

GENERAL

1. OUTLINE

- (a) The plug-in hybrid system of this hybrid vehicle employs the Toyota Hybrid System-II Plug-in (THS-II Plug-in) under the "Hybrid Synergy Drive" concept".
- (b) As a result of installing newly developed lithium-ion batteries in a conventional hybrid vehicle, plug-in hybrids provide more electric energy by charging (plug-in charging) from an external power source. Use of this electric energy allows wider EV range (maximum EV vehicle speed) and longer EV distance.
- (c) The plug-in hybrid vehicle helps to reduce gasoline consumption and CO₂ emissions by performing EV driving. For long distance and high speed driving, the traveling range will not be restricted because the existing infrastructure, including gas stations, can be used and the vehicle may be driven in the same manner as a conventional hybrid vehicle, using both the engine and electric motor.
- (d) Hybrid vehicles have high-voltage electrical circuits. Hybrid vehicles have been developed with consideration given to the protection of drivers and technicians against electrocution.

HINT:
*: The "Hybrid Synergy Drive" concept consists of 4 key benefits: Fuel efficiency, low emissions, seamless acceleration and silent performance.

2. SPECIFICATION

(a) Motor Generator

ITEM	SPECIFICATION	
	MG1	MG2
Type	Permanent Magnet Motor	Permanent Magnet Motor
Function	Generator, Engine Starter	Generator, Drive Wheels
Maximum System Voltage	DC 650 V	DC 650 V
Maximum Output	-	60 kW (80 HP)
Maximum Torque	-	207 N*m (153 ft.*lbf)
Cooling System	Water-cooled	Air-cooled

(b) Inverter with Converter Assembly

ITEM	SPECIFICATION
Rated Voltage (Inverter Side)	DC 650 V
Rated Voltage (HV Battery Side)	DC 345.6 V

(c) HV Battery

ITEM	SPECIFICATION
Type	Lithium-ion Battery
Battery Pack Nominal Voltage	345.6 V
Battery Pack Capacity (3HR)	5.0 Ah

(d) DC-DC Converter Assembly

ITEM	SPECIFICATION
Rated Output Voltage	DC 12.5 V to DC 15.0 V (normal condition) DC 11.5 V (plug-in charge completed or activated at low temperatures)

(e) Electric Vehicle Charger Assembly

ITEM	SPECIFICATION
Rated Input Voltage	AC 100 V to AC 240 V
Rated Input Current	12 A
Input Power Frequency	50 or 60 Hz
Rated Output Power	2.0 kW (AC 200 V input) 1.0 kW (AC 100 V input)
Cooling System	Air-cooled

(f) Cooling System (for Inverter with Converter Assembly and MG1)

ITEM		SPECIFICATION
HV Water Pump with Motor	Motor Type	Brushless
	Discharge Volume	10 Liter (10.6 US qts, 8.8 Imp. qts) /min. or greater
Coolant	Type	Toyota Genuine Super Long Life Coolant (SLLC)
	Color	Pink
	Capacity	2.1 Liters (2.2 US qts, 1.8 Imp. qts)
	Maintenance Intervals	First Time 240000 km (150000 miles) Subsequent Every 80000 km (50000 miles)

(g) Cooling System (for HV Battery)

ITEM		SPECIFICATION
HV Battery Cooling Blower for HV Battery Pack	Motor Type	Brushless
	Fan Type	Sirocco Fan
	Air Flow Volume	93 m ³ /h
	Quantity	3
HV Battery Cooling Blower for DC-DC Converter Assembly	Motor Type	Brushless
	Fan Type	Sirocco Fan
	Quantity	1

