MILITARY
BATTERY RECONDITIONING SYSTEM

REVITALIZE & BRING BACK TO LIFE ANY BATTERY YOU HAVE

Table of Contents

MILLITARY
BATTERY RECONDITIONING SYSTEM

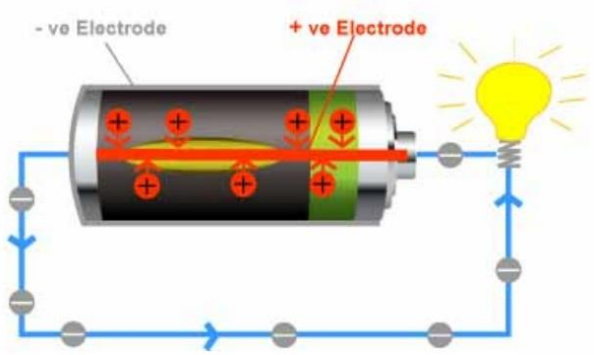
CHAPTER 1: INTRODUCTION

Chapter 1: Introduction

Rechargeable batteries have become an integral part of the life of every human being over the last couple of decades. Initially, the use of batteries was limited to simple everyday electronic devices such as portable radios, watches, electronic clocks, flashlights and a variety of electronic toys, to name but a few. These batteries were non-rechargeable.

Advances in technology brought about a glut of devices that needed more power than was available through dry cell batteries. We now have cell phones, smart phones, tablets, medical equipment, golf carts and even battery powered cars that need a reliable battery to power their operations. To address this need, rechargeable batteries were developed. These batteries are charged prior to use, after which they are used with the relevant device until the charge is depleted. The battery then undergoes a recharge, after which the battery can again be deployed for use, and the cycle goes on and on. Historically, the best known rechargeable batteries are the lead acid car batteries.

But before we go very far, what exactly is a battery? Well, a battery is basically made of a collection of working chemical units, called cells. Each battery cell is made up of three components; a positive electrode (*anode*), a negative electrode (*cathode*), and a separator which is either solid or a liquid called an electrolyte. When the battery is connected to a complete electrical circuit, a chemical reaction takes place whereby protons (positively charged ions) flow in one direction, while electrons (negatively charged ions) flow in the other direction. Due to the anode and cathode being separated by an electrolyte, the electrons are forced to pass through the outer circuit in the cell, and this energy is harnessed to power various devices.



Non-rechargeable batteries use primary cells, whereby electrochemical reactions are irreversible. The battery gets depleted with use and all the cells are used up in the chemical reactions that generate the current. The voltage produced by a primary cell goes on a downward trajectory from the day of first use, until all the cells are completely depleted, after which the battery is discarded. Rechargeable batteries on the other hand are composed of secondary cells. The electrochemical reactions in these cells can be electrically reversed, which gives the battery a longer lifespan in service. Every time the battery is discharged, it is recharged and the cycle of chemical reaction goes on over and over. This book is aimed at equipping you with the requisite skills to utilize the full potential of rechargeable batteries, by enabling you to recondition old batteries and extend the battery life even further.

Why do batteries need to be reconditioned?

Everyone who has used a brand-new battery powered device for a while can attest to the fact that the performance of a new battery is always impressive. It recharges to full capacity within a short time and lasts longer even under intensive use. The narrative, however, changes as the battery gets used regularly. The battery starts to run out very quickly, it takes a longer time to charge to full capacity and taking up charge after it has been completely depleted becomes a problem.

Although fair wear and tear through usage is expected, the problem that affects most rechargeable batteries has more to do with their charging habits and cycles than regular usage.

Some of the most common battery defects include low capacity, high internal resistance and elevated self-discharge. Capacity fade occurs naturally with use and time, while an increase in resistance is common with nickel-based batteries.

Most people who dump their car batteries prematurely do it because of one reason; sulfation. We are talking about the chemical process that forms the white/gray substances that coats your battery terminals after a period of usage.

Sulfation decreases a battery's capacity to recharge, making the owner think it's useful-life is over, when it can be easily restored back to life.

Necessity, they say, is the mother of invention. What if there was a process that could reverse the decline in performance of your battery and restore its initial glory? Well, that is exactly what battery reconditioning does for you. Although some batteries may indeed be spoilt beyond repair, most can be revived by a bit of reconditioning.

Battery reconditioning is a process through which a rechargeable battery which has experienced a downturn in capacity and performance is reconfigured to achieve a near optimum performance capacity.

Even better for environmental conservation enthusiasts, reconditioning reduces the amount of electronic waste discharged to the environment. Batteries are generally the most commonly replaced components of an electrical or electronic device. If we are able to recondition hitherto written off batteries and restore them to proper working order, it follows that we will greatly reduce the amount of electronic waste discharged by increasing the battery life of batteries used by each device. Reconditioning batteries is thus not only friendly to the environment by reducing the number of batteries used by each device, it is also friendly to the pocket; it reduces expenses that would have been incurred with battery replacements.

Is it possible to do it yourself?

Battery reconditioning applies simple scientific principles that can be learnt by anyone, who has sufficient interest, commitment and determination. You do not even need to have a scientific background to learn and understand how it works. If it is your kind of thing, it will be an exciting experience examining the scientific principles behind reconditioning. If it is not, well, it is enough to understand **how** it works **and leave the why** to the scientists and technicians. All you need is to master a few simple tricks and skills and you will be good to go. It calls for commitment, dedication and an initial financial

cost, but once all these are in place, it is very possible to do the reconditioning of your batteries at home, all by yourself.

Here is the thing though, just as making a meal using an instructional recipe takes time before attaining the desired standards, so is reconditioning a battery by following this do it yourself guide. You need to temper down your expectations. The first time you carry out the process, the overall output of your battery is likely to improve just marginally. However, as you master the procedure and nail down the nitty gritty of the steps, you will realize that the reconditioning will now work as expected. Whipping a gourmet meal takes time and practice, not just a recipe and ingredients. So, take your time and exercise patience, and you will master the procedure.

To effectively do it yourself, you need to invest in a number of simple electrical tools. A voltmeter, alligator clips, jumper cables and a battery analyzer would be a good investment - you purchase these only once, but with proper care, they will last for a very long time. Once you have these tools, if you are not familiar with the process or you have carried it out just a few times, get a do it yourself battery reconditioning guide like this one. In the following chapters of this book, we will be providing a detailed step by step procedure that will guide you through the process to the desired results. The guidelines are very simple, with very few technical terms, if any. It should be a pretty straightforward and simple affair to follow it to completion.

How easy is it?

Well, learning something new is never easy, but it can be a fun and exciting experience. If you are a handy person who likes getting things done and tinkering with electronic and electronic devices, this will be an exhilarating experience. Even if it is not your kind of thing, the end results will still be more than sufficient reward for your efforts.

Once you embark on the journey to reconditioning batteries, there is no turning back, you go on to the very end. So, exactly how easy is it? Well, here are five reasons why it is very easy to do battery reconditioning by yourself:

1. The process is guided by a simple, "do it yourself" guide that does not require a user to have any technical expertise. Yes, a basic understanding of physics is desirable, but it is not a prerequisite. As long as you can follow simple written instructions, you are good to go;
2. The procedure for reconditioning the battery is simple with very few steps from the beginning to completion. A user will thus master the same easily after the first few times of use, due to the straightforward manner in which the instructions are structured;
3. The tools required for the job are cheap, easy to obtain and maintain. They cost way less than it would cost to replace a single battery in an electronic device, yet saves you a ton in battery related expenses;
4. The process can be repeated a few times, until you get the desired results, unless your battery is irredeemably broken. The first few times you attempt the procedure, you are unlikely to get very good results. However, with a bit of practice and after repeating the process a few times, you will master the process and get the desired results; and
5. It is something that you can learn, master and do at home with minimum supervision. In fact, it is so simple that the only guide you need is the guidelines provided in this book.

How much can you save?

The answer to this question is not clear cut, but what is clear is that you can save a lot. Taking the trouble to learn how to recondition spent batteries will not only save you heaps of money otherwise spent on new batteries, but also help to protect the environment

from the hazardous waste that old batteries contribute to. The amount saved depends on the device, the battery type and model. A brand-new battery for most portable electronic communication devices such as mobile handsets, smartphones and tablets will set you back a few bucks. Larger industrial scale batteries such as motor vehicle batteries will set you back by a few hundred or even thousands.

Battery users and entrepreneurs often ask, "Is it possible for old and failing batteries to be reconditioned?" The answer is, it depends. A battery failure does not always mean the end of battery life. Rather than discarding the old and failing batteries, ingenious individuals have discovered innovative means that can be applied to grant retired batteries a second lease of life. Considering the growing number of batteries that are being discarded due to the increased use of batteries, especially in portable devices in the telecommunications sector, it offers massive business opportunities that have the potential to grow in leaps and bounds in the years to come.

One leading industry expert Marc S. Keith, says *"The longer batteries last, fewer new batteries are manufactured and fewer end up in our landfills. The market for battery reconditioning is huge. Batteries are needed in nearly every business and industry, the demand is high. Businesses throw away batteries that can be reconditioned every day."* At the end of the day, you save a lot of funds that would have otherwise been spent on battery replacement. Here are the ways in which you will can save a lot through the reconditioning of your rechargeable device batteries.

1. Batteries are the most replaced component in almost all battery powered electrical and electronic devices. By reconditioning your battery, you save a lot in battery replacement costs, just through commitment, dedication and an initial investment in tools of just but a fraction of what you would have otherwise spent. Every penny saved counts. Given the number of battery powered devices that is likely to be used

by a single individual at any given time, the savings are likely to add up to quite a substantial amount.

2. Batteries that drain power really fast end up using more electric power to fulfill their function everyday. Although the sum of money saved per device or battery may seem negligible, it's cumulative potential over time cannot be overstated. Reconditioning batteries restores them this allowing them to last longer while charging less frequently. Overall, you will notice a significant reduction on your power consumption over a long period of time.
3. The world has gone green. We are currently engaged in a race to harness all the renewable energy sources available. The world is also trying to come up with measures to drastically reduce the amount of non-biodegradable waste generated. One of the greatest contributors towards this waste is electronic waste, of which batteries make up a major part. Correct disposal of electronic waste costs a tidy sum. If we reduce the amount of waste generated, we will be saving our country huge amounts of taxpayers' money that would have otherwise been eaten up by waste disposal or waste reduction campaigns.

What type of batteries can you recondition?

Here is the amazing thing, basically every rechargeable battery can be reconditioned, as long as it is not irreparably and irredeemably destroyed. So, how do you know if your battery is ready to be reconditioned? Well, first, do not expect the battery to last forever, a day will come when you have to dispose off the battery and buy a new one, but before you get there, we are here to help you get the best service possible out of the battery. Once you realize that your battery is losing power at a significantly faster rate than before and you are left with a shorter usable time, then it is time to consider a recondition. The following are the battery types that are capable of getting a new lease of life with reconditioning:

1. *Lead acid batteries*: Unlike the other battery types listed below, lead acid batteries need to be continually charged to have a long battery life, through the reduction of discharge cycles. The major reason why lead acid batteries experience a reduction in efficiency is that the chemical reactions taking place inside the battery take their toll, resulting in corrosion of the lead plates, which reduces the effectiveness of the chemical reactions. Shorts may also occur between the battery components, bringing about a reduction in the power output. Reconditioning can work wonders on batteries suffering such challenges and restore them to near optimal functionality;
2. *Nickel Metal Hydride batteries*: These batteries suffer a condition known as the digital memory effect. This means that with each charge-discharge cycle, the battery records the level at which it is normally recharged. With time, the battery begins operating normally until that level, after which it rapidly discharges. If for example you recharge the battery at 50% capacity repeatedly, the battery will be operating normally until the 50% charge capacity level, after which it will rapidly discharge.
3. *Nickel Cadmium batteries*: These batteries also suffer from the digital memory effect. What happens is that in a new battery, the Cadmium is divided into fine grains which maximize the surface area available for chemical reactions in the battery. With time, large crystals start forming on the internal surface of the battery, effectively reducing the surface area available for reactions.

Lithium ion batteries are exceptional in that they do not suffer from the digital memory effect. Instead, the battery has a limited number of discharge cycles, which on average range from 300 – 500 cycles. Each discharge cycle thus reduces the life of the battery; on average, it loses about 10% of its capacity every year.

The Difference between Reconditioning and Recharging

Rechargeable batteries are supposed to function in a very simple way. The battery is charged to full capacity after which it is put into use. During the usage, the battery discharges at a predetermined rate until it is fully depleted. That completes a regular charge-discharge cycle, after which the battery should be recharged before being put to use again. Recharging is this the process through which a rechargeable battery that has been depleted of charge through regular usage is replenished to full capacity.

Reconditioning a battery on the other hand is about capacity. As explained above, sometimes a battery suddenly begins operating at a reduced capacity, resulting in shorter usage time. The causes of this are varied depending on the battery type, with some suffering the digital memory effect and others oxidation and corrosion. Whatever the cause, reconditioning is the process by which a battery operating below regular capacity is restored to full functionality or near optimal capacity.

At the end of the day, the longevity in the life of your rechargeable battery depends on the recharging habits, as well as reconditioning. The frequency of charging your battery at the end of the day determines the oxidation or corrosion observed in it. The discharge level at which you recharge some of the battery types eventually bring about the digital memory effect. Even as you follow this guide and recondition your batteries, we wish to expressly state that reconditioning is not a substitute for proper battery care. In an ideal world, you are supposed to observe proper care for your battery, then recondition it once it's worn out through wear and tear from ordinary usage. To maximize the life of your battery and utilize its full potential, you need to combine proper recharge and battery care techniques with the battery reconditioning instructions given here. Welcome, hope you find this book to be enlightening, interesting, practical and useful in addressing your everyday rechargeable battery needs.

The three main battery defects are low capacity, high internal resistance and elevated self-discharge. Capacity fade occurs naturally with use and time; resistance increase is common with nickel-based batteries; and elevated self-discharge reflects possible stresses endured in the field. Capacity loss can often be reversed with NiCd and NiMH; lead acid with sulfation can sometimes also be improved.

MILLITARY
BATTERY RECONDITIONING SYSTEM

CHAPTER 2:
RECONDITIONING LEAD-ACID BATTERIES/CAR BATTERIES

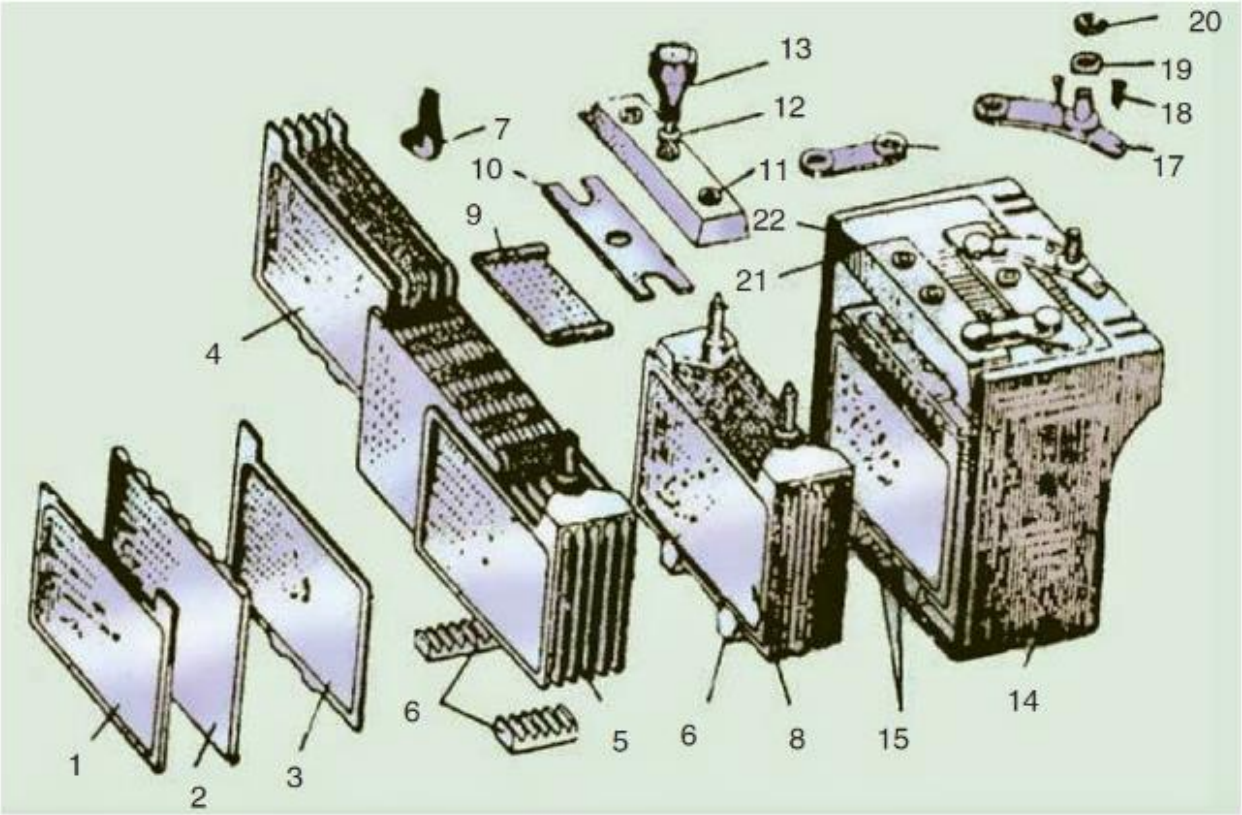
Chapter Two: Reconditioning Lead-Acid Batteries/Car Batteries

Lead acid batteries were invented in 1859 by the French physician, Gaston Planté and they were the first rechargeable batteries to be produced for commercial use. This invention caught the technological world by surprise and it has remained the technology of choice for the vehicle industry as well as automotive SLI (Starting, Lighting, and Ignition). Despite their advanced age, lead acid batteries have a broad range of use – mainly because they are very reliable and based on cost-per-watt principle, relatively inexpensive. In fact, there are very few batteries which can deliver bulk power as cheaply as lead acid batteries, and perhaps this is what makes them ideal for golf cars, automobiles, and marine use. Besides, after lead acid batteries get old and corroded, they can be reconditioned and used again for a significant duration of time.

The Essential Components of a Lead-Acid Battery

All lead acid batteries are not exactly the same, but most share the same components. Understanding the nature and importance of each of these components is crucial in determining how batteries work, which type is best for your application, why batteries die, and how reconditioning work.

All lead acid batteries have negative and positive plates, both of which are submerged in electrolyte. The reaction between the electrolyte and lead plates generates the power. The grids and the electrodes are made of lead, but typically there is an additive mixed with the lead, such as calcium, to improve its mechanical strength. The electrolyte is usually sulfuric acid.



The diagram below and the following key shows parts of a lead acid battery.

1. Negative plate
2. Separator
3. Positive plate.
4. Positive group
5. Negative group
6. Negative group grooved support block
7. Lug
8. Plate group
9. Guard screen
10. Guard plate
11. Cell cover
12. Plug washer
13. Vent plug
14. Mono-block jar
15. Supporting prisms of negative group
16. Inter-cell connector
17. Terminal lug
18. Screws
19. Washer
20. Nut
21. Rubber packing
22. Sealing compound.

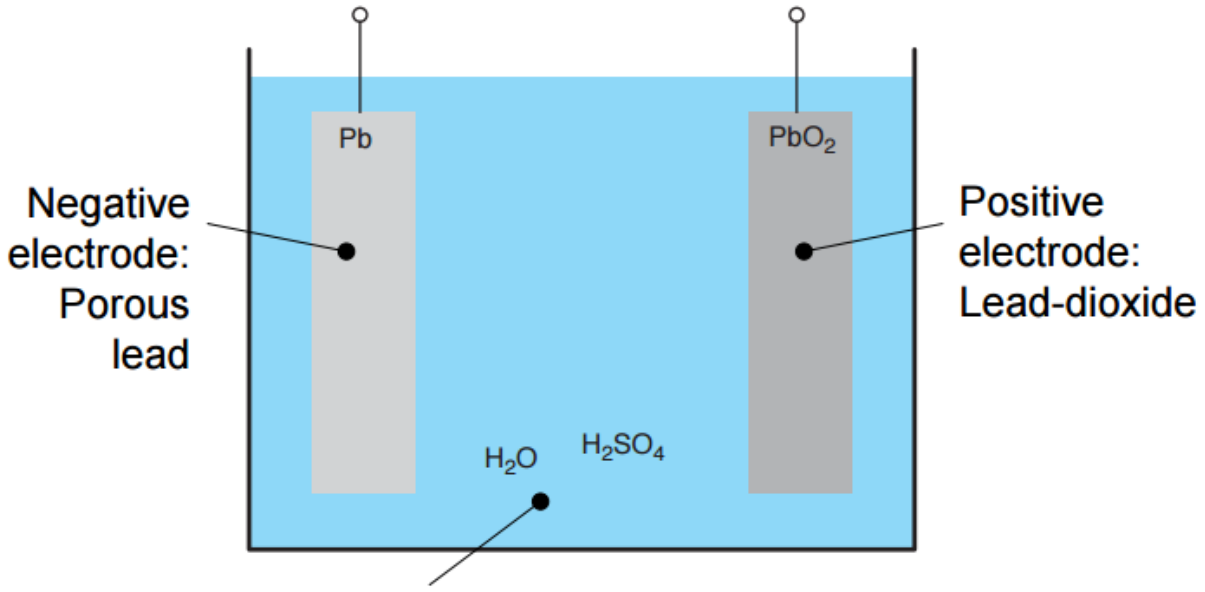
Plates—a battery has positive and negative lead plates. Each plate consists of a lattice type of grid which is covered with an active material. The plates serve as support for active materials, but they conduct electric currents as well. Both plates are normally made in a similar design but the negative plate grid is made somewhat lighter.

