General Information

All Lead-Acid Batteries

Maintenance-free lead-acid batteries, both liquid-electrolyte batteries and gel cells, are electrochemical devices that store chemical energy. When the battery is connected to an external load, such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

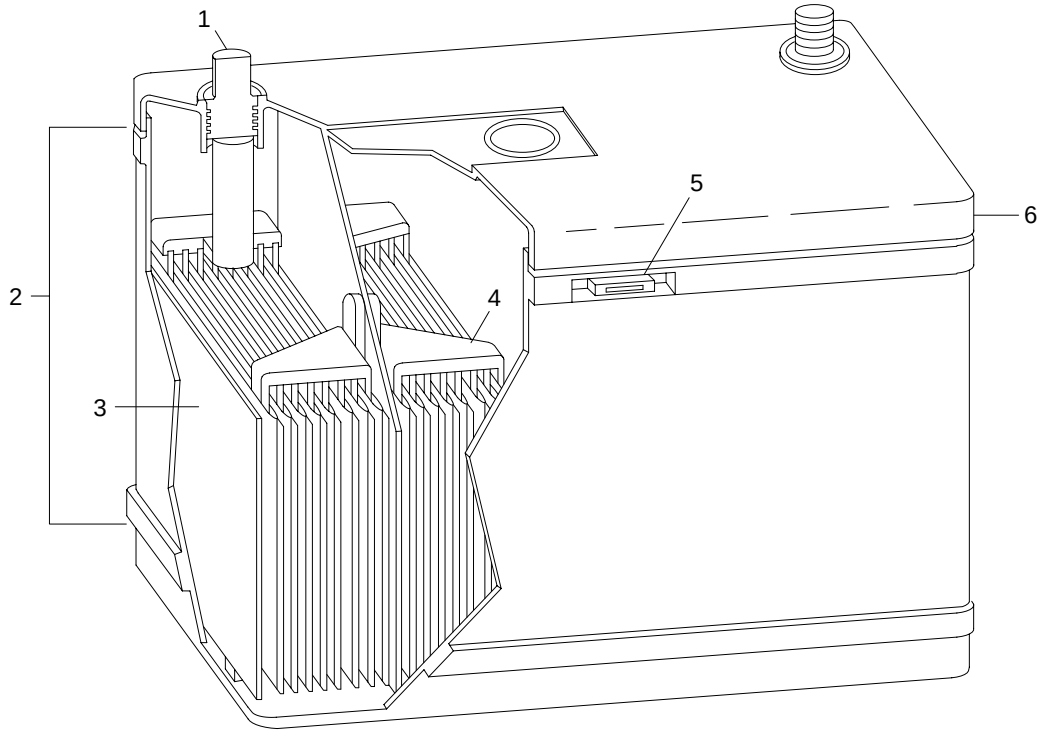
The modern truck battery has three functions:

- To supply power to the starter and ignition system so the engine can be cranked and started.
- To stabilize the voltage in the electrical system by reducing temporary high voltages in the electrical system. These high transient voltages could damage other electrical components if they were not protected by the battery.
- To supply extra power when the vehicle's electrical load requirements go beyond what the charging system can supply, or when the engine is not running.

All lead-acid batteries use plates made of two unlike metals held apart by separators. One of the metals becomes the positive plate, the other the negative plate. These plates are then grouped in pairs, alternating negative and positive. The groups are connected in series, and each plate group (cell) produces about two volts. Thus, a battery with six cells is a 12-volt battery. See **Fig. 1**.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid). In a gel cell battery, the electrolyte is a solid gel, not a liquid.

Maintenance-free wet cells use calcium rather than antimony to improve grid strength. Calcium reduces the tendency for the battery to produce gas at normal



1. Terminal
2. Electrolyte Reservoir
3. Positive Plate Envelope
4. Intercell Connection
5. Vent Hole
6. Plastic Cover

Fig. 1, Typical Maintenance-Free 12-Volt Battery

General Information

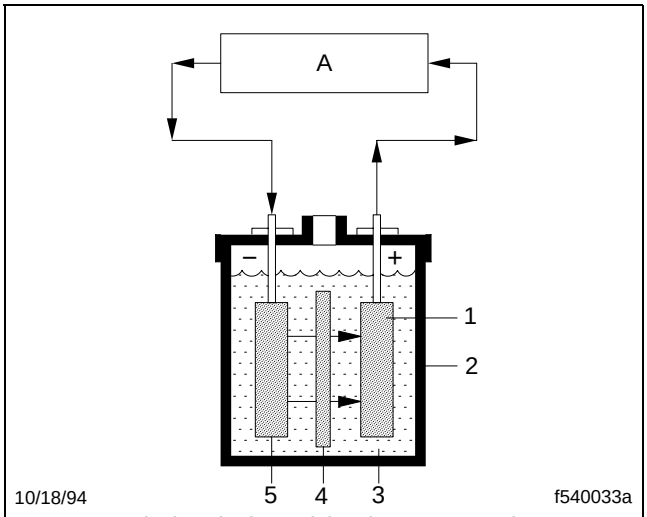
charging voltages. Therefore, little water is lost, unless the battery has been charged at a very high rate. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents allow the escape of gases produced in the battery.

Electrical energy is produced in each cell by chemical changes in the plates (and in the electrolyte whenever a battery is discharged). See **Fig. 2**. A battery produces maximum electrical energy only when the cells are fully charged. As the cells discharge, chemical changes in the plates gradually reduce the potential electrical energy available. Recharging the battery with an opposite flow of direct current reverses the chemical changes within the cells and restores them to their active state. See **Fig. 3**.

NOTE: Liquid-electrolyte batteries must be kept in an upright position to prevent electrolyte leakage. Tipping a wet cell beyond a 45-degree angle in any direction can allow a small amount of electrolyte to leak out the vent holes.

In standard installations, the batteries are mounted on the side of the frame rail.

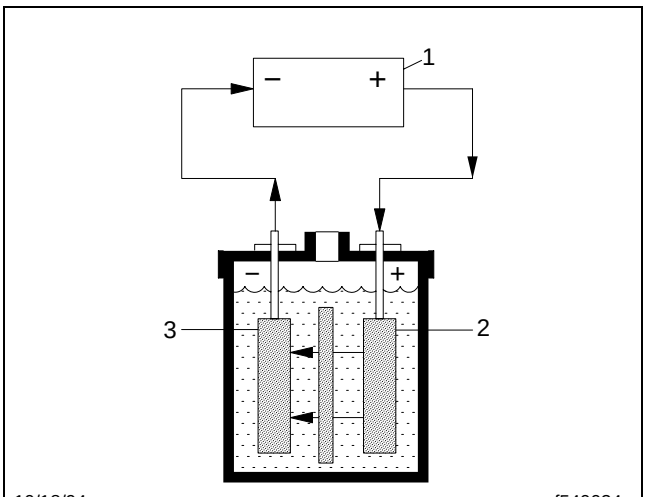
Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 140**.