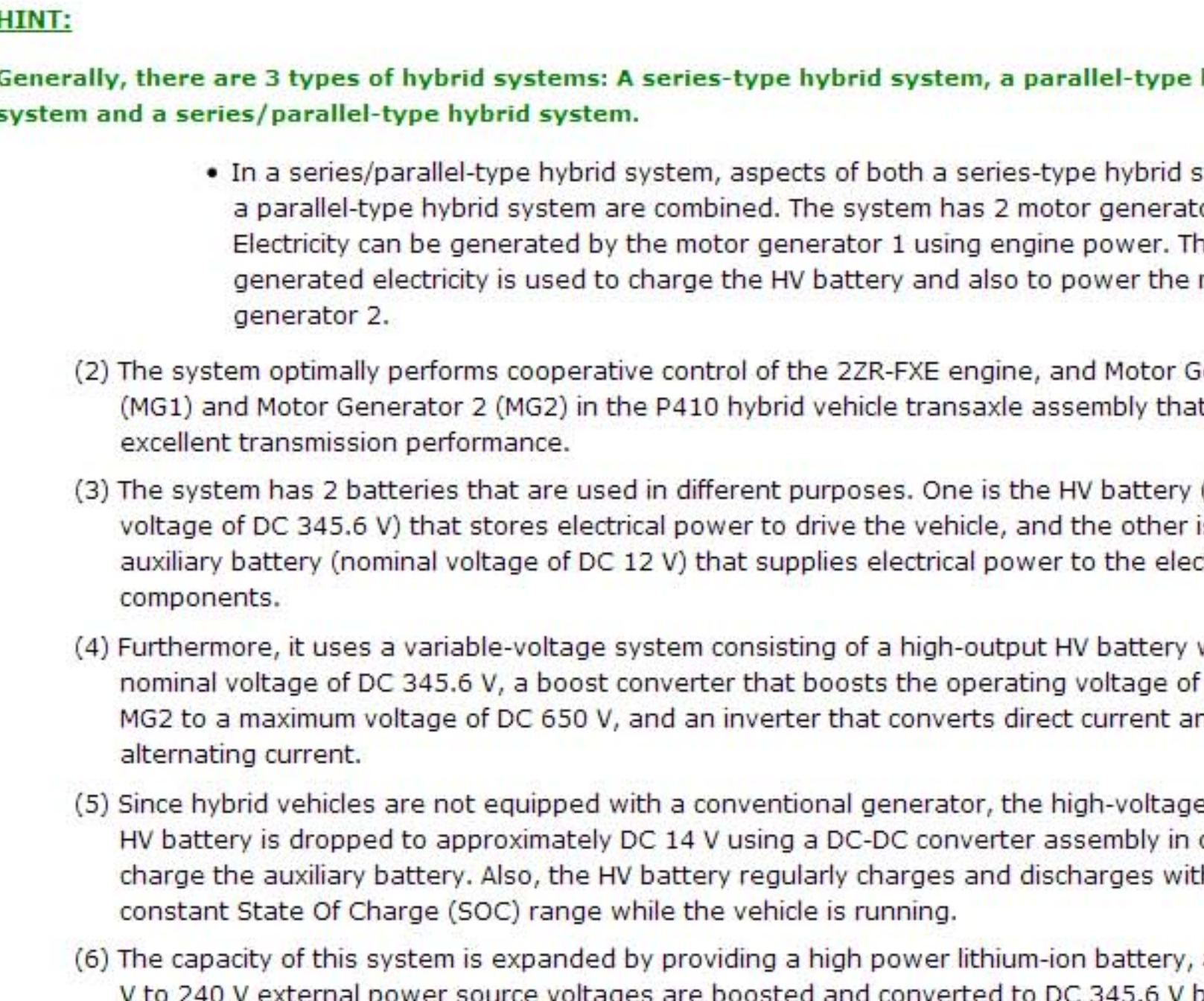
3. MAIN FEATURES

(a) The THS-II Plug-in control has the following features:

ITEM	OUTLINE
Idle Stop	Idling of the engine is automatically stopped (idle stop) to reduce energy loss.
EV Drive + HV Mode (Efficient Drive Control)	This allows the vehicle to be driven using only the electric motor when engine efficiency is low. In addition, electricity is generated when engine efficiency is high. Control is performed to maximize the total efficiency of the vehicle.
Plug-in Charging + Plug-in EV Mode	By charging and accumulating electric power into the larger capacity HV battery from an external power source, the vehicle can be driven at a maximum of approximately 100 km/h (63 mph) using only the electric motor.
Motor Assist	The electric motor supplements the engine power when accelerating.
Regenerative Braking (Energy Regeneration)	During deceleration and while depressing the brake pedal, part of the energy that was lost as heat is collected as electrical energy to be reused, such as for motor power.