Electrolyte—this is another critical component of a lead acid battery; a mixture of sulfuric acid and water. Its reaction with the lead plates causes current flow, hence the phrase "lead acid battery." In low maintenance batteries (as we shall see later) the level of the electrolyte must be checked regularly and replenished with distilled water to immerse the plates completely. However, maintenance free batteries do not require refilling of electrolyte.

Separators—these are thin sheets of a porous material placed in between the plates to prevent contact between them, thus preventing short-circuiting. The separators must be chemically compatible with the electrolyte and resistant to oxidation. They must also be sufficiently porous to allow circulation and diffusion of electrolyte between the positive and negative plates.

Container—a lead acid battery container may be made of different materials depending on its purpose. It may be made of celluloid, glass, ceramics, moulded plastic, or moulded or vulcanized rubber (ebonite). In car batteries, vulcanized rubber is used, while most portable batteries use celluloid containers. Glass containers are better for wireless sets and lighting plants.

In short, a lead acid battery is an electrochemical cell, basically consisting of cathode (a lead grid layered with lead oxide) and anode (a lead grid), both immersed in concentrated sulphuric acid. In most lead acid batteries, like those used in cars, the concentration of the suphuric acid lies in between 4.5-6.0M.



Electrolyte (6.0M).

The chemical reactions that result in generation of electricity in lead acid batteries are shown below:

$$Pb + SO_4^{-2} \text{ ----------> } PbSO_4 + 2e^{-1} \quad (1)$$

Oxidation (anode)

$$PbO_2 + 4H^{+1} + 2e^{-1} + SO_4^{-2} \text{ ----------> } PbSO_4 + 2H_2O \quad (2)$$

Reduction (Cathode)

The two reactions above (1 and 2) are half-cell reactions and they occur at the same time at the cathode and anode.

The types of Lead Acid Batteries

Since Planté's invention in 1859, manufacturers have introduced a range of additives such as Selenium, Antimony, and Calcium to improve the lead acid battery parameters. And for the same reason, different battery and cell constructions have been built to elevate battery performance and their useful life. Here, we look at some of the commonly used types of lead acid batteries.

Flooded Lead-Acid Batteries

Flooded cells refer to the batteries in which the plates or the electrodes are deeply immersed into the electrolyte. The electrolyte can freely move inside the cell compartment. Bearing in mind that the gasses released during the charging process are occasionally vented to the atmosphere, and as such, it is advisable to add distilled water so as to raise the electrolyte to the desired level, as the battery dries out.

Some examples of flooded acid batteries used in wind and solar electric systems are six-volt golf cart batteries, six-volt L-16s and two-volt industrial cells for large systems.

Sealed Lead-Acid Batteries

In this category, the electrolyte is confined, and unlike the flooded batteries, there is no vents. However, during the charging process, sealed lead-acid batteries release oxygen gas at the positive electrode, also known as the anode.

It is crucial to note that this type of lead acid batteries is designed in such a way that the produced gas during recharging process recollects and recombines inside the cell. This phenomenon, known as oxygen recombination cycle, is meant to ensure that the charge rate remains constant. When the charge rate is higher than expected, unwanted circumstances such as case rupture, thermal runaway or internal mechanical might occur. There are several types of sealed lead acid batteries including:

i. ***VRLA (Valve Regulated Lead Acid)***—gas emission in this type of SLA battery is valve regulated, hence the name VRLA. The valve allows for a secure and safe escape of oxygen and hydrogen gasses during the charging process.

ii. ***AGM (Absorbed Glass Matte)***—in this type of SLA, the absorbed glass matte construction enables the electrolyte to dangle near the active material of the plate. Theoretically, this significantly enhances both the recharge and the discharge efficiency. The AGM cells are a variant of Sealed VRLA batteries.

Of late, the AGM batteries have gained a lot of popularity, thanks to their many applications. To be more precise, they are useful in telecommunication and

alarm industries, power sports applications, UPS and mobility vehicles among others.

iii. ***Gel Sealed Lead Acid***—this gel cell is somehow similar to the AGM model mainly because the electrolyte is suspended. However, the difference is that technically, the AGM cell still falls under the wet battery. The electrolyte in the GEL cell contains a silica additive which stiffens it. Small cracks form in the stiffened electrolyte which provides an exit for the oxygen recombination reactions between the negative and the positive plates.

Their construction is in such a way that any instances of electrolyte evaporation, spillage or any other corrosion problem (which are very common with flooded or wet cell batteries) are significantly reduced. Again, they have greater resistance to higher temperatures, shock, and vibration.

Gel batteries are relatively expensive compared to the AGM or Flooded models. Even though they have very low discharge rates, they have specific charging practices. For instance, they must be charged with GEL specific chargers.

Deep Cycle Lead Acid Batteries

Deep cycle batteries are constructed using thicker lead plates, which have smaller overall surface area. And since they have a smaller surface area for chemical reaction, they typically produce relatively less current, but they provide the current for extended periods.

Deep cycle batteries discharge to half of their capacity before being discharged again. This scenario is known as the depth of discharge or DOD. To enjoy their full potential, use them in cases where a constant current is required for extended periods. Mobile scooters, solar energy systems, as well as golf carts, are some of their areas of applications.

When searching for a deep cycle battery, it is advised you go for one with a residual capacity three times your estimated daily consumption. Moreover, to ensure that they remain in their perfect condition, you should fully charge them after every three months.

The Most Common Problems with Lead Acid Batteries

Lead acid batteries are widely used on a mass-scale globally, but due to the nature of their application, they tend to be prone to various technical problems. In this section, we are going to explore some of the technical problems you should expect when handling lead acid batteries—take note, some may risk your health!

1. Gas Emissions

During the recharging process, as the electricity flows through the electrolyte, water (H_20) is broken down into: oxygen and hydrogen. Evidently, these are flammable gasses, and that's why lead acid batteries are always vented. Gas emission in these batteries is referred to as *gassing*—a process that leads to water loss. Therefore, gas emissions not only risk explosion, but by draining the water, also acts as a major catalyst to battery damage.

2. Electrodes Damage due to Corrosion

Corrosion occurs on the grid as a result of the reaction between the lead metal and sulfuric acid. This process is also referred to as *shedding*. Since these two components must be used for electricity generation, lead shedding cannot be entirely eliminated. However, reducing the cycle count, limiting the depth of discharge, controlling instances of overcharge and perhaps operating at moderate temperature are some of the preventive measures that can help keep corrosion in check.

3. Electrolyte Stratification

Electrolyte stratification is the deposition or formation of layers caused by lead material shedding and grid corrosion. Naturally, sulfuric acid is a viscous and dense liquid. Hence, its concentration in the electrolyte decreases as the battery discharges and increases when it is charging. As a result, this acid fluctuation might cause stratification of the electrolyte. This implies that the acid, being heavier, will sink to the bottom whereas a lighter substance such as water will stay near the top.

This chemical phenomenon is a major concern in non-hybrid AGMs and flooded batteries. Electrolyte stratification is known to reduce the performance of lead acid batteries and shorten their life cycle. And while this effect leads to short term loss of performance, very little is known regarding the long-term effect of electrolyte stratification. Similarly, the techniques to control electrolyte stratification are barely available. However, electricians argue that controlled gassing can be used to reduce the deposition or formation of lead sediments.

4. Battery Sulfation

Sulfation is the build-up of crystals of lead sulfate at the electrodes. It is said to be the primary cause of premature failures of lead acid batteries. A sulfated battery can result in extended charging times, loss of cranking power, shorter running times between charges, and excessive heat built-up. Sulfation is inevitable—all lead acid batteries develop it at some point in their life span. Sulfation is developed every time the battery is in use (discharged – recharged). However, processes such as undercharging and overcharging may speed up sulfation. Even when a lead acid battery is stored fully charged, sulfation will still occur not unless a desulfating charger is used.

5. Sulfuric Acid Spillage

Occasional leakage and spillage of sulfuric acid from the battery casing can potentially pose serious environmental health risks. Sulfuric acid is known to be highly corrosive—in

concentrated form it can be potentially explosive. Besides, it can cause severe skin burns, irritate the throat and nose, as well as burn the eyes possibly leading to blindness. However, to significantly reduce the possibility of acid spillage, it is recommended that you apply gelling products on the casing caps.

6. Loss of the Active Materials from the Electrodes

The active materials in a lead acid battery are those that participate in the electrochemical (charge/discharge) process. There are many types of activities and reactions which can lead to loss of active materials from the electrodes. One such activity is severe and consistent volumetric vibrations which could lead to shaking off of the active materials such as lead sulfate. The loss of active materials from the electrodes would mean that the electrochemical reaction would be affected, which reduces the battery's performance.

Before you can tell whether your battery can be restored or not, you have to first test it. There are various ways through which lead acid battery testing is conducted. In this section, we will explore some of the commonly used methods of testing to determine whether a battery can be reconditioned back to life or not.

Equipment Needed for Lead Acid Battery Testing

- A Multi-meter
- An Epson salt
- A battery hydrometer (Calibrated)
- A smart charger solely designed for lead-acids
- A battery terminal cleaner
- A plastic funnel
- A digital thermometer equipped with a sensor probe
- Half-quart sized container

Not compulsory:

- A car battery analyzer (w/temperature meter recommended)

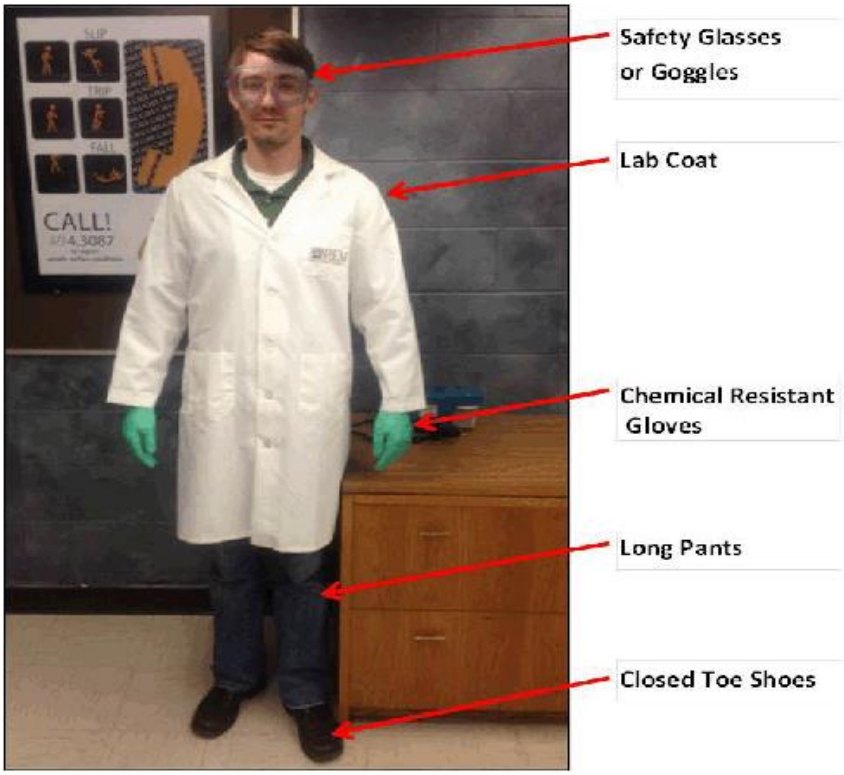
Safety Measures

It is critical to note that before indulging in any lead-acid battery tests process, one must seriously take into account certain security measures. Why? Usually, these cells emit an extremely flammable gas, known as hydrogen gas. Besides, sulfuric acid available in lead acid batteries is extremely corrosive and therefore, is exceedingly harmful to living organisms. The plates of the battery are designed from a liquid solution of weak sulfuric acid and lead. In this regard, the following are some of the safety measures to consider'

Personal Safety

As shown in the figure below, it is important to wear protective gear while handling lead acid batteries to avoid serious repercussions.

- Never smoke or have open flames during the charging sessions since the gasses emitted during can potentially explode if they come into direct contact with fire.
- You should put on an apron as well as rubber gloves to protect your clothes and hands. Moreover, at this point, the practical use of safety eye glasses are a must. Of course, your glasses must have side and front protections. To enhance your safety, it is a good idea using a full-face mask. Acid burns can be pretty ugly and painful.
- Anytime you are either connecting or disconnecting any wire from the car battery; it is advised you disconnect the negative terminal (cathode) first before working on the positive terminal (anode). This as a precaution, can help prevent the occurrence of a spark, which could otherwise result in a dangerous explosion.



Environmental Safety

Lead acid batteries, as earlier mentioned, contain chemicals which are extremely hazardous to your health and the environment. If these batteries are disposed of in a solid waste landfill, both the lead and the sulfuric acid might seep through the soil, contaminating the ground water. Correspondingly, when they are disposed of in the natural water bodies directly or indirectly, they can jeopardize the aquatic life. As a result, great care must be taken to ensure environmental safety. Additionally, it is important to ensure that you are always in line with your state, federal and the local regulations when disposing of these particular batteries.

Steps in Testing Lead Acid Batteries

Step one: Battery inspection

Before embarking on deep battery inspection, it is vital to first conduct a simple battery inspection through observation. There could be common problems easily noticeable

including frayed cables, dirty or wet battery tops, decreased electrolyte levels, corroded or swollen cable terminals, a damaged lead-acid battery case, or even a leaking case.

Step two: Charging

Charge the lead-acid battery to fullness and afterward remove the surface charge before any test. You can accomplish this by allowing the battery to rest for nearly twelve hours or by drawing a load of not less than twenty amps for close to three minutes. If you fail to pluck off the surface charge, your battery may appear fit, which will interfere with the true testing results. After charging and drawing off the surface charge, your battery should be ready for testing.

The Actual Testing

Before looking at the actual testing methods, it is advised that you first clean the battery posts (terminals) using a terminal cleaner (as discussed in the previous chapter). Clean both terminals (negative and positive) by placing the post cleaner on each post and twisting it clockwise or counterclockwise until the corroded terminals are clean. Then proceed to conducting the tests.

1. **No-Load Voltage Testing with a Multi-Meter**

The battery above is fully charged. Using a voltmeter, join the positive probe (red) with the positive terminal of the battery. Again, join the black or the negative probe with the negative terminal and observe the reading. Many battery testers will provide you a no-load voltage reading after you first connect the battery to the multi-meter. You may use a hydrometer or a battery tester for conducting the no-load tests.

Interpreting the no-load voltage reading: The table below explains the percentage level of charge by voltage.

Battery Voltage No- Load

Charge Level	Voltage 12V	Voltage 6V
100%	12.7	6.3
75%	12.4	6.2
50%	12.2	6.2

25%	12.0	6.0
Discharged	11.9 or below	5.9 or below

If your battery is reading zero volts, there is a probability that it experienced a short circuit. If the battery cannot attain a reading higher than 10.5-volts (for 12 Volts batteries), then your battery might be having a dead cell. If the battery is fully charged, but the battery voltage is 12.4 or less, then the battery is sulfated.

2. **Battery Load Testing using a Load Tester**

A load tester takes a guesswork out of an electrical diagnosis making it easy to pinpoint failures in the charging system. To perform this procedure just attach the clips to the terminals; the red to the positive terminal and the black to the negative terminal. Long press the testing button for about 10 seconds to perform a load test and take note.

The following is an interpretation of a 12 volt lead acid battery after load testing. It is important to repeat tests several times just to be sure and record accurate data.

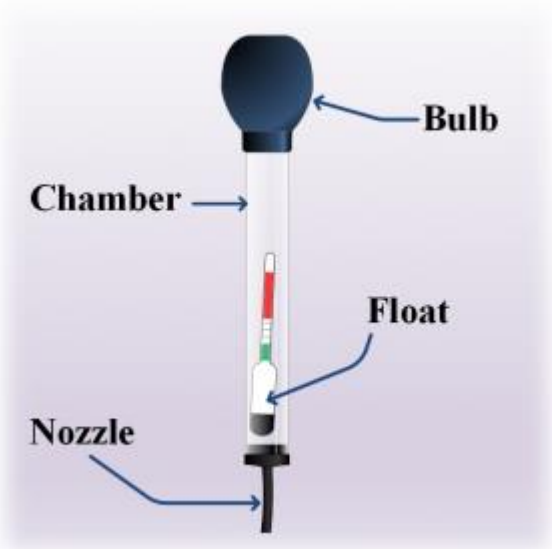
Voltage Under Load	**Battery's State**
6.0 Volts and Below	Bad
6.1 Volts to 9.9 Volts	Weak
10 Volts to 12 Volts	Good

If the battery test falls under good, then your battery is okay. But if your battery test "weak" there is a problem, although this battery can be restored. If the battery's signal repeatedly reads "bad", then it will most likely not be restorable.

3. **Battery Testing using a Hydrometer**

The figure below shows the basic parts of a hygrometer. After opening up the cups to access the electrolyte, follow the following procedure to test a battery's condition.

1. Squeeze the bulb prior to insertion.



2. Insert the hydrometer nozzle into the cells to be tested. Make sure the nozzle is well deep into the electrolyte.

3. Release the bulb and to suck the electrolyte into the chamber.

4. Allow the electrolyte and the float to settle. And record the results. The float as shown in this figure is marked with white, green, and red zones to mark specific gravities of a cell.

5. Repeat the procedure to all other cells. The table below analyze your results and draw conclusions.

Floats Towards Red	The cell is in bad condition
Floats Towards White	The cell is in fair condition

Floats Towards Green	The cell is in good condition

Reconditioning Lead-Acid Batteries

As aforementioned, a battery goes through three stages in its life span—formatting, peak, and decline. And as we've already seen sulfation is the number one malady of a lead acid batteries. However, as long as a battery is mechanically sound it can be revived back to life through a desulfation. This section explores some commonly used methods of battery reconditioning.

1. Reconditioning through an equalizing charge

To equalize a charge is a process that involves charging at a higher voltage than normal. When you purchase a new battery, it is recommended that you apply an initial equalizing charge and then regularly, after every ten cycles or at least on a monthly basis. Reduced efficiency in the overall performance of your battery is a clear indication that an equalizing charge is required. To be more precise, this significantly reduces sulfation and prevents stratification, two factors responsible for the premature failure of lead-acid batteries. To perform this, follow the following procedure:

- Ensure that the battery's electrolyte is full to its capacity by adding distilled water.
- Charge your battery to its capacity.
- Once fully charged, raise the battery's charge to a voltage of 5 to 10% above the standard charging voltage. Typically, the equalizing voltage is around 14.4 to 15-volts for a 12 voltage battery.

- Keep recording the specific gravity values of each cells every hour. How do you test specific gravity? Remember battery hygrometer? Use it when testing specific gravity and record.

  This table shows the approximate state of charge in Specific Gravity (SG) of the 12 volt lead-acid battery.

Charge	**Specific Gravity**
0%	1.120-1.130
25%	1.155-1.165
50%	1.190-1.200
75%	1.225-1.235
100%	1.265-1.275

- When all the cells are gassing correspondingly and the specific gravity values remain constant, **STOP** equalizing. Your battery should be restored!
- To test whether or not the process has worked, discharge 50% of the charge and charge the battery twice in standard method. Now test whether the battery is working properly.

2. Reconditioning through Chemical Additives

This is by far **the best** method to restore a dead lead acid battery and has been in use for decades. Adding chemicals to the electrolyte dissolves the lead sulfate formed on the plates. The most commonly used chemical additives include;

- **Magnesium Sulfate**—also known as **Epsom Salt,**

- **EDTA—**a crystalline acid used in industries, and
- **Caustic Soda.**

What do you need?

i. Protective tools such as protective glasses, gloves, etc. as we've already discussed in this guide.

ii. Distilled water. **DON'T** use tap or well water.

iii. Epsom Salt (or a chemical additive of your choice.)

iv. A plastic funnel to help you add your solution into the battery.

v. A screw driver to help you open up the battery caps.

Follow the following steps:

a. Heat a half quart of distilled water. It must be hot enough to dissolve the Epsom Salt (heated at 150°F). **Note—**Epsom Salt should not be added directly into the batteries electrolyte because the solution inside cannot dissolve it properly.

b. Add 10 table spoons of Epsom salt (250g) with this hot water and stir until the salt is completely dissolved.

c. Use your screw drivers to remove the six battery caps (or drill six holes if you are restoring an SLA battery).

d. With the help of a funnel, simply pour this solution into each cell or the battery. Make sure that you are pouring in the same amount of Epsom Salt solution into each cell. **Note:** if your battery is already full of electrolyte, draw some out to give room for the Epsom solution.

e. Put the caps back on (or plugs in case of a drilled SLA battery) and shake the battery to mix the Epsom salt solution and the electrolyte well.

f. Charge your battery to its max and then discharge it up to 50%. Then charge it again several times. Test the battery to see whether restoration has taken place. It should test positive. If not, don't worry, sometimes it takes up to 10 for total restoration to take place.

