Lithium Ferro Phosphate Batteries Ǿăɸ ±w[! . l·űűŜǊƛŜă

Abstract

The ongoing development and maturation of battery technology as applied in the renewable energy field continue to present new pathways to innovation. Recent advances in cell safety, refinements in energy density, and developments in intelligent on-board battery management systems are driving the growing interest in new technologies.

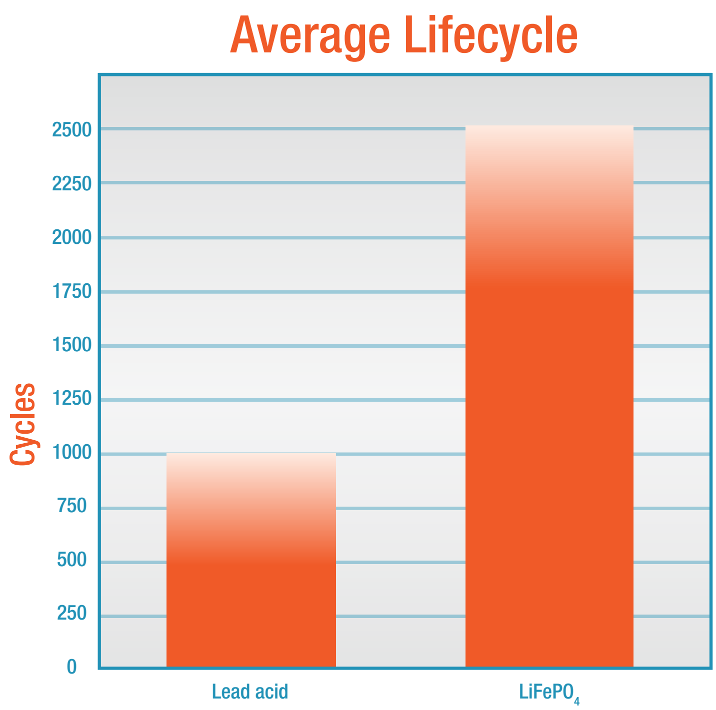
All portable power systems encounter similar challenges in four key areas: power generation, power management, power storage, and the loads placed on the system. In any given scenario, these variables must be considered and the most appropriate technologies employed. While there is a growing selection of equipment to choose from in power generation, the efficient management, storage, and distribution of this energy in a lightweight package remains a formidable challenge.

Utilizing a battery in any electrical circuit ensures operation at the highest level of efficiency. The battery is, quite simply, an electrical storage device that uses a chemical reaction to convert “electrical energy” into “potential chemical energy” and back again.

Introduction

In any highly competitive industry environment, constant innovation and development of new technology is a requisite. While traditional Lead Acid battery chemistries are both well-understood and well-received, there is undoubtedly a major shift underway in field requirements for portable energy. Baseline predictable performance and resistance to neglect and abuse became preferred characteristics of a battery since its inception. However, the evolving requirements in the 21st Century center on significantly reduced weight and a reduced footprint with more useable power. Lithium-Ion technology addresses these emerging requisites.

A correctly-sized VRLA battery bank subjected to moderate (50%) depth of discharge could be expected to last, on average, between 400 to 600 cycles. Taking the same VRLA bank and subjecting it to 80% or deeper discharging could shorten the life of the batteries to as little as 250 to 300 cycles (depending on the manufacturer, battery construction, etc.) possibly even less in extreme temperature environments. By contrast, extensive testing indicates a LiFePO4 battery bank can endure repeated discharges well beyond 50% and be expected to last 5000 or more cycles before it could be considered at the end of its useful life. This capability constitutes an order of magnitude increase in the intervals for scheduled replacement versus the lead acid equivalent.



