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## The Battery

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## **The Battery**

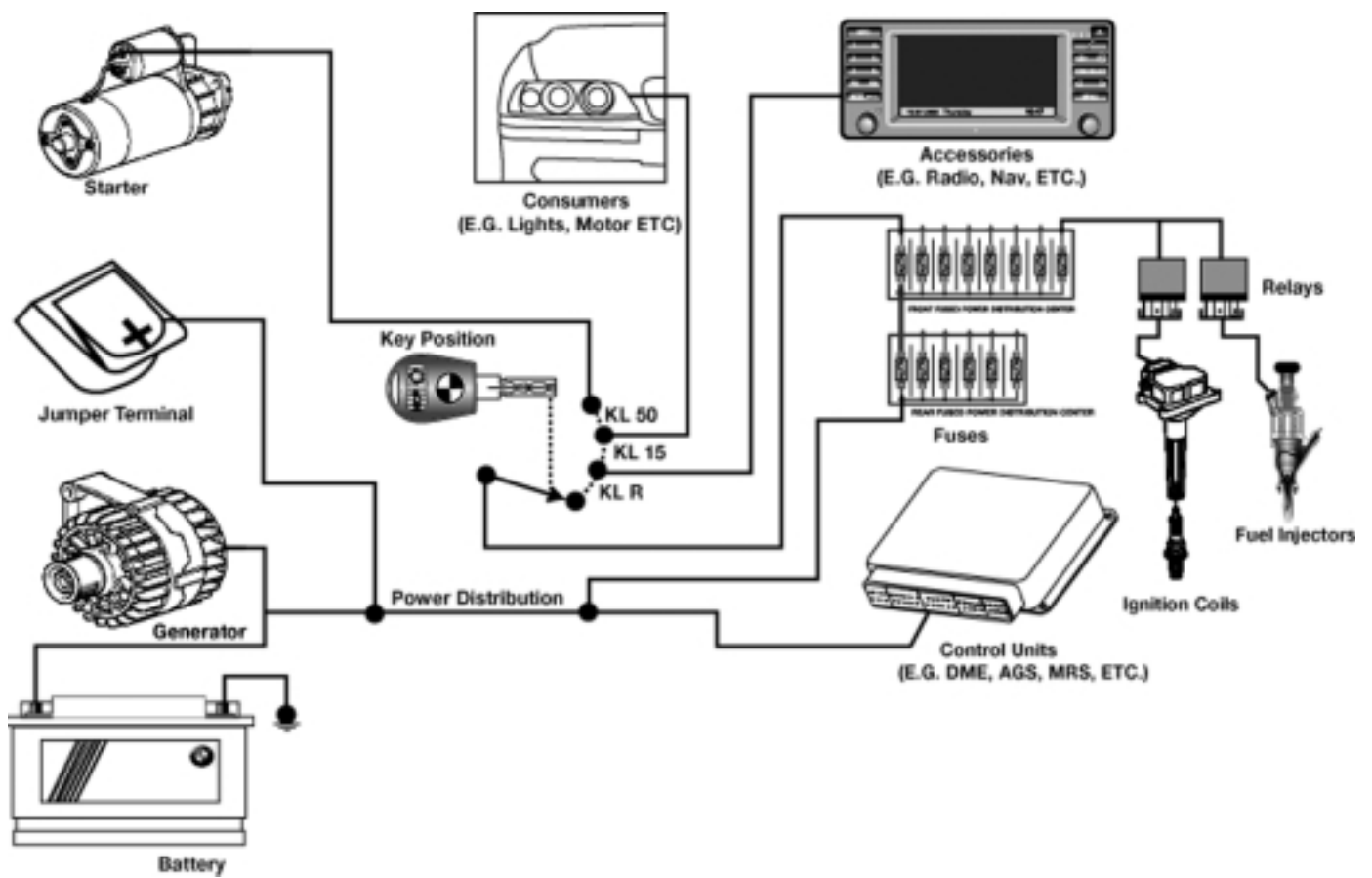
**Model: All**

**Production Date: All**

### **Objectives**

After completing this module you should be able to:

- Explain the battery components and construction.
- Understand the different types of batteries.
- Explain the chemical process of charging and discharging.
- Know common battery terms.
- Perform battery testing.
- Properly charge a battery.
- Know the procedures for the Battery Log Form.
- Understand dual battery systems.



**All things electrical start at the Battery**

## The Battery

### Purpose of the Automotive Battery

The battery is the primary 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.

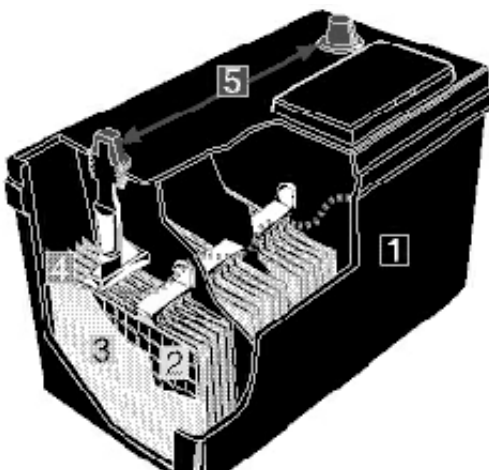
The battery does not store electrical energy. It stores chemical energy that is converted to electrical energy as it discharges.

### Battery Construction

Modern automotive batteries are made of cases (usually plastic) 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.



The plates are covered with electrolyte which is a solution of 35% Sulfuric acid and 65% Water.



1. Plastic container.
2. Positive and negative internal plates made of lead.
3. Plate separators made of porous synthetic material.
4. Electrolyte which is a dilute solution of Sulfuric acid and water better known as Battery Acid.
5. Lead terminals which are the connection point between the battery and whatever it powers.