How does this method work?

When you continuously use your battery's electrolyte it loses its state and became more of a base than an acid. Therefore, the normal chemical reaction that takes place between the lead plates and magnesium sulfate in the battery is reduced.

By adding Epsom salt (magnesium sulfate), you are restoring the chemical reactions that generate energy in the battery. So, not unless the lead plates have broken off, this method has a success rate of 98%. However, this can only be done 2 to 3 times before your battery dies completely.

3. Reconditioning using desulfating equipment

As the batteries age or stay discharged for longer periods, the crystals of sulfate might form on the plates of the battery, a factor that impede the flow of electricity, leading to reduced battery performance. In this case, the best way to restore such a battery is through a process known as desulfation. Today, there are a whole host of desulfation instruments available in the market. A significant number of them utilizes pulses of alternating current to eliminate the build-up of the sulphate crystals, effectively. What's more, you can also desulfate a battery using specialized desulfating chargers.

Maintaining Lead Acid Batteries

In a bid to prolong the life of your lead-acid battery, proper maintenance is crucial. Remember, you can only restore your battery a couple of times before it dies completely. This chapter will focus on ways to maintain your battery to increase its performance and service life.

- Always ensure that the battery terminals are clean and free from corrosion.
- Don't expose your battery to high temperatures.
- Always replenish your battery with distilled water to maintain the right level of the electrolyte. Never add the tap water to your car battery, since it contains impurities as well as minerals which can raise the rate of self-discharge.
- Always disconnect the negative terminals first.
- The specific gravity must be measured after at least two weeks from topping up to make sure that the mixing of water and the electrolyte is thorough.

MILLITARY
BATTERY RECONDITIONING SYSTEM

CHAPTER 3:
HOW TO RECONDITION RECHARGEABLE BATTERIES

Chapter Three: How to Recondition Rechargeable batteries

An Overview of How Rechargeable Batteries Work

With the emergence of portable devices such as cell phones, laptops, MP3 players and even cordless power machines, the need for rechargeable batteries has grown significantly. There are a variety of rechargeable batteries, but the initial concept regarding their functionality is more or less the same. Rechargeable batteries generate current through an electrochemical reaction involving an anode, cathode, and electrolyte.

For a chemical reaction to occur in the electrolyte, the battery must be connected to a complete electrical circuit. After this, the ions (atoms having a positive electrical charge) move via the electrolyte while the electrons (negatively charged ions) move through the external circuit in the opposite direction.

Types of Rechargeable Batteries

Most manufacturers have continued to revolutionize the battery industry by producing cells that match customers' preferences. Manufacturers lay emphasis on affordability, small size, and high energy density.

Many electronic devices have batteries of three main types: lithium-ion (Li-Ion), nickel cadmium (Ni-Cad), and Nickel metal hydride (Ni-MH). The casing of different battery types appear to be similar but there are lots of differences between these little power devices.

Nickel-Cadmium (Ni-Cd) Batteries

Nickel-Cadmium batteries are preferred in areas where high discharge rate, long life, and economical price are a priority. However, they are relatively low in energy density. Ni-Cd batteries are applied in biomedical equipment, two-way radios, power tools, and professional video cameras. Recent developments with lithium-ion (Li-Ion) and nickel metal hydride batteries have rivalled the cost effectiveness and lifespan of Ni-Cd batteries.

Pros

- Rechargeable.
- Perfect for high-drain devices.
- Minimal chances of damage. Hence, they can maintain a deep discharge level for extended periods.
- They are lighter and smaller than their lead-acid counterparts because of the high energy density. So if you are more concerned with weight and size, these should be your ultimate choice.
- Because of their relatively lower internal resistance, they can achieve a higher maximum rate of discharge. This is essential for certain applications such as power tools.
- Ni-Cd batteries directly rival alkaline batteries used in consumer electronics. In fact, Ni-Cd batteries boast of a much longer lifespan of between one to two years, which alkaline batteries cannot achieve primarily because they are not rechargeable.

Cons

- They have a 20% sitting rate of discharge implying that after a week of no use, they are likely to lose a fifth of their charge.

- Their self-discharge rate it at its peak at full charge and does down with a lower state of charge. This is why they give inaccurate measurements on their battery level.
- Perhaps the biggest disadvantage of them is that they exhibit an extreme negative coefficient of temperature. This means that as the temperature of the cell increases, the internal resistance decreases, a factor which makes the charging method more tedious. This is entirely different to lead-acid batteries which can simply be charged by a dynamo connection with a standard electromagnetic cut-out system, to prevent them from overcharging. This is why they cannot be used to start engines.
- Moreover, they pose extreme environmental health risks since they are designed with heavy metals namely, cadmium and nickel.

Nickel-Metal Hydride (Ni-MH) Batteries

Ni-MH batteries contain an anode of Hydrogen absorbing alloys, a cathode of Nikel-hydroide, and a potassium hydroxide electrolyte. They differ from Ni-Cd batteries in that hydrogen is used at the anode instead of cadmium which is why they have higher energy density compared to the Ni-Cd at the expense of reduced cycle of life.

Pros

- The capacity is two to three times that of Ni-Cd batteries of the same size.
- Despite their similarity to Ni-Cd batteries, they have a higher capacity as well as the ability to hold a stable voltage during the discharge process. They are perfect for devices which pull a high energy drain like digital cameras.
- Even though they are pricier than Ni-Cd batteries, they are durable.

- They never experience memory loss effect as their Ni-Cd counterparts. Again, their entire lifespan is longer at three to four years because they can undergo more discharge cycles. Furthermore, they are less toxic.

Cons

- They have a higher sitting rate of self-discharge compared to Ni-Cd batteries. People prefer Ni-Cd batteries for devices whose current draw on the battery is less than the battery's rate of discharge like remote controls. There are low self-discharge Ni-MH batteries which have incredible lower discharge rates compared to either conventional NiMH or Ni-Cd.
- Ni-MH batteries have a high internal resistance and a low maximum charge rate compared to Ni-Cd batteries.

Lithium-ion (Li-Ion) Batteries

For many years, nickel-cadmium had been the only suitable battery for portable devices. Nickel-metal-hydride and lithium-ion emerged in the early 1990s, and struggled to gain the customer's acceptance. Today, lithium-ion is the fastest growing and most promising battery chemistry. In these kinds of batteries, lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. This movement of lithium ions is made possible by the electrolyte. Li-ion batteries are common for portable electronics with low self-discharge, tiny memory effect, and high energy density.

Pros

- They do not suffer from digital memory effect.
- They boast of the longest lifespan of rechargeable batteries, at four to five years. Perhaps this is because they can undergo between three hundred to five hundred discharge cycles.

- Finally, they have all the advantages of the other two types.

Cons

- They approximately lose ten percent of their vital capacity after every year of use. And it's irreversible.

Maintaining Your Li-Ion, Ni-MH and Ni-Cd Batteries

Do you have those rechargeable batteries at your disposal? Do you want to know how to get the most out of them? If yes, then you are in the right place!

There are certain general practices that you can follow and ensure that your batteries remain in their perfect condition. So in this section, we are going to examine each cell, since the practices depend on the chemical composition of every battery.

1. Nickel-Cadmium Batteries

These batteries are more prone to the memory effect. Let's explore some of the best ways to maintain these kinds of batteries.

- If you didn't know, the first three discharge cycles on Ni-Cd batteries determine the characteristics of the cycles that will follow. Initially, when you use a device with a nickel-cadmium battery, you must ensure that you use the deep method of discharge listed below. Use this particular method in your first three discharge cycles.
- Before attempting to recharge these batteries, you must first ensure that the battery level is entirely exhausted. Doing this regularly than charging the battery again after utilizing it up halfway or so can potentially aid it to memorize its extended cycle.

- After your first three discharge cycles on a particular device, about once every thirty days, run the battery through a deep discharge cycle. This is accomplished by draining the battery completely.
- Finally, take note that room temperature is ideal for this type of battery.

2. Nickel-Metal Hydride Batteries

- These types of batteries are perfect at room temperatures. Again, they are prone to overheating, and this implies that appropriate measures must be taken to avoid the heat.
- If you want to store this type of battery for more than two weeks, you should put it through a deep discharge cycle, and then charge it to fifty percent before finally storing it.
- Even though nickel-metal batteries suffer less from the memory effect, it still occurs. As a result put the battery through a deep discharge cycle twice a month or so.

Essential Tools and Supplies for Reconditioning Rechargeable Batteries

On certain occasions, you need an electrical multi-meter to help you examine the health of your batteries.

Besides, there is also a host of other useful and valuable supplies that you must equip yourself with for proper battery testing, maintenance as well as reconditioning. Check them out below.

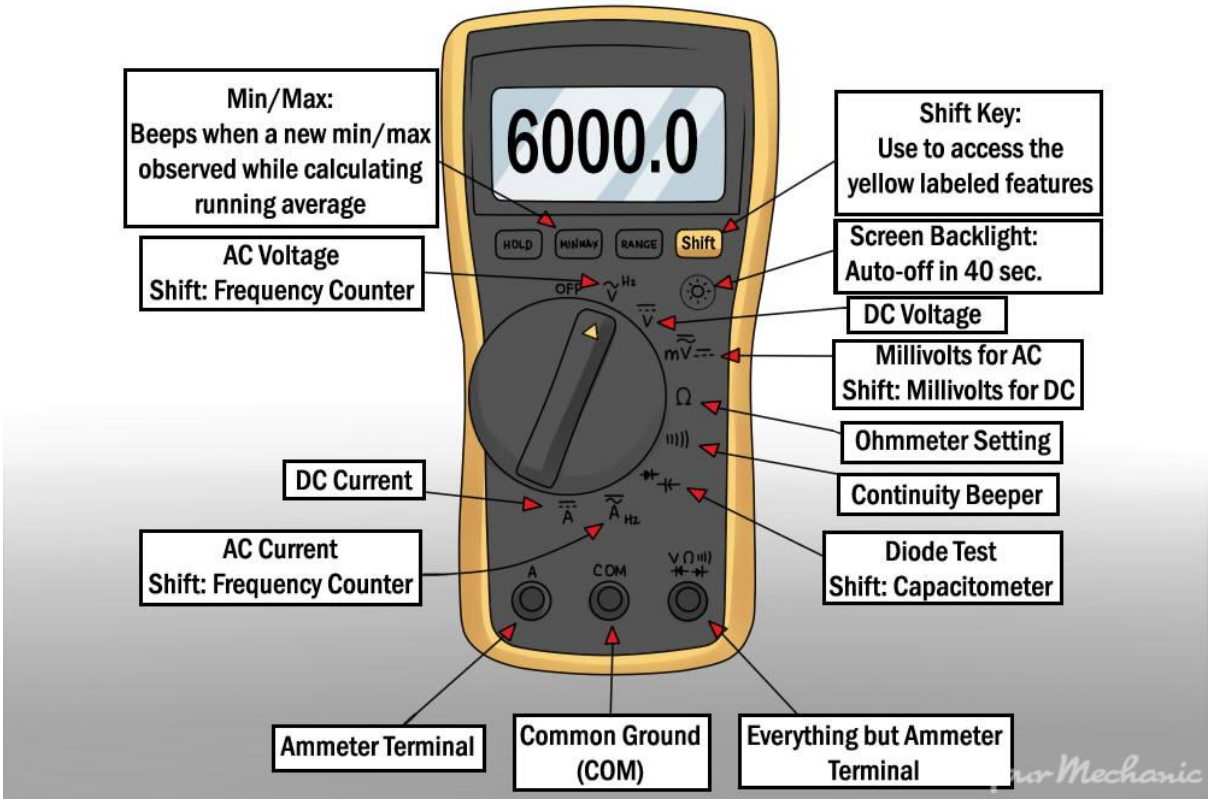
- A smart charger.
- A battery tester.
- A battery analyzer.
- A great pair of safety goggles.
- A multimeter.
- A set of alligator clip test leads.

It is imperative to note that these battery testing and charging equipment have prices which vary depending on the type of the battery, potential output as well as other aspects.

Testing Rechargeable Batteries

Testing Using a Multimeter

Perhaps before we dwell much on this section, it could be important to understand the essential parts of a multimeter. Each and every label on a multimetre is shown in the diagram below. Take note of each part as it is essential for effective handling of the multimetre.



You have the option to measure the alternating current, AC, direct current, DC as well as the electrical resistance, ohms. You can also measure the DC voltage and the AC voltage.

At the center of the device, you'll find a rotary dial where you select what you intend to measure. Typically, there are two types of measurements which you can take directly from a multimeter on a battery. They include the no-load resistance and the no-load voltage. No-load specifically means that the battery is not putting out any energy when the measurements are being taken.

Step 1: First, you'll have to set the dial to the type readings that you intend to make. The ones available should be the alternating current, the direct current, AC volts, the electrical resistance and the DC volts.

There are always two distinct modes for DC and AC voltage. Both have a V, but a DC indication will have two lines (a dashed and a solid one). On the other hand, the AC sign will have a wave close to it.

Step 2: Connect the probes on the multimeter to the correct negatively or positively charged terminals of the battery. As usual, red indicates a positive whereas the black indicates a negative.

Step 3: To readings that are correct, hold the tips of the probe tightly to the intended contact (as opposed to the sides of the probe).

Step 4: You should avoid touching the metal prong on the probes directly when taking down the measurements since this might distort the reading.

Step 5: Before recording the resistance measurement, you should calibrate the ohm setting to 0. On a digital multimeter, this can be accomplished by connecting the two probes. Just ensure that the dial is set to ohms.

Step 6: When using an analog meter, you'll notice a knob or a screw which you should adjust to zero for calibration.

Step 7: Ensure that the probe tips are clean so as to prevent the further contact resistance between the probe tips and the terminal of the battery. Any residue on the tips will result in incorrect readings.

Interpreting the Reading

Table one

Voltage reading	Interpretation
110 to 120% nominal voltage	An indication that your battery is in good condition.
95 to 110% nominal voltage	Your battery is functioning well and there is no need to recondition it.
Less than a hundred percent nominal voltage	The battery is not taking a complete charge. If it is a Ni-MH or Ni-cd battery then try reconditioning it.
Zero nominal voltage	This indicates a dead battery and therefore can never be reconditioned.

Table two

Ohms reading	Indication
Infinite ohms (OL or overload)	There is an unclosed connection or the battery is completely dead. Look for an open connection and if you identify one, then try rejuvenating your battery.
Resistance in the range of zero to infinite overload.	This is a normal reading.
Zero ohms.	This implies that there is an internal short in the battery. You should try rejuvenating it.

Using a Battery Tester

The only measurement that a battery tester determines is the remaining useful charge of a battery. A tester measures the voltage while the load is being applied to the battery. Most laptops and mobile phones come pre-installed with battery testers. With a free standing battery tester, the load resistance is applied to the battery for testing. There are types of testers designed to test only particular sizes and types of cells and as a result, have only one resistance level built in. On the other hand, others can test a variety of sizes or types of batteries.

Using a battery tester

- You'll have to connect the battery to the device appropriately. Every battery tester is different, and you should, therefore, use the available instructions on yours.
- On the device, choose the appropriate settings for the type and the size of the battery, unless yours can automatically detect this information
- Conduct the test following the provided instructions on your tester.
- Put down the reading from the dial or the screen.

Depending on the condition of your tester, it will show you roughly whether your battery is in dire need of reconditioning or not.

Using a Battery Analyzer to Test Rechargeable Batteries

It is imperative to note that a cell analyzer offers a more concrete data regarding the capacity of a battery than both the battery tester and a multimeter. This process involves taking the battery through its entire discharge cycle. After this, you measure its capacity as the total amount of essential current which the battery can provide in amp-hours.

Most battery analyzers are designed for six and twelve-volt batteries of all types. Just as with all the other battery equipment, the costs vary by the battery type and the available voltage. The procedure of using a battery analyzer is discussed above.

i. First, ensure that your battery is charged fully. This will offer a brief idea regarding its capacity.

ii. Connect the analyzer to your battery. Put the red clip (positive) of the analyzer on the positive terminal and the black (negative) clip on the battery's negative terminal.

iii. With the analyzer above, the software will allow you to assign a name to the test. Again, it enables you to select the type of the battery.

iv. Now key in the capacity of the battery in amps-hours (Ah). If your battery has only the milliamp-hours indicated, then divide that particular number by a thousand so as to change it to Ah.

v. Now enter the nominal voltage as described on the pack or the battery.

vi. Enter the number of cells which the battery utilizes.

vii. Leave both the test cutoff voltage and the test amps at their default values as set by the software. Click on the start button which shows on display. Now, the analyzer will drive the battery through its discharge cycle electronically. As this process continues, the current, the battery voltage as well as cumulative amp-hours

and watts will be shown on the screen. After the process is over, you'll see a particular graph in the display showing voltage plotted against the amp-hours.

Interpreting the test results

If you find out that the capacity of the battery is at least 95% of the rated capacity, then your battery is still in good condition and doesn't necessary require reconditioning.

On the other hand, if the measured capacity is somewhere between 50% and 95%, then you'll have to recondition your battery. Again, if the measured capacity is below fifty percent, then it might be a good idea rejuvenating the battery before reconditioning it so as to bring it back to its full capacity.

How to Recondition Rechargeable Batteries

There are three main ways to recondition a battery. All of them are ideal for rechargeable batteries. However, arguably the best way to recondition a rechargeable battery is to use an analyzer. This will take it through a deep discharge cycle and is the more controlled procedure.

Reconditioning a Battery Using a Battery Analyzer

- As usual, charge the battery to about ninety percent of its nominal voltage. For this step, it is better to conduct a battery test on a fully charged battery since the testing process decreases the nominal voltage to about 90%. When you are through with this test, every useful information regarding the battery will be displayed. You should tamper with this information since you'll use it somewhere.
- Next, you'll have to change two of the settings; the test cutoff voltage and the test amps.
- For reconditioning, you should set the test load on your battery between ten to twenty percent of the rated capacity in amp-hours.

- Now, adjust the cutoff voltage to a third of the nominal voltage of the battery. For instance, for a pack of seven Ni-MH cells is indicated as 1.2V per cell. This implies that the nominal voltage of the whole battery would be 8.4-volts. As a result, you'll have to reset the cutoff voltage at 2.8V. (1/3 of the nominal voltage).
- Now click the start button and begin the reconditioning process. Your batteries will be discharged at the test amp rate which you specified in the previous step. Discharge until the level reaches the test cutoff voltage level.
- After this, your battery should have undergone a fully discharged process. You can now test it to determine the new capacity.

Notable improvements will be seen after the first reconditioning process. As explained earlier, you can always conduct the second and the third reconditioning, and try the rejuvenation. However, if you do not see any visible improvements, then ultimately your battery cannot be saved.

How to Rejuvenate Rechargeable Batteries

Sometimes you can have a battery that doesn't respond to reconditioning process. In this case, it is possible that you can bring it back to life through a rejuvenation process.

i. You'll have to find a second battery to serve as the giver of life to be used to apply the voltage to the one you intend to rejuvenate. Depending on your options, you could use a 12v, 9V, 6V low voltage batteries or even a power tool battery to use with higher voltage batteries.
ii. Now, connect your alligator test leads to the correct negative and the positive terminals on your life giving battery.
iii. After this, join the other end of the negative alligator clip to the negative terminal of the cell you are rejuvenating. In brief, touch the other positive clip to the positive terminal of the battery for about two to three seconds.

iv. Now you should now test the new voltage of the battery you rejuvenated. If it is not closer to its original nominal voltage, then you may repeat the whole process. However, this time round, tap the positive terminal about three times with the end of the positive alligator clip. If there are no visible results, then your battery cannot be saved.

v. If your process was a success, then you'll need to recharge the battery to its full capacity.

How to Fix a Reversed Cell

If there is a weak cell in a battery pack, this can sometimes result in the cell to reverse its polarity. When this happens, the positive terminal is shifted to a negative charge whereas the negative terminal becomes a positive charge.

Step 1: Use a multimeter to test the polarity of every single cell. This is done by connecting the positive and the negative probes to the battery terminals appropriately. If the

multimeter shows that the cell has a negative voltage, then ultimately the cell does have a reversed polarity.

Step 2: Usually, applying a charge of about 4.5volts to a reversed cell of 1.2volts will restore its polarity back to the right order. If this doesn't work, then you can try with a higher voltage but should be under 9voltss.

Step 3: After you have successfully corrected the battery's polarity, now assemble the battery pack back together and finally recharge it fully. That should be it.

MILLITARY
BATTERY RECONDITIONING SYSTEM

CHAPTER 4:
HOW TO RECONDITION COMPUTER AND PHONE BATTERIES

Chapter Four: How to Recondition Computer And Phone Batteries

Types of Laptop/Phone Batteries

The best laptop and cell phone batteries emphasis high energy density, small size, and low cost, and they must produce extremely high energy density, deliver a super high 1,000 charge/discharge cycle, and be as thin as possible. Battery life comes second.

