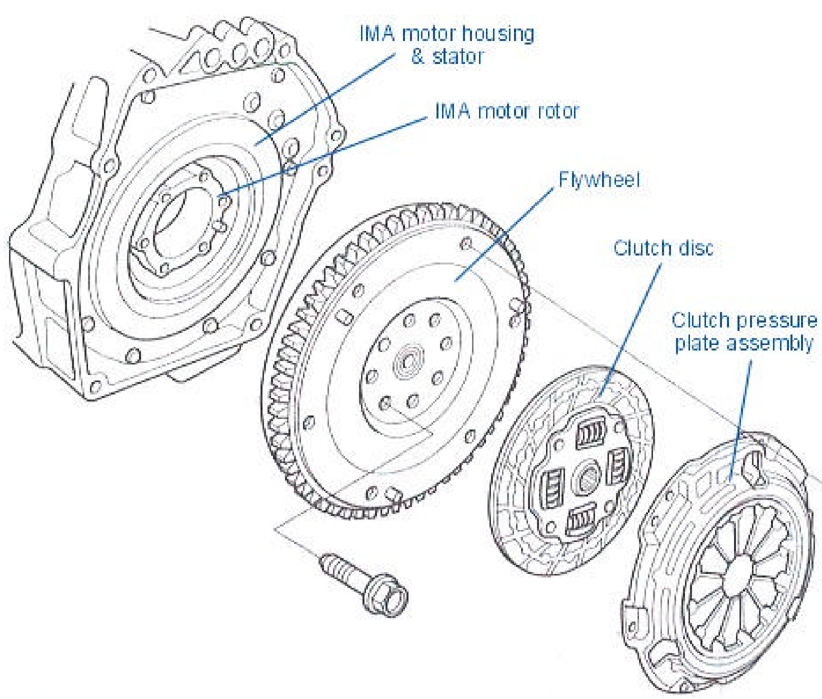
The thin design motor is located between the 3-cylinder engine and the transmission. The IMA motor serves a number of functions:

- It assists in vehicle propulsion when needed, allowing the use of a smaller internal combustion engine.
- It operates as a generator, allowing excess energy (such as during braking) to be used to recharge the IMA Battery Module, and later be used to provide assist.
- It takes the place of the conventional alternator, providing energy that ultimately feeds the Insight's conventional 12v electrical system.
- It is used to start the internal combustion engine very quickly and quietly. This allows the internal combustion engine to be turned off when not need, without any delay in restarting on demand.
- It is used to dampen crankshaft speed variations, leading to smoother idle.

Location

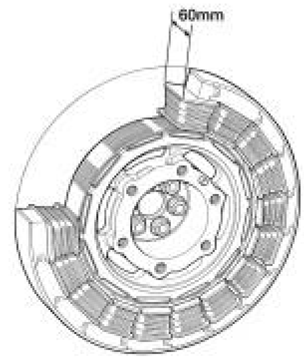
The IMA motor is located between the internal combustion engine (ICE) and clutch. One end of the IMA motor rotor is bolted to the ICE crankshaft, and the other end of the rotor is bolted to the flywheel. Because of the IMA motor adds rotational mass, the weight of the flywheel can be reduced by an amount equal to the weight of the IMA motor rotor.

The flywheel retains gear teeth for the backup 12v starter motor to mesh with when it is engaged. In manual transmission Insights, as with other manual transmission vehicles, the clutch also serves as a surface for the clutch.



Design

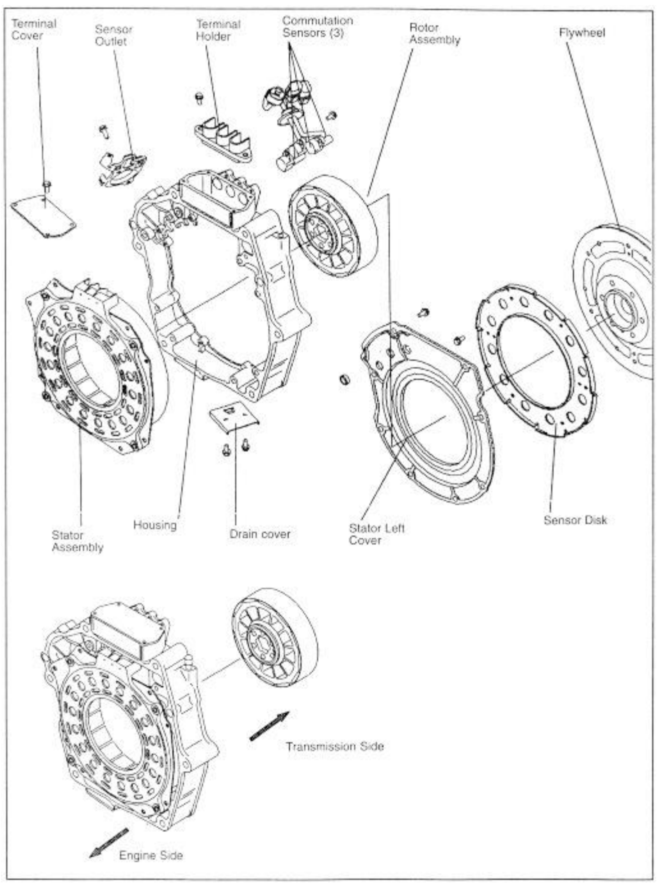
The IMA motor is a permanent-magnet type, brushless DC motor.

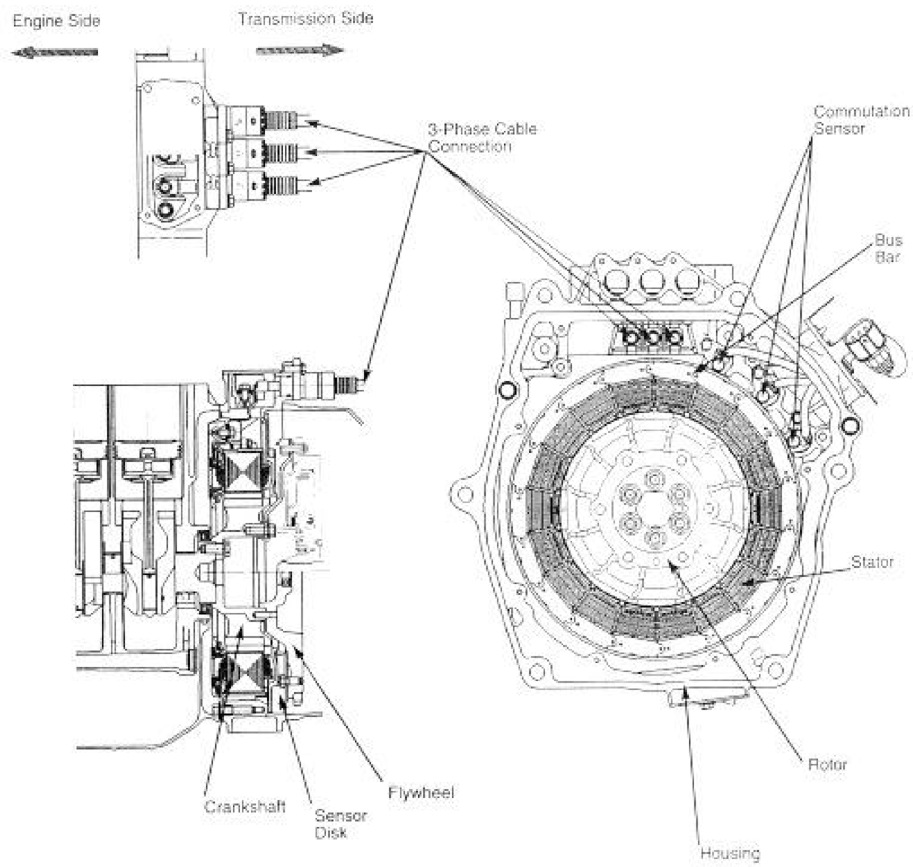


The only moving part in this type of motor, the rotor, consists of nothing but permanent magnets. The electromagnets are located around the perimeter of the stator. There are several key attributes of this type of motor:

- Because the electromagnets are located around the perimeter, the electromagnets can be cooled by conduction to the motor casing, requiring no airflow inside the motor for cooling. This in turn means that the motor's internals can be entirely enclosed and protected from dirt or other foreign matter.
- With no windings on the rotor, they are not subjected to centrifugal forces.
- Commutation (switching current between different sets of electromagnets to produce rotation) is not accomplished by any sort of physical switching, such as brushes that wear out. Instead, this switching is accomplished by an electronic controller - the Motor Drive Module. This allows electronic control over torque and magnet field slip angle, which makes it easy to operate the motor as a generator.
- Inefficiencies caused by brush material resistance, and brush drag friction are eliminated.

The IMA motor's disc shaped design allows it to fit into the same space that would otherwise have been occupied by a fourth cylinder. The thin, relatively large diameter shape means that it produces a great deal or torque.




Engine Side
Transmission Side
3-Phase Cable
Connection
Commutation
Sensor
Bus
Bar
Stator
Rotor
Flywheel
Crankshaft
Sensor
Disk
Housing

BATTERY MODULE

The Battery Module uses nickel metal hydride (NiMH) technology for high energy density and long service life.

The battery is manufactured by Panasonic EV Energy and weighs only 48 lbs. or 22 kg. Its operating temperature range is -30C degrees ~ +60C degrees. The Battery Module is only available as a complete assembly.

The Battery Module is constructed in a modular form. The individual NiMH cells are same size as standard D cells. Constructing the module from standard sized cells should help to ensure cost-effective and continued availability of the battery module components.

The picture above shows the arrangement of these cells, which are grouped together in sealed **packages of two cells each**, positioned end-to-end. That is, the arrangement is 6 cells across by 3 cells high by 7 cells deep, with the rearmost row being only 2 cells high, for a total of 120 cells.