## 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

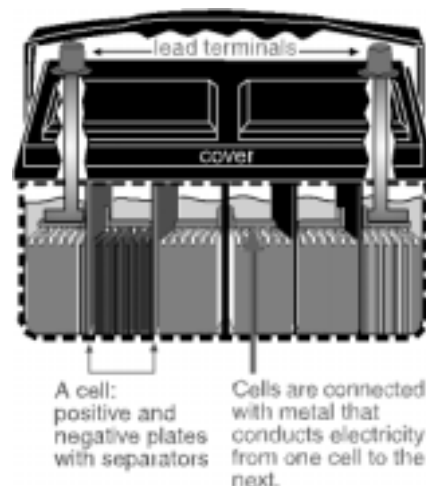
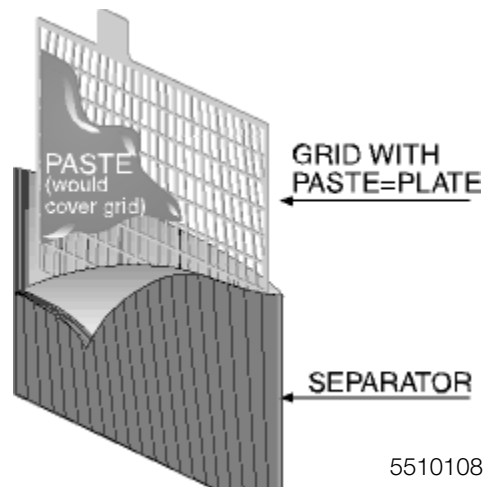
Plates are grids covered with a paste mixture of Lead Oxide and Sulfuric Acid and water. An expander material made of powdered sulfates is added to the paste to produce negative plates.

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.



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## 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.

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.



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## **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 by-product 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.

Hybrid batteries were first installed in the E30 convertible (SIB 61 12 91) during the 1991 Model Year.

# 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).

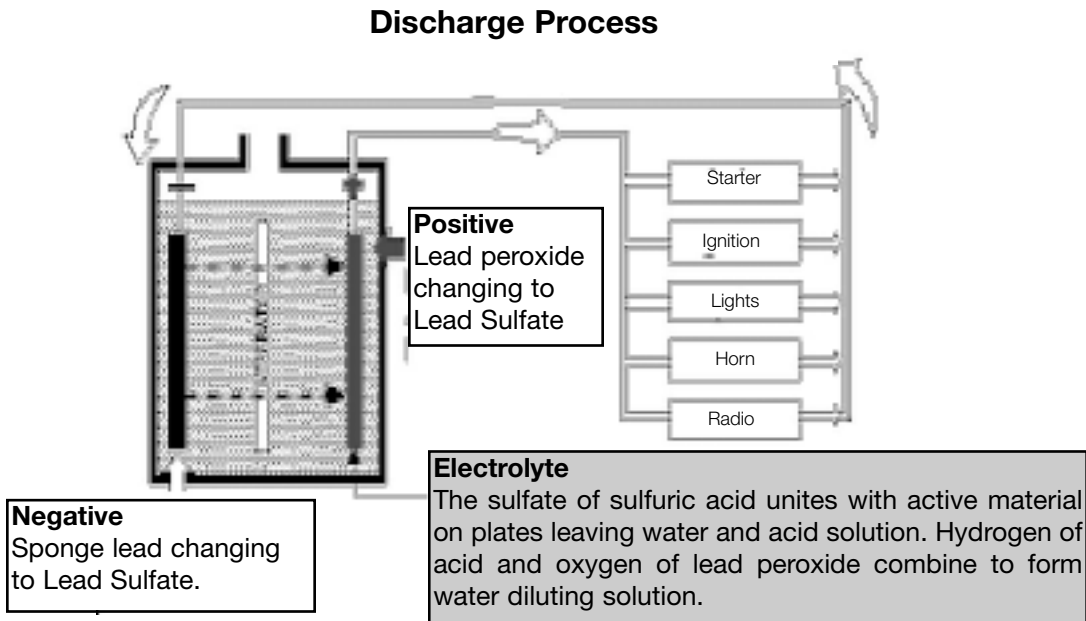
The extra electrons from the negative plate are passed from the negative battery terminal and through the electrical consumer, back to the positive battery terminal. Once back at the battery, the free electrons combine with the positive ions at the positive battery terminal producing lead sulfate and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

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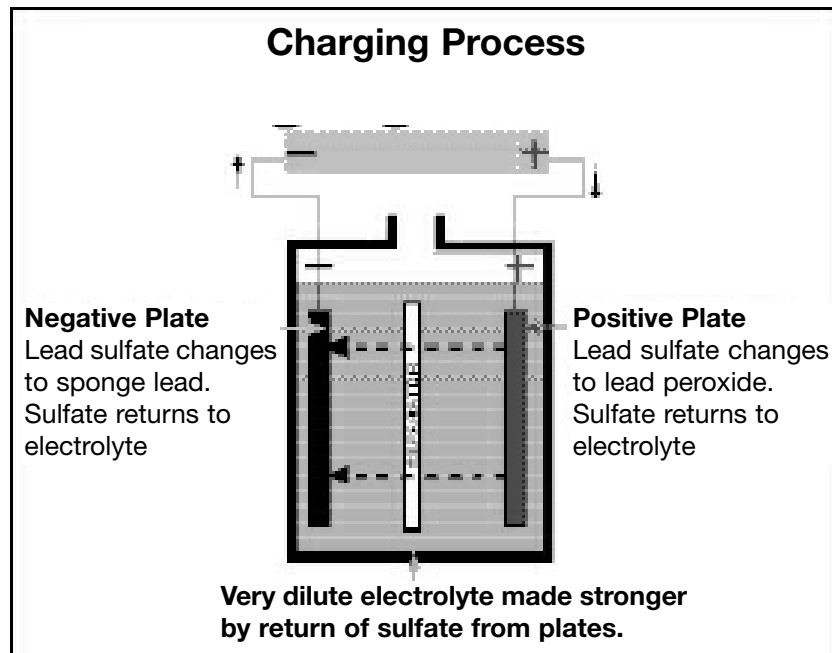
## Charging

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.



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## Common Battery Terms



### Teile-Nr. (Part No.) 61021 6 902 796

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12V 55AH 480A	EN 555 080 048
12V 90RC 425CCA	SAE Group No . 47

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fur Ersatz (for replacement):

Teile - Nr. 61 21 6 902 796 Nass (wet)

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- **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.
- **Ω -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**

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# Original BMW

Teile-Nr.(Part No.) 61 21 8 381 762

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12V 90Ah 720A EN 590 051 072

12 V 175C 850CA SAE

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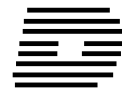
fur Ersatz (for replacement).

