Discover®
Innovative Battery Solutions

TECHNICAL BRIEF

LEAD-ACID VS. LITHIUM BATTERY CAPACITY

DOCUMENT NUMBER
885-0003

DOCUMENT REVISION
REV B

Revision Date	Revision
05/12/2017	A
05/26/2020	B

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Overview

This Technical Brief provides information and analysis of lead-acid battery capacity when compared to Discover Advanced Energy Systems in similar applications.

This discussion provides guidelines to compare battery capacity but makes no guarantee to the details of particular battery brands, battery models or specific applications. Individual battery specifications should be consulted in conjunction with the manufacturer for this information.

Notable exclusions from this brief are temperature effects on the capacity and performance of batteries.

Conventions Used

▲TAKE NOTE
TAKE NOTE Indicates common mistakes made when interpreting battery performance and characteristics.

Abbreviations, Acronyms, and Symbols

A	Amps
Ah	Amp Hour
DOD	Depth of Discharge
HR	Hours
SOC	State of Charge
V	Volts

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1. Lead-Acid Battery Capacity

Battery capacities can be published in a number of ways. The most common method shows the time taken to discharge a battery (HR) vs. the delivered capacity (Ah). Lead-acid batteries have their capacities published with a wide range of discharge times due to the fact that the *CAPACITY* of the battery at different discharge rates will vary significantly.

The following table denotes the capacity of an EV31A-A lead-acid-battery:

Table 1. *Battery Capacity*

Amp Hour					
100 HR	20 HR	10 HR	5 HR	3 HR	1 HR
132 Ah	115Ah	110Ah	96Ah	88 Ah	72Ah

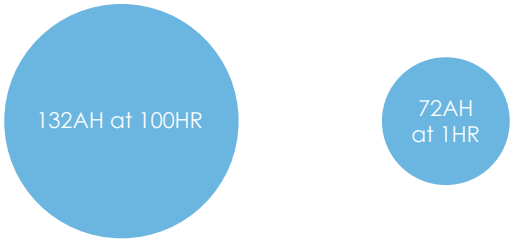
HR = Hours

Ah = Amp hours

**EV31A-A Spec Sheet (May 2020)*

If the discharge period is 100 HR, the battery is capable of delivering 132 Ah. Conversely if the discharge period is 1 HR, the battery is only capable of delivering 72 Ah.

Using bubbles to represent the capacity of a battery, let the size of the bubble equal the battery capacity.



It is now easy to visualize that the same battery will deliver significantly different capacities at different current discharges.

Figure 1. *Bubble Representation of Capacity*

▲TAKE NOTE

A common error among battery users is to evaluate their batteries at the wrong discharge rate. If the application discharges the battery in 5 hours, the 100 HR rate should not be used to characterize the battery. Some battery manufacturers publish material that misleads the user by not specifying the discharge rate the capacity is quoted at. Always verify the discharge rate.

2. Rethinking the Capacity Discussion

The published capacity from ***Table 1*** can be used to determine other important performance guidelines in order to select the right battery. Determining what performance variable to use can be difficult and requires further calculation.

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*Visualizing the values from **Table 1**.*

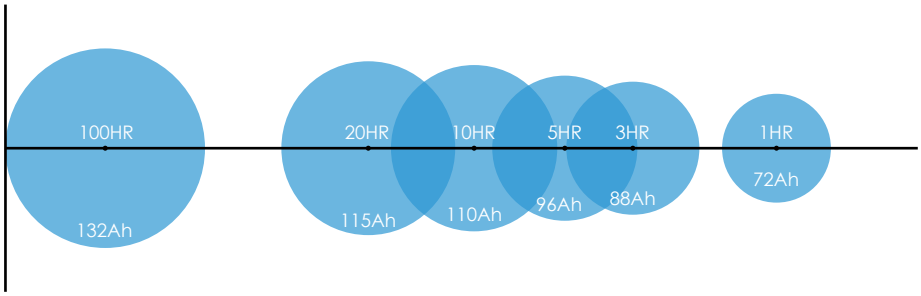

***Figure 2.** Lead-Acid Capacity at Published Rates*

To identify the discharge rate, the most important variable is the continuous current draw of the machine.

