Technical Overview of the SLR Super Long Cycle Life Family of Valve Regulated, Lead Acid Batteries

Abstract

GS Yuasa's new SLR Family of Super Long Cycle Life, Valve Regulated, Advanced (Nanocarbon enhanced) lead-acid batteries feature excellent cycle life performance with 5,000 cycles at 70% depth of discharge. This is more than 3X the performance of typical VRLA cycling batteries. GS Yuasa is the industry leader in battery technologies with over 100 years of experience and expertise in designing Best in Class energy storage devices.

Introduction

Today, environmentally friendly, renewable energy generation is being introduced more and more into North America's power grid. Solar power and wind power generation is becoming common place and widespread. The ability of these renewable energy sources to generate electricity is impacted by changing weather conditions and time of day. To fully utilize renewable energy technologies, the ability to store the electricity they create until it is needed is critical.

One of the measures being promoted is the use of storage batteries. Batteries store the excess power generated when demand is low and discharge that power when demand increases. Valve regulated lead-acid batteries designed for cycling are commonly used because of their reliable performance, safe, and easy maintenance.

SLR Super Long Cycle Life Battery Family – Specifications & Design Features

Performance Specifications

Nominal voltage: 2 volts and 12 volts
Rated capacity: 2V: 1,000Ah @ 10Hr & 500Ah @ 10Hr; 12V: 50Ah @ 10Hr
Design cycle performance: 5,000 cycles at 70% depth of discharge (DOD) @ 25°C
19 years of cycle life based upon IEC-61427
Design life: 15 years @ 25°C
Operating condition: Partial State of Charge

Features

Sealed, valve regulated lead acid (VRLA)
Advanced (Nanocarbon enhanced) AGM design
HT Element X Alloy™, Low Corrosion Alloy for High Temperatures
Proprietary Grid Design
High Density Positive Active Material
Proprietary PP-X Additive to eliminate Premature Capacity Loss in Negative Active Material

Battery Rack Systems Overview

- SLR1000-2, 24V, 24kWh rack system (**Figure 1A**)
- SLR1000-2, 48V, 48kWh rack system (**Figure 1B**)
- SLR500-2, 24V, 12kWh rack system (**Figure 2A**)
- SLR500-2, 48V, 24kWh rack system (**Figure 2B**)

Figure 1A

Figure 1B

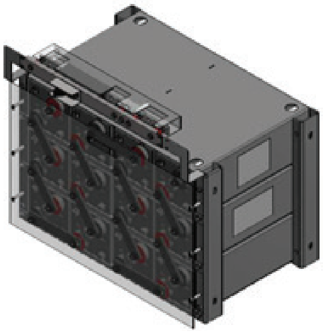


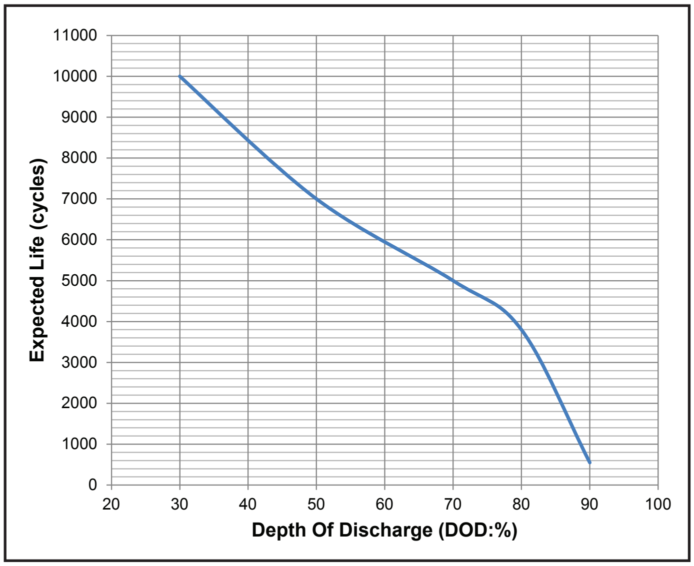
Figure 2A

Figure 2B

Cycle Life Performance

Figure 3 shows the cycle life performance specification of the SLR Family of batteries. Note, the SLR Family is designed to give 5,000 cycles @ 70% DOD with even better performance in shallower DOD situations. This is more than 3X the performance of comparable products available in the market.