A. External Electrical Load (such as a starter)

1. Positive Plate
2. Battery Case
3. Electrolyte
4. Separator
5. Negative Plate

Fig. 2, Discharging the Battery



1. Charger
2. Positive Plate
3. Negative Plate

Fig. 3, Charging the Battery

Selecting a Replacement

Long and trouble-free service is assured when the reserve capacity of the battery is equal to or exceeds 160 minutes and the cold cranking amp (CCA) rating of each replacement battery is at least 625 amperes. The CCA rating of the battery is a measure of its ability to supply high cranking power to the cranking motor at 0°F (–18°C).

The use of an undersized battery may cause poor performance and early failure. It may also cause damage to or reduced life of the starter. With falling temperatures, battery power decreases while the need for engine cranking power increases. Subzero temperatures reduce the capacity of a fully charged battery to 45 percent of the normal power, and at the same time, increase cranking load to 3-1/2 times the normal warm-weather load.

Batteries of a greater capacity should be considered if the electrical load has been increased through the addition of accessories, or if driving conditions are such that the charging system cannot keep the batteries charged.

IMPORTANT: Don’t replace a battery with one designed for automobiles and light trucks. The cold cranking amp (CCA) rating may be the same or higher, but the plates are lighter, and the battery won’t provide the reserve life that is needed. Also, these batteries don’t have the extra vibration protection or temperature resistance required on a heavy-duty vehicle.

Storage

Always store batteries in an upright position. Don't store liquid-electrolyte type batteries on their sides, as electrolyte may escape through the vent holes.

Maintain inventory levels in balance with demand and always rotate battery stock on a strict first-in, first-out basis. To protect against self-discharge, check the date codes stamped on the battery cartons and on the batteries themselves.

IMPORTANT: One of the major causes of problems with replacement batteries is failure to follow the first-in, first-out stock procedure.

Roller racks provide the best way to store batteries. If loaded properly from the back, racks insure that the oldest battery of a particular type will always appear in the front.

Mark the racks clearly, both front and back, to ensure that the same battery type will go in the same rack every time.

If roller racks are not available, use wooden shelving reachable from both the front and the back. Otherwise, old batteries must be removed, to put new batteries in the back.

Never stack batteries on top of one another. If nothing else is available, simple battery storage racks can be made from loose, flat boards.

Maintenance-free batteries can have a shelf life of up to 12 months or more, depending upon storage temperatures, before charging is needed.

NOTE: Batteries in vehicles that are not in service are considered to be in storage. When a vehicle is to be out of service for 30 days or more, disconnect the negative ground terminal of each battery to prevent self-discharge caused by various components.

To minimize self-discharge, store batteries in as cool a place as possible, away from heat ducts in winter, and shielded from direct sunlight in summer.

The best storage conditions are in clean, dry areas where ambient temperatures are stable between 32 and 80°F (0 and 27°C). Storage in temperatures above 80°F (27°C) is not recommended, as this increases the rate of self-discharge. Avoid temperatures below 32°F (0°C) to prevent freezing if a battery becomes discharged.

General Safety Precautions

⚠ WARNING

Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

When charging the batteries, gas forms in each cell and escapes through the vent holes. In poorly ventilated areas, the gas lingers around the battery several hours after it has been charged. The gas is explosive around sparks, flame, or other intense heat; if ignited, it could cause the battery to explode. Follow these precautions when charging the batteries:

1. Wear safety glasses or a face shield when working with batteries. When many batteries are handled, wear rubber gloves and an apron to protect clothing.
2. Make sure that the area is well ventilated.

⚠ WARNING

Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.

3. Make certain that the charger cable leads are clean and making good connections. A poor connection could cause an electrical arc which could ignite the gas mixture and explode the battery.
4. Do not break live circuits at the terminals because a spark usually occurs at the point where a live circuit is broken. Use care when connecting or disconnecting booster leads or cable clamps on chargers.
5. Don't smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
6. If the battery is frozen, let it reach room temperature before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
7. Take care that tools or metal objects do not fall across the battery terminals.

⚠ CAUTION

If a metal object connects an ungrounded battery terminal to a nearby metal part of the vehicle which is grounded, it could short out the batteries, causing sparks and possible property damage.

Battery Electrolyte Safety Precautions

⚠ WARNING

Protect skin and eyes from battery electrolyte (acid). Electrolyte is corrosive and could result in serious personal injury if splashed on your skin or in your eyes.

If electrolyte is splashed on your skin or in your eye, force the eye open, rinse it with cool, clean water for about five minutes, and call a doctor immediately. Do not add eye drops or other medication unless advised by the doctor.

If electrolyte is swallowed, drink several large glasses of milk or water. Follow with milk of magnesia, a beaten raw egg, or vegetable oil. Call a doctor immediately.

Use extreme care to avoid spilling or splashing electrolyte. Electrolyte spilled or splashed on your body or clothing should be neutralized with baking soda or household ammonia and then rinsed with clean water.

Electrolyte can also damage painted or unpainted metal vehicle parts. If electrolyte is spilled or splashed on any metal surface, neutralize and rinse it with clean water.

To prevent possible skin burns, do not wear watches, rings, or other jewelry while performing maintenance work on the batteries.

⚠ WARNING

Do not apply pressure to the end walls of a plastic-case battery. This could cause electrolyte to squirt from the vents, possibly resulting in serious injury to skin or eyes.

When handling plastic-case batteries, use a battery carrier. If one is not available, lift these batteries with your hands placed at opposite corners of the battery.

Emergency (Jump) Starting

⚠ WARNING

Before jump starting a vehicle, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Handle both the charged and the discharged batteries carefully when using jumper cables. Follow the procedure below, being careful not to cause sparks.

⚠ CAUTION

Make sure the starting systems on both vehicles have the same voltage outputs, and make connections as described below. Otherwise, the starter or the charging system could be damaged.

IMPORTANT: At no time during this operation should the vehicles touch each other, as this could establish a ground connection and offset the benefits of this procedure.

⚠ WARNING

Use the following procedure when jump starting. Incorrect battery handling procedures could result in battery explosion and severe personal injury, including blindness.

