STAND-ALONE ENERGY STORAGE BY BATTERIES: NEW CHALLENGES FOR VRLA-AGM

Dr. Bodo Brühl
Oerlikon Stationary Batteries Ltd
Aesch, Switzerland

INTRODUCTION

Storage of electrical energy for use in electrical grids, especially in combination with renewable (wind, hydro, solar) energy production, is a growing application for batteries. Here batteries enable the customer to use electrical energy during time periods in which no direct electrical energy production is possible.

Lead acid batteries have been successfully introduced into this application for a considerable time. In this presentation the advantages of VRLA AGM battery products will be discussed based on electrical measurements and tests including reference sites. It will be shown that the outstanding maintenance free technology of VRLA AGM batteries result in reliable and cost effective service. The investigations attest the excellent performance of VRLA AGM batteries operated under a broad range of ambient conditions from arctic to hot climates. Recent advancement of VRLA AGM batteries keeps up their long service live time also under elevated temperature conditions. Emphasis is put on results regarding the cycle life testing, where VRLA AGM batteries obtain a competitive data performance, especially with shallow discharge cycle profile (or PSOC as it will occur in for example photovoltaic systems).

Followed by the discussion of technical design aspects, a short introduction will be given about recommended practice of VRLA AGM batteries in renewable energy storage applications, taking into account sizing, operation and maintenance.

SPECIFIC CAPACITY DENSITY

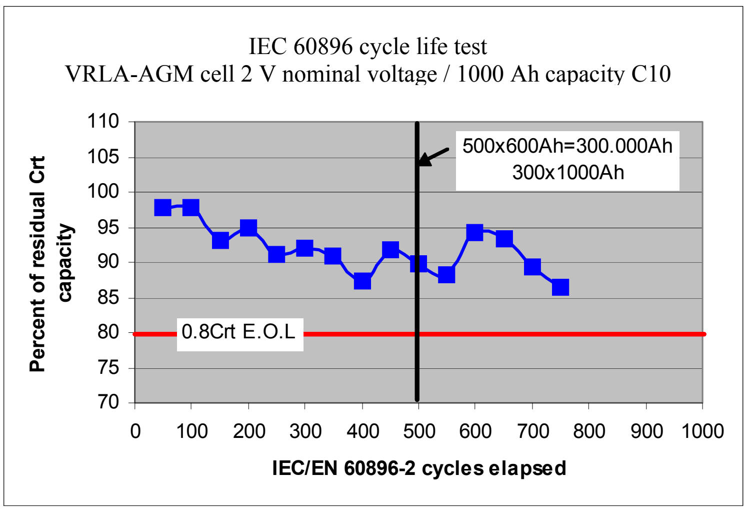
Storage of electrical energy for use in electrical grids, especially in combination with renewable (wind, hydro, solar) energy production, is a growing application for batteries. Here batteries enable the customer to use electrical energy during time periods in which no direct electrical energy production is possible.

Cycling

Main demand for photo solar application refers to cycling. VRLA-AGM cells and monoblocs have been designed for stationary stand-by service and show a cycle life equivalent to 300 discharges to 100% d.o.d at the 10h rate to 1.80Vpc at 20°C. They do not require any conditioning cycle as a capacity recovery maintenance routine and can be cycled with a charge voltage equivalent to the float voltage of 2.23V to 2.27pc at 25°C which make them robust for different charging and service conditions.

The cycle life has been determined according to IEC 60896-21/22 (2004) section 5.3 with the following “24h for 1 cycle” test regime:

- -Discharge the units for 3h with a current equal to $2I_{10}$ (equal to 60% d.o.d. of C_{10})
- -Charge for 21h with a current limited constant voltage charge with an initial charge current of $2I_{10}$ and a maximum voltage of 2.25Vpc.