(b) The mechanism of the THS-II Plug-in is as follows.

- (1) The THS-II Plug-in consists of mainly the engine, hybrid vehicle transaxle assembly, inverter with converter assembly, HV battery and electric vehicle charger assembly, and employs the series/parallel-type hybrid system.



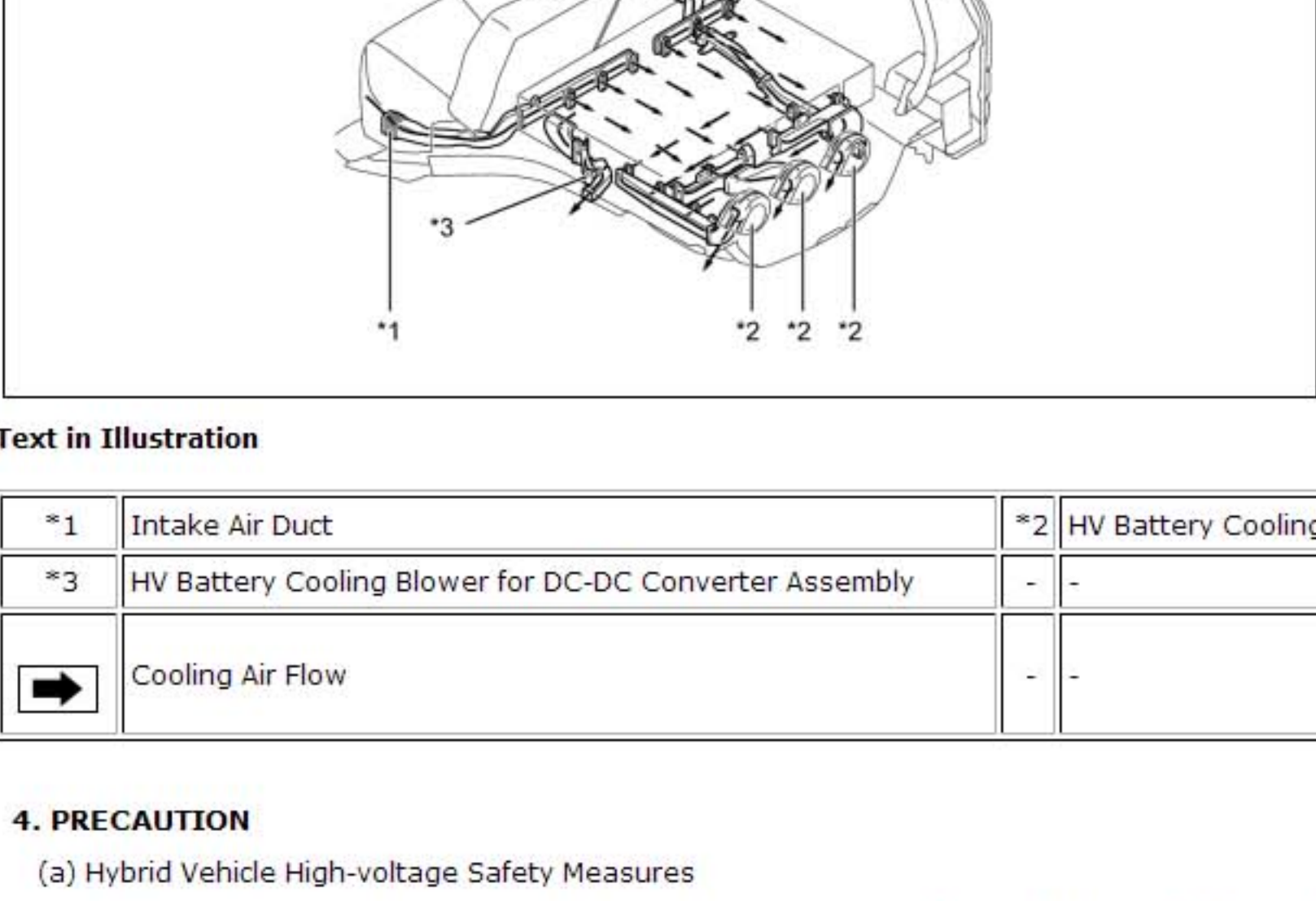
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*1 Engine	*2 Hybrid Vehicle Transaxle Assembly
*3 Motor Generator 1 (MG1)	*4 Motor Generator 2 (MG2)
*5 Power Split Planetary Gear Unit (Compound Gear Unit)	*6 Motor Speed Reduction Planetary Gear Unit (Compound Gear Unit)
*7 Inverter with Converter Assembly	*8 HV Battery
*9 Electric Vehicle Charger Assembly	*10 Electric Vehicle Charger Cable Assembly
Electrical Power Path (DC)	Electrical Power Path (AC)
Mechanical Power Path	-

