#### **General Information**

#### **General Information**

Maintenance-free lead-acid batteries are electrochemical devices which 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 automotive battery has three functions:

- To supply power to the starter and ignition system so the engine can be cranked and started.
- To supply extra power when the vehicle's electrical load requirements go beyond what the charging system can supply.
- 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.

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 group of plates is immersed in a separate cell in a solution of electrolyte (dilute sulfuric acid).

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.

Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 130**.

Maintenance-free batteries do not need additional water during normal service life.

#### **General Information**

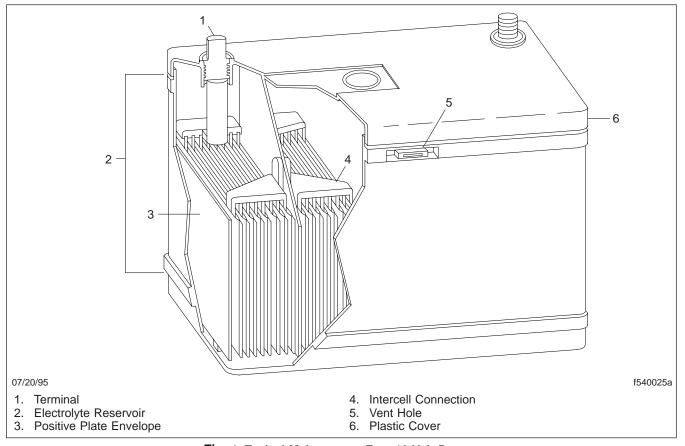


Fig. 1, Typical Maintenance-Free 12-Volt Battery

#### **General Information**

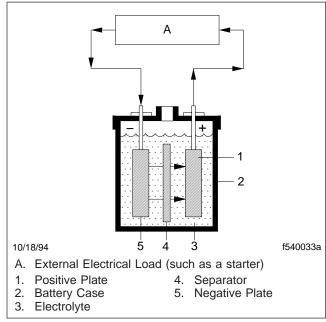


Fig. 2, Discharging the Battery

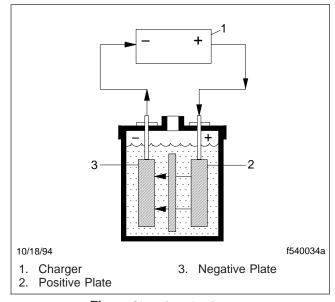


Fig. 3, Charging the Battery

#### **Battery Safety Precautions**

### **General Safety Precautions**

### **WARNING**

WARNING: Never charge a battery while it is connected to the vehicle. If sensitive vehicle components are exposed to excessive charging current, it can cause fires, leading to personal injury and possible loss of life.

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:

### **A** WARNING

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.

- 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**

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.

- 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**

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 15 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.

### **Battery Safety Precautions**

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

### **WARNING**

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 a Battery**

### **Emergency (Jump) Starting**

### **WARNING**

WARNING: Before jump starting a vehicle, read the instructions in Subject 100. 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.

### **A** WARNING

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.

- 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.
- 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

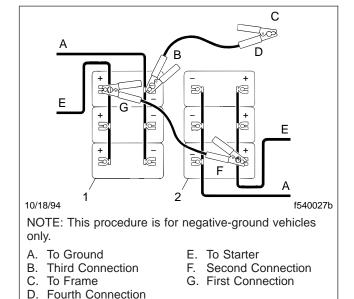


Fig. 1, Jumper Connections, 12-Volt Starting System

2. Discharged Battery

1. Booster Battery

vehicle being started. See Fig. 1. 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 two 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.

# **Emergency (Jump) Starting a Battery**

7. Disconnect the other cable from the discharged battery first, then disconnect the opposite end.

#### **WARNING**

Before charging a battery, read the instructions in Subject 100. 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.

#### **Conventional Battery Charging**

To ensure the optimum condition of the starting and charging system, the starting battery(s) should be kept at a high state of charge. In particular, if operating a vehicle with undercharged battery(s), the alternator can be overworked, which can result in its premature failure.

To charge a conventional liquid-electrolyte battery (wet cell), apply a charge rate in amperes for a pe-

riod of hours. For example, a 10-ampere charge rate for five hours would produce a 50 ampere-hour charge to the battery.

### General Guidelines for Charging Batteries

When charging multiple batteries on one charger, group batteries that have similar voltages and are of similar age. If not, the group will only charge as fast as the battery with the lowest state of charge. Batteries below 5 volts should be charged individually.

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

Use the following tables as a guide for determining how long to charge the battery(s).

