

# WHITE PAPER:

# TUBULAR VS FLAT PLATE BATTERY TECHNOLOGY

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REV A

This document outlines the key technical advantages of Discover Tubular Battery vs Flat Plate Battery for use in renewable and stationary applications. The names for these battery types are derived from the design of the positive plate. A 'Tubular' positive plate design is composed of a series of parallel tubes filled with active material. 'Flat' positive plate design is composed of a lead alloy grid filled with an active paste material. It is helpful to understand how the design of plates, active material, casings, terminals and electrolyte influence the way these batteries perform in service.

## CHARACTERISTICS OF TUBULAR BATTERY

### Plate Design

The positive plates of a Flat Plate battery suffer strong corrosion due to the larger surface area and grid like structure of the vertical and horizontal bars. Unlike a Flat Plate battery, a Tubular battery does not have horizontal bars in their positive plates. The positive plates in a Tubular battery contains a series of vertical spines which improves current transport. Due to the circular design of these spines, voltage loss in the positive plate is lowered and the process of corrosion is slowed. In a tubular design, the positive plate active material is also encapsulated in a non-woven polyester gauntlet to prevent plate shedding. Overall Tubular battery design delivers the highest cycling expectancy amongst lead acid technologies, particularly in Partial State of Charge (PSOC) operation.



Tubular Positive Plate



Flat Positive Plate

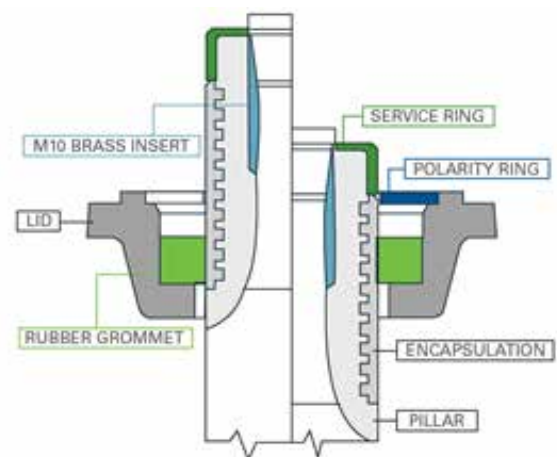
## WHY DOES DISCOVER TUBULAR BATTERY LAST LONGER?

### Terminal Design

Frequently, after 4 - 5 years of use in stationary and renewable applications, positive plate grid growth is a common problem with lead acid batteries. Caused by long-term charge and discharge activity, positive plate growth pushes out the positive pole leading to cracking of the case lid allowing electrolyte to leak out.

Discover Tubular battery features a sliding design that safely absorbs terminal movement due to positive plate expansion. This terminal design reduces cracks in the case lid which prevents acid from leaking out. Discover sliding poles are constructed with a tolerance of 20mm, sufficient for 20 years in operation.

Flat Plate Batteries are not available with sliding poles.



Sliding Pole Terminals

## Case Design

Discover Tubular battery is manufactured with reinforced SAN and ABS container. The thick wall construction features excellent mechanical strength and withstands battery expansion (bulging) during cycling which reduces capacity loss. Tubular flooded models include mud pans at the bottom of the case to accommodate positive plate growth and the missing of the negative terminal and strap as the battery ages.

Flat plate batteries have thinner case walls and often require compression bands to prevent expansion.

## Active Material

During discharge active material density can increase by over 80%. The swelling of active material reduces plate and active material contact leading to rapid capacity loss.

Tubular plates feature a circular tube design that compresses the active material to the battery grid that helps prevent battery expansion during the discharge process. Each tube in a plate is formed with a non-woven polyester gauntlet to ensure strong contact between the active material and the grid. The gauntlet provides counter pressure during discharge in order to prevent expansion and capacity loss.

Flat plate grid structure does not have a mechanism to contain active material expansion which leads to battery case swelling and capacity loss.

## Electrolyte and Specific Gravity

Specific gravity is defined as the ratio between the weight of a specific volume of sulfuric acid and the weight of an equal volume of water, measured at the same temperature. The low specific gravity (1.24) of a Discover Tubular Battery reduces grid corrosion and lowers the self-discharge rate providing a longer service life. In comparison, a high specific gravity provides a higher capacity, but shorter service life. A lower specific gravity value is generally considered useful for renewable systems and back-up applications.