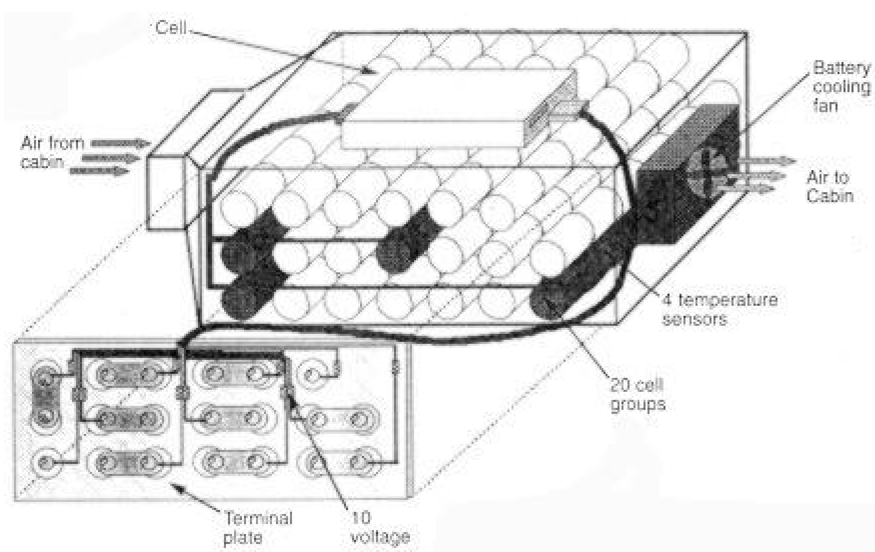
The cells each have a voltage of 1.2v, and are connected in series for a Battery Module terminal voltage of 144V. The Battery Module's rated capacity is 6.5 Ah, resulting in a storage capacity of .936 kWh.

If Battery Module service is required, refer to the Service Manual as serious injury or even death can occur if high voltage safety precautions are not observed. High voltage wires and cables are covered with orange plastic shielding or tape. Never casually handle any orange wiring or the component connected to it!

The Battery Module is used to supply the high voltage to the IMA Motor during the assist mode. The Battery Module is also used to store the re-generated power in the cruising, deceleration and braking modes. Battery Module energy may also be used to charge the conventional 12V battery located in the engine compartment that operates the vehicle's 12V system.

The battery module cell groups are connected in series to the terminal plate, located on the side of the Battery Module.

The Battery Module contains 10 voltage sensors and 4 temperature sensors that send data to the Battery Condition Monitor (BCM).

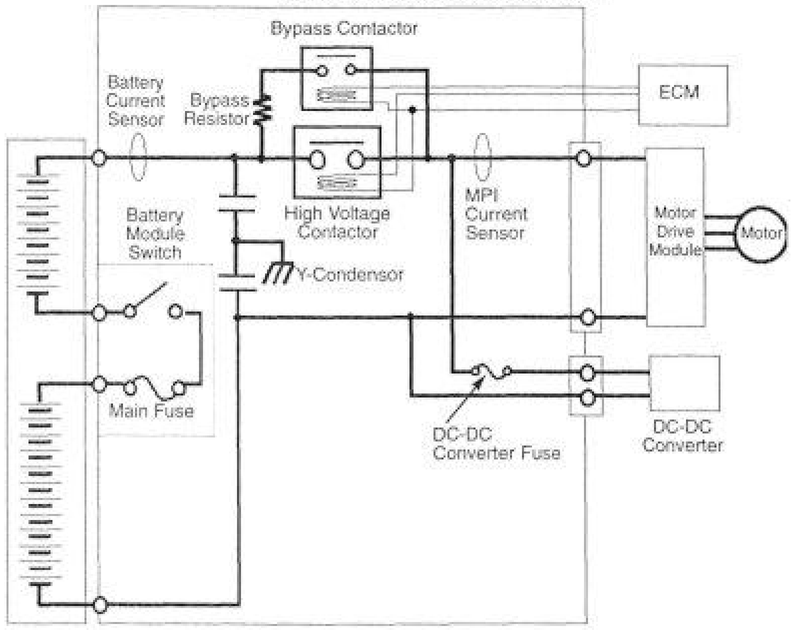


JUNCTION BOARD

The Junction Board is located in the IPU compartment and is attached directly to the Battery Module. Most small components, and the main connections of the high voltage system, are located on the junction board.

The Junction Board itself is not serviceable. If a component attached to the board fails, the Battery Module assembly must be replaced.

Junction Board Circuit Diagram



When the ignition switch is turned on, the Bypass Contactor is closed first, followed by the High Voltage Contactor. Because current supplied to the MDM initially flows through the Bypass Resistor, a smaller amount of current is applied. This reduces the start-up current spike when the system is first powered up.

BATTERY CONDITION MONITOR (BCM)

The Battery Condition Monitor Module (BCM) monitors the condition of the main battery, via four temperature sensors and 10 voltage sensors in the Battery Module. It also uses one current sensor to determine rate of charge/discharge, and supplies information to the Motor Control Module.

The BCM maintains the IMA battery state of charge in a range of 20% to 80%, which optimizes battery life. It never allows the battery to become fully charged or fully discharged.

The Battery Condition Monitor also controls the operation of the 2-speed cooling fan, located on the outside of the battery module. Relays and a resistor that make two different speeds possible, are located on the Junction Board. the Battery Condition Monitor checks the condition of the battery by monitoring the following:

- Calculation of State of Charge (SOC)
- Battery protection needs
- Battery temperature

Motor Control Module (MCM)

The IMA Motor/Generator's function is to charge the Battery Module, to assist the gasoline engine under acceleration, and to start the engine under specific conditions.

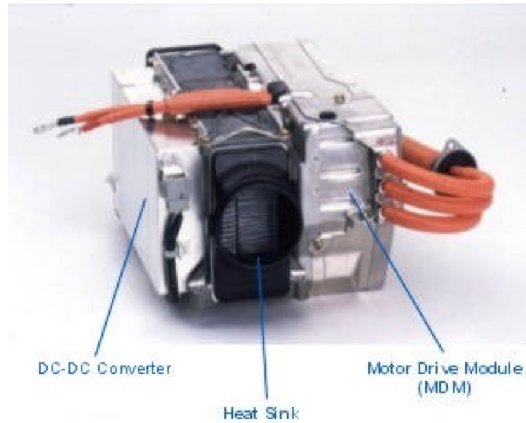
The Motor Control Module controls all these actions. The MCM is a low-voltage, microprocessor controlled device (i.e. a computer). The MDM that it communicates with, in turn contains all the high voltage cicuitry that connects directly to the motor itself.

The function of the MCM is:

- To communicate with the ECM/PCM to determine the vehicle operation mode, and to send DTC codes to the main ECM to report any problems detected in the IMA system.
- To communicate with the BCM that constantly calculates the Battery Module state of charge based on battery temperature, current and voltage. This information is used to protect the Battery Module and maintain proper charge levels.
- To communicate with the instrument panel display to keep the driver informed about the IMA system conditions and operating modes.
- To communicate with the MDM to receive motor commutation information, and to control the Motor Power Inverter Module (IGBT's) through the Voltage Converter Module.

MOTOR DRIVE MODULE (MDM)

The IMA system assists the engine with an electric motor using power from the Battery Module. It must also recharge the Battery Module by using power generated by the motor. It is the Motor Drive Module or MDM which makes this possible. It can bi-directionally send current from the motor to the battery and from the battery to the motor.



During assist mode, power from the Battery Module is supplied to the IMA Motor in the form of 3-phase Alternating Current. The current isn't true AC, but IGBT's (Insulated Gate Bi-polar Transistors) in the Motor Power Inverter Module (part of the MDM) are switched in such a way as to simulate AC current.

The Motor Control Module receives constant feedback from three commutation sensors in the IMA Motor, and therefore knows the position of the motor. Accurate position information is important because each phase of the 3-phase current must be switched on at the correct time to ensure proper motor operation.

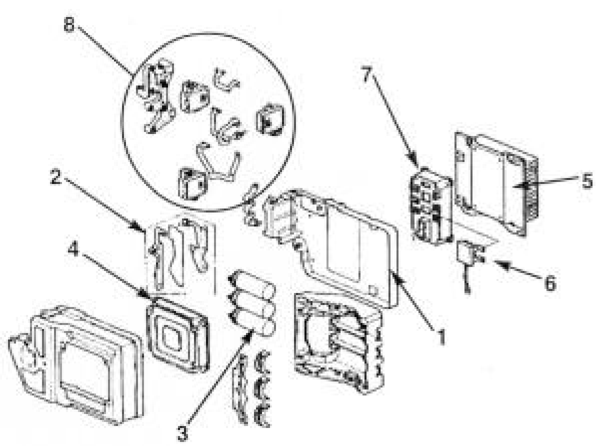
The Voltage Converter Module (also part of the MDM) receives commands from the Motor Control Module, and switches the IGBT's appropriately to meet system demands.

During regeneration mode, current flows from the IMA Motor to the MDM. The motor generates true 3-phase Alternating Current, and that AC must be transformed into DC before it can be used to charge the Battery Module.

Diodes inside the Motor Power Inverter Module are used to rectify the AC power in the same way as they are used in a typical alternator.

It is very important to note that the IMA Motor is a permanent magnet type and will generate power **whenever** it is turning. If the engine were accidentally started with the IPU Compartment opened, the MDM cables will be hot - even when they are disconnected from the Junction Board. For this reason, the MDM cable terminals should be wrapped with electrical tape whenever they are disconnected from the Junction Board.

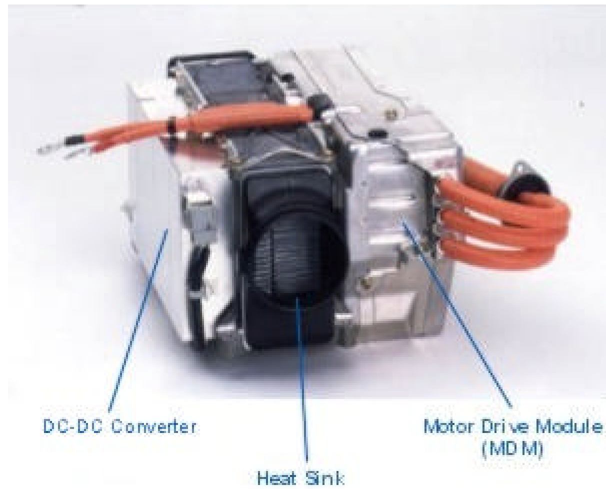
MDM Components



1. MDM cover
2. Bus bar
3. Electrolytic capacitors
4. Voltage Converter Module
5. Heat sink
6. Capacitor module (supresses voltage spikes that are generated during high speed switching at high voltage)
7. Motor Power Inverter (MPI) Module
8. 3 phase current sensors

DC-DC CONVERTER

The Insight engine is not equipped with an ACG (AC Generator or Alternator). Instead, recharging of the 12V battery and powering of the conventional 12V electrical system is performed by a DC-DC converter located in the IPU compartment.