The top three types of batteries used in phones and laptops are Lithium ion (Li-Ion), Nickel-metal hydride (Ni-MH) and Nickel Cadmium (Ni-Cad). In the following subsection, we will discuss each of them in details.

Nickel-Metal Hydride Batteries

Commercial-size nickel-metal hydride batteries first appeared on the market in the late 1980s, replacing the potentially toxic and less-efficient nickel-cadmium types. They have a high-energy density compared to Nickel-cadmium batteries, but a relatively low cycle life. NiMH batteries provide an inexpensive and efficient alternative to standard alkaline batteries, a smoother rate of discharge, and more efficient power transfer that is needed in high current drain applications such as laptops and batteries.

How to Recondition Ni-MH Batteries

Like most other rechargeable sealed batteries, Ni-MH batteries don't need to be opened for reconditioning. Reconditioning Ni-MH batteries is a straightforward procedure that involve running deep charge cycles on the battery to revive their performance. Following the following steps to recondition your Ni-MH Battery:

Step 1: Give your Ni-MH battery a full charge.

Put your Nickel-metal hydride batteries and battery charger and put it for recharge. Make sure it's fully charged before unplugging – you may want to leave it on the charge for one hour after full charge. Just so to be sure it's fully charged.

Step 2: Discharge your Ni-MH batteries fully.

Now, put your batteries under a heavy load until the charge is completely drained. Ideally, use something that can drain out all the charge relatively fast. A TV remote, for instance, will take a lot of time to discharge the battery fully, but something like a digital camera or even a torch is great. Leave the device switched on, and allow it to consume all the charge. Measure the battery and make sure it's reading 1.2 volts or less. Alternatively, switched off the device for about an hour and turn it on again. It should work and gradually die

out. Leave it for another 40 minutes and turn it on. Keep doing this until the battery cannot turn on the device – at this point, it will have discharged fully

Step 3: Repeat steps one and two respectively.

Under the previous two steps, you were running what is known as a charge cycle. It is just an exercise for the battery, meant to allow it to regain fitness. After the charge cycle, leave the battery to stay idle for let's say one hour before use.

Note: Although you will realize significant improvements after two to three cycles, it's advisable to repeat the cycle three to five times for optimal results.

Step 4: Insert the battery in your device and recharge it fully.

This time, it should last longer in the device. If your batteries are still misbehaving, you'll have to rejuvenate or even replace them.

Step-by-Step Guide on Refurbishing Ni-MH Batteries

There are several methods that one can use to refurbish nickel-metal hydride batteries, but the most effective is to replace the damaged cells. Follow the following steps:

Step 1: Charge your Nickel-Metal Hydride Battery Fully

Put the battery in the charge station and make sure it's fully charged. Then, unplug it from the charge station and leave it to sit overnight so that the damaged cells can lose their energy.

Step 2: Remove the Ni-MH Battery Casing

Take your Nickel-Metal hydride battery and move it to a work station or the garage. Ideally, on an outdated table. Use a screw driver (a small Phillips screwdriver is okay) to remove the battery cover to expose the NiMH batteries.

Step 3: Test Each NiMH Batteries

Use a voltmeter and test each cell - do this by simply touching the terminals of the voltmeter to the negative and positive ends of the cells. If the voltmeter reads between 1.1 and 1.2, then the specific cell is okay. If the reading is below 1.1, that's a dead cell. Put all bad cells aside or mark them using a pencil or pen.

Step 4: Replace the Damaged NiMH Cells

Remove the damaged cells and replace them with news ones. In some models of NiMH batteries, the cells are soldered in and you might need to use the soldering iron to remove them. Simply heat the iron and remove the batteries as fast as possible. Other times, they are held together by the plastic case, and you just need to pry them out. Note that if the old cells had been soldered, you must solder the news ones back. Once that is done, close the plastic case and charge your NiMH battery.

NB: Put the damaged cells in a plastic bag to avoid toxic leaks and dispose them responsibly. You may check the manufacturers website for tips on how to dispose the batteries.

Advantages of Reconditioning Nickel-Hydride Metal Batteries.

- They have very high life cycles of about 3000. Reconditioning this type of battery increases their useful life.
- They have a wide temperature range meaning they can be used in a variety of temperature without posing risks of explosion. By extension, this means they are safer to handle as temperature is not something to worry about.

- Nickel Hydride metal batteries can withstand overcharge and over-discharge conditions without being totally damaged. This means they can be reconditioned even after they have completely discharged or overcharged.
- Maintaining this type of batteries is very easy no matter the extreme conditions that may hit them. One can always recondition Nickel Metal Hydride batteries and restore them back to normal operating standards, even after they have been exposed to extreme conditions.
- Even after reconditioning, nickel-hydride metal batteries can still withstand an accident or abuse because of the incorporation of benign materials during manufacturing.
- They are environmentally friendly as they release only mild toxins to the environment.
- Reconditioning them, therefore, does not pose a big environmental risk.

Limitations of reconditioning Nickel-Hydride metal batteries.

- This type of batteries has a high rate of self-discharging, which may not be solved by reconditioning. One must keep on charging it frequently to have it in operation. This makes it hard to depend on them due to the high maintenance costs.
- The cell voltage of nickel hydride metal batteries is only 1.2 volts. This does not change even with reconditioning. To make a high-power battery, one will need to interconnect a lot of batteries.
- Nickel Hydride metal batteries deteriorate after a long-time of storage. This can, however, be solved by reconditioning.
- Reconditioning this type of battery is a little bit complex, meaning they are best reconditioned by experts.

Safety precautions to observe when reconditioning Nickel Hydride Metal batteries.

- When reconditioning this type of batteries, keep moisture or water at bay. Water can cause shock which may lead to body injuries.
- Once the reconditioning process starts, do not leave the battery unattended. Reconditioning should be a continuous process from its start till the end. This will minimize chances of danger and ensures that all guidelines have been followed to the letter, including the exact duration that the whole process should take. Reconditioning it in phases may not bring out the best results.
- When reconditioning, do not allow the cells and batteries to overheat at any given point. In case a cell goes up to 140 degrees Fahrenheit, it should then be placed in a fireproof location to avoid explosions.
- Before embarking on reconditioning batteries, not nickel hydride metal batteries only, carefully inspect it for any damages, dents or cracks. In case you find any of these, do not go ahead with the reconditioning.
- On the same note, if a battery is overheating during reconditioning, disconnect it from the charger to ensure safety of everyone.

- Always have protective clothing such as gloves, lab coat, helmet, protective glasses as well as boots on and ensure that all working surfaces are completely insulated before working on any batteries.

In case of injuries when reconditioning this type of batteries, necessary first aid measures should be taken and medical assistance sought if necessary.

Lithium Ion batteries (Li-ion).

Lithium ion battery technology gained popularity in the mid-1990s and it's the fastest growing battery system. Li-ion are ideal where lightweight and high-energy density are the priority.

Li-ion batteries provide a significant increase in total charge capacity over nickel-metal hydride batteries, and they are not affected by the memory effect. They are also more environmentally friendly than nickel-metal hydride batteries. However, li-ion batteries are delicate, and protection circuit is often needed to guarantee safety. They are mostly used in cell phones and notebooks. The diagram below shows the inside of a Li-ion battery with the cells that form it.

How to Recondition Li-Ion Batteries

Before starting a Li-Ion battery recondition or refurbishment project, it's imperative that you become acquainted with the risk surrounding Li-Ion. This is important to ensure your safety during the re-conditioning project and to help you recondition/refurbish your Li-Ion battery properly. Unlike NiCad and NiMH batteries, you should never discharge a Li-Ion battery below a set minimum voltage as this can cause permanent damage to the battery. Most Li-Ion batteries are fitted with an automatic Off circuit that keeps the battery charge from being drawn below the set minimum voltage. As such, trying to short circuit the battery can easily result in an explosion.

Although they have numerous advantages over other type of rechargeable batteries, refurbishing or reconditioning Li-Ion batteries is cheaper, easy to do, and eco-friendly than buying a new one. With a jump start, a full recharge, or repair, you can recondition and/or refurbish a lifeless Li-Ion battery and have it working almost as when it was new.

Technique 1: Perform a full re-charge of Li-Ion battery

A quick and cost-friendly method to try and refurbish a Li-Ion battery is to fully recharge it. To do so, start by fully draining the battery, up to the set minimum. You can accomplish this by simply putting the battery in a device such as a torch, and keep turning it on and off until there is no power left to boot the torch. Then, plug the lithium battery into AC adapter charger and leave it for at least 48 hours.

NB: You should leave the battery for the 48 hours without turning it off or removing it. After that period, the battery should be refurbished.

Jump Start the Lithium Battery

If the Full recharge fails to recondition the battery, an alternative way is to jumpstart the battery, just the usual way you would jumpstart a lead acid battery. If this is still new to you, just do the following: Remove the battery from the device and identify the two terminals (negative and positive). Then, cut off the B-connector end of an old but working USB cord to expose the black and red wires. With the A-connector of the USB connected to a computer, connect the exposed wires to their respective feeds on the battery (the red wire to the positive and black to negative). After a sometime, the battery will revive itself.

How to Repair Lithium Batteries

Simply put, Lithium batteries stop working due to accumulation of sulfur crystals inside the battery. As such, it's possible to repair damaged lithium batteries using a desulafator.

A battery desulfator sends a high voltage impulse through the lithium battery, effectively breaking the sulfur crystals to restore the battery to its initial performance.

NB: To refurbish lithium-ion batteries like the ones found in laptops, simply open the lithium ion pack and remove the damaged cells. Then test them using a voltmeter and replace the damaged cells with new ones. Check that the new batteries are properly soldered by checking for short circuits using a multimeter.

Safety Measures When Reconditioning Lithium Ion Batteries

When reconditioning this type of batteries, it is important to observe the following safety measures:

- Wear safety clothing. These include a lab coat, gloves, gumboots and safety glasses. You can put on a face mask to protect the body from possible dangers.
- Avoid wearing loose metallic bands or wrist watches because these may connect with the terminals and cause severe injuries and/or damage to the battery.
- Cover the working surfaces with an insulating material. In addition, make sure all all the tools that are to be used in the reconditioning process are properly insulated. This is necessary to avoid dangers such as electrocution that may result during the reconditioning process.
- When reconditioning batteries, it is good to avoid exposure to open flames, sparks and smoking cigarettes near the working area. This is because some batteries give of hydrogen gas which is flammable.
- Sparking the battery terminals to test the charge level is another risky thing that may cause explosions. If you must do it, follow the right procedures.
- When charging a battery, do not charge it for longer periods than necessary. Overcharging spoils and reduced the life of the battery.

- Also, avoid exposing cells and batteries to high voltage DC or AC power sources as this can lead to discharging or damage to the cell. Above all, make sure to follow the manufacturer's instructions on the label and use the right chargers for specific batteries.
- After reconditioning the batteries, it is good to have them stored in an appropriate way. Always store the batteries in a cool well ventilated area. Ensure that the temperatures are within the manufacturers guidelines. This is important to ensure that the reconditioned battery will have maximum shelf-life. Avoid storing heavy stacks of items over reconditioned lithium batteries to avoid crushing or distortion of the cell case. These could cause internal short circuits or explosions which resulting in fire. In the storage area, it is always good to store what is just enough. Never forget to have a fire extinguisher in the storage area for reconditioned batteries. This can save the situation in case of a fire break out.

Incase an injury occurs when reconditioning lithium-ion battery, the following first aid measures should be taken:

- If lithium ion release occurs on the eye, flush the eyes in running water for around 15 minutes while the eyelids are open. One can seek immediate medical help if the situation is severe.
- If contact occurs with the skin, remove the contaminated clothes then flush it with water, probably under a shower before 15 minutes.
- Incase inhalation of a dangerous gas occurs during reconditioning of the battery, move the victim to fresh air and monitor their breathing trend. Administer first aid CPR actions and seek medication immediately.

Nickel-cadmium batteries.

As aforementioned, nickel-cadmium batteries are the oldest among all rechargeable consumer-based batteries. In a nickel-cadmium battery, nickel and cadmium are used as electrodes and potassium hydroxide forms the electrolyte. NiCd batteries offer some great performances, but they are affected by the memory effect. They are mostly used in laptops, digital cameras, and calculators. The following diagrams shows the inner side of a Nickel-Cadmium battery, showing the actual cells that form the battery.

How to Recondition Nickel-cadmium Batteries

Nickel-cadmium batteries can be reconditioned too, but first you have to determine the cause of the damage. In most occasions, this happens due to memory effect which is particularly a huge issue with NiCad batteries where over time, they start losing their charge faster than when they were new.

For instance, the battery will only charge to 60% but when tested using a voltmeter, it will show it's 100% charged. Consequently, when it is inserted in a device, it won't last as long as it should. Overcharging Nickel-cadmium batteries is one of the major cause of memory effect.

So, dead nickel-cadmium batteries are in most cases not dead. It's only that due to memory effect, self-discharge, overcharging, and exposure to extremely high temperatures, sulphur crystals accumulate in the battery and eventually reach the terminals, preventing the battery from recharging.

Thankfully, by passing a high voltage current through these dead batteries, you can revive them and they will be as good as new. Reconditioning is another method to get rid of stubborn sulfur crystals. This is detailed in the following paragraphs:

First, you will need a direct current power supply. Some people use lead acid batteries to recondition dead nickel-cadmium batteries but this is unsafe and you should not try it. Keep in mind that cadmium is a toxic substance and whenever a battery is exposed to high voltage, the risk of it exploding increase significantly. A simpler and safer way to recondition NiCad batteries it to use a capacitor because it produces a high voltage discharge superfast. Most capacitors used to recondition nickel-cadmium batteries are from disposable flash camera.

The simplest way to repair is to use a capacitor because you can get a quick high voltage discharge from them. You can get a capacitor to use from a disposable camera. Charge the capacitor to a voltage which is approximately 2-4 times the voltage of the cell. Then, connect the battery to the capacitor with the same polarities together.

Once the pulse charge is passed through the battery, the Sulphur crystals are destroyed and the cell is ready to be recharged again. Regular exercising and reconditioning will maintain the health of the nickel-cadmium battery.

IMPORTANT NOTE!

The above methods of reconditioning rechargeable laptop and cell phone batteries are based on the DEEP DISCHARGE METHOD. However, there are other methods that you may use, including utilization of a battery analyser as discussed in chapter three.

Benefits of Reconditioning Nickel-Cadmium Batteries.

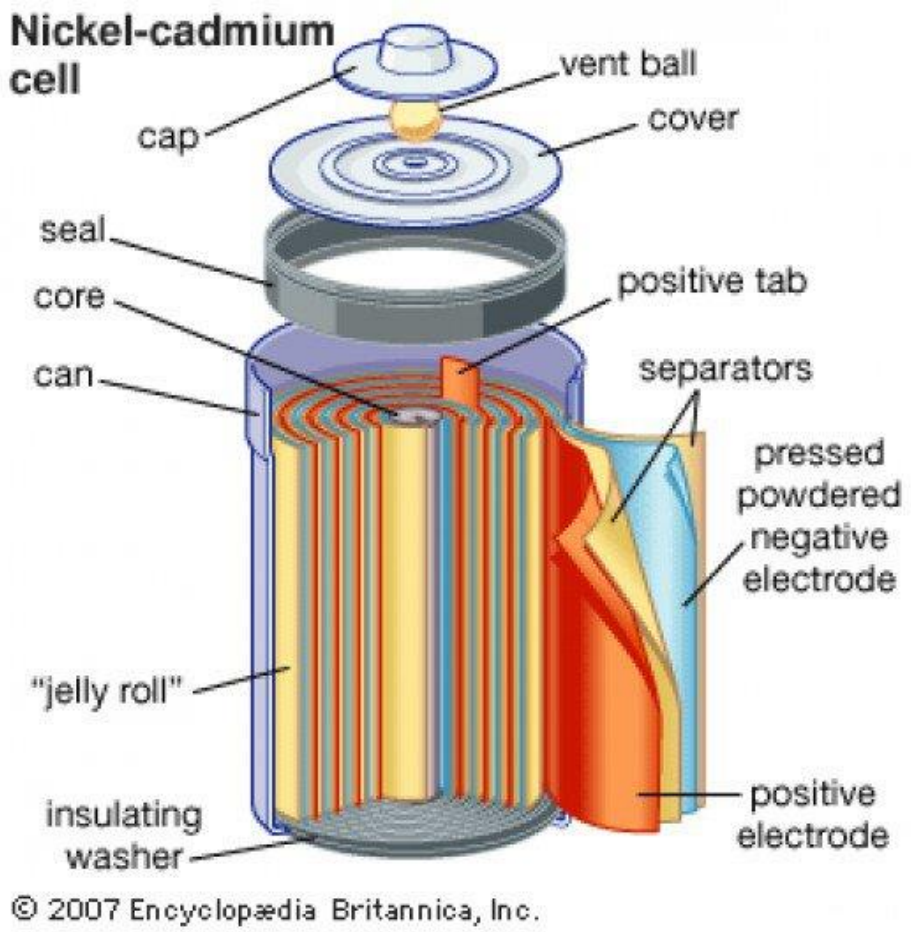
- This is the only type of battery that can be fast charged without a lot of strain. This makes it a favorite choice for many people since they can recondition and have it back and running in the shortest time possible. Fast charging batteries are very reliable for emergencies especially in hospitals and aircrafts.
- They have a long shelf life. This type of batteries can be reconditioned even after staying out of use for a long time. The only thing that one needs to do is to prime it.

Shortcomings Associated with Reconditioning Nickel-Cadmium Batteries.

- They offer relatively low energy as compared to the newer systems that are in the market today. Even when they are reconditioned, they may not compete favorably with the new technology.
- Cadmium is highly poisonous. It needs a lot of caution while handling to prevent injuries to the consumers. Also, while reconditioning, there is dire need for high standards of disposing the byproducts since they are harmful to the ecosystem.
- The nickel-cadmium cells can only give 1.20V of power. One can only join many cells to generate high amounts of energy.

Safety Precautions While Reconditioning Nickel-Cadmium Batteries.

- When reconditioning this type of batteries, do not allow the terminals to connect with material that conducts electricity, including lead wires because it may short circuit the battery and cause excessive power flow, resulting in explosions.
- Do not connect Nickel-Cadmium batteries to a direct power source as this may also cause explosions.
- Cadmium is a very toxic chemical. Always ensure that as you recondition the battery you are in appropriate protective clothing. Never forget to have a fire extinguisher in close proximity just in case there is a fire breakout. A first Aid kit is also a necessity in the working area.
- After reconditioning the battery, always charge it between the temperatures of 0-40◦C to avoid shortening its life cycle or impairing its performance.
- When testing or using, do not connect Nickle-Cadmium batteries in parallel as this may cause leakage of the battery fluid or bursting which results in fire.
- When reconditioning, always refer to the manual guide to be sure that you are doing it the right way.
- Pay special attention to the terminals while reconditioning. Clean any dirt and remove rust appropriately, accumulation of these may lead to low performance, hinder effective charging of the battery and cause loss of power.
- Do not mix reconditioned batteries with old or low power batteries. It is advisable that the reconditioned batteries should be used separately.



Extensive Tips for Improving the Life of Your Smartphone Battery

Batteries are perhaps the most critical components of a smartphone or laptop, but they do not last eternity. For example, most manufacturers of smartphone rate their batteries at 300 to 500 cycles, and Apple claims that its laptop batteries reach eighty percent of their original capacity after one thousand charge cycles. After this point, the batteries won't be able to hold as much power and will support your device for increasingly shorter period. In fact, for some people, just getting through the day is a huge challenge. In this article, we want to give you tips to help you boost your laptop or smartphone life. We will discuss simple, everyday changes that you can make, but tips that will make you greener, save you money, and take the hustles of a phone that dies on you midday away.

1. **Turn-off the Big Battery Suckers**

Before we go into specifics -to behaviour or settings – that you can tweak to prolong the life of your smartphone or laptop battery, let's flag some things that you should avoid if you are concerned about your battery dying on you; we will call them the BIG BATTERY SUCKERS.

One is streaming videos – watching a video or movie on, let's say, Netflix requires your screen to be continuously on (the worse battery sucker), your device to be continuously connected to the web (another significant drain), and the device core processor and graphics processor to be actively decoding the audio and video. For instance, with a new iPhone 6s Plus, which is the device I use, streaming Pee-Wee's Adventure (Netflix), drained 5% of my battery.

So, whenever you note that your battery is going low and you really need it to last for some time, turn off the navigation and GPS and avoid video or audio **streaming till you connect to a source of power.**

2. **Keep the Battery Cool**

Exposing your laptop or cell phone battery to extreme temperature can be more disastrous than cycling. According to an article by Battery University, which conducts a vast array of battery analysis and test, ageing and high temperatures reduce performance and live of your battery. A temperature of 86°F is considered high.

