2002-07 GENINFO

Battery - Overview - MINI

MINI BATTERY

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Purpose of the Automotive Battery

The battery is the primary Electromotive Force (EMF) source in the automobile. In addition the battery performs the following functions:

- Provides voltage and current for the starter motor.
- Provides voltage and current for the ignition during cranking.
- Supplies all electrical power when the charging system is not operating.
- Supplies the extra power necessary when the vehicle's electrical load exceeds the supply from the charging system.
- Acts as a voltage stabilizer in the electrical system. The battery evens out voltage spikes and prevents them from damaging other components in the electrical system.
- Provides power to KL30, KL15 and KLR.

The battery does not store electrical energy. It stores chemical energy that is converted to electrical energy as it discharges.

Battery Construction

The battery used in the MINI is made of a plastic case containing alternating plates of Lead and Lead Dioxide (or Lead Oxide) separated by insulators.

These alternating plates are connected in series to produce a voltage of 12.6 volts, or about 2.1 volts for each set of Lead and Lead Dioxide plates. The negative terminal is connected to a Lead Dioxide plate and the positive terminal to a Lead plate.

Fig. 1: Battery Series Voltage
Courtesy of BMW OF NORTH AMERICA, INC.

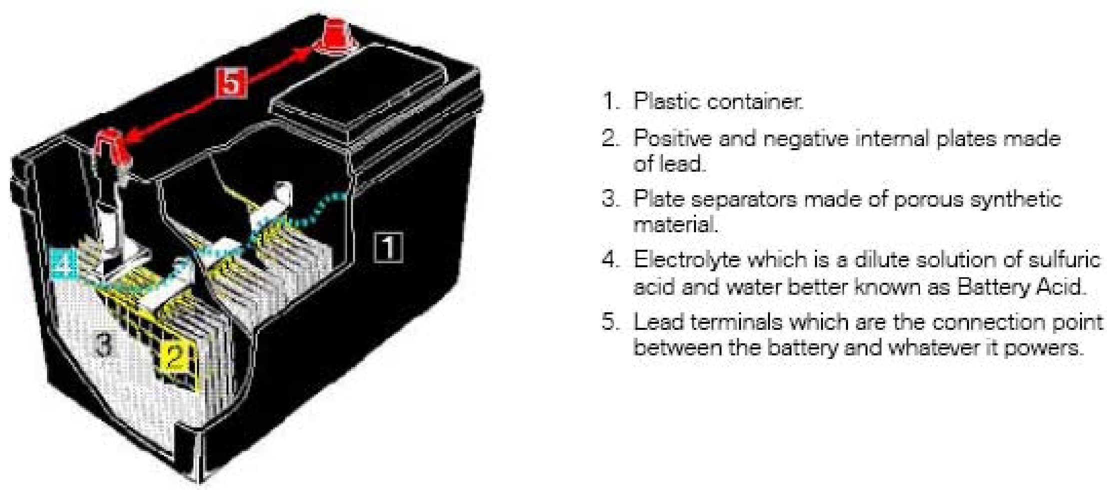

Fig. 2: Section View Of Battery
Courtesy of BMW OF NORTH AMERICA, INC.

Battery Case

Most battery cases and their covers are made of polypropylene. The case is divided into six sections or cells, shaped similar to an ice-cube tray.

The case is designed to:

- Withstand hot and cold temperature extremes.
- Resist damage caused by mechanical shock in automotive applications.
- Resist acid absorption and chemical damage.

The Grids

The grids are the supporting framework for the active material of the plates. They also conduct current to and from the active material plates.

The Plates

Plates are grids covered with a paste mixture of Lead Oxide and Sulfuric Acid and water. An expander material made of powdered sulfates is added to the paste to produce negative plates.

A forming charge is applied to the positive plates converting the Lead Oxide to Lead Dioxide, a highly porous material which allows the electrolyte to freely penetrate the plate.

A forming charge is also applied to the negative plates converting the Lead Oxide to Sponge Lead. The Sponge Lead allows the electrolyte to penetrate freely allowing the material beneath the plate surface to take part in the chemical reaction.

The Separators

Separators are thin sheets of electrically insulating porous material used as spacers between the plates to prevent short circuits within the cells.

Fine pores in the separators allow ionic current flow in the electrolyte between the positive and negative plates.

