BATTERY

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DESCRIPTION AND OPERATION

BATTERY

DESCRIPTION

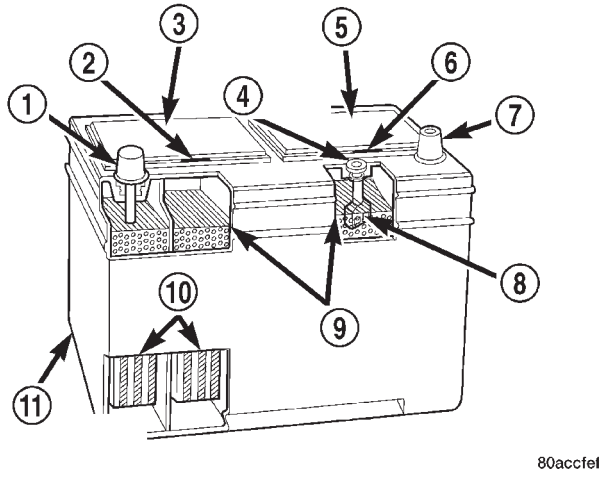


Fig. 1 Low-Maintenance Battery - Typical

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

A large capacity, low-maintenance storage battery (Fig. 1) is standard factory-installed equipment 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 visibly larger in diameter than the negative terminal post, for easy identification. The letters **POS** and **NEG** are also molded into the top of the battery case adjacent to their respective positive and negative terminal posts for additional identification confirmation. Refer to **Battery Cables** in the index of this service manual for the location of more information on the battery cables that connect the battery to the vehicle electrical system.

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

DESCRIPTION AND OPERATION (Continued)

ing against one another. These dissimilar metal plates are submerged in a sulfuric acid and water solution called an electrolyte.

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. For more information on the use of the built-in test indicator, refer to **Battery** in the index of this service manual for the location of the proper battery diagnosis and testing procedures. **The factory-installed low-maintenance battery has removable battery cell caps.** Water can 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. If the electrolyte level in this battery does become low, water must be added. However, rapid loss of electrolyte can be caused by an overcharging condition. Be certain to diagnose the charging system after replenishing the water in the battery for a low electrolyte condition and before returning the vehicle to service. Refer to **Charging System** in the index of this service manual for the location of the proper charging system diagnosis and testing procedures.

For battery maintenance schedules and jump starting procedures, see the owner's manual in the vehicle glove box. Optionally, refer to **Maintenance Schedules** and **Jump Starting, Towing and Hoisting** in the index of this service manual for the location of the recommended battery maintenance schedules and the proper battery jump starting procedures. While battery charging can be considered a maintenance procedure, the battery charging procedures and information are located in the service procedures section of this service manual. This was done because the battery must be fully-charged before any battery diagnosis or testing procedures can be performed. Refer to **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures.

NOTE: This group covers both Left-Hand Drive (LHD) and Right-Hand Drive (RHD) versions of this model. Whenever required and feasible, the RHD versions of affected vehicle components have been constructed as mirror-image of the LHD versions. While most of the illustrations used in this group represent only the LHD version, the diagnostic and service procedures outlined can generally be applied to either version. Exceptions to this rule have been clearly identified as LHD or RHD, if a special illustration or procedure is required.

BATTERY SIZE AND RATINGS

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

- Group Size

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

- Cold Cranking Amperage

The Cold Cranking Amperage (CCA) rating specifies how much current (in amperes) the battery can deliver for thirty seconds at -18° C (0° F). Terminal voltage must not fall below 7.2 volts during or after the thirty second discharge period. The CCA required is generally higher as engine displacement increases, depending also upon the starter current draw requirements.

- Reserve Capacity

The Reserve Capacity (RC) rating specifies the time (in minutes) it takes for battery terminal voltage to fall below 10.5 volts, at a discharge rate of 25 amperes. RC is determined with the battery fully-charged at 26.7° C (80° F). This rating estimates how long the battery might last after a charging system failure, under minimum electrical load.

- Ampere-Hours

The Ampere-Hours (AH) rating specifies the current (in amperes) that a battery can deliver steadily for twenty hours, with the voltage in the battery not falling below 10.5 volts. This rating is also sometimes identified as the twenty-hour discharge rating.

OPERATION

When an electrical load is applied to the terminals of the battery, an electrochemical reaction occurs. This reaction causes the battery to discharge electrical current from its terminals. As the battery discharges, a gradual chemical change takes place within each cell. The sulfuric acid in the electrolyte combines with the plate materials, causing both plates to slowly change to lead sulfate. At the same time, oxygen from the positive plate material combines with hydrogen from the sulfuric acid, causing the electrolyte to become mainly water. The chemical changes within the battery are caused by the move-

DESCRIPTION AND OPERATION (Continued)

ment of excess or free electrons between the positive and negative plate groups. This movement of electrons produces a flow of electrical current through the load device attached to the battery terminals.

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

The battery is vented to release excess hydrogen gas that is created when the battery is being charged or discharged. However, even with these vents, hydrogen gas can collect in or around the battery. If hydrogen gas is exposed to flame or sparks, it may ignite. If the electrolyte level is low, the battery may arc internally and explode. If the battery is equipped with removable cell caps, add distilled water whenever the electrolyte level is below the top of the plates. If the battery cell caps cannot be removed, the battery must be replaced if the electrolyte level becomes low.

In addition to producing and storing electrical energy, the battery serves as a capacitor and voltage stabilizer for the electrical system of the vehicle. It absorbs most abnormal or transient voltages caused by the switching of any of the electrical components in the vehicle.

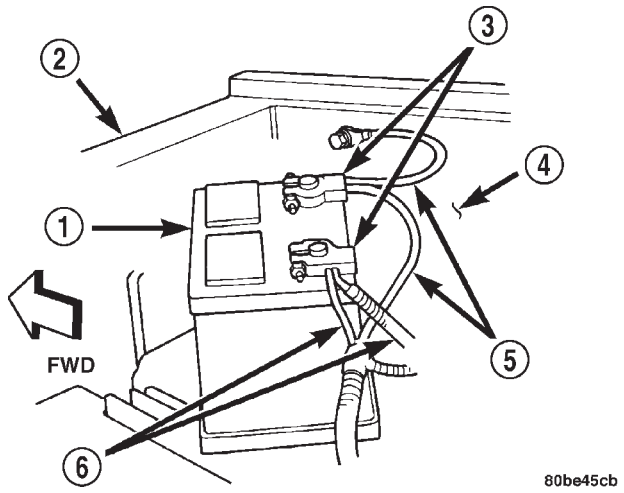


Fig. 2 Battery Cables

1 – BATTERY
2 – RADIATOR CROSSMEMBER
3 – TERMINAL CLAMPS
4 – FENDER INNER SHIELD
5 – NEGATIVE CABLE
6 – POSITIVE CABLE

BATTERY CABLES

DESCRIPTION

The battery cables (Fig. 2) are large gauge, stranded copper wires sheathed within a heavy plastic or synthetic rubber insulating jacket. The wire used in the battery cables combines excellent flexibility and reliability with high electrical current carrying capacity. Refer to **Wiring Diagrams** in the index of this service manual for the location of the proper battery cable wire gauge information.

A clamping type female battery terminal made of soft lead is 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. 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 features a larger female battery terminal clamp to allow connection to the larger battery positive terminal post. The battery negative cable wires have a black insulating jacket and a smaller female battery terminal clamp.

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

OPERATION

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

DESCRIPTION AND OPERATION (Continued)

reliable connection of the battery to the vehicle electrical system.

The battery positive cable terminal clamp is die cast 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 die cast 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 right side of the engine block. The other wire has an eyelet terminal that connects the battery negative cable to the vehicle body through a ground screw on the right front fender inner shield, near the battery.