Figure3



Performance of the SLR Super Long Cycle Life Battery Family

Nanocarbon Particles added to the Negative Active Material

To reduce sulfation on the negative plate, Nanocarbon is added into the negative active material paste. This gives the negative plate more charging reaction and higher capacity retention while providing less risk of sulfation in partial state of charge conditions. Several different paste formulas were tried and analyzed before the optimum mixture for the SLR family's negative active material was found. ***Figure 4*** shows an enhanced image of the lead alloy with Nanocarbon particles. ***Figure 5*** shows reaction progress models of lead sulfate and reduction processes of lead sulfate with and without Nanocarbon added.

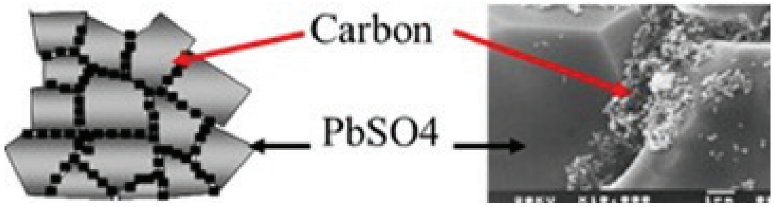


Figure 4

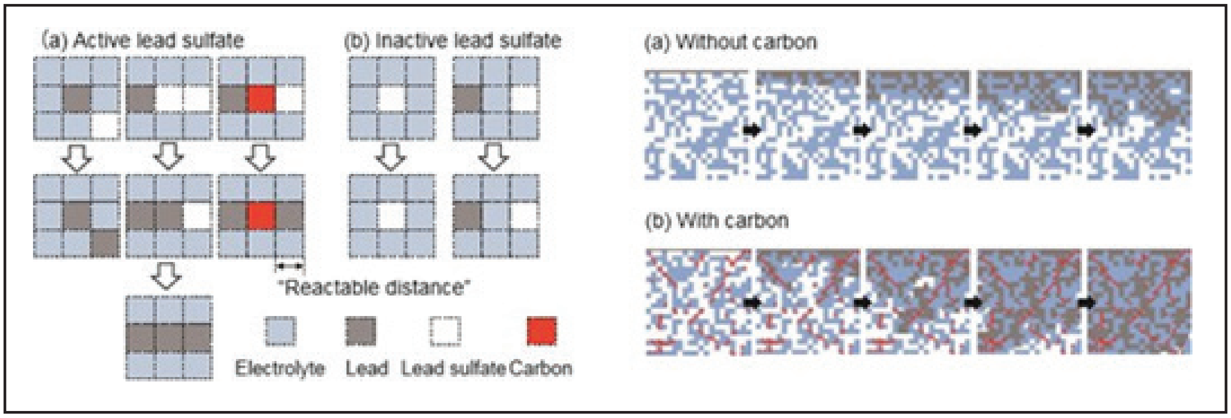


Figure 5

Proprietary Grid Alloys and Grid Designs

VRLA batteries typically use grids made with a lead-calcium alloy. The lead-calcium alloy's primary failure mode is grid corrosion which causes grid growth within the positive plate. When the grids grow, active material is shed from their plates and this reduces the battery's capacity. This plate growth is caused by fractures and gaps which form in the grids. Corrosion develops in these voids, separating the plates' active material from the grid. The reduction in capacity and loss of grid integrity due to corrosion is the cause of the battery's end of life. This failure mechanism is shown in ***Figure 6***.