HINT:
Generally, there are 3 types of hybrid systems: A series-type hybrid system, a parallel-type hybrid system and a series/parallel-type hybrid system.

- In a series/parallel-type hybrid system, aspects of both a series-type hybrid system and a parallel-type hybrid system are combined. The system has 2 motor generators. Electricity can be generated by the motor generator 1 using engine power. The generated electricity is used to charge the HV battery and also to power the motor generator 2.

- (2) The system optimally performs cooperative control of the 2ZR-FXE engine, and Motor Generator 1 (MG1) and Motor Generator 2 (MG2) in the P410 hybrid vehicle transaxle assembly that provides excellent transmission performance.
- (3) The system has 2 batteries that are used in different purposes. One is the HV battery (nominal voltage of DC 345.6 V) that stores electrical power to drive the vehicle, and the other is the auxiliary battery (nominal voltage of DC 12 V) that supplies electrical power to the electrical components.
- (4) Furthermore, it uses a variable-voltage system consisting of a high-output HV battery with a nominal voltage of DC 345.6 V, a boost converter that boosts the operating voltage of MG1 and MG2 to a maximum voltage of DC 650 V, and an inverter that converts direct current and alternating current.
- (5) Since hybrid vehicles are not equipped with a conventional generator, the high-voltage from the HV battery is dropped to approximately DC 14 V using a DC-DC converter assembly in order to charge the auxiliary battery. Also, the HV battery regularly charges and discharges within the constant State Of Charge (SOC) range while the vehicle is running.
- (6) The capacity of this system is expanded by providing a high power lithium-ion battery, and AC 100 V to 240 V external power source voltages are boosted and converted to DC 345.6 V by activating the electric vehicle charger assembly, charge relay, System Main Relays (SMR), DC-DC converter assembly and electric vehicle charger cable assembly and then charged to the HV battery pack.



