On-scene Investigation / Vehicle versus Power Pole
Dynamic Science, Inc. / Case Number: DS01-011
2001 Toyota Prius Hybrid
California
March, 2001

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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 crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient Catalog No.
DS01-011		

4. Title and Subtitle	5. Report Date
In-Depth Accident Investigation	
	6. Performing Organization Report No.

7. Author(s)	8. Performing Organization Report No.
Dynamic Science, Inc.	

9. Performing Organization name and Address	10. Work Unit No. (TRAIS)
Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401	11. Contract or Grant no. DTNH22-94-D-27058

12. Sponsoring Agency Name and Address	13. Type of report and period Covered [Report Month, Year]
U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590	14. Sponsoring Agency Code

15. Supplemental Notes

16. Abstract

This case was initiated because the case vehicle is a gas/electric hybrid vehicle. This single vehicle versus a power pole type collision occurred in March, 2001 at 0720 hours in an agrarian area of northern California. The crash occurred on a two-lane, straight and level, undivided asphalt roadway. The speed limit is 89 km/h (55 mph). There were no road defects or visual obstructions reported.

The case vehicle, a 2001 Toyota Prius Hybrid 4-door, was driven by a restrained 54-year-old female (168 cm-66 in./61 kg-135 lbs). The case vehicle was traveling eastbound at a driver reported 81 km/h (50 mph) while on her way to work. The driver reported that a coyote ran out onto the roadway from an unknown direction. She steered the case vehicle to the right to avoid running over the coyote, and lost control of the vehicle. The case vehicle ran off the south edge of the roadway and onto a dirt field. The driver then steered back to the left causing the case vehicle to begin rotating counterclockwise on the dirt field. The rear right fender of the case vehicle struck a power pole.

The case vehicle was assigned a Collision Deformation Classification (CDC) of 03RBEN3 with a Principle Direction of Force (PDOF) of 090 degrees. The combined direct and induced damage width was 80.0 cm (31.5 in.) [CRASH L = 80.0 cm (31.5 in.)], and the maximum crush depth was 48.5 cm (19.1 in.) located at C_4. The Delta V for the case vehicle was computed using WinSmash version 2.12 and the pole option with size and stiffness coefficients derived from the case vehicle's wheelbase. WinSmash calculated a total delta v of 29.0 km/h (18.0 mph), a longitudinal delta v of 0.0 km/h (0.0 mph) and a lateral delta v of -29.0 km/h (18.0 mph). The results fit the collision model and appear reasonable. The case vehicle was towed from the scene due to damage and was subsequently declared a total loss and sold as a salvage vehicle.

The driver of the case vehicle waited for fifteen minutes until a coworker drove by and drove her to her workplace and the driver checked in to her work. Her supervisor told her to seek medical treatment and a coworker drove her to a hospital. It is unclear at what time she arrived at the hospital. She sustained injuries consisting of abdominal pain and glass in her hands and legs.

17. Key Words	18. Distribution Statement
Injury, hybrid, electric	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price

Dynamic Science, Inc.
Accident Investigation
Case Number:DS01-011

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BACKGROUND:

Description:	This hybrid vehicle case was reported to the NHTSA by DSI on May 21, 2001 and the case was assigned on May 23, 2001. An on-scene investigation was conducted. All field work was completed on February 02, 2002.
Investigation Type:	On-scene
Crash Location:	California
Crash Date:	March, 2001
Notification Date:	May 21, 2001
Field Work Completed:	February 2, 2002

SUMMARY:

This single vehicle collision occurred in March, 2001 at 0720 hours in an agrarian area of northern California. The crash occurred on a two-lane, straight and level, undivided asphalt roadway. There is a single lane for each direction of travel, east-west. The lanes are separated by a painted dashed yellow line. There is a asphalt paved shoulder on both sides of the roadway and dirt agriculture fields beyond that. The speed limit is 89 km/h (55 mph). There were no road defects or visual obstructions reported.

Figure 1. Approach to impact with pole-east.