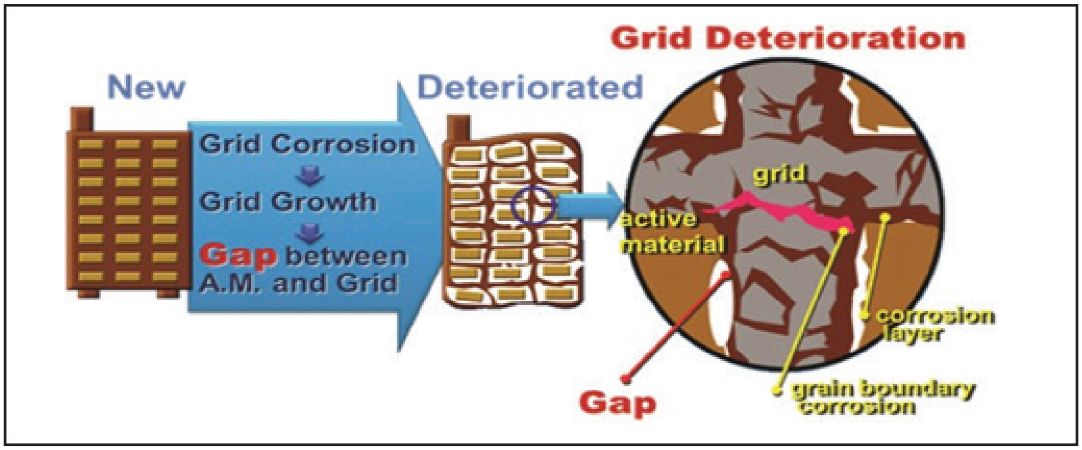


Figure 6

Minimizing grid growth is a key design feature of the SLR family of batteries with their Best in Class cycling performance. A larger cross-sectional area of the grid is critical to minimizing grid growth. GS Yuasa Engineers began the SLR design program by using their first-generation Nanocarbon SLE product grids. Using state of the art, computer design programs, new grids were designed, prototype batteries built and tested. This process yielded the square-shaped grid design now used in the SLR Family of batteries. GS Yuasa's SLR batteries have grid wires 20% thicker than the original SLE product line. The SLR's grids have optimized cross sections which inhibit grid growth by retaining the grid's integrity. As a result, corrosion damage to the battery is minimized and provides a longer life in real world applications. ***Figure 7***.

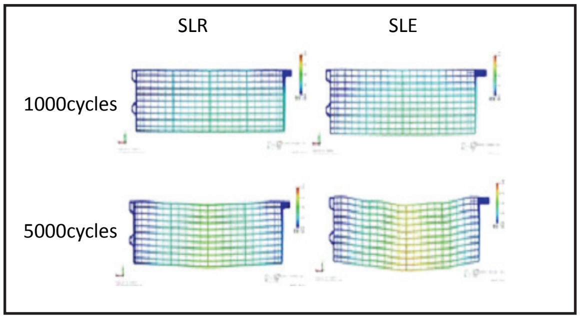


Figure 7

GS Yuasa's optimized grid design used in the SLR Family is shown in ***Figure 8*****.**

Figure 8

High Density Positive Active Material

An increase in the density of the positive active material has the benefit of increasing the number of battery cycles before the active material becomes soft or sulfated and performance deteriorates. There is some reduction in initial capacity and the design of the SLR Family compensates for this. Having a higher active material density means a lower coefficient of utilization of active material during discharging which enhances cycle life performance. To achieve greater cycle life performance, the SLR Family is designed with high density active material and a lower utilization rate.

Figure 9 shows cycle performance by density of positive active material.