Elimination of the conventional Alternator reduces engine load, leading to better fuel efficiency. Another advantage is that by supplying power to the 12V electrical system from the IMA battery, electrical system voltages remain very constant, even under changing electrical system loads. Even during idle stop and restart, headlight brightness, wiper speed, etc. remain constant.

Power is supplied to the DC-DC converter from the IMA Motor/Generator though the MDM, or by the NiMH Battery Module. This power has to be reduced to 12V to charge the Insight's 12V battery and to support the conventional 12V electrical system. It is the DC-DC converter that performs this task. It transforms 144V DC as an input source into 12V DC output power.

The 144V **Direct Current** supplied from the IMA Motor or Battery Module is first converted into high voltage **Alternating Current**, which is then stepped down by a transformer to low voltage AC before being converted back to DC for use by the Insight's 12V electrical system.

The DC-DC converter is a high voltage component, and produces substantial heat during operation. To ensure proper cooling of the DC-DC converter, it is mounted to a finned aluminum heat sink fitted inside a magnesium housing. The PGM-FI ECM controls the output of the DC-DC converter according to power consumption of the 12V electrical system.

The MCM may stop DC-DC converter operation if certain IMA malfunctions occur, or if the DC-DC converter's temperature rises abnormally. Any time that the DC-DC converter is not functioning normally, the charge indicator lamp on the instrument panel will be illuminated.

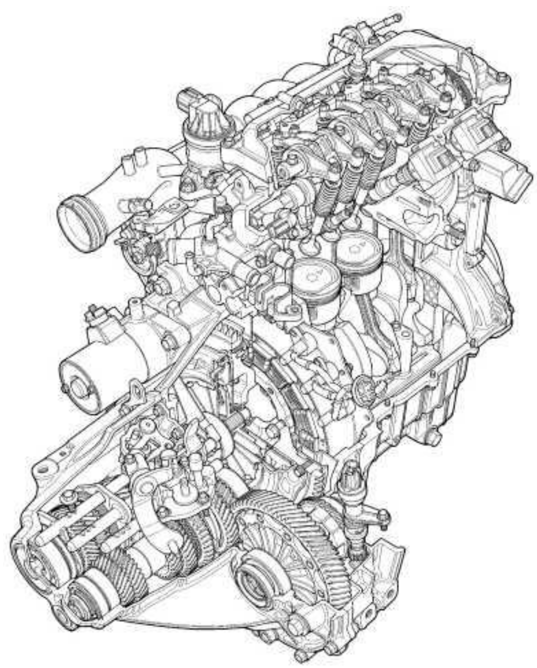
ADVANCED GASOLINE ENGINE

ADVANCED GASOLINE ENGINE

The Insight's internal combustion engine is an in-line three-cylinder with a displacement of 995cc. Its design includes comprehensive weight-reducing and friction-reducing features which ensure fuel-efficient, environmentally-friendly operation. The engine employs a VTEC mechanism which maximizes running performance by optimizing the valve timing and lift at all engine speeds.

Very precise control over fuel injection, a strong air-fuel swirl created in the combustion chamber, a new linear air-fuel sensor and lean-burn NOx catalyst allows the use of stratified-charge lean burn combustion technology. The Insight's engine will operate on air-fuel ratios as low as 22:1, meaning that the amount of fuel drawn into the engine can be reduced to much lower than that of a typical 1.0 liter gasoline engine which operates at 14.7:1. This happens under light load conditions, which will often include cruising as fast as highway speeds.

Stratified-charge combustion means that the air-fuel ratio isn't equal throughout the cylinder. Instead, precise control over fuel injection allows a greater concentration of fuel closer to the spark plug, further improving combustion efficiency.



New Transmission Design

Honda engineers designed a completely new 5-speed manual transmission for the Insight. Like the rest of the Insight, its new transmission is designed to be as lightweight and as compact as possible, and is sized to the power requirements of the IMA system. The new transmission weighs just 91 pounds and is 9.25 pounds lighter and almost a half an inch shorter than the current Civic manual transmission.

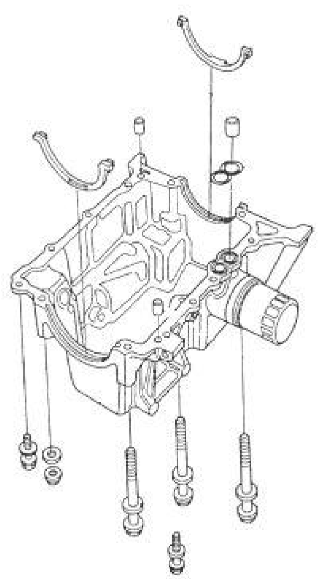
In order to minimize power loss within the transmission, the gears have been carefully machined to reduce rotational mass. The transmission's lubricating system has also been redesigned to provide more efficient lubrication with a smaller oil capacity; thereby saving additional weight and size.

The transmission's shift linkage operates smoothly, with minimal effort, thanks to the use of shortened synchronizer sleeves and a redesigned reverse-gear mechanism. A neutral switch built into the transmission tells the IMA idle-stop feature when the transmission is in neutral.

ENGINE WEIGHT REDUCTION TECHNOLOGIES

All engine parts have been made as light as possible. Major weight-reducing features are:

- Sleeveless cylinders with minimal dimension between bores
- The intake manifold used on the Insight's 1.0-liter engine is made out of plastic resin instead of aluminum alloy. The entire manifold weighs only 2.2 pounds, roughly half the weight of a comparable aluminum manifold. The individual pieces that make up the manifold, such as the intake runners, plenum chamber and throttle-body mounting, are permanently connected with a vibration-welding technique. The cylinder head cover is also made of plastic.
- Additional weight-saving engine components made with plastic resin include a 0.39-pound water-pump pulley, a 0.2-pound air-intake tube and a 0.88-pound valve cover.
- Single rocker arm shaft shared by intake and exhaust valves
- Rocker arms made of aluminum
- Optimally light pistons.
- Borrowing the technology from Honda's high-performance S2000 sports car, the IMA engine uses special compact, high-strength, forged-steel, carburized connecting rods. Carburization toughens the rod's surface so that it resists crack formation. Carburizing allowed Honda engineers to reduce the cross section of the connecting rods, thereby reducing their weight (always a penalty in a reciprocating engine) by 25 percent, while increasing their strength by more than 50 percent.
- The Insight IMA engine features a magnesium-alloy oil pan. Like a cast-aluminum pan, the Insight's magnesium pan adds stiffness to the engine block, helps muffle engine noise and also helps to cool engine oil, but it is 35 percent lighter than aluminum. The magnesium alloy specified for the Insight engine's oil pan is a new type that exhibits less thermal-induced expansion and contraction (creep) at high temperatures, so the oil pan remains oil tight. Honda engineers designed additional weight-saving measures into the Insight's magnesium oil pan by incorporating the engine oil-filter bracket, AC-compressor bracket and an engine-block stiffener into the casting.



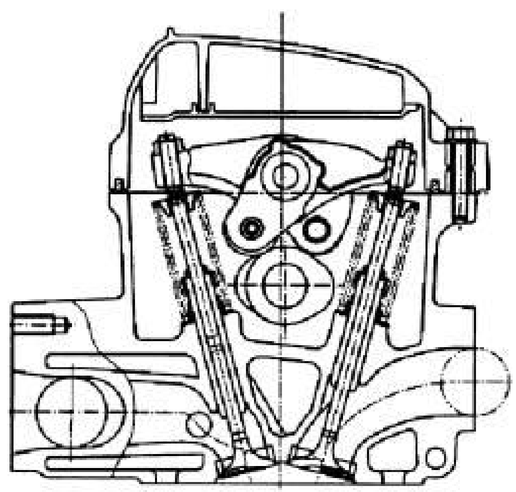
Magnesium-alloy oil pan

ENGINE FRICTION REDUCTION TECHNOLOGIES

To minimize energy losses, friction between moving parts is minimized by utilizing the following features:

- Offset cylinder construction
- In the interest of friction reduction, Honda engineers specified a new lightweight aluminum-alloy piston design for the IMA engine. The pistons have a minimal skirt area and the surface of the skirt has been shot-peened. Shot-peening is a process in which a metal part, such as a piston or connecting rod, is blasted with shot-like particles, creating uniform, microscopic dimples on the surface. This dimpled surface is better able to retain a lubricating oil film. Shot-peening the IMA engine's pistons accounts for another 1.5- to 2.0-percent reduction in internal friction.
- Rocker arms are fitted with rollers that minimize friction on the cam's contact surfaces.
- OW20 friction-reducing engine oil

The overall load on the engine is reduced by using electric power steering. It is also reduced by the elimination of a conventional alternator, instead using the IMA system's DC-DC Converter to power all electrical accessories from IMA Motor/Generator power.

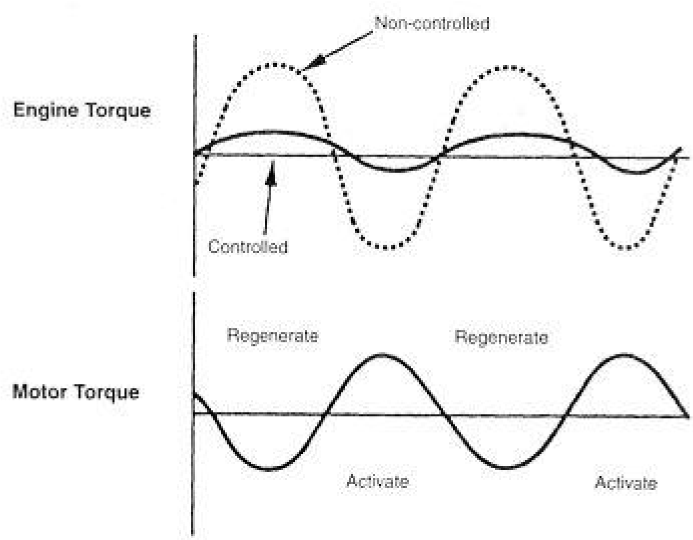


Rocker arms fitted with rollers

VIBRATION CONTROL SYSTEM

A three cylinder engine, without balance shafts (which decrease power and thus fuel efficiency), is inherently prone to vibration. To improve idle quality, the IMA motor is used to smooth out speed fluctuations in the engine's crankshaft.

During a power stroke, the crankshaft speed increases, and the IMA momentarily switches to the regeneration mode to absorb a little of the power pulse. After the power pulse has been absorbed, the IMA is activated in assist mode to speed up the slowing crankshaft. The results are a much more consistent crankshaft rotational velocity and smoother idle quality.

