C&D TECHNOLOGIES, INC.
Power Solutions

MOTIVE POWER DIVISION

Motive Power Batteries

Installation and operating instructions

CAUTION

Lead-acid batteries present certain shock, explosion and acid hazards. For your personal safety and that of others, read and observe the warnings placed on the batteries.

WARNING

Do not wear jewelry or any metallic objects while servicing a battery. Batteries are a source of high electrical energy; contact between metallic objects and battery terminals or intercell connectors could result in electrical shock, serious burns, sparks, or explosion. Never place metallic objects on top of a battery. Before working on a battery, be sure to discharge static electricity that can build up on tools or the technician by touching a grounded surface in the vicinity of the battery but far enough from the cells. Avoid creating sparks or exposing cells to open flames that could ignite the gases produced by a charging battery.

WARNING

Always wear protective goggles, rubber gloves, rubber apron, and rubber boots when cleaning or servicing a battery. Before cleaning the battery or measuring its voltage or specific gravity, expel hydrogen gas from all cells by removing vent caps and directing a stream of LOW-PRESSURE air into the cell openings. Do not permit electrolyte spray to contact eyes, skin or clothing.

WARNING

Replace contacts, shell or connector kit with Anderson parts only, following manufacturer's recommended repair procedures.

WARNING

Always wear protective goggles, rubber gloves, rubber apron, and rubber boots when cleaning or servicing a battery. Before cleaning the battery or measuring its voltage or specific gravity, expel hydrogen gas from all cells by removing vent caps and directing a stream of LOW-PRESSURE air into the cell openings. Do not permit electrolyte spray to contact eyes, skin or clothing. DO NOT REMOVE THE VENT CAPS FROM LIBRA AGM PRODUCTS. DOING SO WILL VOID THE WARRANTY

DANGER
SHOCK HAZARD
DO NOT TOUCH UNINSULATED BATTERY TERMINALS OR CONNECTORS

WARNING
ARC HAZARD
CONNECT OR DISCONNECT BATTERY PLUG ONLY WHEN CHARGE CYCLE IS COMPLETE

DANGER
HIGH VOLTAGE
DISCONNECT CHARGER FROM AC VOLTAGE SUPPLY AND BATTERY BEFORE SERVICING OR DISMANTLING

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1 CLASSIFICATION OF BATTERIES

It is important that the user of motive batteries determine the application of the battery in accordance with the National Electrical Code. The types of motive power batteries are designated as:

- E: Standard, with cover
- EE: Spark-proof, used in Class 3, Division 1; Class 3, Division 2 areas
- EO: Standard, without cover
- EX: Explosion-proof, used in Class 1, Division 1, Group D areas

NOTE: Only personnel who are trained in the specifics of explosion-proof batteries should be permitted to work on EX batteries and EE batteries.

2 TYPES OF BATTERIES

The following types of C&D TECHNOLOGIES batteries are covered by this manual:

- C-LINE
- V-LINE®
- LIBRA®
- C-LINE Plus
- EM-LINE™

For purposes of this manual, C-LINE, V-LINE, C-LINE Plus, and EM-LINE batteries are handled in the same manner, allowing for the differences such as specific gravities. LIBRA batteries are handled in many of the same ways but MUST be charged on equipment specifically designed for their unique requirements.

Figure 2.1 – Types of C&D Motive Power batteries

3 HOW TO HANDLE A NEW BATTERY

3.1 Receiving

Every precaution has been taken to pack the battery for shipment to assure its safe arrival. As soon as you receive the battery, check for evidence of in-transit damage to the tray, terminals, cables, connectors, and cells. Be sure that all vent caps are in place. If you think that a cell may be leaking, check the electrolyte level in all cells. (This is not necessary on LIBRA batteries.) Refer to Section 3.4 for instructions. If all cells have about the same level, there is no leak. However, if one cell is appreciably lower than the others, it may be damaged and leaking.

FIGURE 3.1 – Lifting a motive power battery

IMPORTANT: If the battery is damaged, please note the specifics on the bill of lading before you sign it and notify your C&D representative at once. Do not attempt to place a damaged battery into service before it has been repaired by an authorized C&D service office.

On F.O.B. factory shipments, shipping damage claims must be handled directly with the carrier, not with C&D TECHNOLOGIES.

When handling a battery, it is best to use an insulated lifting beam rigged with two parallel chains or cables of equal length. Properly sized hooks should be engaged through lifting ears on both ends of the battery tray, as shown in Figure 3.1.

When a lifting chain is used, a piece of masonite or plywood should be used to cover the battery top to prevent accidental short circuits. Never use a single lifting chain or cable in a "Y" arrangement, as this can distort the tray and cause serious damage to the battery.

3.2 Identification

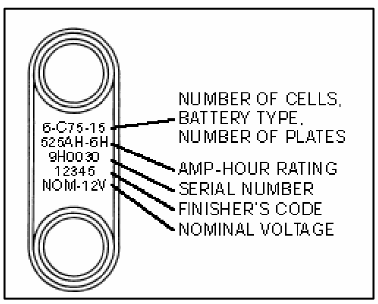


FIGURE 3.2 Identifying a Motive Power Battery

The identifying number on the intercell connector of a C&D motive power battery describes it completely. Knowing the operating characteristics of your battery is essential to proper operation and maintenance and, therefore, to expected service life and coverage under C&D warranty. Read the following explanations and examples carefully. If you have any questions, contact your C&D representative.

NOTE: On vehicles that require a counterbalancing weight, be sure the weight of the battery (stamped on the side of the tray) meets or exceeds the nameplate requirements of your vehicle.
The closest connector to the positive terminal contains stamped numbers that completely identify the battery. To expose these numbers, pry off the plastic connector cover.

EXAMPLE

Top Row: 6-C75-15. This designates the size of the battery. The first number indicates the number of cells. The letters indicate the type of battery: "C" indicates C-LINE, "CH" indicates C-LINE PLUS, "V" indicates V-LINE, "E" indicates EM-LINE and "L" indicates LIBRA. The numbers following the letter indicate the number of ampere-hours each positive plate is rated to provide over a six hour period — here, 75 ampere-hours. The last number indicates the total number of plates per cell — in this case 15. That would mean the battery has seven positive plates and eight negative plates per cell.

Second Row: 525AH-6H. This indicates the battery, properly charged, will deliver 525 ampere-hours when discharged at the 6 hour rate to 1.70 vpc.

3.2 Identification (continued)

NOTE: This is calculated by multiplying the number of positive plates (7) by the number of ampere-hours per plate (75).

Third Row: 9H0030. This is the serial number. It identifies the battery as manufactured by the C&D plant in Huguenot, NY in 1999.

Fourth Row: 12345. This is the identification number of the person at the plant who did the finish burning.
Bottom Row: NOM-12V. This indicates the battery is designed to provide a nominal voltage of 12 volts.

3.3 Storage

If you do not put a battery into service as soon as you receive it, you can store it for up to 12 months in a cool, dry, indoor location. Do not allow the electrolyte to freeze. This will ruin the battery and can cause potentially hazardous leakage.

NOTE: Batteries in storage will self-discharge and reduce the specific gravity of the electrolyte, thereby changing the freezing point. If you plan to store your new battery for an extended period, you should give it a boost charge every three months. See Section 3.4 for details.

BATTERIES MUST BE PLACED IN SERVICE WITHIN SIX MONTHS OF SHIPMENT FROM A C&D FACTORY.

When storing a battery, protect the top from dirt, moisture and falling debris. However, do not seal it with nonporous materials, such as plastic, which could inhibit the flow of air over the cells and prevent the escape of potentially explosive gases.

Storage limitations
C&D motive power batteries are warranted against defects in materials and/or manufacturing. To keep the warranty in effect, you must give the battery a boost charge every three months while in storage.
To provide information that could be of importance in evaluating problems, you should keep adequate battery operation records.

IMPORTANT: Before putting a battery on charge, it is absolutely essential you check the voltage and cable connector polarity. Voltage should be at least two times the number of cells. If it is less, one or more of the cells may be short-circuited or installed with reversed polarity. If voltage is less than the nameplate value, contact a C&D service office at once; do not put the battery on charge. If a voltmeter test indicates reversed polarity of connectors contact your C&D service office to correct this condition. Never attempt to charge a battery with reversed polarity cells.

3.4 Pre-installation boost charging

To assure a new battery is ready for service, you should give it a three to four hour boost charge before installing it in a vehicle. Before charging, the electrolyte level of each cell should be between the high and low levels shown in Figure 3.3 and should be about the same in each cell. (Not applicable to LIBRA.) Differences in electrolyte level can be adjusted by removing electrolyte from high-level cells and adding it to low-level cells. UNLESS NO WATER CAN BE SEEN ABOVE THE MOSS SHIELD, NEVER ADD WATER TO CELLS UNTIL AFTER THE BATTERY HAS BEEN FULLY CHARGED. Charging raises electrolyte levels in all cells, so adding water before charging can cause a potentially hazardous overflow.