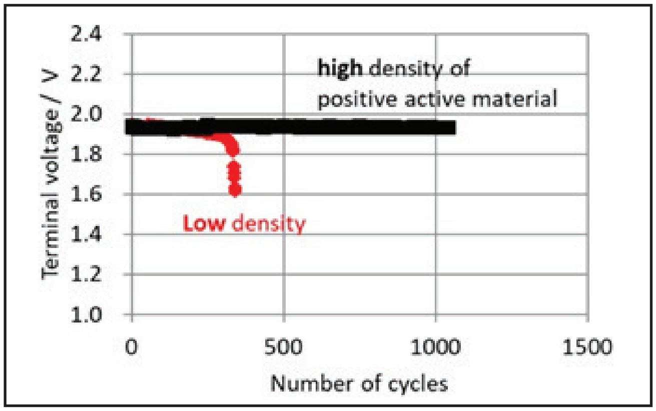


Figure 9

Proprietary PP-X (Prevent PCL by material X) Additive to Eliminate PCL

The phenomenon known as "Premature Capacity Loss"(PCL) is a cause of the early end of a battery's life. This is due to an increase in internal resistance (IR) caused by the formation of a non-conductive layer of lead sulfate at the interface of the grid wire and the surface of active material. This corrosion layer is the result of shallow discharging (10-30% DOD) followed by repeated over-charging of the battery.
The addition of "PP-X" prevents the growth of the lead sulfate layer by enhancing the chemical reaction of the active material.

Figure 10 shows PCL cycle test with results for batteries with the PP-X additive and batteries without the PPX additive.

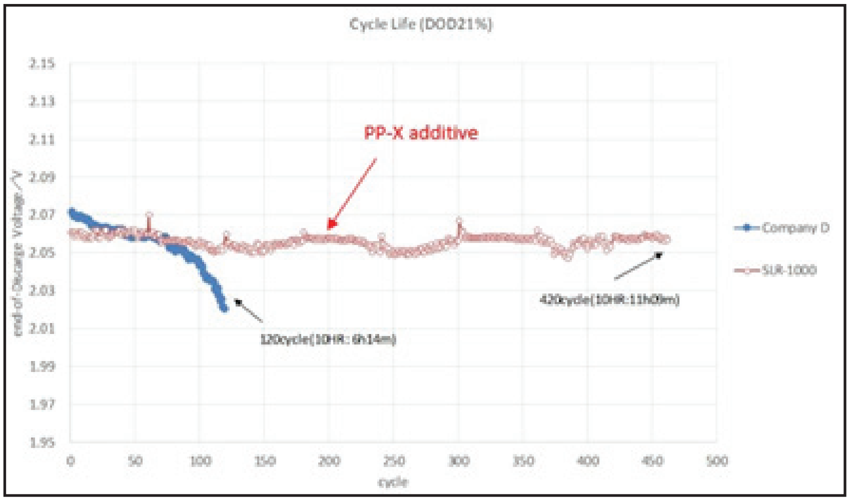


Figure 10

HT Element X Alloy™, a Low Corrosion Alloy for High Temperatures

Approximately ten years ago, GS Yuasa Engineers identified a breakthrough that would enhance GS Yuasa's Low Corrosion Rate Alloy. All purchased lead for battery manufacturing contains trace amounts of impurities. GS Yuasa's required it's purchased lead conforms to the JIS specification for electrolytic industrial batteries which requires 99.99% purity.

GS Yuasa Technology Department's research identified a specific element that, even in miniscule amounts, significantly accelerates positive grid corrosion. This element is referred to as **Element X**. Miniscule amounts of **Element X** degrade battery life. Using advanced analytical techniques, GS Yuasa's changed its proprietary lead procurement specifications, imposing strict purity limits in the parts per billion (PPB) range on the amount of the **Element X** impurity allowed in its ***HT Element X Alloy™***

Figure 11 illustrates the benefit of **Element X** minimization.