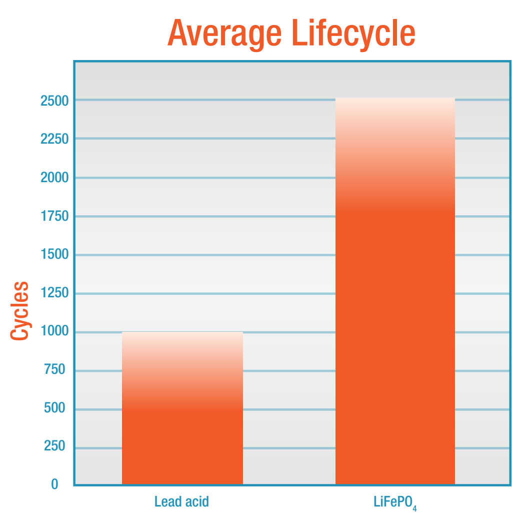
Battery C-Rate

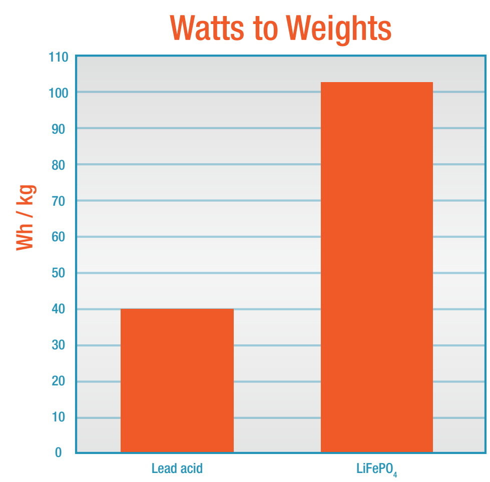
A charge or discharge current rate of a battery expressed in amps. It is numerically a fraction or a multiple of the rated capacity of the battery expressed in amp-hours.

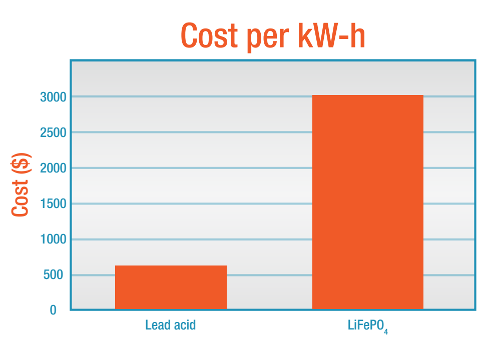
C-Rate	Rated Capacity	Formula	Amps	Discharge / Charge Time
10C	100 Ah	10 x 100A	1000A	6 minute
5C	100 Ah	5 x 100A	500A	12 minutes
3C	100 Ah	3 x 100A	300A	20 minutes
2C	100 Ah	2 x 100A	200A	30 minutes
1C	**100 Ah**	**1 x 100A**	**100A**	**1 hour**
C/2	100 Ah	100A / 2	50A	2 hours
C/3	100 Ah	100A / 3	30A	3 hours
C/5	100 Ah	100A / 5	20A	5 hours
C/10	100 Ah	100A / 10	10A	10 hours

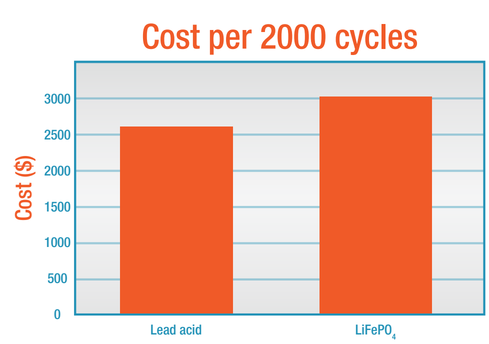
- Lithium Iron Phosphate ($LiFePO_4$) - when high energy density and light weight are desired. $LiFePO_4$ batteries are used for portable power tools, medical devices, and other mobile applications.

- Lead-Acid - most economical for larger power applications where weight is of little concern. Lead-acid is the preferred choice for hospital equipment, wheelchairs, emergency lighting and UPS systems. Lead acid is inexpensive and rugged. It serves a unique niche that would be hard to replace with other systems.









Lithium Iron Phosphate ($LiFePO_4$)

The $LiFePO_4$ battery is one of the most promising of the available Lithium-Ion chemistries for the diverse requirements of portable renewable energy systems. Even though the chemistry is relatively young compared to lead-acid, LiFePO4 cell banks have thus far shown impressive operational attributes that are often at minimum on par with the much more prevalent lead-acid technologies.

$LiFePO_4$ batteries are constructed in two formats “large” and “small”. The large-format cells are often used in “less-portable” power storage devices where the aggregate battery capacity exceeds 4 kW-h. Small format cells are used in “highly-portable” applications where the total capacity is less than 4 kW-h.

