ENGINE SYSTEMS

TABLE OF CONTENTS

BATTERY SYSTEM

TABLE OF CONTENTS

BATTERY SYSTEM

DESCRIPTION

A single 12-volt battery is standard factory-installed equipment on this model. All of the components of the battery system are located within the engine compartment of the vehicle. The battery system for this vehicle covers the following related components, which are covered in further detail later in this section of the service manual:

- **Battery** - The storage battery provides a reliable means of storing a renewable source of electrical energy within the vehicle.
- **Battery Cable** - The battery cables connect the battery terminal posts to the vehicle electrical system.

BATTERY SYSTEM (Continued)

- **Battery Holddown** - The battery holddown hardware secures the battery in the battery tray in the engine compartment.
- **Battery Thermowrap** - The battery thermowrap insulates the battery to protect it from engine compartment temperature extremes.
- **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 and jump starting procedure, see the owner's manual in the vehicle glove box. Optionally, refer to the Lubrication and Maintenance section of this manual for the recommended battery maintenance schedules and for the proper battery jump starting procedure. While battery charging can be considered a maintenance procedure, the battery charging procedure and related information are located later in this section of this service manual. This was done because 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 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 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 failure it detects. Refer to Charging System for the proper charging system onboard diagnostic test procedures.

MICRO 420 BATTERY TESTER

The Micro 420 automotive battery tester is designed to help the dealership technicians diagnose the cause of a defective battery. Follow the instruction manual supplied with the tester to properly diagnose a vehicle. If the instruction manual is not available refer to the standard procedure in this section, which includes the directions for using the Micro 420 battery tester.

BATTERY SYSTEM (Continued)

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 the IGNITION-OFF DRAW TEST Standard Procedure for the proper test procedures. Repair the excessive ignition-off draw, as required.
	2. The charging system is faulty.	2. Determine if the charging system is performing to specifications. Refer to Charging System for additional charging system diagnosis and testing procedures. Repair the faulty charging system, as required.
	3. The battery is discharged.	3. Determine the battery state-of-charge using the Micro 420 battery tester. Refer to the Standard Procedures in this section for additional test procedures. Charge the faulty battery, as required.
	4. The battery terminal connections are loose or corroded.	4. Refer to Battery Cables for the proper battery cable diagnosis and testing procedures. Clean and tighten the battery terminal connections, as required.
	5. The battery has an incorrect size or rating for this vehicle.	5. Refer to Battery System Specifications for the proper size and rating. Replace an incorrect battery, as required.
	6. The battery is faulty.	6. Test the battery using the Micro 420 battery tester. Refer to the Standard Procedures in this section for additional test procedures. Replace the faulty battery, as required.
	7. The starting system is faulty.	7. Determine if the starting system is performing to specifications. Refer to Starting System for the proper starting system diagnosis and testing procedures. Repair the faulty 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 (Continued)

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 Battery System Specifications for the proper specifications. Replace an incorrect battery, as required.
	2. The battery terminal connections are loose or corroded.	2. Refer to Battery Cable for the proper cable diagnosis and testing procedures. Clean and tighten the battery terminal connections, as required.
	3. The electrical system ignition-off draw is excessive.	3. Refer to the IGNITION-OFF DRAW TEST Standard Procedure for the proper test procedures. Repair the faulty electrical system, as required.
	4. The battery is faulty.	4. Test the battery using the Micro 420 battery tester. Refer to Standard Procedures for additional test procedures. Replace the faulty battery, as required.
	5. The starting system is faulty.	5. Determine if the starting system is performing to specifications. Refer to Starting System for the proper starting system diagnosis and testing procedures. Repair the faulty starting system, as required.
	6. The charging system is faulty.	6. Determine if the charging system is performing to specifications. Refer to Charging System for charging system diagnosis and testing procedures. Repair the faulty 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 loads in use.	8. Advise the vehicle operator, as required.
THE BATTERY WILL NOT ACCEPT A CHARGE.	1. The battery is faulty.	1. Test the battery using the Micro 420 battery tester.. Charge or replace the faulty battery, as required.

ABNORMAL BATTERY DISCHARGING

Any of the following conditions can result in abnormal battery discharging:

1. A faulty or incorrect charging system component. Refer to Charging System for additional charging system diagnosis and testing procedures.
2. A faulty or incorrect battery. Use Micro 420 tester and refer to Battery System for additional battery diagnosis and testing procedures.
3. A faulty circuit or component causing excessive ignition-off draw.
4. Electrical loads that exceed the output of the charging system. This can be due to equipment installed after manufacture, or repeated short trip use.
5. A faulty or incorrect starting system component. Refer to Starting System for the proper starting system diagnosis and testing procedures.
6. Corroded or loose battery posts and/or terminal clamps.
7. Slow driving speeds (heavy traffic conditions) or prolonged idling, with high-amperage draw loads in use.

CLEANING

The following information details the recommended cleaning procedures for the battery and related com-

BATTERY SYSTEM (Continued)

ponents. In addition to the maintenance schedules found in this service manual and the owner's manual, 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 of all corrosion. Remove any corrosion using a wire brush or a post and terminal cleaning tool, and a sodium bicarbonate (baking soda) and warm water cleaning solution (Fig. 1).

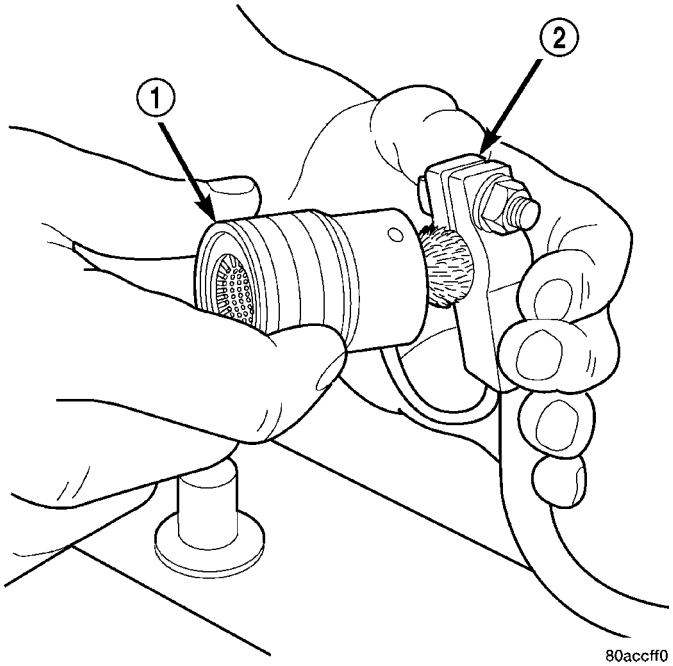


Fig. 1 Clean Battery Cable Terminal Clamp - Typical

1 - TERMINAL BRUSH
2 - BATTERY CABLE

(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 and the top cover with a sodium bicarbonate (baking soda) and warm water cleaning solution using a stiff bristle parts cleaning brush to remove any acid film (Fig. 2). 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 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 thermowrap with a sodium bicarbonate (baking soda) and warm water cleaning solution using a soft bristle parts cleaning brush to remove any acid film.

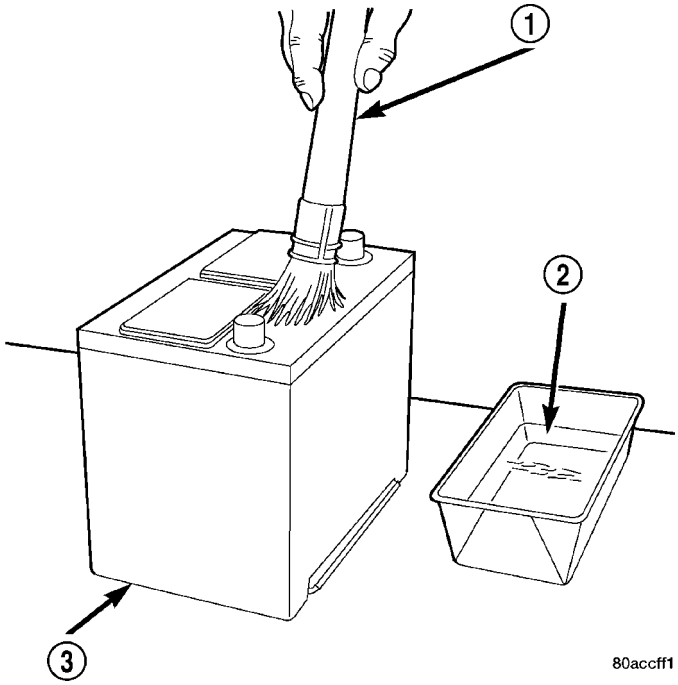


Fig. 2 Battery Cleaning - Typical

1 - CLEANING BRUSH
2 - WARM WATER AND BAKING SODA SOLUTION
3 - BATTERY

(5) Clean any corrosion from the battery terminal posts with a wire brush or a post and terminal cleaner, and a sodium bicarbonate (baking soda) and warm water cleaning solution (Fig. 3).

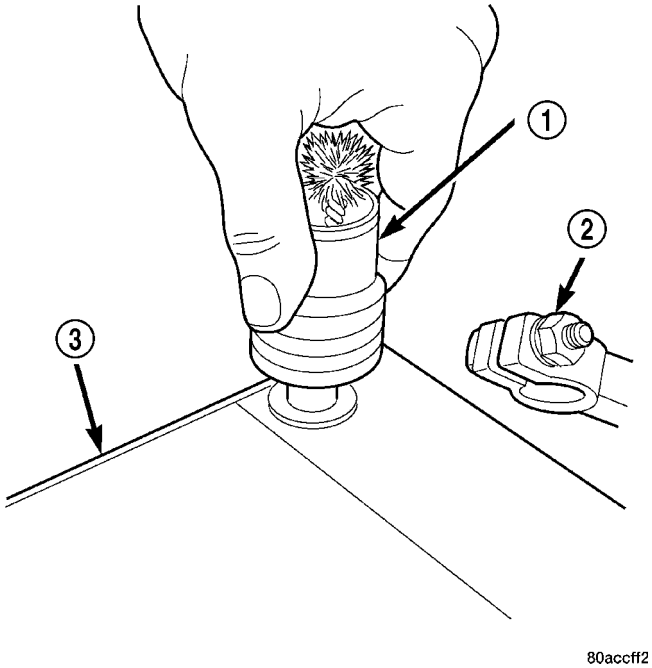


Fig. 3 Clean Battery Terminal Post - Typical

1 - TERMINAL BRUSH
2 - BATTERY CABLE
3 - BATTERY

INSPECTION

The following information details the recommended inspection procedures for the battery and related components. In addition to the maintenance schedules found in this service manual and the owner's manual, 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 thermowrap off of the battery case. 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 thermowrap 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. If the battery is discharged, charge as required. Refer to Standard Procedures for the proper battery built-in indicator test procedures. Also refer to Standard Procedures 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.

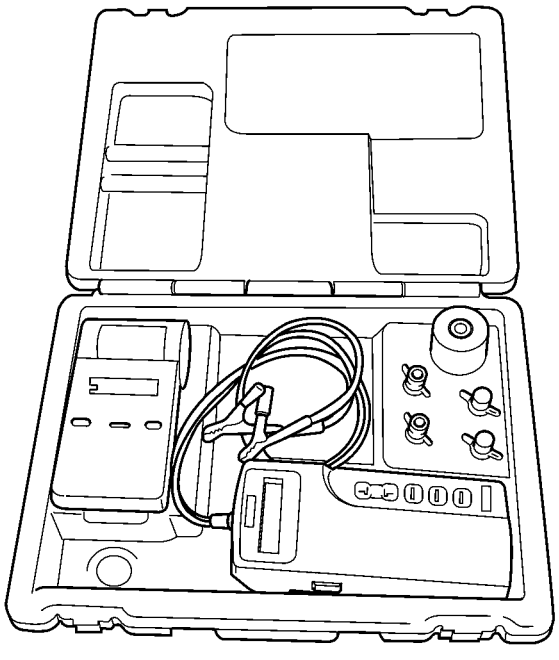
- **Group Size** - The outside dimensions and terminal placement of the battery conform to standards established by the Battery Council International (BCI). Each battery is assigned a BCI Group Size number to help identify a correctly-sized replacement.
- **Cold Cranking Amperage** - The Cold Cranking 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.

BATTERY CLASSIFICATIONS & RATINGS					
Part Number	BCI Group Size Classification	Cold Cranking Amperage	Reserve Capacity	Ampere - Hours	Load Test Amperage
4686158AD	34	500	110 Minutes	60	250
4727159AD	34	600	120 Minutes	66	300
4727242AD	DIN H6	600	120 Minutes	66	300
4868999AA	34	700	95 Minutes	50	350

BATTERY SYSTEM (Continued)

SPECIAL TOOLS

BATTERY SYSTEM SPECIAL TOOLS



Micro 420 Battery Tester

BATTERY

DESCRIPTION

There are three different batteries available on this model. Vehicles equipped with a diesel engine utilize a spiral wound plate designed battery with recombination technology. This is a maintenance-free battery that is capable of delivering more power than a conventional battery. This additional power is required by a diesel engine during cold cranking. Vehicles equipped with a gasoline engine utilize a conventional battery. Refer to the following information for detailed differences and descriptions of these batteries.

SPIRAL PLATE BATTERY - DIESEL ENGINE

Spiral plate technology takes the elements of traditional batteries - lead and sulfuric acid - to the next level. By tightly winding layers of spiral grids and acid-permeated vitreous separators into cells, the manufacturer has developed a battery with more power and service life than conventional batteries the same size. The spiral plate battery is completely, permanently sealed. Through gas recombination, hydrogen and oxygen within the battery are captured during normal charging and reunited to form the water within the electrolyte, eliminating the need to add distilled water. Therefore, these batteries have

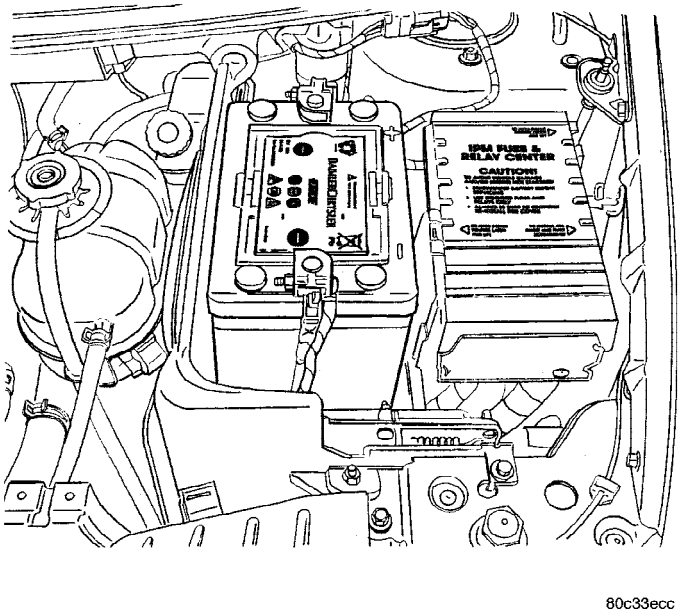


Fig. 4 MAINTENANCE-FREE DIESEL ENGINE BATTERY

non-removable battery vent caps (Fig. 4). Water **cannot** be added to this battery.

