



Motive Power Batteries

Total Cost of Ownership (TCO) Analysis: Cost and Quality Advantages

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“Undisputed financial value of long service life, high quality, and dependable performance.”

Today's motive power operations are more concerned with total optimization of their electrical truck fleets than ever before, especially when it comes to one of the most critical aspects of their operation – batteries. Important factors like extended performance and life expectancy have sometimes been overshadowed by focusing solely on initial product price. However, efficiency-focused operations realize the undisputed financial value of long service life, high quality, and dependable performance.

In order to provide the best solutions to the motive power market, batteries must deliver the highest performance and the **lowest Total Cost of Ownership (TCO)** over the life of the product.

For over 70 years, East Penn has utilized its long-term expertise in technologically advanced battery manufacturing and design, the finest raw materials, and exclusive manufacturing processes to create a product that undeniably delivers proven reliability, quality, and performance. Deka batteries consistently rise above other battery offerings time and time again. While others have tried to compete with different plate geometries and charging methods, Deka Motive Power batteries continue to provide unequaled benefits and proven quality.

The actual savings realized by using Deka Motive Power batteries can be quantified with a Total Cost of Ownership analysis. In strictly controlled testing, Deka batteries illustrated over 33% more cycles and amp-hour throughput versus any competitors' tested product. This translates to 35% more product life by using Deka premium Motive Power batteries.

These projected TCO savings apply for the entire range of Deka Motive Power flooded products. Since its inception, East Penn has never compromised on quality. Purchasing a Deka Motive Power battery assures the user of the highest value product on the market today. ■

Components of Success

East Penn's extensive quality controls, vertical integration, manufacturing excellence, continuous capital investment and dedicated employees result in consistent premium products that deliver the best performance and the **lowest Total Cost of Ownership (TCO)** to its customers.

Quality Control

East Penn has over 250 quality control checks to ensure consistent and premium quality. Strict adherence is followed to ensure process control and continuous testing on raw materials, internal components and finished products.

Vertical Integration

East Penn operates the largest single-site manufacturing facilities in the industry with vertical integration capabilities that encompass every stage of battery production. By incorporating all factions of the battery manufacturing process into one location, it allows the company the ability to optimize its processes and streamline transportation logistics that result in higher output.

Consistent and Continuous Capital Investment

East Penn continues to invest in leading-edge manufacturing facilities, combining decades of experience with the newest technology. East Penn's capital expansion program is significantly more aggressive, per employee, than other large battery manufacturers, year after year. This effort keeps East Penn on the forefront of advanced manufacturing and technologies.

Unparalleled Workforce

Each East Penn employee is trained and committed to producing a product whose name remains synonymous with quality. Many employees are the second or third generation in their families to work at East Penn.

Manufacturing Excellence

East Penn's manufacturing processes are second to none. Advanced equipment and over half a century of expertise enhances critical steps in production to significantly increase product consistency. Two examples include its plate wrapping and stacking and cast-on-strap equipment.

Plate Wrapping and Stacking

East Penn uses advanced computerized monitoring and production analysis instruments to carefully group together extremely large plates and separator material. The plates are delicately picked up with a vacuum system and carefully transported through the machine to be grouped with other plates and separators. A special vision system ensures that no separators are missing and the plates are facing in the correct direction. This results in carefully stacked groups with proper separator placement preventing electrical shorting and extending battery life.

Cast-on-Strap

East Penn uses technologically advanced cast-on-strap equipment. With exacting element alignment and low resistance straps, the batteries have long life and low warranty claims. Advances in the casting process help East Penn maximize current transfer and increase vibration resistance for even greater performance and long battery life. ■

Deka Batteries Deliver More Cycle Life and Ah Throughput

There are two ways to measure the life of a battery: cycle life and Ah throughput.