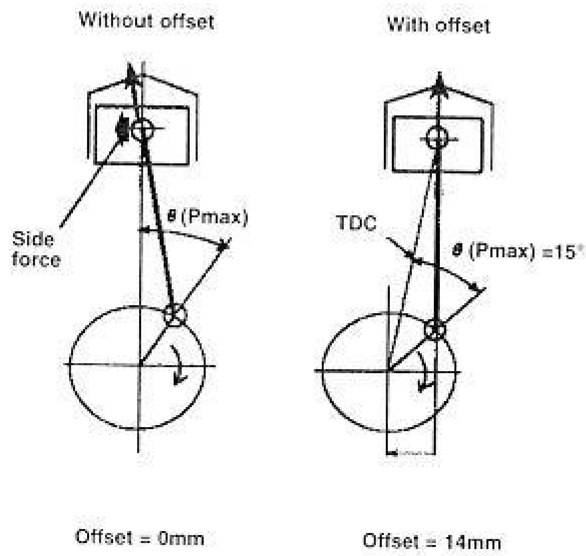


The Insight also uses lightweight aluminum-alloy engine mounting brackets that incorporate hydraulic (liquid-filled) mounts that help damp engine vibration. The mounts are located on the axis of the engine's principal inertial moment (the axes about which the engine vibrates). At these points, the least amplitude of engine vibration is transmitted from engine to frame, which significantly reduces engine-idle vibration.

OFFSET CYLINDER CONSTRUCTION

The engine block has a unique, offset cylinder design in which the bore center is offset 14mm from the crank center. Maximum combustion pressure occurs at a point where the connecting rod is straight up and down in the cylinder. In this position there is zero lateral force so friction and piston slap are reduced.

As a result of the offset construction, the combustion pressure is used more efficiently since the rod is near it maximum leverage point with the crankshaft.



SPARK PLUGS

The Insight uses a new, iridium spark plug that is unique to this vehicle.

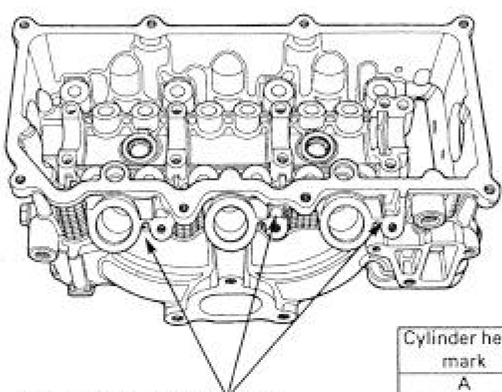
There are *four different part numbers* for the spark plugs, and each has the electrode aligned differently with the plug threads. This allows the orientation of the ground electrode in relation to the intake valve to be optimized for maximum economy and power, and optimum combustion efficiency.

Due to variations inherent to the manufacturing process, *each engine's head will differ*. After each head is manufactured, it is measured and the optimal spark plug for each cylinder in that engine is determined. This information is then stamped on the cylinder head.

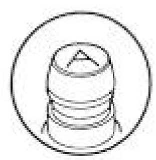
Each spark plug has an identification mark (A, B, C or D) located on the top of the solid post terminal that is to be matched with the corresponding identification mark for each cylinder, as stamped on the cylinder head of the engine in question. The cylinder head marking location is shown below.

To ensure proper electrode position, only replace spark plugs with letter codes that match the stamping on the cylinder head. If the spark plugs are to be reused, they must be returned to the *same* cylinders.

To ensure proper electrode position, it is also doubly important that the plug is torqued to specifications.



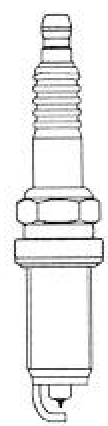
Codes "A to D" are stamped here. Match the plug code with this stamping.



Spark plug mark

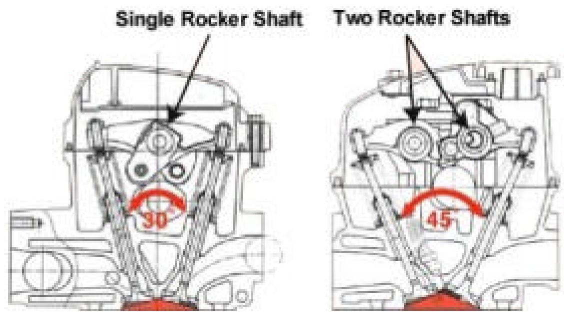
Cylinder head mark	Spark plug
A	A (P/N 12290-PHM-A01)
B	B (P/N 12291-PHM-A01)
C	C (P/N 12292-PHM-A01)
D	D (P/N 12293-PHM-A01)

Torque to 23 N-m (17 lb.-ft.)



ROCKER ARMS & SHAFT

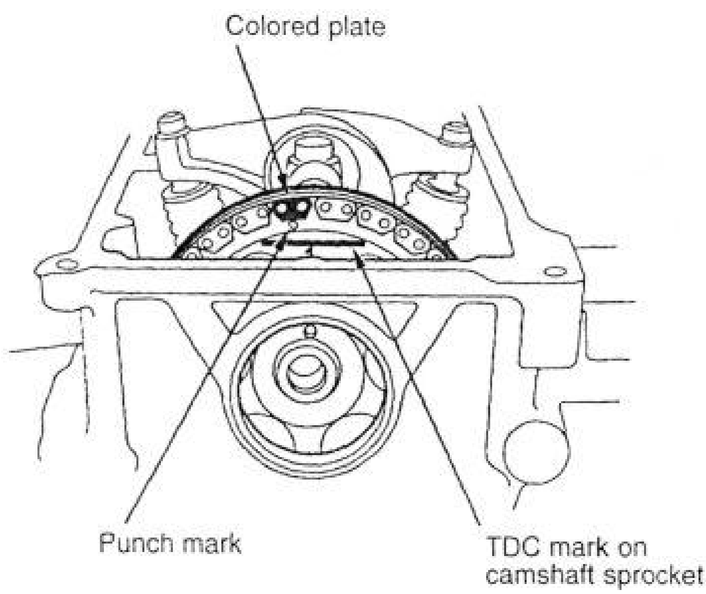
In order to reduce friction and weight, L-shaped, roller rocker arms are mounted on a single shaft. A narrow valve angle (30 degrees) and a compact combustion chamber contribute to an increased swirl ration of the air/fuel mixture, leading to better combustion.



Timing Chain System

Crankshaft rotation is transmitted via a silent type timing chain to the camshaft sprocket.

The illustration below shows correct timing when the crankshaft pully is at TDC.



VTEC-E System

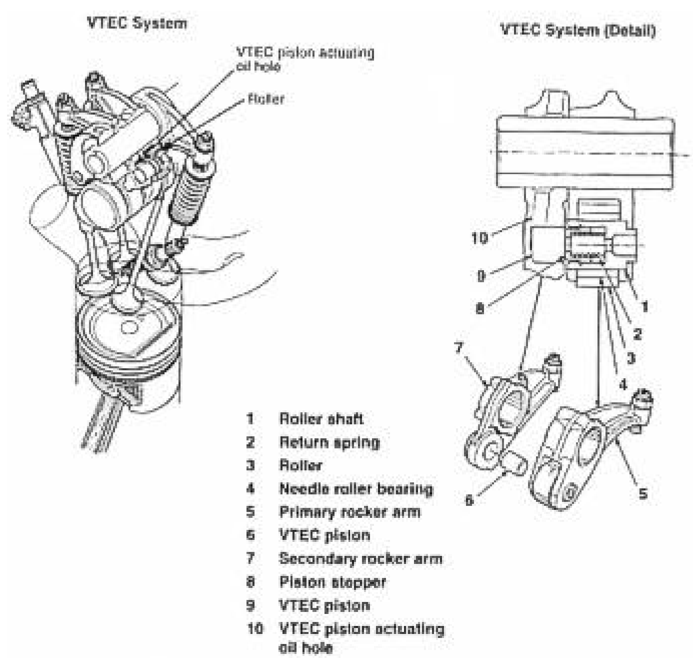
The Honda Insight's engine employs a newly designed VTEC system. In this system, the cam followers of the intake primary rocker arms are fitted with rollers that minimize friction on the cam's contact surfaces. (Each roller turns on a needle roller bearing.)

The VTEC rocker arms are a new, compact, low-friction design, adapted from the S2000 roadster, with the VTEC switching mechanism (pistons) located coaxially with the roller elements. This new design reduces the reciprocating mass of the valvetrain, for more reliable high-rpm operation, and also allowed Honda engineers to reduce valve-spring load by 30 percent.

During acceleration, when engine speed reaches 2500 - 3200 rpm the primary and secondary rocker arms are locked together by the VTEC pistons. During deceleration, when engine speed drops to 2300 rpm the primary and secondary rocker arms separate. The exhaust rocker arms are made of aluminum.

The IMA engine's single overhead camshaft (SOHC) cylinder head uses a compact chain drive in place of a toothed belt, and features a new compact, low-friction VTEC valvetrain that uses a common shaft for both the intake and exhaust rocker arms. Placing all the rocker arms on one shaft eliminates the need for a second rocker-arm shaft, so the valve mechanism can be more compact.

An additional advantage of this design is its narrower included valve angle that better centralizes the stratified air-fuel charge around the spark plug for quick light-off and more complete combustion.



INTEGRATED HEAD

The Honda Insight's cylinder head has a unique, cast-in exhaust manifold that saves weight and increases exhaust heat retention.

The exhaust ports are located inside the cylinder head and are surrounded by a water jacket. As coolant passes through the jacket, its temperature is increased by the exhaust heat.

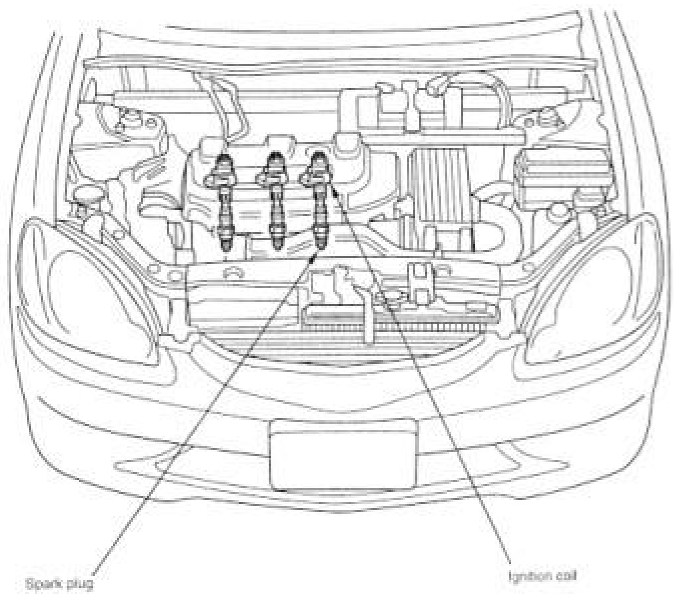
The individual exhaust-manifold runners are part of the head casting, just like the exhaust ports. The shape and length of the manifold runners is optimized for efficient flow, and the system offers the advantages of faster heat transfer to the catalyst, for faster lightoff. This decreases exhaust emissions and increases fuel efficiency. Eliminating the need for a separate exhaust manifold also increases manufacturing efficiency, and offers greater compactness and lower engine weight. The IMA engine is the world's first production gasoline engine to use an integrated exhaust manifold.