The case vehicle, a 2001 Toyota Prius Hybrid 4-door, was driven by a restrained 54-year-old female (168 cm-66 in./61 kg-135 lbs). The case vehicle was traveling eastbound at a driver reported 81 km/h (50 mph) while on her way to work. The driver reported that a coyote ran out onto the roadway from an unknown direction. She steered the case vehicle to the right to avoid running over the coyote, and lost control of the vehicle. The case vehicle ran off the south edge of the roadway and onto a dirt field. The driver then steered back to the left causing the case vehicle to begin rotating counterclockwise on the dirt field. The rear right fender of the case vehicle struck a power pole.

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Figure 2. Damage to case vehicle.

The driver of the case vehicle waited for fifteen minutes until a coworker drove by and drove her to her workplace and the driver checked in to her work. Her supervisor told her to seek medical treatment and a coworker drove her to a hospital. It is unclear at what time she arrived at the hospital. She sustained injuries consisting of abdominal pain and glass in her hands and legs.

At 1000 hours of the same morning, the responding police officer was dispatched to the hospital for a report of a minor injury traffic collision. He arrived at the scene of the collision at 1018 hours and did a scene inspection and noted that the power pole did not appear to sustain any damage. He then went to the hospital and spoke to the driver of the case vehicle.

Scene Diagram

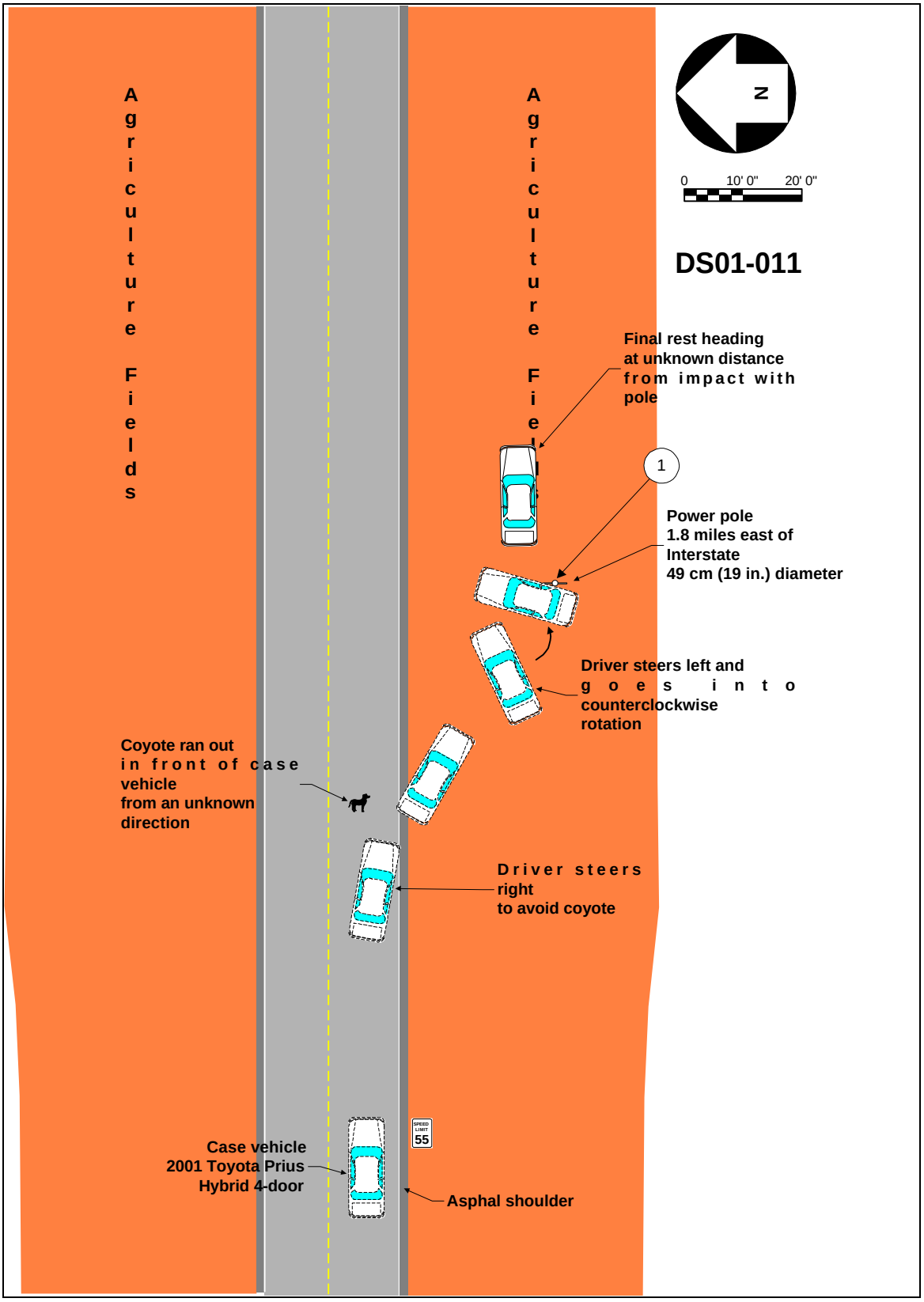


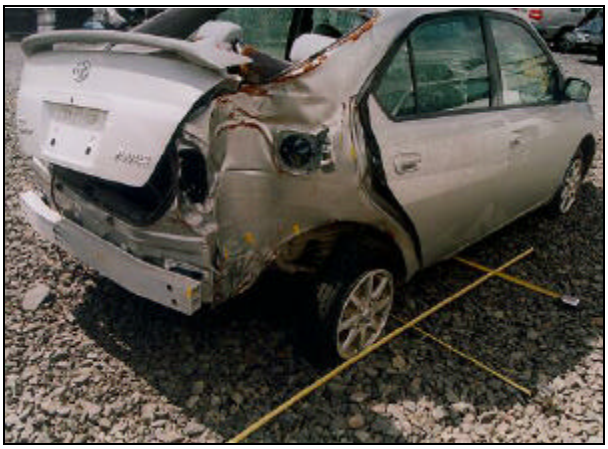
Figure 3. Scene diagram

DETAILED INFORMATION

Vehicles

Case vehicle

Description:	2001 Toyota Prius four-door hybrid electric	
VIN:	JT2BK12U0100xxxxxx	
Odometer:	36,264 kilometers (22,534 miles)	
Engine:	Engine: 1.5 L 4 cylinder gasoline Electric motor type: Permanent magnet Battery type: 38 sealed Nickel-metal Hydride modules	
Reported Defects:	None	