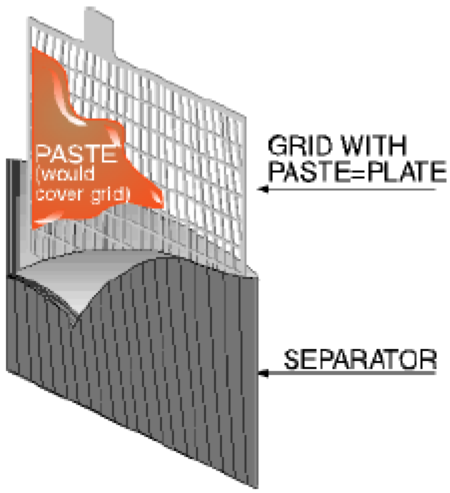

Fig. 3: Separator
Courtesy of BMW OF NORTH AMERICA, INC.

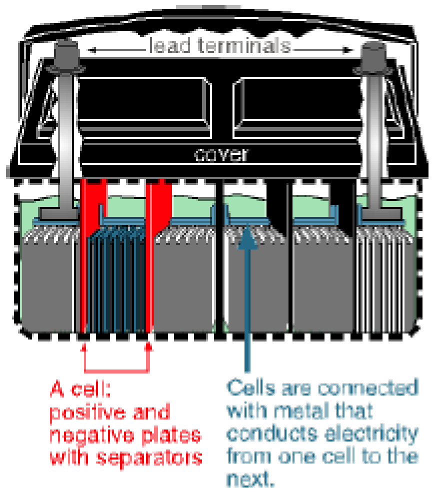

Fig. 4: Electrolyte Between Positive And Negative Plates
Courtesy of BMW OF NORTH AMERICA, INC.

Elements

In the most common method of construction, a stack of alternate positive and negative plates are formed with separators between each positive and negative plate. The lugs of the negative plates are welded together as are those of the positive plates. The plate strap of each group of plates is used to connect them in series with the plate group of the next cell, or with a battery terminal.

The assembly resulting from placing one positive plate group and one negative plate group together, with separators is known as an element. There is one element per battery cell.

More or larger plates per cell will increase plate surface area and increase capacity of the battery but will not affect the voltage output.

Electrolyte

The electrolyte is a mixture of Sulfuric Acid and Water. Electrolyte consists of 35% sulfuric acid and 65% water on a fully charged normal battery.

The electrolyte is the carrier for the electric current to move between the positive and negative plates through the separators.

The Lead Terminals

BMW's use a tapered top terminal. This design uses tapered terminal posts built to industry standards so that all cable clamps will fit any battery with these posts.

The positive terminal is slightly larger than the negative to minimize the danger of installing the battery in reverse. The positive terminal is 17.5mm in diameter at the top. The negative terminal is 15.9mm at the top.

Fig. 5: Battery Positive And Negative Terminals
Courtesy of BMW OF NORTH AMERICA, INC.

Battery Types

There are at least three types of the Lead-acid batteries that are currently used in the Automotive Industry.

Lead-Acid Battery

The three major contributors to battery chemistry are lead, lead dioxide and sulfuric acid. Pure lead is too soft to withstand the physical abuse of mobile applications, so a strengthener is needed. About 6% antimony, a semi metallic element produced as a byproduct to copper and lead ore refining, is added to strengthen the lead.

The antimony added to the grids acts as a catalyst and makes the loss of hydrogen and oxygen through outgassing worse. These batteries require frequent water replenishing.

Lead/Calcium Battery

Introduced in the 1970's Lead/Calcium batteries have Calcium added to the positive and negative grids to reduce the outgassing. These batteries were first referred to as "maintenance free". The Lead/Calcium batteries are not resistant to deep-cycling which occurs when a battery is drained to a very low voltage before being recharged. Frequent deep-cycling renders these batteries unable to sustain a charge. Lead/Calcium batteries need to be charged at higher voltage settings or they will not be recharged to full capacity.

Hybrid Battery

Hybrid batteries use a positive grid strengthened with antimony and a negative grid with

calcium. The hybrid battery is more resistant to deep cycling than the lead/calcium, but still not as good as the original Lead-acid battery. Water usage is greatly reduced in the hybrid battery, although regular checking is advisable. Most cars supplied with hybrid batteries have their voltage regulators set to 14.3 volts.

Notes:

How the Battery Works

Discharging

Batteries don't store electrical energy, they store chemical energy and convert it to electrical energy during the discharging process.