BATTERY HOLD DOWNS

DESCRIPTION

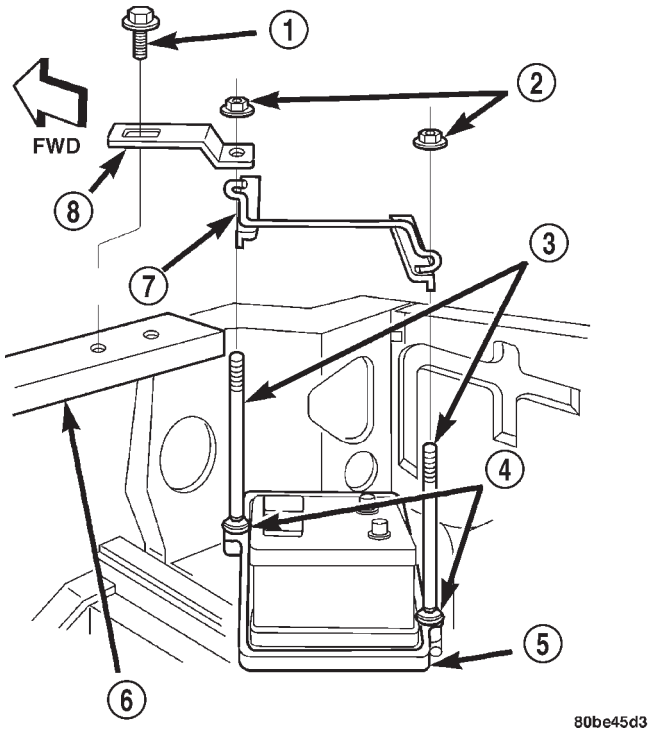


Fig. 3 Battery Hold Downs

1 – SCREW AND WASHER (1)
2 – NUT AND WASHER (2)
3 – T-BOLT (2)
4 – RETAINER (2)
5 – BATTERY TRAY
6 – UPPER RADIATOR CROSS MEMBER
7 – BRACKET
8 – STRAP

The battery hold down hardware (Fig. 3) includes two T-bolts with plastic push-on retainers, a hold down bracket, a stamped steel battery support strap, two hex nuts with coned washers and a single hex screw with a coned washer. 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.

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

OPERATION

The battery hold down hardware secures the battery to the battery tray in the engine compartment. The hold down support strap provides an additional anchor point for the upper end of the battery and hold down hardware at the upper radiator crossmember. This hardware is designed to prevent battery movement during vehicle operation. Unrestrained battery movement during vehicle operation can result in damage to the vehicle, the battery or both.

The hold down T-bolts are installed onto the battery tray before the tray is installed in the engine compartment. The T-bolts are inserted through a hole in a molded formation integral to each side of the battery tray from underneath, with the threaded ends of the bolts extending upward. A plastic push-on retainer is installed over each T-bolt to secure the T-bolts to the battery tray for ease of assembly during the vehicle manufacturing process. However, these plastic push-on retainers are not available or required for service replacement.

The battery hold down bracket is installed across the top of the battery case and over the two upright threaded ends of the T-bolts. The round hole in the support strap is then installed over the threaded end of the forward T-bolt and the slotted hole of the strap is secured by a screw with washer to the upper radiator cross member. A hex nut with coned washer is then installed and tightened onto each of the T-bolts to securely hold down the battery in the battery tray.

DESCRIPTION AND OPERATION (Continued)

BATTERY THERMOGUARD

DESCRIPTION

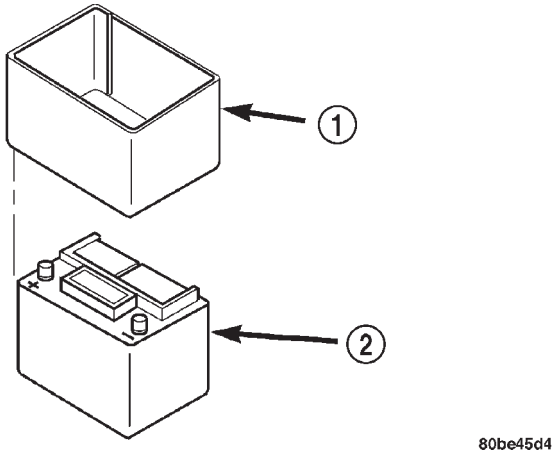


Fig. 4 Battery Thermoguard

1 – THERMOGUARD
2 – BATTERY

A flexible plastic bubble-wrap style thermoguard (Fig. 4) slides over the battery case to enclose the sides of the battery. The thermoguard consists of a heavy black plastic outer skin and two lighter plies of plastic that have been formed into a sheet with hundreds of small air pockets entrapped between them. The resulting material is very similar to the bubble-wrap used to protect items in many parcel packaging and shipping applications.

OPERATION

The thermoguard protects the battery from engine compartment temperature extremes. The air trapped between the plastic plies of the thermoguard create a dead air space, which helps to insulate the sides of the battery case from the surrounding engine compartment air temperature.

BATTERY TRAY

DESCRIPTION

The battery is mounted in a molded plastic tray (Fig. 5) located in the right front corner of the engine compartment. Two T-bolts that are part of the battery hold down hardware are assembled to the battery tray before the tray is installed in the vehicle. The battery tray is secured by three hex nuts with coned washers to three weld studs located on the front extension of the right front wheelhouse inner panel, forward of the right front wheel.

A hole in the bottom of the battery tray is fitted with a battery temperature sensor. Refer to **Battery Temperature Sensor** in the index of this service manual for the location of more information on the battery temperature sensor. Refer to **Battery Hold Downs** in the index of this service manual for the location of more information on the battery hold down hardware.

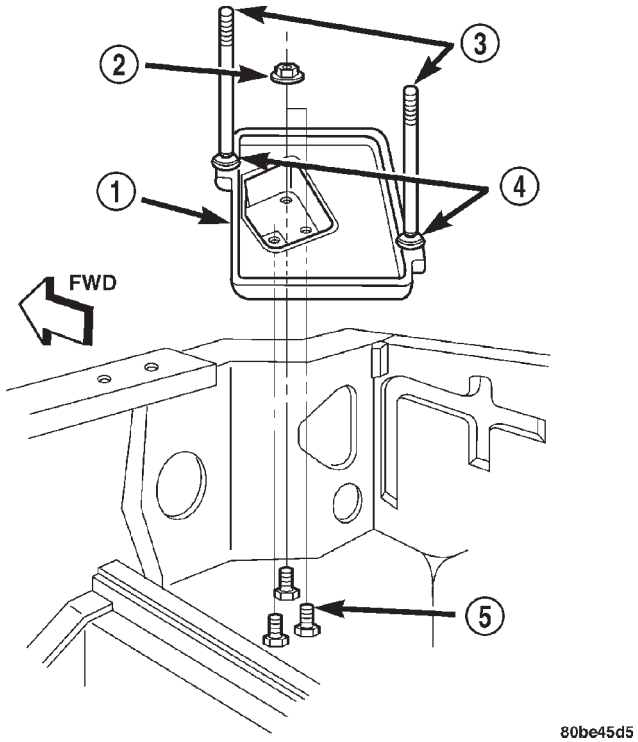


Fig. 5 Battery Tray

1 – TRAY
2 – NUT AND WASHER (3)
3 – T-BOLT (2)
4 – RETAINER (2)
5 – WELD STUD (3)

OPERATION

The battery tray provides a mounting location and support for the vehicle battery. The battery tray also provides anchor points for the battery hold down hardware. The battery tray and the battery hold down 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 can result in damage to the vehicle, the battery or both.

DIAGNOSIS AND TESTING

BATTERY

DIAGNOSIS

The battery, starting system and charging system in the vehicle operate with one another, and must be

DIAGNOSIS AND TESTING (Continued)

tested as a complete system. In order for the engine to start and the battery to charge properly, all of the components that are used in these systems must perform within specifications. It is important that the battery, starting system and charging system be thoroughly tested and inspected any time a battery needs to be charged or replaced. The cause of abnormal 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 system and charging system 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, On-Board Diagnostic Test** in the index of this service manual for the location of the proper on-board diagnostic test procedures.

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** in the index of this service manual for the location of the proper battery cleaning and inspection procedures. Refer to **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures.

WARNING:

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

• 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.

• 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.

• IF THE BATTERY IS EQUIPPED WITH REMOVABLE CELL CAPS, BE CERTAIN THAT EACH OF THE CELL CAPS IS IN PLACE AND TIGHT BEFORE THE BATTERY IS RETURNED TO SERVICE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT FROM LOOSE OR MISSING CELL CAPS.

The condition of a battery is determined by two criteria:

1. State-Of-Charge

This can be determined by checking the specific gravity of the battery electrolyte (built-in test indicator or hydrometer test), or by checking the battery voltage (open-circuit voltage test).

2. 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, view the test indicator to determine the state-of-charge. If the battery has no 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.

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 Battery Charging in the index of this service manual for the location of 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.

