Battery Room Ventilation and Safety

An Online Continuing Education Course for Engineers

Course Number: HV-4020

Credit: 4 Hours / 4 PDH / 4 CPD

Battery Room Ventilation and Safety

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It is common knowledge that lead-acid batteries release hydrogen gas that can be potentially explosive. Battery rooms must be adequately ventilated to prohibit the build-up of hydrogen gas. During normal operations, off gassing of the batteries is relatively small. However, the concern is elevated during times of heavy recharge of the batteries, which occurs immediately following a rapid and deep discharge.

Often HVAC designers underestimate the worst case for dangerous hydrogen accumulation, and display reassuring calculations proving that no danger really exists. But dismissing such a critical safety issue is not a prudent or responsible way to deal with it. Instead, we should be prepared to face the likely possibility of hydrogen build up, clearly identify the conditions when the risk is highest, and design systems that protect against explosive levels in a fail-safe way.

This 4-hour course describes the hazards associated with batteries and highlights those safety features that must be taken into consideration when designing, constructing and fitting out a battery room. The course is for reference only. Anyone involved in the design of a battery room should rely on the experience of a professional engineer who is well versed in applicable codes, standards and regulations for the installation site. Advice on specific ventilation rates required must be sought from the battery suppliers.

This course is applicable to facility professionals, architects, electrical, mechanical and HVAC engineers, controls engineers, contractors, environmentalists, energy auditors, O& M professionals and loss prevention professionals.

The course is divided into 5 chapters:

1. Fundamentals of Lead Acid Battery
2. Rules and Regulations
3. Ventilation Calculations
4. Battery Room Design Criteria
5. Preparation and Safety – Do’s and Don’ts

CHAPTER 1: FUNDAMENTALS OF LEAD ACID BATTERIES

The function of the battery is to store electricity in the form of chemical energy and when required, convert it to electrical energy. Electrical energy can be produced from two plates immersed in a chemical solution. Several linked together give a higher capacity.
Battery cells can be divided into two major types:

- A primary cell is one that cannot be recharged and the cell is discarded at the end of the life.
- A secondary cell is one that is rechargeable.

Examples of primary cells include carbon-zinc (dry cell), alkaline-manganese, mercury-zinc, silver-zinc, and lithium cells (e.g., lithium-manganese dioxide, lithium-sulfur dioxide, and lithium-thionyl chloride). Examples of secondary cells include lead-lead dioxide (lead-acid), nickel-cadmium, nickel-iron, nickel-hydrogen, nickel-metal hydride, silver-zinc, silver-cadmium, and lithium-ion.

Lead-acid Battery

Lead acid battery is a type of secondary battery which uses a positive electrode of brown lead oxide (sometimes called lead peroxide), a negative electrode of metallic lead and an electrolyte of sulfuric acid (in either liquid or gel form). The overall cell reaction of typical lead-acid cell is:

$$\underset{\text{Lead}}{Pb} + \underset{\text{Lead oxide}}{PbO_2} + \underset{\text{Sulphuric acid}}{2H_2SO_4} \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} \underset{\text{Lead sulphate}}{2PbSO_4} + \underset{\text{Water}}{2H_2O}$$

The three major contributors to Lead-Acid battery chemistry are lead, lead dioxide, and sulfuric acid. Unfortunately, pure lead is too soft to withstand the physical abuse, about 6% antimony is added to strengthen it. Antimony added to the lead grids acted as a catalyst and made out gassing (loss of hydrogen and oxygen during use) worse, and frequent water replenishing was required. Battery manufacturers looked for another material that could strengthen the lead grids. Calcium was added to both the positive and negative electrodes. It reduced out gassing enough to allow manufacturers to claim they're building "maintenance-free batteries".

Alkaline Battery (Nickel-Cadmium Battery)

An alkaline storage battery has an alkaline electrolyte, usually potassium hydroxide (KOH), and nickel oxide (nickel oxy-hydroxide) as positive electrode and metallic Cadmium as negative electrode. The overall cell reaction is:

$$\underset{\text{Cadmium}}{Cd} + \underset{\text{Nickel oxyhydroxide}}{2NiOOH} + \underset{\text{Water}}{2H_2O} \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} \underset{\text{Cadmium hydroxice}}{Cd(OH)_2} + \underset{\text{Nickel hydroxide}}{2Ni(OH)_2}$$

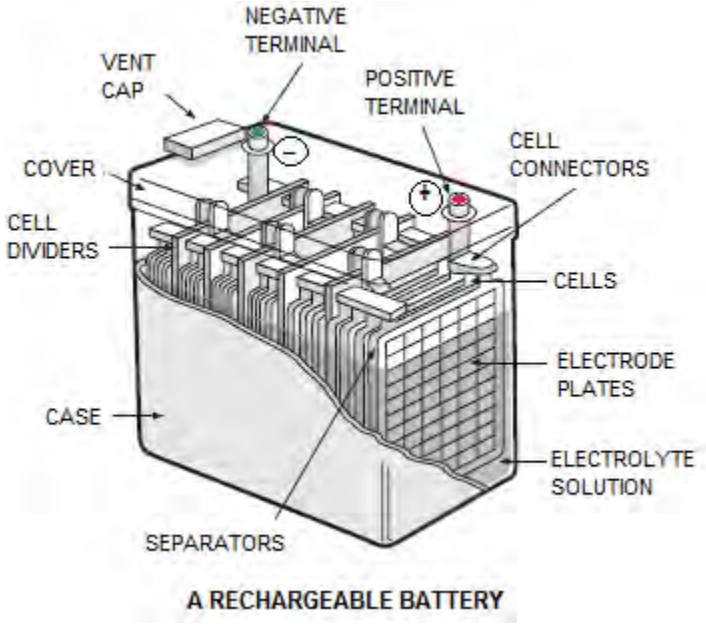
The nominal cell voltage = +1.2V

When compared to lead acid batteries, Nickel Cadmium loses approximately 40% of its stored energy in three months, while lead acid self-discharges the same amount in one year. Lead acid work well at cold temperatures and is superior to lithium-ion when operating in sub-zero conditions.

