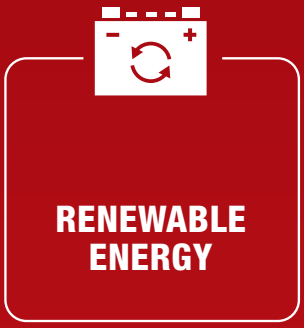
R-SERIES 12V & 24V LFP BATTERY OPERATING MANUAL

Rolls

BATTERY ENGINEERING

Recommended safety, installation, operation & troubleshooting procedures for Rolls R-Series 12V & 24V LFP (Lithium Iron Phosphate) batteries.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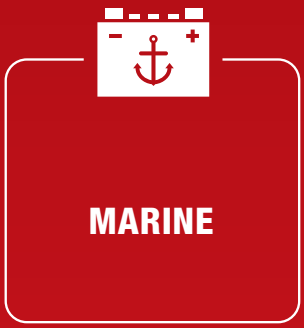
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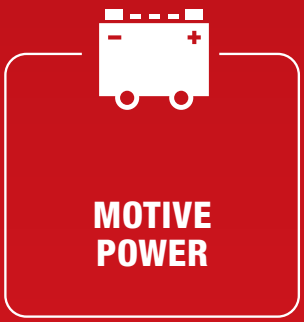
MOTIVE
POWER

TABLE OF CONTENTS

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ROLLS R-SERIES 12V & 24V LITHIUM IRON PHOSPHATE (LFP) BATTERIES

Rolls R-Series 12V & 24V Lithium Iron Phosphate (LFP/LiFePO4) batteries are an ideal replacement for traditional lead-acid batteries of equivalent size & capacity and offer the same quality, reliability & performance found in other Rolls Battery products.

This manual provides detailed instructions for safe and proper installation, operation, and care of Rolls R-Series 12V & 24V R-Series battery models. Please read carefully to clearly understand the operating instructions and any potential safety risks prior to installation.

Failure to install or use this battery as instructed may result in damage to the product that may not be covered under the manufacturer warranty. See warranty terms & conditions for full details.

NOTE: This manual offers installation, charging and troubleshooting guidance for Rolls R-Series 12V & 24V R-Series lithium batteries R12-___LFP & R24-___LFP.

See **Rolls S24-2800LFP & S48-6650LFP ESS Battery Operating Manual** for usage instructions specific to Rolls S24-2800LFP ESS and S48-6650LFP ESS (Energy Storage System) models.

See **Rolls S-Series 12V & 24V LFP Lithium-Ion Battery Operating Manual** (packaged in solid red cases) manual for usage instructions specific to Rolls S-Series models.

This document is NOT APPLICABLE to the following models	
S-Series 12V & 24V LFP (S12-___LFP & S24-___LFP)	**24V & 48V ESS LFP Models** (S48-6650LFP ESS & S24-2800LFP ESS)
	

NOTE: Rolls R-Series Batteries are equipped with a Bluetooth module to enable technical support activities and collect data, upon request, in the unlikely event of an issue in the field. This module is not currently able to provide user-access to battery status or parameters. Any attempt to modify or tamper with the battery via the Bluetooth module will void the manufacturer warranty.

Nominal voltage of an LFP battery differs from equivalent lead-acid batteries.

LFP Battery	Lead-Acid Battery
Cell Voltage = 3.2V	Cell Voltage = 2.0V
Battery Nominal Voltage 12.8V (4 cells)	Battery Nominal Voltage 12.0V (6 cells)

WARNING: Explosion, Electrocution, Or Fire Hazard

- A battery can present a risk of electric shock, burns from high short circuit current, fire, or explosion.
- Ensure cables are properly sized for the system current and cable runs are as short as possible, reducing line inductance and voltage spikes, which can damage the BMS.
- Ensure adequate airflow around batteries and that they are clear of debris.
- Never smoke or allow a spark or flame near the batteries.
- Always use insulated tools.
- Avoid dropping tools onto batteries or other exposed electrical parts.
- Cold temperatures can be especially damaging to batteries after even a single low temperature event.
  - Never charge an R-Series LFP battery below 0°C (32°F).
  - Never discharge an R-Series LFP battery below -20°C (-4°F).
- Never charge a battery with a deformed or bulging case.
- Do not expose a Rolls R-Series battery to heat more than 60°C (140°F) during operation, and do not store for extended periods of time above 45°C (113°F). Do not incinerate or expose to open flames.
- If a battery must be decommissioned/removed, always remove the grounded terminal from the battery first. Make sure all devices are disconnected.
- When installing, leave adequate clearance between batteries.
- When replacing batteries, use the same make, model & quantity of batteries.
- Do not mix old and new batteries.
- Avoid any fall or collision during the installation process.
- Do not dismantle or remove the battery components.
- Battery maintenance should be carried out by qualified personnel.