The acid inside a spiral plate battery is bound within the vitreous separators, ending the threat of acid leaks. This feature allows the battery to be installed in any position anywhere in the vehicle.

Spiral plate technology is the process by which the plates holding the active material in the battery are wound tightly in coils instead of hanging flat, like conventional batteries. This design has a lower internal resistance and also increases the active material surface area.

WARNING: NEVER EXCEED 14.4 VOLTS WHEN CHARGING A SPIRAL PLATE BATTERY. PERSONAL INJURY AND/OR BATTERY DAMAGE MAY RESULT.

Due to the maintanance-free design, distilled water cannot be added to this battery. Therefore, if more than 14.4 volts are used during the spiral plate battery charging process, water vapor can be exhausted through the pressure-sensitive battery vents and lost for good. This can permanently damage the spiral plate battery. Never exceed 14.4 volts when charging a spiral plate battery. Personal injury and/or battery damage may result.

CONVENTIONAL BATTERY - GASOLINE ENGINE

Low-maintenance batteries are used on export vehicles equipped with a gasoline engine, these batteries have removable battery cell caps (Fig. 5). Water **can** be added to this battery. Under normal

BATTERY (Continued)

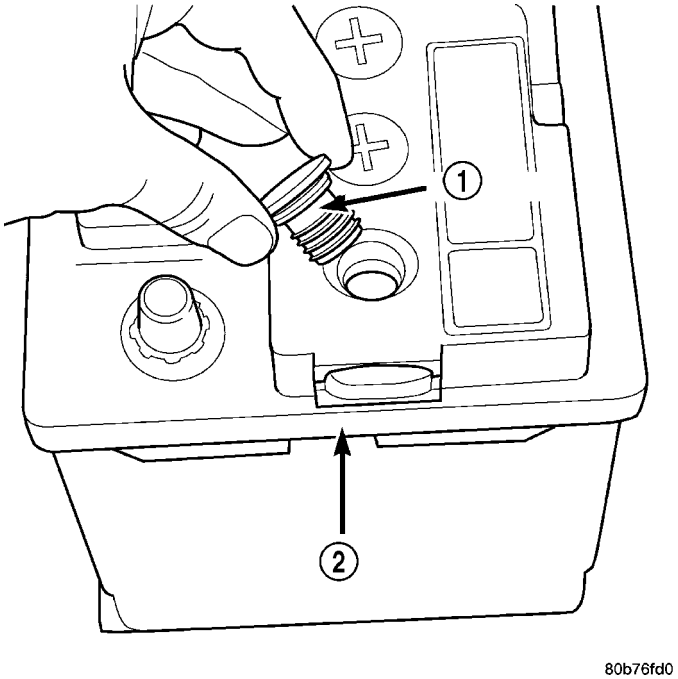


Fig. 5 BATTERY CELL CAP REMOVAL/ INSTALLATION - LOW-MAINTANANCE GASOLINE ENGINE BATTERY - EXPORT

1 - BATTERY CELL CAP
2 - BATTERY CASE

service, the composition of this battery reduces gassing and water loss at normal charge rates. However these batteries may require additional distilled water after years of service.

Maintenance-free batteries are standard factory-installed equipment on all domestic versions of this model. Male post type terminals made of a soft lead material protrude from the top of the molded plastic battery case (Fig. 6)to provide the means for connecting the battery to the vehicle electrical system. The battery positive terminal post is visibly larger in diameter than the negative terminal post, for easy identification. The letters **POS** and **NEG** are also molded into the top of the battery case adjacent to their respective positive and negative terminal posts for additional identification confirmation.

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

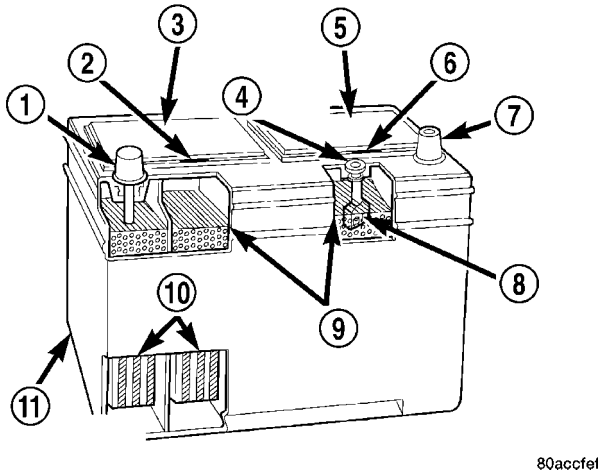


Fig. 6 Maintenance-Free Battery - Domestic

1 - POSITIVE POST
2 - VENT
3 - CELL CAP
4 - VENT
5 - CELL CAP
6 - VENT
7 - NEGATIVE POST
8 - INDICATOR EYE (if equipped)
9 - ELECTROLYTE LEVEL
10 - PLATE GROUPS
11 - MAINTENANCE-FREE BATTERY

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.

Some factory-installed batteries have a built-in test indicator (hydrometer). The color visible in the sight glass of the indicator will reveal the battery condition. For more information on the use of the built-in test indicator, refer to **Standard Procedures**. The chemical composition of the metal coated plates within the low-maintenance battery used in export models reduces battery gassing and water loss at normal charge and discharge rates. Therefore, the battery should not require additional water in normal service. If the electrolyte level in this battery does become low, distilled water must be added. However, rapid loss of electrolyte can be caused by an overcharging condition. Be certain to diagnose the charging system after replenishing the water in the battery for a low electrolyte condition and before returning the vehicle to service. Refer to **Charging System** for additional information.

The battery Group Size number, the Cold Cranking Amperage (CCA) rating, and the Reserve Capacity (RC) rating or Ampere-Hours (AH) rating can be

BATTERY (Continued)

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 **Battery Specifications** in this group for the location of 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 is equipped with removable cell caps, add distilled water whenever the electrolyte level is below the top of the plates. 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 Battery System Cleaning for the proper cleaning procedures, and Battery System Inspection for the proper battery inspection procedures. Refer to Standard Procedures for the proper battery charging procedures.

MICRO 420 BATTERY TESTER

The Micro 420 automotive battery tester is designed to help the dealership technicians diagnose the cause of a defective battery. Follow the instruction manual supplied with the tester to properly diagnose a vehicle. If the instruction manual is not available refer to the standard procedure in this section, which includes the directions for using 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 faulty, and must be replaced. Further testing is not required. A fully-charged battery must be tested to determine its cranking capacity. A battery that is fully-charged, but does not pass the Micro 420 or load test, is faulty and must be replaced.

NOTE: Completely discharged batteries may take several hours to accept a charge. Refer to Standard Procedures for the proper battery charging procedures.

BATTERY (Continued)

STANDARD PROCEDURE

STANDARD PROCEDURE - SPIRAL PLATE BATTERY CHARGING

Vehicles equipped with a diesel engine utilize a unique spiral plate battery. This battery has a maximum charging voltage that must not be exceeded in order to restore the battery to its full potential, failure to use the following spiral plate battery charging procedure could result in damage to the battery or personal injury.

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 battery tester indicates battery is OK.
- Open-circuit voltage of the battery is 12.65 volts or above.
- Battery passes Load Test multiple times.

WARNING: IF THE BATTERY SHOWS SIGNS OF FREEZING, LEAKING, LOOSE POSTS OR LOW ELECTROLYTE LEVEL, DO NOT TEST, ASSIST-BOOST, OR CHARGE. THE BATTERY MAY ARC INTERNALLY AND EXPLODE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT.

CAUTION: Always disconnect and isolate the battery negative cable before charging a battery. Charge the battery directly at the battery terminals. Do not exceed 14.4 volts while charging a battery.

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.

After the battery has been charged to 12.6 volts or greater, perform a load test to determine the battery cranking capacity. Refer to Battery Diagnosis and Testing for the proper battery test procedures. If the battery will endure a load test, return the battery to service. If the battery will not pass a load test, it is faulty and must be replaced.

Clean and inspect the battery hold downs, tray, terminals, posts, and top before completing battery service. Refer to Battery System Cleaning for the proper battery system cleaning procedures, and Battery System Inspection for the proper battery system inspection procedures.

CHARGING A COMPLETELY DISCHARGED BATTERY – SPIRAL PLATE 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 (Fig. 7). Refer to Battery Removal and Installation for access instructions. If the reading is below ten volts, the battery charging current will be low. It could take several hours 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.

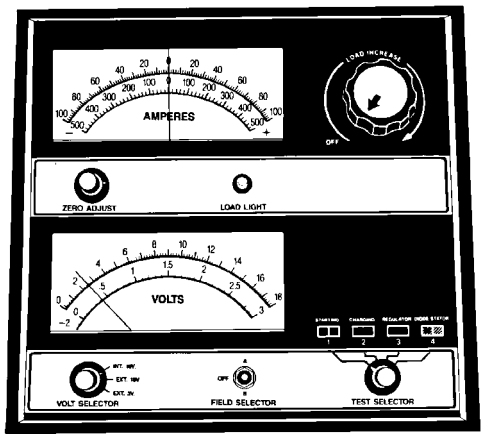


Fig. 7 Voltmeter - Typical

(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 faulty 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.

BATTERY (Continued)

SPIRAL-PLATE BATTERY CHARGE RATE TABLE	
Voltage	Minutes
14.4 volts maximum	up to 10 minutes
13.0 to 14 volts	up to 20 minutes
12.9 volts or less	up to 30 minutes

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 eight amperes 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.

SPIRAL-PLATE BATTERY CHARGING TIME TABLE		
Charging Amperage	5 Amps	8 Amps
Open Circuit Voltage	Hours Charging @ 21° C (70° F)	
12.25 to 12.49	6 hours	3 hours
12.00 to 12.24	10 hours	5 hours
10.00 to 11.99	14 hours	7 hours
Below 10.00	18 hours	9 hours

STANDARD PROCEDURE - CONVENTIONAL BATTERY CHARGING

Vehicles equipped with a diesel engine utilize a unique spiral plate battery. This battery has a maximum charging voltage that must be used in order to restore the battery to its full potential, failure to use the spiral plate battery charging procedure could result in damage to the battery or personal injury.

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 battery tester indicates battery is OK.
- Open-circuit voltage of the battery is 12.65 volts or above.
- Battery passes Load Test multiple times.

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.

BATTERY (Continued)

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.

After the battery has been charged to an open-circuit voltage reading of 12.4 volts or greater, retest the battery with the Micro 420 tester or perform a load test to determine the battery cranking capacity. Refer to Standard Procedures for the proper battery load test procedures. If the battery will pass a load test, return the battery to service. If the battery will not pass a load test, it is faulty and must be replaced.

Clean and inspect the battery hold downs, tray, terminals, posts, and top before completing battery service. Refer to Battery System Cleaning for the proper battery system cleaning procedures, and Battery System Inspection for the proper battery system inspection procedures.

CHARGING A COMPLETELY DISCHARGED CONVENTIONAL 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 (Fig. 8). 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.

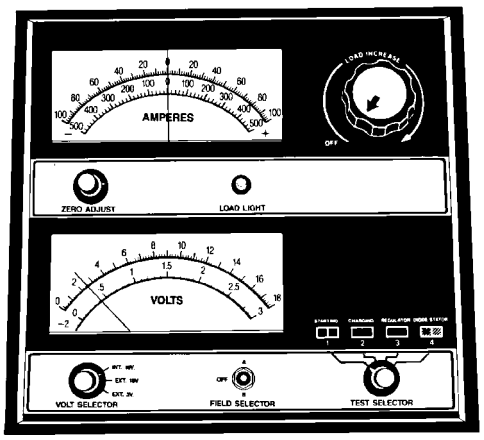


Fig. 8 Voltmeter - Typical

(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 faulty 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.

CONVENTIONAL BATTERY CHARGE RATE TABLE	
Voltage	Minutes
16.0 volts maximum	up to 10 min.
14.0 to 15.9 volts	up to 20 min.
13.9 volts or less	up to 30 min.

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 Conventional 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 (Continued)

CONVENTIONAL 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

STANDARD PROCEDURE - 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 if no other battery tester is available.

Before proceeding with this test, completely charge the battery. Refer to Standard Procedures for the proper battery charging procedures.

(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 (see the instructions provided by the manufacturer of the voltmeter), measure the open-circuit voltage (Fig. 9).

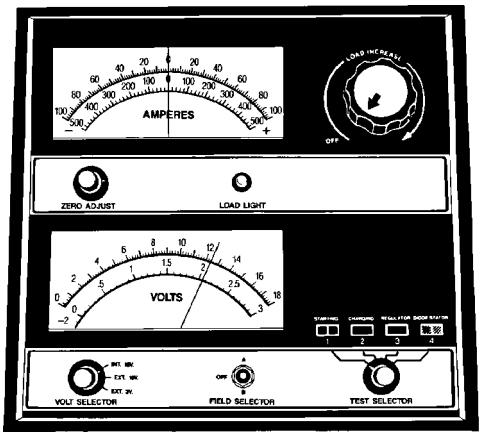


Fig. 9 Testing Open-Circuit Voltage - Typical

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 Standard Procedures for the proper battery load test procedures.

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

STANDARD PROCEDURE - 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 fifteen to twenty-five milliamperes (0.015 to 0.025 ampere) with the ignition switch in the Off position, and all non-ignition controlled circuits in proper working order. Up to twenty-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-one days, may discharge the battery to an inadequate level. When a vehicle will not be used for twenty-one days or more (stored), remove the IOD fuse from the Integrated Power Module (IPM). This will reduce battery discharging.

Excessive IOD can be caused by:

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

If the IOD is over twenty-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 twenty minutes.

(2) Disconnect the battery negative cable.

(3) Set an electronic digital multi-meter to its highest amperage scale. Connect the multi-meter

BATTERY (Continued)

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.

(4) 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 Integrated Power Module (IPM), one at a time until the amperage reading becomes very low, or nonexistent. Refer to the appropriate wiring information in this service manual for complete Integrated Power Module 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, refer to Charging System for the proper charging system diagnosis and testing procedures. 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.