After the new battery has been on charge for one hour, check the specific gravity of the electrolyte in a selected cell and the voltage between the positive and negative terminals of the battery. Record the values. Continue charging for another hour and check these values again, repeating the above procedure. When the specific gravity of the selected cell and the overall voltage of the battery stop changing over a three hour period, the battery is fully charged. Turn off the charger, and check the level of electrolyte in all cells of the battery. (Not necessary on LIBRA batteries.) The level should be at its high point, one-quarter inch below the bottom of the vent well, and should be equal in all cells. If it is not, you should adjust the level with deionized water or water produced by reverse osmosis. Water from a water softener is not suitable for use in industrial, lead-acid batteries. After adding water to the cells, turn on the charger for an additional 30 minutes to mix water with electrolyte, then turn the charger off and disconnect it from the battery.

NOTE: LIBRA BATTERIES MUST BE CHARGED ON C&D APPROVED MOTIVE CHARGERS. FAILURE TO DO SO WILL DAMAGE THE BATTERY AND VOID THE WARRANTY. Check with your C&D representative for a list of approved chargers.

CAUTION

NEVER ADD WATER TO A BATTERY UNLESS IT IS FULLY CHARGED. Before charging, add water only if electrolyte level is below the moss shield, and add only enough to bring the level just above the moss shield. After the battery is fully charged, add water to bring the electrolyte level to within one-quarter inch of the bottom of the vent well.

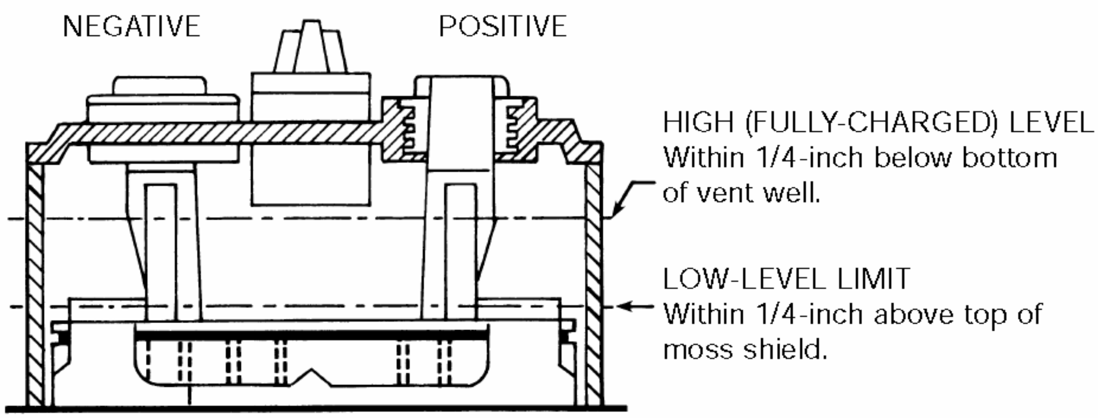


FIGURE 3.3-Upper and lower electrolyte levels

4 Installing and using the battery

4.1 General

C&D motive power batteries are designed and built to deliver years of dependable service. By following the instructions in this manual you can look forward to longer battery life, more uptime, reduced equipment repair costs, and a safer work environment.

Special attention should be paid to training battery service personnel, using a safe and efficient charging area, and properly matching the charger to the batteries.

> **CAUTION**
> Before installing or removing a battery, be sure vehicle brakes are applied and wheels are locked to prevent accidental movement. Always have at least two people on hand for the transfer, one to operate the hoist and one to guide the battery. Care should be taken to keep hands and clothing from becoming caught between battery and compartment.

4.2 Installing the battery

As described in section 3.4, the battery should receive a boost charge for approximately three to four hours before being installed in a vehicle.

In battery-counterbalanced vehicles, battery weight must equal or exceed the nameplate counterbalanced weight for the vehicle to assure safe, stable operation. Use proper equipment to transfer batteries in and out of vehicles. This can include a properly rigged, insulated lifting beam or other equipment designed specifically for battery handling. Refer to Section 3 for details on proper rigging of an insulated lifting beam.

The battery compartment of the vehicle should be clean, dry and well ventilated, with drain holes in the floor. Clearance between the walls of the battery tray and those of the battery compartment must not exceed one-half inch. It is particularly important that six- and 12-cell batteries be secured in the truck compartment in order to minimize mechanical motion and vibration which could affect battery service life.

Secure hold-down bars or other fastening devices, check that all battery vent caps are tight, and connect the battery to the vehicle.

4.3 Charging the battery

Motive power batteries discharged 80 percent during a six-hour shift require approximately eight hours of charging to restore them to full working capacity. Depending on the type of vehicle and the work situation, batteries may be removed for charging or charged while installed in the vehicle. Please note that electrolyte level checks are not necessary or possible with LIBRA batteries, since the LIBRA is a sealed battery.

Before charging, check the level of electrolyte in a selected cell. It should be between the high and low levels shown in Figure 3.3. If not, refer to Section 7 on troubleshooting. IF YOU CAN SEE ELECTROLYTE ABOVE THE MOSS SHIELD, NEVER ADD WATER TO CELLS UNTIL AFTER THE BATTERY HAS BEEN FULLY CHARGED.

Charging raises electrolyte levels in all cells, so adding water before charging can cause a potentially hazardous overflow.

Periodically before charging, you should check and make note of the specific gravity of the selected cell and the voltage of the battery as measured with a voltmeter across the positive and negative terminals.

Refer to Tables 4.1or 4.2 for specific values. The battery is fully charged when the specific gravity and battery voltage stop rising in three successive hourly measurements. Turn off the charger and check the electrolyte level in all cells of the battery. The level should be equal in all cells. If it is not, you should adjust it with deionized water. Water from a water softener is not suitable for use in industrial, lead-acid batteries. After adding water to the cells, turn the charger back on for an additional 30 minutes to mix water with electrolyte, then turn off the charger and disconnect it from the battery.

NOTE: LIBRA BATTERIES MUST BE CHARGED ON C&D APPROVED MOTIVE CHARGERS. FAILURE TO DO SO WILL DAMAGE THE BATTERY AND VOID THE WARRANTY. Check with your C&D representative for a list of approved chargers.

Important precautions

• Compare nameplates on battery and charger to be sure they are matched in voltage and ampere-hour capacity.

• Be sure the charger is turned off before connecting it to or disconnecting it from a battery. Failure to observe this important precaution can lead to potentially hazardous arcing and connector contact damage.

• Before initiating a charge check the electrolyte temperature to make sure it is at least 65ºF (18.3ºC) and no more than 115ºF (46.1ºC), as specified in BCI-I-2(4/97). Do not charge a battery unless the electrolyte temperature falls within this range.

• To avoid overcharging damage, do not charge a battery unless it has been discharged below a specific gravity of 1.240 for all types of batteries. Run it for another shift in the same light service before putting it on charge.

4.4 Effects of cell temperature

Battery capacity and recharge times are based on a nominal electrolyte temperature of 77ºF (25ºC). Below this temperature, batteries will have less capacity, take longer to fully recharge, and produce more gas while on charge. Continued excessive gassing will damage the plates. Above this temperature, batteries will have greater self-discharge and shortened service life. Problems become more severe if electrolyte temperatures do not fall within the 45ºF (7ºC) to 100ºF (38ºC) operating limits of a motive power battery. At lower temperatures, charging times will be extended and excessive gassing may become unacceptable.

At higher temperatures, the battery may accept so much charging current that thermal runaway occurs, with almost certain damage to the battery and possible hazard.

Electrolyte temperature normally rises 10ºF to 25ºF (-12ºC to -4ºC) as a direct result of charging. Ordinarily this causes no problems. However, if the charging area is excessively warm, 90ºF (32ºC) for example, electrolyte temperatures of 110ºF (43ºC) could easily occur. This is very close to the BCI-specified 115ºF (46ºC) upper limit and could damage the battery and reduce its effective service life.

Low temperatures can also damage a battery. The concentrated, high specific gravity electrolyte in a fully charged battery has a freezing point of about –85ºF (-65ºC). However, in a discharged battery where electrolyte concentration and specific gravity are lower, the freezing point can rise to just below 32ºF (0ºC) as the electrolyte turns almost totally to water. Discharged batteries are vulnerable to mechanical damage from freezing.

Hydrometer Reading (sg)	Electrolyte Temperature (°F)	Points Correction for Hydrometer
1.278	117	+12
1.281	107	+9
1.284	97	+6
1.287	87	+3
1.290	77	+0
1.293	67	-3
1.296	57	-6
1.299	47	-9
1.302	37	-12

Table 4.1 Temperature Corrections for Specific Gravity Measurements

When measuring the specific gravity of electrolyte, you must correct for its temperature to get a true reading. As a rule of thumb, specific gravity changes by 0.003 (three points) for every 10 degrees Fahrenheit change in temperature.

