ENGINE SYSTEMS

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BATTERY SYSTEM

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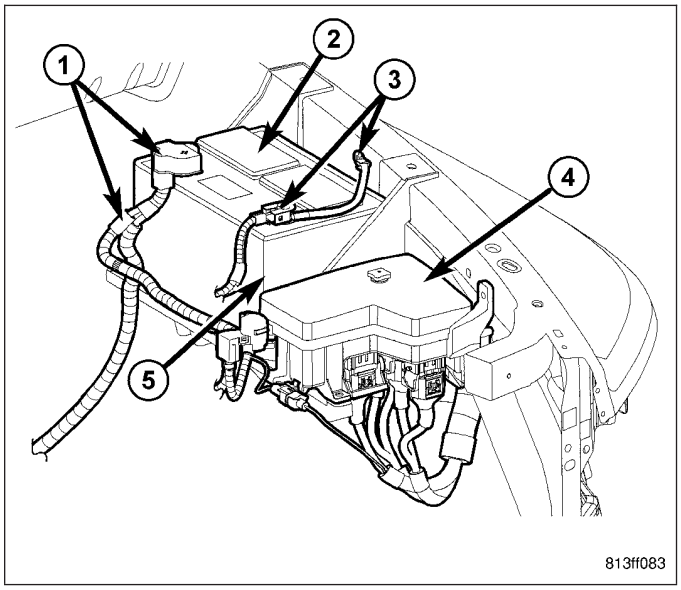
BATTERY SYSTEM

DESCRIPTION

GASOLINE ENGINE

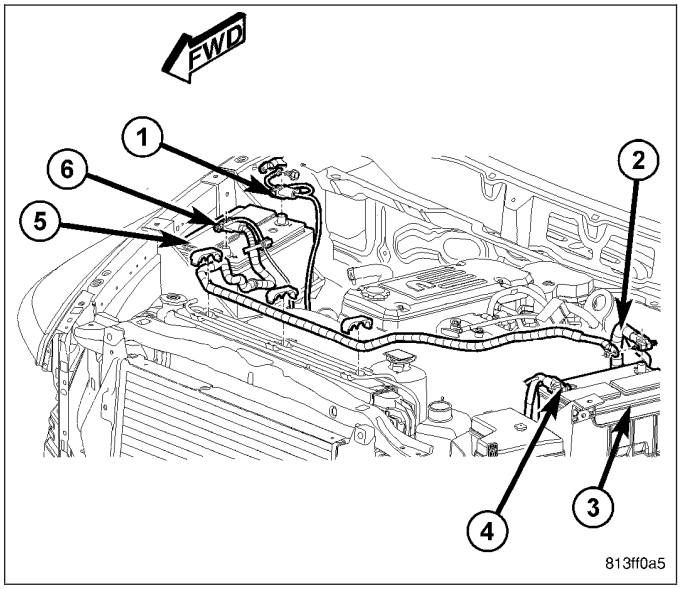
Vehicles with a gasoline engine are equipped with a single 12-volt battery. All of the components of the battery system are located within the engine compartment. The battery system for this vehicle, covers the following related components:



- **Battery (2)** - The storage battery provides a reliable means of storing a renewable source of electrical energy within the vehicle.
- **Positive Battery cable (1)** - The positive battery cable connects the battery positive terminal post to the vehicle electrical system, starter and alternator.
- **Negative Battery Cable (3)** - The negative battery cable connects the battery negative terminal post to the vehicle electrical system through body, chassis and engine grounding points.
- **Battery Thermal Guard (5)** - A thermal guard wraps around the battery case to enclose the sides of the battery. The thermal guard consists of a heavy black plastic outer skin and two lighter plies of plastic that have been formed into a sheet with hundreds of small air pockets entrapped between them.
- **Battery Holddown** - The battery holddown hardware secures the battery in the battery tray in the engine compartment.
- **Battery Tray** - The battery tray provides a secure mounting location in the vehicle for the battery and an anchor point for the battery holddown hardware.

DIESEL ENGINE

Vehicles with a diesel engine utilize two 12-volt batteries connected in parallel. All of the components of the battery system are located within the engine compartment. The battery system for this vehicle, covers the following related components:



- **Left Battery (3)** - The Left storage battery provides a reliable means of storing a renewable source of electrical energy within the vehicle.
- **Right Battery (5)** - The Right storage battery provides a reliable means of storing a renewable source of electrical energy within the vehicle as well as the additional required electrical energy due to high demands of the diesel system.
- **Positive Battery cables (2 & 6)** - The positive battery cables connect the battery positive terminal posts to the vehicle electrical system, starter and alternator as well as connecting the two batteries together.
- **Negative Battery Cables (1 & 4)** - The negative battery cables connect the battery negative terminal posts to the vehicle electrical system through body, chassis and engine grounding points.
- **Battery Thermal Guard** - A thermal guard wraps around the battery case to enclose the sides of the battery. The thermal guard consists of a heavy black plastic outer skin and two lighter plies of plastic that have been formed into a sheet with hundreds of small air pockets entrapped between them.

- **Battery Holddown** - The battery holddown hardware secures the battery in the battery tray in the engine compartment.
- **Battery Tray** - The battery tray provides a secure mounting location in the vehicle for the battery and an anchor point for the battery holddown hardware.

For battery system maintenance schedules, (Refer to LUBRICATION & MAINTENANCE/MAINTENANCE SCHEDULES - DESCRIPTION). For the proper battery jump starting procedure, (Refer to LUBRICATION & MAINTENANCE/JUMP STARTING - STANDARD PROCEDURE). The battery must be fully-charged before any battery system diagnosis or testing procedures can be performed.

OPERATION

The battery system is designed to provide a safe, efficient, reliable and mobile means of delivering and storing electrical energy. This electrical energy is required to operate the engine starting system, as well as many of the other vehicle accessory systems for limited durations while the engine and/or the charging system are not operating. The battery system is also designed to provide a reserve of electrical energy to supplement the charging system for short durations while the engine is running and the electrical current demands of the vehicle exceed the output of the charging system. In addition to delivering, and storing electrical energy for the vehicle, the battery system serves as a capacitor and voltage stabilizer for the vehicle electrical system. It absorbs most abnormal or transient voltages caused by the switching of any of the electrical components or circuits in the vehicle.

DIAGNOSIS AND TESTING

BATTERY SYSTEM

The battery, starting, and charging systems in the vehicle operate with one another and must be tested as a complete system. In order for the engine to start and the battery to maintain its charge properly, all of the components that are used in these systems must perform within specifications. It is important that the battery, starting, and charging systems be thoroughly tested and inspected any time a battery needs to be charged or replaced. The cause of abnormal battery discharge, overcharging or early battery failure must be diagnosed and corrected before a battery is replaced and before a vehicle is returned to service. The service information for these systems has been separated within this service manual to make it easier to locate the specific information you are seeking. However, when attempting to diagnose any of these systems, it is important that you keep their interdependency in mind.

The diagnostic procedures used for the battery, starting, and charging systems include the most basic conventional diagnostic methods, to the more sophisticated On-Board Diagnostics (OBD) built into the Powertrain Control Module (PCM). Use of an induction-type milliampere ammeter, a volt/ohmmeter, a battery charger, a carbon pile rheostat (load tester) and a 12-volt test lamp may be required. All OBD-sensed systems are monitored by the PCM. Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for any inoperative system it detects. (Refer to 8 - ELECTRICAL/CHARGING - DIAGNOSIS AND TESTING) for the proper charging system on-board diagnostic test procedures.

MICRO 420 BATTERY TESTER

The Micro 420 automotive battery system tester is designed to help diagnose the cause of a defective battery. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER) for directions on using the Micro 420 battery tester.

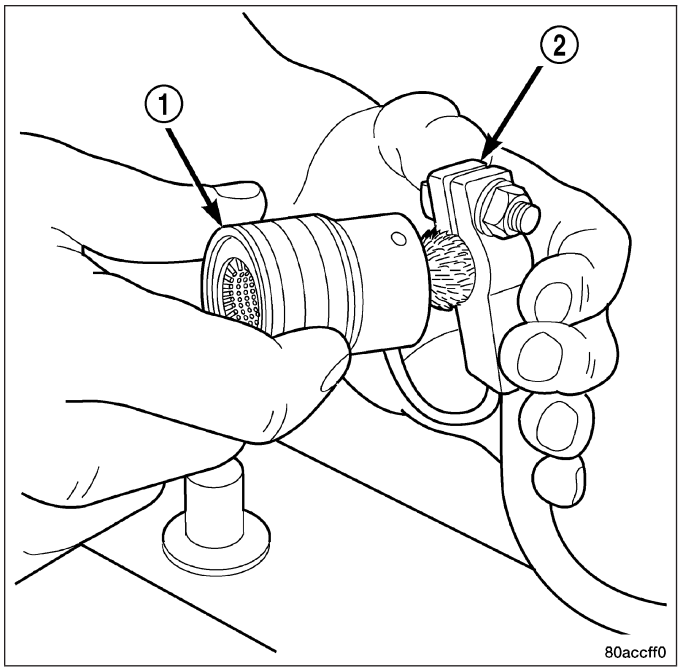
BATTERY SYSTEM DIAGNOSIS		
CONDITION	POSSIBLE CAUSES	CORRECTION
THE BATTERY SEEMS WEAK OR DEAD WHEN ATTEMPTING TO START THE ENGINE.	1. The electrical system ignition-off draw is excessive.	1. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - IGNITION-OFF DRAW TEST) for the proper test procedures. Repair the excessive ignition-off draw, as required.
	2. The charging system is inoperative.	2. Determine if the charging system is performing to specifications. Repair the inoperative charging system, as required.
	3. The battery is discharged.	3. Determine the battery state-of-charge using the Micro 420 battery tester, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER). Charge the inoperative battery as required.
	4. The battery terminal connections are loose or corroded.	4. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING). Clean and tighten the battery terminal connections, as required.
	5. The battery has an incorrect size or rating for this vehicle.	5. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - SPECIFICATIONS) for the proper size and rating. Replace an incorrect battery, as required.
	6. The battery is inoperative.	6. Determine the battery cranking capacity using the Micro 420 battery tester, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER). Replace the inoperative battery, as required.
	7. The starting system is inoperative.	7. Determine if the starting system is performing to specifications. Repair the inoperative starting system, as required.
	8. The battery is physically damaged.	8. Inspect the battery for loose terminal posts or a cracked and leaking case. Replace the damaged battery, as required.

BATTERY SYSTEM DIAGNOSIS		
CONDITION	POSSIBLE CAUSES	CORRECTION
THE BATTERY STATE OF CHARGE CANNOT BE MAINTAINED.	1. The battery has an incorrect size or rating for this vehicle.	1. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - SPECIFICATIONS) for the proper size and rating. Replace an incorrect battery, as required.
	2. The battery terminal connections are loose or corroded.	2. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING). Clean and tighten the battery terminal connections, as required.
	3. The electrical system ignition-off draw is excessive.	3. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - IGNITION-OFF DRAW TEST) for the proper test procedures. Repair the inoperative electrical system, as required.
	4. The battery is inoperative.	4. Test the battery using the Micro 420 battery tester, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER). Replace the inoperative battery, as required.
	5. The starting system is inoperative.	5. Determine if the starting system is performing to specifications. Repair the inoperative starting system, as required.
	6. The charging system is inoperative.	6. Determine if the charging system is performing to specifications. Repair the inoperative charging system, as required.
	7. Electrical loads exceed the output of the charging system.	7. Inspect the vehicle for aftermarket electrical equipment which might cause excessive electrical loads.
	8. Slow driving or prolonged idling with high-amperage draw systems in use.	8. Advise the vehicle operator, as required.
THE BATTERY WILL NOT ACCEPT A CHARGE.	1. The battery is inoperative.	1. Test the battery using the Micro 420 battery tester, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER). Replace the inoperative battery, as required.

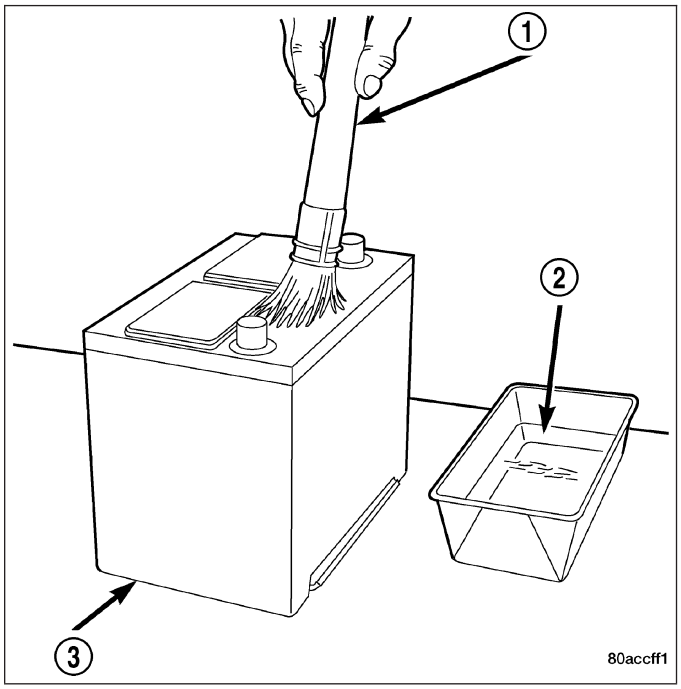
CLEANING

The following information details the recommended cleaning procedures for the battery and related components. In addition to the maintenance schedules, (Refer to LUBRICATION & MAINTENANCE/MAINTENANCE SCHEDULES - DESCRIPTION) for gasoline engines or (Refer to LUBRICATION & MAINTENANCE/MAINTENANCE SCHEDULES - DESCRIPTION) for diesel engines, it is recommended that these procedures be performed any time the battery or related components must be removed for vehicle service.

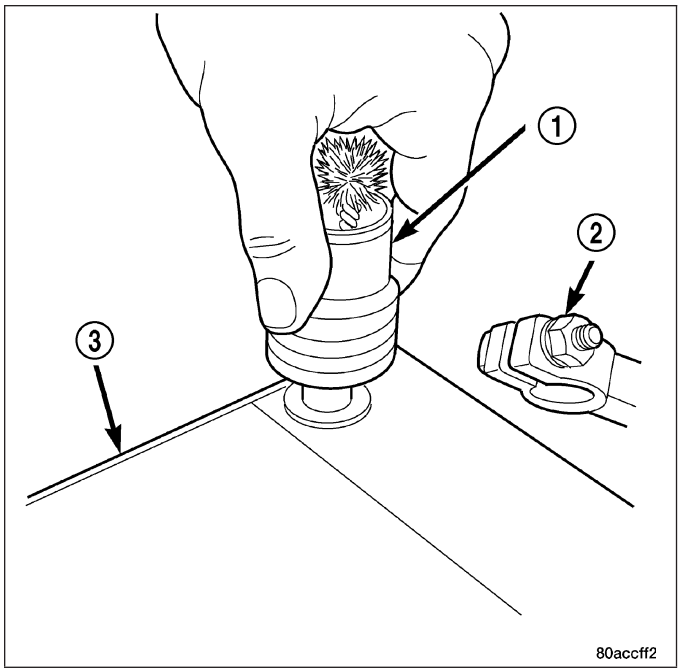
1. Clean the battery cable terminal clamps (2) of all corrosion. Remove any corrosion using a wire brush or a post and terminal cleaning tool (1), and a sodium bicarbonate (baking soda) and warm water cleaning solution.
2. Clean the battery tray and battery holddown hardware of all corrosion. Remove any corrosion using a wire brush and a sodium bicarbonate (baking soda) and warm water cleaning solution. Paint any exposed bare metal.



3. If the removed battery is to be reinstalled, clean the outside of the battery case (3) and the top cover with a sodium bicarbonate (baking soda) and warm water cleaning solution (2) using a stiff bristle parts cleaning brush (1) to remove any acid film. Rinse the battery with clean water. Ensure that the cleaning solution does not enter the battery cells through the vent holes. If the battery is being replaced, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - SPECIFICATIONS) for the factory-installed battery specifications. Confirm that the replacement battery is the correct size and has the correct ratings for the vehicle.
4. Clean the battery thermal guard with a sodium bicarbonate (baking soda) and warm water cleaning solution using a stiff bristle parts cleaning brush to remove any acid film.



5. Clean any corrosion from the battery terminal posts with a wire brush or a post and terminal cleaner (1), and a sodium bicarbonate (baking soda) and warm water cleaning solution.



INSPECTION

The following information details the recommended inspection procedures for the battery and related components. In addition to the maintenance schedules, (Refer to LUBRICATION & MAINTENANCE/MAINTENANCE SCHEDULES - DESCRIPTION) for gasoline engines or (Refer to LUBRICATION & MAINTENANCE/MAINTENANCE SCHEDULES - DESCRIPTION) for diesel engines, it is recommended that these procedures be performed any time the battery or related components must be removed for vehicle service.

1. Inspect the battery cable terminal clamps for damage. Replace any battery cable that has a damaged or deformed terminal clamp.
2. Inspect the battery tray and battery holddown hardware for damage. Replace any damaged parts.
3. Slide the thermal guard off of the battery case (if equipped). Inspect the battery case for cracks or other damage that could result in electrolyte leaks. Also, check the battery terminal posts for looseness. Batteries with damaged cases or loose terminal posts must be replaced.
4. Inspect the battery thermal guard (if equipped) for tears, cracks, deformation or other damage. Replace any battery thermal guard that has been damaged.
5. Inspect the battery built-in test indicator sight glass (if equipped) for an indication of the battery condition, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - BUILT-IN INDICATOR TEST) for the proper battery built-in indicator test procedures. If the battery is discharged, charge as required, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - BATTERY CHARGING) for the proper battery charging procedures.

SPECIFICATIONS

The battery Group Size number, the Cold Cranking Amperage (CCA) rating, and the Reserve Capacity (RC) rating or Ampere-Hours (AH) rating can be found on the original equipment battery label. Be certain that a replacement battery has the correct Group Size number, as well as CCA, and RC or AH ratings that equal or exceed the original equipment specification for the vehicle being serviced. Battery sizes and ratings are discussed in more detail below.

- **Group Size** - The outside dimensions and terminal placement of the battery conform to standards established by the Battery Council International (BCI). Each battery is assigned a BCI Group Size number to help identify a correctly-sized replacement.
- **Cold Cranking Amperage** - The Cold Cranking Amperage (CCA) rating specifies how much current (in amperes) the battery can deliver for thirty seconds at -18° C (0° F). Terminal voltage must not fall below 7.2 volts during or after the thirty second discharge period. The CCA required is generally higher as engine displacement increases, depending also upon the starter current draw requirements.
- **Reserve Capacity** - The Reserve Capacity (RC) rating specifies the time (in minutes) it takes for battery terminal voltage to fall below 10.5 volts, at a discharge rate of 25 amperes. RC is determined with the battery

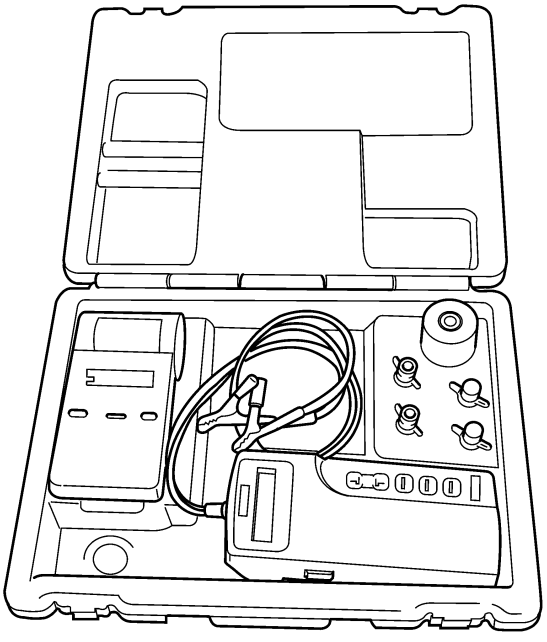
fully-charged at 26.7° C (80° F). This rating estimates how long the battery might last after a charging system failure, under minimum electrical load.

- **Ampere-Hours** - The Ampere-Hours (AH) rating specifies the current (in amperes) that a battery can deliver steadily for twenty hours, with the voltage in the battery not falling below 10.5 volts. This rating is also sometimes identified as the twenty-hour discharge rating.
- **Load Test Amperage** - The Load Test Amperage rating specifies the current (in amperes) that a battery should be tested at with the battery load test equipment. This value should always be 50 percent of the CCA. For example: if the CCA for this battery is 600 amps, the Load Test Amperage is 50 percent of that or 300 amps.

BATTERY CLASSIFICATIONS & RATINGS					
Part Number	BCI Group Size Classification	Cold Cranking Amperage	Reserve Capacity	Ampere - Hours	Load Test Amperage
56029449AB	65	600	120 Minutes	66	300
56029451AB	65	750	150 Minutes	75	375
56028450AA	65	600	120 Minutes	66	300
56028452AA	65	750	150 Minutes	75	375
56028452AB	65	700	130 Minutes	70	350
56029396AA	65	700	130 Minutes	70	350
56029382AA	65	700	130 Minutes	70	350

SPECIAL TOOLS

BATTERY SYSTEM SPECIAL TOOLS



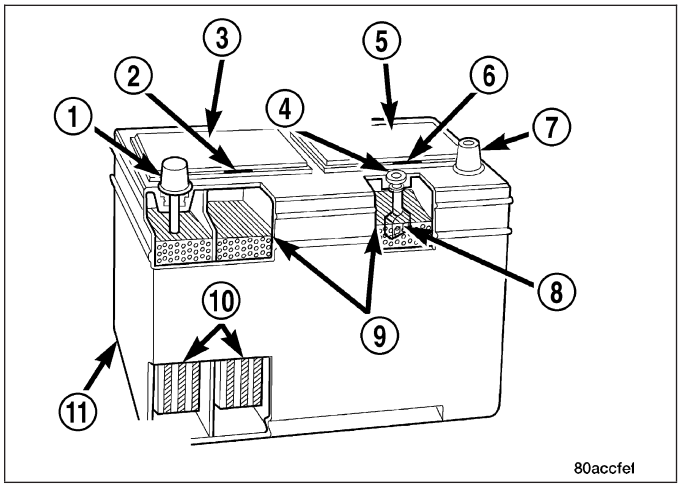
Micro 420 Battery Tester

BATTERY

DESCRIPTION

This vehicle is equipped with a large capacity, low-maintenance storage battery (11). Vehicles equipped with a diesel engine must utilize two 12-volt batteries connected in parallel. The battery is comprised of the following components:

- Positive Post (1)
- Vent (2)
- Cell Cap (3)
- Vent (4)
- Cell Cap (5)
- Vent (6)
- Negative Post (7)
- Indicator Eye (8) if equipped
- Electrolyte Level (9)
- Plate Groups (10)
- Maintenance Free Battery assembly (11)



This battery is designed to provide a safe, efficient and reliable means of storing electrical energy in a chemical form. This means of energy storage allows the battery to produce the electrical energy required to operate the engine starting system, as well as to operate many of the other vehicle accessory systems for limited durations while the engine and/or the charging system are not operating. The battery is made up of six individual cells that are connected in series. Each cell contains positively charged plate groups that are connected with lead straps to the positive terminal post, and negatively charged plate groups that are connected with lead straps to the negative terminal post. Each plate consists of a stiff mesh framework or grid coated with lead dioxide (positive plate) or sponge lead (negative plate). Insulators or plate separators made of a non-conductive material are inserted between the positive and negative plates to prevent them from contacting or shorting against one another. These dissimilar metal plates are submerged in a sulfuric acid and water solution called an electrolyte.

The battery Group Size number, the Cold Cranking Amperage (CCA) rating, and the Reserve Capacity (RC) rating or Ampere-Hours (AH) rating can be found on the original equipment battery label. Be certain that a replacement battery has the correct Group Size number, as well as CCA, and RC or AH ratings that equal or exceed the original equipment specification for the vehicle being serviced. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - SPECIFICATIONS) for the proper factory-installed battery specifications.

OPERATION

The battery is designed to store electrical energy in a chemical form. When an electrical load is applied to the terminals of the battery, an electrochemical reaction occurs. This reaction causes the battery to discharge electrical current from its terminals. As the battery discharges, a gradual chemical change takes place within each cell. The sulfuric acid in the electrolyte combines with the plate materials, causing both plates to slowly change to lead sulfate. At the same time, oxygen from the positive plate material combines with hydrogen from the sulfuric acid, causing the electrolyte to become mainly water. The chemical changes within the battery are caused by the movement of excess or free electrons between the positive and negative plate groups. This movement of electrons produces a flow of electrical current through the load device attached to the battery terminals.

As the plate materials become more similar chemically, and the electrolyte becomes less acid, the voltage potential of each cell is reduced. However, by charging the battery with a voltage higher than that of the battery itself, the battery discharging process is reversed. Charging the battery gradually changes the sulfated lead plates back into sponge lead and lead dioxide, and the water back into sulfuric acid. This action restores the difference in the electron charges deposited on the plates, and the voltage potential of the battery cells. For a battery to remain useful, it must be able to produce high-amperage current over an extended period. A battery must also be able to accept a charge, so that its voltage potential may be restored.

The battery is vented to release excess hydrogen gas that is created when the battery is being charged or discharged. However, even with these vents, hydrogen gas can collect in or around the battery. If hydrogen gas is

exposed to flame or sparks, it may ignite. If the electrolyte level is low, the battery may arc internally and explode. If the battery cell caps cannot be removed, the battery must be replaced if the electrolyte level becomes low.

DIAGNOSIS AND TESTING

BATTERY

The battery must be completely charged and the terminals should be properly cleaned and inspected before diagnostic procedures are performed. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING) and (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - INSPECTION) for the proper battery cleaning and inspection procedures. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - BATTERY CHARGING) for the proper battery charging procedures.