New spark plug positions and other innovations yield compact combustion chambers.

DIRECT IGNITION SYSTEM

The Insight engine employs a direct ignition system similar to those used on the Honda S2000 and the 1999 Odyssey. Separate ignition coils for each cylinder are located directly above the spark plugs.

Two TDC (Top Dead Center) sensors are mounted at the rear of the single camshaft. A Crankshaft Fluctuation Sensor (CKF) is located near the bottom of the timing cover where it generates a signal as the crankshaft timing chain sprocket rotates past it. These sensors establish ignition and fuel injection timing, and monitor crankshaft speed variation.



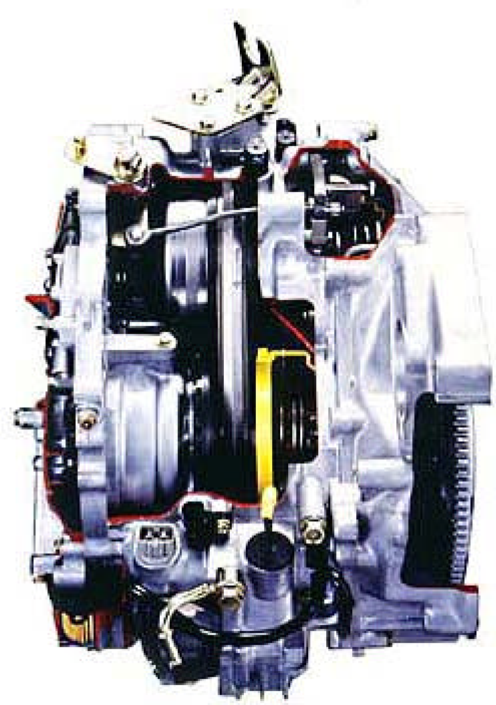
CVT TRANSMISSION

The Insight is made with two transmissions:

- a conventional 5-speed manual transmission, and
- a continuously variable automatic transmission, also referred to at the ***"CVT"*** or ***"Honda Multimatic"*** transmission.

Note that while the Honda Insight and Toyota Prius both offer CVT transmissions that both provide stepless acceleration and a continuous range of motor speed to vehicle speed ratios, the Prius CVT (called 'ECVT' by Toyota) system is mechanically entirely different.

The CVT transmission used in the Insight is very similar to the CVT transmission that Honda has used in other vehicles, including the Civic HX in the United States, and the Honda Logo in Europe & Japan. CVT equipped Civic HX models have been sold in the U.S. since 1996. The Insight and 2001 Civic HX use a redesigned and significantly improved version of the CVT transmission.



* *Note:* Images provided here are based on the version of Honda's CVT transmission used in the '96-'00 generation Civics. By and large this information applies equally well to the CVT transmission used in the Insight, but there may be some minor differences in the new CVT transmission. Consult your service manual before doing any work related to the CVT transmission.

Overview of the CVT Transmission

Rather than having a fixed set of gear combinations, or "ratios", the CVT transmission allows an almost limitless number of engine speed to vehicle speed ratios. This provides significant benefits over a traditional automatic transmission, including:

- The computer can intelligently choose to have the Insight's gasoline engine and electric motor rotating at the optimal speed, regardless of how fast the car is travelling. When cruising under low power demand conditions, the engine & motor will turn relatively slowly, while they will turn faster when accelerating or climbing a hill. This provides improved fuel efficiency as compared to a typical automatic transmission.
- Because of the smooth transition in gear ratios provided by the CVT transmission, the CVT Insight provides constant, stepless acceleration from a stop all the way up to cruising speed. This contrasts with the jerk of gear changes experienced with a typical automatic transmission.
- The CVT transmission provides less power loss than a typical automatic transmission, resulting in better efficiency and acceleration.

Honda claims that their CVT transmission is the world's first mass-produced, high-power, stepless transmission. While such transmissions existed previously, they claim the CVT is "far superior in quality, endurance, power output [and] cost". They have also specifically designed the CVT to respond in the way that drivers are accustomed to other automatic tranmissions responding.

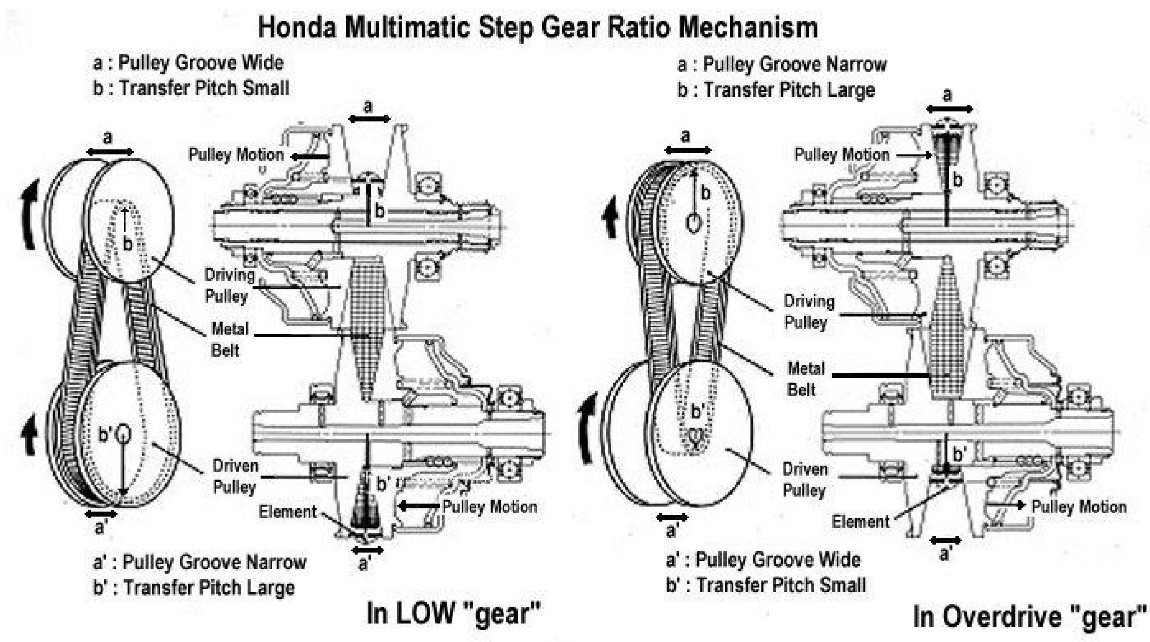
CVT Operation

The CVT transmission consists of an oil-pressure variable input (aka "driving") and output (aka "driven") pulley, and a metal belt that connects the two. With an oil-system clutch on the "driven" side, the Multimatic acts as an automatic transmission. The power output from the engine goes through: Front/Back Switch Mechanism -> Driving Pulley -> Metal Belt -> Driven Pulley -> Clutch.

The two pulley widths, adjusted by oil pressure, react to the position of throttle, speed, and other conditions. For instance, when the accelerator is depressed, the driving pulley width increases. At the same time, the driven pulley width decreases - the two combining for a "lower gear" effect.

By making such adjustments, we have full control over the entire gear range previously available to automatic transmissions. From LOW to OVERDRIVE - and everything in-between. In addition, the metal belt is highly flexible, and easily accommodates the ever-changing width of the pulleys, and transfer power efficiently without any slippage.

This difficult task of adjusting oil pressure, and adjusting to variable driving conditions is handled completely by the ECU, and allows the transmission to extract the maximum performance out of an engine - making this a revolutionary automotive transmission.



CVT Mechanism

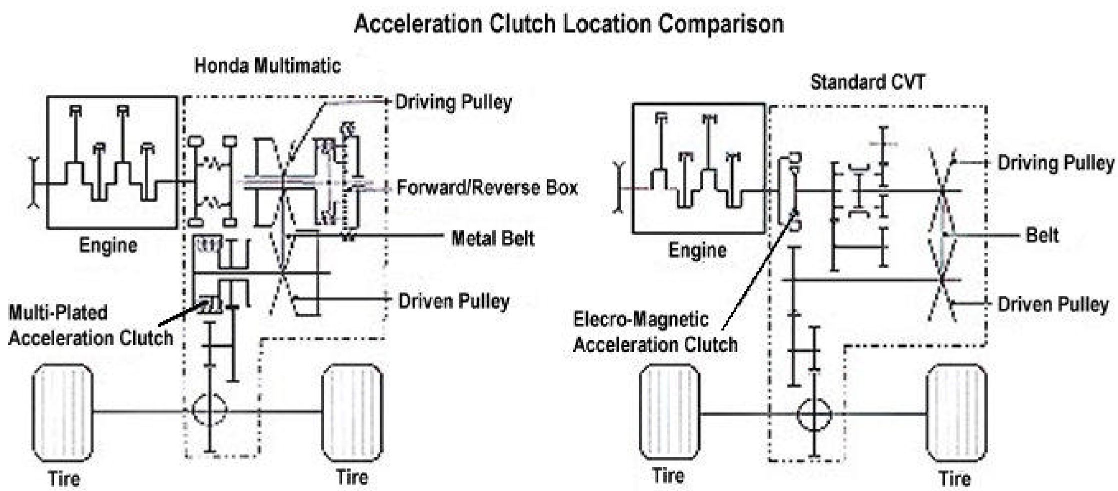
The Unique Features of the Honda Multimatic The Honda Multimatic does not use a torque converter, but uses a newly designed multi-layered clutch. Additionally, to obtain smooth acceleration, various proprietary equipment were added in order to make a step-less transmission with high reliability and durability.