Cargo:	None at the time vehicle inspected	
Damage Description:	Severe lateral crush to the right rear fender beginning just forward of the right rear axle and extends rearward to the right rear bumper corner. Both rear door jammed shut. Rear left door forced open by investigator. Minor longitudinal intrusion of the 2nd seat back.	
CDC:	03RBEN3	
Delta V:	Total	29.0 km/h (18.0 mph)
	Longitudinal	0.0 km/h (0.0 mph)
	Latitudinal	-29.0 km/h (-18.0 mph)
	Energy	139,370 joules (102,794 ft-lbs)



Prius hybrid-electric system discussion[1]

The Toyota Prius is a standard-production hybrid-electric vehicle. The Prius' hybrid powertrain consists of a 70 horsepower 1.5 liter four cylinder gasoline-fueled internal combustion engine, a 33 KW (44 horsepower) permanent magnet electric motor, a generator, a 274 volt nickel metal-hydride battery (the battery pack is comprised of 38 sealed Nickel-Metal Hydride modules that are completely sealed in a carbon composite case and positioned behind the rear seat within the protective unibody of the car), an electronic controller (Advanced Control System), and a 'power split device' which functions as a continuously variable (automatic) transmission. The Prius operates on both the engine and electric motor/battery - one or both of these power sources can drive the Prius depending on load and road conditions - the electronic controller makes that decision with no input from the driver.

Standard equipment includes ABS and regenerative brakes, an eight-year/100,000-mile battery and hybrid-related component warranty.

Prius' primary power is provided by an all-aluminum 1.5-liter 4 cylinder gasoline engine with a peak 70 horsepower at 4,500 rpm and peak torque of 82 lb./ft. at 4,200 rpm. Variable valve timing maximizes efficiency. The 45 liter (11.9 gallon) gas tank has a plastic bladder which reduces gasoline vapors. The EPA fuel economy is 83.7 kilometers (52 miles per gallon) for the city and 72.4 kilometers (45 miles per gallon) for the highway.