Each cell of a battery contains positive and negative plates (grids). The positive plate is made of lead dioxide, the negative plate of a spongy lead. The negative plate combines with the sulfuric acid to create lead sulfate and one extra electron. The positive plate produces hydrogen ions and sulfuric acid ions (positive ions, atoms missing one electron).

The extra electrons from the negative plate are passed from the negative battery terminal and through the electrical consumer, back to the positive battery terminal. Once back at the battery, the free electrons combine with the positive ions at the positive battery terminal producing lead sulfate and water.

It is important to remember that the system is closed. For every electron generated at the negative terminal, there is an electron consumed at the positive terminal.

As the process continues, the active materials (lead and lead dioxide plates and the electrolyte) become depleted and the reactions slow down until the battery is no longer capable of supplying electrons. At this point the battery is discharged.

The discharge process changes the ratio of sulfuric acid to water in the electrolyte, as more water is produced in the discharge process. By measuring the volume of acid in the water, the state of charge of the battery is discovered.

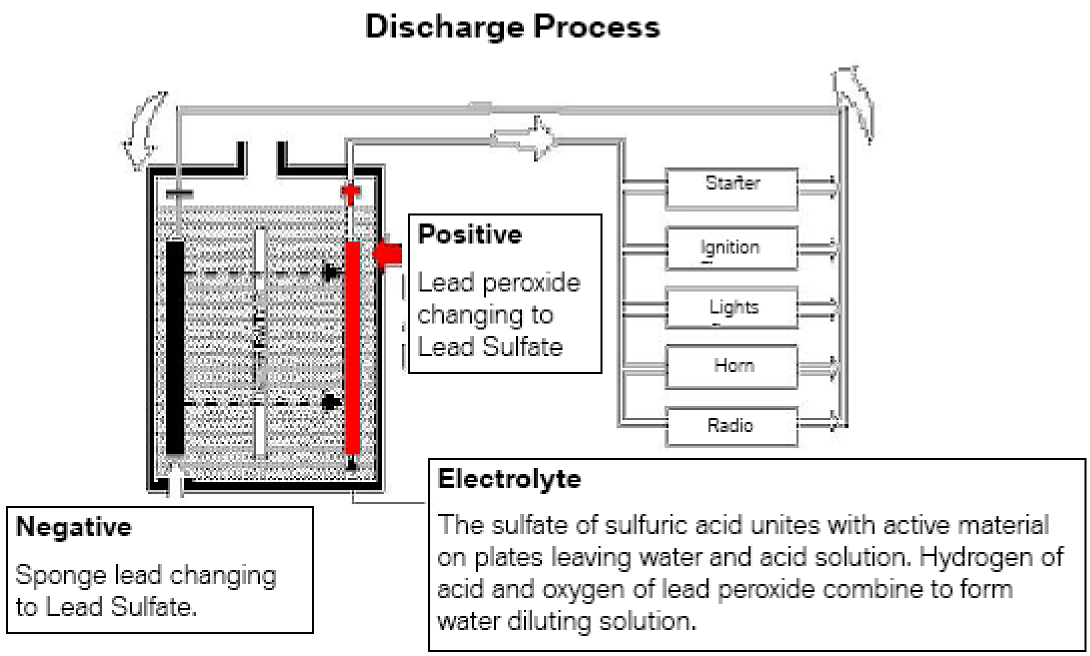

Fig. 6: Battery Discharge Process Diagram
Courtesy of BMW OF NORTH AMERICA, INC.

Charging

Applying voltage to the battery from an external source such as the generator or battery charger reverses the chemical action in the battery.

Reversing the chemical action in the battery, forces the free electrons at the negative terminal of the battery back into the electrolyte raising the sulfuric acid percentage. This chemical action removes the Lead sulfate that had formed on the negative plates leaving pure active material.

The electrons that were forced into the electrolyte are able to react with the lead sulfate on the positive terminal again raising the Sulfuric acid content and leaving pure active material on the positive plates.

This process enables the battery to be used over and over again.