MICRO 420 BATTERY TESTER

The Micro 420 automotive battery tester is designed to help diagnose the cause of an inoperative battery. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER) for instructions on the use of the Micro 420 battery tester.

WARNING: If the battery shows signs of freezing, leaking or loose posts, do not test, assist-boost, or charge. The battery may arc internally and explode. Personal injury and/or vehicle damage may result.

WARNING: Explosive hydrogen gas forms in and around the battery. Do not smoke, use flame, or create sparks near the battery. Personal injury and/or vehicle damage may result.

WARNING: The battery contains sulfuric acid, which is poisonous and caustic. Avoid contact with the skin, eyes, or clothing. In the event of contact, flush with water and call a physician immediately. Keep out of the reach of children.

A battery that will not accept a charge is inoperative, and must be replaced. Further testing is not required. A fully-charged battery must be load tested to determine its cranking capacity. A battery that is fully-charged, but does not pass the load test, is inoperative and must be replaced.

NOTE: Completely discharged batteries may take several hours to accept a charge. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - BATTERY CHARGING) for the proper battery charging procedures.

STANDARD PROCEDURE

BATTERY CHARGING

Battery charging is the means by which the battery can be restored to its full voltage potential. A battery is fully-charged when:

- Micro 420 electrical system tester indicates battery is OK.
- All of the battery cells are gassing freely during battery charging.
- Open-circuit voltage of the battery is 12.4 volts or above.

WARNING: Never exceed twenty amperes when charging a cold (-1° c [30° f] or lower) battery. The battery may arc internally and explode. Personal injury and/or vehicle damage may result.

WARNING: If the battery shows signs of freezing, leaking, loose posts, do not test, assist-boost, or charge. The battery may arc internally and explode. Personal injury and/or vehicle damage may result.

WARNING: Explosive hydrogen gas forms in and around the battery. Do not smoke, use flame, or create sparks near the battery. Personal injury and/or vehicle damage may result.

WARNING: The battery contains sulfuric acid, which is poisonous and caustic. Avoid contact with the skin, eyes, or clothing. In the event of contact, flush with water and call a physician immediately. Keep out of the reach of children.

WARNING: If the battery is equipped with removable cell caps, be certain that each of the cell caps is in place and tight before the battery is returned to service. Personal injury and/or vehicle damage may result from loose or missing cell caps.

CAUTION: Always disconnect and isolate the battery negative cable before charging a battery. Do not exceed sixteen volts while charging a battery. Damage to the vehicle electrical system components may result.

CAUTION: Battery electrolyte will bubble inside the battery case during normal battery charging. Electrolyte boiling or being discharged from the battery vents indicates a battery overcharging condition. Immediately reduce the charging rate or turn off the charger to evaluate the battery condition. Damage to the battery may result from overcharging.

CAUTION: The battery should not be hot to the touch. If the battery feels hot to the touch, turn off the charger and let the battery cool before continuing the charging operation. Damage to the battery may result.

NOTE: Models equipped with the diesel engine are equipped with two 12-volt batteries, connected in parallel (positive-to-positive and negative-to-negative). In order to ensure proper charging of each battery, these batteries MUST be disconnected from each other, as well as from the vehicle electrical system while being charged.

Some battery chargers are equipped with polarity-sensing circuitry. This circuitry protects the battery charger and the battery from being damaged if they are improperly connected. If the battery state-of-charge is too low for the polarity-sensing circuitry to detect, the battery charger will not operate. This makes it appear that the battery will not accept charging current. See the instructions provided by the manufacturer of the battery charger for details on how to bypass the polarity-sensing circuitry.

After the battery has been charged to 12.4 volts or greater, perform a load test to determine the battery cranking capacity. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER) for the proper battery load test procedures. If the battery will endure a load test, return the battery to service. If the battery will not endure a load test, it is inoperative and must be replaced.

Clean and inspect the battery hold downs, tray, terminals, posts, and top before completing battery service. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING) and (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - INSPECTION) for the proper battery system cleaning and inspection procedures.

CHARGING A COMPLETELY DISCHARGED BATTERY

The following procedure should be used to recharge a completely discharged battery. Unless this procedure is properly followed, a good battery may be needlessly replaced.

1. Measure the voltage at the battery posts with a voltmeter, accurate to 1/10 (0.10) volt. If the reading is below ten volts, the battery charging current will be low. It could take some time before the battery accepts a current greater than a few milliamperes. Such low current may not be detectable on the ammeters built into many battery chargers.
2. Disconnect and isolate the battery negative cable. Connect the battery charger leads. Some battery chargers are equipped with polarity-sensing circuitry. This circuitry protects the battery charger and the battery from being damaged if they are improperly connected. If the battery state-of-charge is too low for the polarity-sensing circuitry to detect, the battery charger will not operate. This makes it appear that the battery will not accept charging current. See the instructions provided by the manufacturer of the battery charger for details on how to bypass the polarity-sensing circuitry.
3. Battery chargers vary in the amount of voltage and current they provide. The amount of time required for a battery to accept measurable charging current at various voltages is shown in the Charge Rate Table. If the charging current is still not measurable at the end of the charging time, the battery is inoperative and must be

replaced. If the charging current is measurable during the charging time, the battery may be good and the charging should be completed in the normal manner.

CHARGE RATE TABLE	
Voltage	Hours
16.0 volts maximum	up to 4 hours
14.0 to 15.9 volts	up to 8 hours
13.9 volts or less	up to 16 hours

CHARGING TIME REQUIRED

The time required to charge a battery will vary, depending upon the following factors:

- **Battery Capacity** - A completely discharged heavy-duty battery requires twice the charging time of a small capacity battery.
- **Temperature** - A longer time will be needed to charge a battery at -18° C (0° F) than at 27° C (80° F). When a fast battery charger is connected to a cold battery, the current accepted by the battery will be very low at first. As the battery warms, it will accept a higher charging current rate (amperage).
- **Charger Capacity** - A battery charger that supplies only five amperes will require a longer charging time. A battery charger that supplies twenty amperes or more will require a shorter charging time.
- **State-Of-Charge** - A completely discharged battery requires more charging time than a partially discharged battery. Electrolyte is nearly pure water in a completely discharged battery. At first, the charging current (amperage) will be low. As the battery charges, the specific gravity of the electrolyte will gradually rise.

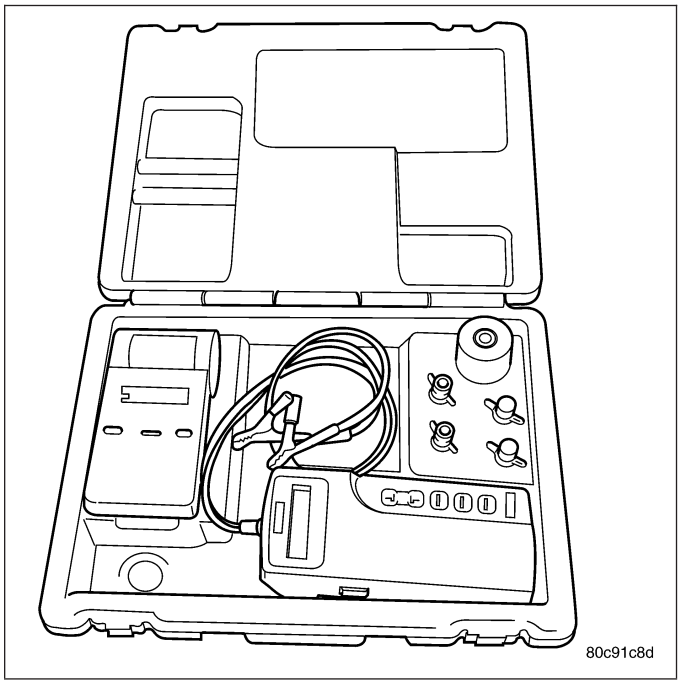
The Battery Charging Time Table gives an indication of the time required to charge a typical battery at room temperature based upon the battery state-of-charge and the charger capacity.

BATTERY CHARGING TIME TABLE			
Charging Amperage	5 Amps	10 Amps	20 Amps
Open Circuit Voltage	Hours Charging @ 21° C (70° F)		
12.25 to 12.49	6 hours	3 hours	1.5 hours
12.00 to 12.24	10 hours	5 hours	2.5 hours
10.00 to 11.99	14 hours	7 hours	3.5 hours
Below 10.00	18 hours	9 hours	4.5 hours

USING MICRO 420 BATTERY TESTER

Always use the Micro 420 Instruction Manual that was supplied with the tester as a reference. If the Instruction Manual is not available the following procedure can be used:

WARNING: Always wear appropriate eye protection and use extreme caution when working with batteries.



BATTERY TESTING

1. If testing the battery OUT-OF-VEHICLE, clean the battery terminals with a wire brush before testing, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING).
2. If testing the battery IN-THE-VEHICLE, make certain all of the vehicle accessory loads are OFF, including the ignition. **The preferred test position is at the battery terminals**. If the battery is not accessible, you may test using both the positive and negative jumper posts. Select TESTING AT JUMPER POST when connecting to that location.
3. Connect the tester to the battery or jumper posts, the red clamp to positive (+) and the black clamp to negative (–).

NOTE: Multiple batteries connected in parallel must have the ground cable disconnected to perform a battery test. Failure to disconnect may result in false battery test readings.

4. Using the ARROW key select **in** or **out** of vehicle testing and press ENTER to make a selection.
5. If not selected, choose the Cold Cranking Amp (CCA) battery rating. Or select the appropriate battery rating for your area (see menu). The tester will then run its self programmed test of the battery and display the results. Refer to the test result table noted below.

CAUTION: If REPLACE BATTERY is the result of the test, this may mean a poor connection between the vehicle's cables and battery exists. After disconnecting the vehicle's battery cables from the battery, retest the battery using the OUT-OF-VEHICLE test before replacing.

6. While viewing the battery test result, press the CODE button and the tester will prompt you for the last 4 digits of the VIN. Use the UP/DOWN arrow buttons to scroll to the correct character; then press ENTER to select and move to the next digit. Then press the ENTER button to view the SERVICE CODE. Pressing the CODE button a second time will return you to the test results.

BATTERY TEST RESULTS	
GOOD BATTERY	Return to service
GOOD - RECHARGE	Fully charge battery and return to service
CHARGE & RETEST	Fully charge battery and retest battery
REPLACE BATTERY	Replace the battery and retest complete system
BAD-CELL REPLACE	Replace the battery and retest complete system

NOTE: The SERVICE CODE is required on every warranty claim submitted for battery replacement.

OPEN-CIRCUIT VOLTAGE TEST

A battery open-circuit voltage (no load) test will show the approximate state-of-charge of a battery. This test can be used in place of the hydrometer test when a hydrometer is not available, or for maintenance-free batteries with non-removable cell caps.

Before proceeding with this test, completely charge the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - BATTERY CHARGING).

1. Before measuring the open-circuit voltage, the surface charge must be removed from the battery. Turn on the headlamps for fifteen seconds, then allow up to five minutes for the battery voltage to stabilize.
2. Disconnect and isolate both battery cables, negative cable first.
3. Using a voltmeter connected to the battery posts measure the open-circuit voltage.

See the Open-Circuit Voltage Table. This voltage reading will indicate the battery state-of-charge, but will not reveal its cranking capacity. If a battery has an open-circuit voltage reading of 12.4 volts or greater, it may be load tested to reveal its cranking capacity (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER).

OPEN CIRCUIT VOLTAGE TABLE	
Open Circuit Voltage	Charge Percentage
11.7 volts or less	0%
12.0 volts	25%
12.2 volts	50%
12.4 volts	75%
12.6 volts or more	100%

IGNITION-OFF DRAW TEST

The term Ignition-Off Draw (IOD) identifies a normal condition where power is being drained from the battery with the ignition switch in the Off position. A normal vehicle electrical system will draw from five to thirty-five milliamperes (0.005 to 0.035 ampere) with the ignition switch in the Off position, and all non-ignition controlled circuits in proper working order. Up to thirty-five milliamperes are needed to enable the memory functions for the Powertrain Control Module (PCM), digital clock, electronically tuned radio, and other modules which may vary with the vehicle equipment.

A vehicle that has not been operated for approximately twenty days, may discharge the battery to an inadequate level. When a vehicle will not be used for twenty days or more (stored), remove the IOD fuse from the Junction Block (JB). This will reduce battery discharging.

Excessive IOD can be caused by:

- Electrical items left on.
- Inoperative or improperly adjusted switches.
- Inoperative or shorted electronic modules and components.
- An internally shorted generator.
- Intermittent shorts in the wiring.

If the IOD is over thirty-five milliamperes, the problem must be found and corrected before replacing a battery. In most cases, the battery can be charged and returned to service after the excessive IOD condition has been corrected.

1. Verify that all electrical accessories are off. Turn off all lamps, remove the ignition key, and close all doors. If the vehicle is equipped with an illuminated entry system or an electronically tuned radio, allow the electronic timer function of these systems to automatically shut off (time out). This may take up to three minutes. See the Electronic Module Ignition-Off Draw Table for more information.

ELECTRONIC MODULE IGNITION-OFF DRAW (IOD) TABLE			
Module	Time Out? (If Yes, Interval And Wake-Up Input)	IOD	IOD After Time Out
Radio	No	1 to 3 milliamperes	N/A
Audio Power Amplifier	No	up to 1 milliampere	N/A
Central Timer Module (CTM)	No	4.75 milliamperes (max.)	N/A
Powertrain Control Module (PCM)	No	0.95 milliampere	N/A
ElectroMechanical Instrument Cluster (EMIC)	No	0.44 milliampere	N/A
Combination Flasher	No	0.08 milliampere	N/A

2. Determine that the underhood lamp is operating properly, then disconnect the lamp wire harness connector or remove the lamp bulb.
3. Disconnect the battery negative cable.
4. Set an electronic digital multi-meter to its highest amperage scale. Connect the multi-meter between the disconnected battery negative cable terminal clamp and the battery negative terminal post. Make sure that the doors remain closed so that the illuminated entry system is not activated. The multi-meter amperage reading may remain high for up to three minutes, or may not give any reading at all while set in the highest amperage scale, depending upon the electrical equipment in the vehicle. The multi-meter leads must be securely clamped to the battery negative cable terminal clamp and the battery negative terminal post. If continuity between the battery negative terminal post and the negative cable terminal clamp is lost during any part of the IOD test, the electronic timer function will be activated and all of the tests will have to be repeated.
5. After about three minutes, the high-amperage IOD reading on the multi-meter should become very low or nonexistent, depending upon the electrical equipment in the vehicle. If the amperage reading remains high, remove and replace each fuse or circuit breaker in the Power Distribution Center (PDC) and then in the Junction Block (JB), one at a time until the amperage reading becomes very low, or nonexistent. Refer to the appropriate wiring information for complete PDC and JB fuse, circuit breaker, and circuit identification. This will isolate each circuit and identify the circuit that is the source of the high-amperage IOD. If the amperage reading remains high after removing and replacing each fuse and circuit breaker, disconnect the wire harness from the generator. If the amperage reading now becomes very low or nonexistent, diagnose and repair the Charging System as necessary. After the high-amperage IOD has been corrected, switch the multi-meter to progressively lower amperage scales and, if necessary, repeat the fuse and circuit breaker remove-and-replace process to identify and correct all sources of excessive IOD. It is now safe to select the lowest milliampere scale of the multi-meter to check the low-amperage IOD.

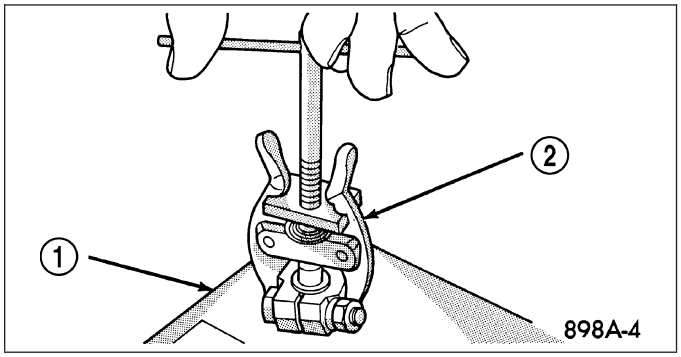
CAUTION: Do not open any doors, or turn on any electrical accessories with the lowest milliampere scale selected, or the multi-meter may be damaged.

6. Observe the multi-meter reading. The low-amperage IOD should not exceed thirty-five milliamperes (0.035 ampere). If the current draw exceeds thirty-five milliamperes, isolate each circuit using the fuse and circuit breaker remove-and-replace process in Step 5. The multi-meter reading will drop to within the acceptable limit

when the source of the excessive current draw is disconnected. Repair this circuit as required; whether a wiring short, incorrect switch adjustment, or an inoperative component is the cause.

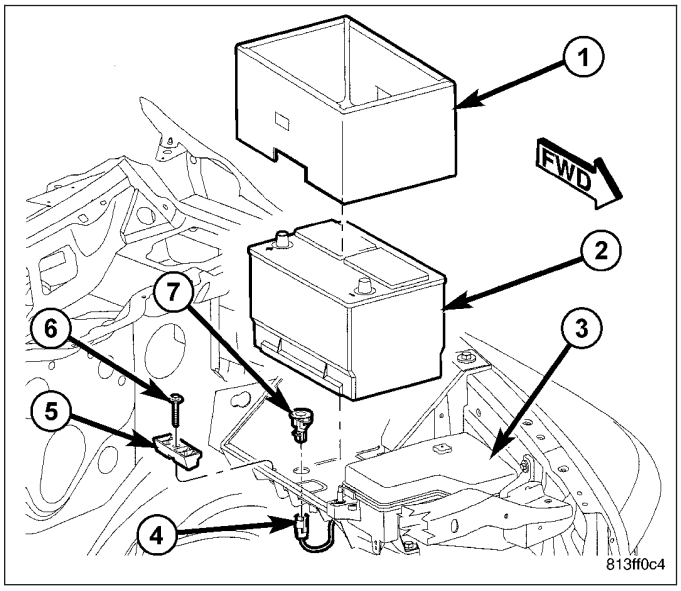
REMOVAL

1. Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
2. Loosen the battery negative cable terminal clamp pinch-bolt hex nut.
3. Disconnect the battery negative cable terminal clamp from the battery negative terminal post. If necessary, use a battery terminal puller (2) to remove the terminal clamp from the battery post.
4. Loosen the battery positive cable terminal clamp pinch-bolt hex nut.
5. Disconnect the battery positive cable terminal clamp from the battery positive terminal post. If necessary, use a battery terminal puller (2) to remove the terminal clamp from the battery post.
6. Remove the battery hold down retaining bolt (6) and battery hold down (5).



WARNING: Wear a suitable pair of rubber gloves (not the household type) when removing a battery by hand. Safety glasses should also be worn. If the battery is cracked or leaking, the electrolyte can burn the skin and eyes.

7. Remove the battery (2) from the battery tray.

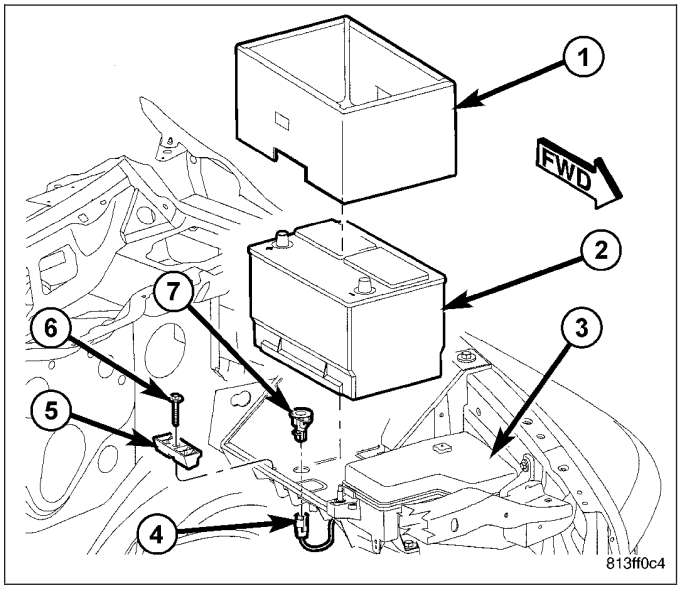


INSTALLATION

1. Clean and inspect the battery (2), (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING) and (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - INSPECTION) for the proper procedures.

CAUTION: Be certain that the battery cable terminal clamps are connected to the correct battery terminal posts. Reversed battery polarity may damage electrical components of the vehicle.

2. Position the battery into the battery tray. Ensure that the battery positive and negative terminal posts are correctly positioned. The battery cable terminal clamps must reach the correct battery terminal post without stretching the cables.
3. Position the battery hold down (5) and install the retaining bolt (6).



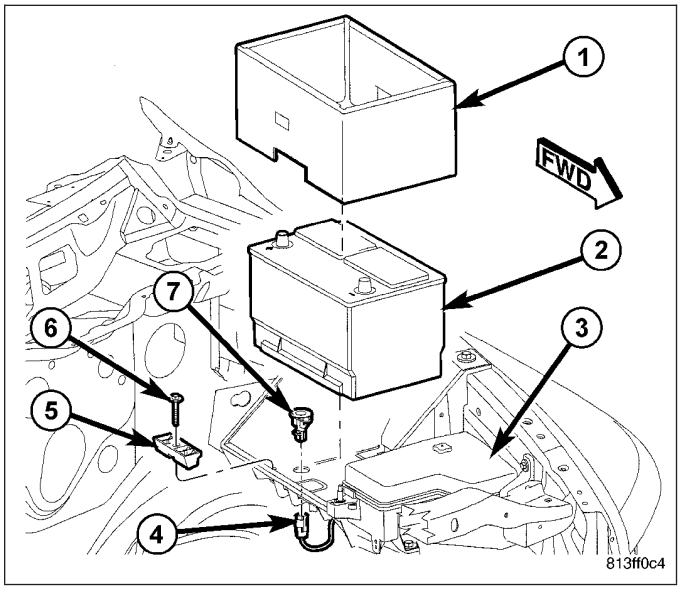
4. Clean the battery cable terminal clamps and the battery terminal posts, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING) for the proper procedures.
5. Reconnect the battery positive cable terminal clamp to the battery positive terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).
6. Reconnect the battery negative cable terminal clamp to the battery negative terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).
7. Apply a thin coating of petroleum jelly or chassis grease to the exposed surfaces of the battery cable terminal clamps and the battery terminal posts.
8. Obtain an appropriate scan tool and check the PCM for any stored battery disconnect trouble codes. Clear codes if required.

BATTERY HOLDDOWN

REMOVAL

CAUTION: Never operate a vehicle without a battery hold down device properly installed. Damage to the vehicle, components and battery could result.

1. Verify that the ignition switch and all accessories are OFF.
2. Disconnect and isolate the battery negative cable.
3. Remove the bolt (6) from the battery hold down bracket (5) and remove the bracket from the vehicle.

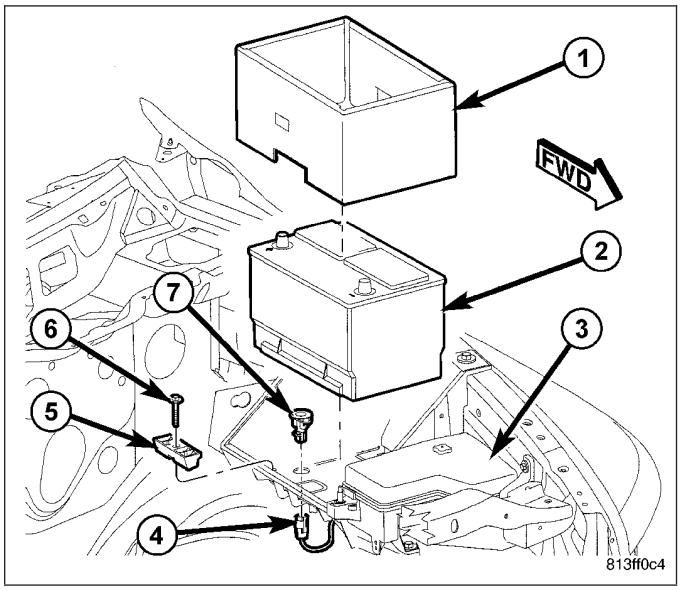


INSTALLATION

1. Clean and inspect the battery hold down bracket (5) and bolt (6) (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING).
2. Position the battery hold down bracket in the battery tray.

CAUTION: Be certain that the hold down bracket is properly positioned in the battery tray before tightening the hold down bolt or damage to the battery and tray may result.

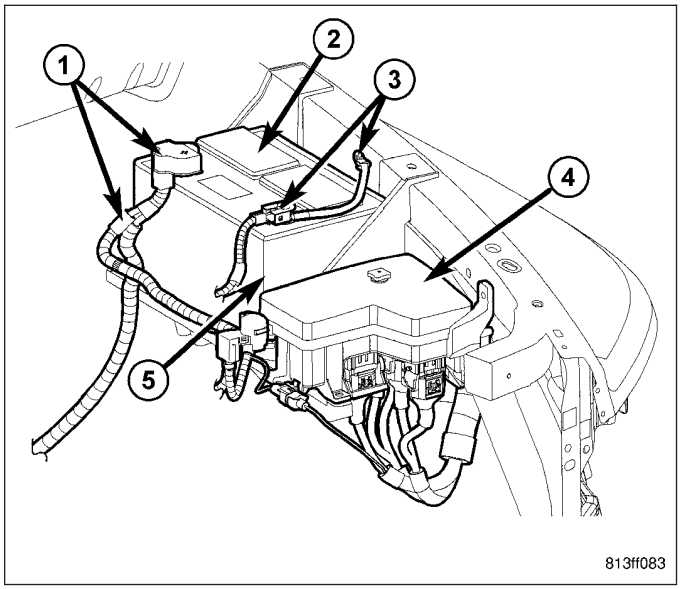
3. Install and tighten the battery hold down retaining bolt.