System modes

The Prius system works in six main modes:

1. When accelerating from a stop, the Prius is powered by the battery/electric motor only.
2. As more acceleration is needed, the engine will turn on automatically and run by itself or in conjunction with the electric motor and the battery.
3. Under full acceleration, the electric motor is supplemented by power from the battery. At high speeds the gas engine is the primary source of power. The electric motor will assist to varying degrees.
4. When the engine is running it uses a generator to charge the battery, and when braking, a regenerative braking system also charges the battery, so there is never a need to recharge the battery separately. When the vehicle is coasting or the brakes are applied, the motor is turned into a generator, capturing energy that would normally be lost as heat or kinetic energy and transforming it into electricity to recharge the batteries.
5. The battery is regulated to maintain a constant charge. When the charge is low, the electric generator routes power to charge the battery.
6. During coasting or braking, the electric motor functions as a generator to charge the battery. When the vehicle is stopped, the gas engine shuts off automatically and

[1] Prius specifications and System modes data obtained from the Internet @ *http://www.toyota.com/html/shop/vehicles/prius/technology/prius_technology.html*

the electric motor stands ready to power up the Prius. This conserves fuel and eliminates exhaust emissions caused by idling.

Recalls

There is one recall in place that might affect this vehicle (NHTSA Campaign ID Number: 00V285000). This potentially affects 1,772 vehicles manufactured between May 2000 and July 2000. On certain passenger vehicles, insufficient electrical contact can occur in the torque sensor that controls the power assist operation of the electric power steering gear box. The torque sensor could output improper electrical signals. If this occurs, the power steering warning icon will be displayed on the center panel, and the driver could experience higher than normal steering effort depending upon vehicle speed.

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 or damage of the battery pack. The frame directly in front of the traction battery–behind 2nd seat back was damaged.
3. The electrical isolation test was partially conducted. There is a circuit near the power cable that prevents access to power unless the ignition switch is in the "ON" position and the vehicle is running. In this case, internal 12v power was available and the engine did crank over but would not start. The net result was that there was no propulsion battery voltage external of the battery system. There were no indications of any arcing, fire, or component meltdown.

An overview of the electrical isolation test is included as Attachment 1.

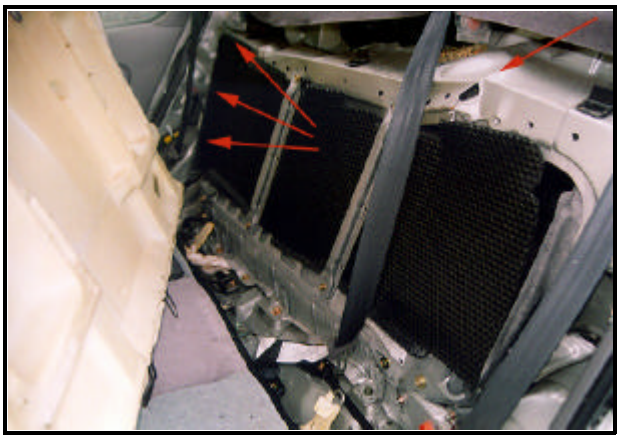


Figure 5. Damage to frame directly in front of traction battery.

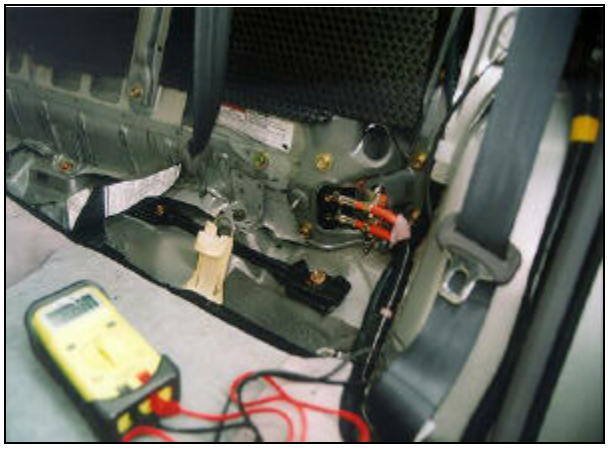


Figure 6. Traction battery voltage.