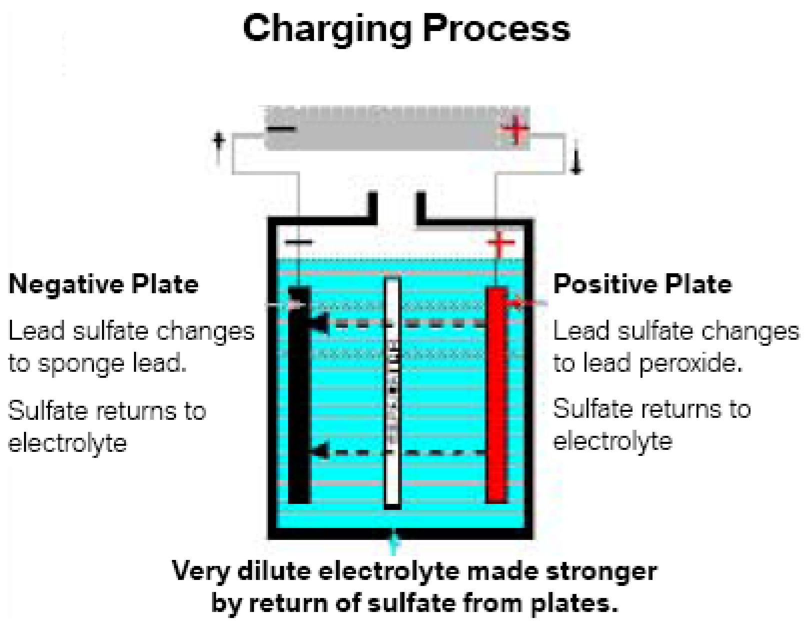

Fig. 7: Battery Charging Process Diagram
Courtesy of BMW OF NORTH AMERICA, INC.

Common Battery Terms

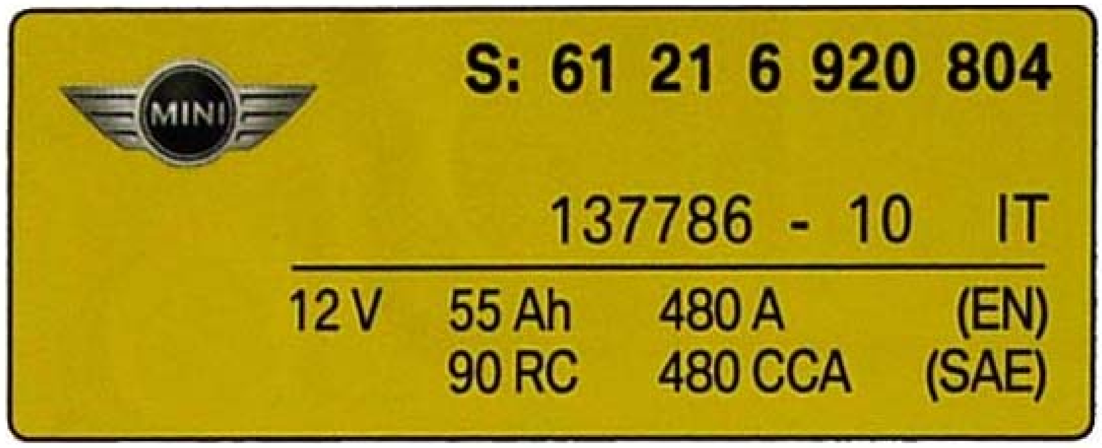

Fig. 8: Common Battery Terms
Courtesy of BMW OF NORTH AMERICA, INC.

- **AH (Amp Hour Capacity)**

  This rating is derived from discharging a fully charged battery at a constant amp draw for 20 hours @ 80° F, without the voltage of the battery falling below 10.5 volts. The constant amp draw is multiplied by the 20 hours to come up with the Amp Hour Rating.

- **CCA (Cold Cranking Performance)**

Represents the amperage capacity a fully charged battery can deliver @ 0°F for 30 seconds before the voltage of the battery falls below 7.2 volts.

- **RC (Reserve Capacity)**

  Reserve capacity is expressed in minutes and relates to the amount of time a fully charged battery can maintain a constant draw of 25 amps @ 80°F before the voltage falls below 10.2 volts.

- **W (Watts)**

  The measurement of electrical power that the battery can deliver for a cold start. It is calculated by multiplying the starter amperage draw @ 0°F times 10 volts.

- **V (Volt)**

  Unit of measure of potential difference (Electrical pressure).

- **A (Amp)**

  The current flow in a circuit. Value is proportional to the number of electrons flowing past a point in one second.

- **W (Ohm)**

  The measurement of the resistance of a component or circuit to current flow.