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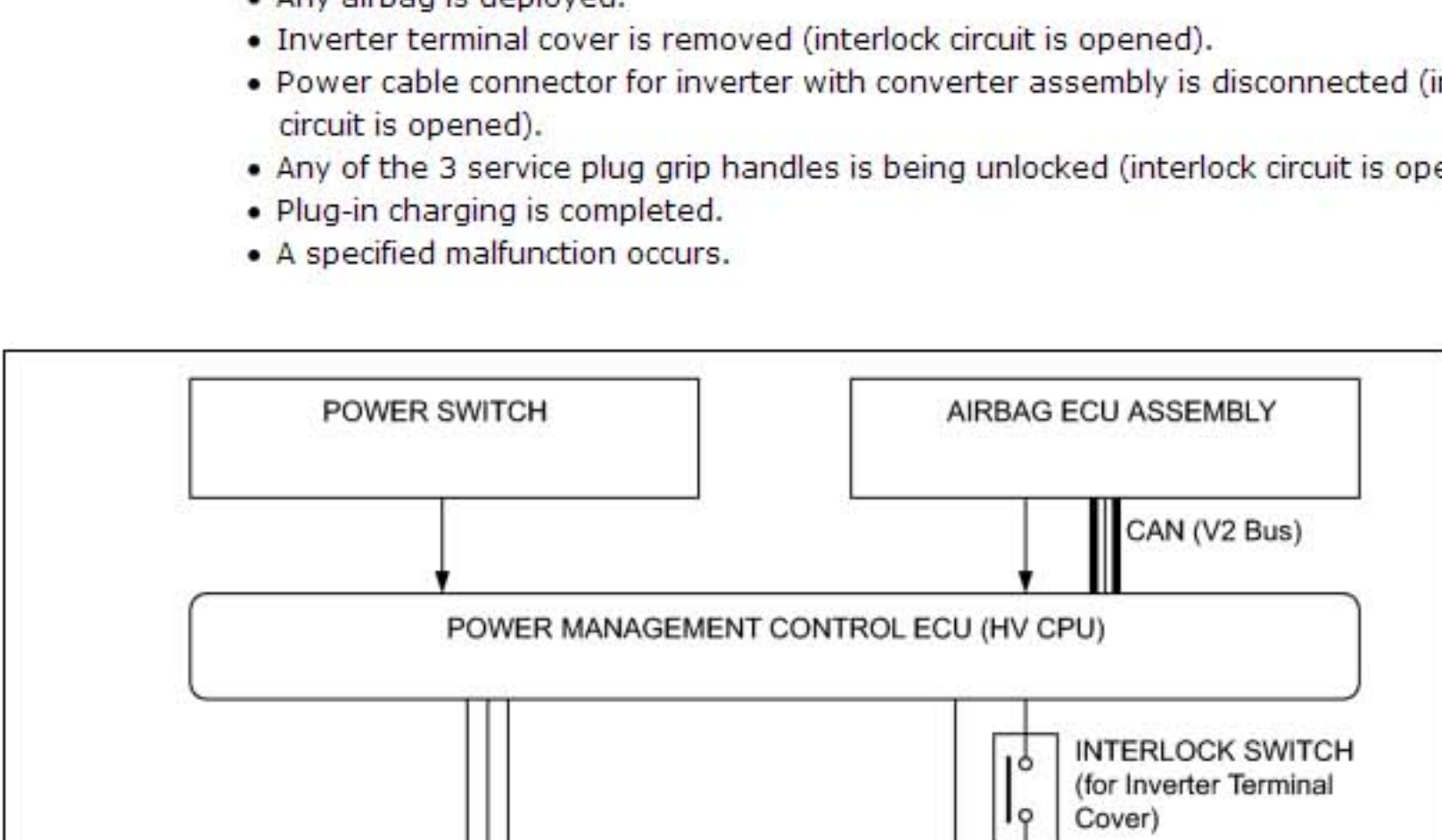
*1 2ZR-FXE Engine	*2 P410 Hybrid Vehicle Transaxle Assembly <ul style="list-style-type: none">• Motor Generator 1 (MG1)• Motor Generator 2 (MG2)
*3 Inverter with Converter Assembly <ul style="list-style-type: none">• Inverter• Boost Converter	*4 HV Battery <ul style="list-style-type: none">• HV Battery Pack• System Main Relays (SMR)• Charge Relay• DC-DC Converter Assembly
*5 Auxiliary Battery	*6 Electric Vehicle Charger Assembly
*7 Electric Vehicle Charger Cable Assembly	-
Electrical Power from External Power Source	-

(7) A cooling system that is independent from the engine cooling system is provided to cool the inverter with converter assembly and MG1.

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*1 HV Water Pump with Motor	*2 HV Radiator
*3 HV Radiator Reserve Tank	-
HV Coolant Flow	-

(8) To ensure the proper performance of the HV battery while it generates heat during the repetitive charge and discharge cycles, a dedicated cooling system is used for the HV battery assembly.



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*1 Intake Air Duct	*2 HV Battery Cooling Blower
*3 HV Battery Cooling Blower for DC-DC Converter Assembly	-
Cooling Air Flow	-