1) Driven-Shaft-Placed Acceleration Clutch

The Honda Multimatic differs from previously existing step-less transmissions is that the acceleration clutch is placed on the driven shaft. The primary reason we took this route was to control torque at the closest possible place to the axle, allowing for smooth acceleration. In addition, we were able to apply a modest creep* which most automatic transmission users have grown accustomed to. This gives the standard advantages of an automatic when parking, as well as starting from a dead-stop on hills. (*creep - you know, how your car with AT will sneak/creep forward unless you apply the brakes)

Secondly, this allows for controlling the speed in all circumstances. In order to control speed, the pulley needs to be continually spinning. By placing the clutch on the driven pulley, the pulley can remain spinning even when the car is stopped. This means that in emergency situations or sudden deceleration, the transmission can quickly step down to LOW gear.

Lastly, this set-up allows for the transmission to be towed. When the engine is stopped, the input from the tires is locked out by the final gear and the driven pulley.



2) Proprietary Oil Pressure Control System

The pulley width and speed control is handled by a high/low pressure regulator. The four-way valve releases oil pressure evenly to the pulleys. Additionally, the force that pinches the metal belt between the pulleys is also controlled by the lower pressure regulator. As a result, the two pulley pistons are of the same design - allowing for a more simple design, yet allowing high power output as needed.

3) Slim Design

The Front/Reverse switching mechanism was placed on the driving shaft, while the acceleration clutch was placed on the driven shaft. Because of this opposing setup, the transmission is very compact, making it ideal for a FF layout. Additionally, the input shaft from the engine is inserted into the driving shaft, allowing for the number of bearings to be decreased - which ultimately means less power lost to friction.

4) Dual Flywheels

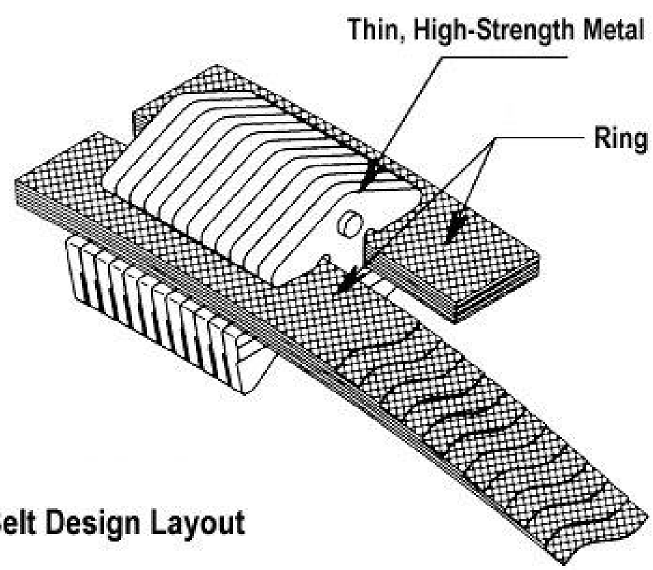
We removed the torque converter, and instead sandwiched two flywheels - resulting in a dual-mass flywheel. Also, the harmonic resonance frequency was lowered to that of below idle - allowing us to shut out the unwanted vibrations often caused by the twisting force generated by the engine during torque rate changes. At the same time, this allows for a more direct connection to the engine, resulting in less slip-loss - which ultimately leads to higher fuel economy.

5) High-Performance Oil Pump

The Honda Multimatic requires a high-pressure oil pump in order to operate the pulleys at optimum settings. Therefore, a highly efficient, low-friction oil pump unit was installed as a separate unit. This not only enhances the reliability of the transmission, but greatly reduces power loss and enhances both driving performance and fuel economy.

6) Newly Designed Metal Belt

The power transfer belt was newly developed by the Dutch company Van Doorne's Transmissie. With careful testing, we were able to take the best of both the belt and the engine to make a superb engine with high output and a wide selection of gear ratios. Additionally, the belt proved to be extremely silent, due to its many hundreds of elements and the use of highly durable, yet thin metals.



Metal Belt Design Layout

Full Electronic Control The transmission is under full electronic control in order to attain its goals of a smooth ride and excellent fuel economy. This is largely separated into 3 sections - Gear Ratio Control, Acceleration Control, and Side Pressure Control.

1) Gear Ratio Control

Gear Ratio is controlled by a pre-set 3D map with car speed, throttle position, and ideal engine rpm as its 3 axis. The difference between current and ideal engine rpm on the chart is continuously fed back to the ECU. Using linear solenoids, the four-way valves controlling pulley width are activated.

In order to prove useful in all situations, there are three 3D maps the user can select from. In D(rive) mode, the upper power band is avoided, resulting in excellent fuel economy. In S(port) mode, the user can redline the engine.

2) Acceleration Control

The acceleration clutch's power transfer amount is controlled via the clutch piston's oil pressure. Additionally, the amount of creep is also controlled here as well. The "smart" creep has two settings - one with the brakes on, and one with the brakes off. While the brake pedal is depressed, there is very little to no creep, while releasing the brake pedal will engage creep again. By dropping the creep level while the automobile is stopped, additional fuel efficiency is realized.

3) Side Pressure Control

In addition to the standard step-less transmission's oil-pressure controlled layout, we considered the effects of torque on the pulleys and belt. By applying linear pressure, friction is lowered, and the oil pump does not have to work as hard. Both yield in high fuel efficiency and better endurance of the transmission.

CVT Advantages

From its unique design, the Honda Multimatic is superior to conventional automatic transmissions using torque converters.

1) Mobility

By using the 3D map control pattern, the Multimatic has the ability to stay in the same power band if/when needed. An example of this is the ability to remain in the high-rpm power band from a standstill to high speed. Because of this, full-throttle acceleration is equivalent to that of a manual transmission. In addition, when traveling at high speeds, because of its ability to infinitely adjust gear ratios, the Multimatic has more passing ability than not only the manual transmission but the conventional automatic transmission using torque converters. With these advantages and the ability to still "shift" to "L" to use the engine brake, there is nothing but advantages.

2) Low Fuel Consumption

Because the Multimatic allows the engine to remain in its most optimal power range, excellent fuel economy is obtained. Compared to conventional automatic transmissions using a torque converter, there is zero slip, which translates into efficiency. In addition, the low-friction design and the side pressure regulator both contribute to excellent fuel economy.

3) Smooth Acceleration

Because the newly designed clutch is installed on the driven shaft, smooth acceleration is possible. With appropriate creep, starting on hills or parking in garages can be done with ease. The difference in "feel" between the Multimatic and a conventional automatic transmission using a torque converter is minimal.

4) Shock-Free "Shifting"

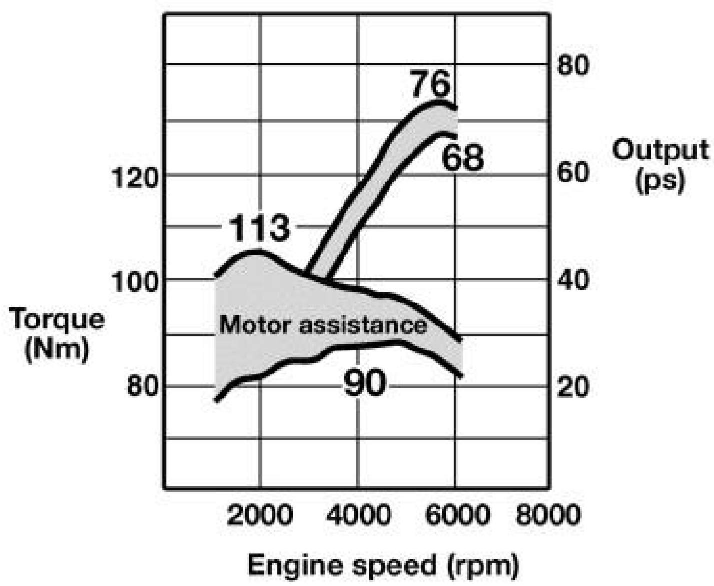
With the infinitely adjustable gear ratios at its disposal, the nudging motion caused by shifting is no longer present. Drastic jolting during lower gear acceleration is no longer present as well, leading to a stress-free, smooth driving experience.

5) 2 Modes of Driving

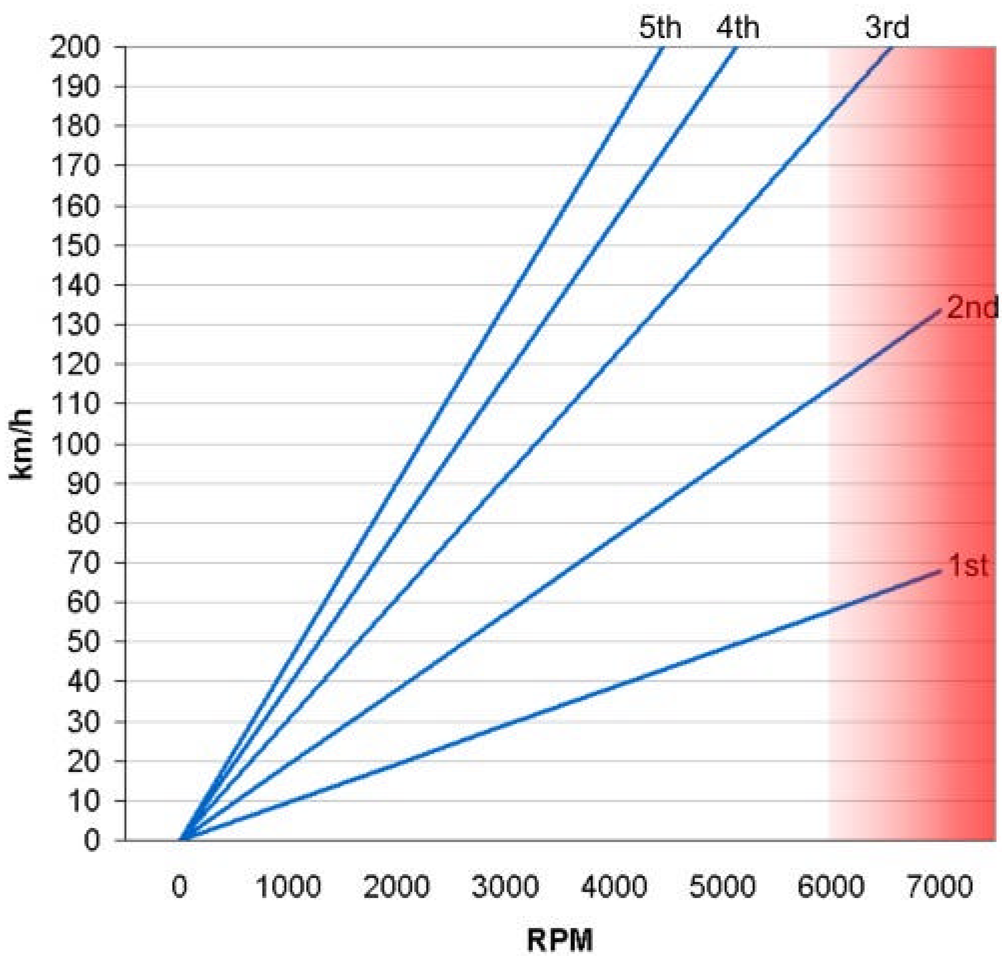
Normal city/freeway driving with "D," and high-rpm power from "S." With the 2 modes of driving, you can select your car's behavior depending on your objectives, or situation you are in. Such precise control is only possible with the Honda Multimatic.

