GETTING TO KNOW THE DEKA DIFFERENCE:

Understanding the Deka® Flat Plate Advantage Over Tubular Designs

I

THE DEKA DIFFERENCE

Introduction

What's Inside?

Deka Motive Power Batteries, made by East Penn Manufacturing, use a flat plate design in their internal construction. While a flat plate design is used by many motive power battery manufacturers, East Penn's flat plate technology process and quality surpasses the competition. The Deka flat plate design and its superior characteristics also out perform "tubular" plate technology. This is especially evident in aspects of the product design and manufacturing process such as the grid, active material, retention system, and formation. Closely examining these subjects will prove that "what's on the inside counts!" It will also show that not only are the internal components of these batteries critical, but how the continual consistency of the manufacturing process can make or break its extended use. In fact, these manufacturing techniques and materials used are so crucial to battery life that lab tests reveal that a Deka flat plate design can deliver over 40% more amp hours than a tubular design (see section VI). This is further proof that Deka batteries are built for the long run providing the lowest cost of ownership in the industry.

II

THE STRENGTH OF A Grid

Why are grids so important?

Grids are so important that they are referred to as the "skeleton" of the battery. Grids are the supporting framework for the active material of battery plates. They serve as a path through which the current is transferred throughout the plate.

What are lead alloys?

Grids are made from an alloy of lead. Some alloys use a small amount of antimony to strengthen the lead. This is necessary so the grids can be handled during the manufacturing process without being bent or damaged.

Why is it important to have the right blend and amount of alloys?

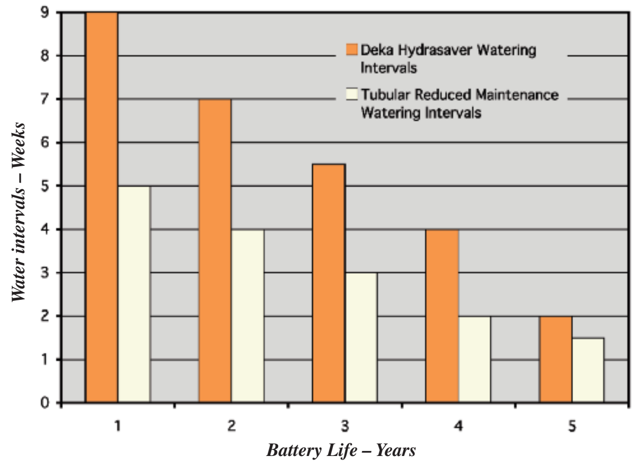
Although an alloy like antimony is necessary to provide strength to the grid, too much will increase gassing. More gassing means more frequent watering which leads to more maintenance. A tubular design relies on a higher percentage of antimony to add strength to its long, thin spines. The flat plate grid requires less antimony because of the natural strength and integrity of a grid-like structure.

Compare the square:

The Deka grid design is composed of many individual squares that hold the active material (a Deka 125 amp-hour plate has 225 squares). If one of these wires would corrode through, there are three other wires surrounding the square that can still conduct current.

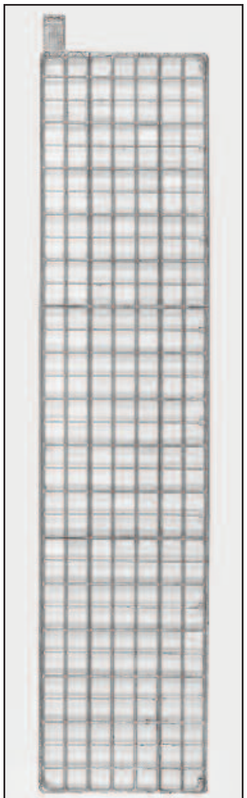
A spine design only has one path to the lug. If the spine would corrode through, there is no surrounding lead to continue to carry the current. All the capacity below the break will be lost.

Deka Flat Plate

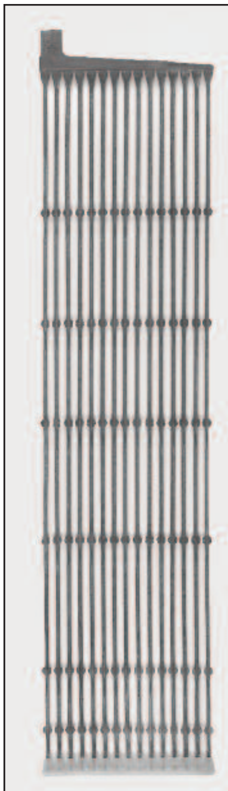


The grid of a Deka flat pasted plate is composed of a criss-cross network of lead alloy. The grid becomes a plate when these spaces are filled in with active material. This active material adheres to each individual square so it is completely surrounded by grid lead alloy. This results in excellent material retention and conductivity. All parts of the plate are electrically connected to maximize current distribution. The amount of antimony alloyed in a flat plate grid is about 4-6%. By comparison, a tubular grid uses about 10% antimony resulting in more gassing and shorter watering intervals than a flat plate design *(see chart above)*.