Teile-Nr.61 21 8 381 762 neB (wet)



ManUFACTURED FOR  
DETA-DOUGLAS  
BATTERIES, INC.

by:



DOUGLAS BATTERY  
Winston-Salem, NC

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## Battery Testing

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

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

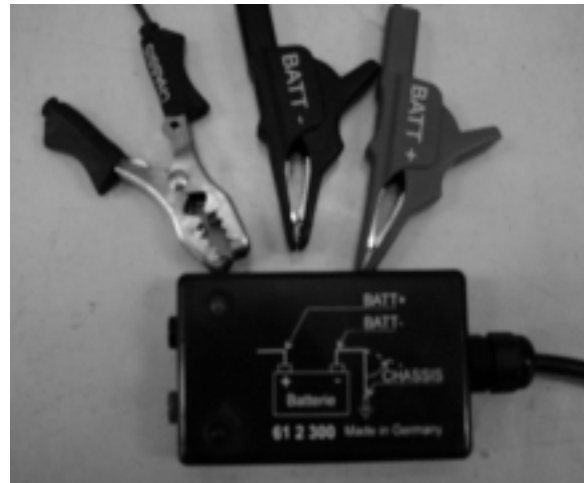
### Tools Needed

To test a battery following tools are needed:

- DVOM Digital Volt Ohm Meter
- Battery Load Tester (i.e. Snap On VAT 60)
- DISplus or MoDic
- Battery Draw Test Special Tool PN 61 2 300
- Closed Circuit Measurement Adapter PN 90 88 6 612 310
- Temperature Compensating Hydrometer

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## 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

**Note:**

The proper electrolyte level is just covering the plates, not all the way to the top of the battery inspection holes.

## 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

Open Circuit Battery Voltage	Approximate State Of Charge	Average Cell SG
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

Use the table to determine the battery's State-of-Charge.

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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.

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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, 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 built-in hydrometers, indicates the battery must be recharged before proceeding.

Replace the battery if one or more the 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 degrees up to 100°.

If the temperature is below 80°F subtract .1 volt for every 10 degrees to 40°.

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## 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.

As described in SIB 61 01 90, battery electrolyte level should be checked on every Inspection I and Inspection II.

Use only distilled water to top up the battery ! Tap water and electrolyte must never be used to refill or top off an automotive battery.

#### Workshop Hint

Electrolyte levels may drop at a higher rate in the winter months, due to higher loads and increased utilization of electrical systems ( SIB 61 01 90).

### 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.

#### Workshop Hint

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

### 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.

Always connect the positive lead of the battery charger to the positive terminal of the battery and the negative lead of the battery charger to the negative terminal of the battery.

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

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

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

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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.

**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.



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## **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.

## **Battery Maintenance (Center Vehicles)**

The battery charge is monitored while the vehicle is at the VPC and before it leaves on the transport. When the vehicle is having the QC I performed at the center the check list requires that the battery voltage be checked and maintained to 12.65V minimum.

In order to facilitate tracking vehicles in inventory, BMW has in place a Battery Maintenance Program. The program uses :

- Battery Log Forms
- Battery Log Binder
- Colored windshield stickers (red, green, yellow and white)  
The Battery Maintenance Program has three possibilities:
- Vehicle in storage, battery disconnect switch removed
- Vehicle in showroom or display
- Vehicle in storage, Battery disconnect switch left in the vehicle

### **Vehicle In Storage, Battery Disconnect Switch Removed**

A four week charging cycle has been established for these cases. All vehicles arrive with a color coded sticker on the windshield. The color corresponds to the week that the battery must be charged. Also the vehicle will be provided with a Battery Log Form.

The "A" portion (Vehicle Receipt) of the Log Form must be completed during the QC I Display check and then has to be filed in the Battery Charge Log Book under the applicable color coded section. All the vehicles in that color section will have to be charged that week.

### **Vehicle In Showroom or Display**

Because of the high consumer demand on vehicles that are being displayed and not driven, a four week charging cycle is not enough. For vehicles in the showroom the battery has to be charged as frequently as necessary to ensure that the battery never drops below 12.5V. Use the "C" portion of the log form (Display Vehicle - Monitored Daily) to keep track of the charging and checking of the battery.

**Vehicle In Storage, Battery Disconnect Switch Left In The Vehicle.**

Since the battery disconnect switch is left installed and in the “OFF” position the 3 month charge cycle can be used. Use the “D” section of the Battery Log Form to document when the battery is charged.

Upon the sale of the vehicle, the Battery Log Form should be removed from the binder and placed in the vehicle file for future reference.

**2000  
Battery Log Form** Stock # \_\_\_\_\_

**VPC USE:** VIN: \_\_\_\_\_  
 Voltage: \_\_\_\_\_  
 Date: \_\_\_\_ / \_\_\_\_ / \_\_\_\_  
 Inspector: \_\_\_\_\_

This form should be filled out when the vehicle is received and updated according to the proper procedure (display vs. storage vehicle). It should be placed in the vehicle history file when sold.

**Note:** Failure to maintain batteries as recommended and documented with this form will be considered sufficient cause to reject warranty claims.

<b>(A) Vehicle Receipt</b>		Model	VIN
Center #	Voltage as received	Inspected by	Date received

**(B) Vehicle In Storage - Charged Every 4 Weeks**      Color indicates battery is to be charged during the week of . . .

Week Of	Voltage Before Charge	Charged By	Week Of	Voltage Before Charge	Charged By	Week Of	Voltage Before Charge	Charged By	Week Of	Voltage Before Charge	Charged By
Jan. 3			Jan. 10			Jan. 17			Jan. 24		
Jan. 31			Feb. 7			Feb. 14			Feb. 21		
Feb. 28			Mar. 6			Mar. 13			Mar. 20		
Mar. 27			April 3			April 10			April 17		
April 24			May 1			May 8			May 15		
May 22			May 29			June 5			June 12		
June 19			June 26			July 3			July 10		
July 17			July 24			July 31			Aug. 7		
Aug. 14			Aug. 21			Aug. 28			Sept. 4		
Sept. 11			Sept. 18			Sept. 25			Oct. 2		
Oct. 9			Oct. 16			Oct. 23			Oct. 30		
Nov. 6			Nov. 13			Nov. 20			Nov. 27		
Dec. 4			Dec. 11			Dec. 18			Dec. 25		

**(C) Display Vehicle - Monitored Daily**

Date									
Voltage before charge									
Charged by									

Date									
Voltage before charge									
Charged by									

## Battery Log Form Stock # \_\_\_\_\_

This form should be filled out when the vehicle is received and updated according to the proper procedure (display vs. storage vehicle). It should be placed in the vehicle history file when sold.

**Note:** Failure to maintain batteries as recommended and documented with this form will be considered sufficient cause to reject warranty claims.