ENGINE PERFORMANCE CURVES

Output Characteristics of the IMA system



GEAR RATIO GRAPHIC



EMISSIONS CONTROL

EMISSIONS STANDARDS

We know that Honda has gone to great lengths in engineering the Insight in the pursuit of low emissions levels, but just how low have they actually achieved?

There are two major categories of vehicle emissions that people are concerned about:

Air polluting compounds that contribute to smog and are health hazards

These are the compounds measured by the various emissions standards. The Insight is certified to meet the ULEV (Ultra-Low Emissions Vehicle) standard when sold in California and some other U.S. states. We aren't aware of any differences in the car itself as sold elsewhere.

As the chart below shows, independent measurements have been done on the Insight, which show that it is far better than the ULEV (and even SULEV) standard in some aspects, while being just about exactly at the ULEV level in hydrocarbon emissions.

Technology in the Insight that allows it to achieve these levels include:

- Careful computer control over fuel injection and ignition timing.
- The VTEC-E valve system, which produces a high degree of swirl for very complete combustion.
- The head/exhaust manifold/catalytic converter configuration that allows the primary catalytic converter to get up to operating temperatures quickly.
- The second (NOx absorptive) catalytic converter designed for lean-burn conditions.
- The various technologies that lead to a reduction of the total amount of fuel burnt.

Greenhouse gas emissions believed to contribute to global warming

Carbon dioxide is the primary "greenhouse gas" of concern in vehicle emissions. Carbon dioxide emission levels are not currently measured by most emissions standards.

The amount of carbon dioxide produced is directly proportional to the amount of fuel burned. As such, it is the Insight's superior fuel efficiency that allows it to achieve the lowest level of CO_2 emissions ever achieved by a mass-produced car.

Insight Emissions Levels

Category	***Smog-Causing Compounds***					***Greenhouse Gas***
	Hydrocarbons		*Carbon Monoxide*	*Nitrogen Oxides*	*Particulate Matter*	*Carbon Dioxide*
	TOG [1] *g/km (g/mi)*	*NMOG* [2] *g/km (g/mi)*	*CO* [3] *g/km (g/mi)*	*NOx* [4] *g/km (g/mi)*	*PM* [5] *g/km (g/mi)*	*CO_2* [6] *g/km (g/mi)*
Insight Emissions Level, According to Honda	ULEV (as certified in California and some other U.S. states)					80 (129)
Insight as Independently Tested on Dynamometer	0.03 (.05)		0.12 (0.2)	None detected	-	-

Comparison to Various Car Emissions Standards						
Category	***Smong-Causing Compounds***					***Greenhouse Gas***
	Hydrocarbons		*Carbon Monoxide*	*Nitrogen Oxides*	*Particulate Matter*	*Carbon Dioxide*
	TOG (1) *g/km (g/mi)*	*NMOG* (2) *g/km (g/mi)*	*CO* (3) *g/km (g/mi)*	*NOx* (4) *g/km (g/mi)*	*PM* (5) *g/km (g/mi)*	*CO_2* (6) *g/km (g/mi)*
Pre-standards (1970)	5.5 (8.8)		54 (86)	2.2 (3.5)	?	?
TLEV (7)	-	0.097 (0.156)	2.6 (4.2)	0.37 (0.6)	0.024 (0.04)	-
LEV (8)	-	0.056 (0.090)	2.6 (4.2)	0.04 (0.07)	0.006 (0.01)	-
ULEV (9)	-	0.034 (0.055)	1.3 (2.1)	0.04 (0.07)	0.006 (0.01)	-
SULEV (10)	-	0.006 (0.010)	0.6 (1.0)	0.01 (0.02)	0.006 (0.01)	-
Canada 1975 standards	1.2 (1.9)		16 (26)	1.93 (3.19)	-	-
Canada 1987 standards	0.25 (0.4)		2.1 (3.38)	0.62 (1.0)	-	-
Canada 1997 standards	0.25 (0.4)	0.16 (0.26)	2.1 (3.38)	0.25 (0.4)	0.05 (0.08)	-

Notes:

1. Total organic gases (hydrocarbons)
2. Non-methane organic gases (hydrocarbons)
3. Carbon monoxide
4. Nitrogen oxides
5. Particulate matter, 2.5 microns and less. A health hazard, such particles are major contributor to smog.
6. Carbon dioxide. Carbon dioxide is a non-toxic "greenhouse gas".
7. Transitionary low emissions vehicle. This is considered to be "50% cleaner" than was the 1999 minimum new car standard in California.
8. Low emissions vehicle. This is considered to be "70% cleaner" than California's 1999 basic new car standard.
9. Ultra-low emissions vehicle. This is considered to be "85% cleaner" than California's 1999 minimum new car standard. In 1999, 5 models available in California met these standards. They were the natural gas Ford Crown Victoria, the gasoline Honda Accord EX/LX sedan, the gasoline Honda Accord EX/LX coupe, the natural gas Honda Civic GX, and the gasoline Mazda Protégé.
10. Super-ultra-low emissions vehicle.

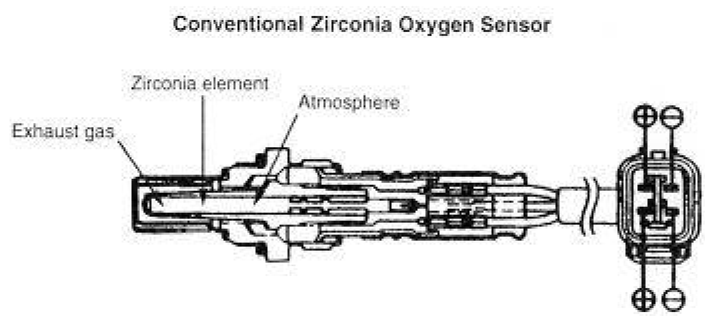
LEAN-BURN OXYGEN SENSOR

A normal zirconia oxygen sensor is only capable of measuring the oxygen content of the exhaust in a narrow air-fuel mixture range, right around stoichiometric (14.7:1). This is fine for normal operating conditions. But, when the car is running in the lean burn mode, the oxygen content of the exhaust is higher than a normal oxygen sensor is capable of measuring.

The Insight uses a LAF (Linear Air-Fuel) sensor for the primary oxygen sensor that is capable of measuring air-fuel ratios as lean as 23:1. This allows the ECM to maintain precise control over the mixture during both normal and lean burn conditions.

The engine's LAF Sensor is designed to detect air-fuel ratios as lean as 25:1. The fuel-injection Electronic Control Module uses this data, along with engine rpm, crankshaft angle, throttle angle, car mass, coolant temperature and valve position, to maintain a lean air-fuel ratio below 2500-3200 rpm (depending on throttle position and engine load).

The VTEC-E engine can burn such a lean mixture partly because of a strong air-fuel swirl created in the combustion chamber, created by the mixture's entry through only one of two intake valves during low-rpm operation. Although the overall air-fuel mixture is lean, optimized injection timing, along with the vortex, creates a "stratified" charge - the air-fuel ratio is richer near the spark plug and leaner toward the combustion chamber periphery. The richer mixture ignites more readily and creates a fast-burning, stable flame that promotes more complete combustion.



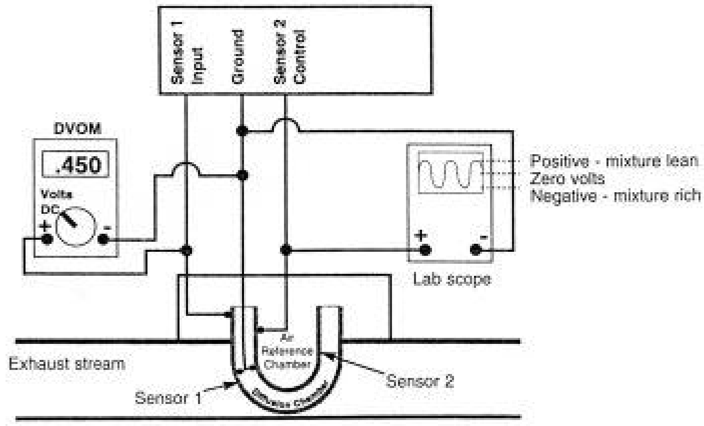
A standard zirconia oxygen sensor uses a thimble shaped zirconia element that is exposed to the atmosphere on one side, and to the exhaust stream on the other side. If the amount of oxygen on the two sides is different, it generates a voltage. Since the amount of oxygen on the atmospheric side is fixed, the generated voltage represents the amount of oxygen in the exhaust. With the engine not running there is atmospheric pressure in the exhaust, and the voltage is zero since the same amount of oxygen exists on both side of the element. When the engine is running there is less oxygen in the exhaust, so voltage is generated up to a maximum of one volt.

The LAF sensor has two zirconia elements that share a diffusion chamber. There are a total of three chambers:

- Exhaust flow chamber
- Diffusion chamber
- Atmosphere reference chamber

The zirconia element that is in contact with the exhaust is the sensor element. The diffusion chamber is the space between the two zirconia elements. By applying varying voltage to the control element, the ECM can control the amount of oxygen in the diffusion chamber. Since the diffusion chamber is the reference chamber for the sensor element, this action changes the output of the sensor element.

The ECM monitors the output of the sensor element as the oxygen content of the exhaust changes, and it applies voltage to the element to try to maintain the sensor output at .450 volts. It then monitors the control voltage to determine the actual air-fuel ratio.



Unlike a conventional sensor, the voltage can be positive or negative, and it reads the opposite direction. That is, positive voltage indicates a lean mixture, and negative voltage indicates a rich mixture. The normal operating range is about 1.5 volts.

The LAF sensor can be identified by its five wire configuration:

- Heater positive
- Heater ground
- Sensor element positive
- Control element positive
- Common ground for sensor and control elements.

