ENGINE SYSTEMS

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BATTERY SYSTEM

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BATTERY SYSTEM

DESCRIPTION

A single 12-volt battery system is standard factory-installed equipment on gasoline engine equipped models. Models equipped with a diesel engine utilize two 12-volt batteries connected in parallel. All of the components of the battery system are located within the engine compartment of the vehicle. The service information for the battery system in this vehicle covers the following related components, which are covered in further detail elsewhere in this service manual:

BATTERY SYSTEM (Continued)

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

For battery system maintenance schedules and jump starting procedures, see the owner's manual in the vehicle glove box. Optionally, refer to Lubrication and Maintenance for the recommended battery maintenance schedules and for the proper battery jump starting procedures. While battery charging can be considered a maintenance procedure, the battery charging procedures and related information are located in the standard procedures 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. Refer to Standard procedures for the proper battery charging procedures.

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.

MIDTRONICS ELECTRICAL SYSTEM TESTER

The Midtronics® automotive battery and charging system tester is designed to help the dealership technicians diagnose the cause of a defective battery or charging system. 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 midtronics electrical system 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 using the Midtronics battery and charging system tester. 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 Midtronics battery and charging system 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. Determine the battery cranking capacity using the Midtronics battery and charging system 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 Midtronics battery and charging system 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 using the Midtronics battery and charging system tester.. Refer to Charging System for additional 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 systems 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 Midtronics battery and charging system tester.. Charge or replace the faulty battery, as required.

BATTERY SYSTEM (Continued)

ABNORMAL BATTERY DISCHARGING

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

- A faulty or incorrect charging system component. Refer to Charging System for the proper charging system diagnosis and testing procedures.
- A faulty or incorrect battery. Refer to Standard Procedures for the proper battery diagnosis and testing procedures. Refer to Battery System Specifications for the proper specifications.
- A faulty circuit or component causing excessive ignition-off draw.
- Electrical loads that exceed the output of the charging system. This can be due to equipment installed after manufacture, or repeated short trip use.
- A faulty or incorrect starting system component. Refer to Starting System for the proper starting system diagnosis and testing procedures.
- Corroded or loose battery posts and terminal clamps.
- A loose or worn generator drive belt.
- Slow driving speeds (heavy traffic conditions) or prolonged idling, with high-amperage draw systems in use.

CLEANING

The following information details the recommended cleaning 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) 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).

(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.

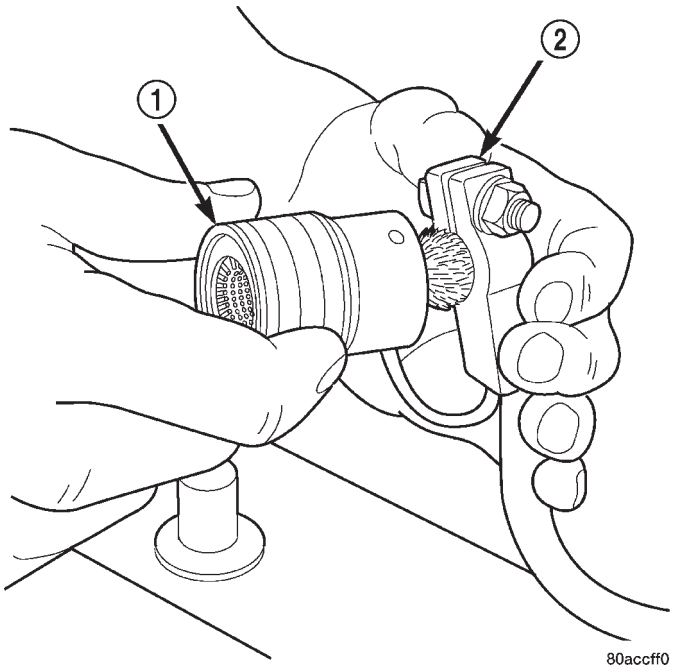


Fig. 1 Clean Battery Cable Terminal Clamp - Typical

1 - TERMINAL BRUSH
2 - BATTERY CABLE

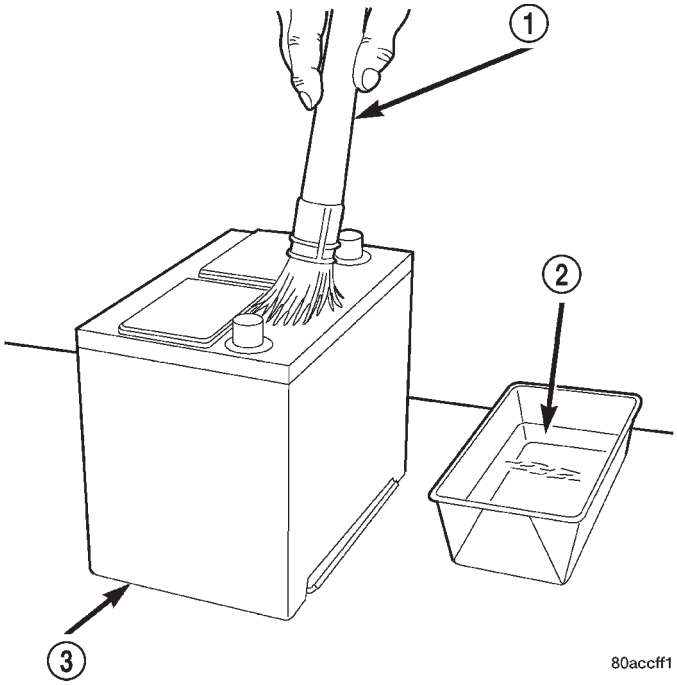


Fig. 2 Clean Battery - Typical

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

BATTERY SYSTEM (Continued)

(4) Clean the battery thermal guard with a sodium bicarbonate (baking soda) and warm water cleaning solution using a stiff bristle parts cleaning brush to remove any acid film.

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

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 thermal guard off of the battery case, if equipped. Inspect the battery case for cracks or other damage that could result in electrolyte leaks. Also, check the battery terminal posts for looseness. Batteries with damaged cases or loose terminal posts must be replaced.

(4) Inspect the battery thermal guard for tears, cracks, deformation or other damage. Replace any battery thermal guard that has been damaged.

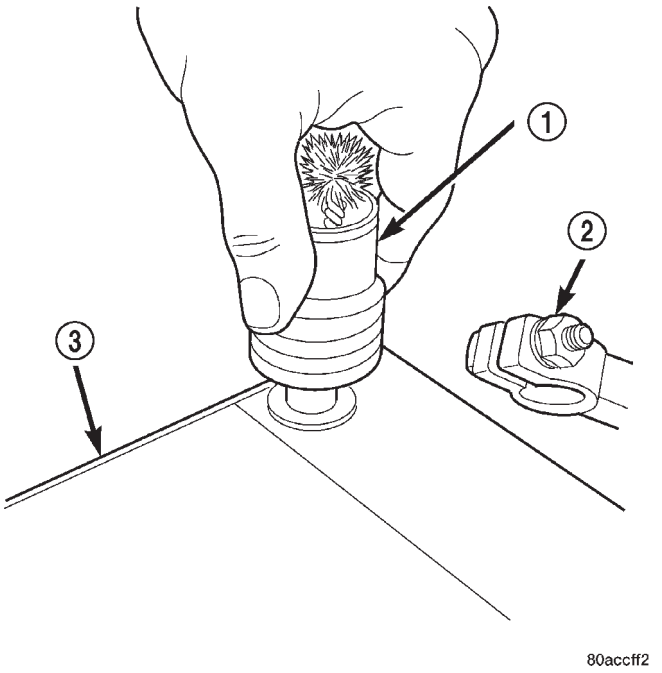


Fig. 3 Clean Battery Terminal Post - Typical

1 - TERMINAL BRUSH
2 - BATTERY CABLE
3 - BATTERY

(5) Inspect the battery built-in test indicator sight glass for an indication of the battery condition. If the battery is discharged, charge as required. (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE).

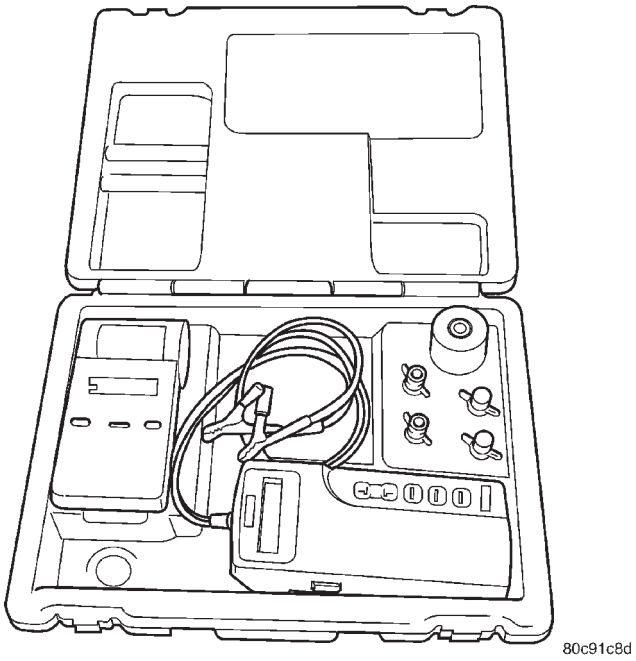
SPECIFICATIONS

BATTERY

Battery Classifications and Ratings					
Part Number	BCI Group Size Classification	Cold Cranking Amperage	Reserve Capacity	Ampere-Hours	Load Test Amperage
56028375AA	27	600	120 Minutes	66	300
56028376AA	27	750	150 Minutes	75	375

BATTERY SYSTEM (Continued)

SPECIAL TOOLS



MIDTRONICS BATTERY AND CHARGING SYSTEM TESTER - Micro420

BATTERY

DESCRIPTION

A large capacity, low-maintenance storage battery (Fig. 4) is standard factory-installed equipment on this model. Refer to Battery System Specifications for the proper specifications of the factory-installed batteries available on this model. Male post type terminals made of a soft lead material protrude from the top of the molded plastic battery case to provide the means for connecting the battery to the vehicle electrical system. The battery positive terminal post is physically larger in diameter than the negative terminal post to ensure proper battery connection. 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 identification confirmation. Refer to Battery Cables for more information on the battery cables that connect the battery to the vehicle electrical system.

The battery is made up of six individual cells that are connected in series. Each cell contains positively charged plate groups that are connected with lead straps to the positive terminal post, and negatively charged plate groups that are connected with lead straps to the negative terminal post. Each plate consists of a stiff mesh framework or grid coated with lead dioxide (positive plate) or sponge lead (negative plate). Insulators or plate separators made of a non-conductive material are inserted between the positive and negative plates to prevent them from contacting or shorting against one another. These dissimilar metal plates are submerged in a sulfuric acid and water solution called an electrolyte.

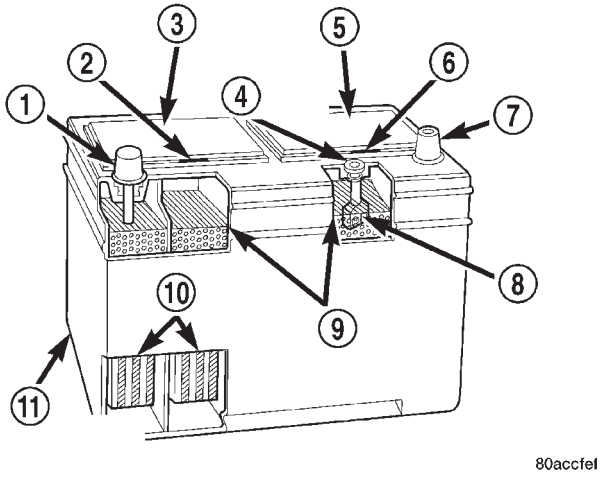


Fig. 4 Low-Maintenance Battery - Typical

1 - POSITIVE POST
2 - VENT
3 - CELL CAP
4 - TEST INDICATOR
5 - CELL CAP
6 - VENT
7 - NEGATIVE POST
8 - GREEN BALL
9 - ELECTROLYTE LEVEL
10 - PLATE GROUPS
11 - LOW-MAINTENANCE BATTERY

The factory-installed battery has a built-in test indicator (hydrometer). The color visible in the sight glass of the indicator will reveal the battery condition. Refer to Standard Procedures for the proper built-in indicator test procedures. **The factory-installed low-maintenance battery has non-removable battery cell caps.** Water cannot be added to this battery. The battery is not sealed and has vent holes in the cell caps. The chemical composition of the metal coated plates within the low-maintenance battery reduces battery gassing and water loss, at normal charge and discharge rates. Therefore, the battery should not require additional water in normal service. Rapid loss of electrolyte can be caused by an overcharging condition. Be certain to diagnose the charging system before returning the vehicle to service. (Refer to 8 - ELECTRICAL/ CHARGING - DIAGNOSIS AND TESTING).

DIAGNOSIS AND TESTING - BATTERY

The battery must be completely charged and the top, posts and terminal clamps 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.

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.

The condition of a battery is determined by two criteria:

- **State-Of-Charge** - This can be determined by checking the specific gravity of the battery electrolyte (built-in indicator test or hydrometer test), or by checking the battery voltage (open-circuit voltage test).
- **Cranking Capacity** - This can be determined by performing a battery load test, which measures the ability of the battery to supply high-amperage current.

First, determine the battery state-of-charge. This can be done in one of three ways. If the battery has a built-in test indicator, perform the built-in indicator test to determine the state-of-charge. If the battery has no built-in test indicator but does have removable cell caps, perform the hydrometer test to determine the state-of-charge. If the battery cell caps are not removable, or a hydrometer is not available, perform the open-circuit voltage test to determine the state-of-charge. Refer to open-circuit voltage test in the Standard Procedures section of this group.

Second, determine the battery cranking capacity by performing a load test. The battery must be charged before proceeding with a load test if:

- The battery built-in test indicator has a black or dark color visible.
- The temperature corrected specific gravity of the battery electrolyte is less than 1.235.
- The battery open-circuit voltage is less than 12.4 volts.

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 load tested to determine its cranking capacity. A battery that is fully-charged, but does not pass the 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.

A battery is fully-charged when:

- All battery cells are gassing freely during charging.
- A green color is visible in the sight glass of the battery built-in test indicator.
- Three corrected specific gravity tests, taken at one-hour intervals, indicate no increase in the specific gravity of the battery electrolyte.
- Open-circuit voltage of the battery is 12.4 volts or greater.

STANDARD PROCEDURE

STANDARD PROCEDURE - BATTERY CHARGING

Battery charging can be performed fast or slow, it terms of time. **Slow** battery charging is the best means of restoring a battery to full potential. Fast battery charging should only be performed when absolutely necessary due to time restraints. A battery is fully-charged when:

- All of the battery cells are gassing freely during battery charging.
- A green color is visible in the sight glass of the battery built-in test indicator.
- Three hydrometer tests, taken at one-hour intervals, indicate no increase in the temperature-corrected specific gravity of the battery electrolyte.
- Open-circuit voltage of the battery is 12.65 volts or above.

WARNING: NEVER EXCEED TWENTY AMPERES WHEN CHARGING A COLD (-1° C [30° F] OR LOWER) BATTERY. THE BATTERY MAY ARC INTERNALLY AND EXPLODE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT.

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.

BATTERY (Continued)

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

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

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

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

After the battery has been charged to 12.4 volts or greater, perform a load test to determine the battery cranking capacity. Refer to Standard Procedures for the proper battery load test procedures. If the battery will endure a load test, return the battery to service. If the battery will not endure a load test, it is 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

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. 5). 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.