<b>(A) Vehicle Receipt</b>		Model	VIN
Center #	Voltage as received	Inspected by	Date received

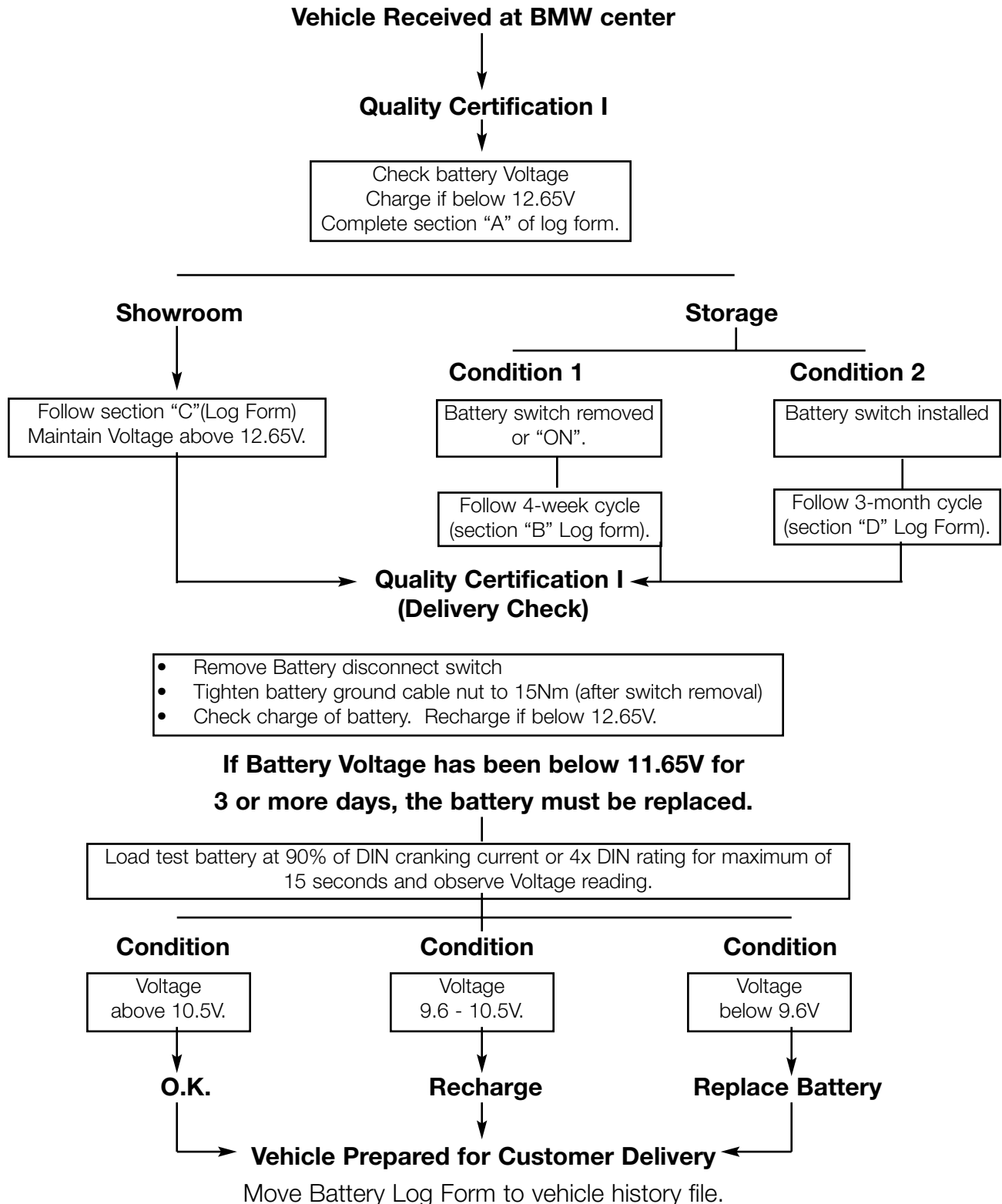
<b>(B) Vehicle In Storage - Charged Every 3 Months</b>					
<b>January</b>	Date	<b>February</b>	Date	<b>March</b>	Date
Voltage Before Charge	Charged By	Voltage Before Charge	Charged By	Voltage Before Charge	Charged By
<b>April</b>	Date	<b>May</b>	Date	<b>June</b>	Date
Voltage Before Charge	Charged By	Voltage Before Charge	Charged By	Voltage Before Charge	Charged By
<b>July</b>	Date	<b>August</b>	Date	<b>September</b>	Date
Voltage Before Charge	Charged By	Voltage Before Charge	Charged By	Voltage Before Charge	Charged By
<b>October</b>	Date	<b>November</b>	Date	<b>December</b>	Date
Voltage Before Charge	Charged By	Voltage Before Charge	Charged By	Voltage Before Charge	Charged By

<b>(C) Display Vehicle - Monitored Daily</b>									
Date									
Voltage before charge									
Charged by									

Date									
Voltage before charge									
Charged by									

**Note:** If the battery voltage drops below 11.6 v for three days or more the battery must be replaced before delivery to the customer

## Battery Maintenance Flowchart



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## 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.

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## Workshop Hints

### Safety Tips

- Proper Clothing:
  - Always wear a face shield or safety goggles.
  - Plastic gloves can prevent acid burns to hands.
- Neutralizing Electrolyte:

Any leakage or spillage of battery electrolyte should be neutralized as soon as possible to prevent damage to paint, body or trunk linings. Depending on the amount of spillage dilute some baking soda in water and apply to areas of the car that have been exposed to the battery electrolyte. The neutralizing action will create some foaming in the area where the chemical action takes place. Flush with ample amounts of water once the chemical reaction has subsided.

### General Battery Hints

- Add only distilled water NEVER TOP OFF WITH ACID.
- Keep electrolyte level above plate separators.
- Keep battery top clean and dry.
- Keep open flame and metal objects away from battery top and terminals.
- Keep vent caps tightly in place (if applicable).
- Use proper charging equipment.

### Notes

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## Workshop Exercise

1.

Vehicle Model: \_\_\_\_\_

Record OCV and Battery Ratings: \_\_\_\_\_

Perform Battery Test: \_\_\_\_\_

Step A: \_\_\_\_\_

Step B: \_\_\_\_\_

Step C: \_\_\_\_\_

Step D: \_\_\_\_\_

What was the State-of-Charge prior to testing: \_\_\_\_\_

At what amperage was this battery tested: \_\_\_\_\_

What was the voltage after Load Testing: \_\_\_\_\_

Did the voltage change after the waiting period: \_\_\_\_\_

\_\_\_\_\_

2.

Vehicle Model: \_\_\_\_\_

Record OCV and Battery Ratings: \_\_\_\_\_

Perform SG test with hydrometer: \_\_\_\_\_

Record Results:

Cell1: \_\_\_\_\_

Cell2: \_\_\_\_\_

Cell3: \_\_\_\_\_

Cell4: \_\_\_\_\_

Cell5: \_\_\_\_\_

Cell6: \_\_\_\_\_

What is the State-of-Charge of this battery: \_\_\_\_\_

Are the SG reading within specified limits: \_\_\_\_\_

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3.