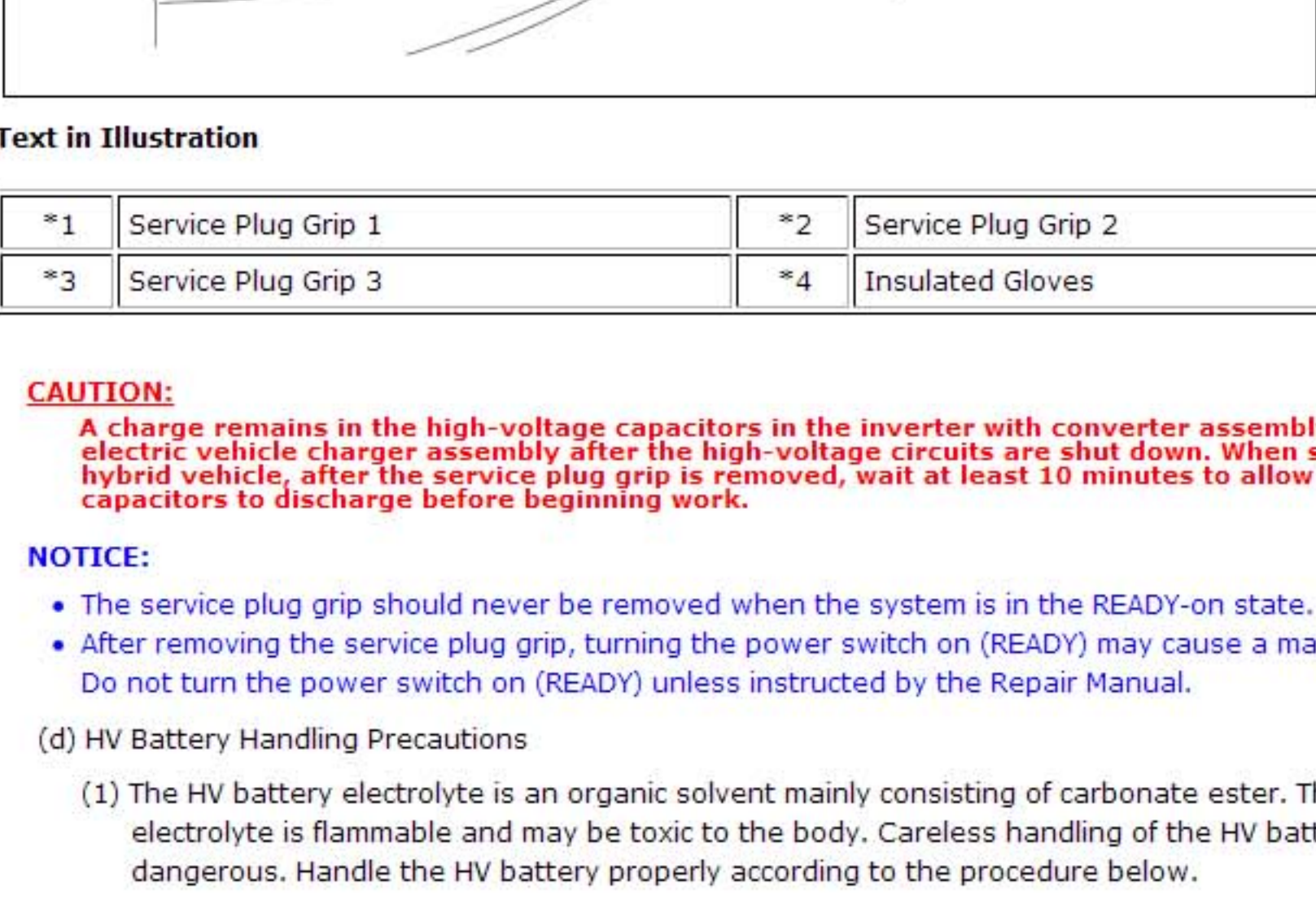
4. PRECAUTION

(a) Hybrid Vehicle High-voltage Safety Measures

- (1) High-voltage safety is comprised of 2 points: "Insulation of High-voltage Circuits" and "Cut-off of High-voltage Circuits". The hybrid system also detects whether or not a decrease in insulation resistance has occurred between the high-voltage system and body ground.

(b) Insulation of High-voltage Circuits

- (1) High-voltage circuits are used between the HV battery assembly and inverter with converter assembly, HV battery assembly and electric vehicle charger assembly, electric vehicle charger assembly and charge inlet, inverter with converter assembly and hybrid vehicle transaxle assembly, and inverter with converter assembly and cooler compressor with motor assembly. Each of these items is connected by the power cables and is electrically insulated using cases and covers.
- (2) Cables are also shielded using a mesh conductor built into the electrical insulation of the wires. The shielding is grounded to the chassis of the vehicle and the main purpose is to prevent electromagnetic interference.