In one of the test, battery capacity dropped by 60% after it was exposed to an elevated temperature of 60 degree for 3 months. For this reason, try and keep your laptop or smartphone cool. Do not leave it in direct sunlight or inside your car on a hot day. It's also on of the reason you should worry about heating issues and smartphones as it can really reduce the useful life of your battery. You can try and reduce the damage by making sure the cooling vents in your device stay open – expose to dust can block them and make your fun work extra hard which is another drain on your battery. It helps to maintain a clean and dust free environment.

3. **Reduce Your Screen Brightness or Use the Auto-Brightness Mode**

We all love the full light, colourful display of our phone. But do you know it consumes more power than anything else on your device? Fortunately, smartphones and laptops

come with an auto-brightness features, which automatically adjusts screen brightness of the phone, to suit the ambient levels of lighting, effectively saving power compared to running your phone display at full brightness all the times.

On your laptop, the cheapest and the simplest priority you have is to reduce the screen brightness to the minimum. Try using the dark theme and dark wallpaper.

4. **Turn the Bluetooth off**

Although Bluetooth does not consume as much power as your phone's cellular radio, it drains a significant percentage. So, when you are not using your Bluetooth, just turn it off.

5. **Limit How You Use the GPS as Well as Location Services**

The other big battery consumer is apps using GPS, Wi-Fi and mobile data for your location activities. As a smart user who cares for his/her gadget, you can opt to revoke your apps' access to location services or customize levels especially in Android to regulate how much power they can use. In your phone's settings, go to the location and select High Accuracy when you need it, or Battery saving when you don't. This will primarily enable you to control the performance of your device, based on power consumption.

6. **Don't Let Your Apps Run in the Background**

Without a doubt, the ability of your smartphone to run numerous apps one at a time is an essential feature. However, this feature burns a lot because every running app uses a portion of your gadgets' processor cycles.

Individual applications are heavy on battery life. For instance, Facebook has confirmed in its investing studies that its iOs is responsible for a significant battery drain. By deactivating the applications which you are not probably using, you can significantly decrease the workload of your CPU and potentially cut down on its energy consumption.

7. **You Should Never Use the Vibration Mode Often**

If you often put your phone in vibration mode, you should seriously consider changing your incoming call settings. Vibration consumes more power than playing a ringtone because a tone only makes a small membrane in your phone's speaker to vibrate, and this is always enough to produce the sound. On the contrary, the vibration motor revolves around a little weight to cause a whole vibration on your phone. This process takes a lot more power.

8. **Do Away with the Less Important Notifications**

Currently, almost every app can access the internet on its own in search of updates, messages, news as well as other related information. When it identifies something, the app might chime, light-up your phone's display and display a message and even make the LED to blink. All these "eats up" a significant percentage of your battery.

Don't turning off important notifications about the missed calls or new text messages, but turning off individual superfluous notifications can make your battery to last a little bit longer.

9. **Push Email**

Even though imperative, letting your smartphone check if there is a new email regularly is a waste of energy. Instead of enabling email to be pushed to your phone regularly, you can just change the setting to collect mail after a certain duration, maybe after fifteen or thirty minutes or so, if you don't need to respond to anyone immediately.

10. **Turn off the Wi-Fi**

Just like the Bluetooth, your little gadgets' Wi-Fi is a great battery drainer. When you are not using this feature, it is better just to turn it off. Toggle the Wi-Fi off when you are not using it, and only turn it on when you intend to use data services within your range.

11. Keep the Display Timeout Very Short

If your screen timeout is currently set at two minutes, you should seriously consider changing it to as low as two seconds. In your phone's display settings menu, there is an option labelled Screen Timeout or something of that sort. If you have an iPhone, search for the Auto-lock in the general settings menu. This setting regulates the time your smartphone remains lit after receiving an input such as a tap.

12. The Magic of the Power-saving Mode

The good news is that almost every phone manufacturer provides regular power-saving features. So, depending on your gadget, you can take advantage of this functionality.

Activating the battery-saving mode manages your phone's power-eating features for you. By default, this feature frequently turns on when your battery levels fall below twenty percent. However, you can set it to start at thirty percent instead. The faster your phone changes to this power-saving mode, the more extended its battery life will last.

13. If It Is Possible, Don't Use the Battery

It might seem unrealistic, but this can help. If your device has an option of a removable battery, use it and avoid using the battery much often. This means that you will just plug in your charger and remove the battery afterward. NB: This option is only available for people living in areas where power fluctuations are extremely rare, otherwise, if power fluctuations occur when on no battery mode, risks of damage to your device are high. As a precaution, before removing the battery, make sure it is not fully drained. Charge it to at least eighty percent. Again, you should not keep the battery unused for extended periods.

14. Avoid Overcharging the Battery

Most people regard this as a myth, but the truth is that overcharging will gradually kill your laptop's battery. This means you should not keep your charger plugged in after your battery is fully charged.

15. Close All the Background Tasks

If you have any tasks in the background that are not useful, closing them will extend your battery life. There are always many applications at the right-hand side of the taskbar that are usually running in the background. All the unnecessary stuff including dropbox, skype, Bluetooth, Wi-Fi, skype as well as torrent client plus are massive battery drainers. In general, multitasking is the practical way to go when you want to save the power of your laptop, but don't leave too many apps running. As soon as you finish with one, close it.

Also, disconnect any peripherals you no longer need, at least in the next few hours or days. External keyboard, mouse and hard disk and such like stuff, all consume lots of power and they will potentially lower your battery life.

MILLITARY
BATTERY RECONDITIONING SYSTEM

CHAPTER 5:
HOW TO RECONDITION SOLAR BATTERIES

Chapter Five: How to Recondition Solar Batteries

In the last decade, solar energy related technology and its applications have come a long way, and its costs (once exorbitant) are reducing day by day. Once considered a forte of big companies, it is now within grasp of the public with a reasonable budget. However, like most batteries, solar batteries deplete over time and necessitate replacement. It is said that you need to replace these kinds of batteries every five to seven years to keep your solar system at its optimum potential. Doing this would cost you loads of money. So! Is there a decent way you could cut back this cost or reduce solar battery replacement necessity?

Of course yes, there is a way. Like most batteries, solar batteries can be reconditioned and revived back to life and save you some precious bucks. But before we embark on this exciting mission, it is essential to first look at the types of solar batteries and take it from there.

Types of Solar Batteries

Batteries for solar applications must meet the demands of irregular full recharging, heavy cycling (charging and discharging), and unstable grid energy. There exists a number of battery types fitted for these exclusive necessities. However, consideration for choosing the best type for your application will depend on maintenance, installation, cycle life, and cost. Let's take a look at these solar batteries' aspects essentially to guide you in selecting the most apt battery for your application.

Flooded Lead Acid Batteries

Flooded lead acid batteries have the longest track record in solar electric applications and are still used in most stand-alone alternative energy systems. These kinds of batteries have the least cost per amp-hour and longest of any renewable batteries. We have already looked at these kinds of batteries in this guide. You already know that a lead acid battery is filled with an acid solution (electrolyte) which suspends the lead plates (positive and negative grids called electrodes).

The electrolyte in these batteries needs to stay full at all times which necessitates refurbishing using distilled water. Therefore, even though flooded batteries (alternatively known as wet batteries) are the most commonly used batteries for solar applications, they require regular maintenance in the form of equalizing charge, water refilling, and regular terminal cleaning.

Advantages of Flooded Batteries for Solar Applications

- Flooded or wet lead acid batteries are offered in numerous sizes and design options and built for many different applications.
- It is easy to access and replenish the electrolyte through the caps. Therefore, they are easy to recondition compared to Gel or AGM batteries.

- Relatively cheaper compared to Gel and AGM batteries.

Disadvantages

- Requires high maintenance.
- High chances of acid spillage.
- High chance of corrosion.
- Dispense charge at a lower rate than AGM and Gel batteries.
- Gassing produced when charging them may cause explosions.
- They aren't vibration resistant which limits their application.

Gel Batteries

Gel batteries are valve regulated lead-acid (VRLA) batteries that do not release corrosive gas like other lead-acid batteries. As we have seen in this guide, the oxygen produced in valve regulated batteries at the positive grids combine with hydrogen from the negative plates to form water—consequently preventing oxidation and water loss. The electrolyte in these kinds of batteries is suspended in the container in a gel-like paste which prevents instances of acid spillage and corrosion. However, it is still recommended that you place a gel battery in an upright position unless specified otherwise by the manufacturer.

Although it is recommended that you charge these batteries regularly, gel batteries are known to recover superbly from deep discharges. Virtually, these batteries are maintenance free and use only one valve that allows the internal gasses to recombine to form water. They are exceedingly robust and versatile and are safe to be installed in areas where ventilation is limited. The life cycle of these batteries is also by far exceed that of AGM and flooded batteries which make them undeniably attractive for solar power applications.

Note: Do not confuse Gel Batteries with AGM Batteries. Both kinds of batteries possesses the some similarities, but their difference in application is extremely indispensable. Both batteries are recombinant, meaning that the oxygen produced on the positive grid is absorbed by the negative grid. Consequently, instead of hydrogen gas being produced on the negative plate water is formed, thus maintaining the electrolyte level in the battery. This is the reason both kinds of batteries can be installed in any position and are resistant to vibration, maintenance free, spill proof, sealed, and valve regulated.

However, there is a striking electrolyte difference between these two types of batteries. In Gel batteries the electrolyte is jelly-like, but in AGM batteries, it is lighter and is absorbed in glass matt separators. Due to this difference in electrolyte form, AGM batteries work better in cold temperatures while Gel batteries work better in warm temperatures.

Advantages of Using Gel Batteries for Solar Applications

- Low cost-per cycle
- Low cost-per month
- Free from sulfuric acid spillage
- Rugged and vibration resistant
- Minimal corrosion, therefore well-suited for sensitive electronic equipment
- Maintenance free

- Suitable for deep cycle applications
- Long life cycle—have a range of up to 5000 cycles.

Disadvantages

- High temperatures may adversely affect the paste-like electrolyte
- Special regulators and chargers are required
- Replenishing using distilled water is complex as it necessitates drilling and capping. This may be hazardous
- High initial cost

AGM Batteries

This is another popular battery used in solar applications. As aforementioned, AGM batteries are very similar to Gel batteries, and the two are often confused. However, they have a distinct electrolyte difference that makes each apposite for specific temperatures. AGM technology became popular in the 1980s as portable batteries for vehicles, military aircraft, and UPS. They were chiefly invented to help reduce weight and improve reliability in these applications. In these batteries, the electrolyte is absorbed by a very fine fiberglass

which makes the battery spill-proof. The electrodes can either be cylindrical, or rectangular to resemble a standard flooded lead acid battery. This battery delivers an effective and efficient upgrade to the traditional battery designs, lifespan, and performance for solar applications. Essentially, AGM batteries are preferred when a high burst of amps may be required.

Advantages of AGM Batteries for Solar Applications

- Maintenance free. AGM don't exhibit terminal corrosion, meaning less battery maintenance.
- Compared to other batteries of the same size, AGM batteries allow additional plate surface are which means higher rating in reserve capacity (RC) and cold cranking amps (CCA).
- Like Gel batteries, these batteries do not produce or expel oxygen/hydrogen gases like is the case with flooded batteries which means no need to regularly refill with distilled water.
- AGM batteries also have lower resistance than flooded batteries which allows faster charging.
- Less costly compared to the Gel batteries.
- Offers higher power capacity as do the same physical size Gel batteries.
- Vibration resistant due to solid sandwich construction.

Disadvantage

- Must be stored while fully charged.
- Capacity has gradual decline as compared to Gel batteries.
- Sensitive to overcharging. Gel batteries are highly tolerant than AGM.
- Higher manufacturing cost than flooded batteries.
- Low specific energy.

Now that we've briefly looked at the three most commonly used batteries in solar applications, we're going to now look at how each and every one of them is reconditioned. By now, you already have an idea of what battery reconditioning is and the following reconditioning procedures will surely be familiar. In fact, the procedures discussed in the following section will be more of reaffirming the already discussed concepts. You already know that it is possible to bring batteries to life again if their cells aren't dead. You also know that sulfation is the main cause of battery failure, and thus, desulfation is the central technique for bringing dead batteries to life. In the following sections, we are going to explore how to recondition each battery type discussed in this chapter.

How to Recondition Flooded Batteries

In chapter two of this guide, we discussed how to recondition lead acid batteries through three different techniques. Even though the process of reconditioning lead acid batteries is somehow universal, there are significant elements that apply to only a specific type. In this section, we are going to look at how to individually recondition one of the lead acid batteries—flooded batteries.

Preliminary Measures

1. Before handling a flooded lead acid battery, it is important to first take precautionary measures. First off, for the safety of your skin, eyes, and clothes, you should ALWAYS wear protective gloves (chemical resistant), safety glasses (full-face shield is highly recommended), a lab coat or rubber apron, long pants, and closed shoes. Anything that can trigger fire during this process should be avoided at all cost to avoid chances of an explosion. Always connect or disconnect the negative (ground) terminal first to avoid sparks that can cause an explosion.
2. Test your flooded battery to determine whether it is restorable or not. As already mentioned in this guide (chapter two), you cannot embark on a mission to revive

your battery, if you cannot tell whether it is restorable in the first place. There are several ways used to test a battery's cell as demonstrated in chapter two. You can test your battery's cells using a hydrometer or a multi-meter. After this procedure, you should tell whether your battery can be serviced or not.

3. Clean the battery terminals using a terminal cleaner by placing the post cleaner on each post and twisting it clockwise or counterclockwise until the corroded terminals are clean. This procedure is an important preliminary step as it proved important during trickle charging.
4. Replenish the battery with distilled water to its capacity. Do ever use tap water as it contains impurities that might react with the electrolyte.
5. Charge your flooded battery to its capacity and then remove the surface charge and your battery should be ready for reconditioning.

After conducting these preliminary steps, your battery should be ready for reconditioning. As discussed in a previous chapter, there are three ways through which you can revive a dead lead acid battery. And since flooded batteries fall under this category, we will use the same steps to accomplish this reconditioning process.

a. Reconditioning through a chemical desulphator

As aforementioned, sulfation is the number one cause of battery failure, therefore, if you find a way to kill off the lead sulfates accumulated in the battery. This is considered one of the best, if not the best method of desulfating flooded batteries. Chemical desulphators have the capability to dissolve desulfation and bring back your battery to life. It's that simple. There are many chemicals that can be added to a battery to extend its life or restore it back to a normal working condition. The most used and effective chemical desulphators include;

- **Magnesium Sulfate** also known as **Epsom Salt.** It is the commonly used desulphator.
- **EDTA—**a crystalline acid used in industries.
- **Caustic Soda.**

Regardless of the desulphator, the procedure used when applying chemical additives is the same. All that needs to be done is addition of the chemical to the electrolyte, allow proper mixing, and then wait for reconditioning to take place. The following procedure is used to desulfate a 12v flooded lead acid battery.

The Procedure:

i. Heat some amount of distilled water at around 66° C (150F) to dissolve Epsom salt. It is important to note that Epsom Salt should not be added directly into the batteries electrolyte because the solution inside cannot dissolve it properly.

ii. Mix 10 heaping table spoons of Epsom salt (250g) with this hot water and stir. Ensure that the salt is completely dissolved.

iii. Remove the six battery caps using a screw driver. Take caution as you open these caps; avoid acid spillage at all cost.

iv. With the help of a funnel, simply pour this solution into each cell of the battery you are restoring, just like you do when filling up the electrolyte with distilled water. Make sure that you are pouring in the same amount of Epsom Salt solution into each cell. **Note:** if your battery is already full of electrolyte, draw some out to give room for the Epsom solution.

v. Put the caps back on and shake the battery well to mix the Epsom salt solution and the electrolyte well.

vi. Charge your battery to its capacity and then discharge it up to 50%. Then charge it again several times. Test the battery to see whether restoration has taken place. It should test positive. If not, don't worry, sometimes it takes up to 10 days for Epsom salt to dissolve completely and work properly.

After completing these steps, your battery should be restored. How does this process work? Well, after you continuously use your flooded lead acid battery to store solar power, its performance keeps on reducing due to continuous charging and discharging. Therefore, the chemical reactions that take place between the electrodes and the electrolyte to produce electricity are reduced. By introducing a chemical desulphator into the electrolyte, you will be breaking off sulfation to allow for normal chemical reaction in your battery. So, not unless the lead plates have broken off completely, this method is said to have a success rate of 98%. However, chemical desulphators can only be used to restore a flooded battery for 2 to 3 times before it dies completely.

b. Reconditioning through an equalizing charge

An equalizing charge is nothing but a deliberate battery overcharge to eradicate sulfate crystals formed as a result of sulfation. Basically, applying a periodic equalizing charge brings back all cells in your battery to a similar level by increasing the voltage to 2.50 volts per cell or hiking the standard charge voltage by 10%. In fact, this method is not only useful in reviving dead batteries, but it is also recommended to keep your battery in shape. You should, therefore, conduct the procedure every now and then to improve your battery's performance. This method is very simple and should work if followed to the letter.

The Procedure

- First, ensure that the electrolyte is full to its capacity by replenishing with distilled water.
- After filling the electrolyte, charge the battery to its maximum using the usual standard charging method.
- Adjust the charging voltage by about 10%. For a normal 12 volts battery, the equalizing charge ranges between 14.4 volts and 15 volts.
- Keep monitoring the battery temperature during equalizing process. If the temperature overboard and the battery starts to overheat, stop the process until the battery cools down and then proceed.
- Avoid any sort of ignition during the equalizing process as gassing is expected and may lead to an explosion.
- Keep recording the specific gravity values of each cells (six cells) every hour using the hydrometer as we discussed in chapter 2. The table below should guide you in your analysis. It shows approximate state of charge in specific gravity of the 12 volt lead-acid battery.

Charge	**Specific Gravity**
0%	1.120-1.130
25%	1.155-1.165
50%	1.190-1.200
75%	1.225-1.235

100%	1.265-1.275

- When all the cells are gassing congruently and the specific gravity values remain constant, stop equalizing. Your battery should be restored! To test whether or not the process has worked, discharge 50% of the charge and charge the battery twice in standard method. From here, monitor your battery's performance, and you will surely notice the difference.

c. Reconditioning through a desulphating equipment

We've already established that sulfate crystals will form as your flooded battery is in use, and this sediments will impede the flow of electricity and eventually cause battery failure. Precisely, these crystals acts as insulators to the flow of electricity in a flooded battery which seriously degrades its capability to have electricity flow, reducing its capabilities to charge and discharge. However, a special equipment (a battery desulphator) can be used to break down sulfate crystals and bring back your dead battery to life.

A battery desulphator uses a sharp pulse of current (as shown in the figure below) to jar the sulfate crystals and cause both electrical and mechanical internal resonance. This process breaks down the crystals and allow it to recombine into the battery's acid. In essence, a battery desulphator gives a short blast of high voltage enough to break away lead sulfate crystals without overheating the battery as a whole. This process should be

repeated regularly for three to four weeks to efficiently break down sulfate crystals. After this, your battery should be restored.

Maintaining Flooded Lead Acid Batteries

After reconditioning your flooded lead acid battery, it is important to ensure that it's kept in the best conditions possible to avoid a relapse. We already talked about how to maintain lead acid batteries, but now we will take a slight diversion and focus on flooded lead acid batteries for solar applications.

- Check the electrolyte level regularly and replenish it using distilled water. Distilled water should be added into each cell so that no metal lead surface are visible. Most flooded lead acid batteries have a "fill line" that indicates where the electrolyte level should be. You should avoid overfilling the electrolyte; you wouldn't want the acid solution to spill.
- Never add acid to your battery!
- Frequently check your battery's charge level (the depth of charge (DOD) or the state of charge). Your battery is likely to undergo the sulfation if you don't keep check of your battery's DOD.
- Regularly, clean your battery's terminals using terminal cleaner brush (shown in the figure below). Remember, make sure to disconnect the negative terminal first before you start cleaning.

- Ensure that all connections are tight enough and coat the metal components with high temperature grease or a commercial sealant.

How to Recondition Gel Batteries

We've looked at how to recondition flooded batteries, and as we've seen, it's pretty an easy undertaking. Moving on to this first type of a VRLA you need to be keen as the procedure is much more demanding that of the flooded batteries. Why? You would ask. To access the cells in a VRLA battery, you need to open up the battery, and as we already know the casing is normally sealed. No need to panic though, this isn't a rocket science kind of procedure, you only need few additional equipment to get the job done.

But these are maintenance free batteries, why do they need reconditioning? You would also ask. The term maintenance free is a misnomer as Gel batteries still require regular functioning testing and cleaning. And like flooded batteries, these too can be revived when they fail. Their construction is mainly done so that they can be mounted in any orientation where large amounts of storage are required at a lower cost than other technologies such as lithium-ion.

Tools Needed

- A variable supply of power, preferably with current limiting
- Superglue or hobby plastic cement
- A hemostat
- Paper towel
- A thin flathead screwdriver (or two)
- Lab coat (long pants and closed shoes. No sandals for goodness sake!)
- Safety goggles
- Rubber gloves. This should be disposable or only used for battery works as they may be contaminated with lead.

