

Hybrid Vehicle Investigation / Vehicle to Object  
Dynamic Science, Inc. / Case Number: DS04013  
2004 Honda Civic Hybrid  
California  
April, 2004

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*The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.*

*Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crash-worthiness performance of the involved vehicle(s) or their safety systems.*

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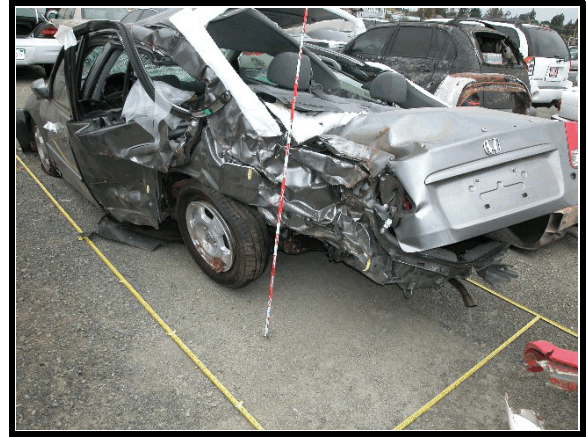
**Dynamic Science, Inc.**  
**Crash Investigation**  
**Case Number: DS04013**

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## BACKGROUND:

This on-site investigation focused on the crash performance of gas/electric hybrid system in a 2004 Honda Civic, as well as conformance to Sec. 571.305 Standard No.305 (Electric-powered vehicles: electrolyte spillage and electrical shock protection). The driver of the Honda Civic lost control of the vehicle on a state highway and the vehicle began a clockwise yaw. The yaw continued until the vehicle had reached a nearly 90 degree angle. The case vehicle mounted the tip of the median in the northern leg of the intersection. The left side of the vehicle struck and knocked down a one-way sign mounted on a wooden pole. The vehicle continued forward and continued its rotation. The left front of the vehicle struck a guardrail on the median. The vehicle rotation increased to approximately 120 degrees from its original direction of travel. At this point the case vehicle struck a tree on the median with its left side. The driver's seat back mounted side air bag deployed as a result of this impact. The right rear occupant was likely ejected during this impact. As a result of the tree impact, the case vehicle was forced into a counterclockwise rotation. The vehicle rotated until it was essentially facing west. It overturned at this time onto its right side. The right door/A pillar area came to rest on the guardrail.



**Figure 1.** Left rear corner of case vehicle, impact 3 (tree)

This Hybrid Vehicle Investigation was initially identified by DSI through existing insurance contacts. NHTSA was notified on June 16, 2004. DSI obtained permissions to inspect the case vehicle and NHTSA assigned the case to DSI on June 17, 2004. The vehicle inspection took place on June 17, 2004.

## SUMMARY

### Crash Site

This is a single vehicle, multiple impact crash that occurred at 0510 hours in April, 2004 in northern California.

The case vehicle was traveling northbound on a seven-lane, divided state roadway approaching a four-leg intersection. The southern leg of the intersection is comprised of a right turn lane, two through northbound lanes, two left hand turn lanes, and two southbound through lanes. The northern leg of the intersection is comprised of



**Figure 2.** Approach to area of impact (north)

two northbound through lanes, a curbed median, a left hand turn lane, two southbound through lanes, and a right hand turn lane. The median in the northern leg has a 5.0 cm (2.0 in) curb. At the tip of the median was a One-Way sign attached to a wooden pole. On the eastern edge of the median is a 42.0 cm (16.5 in) high metal W-beam guardrail with wooden posts that begins 10.2 m (33.6 ft) north of the median tip. In the center of median there is 185 cm (73 in) diameter tree that was 19.8 m (65.0 ft) north of the median tip.

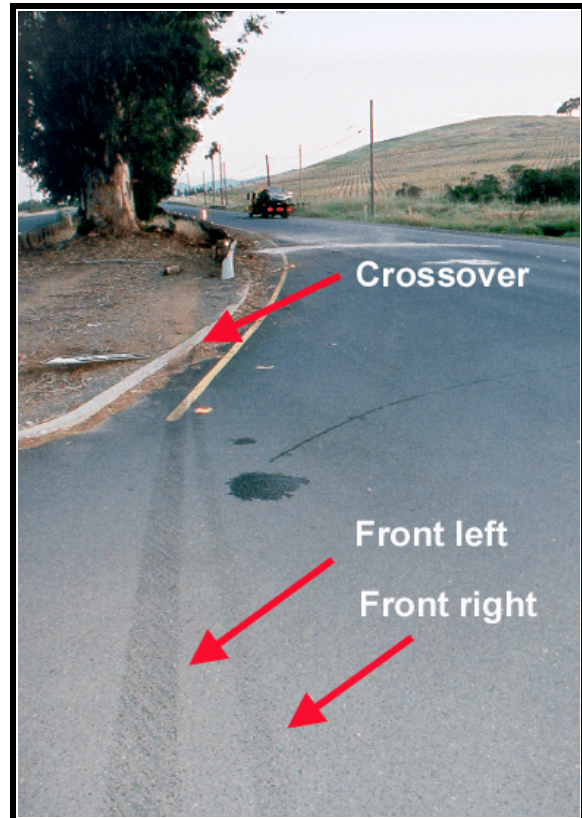
The weather was clear and dry. It was dark and the streetlights were on. The speed limit is 89 km/h (55 mph).