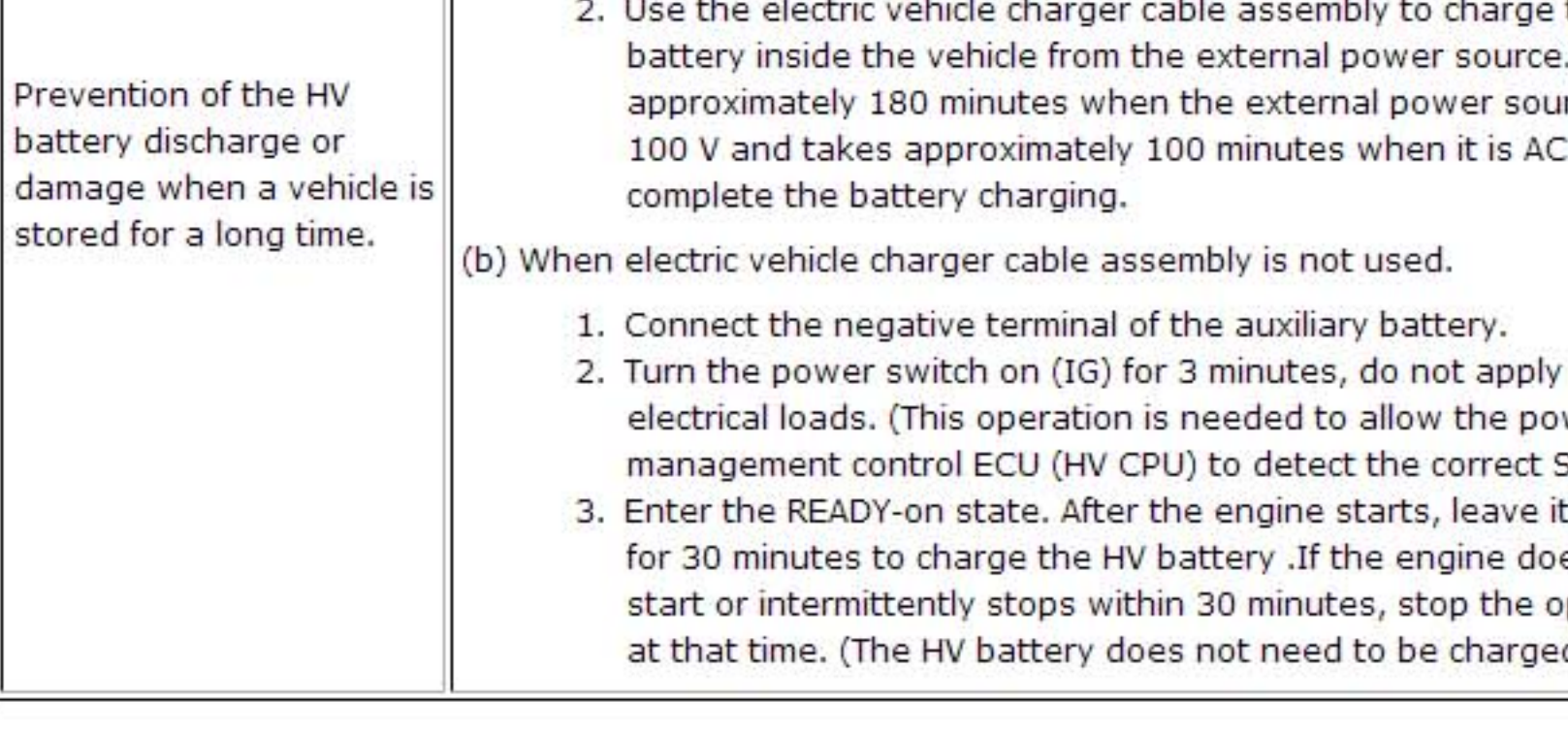
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*1 Cooler Compressor with Motor Assembly	*2 Power Cable
*3 Inverter with Converter Assembly	*4 Hybrid Vehicle Transaxle Assembly
*5 HV Battery Assembly	*6 Electric Vehicle Charger Assembly
*7 Charge Inlet	-

(c) Cut-off of High-voltage Circuits

- (1) When any of the conditions below occurs, the System Main Relays (SMR) are automatically shut off by the power management control ECU (HV CPU).