Figure 7. Battery pack in trunk–no spillage.

Safety features discussion

The case vehicle was equipped with a driver's steering wheel mounted air bag and front right passenger top instrument panel mounted air bag. According to data found in the NCAP test files, these are not advanced, multistage air bags. The case vehicle was also equipped with 3-point seat belts in all five seating positions. The drivers belt was equipped with an emergency locking retractor while the other seat positions are equipped with switchable retractors. The driver and front passenger seat belts are equipped with pretensioners with force limiters.

Figure 8. Driver's air bag.

In this crash, the driver was wearing the lap and shoulder belt. At impact, the pretensioner for the driver's belt did not fire and neither of the frontal air bags deployed.

Occupants

Case vehicle	Occupant 1
Age/Sex:	54/Female
Seated Position:	Front left
Seat Type:	Fabric covered bucket seat, adjusted to rear most track position.
Height:	168 cm (66 in.)
Weight:	61 kg (135 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown, presumed to be greater than 30 years
Body Posture:	Assumed normal, upright
Hand Position:	Both on steering wheel, unknown placement
Foot Position:	Right on accelerator, left on floor
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Steering wheel mounted driver's air bag did not deploy

Injuries and Injury Mechanisms

Case vehicle (Toyota Prius)

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Complained of abdominal pain. Glass in her hands (blood found near driver's seat belt buckle) and legs. Injuries are not codeable.			