The flat plate grid design also provides a reserve of lead to withstand the naturally corrosive action of the acid. If one, or even several, of the grid's internal wires would corrode through, due to multiple intersecting wires, there would still be many paths remaining to maintain performance and life.



Deka Grid



Tubular Spines

Tubular

Spines in a tubular plate construction contain no reserve of lead metal. If one spine corrodes through, the electrical connection is broken resulting in a significant loss of capacity. Since there are normally 15 spines in a plate, the corrosion of one spine can result in a 6% capacity loss. As a battery ages, it is not unlikely for corrosion to occur on several spines, resulting in serious capacity loss and a reduction in service life.

III

Active Consistency

FOR ACTIVE MATERIAL

What is the importance of the plate?

As grids may be compared to the skeleton of the battery, the plate can be compared to the battery's heart. The plate is responsible for the voltage that is generated in the battery due to a chemical reaction between lead in two different chemical states, the positive and negative plate. When exposed to sulfuric acid, electrical energy is produced by the chemical reaction at these two plates.

The main difference between the positive and negative plates is that the negative plate's active material contains "expanders." These "expanders" are required to prevent the negative material from contracting in service and reverting to a dense, inactive state.

What is red lead?

Red lead (Pb_3O_4) is a type of oxide used in a tubular plate. It is less dense and more reactive than the oxide used in Deka batteries; therefore, it is extremely prone to excessive shedding and quick capacity loss. Although red lead's reactive nature is known to produce higher initial capacities, it is not worth the negative impact it has on battery life.

Red lead gets its name from being composed of an increased amount of oxygen causing the red color.

Compare the square:

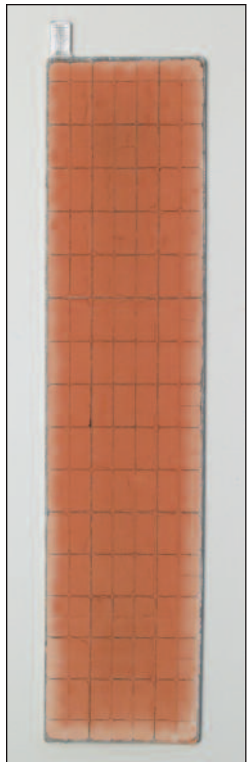
The paste of the Deka plate attaches to all four sides of the many individual squares that comprise the grid's construction (a Deka 125 amp-hour plate has 225 squares). Even without any reinforcement around the plate, the active material has excellent adhesion to the grid's surface.

The paste on a tubular plate has to cling around the spine's surface so it relies heavily on the tube's surrounding material (known as the gauntlet) to help hold the paste. If the gauntlet would split, there is a high probability of severe active material shedding and shorting, all leading to premature battery failure.

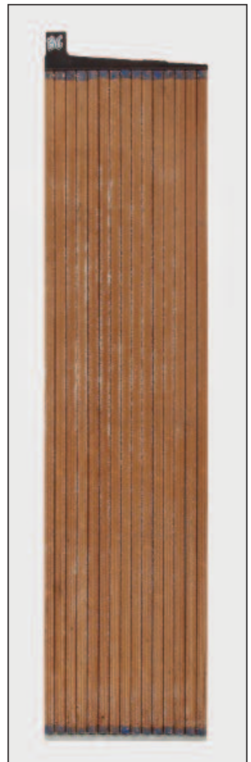
The amount of active material or paste contained in the battery plate is critical for both capacity and life. It is very important that the active material is consistently applied over the entire plate. If the density is too high it will lower capacity, while if too low, will cause shedding and early failure.

Deka Flat Plate

In the Deka flat plate, the density of the active material is controlled carefully by computer-integrated paste mixing machines to predetermined values. The paste density and weight will also be very uniform when applied automatically by East Penn's computer-integrated pasting machines. After pasting, Deka plates are cured in a large temperature and moisture controlled chamber so that they last longer and deliver optimized power performance.