BATTERY CABLES

DESCRIPTION

The battery cables (1) and (3) are large gauge, stranded copper wires sheathed within a heavy plastic or synthetic rubber insulating jacket. The wire used in the battery cables combines excellent flexibility and reliability with high electrical current carrying capacity. The battery cables feature a stamped brass clamping type female battery terminal crimped onto one end of the battery cable wire and then solder-dipped. A square headed pinch-bolt and hex nut are installed at the open end of the female battery terminal clamp. Large eyelet type terminals are crimped onto the opposite end of the battery cable wire and then solder-dipped. The battery positive cable wires (1) have a red insulating jacket to provide visual identification and feature a larger female battery terminal clamp to allow connection to the larger battery positive terminal post. The battery negative cable wires (3) have a black insulating jacket and a smaller female battery terminal clamp.



The battery cables cannot be repaired and, if damaged or inoperative they must be replaced. Both the battery positive and negative cables are available for service replacement. **Refer to the appropriate wiring information for the location of the proper battery cable wire harness diagrams.** The wiring information also includes proper wire and connector repair procedures, further details on wire harness routing and retention, as well as pin-out and location views for the various wire harness connectors, splices and grounds.

OPERATION

The battery cables connect the battery terminal posts to the vehicle electrical system. These cables also provide a path back to the battery for electrical current generated by the charging system for restoring the voltage potential of the battery. The female battery terminal clamps on the ends of the battery cable wires provide a strong and reliable connection of the battery cable to the battery terminal posts. The terminal pinch bolts allow the female terminal clamps to be tightened around the male terminal posts on the top of the battery. The eyelet terminals secured to the opposite ends of the battery cable wires provide secure and reliable connection of the battery cables to the vehicle electrical system.

DIAGNOSIS AND TESTING

BATTERY CABLES

A voltage drop test will determine if there is excessive resistance in the battery cable terminal connections or the battery cables. If excessive resistance is found in the battery cable connections, the connection point should be disassembled, cleaned of all corrosion or foreign material, then reassembled. Following reassembly, check the voltage drop for the battery cable connection and the battery cable again to confirm repair.

When performing the voltage drop test, it is important to remember that the voltage drop is giving an indication of the resistance between the two points at which the voltmeter probes are attached. **EXAMPLE:** When testing the resistance of the battery positive cable, touch the voltmeter leads to the battery positive cable terminal clamp and to the battery positive cable eyelet terminal at the starter solenoid B(+) terminal stud. If you probe the battery positive terminal post and the battery positive cable eyelet terminal at the starter solenoid B(+) terminal stud, you are reading the combined voltage drop in the battery positive cable terminal clamp-to-terminal post connection and the battery positive cable.

VOLTAGE DROP TEST

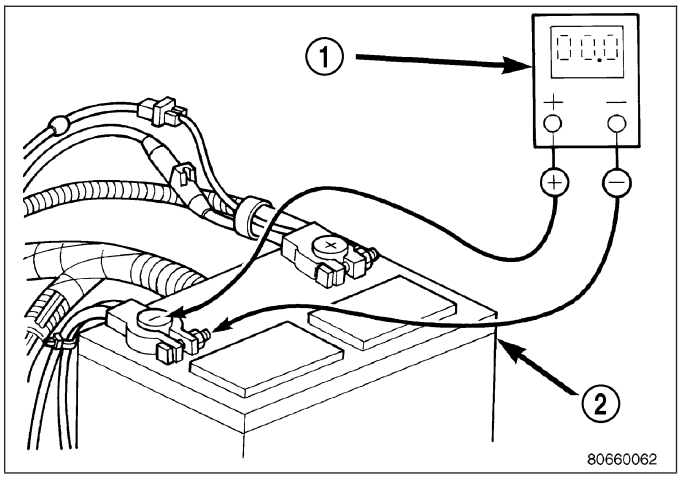
WARNING: Models equipped with a diesel engine have an automatic shutdown (asd) relay located in the power distribution center (pdc). Removal of the asd relay may not prevent the diesel engine from starting. Be certain to disconnect the fuel shutdown solenoid wire harness connector to prevent the engine from starting. Failure to do so may result in personal injury.

The following operation will require a voltmeter accurate to 1/10 (0.10) volt. Before performing this test, be certain that the following procedures are accomplished:

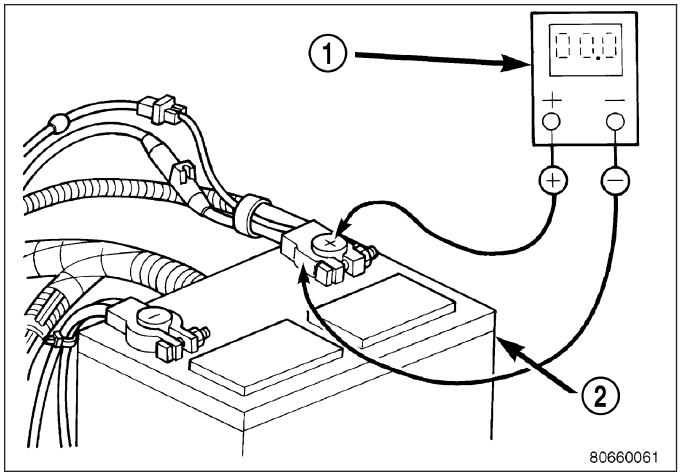
- The battery is fully-charged and tested, (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE - USING MICRO 420 BATTERY TESTER).
- Fully engage the parking brake.
- If the vehicle is equipped with an automatic transmission, place the gearshift selector lever in the Park position. If the vehicle is equipped with a manual transmission, place the gearshift selector lever in the Neutral position and block the clutch pedal in the fully depressed position.
- Verify that all lamps and accessories are turned off.

1. Connect the positive lead of the voltmeter (1) to the battery negative terminal post. Connect the negative lead of the voltmeter to the battery negative cable terminal clamp. Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If voltage is detected, correct the poor connection between the battery negative cable terminal clamp and the battery negative terminal post.

NOTE: If the vehicle is equipped with two 12v batteries, step #1 must be performed twice, once for each battery.

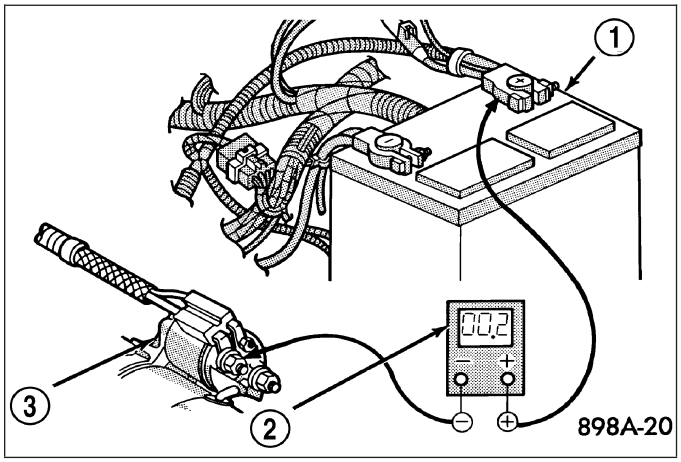


2. Connect the positive lead of the voltmeter (1) to the battery positive terminal post. Connect the negative lead of the voltmeter to the battery positive cable terminal clamp. Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If voltage is detected, correct the poor connection between the battery positive cable terminal clamp and the battery positive terminal post.



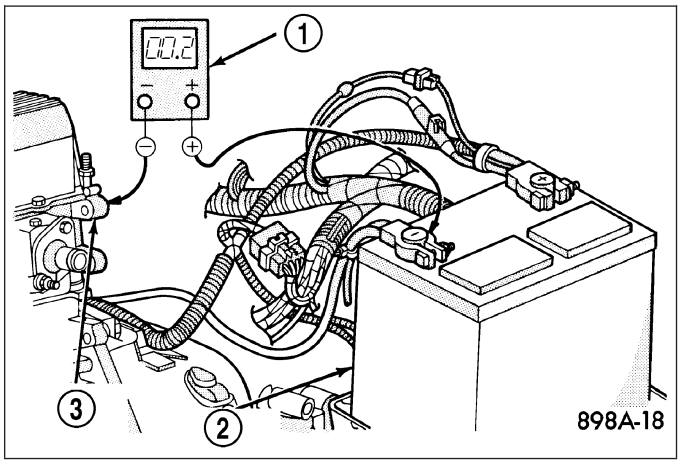
NOTE: If the vehicle is equipped with two 12v batteries, step #2 must be performed twice, once for each battery.

3. Connect the voltmeter (2) to measure between the battery positive cable terminal clamp (1) and the starter solenoid (3) B(+) terminal stud. Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If the reading is above 0.2 volt, clean and tighten the battery positive cable eyelet terminal connection at the starter solenoid B(+) terminal stud. Repeat the test. If the reading is still above 0.2 volt, replace the faulty battery positive cable.



NOTE: If the vehicle is equipped with two 12v batteries, step #3 must be performed twice, once for each battery.

4. Connect the voltmeter (1) to measure between the battery (2) negative cable terminal clamp and a good clean ground on the engine block (3). Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If the reading is above 0.2 volt, clean and tighten the battery negative cable eyelet terminal connection to the engine block. Repeat the test. If the reading is still above 0.2 volt, replace the faulty battery negative cable.

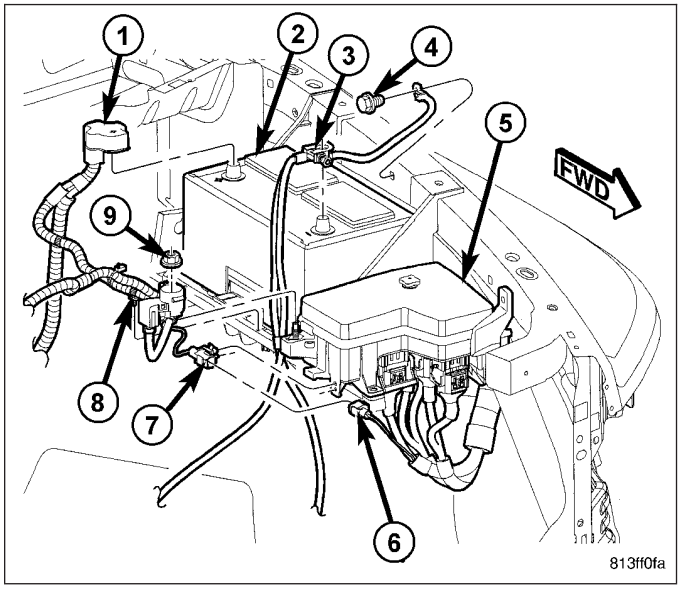


NOTE: If the vehicle is equipped with two 12v batteries, step #4 must be performed twice, once for each battery.

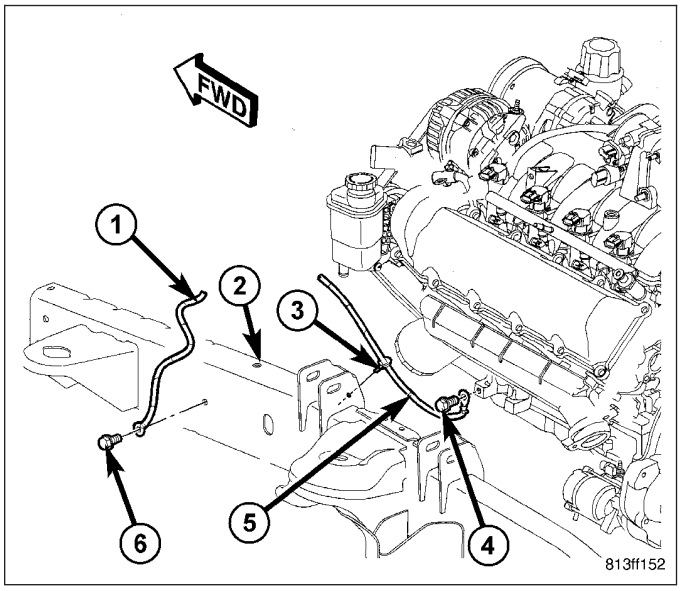
REMOVAL

NEGATIVE - GASOLINE ENGINE

1. Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
2. Disconnect and isolate the battery negative cable terminal clamp (3).
3. Remove the bolt (4) securing the negative cable to the left front fender.

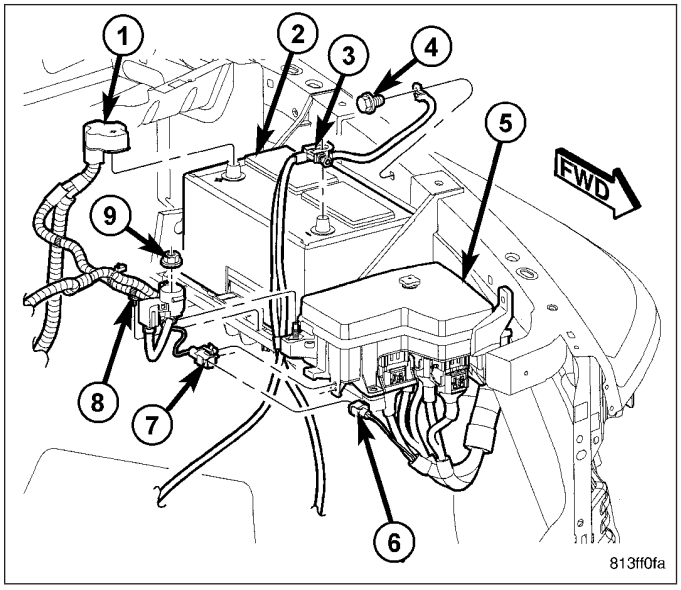


4. One at a time, trace the battery cable retaining pushpins (3) , fasteners and routing clips until the cable is free from the vehicle.
5. Remove the bolt (4) securing the negative cable to the engine.
6. Remove the bolt (6) securing the negative cable to the left frame rail.
7. Remove the battery negative cable from the vehicle.

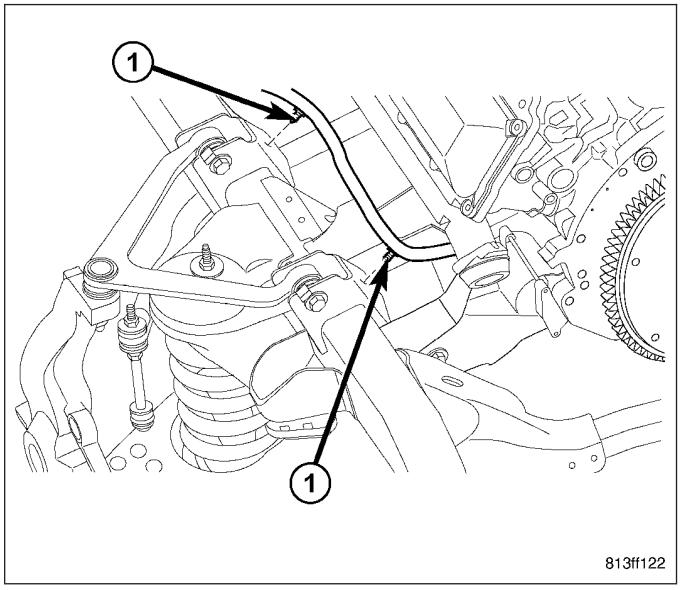


POSITIVE - GASOLINE ENGINE

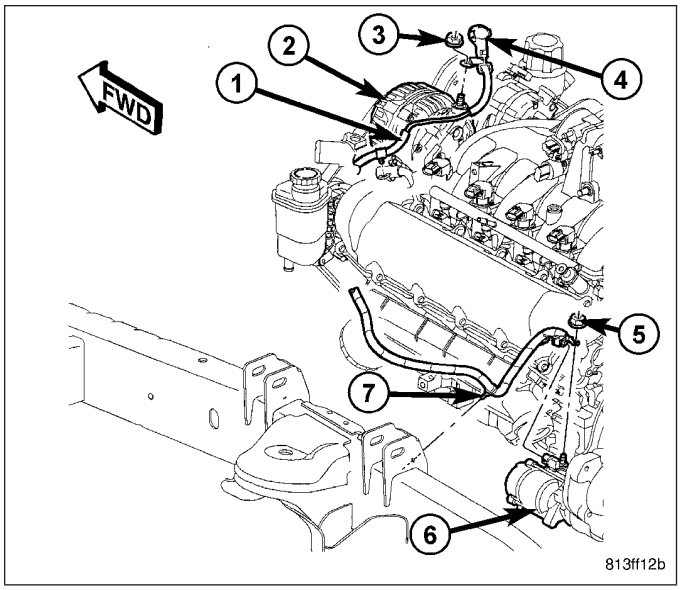
1. Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
2. Disconnect and isolate the battery negative cable terminal clamp (3).
3. Disconnect the battery positive cable terminal clamp (1).
4. Remove the nut (9) securing the cable to the Totally Integrated Power Module (TIPM) (5).
5. Disconnect the wire harness connector (6) at the TIPM.
6. Disconnect the wire harness connector (7) pushpin from the TIPM housing.
7. Disconnect the battery cable retaining pushpin (8) securing the cable to the battery tray.



8. Raise the vehicle on a hoist, (Refer to LUBRICATION & MAINTENANCE/HOISTING - STANDARD PROCEDURE).
9. Disconnect the battery cable retaining pushpins (1) securing the cable to the left frame rail.

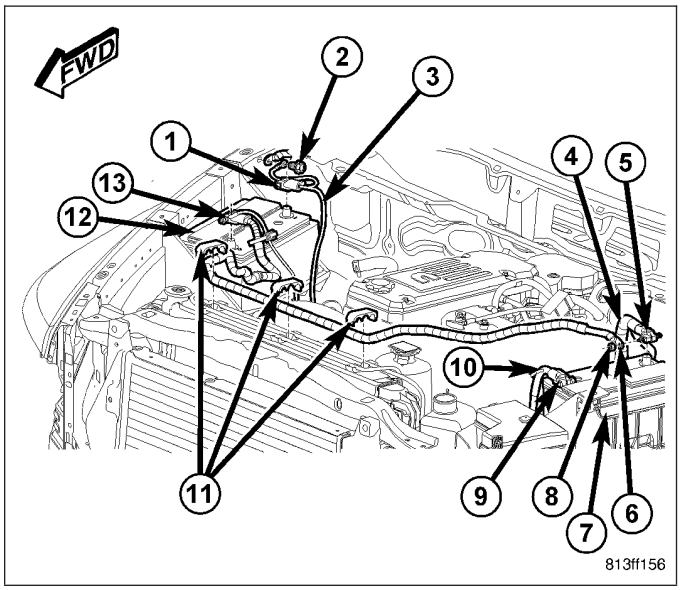


10. Remove the nut (5) securing the cable to the starter solenoid (6).
11. Lower the vehicle.
12. Lift the terminal cap (4) and remove the nut (3) securing the cable (1) to the alternator (2).
13. Disconnect any remaining pushpins securing the cable to the vehicle.
14. Remove the battery positive cable from the vehicle.

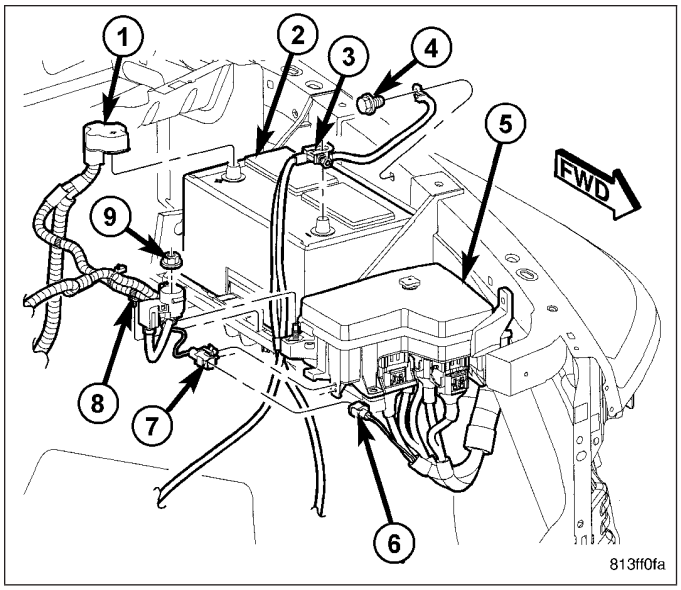


NEGATIVE - DIESEL ENGINE - LEFT

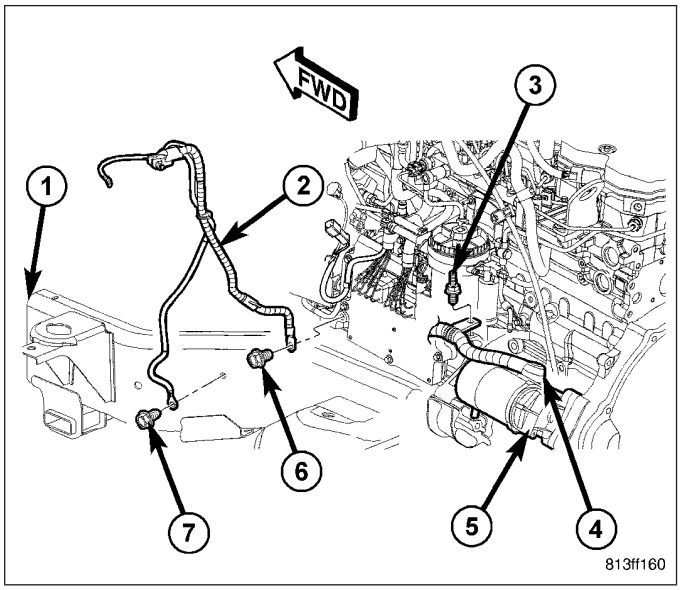
1. Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
2. Disconnect and isolate the battery negative cable terminal clamps (1 and 9).



3. Remove the bolt (4) securing the negative cable to the left front fender.

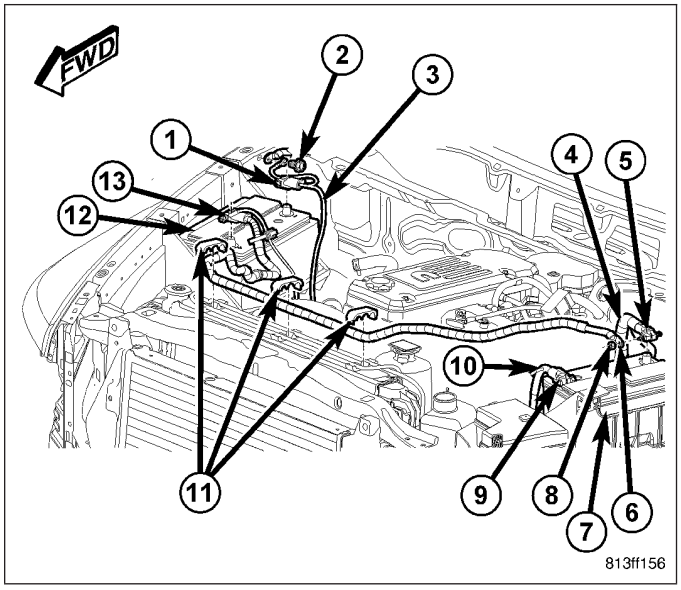


4. Remove the bolt (6) securing the negative cable (2) to the engine.
5. Remove the bolt (7) securing the negative cable (2) to the left frame rail (1).
6. One at a time, trace the battery cable retaining pushpins, fasteners and routing clips until the cable is free from the vehicle.
7. Remove the battery negative cable from the vehicle.

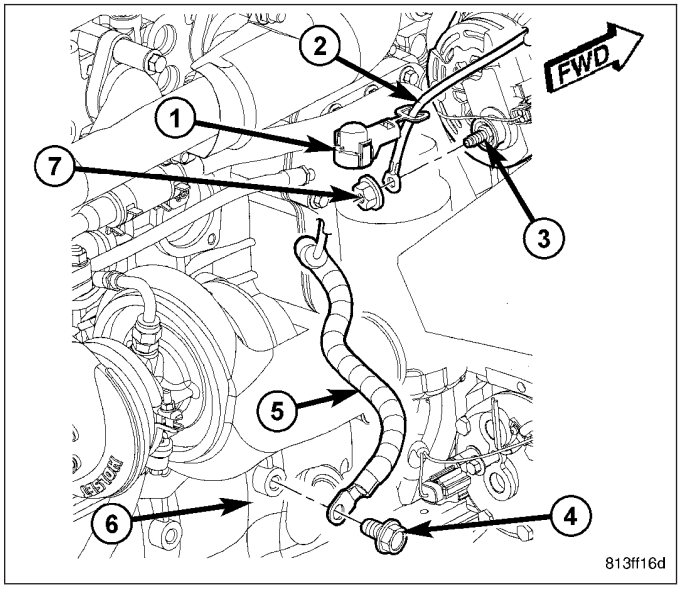


NEGATIVE - DIESEL ENGINE - RIGHT

1. Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
2. Disconnect and isolate the battery negative cable terminal clamps (1 and 9).
3. Remove the bolt (2) securing the negative cable (3) to the right front fender.