	Recharge Time (hours) Using a Shop Charger for a Single Battery				
Open Circuit	State of Charge	te of Charge Charger Maximum Rate		ximum Rate	
Voltage (OCV)		50 Amps	30 Amps	20 Amps	10 Amps
12.6 volts	100%		Ready	to Use	
12.4 volts	75%	0.6 hours	0.9 hours	1.3 hours	2.5 hours
12.2 volts	50%	1.2 hours	1.9 hours	2.7 hours	5.1 hours
12.0 volts	25%	1.8 hours	2.9 hours	4.3 hours	7.8 hours
11.8 volts	0%	2.5 hours	4.0 hours	5.7 hours	10.7 hours

Table 1, Using a Shop Charger for a Single Battery

	Recharge Time (hours) Using a Shop Charger for a Two Battery System				
Open Circuit	State of Charge Charger M			ximum Rate	
Voltage (OCV)		50 Amps	30 Amps	20 Amps	10 Amps
12.6 volts	100%	Ready to Use			
12.4 volts	75%	1.2 hours	1.8 hours	2.6 hours	5.0 hours
12.2 volts	50%	2.4 hours	3.8 hours	5.4 hours	10.2 hours
12.0 volts	25%	3.6 hours	5.8 hours	8.6 hours	15.4 hours
11.8 volts	0%	5.0 hours	8.0 hours	11.4 hours	21.4 hours

Table 2, Using a Shop Charger for a Two Battery System

	Recharge Time (hours) Using a Shop Charger for a Three Battery System				
Open Circuit	State of Charge		Charger Ma	ger Maximum Rate	
Voltage (OCV)		50 Amps	30 Amps	20 Amps	10 Amps
12.6 volts	100%		Ready	to Use	
12.4 volts	75%	1.8 hours	2.7 hours	3.9 hours	7.5 hours
12.2 volts	50%	3.6 hours	5.7 hours	8.1 hours	15.3 hours
12.0 volts	25%	5.4 hours	8.7 hours	12.9 hours	23.1 hours
11.8 volts	0%	7.5 hours	12.0 hours	17.1 hours	32.1 hours

Table 3, Using a Shop Charger for a Three Battery System

Recharge Time (hours) Using a Shop Charger for a Four Battery System					
Open Circuit	State of Charge		Charger Ma	Charger Maximum Rate	
Voltage (OCV)		50 Amps	30 Amps	20 Amps	10 Amps
12.6 volts	100%	Ready to Use			
12.4 volts	75%	2.4 hours	3.6 hours	5.2 hours	10.0 hours
12.2 volts	50%	4.8 hours	7.6 hours	10.8 hours	20.4 hours
12.0 volts	25%	7.2 hours	11.6 hours	17.2 hours	31.2 hours
11.8 volts	0%	10.0 hours	16.0 hours	22.8 hours	42.8 hours

Table 4, Using a Shop Charger for a Four Battery System

Batteries below 11.8 volts should be charged at no more than 10 amps for a minimum of 24 hours per battery. Check after the first hour and ensure that the battery is not getting hot.

If after using the above charging method you receive a "Charge and Retest" result from a Midtronics battery tester and the voltage is above 11.8 volts, continue to charge normally. If the battery voltage is below 11.8 volts, replace the battery.

On optional batteries with a built-in hydrometer (charge indicator), 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.

If the green dot does not appear after a 75 amperehour 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 not be charged if the

indicator color is clear or light yellow; this indicates low electrolyte level. Replace these batteries.

To charge a wet cell battery, 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.
- 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 until the recommended ampere value is reached. Charge rates between 3 and 50 amperes are generally satisfactory for maintenancefree batteries.

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.

### **A** WARNING

Always turn the charger off before disconnecting it from the battery. 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.

 If the engine does not crank satisfactorily when a charged battery is installed, test the battery. For instructions see Subject 130.

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

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

### **Gel Cell Charging**



To avoid shortening the life of a gel cell, carefully regulate the charging voltage between 13.8 and 14.1 volts.

It is hard to determine how long to charge a gel cell. Recharging time depends on the following factors:

- Depth of discharge
- Temperature
- Size and efficiency of the charger
- · Age and condition of the battery

Because the chemical charging reaction slows down as it nears completion, about 60% of the total charging time will be spent bringing the battery from 10.5 volts under load (11.8 volts with no load) to 90% of full charge (12.92 volts, including surface charge). The other 40% of the time is required to charge the remaining 10% (full charge equals 13.0 volts, including surface charge).