The Lead Acid Battery is the most popular type used and we will focus on it in this course.

Components of Lead Acid Battery
The Lead Acid Battery basically consists of the following 4 components:

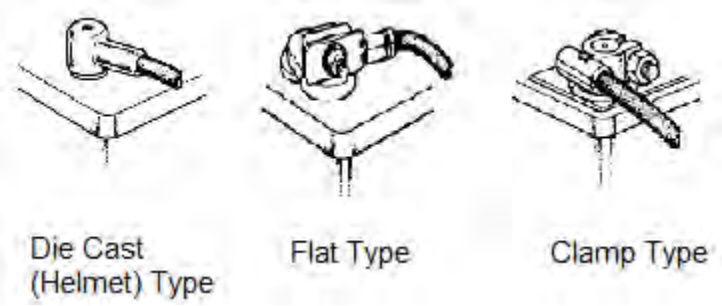
1. Case
2. Terminals
3. Plates
4. Electrolyte



A RECHARGEABLE BATTERY

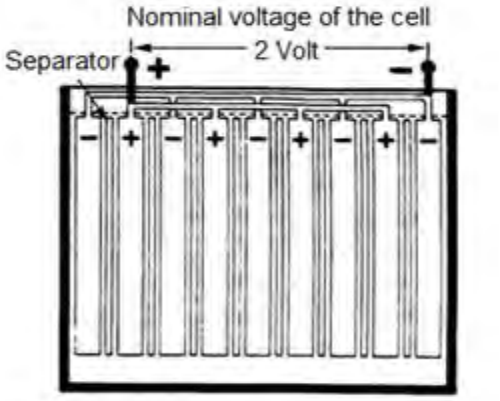
Case
The battery case is constructed of insulating acid resistant material, usually plastic or hard rubber, and has a number of compartments or cells. A 12 volt battery has 6 cells. Recesses in the bottom of the cells collect the sediment that falls from the plates. This prevents the sediment from bridging the plates and causing internal short circuiting. The top of the plate assembly is enclosed by a moulded one piece cover which is sealed to the main case. Each cell has a removable plug to facilitate topping up and testing. These plugs are vented to allow for the escape of gases produced during charging.

Terminals
Positive pole: shown '+' usually red in colour and is the larger of the two.
Negative pole: shown '–' usually black or green and is the smaller of the two.
Battery connectors: Various types of connectors are shown below:

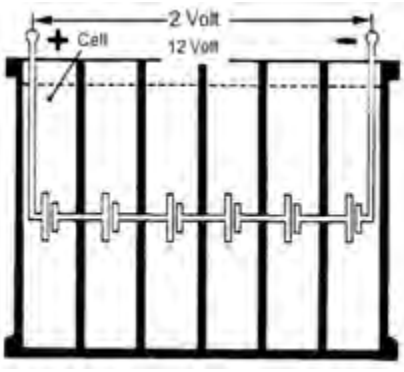


Plates

Batteries are composed of one or more cells; each cell has a number of positive and negative plates with separators fitted between them. The total number of plates per cell is normally not less than seven, usually starting and finishing with a negative plate.



The surface area of the plates in a cell determines its current capacity. In a lead acid battery, the plates are assembled so there is always 1 extra negative plate. The plates are close to each other but do not touch, which would cause a short circuit.



One set of plates is connected to the negative side of a DC source, and the other to the positive side. Direct current is applied to the plates, changing them chemically, until the battery is ready for service.

The nominal voltage of a cell is 2 volts. Cells connected in series make a battery, and the number of cells determines its nominal voltage. The accepted, or nominal, voltage of a cell does not depend on the size of the cell. The size of the cells determines the discharge capacity (current capacity) of the entire battery.

Each cell has its own vent cap designed to relieve excess pressure and allow gases to escape. It also keeps the dust and dirt out of cells and contains electrolyte solution inside the battery cell.

Electrolyte
The battery is filled with electrolyte, which is a mixture of 35% sulfuric acid and 65% de-ionized water. The separators between the plates are porous to allow the circulation of the electrolyte, and the chemical action to take place. When the cell is [illegible] e acid reacts with the plates, converting chemical energy [illegible] rrent flows from one pole of the battery, throug

Discharging
In a fully-charged bat[illegible] nd the negative plates are spongy lead. Durin[illegible]

- Sulphur in the a[illegible];
- The oxygen and[illegible] dilutes the electrolyte.

As the battery is dischar[illegible] d becomes weaker (dilute) until the battery [illegible] possible to tell the state of charge by seeing [illegible] to measure the strength of the electrolyt[illegible] lphate as the battery is discharged by use. The[illegible] or lead peroxide, so if the battery is discharge[illegible] will fall out. This shortens the life of the ba[illegible]

Note: the strength is gener[illegible] of specific gravity, which is the weight of the electrolyte compared to the [illegible] of an equal volume of pure water.

Charging
To charge a battery, a current must be forced back through it. So a positive voltage must be applied to the positive terminal and negative to the negative terminal. Also, the voltage must be high enough to overcome the battery voltage and drive sufficient current into the battery. About 14 Volts is adequate, for a 12V battery.

- Oxygen in the electrolyte combines with the lead sulphate of the positive plate to become lead peroxide;
- Sulphate is released from both plates, which is converted to sulfuric acid and the concentration of the electrolyte is restored;
- The negative plate becomes spongy lead.