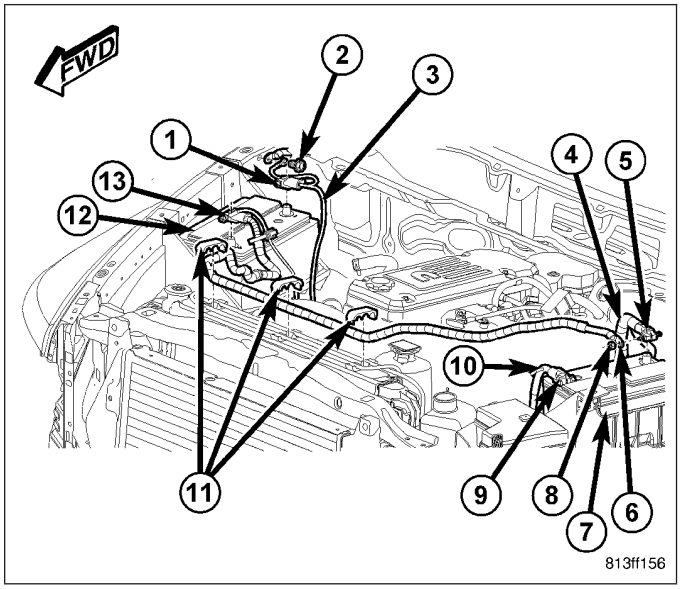


4. Remove the bolt (4) securing the negative cable (5) to the engine (6).
5. One at a time, trace the battery cable retaining pushpins, fasteners and routing clips until the cable is free from the vehicle.
6. Remove the battery negative cable from the vehicle.

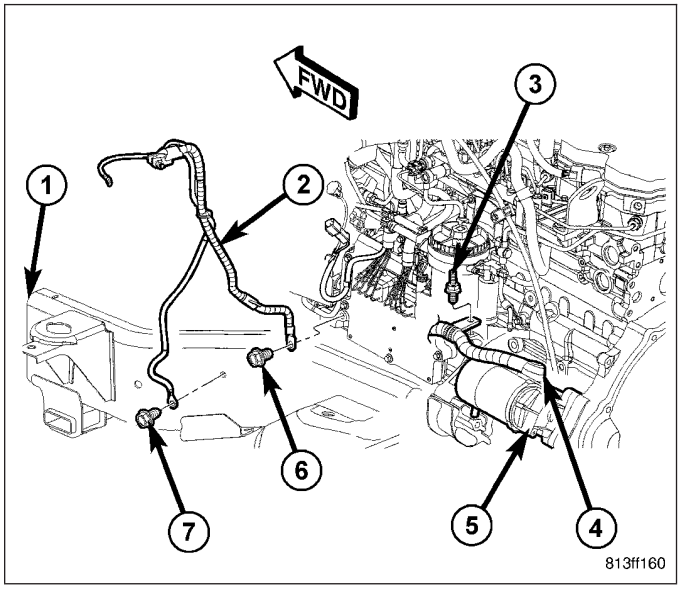


POSITIVE - DIESEL ENGINE - LEFT

1. Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
2. Disconnect and isolate the battery negative cable terminal clamps (1 and 9).
3. Remove the nut (8) securing the right battery positive cable terminal (6) to the left battery positive cable terminal clamp (5).
4. Remove the right cable terminal from the left cable terminal clamp.
5. Disconnect the battery positive cable terminal clamp (5).

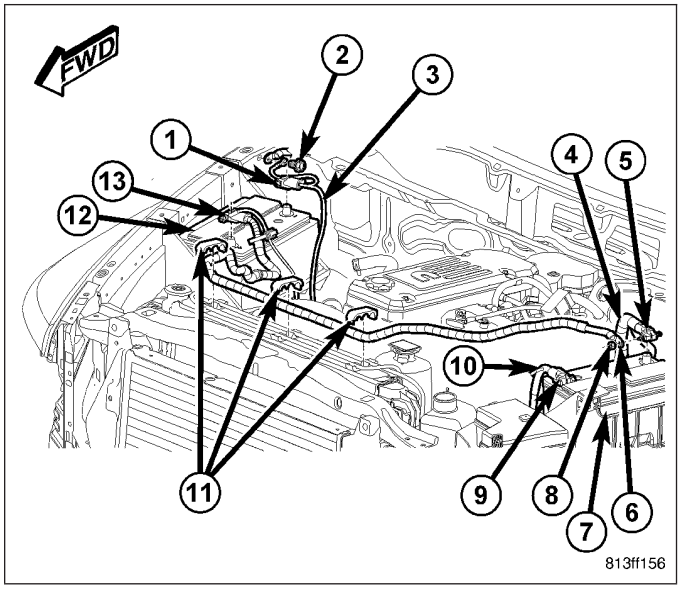


6. Raise the vehicle on a hoist, (Refer to LUBRICATION & MAINTENANCE/HOISTING - STANDARD PROCEDURE).
7. Remove the stud bolt (3) securing the cable to the engine.
8. Lift the terminal cover (4) and remove the nut securing the cable to the starter solenoid (5).
9. Lower the vehicle.
10. One at a time, trace the battery cable retaining pushpins, fasteners and routing clips until the cable is free from the vehicle.
11. Remove the battery positive cable from the vehicle.

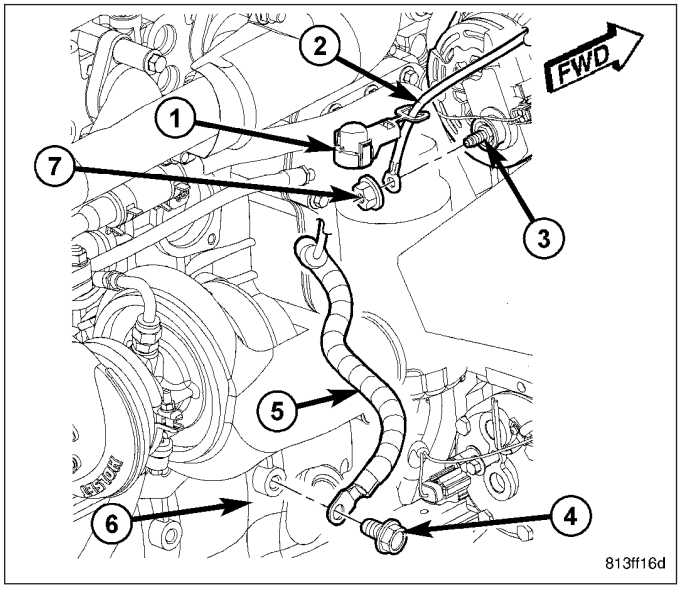


POSITIVE - DIESEL ENGINE - RIGHT

1. Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
2. Disconnect and isolate the battery negative cable terminal clamps (1 and 9).
3. Remove the nut (8) securing the right battery positive cable terminal (6) to the left battery positive cable terminal clamp (5).
4. Remove the right cable terminal from the left cable terminal clamp.
5. Remove the battery cable fastener clips (11) to free the cable from the vehicle.
6. Disconnect the right battery positive cable terminal clamp (13).



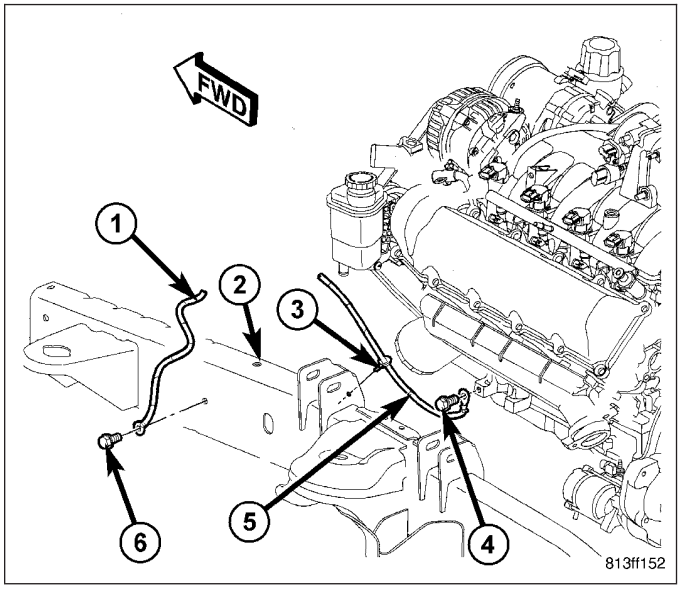
7. Lift the terminal cover (1) and remove the nut (7) securing the cable (2) to the alternator (3).
8. One at a time, trace the battery cable retaining pushpins, fasteners and routing clips until the cable is free from the vehicle.
9. Remove the battery positive cable from the vehicle.



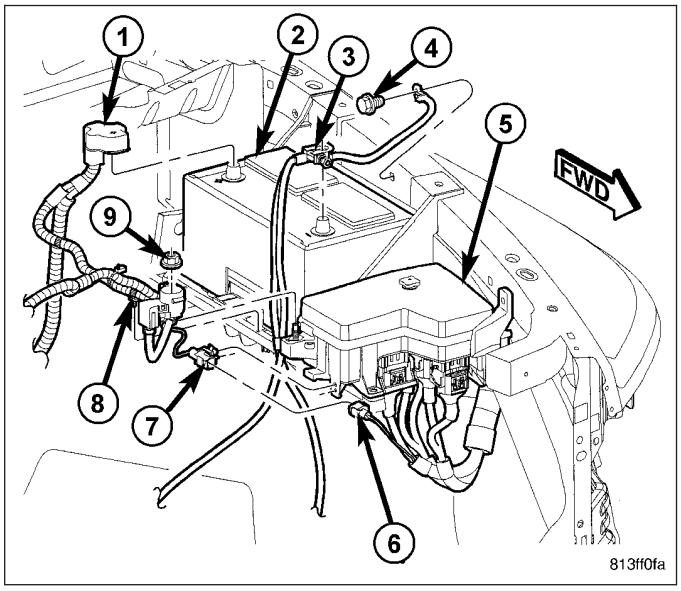
INSTALLATION

NEGATIVE - GASOLINE ENGINE

1. Position the battery negative cable (5) in the vehicle.
2. One at a time, install the battery cable retaining pushpins (3) , fasteners and routing clips until the cable is secure in the vehicle.
3. Install the bolt (6) securing the negative cable (1) to the left frame rail.
4. Install the bolt (4) securing the negative cable (5) to the engine.

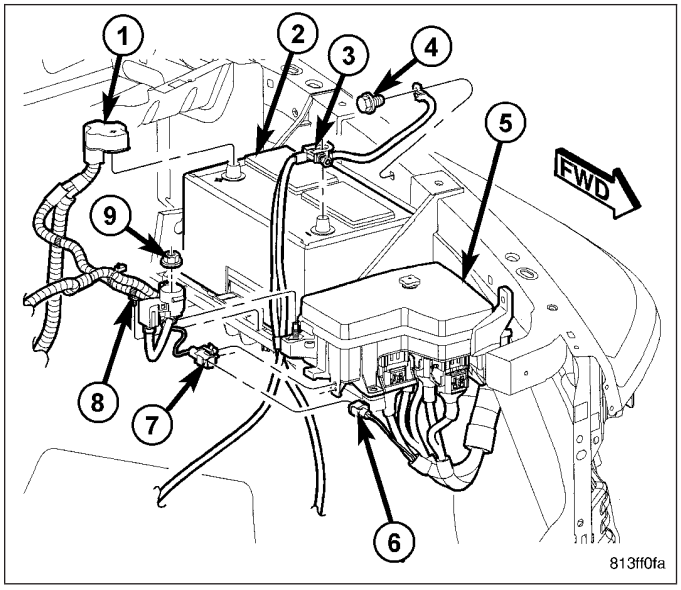


5. Install the bolt (4) securing the negative cable (3) to the left front fender.
6. Connect the battery negative cable terminal clamp (3).
7. Check the vehicle for normal operation.

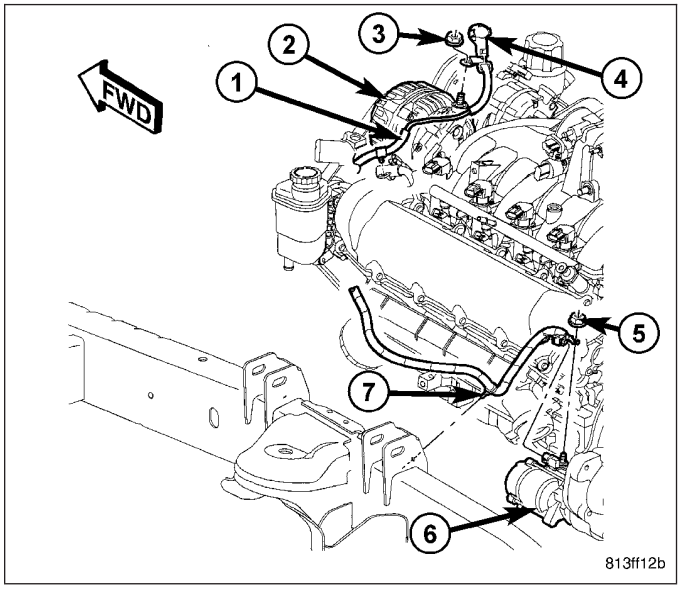


POSITIVE - GASOLINE ENGINE

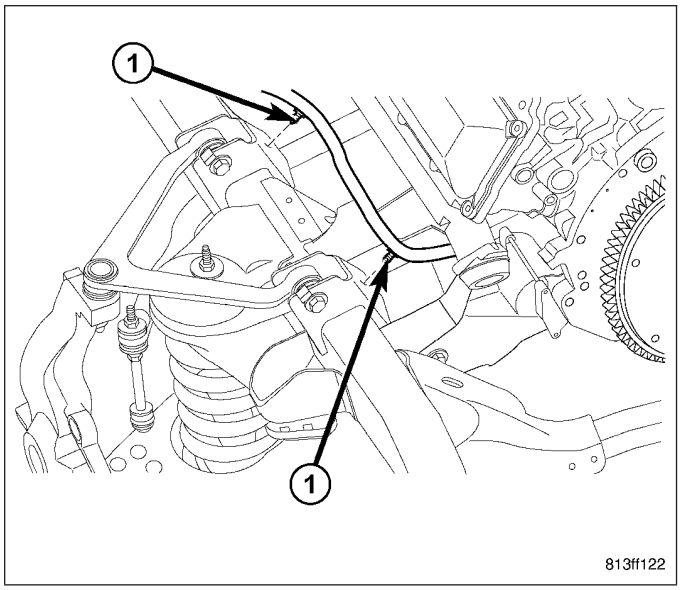
1. Position the battery positive cable (1) in the vehicle.



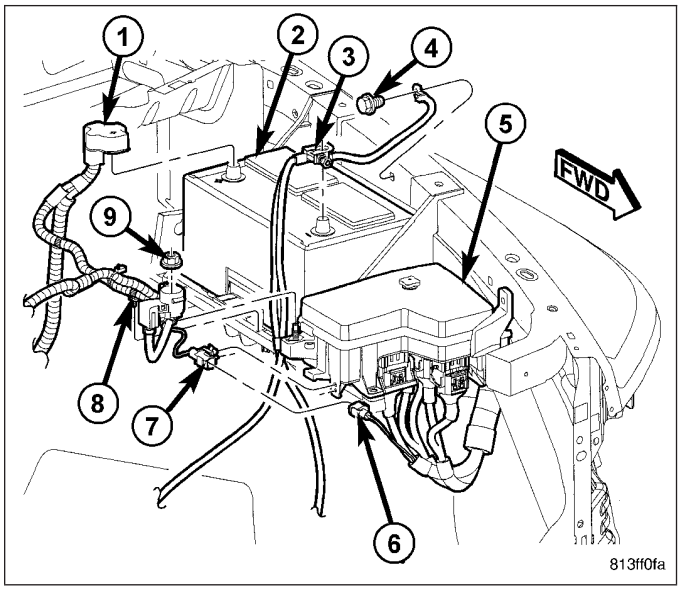
2. Install the nut (3) securing the cable (1) to the alternator (2).
3. Secure the terminal cap (4) to the alternator stud.
4. Install the cable (1) pushpin into the bracket to the left of the alternator.
5. Raise the vehicle on a hoist, (Refer to LUBRICATION & MAINTENANCE/HOISTING - STANDARD PROCEDURE).
6. Install the nut (5) securing the cable to the starter solenoid (6).



7. Connect the battery cable retaining pushpins (1) securing the cable to the left frame rail.
8. Lower the vehicle.

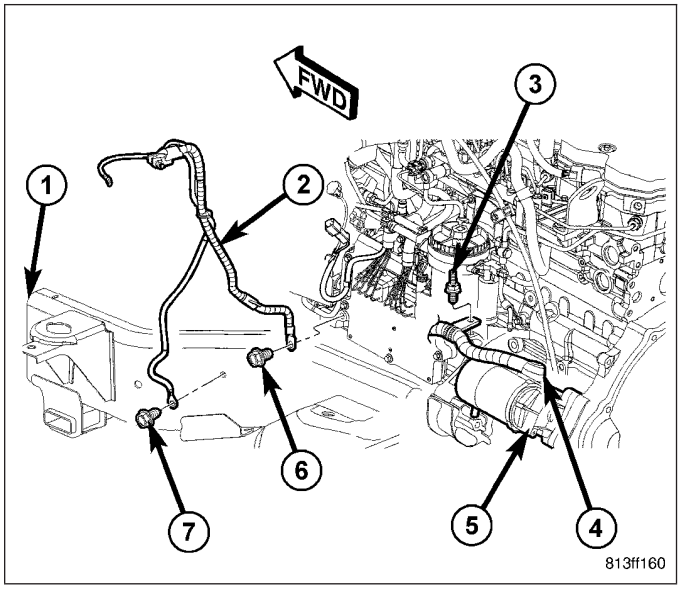


9. Install the battery cable retaining pushpin (8) securing the cable to the battery tray.
10. Install the wire harness connector (7) pushpin into the Totally Integrated Power Module (TIPM) (5) housing.
11. Connect the wire harness connector (6) at the TIPM.
12. Install the nut (9) securing the cable to the TIPM.
13. Connect the battery positive cable terminal clamp (1).
14. Connect the battery negative cable terminal clamp (3).
15. Check the vehicle for normal operation.

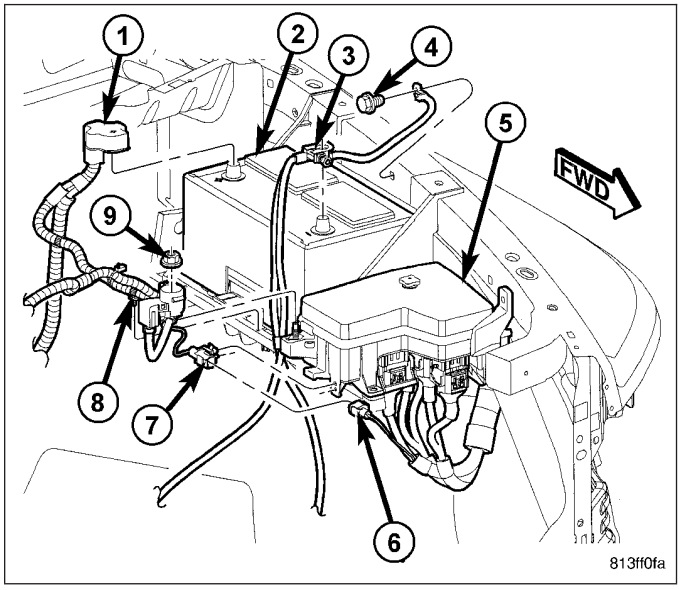


NEGATIVE - DIESEL ENGINE - LEFT

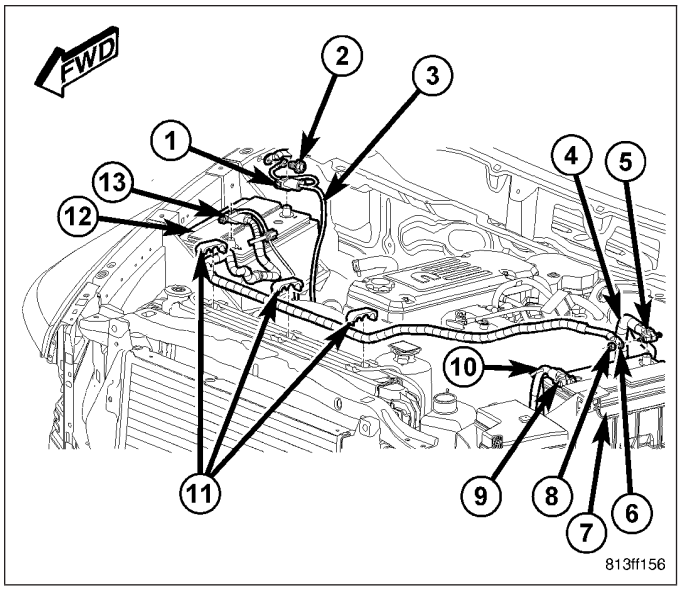
1. Position the battery negative cable (2) in the vehicle.
2. One at a time, install the battery cable retaining pushpins, fasteners and routing clips until the cable is secure in the vehicle.
3. Install the bolt (7) securing the negative cable (2) to the left frame rail (1).
4. Install the bolt (6) securing the negative cable (2) to the engine.



5. Install the bolt (4) securing the negative cable to the left front fender.

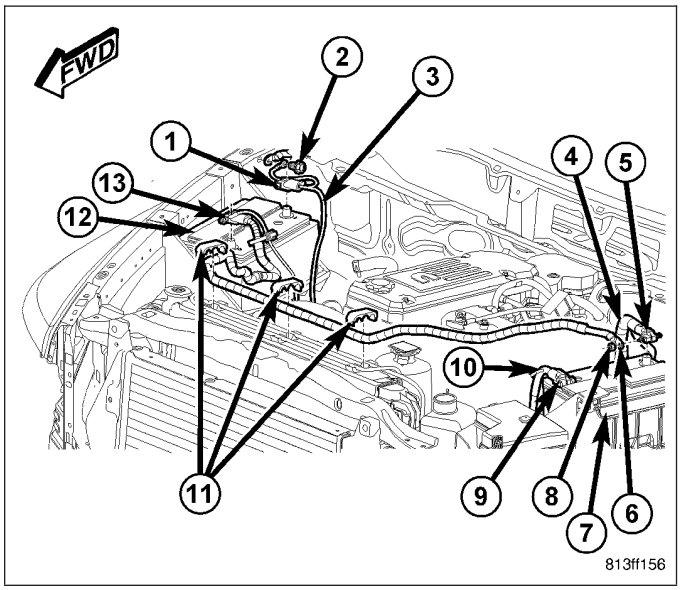


6. Connect the battery negative cable terminal clamps (1 and 9).
7. Check the vehicle for normal operation.

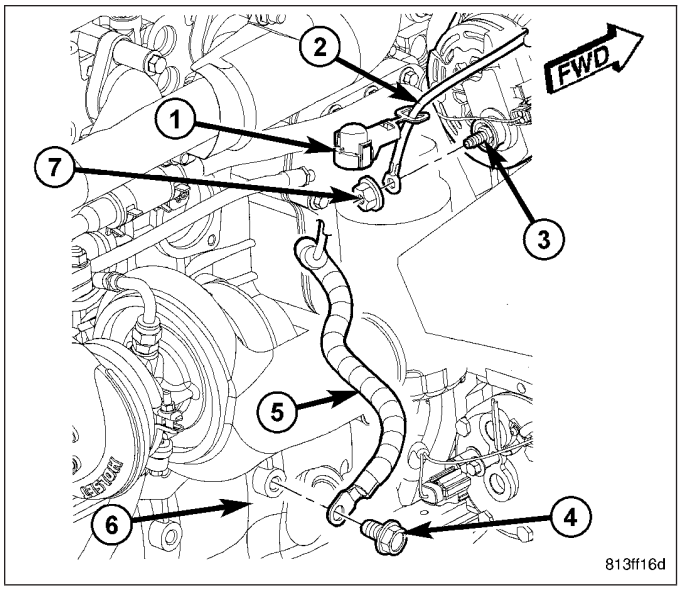


NEGATIVE - DIESEL ENGINE - RIGHT

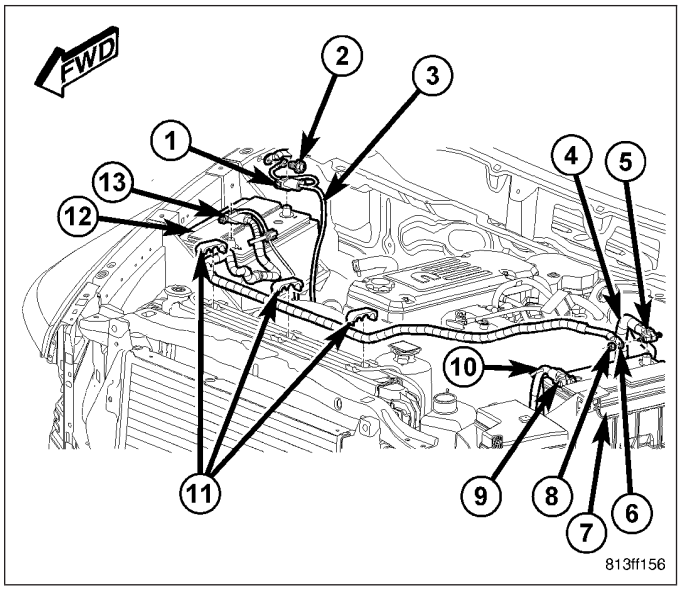
1. Position the battery negative cable (3) in the vehicle.
2. One at a time, install the battery cable retaining pushpins, fasteners and routing clips until the cable is secure in the vehicle.
3. Install the bolt (2) securing the negative cable to the right front fender.