(5) Allow twenty minutes for the IOD to stabilize and observe the multi-meter reading. The low-amperage IOD should not exceed twenty-five milliamperes (0.025 ampere). If the current draw exceeds twenty-five milliamperes, isolate each circuit using the fuse and circuit breaker remove-and-replace process in Step 4. 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 a component failure is at fault.

STANDARD PROCEDURE - CHECKING BATTERY ELECTROLYTE LEVEL

The following procedure can be used to check the electrolyte level in a low-maintenance lead-acid battery.

(1) Unscrew and remove the battery cell caps with a flat-bladed screw driver (Fig. 10).

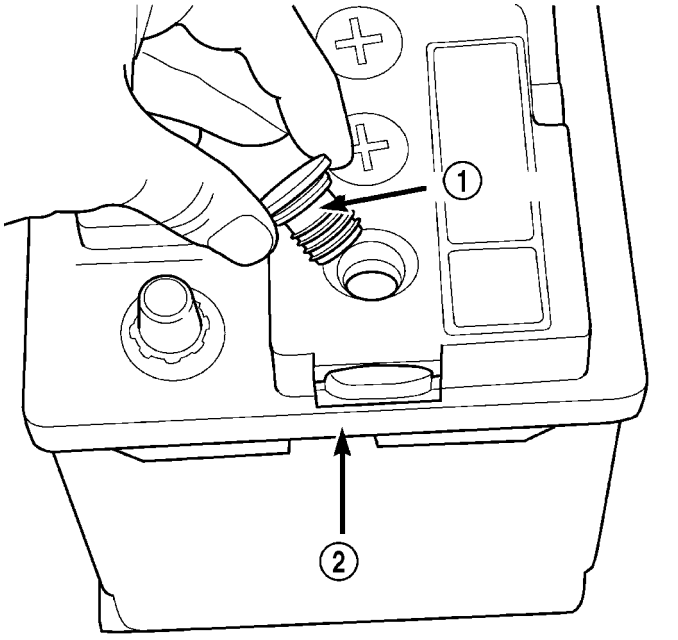


Fig. 10 BATTERY CELL CAP REMOVAL/ INSTALLATION - LOW-MAINTENANCE BATTERY ONLY

1 - BATTERY CELL CAP
2 - BATTERY CASE

WARNING: NEVER PUT YOUR FACE NEAR A GASSING, HOT OR SWELLED BATTERY. SERIOUS PERSONAL INJURY MAY RESULT.

(2) Wearing safety glasses, look through the battery cell cap holes to determine the level of the electrolyte in the battery. The electrolyte should be above the hooks inside the battery cells (Fig. 11).

(3) **Add only distilled water** until the electrolyte is above the hooks inside the battery cells (Fig. 11).

REMOVAL - BATTERY

WARNING: A SUITABLE PAIR OF HEAVY DUTY RUBBER GLOVES AND SAFETY GLASSES SHOULD BE WORN WHEN REMOVING OR SERVICING A BATTERY.

BATTERY (Continued)

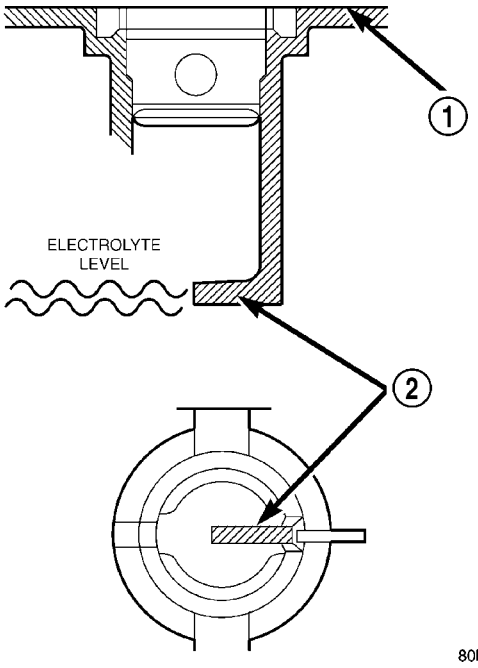


Fig. 11 HOOK INSIDE BATTERY CELLS - LOW-MAINTENANCE BATTERY ONLY

1 - TOP OF BATTERY
2 - HOOK INSIDE BATTERY CELLS

WARNING: REMOVE METALLIC JEWELRY TO AVOID INJURY BY ACCIDENTAL ARCING OF BATTERY CURRENT.

(1) Verify that the ignition switch and all accessories are OFF.
(2) Disconnect the battery cables from the battery posts, negative first (Fig. 12).
(3) Remove the battery hold down retaining nut.
(4) Remove the battery hold down bracket.
(5) Remove the battery from the vehicle.

INSTALLATION

(1) Position the battery in the battery tray.
(2) Install the battery hold down bracket and retaining nut. Torque the nut to 20 N·m (180 in. lbs.).
(3) Connect the battery cables to the battery posts, positive cable first. Torque terminal fasteners to 5 N·m (40 in. lbs.).

BATTERY HOLDDOWN

DESCRIPTION

The battery hold down hardware consists of a molded plastic lip that is integral to the outboard edge of the battery tray and support unit, a molded steel hold down bracket and a single hex nut with a coned washer.

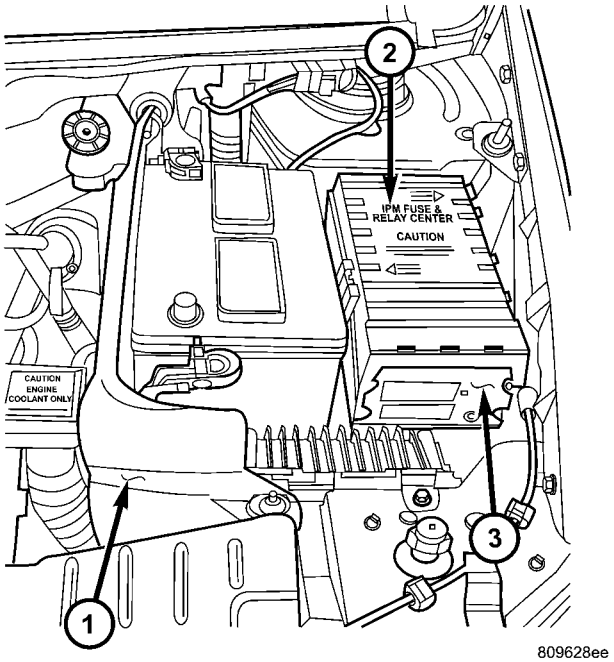


Fig. 12 BATTERY POSITION & ORIENTATION

1 - BATTERY THERMOWRAP (IF EQUIPPED)
2 - INTEGRATED POWER MODULE
3 - FRONT CONTROL MODULE

When installing a battery into the battery tray, be certain that the hold down hardware is properly installed and that the fasteners are tightened to the proper specifications. Improper hold down fastener tightness, whether too loose or too tight, can result in damage to the battery, the vehicle or both. Refer to **Battery Hold Downs** in this section of this service manual for the location of the proper battery hold down installation procedures, including the proper hold down fastener tightness specifications.

OPERATION

The battery holddown secures the battery in the battery tray. This holddown is designed to prevent battery movement during the most extreme vehicle operation conditions. Periodic removal and lubrication of the battery holddown hardware is recommended to prevent hardware seizure at a later date.

NOTE: Never operate a vehicle without a battery holddown device properly installed. Damage to the vehicle, components and battery could result.

REMOVAL

All of the battery hold down hardware can be serviced without removal of the battery or the battery tray and support unit.

(1) Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.

BATTERY HOLDDOWN (Continued)

(2) Remove the nut with washer that secures the battery hold down bracket to the battery tray and support unit.

(3) Remove the battery hold down bracket from the battery tray and support unit.

INSTALLATION

(1) Install the battery hold down bracket in the battery tray and support unit.

(2) Install the nut with washer that secures the battery hold down bracket to the battery tray and support unit. Torque to 20 N·m (180 in. lbs.).

BATTERY CABLES

DESCRIPTION

The battery cables 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. Refer to **Wiring Diagrams** in the index of this service manual for the location of the proper battery cable wire gauge information.

A clamping type female battery terminal made of stamped metal is attached to one end of the battery cable wire. 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 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 have a black insulating jacket and a smaller female battery terminal clamp.

The battery cables cannot be repaired and, if damaged or faulty they must be replaced. Both the battery positive and negative cables are available for service replacement only as a unit with the battery wire harness, which may include portions of the wiring circuits for the generator and other components on some models. Refer to **Wiring Diagrams** in the index of this service manual for the location of more information on the various wiring circuits included in the battery wire harness for the vehicle being serviced.

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 from the female battery terminal clamps provide secure and reliable connection of the battery cables to the vehicle electrical system.

The battery positive cable terminal clamp is attached to the ends of two wires. One wire has an eyelet terminal that connects the battery positive cable to the B(+) terminal stud of the Integrated Power Module (IPM), and the other wire has an eyelet terminal that connects the battery positive cable to the B(+) terminal stud of the engine starter motor solenoid. The battery negative cable terminal clamp is also attached to the ends of two wires. One wire has an eyelet terminal that connects the battery negative cable to the vehicle powertrain through a stud on the left side of the engine cylinder block. The other wire has an eyelet terminal that connects the battery negative cable to the vehicle body through a ground screw on the left front fender inner shield, near the battery.

DIAGNOSIS AND TESTING - BATTERY CABLE

A voltage drop test will determine if there is excessive resistance in the battery cable terminal connections or the battery cable. 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

The following operation will require a voltmeter accurate to 1/10 (0.10) volt. Before performing this

BATTERY CABLES (Continued)

test, be certain that the following procedures are accomplished:

- The battery is fully-charged and load tested. Refer to Standard Procedures for the proper battery charging and load test procedures.
- 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.
- To prevent the engine from starting, remove the Automatic Shut Down (ASD) relay. The ASD relay is located in the Intelligent Power Module (IPM), in the engine compartment. See the fuse and relay layout label affixed to the underside of the IPM cover for ASD relay identification and location.

(1) Connect the positive lead of the voltmeter to the battery negative terminal post. Connect the negative lead of the voltmeter to the battery negative cable terminal clamp (Fig. 13). 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.

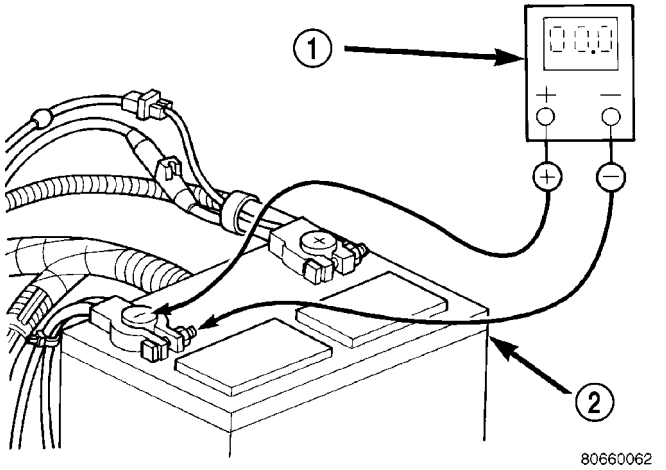


Fig. 13 Test Battery Negative Connection Resistance - Typical

1 - VOLTMETER
2 - BATTERY

(2) Connect the positive lead of the voltmeter to the battery positive terminal post. Connect the negative lead of the voltmeter to the battery positive cable terminal clamp (Fig. 14). 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.

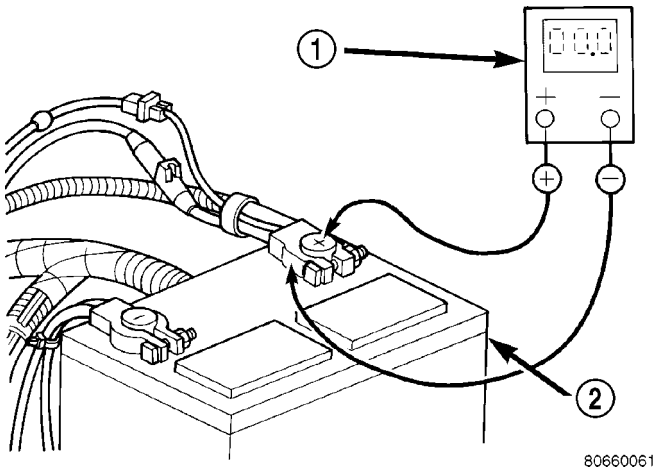


Fig. 14 Test Battery Positive Connection Resistance - Typical

1 - VOLTMETER
2 - BATTERY

(3) Connect the voltmeter to measure between the battery positive cable terminal clamp and the starter solenoid B(+) terminal stud (Fig. 15). 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.

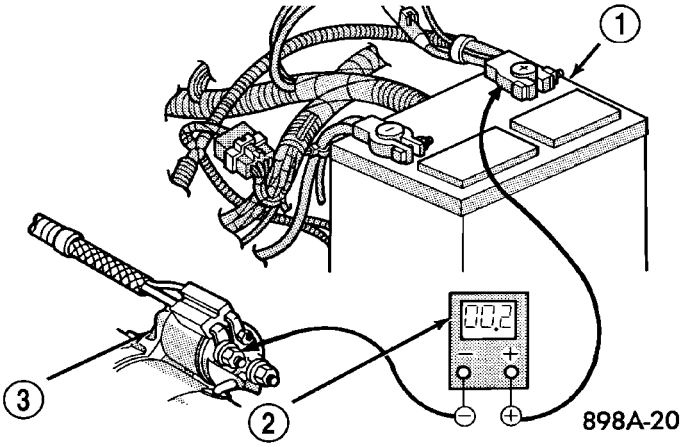


Fig. 15 Test Battery Positive Cable Resistance - Typical

1 - BATTERY
2 - VOLTMETER
3 - STARTER MOTOR

(4) Connect the voltmeter to measure between the battery negative cable terminal clamp and a good clean ground on the engine block (Fig. 16). 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

BATTERY CABLES (Continued)

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.