DIAGNOSIS AND TESTING (Continued)

Battery Diagnosis		
Condition	Possible Causes	Correction
The battery seems weak or dead when attempting to start the engine.	1. The battery has an incorrect size or rating for this vehicle. 2. The battery is physically damaged. 3. The battery terminal connections are loose or corroded. 4. The battery is discharged. 5. The electrical system ignition-off draw is excessive. 6. The battery is faulty. 7. The starting system is faulty. 8. The charging system is faulty.	1. Refer to Battery in the index of this service manual for the location of the proper battery specifications. Replace an incorrect battery, as required. 2. Inspect the battery for loose terminal posts or a cracked and leaking case. Replace the damaged battery, as required. 3. Refer to Battery Cables in the index of this service manual for the location of the proper battery cable diagnosis and testing procedures. Clean and tighten the battery terminal connections, as required. 4. Determine the battery state-of-charge. Refer to Built-In Test Indicator, Hydrometer Test, or Open-Circuit Voltage Test in this section for the proper test procedures. Charge the faulty battery, as required. 5. Refer to Ignition-Off Draw Test in this section for the proper test procedures. Repair the faulty electrical system, as required. 6. Determine the battery cranking capacity. Refer to Load Test in this section for the proper test procedures. Replace the faulty battery, as required. 7. Determine if the starting system is performing to specifications. Refer to Starting System in the index of this service manual for the location of the proper starting system diagnosis and testing procedures. Repair the faulty starting system, as required. 8. Determine if the charging system is performing to specifications. Refer to Charging System in the index of this service manual for the location of the proper charging system diagnosis and testing procedures. Repair the faulty charging system, as required.

DIAGNOSIS AND TESTING (Continued)

Battery 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. 2. The battery terminal connections are loose or corroded. 3. The generator drive belt is slipping. 4. The electrical system ignition-off draw is excessive. 5. The battery is faulty. 6. The starting system is faulty. 7. The charging system is faulty. 8. Electrical loads exceed the output of the charging system. 9. Slow driving or prolonged idling with high-amperage draw systems in use.	1. Refer to Battery in the index of this service manual for the location of the proper battery specifications. Replace an incorrect battery, as required. 2. Refer to Battery Cables in the index of this service manual for the location of the proper battery cable diagnosis and testing procedures. Clean and tighten the battery terminal connections, as required. 3. Refer to Accessory Drive Belt Diagnosis in the index of this service manual for the location of the proper accessory drive belt diagnosis and testing procedures. Replace or adjust the faulty generator drive belt, as required. 4. Refer to Ignition-Off Draw Test in this section for the proper test procedures. Repair the faulty electrical system, as required. 5. Determine the battery cranking capacity. Refer to Load Test in this section for the proper test procedures. Replace the faulty battery, as required. 6. Determine if the starting system is performing to specifications. Refer to Starting System in the index of this service manual for the location of the proper starting system diagnosis and testing procedures. Repair the faulty starting system, as required. 7. Determine if the charging system is performing to specifications. Refer to Charging System in the index of this service manual for the location of the proper charging system diagnosis and testing procedures. Repair the faulty charging system, as required. 8. Inspect the vehicle for aftermarket electrical equipment which might cause excessive electrical loads. 9. Advise the vehicle operator, as required.
The battery will not accept a charge.	1. The battery is faulty.	1. Refer to Battery Charging in the index of this service manual for the location of the proper battery charging procedures. Charge or replace the faulty battery, as required.

ABNORMAL BATTERY DISCHARGING

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

1. Corroded or loose battery posts and terminal clamps.
2. A loose or worn generator drive belt.
3. Electrical loads that exceed the output of the charging system. This can be due to equipment installed after manufacture, or repeated short trip use.
4. Slow driving speeds (heavy traffic conditions) or prolonged idling, with high-amperage draw systems in use.
5. A faulty circuit or component causing excessive ignition-off draw.
6. A faulty or incorrect charging system component. Refer to **Charging System** in the index of this service manual for the location of the proper charging system diagnosis and testing procedures.

DIAGNOSIS AND TESTING (Continued)

7. A faulty or incorrect starting system component. Refer to **Starting System** in the index of this service manual for the location of the proper starting system diagnosis and testing procedures.
8. A faulty or incorrect battery.

TESTING

BUILT-IN TEST INDICATOR

A test indicator (hydrometer) built into the top of the battery case provides visual information for battery testing (Fig. 6). Like a hydrometer, the built-in test indicator measures the specific gravity of the battery electrolyte. The test indicator 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 **Load Test** in this section for the proper battery load testing procedures.

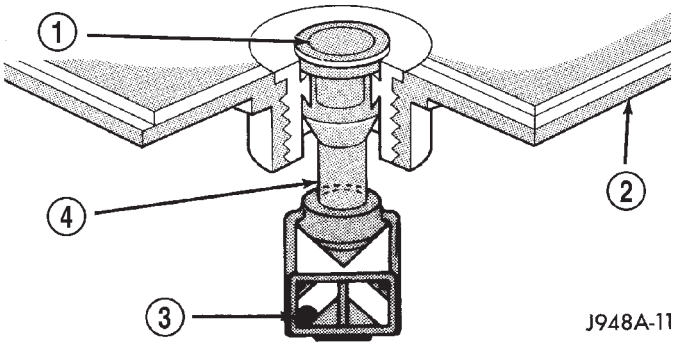


Fig. 6 Built-In Test Indicator

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

WARNING:

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

• 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.

• 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.

• IF THE BATTERY IS EQUIPPED WITH REMOVABLE CELL CAPS, BE CERTAIN THAT EACH OF THE CELL CAPS IS IN PLACE AND TIGHT BEFORE THE BATTERY IS RETURNED TO SERVICE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT FROM LOOSE OR MISSING CELL CAPS.

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 test 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.**

To read the built-in test indicator, look into the sight glass and note the color of the indicator (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 **Load Test** in this section for the proper battery load testing 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 **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures. Also refer to **Abnormal Battery Discharging** in this section for 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 test 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 **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures. A low electrolyte level may be caused by an overcharging condition. Refer to **Charging System** in the index of this service manual for the location of the proper charging system diagnosis and testing procedures.

DIAGNOSIS AND TESTING (Continued)

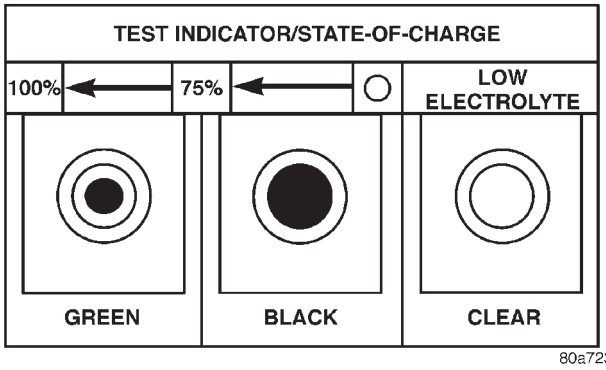


Fig. 7 Built-In Test Indicator Sight Glass

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 **Built-In Test Indicator** or **Open-Circuit Voltage Test** in this section for the proper procedures for performing these alternate tests of 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 battery load testing and/or return to service.

WARNING:

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

• 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.

• 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.

• IF THE BATTERY IS EQUIPPED WITH REMOVABLE CELL CAPS, BE CERTAIN THAT EACH OF THE CELL CAPS IS IN PLACE AND TIGHT BEFORE THE BATTERY IS RETURNED TO SERVICE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT FROM LOOSE OR MISSING CELL CAPS.

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.

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.

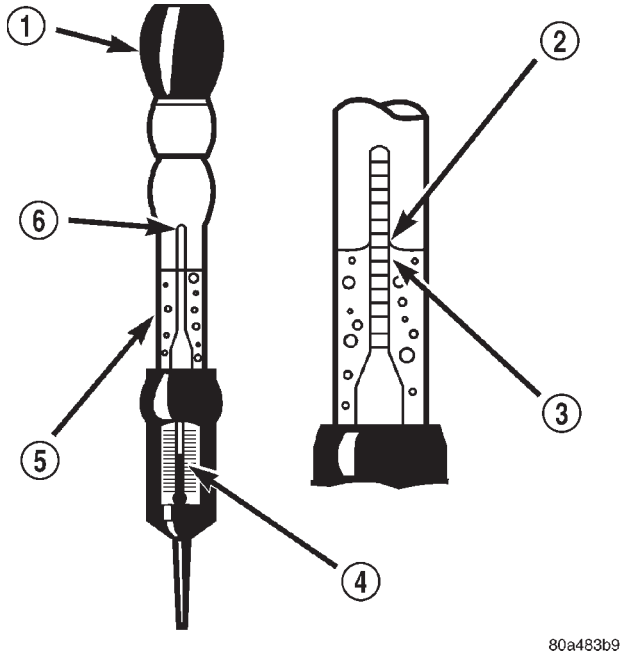


Fig. 8 Hydrometer - Typical

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 (80° F). When testing the specific gravity at any other temperature, a correction factor is required. The cor-

DIAGNOSIS AND TESTING (Continued)

rection 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 (10° F above 80° F), add four points. For each 5.5° C below 26.7° C (10° F below 80° F), subtract four points. Always correct the specific gravity for temperature variation.

