
LITHIUM-ION BATTERIES FROM ENERGY ESSENTIALS DISTRIBUTED BY RAYMOND®

SELECTING THE RIGHT POWER FOR YOUR APPLICATION

RAYMOND

THE RAYMOND CORPORATION
GREENE, NEW YORK

WHY LITHIUM-ION POWER?

The advent of lithium-ion motive power batteries creates an opportunity for the materials handling industry, but it leaves customers with many questions. Why adopt lithium-ion technology? What can lithium-ion technology do for me and my operation? How do I know I am making the right choice? You are not alone in this quest to make gains in operational efficiencies through lithium-ion battery adoption, and the Raymond Energy Solutions team is here to help.

Let's walk through the journey together.

WHY ADOPT ENERGY ESSENTIALS DISTRIBUTED BY RAYMOND® (EEDR) LITHIUM-ION BATTERIES?

1. Limited maintenance: No watering or harmful emissions

- + With lithium batteries, utilize personnel for value added activities
- + Remove the battery changing area from your operation to regain floor space for product, improve SKU count and space allocation
- + Zero emission power source improves indoor air quality

2. Maximize your ability to opportunity charge and rapid charge

- + Lithium-ion batteries can be charged at higher rates than Flooded Lead Acid (FLA) and Thin Plate Pure Lead (TPPL) products
- + No cooling period or warm-up delay; no wasted charge time
- + Bring chargers where lift trucks are used

3. Maintains voltage and power delivery at low states of charge

- + Consistent performance throughout the discharge range
- + Productivity increase: Work at peak performance longer, move more product

4. Run a single battery, in many applications

- + Limited battery changes—eliminate non-value added work
- + Improved total cost of ownership (TCO) and operational efficiency

5. Active battery management and data liberation

- + “Smart” power source, battery data can be accessed via CANBus on truck
- + Battery management system (BMS) allows for communication between battery and truck
- + BMS regulates operating characteristics of battery in operation

6. Longer useful life

- + 5,000 cycle life, compared with up to 1500 cycles from lead-acid batteries (LAB)
- + Expected 7-year life, in high duty 2-shift application

KNOW BEFORE YOU GO — UNDERSTAND WHAT YOU ARE GETTING BEFORE YOU ADOPT

1. Are all lithium-ion batteries created equal? — NO
2. Are all chemistries the same? — NO
3. Are all batteries using the same lithium-ion chemistry the same? — NO
4. Do all lithium-ion batteries have similar cycle life, like Flooded Lead Acid (FLA)? — NO
5. Can I use any lithium-ion battery in my equipment? — NO
6. Are lithium-ion batteries the right choice for me? — MAYBE
7. Do all lithium-ion batteries carry UL listing? — NO
8. Do all lithium-ion batteries offer integral data liberation capability? — NO
9. How does Energy Essentials Distributed by Raymond work for me?

EXPLORING OFFERINGS AND PLANNING

Lithium-ion can provide increased performance, faster charging and limited maintenance. When selecting a lithium-ion battery, standards conformance, chemistry, chemical stability, cycle life, power density, combined with the specific application needs and constraints are important considerations to ensuring the optimum battery selection. With the right choice, the total cost of ownership will be reduced. Power study support is available through Raymond to record data and determine application needs.

An initial consideration is the UL® listing of the power source. This listing is needed to maintain the overall truck-level compliance. The Raymond Corporation has qualified to the applicable UL standards – UL2271 and UL2580. Additionally, UN transportation standards have been met to ensure compliance while transporting modules and the battery, allowing the transportation and use of the batteries to be in full compliance with local and national regulations.



Lithium-ion battery chemistry is also a primary consideration. For electric lift truck applications, lithium iron phosphate (LFP) and nickel manganese cobalt (NMC) are the most common offerings. The customers’ application and their needs will dictate which chemistry is better suited. NMC chemistry offers superior energy density and is utilized to support high-duty applications. High energy density allows for longer run times between charges and a smaller battery can be used, in some cases. LFP chemistry offers a lower price point, but it is less energy-dense than NMC products. When appropriate design procedures are followed for the LIB cell design and the battery management system (BMS) design, the overall

chemical stability of NMC and LFP are equivalent. Calculations and empirical data developed by the Energy Essentials' team have shown that the NMC chemistry is superior to LFP to ensure proper operation supporting high-cycle, demanding applications.