Based on East Penn laboratory tests on competitor's battery designs of the same capacity, Deka batteries delivered **35% more product life consistently over the life of the battery** (Refer to Figure A & B). While some competitors' batteries showed initial higher capacity or slightly more cumulative Ah, the Deka battery remains at the rated capacity longer than the competition, and has longer life before failure. (All testing was in accordance to BCI Standard BCIS-15, Cycle Testing of Lead-Acid Batteries in Motive Power Applications).

For over 40 years, East Penn has operated an extensive battery testing program with three individual on-site laboratories. The program tests both Deka and competitor motive power products in strict accordance to Battery Council International (BCI) testing guidelines. The sample size of the analysis represents twenty five batteries (250 cells) from various domestic competitors. To achieve field conditions and potential product performance variation, the data used was the combined average of all products tested. ■

1. Cycle Life:

For conventionally charged batteries, life is measured in cycles or cycle life. A cycle equals one discharge plus one recharge to 80% of its rated capacity in a twenty-four hour period.

2. Ah Throughput:

For batteries that are charged through opportunity or fast charging, life is measured by Ah throughput. Ah throughput is accumulated Ah recorded during discharge and/or recharge over time.

For further information on charging technologies refer to East Penn Form 0810, Recommended Evaluation Method and Resource Guide for Motive Power Charging.

Figure A
BCI Life Cycle Testing

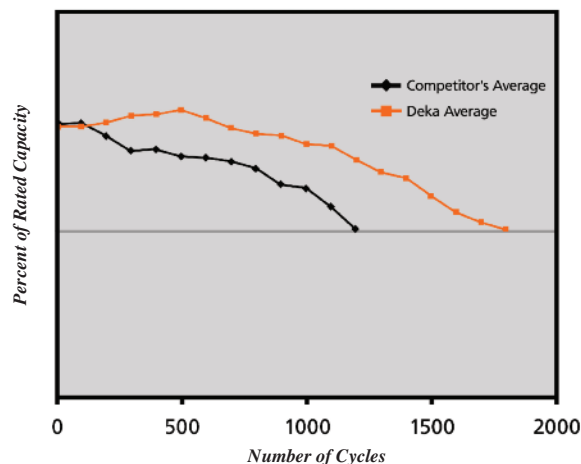
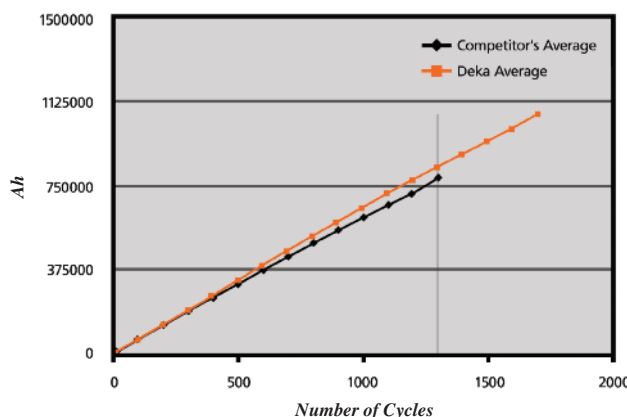