EXAMPLE: A battery is tested at -12.2° C (10° F) 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 (80° F): **26.6° C - -12.2° C = 38.8° C (80° F - 10° F = 70° F)**

(2) Divide the result from Step 1 by 5.5° C (10° F): **38.8° C ÷ 5.5° C = 7 (70° F ÷ 10° F = 7)**

(3) Multiply the result from Step 2 by the temperature correction factor (0.004): **7 X 0.004 = 0.028**

(4) The temperature at testing was below 26.7° C (80° F); therefore, the temperature correction factor is subtracted: **1.240 - 0.028 = 1.212**

(5) The corrected specific gravity of the battery cell in this example is 1.212.

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 **Load Test** in this section for the proper battery load testing procedures.

OPEN-CIRCUIT VOLTAGE TEST

A battery open-circuit voltage (no load) test will show the 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.

WARNING:

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

• 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.

• 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.

• IF THE BATTERY IS EQUIPPED WITH REMOVABLE CELL CAPS, BE CERTAIN THAT EACH OF THE CELL CAPS IS IN PLACE AND TIGHT BEFORE THE BATTERY IS RETURNED TO SERVICE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT FROM LOOSE OR MISSING CELL CAPS.

Before proceeding with this test, completely charge the battery. Refer to **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures.

(1) Before measuring the open-circuit voltage, the surface charge must be removed from the battery. Turn on the headlamps for fifteen seconds, then allow up to five minutes for the battery voltage to stabilize.

(2) Disconnect and isolate both battery cables, negative cable first.

(3) Using a voltmeter connected to the battery posts (see the instructions provided by the manufacturer of the voltmeter), measure the open-circuit voltage (Fig. 9).

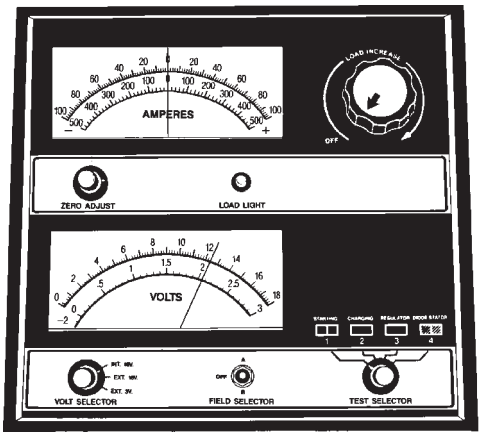


Fig. 9 Testing Open-Circuit Voltage - Typical

See the Open-Circuit Voltage chart. 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 **Load Test** in this section for the proper battery load testing procedures.

DIAGNOSIS AND TESTING (Continued)

Open Circuit Voltage	
Open Circuit Volts	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%

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. See the label affixed to the battery case, or refer to **Battery** in the index of this service manual for the location of the proper factory-installed battery specifications to determine the battery CCA rating.

WARNING:

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

• 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.

• 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.

• IF THE BATTERY IS EQUIPPED WITH REMOVABLE CELL CAPS, BE CERTAIN THAT EACH OF THE CELL CAPS IS IN PLACE AND TIGHT BEFORE THE BATTERY IS RETURNED TO SERVICE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT FROM LOOSE OR MISSING CELL CAPS.

Before proceeding with this test, completely charge the battery. Refer to **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures.

(1) Disconnect and isolate both battery cables, negative cable first. The battery top and posts should be clean.

(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 **Open-Circuit Voltage Test** in this section for the proper battery open-circuit voltage test procedures. The battery open-circuit voltage must be 12.4 volts or greater.

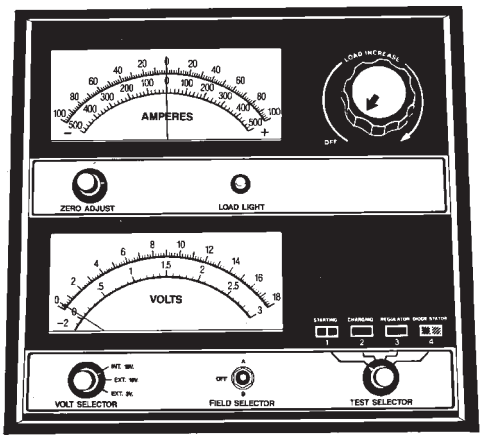


Fig. 10 Volt-Ammeter-Load Tester - Typical

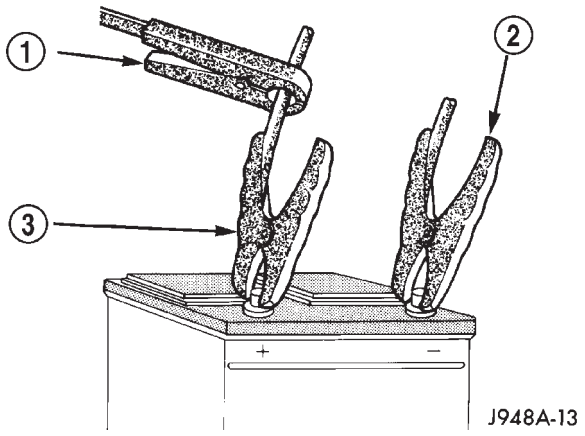


Fig. 11 Volt-Ammeter-Load Tester Connections - Typical

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.

(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

DIAGNOSIS AND TESTING (Continued)

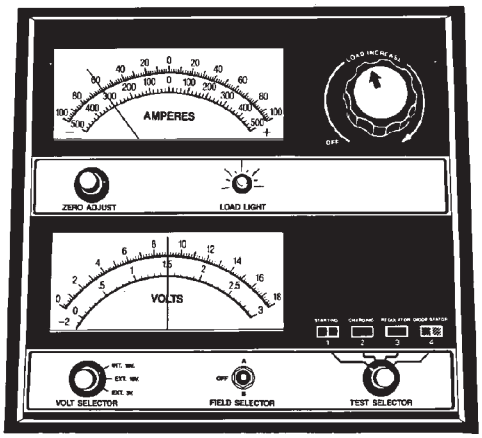


Fig. 12 Remove Surface Charge from Battery - Typical

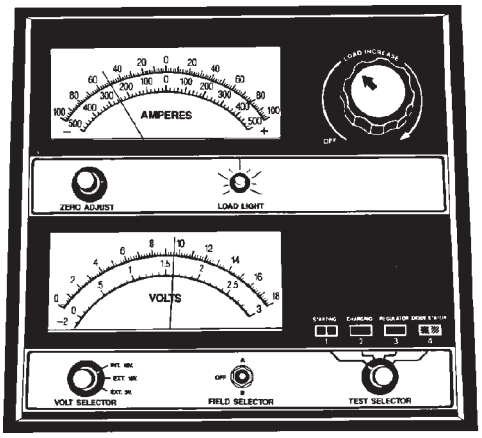


Fig. 13 Load 50% CCA Rating - Note Voltage - Typical

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 chart for the proper loaded voltage reading.

(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.

Load Test Temperature		
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°

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 twenty-five milliamperes (0.005 to 0.025 ampere) with the ignition switch in the Off position, and all non-ignition controlled circuits in proper working order. The twenty-five milliamperes are needed to enable the memory functions for the Powertrain Control Module (PCM), digital clock, electronically tuned radio, and other modules which may vary with the vehicle equipment.

A vehicle that has not been operated for approximately twenty 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 Power Distribution Center (PDC). This will reduce battery discharging.

Excessive IOD can be caused by:

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

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

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

DIAGNOSIS AND TESTING (Continued)

Electronic Module Ignition-Off Draw (IOD)			
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	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 under-hood 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 (refer to **Power Distribution Center** and **Junction Block** in the index of this service manual for the location of complete PDC and JB fuse and circuit breaker identification contained in the wiring diagrams) until the amperage reading becomes very low, or nonexistent. 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** in the index of this service manual for the location of 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 twenty-five milliamperes (0.025 ampere). If the current draw exceeds twenty-five milliamperes, isolate each circuit using the fuse and circuit breaker remove-and-replace process in Step 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.

BATTERY CABLES

DIAGNOSIS

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

DIAGNOSIS AND TESTING (Continued)

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.