Refilling a Gel Battery

Before we can look at how to recondition a sealed gel battery, it is important to first look at how to refill it. As already mentioned, even though AGM and Gel batteries are referred to as maintenance free, they can still run out of the electrolyte which will absolutely reduce their performance. This section is going to take you through the procedure of opening up and refilling a Gel battery (basically all VRLA batteries). Take note; this procedure is indispensable as it is also used during reconditioning.

Steps Followed:

- Have your protective gear on before doing anything. Even though the electrolyte in a gel battery forms a thick putty-like gel/paste and isn't free flowing as it is the case with flooded batteries, it can still come to contact with your skin or clothes.
- The first step is to remove the lid. Disclaimer—this will definitely void your warranty as it will show signs of tampering!

Stick your flathead screwdriver into the small opening between the case and the lid, and pry gently. Then work your way around the battery breaking all the seals. Everything should be done carefully. Remember, any electrolyte that may have been vented out may be around this region or under the lead. Take caution.

- Remove the caps. First, wipe any wet spots using the paper towel before you proceed to opening the caps. Inspect the caps, and if they appear dimpled, it is a sign they are dry and needs replenishing. Using a flashlight, you should also inspect the state of the cells. If there is accumulation of white material, which looks fairly dry, it means that your battery is dry and needs refilling.
- Using a syringe, draw 10cc of distilled water and uniformly add to each cell. Keep track of how much water you add. After you are done, place back the caps and the lid and then seal your battery using the superglue or hobby plastic cement.
- Charge your battery by initially setting the current limit low, and slowly open it up until the voltage is steady. At the start, you will notice that your battery will be drawing all of zero mA this is because the electrolyte hasn't mixed well with the added water. Give it time. The charge will eventually rise and slowly taper off. After some time, increase the charging voltage to allow the battery to charge properly. Monitor the battery's behavior as you charge; any signs of increased temperature, occasional 'pops', bubbling, or hissing would necessitate the reduction of charging voltage.

Testing Gel Batteries

Now that you have learned how to open a sealed lead acid battery, the process of reconditioning will not be too complicated. First, you need to test each cell to determine whether the gel battery is restorable or not. Remember, if you have dead cell(s) your battery cannot be revived back to life. How do you test if your battery cell is healthy? We went through these steps when we investigated various methods of testing a battery. However, for the sake of this section, we are going to briefly review these steps. There are four ways through which you can test your Gel battery;

- Battery voltage testing (no load)

- Battery voltage testing (with load)
- Battery cell voltage testing
- Battery cell testing using a hygrometer

Before you begin testing your battery, it is advised that you first clean the battery terminals using a terminal cleaner. Clean both terminals (negative and positive) by placing the post cleaner on each post and twisting it clockwise or counterclockwise until the corroded posts are clean. Then charge your battery to its capacity and remove the surface charge. To remove the surface charge, you need to use the battery on something with a load of at least 20amps such as turn on cat headlights for about 3 minutes. You can also remove this surface charge by allowing your battery to sit idle for about 12 hours. After completing these two steps, you are ready to test your battery following the four methods.

1. **Battery Testing With No Load**

To conduct this step, you need a multi-meter (shown in the figure above). Connect the red probe on the positive terminal and the black one to the negative terminal (remember

to always connect of disconnect the negative probe first). Record the readings displayed on your multi-meter. You had charged your battery before testing, therefore, if you are testing a 12 volts battery, the reading should not be less than 12 volts. Otherwise, your battery requires reconditioning.

2. **Battery Testing With Load**

This kind of test requires a load tester, as one showed in the figure above. A load tester takes an estimation out of an electrical diagnosis and make it easy to pin down failures in the charging system. To perform this procedure just connect the red clip to the positive terminal and the black to the negative terminal. Long press the testing button for about 10 seconds to perform a load test and record the readings on the load tester.

Load testers are of numerous kinds, some portray results as numbers while others use description in the form of "good", "bad", or "weak". The table below will help you in your analysis.

Voltage Under Load	Battery's State
6.0 Volts and Below	Bad
6.1 Volts to 9.9 Volts	Weak
10 Volts to 12 Volts	Good

If your battery tests good, but its performance is reduced, it is a great idea to proceed and restore it. It tests between 0 and 9.9 Volts "bad" or "weak", repeat the test several times just to be sure and accurate. A weak battery is also restorable, but a bad battery indicates a presence of a bad cell(s) and therefore cannot be restored. In the next two steps, we are going to go a step further and test the battery's cells.

3. **Battery Cell Testing Using a Hydrometer**

We already looked at this in chapter 2, therefore we are going to go through it once again, but briefly. In that section, we didn't talk about how to test the cells of a sealed lead acid battery. However, now that we've gone through the process of opening up a VRLA battery, it wouldn't be difficult for you to access the electrolyte. By testing your Gel battery's state using a load tester and a multi-meter, you can already tell whether it is restorable or not. Testing the cells will just be a step further just to be sure, or just to know which cells are affected.

The Procedure:

- Open up the lid of your Gel battery (as discussed in this chapter) to access the caps. Open the caps to access the electrolyte.
- Squeeze the bulb of the hydrometer before inserting it into the chamber and draw some electrolyte.
- Allow the electrolyte and the float to settle and record the reading. The float is normally marked with white, green, and red zones. This indicators marks specific gravities of a cell.
- Do the same in the remaining cells (should be 5 for a 12 volts battery) and record. Use the table below to interpret the readings.

Floater's Zone	**Interpretation**
Floats Towards Red	The cell is in bad condition
Floats Towards White	The cell is in fair condition
Floats Towards Green	The cell is in good condition

It is important to repeat the procedure for each cell at least a couple of times just to be sure and correct. It is also significant, to ensure that you draw away all of the acid solution in the chamber before dipping it in another cell's electrolyte. Again remember, if one cell is declared "bad", the battery cannot be revived.

4. **Battery Cell Testing Using a Multi-meter**

You also need to access the electrolyte when conducting this procedure. Clip both probes into wires of the same type and lengths then dip the red probe in the first cell and black probe on the second. The reading should also be at least 2 Volts. This procedure must be repeated across all cells. Each cell must be at least 2 Volts. A 12 Volts battery has 6 cells

and each should be tested. If one of the cell or more has a reading of less than 2 Volts then it may be the reason your battery is performing poorly. If the cell doesn't record any voltage, it may be dead and therefore your Gel battery cannot be restored. Be sure to repeat the procedure at least twice to ensure the evaluation is error-free.

Reconditioning a Gel Battery

Now that you've determined the state of your battery, you can proceed and try to revive it. The processes are not new in this guide; you will just have to use the three processes we used for flooded lead acid batteries.

a. **Reconditioning through chemical desulphator**—as we discussed, there are several chemical additives that can be used to revive a dead battery including Epsom salt, EDTA (a crystalline acid used in industries) and Caustic Soda. For this guide, we've used Epsom salt. Mix 10 heaping table spoons of Epsom salt (250g) with this hot water and stir, as discussed in the previous section. Ensure that the salt is completely dissolved. Access each cell's chamber as we discussed in the refilling section and add Epsom solution to each. Place the caps back and gently shake your battery to ensure that the electrolyte and the Epsom solution mix fully. As mentioned earlier, Epsom salt is able to break down sulfate crystals formed as a result of sulfation. Once this crystals are broken, your battery should resume normal functioning, at least.
b. **Restoration using a battery desulphator**—this method can also be used to restore a sulfated Gel battery. As we saw in flooded batteries, a desulphator machine puts through a sulfated battery under sharp charge pulses that are strong enough to break down sulfate crystals back into an acid solution. Once sulfation is eliminated, the performance of your Gel battery will definitely improve.

c. **Reconditioning through an equalizing charge**—equalizing charge in sealed lead acid batteries is not recommended because such batteries are highly sensitive to overheating. However, since we've discussed how to open up a Gel battery, one can conduct controlled over charging while adding distilled water during the process to cool down the battery and supplement water loss. By conducting this process, the sulfate crystals are blown off, thereby rejuvenating the battery and allowing all the surface area of the electrodes to interact with the electrolyte. This method should come third in the pecking order. The first two are much better for sealed lead acid batteries.

Maintaining Gel Batteries

Measures to maintain lead acid batteries are universal regardless of the type. Therefore, the way you would maintain a flooded lead acid battery is the same you would do with a Gel battery. Nevertheless, there are special measures that should be dedicated specifically to Gel batteries.

- As aforementioned, Gel batteries should never be exposed to excessive temperatures. Service life is reduced at operating temperatures above 30° C.
- Once opened for reconditioning, you should use a superglue to reattach the seal. Ensure that it is attached completely to avoid spillage.
- Incessant overcharging or undercharging are absolutely damaging to Gel batteries.
- Ensure that you use a charger controller since many solar panels are capable of producing more than 18 volts—enough to damage your battery.
- Don't store a Gel battery in uncharged condition.

How to Recondition Absorbed Glass Matt (AGM) Batteries

Can an AGM (aka dry cell, maintenance free) battery be reconditioned? Most people have asked this question for years now. Can you recondition it with the "Recondition" button on smart chargers and bring it back to functioning life again? How do you break the sulfate crystals formed as a result of sulfation? These are some of the frequented questions on the AGM reconditioning topic. But as is the case with Gel batteries, you can revive a dead AGM battery. In fact, the processes to revive a dead Gel battery are nearly the same when it comes to AGMs. However, you will notice slight differences during the reconditioning process, mainly brought about by their differences in the electrolyte. Unlike a Gel battery where a silica agent is added to the electrolyte to make it more paste-like, an AGM battery uses an ordinary sulfuric acid as one used in flooded lead acid batteries. However, in AGM batteries the acid solution is absorbed and retained layers of silicate glass matting between the electrodes. While both technologies (Gel and AGM) are considered maintenance free, spill-proof, and leak-proof, AGM is considered a more superior technology.

Before moving a step further and reconditioning a dead AGM, you need to do the following;

- Charge your dead AGM battery with AGM specific chargers. Your battery may as well not be dead-dead, but won't charger with the regulator connected to the solar panel. Since this is a moder technology, there are specific chargers that have AGM-specific settings and desulfating steps that will help a great deal in recovering a dead AGM battery. This step might save you a lot of trouble if it works.
- If your battery still won't work, it is time to go to the next step and test it. Remember the procedure followed when testing a Gel battery? That's the same procedure used in AGM batteries. Since this is a sealed lead acid battery, you also

need to open up the lid to test the cells and replenish the electrolyte with distilled water.

i. Test load using a load tester and record the readings.
ii. Test the battery with no load using a multi-meter, and also record the readings.
iii. Test cells using the hydrometer and use the table on the previous section to interpret the readings.
iv. Test the voltage of each cell using a multi-meter to determine the health of each cell.

Now that you have tested your battery, you can tell whether it can be reconditioned or not. For the sake of mentioning—if your battery has a dead cell, it can't be restored. It's only advisable to discard it through appropriate means and purchase a new one. But if all the cells are in good condition, you can proceed and recondition it through the three steps discussed in this guide.

a. **Through a desulphating equipment**—an AGM battery for solar applications spends a lot of time charging and discharging which allows faster accumulation of

lead sulfate crystals through the process of sulfation. As aforementioned in the previous chapters, a desulphating equipment is perfect for breaking down these crystals and allow efficient flow of electricity in the battery. The desulphator uses a sharp pulse of current forced into the battery to grind down sulfate crystals and allow it to recombine into the electrolyte. Battery desulphators came in many forms and shapes (see figures below) and are considered the best option to desulfate a sulfated AGM battery since it doesn't necessitate opening up the battery.

b. **Through equalizing charge**—can I equalize an AGM? This question comes up every day. The short answer to this is—yes. It's true that some manufacturers don't recommend this since an AGM battery is sealed and overheating would mean havoc, but since we already know how to open up sealed lead acid batteries, this should be the least of our concern. One of the concerns raised when equalizing a sealed battery is that it will overheat which to some extent would cause more harm than good, but if you can open up a battery and control overheating and water loss, you can well desulfate using a desulphator. Fundamentally, an equalizing charge is meant to convert lead sulfate crystals into active material in the electrolyte.

   For AGM batteries, this has to be done within a reasonable amount of time for it to work. For a 12 volts battery, the amount of voltage used to equalize should be between 15.5 and 16.3 for about 6 to 8 hours. You need to first charge your battery and then proceed with equalization. Depending on the severity of sulfation, you may need to equalize your AGM 2 to 3 times. The basic idea here is to get the amperage that the battery have lost back in to them and allow smooth flow of electricity.

c. **Recondition through chemical additives**—this process should be simple considering you already know how to open a sealed AGM battery. Besides, the

electrolyte in AGMs is the same as the one found in flooded batteries, meaning that it mixes freely with chemical additives compared to Gel batteries. All you need to do is prepare a solution with a chemical desulphator (Epsom salt) as we discussed in the previous section and add to each cell. Allow the solution to ix well with the electrolyte and then charge your battery. The solution may take time to mix with the electrolyte and therefore the battery may take several days before it can be fully reconditioned. Always remember to seal back the battery with superglue or hobby plastic cement.

Factors to Consider When Choosing a Solar Battery

The type of battery you would choose for a solar application will vary depending on a variety of factors. There are certain specifications one should evaluate in order to pick the best battery to serve their purpose. For example, the aspects of how much power it can provide or how long its charge will last are some of the basic considerations. In this section, we are going to look at some of the factors you should consider before purchasing a battery for your solar application.

- **Manufacturer**

Many different types of companies for manufacturing solar batteries and products are emerging. It is important to pick reputable manufacturers in this area, rather than go with start-ups that are not yet proven. You should also consider a company not only for its name in the market, but in terms of its products and how it has revolutionized the battery technology. It is therefore crucial to conduct a research on the best companies in the market before settling for a solar battery.

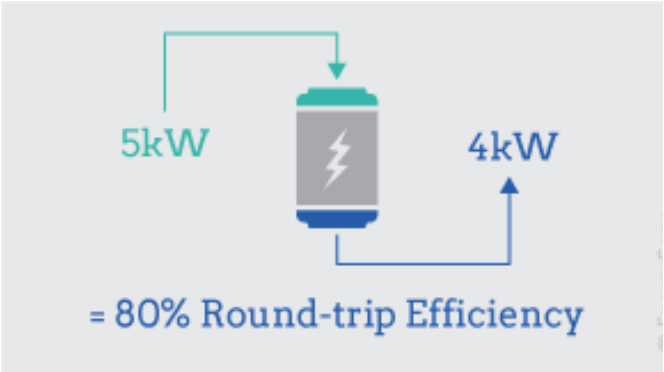
- **Battery Life and Warranty**

For most home energy storage, your batter will “cycle” charge and drain daily. Over time, you will notice that the battery’s ability to hold charge will decrease. A credible company

would indicate the cycles the battery is supposed to undergo before its capacity to hold charge is reduced. For instance a battery may be warrantied for 5000 cycles or 10 years at 70% its original capacity meaning that at the end of the warranty the battery will have lost more than 30% of its original capacity.

- **Round-Trip Efficiency**

A round trip efficiency refers to the amount of energy a battery can deliver against the amount of energy it took to store it. If you feed your battery 5kWh and get 4kWh your



battery gives you an 80% round-trip. Essentially, a higher round-trip efficiency would mean getting more value out of your battery.

- **Depth of Discharge (DoD)**

Most storage batteries need to retain some charge at all times to remain active. Using 100% of a battery's charge normally shortens its useful life. If we say a battery's full charge is 100%, the DoD of this battery would be 0%. On the other hand if a battry is 100% when empty, the DoD would be 100%. Principally, a battery's DoD refers to the amount of its capacity that has been used. Accordingly, most battery makers would specify a battery's DoD for optimal performance. For instance, if a battery of 12 kWh has a DoD of 80%, you will be able to use 9.6 kWh before recharging it. Go for a battery with a higher DoD as it means you will be able to utilize more of its stored energy before recharging.

- **Capacity and Power**

This is virtually the most important factor to consider before selecting a solar battery. Capacity refers to the total amount of electricity a battery can store—and is measured in kilowatts-hours (kWh). However, while knowing the capacity of your battery is vital, it is doesn't tell the whole story. You may have a battery with high capacity but low power rating which would mean low amount of electricity for a long time. A low capacity with high power rating would mean enough power to run your entire home but for a short period of time. You should go for batteries that has bigger capacity and high power rating.

MILLITARY
BATTERY RECONDITIONING SYSTEM

CHAPTER 6:

HOW TO OPTIMIZE THE LIFE AND PERFORMANCE OF YOUR BATTERY

Chapter 6: How to Optimize the Life and Performance of Your Battery

Whether a battery is in use or has just been shelved, its useful life and performance deteriorates over time. In most cases, the deterioration is caused by accumulation of unwanted chemicals, loss of the active chemical components of the battery, occurrence of undesirable chemical reactions in the battery or physical impact. Some of these changes are reversible, using the battery reconditioning methods discussed above, but others are irreversible and they affect the overall performance of the battery. Doing away with or minimizing the occurrence of these issues can improve performance and life of any battery. Some of the ways through which you can improve performance and life of your battery are discussed in the following sections, but first things first:

What Is Battery Life Cycle?

Battery cycle life refers to the total number of complete charge-discharge cycles the battery can undergo before it's decreasing capacity falls under 80% of its manufacturers rated capacity. Most batteries come with lifetimes of 500-1,200 cycles. However, with passage of time and usage, the manufacturer's rated capacity keeps on decreasing, but even after hitting the specified lifetime, a battery does not die suddenly; the aging continuous at the same rate. For example, a battery whose nominal capacity has decreased to 80% after 500 cycle, will continue working maybe up to 1,000 cycles when it's actual capacity will have decreased to 60% of its manufacturer's rated capacity. As such, you do not need to fear that a battery will die on you suddenly, just because it's approaching its designated end of life.

Factors That Affect Battery Performance and Life

1. Temperature

Battery performance depends on electrochemical reactions; both during charging and discharging. They work by turning chemical energy into electrical energy and vice versa, but as we already mentioned in chapter 1, chemical reactions are influenced a lot by temperature variations. As such, environmental temperature affect the life and performance of a battery significantly. The normal temperature range for most batteries is between 20◦C and 30◦C. If a battery is stored beyond these specifications, it is likely to sustain significant dents to it's useful life. For optimal performance, it is good to keep batteries within the temperature range specified by the manufacturer.

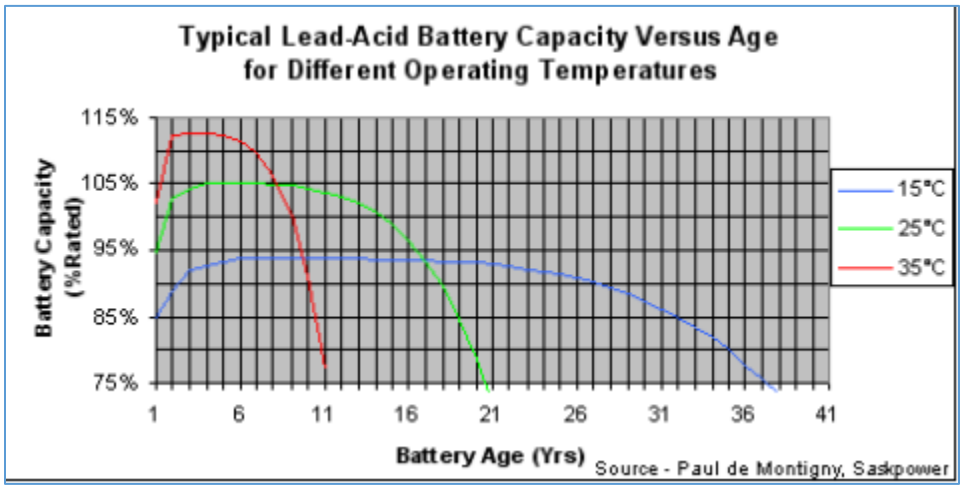
Bear in mind the type of chemical reaction that occurs in your specific type of battery so that you can better regulate internal temparature. For instance, in lead-acid and NiMH batteries, the reactions are exothermic. This means that the chargers should be made in a way that enables them to handle the temperature change to prevent damage to the cells. It is good to watch out for overcharging which can damage the battery and lower its performance as well. In lithium and NICad batteries, the reactions are endothermic.

The performance of a battery (the internal chemical reactions) is driven by both voltage and temparature. As such, the hotter the battery becomes, the faster the reactions will happen. This means that as temperature increases, the perfomance of the battery will increase, but this is matched by a corresponding decrease in its useful life. The charge retention and shelf life of a battery is influnced by the rate of self-discharge, and self-discharge results from undesirable chemical reactions inside the battery. Also, undesirable reactions such as gassing, corrossion and passivation of electrodes reduce battery cyle life, and these increases as the battery becomes hotter. Simply put, high temparature decreases both the cyle life and the charge retention capacity of a battery.

Even battery designed for use in high temprature environement are not immuse to parastic reactions that set in as a result of the high temperatures.

The effect of high temparature on the life cyle of a battery is better explained using the Arrhenius equation. The equation characterizes the relationship between the rate of a chemical reaction and temparature. It shows that the rate of chemical reactions rise exponetially with increase in the environmental temprature. As a rule of thumb, the rate of a chemical reaction double with every 10°C increase in temperature. Simply put, 60 minutes at 35°C is identical in battery life to 120 minutes at a temperature of 25°C which means that heat is the number one enemy of battery performance and life. Even a decimal increase in temperature has profound negative effect on both battery performance.