To deliver the maximum potential benefit, Raymond has pursued a high-density, high-stability, long-life power source. The EEDR NMC offering uses a proprietary cell construction and manufacturing process to provide best-in-class cycle life. NMC chemistry permits higher cell voltage and energy density at the module and final battery assembly level. Using a special ceramic separator, NMP-free electrode and advanced BMS, we provide a very stable, longer-life power source than LFP and other similar chemistries. The use of higher temperature production methods, allowed by the separator, permits for

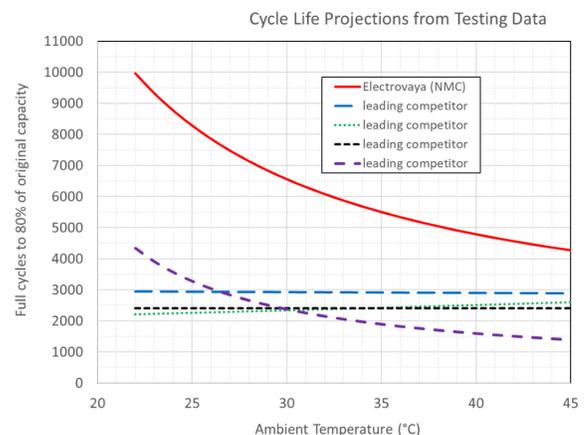
more residual water dissipation from the cell. This translates directly into increased cycle life. Additionally, electrolyte additives help to address higher temperature utilization and allow continued stable, strong performance. These patented innovations, and a proprietary BMS, are optimized to create a battery that excels in high-throughput, multishift applications. The below images demonstrate thermal stability between ceramic separators and other separators for NMC batteries. This prevents thermal runaway.

MATERIALS INNOVATION



	ONE CHARGE & GREEN CUBES PRODUCTS	EAST PENN NAVITAS SYSTEMS & FLUX POWER PRODUCTS	TRIATHLON (Crown, Jungheinrich, Linde, private label products)	RAYMOND ENERGY ESSENTIALS PRODUCTS
CYCLE LIFE	3,000	3,000	3,200	5,000
STANDARDS COMPLIANCE	First generation separator – No UL	Second generation separator – UL 2580 Listed	Second generation separator – UL 2580 Listed	Third generation fully ceramic separator SEPARION® UL 2580 Listed
CHEMISTRY	LFP	LFP	NCA, NMC, LFP	NMC

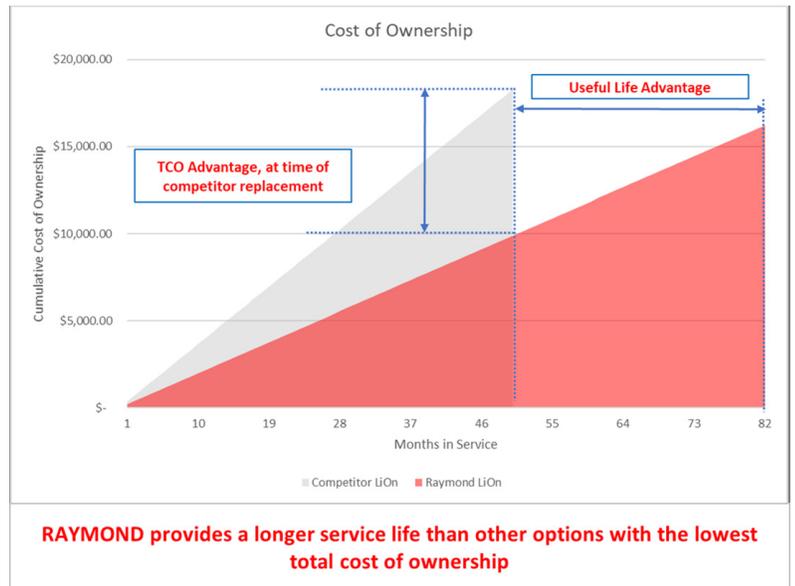
Application duty cycles drive different requirements by facility. To ensure the best possible match, the Raymond Energy Solutions team designed the battery architecture to support two-shift high-duty applications. This allows the battery to support the toughest use cases while maintaining reserve power and flexibility for other applications. The battery can support full 1C charging to allow for rapid refill of battery capacity, providing the means for maximum vehicle utilization via opportunity charging during short breaks and rapid charging during longer lunch breaks. The total cost of ownership (TCO) is minimized via the tailoring of the battery size and the charging strategy for the specific application need. As shown in the graph at right, both cell supplier and third-party testing illustrate that a carefully selected battery will consistently outlast and outperform lower-cost, lower-density offerings, designed only to compete on initial price instead of total cost of ownership. The EEDR battery demonstrates superior cycle life across the operating temperature spectrum.