STORAGE

Rolls 12V & 24V R-Series batteries should be stored in an environment with temperatures between -5°C (23°F) and +45°C (113°F).

If seasonally stored in a space which will fall below -5°C (23°F), it is recommended to **discharge** the battery to between 60-80%, **disconnect** the battery from any external system and store the battery above -5°C (23°F).

Rolls R-Series LFP batteries do self-discharge and should be charged once per year, at minimum when stored for extended periods. For temperatures above 40°C (104°F) the battery should be charged every 3 months. Do not store Rolls 12V & 24V R-Series LFP batteries at temperatures above 45°C (113°F).

INSTALLATION

Rolls 12V & 24V R-Series batteries may be installed in any orientation as required by the application. Rolls R-Series models must be installed in an indoor space and out of direct sunlight.

All installations should consider the ambient temperature. If installed in a region with freezing temperatures or extreme heat, special care should be given. **Rolls R-Series batteries cannot be charged below 0°C (32°F), nor discharged below -20°C (-4°F)** and doing so will severely degrade the internal cells. Similarly, operation above 55°C (131°F) will negatively impact longevity, performance, and safety.

CABLE CONNECTIONS

All cable connections should be adequately sized, insulated and free of damage. The cable connectors should be clean and properly mated with the battery terminals to ensure a snug connection. Terminal connections should be torqued to the recommended specification below. Although Rolls R-Series batteries do not require maintenance, routine inspection of cabling and terminal connections is recommended.

Amperage	25	30	40	55	75	95	130	150	170	195	260
Wire Gage	14	12	10	8	6	4	2	1	1/0	2/0	4/0

NOTE: Undersized cables may lead to cable and/or battery damage, charging issues, terminal heating, or fire.

TERMINAL TORQUE

Terminal connections must be properly torqued. 12V and 24V Rolls R-Series batteries using M8 fasteners should be torqued to **10-12Nm**.

DO NOT OVERTORQUE: In the event of a damaged terminal, do not attempt to repair the terminal, do not use the battery if the recommended torque cannot be met.

BATTERY MANAGEMENT SYSTEM (BMS) PROTECTION SUMMARY

Rolls R-Series batteries include a built-in battery management system (BMS) which offers protection in conditions where the battery voltage, current or operating/cell temperature may be unsafe or damaging. The switch architecture of the BMS allows charge and discharge to be stopped independently. Under these undesirable operating conditions, the internal BMS will interrupt the current into or out of the battery, or disconnect it fully, as required.

BATTERY LIMIT	PROTECTION	RESET METHOD	COMMENTS
Cell/Pack Overvoltage	Charge Interruption	Automatic reset after time delay or discharge	If occurring more than 3 times in 2 minutes, discharge is required
Cell/Pack Undervoltage	Discharge Interruption	Automatic reset after time delay or charge	If occurring more than 3 times in 2 minutes, charge is required
Extended Pack Undervoltage (Stored While Empty)	Battery Cannot be Recovered	Always charge R-Series Batteries within 72 hours of full discharge	–
Pack Overcurrent or Short Circuit	Charge and Discharge Interruption	Automatically reset after time delay	If occurring more than 3 times in 2 minutes, charge is required
High temperature at BMS or Cell*	Charge and Discharge Interruption	Automatically reset after cooling	BMS will display alarm when approaching disconnect
Low temperature at BMS or Cell*	Charge Interruption	Automatically reset after warming	BMS will display alarm when approaching disconnect
Extreme low temperature at BMS or Cell	Charge and Discharge Interruption	Automatically reset after warming	BMS will display alarm when approaching disconnect

*Temperatures outside of the ideal operating range require a reduction in charge/discharge current for optimal battery life.

The BMS also has cell-balancing functionality to balance each internal cell to the same state of charge, enabling the full pack capacity. However, this is not sufficient to balance severely imbalanced cells with a substantial SOC difference, see below.