### Pre-Crash

The case vehicle is a 2004 Honda Civic Hybrid gasoline-electric four door sedan driven by a restrained 20-year-old male. The Civic Hybrid uses Honda's Integrated Motor Assist (IMA) technology—a 1.3-liter 4-cylinder gasoline engine coupled with a high output electric motor. The front right seat was occupied by a restrained<sup>1</sup> 22-year-old male. The rear right seat was occupied by an unrestrained 21-year-old male.

The case vehicle was equipped with a driver's air bag, a front right passenger air bag, front seat back mounted side air bags, and front seat belt pretensioners. The front right side air bag was equipped with Honda's Passenger Side Occupant Position Detection System (OPDS).

The case vehicle was traveling at a driver estimated speed of 80 km/h (50 mph). The vehicle had entered the second (closest to the median) left hand turn lane. The driver had been drinking. The driver attempted to change lanes to the right to re-enter the northbound travel lanes. He lost control of his vehicle and the vehicle began a clockwise yaw. The yaw continued until the vehicle had reached a nearly 90 degree angle.



**Figure 3.** Approach to impact area. Vehicle in clockwise rotation, front tires cross and vehicle is at a 90 degree angle.



**Figure 4.** Area of guardrail and tree impact (north)

<sup>1</sup>Police report indicates unrestrained, but evidence on the vehicle shows that the lap and shoulder belt was in use at the time of the crash.

## Crash

The case vehicle mounted the tip of the median in the northern leg of the intersection. The left side of the vehicle struck and knocked down a one-way sign mounted on a wooden pole (impact 1). The vehicle continued forward and continued its rotation. The left front of the vehicle struck a guardrail on the median (impact 2). The vehicle rotation increased to approximately 120 degrees from its original direction of travel. At this point the case vehicle struck a tree on the median with its left side (impact 3). The total velocity change as calculated by the Barrier algorithm of WinSmash collision model was 27.4 km/h (17.0 mph). The longitudinal and lateral delta V components were 4.8 km/h (3.0 mph) and 27.0 km/h (16.8 mph), respectively. The driver's seat back mounted side air bag deployed as a result of this impact. The right rear occupant was likely ejected during this impact. As a result of the tree impact, the case vehicle was forced into a counterclockwise rotation. The vehicle rotated until it was essentially facing west. It overturned at this time onto its right side. The right door/A pillar area came to rest on the guardrail (impact 4).

## Post-Crash

The driver of the case vehicle sustained abrasions to his arms and hands, and a minor abrasion to the top of his left shoulder. He was transported by ground ambulance to a local hospital for treatment. Following treatment, he was transported to and booked in the local jail for driving under the influence of an alcohol beverage.

The front right occupant sustained minor abrasions. He was transported by ground ambulance to a local hospital for treatment.

The right rear occupant was ejected from the vehicle. He sustained multiple abrasions and contusions, as well as a left inferior pubic ramus fracture. He came to rest in the travel lane 3 m (10 ft) north of the case vehicle. He was initially treated by law enforcement personnel. He was transported by ground ambulance to a local hospital for treatment. He arrived at the hospital



Figure 5. Front left, impact 2, guardrail



Figure 7. Left rear corner of case vehicle, impact 3 (tree)

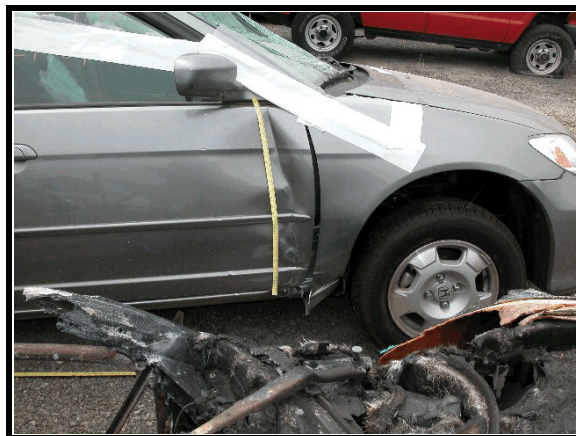


Figure 6. Damage from guardrail from rollover

with a Glasgow Coma Scale (GCS) score of 13. He lost points for orientation and for eye opening only to verbal. He was examined and then hospitalized overnight.

The case vehicle was towed from the scene due to damage. It was subsequently declared a total loss by the insurance company.