4.5 Balancing a battery electrically with an equalizing charge (not applicable to LIBRA)

The charge levels of individual cells within an operating battery tend to become slightly unbalanced with time. To correct these imbalances and assure all cells are equalized and able to deliver the full, rated capacity, we recommend leaving the battery on charge for an additional three hours beyond the normal charge cycle once a week.

Be sure to record the voltage and specific gravity of every cell after this procedure, as a point of reference for service records.

NOTE: LIBRA BATTERIES MUST BE CHARGED ON C&D APPROVED MOTIVE CHARGERS. Check with your C&D representative for a list of approved chargers.

4.6 How to size a charger to a battery

MPORTANT: Before initiating a charge cycle, compare the nameplates on the battery and charger to be sure they are matched in voltage, ampere-hour capacity and number of cells.

If a charger does not have the capacity to completely restore the electro-chemical energy of a battery, it can cause operating problems and damage the equipment and the battery. During a normal, six-hour discharge, an inadequately charged battery will be discharged below the recommended 80 percent level, resulting in progressively shallower charges until possible equipment failure or battery failure, or both, occur. On the other hand, if a charger is too large for a battery, it will cause the battery to overheat, soften the active material, require an excessive amount of water and substantially reduce its service life.

A properly sized charger should fully restore a battery in about eight to ten hours. A recommended start rate for charging is 20 amperes per 100 ampere-hours of battery capacity at the six-hour rating.

At the end of a charge, the charger should be providing approximately three amperes per 100 ampere-hours for a new battery. For an older, conventional battery, the current will increase to approximately four to five amperes per 100 ampere-hours but at a proportionally lower final voltage. LIBRA will remain essentially constant throughout life.

Figures 4.1 and 4.2 show the variations in voltage and specific gravity that occur during a typical charging cycle. As energy is returned to the battery in the form of charging current, cell voltage rises, approaching a maximum value. Cell voltages, specific gravity and ampere-hour capacity continue to rise until they stabilize at end of charge.

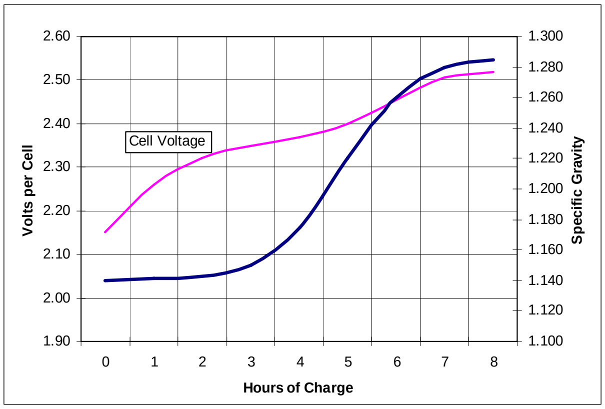


FIGURE 4.1 Typical variations in voltage and specific gravity that occur during charging of a flooded battery.

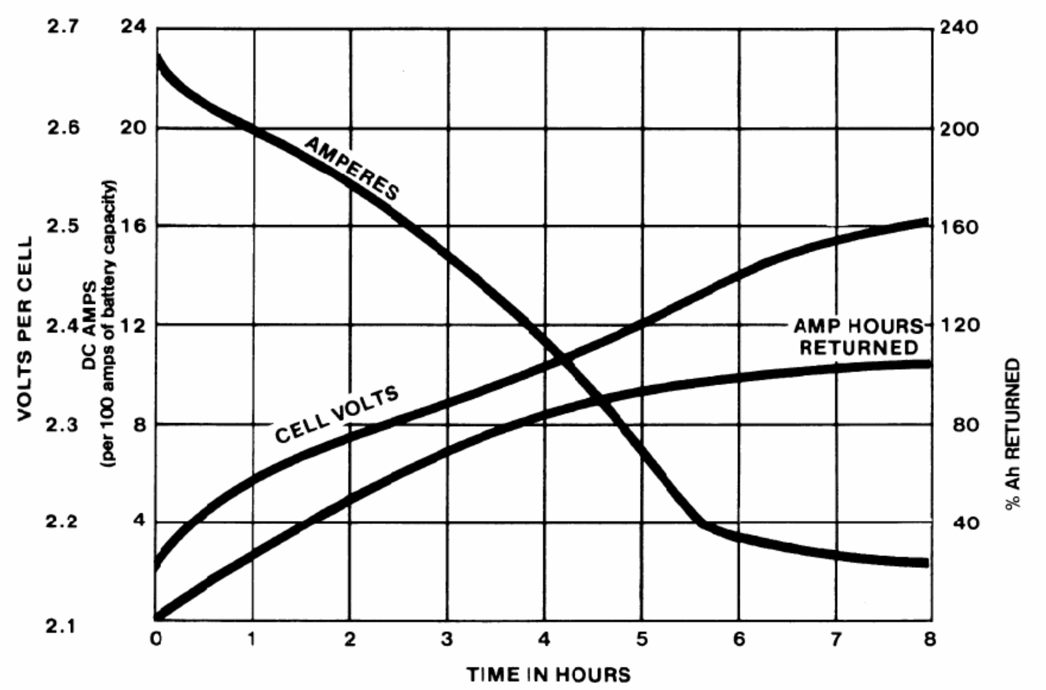


FIGURE 4.2 Typical charging characteristics of a C-LINE or V-LINE lead acid battery connected to a properly sized charger. LIBRA, C-LINE Plus, and EM-LINE exhibit similar curves.

NOTE: Some battery lines, such as LIBRA and C-LINE PLUS, will recharge properly on a matched charger but require a microprocessor-based control with derivative action such as the C&D CompuCharge or Ranger II. If it is discharged beyond 80 percent, a higher gravity battery may require more than eight hours to fully recharge.

4.7 Discharging a battery

As a battery is discharged, its specific gravity, cell voltages and available kilowatt hours (kWh) are reduced. As Table 4.2 shows, a typical, fully charged battery has a specific gravity of approximately 1.290 at 77ºF (25ºC) and an open circuit voltage of about 2.125 volts per cell. Assuming the workload is distributed evenly over a six-hour period, specific gravity would decrease as evident in Table 4.2. It is essential you monitor the specific gravity of a battery in service to prevent discharging below 80 percent of its rated six-hour capacity.

Battery Type	Ah per Positive Plate @ 6 Hr Rate	Fully Charged Gravity	Specific Gravity 80% Discharged	Specific Gravity 100% Discharged
C45	45	1.290±.005	1.177	1.150
C55	55	1.290±.005	1.186	1.160
C75	75	1.290±.005	1.177	1.150
C75E	75	1.260±.005	1.180	1.160
C85	85	1.290±.005	1.150	1.120
C85E	85	1.260±.005	1.172	1.150
C90L	90	1.290±.005	1.153	1.120
C100	100	1.290±.005	1.165	1.135
C125	125	1.290±.005	1.145	1.110
C150	150	1.290±.005	1.169	1.140
C170	170	1.290±.005	1.145	1.110
CH95	95	1.310±.005	1.168	1.135
CH137	137	1.310±.005	1.162	1.125
V85	85	1.290±.005	1.168	1.139
V100	100	1.290±.005	1.155	1.122
V125	125	1.290±.005	1.157	1.125
EM80	80	1.290±.005	1.185	1.160
EM120	120	1.290±.005	1.185	1.160

TABLE 4.2 Specific gravities of standard-height batteries. All gravities are with electrolyte at high level and fully mixed prior to discharge.

4.8 Effects of depth of discharge

A flooded battery is usually sized to use no more than 80 percent of its rated ampere-hour capacity during a six-hour shift. This provides reserve capacity for emergencies and allows for the gradual decrease in capacity that occurs as a battery ages. Flooded battery warranties are based on an 80 percent maximum discharge. LIBRA AGM products are sized on a 60% maximum routine depth of discharge.

An overdischarged battery may require extended charging time to restore it to full capacity and cause overheating. If full capacity is not restored, discharge can become progressively deeper and shorten battery life. On the other hand, if a battery is not discharged near its maximum capacity, it is possible to use it for another light shift before recharging it. Do not repeat for more than one shift, being careful not to discharge the battery below the maximum recommended values.

> **CAUTION**
> Removing more than the maximum recommended capacity from the battery will shorten the useful service life and could invalidate the warranty.

The 100 percent discharge specific gravities listed in Table 4.2 represent low limits.

NOTE: All values in Table 4.2 are derived from calculations. Actual values, read immediately after a discharge, will be somewhat higher until diffusion stabilizes. Differences of 20 to 40 points in specific gravity may be noticed.

4.9 Batteries with SMARTBATTERY®III

SMARTBATTERYIII is a computerized module that mounts onto the top of your battery. Batteries with and without SMARTBATTERY III operate exactly the same way, but the SMARTBATTERY III module measures ampere-hours, temperature and voltage, giving you a better idea how well the battery is being used. This information is viewed through a laptop computer, Ranger® II charger control or RMS-2000 system. Detailed instructions for retrieving this information from a RANGER II charger control are in the charger manual. For more information on the SMARTBATTERY III module, contact your local C&D representative.