## High Temperature Performance

A Tubular battery performs better in high temperatures than a flat plate battery:

- Deliver less heat build-up in a Valve Regulated Lead Acid battery
- More space for water within each cell reduces risk of battery dry out failures
- Mechanical stability of the plates is more consistent across service life
- Lower specific gravity offers better performance in higher operating temperatures

## THE REAL COST OF TUBULAR

For this comparison two highly regarded manufacturers of flat plate batteries were selected. Manufacture A is represented by a 2V AGM battery and Manufacturer B is represented by a 6V AGM battery. For the purpose of comparison a 10 kWh daily load with three days of autonomy was used for the design target. This means the batteries need to have at least 30 kWh of usable stored energy. The results show that if initial cost was the only consideration, then flat plate technology would be the clear winner. However, the results also show that the battery investment in relation to cycle life provides a more holistic way of assessing true value as well cost.



Tubular Flooded and Gel Batteries



Tubular Cell Design.

## SYSTEM SIZING

Nominal DC Voltage	48 V	48 V	48 V
Battery Type	Tubular Gel	AGM Flat Plate	AGM Flat Plate
Design Depth of Discharge (DoD)	50 %	50 %	50 %
Energy Storage Requirement (useful kWh)	30 kWh	30 kWh	30 kWh

## BATTERY SPECIFICATIONS

Manufacturer	Discover Battery	Manufacturer A	Manufacturer B
Model	2VRE-3200TG	AGM 1150 2V	AGM L16
Battery Nominal Voltage	2 V	2 V	6 V
Battery Ahr rating (20 hr Rate)	1265 Ahr	1150 Ahr	415 Ahr
Expected Cycle Life at Rated DoD	2950	1500	1300
Retail Cost per Battery	\$ 900	\$ 600	\$ 610

## ENERGY STORAGE SYSTEM SUMMARY

Number of Batteries Required for System	24	24	24
Number of Parallel Battery Strings	1	1	3
System Energy Storage Capacity (kWh)	61 kWh	55 kWh	60 kWh
System Useful Energy Storage Capacity (kWh)	30 kWh	28 kWh	30 kWh

## INITIAL CAPITAL COST (CAPEX) SUMMARY

Initial Battery System Cost	\$ 21,600	\$ 14,400	\$ 14,640
Initial \$/kWh of Energy Storage (useful kWh)	\$ 711	\$ 522	\$ 490

## 8 YEAR CAPITAL COST (CAPEX) SUMMARY

Number of Planned System Purchase (365 daily cycling / expected battery cycle life)	1	2	2
8 Year Total Battery System Cost	\$ 21,600	\$ 28,800	\$ 29,280
8 Year \$/kWh of Energy Storage (useful kWh)	\$ 711	\$ 1,043	\$ 980

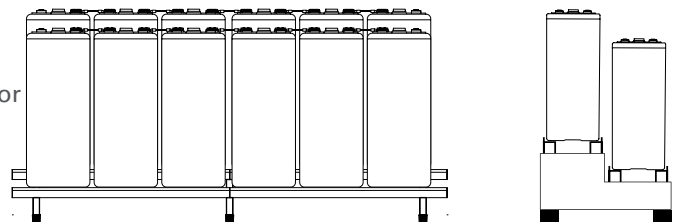
## 8 YEAR ENERGY STORAGE OPERATING COST (OPEX)

Energy Storage Cost per Cycle (Depreciation cost of each complete cycle)	\$ 7.32	\$ 9.86	\$ 10.03
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Compared with the cycle life of the tubular batteries, flat plate batteries will likely have to be replaced at least once. The Total Cost of Ownership (TCO) over 8 years daily cycling will be reduced by approximately 30% when comparing Tubular vs Flat plate.

## SYSTEM INTEGRATION

Discover Tubular Battery is available as a complete solution for 24 VDC and 48 VDC energy storage systems. The knock-down kit includes tubular battery cells, racking, inter-cell and inter-row connectors.



For more information please visit:

<https://discoverbattery.com/product-search>

## SUMMARY

Due to the advanced tubular battery design, the total cost of ownership is 30% lower than a flat plate battery when cycle and service life performance is taken into consideration.

DiscoverTubular Battery provides twice as much cycle life at 50% Depth of Discharge when compared to a lead-acid flat plate battery.

The electrical and mechanical capabilities of a tubular battery outperforms a flat plate battery for renewable and stationary applications.

In applications which require a long service life and from amongst the lead-acid technologies available, a tubular plate battery provides the best value and most reliable power for the money.