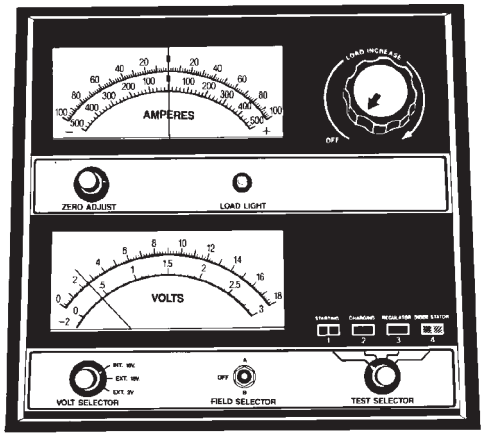


Fig. 5 Voltmeter - Typical

(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.

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

CHARGING TIME REQUIRED

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

- **Battery Capacity** - A completely discharged heavy-duty battery requires twice the charging time of a small capacity battery.

BATTERY (Continued)

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

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

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

STANDARD PROCEDURE - BUILT-IN INDICATOR TEST

An indicator (hydrometer) built into the top of the battery case provides visual information for battery testing (Fig. 6). Like a hydrometer, the built-in indicator measures the specific gravity of the battery electrolyte. The specific gravity of the electrolyte reveals the battery state-of-charge; however, it will not reveal the cranking capacity of the battery. A load test must be performed to determine the battery cranking capacity. Refer to Standard Procedures for the proper battery load test procedures.

Before testing, visually inspect the battery for any damage (a cracked case or cover, loose posts, etc.) that would cause the battery to be faulty. In order to obtain correct indications from the built-in indicator, it is important that the battery be level and have a clean sight glass. Additional light may be required to view the indicator. **Do not use open flame as a source of additional light.**

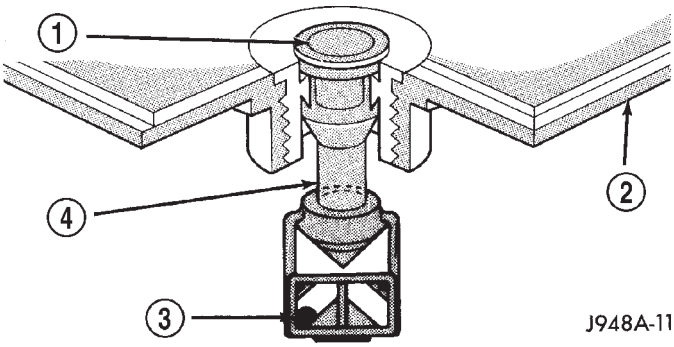


Fig. 6 Built-In Indicator

1 - SIGHT GLASS
2 - BATTERY TOP
3 - GREEN BALL
4 - PLASTIC ROD

To read the built-in indicator, look into the sight glass and note the color of the indication (Fig. 7). The battery condition that each color indicates is described in the following list:

- **Green** - Indicates 75% to 100% battery state-of-charge. The battery is adequately charged for further testing or return to service. If the starter will not crank for a minimum of fifteen seconds with a fully-charged battery, the battery must be load tested. Refer to Standard Procedures for the proper battery load test procedures.
- **Black or Dark** - Indicates 0% to 75% battery state-of-charge. The battery is inadequately charged and must be charged until a green indication is visible in the sight glass (12.4 volts or more), before the battery is tested further or returned to service. Refer to Standard Procedures for the proper battery charging procedures. Also refer to Diagnosis and Testing for more information on the possible causes of the discharged battery condition.
- **Clear or Bright** - Indicates a low battery electrolyte level. The electrolyte level in the battery is below the built-in indicator. A maintenance-free battery with non-removable cell caps must be replaced if the electrolyte level is low. Water must be added to a low-maintenance battery with removable cell caps before it is charged. Refer to Standard Procedures for the proper battery filling procedures. A low electrolyte level may be caused by an overcharging condition. Refer to Charging System for the proper charging system diagnosis and testing procedures.

BATTERY (Continued)

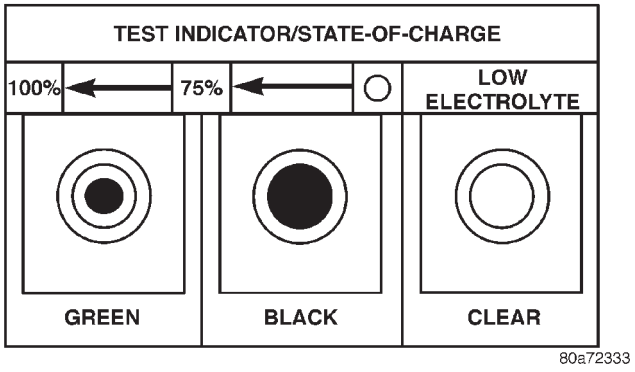


Fig. 7 Built-In Indicator Sight Glass Chart

STANDARD PROCEDURE - HYDROMETER TEST

The hydrometer test reveals the battery state-of-charge by measuring the specific gravity of the electrolyte. **This test cannot be performed on maintenance-free batteries with non-removable cell caps.** If the battery has non-removable cell caps, refer to Diagnosis and Testing for alternate methods of determining the battery state-of-charge.

Specific gravity is a comparison of the density of the battery electrolyte to the density of pure water. Pure water has a specific gravity of 1.000, and sulfuric acid has a specific gravity of 1.835. Sulfuric acid makes up approximately 35% of the battery electrolyte by weight, or 24% by volume. In a fully-charged battery the electrolyte will have a temperature-corrected specific gravity of 1.260 to 1.290. However, a specific gravity of 1.235 or above is satisfactory for the battery to be load tested and/or returned to service.

Before testing, visually inspect the battery for any damage (a cracked case or cover, loose posts, etc.) that would cause the battery to be faulty. Then remove the battery cell caps and check the electrolyte level. Add distilled water if the electrolyte level is below the top of the battery plates. Refer to Battery System Cleaning for the proper battery inspection procedures.

See the instructions provided by the manufacturer of the hydrometer for recommendations on the correct use of the hydrometer that you are using. Remove only enough electrolyte from the battery cell so that the float is off the bottom of the hydrometer barrel with pressure on the bulb released. To read the hydrometer correctly, hold it with the top surface of the electrolyte at eye level (Fig. 8).

CAUTION: Exercise care when inserting the tip of the hydrometer into a battery cell to avoid damaging the plate separators. Damaged plate separators can cause early battery failure.

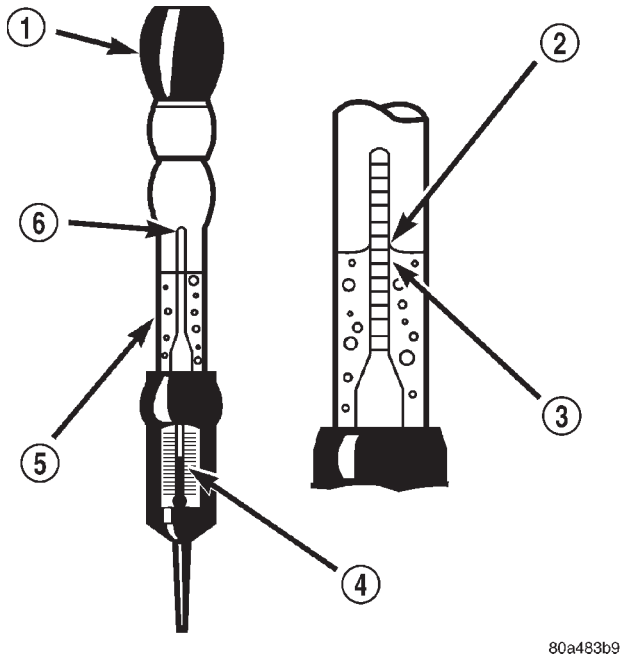


Fig. 8 Hydrometer - Typical

1 - BULB
2 - SURFACE COHESION
3 - SPECIFIC GRAVITY READING
4 - TEMPERATURE READING
5 - HYDROMETER BARREL
6 - FLOAT

Hydrometer floats are generally calibrated to indicate the specific gravity correctly only at 26.7° C. When testing the specific gravity at any other temperature, a correction factor is required. The correction factor is approximately a specific gravity value of 0.004, which may also be identified as four points of specific gravity. For each 5.5° C above 26.7° C, add four points. For each 5.5° C below 26.7° C, subtract four points. Always correct the specific gravity for temperature variation.

EXAMPLE: A battery is tested at -12.2° C and has a specific gravity of 1.240. Determine the actual specific gravity as follows:

(1) Determine the number of degrees above or below 26.7° C: **26.7° C + -12.2° C = 14.5° C below the 26.7° C specification**

(2) Divide the result from Step 1 by 5.5° C: **14.5° C ÷ 5.5° C = 2.64**

(3) Multiply the result from Step 2 by the temperature correction factor (0.004): **2.64 X 0.004 = 0.01**

(4) The temperature at testing was below 26.7° C; therefore, the temperature correction factor is subtracted: **1.240 - 0.01 = 1.23**

(5) The corrected specific gravity of the battery cell in this example is 1.23.

BATTERY (Continued)

Test the specific gravity of the electrolyte in each battery cell. If the specific gravity of all cells is above 1.235, but the variation between cells is more than fifty points (0.050), the battery should be replaced. If the specific gravity of one or more cells is less than 1.235, charge the battery at a rate of approximately five amperes. Continue charging the battery until three consecutive specific gravity tests, taken at one-hour intervals, are constant. If the cell specific gravity variation is more than fifty points (0.050) at the end of the charge period, replace the battery.

When the specific gravity of all cells is above 1.235, and the cell variation is less than fifty points (0.050), the battery may be load tested to determine its cranking capacity. Refer to Standard Procedures for the proper battery load test procedures.

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 in place of the hydrometer test when a hydrometer is not available, or for maintenance-free batteries with non-removable cell caps.

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

(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).

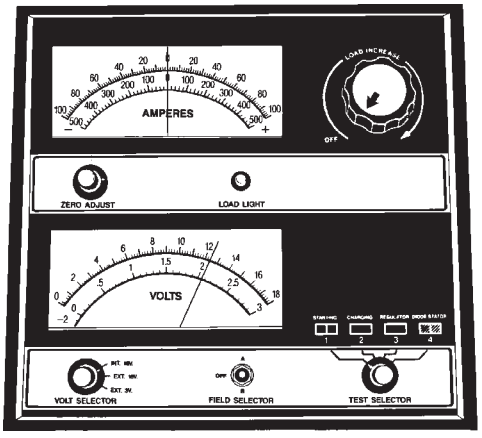


Fig. 9 Testing Open-Circuit Voltage - Typical

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 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE).

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

STANDARD PROCEDURE - LOAD TEST

A battery load test will verify the battery cranking capacity. The test is based on the Cold Cranking Amperage (CCA) rating of the battery. To determine the battery CCA rating, see the label affixed to the battery case or refer to Battery Specifications for the proper factory-installed specifications.

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

(1) Disconnect and isolate both battery cables, negative cable first. The battery top and posts should be clean (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING).

(2) Connect a suitable volt-ammeter-load tester (Fig. 10) to the battery posts (Fig. 11). See the instructions provided by the manufacturer of the tester you are using. Check the open-circuit voltage (no load) of the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE). The battery open-circuit voltage must be 12.4 volts or greater.

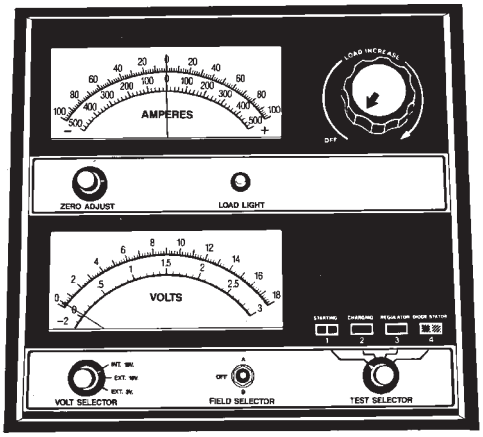


Fig. 10 Volt-Ammeter-Load Tester - Typical

BATTERY (Continued)

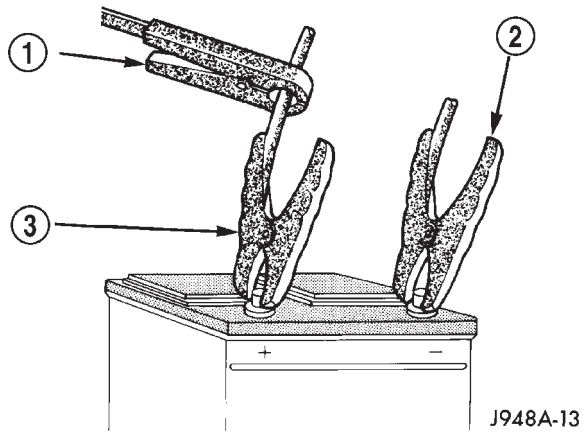


Fig. 11 Volt-Ammeter-Load

1 - INDUCTION AMMETER CLAMP
2 - NEGATIVE CLAMP
3 - POSITIVE CLAMP

(3) Rotate the load control knob (carbon pile rheostat) to apply a 300 ampere load to the battery for fifteen seconds, then return the control knob to the Off position (Fig. 12). This will remove the surface charge from the battery.

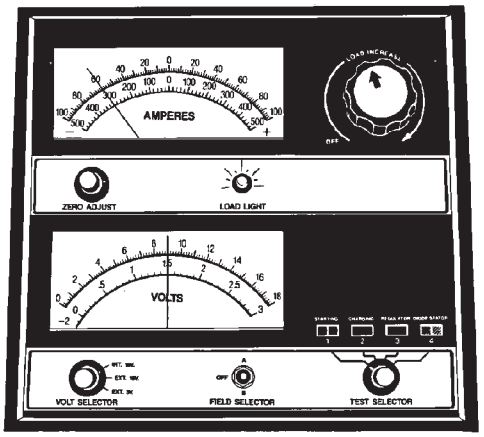


Fig. 12 Remove Surface Charge from Battery

(4) Allow the battery to stabilize to open-circuit voltage. It may take up to five minutes for the battery voltage to stabilize.

(5) Rotate the load control knob to maintain a load equal to 50% of the CCA rating of the battery (Fig. 13). After fifteen seconds, record the loaded voltage reading, then return the load control knob to the Off position.

(6) The voltage drop will vary with the battery temperature at the time of the load test. The battery temperature can be estimated by using the ambient temperature during the past several hours. If the battery has been charged, boosted, or loaded a few minutes prior to the test, the battery will be somewhat warmer. See the Load Test Temperature Table for the proper loaded voltage reading.