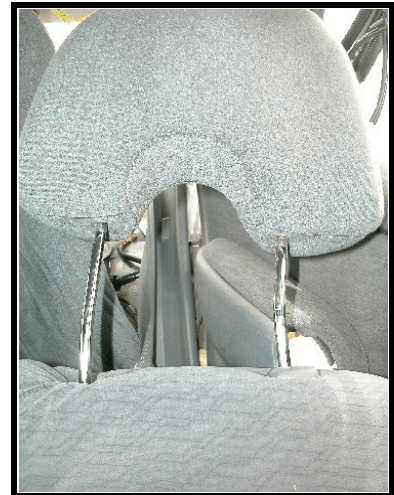
### **VEHICLE DATA - 2004 Honda Civic Hybrid**

The 2004 Honda Civic Hybrid was identified by its Vehicle Identification number (VIN): JHMES96614Sxxxxxx. The four door Civic was equipped with a 1.3 liter four cylinder engine, a gear-less, belt-driven CVT (continuously variable transmission) automatic transmission, front wheel drive, power steering, tilt steering wheel, front disc and rear drum brakes.

The 2004 Honda Civic Hybrid was equipped with Bridgestone B381 P185/70R14 tires. The specific tire data is as follows:

<b>Tire</b>	<b>Tread</b>	<b>Pressure</b>	<b>Maximum pressure</b>
LF	8 mm (10/32 in)	Flat	303 kPa (44 psi)
LR	11 mm (14/32 in)	Flat	303 kPa (44 psi)
RF	9 mm (11/32 in)	Unknown	303 kPa (44 psi)
RR	9 mm (11/32 in)	Unknown	303 kPa (44 psi)

The front seating positions in the 2004 Honda Civic Hybrid were equipped with bucket seats with adjustable head restraints. The driver's seat back had a 54 degree post-crash angle; the front right seat had a 43 degree post-crash angle. The driver's seat back was deformed laterally to the left. The rear seating positions were configured with a bench seat with adjustable head restraints for the outboard positions. The driver's head restraint was deformed rearward.



**Figure 8.** Deformed driver's head restraint



## VEHICLE DAMAGE

### Exterior Damage - 2004 Honda Civic Hybrid

Damage Description:	Major lateral crush to left rear corner.	
CDC:	Impact 1: 10LZAN2 (One-way sign impact) Impact 2: 09LFEE2 (Guardrail impact) Impact 3: 08LZAW4 (Tree impact) Impact 4: 00RYEO1 (Rollover)	
Delta V (Impact 3):	Total	27.4 km/h (17.0 mph)
	Longitudinal	4.8 km/h (3.0 mph)
	Latitudinal	27.0 km/h (16.8 mph)
	Energy	66,384 joules (48,962 ft-lbs)

There was direct contact damage that began at the front left bumper corner and extended into the front left wheel area as a result of the guardrail impact. There was 154.0 cm (60.6 in) of direct contact from the third impact that began 82.0 cm (32.2 in) rear of the rear axle and extended forward. The maximum crush was located at C1 and measured 66.0 cm (25.9 in). There was diagonal crease type damage to the front right door. The damage was 3.0 cm (1.2 in) wide and measured 92.0 cm (36.2 in) in vertical height.

The wheelbase on the left side was shortened by 18.0 cm (7.1 in) and the track width was compressed by 27.0 cm (10.6 in).



**Figure 9.** Front left, Honda Civic

### Interior Damage - 2004 Honda Civic Hybrid

The interior of the Honda Civic sustained major damage. Both left side doors were jammed shut. There was crash related glazing damage to the backlight, windshield, and left rear door glass. The right side seam of the roof panel separated during the crash. The separation measured 32.0 cm (12.6 in) laterally at the right rear edge and continued longitudinally for 116.0 cm (45.7 in). There was lateral intrusion into the left rear seat position from the left rear door and C pillar with a maximum intrusion of 20.0 cm (7.9 in). The center console was shifted to the driver's side 10.0 cm (3.9 in) due to contact from the front right occupant. The driver's seat back had a 54 degree post-crash angle; the front right seat had a 43 degree post-crash angle. The driver's seat back was deformed laterally to the left. The driver's head restraint was deformed rearward. There was a heavy vertical abrasions to the left side of the front right seat back and to the second row left seat back due to occupant movement.