Energy Density, or the measure of “overall unit weight” to “useable energy provided”, is a primary factor under consideration for all portable systems. $LiFePO_4$ batteries have proven to be an excellent solution in regards to Watt-hours per Kg. Although other variations of Lithium-Ion battery chemistries can achieve higher energy densities than $LiFePO_4$, their particular operational characteristics are not necessarily consistent with modern portable energy systems.

$LiFePO_4$ Battery Advantages:

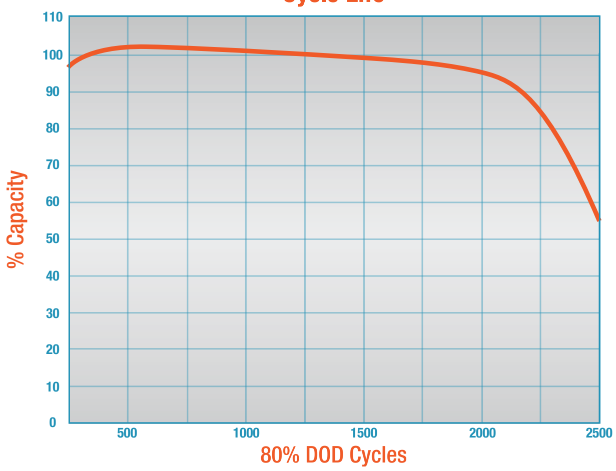
- Safety - $LiFePO_4$ batteries will not catch fire or explode during rapid charge/discharge; unlike other Li-ion technologies, $LiFePO_4$ batteries are virtually incombustible due to chemical stability of their Iron Phosphate cathode material.
- Physically light - good “weight-to-energy density” ratio – particularly well suited for mobile applications where light weight is important.
- Long cycle life - can be discharged and recharged many times with minimal performance degradation.
- The self-discharge is among the lowest of all rechargeable battery systems (<2% / month)
- Environmentally-friendly - contains no toxic heavy metals or caustic materials.
- Tolerant of exposure to high temperatures.

$LiFePO_4$ Limitations:

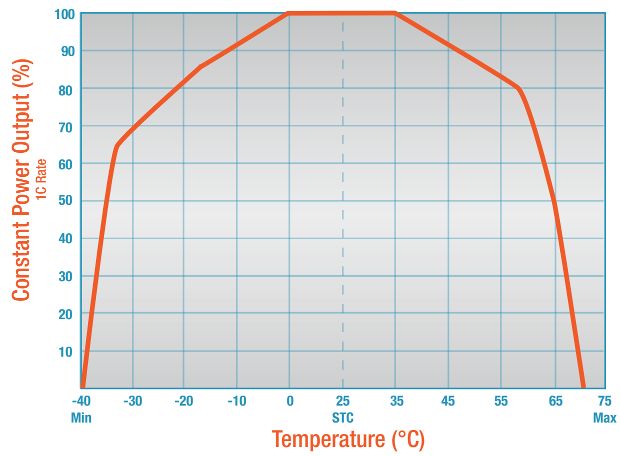
- Higher cost - return on investment is primarily based on long-term deployment.
- HAZ-MAT transport - can only be transported under restricted conditions (set by D.O.T.).
- Less resistant to shock and vibration.
- Requires additional power management devices for integration into traditional applications.
- Relatively young technology - will not operate at full potential using available COTS lead-acid chargers & power management appliances. Many associated charging/management technologies are more expensive, further driving up the cost to operate.

$LiFePO_4$ Performance Graphs (4 kW-h 24V Battery)