5 Maintaining the battery

5.1 General precautions

5.2 Cleaning and inspection

CAUTION

Lead-acid batteries present certain shock, explosion and acid hazards. For your personal safety and that of others, read and observe the warnings placed on the batteries.

WARNING

Do not wear jewelry or any metallic objects while servicing a battery. Batteries are a source of high electrical energy; contact between metallic objects and battery terminals or intercell connectors could result in electrical shock, serious burns, sparks, or explosion. Never place metallic objects on top of a battery. Before working on a battery, be sure to discharge static electricity that can build up on tools or the technician by touching a grounded surface in the vicinity of the battery but far enough from the cells. Avoid creating sparks or exposing cells to open flames that could ignite the gases produced by a charging battery.

WARNING

Always wear protective goggles, rubber gloves, rubber apron, and rubber boots when cleaning or servicing a battery. Before cleaning the battery or measuring its voltage or specific gravity, expel hydrogen gas from all cells by removing vent caps and directing a stream of LOW-PRESSURE air into the cell openings. Do not permit electrolyte spray to contact eyes, skin or clothing. DO NOT REMOVE THE VENT CAPS FROM LIBRA AGM PRODUCTS. DOING SO WILL VOID THE WARRANTY

WARNING

Replace contacts, shell or connector kit with Anderson parts only, following manufacturer's recommended repair procedures.

For safe, efficient operation, battery tops should be kept dry and free of dirt. Remove dirt and other contaminants with a dry, nonmetallic brush. With vent caps in place, apply a solution of water and mild household detergent with a paintbrush and flush away the residue with low-pressure water, taking care not to let the cleaning solution enter the cells. Dry the battery thoroughly by wiping with clean cloths. Check batteries periodically for damage to the tray or cell tops.

CAUTION

Avoid dangerous arcing or heat build-up by periodically checking intercell connectors, battery terminals, and connectors for looseness, pitting and corrosion.

5.3 Neutralizing spilled electrolyte

Neutralize spilled electrolyte IMMEDIATELY with a solution of one pound baking soda per gallon of water. With vent caps in place, apply solution with a clean paintbrush, working it around the battery top and under the intercell connectors until all "fizzing" stops. Flush away all traces of baking soda using clear, LOW-PRESSURE water. Do not allow the baking soda solution to enter battery cells.

5.4 Measuring voltage and specific gravity (Not applicable for LIBRA product)

All measurements must be made on a fully charged battery. Voltages and specific gravities of individual cells and overall battery voltage across the terminals should be measured and recorded once a week, following the completion of charging. Individual C-LINE and V-LINE cells should have a voltage of at least 2.50 to 2.55 volts per cell on charge and a specific gravity of at least 1.275 on a new battery. Voltage across the battery terminals should equal the number of cells multiplied by the average voltage per cell. Cells measuring more than -0.075 volts below average and lower than 1.265 specific gravity should be rechecked for possible internal problems. Refer to the troubleshooting and cadmium electrode testing information in Section 7.

Use a voltmeter to measure cell and battery voltages. After selecting the proper scale on the meter and matching battery/probe polarities, position measuring probes for individual cells and for the battery terminals. Be careful not to contact terminals or exposed intercell connectors with anything but the measuring probes.

A graduated hydrometer is used to measure the specific gravity of the electrolyte in a cell.

As a cell is discharged, the specific gravity drops; as it is charged, it rises.
A hydrometer reading is, therefore, an indication of the level of charge. When taking hydrometer readings, always hold the syringe vertically and be sure the float can move up and down freely with no pressure applied to the bulb. Be sure your eye is on a level with the surface of the liquid, as shown in Figure 5.1.

FIGURE 5.1 – Measuring specific gravity of cell electrolyte with a hydrometer

5.4 Measuring voltage and specific gravity (continued)

NOTE: Keep eye on level with surface of liquid; disregard surface tension curvature or meniscus. Following use, the glass parts of the hydrometer syringe should be washed with soap and warm water and rinsed with clear water to keep them clean and accurate.

As shown in Figure 5.2, specific gravity is read on the hydrometer scale at the level at which the float comes to rest in the electrolyte.

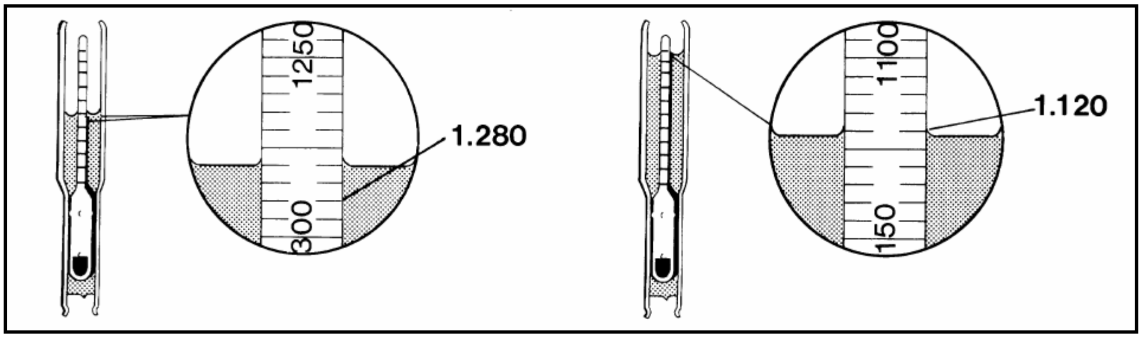


FIGURE 5.2-The correct way to read a hydrometer

5.5 Watering the battery (not necessary for LIBRA product)

Charging, in addition to raising the specific gravity of the electrolyte in the cells, also causes some of the electrolyte to decompose into gas, which escapes through the vent caps. This loss causes the electrolyte level to drop in all cells, requiring replenishment with deionized water before the battery is returned to service.

With the fully charged battery still on charge, remove the vent caps and add enough deionized water to each cell to bring the electrolyte level to one-quarter inch below the vent well. After watering all cells and replacing the vent caps, leave the battery on charge for another half-hour so the gassing action in the cells can mix the added water thoroughly with the electrolyte.

IMPORTANT: Use only deionized water or distilled water or water by reverse osmosis to top off the electrolyte in a lead-acid cell. Demineralized water is unsuitable, as it contains contaminants which will reduce the capacity of the battery and shorten its useful life.

5.6 Adjusting specific gravity of the electrolyte

CAUTION
Acid adjustment should be performed only by a trained battery technician. If you have any questions, please address them to an authorized C&D service office.

Adjusting the specific gravity of a cell is a potentially hazardous procedure, possibly involving the addition of sulfuric acid. Never attempt such adjustments unless you have established over several weeks of operation that normal charging, together with periodic equalize charging, will not restore the specific gravities to within the nominal limits. When raising the specific gravity of a cell(s), handle acid with care and always wear the appropriate protective goggles, gloves, apron and boots. Use only approved electrolyte grade sulfuric acid of 1.400 specific gravity. Never use acid with a specific gravity higher than 1.400, as it can permanently damage a cell.

The electrolyte in a fully charged cell should have a specific gravity as shown in Table 4.2 at 77ºF (25ºC), corrected for level and temperature. Specific gravities above this range for standard height cells/batteries should be corrected by the addition of water; below this range, by the addition of acid. Adjusting the specific gravity of the electrolyte in a cell is not a simple task. It should be undertaken only when other corrective actions have failed and only by a trained battery technician.

To adjust specific gravities, place the fully charged battery on charge for at least one hour and allow it to gas. Select the cell or cells with abnormal specific gravities and, after removing some electrolyte, slowly add either a small quantity of 1.400 acid to raise specific gravity or deionized water to lower it. Acid is heavier than electrolyte; adding it too quickly will cause it to settle to the bottom of the cell. By adding acid slowly, the gassing of the cell will mix it thoroughly with existing electrolyte.

Depending on plate size, raising the electrolyte level of a cell one-quarter inch by adding 1.400 acid will raise the specific gravity by four or five points; for example, a specific gravity of 1.265 will be raised to approximately 1.270. Conversely, adding one-quarter inch of water will drop specific gravity by four or five points to 1.260.

5.7 Correcting unequal cell voltages

Unless a cell develops an internal short circuit, most cases of unequal cell voltage can be corrected by an equalizing charge or by carefully checking and adjusting the specific gravity of the electrolyte. Please refer to Section 7 for troubleshooting suggestions.

5.8 Restoring sulfated cells

Sulfated cells are those in which the plates are partially coated with unreacted lead sulfate. This occurs if the battery is not fully recharged after many discharges or if it is allowed to remain partially or fully discharged for extended periods of time. Sulfation decreases battery capacity by reducing the effective surface area of the plates. It is indicated by lower-than-normal cell voltage and specific gravity.

To restore a lightly sulfated cell to normal operation, use the following procedure:

1) Give the battery an equalizing charge.
2) Near the end of the charge, add water to bring electrolyte levels within recommended limits.
3) Discharge the battery, either through a load bank or by placing it in service.
4) Recharge the battery fully and maintain it on charge until the specific gravities of all cells stabilize over three successive hourly measurements. Check the specific gravity of selected cells several times during this period.
5) Repeat this charge/discharge procedure — several times, if necessary — until all cells are within ±.005 of the recommended specific gravity.