Vehicle Model: \_\_\_\_\_

Record OCV and Battery Rating: \_\_\_\_\_

Perform Battery Sulphation Test: \_\_\_\_\_

Is this battery sulphated: \_\_\_\_\_

A voltage reading during this test of 15V indicates: \_\_\_\_\_

What should be done with a battery which fails this test: \_\_\_\_\_

What would be the optimum charge rate and time to charge this battery in an attempt to recover the battery: \_\_\_\_\_

Why is a slow charging time preferred: \_\_\_\_\_

At what temperature would this battery freeze: \_\_\_\_\_

Battery Notes:

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## Special Battery Systems

Special battery systems are broken into two groups:

- Vibration Compensating Battery Systems
- Dual Battery Systems

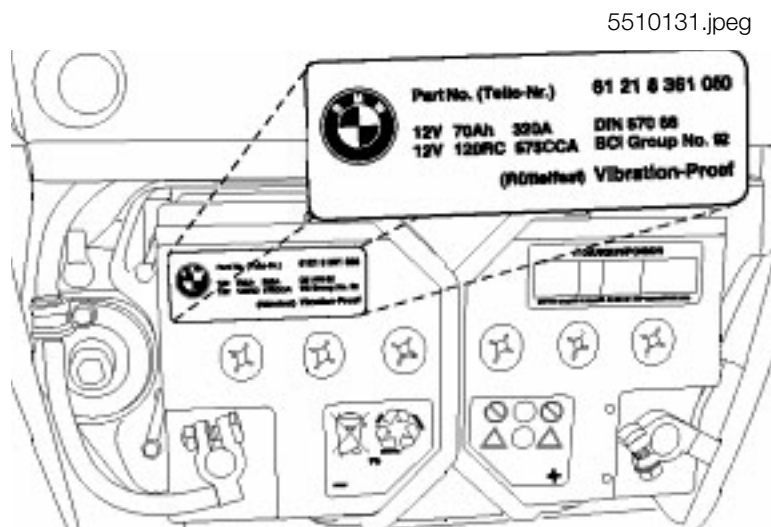
### Vibration Compensating Battery Systems

Vibration Compensating Battery Systems act as vibration absorbers, smoothing out road vibrations in the E36 and E46 convertibles.

#### E36 :

The E36 convertible is not only an energy source. The battery is designed as a vibration dampener. Due to this additional function the battery also has a special tray with an integrated vibration absorber.

**Note:** E36 convertible batteries are labeled “Vibration Proof”. Replacement batteries must be of the same type.



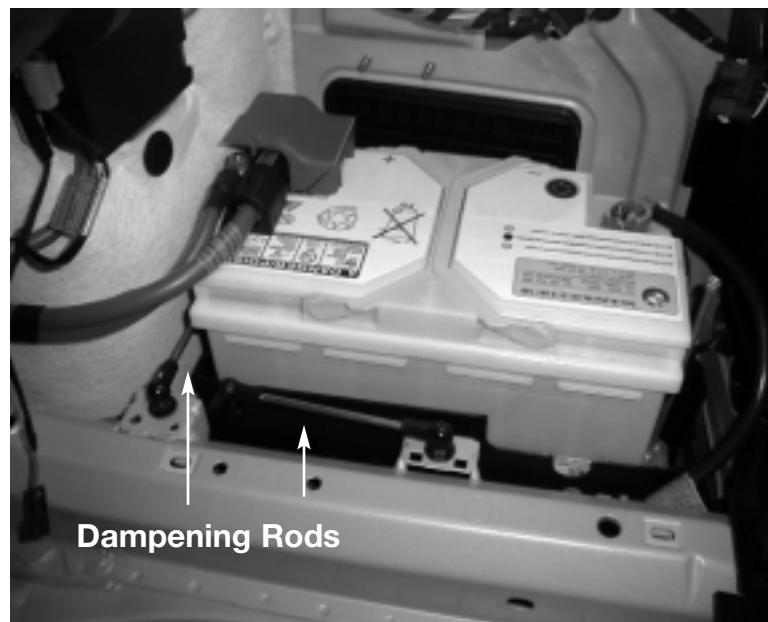
5510131.jpeg

5510133.jpeg

#### E46:

The E46 convertible uses the same battery as the E46 sedan, coupe and touring. The battery box is specially designed to float on the vertical axis through three articulated rods.

This allows the battery to act as an inertia mass and dampen various vibrations while the vehicle is driven.



Dampening Rods

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## Dual Battery Systems

### E31 (850i):

The dual battery system on the 850i was introduced to handle the higher level of electronic technology with increased functions and safety features that were added to the vehicle, as well as the added diagnostic information.

Design considerations were made to minimize electrical loads during Key Off and periods of driving with low engine speeds while certain timed operations (e.g. Glove compartment light, courtesy lights and seat heating) were active.

Special testing and charging procedures exist for the dual battery system on the 850i, refer to **SIB 61 10 90** and **SIB 61 06 91** for specific information.

### E38 750iL:

The dual battery system on the 750iL is necessary due to the addition of the E-CATs. If a single battery system was used, the E-CATs would be provided power from the single battery just after cold engine start-up when the battery is at its lowest capacity. This would increase engine loads due to charging of the single battery and cause an increase in injector "On" time during the cold engine warm-up period, which result in unnecessary tail pipe emissions.

Providing separate battery systems for the starting circuit and the vehicle circuits also minimizes the possibility of a discharged starter battery ensuring reliable engine starting.

### Components of E38 Dual Battery System

- Starter Battery: Located in the right rear trunk wheel, the starter battery is connected to the starter motor and to the heating coils of the E-CATs (via the E-CAT module).
- Vehicle Circuit Battery: Located above the starter battery on a swing out mount, the vehicle circuit battery provides operating power for the balance of the vehicles electrical requirements and is directly connected to the vehicle generator.
- Battery Isolation Switch: Located on the swing out mount of the vehicle circuit battery the battery isolation switch opens and closes the circuit between both batteries based on monitored conditions.

#### Note:

The battery isolation switch is **NOT** used to boost a discharged starter battery with the voltage of the vehicle circuit battery to start the engine.

**The battery isolation switch can only withstand a maximum current flow of 60 amps.**

## Battery Isolation Switch

The Battery Isolation Switch provides the vehicle with separate battery systems for the vehicle circuits and the starting circuit.

When the isolation switch is open, the vehicle circuit battery is the only power source connected to the power distribution center.