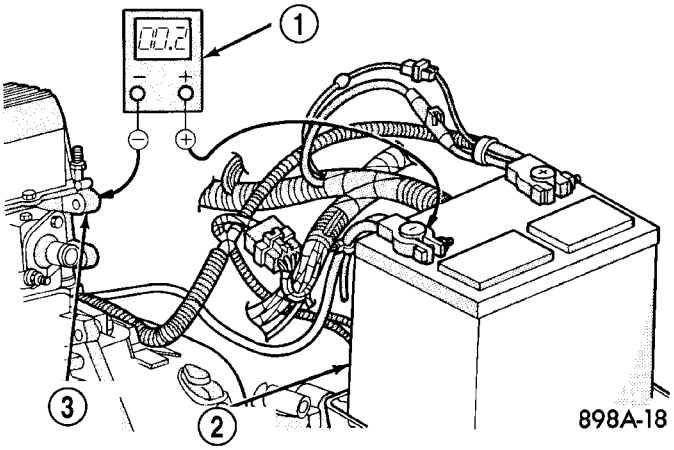


Fig. 16 Test Ground Circuit Resistance - Typical

1 - VOLTMETER
2 - BATTERY
3 - ENGINE GROUND

REMOVAL

The battery cables on this model may include portions of wiring circuits for the generator and other components on the vehicle. If battery cable replacement is required, it will be necessary to extract the cables out of the engine wire harness assembly. Use care not to damage the other wires and circuits which are also packaged into the engine wire harness assembly.

(1) Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.

(2) Disconnect and isolate the negative battery cable terminal.

(3) Remove the battery thermowrap (if equipped) from the battery tray.

(4) Remove the tape from the engine wire harness assembly, to access the desired battery cable.

(5) One at a time, trace and disconnect the battery cable retaining fasteners and routing clips until the desired cable is free from the vehicle.

(6) Feed the battery cable out of the vehicle.

INSTALLATION

(1) Position the battery cable in the vehicle.

(2) One at a time, trace and install the battery cable retaining fasteners and routing clips until the desired cable is properly installed in the engine wire harness assembly.

(3) Install the tape on the engine wire harness assembly.

(4) Install the battery thermowrap (if equipped) on the battery tray.

(5) Connect the negative battery cable terminal.

BATTERY TRAY

DESCRIPTION

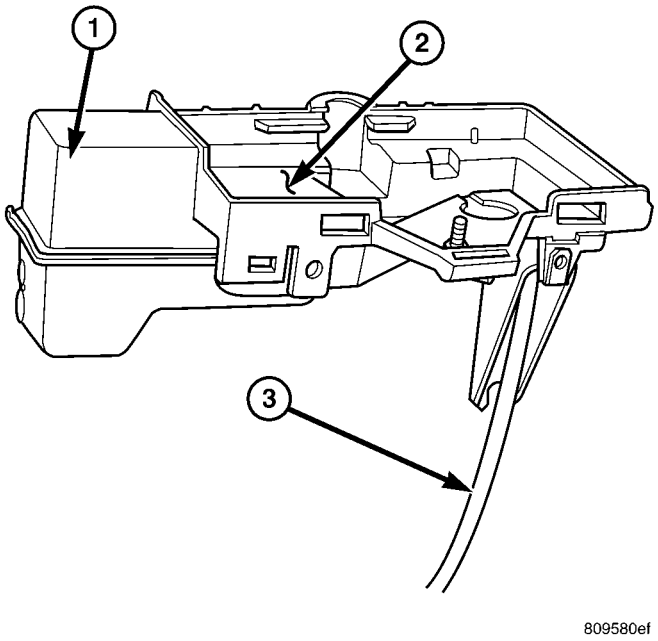


Fig. 17 RS BATTERY TRAY

1 - ENGINE VACUUM RESERVOIR
2 - BATTERY TRAY ASSEMBLY
3 - DRAINAGE HOSE

The battery is mounted in a molded plastic battery tray and support unit located in the left front corner of the engine compartment. The battery tray and support unit is secured with two nuts, one is located directly under the battery and the other is located on the right side of the tray which also serves as a coolant bottle neck retaining bolt. An additional bolt is located directly under the battery.

The battery tray and support unit also includes a engine vacuum reservoir, located in the rear of the unit (Fig. 17). And a drainage hose, located in the front of the unit (Fig. 17).

OPERATION

The battery tray provides a secure mounting location and supports the battery. The battery tray also provides the anchor point for the battery holddown hardware. The battery tray and the battery holddown hardware combine to secure and stabilize the battery in the engine compartment, which prevents battery movement during vehicle operation. Unrestrained battery movement during vehicle operation could result in damage to the vehicle, the battery, or both.

The battery tray used on this model also includes a engine vacuum reservoir and drainage hose. The vac-

BATTERY TRAY (Continued)

uum reservoir provides a storage container for engine vacuum. Refer to the engine section of the service manual for more engine vacuum information. The drainage hose provides means for any liquid that might collect in the bottom of the battery tray to drain under the vehicle.

REMOVAL

(1) Disconnect and isolate the negative battery cable.

(2) Remove the battery from the vehicle. Refer to the procedure in this section.

(3) Remove the battery tray retaining fasteners (Fig. 18).

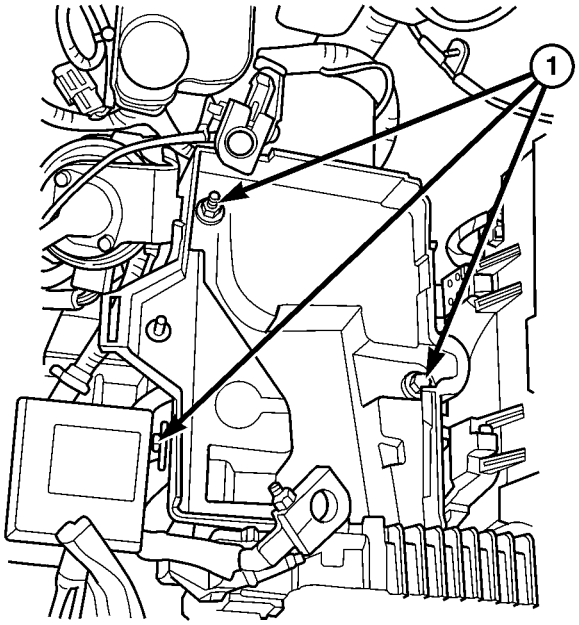


Fig. 18 BATTERY TRAY POSITION & ORIENTATION

1 - BATTERY TRAY RETAINING FASTENERS

(4) Pull battery tray up far enough to disconnect the engine vacuum harness hose from the battery tray mounted, vacuum reservoir.

(5) Remove the battery tray from the vehicle.

INSTALLATION

(1) Position the battery tray in the vehicle.

(2) Connect the engine vacuum harness hose on the battery tray mounted vacuum reservoir.

(3) Position drainage hose and install the battery tray retaining fasteners (Fig. 18).

(4) Install the battery in the vehicle. Refer to the procedure in this section.

(5) Connect the negative battery cable.

THERMOWRAP

DESCRIPTION

A one-piece slip-on thermowrap unit shields the battery case from engine compartment heat. The thermowrap slips over the battery case and due to its one piece design, the battery cables must be removed in order to install or remove the thermowrap.

OPERATION

The thermowrap protects the battery from engine compartment temperature extremes. The temperature of the battery can affect battery life. The air trapped in the padded material of the thermowrap creates a dead air space, which helps to insulate the sides of the battery case from the air temperature found in the surrounding engine compartment.

REMOVAL

(1) Disconnect and isolate the negative battery cable.

(2) Disconnect the positive battery cable.

(3) Lift the battery thermowrap straight up to remove from the battery.

INSTALLATION

(1) Position the thermowrap on the battery.

(2) Connect the negative and positive battery cables.

CHARGING

TABLE OF CONTENTS

CHARGING

DESCRIPTION - CHARGING SYSTEM

The charging system consists of:

- Generator
- Decoupler Pulley (If equipped)
- Electronic Voltage Regulator (EVR) circuitry within the Powertrain Control Module (PCM)
- Ignition switch (refer to the Ignition System section for information)
- Battery (refer to the Battery section for information)
- Ambient Air Temperature (If equipped)
- Inlet Air Temperature (calculated battery temperature)(If equipped)
- Voltmeter (refer to the Instrument Cluster section for information if equipped)
- Wiring harness and connections (refer to the Wiring section for information)
- Accessory drive belt (refer to the Cooling section for more information)
- Battery Temperature sensor (if equipped)

OPERATION - CHARGING SYSTEM

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. The ASD relay is energized when the PCM grounds the ASD control circuit. This voltage is connected through the PCM or IPM (intelligent power module) (if equipped) and supplied to one of the generator field terminals (Gen. Source +) at the back of the generator.

The generator is driven by the engine through a serpentine belt and pulley or decoupler pulley arrangement.

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

An Ambient air temperature sensor is used to calculate the temperature near the battery. This temperature data, along with data from monitored line voltage (battery voltage sense circuit), is used by the PCM 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 to maintain system voltage at the targeted system voltage based on battery temperature.

All vehicles are equipped with On-Board Diagnostics (OBD). All OBD-sensed systems, including EVR (field control) circuitry, 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 certain failures it detects and illuminate the (MIL) lamp. Refer to On-Board Diagnostics in the Electronic Control Modules(Refer to 8 - ELECTRICAL/ELECTRONIC CONTROL MOD-

CHARGING (Continued)

ULES/POWERTRAIN CONTROL MODULE - DESCRIPTION) section for more DTC information.

The Charging system "Battery" light indicates problems with the charging system (voltage too high/low, generator failure, etc.). If an extreme condition is indicated, the lamp will be illuminated. The signal to activate the lamp is sent via the PCI bus circuits. The lamp is located on the instrument panel. Refer to the Instrument Cluster section for additional information.

The PCM uses the ambient air temperature sensor to control the charge system voltage. This temperature, along with data from monitored line voltage, is used by the PCM to vary the battery charging rate. The system voltage is higher at cold temperatures and is gradually reduced as the calculated battery temperature increases.

The ambient temperature sensor is used to control the battery voltage based upon ambient temperature (approximation of battery temperature). The PCM maintains the optimal output of the generator by monitoring battery voltage and controlling it to a range of 13.5 - 14.7 volts based on battery temperature.

DIAGNOSIS AND TESTING - ON-BOARD DIAGNOSTIC SYSTEM

The Powertrain Control Module (PCM) 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 OBD system. Some circuits are checked continuously and some are checked only under certain conditions.

If the OBD system senses that a monitored circuit is bad, it will put a DTC into electronic memory. The DTC will stay in electronic memory as long as the circuit continues to be bad. The PCM is programmed to clear the memory after 40 good trip if the problem does not occur again.

DIAGNOSTIC TROUBLE CODES

A DTC description can be read using the DRBIII® scan tool. Refer to the appropriate Powertrain Diagnostic Procedures manual for information.

A DTC does not identify which component in a circuit is bad. Thus, a DTC should be treated as a symptom, not as the cause for the problem. In some cases, because of the design of the diagnostic test procedure, a DTC can be the reason for another DTC to be set. Therefore, it is important that the test procedures be followed in sequence, to understand what caused a DTC to be set.

ERASING DIAGNOSTIC TROUBLE CODES

The DRBIII® Scan Tool must be used to erase a DTC.

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

- the check gauges lamp or battery lamp 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 (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE)
- loose generator belt.

INSPECTION

The Powertrain Control Module (PCM) 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. This will include a complete list of DTC's including DTC's for the charging system.

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

(1) Inspect the battery condition. Refer to the Battery section (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - DIAGNOSIS AND TESTING) 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) or IPM (if equipped) 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

CHARGING (Continued)

torque specifications (Refer to 8 - ELECTRICAL/ CHARGING - SPECIFICATIONS).

(5) Inspect generator drive belt condition and tension. Tighten or replace belt as required. Refer to Belt Tension Specifications(Refer to 7 - COOLING/ ACCESSORY DRIVE - SPECIFICATIONS).

(6) Inspect decoupler pulley (if equipped). Ensure decoupler pulley is driving the alternator rotor.

(7) Inspect automatic belt tensioner (if equipped). Refer to the Cooling System for more information.

(8) 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

Type	Engine	Minimun Test Amperage
Denso	2.4 L	80 Amp (HOT)
Denso	3.3/3.8L	100 Amp or 115 Amp (HOT)
Test Specification: 1. Engine RPM : 2500 RPM ±20 RPM (HOT) 2. Voltage Output : 14.0 V ± 0.5 V 3. Field Current : 5 amps ± 0.1 amps		

Part number is located on the side of the generator.

TORQUE

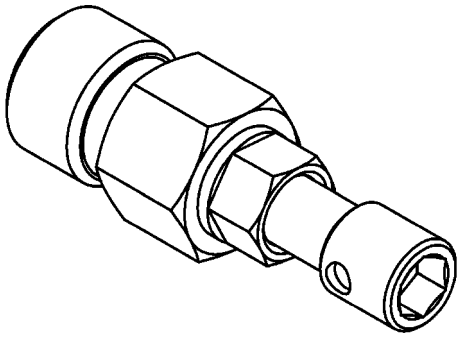
DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Battery Hold Down Clamp Bolt	20	14.7	180
Generator B+ Nut	12.4	9.2	110
Battery Terminal Nut	4		35
Generator Mounting Bolt 2.4L	28.2	20.8	250
Generator Mounting Bolts 3.3/3.8L	54.2	40	
Starter Solenoid Battery Nut 3.3/3.8L	11.3	8.3	100
Generator Decoupler	109.8	81	

SPECIFICATIONS - BATTERY TEMPERATURE SENSOR

°C	°F	K-Ohms Min.	K-Ohms Max.
(40)	(40)	291.4	381.7
(20)	(4)	85.8	108.4
20	68	11.4	13.6
25	77	9.1	10.9
120	248	0.37	0.41
130	266	0.28	0.32

CHARGING (Continued)

SPECIAL TOOLS



GENERATOR DECOUPLER 8433

BATTERY TEMPERATURE SENSOR

DESCRIPTION

(NGC Vehicles) The PCM incorporates a Battery Temperature Sensor (BTS) on its circuit board.

OPERATION

The PCM uses the temperature of the battery area to control the charge system voltage. This temperature, along with data from monitored line voltage, is used by the PCM to vary the battery charging rate. The system voltage is higher at cold temperatures and is gradually reduced as temperature around the battery increases.

For vehicles with 1.6L engine, there is no physical battery temp sensor in place to detect battery temp. Rather, an algorithm buit in PCM is employed to predict battery temp using inlet air temp, vehicle speed, and coolant temp, among other signals. The PCM maintains the optimal output of the generator by monitoring battery voltage and controlling it to a range of 13.5 - 14.7 volts based on battery temperature. The system target voltage is 13.5 – 14.7 volts. However the actual voltage go below this during heavy electrical loads and generator speeds. Also the actual voltage can be lower than the target voltage between the battery and the battery voltage sense circuit, approximately 0.2 — 0.3 volts.

The battery temperature sensor is also used for OBD II diagnostics. Certain faults and OBD II monitors are either enabled or disabled depending upon the battery temperature sensor input (example: disable purge and EGR, enable LDP). Most OBD II monitors are disabled below 20°F.

REMOVAL

The battery temperature sensor is not serviced separately. If replacement is necessary, the PCM must be replaced.