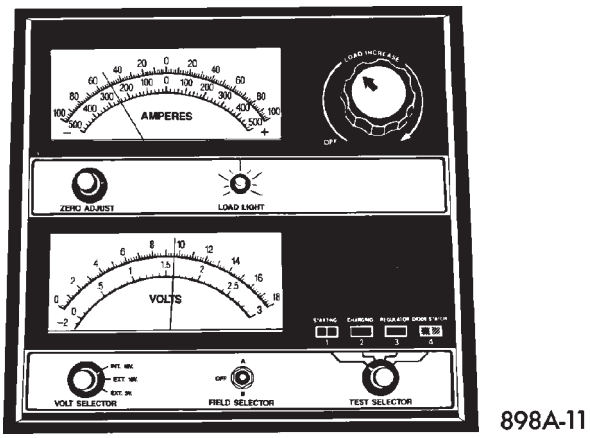


Fig. 13 Load 50% CCA Rating - Note Voltage - Typical

LOAD TEST TEMPERATURE TABLE		
Minimum Voltage	Temperature	
	°F	°C
9.6 volts	70° and above	21° and above
9.5 volts	60°	16°
9.4 volts	50°	10°
9.3 volts	40°	4°
9.1 volts	30°	-1°
8.9 volts	20°	-7°
8.7 volts	10°	-12°
8.5 volts	0°	-18°

(7) If the voltmeter reading falls below 9.6 volts, at a minimum battery temperature of 21° C (70° F), the battery is faulty and must be replaced.

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 five to thirty-five milliamperes (0.005 to 0.035 ampere) with the ignition switch in the Off position, and all non-ignition controlled circuits in proper working order. Up to thirty-five milliamperes are needed to enable the memory functions for the Powertrain Control Module (PCM), digital clock, electronically tuned radio, and other modules which may vary with the vehicle equipment.

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

BATTERY (Continued)

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

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

ELECTRONIC MODULE IGNITION-OFF DRAW (IOD) TABLE

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

(2) Determine that the underhood lamp is operating properly, then disconnect the lamp wire harness connector or remove the lamp bulb.

(3) Disconnect the battery negative cable.

(4) Set an electronic digital multi-meter to its highest amperage scale. Connect the multi-meter between the disconnected battery negative cable terminal clamp and the battery negative terminal post. Make sure that the doors remain closed so that the illuminated entry system is not activated. The multi-meter amperage reading may remain high for up to three minutes, or may not give any reading at all while set in the highest amperage scale, depending upon the electrical equipment in the vehicle. The multi-meter leads must be securely clamped to the battery negative cable terminal clamp and the battery negative terminal post. If continuity between the battery negative terminal post and the negative cable terminal clamp is lost during any part of the IOD test, the electronic timer function will be activated and all of the tests will have to be repeated.

(5) After about three minutes, the high-amperage IOD reading on the multi-meter should become very low or nonexistent, depending upon the electrical equipment in the vehicle. If the amperage reading remains high, remove and replace each fuse or circuit breaker in the Power Distribution Center (PDC) and then in the Junction Block (JB), one at a time until the amperage reading becomes very low, or nonexistent. Refer to the appropriate wiring information in this service manual for complete PDC and JB fuse, circuit breaker, and circuit identification. This will isolate each circuit and identify the circuit that is the source of the high-amperage IOD. If the amperage reading remains high after removing and replacing each fuse and circuit breaker, disconnect the wire harness from the generator. If the amperage reading now becomes very low or nonexistent, 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.

(6) Observe the multi-meter reading. The low-amperage IOD should not exceed thirty-five milliamperes (0.035 ampere). If the current draw exceeds

BATTERY (Continued)

thirty-five milliamperes, isolate each circuit using the fuse and circuit breaker remove-and-replace process in Step 5. The multi-meter reading will drop to within the acceptable limit when the source of the excessive current draw is disconnected. Repair this circuit as required; whether a wiring short, incorrect switch adjustment, or a component failure is at fault.

STANDARD PROCEDURE - USING MIDTRONICS ELECTRICAL TESTER

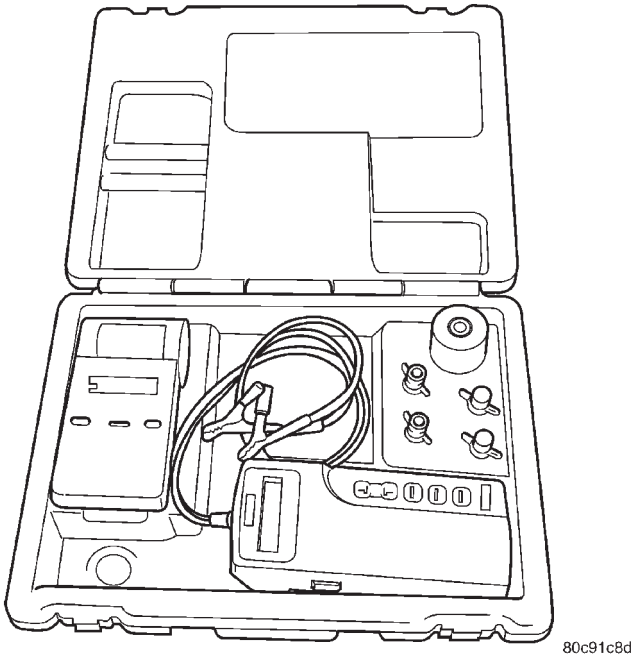


Fig. 14 MIDTRONICS BATTERY AND CHARGING SYSTEM TESTER - Micro420

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

WARNING: ALWAYS WEAR APPROPRIATE EYE PROTECTION AND USE EXTREME CAUTION WHEN WORKING WITH BATTERIES.

BATTERY TESTING

(1) If testing the battery OUT-OF-VEHICLE, clean the battery terminals with a wire brush before testing. If the battery is equipped with side post terminals, install and tighten the supplied lead terminal stud adapters. Do not use steel bolts. Failure to properly install the stud adapters, or using stud adapters that are dirty or worn-out may result in false test readings.

(2) If testing the battery IN-THE-VEHICLE, make certain all of the vehicle accessory loads are OFF, including the ignition. **The preferred test position is at the battery terminal**. If the battery is not accessible, you may test using both the positive and negative jumper posts. Select TESTING AT JUMPER POST when connecting to that location.

(3) Connect the tester to (Fig. 14) the battery or jumper posts, the red clamp to positive (+) and the black clamp to negative (–).

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

NOTE: When testing the battery in a PT Cruiser, always test at the battery terminals

(4) Using the ARROW key select **in** or **out** of vehicle testing and press ENTER to make a selection.

(5) If not selected, choose the Cold Cranking Amp (CCA) battery rating. Or select the appropriate battery rating for your area (see menu). The tester will then run its self programmed test of the battery and display the results. Refer to the test result table noted below.

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

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

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

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

BATTERY (Continued)

REMOVAL

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

(2) Loosen the battery negative cable terminal clamp pinch-bolt hex nut.

(3) Disconnect the battery negative cable terminal clamp from the battery negative terminal post. If necessary, use a battery terminal puller to remove the terminal clamp from the battery post (Fig. 15).

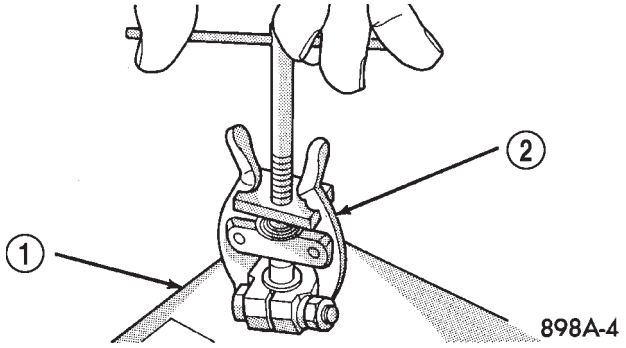


Fig. 15 Remove Battery Cable Terminal Clamp - Typical

1 - BATTERY
2 - BATTERY TERMINAL PULLER

(4) Loosen the battery positive cable terminal clamp pinch-bolt hex nut.

(5) Disconnect the battery positive cable terminal clamp from the battery positive terminal post. If necessary, use a battery terminal puller to remove the terminal clamp from the battery post.

(6) Remove the battery hold downs from the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/ BATTERY HOLDDOWN - REMOVAL).

WARNING: WEAR A SUITABLE PAIR OF RUBBER GLOVES (NOT THE HOUSEHOLD TYPE) WHEN REMOVING A BATTERY BY HAND. SAFETY GLASSES SHOULD ALSO BE WORN. IF THE BATTERY IS CRACKED OR LEAKING, THE ELECTROLYTE CAN BURN THE SKIN AND EYES.

(7) Remove the battery from the battery tray.

INSTALLATION

(1) Clean and inspect the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING).

(2) Position the battery onto the battery tray. Ensure that the battery positive and negative terminal posts are correctly positioned. The battery cable terminal clamps must reach the correct battery terminal post without stretching the cables (Fig. 16).

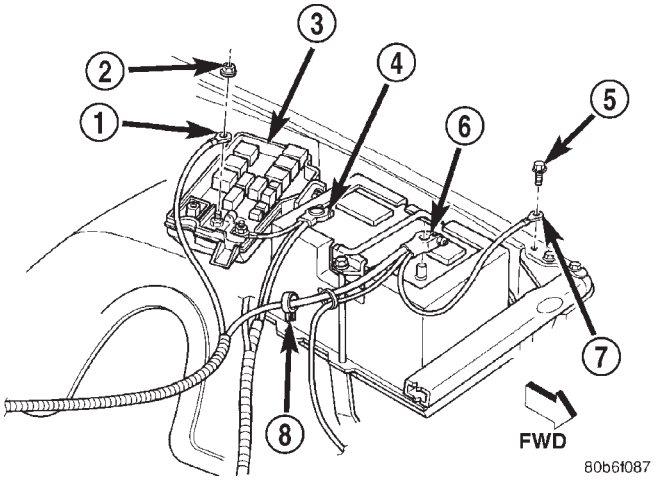


Fig. 16 Battery Cables - Typical

1 - EYELET
2 - NUT
3 - POWER DISTRIBUTION CENTER
4 - POSITIVE CABLE
5 - SCREW
6 - NEGATIVE CABLE
7 - EYELET
8 - CLIP

(3) Reinstall the battery hold downs onto the battery (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/ BATTERY HOLDDOWN - INSTALLATION).

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

(4) Clean the battery cable terminal clamps and the battery terminal posts.

(5) Reconnect the battery positive cable terminal clamp to the battery positive terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).

(6) Reconnect the battery negative cable terminal clamp to the battery negative terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).

(7) Apply a thin coating of petroleum jelly or chassis grease to the exposed surfaces of the battery cable terminal clamps and the battery terminal posts.

BATTERY HOLDDOWN

DESCRIPTION

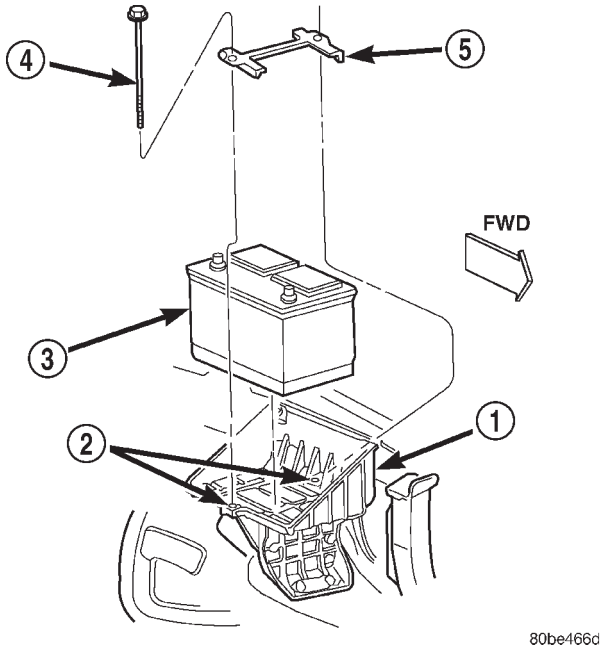


Fig. 17 Battery Hold Downs - Typical

1 - BATTERY TRAY
2 - U-NUT (2)
3 - BATTERY
4 - BOLT (2)
5 - HOLD DOWN STRAP

The battery hold down hardware (Fig. 17) includes two bolts, two U-nuts and a hold down strap. The battery hold down bracket consists of a formed steel rod with a stamped steel angle bracket welded to each end. The hold down bracket assembly is then plastic-coated for corrosion protection. Models equipped with the optional diesel engine have a second battery installed in a second battery tray on the right side of the engine compartment. The hold down hardware for the right side battery is mirror image of the hold down hardware used for the left side battery.

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.

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.

CAUTION: 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 except for the outboard U-nut can be serviced without removal of the battery or the battery tray. The battery tray must be removed from the vehicle to service the outboard U-nut. If the outboard U-nut requires service replacement, refer to **Battery Tray** in the index of this service manual for the location of the proper battery tray removal and installation procedures.

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

(2) Loosen the battery negative cable terminal clamp pinch-bolt hex nut.

(3) Disconnect the battery negative cable terminal clamp from the battery negative terminal post. If necessary, use a battery terminal puller to remove the terminal clamp from the battery post.

(4) Remove the two battery hold down bolts from the battery hold down strap (Fig. 18).

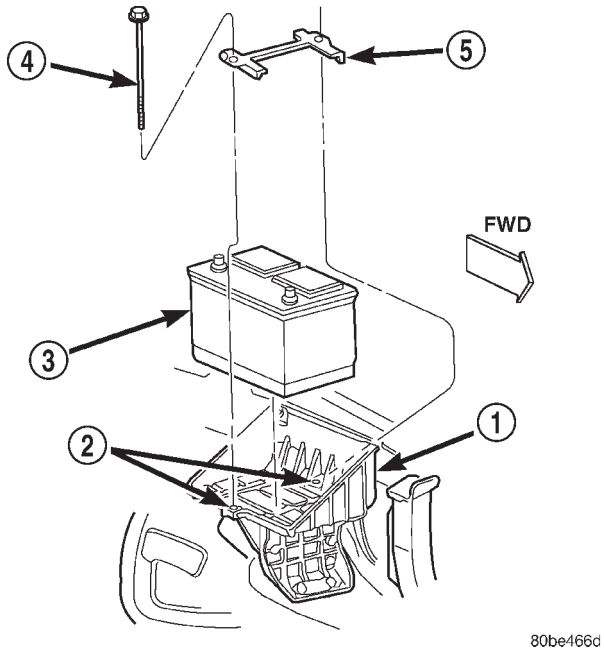


Fig. 18 Left Battery Hold Downs Remove/Install - Typical for Right Battery

1 - BATTERY TRAY
2 - U-NUT (2)
3 - BATTERY
4 - BOLT (2)
5 - HOLD DOWN STRAP

BATTERY HOLDDOWN (Continued)

(5) Remove the battery hold down strap from the top of the battery case.

INSTALLATION

(1) Clean and inspect the battery hold down hardware (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING).

(2) Position the battery hold down strap across the top of the battery case.

(3) Install and tighten the two battery hold down bolts through the holes on each end of the hold down strap and into the U-nuts on each side of the battery tray. Tighten the bolts to 4 N·m (35 in. lbs.).

(4) Reconnect the battery negative cable terminal clamp to the battery negative terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).