Figure B
Cumulative Ah – BCI Life Cycle Testing





TCO ANALYSIS

Extended Cost Savings

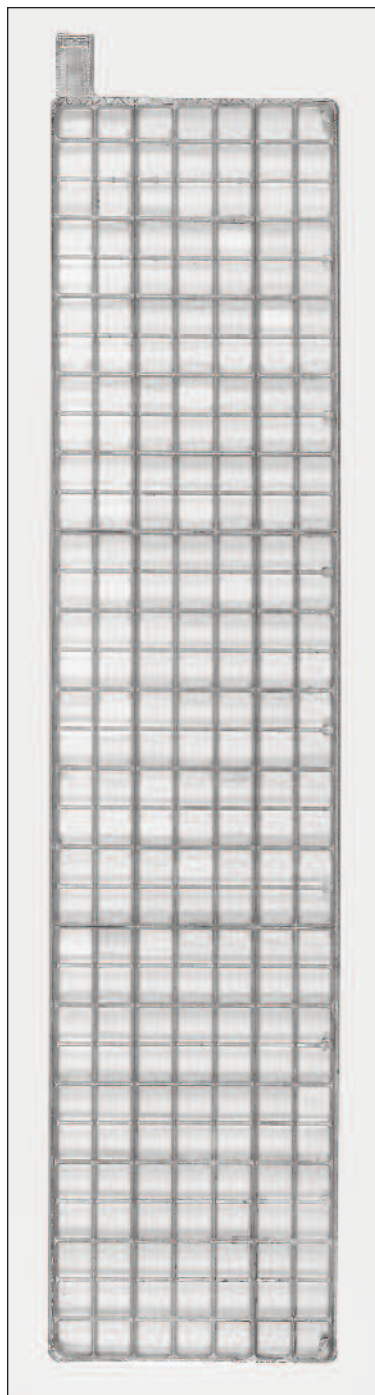
Manufacturer	Deka	Competitor A	Competitor B	Competitor C
Battery Price	\$4,000	\$4,000	\$3,700	\$3,500
Cycles ¹	1,728	1,298	1,298	1,298
Cumulative Ah Throughput	1,073,026	783,860	783,860	783,860
Cost per Year	\$694	\$924	\$855	\$809
Cost per Cycle ¹	\$2.31	\$3.08	\$2.85	\$2.70
Cost per Ah	\$0.0037	\$0.0051	\$0.0047	\$0.0045
Life Expectancy in Years (300 cycles per year) ¹	5.8	4.3	4.3	4.3
Percentage of increased life expectancy with Deka Product	35%			

1 - Based on conventional charging.

Deka batteries provide a significant cost savings whether measured in cycle life or Ah throughput. Using the information from the previously noted test results, this analysis shows that the Deka motive power battery has both **the lowest cost per cycle** and the **lowest cost per Ah throughput** compared to the competition. A Deka battery delivers a 35% increase in product life. This is based on both identical and discounted pricing models for competitor's product pricing. ■

The Quality Inside

East Penn's extensive background with over 70 years of experience in the battery industry along with detailed workmanship, proven manufacturing, and the finest raw material resources deliver the industry's most reliable service and product for Motive Power applications.



Deka Grid

Grid Casting

Grids serve as the supporting framework for the active material of battery plates. Deka grids are composed of a criss-cross network of many individual squares that hold the active material. These squares serve as a path through which the current is transferred throughout the plate.

Using a computer-controlled process, a Deka grid is manufactured with lead and lead alloys. These alloys are used to strengthen the lead and optimize battery life.

The rugged Deka grid also provides a reserve of lead to withstand the naturally corrosive action of the acid. If one or even several of the grid's multiple intersecting internal wires would corrode through, there are still numerous paths remaining to maintain performance and life.

Pasting & Curing

A grid becomes a plate when the spaces of the grid are filled in with paste. This material adheres to each individual square and is completely surrounded by the grid. This results in excellent material retention and conductivity. All parts of the plate are electronically connected to maximize current distribution.

The plate is responsible for the voltage that is generated in the battery due to a chemical reaction between lead in two different states, the positive and negative plate. When exposed to sulfuric acid, electrical energy is produced by the chemical reaction at these two plates.

Deka's paste is composed of a mixture of sulfuric acid, water, and a specially formulated and proprietary lead oxide. Unique computerized-integrated systems allow the combination of these materials to be precisely mixed into a paste-like consistency and uniformly applied to the grid. This exacting process for applying the correct amount and density of paste is critical for capacity and life. If the density is too high it will lower capacity, while if too low will cause shedding and early failure.

The plates are then moved into state-of-the-art hydrosetting chambers, which rigidly control time, temperature and humidity, all crucial factors to proper plate curing. The exclusive curing process paired with the unique crystallization structure of Deka's paste optimizes the plate's performance and extends life.