TESTING

VOLTAGE DROP TEST

WARNING:

- **IF THE BATTERY SHOWS SIGNS OF FREEZING, LEAKING, LOOSE POSTS, OR LOW ELECTROLYTE LEVEL, DO NOT TEST, ASSIST-BOOST, OR CHARGE. THE BATTERY MAY ARC INTERNALLY AND EXPLODE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT.**
- **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.**
- **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.**
- **IF THE BATTERY IS EQUIPPED WITH REMOVABLE CELL CAPS, BE CERTAIN THAT EACH OF THE CELL CAPS IS IN PLACE AND TIGHT BEFORE THE BATTERY IS RETURNED TO SERVICE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT FROM LOOSE OR MISSING CELL CAPS.**

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 **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures. Refer to **Battery** in the index of this service manual for the location of the battery diagnosis and testing procedures, including the proper battery load test procedures.
- Fully engage the parking brake.
- If the vehicle is equipped with an automatic transmission, place the gearshift selector lever in the Park position. If the vehicle is equipped with a manual transmission, place the gearshift selector lever in the Neutral position and block the clutch pedal in the fully depressed position.
- Verify that all lamps and accessories are turned off.
- To prevent the engine from starting, remove the Automatic 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.

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

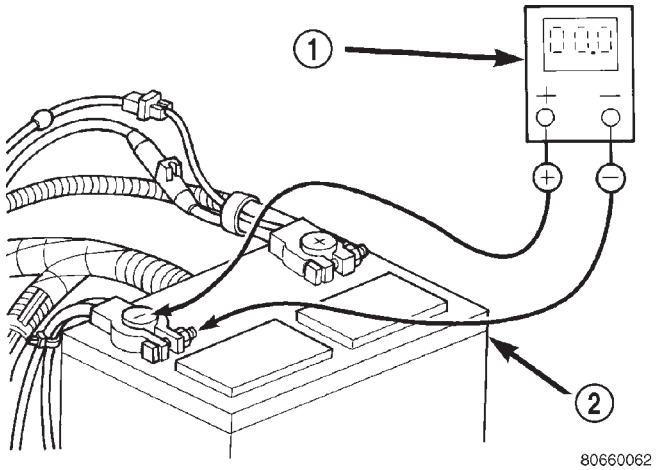


Fig. 14 Test Battery Negative Connection Resistance - Typical

1 – VOLTMETER
2 – BATTERY

(2) Connect the positive lead of the voltmeter to the battery positive terminal post. Connect the negative lead of the voltmeter to the battery positive cable terminal clamp (Fig. 15). 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.

(3) Connect the voltmeter to measure between the battery positive cable terminal clamp and the starter solenoid B(+) terminal stud (Fig. 16). Rotate and hold the ignition switch in the Start position. Observe the

DIAGNOSIS AND TESTING (Continued)

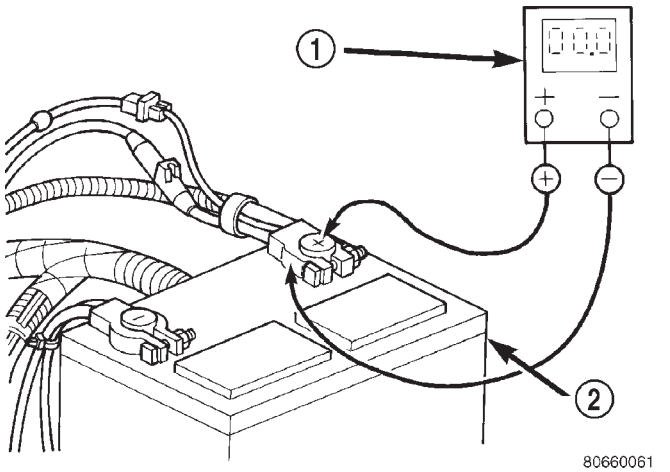


Fig. 15 Test Battery Positive Connection Resistance - Typical

1 – VOLTMETER
2 – BATTERY

voltmeter. If the reading is above 0.2 volt, clean and tighten the battery positive cable eyelet terminal connection at the starter solenoid B(+) terminal stud. Repeat the test. If the reading is still above 0.2 volt, replace the faulty battery positive cable.

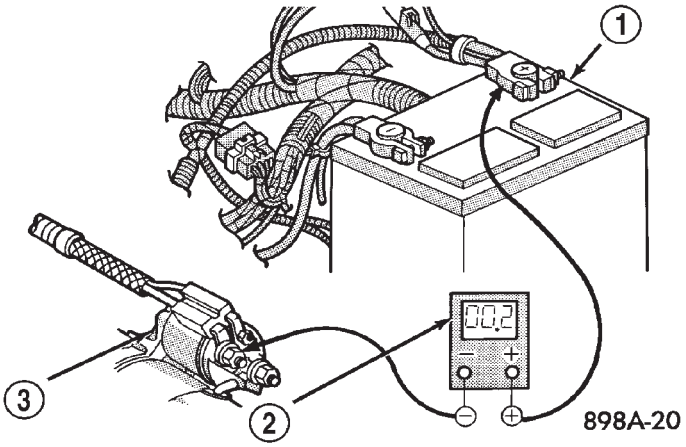


Fig. 16 Test Battery Positive Cable Resistance - Typical

1 – BATTERY
2 – VOLTMETER
3 – STARTER MOTOR

(4) Connect the voltmeter to measure between the battery negative cable terminal clamp and a good clean ground on the engine block (Fig. 17). 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.

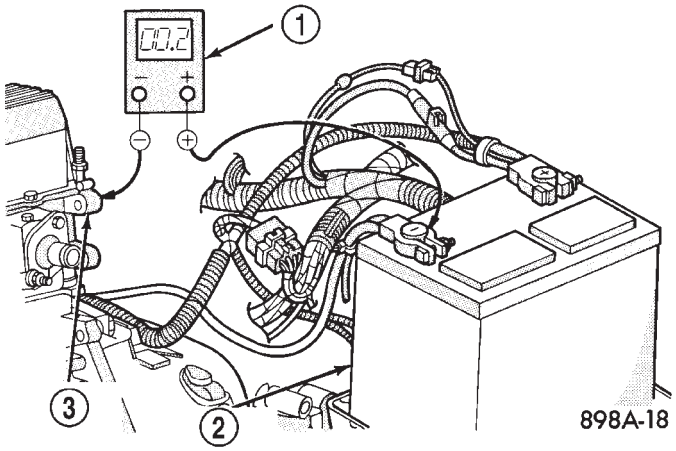


Fig. 17 Test Ground Circuit Resistance - Typical

1 – VOLTMETER
2 – BATTERY
3 – ENGINE GROUND

SERVICE PROCEDURES

BATTERY CHARGING

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

- 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 12.4 volts or above.

SERVICE PROCEDURES (Continued)

WARNING:

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

• 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.

• 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.

• IF THE BATTERY IS EQUIPPED WITH REMOVABLE CELL CAPS, BE CERTAIN THAT EACH OF THE CELL CAPS IS IN PLACE AND TIGHT BEFORE THE BATTERY IS RETURNED TO SERVICE. PERSONAL INJURY AND/OR VEHICLE DAMAGE MAY RESULT FROM LOOSE OR MISSING CELL CAPS.

CAUTION:

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

• 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.

• 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.

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.

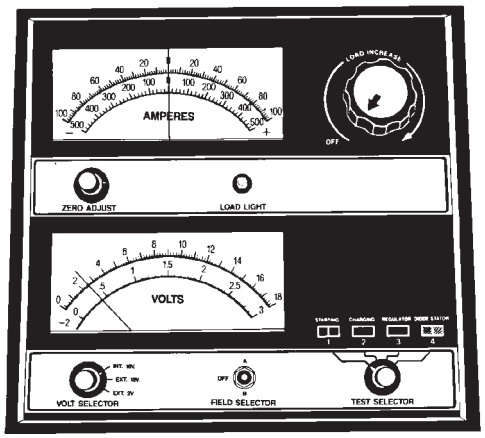
After the battery has been charged to 12.4 volts or greater, perform a load test to determine the battery cranking capacity. Refer to **Battery** in the index of this service manual for the location of the battery diagnosis and testing procedures for more information on the proper battery load testing 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** in the index of this service manual for the location of the proper battery cleaning and inspection procedures.

CHARGING A COMPLETELY DISCHARGED BATTERY

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

(1) Measure the voltage at the battery posts with a voltmeter, accurate to 1/10 (0.10) volt (Fig. 18). 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.



898A-12

Fig. 18 Voltmeter Accurate to 1/10 Volt Connected - 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.