GENERATOR

DESCRIPTION

The generator is belt-driven by the engine. The generator produces DC voltage at the B+ terminal. If the generator is failed, the generator assembly subcomponents (generator and decoupler pulley) must be inspected for individual failure and replaced accordingly.

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 Y type stator winding connections deliver the induced AC current to 3 positive and 3 negative diodes for rectification. From the diodes, rectified DC current is delivered to the vehicles electrical system through the generator, battery, and ground terminals.

Excessive or abnormal noise emitting from the generator may be caused by:

- Worn, loose or defective bearings
- Loose or defective drive pulley (2.4L) or decoupler (3.3/3.8L)
- Incorrect, worn, damaged or misadjusted drive belt
- Loose mounting bolts
- Misaligned drive pulley
- Defective stator or diode
- Damaged internal fins

REMOVAL

REMOVAL - 2.4L

(1) Release hood latch and open hood.
(2) Disconnect battery negative cable.
(3) Disconnect the Inlet Air Temperature sensor.
(4) Remove the Air Box, refer to the Engine/Air Cleaner for more information.
(5) Remove the EVAP Purge solenoid from its bracket and reposition.
(6) Disconnect the push-in field wire connector from back of generator.
(7) Remove nut holding B+ wire terminal to back of generator.
(8) Separate B+ terminal from generator.

GENERATOR (Continued)

(9) Remove accessory drive belt, refer to the Cooling System section for proper procedures.
(10) Remove the generator.

REMOVAL - 2.5L

(1) Disconnect the negative battery cable (Fig. 1).

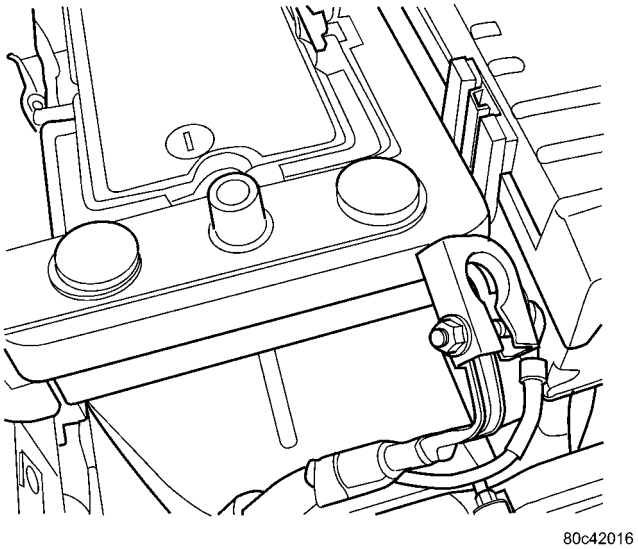


Fig. 1 BATTERY CONNECTION

(2) Remove the engine cover (Fig. 2).

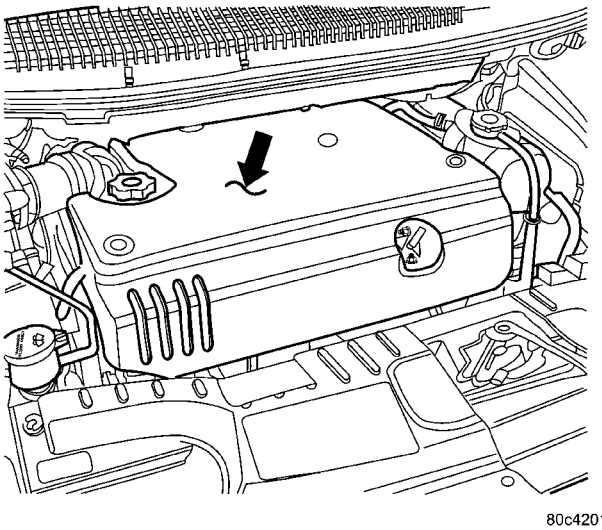


Fig. 2 ENGINE COVER

(3) Raise vehicle and support.
(4) Turn wheels to the right. Remove the right front splash shield (Fig. 3).

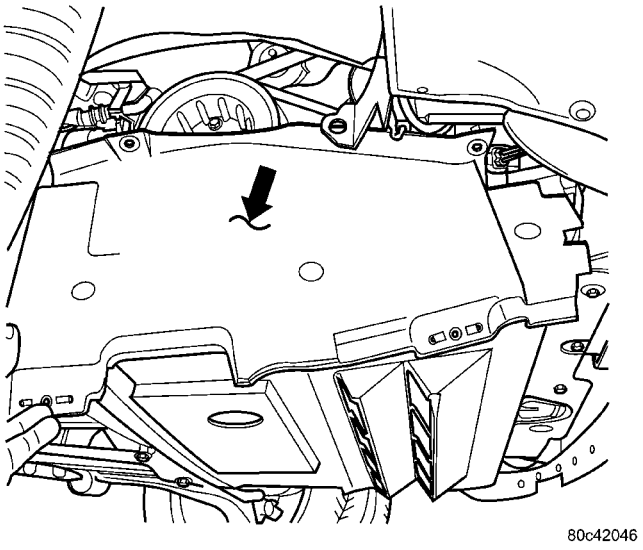


Fig. 3 SPLASH SHIELD

(5) Remove the generator drive belt (Fig. 4).

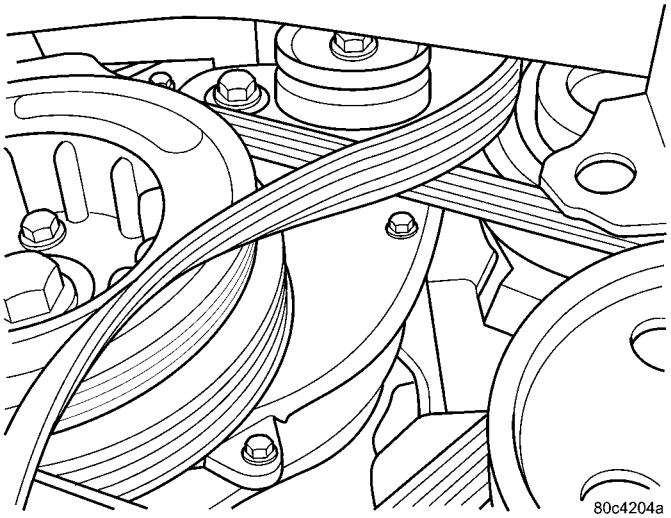


Fig. 4 GENERATOR BELT

(6) Lower vehicle.
(7) Disconnect the generator battery connection (Fig. 5).
(8) Disconnect the field connection (Fig. 5).
(9) Relocate the wiring harness on upper generator bracket (Fig. 6).
(10) Remove the Air Cleaner Box (Fig. 7).
(11) Remove the 2 lower mounting Bolts (Fig. 8).
(12) Remove generator.

GENERATOR (Continued)

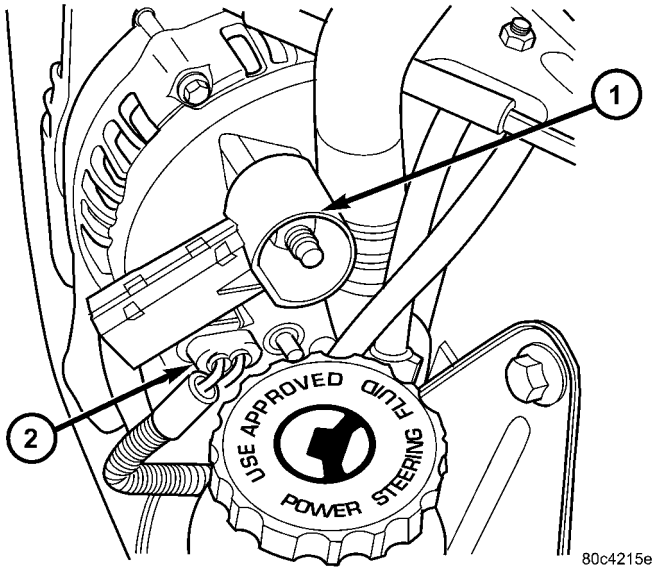


Fig. 5 GENERATOR CONNECTIONS

1 - Battery Connection
2 - Field Connection

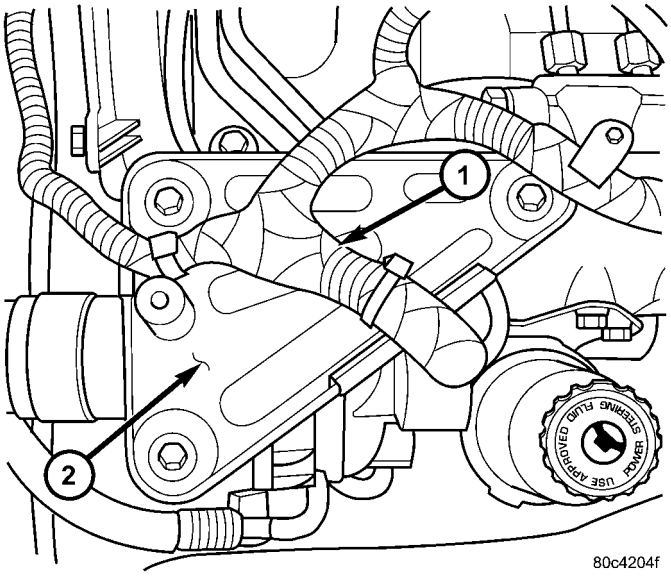


Fig. 6 UPPER SUPPORT BRACKET

1 - Wiring Harness
2 - Upper Bracket

REMOVAL - 3.3/3.8L

(1) Release hood latch and open hood.
(2) Disconnect battery negative cable.
(3) Disconnect the push-in field wire connector from back of generator.

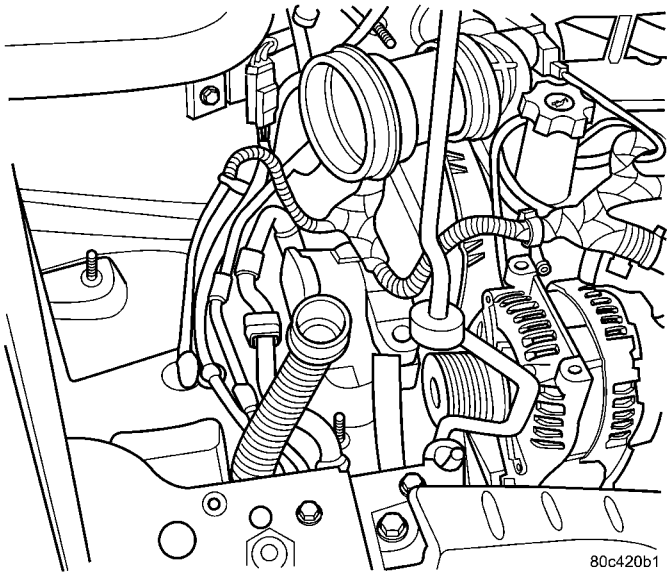


Fig. 7 AIR BOX REMOVED

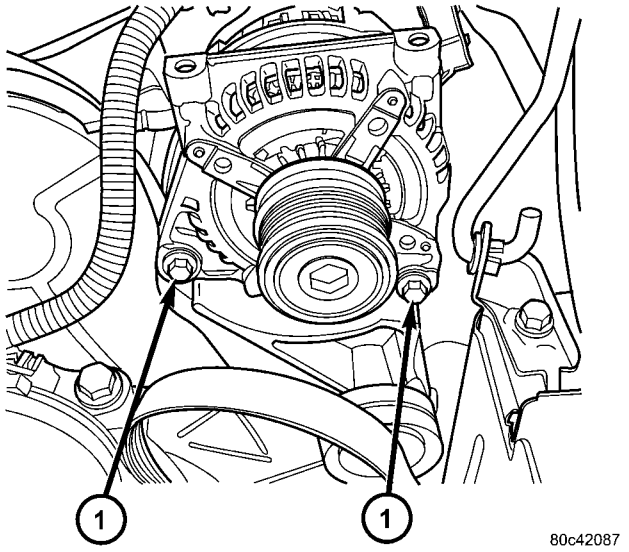


Fig. 8 GENERATOR LOWER BOLTS

1 - Lower Mounting Bolts

(4) Remove nut holding B+ wire terminal to back of generator.
(5) Separate B+ terminal from generator.
(6) Raise vehicle and support.
(7) Remove the right front lower splash shield.
(8) Remove accessory drive belt, refer to the Cooling System section for proper procedures.
(9) Remove the lower oil dip stick tube bolt (Fig. 9).
(10) Remove wiring harness from the oil dip stick tube

GENERATOR (Continued)

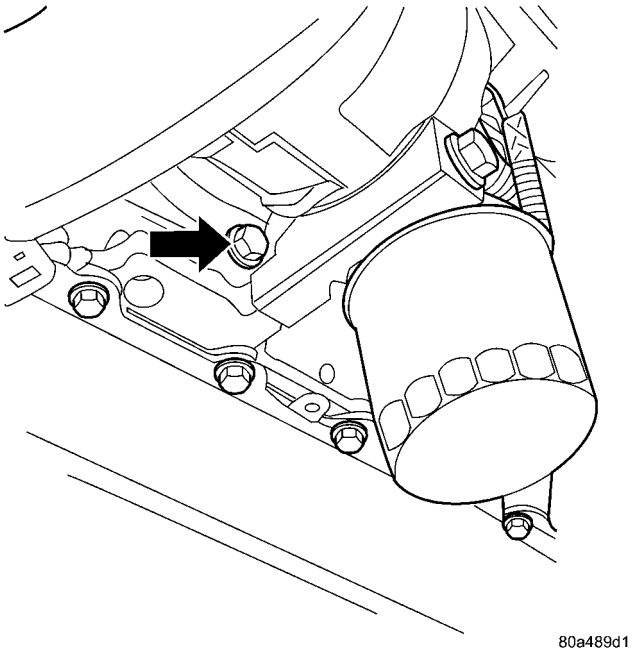


Fig. 9 DIP STICK LOWER BOLT

(11) Remove the 3 mounting bolts.
(12) Lower vehicle.
(13) Remove oil dip stick tube from vehicle.
(14) Roll and remove the generator from vehicle (Fig. 10).