- **Electrolyte**

  The mixture of sulfuric acid and water. 35% sulfuric acid, 65% water.

- **Specific Gravity**

  The measurement (by weight) of the volume of sulfuric acid in the electrolyte. A specific gravity of 1.275 (the specific gravity of a fully charged battery) means that the electrolyte is 1.275 times heavier than water. The specific gravity of water is 1.000.

- **Sulfate**

  Deposits formed on the plates of the battery as the electrolyte gives up its sulfuric acid.

  Excessive deep cycling of a battery can cause a hardening of this deposit and make it impossible to return sulfate to the electrolyte. A sulfated battery is one which has these hardened deposits on the plates and cannot be recharged to full capacity.

- **OCV Open Circuit Voltage**

  The measurement of the voltage of a battery across the terminals.

Notes:

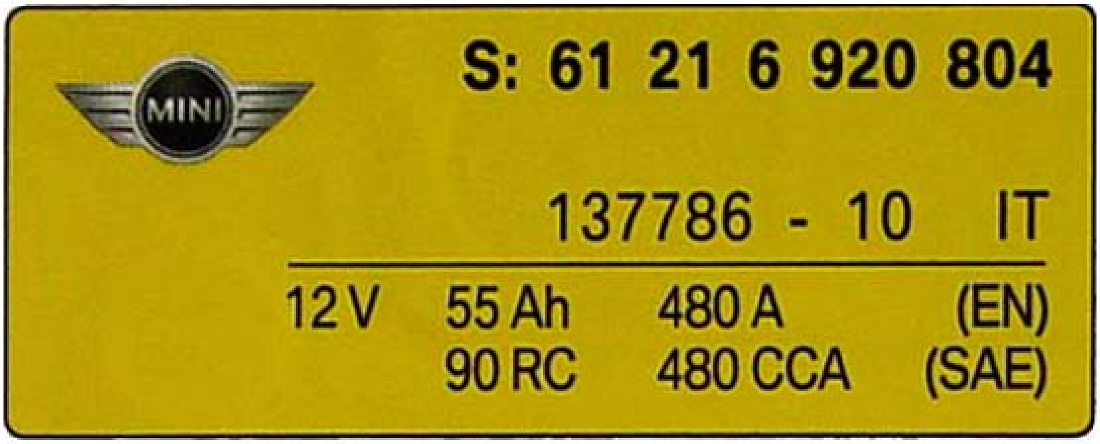

Fig. 9: OCV Open Circuit Voltage
Courtesy of BMW OF NORTH AMERICA, INC.

Battery Testing

There are four steps to follow in testing an automotive battery:

- Inspection
- Removal of Surface Charge
- State-of-Charge Test
- Load Test

Inspection

Visual inspection is important for the detection of obvious problems:

- Loose Generator Belt
- Low Electrolyte Level
- Corroded Cable or Terminal Clamps
- Loose Hold-Down Camps or Cable Terminals
- Damaged Battery Case

Removal of Surface Charge

If the battery has just been recharged, or the car has been driven, eliminate any surface charge by one of the following methods:

- Allow the battery to sit for 2-3 hours.
- Turn the headlights on high beam for 5 minutes and wait 5 minutes after turning off.
- With battery load tester, apply a load of 1/2 the battery's CCA for 15 seconds, then wait 5 minutes.

State-of-Charge Test

Using the measured battery voltage, the state of charge can be determined. Use the table to determine the battery's state-of-charge.

BATTERY VOLTAGE CHART

Open Circuit Battery Voltage	Approximate State of Charge	Average Cell Specific Gravity
12.65 +	100%	1.265 +
12.45	75%	1.225
12.24	50%	1.190
12.06	25%	1.155
11.89	0%	1.120

Pay special attention if the DVOM measurement of OCV is equal to:

- 0 volts -Indicate an open cell.
- 10.45 - 10.65 volts -Indicates a shorted cell.

For non-sealed batteries, check both specific gravity (SG) in each cell with a temperature compensated hydrometer and battery OCV, without the engine running.

For sealed batteries (installed in all MINI's), measuring the battery's OCV (without the engine running) with an accurate DVOM is the only way to determine the state-of-charge.

Batteries with a built-in hydrometer measure the state-of-charge **in one cell only.** If the indicator is clear or light yellow, the battery has a low electrolyte level and should be refilled before proceeding or replaced.