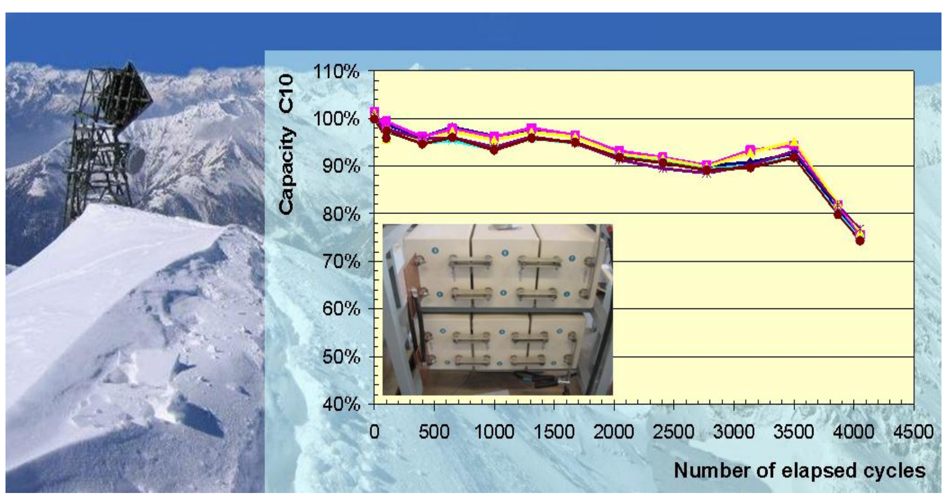


After 50 of such cycles and without any equalization or boost charge, determine the residual capacity of the units with a C_{10} discharge to 1.80Vpc, the results are shown in the diagram.

The standardized laboratory test must be discussed with experience data from reference sites, where an example is presented in the following.

REFERENCE SITE FOR CYCLING LOADING

A Swiss telecom operator installed a repeater station power by a photovoltaic energy storage system on a mountain peak (3294m altitude) consisting of solar panels (rated power 4.3kW) maximum power tracking and charging controllers. The photovoltaic energy is stored in 24v batteries using 2V VRLA/AGM cells with rated capacity of 1000Ah C10 to 1.8Vpc at 20°C. The reference test site was operated since 12 year up to now with a daily discharge cycle duty.



Solar cycle service : 6 month/y at 17-25°C, 6 month/y at 22°C-35°C

daily cycle : discharge= 24% DOD / 12 h, recharge= 0.6*I10 / 12h

capacity test: discharge with 100A to 1.82Vpc, in % of the rated capacity

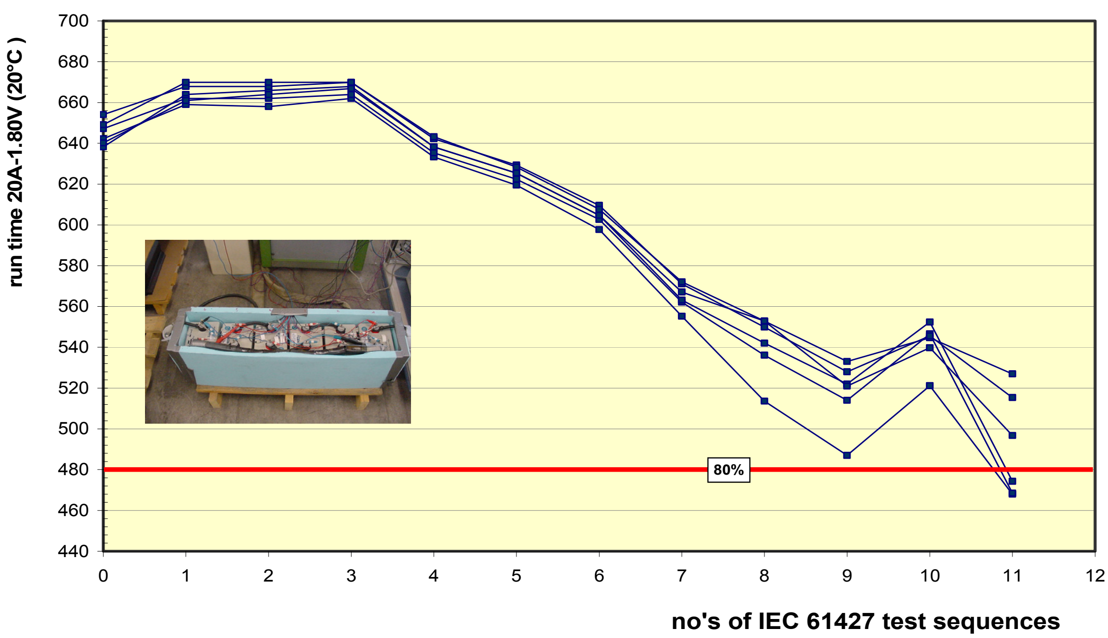
SOLAR DUTY CYCLE

The standard IEC 61427 “Secondary cells and batteries for solar photovoltaic energy systems” suggest in chapter 15 a cycle endurance test which reflects the specific service conditions of PV energy systems. One test sequence consist of cycles defined in phase A and B is described :