The Quality Inside *(continued)*

Plate Formation

Once pasted and cured, battery plates 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 material to a dark gray, spongy 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.

East Penn uses a two-step formation process that ensures optimized power capacity, cell consistency, and long term reliability from every plate and ultimately each cell, in terms of amphoter capacity and cycle life. Key factors such as temperature control, specific gravity density, and charging create a unique East Penn formation profile. This profile creates maximum plate to paste reaction efficiency and adhesion characteristics that ensure voltage uniformity and extended life performance. Each cell is checked for voltage and specific gravity meeting strict quality parameters. As a result of the uniform formation of each plate, cell voltages are equalized and

consistent. When cells have equal voltages, charging will be more efficient preventing gassing and sulfation, significantly extending the battery’s overall life. When cells have a range of unequal voltages than the average charging voltage, these cells will continuously 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 and discharging cells will cause more heat and gassing leading to more shedding and the need for increased watering, all factors detrimental to a battery’s life cycle performance.

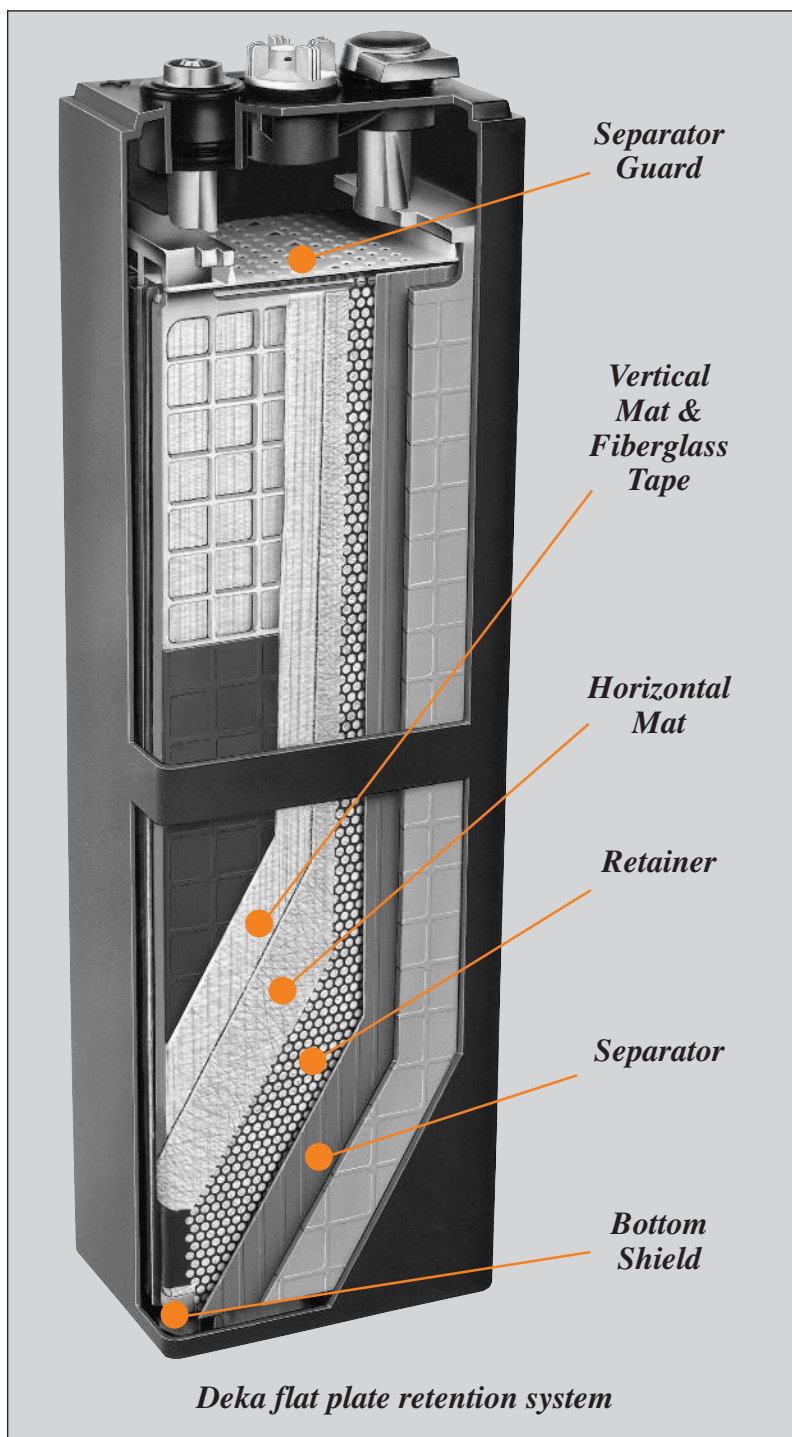


Fully formed Deka plate using East Penn’s formation processes.



Competitor’s plates. White areas indicate plate is not fully formed.

The Quality Inside *(continued)*



Retention

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 batteries use an industry leading five-step retention system. The first two retention steps wrap the positive plate with a vertical mat consisting of fiberglass tape and interwoven glass fiber strands. 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. A bottom plate shield is then inserted to prevent sediment from bridging across the bottom of the plate and shorting out the cell.

There is more resistance to current with a multiple retention system than one with fewer layers. However, this does not require any unique charging regimen. 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 plates. The benefit of this retention system is longer battery life. ■



THE VALUE BEHIND THE PRODUCT

Environmental Stewardship and Innovative Recycling

East Penn has a long history of industry leadership with environmental responsibility and good stewardship. Surrounded by thousands of acres of fertile farmland, East Penn strives to preserve the environment.