SERVICE PROCEDURES (Continued)

(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 chart. 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	
Voltage	Hours
16.0 volts maximum	up to 4 hours
14.0 to 15.9 volts	up to 8 hours
13.9 volts or less	up to 16 hours

CHARGING TIME REQUIRED

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

- Battery Capacity

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

- Temperature

A longer time will be needed to charge a battery at -18° C (0° F) than at 27° C (80° F). When a fast battery charger is connected to a cold battery, the current accepted by the battery will be very low at first. As the battery warms, it will accept a higher charging current rate (amperage).

- Charger Capacity

A battery charger that supplies only five amperes will require a longer charging time. A battery charger that supplies twenty amperes or more will require a shorter charging time.

- State-Of-Charge

A completely discharged battery requires more charging time than a partially discharged battery. Electrolyte is nearly pure water in a completely discharged battery. At first, the charging current (amperage) will be low. As the battery charges, the specific gravity of the electrolyte will gradually rise.

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

Battery Charging Timetable			
Charging Amperage	5 Amperes	10 Amperes	20 Amperes
Open Circuit Voltage	Hours Charging at 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
*Refer to Charging A Completely Discharged Battery			

REMOVAL AND INSTALLATION

BATTERY CABLES

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.

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.

(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) Unlatch and remove the B(+) terminal stud cover from the front of the Power Distribution Center (PDC).

(7) Remove the nut that secures the battery positive cable eyelet terminal and the generator output cable eyelet terminal to the B(+) terminal stud on the PDC.

(8) Remove the battery positive cable eyelet terminal and the generator output cable eyelet terminal from the B(+) terminal stud on the PDC.

(9) Disconnect the battery wire harness connector from the headlamp and dash wire harness connector located below the front of the PDC.

REMOVAL AND INSTALLATION (Continued)

(10) Remove the screw that secures the battery negative cable eyelet terminal to the inner fender shield near the battery.

(11) On LHD models with air conditioning, disconnect the compressor clutch wire harness connector from the battery wire harness connector.

(12) Unlatch and remove the cover from the generator output terminal stud housing on the back of the generator.

(13) Remove the nut that secures the generator output cable eyelet terminal to the generator output terminal stud.

(14) Remove the generator output cable eyelet terminal from the generator output terminal stud.

(15) Disconnect the battery wire harness connector from the generator field terminal connector receptacle on the back of the generator.

(16) Remove the nut that secures the battery negative cable ground eyelet terminal to the stud on the right side of the engine block.

(17) Remove the battery negative cable ground eyelet terminal from the engine block stud.

(18) On models with a 2.5L engine, remove the nut that secures the battery wire harness locator clip to the stud on the right side engine block oil pan rail below and forward of the engine oil filter adapter.

(19) On models with a 4.0L engine, remove the screw that secures the battery wire harness locator clip to the right side of the engine block between and below the right engine mount and the oil filter adapter.

(20) Remove the nut that secures the battery positive cable eyelet terminal to the B(+) terminal stud on the starter solenoid.

(21) Remove the battery positive cable eyelet terminal from the B(+) terminal stud on the starter solenoid.

(22) Disconnect the battery wire harness connector from the connector receptacle on the starter solenoid.

(23) Remove the battery wire harness from the engine compartment.

INSTALLATION

(1) Clean and inspect the battery cable terminal clamps and the battery terminal posts. Refer to **Battery** in the index of this service manual for the location of the proper battery cable terminal clamp and battery terminal post cleaning and inspection procedures.

(2) Position the battery wire harness into the engine compartment.

(3) Reconnect the battery wire harness connector to the connector receptacle on the starter solenoid.

(4) Install the battery positive cable eyelet terminal onto the B(+) terminal stud on the starter solenoid.

(5) 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.).

(6) On models with a 2.5L engine, install and tighten the nut that secures the battery wire harness locator clip to the stud on the right side engine block oil pan rail below and forward of the engine oil filter adapter. Tighten the nut to 8.4 N·m (75 in. lbs.).

(7) On models with a 4.0L engine, install and tighten the screw that secures the battery wire harness locator clip to the right side of the engine block between and below the right engine mount and the oil filter adapter. Tighten the screw to 8.4 N·m (75 in. lbs.).

(8) Install the battery negative cable ground eyelet terminal onto the stud on the right side of the engine block.

(9) Install and tighten the nut that secures the battery negative cable ground eyelet terminal to the stud on the right side of the engine block. Tighten the nut to 15.8 N·m (140 in. lbs.).

(10) Reconnect the battery wire harness connector to the generator field terminal connector receptacle on the back of the generator.

(11) Install the generator output cable eyelet terminal onto the generator output terminal stud.

(12) 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.).

(13) Position the cover for the generator output terminal stud housing onto the back of the generator and snap it into place.

(14) On LHD models with air conditioning, reconnect the compressor clutch wire harness connector to the battery wire harness connector.

(15) Install and tighten the screw that secures the battery negative cable eyelet terminal to the inner fender shield near the battery. Tighten the screw to 24.8 N·m (220 in. lbs.).

(16) Reconnect the battery wire harness connector to the headlamp and dash wire harness connector located below the front of the PDC.

(17) Install the battery positive cable eyelet terminal and the generator output cable eyelet terminal onto the PDC B(+) terminal stud.

(18) 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 10.7 N·m (95 in. lbs.).

(19) Engage the tabs on the lower edge of the B(+) terminal stud cover in the slots on the front of the PDC housing, then engage the latch on the top of the cover with the latch tabs on the PDC housing.

REMOVAL AND INSTALLATION (Continued)

(20) Reconnect the battery positive cable terminal clamp to the battery positive terminal post. Tighten the terminal clamp pinch-bolt hex nut to 8.4 N·m (75 in. lbs.).

(21) Reconnect the battery negative cable terminal clamp to the battery negative terminal post. Tighten the terminal clamp pinch-bolt hex nut to 8.4 N·m (75 in. lbs.).

(22) 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 HOLD DOWNS

All of the battery hold down hardware except for the T-bolts can be serviced without removal of the battery or the battery tray. The battery tray must be removed from the vehicle to service the T-bolts. If the T-bolts require 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.

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.

(4) Remove the nut with washer from the threaded end of each of the two T-bolts (Fig. 19).

(5) Remove the screw with washer that secures the end of the battery support strap with a slotted hole to the top of the upper radiator crossmember.

(6) Remove the battery support strap from the threaded end of the T-bolt nearest to the front of the vehicle.

(7) Remove the battery hold down bracket from the threaded ends of the two T-bolts and the top of the battery case.

INSTALLATION

(1) Clean and inspect the battery hold down hardware. Refer to **Battery** in the index of this service manual for the location of the proper battery hold down hardware cleaning and inspection procedures.

(2) Position the battery hold down bracket onto the threaded ends of the two T-bolts and across the top of the battery case.

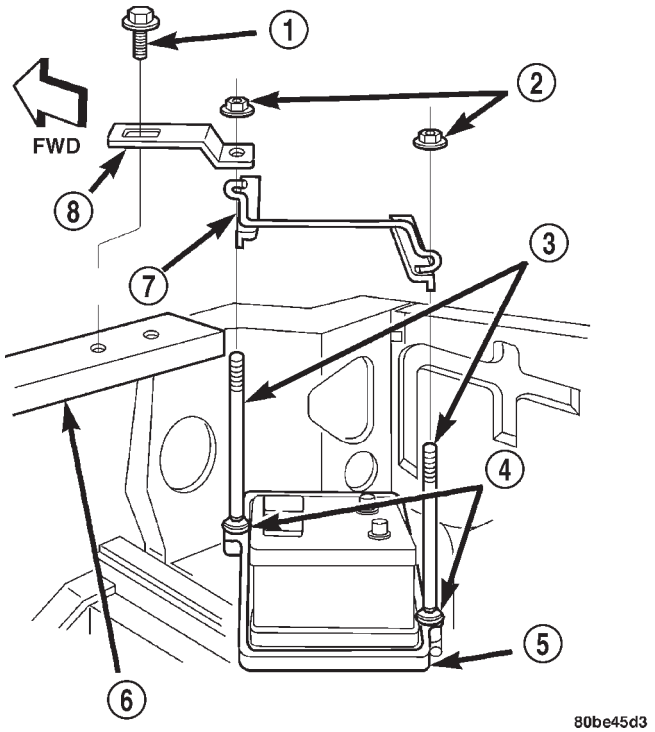


Fig. 19 Battery Hold Downs Remove/Install

1 – SCREW AND WASHER (1)
2 – NUT AND WASHER (2)
3 – T-BOLT (2)
4 – RETAINER (2)
5 – BATTERY TRAY
6 – UPPER RADIATOR CROSS MEMBER
7 – BRACKET
8 – STRAP

(3) Position the battery support strap with the round hole over the threaded end of the T-bolt nearest to the front of the vehicle and the slotted hole over the mounting hole in the top of the upper radiator crossmember.