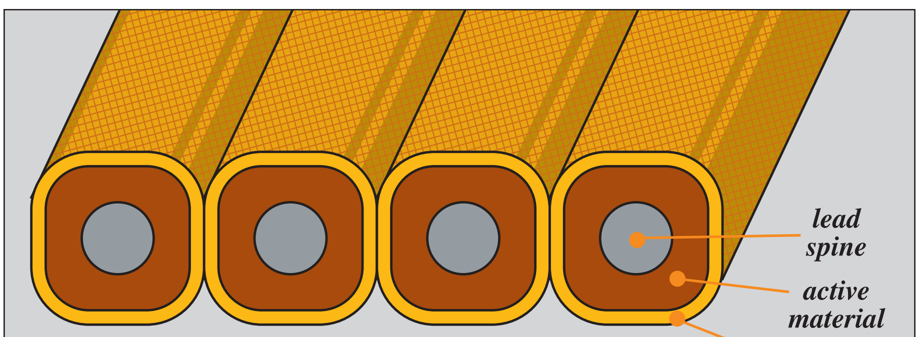
Deka Flat Plate



Tubular Plate

Tubular

Gauntlets are filled with either dry or wet active material creating the individual tubes. The dry form uses a mixture of red lead and lead oxide powder while vibrating the plate. Vibration is necessary to prevent the oxide powder mixture from clogging and assist in the flow. A slurry form of liquid and active material can also be used to fill the gauntlets. These methods can produce variation in the filling process. This variation in density results in an uneven discharge and charge of the active material leading to premature failure. In some cases, the extremely dense material can split the retaining gauntlet resulting in severe shedding and major capacity loss.



Close-up of end of tubes

IV

Five Retention Steps

ARE BETTER THAN TWO

Is there more resistance to current with a multiple retention system?

Yes, but remember, a Deka battery is designed and manufactured to meet or exceed its specified ratings. In addition, the multiple retention system is extremely important as it prevents shorts, resists active material shedding, and protects and reinforces the plate. The benefit of this retention system is longer battery life.

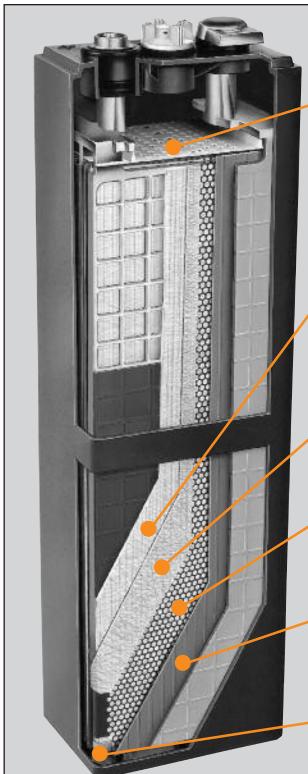
Review the tube:

In reviewing the tubular battery design, multiple factors prove that it has significant tendencies towards active material shedding. ***Active material shedding is one of the top causes of premature battery failure.***

- **The Spine –** If a spine corrodes through, there is no surrounding lead to support the active material.
- **The Plate –** The red lead used in a tubular plate is less dense and extremely prone to excessive shedding.
- **The Retention –**The paste on a tubular plate has to cling around the spine's surface so it relies heavily on the surrounding gauntlet to help hold the paste. Using a limited retention system with poor grid-to-lead adhesion will lead to more active material shedding.
- **The Sediment Space –** Tubular batteries are actually designed to account for significant active material loss or sediment. Up to 1½ inches of the cell is utilized for sediment space. Once the active material lays in this space, it becomes inactive and a potential risk to the life of the battery.

  Deka flat plates have excellent active material retention with only a ½ inch of sediment space in each battery cell. With less inactive sediment, more active material remains on the plate, made evident by its long life performance.

The retention system is the combination of material used to prevent active material in the positive plate from softening and shedding. An effective retention system is a sure way to help achieve long life.



Deka flat plate retention system

Deka Flat Plate

A Deka flat plate battery uses a multiple-step retention system. The first two retention steps wrap the positive plate with a vertical mat consisting of fiberglass tape and interwoven glass fibers. The glass fibers imbed into the active material, strengthening in a way similar to reinforcing rods in concrete. A horizontal glass fiber mat is then wrapped around the plate to break up any gas bubbles and increase the plate's insulation. In the next step, the wrapped plate is then encased in a perforated plastic retainer envelope that firmly holds the glass wrap in contact with the plate while allowing the free-flow of electrolyte to have access to every part of the plate surface. The final step is the separator, the last barrier between the positive and negative plate, protecting against shorts and corrosion. Deka flat plate cells also use a bottom plate shield to prevent sediment from bridging across the bottom of the plates and shorting out the cell.