CONNECTIONS

R-SERIES MODEL	MAX UNITS SERIES CONNECTION	MAX UNITS PARALLEL CONNECTION
12 VOLT LFP	4 (48V System)	4
24 VOLT LFP	2 (48V System)	4

CONNECTING IN SERIES

Rolls 12V and 24V LFP batteries can be combined in series strings (maximum four (4) 12V batteries and two (2) 24V for 48-volts) to achieve higher operating voltages by connecting the positive terminal of one battery to the negative terminal of the next battery.

EXAMPLE SERIES CONFIGURATIONS

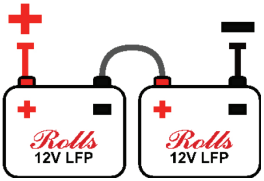
12V batteries in series - Two (2)	2 x 12.8V = 25.6V	For **24V** Applications
24V battery in series - One (1)	1 x 25.6V = 25.6V	

12V batteries in series - Three (3)	3 x 12.8V = 38.4V	For **36V** Applications
24V battery in series [can't be used]	_	

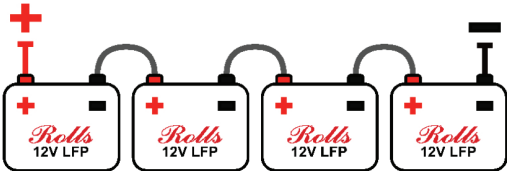
12V batteries in series - Four (4)	4 x 12.8V = 51.2V	For **48V** Applications
24V batteries in series - Two (2)	2 x 25.6V = 51.2V	

NOTE: Do not connect batteries in strings above 48V nominal as this will exceed the voltage limit of the BMS.

Example 24V Configuration: connecting two (2) 12V R-Series batteries in series



Example 48V Configuration: connecting four (4) 12V R-Series batteries in series



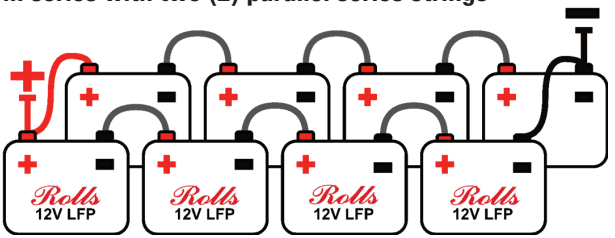
CONNECTING IN PARALLEL

You may combine Rolls 12V R-Series batteries together in up to four (4) parallel strings to increase battery bank capacity.

Refer to the example below showing eight (8) 12V R-Series batteries connected in a 48V configuration; four (4) connected in series and two (2) parallel strings (4S2P). Up to four (4) 48V parallel strings of 12V or 24V R-Series models may be connected. Parallel string configurations greater than 48V in series, four in parallel (4S4P or 2S4P) are not supported at this time.

NOTE: with updated rolls R-Series batteries, the recommended current limit increases proportional to the number of parallel strings.

48V Configuration: Connecting Eight (8) x 12V R-Series batteries
Four (4) in series with two (2) parallel series strings



NOTE: Strings are independent. External connections should be staggered, i.e., the positive lead is connected to string one, whereas the negative lead is connected to string two.

NOTE: Keep cabling the same resistance (gauge and length) between batteries and strings to ensure proper current sharing. Attempt to minimize length to reduce the magnitude of inductive voltage spikes at the battery.

CAUTION

- Failure to follow the following safety instructions may result in personal injury or damage to the equipment.
- R-Series batteries should be fully charged in parallel before connecting for series cycling, see below.
- Do not connect more than four (4) strings of batteries in parallel.

BATTERY VOLTAGE - CONNECTING IN SERIES/ PARALLEL

For initial balancing prior to connecting batteries in series, each battery should be connected in parallel (above the maximum of four (4) batteries in parallel, but **not** for regular cycling) and fully charged (or charged individually) using a 2-stage CC/ CV charger at a reduced CV voltage corresponding to the low end of the acceptable charge range (see below), leaving the battery at the absorption/CV voltage for at least 24 hours.

SYSTEM VOLTAGE	12V NOMINAL	24V NOMINAL	48V NOMINAL
RECOMMENDED INITIAL BALANCING VOLTAGE	14.0V	**Balance initially at 12V NOMINAL**	

If you are unable to charge the batteries individually, the voltage of each battery should be within 30mV (0.03V) before putting them in service. This will minimize the severity of a charge imbalance between batteries which results in reduced pack capacity. LFP batteries, even those with similar open circuit voltages may be at drastically different SOC, due to the flat relationship between open circuit voltage and SOC for LFP cells.