A state-of-charge reading BELOW 75% using SG, voltage measurement or dark indicator in batteries with a built-in hydrometer, indicates the battery must be recharged before proceeding.

Replace the battery if one or more the following conditions are met:

- More than 0.050 difference in the specific gravity readings between the highest and lowest cell (There is a weak or dead cell).
- The battery will not recharge to 75% or greater state-of-charge or the built in hydrometer does not indicate good (green indicates 65% or better).
- DVOM reading indicates 0 volts (Open cell).
- DVOM reading indicates 10.45 - 10.65 volts (Shorted cell).

Load Test

A battery which has a state-of-charge of 75% or greater or has a "good" built-in hydrometer indication may be load tested.

With a battery load tester properly installed, load the battery for 15 seconds to one of the following:

- One-half (1/2) the CCA (Cold Cranking Amps).
- Three (3) times the AH Rating (Amp Hour Rating).

The voltage on a good battery will NOT drop below 9.7 volts during the battery load test. After the load is removed, wait 5 minutes, the battery should bounce back to 50% or greater state-of-charge. If a battery drops below 9.7 volts during the load test, does not bounce back or fails to start the engine, the battery should be replaced. Batteries which pass this test should be recharged to restore peak performance.

Load Test Conditions

- Tests assume electrolyte temperature of 80°F, 26.7°C.
- If the electrolyte temperature is above 80°F add .1 volt for every 10° up to 100°F.
- If the temperature is below 80°F subtract .1 volt for every 10° to 40°.

Battery Maintenance

Electrolyte Level

If battery electrolyte level is allowed to drop substantially, the gas volume inside the battery grows proportionately resulting in an increased amount of flammable gas mixture. Any external or internal spark may result in an oxyhydrogen explosion. Additionally the plates are no longer covered by the electrolyte and may corrode.

Because MINI vehicles use a maintenance free battery, the electrolytic level cannot be topped off or maintained.

Battery Cable Connections

The top of the battery should be clean.

Check for and correct corrosion on the top of the battery and the cable connections.

Battery Charging

The purpose of charging a battery is to put back the energy that has been removed. A battery that is not properly charged will deliver sub-standard performance and display a shorter life span.

A battery should be charged only after performing a visual inspection on the battery case and the electrolyte levels. Never attempt to charge a battery with a damaged case or low electrolyte levels.

A state-of-charge test should be performed before attempting to charge a battery.

Unplug the charger or turn it off **before** disconnecting the leads at the battery.

The best charging method is to SLOWLY recharge the battery using the BMW approved battery charger. A slow charging rate allows more time for the electrolyte to penetrate the plates.

Batteries that are fully discharged should be charged according to the following table.

RESERVE CAPACITY RATING (RC) CHART

Reserve Capacity Rating (RC)	Slow Charge	Fast Charge
80 minutes or less	15 hours @ 3 amps	2.5 hours @ 20 amps
80 - 125 minutes	21 hours @ 4 amps	3.75 hours @ 20 amps
125 - 170 minutes	22 hours @ 5 amps	5 hours @ 20 amps
170 - 250 minutes	23 hours @ 6 amps	7.5 hours @ 10 amps
above 250 minutes	24 hours @ 10 amps	6 hours @ 40 amps

Workshop Hint

Electrolyte levels may drop at a higher rate in the winter months, due to higher loads and increased utilization of electrical systems.

Workshop Hint

Many battery problems are caused by loose or corroded connections. Insure that cables are free from corrosion and tight before continuing diagnosis.

Sulfated Batteries

Continuous discharging of the battery or low electrolyte levels cause crystals to form on the plates. These crystals of lead sulphate occur when a battery is discharged. The deeper the discharge the more serious the sulphation. The sulphur molecules that form the sulphate are then absent from the electrolyte, causing the electrolyte to become inefficient.

A battery relies on clean plates and strong electrolyte to both receive charging current and offer strong current discharge. A sulphated battery can do neither. Proper recharging of the battery will remove some but not all of the sulphate. Eventually the battery plates are coated with enough sulphate that it is impossible to achieve an efficient recharge.

Testing a Battery for Sulphation

A battery which fails the load test should be tested for sulphation. To test a battery for sulphation, place it on a battery charger for three minutes with the charger set on 40 amps.

After three minutes check the OCV, if the reading is greater than 15.0 volts the battery is sulphated. Batteries which indicate a sulphated condition should be recharged slowly and retested before being discarded.