For example, if it takes 3-1/2 hours to charge a battery to 90%, it will take another 2-1/2 hours to bring it to full (100%) charge.

See **Table 5** for a list of estimated charging times to 90% of full charge. See **Table 6** for a list of estimated charging times to 100% of full charge. All charging times are based on the initial charge current accepted by the battery, using an automatic, temperature-sensing voltage-regulating charger set at 13.8 (2.30 to 2.35 volts per cell) on a totally discharged battery (at 11.80 to 12.00 volts, with no load).

Charging Time to 90% of Full Charge			
Battery	Initial Amps Needed To Recharge Battery in a Specific Number of Hours		
	13 Hours	6 Hours	3-1/2 Hours
Group 27	8 Amps	21 Amps	41 Amps
Group 31	9 Amps	24 Amps	45 Amps

Table 5, Gel Cell Charging Guide (90% Charge)

Charging Time to 100% of Full Charge			
Battery	Initial Amps Needed To Recharge Battery in a Specific Number of Hours		
	22 Hours	10 Hours	6 Hours
Group 27	8 Amps	21 Amps	41 Amps
Group 31	9 Amps	24 Amps	45 Amps

Table 6, Gel Cell Charging Guide (100% Charge)

#### **How To Use These Charts**

Read amps about one minute after the charger is first turned on. Use this initial reading to estimate the approximate charging time.

For example, if a Group 31 (G31) battery reads about 24 amps when first turned on, the battery will be at 90% charge in about six hours, and will be fully charged (100%) in about ten hours.

To charge a gel cell battery, do the following steps:

- 1. Remove the gel cell from the vehicle.
- 2. Clean the battery terminals.

NOTE: If the gel cell is cold, let it warm up to 68°F (20°C). This will allow a normal charging rate.

3. Make sure that the charger is turned off.



Use a reliable, automatic, temperature-sensing, voltage-regulated charger to charge the cells. Any other type of charger will damage the gel cell.

- 4. Connect the charger leads directly to the battery, following the charger manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
- 5. Turn on the charger and set the charging rate between 13.8 and 14.1 volts (2.30 to 2.35 volts per cell).
- After about one minute, check the initial charge current. To charge to 90% of full charge, see Table 5 to determine the approximate time of completion. To charge to 100% of full charge, see Table 6 to determine the approximate time of completion.
- 7. Turn the charger off when finished.

# **WARNING**

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

8. Disconnect the charger cables from the battery.

#### **General Information**

### **A** WARNING

Before testing a battery, read the instructions in Subject 100. 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 120**. 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.
- At the start of the test, make sure all vehicle accessory loads are off and the ignition is in the off position.

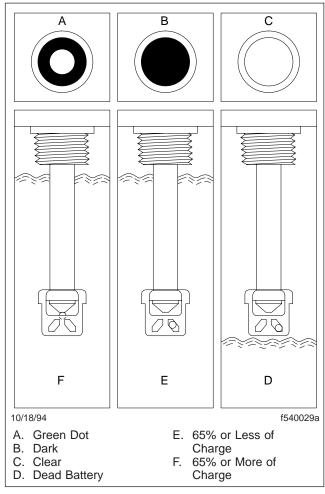


Fig. 1, Built-In Hydrometer or Charge Indicator (on optional batteries only)

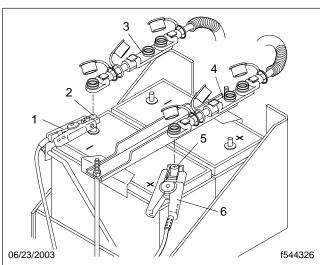
#### Midtronics PowerSensor Micro740 Test

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.

#### Connecting the Midtronics Tester

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



- 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

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.

- Connect the red clamp to the positive-terminal stud adaptor.
- 3. Connect the black clamp to the negative-terminal stud adaptor.
- 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.

#### **Battery Test**

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

- Use the arrow buttons at the top of the keypad to scroll to menu choices. Select BATTERY TEST. Press ENTER to select.
- Enter the number of batteries being tested (1 to 6) and press ENTER to select.
- Select the rating system; CCA, SAE, EN, IEC, DIN, or JIS then press ENTER.
- 4. Select the appropriate rating value then press ENTER. See **Table 1**.
- 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.
- 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 <b>Subject 120</b> .	
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 <b>Subject 120</b> .	
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 <b>Subject 120</b> .	
Poor connection at battery terminal.	Connect the battery cables and retest.	

#### 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 120.	

#### 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.

 Before beginning the load test, make sure the battery to be tested is fully charged. See Subject 120 for conventional battery and gel cell charging instructions.