In order to convert battery capacity given in ***Table 2*** from Hours of Discharge (HR) to estimated Current (A) draws, the following formula should be applied:

Capacity (Ah) ÷ Hour Rate (HR) = Current (A) *(1)*

***Table 2.** Capacity Conversion from HR to A*

Rate	Capacity	Calculation				Current	Description
1 HR	72 Ah	72 Ah	÷	1 HR	= 72 A	72A	If your load draws 72A the battery will last for 1 hour and deliver 72 Ah
3 HR	88 Ah	88 Ah	÷	3 HR	= 29 A	29A	If your load draws 29A the battery will last for 3 hours and deliver 88 Ah
5 HR	96 Ah	96 Ah	÷	5 HR	= 19 A	19A	If your load draws 19A the battery will last for 5 hours and deliver 96 Ah
10 HR	110 Ah	110 Ah	÷	10 HR	= 11 A	11A	If your load draws 11A the battery will last for 10 hours and deliver 110 Ah
20 HR	115 Ah	115 Ah	÷	20 HR	= 5.8 A	5.8A	If your load draws 5.8A the battery will last for 20 hours and deliver 115 Ah
100 Hr	132 Ah	132 Ah	÷	100 HR	= 1.3 A	1.3A	If your load draws 1.3A the battery will last for 100 hours and deliver 132 Ah

Displaying capacity delivered for given current draws.

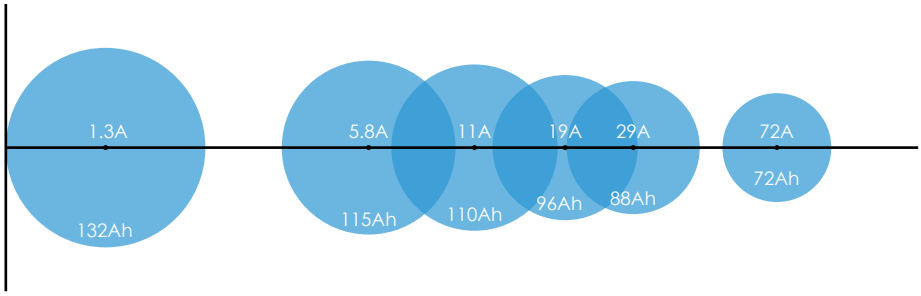

***Figure 3.** Published Lead-acid Capacity with Discharge Rates Converted to Approximate Discharge Current*

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▲TAKE NOTE

Current (A) ↑ ↓ Capacity (Ah)

Remember. As Current (A) draw increases, lead-acid battery Capacity (Ah) decreases.

3. Depth of Discharge

Depth of Discharge (DOD) is another important consideration to be taken when reading published battery capacity.

Lead-acid battery capacity is published at 100% DOD. This does not represent the recommended capacity of the battery. In order to optimize a battery's life, the DOD should not exceed 50%. Due to the demands of semi-traction applications, a maximum 80% DOD is suggested.

▲TAKE NOTE

In Renewable and Stationary applications, do not exceed 50% DOD with lead-acid batteries.

In semi-traction applications, do not exceed 80% DOD with lead-acid batteries.

Usable lead-acid battery capacity with 80% DOD recommendations in consideration.

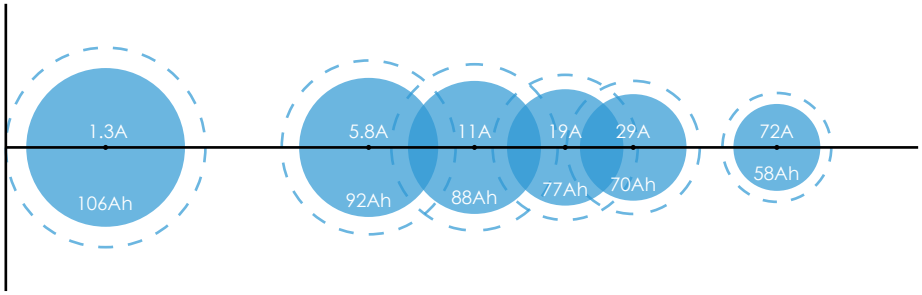

Figure 4. *Lead-Acid Battery Capacity at 80% DOD*

▲TAKE NOTE

Care should be taken to adjust usable capacity for Depth of Discharge

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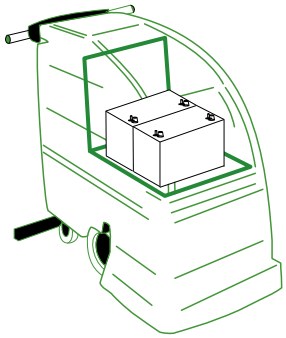
4. Lead-Acid Battery Capacity Case Study

Consider this piece of equipment (floor scrubber) with a space limitation that restricts the battery's installation to two pieces of EV31A-A. The machine draws approximately 30 A when running and it is normally used for 2 hours or less at a time.