<table>
<tr><td colspan="4">battery has successfully passed capacity test and is fully charged</td></tr>
<tr><td rowspan="8">Test Sequence</td><td rowspan="4">Phase A “shallow cycling at low stage of charge”</td><td rowspan="4">50 cycles</td><td>discharge with current = I_{10}[A] for 9h</td></tr>
<tr><td>recharge with current = 1,03 * I_{10}[A] for 3h</td></tr>
<tr><td>discharge with current = I_{10}[A] for 3h</td></tr>
<tr><td>recharge with current = I_{10}[A] for 3h</td></tr>
<tr><td colspan="3">recharge battery to fully charged condition</td></tr>
<tr><td rowspan="2">Phase B “shallow cycling at high stage of charge”</td><td rowspan="2">100 cycles</td><td>discharge with current = 1,25 * I_{10}[A] for 2h</td></tr>
<tr><td>recharge with current = I_{10}[A] for 6h</td></tr>
<tr><td colspan="3">capacity test : discharge with current = I_{10}[A] final voltage = 1.80V_{pc}
recharge to fully charged condition</td></tr>
</table>

The complete test (cycles and capacity testing) is performed under elevated temperature (+40 °C ± 3 °C).

It could be shown in such tests that an optimized VRLA-AGM cell (nominal voltage 2V / 100 Ah C10 rating) is performing more than 11 of such cycles, represented up to 10 years real operation service time.

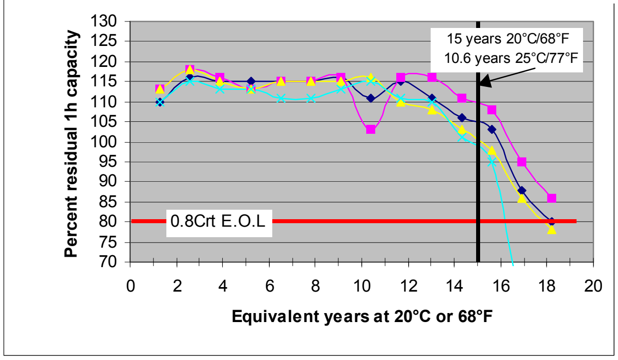


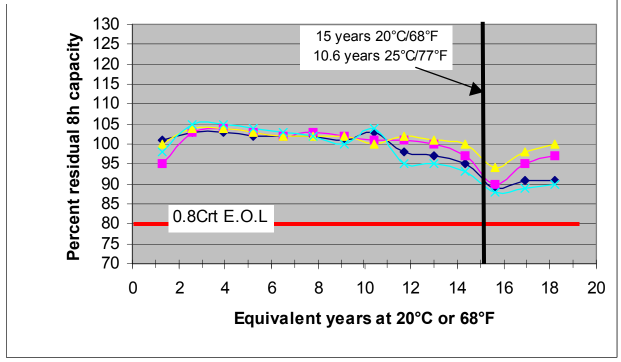
Service life

The time from the battery installation until its capacity loss falls below 80% of its rated capacity at 25°C defines the service life of the battery. In the following typical results are presented for VRLA/AGM cells and monoblocks according temperature life test according to the British Standard BS629 Part 4. These tests are carried out over multiple 42 day periods at 55°C or 131°F with C_8 and C capacity discharges between these periods of 2.25Vpc float charge service.

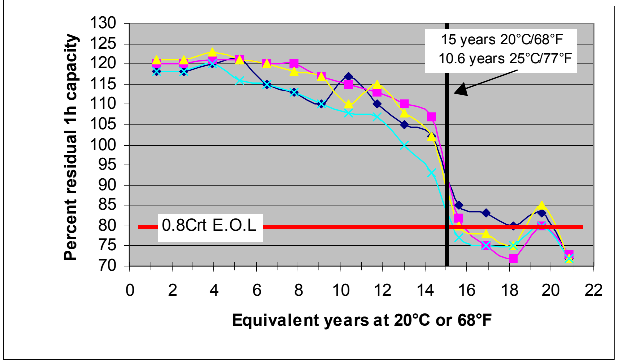
Test temperature	Percent life
20°C/ 68°F	100%
25°C / 77°F	71%
30°C / 86°F	50%
40°C / 104°C	25%