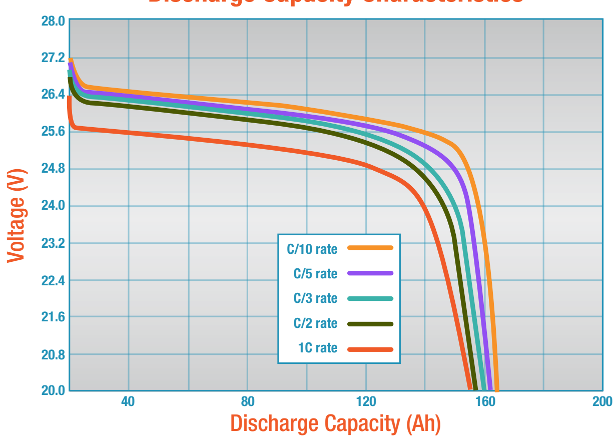
Cycle Life



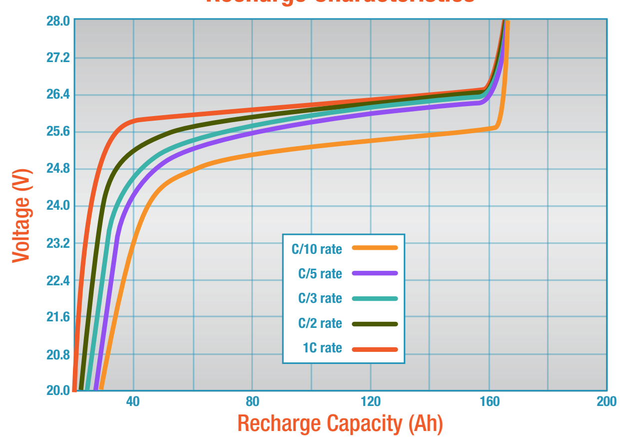
$LiFePO_4$ Temperature Performance



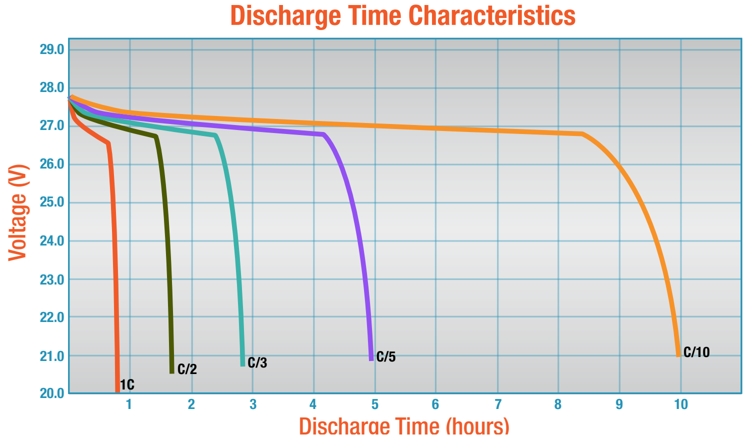
Discharge Capacity Characteristics



Recharge Characteristics



Discharge Time Characteristics



Lead Acid Batteries

There are many newer battery technologies available in the market-place, however, lead-acid technologies are the most-understood, and widely accepted as the “standard” by which all other batteries are measured. Newer battery technologies often have operational constraints like maximum & minimum operating temperatures and special charging requirements that make them less versatile and usable for the average consumer in everyday applications.

“Deep-cycle” Lead Acid Battery

Compared to other lead acid battery types, the deep-cycle battery is designed for maximum energy storage capacity and high cycle-count (long life).

Absorbed Glass Mat Batteries (AGM)

The AGM battery is a newer type sealed lead-acid that uses absorbed glass mats between the plates. It is sealed, maintenance-free, and the plates are rigidly mounted to withstand extensive shock and vibration. AGM batteries feature a thin fiberglass felt that holds the electrolyte in place like a sponge. The AGM battery is used in applications where high performance lead-acid is demanded.

AGM Lead-Acid Advantages:

- Low Cost - Inexpensive & simple to manufacture, provides good return on investment (ROI).
- Unrestricted Transport - D.O.T. approved for all land, sea, and air transport.
- Mature, reliable and well-understood technology - works well with many COTS devices (chargers & power management appliances).
- Durable and provides dependable service.
- The self-discharge is among the lowest of all rechargeable battery systems (~2% / month).
- Usually field-serviceable.

AGM Lead-Acid Limitations:

- Physically Heavy - poor “weight-to-energy density” ratio.
- Cannot be stored in a discharged condition
- Allows only a limited number of full discharge cycles - well suited for standby applications that require only occasional deep discharges.
- Hazardous Disposal – must be properly recycled or disposed of when life cycle is complete.

pbq®
professional battery quality

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AGM Lead-Acid Performance Graphs