The following diagram shows how the life of a lead acid battery varies with environmental temperature over many years. Note that operating the battery at 35°C makes it exceed the manufacturers rated capacity but its cycle life is shorted dramatically. On the contrary, if the battery is maintained at 15°C, the useful life increases significantly.



To emphasis the need for storing batteries at optimal tempature – NiMH batteries are very sensitive to excess temparature. Labalatory studies have shown that consistent exposure to temparatures above 45°C will reduce the life of NiMH batteries by more than 605 of their manufacturers rated capacity, and the same holds true for other batteies.

The verdict: Keeping your battery at the right temperature will optimize its cycle life and performance.

2. Voltage Effect

Every battery has a certain limit of the voltage it can carry. When optimally charged, a battery functions without any complications, but when one tries to keep charging a battery beyond what it can hold, the result is overheating and unwanted chemical reactions that produce chemicals that cannot be recombined to make for a fully charged battery. Simply put, overcharging the battery produces irreversible chemical reactions which destroy the cell. Even worse, the increase in pressure and temparature that accompanies overcharging can endup in an explosion and release of harmful chemical and/or fire. Also, discharging a cell beyond it's recommended lower voltage, though not as dangerous as overcharging, can cause permanent cell damage.

It is good to buy a battery with cell protection circuits which ensure it stays under the charging and discharge capacity. Otherwise, ensure that charging and discharging are kept under control to avoid overcharging or undercharing your battery.

3. Battery age

Novelty is associated with excellence and the same holds for batteries; age is accompanied by low performance. This is because the morphology of the active chemicals in them keeps depreciating until the battery becomes impossible to service. To understand the relationship between age and battery performance, it's important to understand cell formation.

Cell formation refers to the process through which the active materials in a new cell are transformed into their useable form. Note that the initial condition and structure of the electrodes and electrolyte are detemined by how they were manufactured and how the electrodes were coated. Often, this strucure does not provide the maximum contact between elecrodes and electrolyte, and it may not minimize internal resistance. AS such, cell formation, which involves passing current through the battery, is done before the battery is released into the market.

Passage of current via a cell, cooling, or heating it triggers small changes in the morphology of the active substances in the battery. In essence, formation refers to the first charge and this is normally carried out by the manufacturer under highly contolled temparature, current, and time to create develop the optimal morphology and content of the active components of the battery. With some batteries, the manufacturers performs up to 10 cycles before realizing the full power of the battery.

4. Growing Old

Once the battery has been purchased, the usage profile is at the hand of the buyer. As it ages, even if there are no noticeable adverse change in the composition of the active materials, its structure will keep on changing for the worse. As a result, the capacity of the cell will keep on deteriorating untill it's unserviceable.

The age related change in the morphology of the active materials leads to poor battery performance in several ways:

- It stimulates the small cystals formed during cell formation to grow in size, reducing battery capacity.
- Secondly, it stimulates formation of mettalic dendrites around the electrodes, and this together with the large cystals exerts pressure on both the separator and electrolyte.

- The result of this is increased self-discharge which impairs performance significantly.

Once the battery starts self-disharging, there is no remedy. It has reached the end of it's serviceable life.

5. Reconditioning

Battery reconditioning is a well-known hack to keep batteries that seem damaged working. It is a good way of bringing them back to life. Most types of batteries are reconditionable except just for a few. Reconditioning is believed to restore cells and batteries upto 80% of their intial performance. Reconditioning works by repeating the formation process to break down the larger crystals into small ones. This boosts the performance incredibly for most cells. However, this does not work for old cells because it worsens the self-discharge. When reconditioning batteries, it is good to be careful so as not to cause the memory loss effect. When done in the right procedure, battery reconditioning can save you a lot of money.

6. Electrolyte loss

The loss of electrolyte in any battery affects its performance and cycle life directly. Loss of electrolyte can be caused by leakage which occurs due to depletion of the cases covering cells. But even if the cases holds well in place, the electrolyte may finally permeate through the seals as the battery ages, especially if the battery is stored in a very dry environment or if the internal components of the battery are under pressure due to high pressure or formation of large cyrstals. Electrochemical reactions that turn electrolyte into an inactive compound also decrease it's volume in the battery. The most popular processes that bring about electrolyte loss include corrosion, gassing, and evaporation.

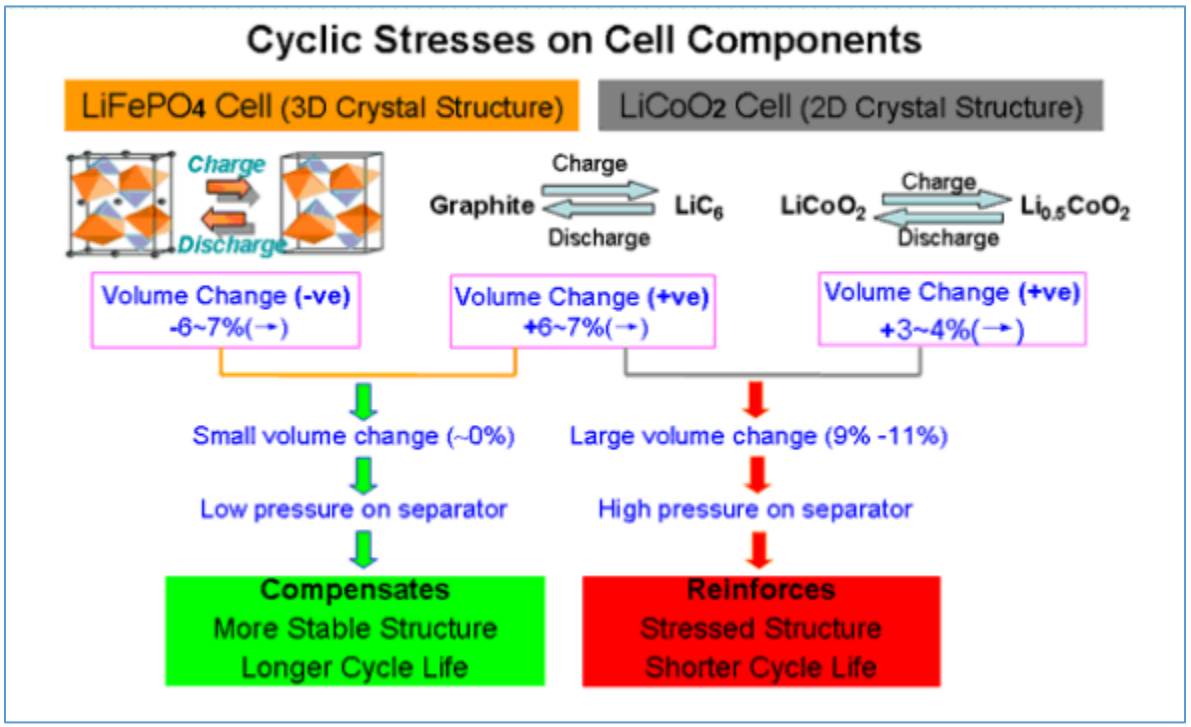
Although most modern batteries come with sealed construction to avoid electrolyte loss, most of them have a vent that is designed to reduce the pressure if the battery is at

risk of exploding. However, as the vents operate, they release some of the active chemicals in the battery, eventually decreasing its electrolyte level. To determine whether or not the electrolyte has been lost, the cell should be weighed and the actual weight compared to the manufucturer's weight.

In order to avoid loss of electrolyte from secondary cells through gassing, the cell need to be fully sealed. Batteries in which the cell is closed to force recombination of the gases to reimburse the active materials are called recombinant systems. SLA and Nicads batters are examples of batteries that use Recombinant designs.

7. Cyclic Stresses

In Lithium-ion batteries, ejection or insertion of the lithium ions out or into the intercalation spaces during discharge and charging makes the electrodes to contract or swell. With repetative charging and discharges, the electrodes keep on growing week and this reduces their adhesion to the current collector, resulting in the swelling of the cell. Eventually, the charging capacity decreases, and eventually the cell fails.



The extent to which the electodes expands or contracts is determined by the nature of the material from which they are made. In cobalt cell, the change in volume of the electrodes tend to reinforce each other causing swelling of the cell, but in Lithium phospahte batteries, they compensate each other, confining the swelling to the minimum possible. Note that using Silicon in place of carbon would give dramatically high charge capacities, upto 10 times, but silicon anodes are likely to change in volume by up to 400% pausing the risk of breakdown of the anode coating. However, the possiblity of using silicon instead of carbon is still beign investigated, but the problem is yet to be solved.

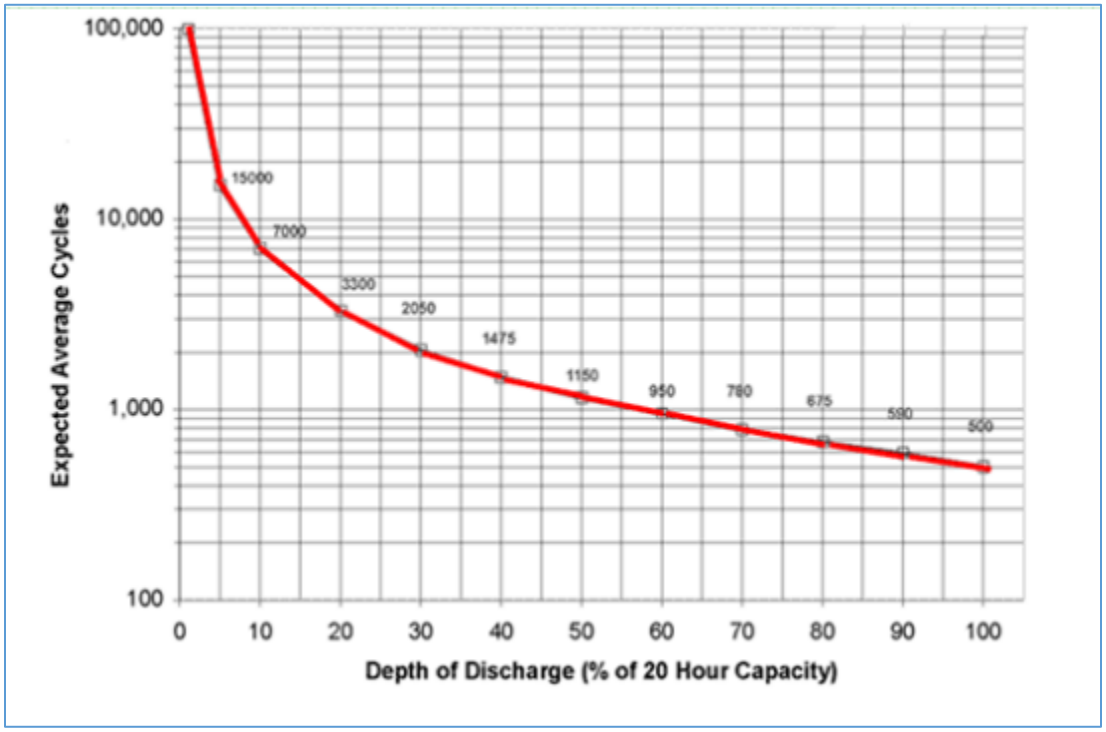
8. Interactions of Cells

This happens in multi-cell batteries and it results due to the spread of characteristics of the cells in a pack. This results from non-uniform aging, or uneven heating or manufacturer tolerance, and the result is that some cells take less charge than other cells in the same pack. As a result, the weak cell will attain it's full charge capacity very fast, and as the charger attempts to charge the rest of the cells to their full capacity, the weaker cells will overcharge and heat up, posing the risk of explosion or further damage.

The weaker cells voltage also tend to reach zero charge earlier than the rest and may even reverse the process. Such an occurrence can make the weaker cell discharge the rest. When coupling up cells to be connected together, ensure that they match in every aspect.

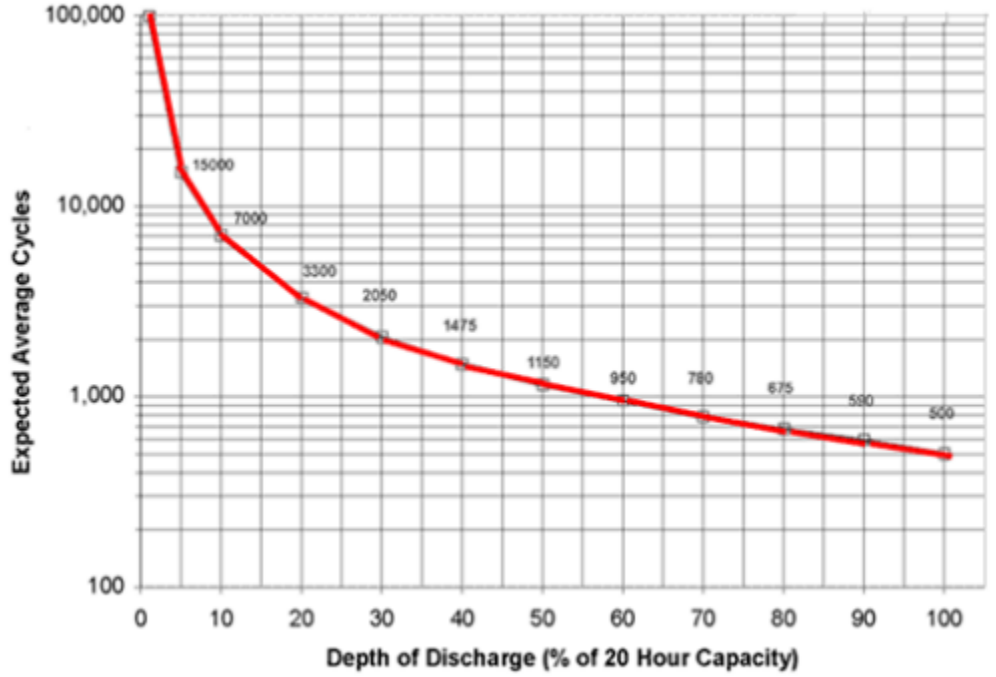
9. The Rate of Charging

The relationship between depth of discharge (DOD) and cycle life is loglithmic as detailed in the diagram below:



In simpler words, as the total number of cycles increases, the DOD decreases. As such, if the manufacturer limits the DOD, the useful life of the battery increases. On the same note, users can increase the life of a battery by using it in application that require less capacity than designated on the battery, or charging it before it's fully discharged. For batteries used in microcycle apps, the typical cycle life is somewhere between 300k and 500k.

10. Depth of Discharge vs Life Cycle



Most cell phone users normally recharge their phones when the depth of discharge is just about 25-30 percent. At such low DOD, Lithium-ion batteries can achieve about 5-6 percent increase in their cycle life compared to similar batteries but which are discharged fully each cycle. Therefore, as the DOD is reduced, the battery cycle life goes up significantly.

Nickel Cadmium batteries are an exception to this rule. If a Nickel Cadmium battery is discharged partly, memory effect (discussed in chapter 1) sets in and the only way to reverse it is through deep discharging.

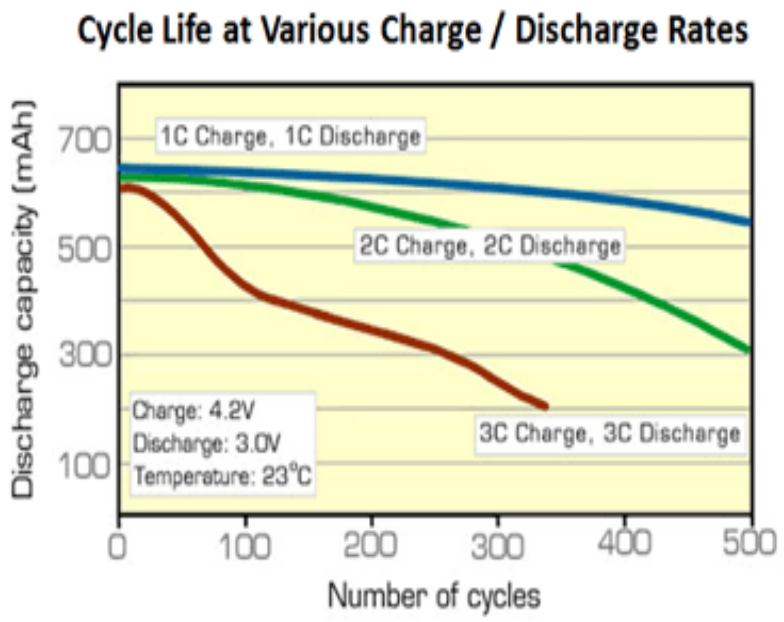
In some applications, such as in marine and electric vehicles, the battery has to be discharged to the maximum which means discharging it to the maximum possible. For such purposes, specially designed deep cycle battery designs must be used. High DOD would definitely damage ordinary batteries. In particular, SLI batteries are meant to be

discharged to only 50% of their maximum DOD and traction batteries are designed to discharge to 80% of their complete DOD capacity.

11. Charge Rates

High charging rates can affect the life and performance of any battery negatively. As the rate of charging increases, so does the risk of overheating the battery and overcharging it. As such, stopping the charging process as soon as the battery reaches the optimal charge capacity is really important. Each type of battery has it's unique battery charger and charging curve, and these should be kept in mind while charging the battery. In addition, go for batteries that come with thermal fuses and TCO (Tempera Cut Off) to keep the battery from overheating during charging. If you really have to fast or quick charge your battery, make sure to use the charge designed specifically for that purpose and for the specific type of battery you have.

If you intend to use a universal charger – a charger designed to be compatible with a large number of batteries - go for one with a sensor that allows it to automatically identify the specific battery type and consequently apply the right charging profile.



Note that most battery issues emanate from charging habits of the user. It is good to ensure that you use the charger that is recommended by the manufacturer for each particular battery. This will reduce the risk of high or lower voltages from the wrong chargers. Charging batteries should only be done for the stipulated time, and once the battery has reached full charge, it is important to unplug the charger to avoid overcharging which shortens battery life. The right amount of current should also be used to avoid accelerating battery death.

12. Effects of Pressure

There are many factors that can lead to increase in the internal pressure of a battery. These include temperature rise which makes the electrolyte swell and exert pressure on the vents, very high voltages, and high ambiance temperatures. Increased pressure cause a thermal runaway and accelerates self-discharge rate which shortens the cycles of the battery. Low pressure can also be dangerous since it causes loss of electrolyte. If batteries have to be transported by air, it is important to deal with the issue of changes in external pressure.

Simple **Ways of Improving Battery L**ife

Despite all the risk that threaten to reduce the life and pefomrance of batteries, there are still some things that one can do to improve the life of a battery. When handled carefully, batteries can serve as a primary or alternative source of energy in both domestic and commercial settings. Some of these ways include:

1. Us**ing a Battery Management System**

This is simply a system that helps battery users to keep an eye on different parameters during charging or discharging of different types of batteries. The main aim of adopting a BMS is to ensure the protection of the battery from risks such as overheating, overcharging, deep discharge, high voltages, and such. In most battery management systems, when one of the parameters of the battery goes out of limits, they raise an

alarm and immediately disconnect the battery from the load. Battery Management Systems provide all in one control system of the battery ranging from charging to maintenance measures. Some BMS perform cell balancing in multiple cell connections to ensure that weaker cells are not connected with stronger ones since they pose an operational hazard. BMS can be adopted by small-scale battery users, industrial battery users, and even in locomotives that use batteries.

2. Temperature management

In every cell operation, the temperature is a capital concern. Ensure that batteries are operating in the right temperature range as recommended by the manufacturer. Also, put in place the right cooling and heating measures to ensure that temperature is no longer a threat to the life of your batteries. Keeping an eye on the temperature enables you to keep track and ensure uniform heat distribution in each cell, effectively guarding cells against overheating and promoting proper dissipation of heat.

3. Sharing the power load

When interconnecting batteries, it is important to ensure that the load is equally shared in the connection system. This ensures that there is no overload to some part of the connection and helps in keeping the batteries in a functional state for a longer time.

4. Managing power demand

To ensure that the battery is not overworked, it is wise to regulate load demand. This ensures that battery life is prolonged and that no unwanted charging is done. Ideally, make sure the load is what the battery can comfortably supply without strain.