4. Install the bolt (4) securing the negative cable (5) to the engine (6).

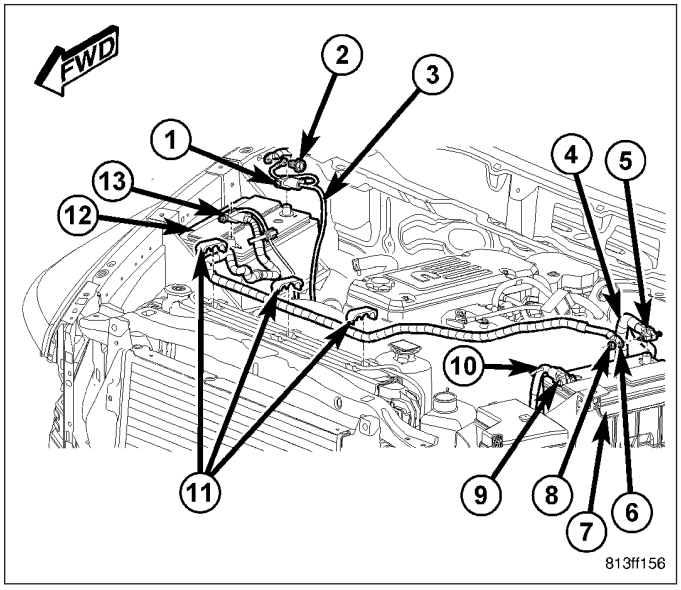


5. Connect the battery negative cable terminal clamps (1 and 9).
6. Check the vehicle for normal operation.

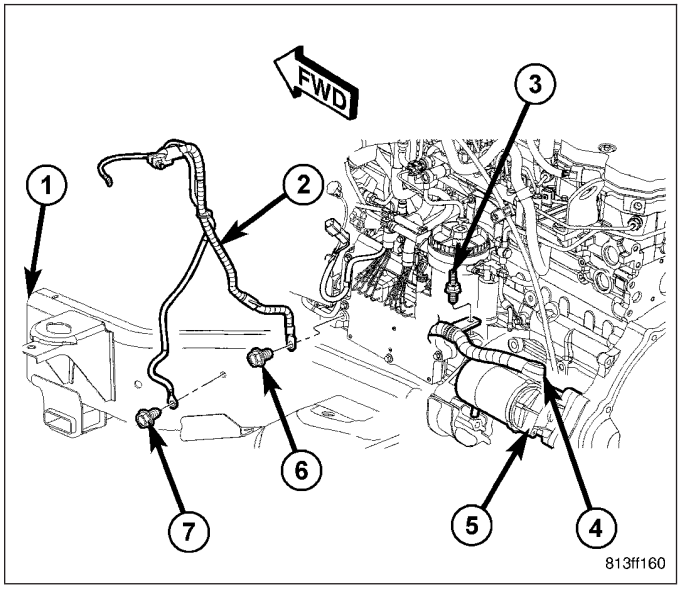


POSITIVE - DIESEL ENGINE - LEFT

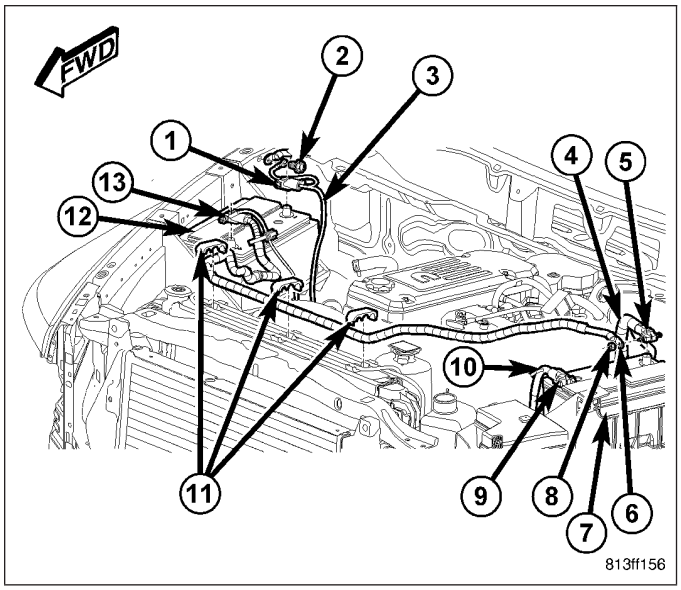
1. Position the battery positive cable (4) in the vehicle.
2. One at a time, install the battery cable retaining pushpins, fasteners and routing clips until the cable is secure in the vehicle.



3. Raise the vehicle on a hoist, (Refer to LUBRICATION & MAINTENANCE/HOISTING - STANDARD PROCEDURE).
4. Install the nut securing the cable to the starter solenoid (5) and secure the terminal cover (4) in place.
5. Install the stud bolt (3) securing the cable to the engine.
6. Lower the vehicle.

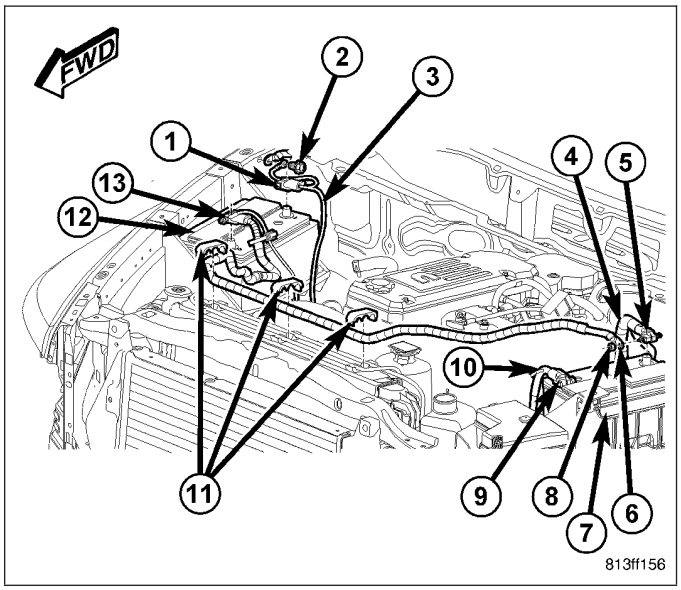


7. Install the battery positive cable terminal clamp (5).
8. Install the right battery positive cable terminal (6) onto the left cable terminal clamp (5).
9. Install the nut (8) securing the right cable terminal (6) to the left positive battery cable terminal clamp (5).
10. Connect the battery negative cable terminal clamps (1 and 9).
11. Check the vehicle for normal operation.

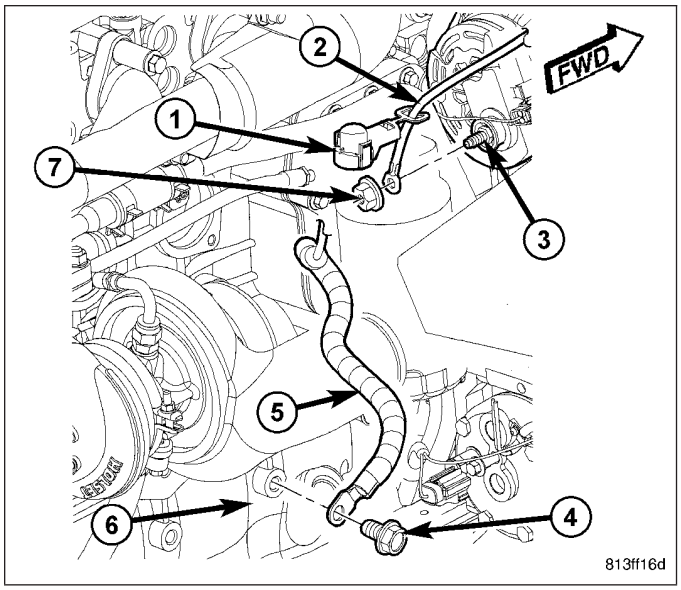


POSITIVE - DIESEL ENGINE - RIGHT

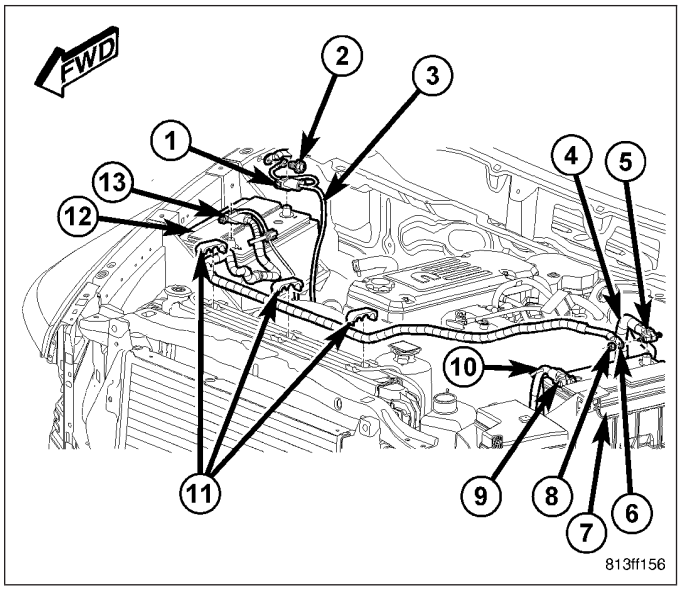
1. Position the right battery positive cable (13) in the vehicle.
2. After positioning the cable install the battery cable fastener clips (11) to the vehicle.
3. Install the right battery positive cable terminal (6) to the left battery positive cable terminal clamp (5).
4. Install the nut (8) securing the right cable terminal (6) to the left cable terminal clamp (5).
5. Connect the right battery positive cable terminal clamp (13).



6. Lift the terminal cover (1) and install the nut (7) securing the cable (2) to the alternator (3). Secure the terminal cover to the alternator.



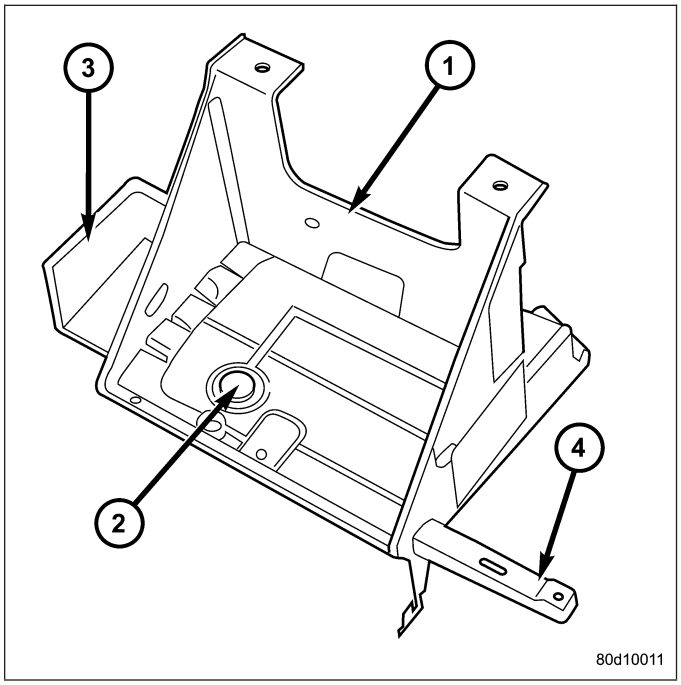
7. Connect the battery negative cable terminal clamps (1 and 9).
8. Check the vehicle for normal operation.



BATTERY TRAY

DESCRIPTION

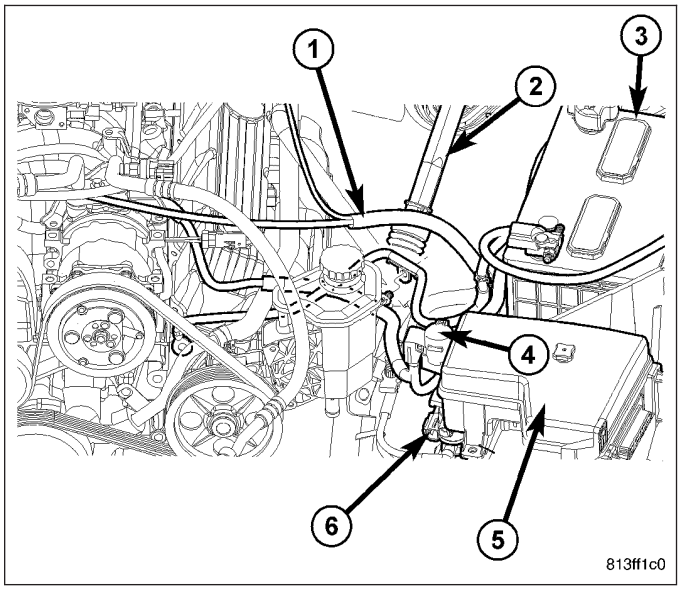
The molded plastic battery tray (1) is located in the left front corner of the engine compartment. On this vehicle, the battery tray also provides an anchor point for the anti-lock brake controller (3), cruise control servo (if equipped) and the integrated power module (4). The battery hold down hardware is contained within the battery tray. A hole in the bottom of the battery tray (2) is fitted with a battery temperature sensor. (Refer to 8 - ELECTRICAL/CHARGING - DIAGNOSIS AND TESTING) for additional information on the battery temperature sensor.



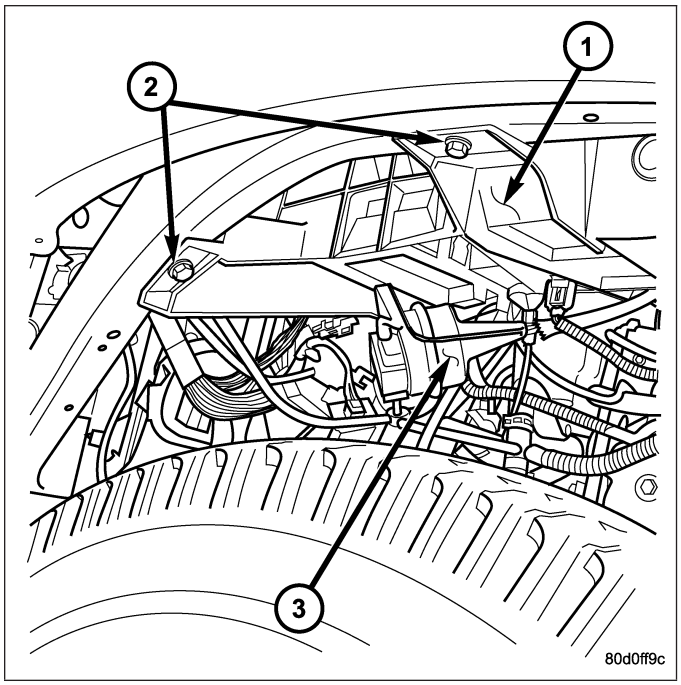
REMOVAL

LEFT SIDE

1. Remove the battery (3) from the battery tray (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - REMOVAL).
2. Remove the Totally Integrated Power Module (TIPM) (5) (Refer to 8 - ELECTRICAL/POWER DISTRIBUTION/INTELLIGENT POWER MODULE - REMOVAL).
3. Disconnect the wire harness retainers from the battery tray assembly.
4. Disconnect the purge solenoid (6) from its mounting bracket.
5. Remove the anti-lock brake controller (if equipped) retaining bolts and support the brake controller with mechanics wire. It is not necessary to completely remove the anti-lock brake control unit.
6. Remove the left front wheelhouse splash shield (Refer to 23 - BODY/EXTERIOR/LF WHEELHOUSE SPLASH SHIELD - REMOVAL).

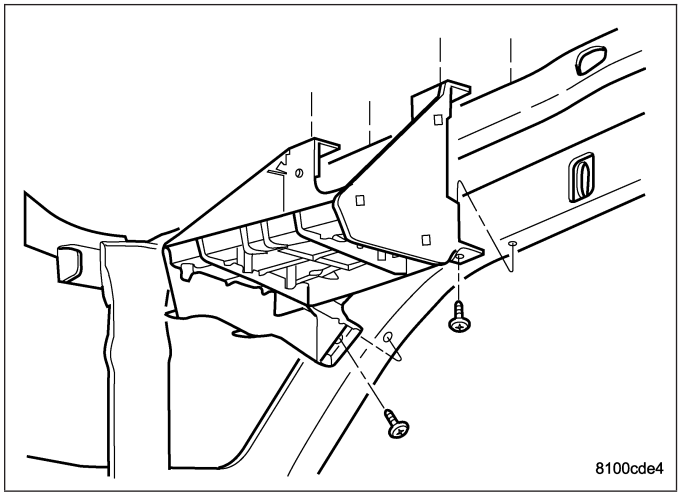


7. Mark the location of the cruise servo (3) (if equipped) and remove the retaining screws. Position the servo out of the way.
8. Remove the battery temperature sensor from the battery tray (Refer to 8 - ELECTRICAL/CHARGING/BATTERY TEMPERATURE SENSOR - REMOVAL).
9. Disconnect the left front fender ground wire.
10. Remove the remaining battery tray retaining bolts (2).
11. Remove the battery tray from the vehicle.



RIGHT SIDE

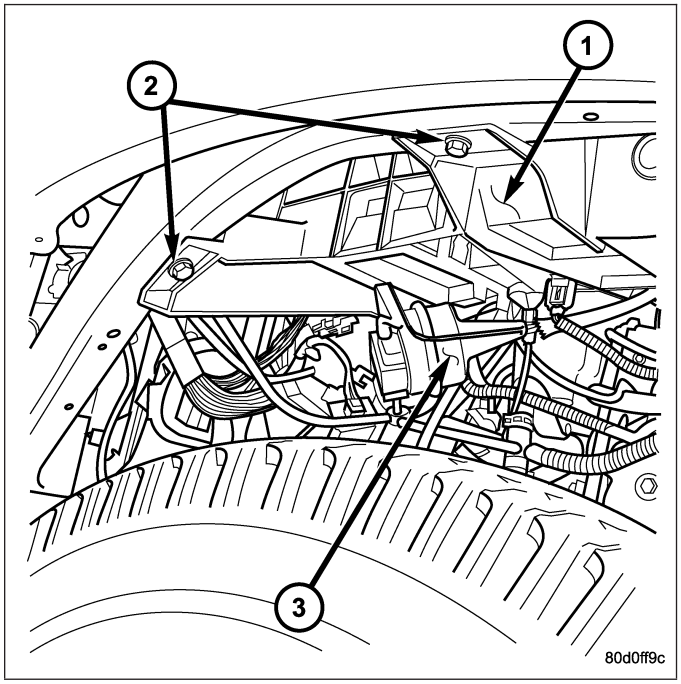
1. Remove the battery from the battery tray (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - REMOVAL).
2. Remove the right front wheelhouse splash shield, (Refer to 23 - BODY/EXTERIOR/LF WHEELHOUSE SPLASH SHIELD - REMOVAL).
3. Disconnect the right front fender ground wire.
4. Remove fasteners from grid heater relay bracket.
5. Remove air box.
6. Remove the remaining battery tray retaining bolts.
7. Remove the battery tray from the vehicle.



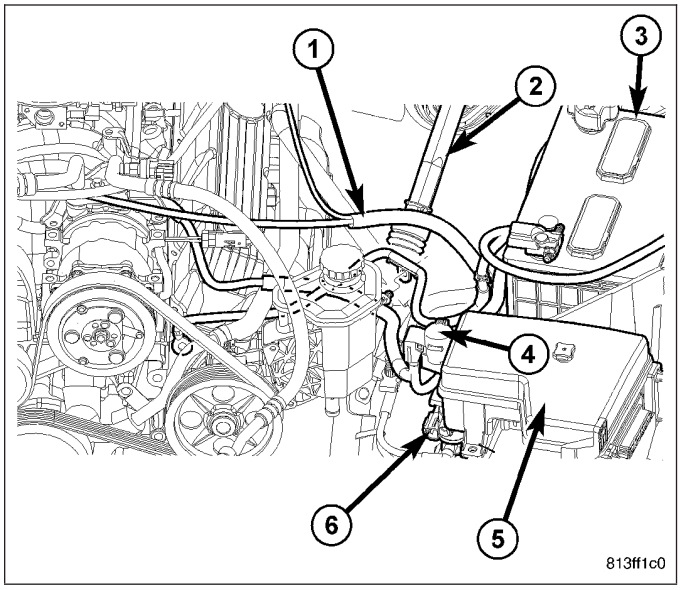
INSTALLATION

LEFT SIDE

1. Position the battery tray assembly (1) and install the retaining bolts (2).
2. Connect the left front fender ground wire.
3. Install the battery temperature sensor in the battery tray (Refer to 8 - ELECTRICAL/CHARGING/BATTERY TEMPERATURE SENSOR - INSTALLATION).
4. Install the cruise servo (3) (if equipped) and retaining screws.
5. Install the left front wheelhouse splash shield (Refer to 23 - BODY/EXTERIOR/LF WHEELHOUSE SPLASH SHIELD - INSTALLATION).

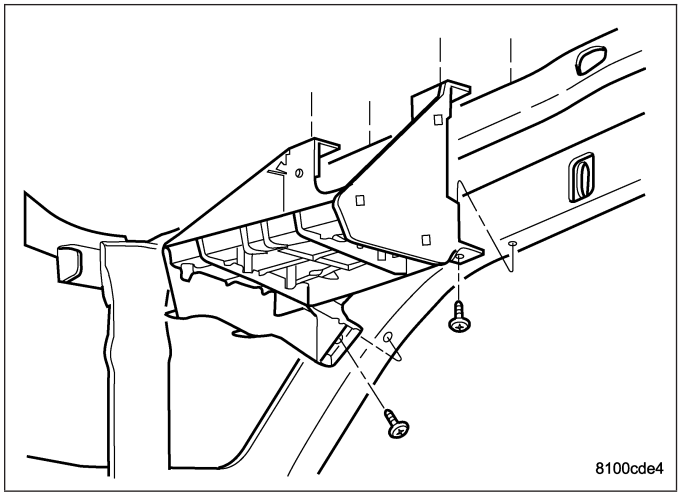


6. Install the anti-lock brake controller (if equipped).
7. Install the purge solenoid (6) on its mounting bracket.
8. Connect the wire harness retainers on the battery tray assembly.
9. Install the Totally Integrated Power Module (TIPM) (5) (Refer to 8 - ELECTRICAL/POWER DISTRIBUTION/INTELLIGENT POWER MODULE - INSTALLATION).
10. Install the battery (3) (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - INSTALLATION).



RIGHT SIDE

1. Position the battery tray assembly and install the retaining bolts.
2. Connect the right front fender ground wire.
3. Install the air box.
4. Install the grid heater relay bracket.
5. Install the right front wheelhouse splash shield (Refer to 23 - BODY/EXTERIOR/LF WHEELHOUSE SPLASH SHIELD - INSTALLATION).
6. Install the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - INSTALLATION).



CHARGING

TABLE OF CONTENTS

CHARGING

DESCRIPTION

The charging system consists of:

- Generator
- Electronic Voltage Regulator (EVR) circuitry within the Powertrain Control Module (PCM). Electronic Control Module (ECM) for diesel engines.
- Ignition switch
- Battery (refer to 8, Battery for information)
- Battery temperature sensor
- Check Gauges Lamp (if equipped)
- Voltmeter (refer to 8, Instrument Panel and Gauges for information)
- Wiring harness and connections (refer to 8, Wiring Diagrams for information)

OPERATION

The charging system is turned on and off with the ignition switch. The system is on when the engine is running and the ASD relay is energized. When the ASD relay is on, voltage is supplied to the ASD relay sense circuit at the PCM (ECM Diesel). This voltage is connected through the PCM (ECM Diesel) and supplied to one of the generator field terminals (Gen. Source +) at the back of the generator.

The amount of direct current produced by the generator is controlled by the EVR (field control) circuitry contained within the PCM (ECM Diesel). This circuitry is connected in series with the second rotor field terminal and ground.

A battery temperature sensor, located in the battery tray housing, is used to sense battery temperature. This temperature data, along with data from monitored line voltage, is used by the PCM (ECM Diesel) to vary the battery charging rate. This is done by cycling the ground path to control the strength of the rotor magnetic field. The PCM then compensates and regulates generator current output accordingly.

All vehicles are equipped with On-Board Diagnostics (OBD). All OBD-sensed systems, including EVR (field control) circuitry, are monitored by the PCM (ECM Diesel). Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for certain failures it detects.

The Check Gauges Lamp (if equipped) monitors: **charging system voltage,** engine coolant temperature and engine oil pressure. If an extreme condition is indicated, the lamp will be illuminated. This is done as reminder to check the three gauges. The signal to activate the lamp is sent via the CCD bus circuits. The lamp is located on the instrument panel. Refer to 8, Instrument Panel and Gauges for additional information.

DIAGNOSIS AND TESTING - CHARGING SYSTEM

The following procedures may be used to diagnose the charging system if:

- the check gauges lamp (if equipped) is illuminated with the engine running
- the voltmeter (if equipped) does not register properly
- an undercharged or overcharged battery condition occurs.

Remember that an undercharged battery is often caused by:

- accessories being left on with the engine not running
- a faulty or improperly adjusted switch that allows a lamp to stay on. Refer to Ignition-Off Draw Test in 8, Battery for more information.

INSPECTION

The PCM (Powertrain Control Module), or ECM (Diesel) monitors critical input and output circuits of the charging system, making sure they are operational. A Diagnostic Trouble Code (DTC) is assigned to each input and output circuit monitored by the On-Board Diagnostic (OBD) system. Some charging system circuits are checked continuously, and some are checked only under certain conditions.

Refer to Diagnostic Trouble Codes in; Powertrain Control Module; Electronic Control Modules for more DTC information.

To perform a complete test of the charging system, refer to the appropriate Powertrain Diagnostic Procedures service manual and the DRB® scan tool. Perform the following inspections before attaching the scan tool.

1. Inspect the battery condition. Refer to 8, Battery for procedures.
2. Inspect condition of battery cable terminals, battery posts, connections at engine block, starter solenoid and relay. They should be clean and tight. Repair as required.
3. Inspect all fuses in both the fuseblock and Power Distribution Center (PDC) for tightness in receptacles. They should be properly installed and tight. Repair or replace as required.
4. Inspect generator mounting bolts for tightness. Replace or tighten bolts if required. Refer to the Generator Removal/Installation section of this group for torque specifications.
5. Inspect generator drive belt condition and tension. Tighten or replace belt as required. Refer to Belt Tension Specifications in 7, Cooling System.
6. Inspect automatic belt tensioner (if equipped). Refer to 7, Cooling System for information.
7. Inspect generator electrical connections at generator field, battery output, and ground terminal (if equipped). Also check generator ground wire connection at engine (if equipped). They should all be clean and tight. Repair as required.