Floor Scrubber
24V
30A continuous current

The following table shows that EV31A-A batteries deliver a published capacity of 88 Ah over 3 HR and therefor the continuous current delivered will be approximately 30 A.

Table 3. *Capacity Conversion from HR to A*

Capacity	Rate	Current
88 Ah	3 HR	30 A

Accounting for a maximum of 80 % DOD, the EV31A-A usable capacity will be 70 Ah in this application.

Usable capacity vs published capacity.

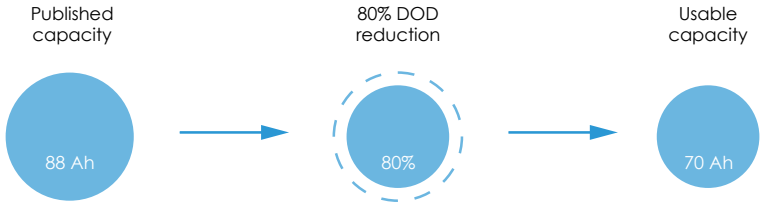


Figure 5. *Lead-Acid Case Study Capacity*

Therefor, a lead-acid battery that is commonly referred to by its published nameplate 20 HR capacity as a '115 Ah battery' will actually deliver 70Ah of usable capacity.

Table 4. *Runtime Calculations*

	Rate	Capacity	Calculation			Runtime
3 HR usable capacity	3 HR	70 Ah	70 Ah	÷	30 A	2 hours 20 minutes
nameplate 20 HR usable capacity	20 HR	115 Ah	115 Ah	÷	30 A	3 hours 50 minutes

As calculated in ***Table 4***, 70 Ah of usable capacity will provide 2 hours and 20 minutes of runtime, far less than the 3 hours and 50 minutes miscalculated when using the nameplate 20 HR usable capacity.

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5. Discover AES LiFePO$_4$ Mobile Industrial Battery

The capacity discussion with Discover AES LiFePO$_4$ Mobile Industrial batteries requires a new perspective. Lithium batteries are more efficient during charge and discharge and perform at the same level for all allowable discharge rates. For this reason AES LiFePO$_4$ Mobile Industrial battery capacity is only published at the 1 HR rate.

Table 5. *AES LiFePO$_4$ 14-24-2800 Battery Capacity*

Rate	Watt Hour	Amp Hour @ 25.6V	DOD	Amp Hour Usable
1 HR	3098 Wh	121	90 ~ 91 %	110Ah

AES LiFePO$_4$14-24-2800 Spec Sheet (May 2020)

AES LiFePO$_4$ battery's allowable DOD is 90 ~ 91%. Therefore 110Ah is the usable capacity.

Discover AES LiFePO$_4$ batteries deliver the same capacity at all discharge rates.

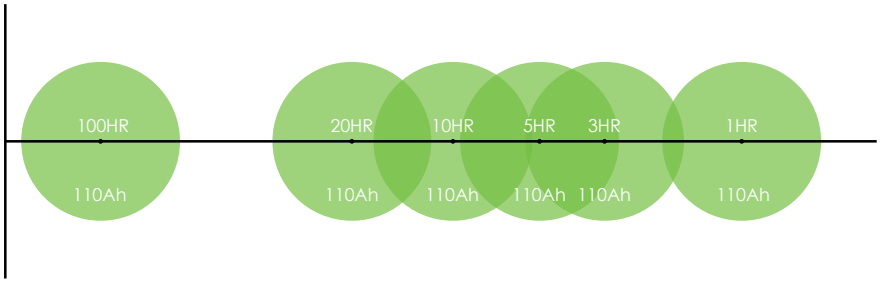

Figure 6. *AES LiFePO$_4$ 14-24-2800 Usable Capacity.*

6. Lead-Acid vs Discover AES LiFePO$_4$ Mobile Industrial Battery Capacity

The proper calculations need to be made to adjust lead-acid published capacity when comparing with AES LiFePO$_4$ Mobile Industrial batteries.