5. Don’t allow cell voltage to fall too low

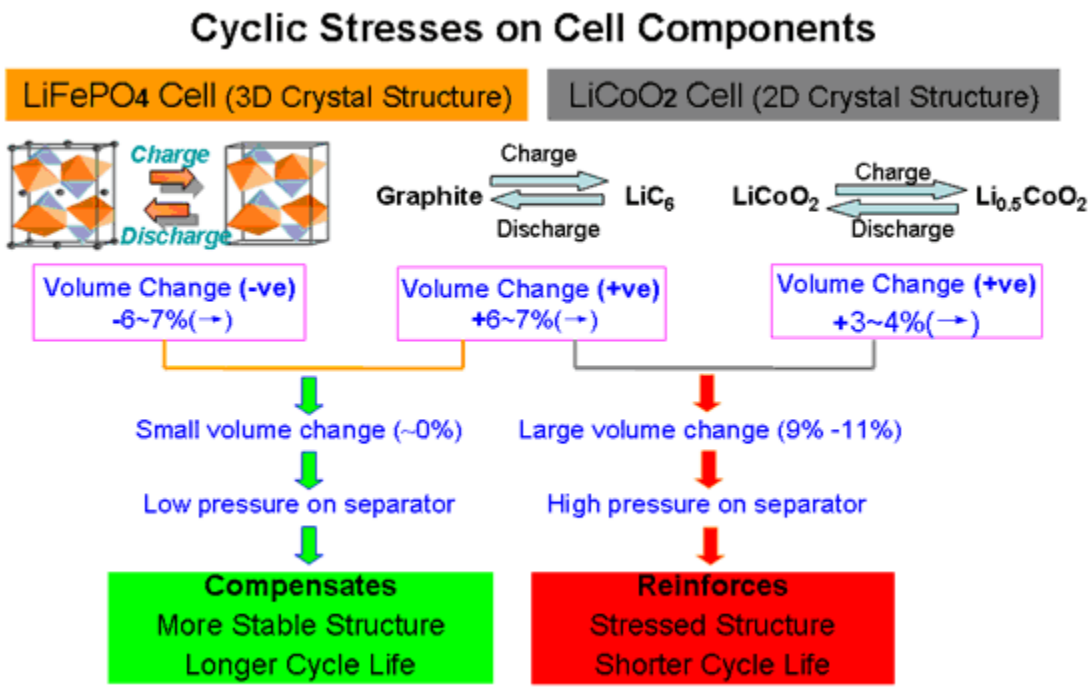
Allowing the cell voltage to go below 2 volts is risky for any battery, this is because the electrolyte can dissolve and therefore render the battery dysfunctional. When storing batteries, ensure it is fully charged and this will save you unnecessary expenses.

6. Keep an eye on the electrolyte

This is specific to lead acid batteries. The electrolyte should always be at ¼ an inch above the fill level.

7. Expose cells to the least mechanical stress

Avoid unnecessary installation and ejection of cells from the charger. This is because it causes the components of the electrolyte to swell. Swelling weakens the structure of the electrodes and lowers its effectiveness to pick current.



8. Avoid undercharging

Batteries that are always undercharged can never be effective in delivering charge. Signs of a battery that has been undercharged consistently include low cell voltage, low specific gravity and plates turning into a lighter color. Undercharging causes sulfation, which can be explained as the buildup of lead sulfate on the battery plates. Chronic sulfation can cause warping of the lead plates which affects battery performance adversely.

MILLITARY
BATTERY RECONDITIONING SYSTEM

CHAPTER 7:
RENEWABLE ENERGY: HOW TO MAKE YOUR HOME PERFORMANCE OF YOUR BATTERY

Chapter 7: Renewable Energy: How to Make Your Home Energy Sufficient and Save Money

Power is a necessity in every modern home today, and although there are many sources of power, the biggest percentage of the American population relies on the national electricity supply to power their homes. However, there are other alternative sources of energy that home owners can embrace to become self-reliant and generate their own power at home. Some of the alternative sources of energy are renewable and capable of meeting every need at home from lighting to water heating. To be specific, renewable energy refers to energy generated from renewable sources such as solar, tides, and wind power, and it doesn't produce the dangerous green-houses gases. Green energy is beneficial because it's eco-friendly and in most cases, cheaper.

Before choosing which way to go about installing an energy generating system, it's good to have comprehensive knowledge on how they operate and every other detail surrounding them. The 3 common ways of generating renewable energy at homes include:

1. Wind energy

If you want to green power your home, investing in a wind turbine maybe a worthwhile investment. Designed for home wind turbines are electric generators that utilize wind to generate clean, greenhouse gas emission-free power for home, farm, and small business use.

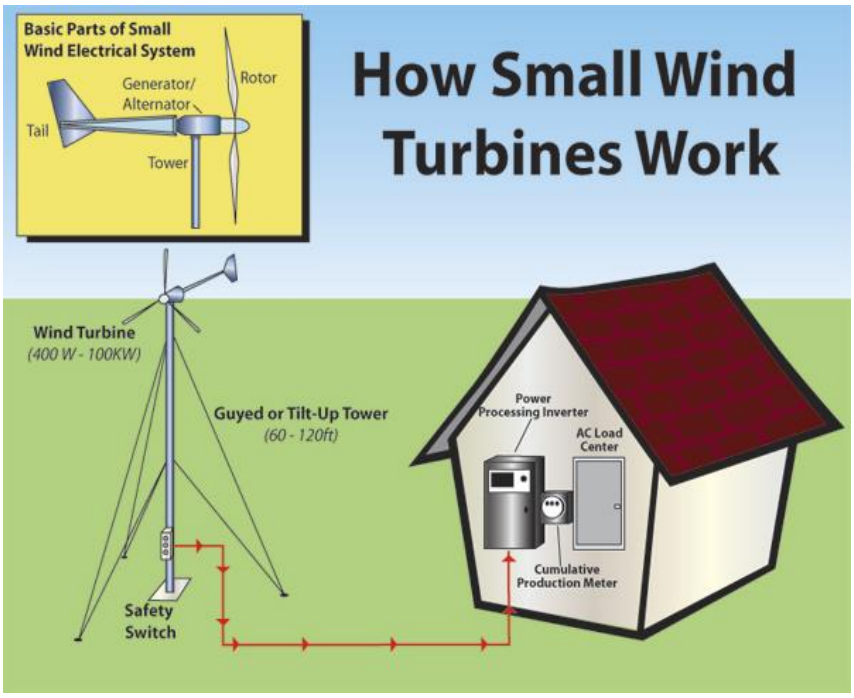
On its own, a wind turbine can generate between 50-90% of the energy needs in an average home. If used with a battery, a wind power system can supply an entire home or building with 100% of its energy demands.

Unlike utility wind power turbines used to generate large voltage electricity, small wind turbines are suitable for installation in properties as less as 1 acre. Wind power is

becoming increasingly popular, mainly because it gives home owners a chance to generate their own power, protect the environment, and save money.

How wind turbines work.

Wind is brought about by the uneven heating of the earth by the sun. Wind power is generated when wind turbines convert the kinetic energy in the wind into mechanical energy. The mechanical energy then causes the generator to spin, which produces clean electrical energy. In simpler terms, the blades are turned by the wind, and as they rotate, they spin the shaft which connects to a generator that produces electricity. Today, wind turbines are designed to yield maximum efficiency.



How to Install

Installing a small wind turbine in a home or property is super easy, follow the following steps:

i. Evaluate whether the wind energy in your region makes a home-based wind power system viable.
ii. Calculate your home power usage; you can do this by checking your monthly or annual power usage.
iii. Check whether your local laws allows installation of small wind turbines.
iv. Buy and install a wind turbine the size of your household.

Circumstances in which wind power works best.

Wind power is the best choice in the following circumstances:

1. The project is a long-term investment. A wind power system is not something that can be put up for a short time and dismounted any time thereafter. The initial cost dictates that the system should be used for years before upgrading or being brought down. Those interested in a long-term source of clean energy should undoubtedly try wind energy; it works.
2. Location of the home is in a remote place far from the normal utility grid. Most people who can still access the normal utility grid never consider this method of generating electricity. However, for those that cannot access it, wind power is the way to go.
3. Homes whose monthly electricity bills stand at $150 and above. This is a good range of measuring whether wind energy will bail out it associated expense or not.
4. The home is located on a one-acre land with a good wind resource. This is very important to ensure that any neighboring obstacles do not tamper with the

amount of wind supply to the turbines. A one-acre allowance is enough to trap maximum wind energy that is needed for the home.

5. Areas whose covenants and zoning codes allow for wind turbine erection. Before starting any work on the ground, always consult with the local authorities to know whether its allowed to put up wind turbines in the area.

Types of wind power systems.

There are two types of wind power systems, stand-alone and grid systems.

Stand-alone systems: These are not connected to the utility grid; they use batteries for storage of the excess power which is then harnessed when the wind is calm. A charge controller is used to keep the battery from overcharging. The best type of batteries used for wind systems are deep-cycle batteries. Since most small wind power systems generate DC energy, the DC appliances can operate without the battery. However, for the sake of appliances which use AC power, an inverter is incorporated to convert DC energy into AC. One hitch about inverters is that they can lower the efficiency of the whole system. Always keep batteries away from the living areas for safety reasons.

Grid systems: It is pretty much like the standalone system, the only difference being the power conditioning unit which makes the wind power compatible with the rest of the utility grid. Batteries are not a necessity in this system.

The cost of wind systems.

The cost of installing wind systems varies widely due to interconnection and utility costs, local zoning and permitting costs. The American Wind Energy Association advocates for small systems to cost between $3000-$5000 per KW. Cost effectiveness of wind energy increases in relation to the turbines rotor size. Other accessories such as the tower, batteries and inverter introduce additional costs which may make the installation a bit expensive. The payback period may also be a bit lengthy. However, wind power can

compete with the conventional energy on the basis that there are no more electricity utility bills for the rest of its lifetime.

Things to consider when buying a wind turbine.

When buying a wind turbine, consider the following factors:

1. Credibility of the vendor: Ensure that the supplier from whom you purchase the turbine is reliable: he or she should have a physical office where you can locate them in case of anything. Reputation also matters. Check reviews of the vendor from previous clients regarding their service delivery and effectiveness. Be careful also to choose a retailer who can offer maintenance services and installation as part of the package. Doing a thorough research will go a long way in directing you to the right dealer.

2. Cost: Always go for the package that you can afford. Draw a budget of everything that you need to buy as a package before you go shopping. This will help you to stay within the budget. It will also help in cutting costs where possible.

3. Maintenance costs: Choose a wind system that has the least maintenance costs. The lower the cost, the higher the efficiency of the whole system.

Choosing the best site for the wind turbine.

When choosing the site for turbine installation, consider the following:

Security: This is very important for the safety of the assets. Vandalism is a very big threat to wind power system. Ensure that there is no vandalism threat to the wind system. For enhanced security of your system, one can install cameras on the site.

Access: Consider accessibility of the site. Consider if you will have to incur extra costs in improving the accessibility of the site. All in all, focus on cutting costs by choosing an accessible site.

Quality of the wind resource: Consider any barriers to optimal speed of the wind required to run the turbine. If there must be a barrier near the turbine, let it be at least a distance that is twice the height of the turbine. This ensures that the turbine can at least get the required wind for operation.

Advantages of wind power.

- It is clean, wind energy does not contribute to environmental pollution in any way. Hence it is fosters ecological balance.
- It can never be exhausted. As long as the sun heats the earth, wind energy will always be there to be harnessed.
- It is cost- effective. This is a type of investment which every average citizen can afford, either by self-financing or through loans and incentives.
- Wind turbines can be installed on existing farms or even buildings. This makes them easy to install with minimal demands.

Shortcomings of wind energy.

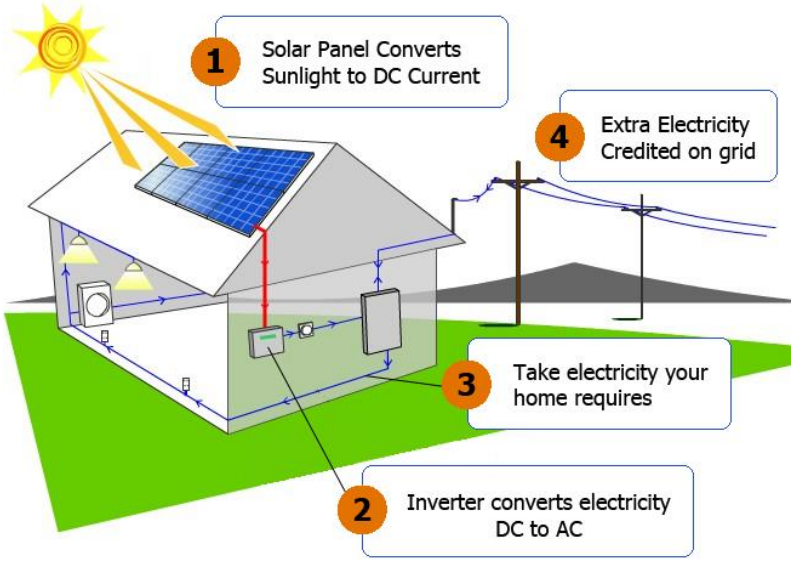
- Wind energy can be insufficient if the area has inadequate supply of wind.
- The blades turbines can harm wildlife, which is not something desirable.
- Sometimes it can be hard to locate a good wind site within or near the home, which is a real challenge to home owners today.
- In some areas, it is not allowed to have wind turbines. This may lock out citizens who would like to have wind power installed in their homes.

2. Solar energy

This is energy that is harnessed directly from the sun and can be used for lighting, heating and every other electrical use in the home. With the current improvements on the photovoltaic systems, the cost of installing solar energy systems has dropped

significantly, making it a favorite for people who would like to save on their utility bills or completely be out of the grid.

How Solar Energy Systems Work



The most basic unit of the photovoltaic technology is the solar cell. A solar panel is made up of one or more solar cells that are put together as a pre-wired unit. Most home owners combine an array of solar panels together to achieve the desired KW. This is dependent on the needs of specific home owners. Most of the PV arrays are usually mounted on the rooftop of the house where there are no barriers in accessing the sun, but they can also be erected in other places in the home on their own.

The solar power system might have a central inverter which is used to convert the DC energy to AC. Otherwise, each panel can as well be connected to a micro-inverter which is better in case one panel fails. Having the micro-inverter system helps in avoiding a complete loss of power in case the inverter fails. Also, it makes it possible to expand the system without changing a lot of things or incurring a lot of expense. The inverter

consumes some of the energy harnessed in converting the energy to AC. To save on this, one can buy solar ready house equipment that can directly use solar power.

Types of solar systems that can be used in homes.

Stand- alone systems: Here, the system is not connected to the utility power grid. It is characterized by use of batteries to store power which is used to light the home at night and supply power for extended periods when supply of sunlight is low. Off-grid power systems can also be used as a back-up plan in case the fuel generator fails.

Utility- interactive systems: This is the most-used system by home owners. The system is connected to the utility power grid such that the electricity produced is supplied to the main electrical panel of the house. The bills are greatly subsidized by the solar power hence saving on electricity costs. The benefit of adopting this system at home is that it gives continuous power supply even when the solar unit fails. Also, it helps in generating extra power to adequately meet all the needs of your home as well as cutting costs on electricity bills.

Factors to Consider When Installing a Home-Solar Power System.

The type of roofing: PV arrays can be installed on almost all types of roofs. However, some roof types such as Spanish shingles have been posing a challenge for some electricians. This means that homeowners with this type of roof have to be very careful and precise on who should install their solar systems.

Cost: Every person who needs to install a solar panel will always look at the cumulative cost first. Go for an affordable package, but one that adequately meets your needs. It helps to develop a budget to guide you when shopping, wiring and even installing the system in the house. Always look for ways to cut cost, but bear in mind that cost reduction is not the final goal; it’s just one of the factors.

Geography: Solar power can be harnessed optimally when the panels are exposed to direct sunlight, choose a location with the least shade. In case there are trees nearby your roof, you can trim them or cut them down entirely.

Permits: Before starting the project, obtain all permits required from the relevant authorities. This will keep you from unnecessary fines and even being forced to pull down such a big investment.

The amount of energy needed: The energy amounts that you desire to get out of the system. This is determined by the size of the home and the capacity needed by the equipment to be used. For instance, a person who requires solar energy for water heating will need to invest on a bigger system than another one who uses it just for lighting.

Advantages of Using Solar Energy

- Solar energy is clean: It does not pollute the environment in any way.
- Solar energy is a reliable source of power. As long as the sun rises every day, one is assured that power will be generated. The only thing that must be working is the solar system and power will be available.
- Adopting solar energy promotes independence. This means that one can generate their own power from the sun and use it the way they want without being put under rules, regulations and rationing.
- Solar energy has diverse uses. From heating, lighting and operations, one can do typically anything using solar power. With the invention of solar ready equipment, one can even use the energy without the inverter.
- Solar energy is renewable. One can never exhaust solar energy. Every day, the sun will always rise, promising an opportunity to harvest power.

- Solar systems have low maintenance costs. PV arrays will always require minimum attention. They can always be serviced once or twice a year as a norm. This makes it very convenient for people with a busy schedule.

Disadvantages of solar energy

- **Costs.** Buying a complete solar system that can sufficiently supply the home with energy is expensive. Though there may be some grants and incentives from various organizations, one will always incur costs on the solar panels, inverters, batteries and wiring which are always paid up front.
- Energy yields depend on weather. The amount of energy harvested is dependent on how sunny the day was. On cloudy and rainy days, power supply in the home will always be low. This may affect some daily operations, which is not desirable.
- Installation of solar panels consumes a lot of space. Some roofs may not be able to accommodate the number of panels required to produce power, hence one may be forced to have them on the yard, which may make it look congested.

3. Biogas

This is a mixture of carbon dioxide and methane which come from anaerobic respiration. This kind of respiration occurs in the absence of oxygen. Some of the rich sources of biogas include animal waste or lake bottoms where a lot of decay takes place. Biogas energy is renewable because the source can never be exhausted by consumption. The cycle keeps on recurring.

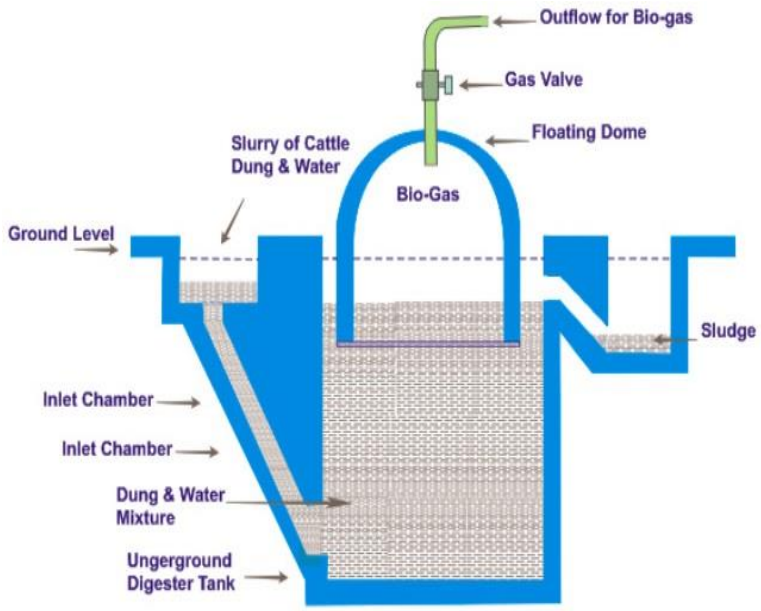
How to generate biogas simply in the home

Biogas is simply made by collecting the organic waste in a tank. Due to anaerobic respiration, methane gas accumulates in the tank from which it is used in place of natural gas for the purposes of cooking, heating and lighting. To make the process continuous, organic waste is fed and removed from the tank from time to time. For a

new biogas plant to start producing energy, it takes around 6-8 weeks since anaerobic respiration is not a fast process.

Components of a biogas production plant

- Digester. This is a cylindrical tank in which fermentation takes place. Most of the tanks are fully underground while others are partially built.
- Mixing tank. This is where the slurry is mixed with water and then fed into the digester using an inlet pipe.
- Gas holder. This is where the gas comes in after leaving the digester. This can be a tank or a dome which is usually tightly closed. From here, the gas is directed for other uses either for cooking or lighting.
- Slurry pit. This is where the slurry is thrown in from the digester to be used directly for other purposes.



Floating Dome type Bio-gas Plant

Advantages of using biogas energy

- It is a renewable source of energy. One can always keep producing biogas as long as there is supply of slurry. This makes it a reliable source.
- It helps in saving money. Instead of buying cooking gas or using grid electricity to light the home, one can use biogas.
- Helps in environmental conservation. Biogas production uses organic wastes which are found in landfills. Most of the times, these wastes make the environment unsightly. This can be addressed by biogas production.
- It requires less capital to start. Biogas production is not a capital intensive venture. One can start by improvising locally available materials to make the production plant.

Disadvantage of biogas.

- Can only be used in small scale. It is not viable to use in large scale due to efficiency issues.
- It is not a stable method of energy production. This is because methane can easily explode if it comes into contact with oxygen
- Biogas contains gas impurities which can cause corrosion to the metallic parts of internal combustible engines.
- Biogas energy has a low calorific value which makes it less competitive with other forms of fuels such as LPG gas and petroleum.

Safety precautions to undertake in biogas production.

- Always have a fire extinguisher on the site just in case of a fire breaks out.
- Always keep children and unaware visitors far away from the plant. This is because they may wander in to dangerous areas and injure themselves and others.
- Keep all the tanks and the slurry pit to avoid potential drowning and falling off.

- When entering the production area, always wear appropriate protective clothing to keep yourself safe from all types of danger.
- Do not smoke or light any open flame near the biogas digesters. These could cause an explosion or fire leading to loss of lives and property.
- Ensure that you have flame arresters near the gas openings to lower the risk of fire outbreaks in the production plant.
- Ensure that there is adequate ventilation around all the das lines to prevent accumulation of harmful gases.