1. Apply the parking brakes. Turn off the lights, heater, and all other electrical loads.

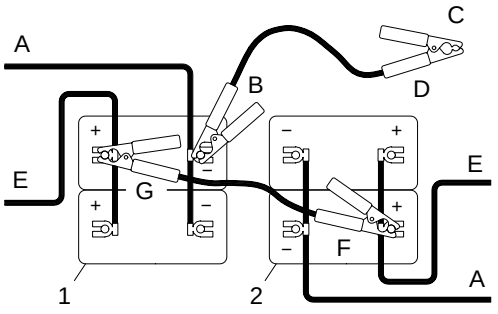
IMPORTANT: If the vehicles are exposed to traffic, activate the warning flashers on the booster vehicle.

2. For your first connection, attach one end of the jumper cable to the positive terminal of the booster battery. For your second connection, attach the opposite end of the same cable to the positive terminal of the discharged battery. See **Fig. 1** and **Fig. 2**.
3. For your third connection, attach one end of the other jumper cable to the negative terminal of the booster battery. For the fourth connection, attach the opposite end of that cable to a ground at least 12 inches (300 mm) from the battery of the vehicle being started. See **Fig. 1** and **Fig. 2**. The vehicle frame is usually a good ground.

IMPORTANT: The final ground connection must provide good electrical conductivity and current-carrying capacity. To prevent sparks and explosions of hydrogen gas, don't connect directly to the negative post of the discharged battery.

4. Make sure that the clamps from one cable do not touch the clamps on the other cable. Don't lean over the batteries when making connections.
5. Make sure that everyone is standing away from the vehicles. Start the engine of the vehicle with the booster batteries. Wait a few minutes, then attempt to start the engine of the vehicle with the discharged batteries.

   Don't operate the starter longer than 30 seconds. Wait at least 2 minutes between starting attempts to allow the starter to cool. If the engine doesn't start after several attempts, check for the cause.
6. After starting, allow the engine to idle. Disconnect the ground connection from the vehicle with the discharged battery. Then disconnect the opposite end of the cable.
7. Disconnect the other cable from the discharged battery first, then disconnect the opposite end.

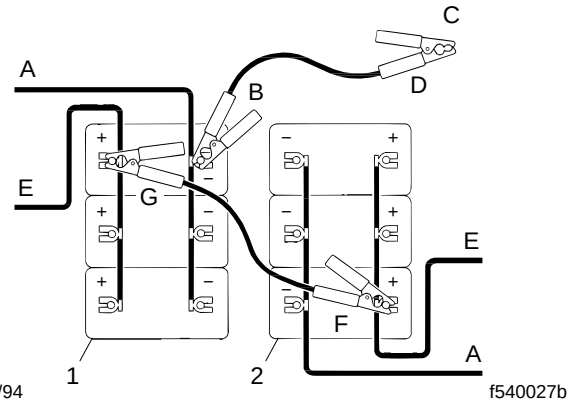


NOTE: This procedure is for negative-ground vehicles only.

A. To Ground
B. Third Connection
C. To Frame
D. Fourth Connection
E. To Starter
F. Second Connection
G. First Connection
1. Booster Battery
2. Discharged Starting Battery

Fig. 1, Jumper Connections, Two-Battery System

Emergency (Jump) Starting a Battery



NOTE: This procedure is for negative-ground vehicles only.

A. To Ground
B. Third Connection
C. To Frame
D. Fourth Connection
E. To Starter
F. Second Connection
G. First Connection
1. Booster Battery
2. Discharged Starting Battery

Fig. 2, Jumper Connections, Three-Battery System

General Information

⚠ WARNING

Before testing a battery read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Test any maintenance-free battery that does not hold a charge to see if it needs to be replaced, or if the problem lies elsewhere in the electrical system. Accuracy of the test depends on variables such as temperature and age of the battery. Follow the recommended testing instructions listed below.

IMPORTANT: Two types of battery tests are discussed in this subject. The first, Midtronics PowerSensor Micro740 Test, uses the Midtronics Micro740 battery tester and must be used by all U.S. and Canadian dealers for battery warranty claims. The second test is a load test using a carbon pile type tester and should **not** be used by U.S. or Canadian dealers for battery warranty claims.

Visual Inspection

Check for obvious damage such as a cracked or broken case that could permit loss of electrolyte. If there is physical damage replace the battery. Find the cause of the damage and correct it as needed.

On maintenance-free batteries without a built-in hydrometer, perform the Midtronics PowerSensor Micro740 test or the load test.

On maintenance-free batteries with a built-in hydrometer, check the sight glass. If a green dot shows in the sight glass test the battery. If the sight glass is dark recharge the battery, then test it. See **Subject 150**. If the sight glass is clear replace the battery. See **Fig. 1**.

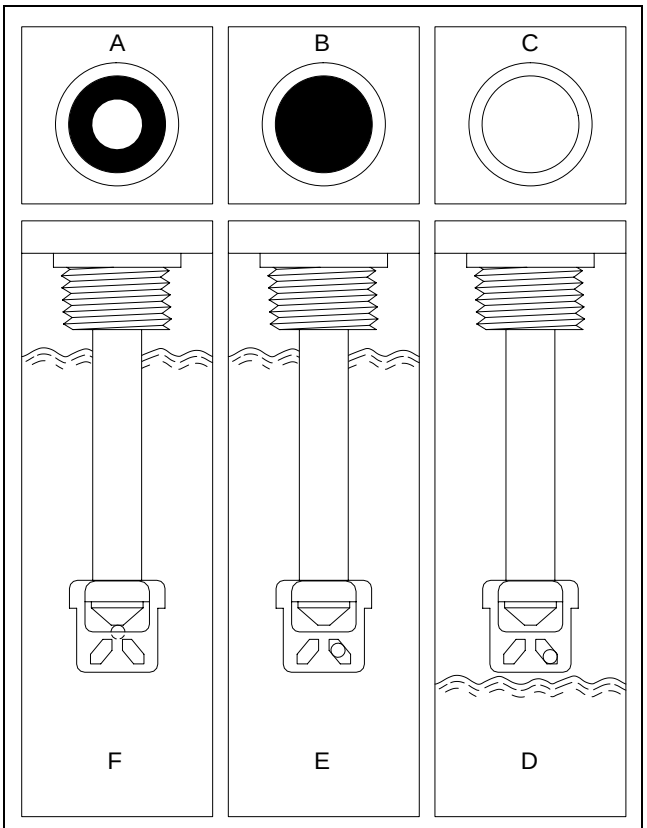
Prior to Testing

1. Clean the battery terminals with a soft wire brush before testing.
2. At the start of the test, make sure all vehicle accessory loads are off and the ignition is in the off position.

Midtronics PowerSensor Micro740 Test

NOTE: This test must be used by all U.S and Canadian dealers for battery warranty claims.

Every battery in a pack of two or more must be disconnected before testing. If more than one battery is selected to be tested, the analyzer will test the first battery, then prompt you to connect to the next battery after the test has been completed. If the analyzer detects that the batteries are connected it will remind you to disconnect the pack before starting the test.