Batteries that do not respond to this treatment should be referred to your local C&D service representative.
NOTE: DIFFERENT PROCEDURES ARE NECESSARY FOR LIBRA PRODUCTS. PLEASE CONTACT YOUR C&D REPRESENTATIVE FOR MORE INFORMATION.

5.9 Removing and replacing a defective cell

NOTE: FLOODED PRODUCT ONLY. CONTACT YOUR C&D REPRESENTATIVE FOR INSTRUCTIONS ON REPLACING LIBRA CELLS.

The first step in removing a cell from a battery is to disconnect it from adjacent cells. First, remove intercell connector covers. Then, drill out the intercell connectors, as shown in Figure 5.3, and lift them off the posts. With the special, annular shaped tool and a motorized drill, you can carefully remove connectors so as to not damage them so they can be used again.

To prevent short circuits and contamination, cover adjacent cells with clean, wet cloths before drilling.

After intercell connectors are lifted off, carefully remove all metallic particles from the top of the battery. For batteries that are finished with sealing compound, work a long, heated spatula down to the bottom of the compound-filled spaces around the cell to cut through the compound and separate the damaged cell from adjacent cells and from the tray. Connect a post lifter (C&D Part No. RE-642) to the negative post(s) and, using an appropriate lifting device, lift the cell out of the battery tray, as shown in Figure 5.4. NEVER LIFT A CELL BY THE POSITIVE POST(S).

With the cell removed, thoroughly clean the empty space and adjacent surfaces with a baking soda solution, removing all intercell compound and old packing. A suitable cleaning/neutralizing solution can be made by mixing one pound of baking soda with one gallon of water.

IMPORTANT: Be sure the new cell has the same rated ampere-hour capacity and dimensions as the cell it replaces. Cell terminals should be connected with the proper orientation and polarity in the battery.

WARNING

Only personnel with training should undertake the removal and replacement of battery cells, as the dangers from electrical and sulfuric acid hazards are significant. In addition to personal hazards, improper procedures and handling can damage adjacent cells in the battery.

Do not permit electrolyte spray to contact eyes, skin or clothing. Always wear protective goggles, rubber gloves, rubber aprons, and rubber boots. Use only insulated hand tools when working on battery cells, and before using processes that require elevated temperatures or an open flame, purge hydrogen gas from the cell with low pressure air. Before working on a battery, it must be removed from the vehicle.

Connect the post lifter to the negative post(s) and with an appropriate lifting device, lift the new cell into position in the tray. Add sufficient packing, if required, around the cell walls to create a snug and evenly spaced fit. Be sure the new cell rests evenly on the bottom of the tray, as evidenced by the cell cover being even with adjacent cell covers. For batteries finished with sealing compound, seal the new cell to the tray and to adjacent cells with a deep layer and a shallow "cap" layer of PS-109 sealing compound, available from your C&D service representative.

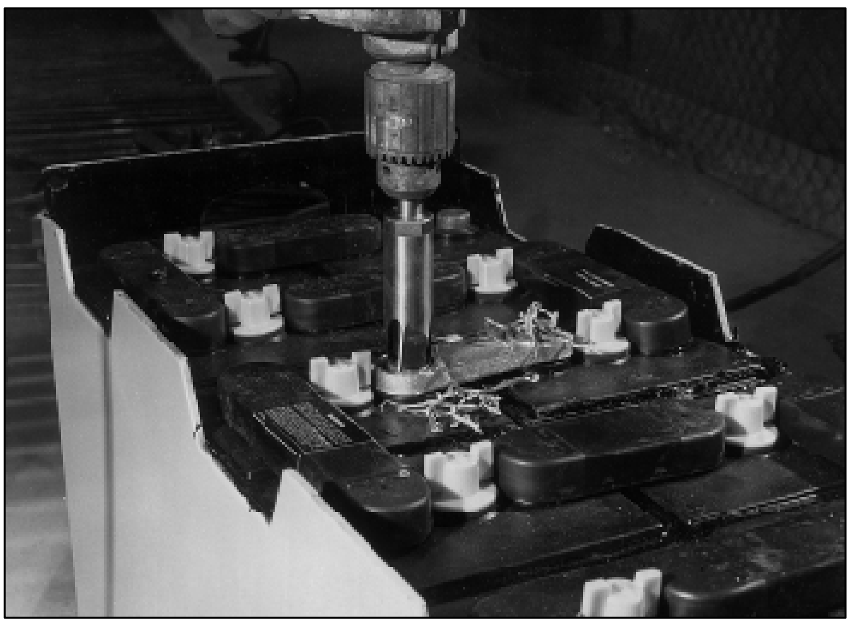


FIGURE 5.3 Removing intercell connector with a special annular drill bit (protective cloths are removed for clarity of photograph)

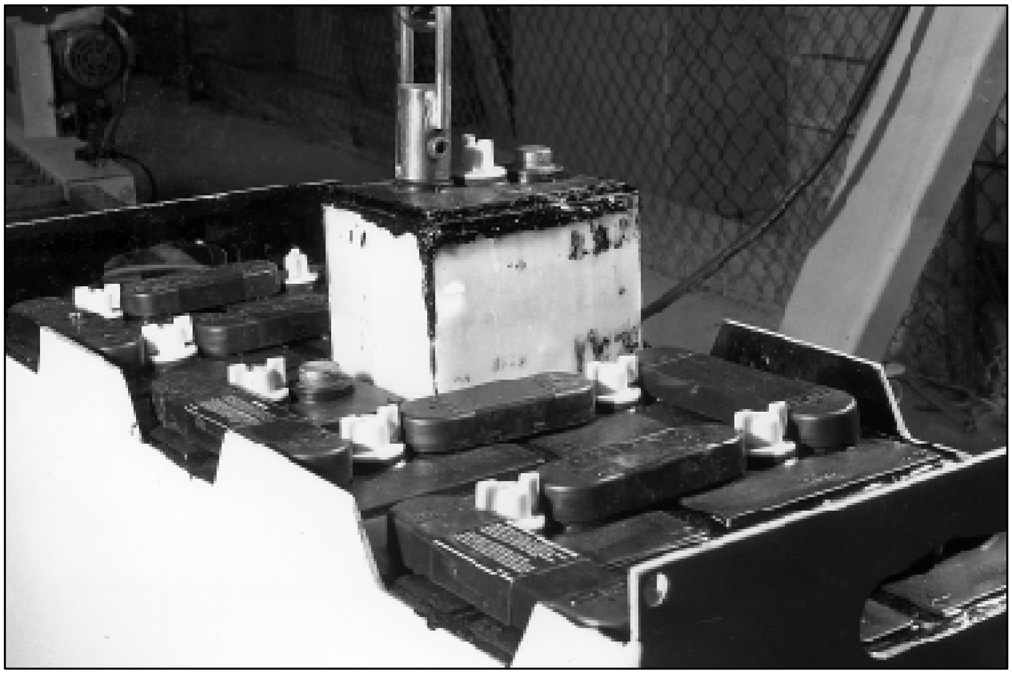


FIGURE 5.4 Removing a cell from a battery (protective cloths are removed for clarity of photograph)

WARNING
Melted sealing compound is extremely hot and can cause severe burns if it contacts the skin.

Heat the compound in a small pan. When it is completely melted, pour it into the channel around the new cell, filling the channel on all four sides. DO NOT OVERHEAT THE SEALING COMPOUND. With a torch set to a narrow, soft (yellow) flame, carefully heat the compound to assure adherence to all cell walls and covers for a complete seal. BE CAREFUL NOT TO BURN THE PLASTIC JAR, CELL COVERS, OR THE TRAY FINISH.

Apply a “cap” layer of melted compound over the existing layer and reflame it until the surface is smooth and the channel is well sealed.

With a baking soda/water solution and a wire brush, clean the posts and intercell connectors that are to be reconnected. Remove all residue with a clean, dry cloth. Build posts with tool RE-481. If necessary, use tool RE-483 for post insert rebuilding. Position the connector over its posts, placing button molds (C&D Part No. PH-557, PH-558, or PH-559) as shown in Figure 5.5. Place strips of damp cloth around adjacent connectors.

All interconnecting parts of the battery are lead alloy, and the new intercell connector must be welded or “burned” back onto the cell posts. A standard, commercially available burning torch with a small, hot (blue) flame, fueled by natural gas and oxygen or propane and oxygen should be used. DO NOT USE OXYGEN-ACETYLENE OR ACETYLENE FLAME, AS IT IS TOO HOT AND PRODUCES AN UNDESIRABLE CARBON RESIDUE.

After you have sealed and reconnected the new cell to the adjacent cells, replace connector covers, place the battery on an equalizing charge, check the electrolyte level in all cells, and return the battery to service. If any electrolyte spillage has occurred, clean battery top.