* NY Best Test and Commercialization Center.

Projections shown above are calculated using degradation rates from cell cycle physical testing under controlled conditions. Actual battery life will vary based on application and duty cycle. Please consult your local Solutions and Support Center for assistance in selecting the best power solution for your operation or assessing potential battery life.

Industry leading cycle life ensures your battery is always ready to perform, whether it is today or years from now. Third party verified, battery cell Accelerates Life Testing (ALT) suggests that Energy Essentials distributed by Raymond outlasts competitors, even in the most demanding applications. Raymond's lithium-ion battery testing was run to simulate high cycle applications. This shows the battery's integrity in the most demanding use cases. This testing was completed at 100% rated charge and discharge rates, evaluating performance under maximum allowed conditions. Users not utilizing these peak rates can expect even longer useful life from the battery. Further illustrating the performance, field data from Tier 1 customers show that the battery capacity only minimally degrades, even after years of use, surpassing expectations in application use. Raymond's unique design and test approach ensures the battery and its technology has been optimized to lift truck applications and their high draw demands. Our commitment to the industry and best-in-class product ensures availability and operational efficiency for years to come. Next-generation enhancements are already under way to bring even more value.



****ASSUMES 2 SHIFT HIGH USE APPLICATION WITH OPPORTUNITY OR RAPID CHARGING**

Power Type	Days/Year Usage	Design cycle life	Useful life Yrs	Useful Life Mo	Initial Acquisition \$	\$/Mo Operation
LiOn Competitor	245	3000	6.15	73.8	\$ 18,205	\$ 246.68
	300	3000	5	60	\$ 18,205	\$ 303.42
	365	3000	4.15	49.8	\$ 18,205	\$ 365.56
Raymond LiOn	245	5000*	10.25	123	\$ 16,258	\$ 132.18
	300	5000*	8.35	100.2	\$ 16,258	\$ 162.26
	365	5000*	6.85	82.2	\$ 16,258	\$ 197.79

*highlighted data used to generate comparison graph

Being the market leader in total cost of ownership and application support allows us to be confident we can support your application. Industry-leading cycle life and high-energy density will keep your equipment's power covered and your application running with minimal downtime. Integration between the Raymond® family of trucks and Raymond's battery allows seamless use of the two assets together. BMS and truck master controller integrations ensure future ability to expand and support future customer needs. Through the use of our PSI interface and iWAREHOUSE® telematics solution, customers have easy access to key operating metrics and reports for their review all in one place. Using data from both the truck and battery allows for more informed decisions, fleet optimization and continuous improvement in operational efficiency. The integration and coordination of truck and battery technologies allows your local Raymond Solutions and Support Center to be a one-stop shop for your material handling needs.

Have questions? The Raymond Energy Solutions business team or your local Solutions and Support Center can assist in the energy selection process. We routinely conduct power studies and application reviews to aid customer equipment and power selections. We can match the truck, battery, charger and supporting technology options to provide you with the best, most efficient experience in your operations. Training and support services are ready to assist your personnel after the new equipment is commissioned. Why choose one benefit when you can have them all? One contact, one satisfied customer.

IF YOU'RE LOOKING FOR A PARTNER WITH THE TOOLS AND EXPERIENCE TO HELP YOU RUN BETTER AND MANAGE SMARTER, LET'S TALK.



RUN BETTER. MANAGE SMARTER.®

At Raymond, our aim is to deliver the utmost quality and to work for continuous improvement every day, in every aspect of our business. We are proud of what we build. We are proud of the level of service we provide to keep our customers' business up and running. We take pride in our commitment to our customers through our end-to-end approach in helping them find smarter, more efficient and more effective solutions.

We value the trust that Raymond has earned through decades of proven performance and hands-on innovation. Since the patenting of the first hand-pallet truck to the invention of the reach truck to our pioneering work in narrow aisle operations and beyond, Raymond has led the way in providing customers with the tools and expertise to improve their business.

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