A. Green Dot
B. Dark
C. Clear
D. Dead Battery
E. 65% or Less of Charge
F. 65% or More of Charge

Fig. 1, Built-In Hydrometer or Charge Indicator (on optional batteries only)

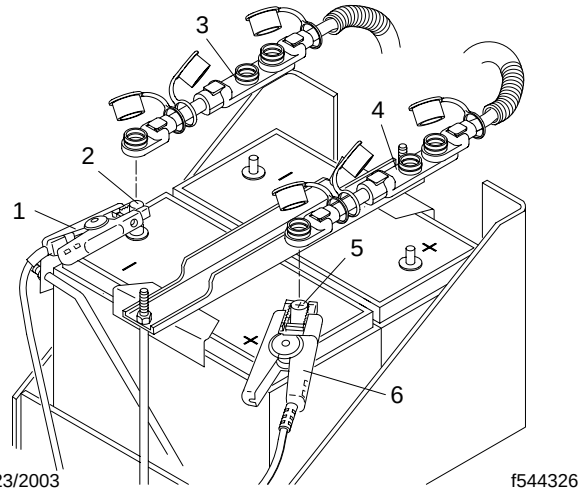
Battery Testing

Connecting the Midtronics Tester

1. Screw an adapter onto the negative-terminal stud and one onto the positive-terminal stud. See **Fig. 2**.

IMPORTANT: For accurate test results, connect the clamps to the lead adaptors or to the lead bases of threaded studs. Lead stud adaptors are included with the Micro740. Do not connect the clamps directly onto the threaded studs or an inaccurate test result may occur.

2. Connect the red clamp to the positive-terminal stud adaptor.
3. Connect the black clamp to the negative-terminal stud adaptor.
4. Rock the clamps back and forth to ensure a secure connection. Both sides of the clamp must be firmly connected to the adaptors before testing. If the test message CHECK CONNECTION appears, clean the terminals and/or reconnect the clamps.



1. Negative-Terminal Clamp
2. Negative-Terminal Adaptor
3. Negative-Terminal Battery Jumper
4. Positive-Terminal Jumper
5. Positive-Terminal Adaptor
6. Positive-Terminal Clamp

Fig. 2, Battery Connection

Battery Test

NOTE: If the analyzer displays a test message after you start the test see *Test Messages* to determine the cause and remedy.

1. Use the arrow buttons at the top of the keypad to scroll to menu choices. Select BATTERY TEST. Press ENTER to select.
2. Enter the number of batteries being tested (1 to 6) and press ENTER to select.
3. Select the rating system; CCA, SAE, EN, IEC, DIN, or JIS then press ENTER.
4. Select the appropriate rating value (see **Table 1**) then press ENTER.
5. If the analyzer detects that the temperature of the battery may make a difference in the results it will ask you to select whether the battery temperature is above or below 32°F (0°C). It will resume the test after you make the selection and press ENTER.
6. At the end of the test, the Micro740 will display one of the following results from **Table 2** and the measured voltage and CCA, if applicable.

   If the result is REPLACE BATTERY or BAD CELL—REPLACE, the analyzer will prompt you to press ENTER to generate a battery code.

   When the prompt BAT.SERIAL # appears enter the battery serial number. Use the ARROW buttons to scroll to the correct digit, then press ENTER to select it and move to the next digit. Pressing the BACK button will move the cursor back one space. When finished, press ENTER.
7. Turn on the printer and align the analyzer transmitter with the printer receiver. Press and hold the MENU button. Select PRINT RESULTS from the option menu by using the arrow buttons and pressing ENTER. It will take about 30 seconds to print all test results, which are displayed simultaneously on the screen.

Battery Rating Systems		
Rating System	**Description**	**Value Range**
CCA	Cold Cranking Amps, as specified by SAE. The most common rating for cranking batteries at 0 F (-18 C)	100 to 1700 A
SAE	European labeling of CCA	100 to 1700 A
EN	Europa-Norm	100 to 1700 A
IEC	International Electrotechnical Commission	100 to 1000 A
DIN	Deutsche Industrie-Norm	100 to 1000 A
JIS	Japanese Industrial Standard: (shown on a battery as a combination of numbers and letters, for example: 80D26)	43 values from 26A17 to 245H52

Table 1, Battery Rating Systems

Battery Test Results	
Result	**Recommendation**
Good Battery	Return to service.
Good – Recharge	The battery is good, but has an insufficient state of charge. Fully charge the battery and return to service. See **Subject 150**.
Charge and Retest	The battery has a very low state of charge. Fully charge the battery and retest. Failure to fully charge the battery before retesting may cause false readings. See **Subject 150**.
Replace Battery	Replace the battery and generate a test code.
Bad Cell – Replace	Replace the battery and generate a test code.

Table 2, Battery Test Results

Test Messages

Test Message—SYSTEM NOISE

Test Message—SYSTEM NOISE	
Possible Cause	**Remedy**
The analyzer has detected computer or ignition noise and will attempt to retest.	Make sure all vehicle loads are off and the ignition is in the off position. The analyzer will automatically retest when it no longer detects system noise
You may be testing too close to a noise source.	Move away from any high-current device and retest.
Battery charge is too low to test properly.	Recharge the battery and retest. If the message reappears, replace the battery. See **Subject 150**.
Poor connection at battery terminal.	Connect the battery cables and retest.

Battery Testing

Test Message—NON 12-VOLT BATTERY DETECTED

Test Message—NON 12-VOLT BATTERY DETECTED	
Possible Cause	**Remedy**
You are attempting to test both batteries in a 24-volt system at the same time.	Disconnect the batteries and test each one individually.

Test Message—INTERNAL ERROR, SERVICE REQUIRED

Test Message—INTERNAL ERROR, SERVICE REQUIRED	
Possible Cause	**Remedy**
The analyzer has detected a hardware or software problem.	See the Midtronics Micro740 *Instruction Manual*.

Test Message—REVERSE CONNECTION

Test Message—REVERSE CONNECTION	
Possible Cause	**Remedy**
The clamps are connected in reverse polarity. IE: Red to negative(-), and black to positive (+).	Disconnect the clamps and reclamp to proper polarity.

Test Message—UNSTABLE BATTERY

Test Message—UNSTABLE BATTERY	
Possible Cause	**Remedy**
Batteries that are very weak or that have just been charged may have sufficient electrical activity to alter test results. The analyzer will automatically retest when the battery has stabilized. Fully charged batteries should stabilize quickly.	Charge weak batteries and then retest. See **Subject 150**.