When the isolation switch is closed the starter battery is charged and the vehicle circuit battery is boosted by the starter battery.

Modes of the isolation switch:

- Starting Mode
  - Normal Starting
  - Safety Starting
- Driving Mode
- Charging Mode
- Sleep Mode

### Starting Mode

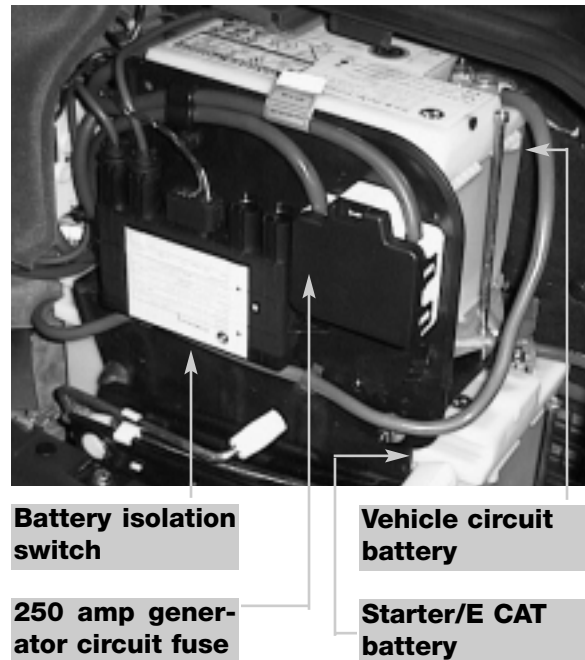
When the isolation switch recognizes KL15 via the K Bus, it determines the voltage of the vehicle circuit battery.

- If the vehicle circuit battery **IS** sufficiently charged, it proceeds with **Normal Starting**.
- If the vehicle circuit battery **IS NOT** sufficiently charged, it proceeds with **Safety Starting**.

### Normal Starting

- The isolation switch is open.
- Within 0.5 seconds of engine start-up the E-CAT module energizes the E-CAT heating coils (program dependent) and simultaneously signals the isolation switch that the E-CATs are "On" via signal "KATON" (low signal).
- Upon completion of the heating period, the E-CAT module signals the isolation switch that the E-CATs are off (High Signal).
- Under normal conditions, the isolation switch is not closed before the heating procedure is finished.

5510137.jpeg



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## **Safety Starting**

- In response to a discharged condition of the vehicle circuit battery, the isolation switch closes to momentarily boost the vehicle circuit battery and supply all systems with starter battery voltage via the power distribution center. This operation lasts for a maximum of 30 seconds or until confirmation of engine start up is received. (TD signal on the K Bus)
- Receiving the TD signals causes the isolation switch to immediately open for the duration of the E-CAT heating cycle.
- If the engine is not started within the 30 seconds, the isolation switch opens and remains open until KL 15 is recognized on the next start-up cycle.

## **Driving Mode**

The vehicle circuit battery is permanently connected in parallel to the generator and is charged when the engine is running. When the isolation switch is closed, the generator simultaneously charges the starter battery.

As the vehicle is driven the isolation switch cycles between open and closed based on:

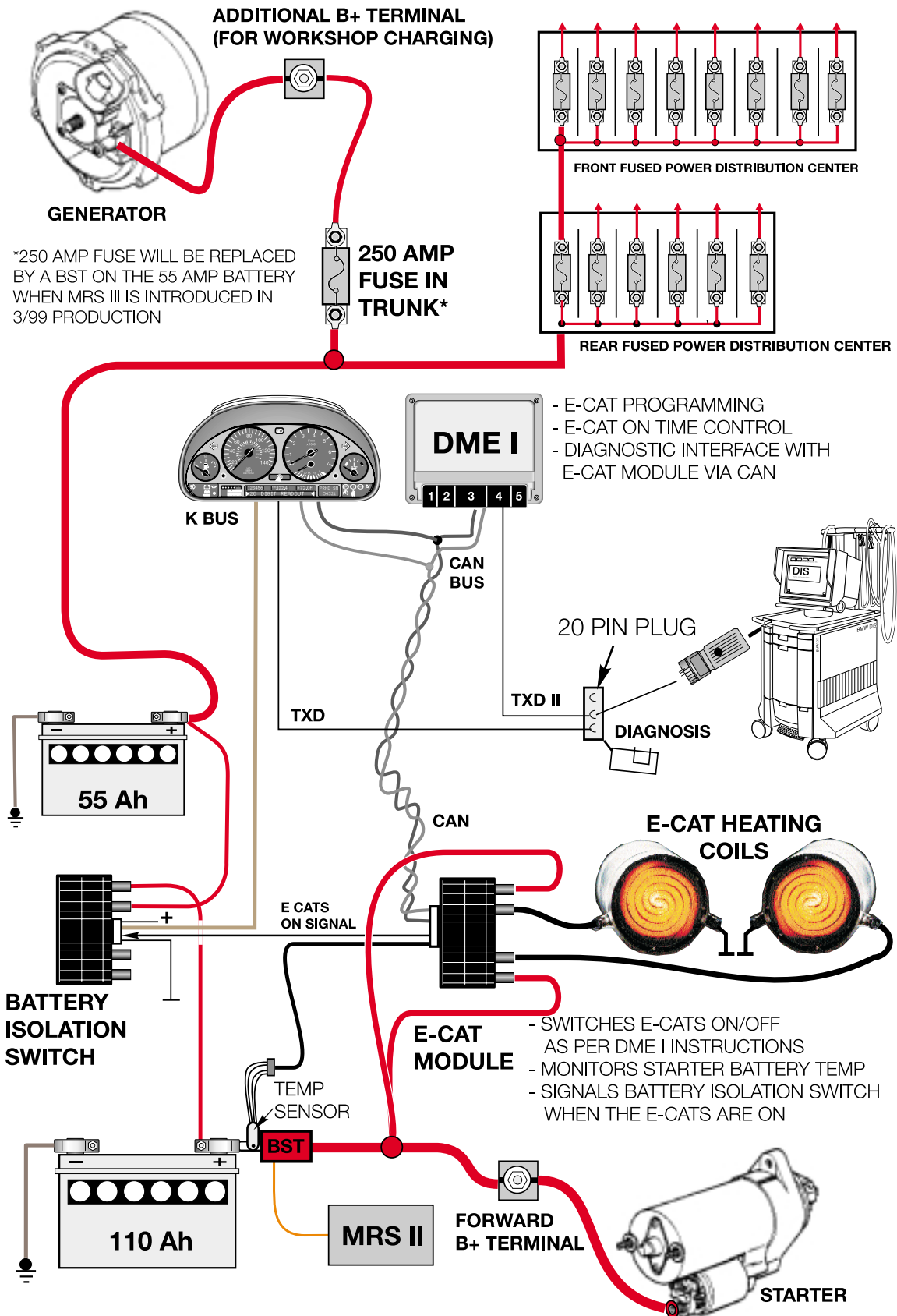
- Voltage values of both batteries.
- Current transfer between both batteries as monitored by the isolation switch.
- Internal temperature of isolation switch.

