VRLA batteries in photovoltaic energy storage systems for telecom applications
(Intelec 1993)

Summary
Swisscom has installed an active repeater station powered by a photovoltaic energy storage system on peak Piz Muttler situated in the vicinity of the border corner Switzerland-Austria-Italy at an altitude of 3294m. The PVES system consists of 72 60W (4.32kW-36m^2) solar panels with associated maximum power tracker and charging controllers. The photovoltaic energy is stored in 24V batteries using 2V VRLA/AGM cells with a rated capacity of 1000Ah C_{10} at 20°C to 1.80Vpc.
In order to evaluate the worst case condition of extremely low temperatures within the battery room, the low temperature (-30°C) and the low voltage (0.00Vpc) behavior of such cells is reported. The batteries survived unscathed freeze/thaw cycles and can be recharged with the electrolyte ñfrozenò

The thermal behavior of VRLA/AGM cells and monoblocs
(Intelec 1995)

Summary
VRLA/AGM cells and monoblocs were investigated concerning parameters influencing the onset of thermal runaway conditions. For this purpose 2V 1000Ah and 2V 300Ah cells were specially assembled so to include electrolyte starvation conditions simi8lar to service life dry-out. Key cell performance parameters determined experimentally indicate that also large VRLA/AGM cells show a stable behavior in increased temperature environments. When however dry-out or electrolyte volume level reductions of >15% are experienced, the unfavorable environmental conditions could cause a slow but steady escalation of the cell float current.
The trapping of the current generated within the cell may yield thermal runaway conditions. The monitoring of the temperature differential ñcell case ï surrounding air temperatureò could give a warning signal of unsafe conditions to the battery plant operator.

The effect of selenium on the electrochemical behavior and corrosion of Pb-Sn alloys used in lead acid batteries
(J. Electrochemical Society 1995)

Summary
In valve regulated batteries of the adsorbed glass mat type the connecting strap and lugs of the plates (top lead) are covered by a thin liquid film of H_2SO_4 solution. The H_2SO_4 is consumed for the formation of a $PbSO_4$ corrosion layer. The liquid film has high ohmic resistance and hence the strap and lugs of the plates are cathodically unprotected. As a result of this, often the life of the battery is limited by corrosion of the negative semiblock top lead. In battery manufacturing practice, Pb-Sn alloys are often used for the straps in the above battery type. The present paper examines creeping of the thin liquid film up a strap electrode, the structure and phase composition of the corrosion layer formed on the electrode surface, as well as the rate of corrosion of Pb-Sn and Pb-Sn-Se electrodes partly immersed in an absorbing glass mat soaked in H_2SO_4 or H_2SO_4 + Na_2SO_4 solutions. It has been established that the potential of that part of the electrode immersed in the solution controls the potential of the electrode up to a height of 1 cm above the solution level. The corrosion layer formed on the

electrode surface above the solution (in the air) features zones of different phase compositions. The introduction of Na_2SO_4 to the H_2SO_4 solution leads to a sevenfold increase in corrosion rate of Pb-Sn alloys, while the addition of 0.03%Se to the alloy suppresses completely this effect of Na_2SO_4. When the Sn content in the alloy is below 1%, the rate of corrosion increases. Selenium suppresses this effect, too, in alloys containing 0.6% Sn. Selenium has an anticorrosion effect and acts as a grain refiner in Pb-Sn alloys decreasing also the size of $PbSO_4$ crystals and facilitating their nucleation.

The corrosion behavior of positive grids with lead calcium aluminum alloy in VRLA/AGM cells and monoblocs (Intelec 1996)

Summary
Accelerated aging tests of VRLA batteries show the excellent corrosion resistance of a PbCaAl with an addition of 2% Sn. This grid alloy shows a large grain microstructure and much reduced amounts of secondary recrystallization with little coarse $(Pb_{1-x}Sn_x)_3Ca$ precipitate. The increase of the tin content from 0.7% to2.0% results in an approximate doubling of VRLA service life deducible form accelerated float life test at 60°C (140°F). The addition of 0.05%Ag does not improve the corrosion resistance of the PbCaAl-2%Sn alloy.