Test Message—CHECK CONNECTION

Test Message—CHECK CONNECTION	
Possible Cause	**Remedy**
Poor connection. Both sides of the clamps must be firmly connected before testing.	Clean the battery terminals using a wire brush and a mixture of baking soda and water. Inspect and clean the clamps. Liberally apply baking soda and water with a clean cloth and thoroughly rub the jaw and spring. Use a soft wire brush to remove corrosion buildup. Rinse with water and let dry.

Load Test

NOTE: This test must **not** be used by U.S and Canadian dealers for battery warranty claims.

1. Before beginning the load test, make sure the battery to be tested is fully charged. See **Subject 150** for conventional battery and gel cell charging instructions.

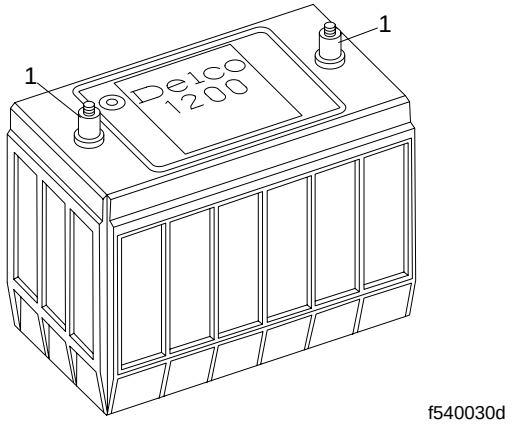
⚠ WARNING

Before charging a battery, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

2. Test each battery separately, either installed or removed. Disconnect the battery ground cable first.
3. Connect the tester leads to the battery terminals following the tester manufacturer's instructions. Batteries with sealed terminals require adaptors to provide a place for attaching the tester's leads. See **Fig. 3**.
4. Check the rated CCA of the battery. Apply a load equal to one-half the rated CCA across the terminals for 15 seconds to remove the surface charge from the battery. Remove the load and wait 15 seconds for the battery to recover.

   Example: For a battery rated at 620 CCA, apply a load of 310 amperes across the terminals.
5. Estimate the battery temperature by touch and by the ambient temperature the battery was exposed to before this test, then find the voltage in Table 1, **Specifications 400** that must be maintained while the battery supplies a specified electrical load.



1. Terminal Adaptor

Fig. 3, Sealed Battery

   Example: At 70°F, (21°C) the battery must supply 9.6V minimum.
6. Apply the specified test load to the battery for 15 seconds. The test load (amperes) is equal to one-half of the cold-cranking amperes of the 0°F (–18°C) rating of the battery.
7. Read the terminal voltage at the end of 15 seconds with the load still connected. Do not keep the load attached for a longer period of time before reading the voltage, as this would alter the test results.
8. Remove the load after 15 seconds and note the tester reading.

   If the voltage drops below the minimum listed in the table replace the battery.

   If the voltage is the same or greater than the minimum listed in the table the battery is capable of further service.

⚠ WARNING

Before charging a battery, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

Battery Charging

To charge a conventional liquid-electrolyte battery (wet cell), apply a charge rate in amperes for a period of hours. A 10-ampere charge rate for 5 hours would produce a 50 ampere-hour charge to the battery. Charge rates between 3 and 50 amperes are generally satisfactory for maintenance-free batteries.

An emergency boost-charge, or fast-charge, provides a high charging rate for a short period of time. Limit fast charges to specific charging times. See the charging table in **Specifications, 400**. The battery cannot be fully charged within these time periods, but it will receive a sufficient charge (70 to 90 percent) for practical service. To completely charge a battery, follow the fast-charge with a slow-charge.

IMPORTANT: Do not overcharge maintenance-free batteries. Overcharging causes excessive loss of water from the electrolyte and eventual battery damage.

On optional batteries with built-in hydrometers (charge indicators), the battery is sufficiently charged when the green dot in the hydrometer is visible. Gently shake or tilt the battery at hourly intervals during charging to mix the electrolyte and check to see if the green dot appears. Do not tilt the battery beyond a 45-degree angle.

⚠ CAUTION

Before shaking the battery, shut off the charger and disconnect it from the batteries. Shaking a battery with the charger hooked up may cause a spark that could ignite discharging gasses, leading to personal injury or property damage.

If the green dot does not appear after a 75 ampere-hour charge, continue charging for another 50 to 75 ampere-hours. If the green dot still does not appear, replace the battery.

NOTE: Batteries with built-in hydrometers (charge indicators) can't be charged if the indicator color is clear or light yellow; this indicates low electrolyte level. Replace these batteries.

To charge a wet cell, do the following steps:

1. Clean the battery terminals.

NOTE: If the battery is cold, let it warm up. This will allow a normal charging rate.

2. Make sure that the charger is turned off.
3. Connect the charger to the battery following the manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
4. Turn on the charger and slowly increase the charging rate until the recommended ampere value is reached. See the charging table in **Specifications, 400**.

IMPORTANT: If the battery feels hotter than 125° F (52° C), or if rapid gassing or spewing of electrolyte occurs, lower the charging rate or stop charging the battery and allow it to cool.

5. Turn the charger off.

⚠ WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

6. Disconnect the charger cables from the battery.

NOTE: If the vehicle is equipped with an isolated battery system, be sure that both battery systems are charged.

7. If the engine does not crank satisfactorily when a charged battery is installed, test the battery. For instructions, see **Subject 140**.

   If the battery passes the test, check the fuel, ignition, cranking, and charging systems to find and correct the problem.

   If the battery does not pass the test, replace it.

Battery Removal, Cleaning and Inspection, and Installation

⚠ WARNING

Before doing any of the following procedures, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Removal

1. Before working on the battery, make sure all electrical loads (lights, ignition, accessories) are turned off.
2. Open the battery access door, release the pin latches, and slide the drawer out.
3. Disconnect the negative battery cable lead.
4. Disconnect the negative battery jumper post.
5. Disconnect the positive battery cable lead.
6. Disconnect the positive battery jumper post.
7. Remove the battery holddown and retainer, if so equipped; then remove the batteries from the carrier.

Cleaning and Inspection

1. Inspect all battery cables and inter-connectors for wear, and replace them if necessary. Remove corrosion from cables, terminals, and battery posts with a wire brush and a solution of baking soda and water. Rinse thoroughly with clean water, and dry.
2. Clean and tighten the battery ground cable at the weld stud on the frame rail. There are two locations to service. First, at the battery, and, second, at the engine behind the left wheel. Inspect and ensure that the nut is a self-locking type and that a flat washer is used. Do not use a split-lock washer or star washer. Torque the nut 15 to 18 lbf·ft (20 to 24 N·m). Seal the area with red dielectric spray enamel sealant.
3. Inspect the retainer assembly and battery box. Replace worn or damaged parts. Remove any corrosion with a wire brush, and wash with a weak solution of baking soda and water. Rinse with clean water, and dry. Paint the retainer assembly, if needed, to prevent rusting.
4. Be sure foreign objects, such as stones, bolts, and nuts, are removed from the battery box.