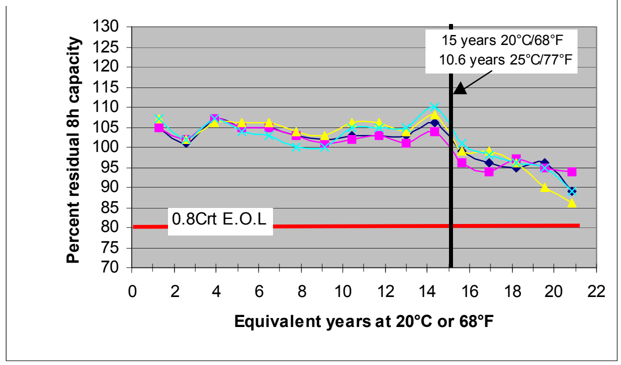
VRLA-AGM monobloc 6 V nominal voltage / 155 Ah capacity



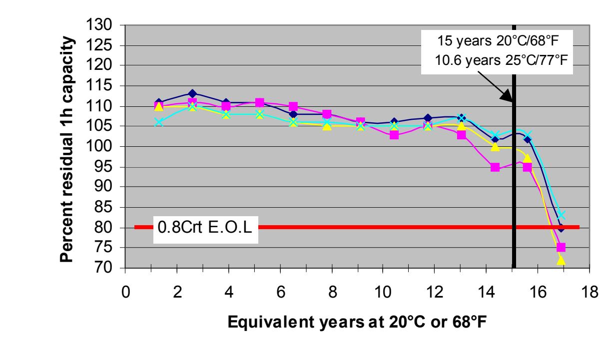


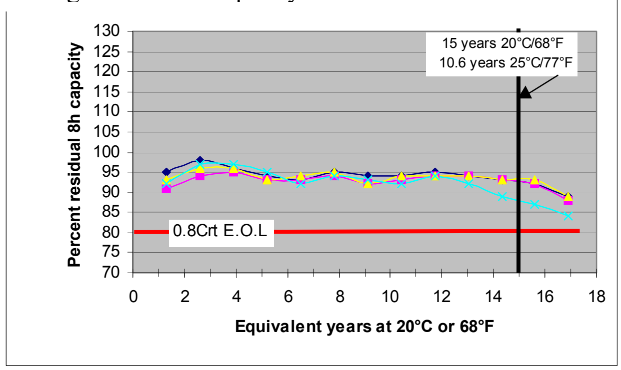
VRLA-AGM monobloc 4 V nominal voltage / 225 Ah capacity





VRLA-AGM cell 2 V nominal voltage / 1000 Ah capacity

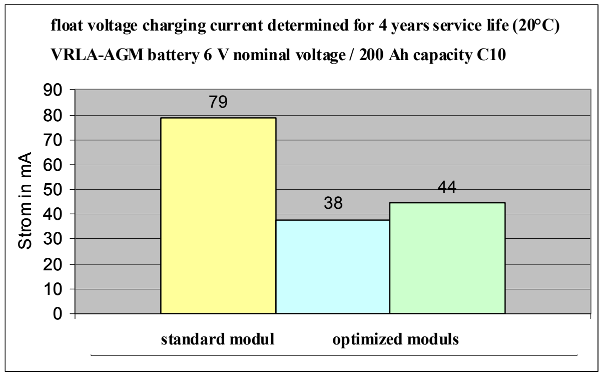




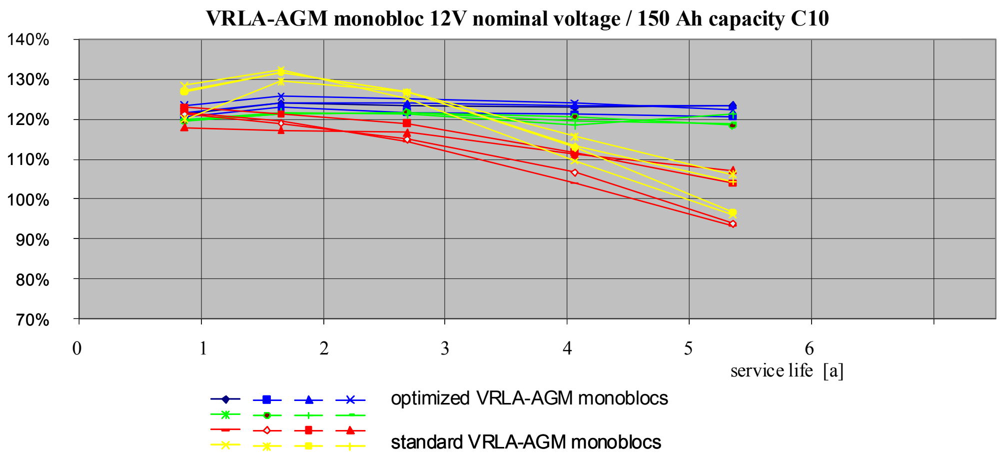
The data plotted show the capacity evolution under high rate (C – left side) and low rate (C_8 – right side) capacity test condition carried out on the same 4 cells and monoblocs as function of the service life at 20°C or 68°F .A service life of 10+ years at 20°C/68°F is assured with at least 15 years experimentally confirmed with high rate discharges and >18 years confirmed with low rate discharges. From these data a service life of 10 to 12 years at 25°C/77°F can be deduced.