Tubular retention system

Tubular

Tubular designs have a two-step retention system, which consists of a tube of polyester fabric (known as the gauntlet) and a separator. Using only two methods for retention, a tubular construction is prone to significantly more active material shedding. Loose active material floating free in the electrolyte can settle on the negative plate where it is electrochemically reduced to a spongy lead moss deposit. This deposit is likely to cause a short between positive and negative plates leading to premature battery failure. Another problem that can occur with limited retention is split tubes. Through excessive discharge and charging, the active material can swell and increase pressure on the tube. A split tube results in catastrophic shedding leading to significant capacity loss…a loss that can reach up to 6% for each tube in each plate.

V

THE INDUSTRY'S FINEST
Formation

What is the formation process?

Batteries need to be electrically formed in a sulfuric acid electrolyte solution. This initial charge electrochemically converts the lead sulfate on the positive plate to lead dioxide. Lead sulfate is a highly porous material, which allows electrolyte to freely penetrate the plate. The "forming" charge converts the lead sulfate on the negative plate to a dark gray, sponge lead. The "spongy" lead also allows the electrolyte to penetrate freely and allows the material beneath the plate surface to take part in the chemical reaction.

What is sulfation?

Sulfation is the sulfate (SO_4) in the acid that forms crystals and attaches to the plates. This acts as a current resistant insulation, preventing the plate from accepting the charge.

Review the tube:

Charging the entire cell is more prone to unequal plate formation. Inconsistent formation will cause unequal voltages and specific gravities between battery cells. For a Deka flat plate battery, the cell's voltages and specific gravities are extremely close.

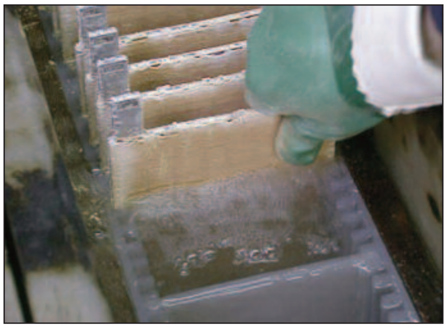
Comparing the consistent voltages and specific gravities of the cells are good indications of how well the battery was formed.

Deka Flat Plate

Deka motive power batteries go through an exclusive two-step formation/charging process. First, Deka plates are individually formed in tanks, which means that every plate goes through an individual formation process. Each plate is visually inspected to make sure it is completely formed. Open tank formation provides precision temperature and voltage control on all tanks in the circuit during this critical phase of capacity development. The process ensures maximum and uniform performance from every plate, and ultimately each cell, in terms of amp-hour capacity and cycle life.

During the second process, the cell goes through a boost charging phase where the cells are charged and optimized for long cycle use. As a result of the uniform formation of each plate, cell voltages are equalized and consistent.

A battery charger is designed to detect the battery voltage of the cells and use that voltage to bring the battery to full charge. When cells have equal voltages, charging will be more efficient preventing gassing and sulfation, significantly extending the battery's overall life.



Individual plate formation

Visual inspection of fully formed plate

A Deka fully formed flat plate after tank formation

Tubular

Tubular and other flat plate manufacturers only form the fully assembled cell in the jar. There is no way of inspecting the plates without tearing down the battery to determine complete plate formation. This process creates an environment more prone to unequal plate formation leading to unequal cell-to-cell voltages, which is especially detrimental to the battery during the charging process. When cells have lower or higher voltages than the average charging voltage, those cells will continually be under or overcharged. Undercharged cells will build up detrimental sulfate on the plates that crystallize and cause parts of the plate to harden and become inactive. Overcharging cells will cause more heat and gassing leading to more shedding and the need for increased watering, all factors detrimental to a battery's cycle life performance.

VI

QUICK ENERGY DOESN'T MEAN
More Power

What is an amp?

An amp is a unit of measure of the electron flow rate, or current, through a circuit.

What is an amp-hour?

A unit of measure for a battery's electrical storage capacity obtained by multiplying the current in amps by the time in hours of discharge. (Example: A battery which delivers 100 amps per 6 hours delivers 100 amps x 6 hours = 600 amp-hr of capacity at the 6 hour rating)

What is capacity?

The ability of a fully charged battery to deliver a specified quantity of current, at a given rate, over a definite period of time.

What is a cycle?

In a battery, one discharge plus one recharge equals a cycle.

What is cycle life?

The number of cycles completed during the life of a battery. A battery is considered at the end of its life cycle when it fails to deliver 80% of its rated capacity.