Although the BMS provides over-voltage protection to each cell, developing a charge imbalance between batteries is still possible. Rolls recommends disconnecting and fully charging each battery individually once per year, at minimum. If the batteries are cycled frequently at high charge/discharge currents this may be done more often.

BATTERY CHARGING

Although a lithium-specific charger is recommended, Rolls 12V R-Series models are compatible with most common lead-acid battery chargers for nominal voltage of the pack. The recommended and maximum continuous charge currents are specified on the product label.

Rolls R-Series batteries may cycle or be stored in a partial state-of-charge (PSOC). Rolls R-Series batteries should be cycled from 0% depth of discharge (DoD) or 100% state of charge (SOC), to 80% DOD or 20% SOC for optimal cycle life. To prevent over-discharge, the BMS will disconnect the battery when the low voltage cut-off is reached, protecting the battery from overdischarge.

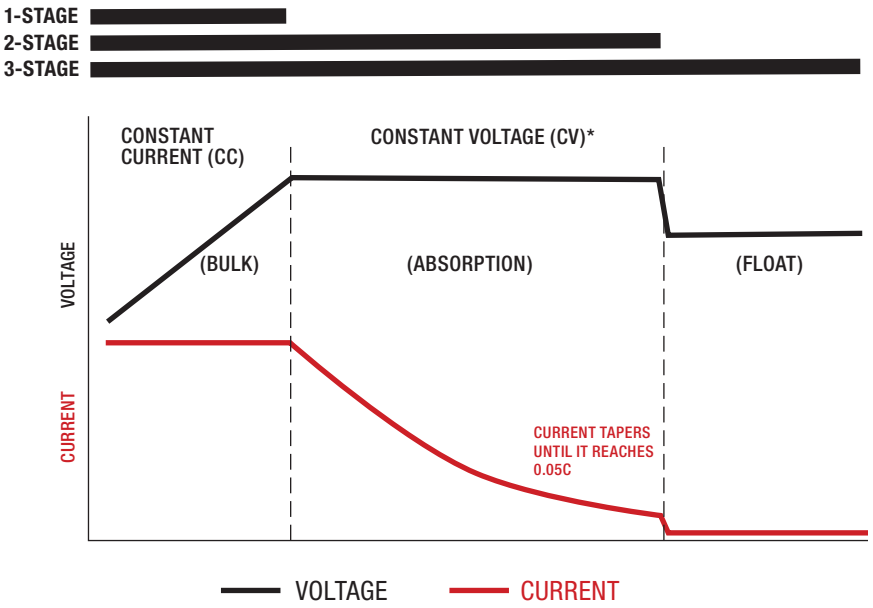
NOTE: Chargers that require the detection of voltage at the battery terminals to charge may fail to wake the R-Series battery from a state of under-voltage protection.

NOTE: LFP cells do not need maintenance charges like equalisation, pulse charge, overcharge, or any others typically recommended or required for lead acid batteries.

NOTE: The recommended and maximum continuous charge & discharge rates are specific to each R-Series model by cell and BMS technology. This is provided on the product label.

CHARGING GUIDELINES

Rolls R-Series Batteries can be charged in a 1, 2, or 3-Stage charge profile, shown below. The specifics and recommended setpoints for these charge regimes are explained in this section, with the recommended charge profile being a 2-Stage charge.



Representation of recommended 2-Stage Constant Current/Constant Voltage (CC/CV) charging. The dotted line represents the transition from CC to CV when the voltage limit is reached. Once the battery reaches the constant voltage limit, the battery is held by the charger at this voltage until the current decreases to 0.05C. At this point the battery is at 100% state-of-charge (SOC). Any current continuing to flow in the float stage is attributable to balancing activity of the BMS.

1-STAGE CHARGING – CC (CONSTANT CURRENT)

When charging with a single-stage constant current charger, charge at the recommended charge current, by operating temperature, until the battery reaches its termination voltage.

1-STAGE CHARGE PROFILE		CHARGE CURRENT & PARAMETERS	
RECOMMENDED CHARGE CURRENT *Do not exceed maximum continuous charge current		≤ 0.2C at 0-10°C (32-50°F) ≤ 0.5C at 10-35°C (50-95°F) ≤ 0.2C at 35-55°C (95-131°F)	
SYSTEM VOLTAGE	**12V NOMINAL**	**24V NOMINAL**	**48V NOMINAL**
TERMINATION VOLTAGE	14.4V	28.8V	57.6V

NOTE: 1-Stage CC Charging may be required if charging from a source which is not efficient to run at lower power. However, it may only charge the battery to 90-95% SOC. 1-Stage charging also offers very little time to balance cells. For these reasons, 2-Stage CC/CV charging is recommended to ensure the battery reaches full SOC.