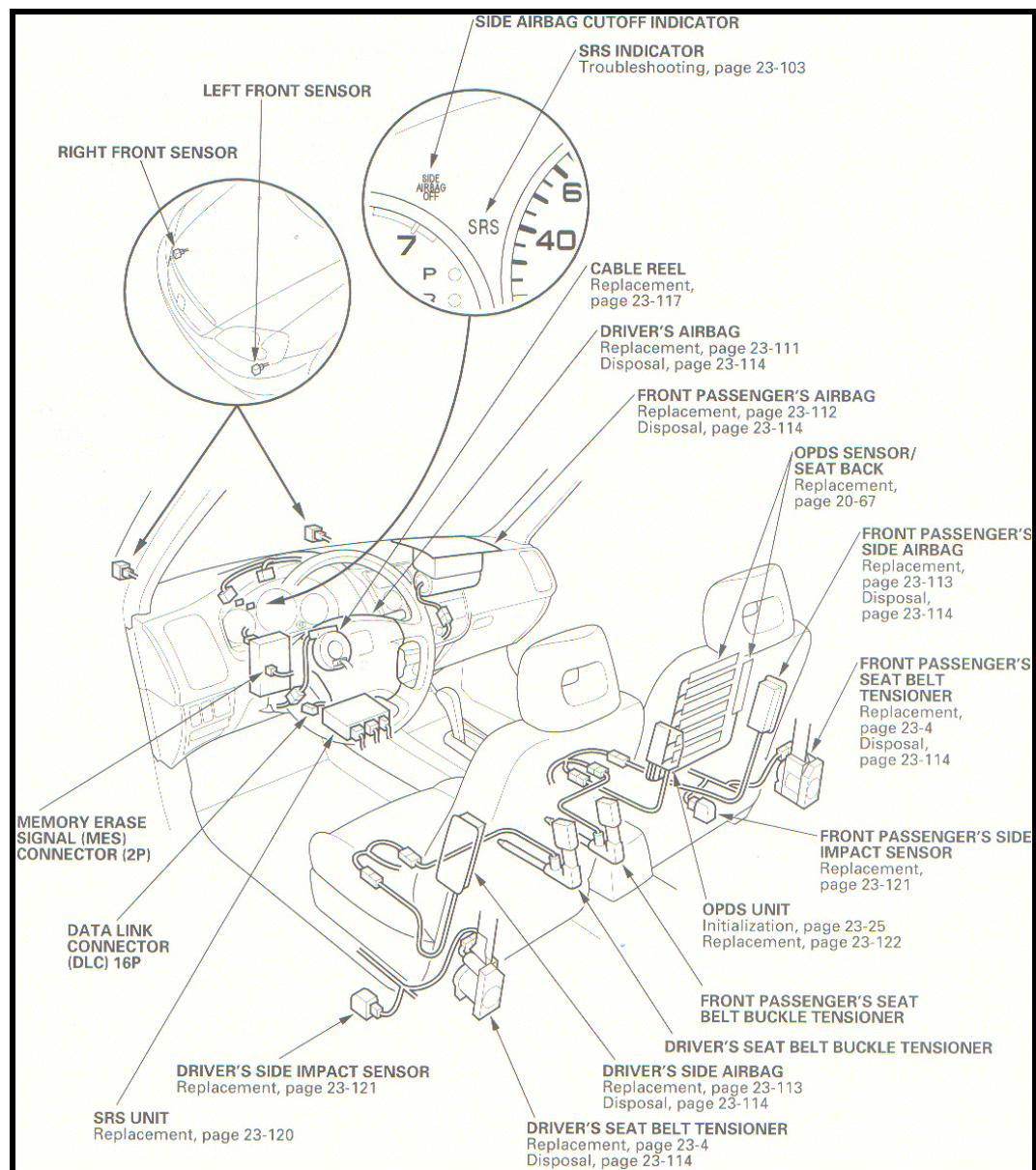
**Figure 10.** Back light area

### MANUAL RESTRAINT SYSTEMS - 2004 Honda Civic Hybrid

The Civic was configured with manual 3-point lap and shoulder belts for both front positions and all three rear seat positions. The front seat restraints were configured with adjustable shoulder belt upper anchorages. The driver anchorage had been adjusted to the full down position. The front right anchorage had been adjusted to the middle position. All the seat belts were equipped with sliding latch plates. The driver's seat belt was equipped with an emergency locking retractor. The front right passenger's seat belt and all three rear seat belts were equipped with switchable retractors (retractors that can be changed from an emergency locking retractor to an automatic locking retractor to assist in securing child seats).

## AIR BAG SYSTEM - 2004 Honda Civic Hybrid

The Honda Civic was equipped with frontal air bags for the driver and front right passenger positions. The driver's air bag was housed in the steering wheel hub. The front right passenger's air bag was housed on top of the instrument panel. The front seats were also equipped side air bags that were housed in the seat backs. The front right passenger seat back was equipped with an occupant position detection system that can prevent a side air bag deployment if someone is leaning into the air bag deployment path. A dashboard warning light illuminates to alert the driver if the side air bag has been deactivated. The front seat belts were equipped with both buckle and B pillar pretensioners. There was no pretensioner actuation. See overview of system below.