(4) Install and tighten the screw with washer that secures the end of the battery support strap with a slotted hole to the top of the upper radiator crossmember. Tighten the screw to 8.7 N·m (77 in. lbs.).

(5) Install and tighten the nut with washer onto the threaded end of each of the two T-bolts. Tighten the nuts to 2.2 N·m (20 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 8.4 N·m (75 in. lbs.).

REMOVAL AND INSTALLATION (Continued)

BATTERY

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. 20).

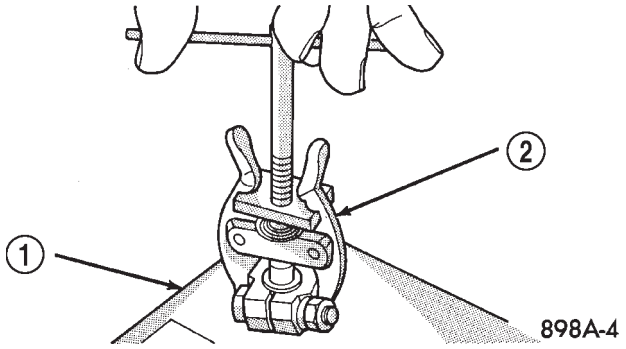


Fig. 20 Remove Battery Cable Terminal Clamp - Typical

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 **Battery Hold Downs** in the index of this service manual for the location of the proper battery hold down removal procedures.

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 and the battery thermoguard from the battery tray as a unit.

(8) Remove the battery thermoguard from the battery case. Refer to **Battery Thermoguard** in the index of this service manual for the location of the proper battery thermoguard removal procedures.

INSTALLATION

(1) Clean and inspect the battery. Refer to **Battery** in the index of this service manual for the location of the proper battery cleaning and inspection procedures.

(2) Reinstall the battery thermoguard onto the battery case. Refer to **Battery Thermoguard** in the index of this service manual for the location of the proper battery thermoguard installation procedures.

(3) Position the battery and the battery thermoguard onto the battery tray as a unit. 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. 21).

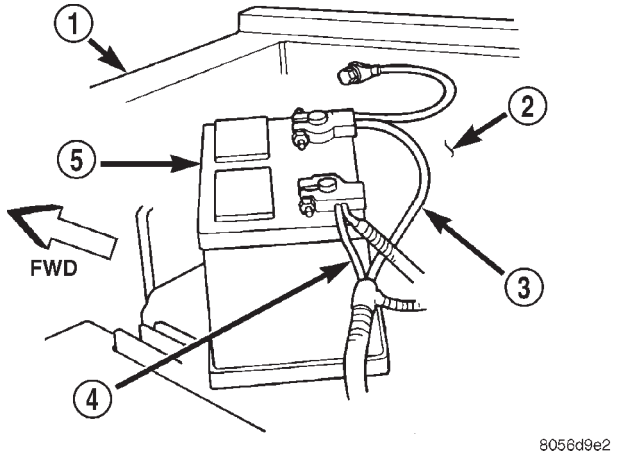


Fig. 21 Battery Cables

1 – RADIATOR CROSSMEMBER
2 – WHEELHOUSE INNER PANEL
3 – NEGATIVE CABLE
4 – POSITIVE CABLE
5 – BATTERY

(4) Reinstall the battery hold downs onto the battery. Refer to **Battery Hold Downs** in the index of this service manual for the location of the proper battery hold down installation procedures.

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

(5) Clean the battery cable terminal clamps and the battery terminal posts. Refer to **Battery** in the index of this service manual for the location of the proper battery cleaning and inspection procedures.

(6) Reconnect the battery positive cable terminal clamp to the battery positive terminal post. Tighten the terminal clamp pinch-bolt hex nut to 8.4 N·m (75 in. lbs.).

(7) Reconnect the battery negative cable terminal clamp to the battery negative terminal post. Tighten the terminal clamp pinch-bolt hex nut to 8.4 N·m (75 in. lbs.).

REMOVAL AND INSTALLATION (Continued)

(8) 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 THERMOGUARD

REMOVAL

(1) Remove the battery and the battery thermoguard from the battery tray as a unit. Refer to **Battery** in the index of this service manual for the location of the proper battery removal procedures.

(2) Carefully and evenly slide the battery thermoguard up off of the battery case (Fig. 22).

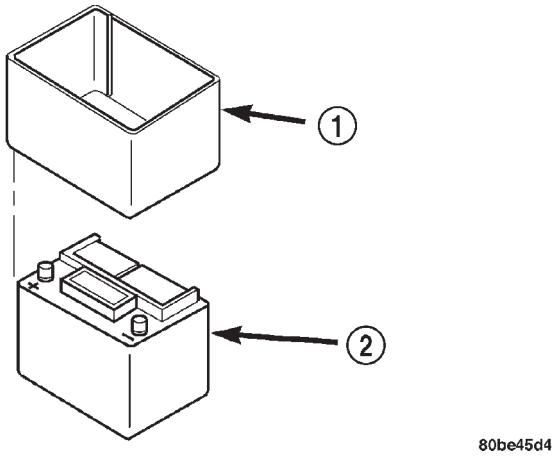


Fig. 22 Battery Thermoguard Remove/Install

1 – THERMOGUARD
2 – BATTERY

INSTALLATION

(1) Clean and inspect the battery thermoguard. Refer to **Battery** in the index of this service manual for the location of the proper battery thermoguard cleaning and inspection procedures.

(2) Carefully and evenly slide the battery thermoguard down over the battery case.

(3) Install the battery and the battery thermoguard into the battery tray as a unit. Refer to **Battery** in the index of this service manual for the location of the proper battery installation procedures.

BATTERY TRAY

REMOVAL

(1) Remove the battery from the battery tray. Refer to **Battery** in the index of this service manual for the location of the proper battery removal procedures.

(2) Remove the battery temperature sensor from the battery tray. Refer to **Battery Temperature Sensor** in the index of this service manual for the location of the proper battery temperature sensor removal procedures.

(3) Remove the three nuts with washers that secure the battery tray to the weld studs on the front extension of the right front wheelhouse inner panel (Fig. 23).

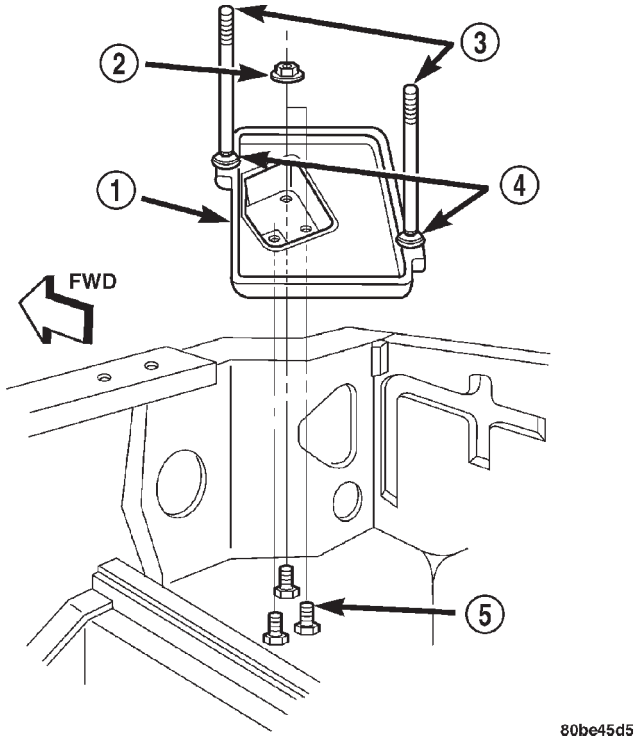


Fig. 23 Battery Tray Remove/Install

1 – TRAY
2 – NUT AND WASHER (3)
3 – T-BOLT (2)
4 – RETAINER (2)
5 – WELD STUD (3)

(4) Remove the battery tray from the weld studs on the front extension of the right front wheelhouse inner panel.

(5) From the top of the battery tray, remove the plastic push-on retainers from the T-bolts that secure them to the tray.

(6) From the bottom of the battery tray, remove the two T-bolts from the T-bolt mounts on the tray.