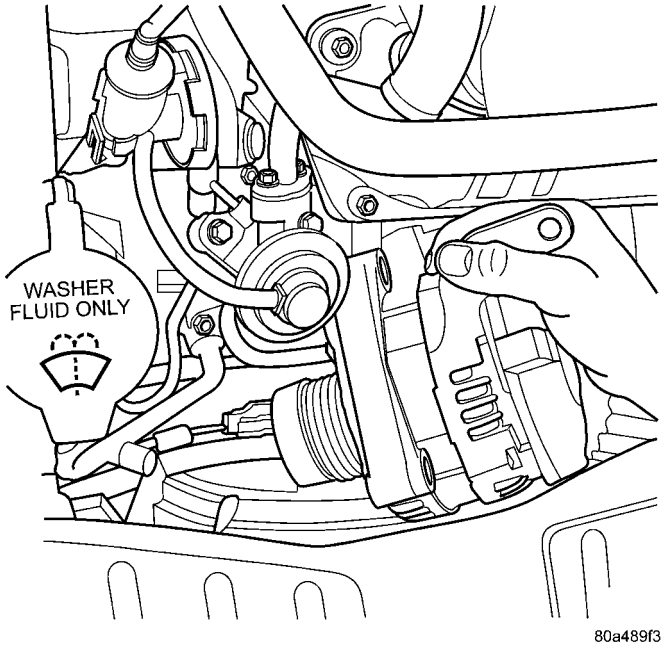


Fig. 10 GENERATOR 3.3/3.8L

INSTALLATION

INSTALLATION - 2.4L

(1) Install the generator.
(2) Install the accessory drive belt, refer to the Cooling System section for proper procedures.
(3) Connect B+ terminal to generator.
(4) Install nut holding B+ wire terminal to back of generator.
(5) Connect the push-in field wire connector to back of generator.
(6) Install the EVAP Purge solenoid to its bracket.
(7) Install the Air Box, refer to the Engine/Air Cleaner for more information.
(8) Connect the Inlet Air Temperature sensor.
(9) Connect battery negative cable.

INSTALLATION - 2.5L

(1) Install generator.
(2) Install the 2 lower mounting Bolts (Fig. 8).
(3) Install the Air Cleaner Box (Fig. 7).
(4) Install the upper support bracket (Fig. 6).
(5) Install the wiring harness on upper generator bracket (Fig. 6).
(6) Connect the field connection (Fig. 5).
(7) Connect the generator battery connection (Fig. 5).
(8) Raise vehicle and support.
(9) Install the generator drive belt (Fig. 4).
(10) Install the right front splash shield (Fig. 3).
(11) Lower vehicle.
(12) Install the engine cover (Fig. 2).
(13) Connect the negative battery cable (Fig. 1).

INSTALLATION - 3.3/3.8L

(1) Roll and place generator in position on vehicle (Fig. 10).
(2) Install upper bolts to hold generator in place.
(3) Lubricate the o-ring. Install oil dip stick tube.
(4) Install the upper oil dip stick tube bolt.
(5) Place B+ terminal in position on generator.
(6) Install nut to hold B+ wire terminal to back of generator.
(7) Connect the push-in field wire connector into back of generator.
(8) Raise vehicle and support.
(9) Install the lower mounting bolt and tighten.
(10) Install the lower oil dip stick tube bolt and tighten (Fig. 9).

GENERATOR (Continued)

(11) Install accessory drive belt, refer to the Cooling System section for proper procedures.
(12) Install the right front lower splash shield.
(13) Lower vehicle.
(14) Install wiring harness to the oil dip stick tube
(15) Connect battery negative cable.
(16) Verify generator output rate.

GENERATOR DECOUPLER PULLEY

DESCRIPTION

The Generator Decoupler is a one way clutch (Fig. 11). It is attached to the generator and replaces the standard pulley. It is a non-serviceable item and is to be replaced as an assembly. It is a dry operation (no grease or lubricants). The operation of it is not temperature sensitive and has a low sensitivity to electrical load.

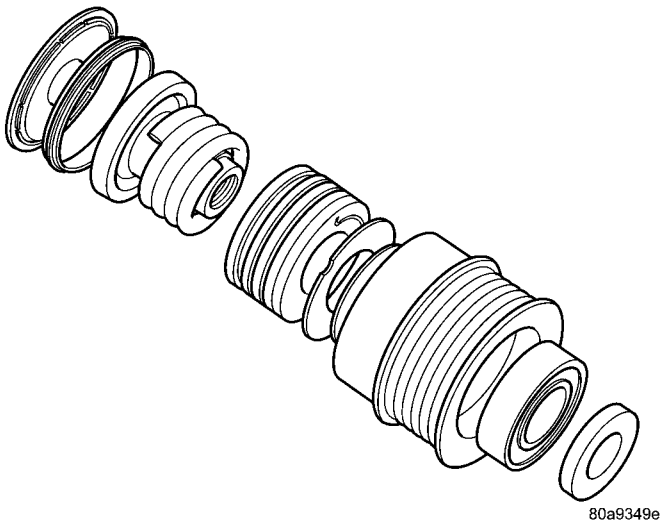


Fig. 11 GENERATOR DECOUPLER 3.3/3.8L

OPERATION

The generator decoupler is a one way clutch and should be replaced as an assembly. It is designed to help reduce belt tension fluctuation, reduce fatigue loads, improve belt life, reduce hubloads on components, and reduce noise.

DIAGNOSIS AND TESTING - GENERATOR DECOUPLER PULLEY

CONDITION	VERIFICATION PROCEDURE	POSSIBLE CAUSES	CORRECTION
Does not drive generator (Generator not Charging)	1. Start engine and allow engine to idle. 2.Verify generator pulley is rotating. 3. View generator internal fins thru generator housing. 4. Fins either do not rotate or rotate very erratic. 5. Rotate decoupler pulley in clockwise direction then quickly rotate in counterclockwise direction to see if clutch engages.	Clutch failure	Replace Decoupler
Noise from generator at engine shut down.	1. Start engine and allow engine to idle. 2. Shutdown engine and listen to generator. 3. Noise heard just as engine stops. Sounds like a click. 4. Remove accessory drive belt. 5. Verify rotation in counterclock wise direction is rough.	Defective decoupler pulley bearing.	Replace decoupler pulley.

GENERATOR DECOUPLER PULLEY (Continued)

REMOVAL

(1) Release hood latch and open hood.
(2) Disconnect battery negative cable.
(3) Raise vehicle and support.
(4) Remove the right front lower splash shield.
(5) Remove accessory drive belt, refer to the Cooling System section for proper procedures (Fig. 12).

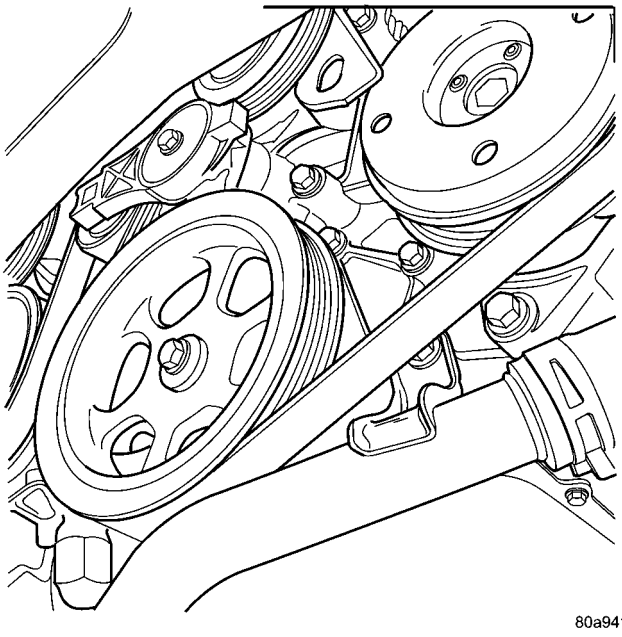


Fig. 12 DRIVE BELT 3.3/3.8L

(6) Lower vehicle.
(7) Remove the Air Box, refer to the Engine section for more information.
(8) Remove the decoupler pulley cover.
(9) Use Special Tool #8433 (Fig. 14) to loosen the Generator Decoupler (Fig. 13).
(10) Remove the tool.
(11) Remove the Generator Decoupler.

INSTALLATION

(1) Install the Generator Decoupler to the generator shaft.
(2) Use Special Tool #8433 (Fig. 14) to tighten the Generator Decoupler (Fig. 15). Refer to the torque chart for the proper torque.
(3) Install a new decoupler pulley cover.
(4) Install the Air Box, refer to the Engine section for more information.
(5) Raise vehicle and support.
(6) Install accessory drive belt, refer to the Cooling System section for proper procedures (Fig. 12).
(7) Install the right front lower splash shield.
(8) Lower vehicle.
(9) Connect battery negative cable.

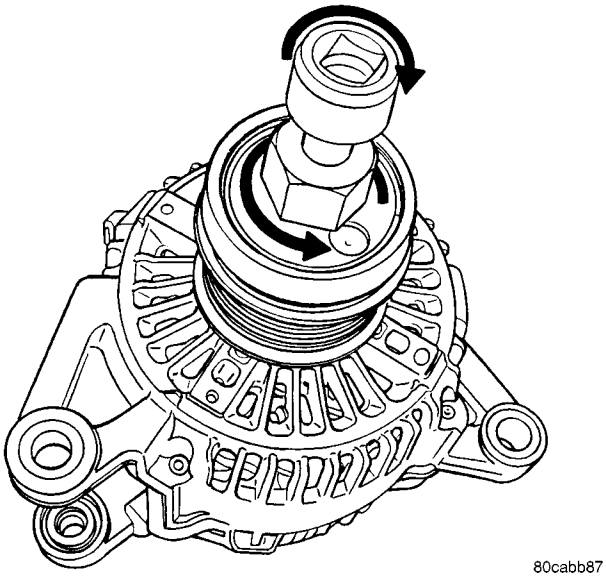


Fig. 13 DECOUPLER REMOVAL (LITENS)

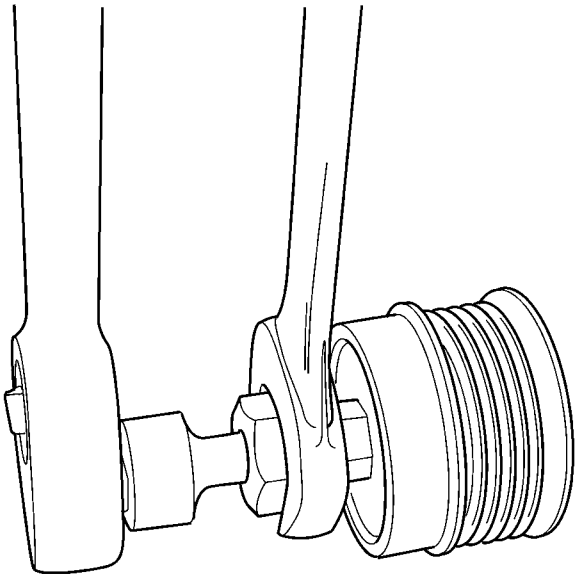


Fig. 14 SPECIAL TOOL 8433 AND DECOUPLER

GENERATOR DECOUPLER PULLEY (Continued)

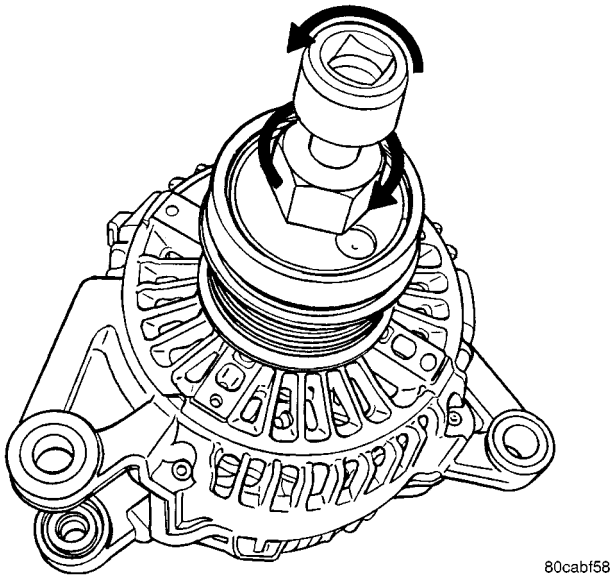


Fig. 15 DECOUPLER INSTALLATION (Litens)

VOLTAGE REGULATOR

DESCRIPTION

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

OPERATION

The amount of DC 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 within the PCM on the NGC vehicles, to control the strength of the rotor magnetic field. The EVR circuitry monitors system line voltage at the PDC and calculated battery temperature or inlet air temperature sensor (refer to Inlet Air Temperature Sensor, if equipped, for more information). It then determines a target charging voltage. If sensed battery voltage is lower than the target voltage, the PCM feeds the field winding until sensed battery voltage is at the target voltage. A circuit in the PCM cycles the feed side of the generator field at 250 times per second (250Hz), but has the capability to feed 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 20% 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.

OPERATION

These components form two separate circuits. A high amperage circuit that feeds the starter motor up to 300+ amps, and a control circuit that operates on less than 20 amps.

The PCM controls a double start over-ride safety that does not allow the starter to be engaged if the engine is already running.

DIAGNOSIS AND TESTING

DIAGNOSIS AND TESTING - STARTING SYSTEM TEST

For circuit descriptions and diagrams, refer to the Wiring Diagrams.

WARNING: ON VEHICLES EQUIPPED WITH AIRBAGS, REFER TO THE PASSIVE RESTRAINT SYSTEMS BEFORE ATTEMPTING 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.

INSPECTION

Before removing any unit from the starting system for repair or diagnosis, perform the following inspections:

- **Battery** - Visually inspect the battery for indications of physical damage and loose or corroded cable connections. Determine the state-of-charge and cranking capacity of the battery. Charge or replace

STARTING (Continued)

the battery, if required. Refer to the Battery section for more information.

- **Ignition Switch** - Visually inspect the ignition switch for indications of physical damage and loose or corroded wire harness connections.
- **Transmission Range Sensor or Park/Neutral Switch** - Visually inspect the transmission range sensor for indications of physical damage and loose or corroded wire harness connections.
- **Starter Relay** - Visually inspect the starter relay for indications of physical damage and loose or corroded wire harness connections.
- **Starter Motor** - Visually inspect the starter motor for indications of physical damage and loose or corroded wire harness connections.
- **Starter Solenoid** - Visually inspect the starter solenoid for indications of physical damage and loose or corroded wire harness connections.
- **Wiring** - Visually inspect the wire harness for damage. Repair or replace any faulty wiring, as required. Check for loose or corroded wire harness connections at main engine ground and remote jump post.
- **Power Distribution Center (PDC)** - Visually inspect the B+ connections at the PDC for physical damage and loose or corroded harness connections.