**Figure 11.** SRS Component Location Index, page 23-11, 2003 Civic Hybrid Service Manual

The driver's side seat back mounted side air bag deployed as a result of the impact with the tree (impact 3). The air bag measured 32.0 cm (12.6 in) wide by 27.0 cm (10.6 in) high. There were two circular vent ports on the leading edge of the bag at the 12 and 6 o'clock positions. There was a single, rectangular tether in the center of the bag. There was no damage to the air bag.



**Figure 12.** Driver's seat back mounted side air bag

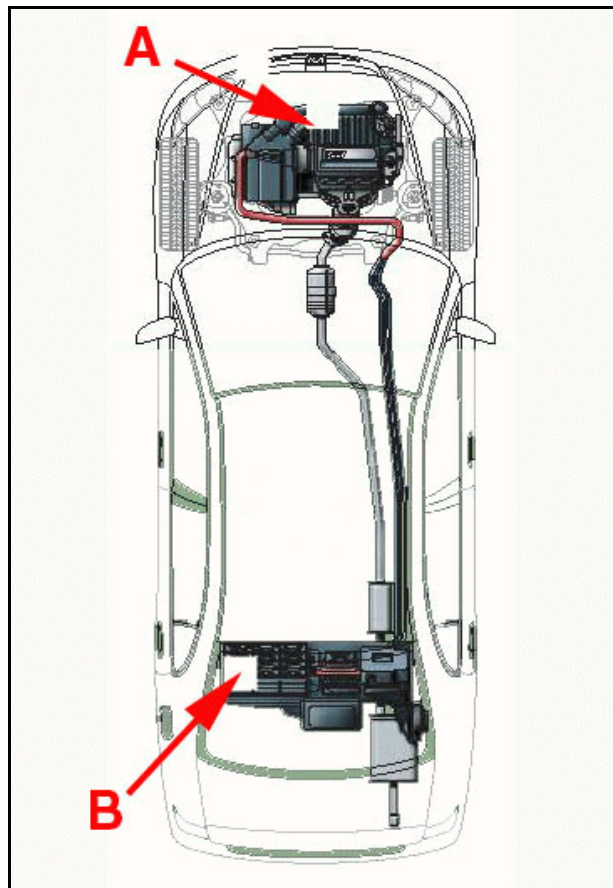


**Figure 13.** Driver's side seat back mounted side air bag—interior side

### Additional vehicle details

The IMA is composed of a gasoline engine and an electric motor. Located between the engine and transmission, the electric motor supplies additional power during acceleration. It also functions as a high-speed starter and as a generator for the charging system during regenerative braking. The IMA electric motor works in conjunction with the gasoline engine, and supplies additional torque in assist mode. It is powered by a 144 volt nickel metal hydride (NI-MH) battery pack, which is stowed at the back of the car (behind the rear seat) and consists of 120 cells providing 1.2 volts each. The engine and electric motor operate together under the following modes:

- Starting is normally done by the IMA. If the IMA battery pack charge is low, a separate 12-volt battery and starter motor are used.
- When the IMA system detects a demand for additional power, via the throttle position sensor, the electric motor starts and adds horsepower.
- When cruising at a steady speed the gasoline engine works by itself.
- When the driver is using the brakes, the electric motor becomes a generator, recharging the battery.
- At a stop, the engine cuts off automatically due to the idle-stop feature. It restarts itself when the vehicle is ready to go.



**Figure 14.** (A) Combination gasoline/electric powerplant, (B) Ni-MH battery pack

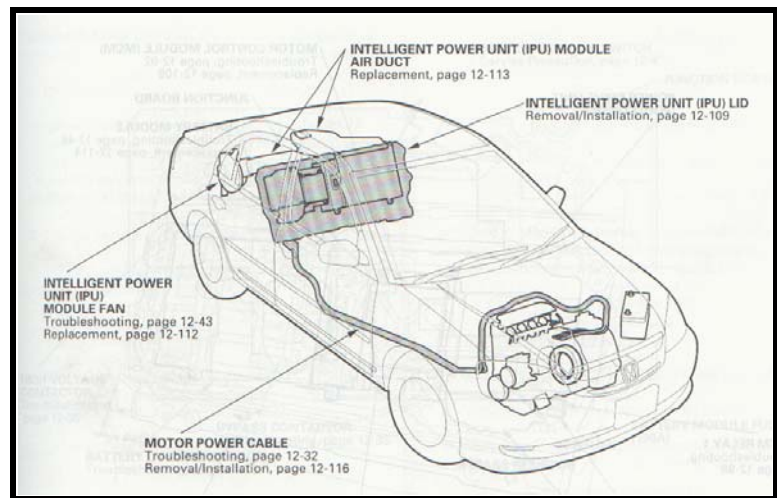
Compliance with Sec.571.305 Standard No.305; Electric-powered vehicles: electrolyte spillage and electrical shock protection

The case vehicle was examined to determine compliance with the 305 standards.