Battery Freezing

A fully charged battery can be stored at sub-freezing temperatures with no damage. The battery is protected from freezing to a temperature of -75°F A fully discharged battery however will freeze at +27°F.

Avoid freezing by keeping the battery fully charged.

Carefully inspect a battery which has frozen for a cracked case.

Dealership Inventory Maintenance

Notes:

Battery Replacement

Batteries determined to be defective through testing procedures should be replaced using the following guidelines.

- Reconfirm battery is actually defective and it does not need charging.
- Insure that ignition switch is in "Off" position and engine is not running.
- Disconnect negative battery terminal first.
- Place negative battery cable in a position so that it can not come in contact with battery during removal process.
- Reinstall battery hold down clamp.
- Install positive cable first.
- Recheck output of vehicle generator and balance of electrical system for other problems.
- Provide clear and concise description of the defect including cell readings, load test results and any other pertinent information which led to the battery replacement.
- Tag battery with VIN and repair order number.

Battery Failures

An analysis of batteries replaced under warranty shows that many claims could have been avoided had the batteries been maintained in a full state of charge.

Batteries must be maintained at all times when vehicles are at a retailer whether they are new cars, used cars, in storage (back lot), on display, or customer cars in for maintenance or repairs.

Batteries replaced due to lack of maintenance will not be covered by warranty.

Most Common Causes of Premature Battery Failures:

- Failure to maintain proper state of charge
- Loss of electrolyte due to overcharging or excessive heat
- Deep discharging (Leaving lights on or other parasitic draws)
- Undercharging of battery
- Vibration (Loose battery hold down clamp)
- Using tap water (instead of distilled water)
- Corrosion
- Freezing.

CLOSED CIRCUIT CURRENT DRAW TESTING

Increased closed-circuit currents may occur permanently or intermittently and cause the battery to discharge prematurely. The increase in closed circuit current may be caused by a faulty control unit or by the installation of a non-approved accessory.

Minimal amounts of parasitic draw can be overcome by the chemical reaction that takes place inside the battery. A problem occurs when the average vehicle current consumption higher that the battery can produce chemically.

In a situation where a vehicle has broken down due to a discharged battery, for diagnostic purposes it is important not to disconnect the battery. The control unit may reset if the battery is disconnected. Following a reset, a faulty control unit may start functioning correctly again, making accurate diagnosis impossible.

Tools Needed

- Current Measurement Adapter
- DISplus, GT1 or DVOM
- MIB

To correctly measure closed-circuit current, the 50-amp clip-on probe can be used in conjunction with the DISplus to properly diagnosis closed circuit current problems over an extended period of time.

Performing a Closed Current Measurement

- Check and test the battery. If necessary, recharge or replace the battery.
- If the battery is installed in the trunk, open the trunk and turn the lock to the locked position using a screwdriver or similar (simulates the trunk lid being closed). The hood must be closed.

  If the battery is installed in the engine compartment, open the hood and disconnect the passenger's side hood latch microswitch wiring (workshop position, simulates the front lid being closed). The trunk must be closed.

- With the exception of the trunk / hood above, all other doors / lids must be closed.
- In order to simulate normal closed-circuit conditions:
  - Turn ignition on and activate all electrical consumers, including any accessories.
  - Turn ignition off. In some cases a drive cycle may need to be carried out in order to duplicate a closed circuit current problem.
  - Open and close the driver's door (simulates somebody getting out).
  - Lock the car, arming DWA if this is installed.
- In general, closed-circuit current consistently over 50 mA must be investigated.

Closed-circuit current measurement with the DISPlus/GT1:

This technique with a DISPlus/GT1 is particularly suitable for extended measurements and provides a graphical readout of recorded measurements over time. It is recommended for situations where the use of a multimeter provided insufficient information for problem diagnosis.

- Select "Oscilloscope display" on the Oscilloscope settings screen to start recording measurements.
- Select the Log Scale/Lin Scale button to switch over to the Log Scale. This will provide the best visual trace of the closed circuit measurement.

NOTE: Pressing the "Oscilloscope settings" button will delete any recorded measurements.

Oscilloscope Setting

Frequency Range

The frequency range determines how frequently and for how long a measured value is recorded.

The larger the frequency range, the more frequently a measured value is recorded, and the shorter the maximum stored recording duration.