NOTE: The new cell may not achieve full, rated capacity until after several charge/discharge cycles.

FIGURE 5.5 “Burning in” a new intercell connector to cell posts (protective cloths are removed for clarity of photograph)

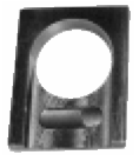
5.10 Repairing jar-to-cover seal (compound-sealed covers)

As a battery progresses through its useful life, varying degrees of degradation may occur between the jar and cover. It is recommended the repair of any jar-to-cover seal be performed at a C&D service facility.

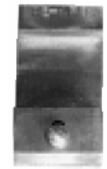
5.11 Service tools

The following special tools, required for removal and replacement of battery cells, are available through your C&D representative.

PH-557 Connector button mold



PH-558 Connector button mold



RE-479 Connector splicing mold

RE-481 Post rebuilder mold (used when cover is removed)

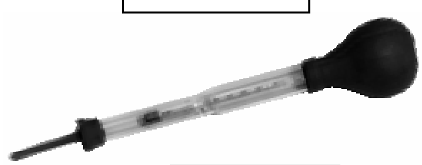
RE-2005 Annular one-inch bit (for connector removal)

RE-642 Large loop clamp post lifter

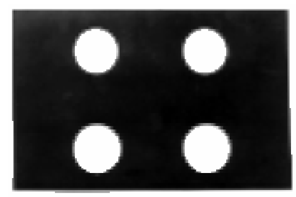
RE-483 Post rebuilder mold (used when cover is in place)

PL-644 Thermometer

Cadmium stick RE-776



PL-515 Hydrometer



RA-2072 Heat shield, four hole (used as an aid in burning)

FIGURE 5.6-Tools used in battery cell removal, replacement and maintenance

PH-557	Connector button mold for intercell connector
PH-558	Connector button mold for logo
PH-559	Connector button mold – ¾ inch
PL-0672	Air test pump and gauge
PL-515	Hydrometer
PL-644	Thermometer
RA-2071	Heat shield, two hole (used as an aid in burning)
RA-2072	Heat shield, four hole (used as an aid in burning)
RE-149	One set of jar hold-down clamps
RE-479	Connector splicing mold
RE-481	Post rebuilder mold (used when cover is removed)
RE-642	Large loop clamp post lifter – ¾ inch
RE-776	Cadmium stick
RE-2005	Annular one-inch bit (for connector removal)
RE-2624	Carbon burner clip assembly
RE-2666	Heat seal welding kit (Laramie)

6 How a battery works

6.1 General

The lead-acid battery is based on the principle that an electrical potential (voltage) is developed when two dissimilar metals are immersed in a conductive solution (electrolyte). The basic components of a typical lead-acid battery are shown in Figure 6.1.

Comprised of a number of cells, the voltage of a battery depends on how many cells are connected in series. The ampere-hour capacity of a battery depends on the total surface area and volume of active material in the positive plates and the reactivity of the active material with free electrolyte sulfate ions.
As electrical energy is removed from a cell, an electrochemical reaction takes place. The available energy is removed as the sulfuric acid electrolyte (H2SO4) is depleted and both the positive and negative plates are partially converted to lead sulfate. When electrical energy is restored by a battery charger, the electrochemical reaction is reversed and the battery is recharged, restoring the electrolyte to its original specific gravity and the plates to their original, sponge lead (negative plate) and lead dioxide (positive plate). The following chemical equation occurs:

$$Pb + PbO_2 + 2H_2SO_4 \rightleftharpoons 2PbSO_4 + 2H_2O$$

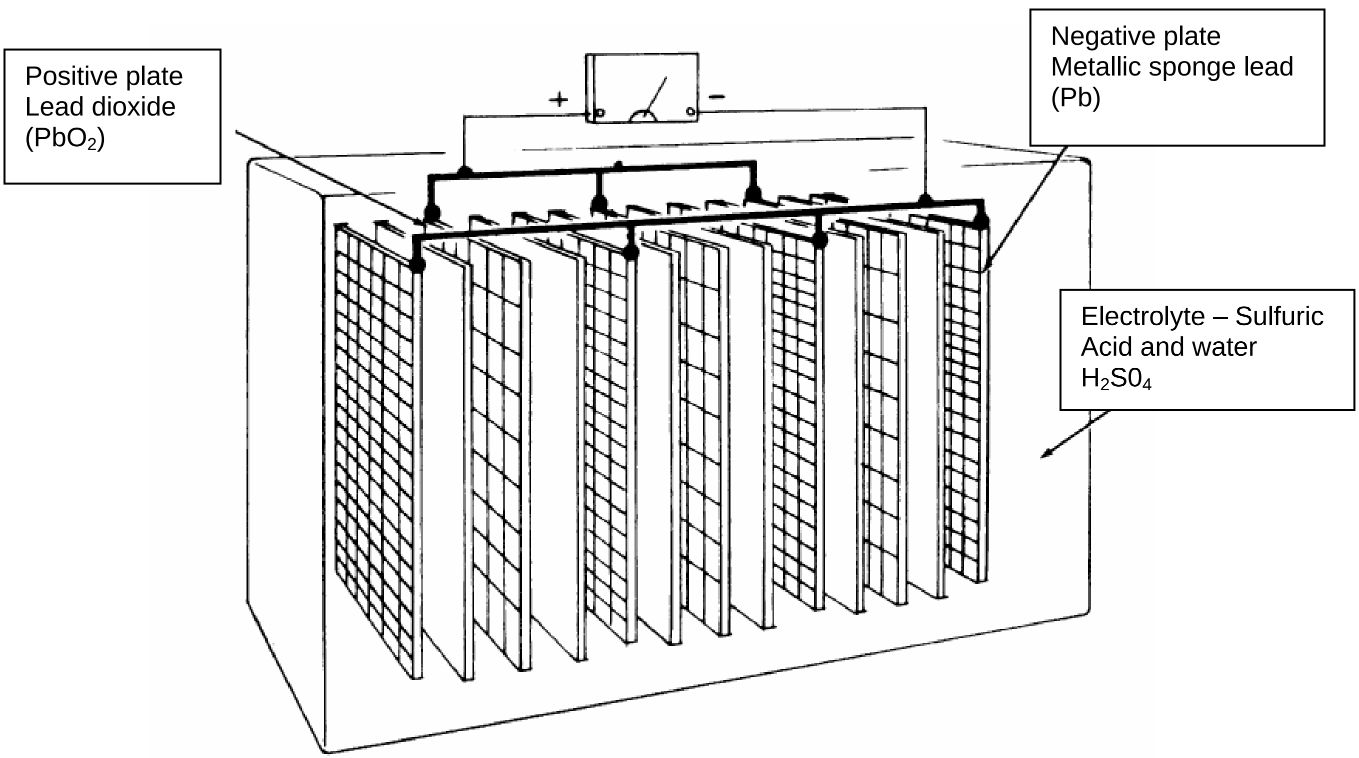
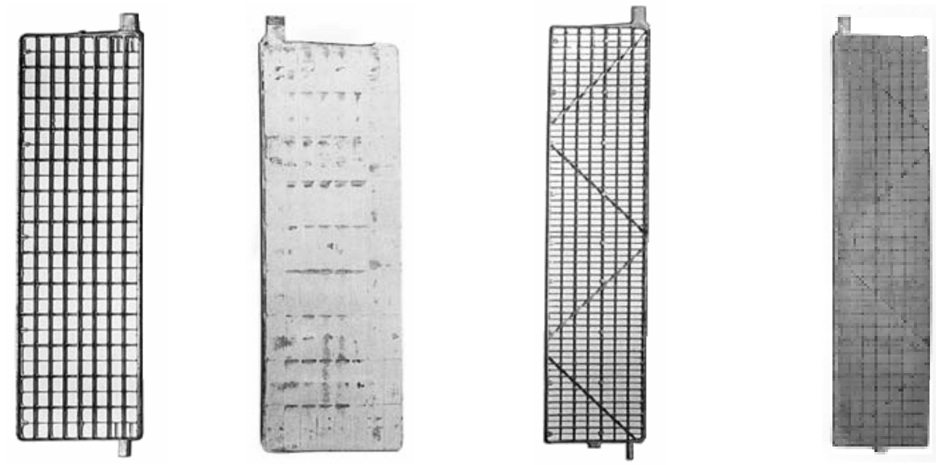


FIGURE 6.1-Basic components of a flat-plate, lead-acid battery

6.2 Construction



Positive Grid Positive Plate Negative Grid Negative Plate

FIGURE 6.2-Positive grid structure and positive plate, negative grid structure and negative plate

A flat-plate, lead-acid cell is constructed of lead-alloy grids with many rectangular openings into which lead oxides are embedded to subsequently form pasted negative and positive plates (Figure 6.2). The grid structure supports the active materials and conducts electrical current to and from the cell posts. The process of placing active material in the grids of flat-plate type, lead-acid batteries is known as "pasting."