SPECIFICATIONS

GENERATOR RATINGS

TYPE	RATED SAE AMPS	ENGINES
DENSO	136	3.7L / 4.7L
BOSCH	136	3.7L / 4.7L
DENSO	136	5.7L Gas/5.9L Diesel
BOSCH	136	5.7L Gas/5.9L Diesel

TORQUE - GENERATOR / CHARGING SYSTEM

DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Generator Mounting Bolts - 5.7L	41	30	-
Generator Support Bracket Bolt/Nuts - 5.7L	41	30	-
Generator Upper Mounting Bolt - 5.9L Diesel Engine	41	30	-
Generator Vertical Mounting Bolt - 3.7L / 4.7L Engines	55	40	-
Generator (long) Horizontal Mounting Bolt - 3.7L / 4.7L Engines	55	40	-
Generator (short) Horizontal Mounting Bolt - 3.7L / 4.7L Engines	74	55	-
Generator Upper & Lower Mounting Bolt - 8.3L Engine	55	41	-
Generator B+ Output Cable Terminal Nut	12	-	108

SENSOR-BATTERY TEMPERATURE

DESCRIPTION

The Battery Temperature Sensor (BTS) is attached to the battery tray located under the battery.

OPERATION

The BTS is used to determine the battery temperature and control battery charging rate. This temperature data, along with data from monitored line voltage, is used by the PCM (ECM Diesel) to vary the battery charging rate. System voltage will be higher at colder temperatures and is gradually reduced at warmer temperatures.

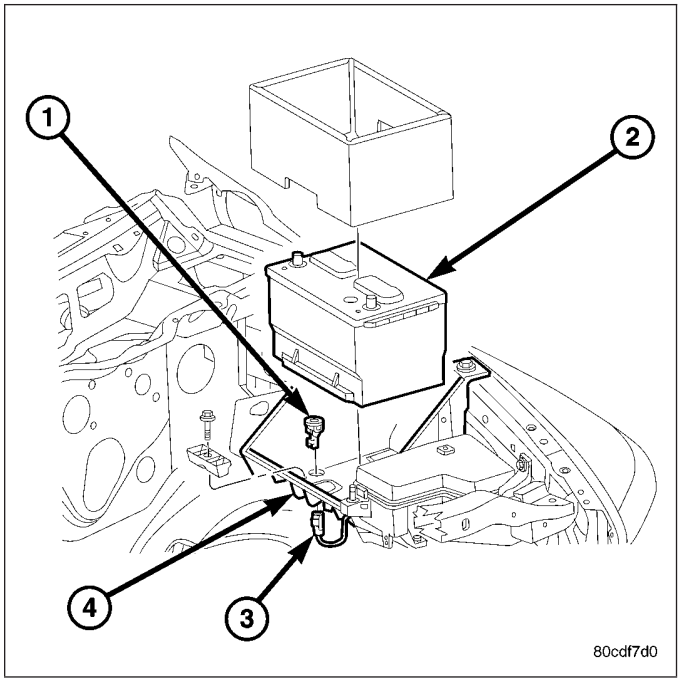
The PCM sends 5 volts to the sensor and is grounded through the sensor return line. As temperature increases, resistance in the sensor decreases and the detection voltage at the PCM increases.

The BTS is also used for OBD II diagnostics. Certain faults and OBD II monitors are either enabled or disabled, depending upon BTS input (for example, disable purge and enable Leak Detection Pump (LDP) and O2 sensor heater tests). Most OBD II monitors are disabled below 20°F.

REMOVAL

The battery temperature sensor (1) is located under the vehicle battery and is attached (snapped into) a mounting hole on battery tray (4).

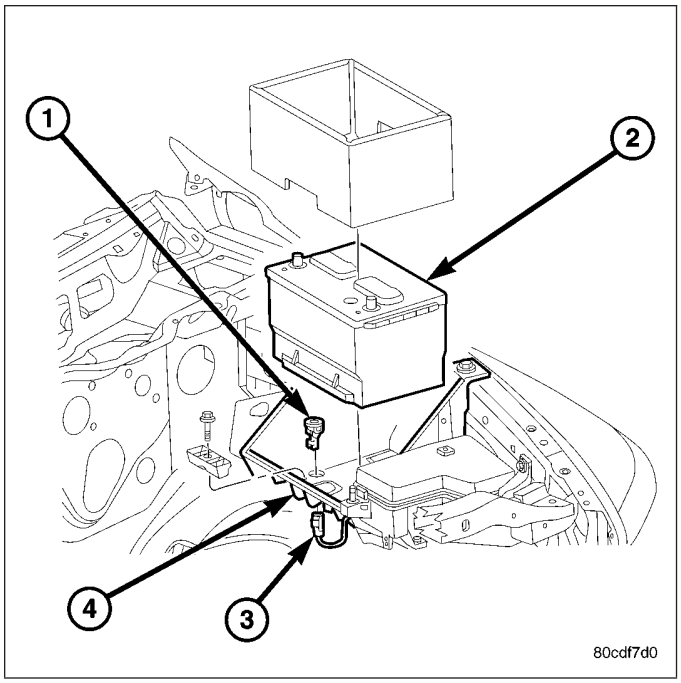
1. Remove battery. Refer to 8, Battery for procedures.
2. Pry sensor (1) straight up from battery tray mounting hole to gain access to electrical connector (3).
3. Disconnect sensor from engine wire harness electrical connector.



INSTALLATION

NOTE: The battery temperature sensor (1) is located under the vehicle battery and is attached (snapped into) a mounting hole on battery tray (4).

1. Pull electrical connector (3) up through mounting hole in top of battery tray.
2. Connect sensor.
3. Snap sensor into battery tray.
4. Install battery. Refer to 8, Battery for procedures.



GENERATOR

DESCRIPTION

The generator is belt-driven by the engine using a serpentine type drive belt. It is serviced only as a complete assembly. If the generator fails for any reason, the entire assembly must be replaced.

OPERATION

As the energized rotor begins to rotate within the generator, the spinning magnetic field induces a current into the windings of the stator coil. Once the generator begins producing sufficient current, it also provides the current needed to energize the rotor.

The stator winding connections deliver the induced alternating current to 3 positive and 3 negative diodes for rectification. From the diodes, rectified direct current is delivered to the vehicle electrical system through the generator battery terminal.

Although the generators appear the same externally, different generators with different output ratings are used on this vehicle. Be certain that the replacement generator has the same output rating and part number as the original unit. Refer to Generator Ratings in the Specifications section at the back of this group for amperage ratings and part numbers.

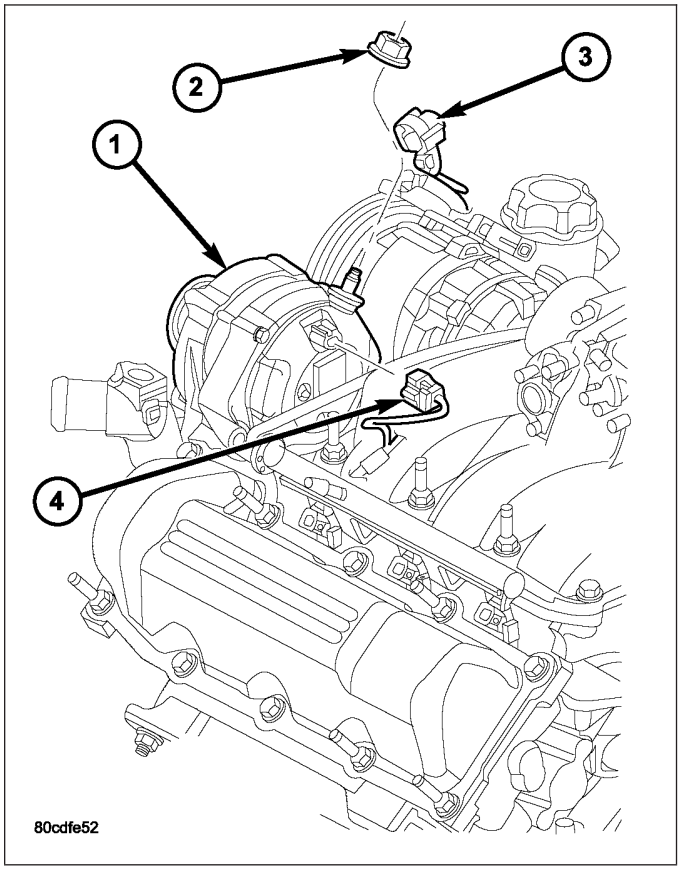
Noise emitting from the generator may be caused by: worn, loose or defective bearings; a loose or defective drive pulley; incorrect, worn, damaged or misadjusted fan drive belt; loose mounting bolts; a misaligned drive pulley or a defective stator or diode.

REMOVAL

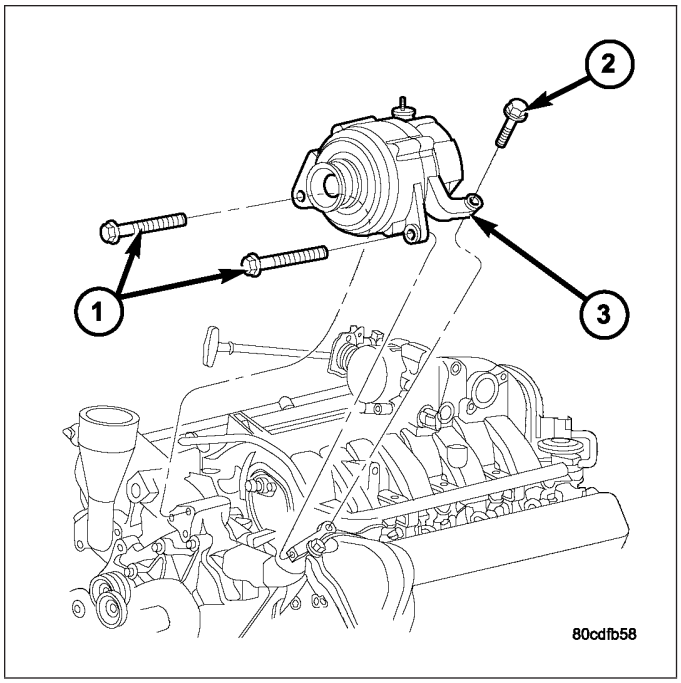
3.7L / 4.7L

WARNING: Disconnect negative cable from battery before removing battery output wire (b+ wire) from generator. Failure to do so can result in injury or damage to electrical system.

1. Disconnect negative battery cable at battery.
2. Remove generator drive belt. Refer to 7, Cooling System for procedure.
3. Unsnap plastic insulator cap from B+ output terminal (3).
4. Remove B+ terminal mounting nut at rear of generator (2). Disconnect terminal from generator.
5. Disconnect field wire connector at rear of generator (4) by pushing on connector tab.



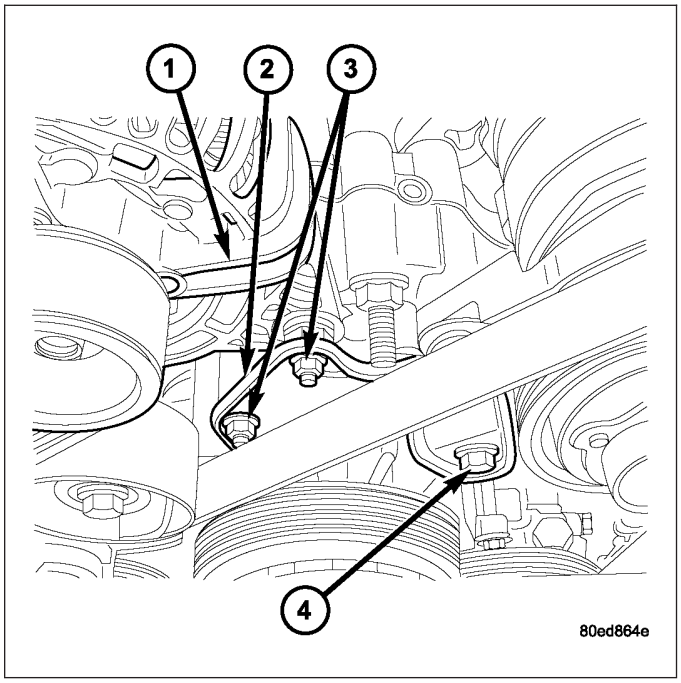
6. Remove 1 rear vertical generator mounting bolt (2).
7. Remove 2 front horizontal generator mounting bolts (1).
8. Remove generator from vehicle.



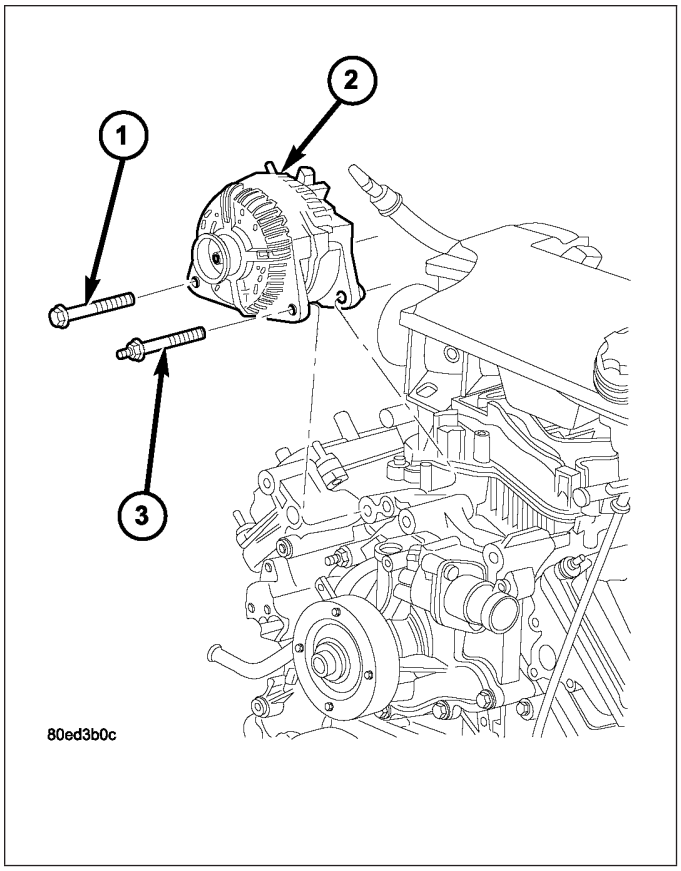
5.7L

WARNING: Disconnect negative cable from battery before removing battery output wire (b+ wire) from generator. Failure to do so can result in injury or damage to electrical system.

1. Disconnect negative battery cable at battery.
2. Remove generator drive belt. Refer to 7, Cooling System for procedure.
3. Unsnap plastic insulator cap from B+ output terminal.
4. Remove B+ terminal mounting nut at rear of generator. Disconnect terminal from generator.
5. Disconnect field wire connector at rear of generator by pushing on connector tab.
6. Remove generator support bracket nuts (3) and bolt (4) and remove support bracket.



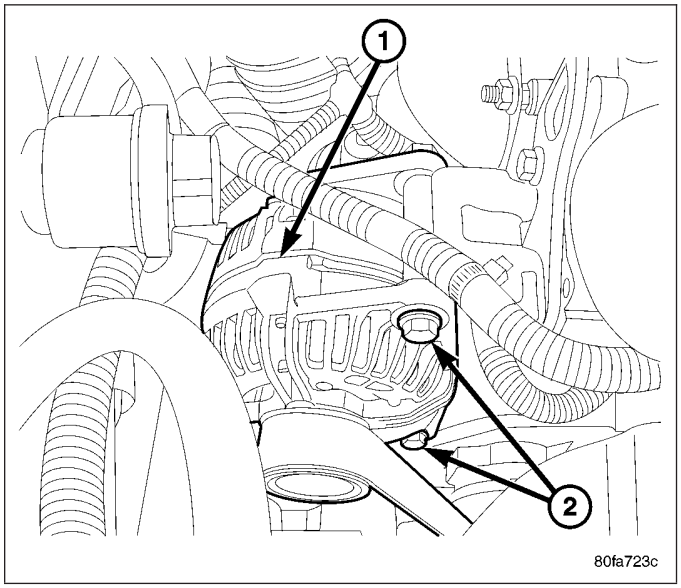
7. Remove 2 generator mounting bolts (1) and (3).
8. Remove generator from vehicle.



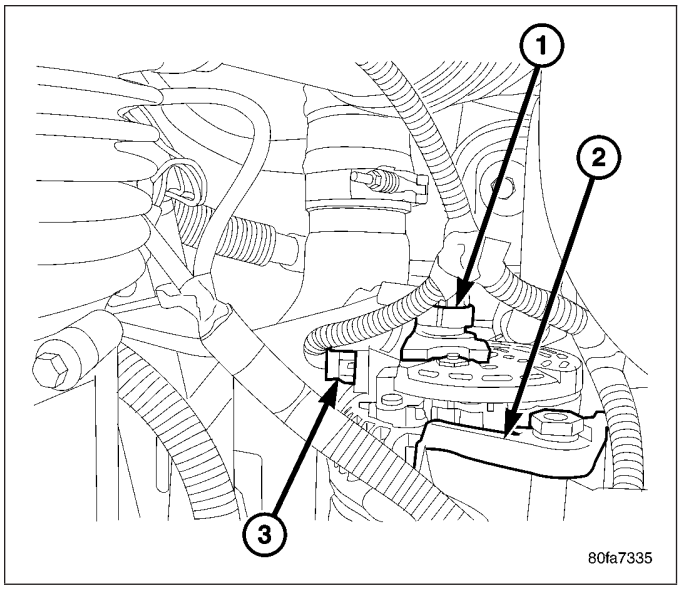
5.9L Diesel

WARNING: Disconnect both negative cables from both batteries before removing battery output wire (b+ wire) from generator. Failure to do so can result in injury or damage to electrical system.

1. Disconnect both negative battery cables at both batteries.
2. Remove generator drive belt. Refer to 7, Cooling System for procedure.
3. Remove upper mounting bracket bolt (2).
4. Remove lower mounting bracket bolt and nut (2).
5. Remove generator from engine.

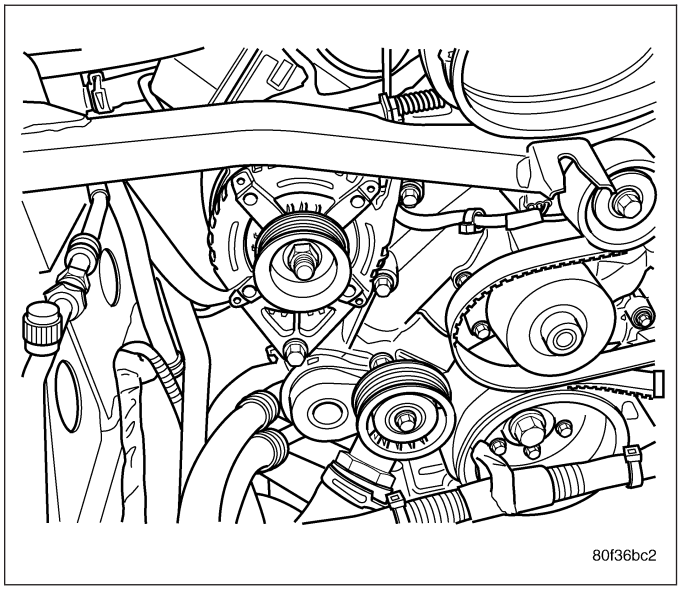


6. Unsnap plastic insulator cap (1) from B+ output terminal.
7. Remove B+ terminal mounting nut at rear of generator. Disconnect terminal from generator.
8. Disconnect field wire connector (3) at rear of generator by pushing on connector tab.

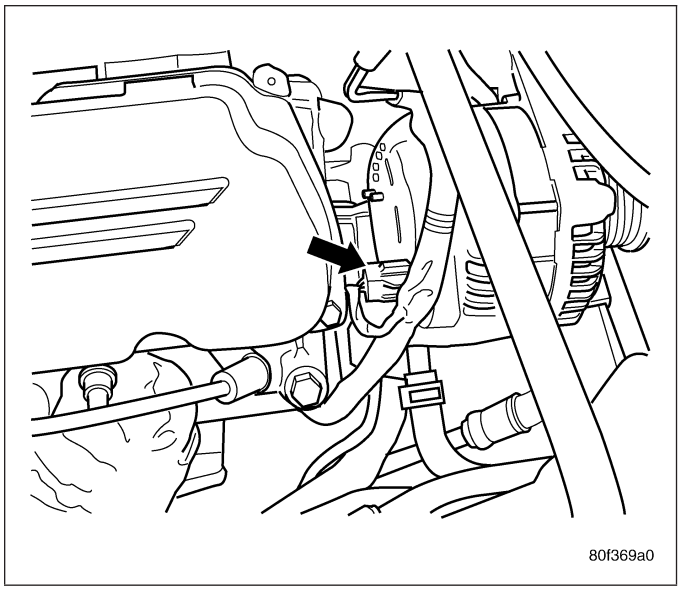


8.3L - SRT-10

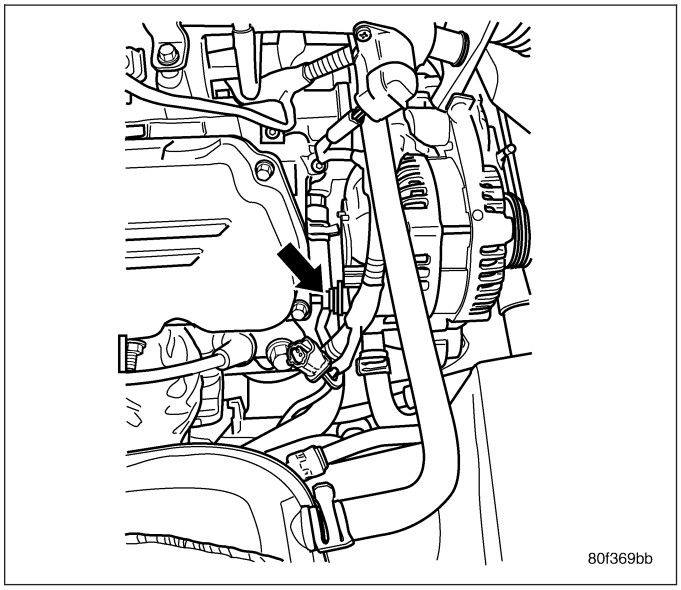
1. Disconnect the negative battery cable.
2. Remove air cleaner assembly, refer to the Engine/air Intake System for more information.
3. Remove the accessory drive belt. Refer to the Cooling section for more information.
4. Disconnect the field connector.



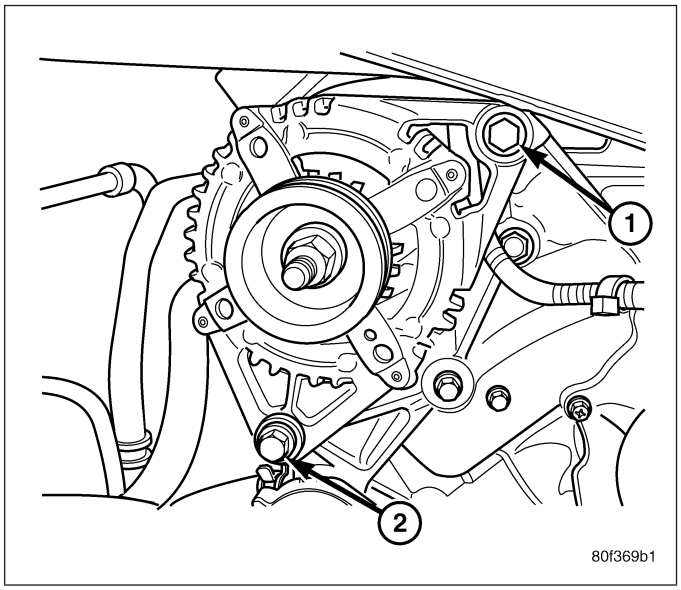
5. Disconnect the battery positive cable from the generator first disconnect the B+ cap on the wiring harness side.



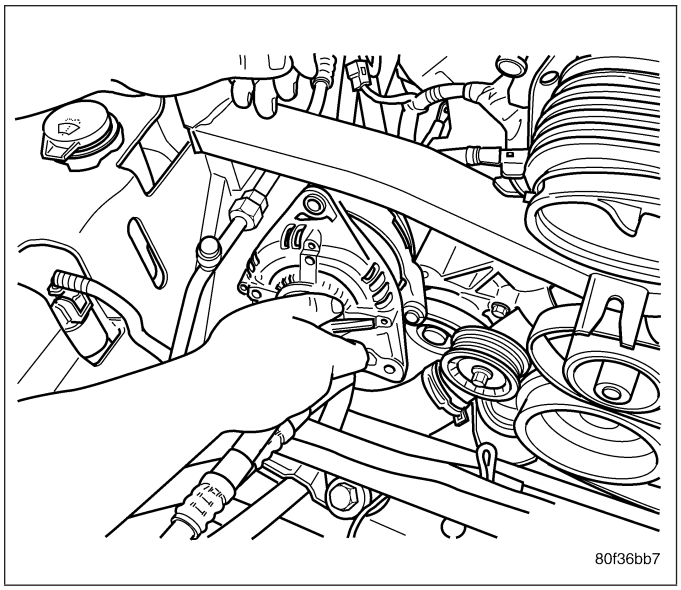
6. Remove the upper mounting bolt (1).
7. Remove the lower mounting bolt and nut (2).



8. Remove generator.



INSTALLATION



3.7L / 4.7L

1. Position generator to engine and install 2 horizontal bolts and 1 vertical bolt.
2. Tighten all 3 bolts to 40 ft. lbs. (55 N·m).
3. Snap field wire connector into rear of generator.
4. Install B+ terminal eyelet to generator output stud. Tighten mounting nut to 8.8 ft. lbs. (12 N·m).