- Select "Writer mode"
- Select "Current 50A" under "Test connection"
- Select "=" under "Type of measurement"
- Set "Measuring range" to "10 A" scale
- Set "Frequency range" based on how long of a trace is required. Refer to the chart below for examples.

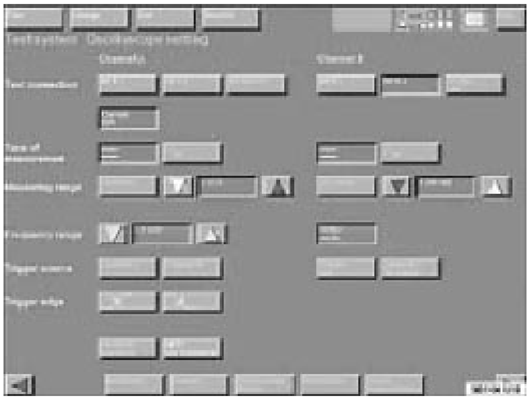

Fig. 10: Oscilloscope Setting Screen Display
Courtesy of BMW OF NORTH AMERICA, INC.

FREQUENCY RANGE CHART

Set "Frequency Range"	Number of Measurements	Maximum Duration of Recording
2 mHz	1 per second	83 minutes
1 mHz	1 every 2 seconds	2.7 hours
0.4 mHz	1 every 5 seconds	5.5 hours
0.2 mHz	1 every 20 seconds	27.7 hours

Oscilloscope Display

- Select "Oscilloscope Display"
- A box will pop up calibrating the 50-Amp clamp. Make sure the clamp is not connected to anything, then select "OK".
- Once the display screen is present the measurement will be started. Select Log Scale/Lin Scale to switch over to Log Scale. The Log Scale screen will then be displayed in 3 different measurement ranges. This ensures that when the closed circuit current measurement drops through the various ranges, the reading will be graphically displayed on one screen without changing settings.

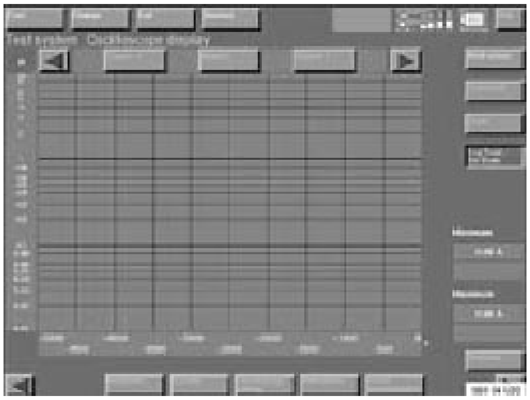

Fig. 11: Oscilloscope Display
Courtesy of BMW OF NORTH AMERICA, INC.

Displaying and Understanding Measurements

- Stop recording measurements by pressing the "Hold Screen" button. Note: If the "Hold Screen" button is pressed again, the recorded measurements will immediately be deleted and new measurements started.
- Recorded data may be called up by pressing the screen button "Memory" and paged through with the aid of the "arrow keys" on the upper corners of the screen. When the maximum recording duration has been used, measured values can be called up for a total of 10 screens.
- Momentary current fluctuations are normal and should be ignored. "Maximum" display captures these momentary fluctuations and also should be ignored.
- An increased closed-circuit current will also be intermittently measured for a few seconds due to the use of remote-control keys of other vehicles, or other radio transmitters in the frequency range 315 MHz. In these cases, the BC1 wakes up for key identification, then goes back to sleep when its own key is not recognized.

  This is normal operation.

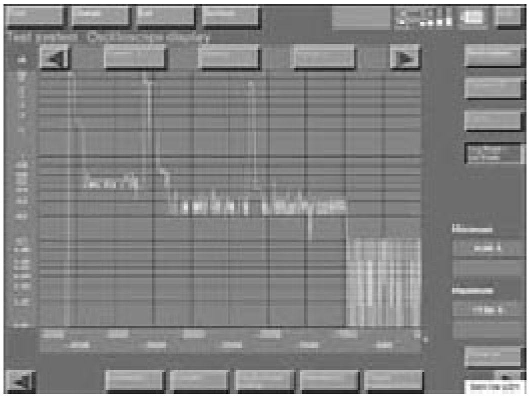

Fig. 12: Displaying And Understanding Measurements
Courtesy of BMW OF NORTH AMERICA, INC.