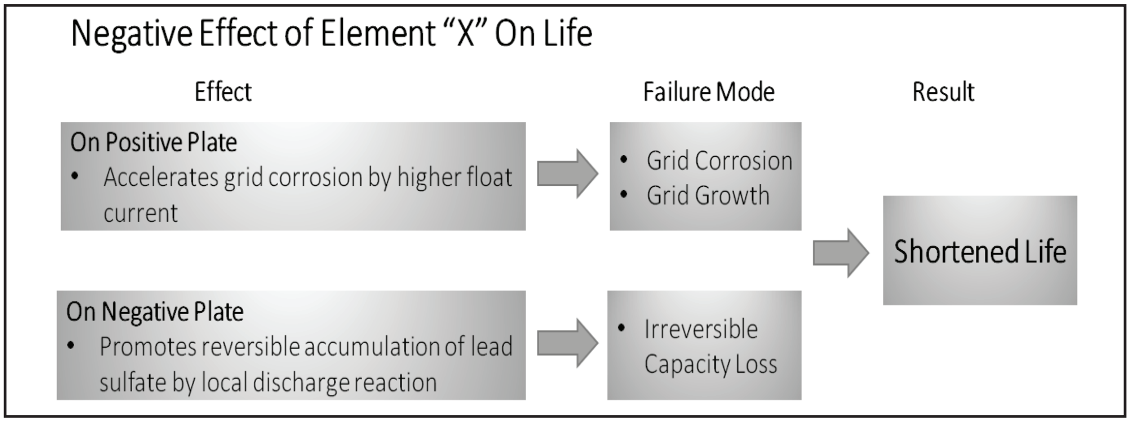


Figure 11

The relative scale of the allowable amount of ***Element X*** compared to the JIS standard's allowable amounts of impurity elements iron (Fe) and bismuth (Bi) are illustrated in ***Figure 12.***

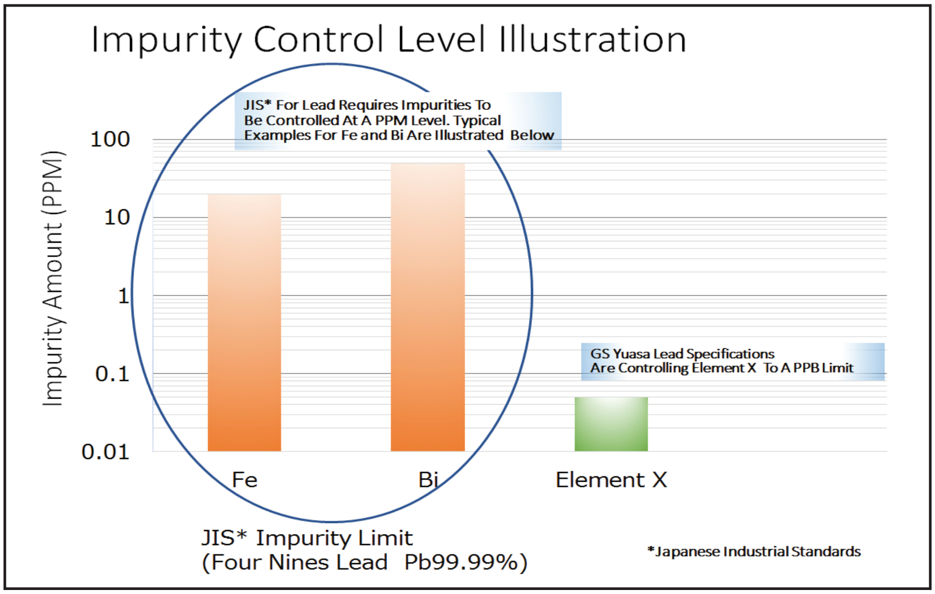


Figure 12

Figure 13 Illustrates the amount of ***Element X*** identified in analysis of competitive products. The analysis indicates that ***Element X*** is not controlled and typically exceeds GS Yuasa's specification.