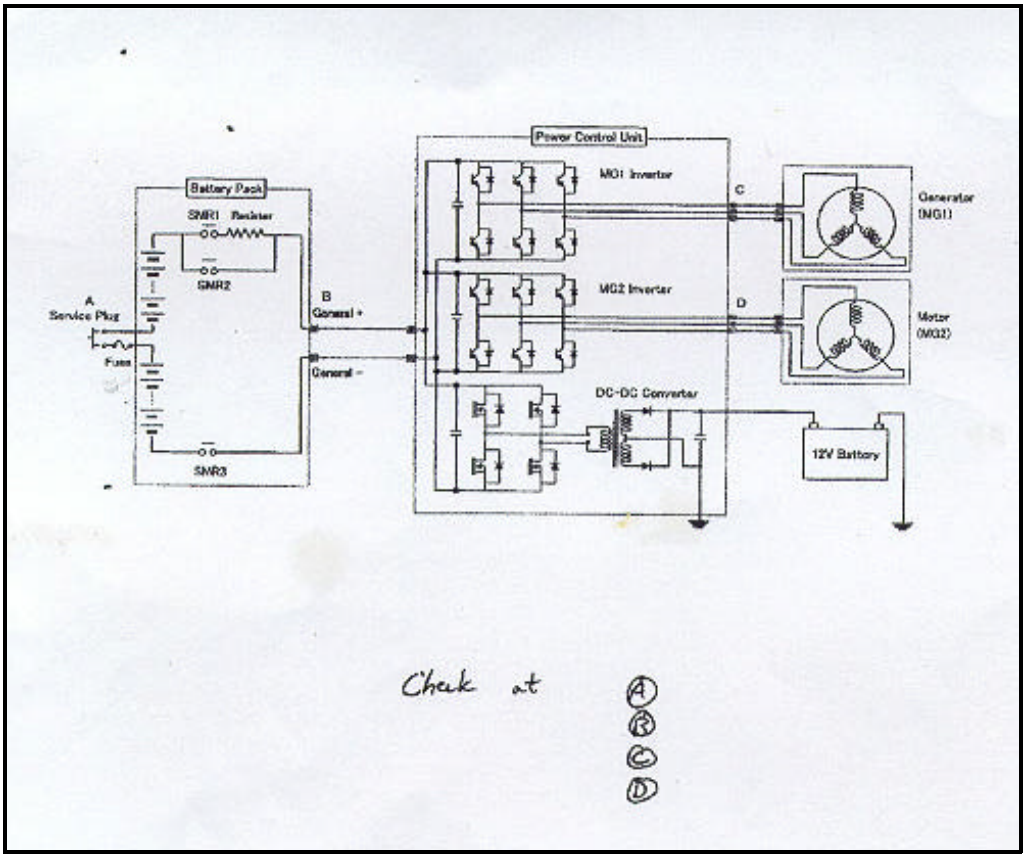
Occupant Kinematics

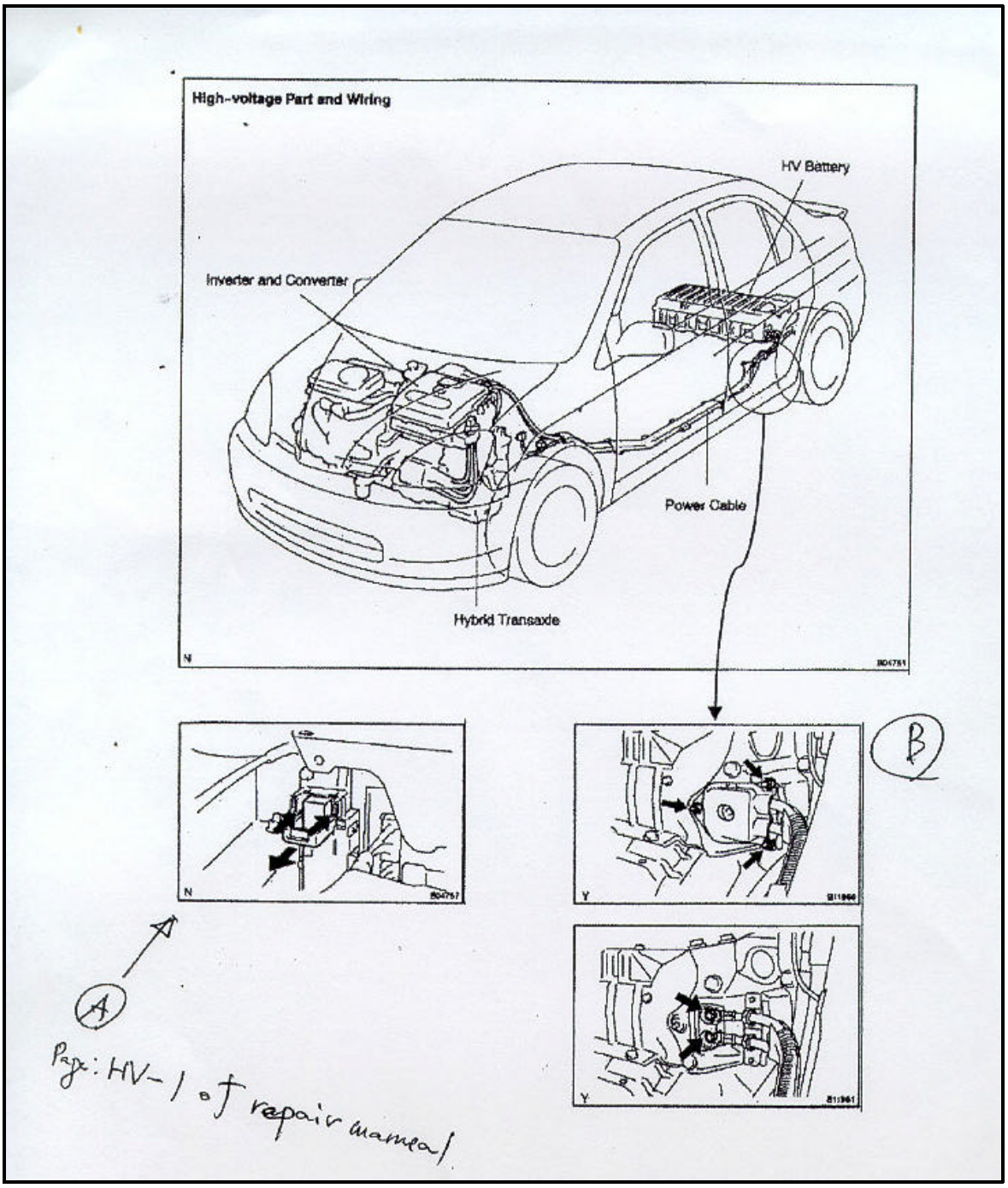
The 54-year-old female driver of the case vehicle was seated in the front left position. She was seated in a bucket seat in an assumed normal, upright position. The seat was adjusted to the rear-most track position. She was wearing the available lap and shoulder belt and the shoulder belt upper anchorage adjustment was in the full up position. Both of her hands were probably on the steering wheel. Her right foot was on the accelerator.