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**.

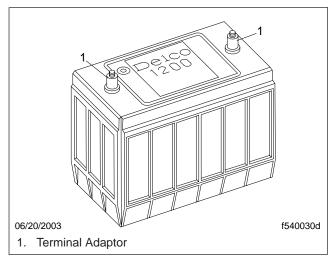


Fig. 3, Sealed Battery

- 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.
- 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.
  - 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.
- 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.

#### **Battery Cleaning and Inspection**

#### **A** WARNING

WARNING: Before doing any of the following procedures, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.

### **Cleaning and Inspection**

- Inspect the battery cables for wear, and replace them if necessary. Clean the cable connector terminals with a wire brush and tighten all battery interconnecting cables.
- Clean and tighten the battery ground cable, terminals, and clamps.
- Inspect the retainer assembly (or battery hold-downs) 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.

#### **Battery Storage**

#### **Storage**

Always store batteries in an upright position. Don't store 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, they 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 twelve 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.

#### **Replacement Battery Selection**

#### Selection

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.

#### **Troubleshooting**

### **Troubleshooting**

If the battery tests good, but fails 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.
- There are loose or damaged battery cable-toterminal connections.
- 6. The battery is 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. A battery left in a discharged condition for a prolonged period of time is subject to freezing and may become difficult to charge.

#### Problem—The Batteries Seem Undercharged

Problem—The Batteries Seem Undercharged	
Possible Cause	Remedy
The drive belt is loose.	Check the drive belt. See the drive belt subject in the appropriate engine section in <b>Group 01</b> for instructions. If necessary, tighten to the manufacturer's specifications.
	Start the engine and check the alternator voltage and amperage output. See the troubleshooting subject in the appropriate alternator section in <b>Group 15</b> for instructions.
The drive below is described as and it	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine.
The drive belt is damaged or missing.	Check the alternator voltage and amperage output. See the troubleshooting subject in the appropriate alternator section in Group 15 for instructions.
The battery is undercharged.	Do a load test on the battery. See <b>Subject 130</b> for instructions. Charge or replace the battery as needed.
	If the batteries were discharged, start the engine and check the alternator voltage and amperage output. See the troubleshooting subject in the appropriate alternator section in <b>Group 15</b> for instructions.
The cranking circuit is broken.	If the batteries were fully charged and passed the load test, check the cranking circuit. Go to "Cranking Circuit Test" in <b>Section 15.00</b> for instructions. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Go to "Starter Wiring Test" in <b>Section 15.00</b> for instructions. Make repairs as needed. Start the engine to verify the repair.
The starter is cold.	Go to "Cold Weather Starting Test" in Section 15.00 for instructions.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage. Go to "Available Cranking Voltage Test" in <b>Section 15.00</b> for instructions.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears. Go to "Ring and Pinion Gear Test" in <b>Section 15.00</b> for instructions.
The starter is damaged.	Replace the starter.
The alternator is malfunctioning.	See the troubleshooting subject in the appropriate alternator section in <b>Group 15</b> for instructions.

# **Troubleshooting**

#### Problem—The Starting Batteries Seem Overcharged

Problem—The Starting Batteries Seem 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. See the troubleshooting subject in the appropriate alternator section in <b>Group 15</b> for instructions.
	If the voltmeter reads 15.0V or above (15.5V or above on Leece-Neville alternators), replace the alternator.
The dash voltmeter is broken.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. See the troubleshooting subject in the appropriate alternator section in <b>Group 15</b> for instructions.
	If the voltmeter reads below 15.0V (15.5V on Leece-Neville alternators), check voltage at the gauge terminals 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. See the troubleshooting subject in the appropriate alternator section in <b>Group 15</b> for instructions.
	If 119°F (48°C) or below, load test the batteries. See <b>Subject 130</b> for instructions.
The batteries need replacing.	Check battery temperatures.
	If 119°F (48°C) or below, load test the batteries. See <b>Subject 130</b> for instructions.

# **Specifications**

Minimum Permissible Voltages	
Ambient Temperature °F (°C)	Minimum Voltage (after 15 seconds at 300 amps)
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 †		
(Reserve Willutes)	Hours @	Amperes	Hours @	Amperes
	30	5	7-1/2	20
180	15	10	5	30
	_	_	2-1/2	45

<sup>\*</sup> Slow charging is recommended for completely charging the batteries.

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	650

**Table 4, Standard Battery Specifications** 

<sup>&</sup>lt;sup>†</sup> 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