1. There were no indications of electrolyte spillage from the propulsion battery.
2. There was no movement of the battery module.
3. The electrical isolation test was conducted at the battery side. There were no indications of any arcing, fire, or component meltdown.

Electrical Isolation Test Discussion

This contractor reviewed publicly available manufacturer information regarding the electrical system of the Civic Hybrid to determine likely points to assess vehicle electrical isolation. The system basically consists of the intelligent power unit (IPU) which is located behind the rear seat, the electric motor which is located in the engine compartment, and the motor power cable which is the cable that connects the power unit to the drive unit. The system uses high voltage (144 V) circuits. The high voltage cables and their covers are identified by orange coloring. There are two likely points of electrical exposure: the cable connection to the IPU and the cable connection to the electric motor.

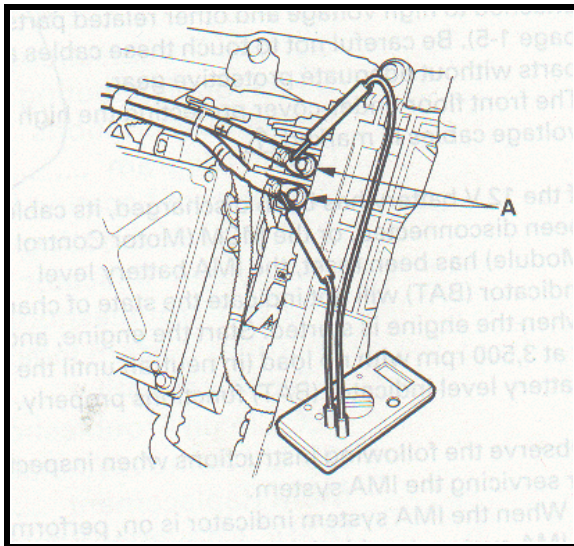


**Figure 15.** Overview, IMA system

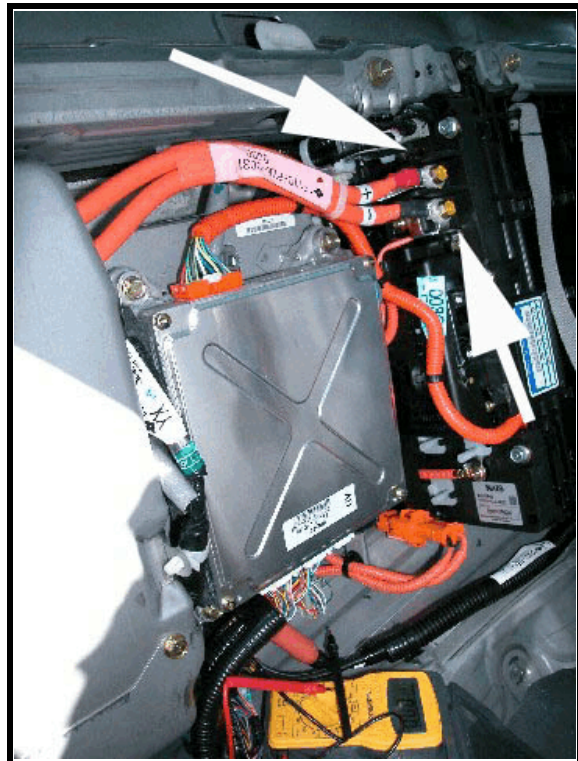
The test for IPU isolation/circuit problems includes the following steps as paraphrased from the Civic Hybrid Service Manual:

1. Ignition switch off.
2. Remove back seat back.
3. Access battery module switch and turn to off.
4. Remove IPU lid.
5. Measure voltage at the junction board terminals. There should be 30 V or less. If more than 30 V is present, there is a problem in the circuit.

This test was conducted during the vehicle inspection. The voltage measurement was less than 30 V.



**Figure 16.** IPU circuit test at battery end of high voltage line

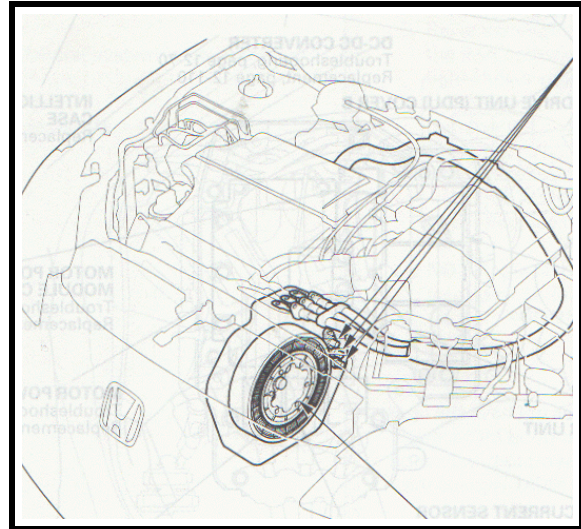


**Figure 17.** IPU circuit test. Junction board terminals as viewed with rear seat and IPU lid removed.

A second test will reveal if there is a short in the high voltage line. This test would involve the following steps:

1. Disconnect the high voltage cables from the output terminals on the junction board.
2. Measure resistance between high-voltage cables and body ground individually.
3. If the resistance is 350 k ohms or lower, there is a short in the high voltage line.