On impact with the power pole, the restrained driver responded to the 03 o'clock direction of force by moving to the left. The driver loaded the seat belt–causing the abdominal pain. Her lateral movement to the right also deformed the seat back. Flying glass from the disintegrated backlight contacted her hands and probably caused a laceration to her right hand and as she un-buckled the seat belt, blood was deposited on the center console area.

Figure 9. Driver's seat–deformed seat back and blood deposited on center console.

Attachment 1. Electrical Isolation Test

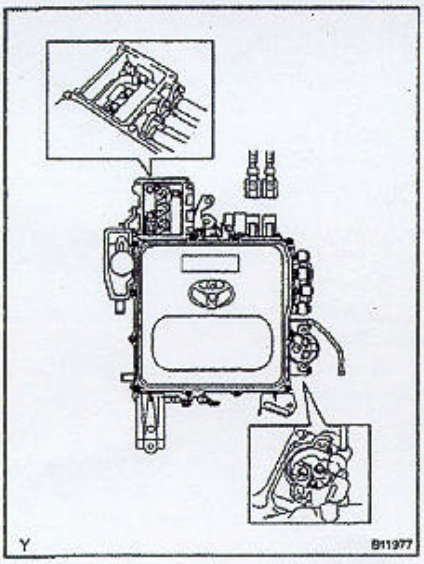



High-voltage Part and Wiring
HV Battery
Inverter and Converter
Power Cable
Hybrid Transaxle
N
B
A
Page: HV-1 of repair manual

REMOVAL

1. REMOVE SERVICE PLUG (See page HV–1)
2. DRAIN HV COOLANT (See page HT–6)
3. REMOVE COWL TOP PANEL (See page BO–27)

You do not need to conduct 2. and 3 just to reach to the MG Terminals.



4. VERIFY 0 V

NOTICE:

- **Before starting step (a), 5 minutes or more should be passed after removing the service plug.**
- **Be careful to prevent foreign matter from entering the inside of connector cover.**

(a) Disconnect the connector of the battery power cable and insulate it with packaging tape.

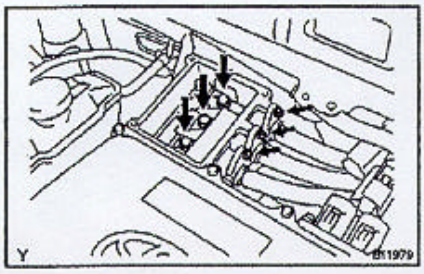
(b) Using a torx socket wrench (T30), remove the 4 screws and inverter terminal cover.

(c) Using a torx socket wrench (T40), remove the 2 screws, circuit breaker sensor and connector cover.

HINT:

Slide the connector cover to disconnect the circuit breaker sensor connector.

(d) Using a voltmeter, measure the voltage between terminals of 3 phases (U–V, V–W, U–W) and each terminal and body ground to verify them to be approx. 0 V.

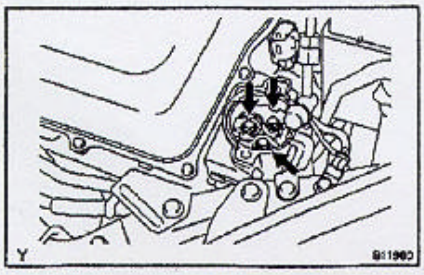


5. REMOVE CONVERTER & INVERTER ASSEMBLY

(a) Remove the 6 bolts and 3 power cables for MG2.

NOTICE:

Be careful to prevent foreign matter from entering the inside of connector cover.