BATTERY CABLE

DESCRIPTION

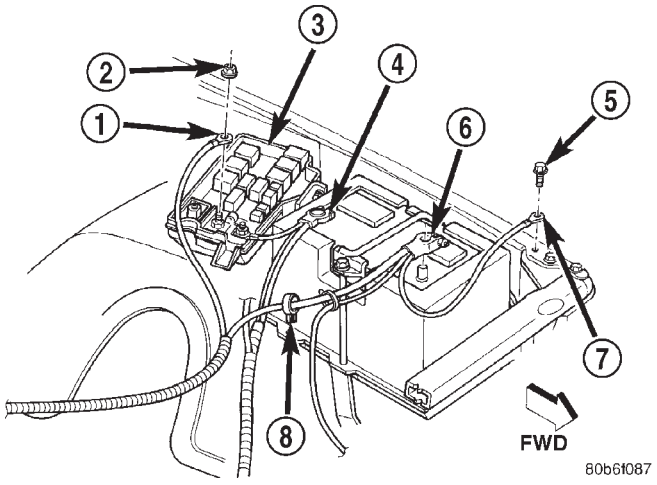


Fig. 19 Battery Cables - Typical

1 - EYELET
2 - NUT
3 - POWER DISTRIBUTION CENTER
4 - POSITIVE CABLE
5 - SCREW
6 - NEGATIVE CABLE
7 - EYELET
8 - CLIP

The battery cables (Fig. 19) 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** for the location of the proper battery cable wire gauge information.

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 positive cable wire harness or the battery negative cable wire harness, which may include portions of the wiring circuits for the generator and other components on some models.

GASOLINE ENGINE BATTERY CABLES

Gasoline engine models feature a stamped brass clamping type female battery terminal crimped onto one end of the battery cable wire and then solder-dipped. A square headed pinch-bolt and hex nut are installed at the open end of the female battery terminal clamp. The battery positive cable also includes a red molded rubber protective cover for 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.

DIESEL ENGINE BATTERY CABLES

Diesel engine models feature a clamping type female battery terminal made of soft lead die cast onto 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. The pinch-bolt on the left side battery positive cable female terminal clamp also has a stud extending from the head of the bolt. 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.

OPERATION

The battery cables connect the battery terminal posts to the vehicle electrical system. These cables also provide a return path 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

BATTERY CABLE (Continued)

the top of the battery. The eyelet terminals secured to the ends of the battery cable wires opposite the female battery terminal clamps provide secure and reliable connection of the battery to the vehicle electrical system.

GASOLINE ENGINE

The battery positive cable terminal clamp is crimped onto the ends of two wires. One wire has an eyelet terminal that connects the battery positive cable to the B(+) terminal stud of the Power Distribution Center (PDC), 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 crimped onto 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 front of the left engine cylinder head. 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, just ahead of the battery. An additional ground wire with two eyelet terminals is used to provide ground to the vehicle frame. One eyelet terminal of this ground wire is installed under the head of the battery negative cable terminal clamp pinch-bolt, and the other eyelet terminal is secured with a ground screw to the outer surface of the left frame rail, below the battery.

DIESEL ENGINE

The left battery positive cable terminal clamp is die cast onto the ends of two wires. One wire has an eyelet terminal that connects the left battery positive cable to the B(+) terminal stud of the Power Distribution Center (PDC), and the other wire has an eyelet terminal that connects the left battery positive cable to the B(+) terminal stud of the engine starter motor solenoid. The right battery positive cable terminal clamp is die cast onto the end of a single wire. The eyelet terminal on the other end of the right battery positive cable is connected to the stud on the pinch-bolt of the left battery positive cable terminal clamp. This stud also provides a connection point for the eyelet terminals from the fuel heater relay and intake air heater relay jumper harness take outs. All of these eyelet terminals are secured to the left battery positive cable terminal clamp pinch-bolt stud with a single hex nut.

The left battery negative cable terminal clamp is die cast onto the ends of two wires. One wire has an eyelet terminal that connects the left battery negative cable to the vehicle powertrain through a ground screw on the left side of the engine block, below the power steering and vacuum pumps. The other wire has an eyelet terminal that connects the left battery negative cable to the vehicle body through a ground screw on the left front fender inner shield, just ahead of the left battery. An additional ground wire with two eyelet terminals is used to provide ground to the vehicle frame. One eyelet terminal of this ground wire is installed under the nut of the left battery negative cable terminal clamp pinch-bolt, and the other eyelet terminal is secured with a ground screw to the outer surface of the left frame rail, below the left battery. The right battery negative cable terminal is also die cast onto the ends of two wires. One wire has an eyelet terminal that connects the right battery negative cable to the vehicle powertrain through a ground screw on the right side of the engine block, just forward of the right engine mount. The other wire has an eyelet terminal that connects the right battery negative cable to the vehicle body through a ground screw on the right front fender inner shield, just behind the right battery.

DIAGNOSIS AND TESTING - BATTERY CABLES

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

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

BATTERY CABLE (Continued)

VOLTAGE DROP TEST

WARNING: MODELS EQUIPPED WITH THE DIESEL ENGINE OPTION ALSO HAVE AN AUTOMATIC SHUTDOWN (ASD) RELAY LOCATED IN THE POWER DISTRIBUTION CENTER (PDC), IN THE ENGINE COMPARTMENT. HOWEVER, REMOVAL OF THE ASD RELAY MAY NOT PREVENT THE DIESEL ENGINE FROM STARTING. BE CERTAIN TO ALSO DISCONNECT THE FUEL SHUTDOWN SOLENOID WIRE HARNESS CONNECTOR ON MODELS WITH A DIESEL ENGINE. FAILURE TO DO SO MAY RESULT IN PERSONAL INJURY.

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

- The battery is fully-charged and load tested (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - STANDARD PROCEDURE).
- 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 a gasoline engine from starting, remove the Automatic ShutDown (ASD) relay. The ASD relay is located in the Power Distribution Center (PDC), in the engine compartment. See the fuse and relay layout label affixed to the underside of the PDC cover for ASD relay identification and location. To prevent a diesel engine from starting, disconnect the fuel shutdown solenoid wire harness connector (Fig. 20).

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

NOTE: If the vehicle is equipped with a dual battery system, Step 1 must be performed twice, once for each 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. 22). 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.

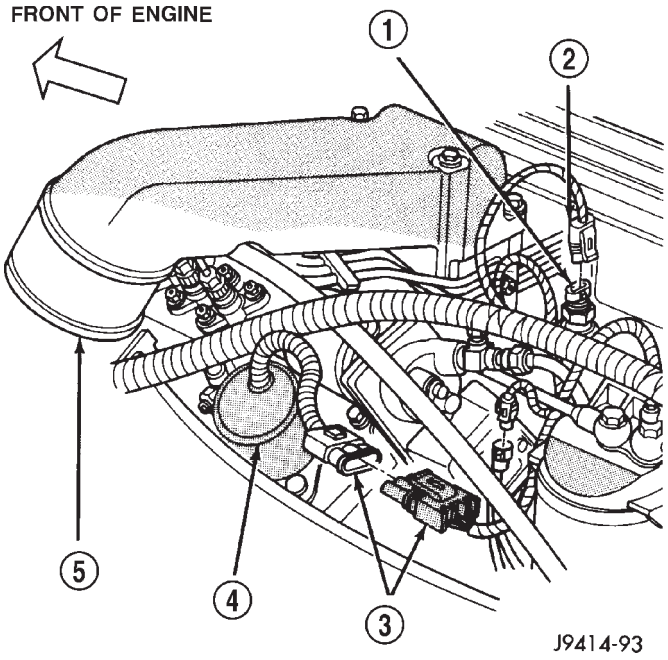


Fig. 20 Fuel Shutdown Solenoid Connector - Diesel Engine

1 - AIR TEMPERATURE SENSOR
2 - SENSOR ELECTRICAL CONNECTOR
3 - SOLENOID ELECTRICAL CONNECTOR
4 - FUEL SHUTDOWN SOLENOID
5 - INTAKE MANIFOLD (UPPER HALF)

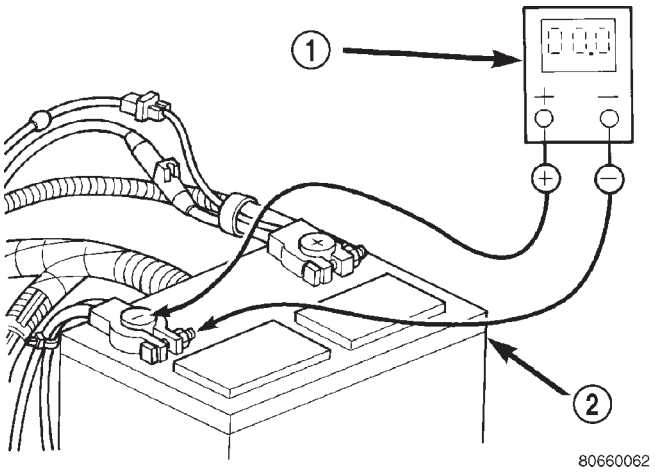


Fig. 21 Test Battery Negative Connection Resistance - Typical

1 - VOLTMETER
2 - BATTERY

BATTERY CABLE (Continued)

NOTE: If the vehicle is equipped with a dual battery system, Step 2 must be performed twice, once for each battery.

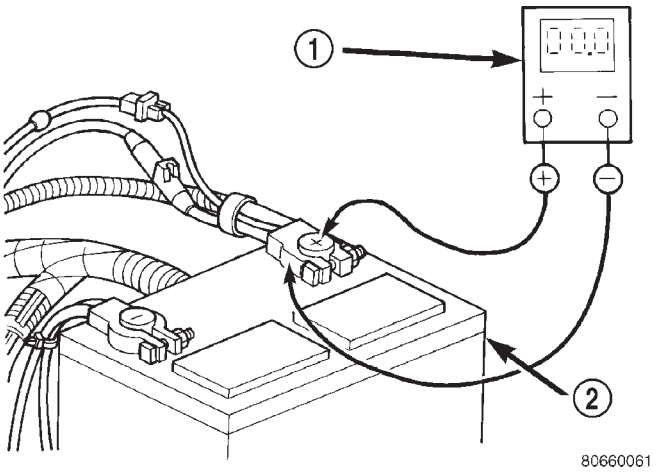


Fig. 22 Test Battery Positive Connection Resistance - Typical

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

NOTE: If the vehicle is equipped with a dual battery system, Step 3 must be performed on the driver side battery only.

(4) Connect the voltmeter to measure between the battery negative cable terminal clamp and a good clean ground on the engine block (Fig. 24). Rotate and hold the ignition switch in the Start position. Observe the voltmeter. If the reading is above 0.2 volt, clean and tighten the battery negative cable eyelet terminal connection to the engine block. Repeat the test. If the reading is still above 0.2 volt, replace the faulty battery negative cable.

NOTE: If the vehicle is equipped with a dual battery system, Step 4 must be performed twice, once for each battery.

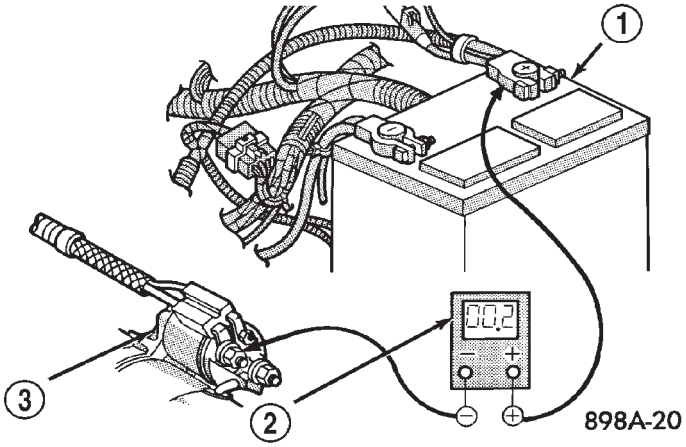


Fig. 23 Test Battery Positive Cable Resistance - Typical

1 - BATTERY
2 - VOLTMETER
3 - STARTER MOTOR

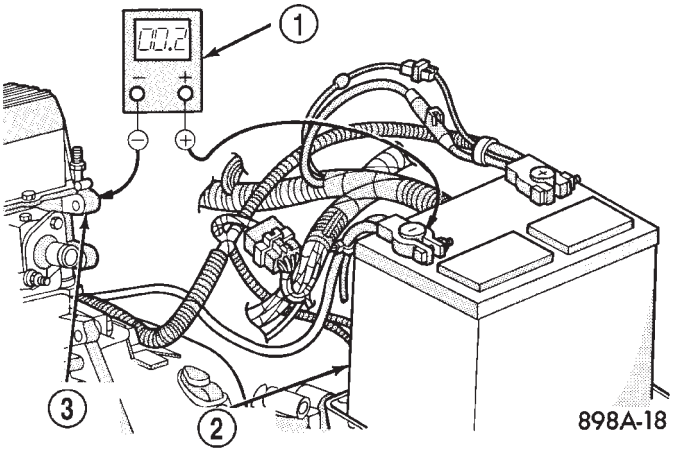


Fig. 24 Test Ground Circuit

1 - VOLTMETER
2 - BATTERY
3 - ENGINE GROUND

REMOVAL

POSITIVE CABLE REMOVAL - GASOLINE ENGINE

Both the battery negative cable and the battery positive cable are serviced in the battery wire harness. If either battery cable is damaged or faulty, the battery wire harness assembly must be replaced.

(1) Remove the positive battery cable from the battery.

(2) Remove the cover from the PDC.

(3) Remove the positive battery cable from the PDC.

BATTERY CABLE (Continued)

(4) Disconnect the starter motor signal wire harness connector, located on the PDC housing.
(5) Disengage wire harness assembly pushpin retainers.
(6) From under the vehicle, disengage wire harness assembly pushpin retainers.
(7) Remove the positive battery cable from the starter motor B+ terminal stud.
(8) Remove the starter motor trigger wire from the starter motor.
(9) Remove the positive cable wire harness assembly from the vehicle.

NEGATIVE CABLE REMOVAL - GASOLINE ENGINE

Both the battery negative cable and the battery positive cable are serviced in the battery wire harness. If either battery cable is damaged or faulty, the battery wire harness unit must be replaced.
(1) Turn the ignition switch to the Off position. Be certain that all electrical accessories are turned off.
(2) Loosen the battery negative cable terminal clamp pinch-bolt hex nut.
(3) Disconnect the battery negative cable terminal clamp from the battery negative terminal post. If necessary, use a battery terminal puller to remove the terminal clamp from the battery post.
(4) Remove the negative cable jumper from the left side of the radiator closure panel.
(5) Remove the negative cable jumper from the left side of the frame assembly.
(6) Remove the PDC cover and remove the generator output wire from the PDC.
(7) Following the wire, remove the pushpin retainers holding the wire assembly in place.
(8) Remove the negative cable eyelet from the power steering pump pivot bolt.
(9) Remove the generator output wire from the generator.
(10) Remove the negative battery cable assembly, by fishing out from under the compressor mounting bracket, if equipped.

INSTALLATION

POSITIVE CABLE INSTALLATION - GASOLINE ENGINE

(1) Position the battery wire harness into the engine compartment.
(2) Install the positive battery cable on the battery.
(3) Install the positive battery cable on the PDC.
(4) Install the cover on the PDC.
(5) Connect the starter motor signal wire harness connector, located on the PDC housing.
(6) Install wire harness assembly pushpin retainers in their original position.
(7) From under the vehicle, install wire harness assembly pushpin retainers.
(8) Install and tighten the nut that secures the battery positive cable eyelet terminal to the B(+) terminal stud on the starter solenoid. Tighten the nut to 10 N·m (90 in. lbs.).
(9) Connect the starter motor trigger wire on the starter motor.
(10) Reconnect the battery positive cable terminal clamp to the battery positive terminal post. Tighten the terminal clamp pinch-bolt hex nut to 4 N·m (35 in. lbs.).
(11) Apply a thin coating of petroleum jelly or chassis grease to the exposed surfaces of the battery cable terminal clamps and the battery terminal posts.