2-STAGE CHARGING – CC/CV (CONSTANT CURRENT/CONSTANT VOLTAGE)

When charging with a two-stage constant current/constant voltage (CC/CV) charger, charge at the recommended charge current, by operating temperature, until the battery reaches the “absorption” voltage or constant voltage (CV) limit. The charger then holds the battery at CV until the charge current decreases to ≤0.05C (termination current).

The recommended absorption (constant voltage) voltage is shown below. If the charger has a pre-set voltage setting or cannot be programmed, an absorption voltage in the range below is also acceptable. Note: lower voltage will lead to longer charge times.

2-STAGE CHARGE PROFILE		CHARGE CURRENT & PARAMETERS	
RECOMMENDED CHARGE CURRENT *Do not exceed maximum continuous charge current		≤ 0.2C at 0-10°C (32-50°F) ≤ 0.5C at 10-35°C (50-95°F) ≤ 0.2C at 35-55°C (95-131°F)	
SYSTEM VOLTAGE	**12V NOMINAL**	**24V NOMINAL**	**48V NOMINAL**
TERMINATION VOLTAGE	14.4V	28.8V	57.6V
ABSORPTION VOLTAGE RANGE (ACCEPTABLE)	14.0V – 14.6V	28.0V - 29.2V	56.0V - 58.4V
TERMINATION CURRENT	≤0.05C		

NOTE: If charge time is not a concern within your system architecture, reducing the absorption voltage will increase charge time, but allows the BMS more time to ensure all cells remain balanced. As batteries age, small changes in manufacturing or due to uneven wear may present themselves, requiring more time to maintain balance.

3-STAGE CHARGING - LEGACY LEAD-ACID SYSTEMS, INVERTER/CHARGER HARDWARE

When programming an inverter/charger or charge controller equipment using a 3-stage charge sequence (2-stage with an additional "float voltage" after the charge is terminated), the following charging parameters should be programmed to properly charge Rolls 12V & 24V R-Series batteries:

3-STAGE CHARGE PROFILE		CHARGE CURRENT & PARAMETERS	
RECOMMENDED CHARGE CURRENT *Do not exceed maximum continuous charge current		≤ 0.2C at 0-10°C (32-50°F) ≤ 0.5C at 10-35°C (50-95°F) ≤ 0.2C at 35-55°C (95-131°F)	
SYSTEM VOLTAGE	**12V SYSTEM**	**24V SYSTEM**	**48V SYSTEM**
BULK to ABS VOLTAGE	14.4V	28.8V	57.6V
ABSORPTION VOLTAGE	14.4V	28.8V	57.6V
ABS to FLOAT	≤0.05C	≤0.05C	≤0.05C
FLOAT VOLTAGE	13.6V	27.2V	54.4V

Temperature Compensation: If the inverter/charger or charge controller uses temperature compensation this should be turned off when charging Rolls R-Series models. Turn off the temperature compensation settings and disconnect the sensor to ensure the correct voltage regulation from the charging device.

Equalization: Equalization should never be used; elevated charge voltages are unacceptable for LFP batteries and will simply lead to the BMS disconnecting the charging path. It should be turned off, or the equalization voltage setpoint should be reduced to the appropriate system float voltage, above.

Some charger models may require additional firmware, programming, or parameters. Please contact your inverter/charger or charge controller manufacturer for assistance with these settings, if required.

CHARGING SOURCE: LEAD-ACID BATTERY CHARGER

Customers may choose to replace lead-acid batteries with lithium models. Most lead-acid battery chargers may be used to charge Rolls R-Series models if the charger is properly configured to operate within recommended charge current and voltage limits.

The pre-programmed voltage settings for AGM or OPzV GEL models may be in line with LFP charge voltage settings and can sometimes be used if direct voltage control is not possible for your charger. However, flooded batteries often require higher charge voltage settings. If left configured for charging flooded batteries, the higher charge voltage can trigger the BMS to restrict charging to protect the battery, effectively resulting in a 1-stage charge. If this occurs repeatedly, or the charger cannot be configured at a lower charge voltage, it may be necessary to replace the charger.