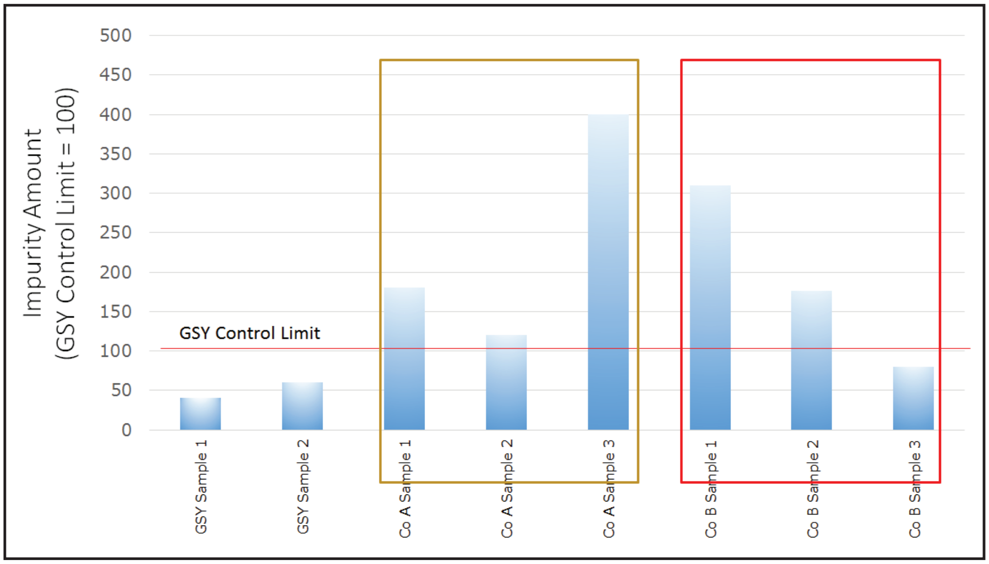


Figure 13

Using 99.99% purity lead and imposing strict PPB limits of ***Element X*** inhibits grid corrosion growth and provides longer life without quality variance.

Cycle Life Test Results for the SLR Family of Batteries

Performed by an independent test laboratory, the accelerated cycle life test portion of IEC-61427 provides performance in simulated PV operating conditions by accounting for seasonal cycling variability in a partial state of charge condition and in high temperatures, 40°C ± 3°C (104°F ± 5.4°F).

In Phase 1, the test repeats 50 shallow cycles in a low state of charge, and in Phase 2, the test performs 100 shallow cycles in a high state of charge. The completion of these 2 cycles is considered the equivalent to one year of actual service in the field. The IEC-61427 test results for GS Yuasa's SLR are provided in ***Figure 14***. The SLR1000-2 completed the equivalent of 19 years of in-field use before the test was ended.

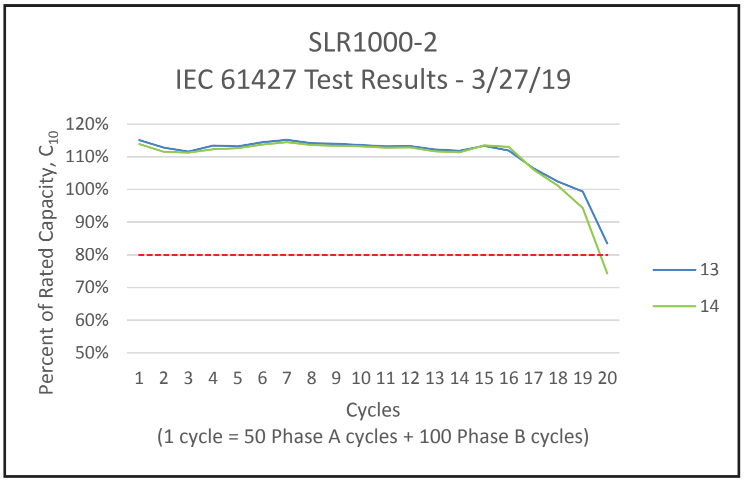


Figure 14

Conclusion

These unique design features significantly increase the performance of the SLR Family of batteries:

- Nanocarbon enhanced negative active paste material
- Thicker grid design
- Increased density of the positive active paste material
- PPX additive to prevent premature capacity loss
- ***HT Element X Alloy™*** to minimize corrosion in high heat temperatures

Independent testing indicates GS Yuasa's goal to design and bring to market a lead-acid battery family with super long cycle life and achieve 5,000 cycles @ 70% DOD was accomplished. Results from the cycle testing in IEC-61427, an accelerated life test specification, indicates the SLR Family provides 19 years of cycle life performance.

ABOUT GS YUASA ENERGY SOLUTIONS, INC.

GS Yuasa Energy Solutions, Inc. is an American subsidiary of GS Yuasa Corporation, the world's second largest battery company and a 100+ year old Japanese corporation. GS Yuasa Energy Solutions (GYES) was formed in 2019 to address the growing energy storage and reserve power markets. GYES brings together and leverages GS Yuasa Group's advanced technologies with proven American market successes in lithium, telecom, UPS, alarm & security, and energy storage into a single business unit.

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