Steps to convert published lead-acid capacity to usable capacity

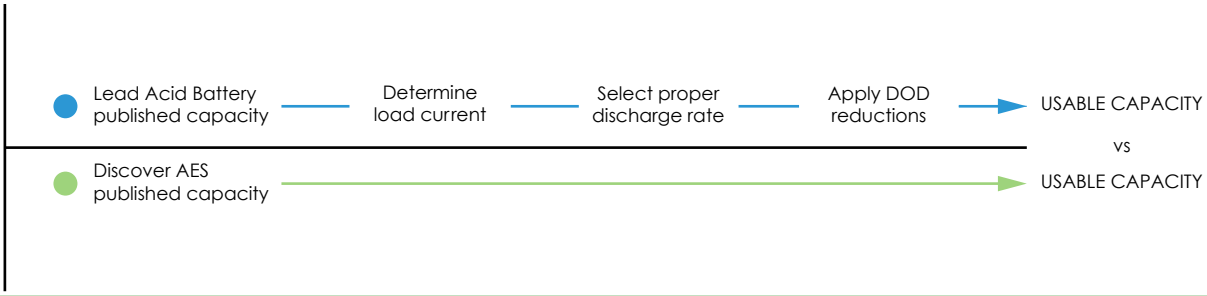

Figure 7. *Usable capacity calculation steps*

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When the calculations are complete, a true comparison can be made. As seen in ***Figure 8***, the AES LiFePO$_4$ 14-24-2800 will outperform the Discover EV31A-A with up to twice the runtime at high discharge rates.

Discover AES LiFePO$_4$ batteries deliver the same capacity at all discharge rates.

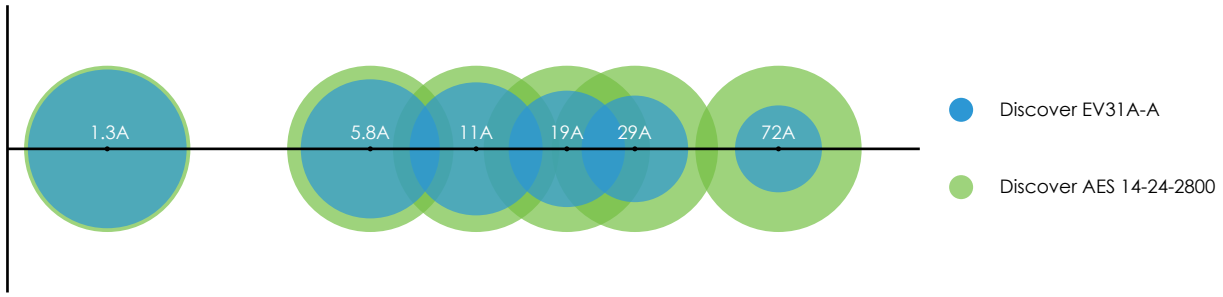
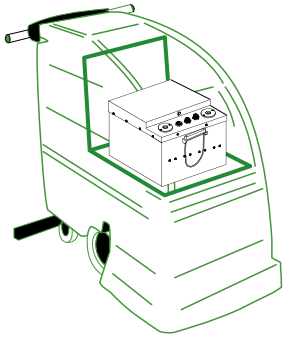


Figure 8. *Lead-acid vs Lithium*

7. Discover AES LiFePO$_4$ Mobile Industrial Battery Capacity Study

Using the same of equipment from **Section 4**, switching the lead-acid batteries to an AES LiFePO$_4$ 14-24-2800 will provide an increase of 57% in runtime.



Floor Scrubber
24V
30A continuous current

Table 5. *AES LiFePO$_4$ Usable Battery Capacity*

Usable Capacity	Calculation			Runtime
110 Ah	110 Ah	÷	30 A	3 hours 40 minutes

The lead-acid batteries will provide 2 hours and 20 minutes of runtime. The AES LiFePO$_4$ 12-24-2800 battery will provide 3 hours and 40 minutes runtime, increasing the runtime by 57%.

8. Final Note

When the steps outlined in this Technical Note are followed, published lead-acid battery capacity can quickly be converted into usable capacity.

When comparing the usable capacity of lead-acid batteries to Discover AES ES LiFePO$_4$ Mobile Industrial batteries, dramatic runtime improvements will be observed.

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