Lead in its pure state has good electrical conductivity and excellent resistance to corrosion. However, it is relatively soft with poor tensile strength. To provide the strength and hardness required for use as a battery grid, pure lead is often combined with small amounts of antimony to form an alloy used for motive power batteries.

Antimony has the unfortunate side effect of requiring more water and accelerating corrosion of the lead. It depresses the end of charge voltage, which causes the battery to require more water. This need for water also increases as the battery ages. The logical step to reduce watering is therefore to reduce the amount of antimony in the alloy. The range of antimony needed is 4 to 6%; anything under 4% requires an additional element to stabilize and harden.

Positive and negative plates are assembled as shown in Figure 6.2. Because the plates on each end are always negative, a lead-acid cell always contains one more negative plate than positive plates. The total number of plates in a cell is always an odd number. Microporous separators are inserted between positive and negative flat plates to provide electrical insulation.

LIBRA batteries incorporate a totally different wrapping and separation system. In LIBRA batteries, both plates are wrapped with a special glass fiber mat which provides both active material retention and separation. Plate alloys are selected for corrosion resistance and strength. These alloys do not contain hazardous cadmium, allowing the battery to be recycled at any lead acid battery recycler without special hazardous material charges.

6.3 Assembling cells into batteries

After plates are assembled in the proper orientation (negative-positive-negative), a moss shield is fitted over the tops of the cell in flooded products. The moss shield helps prevent short circuits caused by active material shedding and also protects the tops of plates from damage during specific gravity measurement.

Finally, positive and negative plate groups are connected and terminated to posts to form a complete element. This element is lowered into a jar, which is later heat sealed to a cover, and the completed cell is filled with electrolyte.

The cells are formed, inspected and assembled into a battery tray where they receive a final sealing and are interconnected to form a battery.

Since each cell has a nominal voltage of 2 volts, connecting six cells in series (positive-to-negative), as shown in Figure 6.3, produces a 12-volt battery. A 12-cell battery would have 24 volts; an 18-cell battery, 36 volts; and so on.

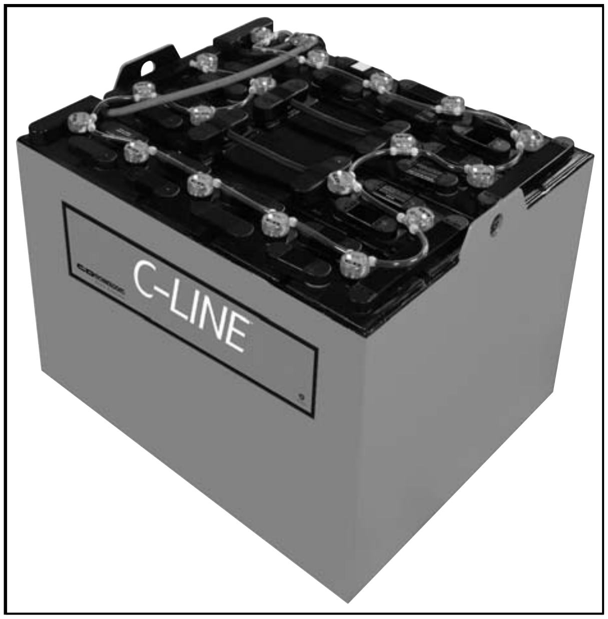


FIGURE 6.4 shows a typical 18-cell motive power battery. The steel tray has lifting ears for ease of handling.

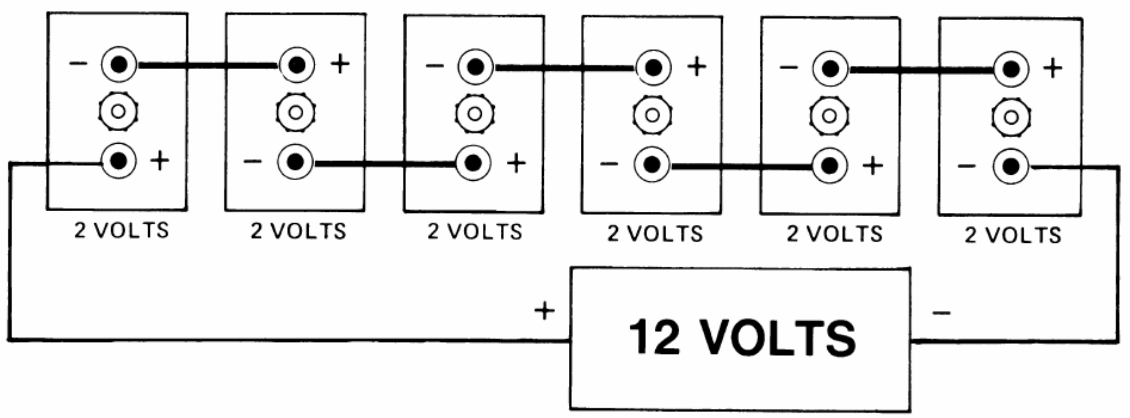


FIGURE 6.3-Motive power cells are connected in series to produce battery voltage

7 Troubleshooting

7.1 General

If promptly and properly detected, evaluated and corrected, problems that develop in lead-acid batteries can be resolved, assuring optimum service and full expected life. The following table will help you identify improper battery conditions, their probable causes and recommended corrective actions. Contact your C&D representative for further assistance. While the general principles of operation and troubleshooting are identical for all batteries, since it is not possible to check electrolyte levels, add water, or measure specific gravity of a LIBRA battery, those references are not applicable to LIBRA.

Condition	Probable Cause	Corrective Action
Excessive watering required	1.Overcharging	a. Use a properly sized charger b. Decrease charging time c. Do not put battery on charge at end of shift if specific gravity is above 1.240
	2. Broken or leaking cell jar	d. Repair or replace cell
	3. Excessive temperature	e. See below
Unequal or low specific gravities	1. Loss of electrolyte due to overwatering or watering before charge is completed	a. Give equalizing charge and obtain help from a C&D service office
	2. Incomplete charge	b. Give equalizing charge
	3. Stratified electrolyte	c. Give equalizing charge
	4. Charger malfunction	d. Contact C&D service office
Low cell voltages	1. Low specific gravity	a. Give equalizing charge
	2. Short circuit within cell	b. Clear short or replace cell
	3. Voltage leak between cells and tray	c. Clean battery top
Excessive cell temperatures	1. Weak or defective cell	a. Repair or replace cell
	2. Charger too large for battery	b. Use properly sized charger
	3. Low electrolyte level	c. Water cell after battery is fully charged
	4. Short circuit within cell	d. Clear short or replace cell
	5. Insufficient air circulation around battery on charge	e. Reduce charging room temperature and increase ventilation
	6. Inadequate cooling time	f. Allow at least 8 hrs. cooling after charge
	7. Overdischarge	g. Limit discharge to 80% of rating
Incomplete shift operation	1. Undersized battery	a. Replace with battery of greater capacity
	2. Undercharged battery	b. Check charger and charge termination devices; extend charging time
	3. Defective cell(s)	c. Replace cell(s)
	4. Defective cable or connector	d. Replace defective parts -Check connector for mechanical damage -Check contacts for secure crimp contact to cable - Check contacts for pitting - Replace contacts, shell, or connector kit with Anderson parts only, following manufacturer's recommended repair procedures. All work must be performed by a qualified service technician
	5. Improper connections	e. Check and reconnect
	6. Battery at end of useful life	f. Replace battery

TABLE 7.1-Identification of improper battery conditions, causes and corrections

7.2 Testing plate over voltage with a cadmium electrode (Applicable to flooded products)

If a certain cell continues to have lower than average voltages, even after the corrective actions suggested in Table 7.1 have been taken, the cadmium electrode test can often define the nature of the problem and verify the need for cell replacement. A voltmeter may be used for these tests, with the positive or negative meter probes connected to the cadmium electrode as described below and shown in Figure 7.1.

NOTE: A new cadmium electrode should be soaked in electrolyte of approximately 1.210 specific gravity for at least 72 hours before using. If the electrode dries out between tests, resoak it in electrolyte for about a half-hour.

CAUTION

Do not soak a cadmium electrode in a battery cell, as this may contaminate the cell. Soak the electrode in a separate glass container filled with sulfuric acid of 1.210 specific gravity.

CAUTION

Cadmium is a toxic material; be careful in handling and follow appropriate precautions.

Figure 7.1 Taking a Cadmium Reading

To test the positive plate voltage, readings must be taken with the battery fully charged and still on charge. Connect the negative probe of the meter to the cadmium electrode and the positive probe of the meter to the positive terminal of the cell under test. Insert the cadmium electrode into the electrolyte of the cell, gently stir it around for several seconds, and read the positive cadmium voltage on the meter.

Negative plate voltage readings are taken when the battery is near the end of its discharge or cell voltages are 1.70 to 1.75 volts per cell at rated six-hour discharge current. Connect the positive meter probe to the cadmium electrode and the negative meter probe to the negative terminal of the cell under test and proceed as above. Examples of cadmium electrode voltage readings on typical motive power batteries, some showing problematic cells, are presented in Table 7.2.