This area of the vehicle could not be accessed and the test was not completed. There were no indications of any damage to the high voltage cables.



**Figure 18.** Engine side of high voltage line



**OCCUPANT DEMOGRAPHICS - 2004 Honda Civic Hybrid**

	Driver	Occupant 2
Age/Sex:	20/Male	22/Male
Seated Position:	Front left	Front right
Seat Type:	Fabric covered bucket seat, seat at rear most track position, seat back slightly reclined	Fabric covered bucket seat, seat at rear most track position, seat back slightly reclined
Height:	191 cm (75 in)	Unknown
Weight:	91 kg (200 lbs)	Unknown
Occupation:	Unknown	Unknown
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	Cited for felony DUI with a BAC .08% or greater	NA
Driving Experience:	Unknown	NA
Body Posture:	Presumed to be normal, upright	Presumed to be normal, upright
Hand Position:	Unknown, actively steering prior to impact	Unknown
Foot Position:	Right foot on brake, left on floor	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used
Air bag:	Front air bag, did not deploy. Seat back mounted side air bag, deployed.	Front air bag, did not deploy. Seat back mounted side air bag, did not deploy

	Occupant 3
Age/Sex:	21/Male
Seated Position:	Second row right seat
Seat Type:	Fabric covered bench seat
Height:	Unknown
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	NA
Driving Experience:	NA
Body Posture:	Presumed to be normal, upright
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, not used

**OCCUPANT INJURIES - 2004 Honda Civic Hybrid**

Driver: Injuries obtained from the police report. Medical records indicate pain to left anterior chest and blood in the urine at the microscopic level (i.e., microhematuria).

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Bilateral hand abrasions	790202.1,3	Glass fragments	Possible
Bilateral arm abrasions	790202.1,3	Glass fragments	Possible
Abrasion, minor, top of left shoulder	790202.1,2	Shoulder belt	Probable

Front right occupant: Injuries obtained from radiological and emergency room reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Left scapular fracture	753000.2,2	Seat back	Probable
Left sternoclavicular subluxation	751230.2,2	Seat back	Probable
Small laceration, right hand, 3 cm	790602.1,1	Unknown	Unknown

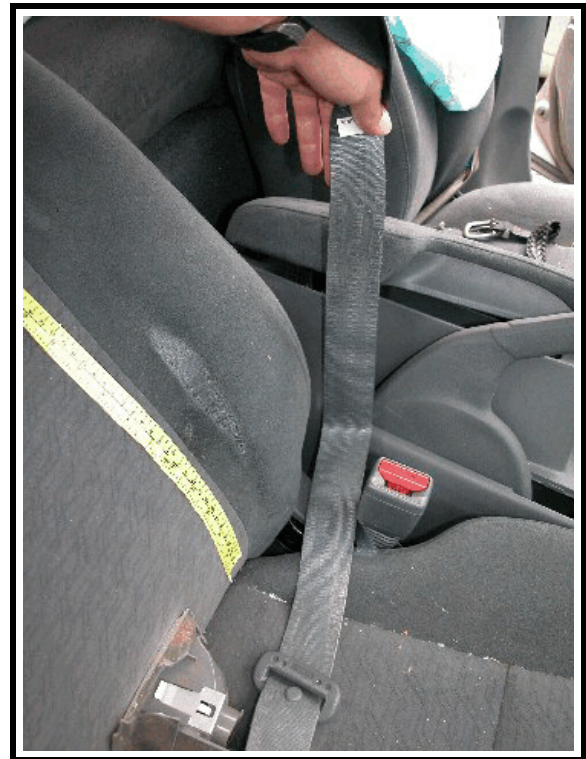
Rear right seat occupant: Injuries obtained from emergency room records and CT scan.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Left inferior pubic ramus fracture	852602.2,5	Left side vehicle interior	Probable
Large forehead hematoma measuring 3 x 3 cm, raised approximately 2 cm	290402.1,7	Left interior roof side rail	Possible
Puncture wound over left hip area	890800.1,2	Left side vehicle interior	Probable
Abrasions, both anterior knees	890202.1,3	Ground	Possible
Abrasion, right hip	890202.1,1	Ground	Possible
Abrasion, left hip	890202.1,2	Left side vehicle interior	Possible