STARTING SYSTEM DIAGNOSIS

CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER FAILS TO ENGAGE.	1. BATTERY DISCHARGED OR FAULTY.	1. REFER TO THE BATTERY SECTION FOR MORE INFORMATION. CHARGE OR REPLACE BATTERY, IF REQUIRED.
	2. STARTING CIRCUIT WIRING FAULTY.	2. REFER TO FEED CIRCUIT RESISTANCE TEST AND FEED CIRCUIT TEST IN THIS SECTION.
	3. STARTER RELAY FAULTY.	3. REFER TO RELAY TEST, IN THIS SECTION. REPLACE RELAY, IF NECESSARY.
	4. IGNITION SWITCH FAULTY.	4. REFER TO IGNITION SWITCH TEST, IN THE STEERING SECTION OR 8 WIRING DIAGRAMS. REPLACE SWITCH, IF NECESSARY.
	5. PARK/NEUTRAL POSITION SWITCH (AUTO TRANS) FAULTY OR MIS-ADJUSTED.	5. REFER PARK/NEUTRAL POSITION SWITCH TEST, IN THE TRANSAXLE. SECTION FOR MORE INFORMATION. REPLACE SWITCH, IF NECESSARY.
	6. CLUTCH INTERLOCK SWITCH (MAN TRANS) FAULTY.	6. REFER TO CLUTCH PEDAL POSITION SWITCH TEST, IN THE CLUTCH. SECTION. REPLACE SWITCH, IF NECESSARY.
	7. STARTER SOLENOID FAULTY.	7. REFER TO SOLENOID TEST, IN THIS SECTION. REPLACE STARTER ASSEMBLY, IF NECESSARY.
	8. STARTER ASSEMBLY FAULTY.	8. IF ALL OTHER STARTING SYSTEM COMPONENTS AND CIRCUITS CHECK OK, REPLACE STARTER ASSEMBLY.
	9. FAULTY TEETH ON RING GEAR.	9. ROTATE FLYWHEEL 360°, AND INSPECT TEETH AND RING GEAR REPLACED IF DAMAGED.
	10. PCM DOUBLE START OVERRIDE OUTPUT FAILURE.	10. REFER TO PCM DIAGNOSTIC. CHECK FOR CONTINUITY BETWEEN PCM AND TERMINAL 85. REPAIR OPEN CIRCUIT AS REQUIRED. IF OK, PCM MAY BE DEFECTIVE.
STARTER ENGAGES, FAILS TO TURN ENGINE.	1. BATTERY DISCHARGED OR FAULTY.	1. REFER TO THE BATTERY SECTION FOR MORE INFORMATION. CHARGE OR REPLACE BATTERY AS NECESSARY.

STARTING (Continued)

CONDITION	POSSIBLE CAUSE	CORRECTION
	2. STARTING CIRCUIT WIRING FAULTY.	2. REFER TO THE FEED CIRCUIT RESISTANCE TEST AND THE FEED CIRCUIT TEST IN THIS SECTION. REPAIR AS NECESSARY.
	3. STARTER ASSEMBLY FAULTY.	3. IF ALL OTHER STARTING SYSTEM COMPONENTS AND CIRCUITS CHECK OK, REPLACE STARTER ASSEMBLY.
	4. ENGINE SEIZED.	4. REFER TO THE ENGINE SECTION, FOR DIAGNOSTIC AND SERVICE PROCEDURES.
	5. LOOSE CONNECTION AT BATTERY, PDC, STARTER, OR ENGINE GROUND.	5. INSPECT FOR LOOSE CONNECTIONS.
	6. FAULTY TEETH ON RING GEAR.	6. ROTATE FLYWHEEL 360°, AND INSPECT TEETH AND RING GEAR REPLACED IF DAMAGED.
STARTER ENGAGES, SPINS OUT BEFORE ENGINE STARTS.	1. BROKEN TEETH ON STARTER RING GEAR.	1. REMOVE STARTER. INSPECT RING GEAR AND REPLACE IF NECESSARY.
	2. STARTER ASSEMBLY FAULTY.	2. IF ALL OTHER STARTING SYSTEM COMPONENTS AND CIRCUITS CHECK OK, REPLACE STARTER ASSEMBLY.
STARTER DOES NOT DISENGAGE.	1. STARTER IMPROPERLY INSTALLED.	1. INSTALL STARTER. TIGHTEN STARTER MOUNTING HARDWARE TO CORRECT TORQUE SPECIFICATIONS.
	2. STARTER RELAY FAULTY.	2. REFER TO RELAY TEST, IN THIS SECTION. REPLACE RELAY, IF NECESSARY.
	3. IGNITION SWITCH FAULTY.	3. REFER TO IGNITION SWITCH TEST, IN THE STEERING SECTION. REPLACE SWITCH, IF NECESSARY.
	4. STARTER ASSEMBLY FAULTY.	4. IF ALL OTHER STARTING SYSTEM COMPONENTS AND CIRCUITS CHECK OK, REPLACE STARTER ASSEMBLY.
	5. FAULTY TEETH ON RING GEAR.	5. ROTATE FLYWHEEL 360°, AND INSPECT TEETH AND RING GEAR REPLACED IF DAMAGED.

DIAGNOSIS AND TESTING - CONTROL CIRCUIT TEST

The starter control circuit has:

- Starter motor with integral solenoid
- Starter relay
- Transmission range sensor, or Park/Neutral Position switch with automatic transmissions
- Ignition switch
- Battery
- All related wiring and connections
- Powertrain Control Module (PCM)

CAUTION: Before performing any starter tests, the ignition and fuel systems must be disabled.

- To disable ignition and fuel systems, disconnect the Automatic Shutdown Relay (ASD). The ASD relay is located in the Power Distribution Center (PDC). Refer to the PDC cover for the proper relay location.

STARTER SOLENOID

WARNING: CHECK TO ENSURE THAT THE TRANSMISSION IS IN THE PARK POSITION WITH THE PARKING BRAKE APPLIED. THIS MAY RESULT IN PERSONAL INJURY OR DEATH.

(1) Verify battery condition. Battery must be in good condition with a full charge before performing any starter tests. Refer to Battery Tests.

STARTING (Continued)

(2) Perform Starter Solenoid test BEFORE performing the starter relay test.

(3) Perform a visual inspection of the starter/starter solenoid for corrosion, loose connections or faulty wiring.

(4) Locate and remove the starter relay from the Power Distribution Center (PDC). Refer to the PDC label for relay identification and location.

(5) Connect a remote starter switch or a jumper wire between the remote battery positive post and terminal 87 of the starter relay connector.

(a) If engine cranks, starter/starter solenoid is good. Go to the Starter Relay Test.

(b) If engine does not crank or solenoid chatters, check wiring and connectors from starter relay to starter solenoid and from the battery positive terminal to starter post for loose or corroded connections. Particularly at starter terminals.

(c) Repeat test. If engine still fails to crank properly, trouble is within starter or starter mounted solenoid, and replace starter. Inspect the ring gear teeth.

STARTER RELAY

WARNING: CHECK TO ENSURE THAT THE TRANSMISSION IS IN THE PARK/NEUTRAL POSITION WITH THE PARKING BRAKE APPLIED. THIS MAY RESULT IN PERSONAL INJURY OR DEATH.

RELAY TEST

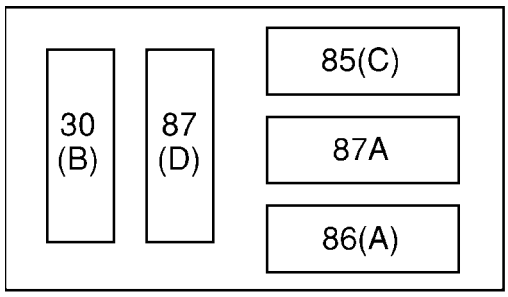
The starter relay is located in the Power Distribution Center (PDC) in the engine compartment. Refer to the PDC label for relay identification and location.

Remove the starter relay from the PDC as described in this group to perform the following tests:

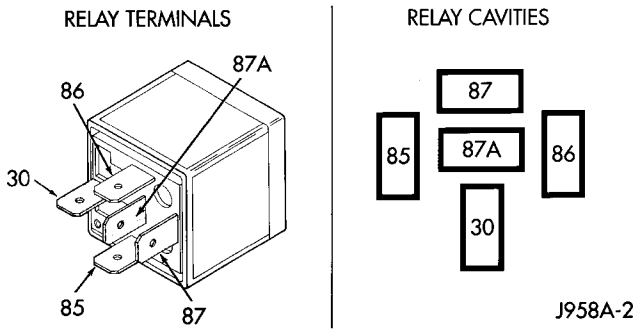
(1) A relay in the de-energized position should have continuity between terminals 87A and 30, and no continuity between terminals 87 and 30. If OK, go to Step 2. If not OK, replace the faulty relay.

(2) Resistance between terminals 85 and 86 (electromagnet) should be 75 ±5 ohms. If OK, go to Step 3. If not OK, replace the faulty relay.

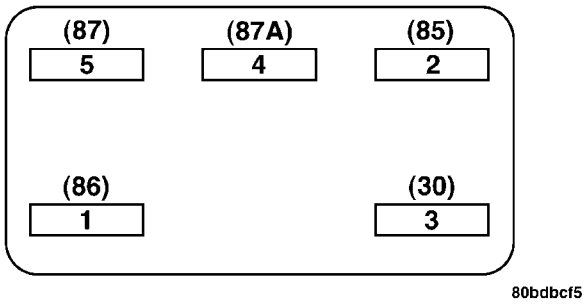
(3) Connect a battery B+ lead to terminals 85 and a ground lead to terminal 86 to energize the relay. The relay should click. Also test for continuity between terminals 30 and 87, and no continuity between terminals 87A and 30. If OK, refer to Relay Circuit Test procedure. If not OK, replace the faulty relay.



Starter Relay Pinout



Starter Relay Pinout



Starter Relay Pinout

CAV	FUNCTION
30	B (+)
85	IGNITION SWITCH OUTPUT
86	PCM-CONTROLLED GROUND
87	STARTER RELAY OUTPUT
87A	NO CONNECT

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 the open circuit to the PDC fuse as required.

STARTING (Continued)

(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 the common feed terminal (30) in the energized position. This terminal supplies battery voltage to the starter solenoid field coils. There should be continuity between the cavity for relay terminal 87 and the starter solenoid terminal at all times. If OK, go to Step 4. If not OK, repair the open circuit to the starter solenoid as required.

(4) The coil battery terminal (85) is connected to the electromagnet in the relay. It is energized when the ignition switch is held in the Start position and the clutch pedal is depressed (manual trans). Check for battery voltage at the cavity for relay terminal 86 with the ignition switch in the Start position and the clutch pedal is depressed (manual trans), and no voltage when the ignition switch is released to the On position. If OK, go to Step 5. If not OK, check for an open or short circuit to the ignition switch and repair, if required. If the circuit to the ignition switch is OK, see the Ignition Switch Test procedure in this group.

(5) The coil ground terminal (86) is connected to the electromagnet in the relay. It is grounded by the PCM if the conditions are right to start the car. For automatic trans. cars the PCM must see Park Neutral switch low and near zero engine speed (rpm). For manual trans. cars the PCM only needs to see near zero engine speed (rpm) and low clutch interlock input and see near zero engine speed (rpm). To diagnose the Park Neutral switch of the trans range sensor refer to the transaxle section. Check for continuity to ground while the ignition switch is in the start position and if equipped the clutch pedal depressed. If not OK and the vehicle has an automatic trans. verify Park Neutral switch operation. If that checks OK check for continuity between PCM and the terminal 86. Repair open circuit as required. Also check the clutch interlock switch operation if equipped with a manual transmission. If OK, the PCM may be defective.

SAFETY SWITCHES

For diagnostics of the Transmission Range Sensor, refer to the Transaxle section for more information.

If equipped with Clutch Interlock/Upstop Switch, refer to Diagnosis and Testing in the Clutch section.

IGNITION SWITCH

After testing starter solenoid and relay, test ignition switch and wiring. Refer to the Ignition Section or Wiring Diagrams for more information. Check all wiring for opens or shorts, and all connectors for being loose or corroded.

BATTERY

For battery diagnosis and testing, refer to the Battery section for procedures.

ALL RELATED WIRING AND CONNECTORS

Refer to Wiring Diagrams for more information.

DIAGNOSIS AND TESTING - FEED CIRCUIT RESISTANCE TEST

Before proceeding with this operation, review Diagnostic Preparation and Starter Feed Circuit Tests. The following operation will require a voltmeter, accurate to 1/10 of a volt.

CAUTION: Ignition and Fuel systems must be disabled to prevent engine start while performing the following tests.

(1) To disable the Ignition and Fuel systems, disconnect the Automatic Shutdown Relay (ASD). The ASD relay is located in the Power Distribution Center (PDC). Refer to the PDC cover for proper relay location.

(2) Gain access to battery terminals.

(3) With all wiring harnesses and components properly connected, perform the following:

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

(b) Connect positive lead of the voltmeter to the battery positive post, and negative lead to the battery positive cable clamp. Rotate and hold the ignition switch key in the START position. Observe the voltmeter. If voltage is detected, correct poor contact between the cable clamp and post.

(c) Connect negative lead of voltmeter to battery negative terminal, and positive lead to engine block near the battery cable attaching point. Rotate and hold the ignition switch in the START position. If voltage reads above 0.2 volt, correct poor contact at ground cable attaching point. If voltage reading is still above 0.2 volt after correcting poor contacts, replace ground cable.

(4) Connect positive voltmeter lead to the starter motor housing and the negative lead to the battery negative terminal. Hold the ignition switch key in the START position. If voltage reads above 0.2 volt, correct poor starter to engine ground.

(a) Connect the positive voltmeter lead to the battery positive terminal, and negative lead to battery cable terminal on starter solenoid. Rotate and hold the ignition switch in the START position. If voltage reads above 0.2 volt, correct poor contact at

battery cable to solenoid connection. If reading is still above 0.2 volt after correcting poor contacts, replace battery positive cable.

(b) If resistance tests do not detect feed circuit failures, replace the starter motor.

DIAGNOSIS AND TESTING - FEED CIRCUIT TEST

NOTE: The following results are based upon the vehicle being at room temperature.

The following procedure will require a suitable volt-ampere tester (Fig. 1).

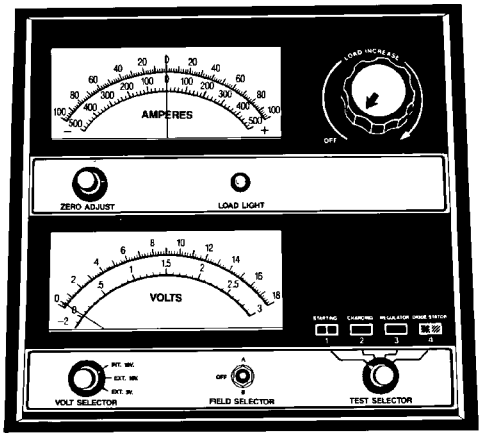


Fig. 1 Volt Ampere Tester

CAUTION: Before performing any starter tests, the ignition and fuel systems must be disabled.