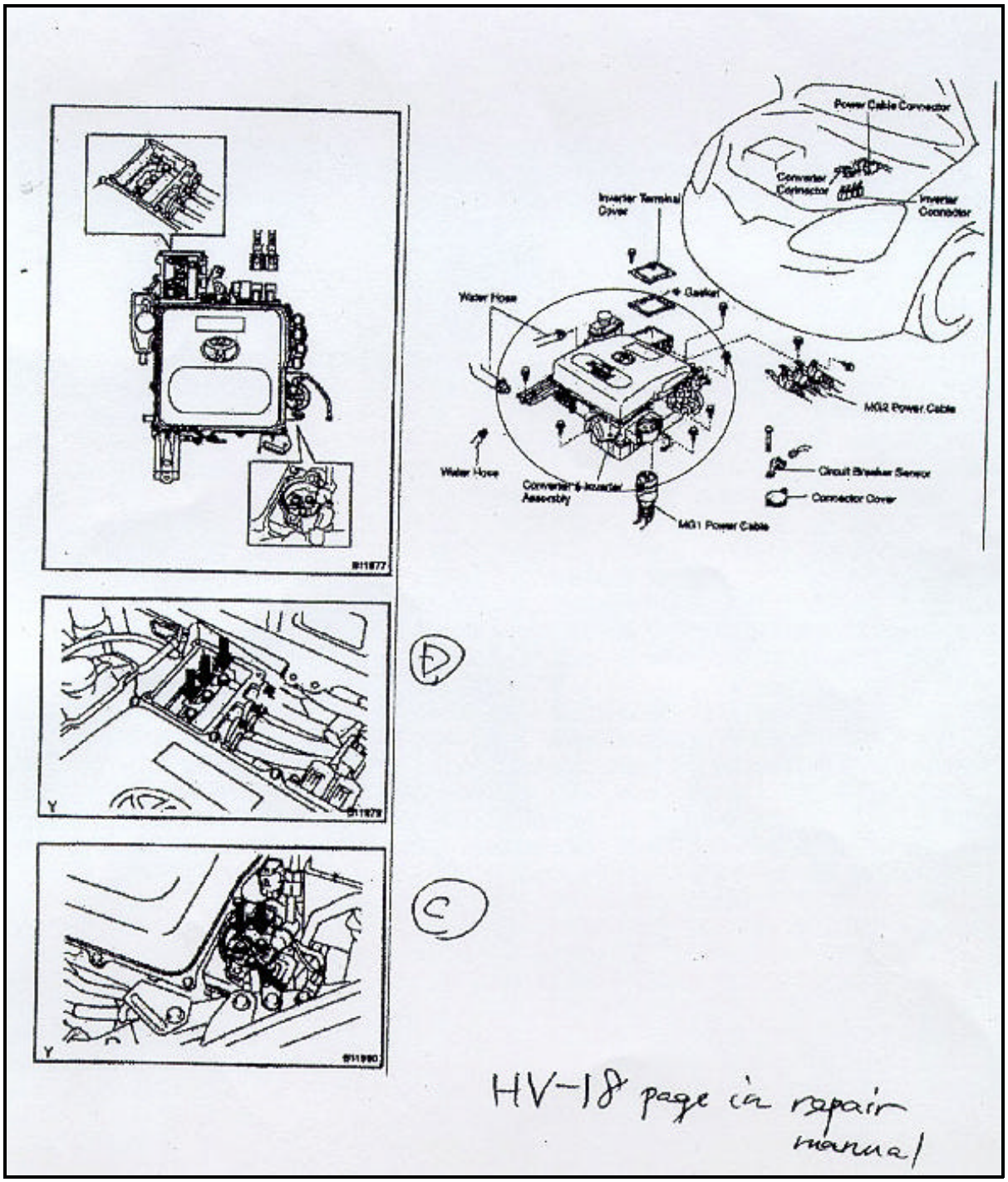


(b) Remove the 3 bolts and power cable for MG1.

NOTICE:

- **Remove the power cable for MG1 together with converter & inverter assembly.**
- **Be careful to prevent foreign matter from entering the inside of connector cover.**

(c) Remove the bolt and ground cable.


Power Cable Connector
Converter Connector
Inverter Terminal Cover
Inverter Connector
Water Hose
Gasket
MG2 Power Cable
Water Hose
Converter & Inverter Assembly
Circuit Breaker Sensor
Connector Cover
MG1 Power Cable
B11877
B11878
B11880
D
C
HV-18 page in repair manual