Improvement of service life.

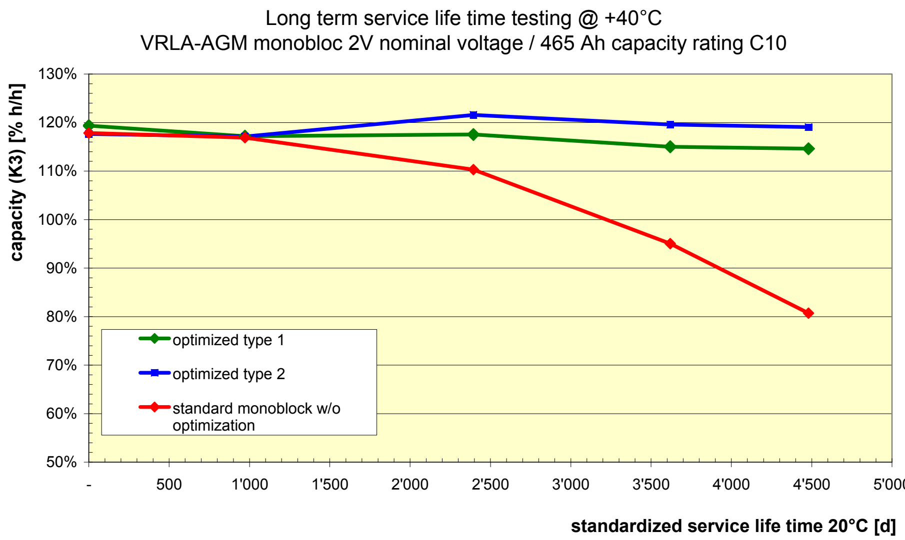
The life time effecting mechanism of VRLA-AGM batteries is water loss, even if these values are significantly below other lead-acid battery technologies. It is possible to further improve this water loss, which is also correlated wit decreasing of float voltage current.



This enhancement results in increasing of service life as shown in the following diagram. VRLA-AGM monobloc (12V / 150 Ah C10) were tested in float voltage charging cycles with periodically capacity testing.



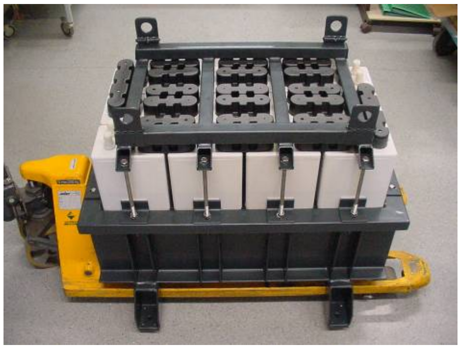
The need for improving service life time is especially for elevated ambient temperature conditions. Therefore a test result is presented for float voltage charging test with periodically capacity (c3) testing on VRLA-AGM monoblocs with 2V nominal voltage / 150 Ah capacity.



In all example the improvement can be seen as significantly be the in the range of at least factor of 2.

Robustness in service

As an example for the mechanical robustness in service, VRLA cells and monoblocs are capable to meet the zone 4 seismic requirements (e.g. 3 axis – 30s/axis – 3g acceleration), which is possible due to the design concept of VRLA consisting of its tightly packed plate group.



This performance is reached in both vertical as well as in horizontal orientation of plates, as it is shown in the figures. Here UPS batteries sets are shown during homologation tests concerning earthquake and shock impact. All sets are based on 2V / 1000 Ah cells in VRLA / AGM technology.

This robustness supports the use of VRLA-AGM batteries in harsh environmental conditions und are a proof for rigid design.

CONCLUSION

As it was shown, VRLA-AGM batteries are able to be in service for photo solar applications. Their rigid and electrically optimized design show a sufficient cycling performance what is proven in standard test as well as in long term operated test reference sites.