(1) Check battery before performing this test. Battery must be fully charged.

(2) Connect a volt-ampere tester to the battery terminals. Refer to the operating instructions provided with the tester being used.

(3) To disable the ignition and fuel systems, disconnect the Automatic Shutdown Relay (ASD). The ASD relay is located in the Power Distribution Center (PDC). Refer to the PDC cover for proper relay location.

(4) Verify that all lights and accessories are OFF, and the transmission shift selector is in the PARK and SET parking brake.

CAUTION: Do not overheat the starter motor or draw the battery voltage below 9.6 volts during cranking operations.

(5) Rotate and hold the ignition switch in the START position. Observe the volt-ampere tester (Fig. 1).

- If voltage reads above 9.6 volts, and amperage draw reads above 280 amps, check for engine seizing or faulty starter.
- If voltage reads 12.4 volts or greater and amperage reads 0 to 10 amps, check for corroded cables and/or bad connections.
- Voltage below 9.6 volts and amperage draw above 300 amps, the problem is the starter. Replace the starter refer to starter removal.

(6) After the starting system problems have been corrected, verify the battery state-of-charge and charge battery if necessary. Disconnect all testing equipment and connect ASD relay. Start the vehicle several times to assure the problem has been corrected.

SPECIFICATIONS

Torques

DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Starter Mounting Bolts	47.4	35	
Starter Solenoid Battery Nut	11.3	8.3	100

STARTING (Continued)

STARTER

MANUFACTURER	NIPPONDENSO
Engine Application	2.4L /3.3/3.8L
Power rating	1.2 Kw
Voltage	12 VOLTS
No. of Fields	4
No. of Poles	4
Brushes	4
Drive	Conventional Gear Train
Free running Test	
Voltage	11
Amperage Draw	73 Amp
Minimum Speed	3401 RPM
SolenoidClosing Voltage	7.5 Volts
Cranking Amperage Draw test	150 - 200 Amps.

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

STARTER MOTOR

REMOVAL

REMOVAL - 2.4L

(1) Release hood latch and open hood (Fig. 2).
(2) Disconnect and isolate the battery negative cable.
(3) Disconnect solenoid wire connector from terminal (Fig. 3).
(4) Remove nut holding B+ wire to terminal.
(5) Disconnect solenoid and B+ wires from starter terminals.
(6) Remove the lower bolt.
(7) Remove the upper bolt and ground wire (Fig. 4).
(8) Remove starter.

REMOVAL - 3.3/3.8L

(1) Release hood latch and open hood.
(2) Disconnect and isolate the battery negative cable.
(3) Hoist and support vehicle on safety stands.
(4) Remove nut holding B+ terminal to starter solenoid (Fig. 5).
(5) Disconnect solenoid connector from starter.
(6) Remove bolts holding starter to transaxle bellhousing (Fig. 6).
(7) Remove starter from bellhousing (Fig. 7).

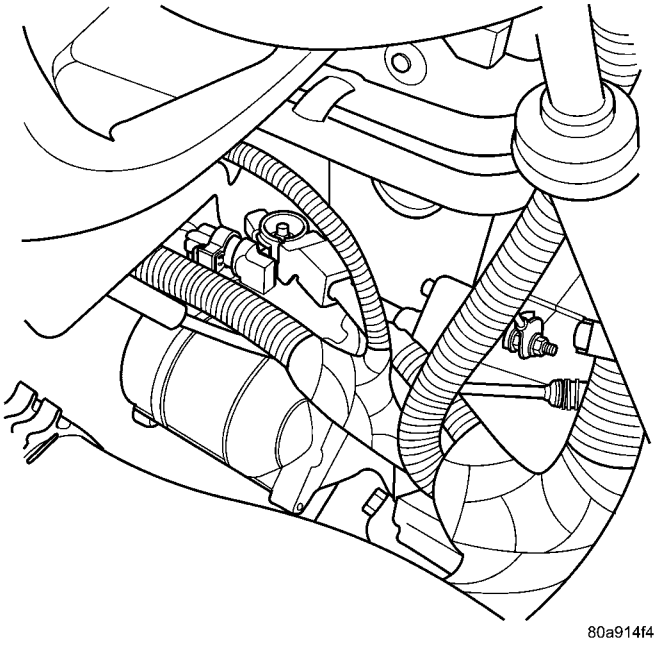


Fig. 2 STARTER 2.4L

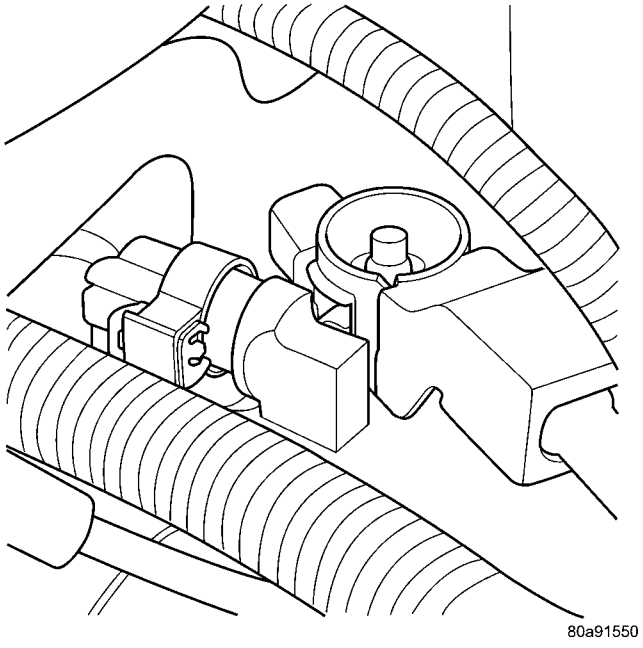


Fig. 3 BATTERY CABLE AND FIELD WIRE 2.4L

(8) Separate starter spacer from transaxle bellhousing.

REMOVAL - 2.5L

(1) Disconnect the negative battery cable.
(2) Raise vehicle and support.
(3) Remove the lower engine splash shield.
(4) Remove the electrical connectors from the starter (Fig. 8).

STARTER MOTOR (Continued)

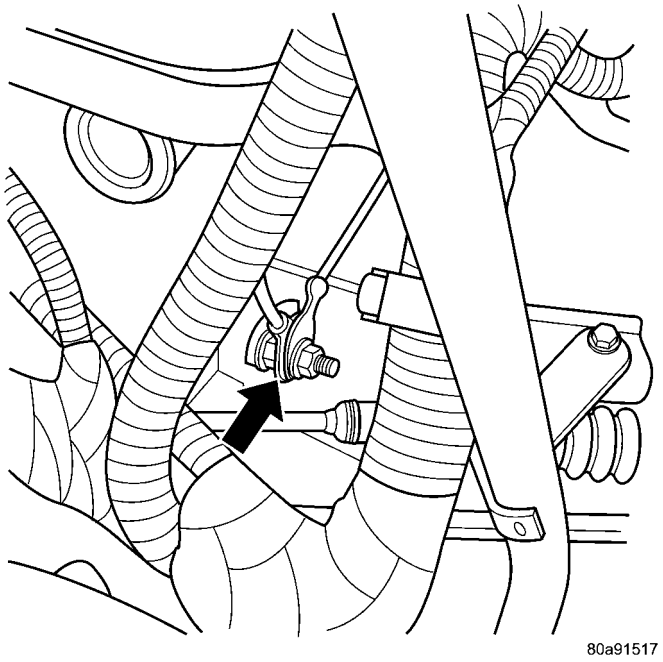


Fig. 4 Upper Bolt and Ground Wire

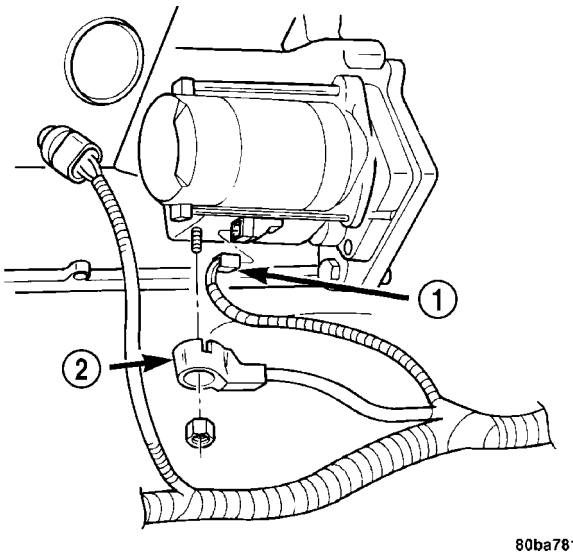


Fig. 5 Starter

1 - SOLENOID CONNECTOR
2 - B+ CONNECTOR

(5) Remove the starter mounting bolts (Fig. 9).
(6) Remove the starter.

INSTALLATION

INSTALLATION - 2.4L

(1) Place starter in position on vehicle.
(2) Install the lower bolts to hold starter to transaxle bellhousing.
(3) Install the upper bolt and ground wire (Fig. 4).

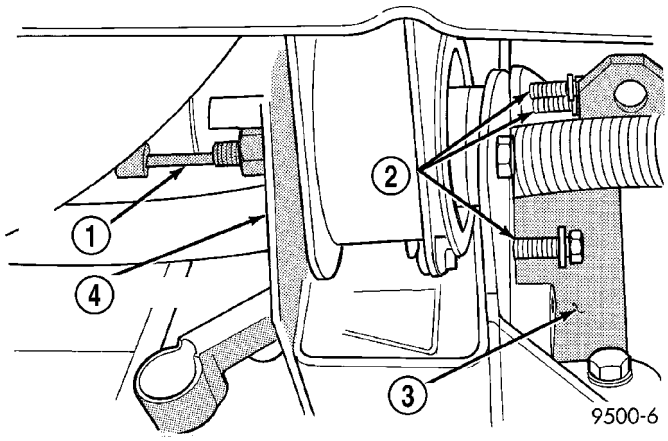


Fig. 6 Starter Bolts

1 - STARTER
2 - STARTER BOLTS
3 - TRANSAXLE
4 - ENGINE MOUNT

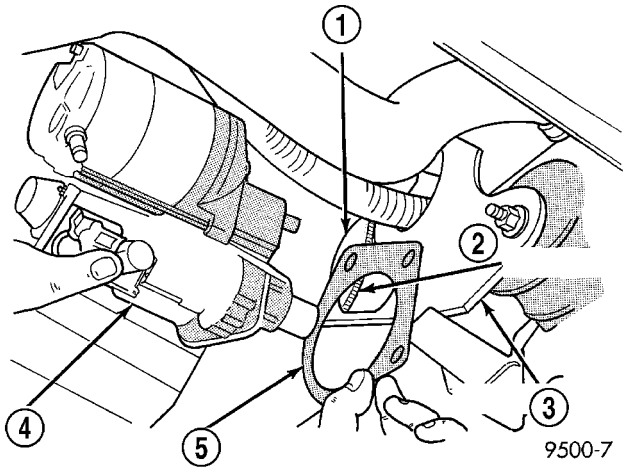


Fig. 7 STARTER 3.3/3.8L

1 - BELL HOUSING PLATE
2 - FLYWHEEL
3 - ENGINE MOUNT
4 - STARTER
5 - SPACER

(4) Place solenoid and B+ wires in position on starter terminals (Fig. 3).
(5) Install nut to hold B+ wire to terminal.
(6) Connect solenoid wire connector onto terminal.
(7) Connect battery negative cable.
(8) Verify starter operation.

INSTALLATION - 3.3/3.8L

(1) Place starter spacer in position on transaxle bellhousing, flange toward flywheel.
(2) Place starter in position on bellhousing.
(3) Install bolts and ground wire (Fig. 4) to hold starter to transaxle bellhousing.
(4) Connect solenoid connector into starter.

STARTER MOTOR (Continued)

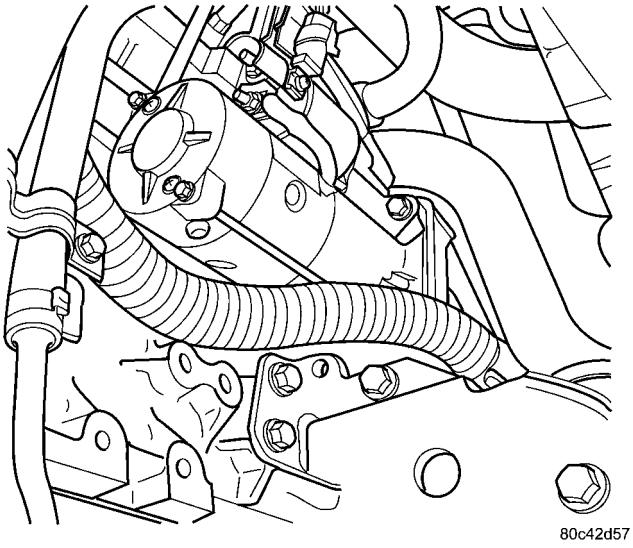


Fig. 8 STARTER LOCATION

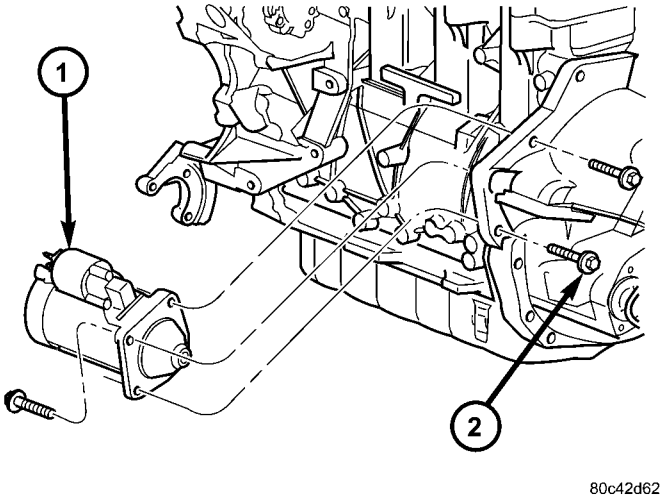


Fig. 9 STARTER MOUNTING BOLTS

1 - Starter
2 - Mounting Bolts

(5) Install nut to hold B+ terminal to starter solenoid.
(6) Lower vehicle.
(7) Connect battery negative cable.
(8) Verify starter operation.

INSTALLATION - 2.5L

(1) Raise vehicle and support.
(2) Install the starter.
(3) Install the starter mounting bolts (Fig. 9).
(4) Install the electrical connectors to the starter (Fig. 8).
(5) Install the lower engine splash shield.
(6) Connect the negative battery cable.
(7) Lower vehicle.