Installation

1. Be sure that the battery to be installed has a sufficient capacity to cover the electrical needs of the vehicle. For more information, see **Subject 100**.

⚠ CAUTION

Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.

2. Be sure the battery is at full charge when installed. If the battery has been in storage for some time, or if the installation is being made in subfreezing temperatures, give the battery a boost-charge before installing it. For instructions, see **Subject 150**.
3. Place the batteries in the carrier with the terminals in the proper position, as referenced earlier. The batteries should rest level in the carrier.
4. Install the battery holddown, and tighten it until the batteries are secure. See **Fig. 1**.

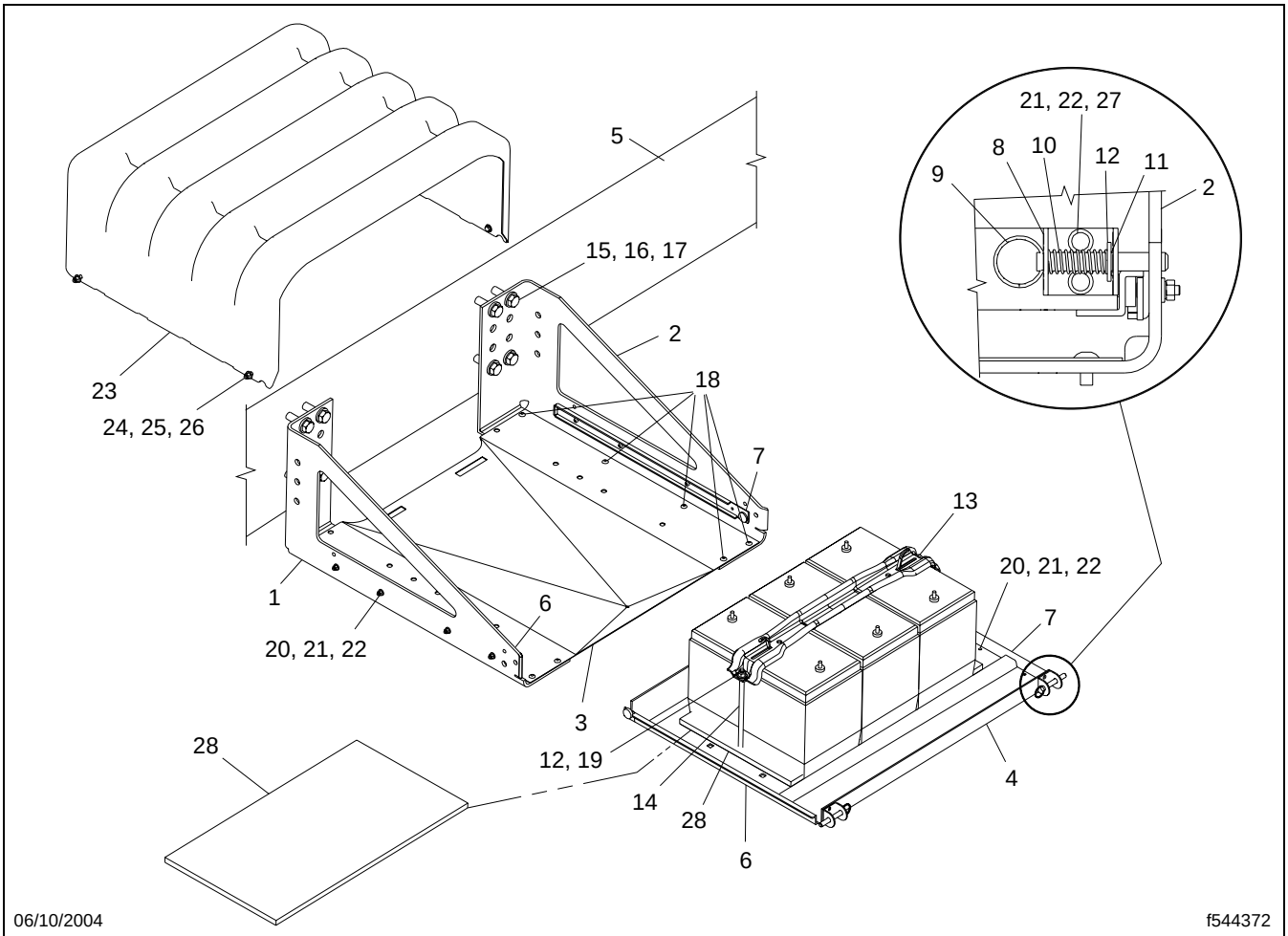
⚠ CAUTION

Do not overtighten the battery holddown. Overtightening could damage the batteries.

5. To provide corrosion protection, apply pumpable dielectric grease liberally to the terminal pads, then install the inter-connectors. For a list of approved suppliers, see **Specifications, 400**.

IMPORTANT: Many electrical components are located outside of the cab in areas subjected to harsh weather, road spray, etc. Some components also have exposed metal electrical terminals, which, when subjected to harsh conditions, may suffer corrosion at the electrical connection. Spray dielectric sealant on all exposed electrical terminals, and use dielectric grease on all covered terminals. See **Specifications, 400** for a list of approved products.

Battery Removal, Cleaning and Inspection, and Installation



1. LH Mounting Bracket
2. RH Mounting Bracket
3. Drip Pan
4. Drawer
5. Frame Rail
6. LH Drawer Slide
7. RH Drawer Slide
8. Latch Bracket
9. Latch Pin
10. Latch Spring
11. Cotter Pin, 1/16 x 3/4-inch
12. Washer
13. Battery Holddown
14. Bolt, Round Head, Square Neck, 3/8–16
15. Capscrew, Hex 5/8–11
16. Washer
17. Hexnut, 5/8–11
18. Monobolt, 1/4–0.375
19. Hexnut, 3/8–16
20. Machine Screw, 10–24
21. Flatwasher, #10
22. Hexnut, Locking Collar, 10–24
23. Battery Cover
24. Machine Screw 1/4–20, 3/4-inch
25. Washer, 1/4-inch
26. Hexnut, 1/4–20
27. Not shown
28. Machine Screw, 10–24
29. Plywood Liner (8D batteries only)

Fig. 1, Frame-Mounted Battery Box

6. Connect the battery cables to the batteries; check for correct polarity with respect to the vehicle. Connect the ground cable last.
   - 6.1 Install the positive battery jumper post.
   - 6.2 Install the positive battery cable lead.
   - 6.3 Install the negative battery jumper post.
   - 6.4 Install the negative battery cable lead.