- Power switch is off.
- Any airbag is deployed.
- Inverter terminal cover is removed (interlock circuit is opened).
- Power cable connector for inverter with converter assembly is disconnected (interlock circuit is opened).
- Any of the 3 service plug grip handles is being unlocked (interlock circuit is opened).
- Plug-in charging is completed.
- A specified malfunction occurs.



(2) By removing the service plug grip before performing any inspection or service, the high-voltage circuit is shut off at the intermediate position of HV battery, thus ensuring safety during service.

Text in Illustration

*1 Service Plug Grip 1	*2 Service Plug Grip 2
*3 Service Plug Grip 3	*4 Insulated Gloves

CAUTION:
A charge remains in the high-voltage capacitors in the inverter with converter assembly and electric vehicle charger assembly after the high-voltage circuits are shut down. When servicing a hybrid vehicle, after the service plug grip is removed, wait at least 15 minutes to allow the capacitors to discharge before beginning work.

NOTICE:

- The service plug grip should never be removed when the system is in the READY-on state.
- After removing the service plug grip, turning the power switch on (READY) may cause a malfunction. Do not turn the power switch on (READY) unless instructed by the Repair Manual.

(d) HV Battery Handling Precautions

- (1) The HV battery electrolyte is an organic solvent mainly consisting of carbonate ester. The electrolyte is flammable and may be toxic to the body. Careless handling of the HV battery is very dangerous. Handle the HV battery properly according to the procedure below.

ITEM	PROCEDURE
When there is liquid leakage present in the area of the HV battery.	<ul style="list-style-type: none">• Use drying sand, saw dust or waste cloth to absorb and recover the liquid to a container which can be sealed.• Do not leave the recovered or disposed items behind but take them to an appropriate site and treat them appropriately.
When battery electrolyte gets on skin, eyes etc.*	<ul style="list-style-type: none">• If it gets on skin, wash the contact areas immediately with plenty of clean water and soap, and seek medical attention.• If contact with eyes, flush eyes immediately with plenty of clean water for 15 minutes or more and seek medical attention.• If swallowed, rinse mouth with plenty of clean water or salt water and seek medical attention immediately.• If vapor inhaled, immediately move to place with good ventilation and fresh air, rest, and seek medical attention.
When HV battery catches fire.	<ul style="list-style-type: none">• Use fire extinguishant appropriate to the surrounding fire situations such as fire extinguishing foam or plenty of water.• Extinguish the fire at its origin from the windward side and use water to cool the surrounding areas to prevent the fire from spreading.• Vapor, produced by the combustion may be irritating to eyes, nose and throat. Wear breathing protection equipment where necessary.
When a vehicle is scrapped.	Remove the HV battery from the vehicle for collection via the specified route.
When the HV battery is stored.	Do not store the battery in high temperature, high humidity locations and where the battery is exposed to rains, frost or direct sunlight. Store the battery in a place without any risk of toxic gas, liquid or dust generation or entrance, flooding and freezing.
Prevention of the HV battery discharge or damage when a vehicle is stored for a long time.	<ul style="list-style-type: none">• Disconnect the auxiliary battery negative terminal.• When in storage, the HV battery should be charged every 2 month. Using the following procedure, charge the HV battery with the vehicle. <p>(a) When electric vehicle charger cable assembly is used.</p> <ol style="list-style-type: none">1. Connect the negative terminal of the auxiliary battery.2. Use the electric vehicle charger cable assembly to charge the HV battery inside the vehicle from the external power source. It takes approximately 180 minutes when the external power source is AC 100 V and takes approximately 100 minutes when it is AC 200 V to complete the battery charging. <p>(b) When electric vehicle charger cable assembly is not used.</p> <ol style="list-style-type: none">1. Connect the negative terminal of the auxiliary battery.2. Turn the power switch on (IG) for 3 minutes, do not apply any electrical loads. (This operation is needed to allow the power management control ECU (HV CPU) to detect the correct SOC.)3. Enter the READY-on state. After the engine starts, leave it running for 30 minutes to charge the HV battery .If the engine does not start or intermittently stops within 30 minutes, stop the operation at that time. (The HV battery does not need to be charged.)