Since 1946, East Penn has made safe recycling an everyday practice. The company began as a battery rebuilding company, cleaning and repairing old batteries for reuse. More than 68 years later, East Penn operates the industry's most technologically advanced recycling facility where thousands of batteries are recycled

a day. This on-site smelter saves transportation costs of 100,000 tons of lead from off-site locations and allows tighter controls of lead quality. The facility has been selected as a model site by the U.S. EPA.

Its Lyon Station, Topton, and Kutztown facilities are certified to ISO14001 Environmental Management System standards. These standards are recognized worldwide and prove a company's compliance to a complete environmental management system, helping to protect the environment for future years to come.

East Penn's dedication to safe battery recycling means complete commitment to proper battery disposal. The customer will never have to worry about hefty fines, penalties, or paperwork burdens associated with hazardous waste disposal laws. East Penn's modern facilities and good stewardship makes it the most environmentally conscious and proactive battery manufacturer in the world. ■



Since 1946, East Penn has been producing high quality batteries and battery accessories for the automotive, commercial, marine, industrial, stationary, and specialty markets.

Facilities at its 520-acre single-site manufacturing complex in Lyon

Station, PA include four automotive battery plants, an industrial battery plant, a specialty battery plant, a state-of-the-art oxide facility, an innovative recycling infrastructure, and dozens of vertically integrated capabilities and other support facilities. An additional manufacturing facility in Corydon, IA helps accommodate widespread growth.

East Penn owns and operates a wire, cable, and battery accessory plant and a multiple facility distribution center just miles away from its Lyon Station complex.

New high-tech facilities and computer monitoring and control systems have made the company an industry leader in advanced battery manufacturing.

East Penn's quality manufacturing is recognized worldwide and has met the global requirements of ISO 9001 and ISO/TS 16949 certification standards. East Penn is also a leader in innovative recycling and has met global environmental requirements of ISO 14001 certification standards.

Staffed with a long-term management team, East Penn is an independent company committed to the future and dedicated to producing high-class products and service to assure complete satisfaction, above and beyond the industry standard, to its partners and customers worldwide. ■



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