### **Conditions Causing Switch To Open While Driving**

- Sufficiently charged starter battery.
- Current flow through switch exceeding 0.5 amps.  
The starter battery will supplement vehicle electrical needs during periods of high demand (e.g continuous wiper operation combined with lights and blower).
- The internal temperature of the isolation switch exceeds programmed maximum value.

### **Conditions Causing Switch To Close While Driving**

- Monitored voltage of vehicle circuit battery exceeds that of starter battery by 0.7 volts.
- The voltage of the vehicle circuit battery drops below 9 volts three times within one minute.



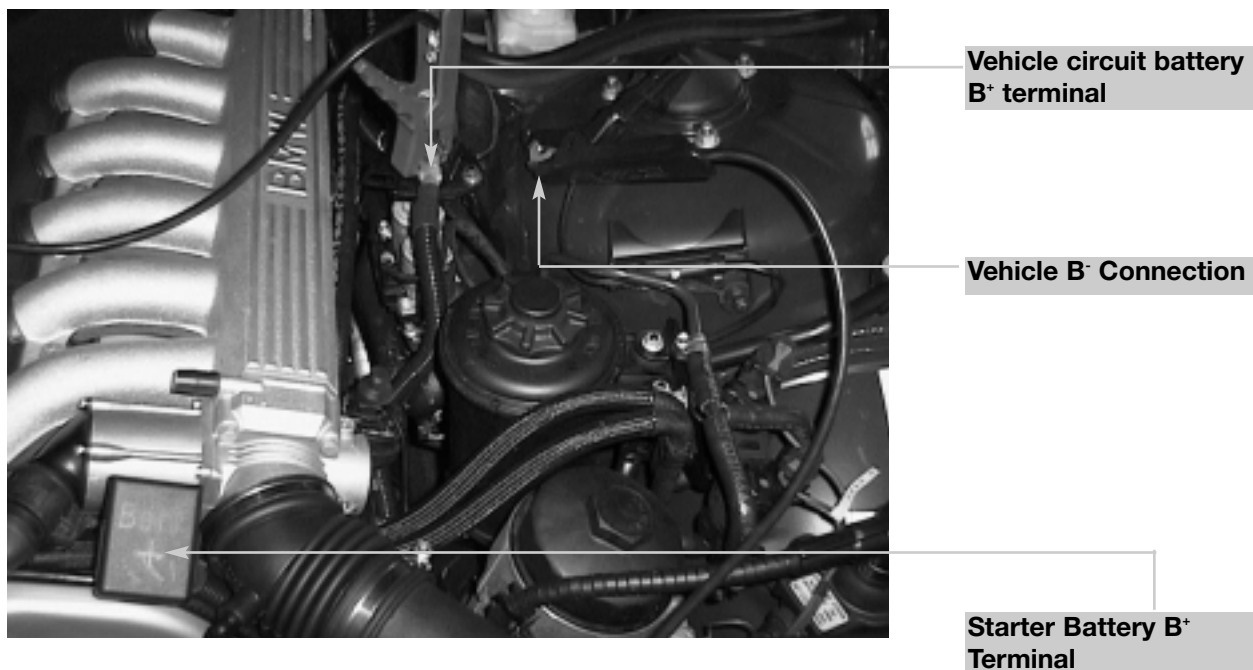
## Charging Mode (in the workshop)

The isolation switch monitors starter battery voltage during key off conditions and continues monitoring after the vehicle and the isolation switch have entered sleep mode.

- If starter battery voltage exceeds 13.8 volts during charging in the workshop, the isolation switch comes out of sleep mode and closes.

This causes the starter battery voltage to bleed off to the vehicle circuit battery, charging the circuit battery and protecting the starter battery from overcharging.

The isolation switch remains closed until the next key on cycle.



## Sleep Mode

The isolation switch goes into sleep mode as soon as the engine is switched off. The current draw of the isolation switch drops below 1mA. The isolation switch comes out of sleep mode if:

- KL15 is recognized
- Starter battery voltage exceeds 13.8 volts (charging mode)

## Failure of KATON signal

If the **KATON** signal is not received due to:

- Open or short to B<sup>+</sup> - isolation switch closes for 4 seconds after start-up, TD received.
- Short to B<sup>-</sup> - isolation switch opens 60 seconds after receiving TD

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## Workshop Exercise

1.

Vehicle Model: \_\_\_\_\_

Access battery isolation switch through Diagnosis: \_\_\_\_\_

Though Component Activation, check status of disconnecting switch: \_\_\_\_\_

Trigger closing of disconnecting switch: \_\_\_\_\_

Observe and record voltage change in system and starter battery and note change when status of switch is changed: \_\_\_\_\_

What is the nominal resistance of the semiconductor switch with disconnect switch closed: \_\_\_\_\_

Open: \_\_\_\_\_

What is the temperature of the power circuit-breaker in the disconnect switch:

How many Test Modules are available for the disconnect switch: \_\_\_\_\_

Start engine and observe status of disconnect switch: \_\_\_\_\_

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## 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.

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

- Closed Circuit Current Measurement Adapter
- MoDic Adapter
- DISplus, MoDic or DVOM

To correctly measure closed-circuit current, measurement adapter **61 2 300** (P/N 90 88 6 612 300) should be used. This tool provides a bridge to ground, before the negative battery terminal is disconnected, and this prevents the control units from being reset.

The additional use of MoDiC adapter **61 2 310** (P/N 90 88 6 612 310) provides a method for current measurements over an extended period of time.

The measuring device needed depends on the situation.

The DISplus may be used in situations of suspected high current draw.

The 1000 amp probe measures AC and DC current from 0 to 1000 amps. It is a self calibrating inductive pick-up. (Use this pick-up with current draws over 10 amps)

The DISplus, through MFK 1 is capable of measuring up to 2 amps.

The MoDic is particularly suitable for extended measurements and provides a graphical readout of recorded measurements over time. It is recommended for the situations where the use of a multimeter provided insufficient information for problem diagnosis.

The DVOM may be used for measurements up to 10 amps either with the measurement adapter or alone.