Review the tube:

Tubular battery designers claim that their tubular shape provides more active material surface area when exposed to the sulfuric acid. **While an increase in surface area can produce higher voltages under load, it also utilizes more active material faster. This increased utilization causes the active material to breakdown quicker and leave the spines vulnerable to corrosion. This further illustrates a tubular plate design sacrifices battery life in an attempt to deliver quick power.**

A tubular battery design begins a continuous capacity deterioration almost immediately when placed in service. Some have labeled it the "first day battery" because its first few days are usually its best. Although it may have high voltages during its initial stages of use, this is a minor power advantage due to the tubular battery design's significantly shorter life.

A Deka flat plate design slowly increases capacity, remains at the rated capacity longer than the tubular, and has a longer time span before failure. This flat plate design delivers more amp hours consistently over a much longer period of time.

According to various lab tests between Deka flat plate and tubular batteries of the same capacity, the Deka flat plate delivered more life cycles consistently over the life of the battery (refer to Figure A). Additional test results showed that up to 1300 cycles, a tubular design delivered slightly more cumulative amp-hours than the flat plate. However, at 1300 cycles the tubular designed battery failed (refer to Figure B). The Deka flat plate battery went past 1800 cycles delivering above 80% capacity *(that's over 1/3 more life than the tubular)*.

The results showed the Deka flat plate battery delivering over 40% more amp hours than the tubular battery because of the flat plate battery's longer life.

Figure A

EPM P140 vs. Tubular Battery – BCI Life Cycle Testing

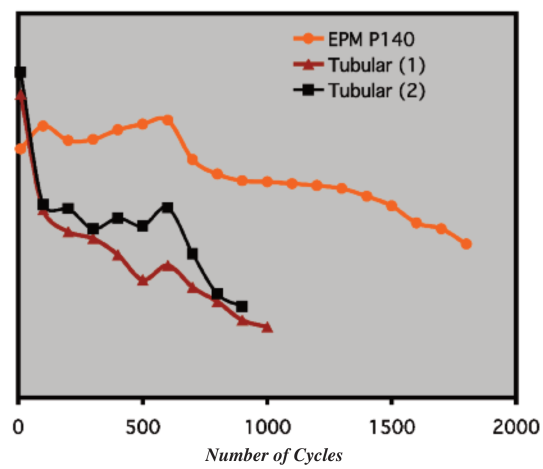
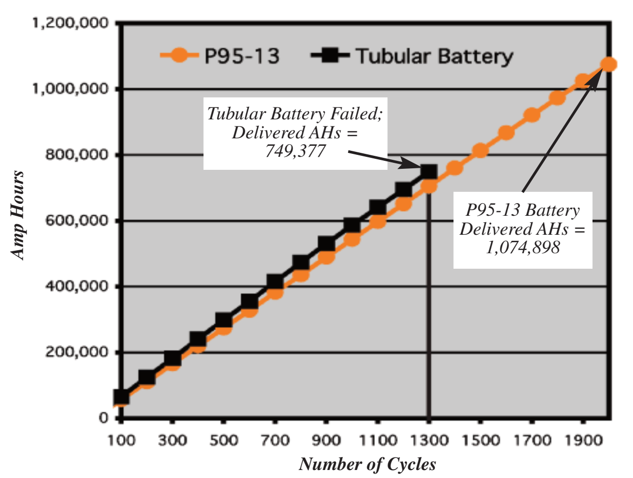


Figure B

Cumulative Amp-Hours – BCI Life Cycle Testing



VII

Choosing a Company
YOU CAN TRUST

Choose a Deka®

It's One Powerful Package backed by One Powerful Company!

At Deka, it's not just our wide selection of motive power products that makes us different from the rest. When it comes to a powerful package, Deka delivers:

- **Lowest operating costs**
  Deka products are built for the long term – period! This lowers your overall cost per cycle.

- **Superior quality products**
  Superior battery quality teamed with a workforce whose number one goal is complete customer satisfaction.

- **Best nationwide service**
  Our experienced agent network is second to none for sales and service support.

- **Environmental excellence**
  The industry's most advanced, environmentally safe recycling facility handles all your disposal needs.

For over 60 years, East Penn has been perfecting the Deka flat plate manufacturing process. Year after year, East Penn invests in this technology to continue to produce the highest quality products the Deka reputation demands.

Deka batteries use the finest materials, workmanship, and most stringent process controls ensuring dependable products…products that are manufactured with the highest quality and have the lowest defect rate in the entire Motive Power industry.

Deka Motive Power designs have always and will always be "built to last" providing the performance and dependability demanded by Motive Power applications. By choosing a Deka battery, you're getting a great product backed by a company that you can trust.

"POWERED FOR PERFORMANCE"®

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