NEGATIVE CABLE INSTALLATION - GASOLINE ENGINE

(1) Position the battery wire harness into the engine compartment and under the compressor mounting bracket, if equipped.
(2) Install and tighten the nut that secures the battery negative cable ground eyelet terminal to the stud on the power steering pump pivot bolt.
(3) Install the generator output cable eyelet terminal onto the generator output terminal stud.
(4) Install and tighten the nut that secures the generator output cable eyelet terminal to the generator output terminal stud. Tighten the nut to 8.4 N·m (75 in. lbs.).
(5) Position the cover for the generator output terminal stud housing onto the back of the generator and snap it into place.
(6) Secure wire assembly in place with pushpin retainers in there original positions.
(7) Install and tighten the screw that secures the battery negative cable eyelet terminal to the radiator closure panel, near the battery. Tighten the screw to 40 in. lbs.
(8) Install and tighten the screw that secures the battery negative cable eyelet terminal to the left front side of the frame assembly. Tighten the screw to 80 in. lbs.
(9) Install and tighten the nut that secures the battery positive cable eyelet terminal and the generator output cable eyelet terminal to the PDC B(+) terminal stud. Tighten the nut to 80 in. lbs.
(10) Reconnect the battery negative cable terminal clamp to the battery negative terminal post. Tighten the terminal clamp pinch-bolt hex nut to 35 in. lbs.
(11) Apply a thin coating of petroleum jelly or chassis grease to the exposed surfaces of the battery cable terminal clamps and the battery terminal posts.

BATTERY TRAY

DESCRIPTION

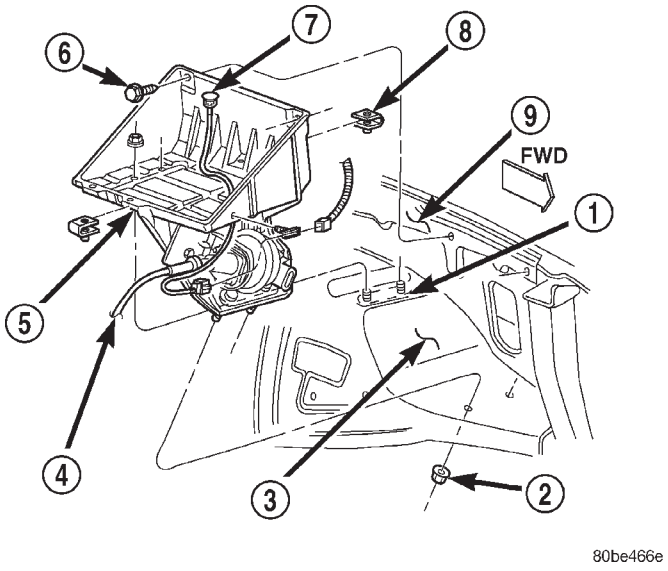


Fig. 25 Battery Tray - Typical

1 - STUD PLATE (2)
2 - NUT AND WASHER (4)
3 - FRONT WHEELHOUSE INNER PANEL
4 - SPEED CONTROL SERVO
5 - TRAY
6 - SCREW AND WASHER (2)
7 - BATTERY TREMPERATURE SENSOR
8 - U-NUT (2)
9 - FENDER INNER SHIELD

The battery is mounted in a molded plastic tray (Fig. 25) with an integral support located in the left front corner of the engine compartment. A U-nut held in a molded formation on each side of the battery tray provides anchor points for the battery hold down bolts. The battery tray is secured on the outboard side to the inner fender shield by two hex screws with washers, and from underneath the integral battery tray support is secured to the left front wheelhouse inner panel by two stud plates. Each stud plate has two studs and is secured by two nuts with washers. The stud plate that secures the front of the battery tray support to the wheelhouse inner panel is installed through the wheelhouse panel from the top. The stud plate that secures the rear of the battery tray support to the wheelhouse inner panel is installed through the wheelhouse panel from the bottom.

A hole in the bottom of the battery tray is fitted with a battery temperature sensor (Refer to 8 - ELECTRICAL/CHARGING/BATTERY TEMPERATURE SENSOR - DESCRIPTION). Models that are equipped with an optional vehicle speed control system have the speed control servo secured to the integral battery tray support.

Models that are equipped with the diesel engine option have a second battery tray located in the right front corner of the engine compartment. This second battery tray and its mounting are mirror image of the standard equipment left battery tray. However, the right battery tray and support have no provisions for a battery temperature sensor or a speed control servo mounting bracket.

OPERATION

The battery tray provides a secure mounting location and supports the battery. On some vehicles, the battery tray also provides the anchor point/s 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.

REMOVAL

(1) Remove the battery from the battery tray (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - REMOVAL).

(2) If the left battery tray is being removed, remove the battery temperature sensor from the left battery tray (Refer to 8 - ELECTRICAL/CHARGING/BATTERY TEMPERATURE SENSOR - REMOVAL).

(3) Remove the two screws with washers that secure the outboard side of the battery tray to the inner fender shield (Fig. 26).

(4) From the engine compartment, remove the two nuts with washers that secure the rear of the battery tray support to the two studs that extend through the top of the front wheelhouse inner panel.

(5) From inside the front fender wheelhouse, remove the two nuts with washers that secure the front of the battery tray support to the two studs that extend through the underside of the front wheelhouse inner panel.

(6) From inside the front fender wheelhouse, remove the stud plate that secures the rear of the battery tray support from the underside of the front wheelhouse inner panel.

(7) From the engine compartment, remove the battery tray and the stud plate that secures the front of the battery tray support from the front wheelhouse inner panel as a unit.

(8) If the vehicle is equipped with the optional vehicle speed control package, the speed control servo must be removed from the left battery tray support to complete battery tray removal.

BATTERY TRAY (Continued)

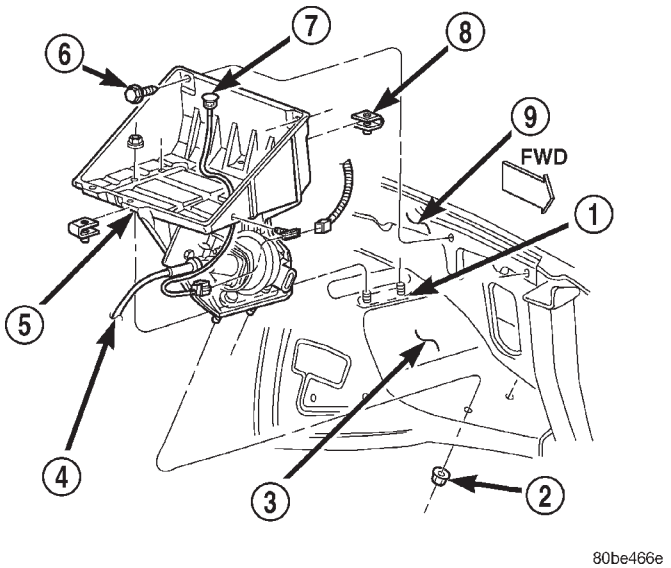


Fig. 26 Left Battery Tray Remove/Install - Typical for Right Battery Tray

1 - STUD PLATE (2)
2 - NUT AND WASHER (4)
3 - FRONT WHEELHOUSE INNER PANEL
4 - SPEED CONTROL SERVO
5 - TRAY
6 - SCREW AND WASHER (2)
7 - BATTERY TREMPERATURE SENSOR
8 - U-NUT (2)
9 - FENDER INNER SHIELD

INSTALLATION

(1) Clean and inspect the battery tray (Refer to 8 - ELECTRICAL/BATTERY SYSTEM - CLEANING).

(2) If the vehicle is equipped with the optional vehicle speed control package, the speed control servo must be installed onto the left battery tray support to complete battery tray installation.

(3) Install the stud plate onto the front of the battery tray support.

(4) From the engine compartment, position the battery tray and the stud plate that secures the front of the battery tray support onto the front wheelhouse inner panel as a unit.

(5) From inside the front fender wheelhouse, loosely install the two nuts with washers that secure the front of the battery tray support to the two studs that extend through the underside of the front wheelhouse inner panel.

(6) From inside the front fender wheelhouse, position the stud plate that secures the rear of the battery tray support onto the underside of the front wheelhouse inner panel.

(7) From the engine compartment, loosely install the two nuts with washers that secure the rear of the battery tray support to the two studs that extend through the top of the front wheelhouse inner panel.

(8) Install and tighten the two screws with washers that secure the outboard side of the battery tray to the inner fender shield. Tighten the screws to 15.8 N·m (140 in. lbs.).

(9) Final tighten the four nuts with washers that secure the battery tray support to the stud plates on the front wheelhouse inner panel. Tighten the nuts to 15.8 N·m (140 in. lbs.).

(10) If the left battery tray is being installed, install the battery temperature sensor onto the left battery tray (Refer to 8 - ELECTRICAL/CHARGING/ BATTERY TEMPERATURE SENSOR - INSTALLATION).

(11) Install the battery onto the battery tray (Refer to 8 - ELECTRICAL/BATTERY SYSTEM/BATTERY - INSTALLATION).

CHARGING

TABLE OF CONTENTS

CHARGING

DESCRIPTION

The charging system consists of:

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

OPERATION

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

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

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

All vehicles are equipped with On-Board Diagnostics (OBD). All OBD-sensed systems, including EVR (field control) circuitry, are monitored by the PCM. Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for certain failures it detects. Refer to On-Board Diagnostics in 25, Emission Control System for more DTC information and a list of codes.

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

DIAGNOSIS AND TESTING - CHARGING SYSTEM

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

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

Remember that an undercharged battery is often caused by:

- accessories being left on with the engine not running

CHARGING (Continued)

• a faulty or improperly adjusted switch that allows a lamp to stay on. Refer to Ignition-Off Draw Test in 8, Battery for more information.

INSPECTION

The 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 DRB® scan tool. Perform the following inspections before attaching the scan tool.

(1) Inspect the battery condition. Refer to 8, Battery for procedures.

(2) Inspect condition of battery cable terminals, battery posts, connections at engine block, starter solenoid and relay. They should be clean and tight. Repair as required.

(3) Inspect all fuses in both the fuseblock and Power Distribution Center (PDC) for tightness in receptacles. They should be properly installed and tight. Repair or replace as required.

(4) Inspect generator mounting bolts for tightness. Replace or tighten bolts if required. Refer to the Generator Removal/Installation section of this group for torque specifications.

(5) Inspect generator drive belt condition and tension. Tighten or replace belt as required. Refer to Belt Tension Specifications in 7, Cooling System.

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

(7) Inspect generator electrical connections at generator field, battery output, and ground terminal (if equipped). Also check generator ground wire connection at engine (if equipped). They should all be clean and tight. Repair as required.

SPECIFICATIONS

GENERATOR RATINGS

TYPE	PART NUMBER	RATED SAE AMPS	ENGINES	MINIMUM TEST AMPS
DENSO	56028920AB	136	5.9L GAS	100
DENSO	56029913AA	117	5.9L GAS	90
BOSCH	56028237AB	117	5.9L GAS	90
BOSCH	56028238AB	136	5.9L GAS	100
DENSO	56027221AD	136	5.9L DIESEL	120
BOSCH	56028239AB	136	5.9L DIESEL	120
BOSCH	56028560AA	136	8.0L	100
DENSO	560289200AC	136	8.0L	100

CHARGING (Continued)

SPECIFICATIONS - TORQUE - GENERATOR/ CHARGING SYSTEM

DESCRIPTION	N·m	Ft. Lbs.	In. Lbs.
Generator Mounting Bolts - Gas Engine	41	30	-
Generator Upper Mounting Bolt - Diesel Engine	54	40	-
Generator Pivot Bolt/Nut - Diesel Engine	54	40	-
Generator Mounting Bracket-to-Engine Bolt - Diesel Engine	24	18	-
Generator B+ Cable Eyelet Nut	12	9	108

BATTERY TEMPERATURE SENSOR

DESCRIPTION

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

OPERATION

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

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

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

REMOVAL

The battery temperature sensor is located under the vehicle battery (Fig. 1) and is attached (snapped into) a mounting hole on battery tray. On models equipped with a diesel engine (dual batteries), only one sensor is used. The sensor is located under the battery on drivers side of vehicle.

(1) Remove battery. Refer to 8, Battery for procedures.

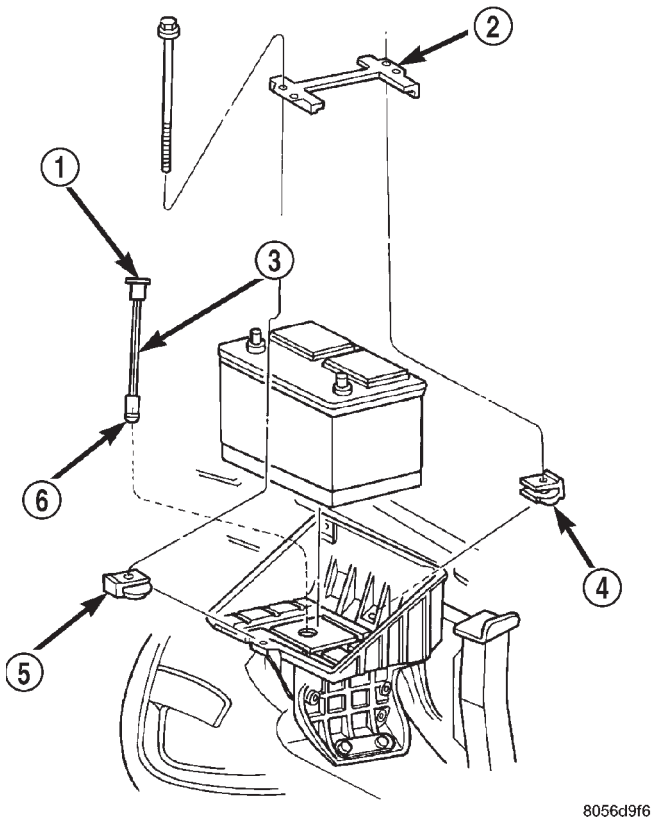


Fig. 1 Battery Temperature Sensor Location

1 - BATT. TEMP. SENSOR
2 - BATTERY HOLD DOWN STRAP
3 - PIGTAIL HARNESS
4 - U-NUT
5 - U-NUT
6 - ELEC. CONNEC.

BATTERY TEMPERATURE SENSOR (Continued)

(2) Disconnect sensor pigtail harness from engine wire harness.

(3) Pry sensor straight up from battery tray mounting hole.

INSTALLATION

The battery temperature sensor is located under the vehicle battery (Fig. 1) and is attached (snapped into) a mounting hole on battery tray. On models equipped with a diesel engine (dual batteries), only one sensor is used. The sensor is located under the battery on drivers side of vehicle.

(1) Feed pigtail harness through mounting hole in top of battery tray and press sensor into top of tray (snaps in).

(2) Connect pigtail harness.

(3) Install battery. Refer to 8A, Battery for procedures.

GENERATOR

DESCRIPTION

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

OPERATION

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

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

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

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

REMOVAL

WARNING: DISCONNECT NEGATIVE CABLE FROM BATTERY BEFORE REMOVING BATTERY OUTPUT WIRE (B+ WIRE) FROM GENERATOR. FAILURE TO DO SO CAN RESULT IN INJURY OR DAMAGE TO ELECTRICAL SYSTEM.