#### Note:

It is extremely important that the battery is **NOT** disconnected during the installation of test equipment. Disconnection of battery may cause faulty component to function normal.

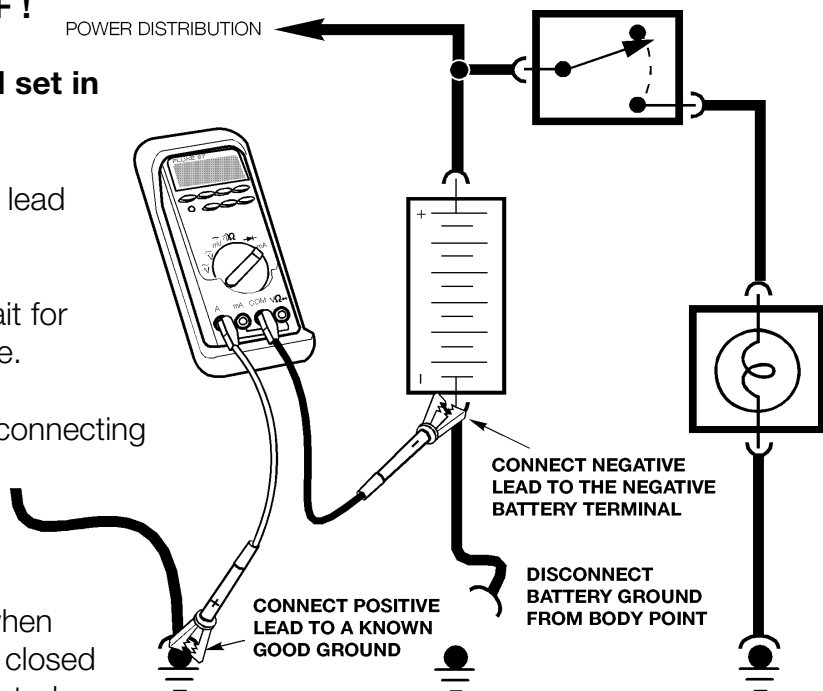


## Performing Closed Current Draw Test

- Select proper measuring device (DISplus, MoDic or DVOM)
  - Remember amperage draw in excess of 10A will damage DVOM.
  - Use inductive amp probe of DISplus when amperage draw is high.
    - When using DISplus inductive probe, clamp on negative battery cable with arrow pointing away from battery. Switch off all consumers.
    - (It is not necessary to disconnect B- from body when using inductive probe)
- Connect (-) test lead to negative battery terminal and (+) test lead to a known good ground.

- Ensure all systems are **OFF !**
- **Be sure DVOM is on and set in proper mode.**

- Disconnect battery ground lead from body.
- Observe meter reading, wait for vehicle to enter sleep mode.
- Identify faulty circuit by disconnecting fuses, relays, control modules or connectors, observing meter readings.
- Defective circuit is found when current is below maximum closed current for vehicle being tested.



Maximum closed current by vehicle	
E31	50mA
E32	50mA
E34	40mA
E36	30mA
E38	50mA
E39	40mA
E46	40mA
E52	50mA
E53	40mA
Z3	30mA

### Note:

Refer to SIB 61 08 00 for complete instructions to perform closed circuit current measurement using measurement adapter and MoDic adapter.

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## Workshop Exercise

1.

Vehicle Model: \_\_\_\_\_

Perform Closed Current Draw Testing: \_\_\_\_\_

Record current at:

Initial: \_\_\_\_\_

5 Minutes: \_\_\_\_\_

10 Minutes: \_\_\_\_\_

16 Minutes: \_\_\_\_\_

2.

Vehicle Model: \_\_\_\_\_

Customer Complaint: Battery goes dead overnight.

Observations/Symptoms/Faults stored: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Test steps/modules recommended by diagnostic program: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Test steps/modules performed: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Results: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Repair Recommendation: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Notes: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

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## Review Questions

1. What functions does the battery provide? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
2. What is electrolyte? \_\_\_\_\_
3. A battery rating of 425CCA indicates what? \_\_\_\_\_  
\_\_\_\_\_
4. What four steps are followed during a battery test? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
5. An OCV of 12.65 indicates? \_\_\_\_\_
6. What would be the expected OCV for a battery with a shorted cell? \_\_\_\_\_
7. A battery should be replaced if the SG readings vary by more than \_\_\_\_\_ per cell.
8. What is the state-of-charge in a battery with a SG of 1.190? \_\_\_\_\_
9. A battery should be load tested to the CCA rating. True \_\_\_\_\_ False \_\_\_\_\_
10. During a load test, the electrolyte temperature is 100°F, and the voltage drops to 9.8 volts. Is this acceptable? \_\_\_\_\_
11. How can a battery be tested for sulphation? \_\_\_\_\_
12. What section of the Battery Log Form must be filed out during QC I? \_\_\_\_\_
13. What is the most common cause of battery failure? \_\_\_\_\_  
\_\_\_\_\_
14. When is it OK to add acid to a battery? \_\_\_\_\_
15. Does the E46 convertible use a "Vibration Proof " battery similar to the E36 convertible? \_\_\_\_\_
16. Why was a dual battery system added to the E38 750iL? \_\_\_\_\_  
\_\_\_\_\_

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17. What is the maximum current flow the battery isolation switch can withstand? \_\_\_\_\_

18. When does the battery isolation switch allow the vehicle circuit battery to boost the starter battery? \_\_\_\_\_

19. What three conditions may cause the battery isolation switch to open while driving?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

20. When does the battery isolation switch come out of the sleep mode? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

21. How does current flow through the separators in a battery? \_\_\_\_\_  
\_\_\_\_\_

22. As a battery is discharged, what happens to the electrolyte? \_\_\_\_\_  
\_\_\_\_\_

24. What is the freezing point of a fully charged battery? \_\_\_\_\_

25. Why should the battery NOT be disconnected while preparing for a closed current measurement test? \_\_\_\_\_

26. During a closed circuit measurement test using a DVOM, the meter reading shows out-of-range. How is the test best completed? \_\_\_\_\_  
\_\_\_\_\_

27. When charging a fully discharged battery with a RC rating of 90, the battery should be charged \_\_\_\_\_ @ \_\_\_\_\_ .

28. The starter battery is located above the vehicle circuit battery on a swing out mount  
True \_\_\_\_\_ False \_\_\_\_\_ .

29. Which type of battery is more resistant to deep cycling than the Lead/Calcium?  
\_\_\_\_\_

30. What is an OHM? \_\_\_\_\_  
\_\_\_\_\_