CHARGING TEMPERATURE

Due to the chemistry of Lithium-ion cells, these batteries cannot accept high charge current at lower operating temperatures without risking cell damage and permanent loss of capacity.

Rolls R-Series batteries may be safely charged between 0°C to 55°C (32°F to 131°F). However, because cycle wear is accelerated below 10°C (50 °F) the charge should be limited to 0.2C (20% of battery capacity) for optimal longevity. Similarly, at high temperatures, charge current should be limited to ≤0.2C when operating at temperatures from 35°C to 55°C (95°F to 131°F) as noted below.

To maintain optimum performance and durability of Rolls R-Series batteries, the following charge current limits should be followed:

TEMPERATURE	RECOMMENDED CHARGE CURRENT
< 0°C (< 32°F)	DO NOT CHARGE
0-10°C (32-50°F)	≤ 0.2C
10~35°C (50-95°F)	≤ 0.5C
35~55°C (95-122°F)	≤ 0.2C
> 55°C (> 122°F)	DO NOT CHARGE

NOTE: Due to the internal chemistry, batteries can be discharged at lower temperatures than they can be charged at. So, at low temperatures between -20°C and 0°C, batteries can still be effective energy storage, if no energy is put into the batteries.

The recommended and maximum continuous charge current is specified for each Rolls R-Series model as a function of capacity. This information is noted in the model specifications and on the battery label.

RECYCLING

Rolls R-Series batteries should be properly disposed of at an authorized lithium recycling facility. Do not remove product labels and/or recycling information from the battery case. The battery should be fully discharged before disposal. To prevent a possible short circuit or explosion, the terminals should be covered with a protective cap or non-conductive tape before disposal.

LFP GLOSSARY

AMP, AMPERE
Unit of electrical current. Abbreviated “A”.

AMP-HOUR
Unit of electrical energy, one amp of current flowing for one hour. Abbreviated “Ah”.

BMS (BATTERY MANAGEMENT SYSTEM)
The BMS, or Battery Management System, is an electronic device which protects the cells inside a battery. The BMS used in Rolls R-Series batteries protects them from unsafe voltage, current, and temperature conditions, and balances cells for optimal pack performance. A BMS is required for any lithium-ion battery system with series-connected cells due to the safety requirements and performance characteristics of the cells.

C-RATE
Battery charge and discharge rates are often described as a “C-Rate”, defined as:

$$C\text{-}Rate = \frac{(Rated\ Capacity)}{(Charge/Discharge\ Current)}$$

For example, if a 100Ah battery was charged at 50A, but discharged at 100A, it would be charged at a rate of C/2 and discharged at a rate of C. This rate is independent of system voltage.

CELL
A single battery, independent of chemistry. Each cell is at the base voltage for the given chemistry; 2.0V for flooded lead acid, 3.2V for lithium iron phosphate. Many cell form factors exist, resulting in different capacities and performance characteristics. These may be combined in series to form a battery of higher voltage.

CC/CV (CONSTANT CURRENT / CONSTANT VOLTAGE)
The typical charge profile of a LFP battery. CC/CV or Constant Current/Constant Voltage charging is a 2-stage charge, first at constant current until the battery voltage reaches a given limit, and then at constant voltage as the current accepted by the battery naturally reduces until the battery is full.

CYCLE
A “cycle” is a somewhat arbitrary term used to describe the process of discharging a fully charged battery down to a particular state of discharge. For Rolls R-Series Batteries, a cycle is defined as 90% depth of discharge, or going from full charge down to 10% state-of-charge.

CYCLE LIFE
The total energy throughput of a battery, defined in terms of the amount of equivalent charge/discharge cycles it can withstand before its effective capacity is reduced to a certain amount, usually 80% of original/rated capacity.

LFP (LITHIUM IRON PHOSPHATE)
LFP, or Lithium Iron Phosphate is a specific type of Lithium-ion battery chemistry. Referring to the cathode material of the battery, this chemistry is characterized by its long cycle life, long calendar life and safety, in overcharge conditions, compared to other battery chemistries.

SOC (STATE OF CHARGE)
State of Charge (SOC) represents the fullness of the battery from 0%-100%.

VOLT
The unit of electrical potential or “pressure”. For the LFP cell chemistry, these are multiples of 3.2V, sometimes simplified to 12V, 24V and 48V to match with compatible lead-acid syste

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