## OCCUPANT KINEMATICS - 2004 Honda Civic Hybrid

### Driver kinematics

The 20-year-old male driver of the Honda Civic was likely seated in a normal, upright fashion in the fabric covered bucket seat. The seat was adjusted to the rear most track position. The driver was wearing the available 3-point manual lap and shoulder belt. The shoulder belt anchorage was in the full down position. Prior to impact, the driver began actively steering to the right and braking. The vehicle went into a clockwise yaw. This action caused the driver to shift to the left. The impact with the wooden pole through the left side plane had a negligible lateral effect. As the left front corner of the vehicle impacted the guardrail end, the vehicle's yaw likely increased. This impact was also relatively light. The vehicle rotation increased to approximately 120 degrees from its original direction of travel. At this point the case vehicle struck a tree on the median with its left side. The driver's seat back mounted side air bag likely deployed at this point. The driver pitched sharply to the left and to the rear and engaged the side air bag and the seat back with his torso. His head struck and loaded the head restraint rearward. The driver sustained a minor abrasion to his left shoulder that was likely related to seat belt loading. The driver also sustained multiple hand and arm abrasions that were likely related to flying glass. He was transported by ground ambulance to a local hospital for treatment.

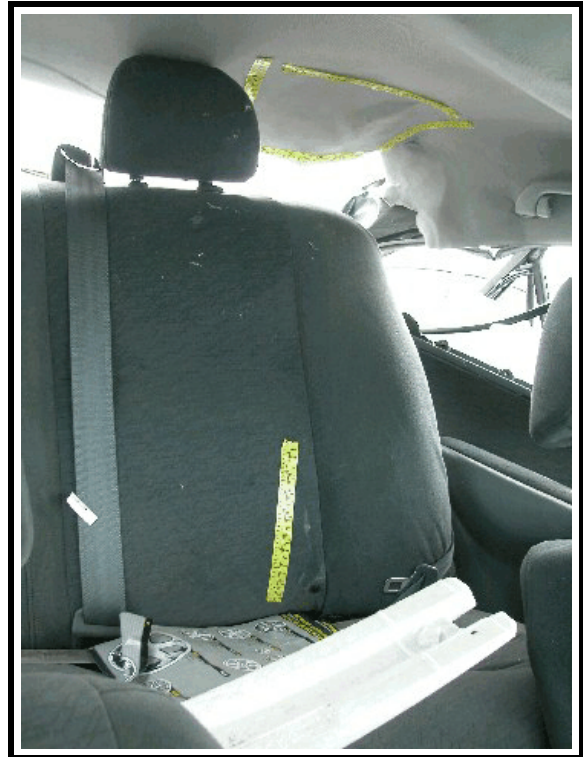


### Front right seat occupant kinematics

The 22-year-old male front right occupant was likely seated in a normal, upright fashion in the fabric covered bucket seat. The seat was adjusted to the rear most track position. The front right occupant was wearing the available 3-point manual lap and shoulder belt. The shoulder belt anchorage was in the middle position. Prior to impact, the driver began actively steering to the right and braking. The vehicle went into a clockwise yaw. This action caused this occupant to shift to the left. The impact with the wooden pole through the left side plane had a negligible lateral effect. As the left front corner of the vehicle impacted the guardrail end, the vehicle's yaw increased. This impact was also relatively light. The vehicle rotation increased to approximately 120 degrees from its original direction of travel. At this point the case vehicle struck a tree on the median with its left side. This occupant pitched sharply to the left and to the rear in response to the 260 degree direction of force and engaged the seat back with his left flank area—abrading the fabric to some degree. It appears that the lap portion of the seat belt held his lower body in place. His left shoulder engaged the upper seat back—causing the left scapula fracture and the left sternoclavicular subluxation. He was able to exit the vehicle under his own power. He was transported by ground ambulance to a local hospital for treatment.

### Second row right seat occupant kinematics

The 21-year-old male second row right seat occupant was likely seated in a normal, upright fashion in the fabric covered bench seat. He was not wearing the available 3-point manual lap and shoulder belt. Prior to impact, the driver began actively steering to the right and braking. The vehicle went into a clockwise yaw. This action caused this occupant to shift to the left, possibly all the way over to the left door area. The impact with the wooden pole through the left side plane had a negligible lateral effect. As the left front corner of the vehicle impacted the guardrail end, the vehicle's yaw increased. This impact was also relatively light. The vehicle rotation increased to approximately 120 degrees from its original direction of travel. At this point the case vehicle struck a tree on the median with its left side. Just prior to ejection, it appears that this occupant was in the left rear seating position. The vehicle rotated sharply in a counterclockwise direction around the tree and pitched onto its right side. This occupant was ejected through the left side back light area. He sustained multiple abrasions and contusions, as well as a left inferior pubic ramus fracture. He came to rest in the travel lane 3 m (10 ft) north of the case vehicle. He was initially treated by law enforcement personnel. He was transported by ground ambulance to a local hospital for treatment.



**Figure 20.** Ejection path for Occupant 3



**Figure 21.** Area of clothing transfer/ejection area

Attachment 1. Scene Diagram