From Table 7.2 you can see that cells 1, 2, 3, and 6 exhibit normal charge voltages, while readings taken on cells 4 and 5 indicate problems.

Cell 4 has a rather low voltage across its terminals, suggesting a problem. The positive cadmium voltage is well below normal, verifying the need to open the cell and check for internal problems, such as a damaged separator between a positive and a negative plate or a short circuit between the plates.

Cell 5 also shows below-normal terminal voltage; however, its positive cadmium voltage is normal. The abnormal negative cadmium voltage indicates either insufficient charge or that the problem is with the negative plates.

Cell No.	Terminal Voltage	Specific Gravity	Positive Cadmium Voltage	Negative Cadmium Voltage
1	2.53	1.285	2.45	-.08
2	2.53	1.285	2.44	-.09
3	2.53	1.285	2.44	-.09
4	2.26	1.205	2.37	+.11
5	2.38	1.270	2.44	+.06
6	2.53	1.285	2.44	-.09

Table 7.2 Hypothetical cadmium electrode voltage readings taken at 77ºF on a constant potential charger and a finish current of 2.5A/100Ah

8 Glossary of Terms

Acid
A chemical compound which yields hydrogen ions and sulfate ions when dissolved in water. In the lead-acid battery industry, sulfuric acid is referred to as acid.

Active materials
The substances which are embedded (filled or pasted) into the spaces in positive and negative grids to form plates. The positive plate is formed to produce lead dioxide; the negative is formed to produce sponge lead. These materials react with sulfuric acid during charging and discharging of a lead-acid battery.

AGM
AGM (absorptive glass mat) technology allows lead acid batteries to operate without free electrolyte. AGM batteries have special separators, one-way venting systems, and plate alloys that eliminate the need for water additions or the electrolyte maintenance normally associated with standard flooded product.

Ambient temperature
The temperature of the surrounding area; usually referring to room or air temperature.

Ampere-hour (Ah)
A unit of measure for the electrical storage capacity of a battery, obtained by multiplying the current in amperes by the time of discharge in hours. Example: 100 amperes for six hours, or 600 Ah of capacity.

Boost charge
A charge given to a battery immediately before placing it in service to replace self-discharge losses. This includes the first time in service or after prolonged periods of non-use.

Burning
The welding together of two or more lead-alloy parts, such as plate lugs to cell straps and posts or cell posts to intercell connectors.

Button
The finished “button shaped” area produced on the top surface of an intercell connector or battery terminal by the burning operation.

Cell
The basic electrochemical, current-producing unit in a battery, consisting of positive plates, negative plates, separators, electrolyte, jar, cover, and posts.

Charge
The conversion of electrical energy into chemical energy within a cell or battery. See also DISCHARGE.

Charged
The state of charge of a cell or battery when it is at the maximum ability to deliver current. Compare with DISCHARGED.

Charger
A device that converts alternating current to direct current in order to charge a battery. A charger must be matched to the battery it is charging in voltage (V) and capacity (Ah).

Charging rate
The charging current expressed in amperes (A).

Circuit, electrical
A path over which an electric current can flow. A closed circuit has a complete path; an open circuit, an incomplete or broken path.

Circuit, parallel
A circuit which provides more than one path for current flow. Cells or batteries connected in parallel (positive-to-positive and negative-to-negative) produce an additive ampere-hour capacity while maintaining the same voltage. For example, if two 12-volt batteries of 50 Ah capacity each are connected in parallel, the combined capacity will be 100 Ah, but the combined voltage will remain 12 volts.

Circuit, series
A circuit which has only one path over which an electric current can flow. Cells or batteries connected in series (negative-to-positive) produce an additive voltage while maintaining the same ampere-hour capacity. Thus, if you connect two 12-volt batteries of 50 Ah capacity each, in series, the combined voltage will be 24 volts, but the combined capacity will remain 50 Ah.

Compound, sealing
An asphaltic material used to seal the spaces around cells in a battery tray.

Connector, cable
In a motive power battery, the polarized terminal assembly at the end of the cables which connects the battery to the truck or to the charger.

Connector, intercell
An electrical conductor used to interconnect cell posts within a battery.

Cover
The lid or cover of an enclosed cell through which extend the posts and vent assembly.

Current
The rate of flow of electricity or the movement rate of electrons along a conductor. Its unit of measurement is the ampere (A).

Current, alternating (ac)
A current that varies periodically in magnitude and direction. Electrical utility power is normally alternating current.

Current, direct (dc)
An electrical current flowing in an electrical circuit in one direction only. A battery delivers direct current and must be charged with direct current.

Cut-off voltage
A prescribed voltage at which a battery discharge is to be terminated, usually chosen to provide the optimum useful capacity of the battery and in the case of motive power batteries, to allow a full recharge within eight hours.

Cycle
In a battery, one discharge plus one charge equals one cycle.

Cycle service
A type of service in which a battery is continuously charged and discharged in successive cycles. Motive power batteries are operated in cycle service.

Discharge

The conversion of electrochemical energy into electrical energy. The state of charge of a cell or battery after it has delivered current. In practice, discharges are terminated when a cell or battery reaches 80 percent of the rated ampere-hour capacity.

Discharge rate
The rate in amperes at which a cell or battery is discharged.

Electrolyte
A mixture of acid and water which conducts electricity. Lead-acid batteries generally use sulfuric acid.

Element
In a battery, a set of positive and negative plates assembled with separators.

End gravity
The specific gravity of a cell at the end of a prescribed discharge (usually six hours for a motive power cell).

Equalizing, acid
The adjustment of the specific gravity of the electrolyte in a fully charged cell to within prescribed values by the addition of water or sulfuric acid.

Equalizing charge
An extended charge given to a battery following a normal recharge to bring the specific gravity and voltage of all cells to within prescribed values.

Final voltage
See CUT-OFF VOLTAGE.

Forming or formation
In battery manufacturing, the process of charging the battery the first time.

Freshening charge
A charge given to batteries, in storage or just received, to replace losses caused by self-discharge. Compare with BOOST CHARGE.

Gassing
The release of gases from a cell due to electrochemical action, especially during charging.

Hydrometer
A bulb-type glass syringe that uses a float to measure the specific gravity (concentration of sulfuric acid) of the electrolyte in a lead-acid battery cell.

Jar
A plastic enclosure which houses one complete cell (element and electrolyte). Sealed with a cover, it is installed with other cells in a protective steel tray and interconnected to form a motive power battery.

Lead
A heavy, malleable metal (chemical symbol Pb) of blue-gray color used in the manufacture of lead-acid battery grids, plates, posts, and connectors.

Lead dioxide
A chemical term for the active material of the positive plate of a lead-acid battery. See LEAD PEROXIDE.

Lead peroxide
A battery industry term for positive plate active material. A dark brown or black oxide of lead with the formula PbO_2.

Lead sulfate
A white crystalline compound formed on positive and negative plates by the reaction of lead compounds with sulfuric acid during cell discharge. Its chemical formula is PbSO4.

Leveling
The adjustment of the electrolyte level in a cell to the correct height.

Lifting ears
Extensions on the two end walls of a battery tray provided with a hole or slot for lifting the battery.

Negative
A negative plate or group of plates in a lead-acid battery. The negative terminal of a cell or battery.

Open-circuit voltage
The voltage of a battery when it is not delivering or receiving power. The open-circuit voltage for a fully charged battery cell is 2.13 volts.

Packing
Any thin sheet of nonconductive material used to reduce the clearance between the walls of adjacent cell jars for a snug fit when replacing a cell in a battery tray.

Positive
A positive plate or plates in a lead-acid battery. The positive terminal of a cell or battery.

Post
A vertical extension used to electrically connect a cell to an adjacent cell within the battery. It is the pathway for electrical energy entering and leaving the cell.

Rated capacity
The number of ampere-hours specified by a manufacturer that a fully charged cell or battery will deliver when discharged at prescribed conditions of temperature and current to a specific final (cut-off) voltage.

Specific gravity
1. The weight of a liquid at a specified temperature compared with the weight of an equal volume of pure water. 2. A measure of the concentration of sulfuric acid electrolyte.

Sponge (spongy) lead
A soft, porous form of metallic lead which is the active material in a negative plate.

State of charge
The amount of electrical energy in a battery at a specific time, expressed as a percentage of the energy in the battery when it is fully charged.

Stratification
The electrolyte concentration gradient that may exist in a newly watered cell or on one that has been improperly charged.

Sulfation
The formation of large crystals of lead sulfate (PbSO4) on a plate or other internal cell parts as a result of discharge or self-discharge and inadequate charge.

Sulfuric acid
The principal acid compound of sulfur, used diluted with water as the electrolyte in lead-acid batteries. The formula for sulfuric acid is H_2SO_4.
Vent
An opening provided in a cell cover to permit the escape of gas from the cell and for addition of water to the electrolyte.

Vent plug
An assembly used to seal the vent well of a cell cover to prevent the intrusion of foreign substances.

For warranty information please visit our website at www.cdtechno.com under the library link.

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