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

5. Install generator drive belt. Refer to 7, Cooling System for procedure.
6. Install negative battery cable to battery.

5.7L

1. Position generator to engine and install 2 mounting bolts.
2. Tighten bolts to 30 ft. lbs. (41 N·m).
3. Position support bracket to front of generator and install bolt and nuts. Tighten bolt/nuts to 30 ft. lbs. (41 N·m).
4. Snap field wire connector into rear of generator.
5. Install B+ terminal eyelet to generator output stud. Tighten mounting nut to 8.8 ft. lbs. (12 N·m).

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

6. Install generator drive belt. Refer to 7, Cooling System for procedure.
7. Install negative battery cable to battery.

5.9L Diesel

1. Position generator to upper and lower mounting brackets and install upper bolt and lower bolt / nut.
2. Tighten all bolts/nut to 30 ft. lbs. (41 N·m).
3. Snap field wire connector into rear of generator.
4. Install B+ terminal eyelet to generator output stud. Tighten mounting nut. Refer to Torque Specifications.

CAUTION: Never force a belt over a pulley rim using a screwdriver. The synthetic fiber of the belt can be damaged.

CAUTION: When installing a serpentine accessory drive belt, the belt MUST be routed correctly. The water pump may be rotating in the wrong direction if the belt is installed incorrectly, causing the engine to overheat. Refer to belt routing label in engine compartment, or refer to Belt Schematics in 7, Cooling System.

5. Install generator drive belt. Refer to 7, Cooling System for procedure.
6. Install both negative battery cables to both batteries.

8.3L - SRT-10

1. Install generator.
2. Install lower mounting bolt and nut.
3. Install upper mounting bolt.
4. Tighten bolts to 55 N·m (41 ft. lbs).
5. Connect battery positive cable to generator , and install B+ stud cap..
6. Connect field connector.
7. Install accessory drive belt , refer to Cooling section for more information.
8. Install air cleaner assembly, refer to Engine/air Intake System for more information.
9. Connect negative battery cable.

VOLTAGE REGULATOR

DESCRIPTION

The Electronic Voltage Regulator (EVR) is not a separate component. It is actually a voltage regulating circuit located within the PCM (Powertrain Control Module) (within the ECM for diesel engines). The EVR is not serviced separately. If replacement is necessary, the PCM must be replaced.

OPERATION

The amount of direct current produced by the generator is controlled by EVR circuitry contained within the PCM. This circuitry is connected in series with the generators second rotor field terminal and its ground.

Voltage is regulated by cycling the ground path to control the strength of the rotor magnetic field. The EVR circuitry monitors system line voltage (B+) and battery temperature (refer to Battery Temperature Sensor for more information). It then determines a target charging voltage. If sensed battery voltage is 0.5 volts or lower than the target voltage, the PCM grounds the field winding until sensed battery voltage is 0.5 volts above target voltage. A circuit in the PCM cycles the ground side of the generator field up to 100 times per second (100Hz), but has the capability to ground the field control wire 100% of the time (full field) to achieve the target voltage. If the charging rate cannot be monitored (limp-in), a duty cycle of 25% is used by the PCM in order to have some generator output. Also refer to Charging System Operation for additional information.

STARTING

TABLE OF CONTENTS

STARTING

DESCRIPTION

The starting system consists of:

- Starter relay
- Starter motor (including an integral starter solenoid)

Other components to be considered as part of starting system are:

- Battery
- Battery cables
- Ignition switch and key lock cylinder
- Clutch pedal position switch (manual transmission)
- Park/neutral position switch (automatic transmission)
- Wire harnesses and connections.

The Battery, Starting, and Charging systems operate in conjunction with one another, and must be tested as a complete system. For correct operation of starting/charging systems, all components used in these 3 systems must perform within specifications. When attempting to diagnose any of these systems, it is important that you keep their interdependency in mind.

The diagnostic procedures used in each of these groups include the most basic conventional diagnostic methods, to the more sophisticated On-Board Diagnostics (OBD) built into the Powertrain Control Module (PCM). Use of an induction-type milliampere ammeter, volt/ohmmeter, battery charger, carbon pile rheostat (load tester), and 12-volt test lamp may be required.

Certain starting system components are monitored by the PCM and may produce a Diagnostic Trouble Code (DTC).

OPERATION

The starting system components form two separate circuits. A high-amperage feed circuit that feeds the starter motor between 150 and 350 amperes (700 amperes - diesel engine), and a low-amperage control circuit that operates on less than 20 amperes. The high-amperage feed circuit components include the battery, the battery cables, the contact disc portion of the starter solenoid, and the starter motor. The low-amperage control circuit components include the ignition switch, the clutch pedal position switch (manual transmission), the park/neutral position switch (automatic transmission), the starter relay, the electromagnetic windings of the starter solenoid, and the connecting wire harness components.

If the vehicle is equipped with a manual transmission, it has a clutch pedal position switch installed in series between the ignition switch and the coil battery terminal of the starter relay. This normally open switch prevents the starter relay from being energized when the ignition switch is turned to the Start position, unless the clutch pedal is depressed. This feature prevents starter motor operation while the clutch disc and the flywheel are engaged. The starter relay coil ground terminal is always grounded on vehicles with a manual transmission.

If the vehicle is equipped with an automatic transmission, battery voltage is supplied through the low-amperage control circuit to the coil battery terminal of the starter relay when the ignition switch is turned to the Start position. The park/neutral position switch is installed in series between the starter relay coil ground terminal and ground. This normally open switch prevents the starter relay from being energized and the starter motor from operating unless the automatic transmission gear selector is in the Neutral or Park positions.

When the starter relay coil is energized, the normally open relay contacts close. The relay contacts connect the relay common feed terminal to the relay normally open terminal. The closed relay contacts energize the starter solenoid coil windings.

The energized solenoid pull-in coil pulls in the solenoid plunger. The solenoid plunger pulls the shift lever in the starter motor. This engages the starter overrunning clutch and pinion gear with the starter ring gear.

As the solenoid plunger reaches the end of its travel, the solenoid contact disc completes the high-amperage starter feed circuit and energizes the solenoid plunger hold-in coil. Current now flows between the solenoid battery terminal and the starter motor, energizing the starter.

Once the engine starts, the overrunning clutch protects the starter motor from damage by allowing the starter pinion gear to spin faster than the pinion shaft. When the ignition switch is released to the On position, the starter relay coil is de-energized. This causes the relay contacts to open. When the relay contacts open, the starter solenoid plunger hold-in coil is de-energized.

When the solenoid plunger hold-in coil is de-energized, the solenoid plunger return spring returns the plunger to its relaxed position. This causes the contact disc to open the starter feed circuit, and the shift lever to disengage the overrunning clutch and pinion gear from the starter ring gear.

DIAGNOSIS AND TESTING

STARTING SYSTEM

The battery, starting, and charging systems operate in conjunction with one another, and must be tested as a complete system. For correct starting/charging system operation, all of the components involved in these 3 systems must perform within specifications.

Starting System Diagnosis		
CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER FAILS TO OPERATE.	1. Battery discharged or faulty.	1. Refer to Battery. Charge or replace battery, if required.
	2. Starting circuit wiring faulty.	2. Refer to 8, Wiring Diagrams. Test and repair starter feed and/or control circuits, if required.
	3. Starter relay faulty.	3. Refer to Starter Relay in Diagnosis and Testing. Replace starter relay if required.
	4. Ignition switch faulty.	4. Refer to Ignition Switch and Key Lock Cylinder. Replace ignition switch if required.
	5. Clutch pedal position switch faulty.	5. Refer to Clutch Pedal Position Switch.
	6. Park/Neutral position switch faulty or misadjusted.	6. Refer to Park/Neutral Position Switch. Replace park/neutral position switch if required.
	7. Starter solenoid faulty.	7. Refer to Starter Motor. Replace starter motor assembly if required.
	8. Starter motor faulty.	8. If all other starting system components and circuits test OK, replace starter motor.
STARTER ENGAGES, FAILS TO TURN ENGINE.	1. Battery discharged or faulty.	1. Refer to Battery. Charge or replace battery if required.
	2. Starting circuit wiring faulty.	2. Refer to 8, Wiring Diagrams. Test and repair starter feed and/or control circuits if required.
	3. Starter motor faulty.	3. If all other starting system components and circuits test OK, replace starter motor assembly.
	4. Engine seized.	4. Refer to Engine Diagnosis in the Diagnosis and Testing section of 9, Engine.
STARTER ENGAGES, SPINS OUT BEFORE ENGINE STARTS.	1. Starter ring gear faulty.	1. Refer to Starter Motor Removal and Installation. Remove starter motor to inspect starter ring gear. Replace starter ring gear if required.
	2. Starter motor faulty.	2. If all other starting system components and circuits test OK, replace starter motor assembly.
STARTER DOES NOT DISENGAGE.	1. Starter motor improperly installed.	1. Refer to Starter Motor Removal and Installation. Tighten starter mounting hardware to correct torque specifications.
	2. Starter relay faulty.	2. Refer to Starter Relay Diagnosis and Testing. Replace starter relay if required.
	3. Ignition switch faulty.	3. Refer to Ignition Switch and Key Lock Cylinder. Replace ignition switch if required.
	4. Starter motor faulty.	4. If all other starting system components and circuits test OK, replace starter motor.

INSPECTION

For complete starter wiring circuit diagrams, refer to 8, Wiring Diagrams. Before removing any unit from starting system for repair or diagnosis, perform the following inspections:

WARNING: On vehicles equipped with airbags, refer to 8, passive restraint systems, before attempting any steering wheel, steering column, or instrument panel component diagnosis or service. Failure to take the proper precautions could result in accidental airbag deployment and possible personal injury.

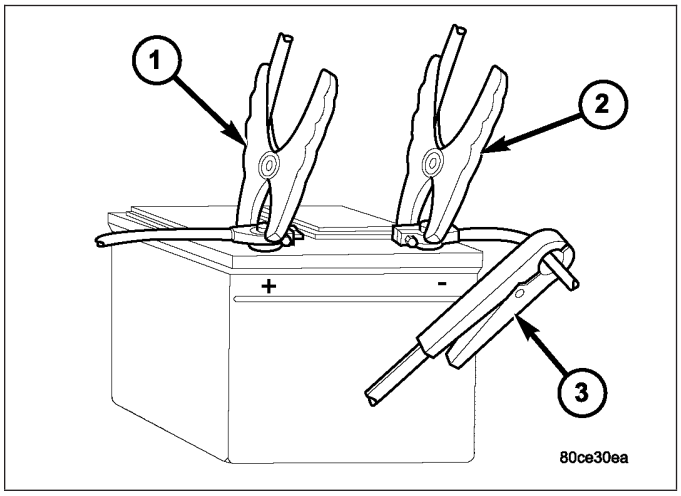
- **Battery** - Visually inspect battery for indications of physical damage and loose or corroded cable connections. Determine state-of-charge and cranking capacity of battery. Charge or replace battery if required. Refer to **Battery** in 8, Battery. **Note: If equipped with diesel engine, a dual battery system may be used, and both batteries must be inspected.**
- **Ignition Switch** - Visually inspect ignition switch for indications of physical damage and loose or corroded wire harness connections. Refer to **Ignition Switch and Key Lock Cylinder.**
- **Clutch Pedal Position Switch** - If equipped with manual transmission, visually inspect clutch pedal position switch for indications of physical damage and loose or corroded wire harness connections. Refer to **Clutch Pedal Position Switch** in 6, Clutch.
- **Park/Neutral Position Switch** - If equipped with automatic transmission, visually inspect park/neutral position switch for indications of physical damage and loose or corroded wire harness connections. Refer to **Park/Neutral Position Switch** in 21, Transmission.
- **Starter Relay** - Visually inspect starter relay for indications of physical damage and loose or corroded wire harness connections.
- **Starter Motor** - Visually inspect starter motor for indications of physical damage and loose or corroded wire harness connections.
- **Starter Solenoid** - Visually inspect starter solenoid for indications of physical damage and loose or corroded wire harness connections.
- **Wiring** - Visually inspect wire harnesses for damage. Repair or replace any faulty wiring, as required. Refer to 8, Wiring Diagrams.

TESTING

COLD CRANKING TEST

NOTE: For complete starter wiring circuit diagrams, refer to 8, Wiring Diagrams. The battery must be fully-charged and load-tested before proceeding. Refer to Battery in 8, Battery.

1. Connect volt-ampere tester (1) and (2) to battery terminals. See instructions provided by manufacturer of volt-ampere tester being used. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, tester should be connected to battery on left side of vehicle only. Also, tester current reading must be taken from positive battery cable lead that connects to starter motor.**
2. Fully engage parking brake.
3. If equipped with manual transmission, place gearshift selector lever in Neutral position and block clutch pedal in fully depressed position. If equipped with automatic transmission, place gearshift selector lever in Park position.
4. Verify that all lamps and accessories are turned off.
5. To prevent a gasoline engine from starting, remove Automatic ShutDown (ASD) relay. To prevent a diesel engine from starting, remove Fuel Pump Relay. These relays are located in Power Distribution Center (PDC). Refer to label on PDC cover for relay location.



WARNING: If equipped with diesel engine, attempt to start engine a few times before proceeding with following step.

NOTE: A cold engine will increase starter current (amperage) draw reading, and reduce battery voltage reading.

6. Rotate and hold ignition switch in Start position. Note cranking voltage and current (amperage) draw readings shown on volt-ampere tester.
   a. If voltage reads below 9.6 volts, refer to **Starter Motor** in Diagnosis and Testing. If starter motor is OK, refer to **Engine Diagnosis** in 9, Engine for further testing of engine. If starter motor is not OK, replace faulty starter motor.
   b. If voltage reads above 9.6 volts and current (amperage) draw reads below specifications, refer to **Feed Circuit Test** in this section.
   c. If voltage reads 12.5 volts or greater and starter motor does not turn, refer to **Control Circuit Testing** in this section.
   d. If voltage reads 12.5 volts or greater and starter motor turns very slowly, refer to **Feed Circuit Test** in this section.

FEED CIRCUIT TEST

The starter feed circuit test (voltage drop method) will determine if there is excessive resistance in high-amperage feed circuit. For complete starter wiring circuit diagrams, refer 8, Wiring Diagrams.

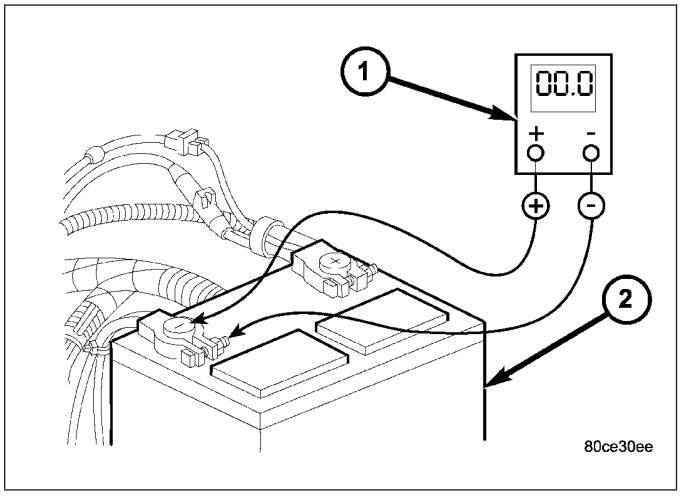
When performing these tests, it is important to remember that voltage drop is giving an indication of resistance between two points at which voltmeter probes are attached.

Example: When testing resistance of positive battery cable, touch voltmeter leads to positive battery cable clamp and cable connector at starter solenoid. If you probe positive battery terminal post and cable connector at starter solenoid, you are reading combined voltage drop in positive battery cable clamp-to-terminal post connection and positive battery cable.

The following operation will require a voltmeter accurate to 1/10 (0.10) volt. Before performing tests, be certain that following procedures are accomplished:

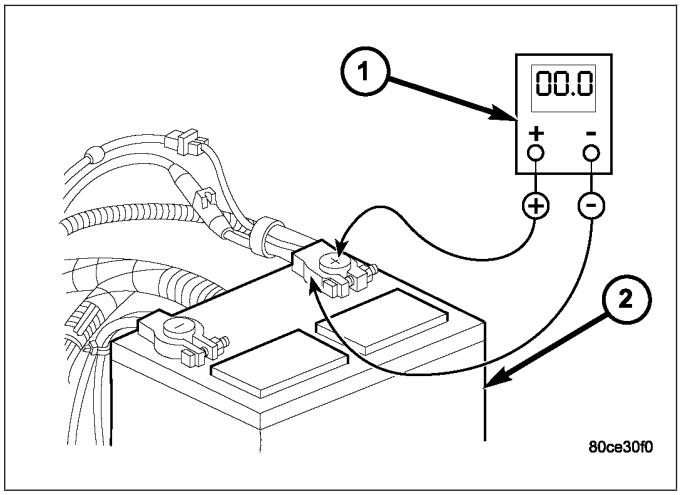
- Battery is fully-charged and load-tested. Refer to **Battery** in 8, Battery.
- Fully engage parking brake.
- If equipped with manual transmission, place gearshift selector lever in Neutral position and block clutch pedal in fully depressed position. If equipped with automatic transmission, place gearshift selector lever in Park position.
- Verify that all lamps and accessories are turned off.
- To prevent a gasoline engine from starting, remove Automatic ShutDown (ASD) relay. To prevent a diesel engine from starting, remove Fuel Pump Relay. These relays are located in Power Distribution Center (PDC). Refer to label on PDC cover for relay location.

1. Connect positive lead of voltmeter (1) to negative battery cable terminal post. Connect negative lead of voltmeter to negative battery cable clamp. Rotate and hold ignition switch in Start position. Observe voltmeter. If voltage is detected, correct poor contact between cable clamp and terminal post. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery**

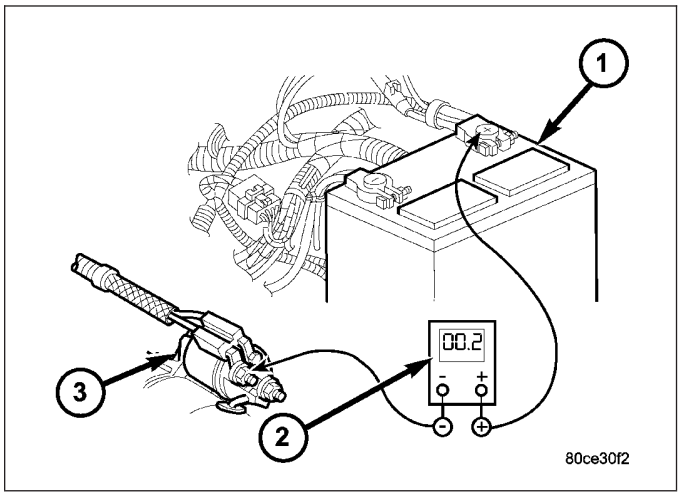


system, procedure must be performed twice, once for each battery.

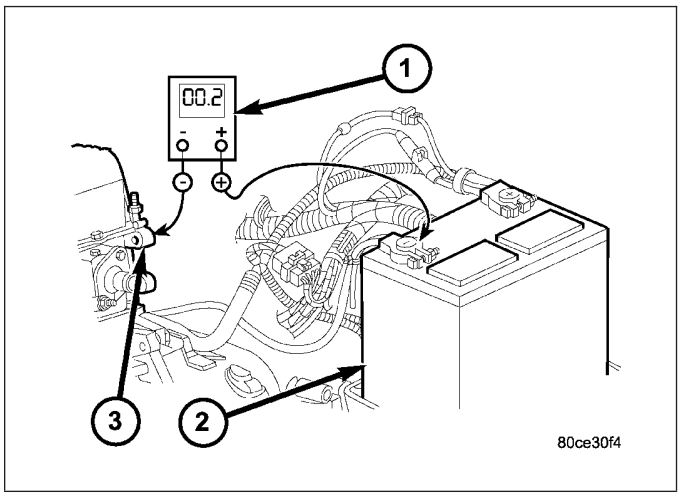
2. Connect positive lead of voltmeter to positive battery terminal post. Connect negative lead of voltmeter to battery positive cable clamp. Rotate and hold ignition switch in Start position. Observe voltmeter. If voltage is detected, correct poor contact between cable clamp and terminal post. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed twice, once for each battery.**



3. Connect voltmeter to measure between battery positive terminal post and starter solenoid battery terminal stud. Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten battery cable connection at solenoid. Repeat test. If reading is still above 0.2 volt, replace faulty positive battery cable. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed on driver side battery only.**

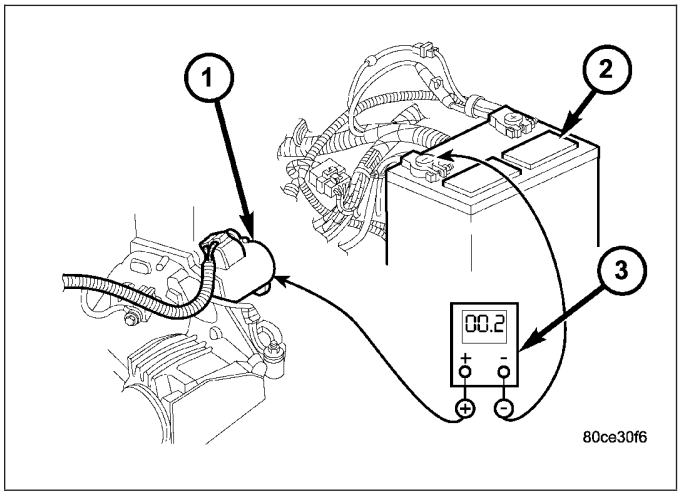


4. Connect voltmeter to measure between negative battery terminal post and a good clean ground on engine block. Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten negative battery cable attachment on engine block. Repeat test. If reading is still above 0.2 volt, replace faulty negative battery cable. **Note: Certain diesel equipped models use dual batteries. If equipped with dual**



battery system, this procedure must be performed twice, once for each battery.

5. Connect positive lead of voltmeter to starter housing. Connect negative lead of voltmeter to negative battery terminal post. Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, correct poor starter to engine block ground contact. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed on driver side battery only.**



6. If equipped with dual battery system (certain diesel equipped models), connect positive lead of voltmeter to positive battery cable clamp on battery located on left side of vehicle. Connect negative lead of voltmeter to positive battery terminal post on battery located on right side of vehicle. Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten battery cables at both batteries. Repeat test. If reading is still above 0.2 volt, replace faulty positive battery cable.

If resistance tests detect no feed circuit problems, refer to **Starter Motor** in the Diagnosis and Testing.

CONTROL CIRCUIT TESTING

The starter control circuit components should be tested in the order in which they are listed, as follows:

- **Starter Relay** - Refer to **Starter Relay** Diagnosis and Testing.
- **Starter Solenoid** - Refer to **Starter Motor** Diagnosis and Testing.
- **Ignition Switch** - Refer to **Ignition Switch and Key Lock Cylinder**
- **Clutch Pedal Position Switch** - If equipped with manual transmission, refer to **Clutch Pedal Position Switch** in 6, Clutch.
- **Park/Neutral Position Switch** - If equipped with automatic transmission, refer to **Park/Neutral Position Switch** in 21, Transmission.
- **Wire harnesses and connections** - Refer to 8, Wiring Diagrams.

SPECIFICATIONS

STARTING SYSTEM

Starter Motor and Solenoid		
Engine Application	3.7L / 4.7L / 5.7L	5.9L Diesel
Power Rating	1.4 Kilowatt / 1.9 Horsepower	2.7 Kilowatt / 3.6 Horsepower
Voltage	12 Volts	12 Volts
Number of Brushes	4	4
Drive Type	Gear Reduction	Conventional
Free Running Test Voltage	11 Volts	11 Volts
Free Running Test Amperage Draw	73 Amperes	200 Amperes
Free Running Test Minimum Speed	3601 rpm	3000
Solenoid Closing Maximum Voltage Required	7.5 Volts	8.0 Volts

Starter Motor and Solenoid		
* Cranking Amperage Draw Test	125 - 250 Amperes	450 - 700 Amperes
* Test at operating temperature. Cold engine, tight (new) engine, or heavy oil will increase starter amperage draw.		

STARTER - 8.3L - SRT-10

Engine Application	8.3L (V 10)
Power rating	2.0 Kw
Voltage	12 VOLTS
No. of Fields	4
No. of Poles	4
Brushes	4
Drive	Offset Reduction Gear
Cranking Amperage Draw test	150 - 280 Amps.

Engine should be up to operating temperature. Extremely heavy oil or tight engine will increase starter amperage draw.

TORQUE

DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Battery Cable Eyelet Nut at Solenoid (large nut - gas engines)	25	19	221
Battery Cable Eyelet Nut at Solenoid (large nut - diesel engine)	14	-	120
Starter Solenoid Nut (small nut - diesel engine)	6	-	55
Starter Mounting Bolts - Gas Engines	68	50	-
Starter Mounting Nut - Gas Engines	68	50	-
Starter Mounting Bolts - Diesel	43	32	-
Starter Mounting Bolts 8.3L	40	30	-
Starter Battery Cable Nut 8.3L	10	-	90

STARTER MOTOR

DIAGNOSIS AND TESTING - STARTER MOTOR

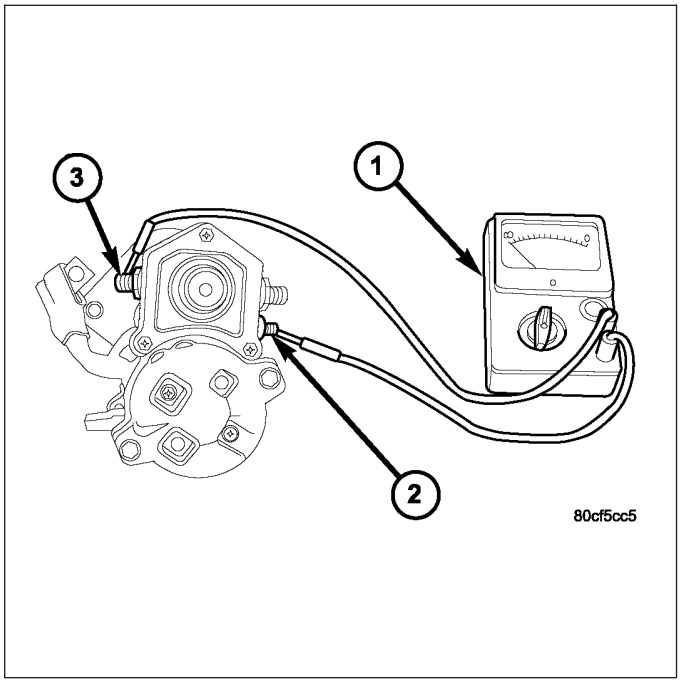
Correct starter motor operation can be confirmed by performing the following free running bench test. This test can only be performed with starter motor removed from vehicle. Refer to Specifications for starter motor specifications.