(1) Disconnect negative battery cable at battery. Diesel Engines: Disconnect both negative battery cables at both batteries.

(2) Remove generator drive belt. Refer to 7, Cooling System for procedure.

(3) Gasoline Engines: Remove generator pivot and mounting bolts/nut (Fig. 2) or (Fig. 3).

(4) Diesel Engines: Loosen (but do not remove) generator mounting bracket-to-engine bolt (Fig. 4).

(5) All Engines: Remove upper generator mounting bolt and lower mounting bolt/nut.

(6) Remove B+ terminal mounting nut at rear of generator (Fig. 5) or (Fig. 6). Disconnect terminal from generator.

(7) Disconnect field wire connector at rear of generator by pushing on connector tab.

(8) Remove generator from vehicle.

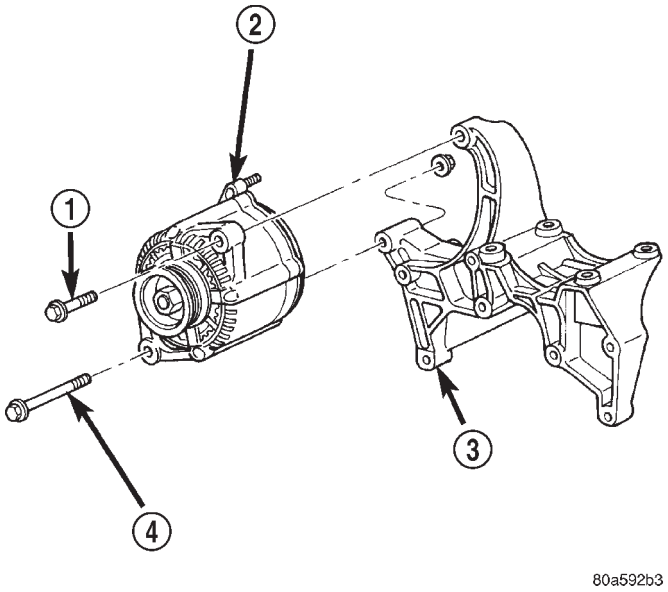


Fig. 2 Remove/Install Generator—5.9L Engines

1 - MOUNTING BOLT
2 - GENERATOR
3 - MOUNTING BRACKET
4 - MOUNTING BOLT/NUT

GENERATOR (Continued)

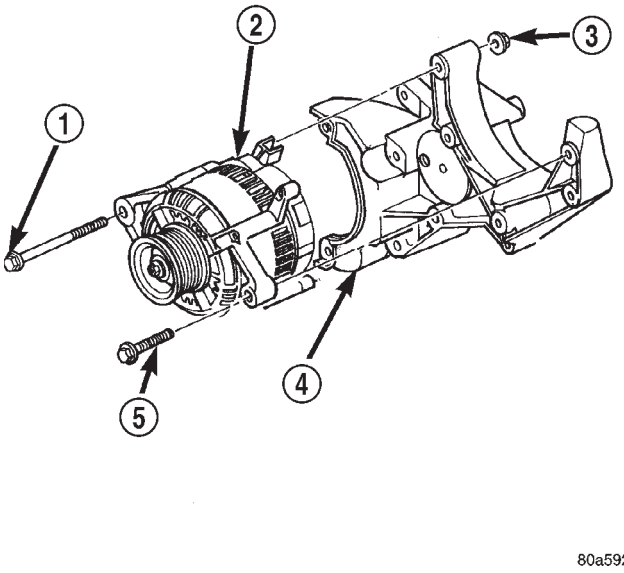


Fig. 3 Remove/Install Generator—8.0L Engine

1 - MOUNTING BOLT
2 - GENERATOR
3 - NUT
4 - MOUNTING BRACKET
5 - MOUNTING BOLT

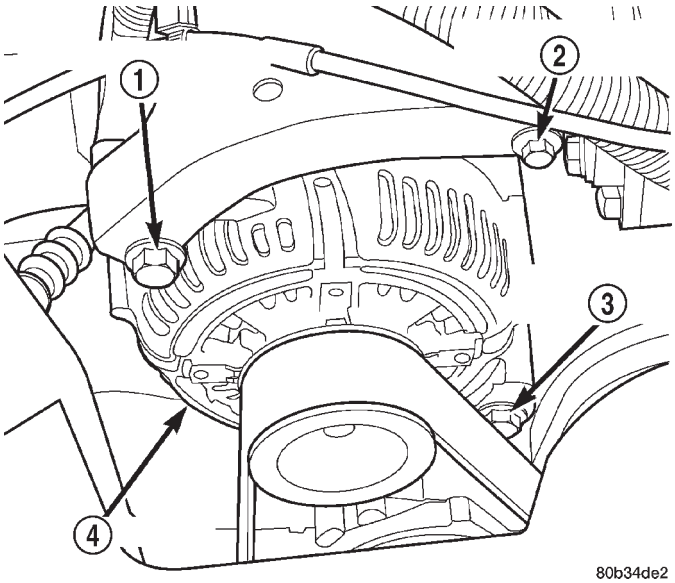


Fig. 4 Remove/Install Generator—Diesel Engine

1 - UPPER MOUNTING BOLT
2 - BRACKET-TO-ENGINE BOLT
3 - LOWER MOUNTING BOLT/NUT
4 - GENERATOR

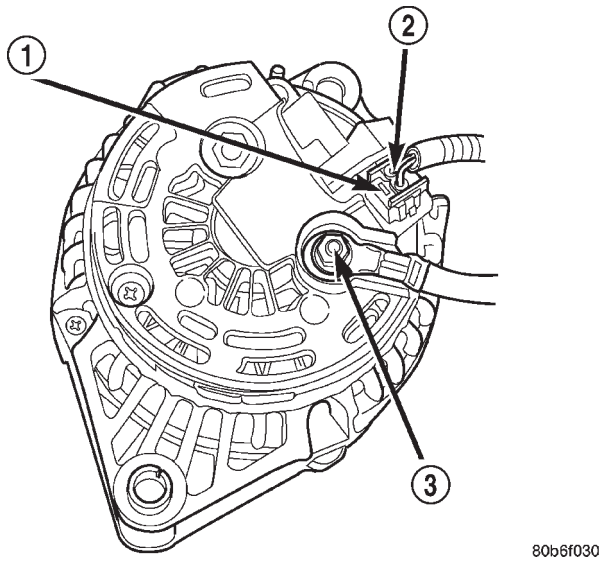


Fig. 5 Generator Connectors—Typical Bosch

1 - FIELD WIRE CONNECTOR
2 - FIELD WIRES
3 - B+ (OUTPUT TERMINAL)

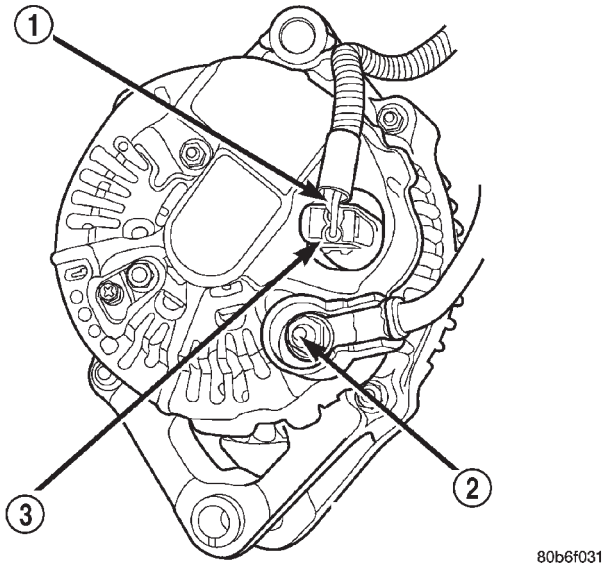


Fig. 6 Generator Connectors—Typical Denso

1 - FIELD WIRES
2 - B+ (OUTPUT TERMINAL)
3 - FIELD WIRE CONNECTOR

GENERATOR (Continued)

INSTALLATION

(1) Position generator to engine and snap field wire connector into rear of generator.

(2) Install B+ terminal eyelet to generator stud. Tighten mounting nut to 12 N·m (108 in. lbs.) torque.

(3) Install generator mounting fasteners and tighten as follows:

- Generator mounting bolt—All gas powered engines—41 N·m (30 ft. lbs.) torque.
- Generator pivot bolt/nut—All gas powered engines—41 N·m (30 ft. lbs.) torque.
- Generator mounting bolt—Diesel powered engines—54 N·m (40 ft. lbs.) torque.
- Generator pivot bolt/nut—Diesel powered engines—54 N·m (40 ft. lbs.) torque.

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

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

(4) Install generator drive belt. Refer to 7, Cooling System for procedure.

(5) Install negative battery cable(s) to battery(s).

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

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

STARTING

TABLE OF CONTENTS

STARTING

DESCRIPTION

The starting system consists of:

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

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

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

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

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

Certain starting system components are monitored by the PCM and may produce a Diagnostic Trouble Code (DTC). Refer to Emission Control. See Diagnostic Trouble Codes for additional information and a list of codes.

OPERATION

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

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

If the vehicle is equipped with an automatic transmission, battery voltage is supplied through the low-amperage control circuit to the coil battery terminal of the starter relay when the ignition switch is turned to the momentary Start position. The park/neutral position switch is installed in series between the starter relay coil ground terminal and ground.

STARTING (Continued)

This normally open switch prevents the starter relay from being energized and the starter motor from operating unless the automatic transmission gear selector is in the Neutral or Park positions.

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

The energized solenoid pull-in coil pulls in the solenoid plunger. The solenoid plunger pulls the shift lever in the starter motor. This engages the starter overrunning clutch and pinion gear with the starter ring gear on the manual transmission flywheel or on the automatic transmission torque converter or torque converter drive plate.

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

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

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

DIAGNOSIS AND TESTING - STARTING SYSTEM

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

Starting System Diagnosis

CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER FAILS TO OPERATE.	1. Battery discharged or faulty.	1. Refer to Battery. Charge or replace battery, if required.
	2. Starting circuit wiring faulty.	2. Refer to 8, Wiring Diagrams. Test and repair starter feed and/or control circuits, if required.
	3. Starter relay faulty.	3. Refer to Starter Relay in Diagnosis and Testing. Replace starter relay if required.
	4. Ignition switch faulty.	4. Refer to Ignition Switch and Key Lock Cylinder. Replace ignition switch if required.
	5. Clutch pedal position switch faulty.	5. Refer to Clutch Pedal Position Switch.
	6. Park/Neutral position switch faulty or misadjusted.	6. Refer to Park/Neutral Position Switch. Replace park/neutral position switch if required.
	7. Starter solenoid faulty.	7. Refer to Starter Motor. Replace starter motor assembly if required.
	8. Starter motor faulty.	8. If all other starting system components and circuits test OK, replace starter motor.
STARTER ENGAGES, FAILS TO TURN ENGINE.	1. Battery discharged or faulty.	1. Refer to Battery. Charge or replace battery if required.
	2. Starting circuit wiring faulty.	2. Refer to 8, Wiring Diagrams. Test and repair starter feed and/or control circuits if required.
	3. Starter motor faulty.	3. If all other starting system components and circuits test OK, replace starter motor assembly.
	4. Engine seized.	4. Refer to Engine Diagnosis in the Diagnosis and Testing section of 9, Engine.

STARTING (Continued)

Starting System Diagnosis		
CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER ENGAGES, SPINS OUT BEFORE ENGINE STARTS.	1. Starter ring gear faulty.	1. Refer to Starter Motor Removal and Installation. Remove starter motor to inspect starter ring gear. Replace starter ring gear if required.
	2. Starter motor faulty.	2. If all other starting system components and circuits test OK, replace starter motor assembly.
STARTER DOES NOT DISENGAGE.	1. Starter motor improperly installed.	1. Refer to Starter Motor Removal and Installation. Tighten starter mounting hardware to correct torque specifications.
	2. Starter relay faulty.	2. Refer to Starter Relay Diagnosis and Testing. Replace starter relay if required.
	3. Ignition switch faulty.	3. Refer to Ignition Switch and Key Lock Cylinder. Replace ignition switch if required.
	4. Starter motor faulty.	4. If all other starting system components and circuits test OK, replace starter motor.

INSPECTION

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

WARNING: ON VEHICLES EQUIPPED WITH AIRBAGS, REFER TO 8, PASSIVE RESTRAINT SYSTEMS, BEFORE ATTEMPTING ANY STEERING WHEEL, STEERING COLUMN, OR INSTRUMENT PANEL COMPONENT DIAGNOSIS OR SERVICE. FAILURE TO TAKE THE PROPER PRECAUTIONS COULD RESULT IN ACCIDENTAL AIRBAG DEPLOYMENT AND POSSIBLE PERSONAL INJURY.

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

TESTING

COLD CRANKING TEST

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

(1) Connect volt-ampere tester to battery terminals (Fig. 1). See instructions provided by manufacturer of volt-ampere tester being used. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, tester should be connected to battery on left side of vehicle only. Also, tester current reading must be taken from positive battery cable lead that connects to starter motor.**

(2) Fully engage parking brake.

(3) If equipped with manual transmission, place gearshift selector lever in Neutral position and block clutch pedal in fully depressed position. If equipped with automatic transmission, place gearshift selector lever in Park position.

STARTING (Continued)

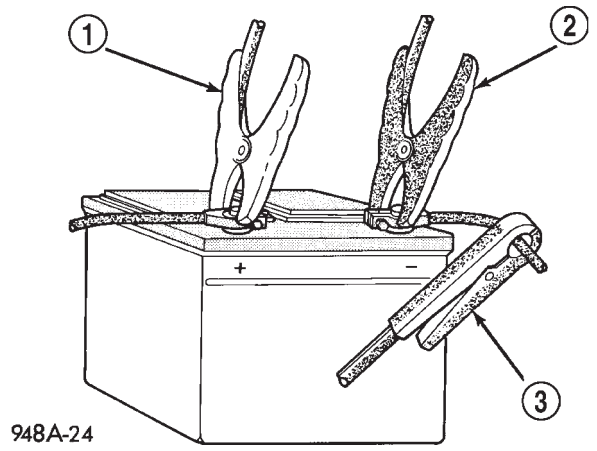


Fig. 1 Volts-Amps Tester Connections - Typical

1 - POSITIVE CLAMP
2 - NEGATIVE CLAMP
3 - INDUCTION AMMETER CLAMP

(4) Verify that all lamps and accessories are turned off.

(5) To prevent a gasoline engine from starting, remove Automatic ShutDown (ASD) relay. To prevent a diesel engine from starting, remove Fuel Pump Relay. These relays are located in Power Distribution Center (PDC). Refer to label on PDC cover for relay location.

WARNING: IF EQUIPPED WITH DIESEL ENGINE, ATTEMPT TO START ENGINE A FEW TIMES BEFORE PROCEEDING WITH FOLLOWING STEP.

(6) Rotate and hold ignition switch in Start position. Note cranking voltage and current (amperage) draw readings shown on volt-ampere tester.

(a) If voltage reads below 9.6 volts, refer to **Starter Motor** in Diagnosis and Testing. If starter motor is OK, refer to **Engine Diagnosis** in 9, Engine for further testing of engine. If starter motor is not OK, replace faulty starter motor.

(b) If voltage reads above 9.6 volts and current (amperage) draw reads below specifications, refer to **Feed Circuit Test** in this section.

(c) If voltage reads 12.5 volts or greater and starter motor does not turn, refer to **Control Circuit Testing** in this section.