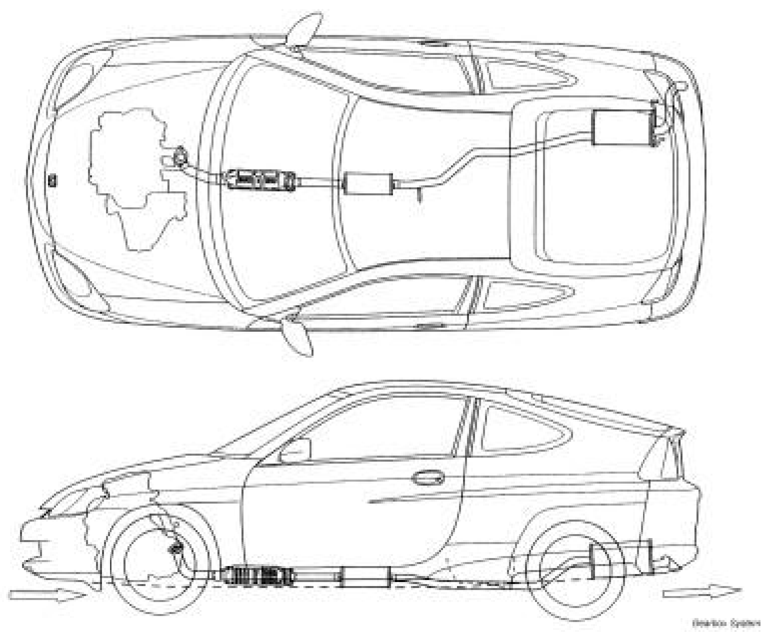
ADVANCED CATALYST SYSTEM

The insight is designed to operate at a very lean air fuel ratio during light throttle cruise conditions. The mixture can be as lean as 22:1 if conditions allow. This provides very good fuel economy, and low HC and CO emissions. However, the lean mixture also causes a rise in combustion temperature, and high NOx production is the result.

In order to prevent high NOx tailpipe emissions during lean burn operation, the Insight uses a dual catalyst system that includes an extra NOx storage/NOx reduction catalyst.

The 3-way catalyst is closely coupled to the exhaust manifold to minimize heat-up time, thus reducing emissions after a cold start.

The lean NOx catalyst is in the conventional location, underneath the car.



Lean NOx Catalyst Functioning

The lean NOx catalytic converter is comprised of a ceramic A1203 substrate, a platinum (Pt) catalyzing surface, and a titanium-sodium (Ti-Na) NOx storage surface.

During lean burn operation, the exhaust gas contains a larger percentage of oxygen (O2) and NOx, the NOx being primarily nitrogen monoxide (NO). The platinum catalyzes the O2 and NO to produce nitrogen dioxide (NO2), which is able to be stored on the Ti-Na surface.

When it determines that the Ti-Na surface is saturated, the Insight temporarily richens the mixture. This action decreases the NOx and O2 in the exhaust, and raises the levels of hydrocarbons (HC) and carbon monoxide (CO). The platinum is then able to use the HC and CO to catalyze the NO2 (that has been stored) into harmless nitrogen gas (N2), carbon dioxide (CO2) and water vapor (H20).

Catalytic Converter Deterioration Detection / Replacement

The Insight uses 2 oxygen sensors to monitor the condition of the 3-way catalyst as required by OBD-II and EU2000 regulations. However, the detection system is not able to directly monitor the condition of the lean NOx catalyst.

If the ECM sets a code for a deteriorated catalyst, both catalysts have to be replaced. It must be assumed that the same conditions that caused the 3--way catalyst to deteriorate also deteriorated the lean NOx catalyst.

Exhaust Syste, Weight Saving Measures

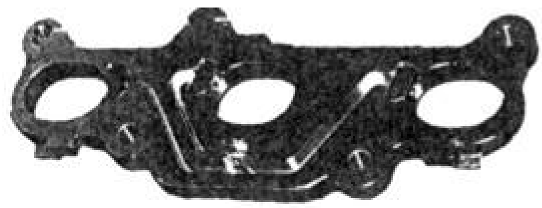
The Insight's exhaust system incorporates several weight- and space-saving measures made possible by the IMA engine's reduced size. For example, smaller-diameter, thinner gauge pipe is used, thereby saving the weight that would be required for a larger engine. In addition, the system's smaller weight and the elimination of the exhaust header (the header is now integral with the cylinder head) allowed it to be constructed as a single unit, thus eliminating the additional weight of interconnecting exhaust flanges.

EXHAUST GAS RECIRCULATION SYSTEM

The Insight uses a linear-solenoid-operated EGR valve that feeds recirculated exhaust gas into an equal-length EGR manifold that is sandwiched between the intake manifold and the cylinder head.

This design ensures equal distribution of recirculated exhaust gas between the three cylinders and prevents the exhaust gas from liquefying before reaching the intake ports.

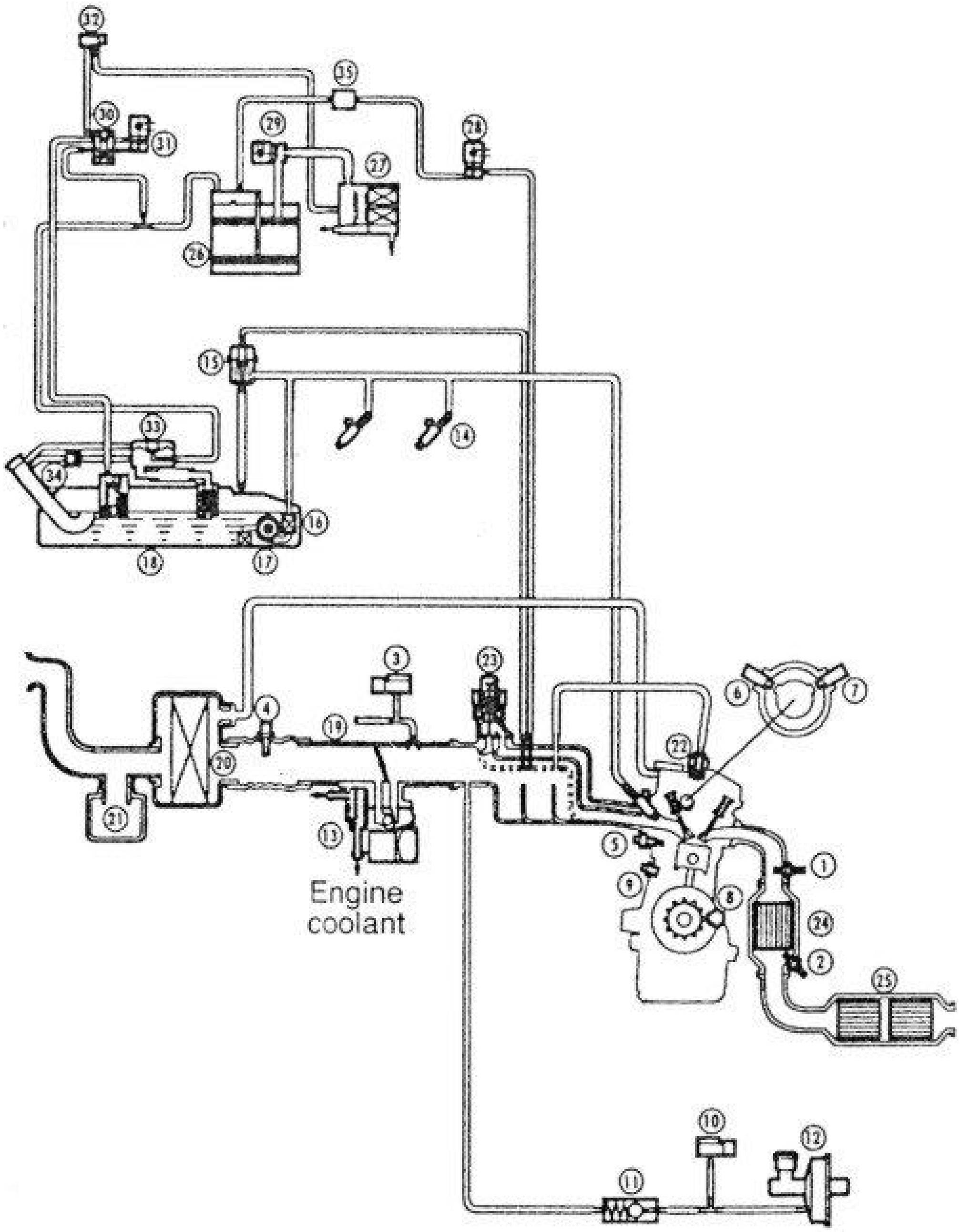
This high-precision EGR system is required to help control NOx production during lead-burn operation.



ORVR & VACUUM DISTRIBUTION

U.S. and Canada model Insights are equipped with On-board Refueling Vapor Recovery (ORVR) systems that are identical to the system introduced on the 1998 Accord.

The following diagram shows the entire vacuum distribution system including the ORVR system:



1. Primary heated oxygen sensor (primary HO2S)
2. Secondary heated oxygen sensor (secondary HO2S)
3. Manifold absolute pressure (MAP) sensor
4. Intake air temperature (IAT) sensor
5. Engine coolant temperature (ECT) sensor
6. Top dead center 2 (TDC2) sensor
7. Top dead center 1 (TDC1) sensor
8. Crankshaft position (CKP) sensor
9. Knock sensor (KS)
10. Master power vacuum sensor
11. Check valve
12. Brake booster
13. Idle air control (IAC) valve
14. Fuel injector
15. Fuel pressure regulator
16. Fuel filter
17. Fuel pump (FP)
18. Fuel tank
19. Throttle body (TB)
20. Air cleaner
21. Resonator
22. Positive crankcase ventilation (PCV) valve
23. Exhaust gas recirculation (EGR) valve
24. Three way catalytic converter (TWC)
25. NOx adsorptive three way catalyst
26. Evaporative emission (EVAP) control canister
27. Evaporative emission (EVAP) control canister filter
28. Evaporative emission (EVAP) purge control solenoid valve
29. Evaporative emission (EVAP) control canister vent shut valve
30. Evaporative emission (EVAP) two way valve
31. Evaporative emission (EVAP) bypass solenoid valve
32. Fuel tank pressure sensor
33. Onboard refueling vapor recovery (ORVR) vent shut valve
34. Onboard refueling vapor recovery (ORVR) vapor recirculation valve
35. Purge joint