Battery Removal, Cleaning and Inspection, and Installation

CAUTION

Reversed polarity may cause serious damage to the electrical system.

7. Tighten all battery connections to the torque specifications listed on the battery. Generally those are 10 to 15 lbf·ft (14 to 20 N·m). Proper torque is important for electrical system operation.
8. Start the engine, and check the operation of the charging system. If needed, adjust or repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.

Battery Box Removal and Installation

⚠ WARNING

Before doing any of the following procedures, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Removal

1. Before working on the battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.
2. Open the battery access door, release the pin latches, slide out the drawer, and remove the batteries.
3. See **Subject 160** for procedures to remove the batteries.
4. Free the battery cables from the side of the battery box.
5. Remove the drawer from the drawer slides. See **Fig. 1**.
6. Remove the four fasteners from the battery cover and remove the cover.
7. Remove the eight sets of capscrew, nuts, and washers that attach the battery box to the frame rail.
8. Remove the battery box.

Installation

1. Line up the holes in the battery box with the holes in the frame rail.
2. Install the eight sets of capscrews, nuts, and washers that attach the battery box to the frame rail. **Do not tighten.**
3. Install the drawer in the slides.
4. Test the drawer operation by sliding it in and out several times. Adjust the mount brackets as necessary.

NOTE: The drawer latch pins should snap into the locked position without extra effort.

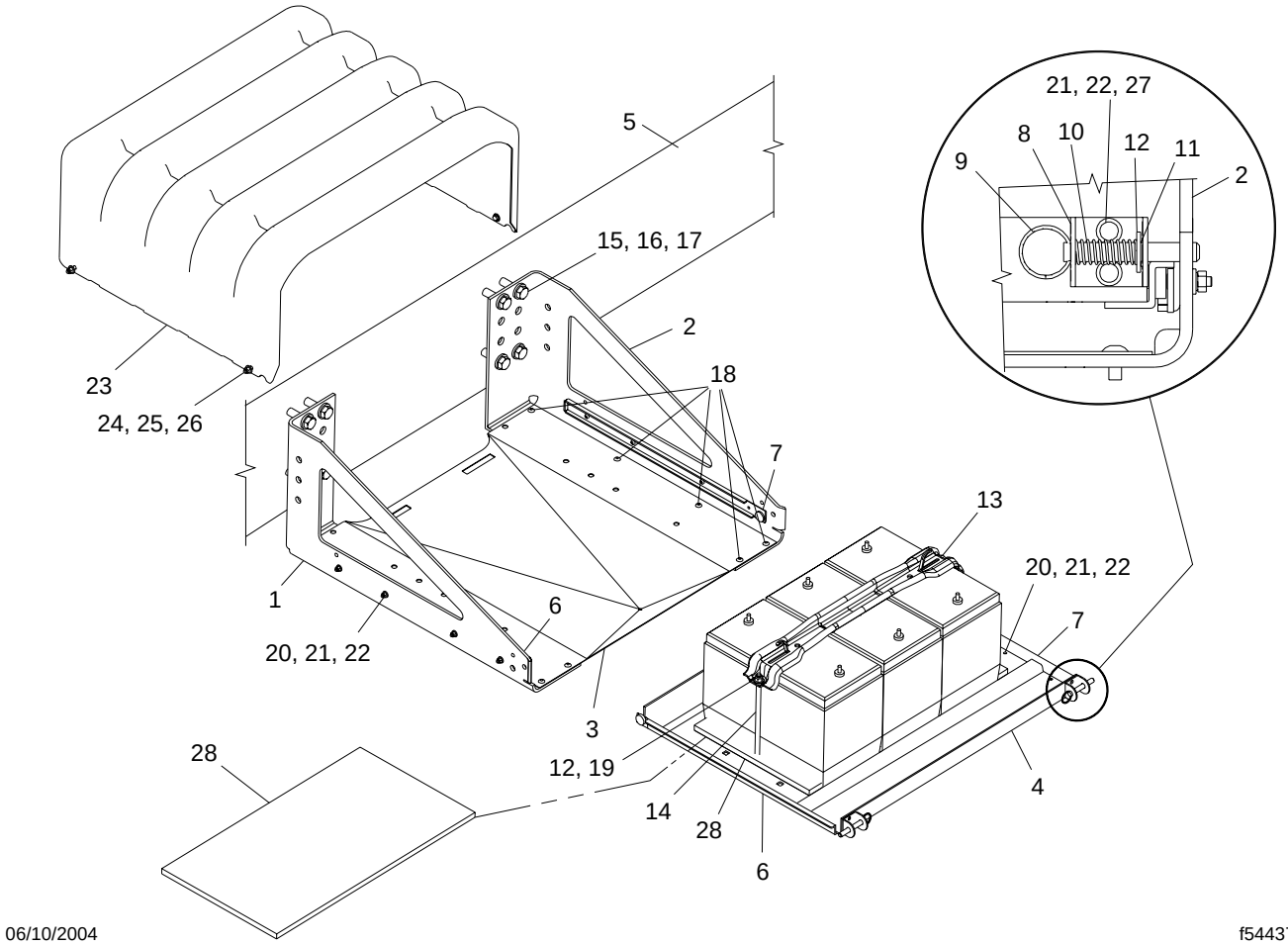
5. Tighten the mount bolts to 128 lbf·ft (173 N·m).
6. Install the battery box cover.
7. Place the batteries in the battery box with the terminals in the proper position. Make sure the batteries rest level in the box. See **Subject 160** for procedures to correctly install the batteries.
8. Install the battery holddowns. Tighten each nut to 10 lbf·ft (14 N·m).

⚠ CAUTION

Do not overtighten the battery holddowns. Overtightening could damage the batteries.

9. Return the battery drawer to the closed position. Close the access door.

Battery Box Removal and Installation



1. LH Mounting Bracket
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25. Washer, 1/4-inch
26. Hexnut, 1/4–20
27. Machine Screw, 10–24
28. Plywood Liner (8D batteries only)

Fig. 1, Frame-Mounted Battery Box

Troubleshooting

If the starting batteries test good, but fail to perform satisfactorily in service, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or an inoperative voltage regulator is causing the batteries to discharge.
3. The electrical load is exceeding the charging system capacity.
4. Wires in the electrical system are shorted or pinched.
5. There are loose or damaged battery cable-to-terminal connections.
6. The batteries are still connected in a vehicle that has been out of service. Small current drains of accessories that are connected all the time can discharge the batteries in six to eight weeks. Batteries left in a discharged condition for a prolonged period of time are subject to freezing and may become difficult to charge.