(d) If voltage reads 12.5 volts or greater and starter motor turns very slowly, refer to **Feed Circuit Test** in this section.

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

FEED CIRCUIT TEST

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

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

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

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

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

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

(2) Connect positive lead of voltmeter to positive battery terminal post. Connect negative lead of voltmeter to battery positive cable clamp (Fig. 3). Rotate and hold ignition switch in Start position. Observe voltmeter. If voltage is detected, correct poor contact between cable clamp and terminal post. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed twice, once for each battery.**

STARTING (Continued)

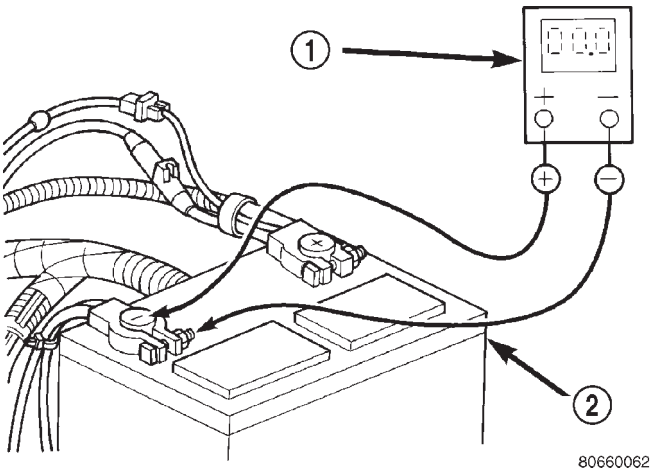


Fig. 2 Test Negative Battery Cable Connection Resistance - Typical

1 - VOLTMETER
2 - BATTERY

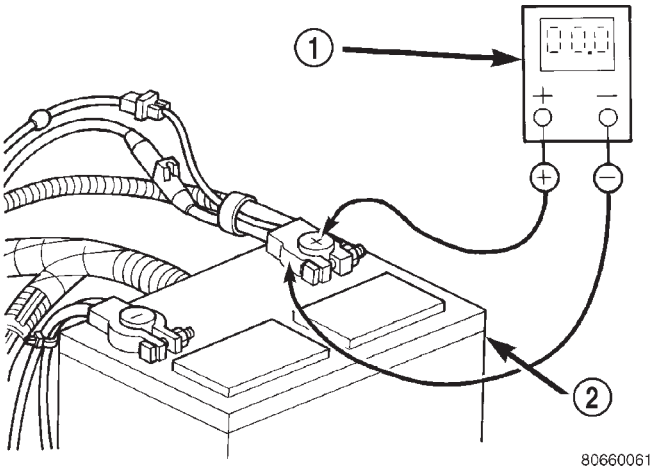


Fig. 3 Test Positive Battery Cable Connection Resistance - Typical

1 - VOLTMETER
2 - BATTERY

(3) Connect voltmeter to measure between battery positive terminal post and starter solenoid battery terminal stud (Fig. 4). Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten battery cable connection at solenoid. Repeat test. If reading is still above 0.2 volt, replace faulty positive battery cable. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed on driver side battery only.**

(4) Connect voltmeter to measure between negative battery terminal post and a good clean ground on engine block (Fig. 5). Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, clean and tighten negative battery cable attachment on engine block. Repeat test. If reading is still above 0.2 volt, replace faulty negative battery cable. **Note: Certain diesel equipped models use dual batteries. If equipped with dual battery system, this procedure must be performed twice, once for each battery.**

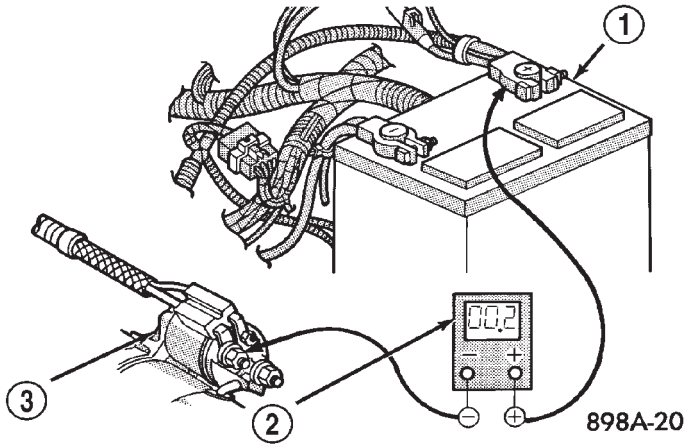


Fig. 4 Test Positive Battery Cable

1 - BATTERY
2 - VOLTMETER
3 - STARTER MOTOR

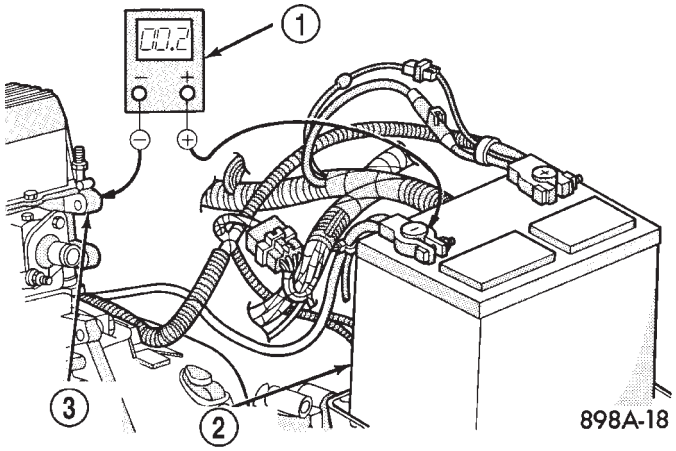


Fig. 5 Test Ground Circuit Resistance - Typical

1 - VOLTMETER
2 - BATTERY
3 - ENGINE GROUND

(5) Connect positive lead of voltmeter to starter housing. Connect negative lead of voltmeter to negative battery terminal post (Fig. 6). Rotate and hold ignition switch in Start position. Observe voltmeter. If reading is above 0.2 volt, correct poor starter to engine block ground contact. **Note: Certain diesel equipped models use dual batteries. If equipped**

STARTING (Continued)

with dual battery system, this procedure must be performed on driver side battery only.

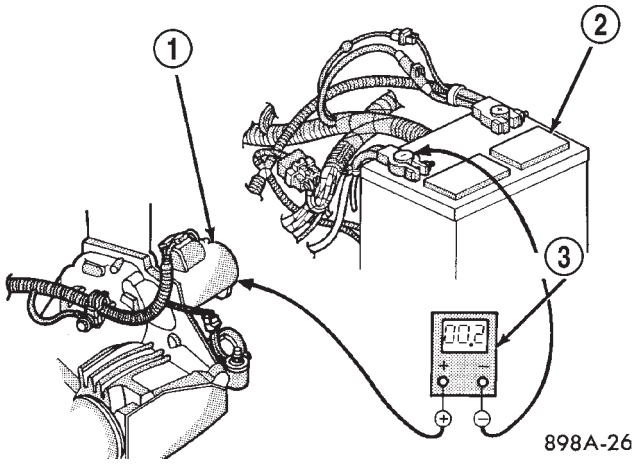


Fig. 6 Test Starter Ground - Typical

1 - STARTER MOTOR
2 - BATTERY
3 - VOLTMETER

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

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

CONTROL CIRCUIT TESTING

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

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

SPECIFICATIONS

STARTING SYSTEM

Starter Motor and Solenoid			
Manufacturer	Nippon Denso	Nippon Denso	Nippon Denso
Part Number	56027702AB	56027703AB	4741012
Engine Application	5.9L (Gasoline)	8.0L (Gasoline)	5.9L (Diesel)
Power Rating	1.4 Kilowatt 1.9 Horsepower	1.4 Kilowatt 1.9 Horsepower	2.7 Kilowatt 3.6 Horsepower
Voltage	12 Volts	12 Volts	12 Volts
Pinion Teeth	10	11	13
Number of Fields	4	4	4
Number of Poles	4	4	4
Number of Brushes	4	4	4
Drive Type	Reduction Gear Train	Reduction Gear Train	Conventional Gear Train
Free Running Test Voltage	11 Volts	11 Volts	11 Volts
Free Running Test Amperage Draw	73 Amperes	73 Amperes	200 Amperes
Free Running Test Minimum Speed	3601 rpm	3601 rpm	3000 rpm

STARTING (Continued)

Starter Motor and Solenoid			
Solenoid Closing Maximum Voltage Required	7.5 Volts	7.5 Volts	8.0 Volts
* Cranking Amperage Draw Test	125 - 250 Amperes	125 - 250 Amperes	450 - 700 Amperes
* Test at operating temperature. Cold engine, tight (new) engine, or heavy oil will increase starter amperage draw.			

SPECIFICATIONS - TORQUE - STARTING SYSTEM

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

STARTER MOTOR

DESCRIPTION

The starter motors used for the 5.9L diesel engine and the 8.0L gasoline engine available in this model are not interchangeable with each other, or with the starter motors used for the other available engines.

The starter motor for the 5.9L diesel engine is mounted with three screws to the flywheel housing on the left side of the engine. The starter motor for the 8.0L gasoline engine is mounted with two screws to the flange on the left rear corner of the engine block, while the starter motor for the 5.9L Gas engine is mounted with one screw, a stud and a nut to the manual transmission clutch housing or automatic transmission torque converter housing and is located on the left side of the engine.

Each of these starter motors incorporates several of the same features to create a reliable, efficient, compact, lightweight and powerful unit. The electric motors of all of these starters have four brushes contacting the motor commutator, and feature four electromagnetic field coils wound around four pole shoes. The 5.9L and 8.0L gasoline engine starter motors are rated at 1.4 kilowatts (about 1.9 horsepower) output at 12 volts, while the 5.9L diesel engine starter motor is rated at 2.7 kilowatts (about 3.6 horsepower) output at 12 volts.

All of these starter motors are serviced only as a unit with their starter solenoids, and cannot be repaired. If either component is faulty or damaged, the entire starter motor and starter solenoid unit must be replaced.

OPERATION

These starter motors are equipped with a gear reduction (intermediate transmission) system. The gear reduction system consists of a gear that is integral to the output end of the electric motor armature shaft that is in continual engagement with a larger gear that is splined to the input end of the starter pinion gear shaft. This feature makes it possible to reduce the dimensions of the starter. At the same time, it allows higher armature rotational speed and delivers increased torque through the starter pinion gear to the starter ring gear.

The starter motors for all engines are activated by an integral heavy duty starter solenoid switch mounted to the overrunning clutch housing. This electromechanical switch connects and disconnects

STARTER MOTOR (Continued)

the feed of battery voltage to the starter motor, also engaging and disengaging the starter pinion gear with the starter ring gear.

All starter motors use an overrunning clutch and starter pinion gear unit to engage and drive a starter ring gear that is integral to the flywheel (manual transmission), torque converter or torque converter drive plate (automatic transmission) mounted on the rear crankshaft flange.

DIAGNOSIS AND TESTING - STARTER MOTOR

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

(1) Remove starter motor from vehicle. Refer to **Starter Motor** Removal and Installation.

(2) Mount starter motor securely in a soft-jawed bench vise. The vise jaws should be clamped on mounting flange of starter motor. Never clamp on starter motor by field frame.

(3) Connect suitable volt-ampere tester and 12-volt battery to starter motor in series, and set ammeter to 100 ampere scale (250 ampere scale for diesel engine starters). See instructions provided by manufacturer of volt-ampere tester being used.

(4) Install jumper wire from solenoid terminal to solenoid battery terminal. The starter motor should operate. If starter motor fails to operate, replace faulty starter motor assembly.

(5) Adjust carbon pile load of tester to obtain free running test voltage. Refer to Specifications for the starter motor free running test voltage specifications.

(6) Note reading on ammeter and compare this reading to free running test maximum amperage draw. Refer to Specifications for starter motor free running test maximum amperage draw specifications.

(7) If ammeter reading exceeds maximum amperage draw specification, replace faulty starter motor assembly.

STARTER MOTOR SOLENOID

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

(1) Remove starter motor. Refer to **Starter Motor** Removal and Installation.

(2) Disconnect wire from solenoid field coil terminal.

(3) Check for continuity between solenoid terminal and solenoid field coil terminal with continuity tester (Fig. 7). There should be continuity. If OK, go to Step 4. If not OK, replace faulty starter motor assembly.

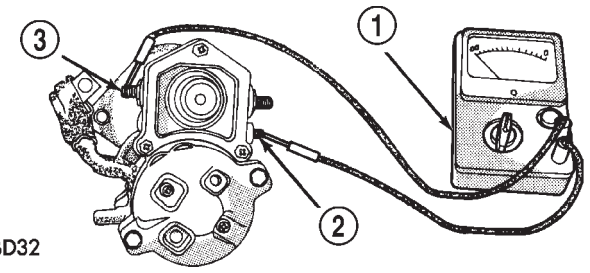


Fig. 7 Continuity Test Between Solenoid Terminal and Field Coil Terminal - Typical

1 - OHMMETER
2 - SOLENOID TERMINAL
3 - FIELD COIL TERMINAL

(4) Check for continuity between solenoid terminal and solenoid case (Fig. 8). There should be continuity. If not OK, replace faulty starter motor assembly.

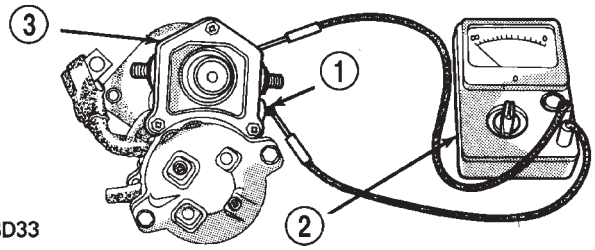


Fig. 8 Continuity Test Between Solenoid Terminal and Solenoid Case - Typical

1 - SOLENOID TERMINAL
2 - OHMMETER
3 - SOLENOID

REMOVAL

5.9L GASOLINE ENGINE

(1) Disconnect and isolate negative battery cable.

(2) Raise and support vehicle.

(3) Remove nut and lock washer securing starter motor to mounting stud (Fig. 9).

(4) While supporting starter motor, remove upper mounting bolt from starter motor.

(5) If equipped with automatic transmission, slide cooler tube bracket forward on tubes far enough for starter motor mounting flange to be removed from lower mounting stud.

(6) Move starter motor towards front of vehicle far enough for nose of starter pinion housing to clear housing. Always support starter motor during this process, do not let starter motor hang from wire harness.