1. Remove starter motor from vehicle. Refer to Starter Motor Removal and Installation.
2. Mount starter motor securely in a soft-jawed bench vise. The vise jaws should be clamped on the mounting flange of starter motor. Never clamp on starter motor by field frame.
3. Connect a suitable volt-ampere tester and a 12-volt battery to starter motor in series, and set ammeter to 100 ampere scale. See instructions provided by manufacturer of volt-ampere tester being used.
4. Install jumper wire from solenoid terminal to solenoid battery terminal. The starter motor should operate. If starter motor fails to operate, replace faulty starter motor assembly.
5. Adjust carbon pile load of tester to obtain free running test voltage. Refer to Specifications for starter motor free running test voltage specifications.
6. Note reading on ammeter and compare reading to free running test maximum amperage draw. Refer to Specifications for starter motor free running test maximum amperage draw specifications.
7. If ammeter reading exceeds maximum amperage draw specification, replace faulty starter motor assembly.

STARTER SOLENOID

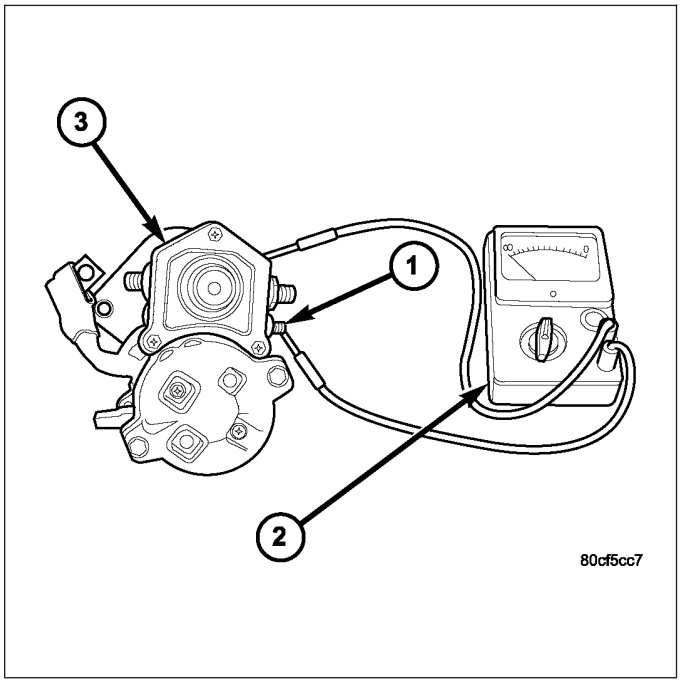
This test can only be performed with starter motor removed from vehicle.

1. Remove starter motor from vehicle. Refer to Starter Motor Removal and Installation.
2. Disconnect wire from solenoid field coil terminal.
3. Check for continuity between solenoid terminal and solenoid field coil terminal with a continuity tester



(1). There should be continuity. If OK, go to Step 4. If not OK, replace faulty starter motor assembly.

4. Check for continuity (2) between solenoid terminal and solenoid case. There should be continuity. If not OK, replace faulty starter motor assembly.

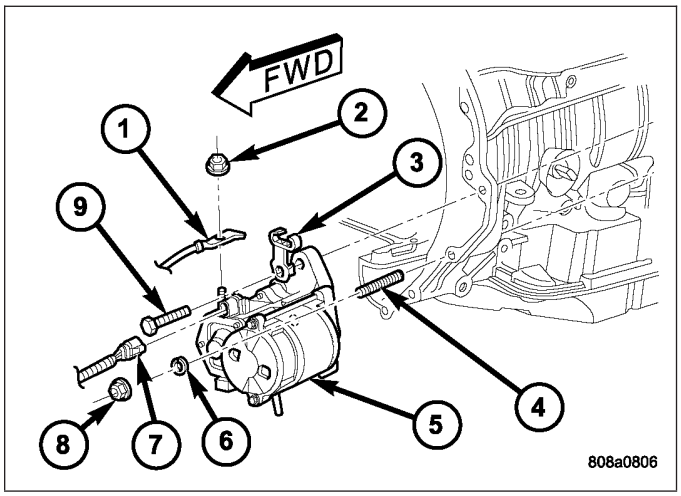


REMOVAL

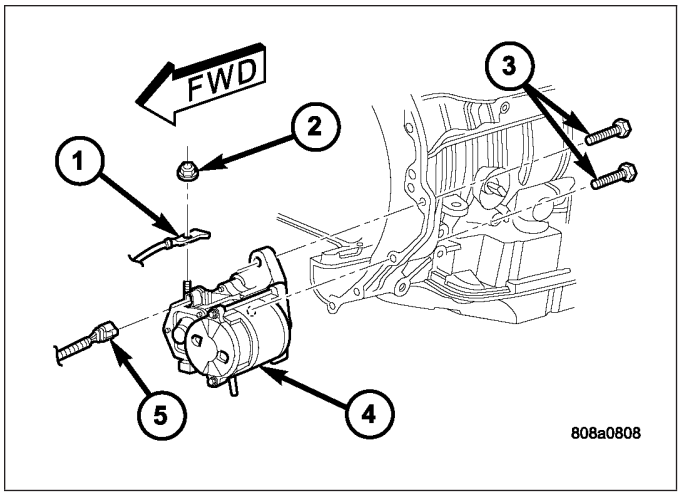
REMOVAL

3.7L / 4.7L

1. Disconnect and isolate negative battery cable.
2. Raise and support vehicle.
3. Note: If equipped with 4WD and certain transmissions, a support bracket is used between front axle and side of transmission. Remove 2 support bracket bolts at transmission. Pry support bracket slightly to gain access to lower starter mounting bolt.
4. Remove 1 bolt and 1 nut if equipped with a manual transmission.



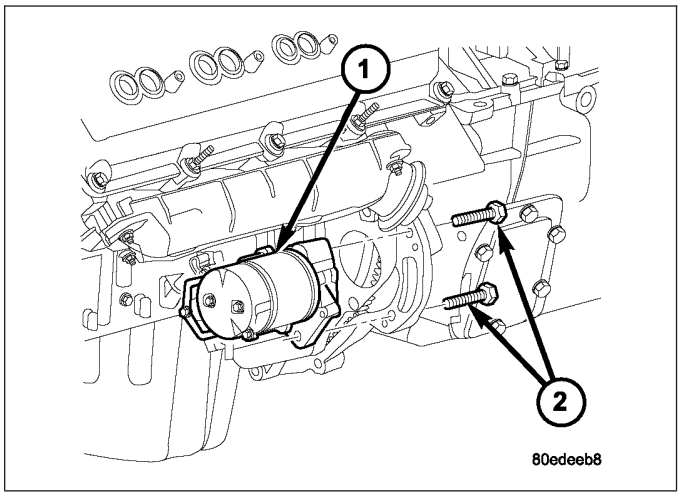
5. Remove 2 bolts if equipped with an automatic transmission.



6. Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear housing. Always support starter motor during this process, do not let starter motor hang from wire harness.
7. Tilt nose downwards and lower starter motor far enough to access and remove nut that secures battery positive cable wire harness connector eyelet to solenoid battery terminal stud. Do not let starter motor hang from wire harness.
8. Remove battery positive cable wire harness connector eyelet from solenoid battery terminal stud.
9. Disconnect battery positive cable wire harness connector from solenoid terminal connector receptacle.
10. Remove starter motor.

5.7L Gas

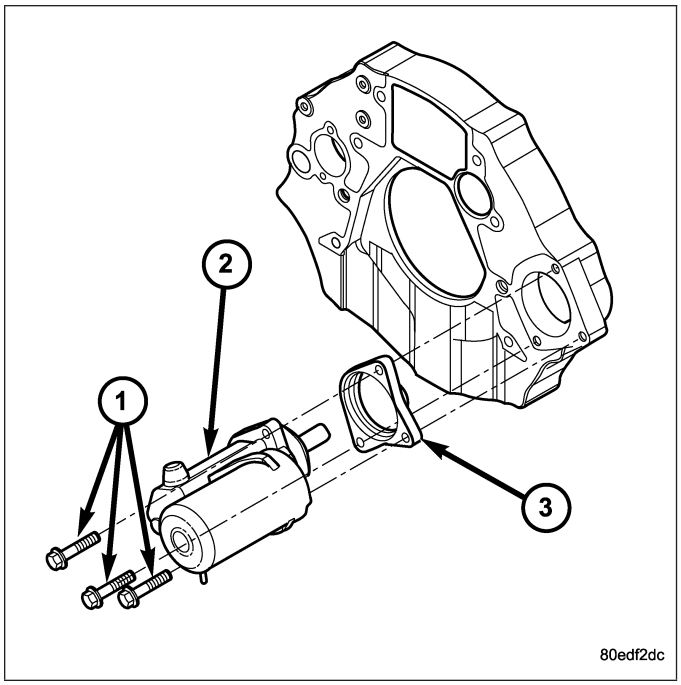
1. Disconnect and isolate negative battery cable.
2. Raise and support vehicle.
3. Note: If equipped with 4WD and certain transmissions, a support bracket is used between front axle and side of transmission. Remove 2 support bracket bolts at transmission. Pry support bracket slightly to gain access to lower starter mounting bolt.
4. Remove 2 mounting bolts.
5. Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear housing. Always support starter motor during this process, do not let starter motor hang from wire harness.
6. Tilt nose downwards and lower starter motor far enough to access and remove nut that secures battery positive cable wire harness connector eyelet to solenoid battery terminal stud. Do not let starter motor hang from wire harness.
7. Remove battery positive cable wire harness connector eyelet from solenoid battery terminal stud.
8. Disconnect battery positive cable wire harness connector from solenoid terminal connector receptacle.
9. Remove starter motor.



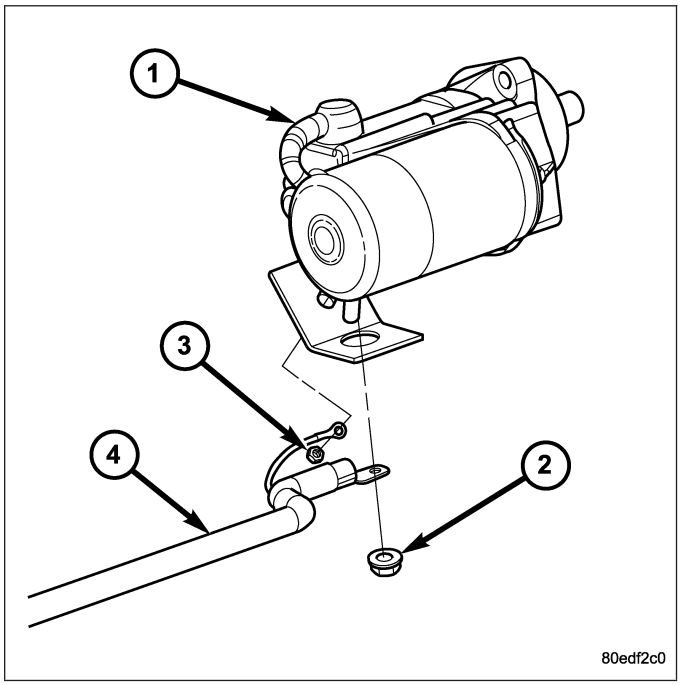
5.9L Diesel

1. Disconnect and isolate both negative battery cables at both batteries.
2. Raise and support vehicle.

3. Remove 3 starter mounting bolts.

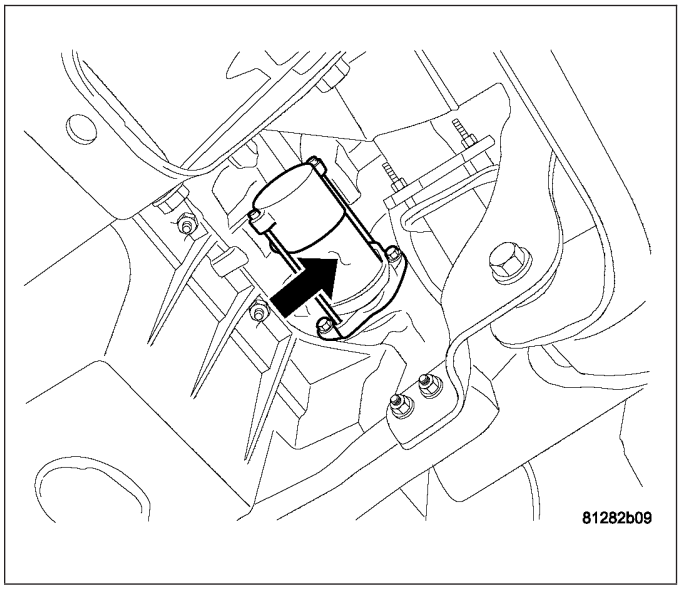


4. Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear housing. Always support starter motor during this process. Do not let starter motor hang from wire harness.
5. Tilt nose downwards and lower starter motor far enough to access and remove nuts securing starter wiring harness to starter. Do not let starter motor hang from wire harness.
6. Remove starter motor from engine. Note: Certain diesel engines use an aluminum spacer. Note position and orientation of spacer before removal.

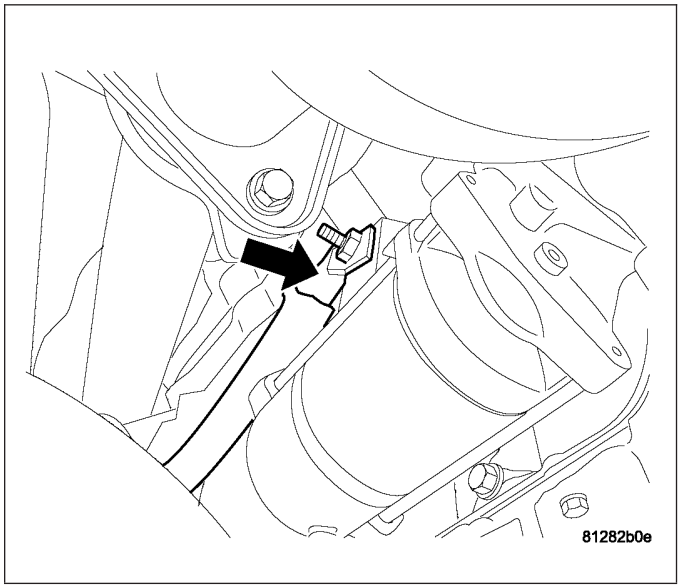


8.3L - SRT-10

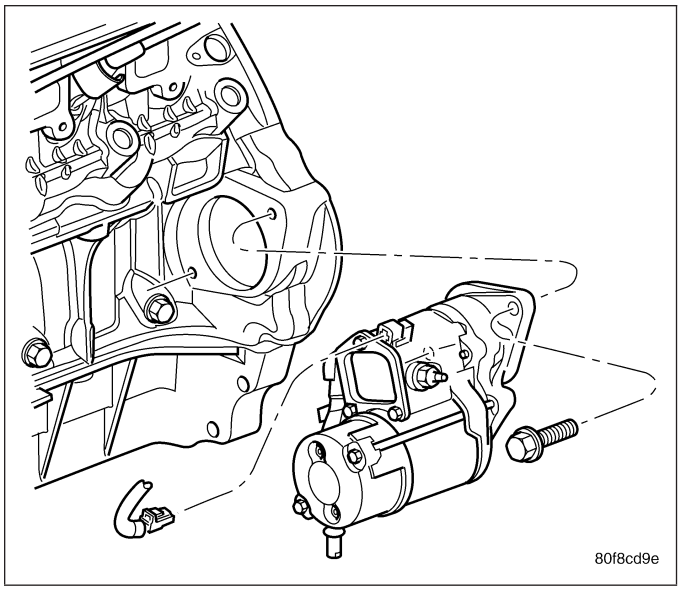
1. Disconnect the negative battery cable.
2. Raise vehicle and support.



3. Disconnect the solenoid connector.
4. Remove the positive battery cable.



5. Remove the upper bolt.



6. Remove the lower bolt.
7. Remove the starter.

INSTALLATION

INSTALLATION

3.7L / 4.7L

1. Connect solenoid wire to starter motor (snaps on).
2. Position battery cable to solenoid stud. Install and tighten battery cable eyelet nut to 19 ft. lbs. (25 N·m). Do not allow starter motor to hang from wire harness.
3. Position starter motor to transmission.
4. If equipped with automatic transmission, slide cooler tube bracket into position.
5. Install and tighten both bolts (auto. trans.), or 1 nut and 1 bolt (man. trans.) to 50 ft. lbs. (68 N·m).
6. Lower vehicle.
7. Connect negative battery cable.

5.7L

1. Connect solenoid wire to starter motor (snaps on).
2. Position battery cable to solenoid stud. Install and tighten battery cable eyelet nut. Refer to Torque Specifications. Do not allow starter motor to hang from wire harness.
3. Position starter motor to engine.
4. If equipped with automatic transmission, slide cooler tube bracket into position.
5. Install and tighten both mounting bolts to 30 ft. lbs. (41 N·m).. Refer to Torque Specifications.
6. Lower vehicle.
7. Connect negative battery cable.

5.9L Diesel

1. **If Equipped:** Position and hold aluminum spacer to rear of starter while positioning starter to engine.
2. Connect solenoid wire to starter motor. Tighten nut to 4.4 ft. lbs. (6 N·m)..
3. Position battery cable to starter stud. Install and tighten battery cable nut to 10.3 ft. lbs. (14 N·m). Do not allow starter motor to hang from wire harness.
4. Position starter motor to transmission.
5. If equipped with automatic transmission, slide cooler tube bracket into position.

6. Install and tighten 3 starter mounting bolts to 32 ft. lbs. (43 N·m).
7. Lower vehicle.
8. Connect both negative battery cables to both batteries.

8.3L - SRT-10

1. Install starter.
2. Install lower bolt.
3. Install upper bolt.
4. Install positive battery cable.
5. Connect solenoid connector.
6. Lower vehicle.
7. Connect negative battery cable.

RELAY-STARTER

DESCRIPTION

The starter relay is an electromechanical device that switches battery current to the pull-in coil of the starter solenoid when ignition switch is turned to Start position. The starter relay is located in the Power Distribution Center (PDC) in the engine compartment. See PDC cover for relay identification and location.

The starter relay is a International Standards Organization (ISO) relay. Relays conforming to ISO specifications have common physical dimensions, current capacities, terminal patterns, and terminal functions.

The starter relay cannot be repaired or adjusted. If faulty or damaged, it must be replaced.

OPERATION

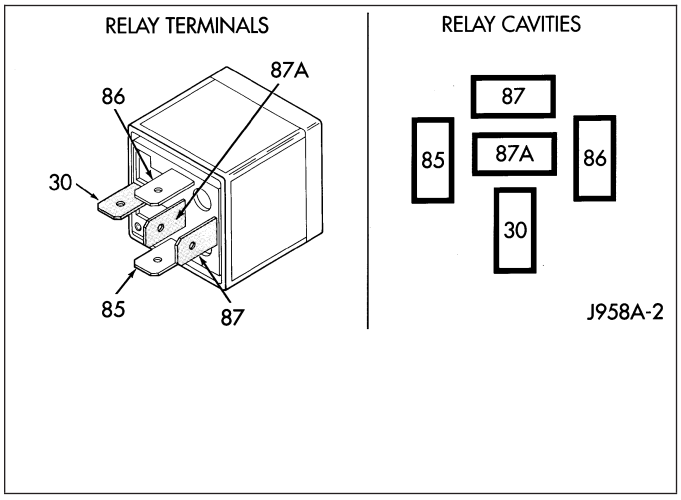
The ISO relay consists of an electromagnetic coil, a resistor or diode, and three (two fixed and one movable) electrical contacts. The movable (common feed) relay contact is held against one of the fixed contacts (normally closed) by spring pressure. When electromagnetic coil is energized, it draws the movable contact away from normally closed fixed contact, and holds it against the other (normally open) fixed contact.

When electromagnetic coil is de-energized, spring pressure returns movable contact to normally closed position. The resistor or diode is connected in parallel with electromagnetic coil within relay, and helps to dissipate voltage spikes produced when coil is de-energized.

DIAGNOSIS AND TESTING

STARTER RELAY

The starter relay is located in Power Distribution Center (PDC). Refer to PDC cover for relay identification and location. For complete starter relay wiring circuit diagrams, refer to 8, Wiring Diagrams.



1. Remove starter relay from PDC.
2. A relay in de-energized position should have continuity between terminals 87A and 30, and no continuity between terminals 87 and 30. If OK, go to Step 3. If not OK, replace faulty relay.
3. Resistance between terminals 85 and 86 (electromagnet) should be 75 ± 5 ohms. If OK, go to Step 4. If not OK, replace faulty relay.
4. Connect 12V battery to terminals 85 and 86. There should now be continuity between terminals 30 and 87, and no continuity between terminals 87A and 30. If OK, perform Relay Circuit Test that follows. If not OK, replace faulty relay.

RELAY CIRCUIT TEST

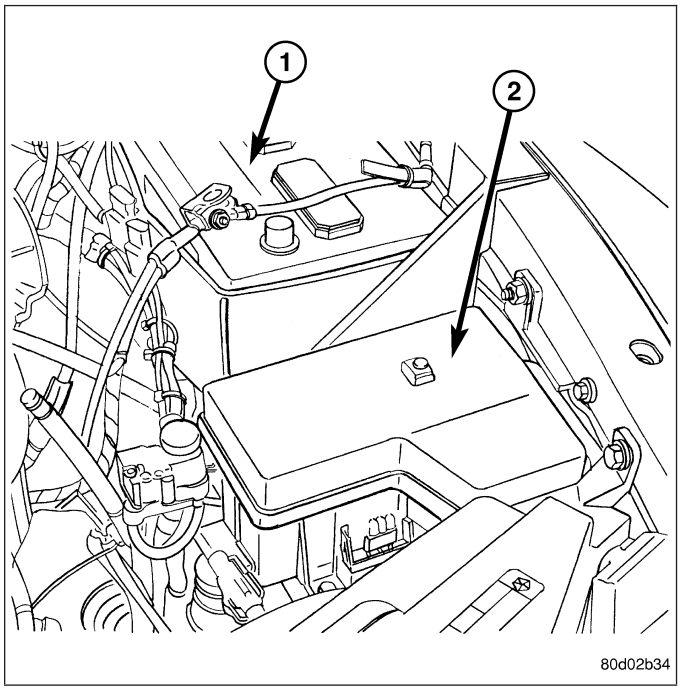
1. The relay common feed terminal cavity (30) is connected to battery voltage and should be hot at all times. If OK, go to Step 2. If not OK, repair open circuit to fuse in PDC as required.
2. The relay normally closed terminal (87A) is connected to terminal 30 in the de-energized position, but is not used for this application. Go to Step 3.

3. The relay normally open terminal (87) is connected to common feed terminal (30) in the energized position. This terminal supplies battery voltage to starter solenoid field coils. There should be continuity between cavity for relay terminal 87 and starter solenoid terminal at all times. If OK, go to Step 4. If not OK, repair open circuit to starter solenoid as required.
4. The coil battery terminal (86) is connected to electromagnet in relay. It is energized when ignition switch is held in Start position. On vehicles with manual transmission, clutch pedal must be fully depressed for this test. Check for battery voltage at cavity for relay terminal 86 with ignition switch in Start position, and no voltage when ignition switch is released to On position. If OK, go to Step 5. If not OK with automatic transmission, check for open or short circuit to ignition switch and repair, if required. If circuit to ignition switch is OK, refer to **Ignition Switch and Key Lock Cylinder**. If not OK with a manual transmission, check circuit between relay and clutch pedal position switch for open or a short. If circuit is OK, refer to **Clutch Pedal Position Switch** in 6 , Clutch.
5. The coil ground terminal (85) is connected to the electromagnet in the relay. On vehicles with manual transmission, it is grounded at all times. On vehicles with automatic transmission, it is grounded through park/neutral position switch only when gearshift selector lever is in Park or Neutral positions. Check for continuity to ground at cavity for relay terminal 85. If not OK with manual transmission, repair circuit to ground as required. If not OK with automatic transmission, check for pen or short circuit to park/neutral position switch and repair, if required. If circuit to park/neutral position switch is OK, refer to **Park/Neutral Position Switch** in 21, Transmission.

REMOVAL

The starter relay is located in the Power Distribution Center (PDC). Refer to label on PDC cover for relay location.

1. Disconnect and isolate negative battery cable.
2. Remove cover (2) from Power Distribution Center (PDC) for relay identification and location.
3. Remove starter relay from PDC.
4. Check condition of relay terminals and PDC connector terminals for damage or corrosion. Repair if necessary before installing relay.
5. Check for pin height (pin height should be the same for all terminals within the PDC connector). Repair if necessary before installing relay.



INSTALLATION

1. Push down firmly on starter relay until terminals are fully seated into PDC receptacle.
2. Install PDC cover.
3. Connect battery cable.