INSTALLATION

(1) Clean and inspect the battery tray. Refer to **Battery** in the index of this service manual for the location of the proper battery tray cleaning and inspection procedures.

(2) From the bottom of the battery tray, position the two T-bolts into the T-bolt mounts on the tray.

(3) From the top of the battery tray, install the plastic push-on retainers onto the T-bolts to secure them to the tray.

REMOVAL AND INSTALLATION (Continued)

(4) Position the battery tray onto the weld studs on the front extension of the right front wheelhouse inner panel.

(5) Install and tighten the three nuts with washers that secure the battery tray to the weld studs on the front extension of the right front wheelhouse inner panel. Tighten the nuts to 5 N·m (45 in. lbs.).

(6) Install the battery temperature sensor onto the battery tray. Refer to **Battery Temperature Sensor** in the index of this service manual for the location of the proper battery temperature sensor installation procedures.

(7) Install the battery onto the battery tray. Refer to **Battery** in the index of this service manual for the location of the proper battery installation procedures.

CLEANING AND INSPECTION

BATTERY

The following information details the recommended cleaning and 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.

CLEANING

(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. 24).

(2) Clean the battery tray and battery hold down 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. 25). 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** in the index of this service manual for the location of the factory-installed battery specifications. Confirm that the replacement battery is the correct size and has the correct ratings for the vehicle.

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

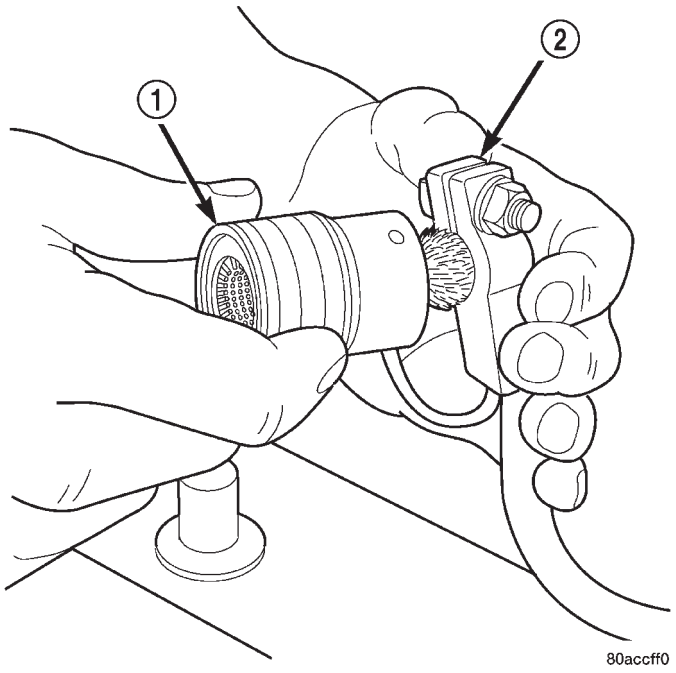


Fig. 24 Clean Battery Cable Terminal Clamp - Typical

1 – TERMINAL BRUSH
2 – BATTERY CABLE

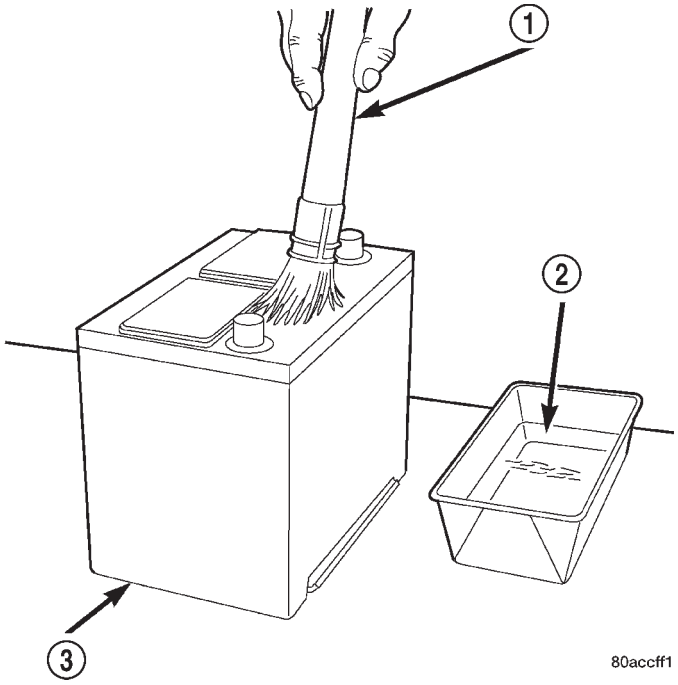


Fig. 25 Clean Battery - Typical

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

CLEANING AND INSPECTION (Continued)

(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. 26).

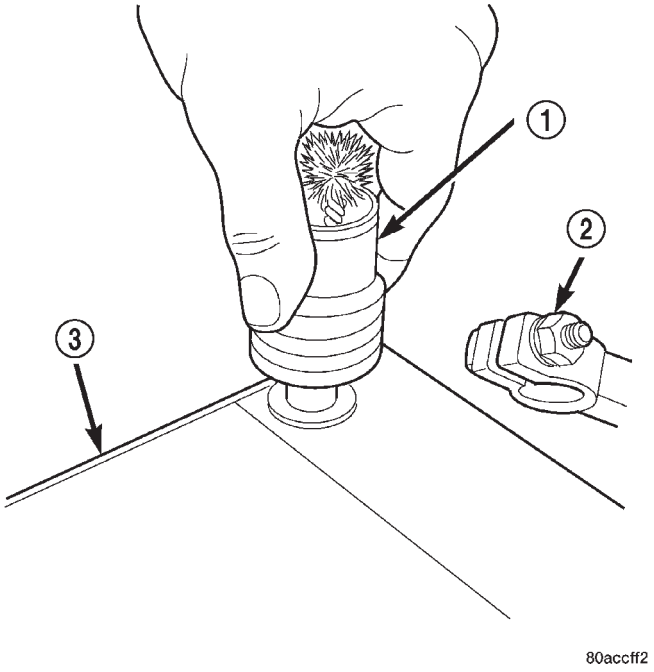


Fig. 26 Clean Battery Terminal Post - Typical

1 – TERMINAL BRUSH
2 – BATTERY CABLE
3 – BATTERY

INSPECTION

(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 hold down hardware for damage. Replace any damaged parts.

(3) Slide the thermoguard off of the battery case. Inspect the battery case for cracks or other damage that could result in electrolyte leaks. Also, check the battery terminal posts for looseness. Batteries with damaged cases or loose terminal posts must be replaced.

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

(5) Inspect the electrolyte level in the battery. Use a putty knife or another suitable wide flat-bladed tool to pry the cell caps off (Fig. 27). Do not use a screwdriver. Add distilled water to each cell until the liquid reaches the bottom of the vent well. **DO NOT OVERFILL.**

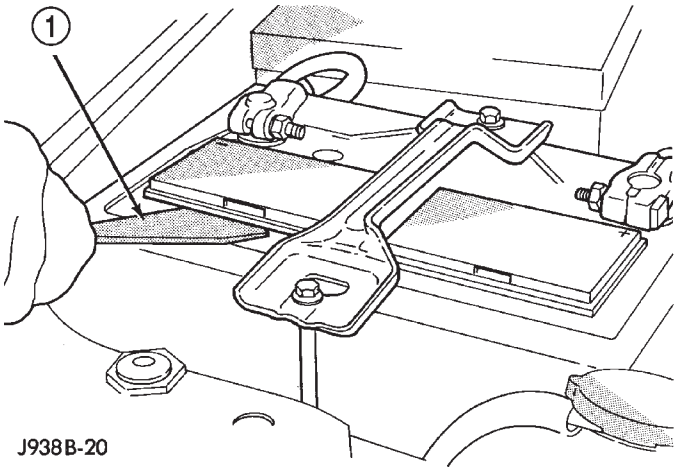


Fig. 27 Removing Battery Cell Caps - Typical

1 – PUTTY KNIFE

(6) 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 **Battery** in the index of this service manual for the location of the proper battery diagnosis and testing procedures for more information on the use of the battery built-in test indicator. Also refer to **Battery Charging** in the index of this service manual for the location of the proper battery charging procedures.

SPECIFICATIONS

BATTERY

Battery Classifications and Ratings					
Part Number	BCI Group Size Classification	Cold Cranking Amperage	Reserve Capacity	Ampere-Hours	Load Test Amperage
56041105AB	34	500	110 Minutes	60	250