Problem—The Starting Batteries Are Undercharged

Problem—The Starting Batteries Are Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The batteries are undercharged.	Do a load test on the batteries. Refer to **Subject 140** for instructions. Charge or replace batteries as needed. If the batteries were discharged, start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The cranking circuit is broken.	If the batteries were fully charged and passed the load test, check the cranking circuit. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Make repairs as needed. Start the engine to verify the repair.
The starter is cold.	Perform a cold weather starting test.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears.
The starter is damaged.	Replace the starter.
The alternator is malfunctioning.	Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The isolator relay is not operating correctly (optional battery isolator system only).	Replace the isolator relay with an exact replacement continuous-duty relay.

Troubleshooting

Problem—The Starting Batteries Are Overcharged

Problem—The Starting Batteries Are Overcharged	
Possible Cause	**Remedy**
The voltage regulator is damaged.	Run engine at approximately 2000 rpm. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads 15.5V or above, replace the alternator.
The dash voltmeter is broken.	Run engine at approximately 2000 rpm. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads below 15.5V, check and, if necessary, replace the dash voltmeter.
The batteries are overheated.	Check battery temperatures. If 120°F (49°C) or above, connect cool, fully charged batteries and recheck the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If 119°F (48°C) or below, load test the batteries. Refer to **Subject 140** for instructions.
The batteries need replacing.	Check battery temperatures. If 119°F (48°C) or below, load test the batteries. Refer to **Subject 140** for instructions.

Electrical Drain and Parasitic Load Test

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough to cause a no-start condition.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off. Some devices, such as the electronic control unit (ECU), the bulkhead module (BHM), the chassis module (CHM), the antilock braking system (ABS), and radio memory are intended to draw a very small current continuously. These draws are measured in milliamps (mA). Current draw should be less than 325 milliamps with no circuits active and the ECU, BHM, CHM, and ABS turned off.

Determining the Correct Parasitic Load

As more electronic content is installed, parasitic drain issues become more prevalent. The reserve capacity (RC) rating multiplied by 0.6 gives the approximate available ampere-hours (AH) from full charge to complete drain. Between full charge and complete battery drain there is a point where some of the electrical accessories still operate but the vehicle will not start.

NOTE: When there is bodybuilder-added equipment, contact the bodybuilder to get their specifications for parasitic draw and add it to the following numbers where appropriate.

Using up approximately 40 percent of the total available ampere-hours will usually take fully charged batteries to a no-start condition at moderate temperatures of 77°F (25°C). For typical batteries in a storage situation, depleting the available ampere-hours by 20 to 325 (depending on the number of batteries) will result in a no-start condition.

The recommendation for maximum parasitic drain is approximately 325 mA (0.325 amps). A typical drain falls into the 25 to 325 mA (0.025 to 0.325 amps) range. Multiply the drain (in amps) by the time (in hours) the batteries sit without being recharged. The result is the amount of ampere-hours consumed by the parasitic drain. The actual drain may be small, but over time the batteries grow steadily weaker.

A vehicle with a 325 mA drain and a fully charged 70 RC battery will last between five and six days. But if the batteries are at only 65 percent of full-charge,

they are going to last only two days before causing a no-start condition.

Important: If the batteries begin storage at 90 percent of full charge, reduce the available ampere-hours accordingly.

Battery Electrical Drain and Parasitic Load Test

If the batteries in a vehicle become discharged in a shorter time than described earlier, the vehicle may have a parasitic load that is out of specification. Refer to the instructions in this subject to determine the source of parasitic loads.

A J38758 Parasitic Draw Test Switch (available from Kent-Moore) and a digital multimeter set to the 10A scale is required for this test.

Before performing the load test, ensure that the following conditions are met:

- the ignition key is out of the ignition;
- all doors are closed;
- the headlights and park lights are off;
- the courtesy lights are off;
- the batteries are fully charged.

1. With the vehicle parked, apply the parking brakes, and shut down the engine.
2. Disconnect the cable from the negative battery terminal.
3. Install the draw test tool, with the male end connected to the negative battery terminal.
4. Turn the draw test tool to the open position.
5. Attach the negative battery cable to the female end of the draw test tool.
6. Turn the draw test tool to the closed position.
7. Road test the vehicle while activating all accessories.
8. Shut down the engine and remove the ignition key.
9. Set the ammeter to the 10-amp scale and connect to the terminal on the draw test tool.
10. Turn the drain tool to the open position to allow current to flow thorough the ammeter.
11. Wait at least 60 seconds, then check the current reading. If the current reading is at or below 2 amps, close the drain tool (to maintain continuity in the electrical system) and switch down to the 2-amp scale for a more accurate reading when the drain tool is re-opened.
12. The ECU/BHM/CHM/ABS current draw should be less than 325 mA with no circuits active. The following measurement reflects the value of the current draw with all systems off.
    - A measurement below 325 mA indicates that the ECU/BHM/CHM/ABS is OK.
    - A measurement above 325 mA indicates a possible problem with the ECU/BHM/CHM/ABS. Disconnect each component and re-check the current draw as directed.
    - A measurement significantly over 325 mA indicates a problem unrelated to the ECU/BHM/CHM/ABS.
    - A measurement of approximately 0 amps indicates a faulty ECU, BHM, CHM, or ABS.
13. Repeat the parasitic current drain procedure after any repair is completed.
14. Remove the draw test tool and reconnect the negative battery cable.
15. Remove the chocks from the tires.

Specifications

Minimum Permissible Voltages	
Ambient Temperature: °F (°C)	Minimum Voltage (After 15 seconds at 300 amps)
	12-Volt
70 (21) and Above	9.6
60 (16)	9.5
50 (10)	9.4
40 (4)	9.3
30 (–1)	9.1
20 (–7)	8.9
10 (–12)	8.7
0 (–18)	8.5

Table 1, Minimum Permissible Voltage at Various Ambient Temperatures

Charging Rates for Starting Batteries				
Rated Battery Capacity (Reserve Minutes)	Slow Charge*		Fast Charge†	
	Hours @	Amperes	Hours @	Amperes
180	30	5	7-1/2	20
	15	10	5	30
			2-1/2	45

* Slow charging is recommended for completely charging the batteries.
† An emergency boost charge, which consists of a high charging rate, can be obtained by reducing the fast-charge time to half, while maintaining the same recommended ampere charge may be used to crank an engine.

Table 2, Charging Rates

Manufacturer	Lubricant or Part Number
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK–77

Table 3, Approved Electrical Lubricants

Reserve Capacity	Cold Cranking Amps (CCA)
180 minutes	750

Table 4, Standard Battery Specifications

Protectant Material	Approved Brand
Dielectric Red Enamel Spray	MMM 1602 IVI–Spray Sealer, Red Electric Grade (Spray-On B–6–665)

Table 5, Approved Dielectric Red Enamel