(7) Tilt nose downwards and lower starter motor far enough to access and remove nut that secures battery positive cable wire harness connector eyelet

STARTER MOTOR (Continued)

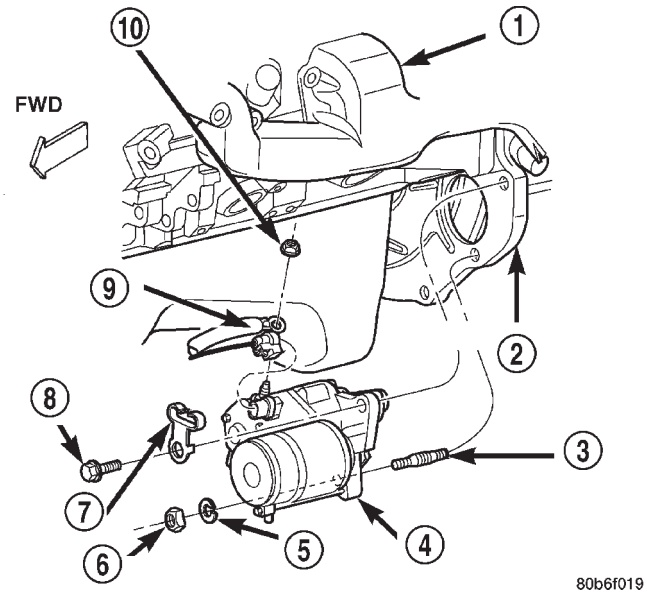


Fig. 9 Starter Motor Remove/Install - 5.9L Gasoline Engine

1 - ENGINE
2 - STARTER MOUNTING FLANGE
3 - STUD
4 - STARTER MOTOR
5 - LOCK WASHER
6 - NUT
7 - BRACKET
8 - BOLT
9 - POSITIVE BATTERY CABLE WIRE HARNESS
10 - POSITIVE BATTERY CABLE WIRE HARNESS NUT

to solenoid battery terminal stud. Do not let starter motor hang from wire harness.

(8) Remove battery positive cable wire harness connector eyelet from solenoid battery terminal stud.

(9) Disconnect battery positive cable wire harness connector from solenoid terminal connector receptacle.

(10) Remove starter motor.

5.9L DIESEL ENGINE

(1) Disconnect and isolate negative cables of both batteries.

(2) Raise and support vehicle.

(3) Pull back protective rubber boot from solenoid battery terminal far enough to access and remove nut securing battery positive cable wire harness connector eyelet to solenoid battery terminal stud (Fig. 10).

(4) Remove nut securing battery positive cable wire harness solenoid connector eyelet to solenoid terminal stud.

(5) Remove battery positive cable wire harness connector eyelets from solenoid terminal studs.

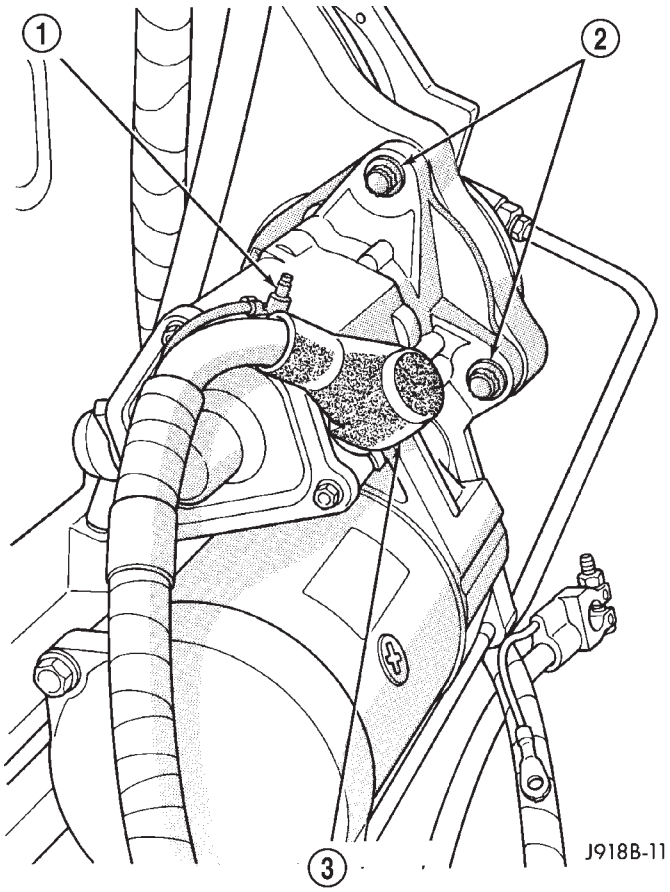


Fig. 10 Starter Motor Wire Harness Remove/Install - 5.9L Diesel Engine

1 - SOLENOID WIRE
2 - MOUNTING BOLTS (3)
3 - BATTERY TERMINAL

(6) While supporting starter motor, remove three bolts securing starter motor to flywheel housing (Fig. 10) and (Fig. 11).

(7) Remove starter motor from engine (certain diesel engines have an aluminum spacer mounted between the starter and the starter mounting flange. Note position and orientation of spacer before removal).

8.0L GASOLINE ENGINE

(1) Disconnect and isolate negative battery cable.

(2) Raise and support vehicle.

(3) Remove nut securing battery positive cable wire harness connector eyelet to solenoid battery terminal stud (Fig. 12).

(4) Remove battery positive cable connector eyelet from solenoid battery terminal stud.

(5) Disconnect battery positive cable wire harness connector from solenoid terminal connector receptacle.

STARTER MOTOR (Continued)

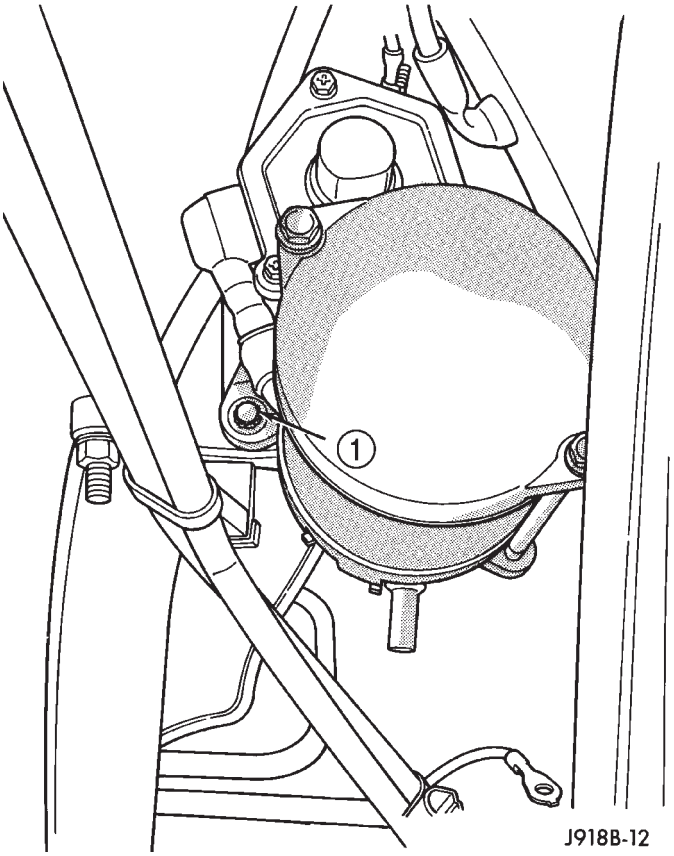


Fig. 11 Starter Motor Remove/Install - 5.9L Diesel Engine

1 - MOUNTING BOLT

(6) Support starter motor and remove two bolts securing starter motor to engine.

(7) Remove starter motor from engine.

INSTALLATION

5.9L GASOLINE ENGINE

(1) Connect wiring harness to starter motor and tighten eyelet nut to 25 N·m (221 in. lbs.). Do not allow starter motor to hang from wire harness.

(2) Position starter motor to starter mounting flange.

(3) If equipped with automatic transmission, slide cooler tube bracket into position.

(4) Loosely install upper bolt.

(5) Position lock washer and loosely install lower nut.

(6) Tighten upper bolt to 67.8 N·m (50 ft. lbs.).

(7) Tighten lower nut to 67.8 N·m (50 ft. lbs.).

(8) Lower vehicle.

(9) Connect battery cable.

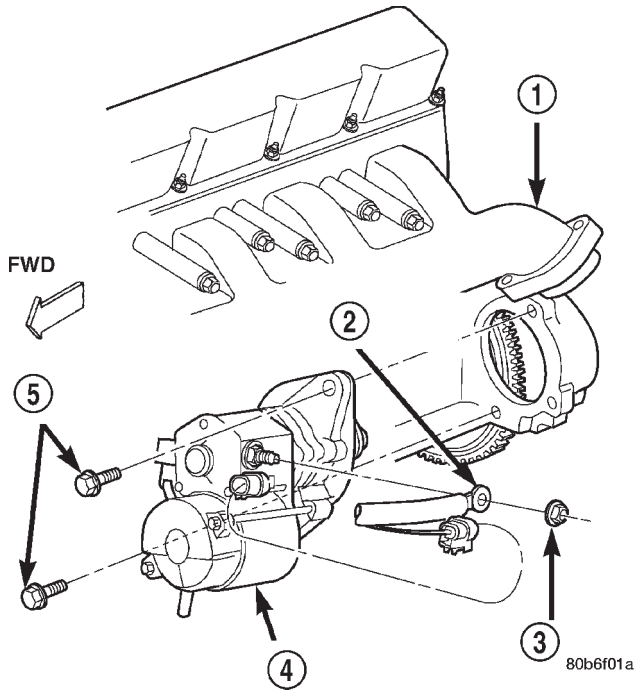


Fig. 12 Starter Motor Remove/Install - 8.0L Gasoline Engine

1 - ENGINE
2 - BATTERY POSITIVE CABLE WIRE HARNESS
3 - NUT
4 - STARTER MOTOR
5 - SCREW AND WASHER (2)

5.9L DIESEL ENGINE

(1) If equipped, position aluminum spacer to rear of starter.

(2) Position starter motor to engine.

(3) Support starter and loosely install three mounting bolts.

(4) Tighten 3 bolts to 43.4 N·m (32 ft. lbs.).

(5) Position wiring eyelets to starter studs and install nuts. Tighten small nut to 6.2 N·m (55 in. lbs.). Tighten large nut to 13.6 N·m (120 in. lbs.).

(6) Install protective rubber boot over stud.

(7) Lower vehicle.

(8) Connect battery cables to both batteries.

8.0L GASOLINE ENGINE

(1) Support starter motor and loosely install two bolts securing starter motor to engine.

(2) Tighten 2 bolts to 67.8 N·m (50 ft. lbs.).

(3) Connect solenoid wire to solenoid terminal.

(4) Position battery cable eyelet to starter stud. Install nut and tighten to 13.6 N·m (120 in. lbs.).

(5) Lower vehicle.

(6) Connect battery cable.

STARTER MOTOR RELAY

DESCRIPTION

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

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

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

OPERATION

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

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

DIAGNOSIS AND TESTING - STARTER RELAY

The starter relay (Fig. 13) is located in Power Distribution Center (PDC). Refer to PDC cover for relay identification and location. For complete starter relay wiring circuit diagrams, refer to 8, Wiring Diagrams.

(1) Remove starter relay from PDC.

(2) A relay in de-energized position should have continuity between terminals 87A and 30, and no continuity between terminals 87 and 30. If OK, go to Step 3. If not OK, replace faulty relay.

(3) Resistance between terminals 85 and 86 (electromagnet) should be 75 ± 5 ohms. If OK, go to Step 4. If not OK, replace faulty relay.

(4) Connect 12V battery to terminals 85 and 86. There should now be continuity between terminals 30 and 87, and no continuity between terminals 87A and 30. If OK, perform Relay Circuit Test that follows. If not OK, replace faulty relay.

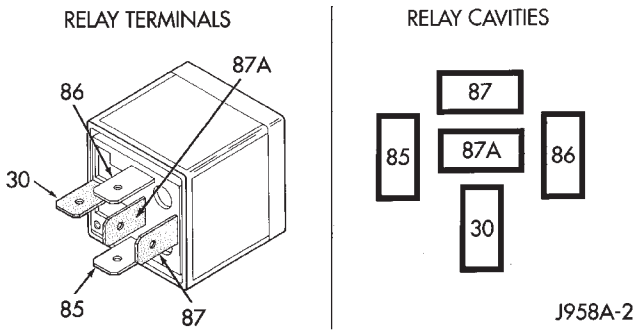


Fig. 13 Starter Relay

TERMINAL LEGEND

NUMBER	IDENTIFICATION
30	COMMON FEED
85	COIL GROUND
86	COIL BATTERY
87	NORMALLY OPEN
87A	NORMALLY CLOSED

RELAY CIRCUIT TEST

(1) The relay common feed terminal cavity (30) is connected to battery voltage and should be hot at all times. If OK, go to Step 2. If not OK, repair open circuit to fuse in PDC as required.

(2) The relay normally closed terminal (87A) is connected to terminal 30 in the de-energized position, but is not used for this application. Go to Step 3.

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

(4) The coil battery terminal (86) is connected to electromagnet in relay. It is energized when ignition switch is held in Start position. On vehicles with manual transmission, clutch pedal must be fully depressed for this test. Check for battery voltage at cavity for relay terminal 86 with ignition switch in Start position, and no voltage when ignition switch is released to On position. If OK, go to Step 5. If not OK with automatic transmission, check for open or short circuit to ignition switch and repair, if required. If circuit to ignition switch is OK, refer to **Ignition Switch and Key Lock Cylinder**. If not OK with a manual transmission, check circuit between relay and clutch pedal position switch for open or a short.

STARTER MOTOR RELAY (Continued)

If circuit is OK, refer to **Clutch Pedal Position Switch** in 6 , Clutch.

(5) The coil ground terminal (85) is connected to the electromagnet in the relay. On vehicles with manual transmission, it is grounded at all times. On vehicles with automatic transmission, it is grounded through park/neutral position switch only when gear-shift selector lever is in Park or Neutral positions. Check for continuity to ground at cavity for relay terminal 85. If not OK with manual transmission, repair circuit to ground as required. If not OK with automatic transmission, check for pen or short circuit to park/neutral position switch and repair, if required. If circuit to park/neutral position switch is OK, refer to **Park/Neutral Position Switch** in 21, Transmission.

REMOVAL

(1) Disconnect and isolate negative battery cable (both negative cables if diesel).

(2) Remove cover from Power Distribution Center (PDC) (Fig. 14).

(3) Refer to PDC cover for relay identification and location.

(4) Remove starter relay from PDC.

INSTALLATION

(1) Position starter relay in proper receptacle in PDC.

(2) Align starter relay terminals with terminal cavities in PDC receptacle.

(3) Push down firmly on starter relay until terminals are fully seated in terminal cavities in PDC receptacle.

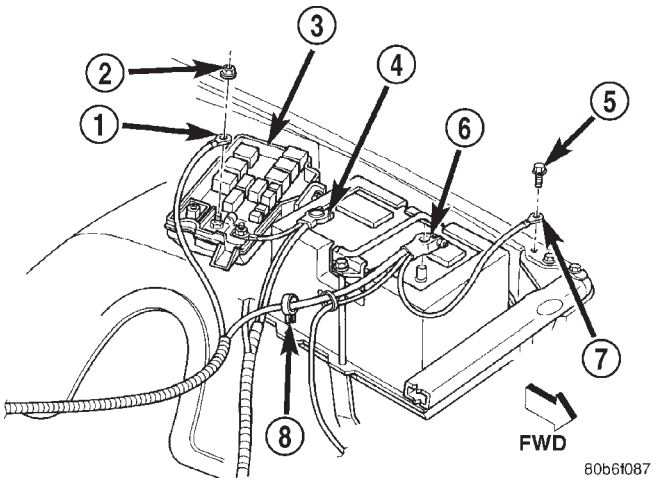


Fig. 14 Power Distribution Center

1 - EYELET
2 - NUT
3 - POWER DISTRIBUTION CENTER
4 - POSITIVE CABLE
5 - SCREW
6 - NEGATIVE CABLE
7 - EYELET
8 - CLIP

(4) Install PDC cover..

(5) Reconnect negative battery cable(s).