Abusive discharges to zero Volt of VRLA/AGM monoblocs in 24V strings (Intelec 1997)

Summary
Lead acid batteries may experience an abusive ñdeepò discharge condition when more than 100% of the rated capacity is withdrawn. This paper describes the behavior of a VRLA/AGM battery under such discharge conditions by examining temperature and voltage parameters. As results show, certain designs of VRLA/AHM batteries exhibit a good tolerance against such abusive conditions
A discharge for a period of 130h below 1.80Vpc did not induce, after recharge at the float voltage of 2.25Vpc, any capacity loss in such a battery.

Investigation of thermal phenomena in VRLA/AGM stationary lead acid batteries with a thermal video imaging system (J. Power Sources 1997)

Summary
Thermal imaging has been utilized to detect heat evolution phenomena in VRLA/AGM cells and monoblocs. With the method cell reversals during discharges of 12v monoblocs as also the site of the oxygen recombination and associate electrolyte movements in large cells was detectable at ease.

The operation of VRLA lead acid batteries in parallel strings of dissimilar capacity
(Intelec 1999)

Summary
The operation of a 24V VRLA battery formed by two strings of dissimilar cells and monoblocs in a 100% d.o.d C_3 discharge/charge cycle service has revealed not unexpectedly that an asymmetric current flow from the strings occurs but that its implication on ultimate cycle service life is less significant than the strict rule of ñdo-not parallel dissimilar stringsòwould indicate.

Very rapid recharging of large VRLA cells
(Intelec 2000)

Summary
The high rate charge behavior of 2V 1000 Ah VRLA cells, subsequent to a full 12 minute rate discharge, is described. Charging rates with current equal to I_{10}, $3I_{10}$ and $7I_{10}$ were evaluated for their influence on cell and connector temperatures and gas evolution. The result show that high rate charging, at the $3I_{10}$ rate, can restore the UPS autonomy time within 1 hour without excessive cell heating and gas emission. The thermal imaging of the cells during the discharge and charge event allowed detecting the sites of maximum heating and heating transfer effects.

The operation of VRLA monoblocs with an on/off float charge regime
(Intelec 2001)

Summary
Stationary lead acid batteries of the VRLA type are the preferred power backup storage to safeguard communication systems and data networks. In such a standby power layout the battery is permanently on charge and connected to the load circuit requiring protection. Operation of VRLA batteries with an on/off or ñdroppedò charge voltage routine and combined with good thermal insulation appears to be a viable method to prevent that unstable temperature conditions develop in thermally unfavorable Telecom and UPS power installations. This passive protection method will require some modification of the power supply units control logic. Part of this is already implemented in advanced temperature vs. voltage management software

Overview of the revised IEC 60896-2-1 standard for the test of VRLA batteries for stationary service - An update
(Intelec 2001)

Summary
The evolution of the IEC Standard 896-2 for Stationary Lead Acid Batteries of the VRLA Type is shown together with the background for its revision. The revised standard IEC 60896-2-1 has reached the IEC CD Committee draft stage and defines in three sets of test clauses the methods to define safety, performance and durability.

A total of 23 test clauses and associated methods should allow defining the stationary VRLA batteries of a manufacturerõs product portfolio in such a fashion that the battery specifier or end-user can pick with confidence the most suited for his application field.

The performance of VRLA cells and monoblocs under artic conditions (Intelec 2002)

Summary
Stationary lead acid batteries of the VRLA-AGM design have been tested under Artic temperature conditions so to evaluate their performance under quite abusive conditions. The results show that up to 56% of the room temperature capacity is available at ï 30°C and that repetitive and severe electrolyte freezing within the cells and monoblocs does not result in any functional degradation.
ñFrozenò electrolyte cells can be recharged, albeit with low current acceptance, even at ï 30°C and the presence of ice does not result in active mass spalling.
The survival of monoblocs trapped in solid ice is also reported.

IEC 60896-22 ï The technical requirements for stationary VRLA batteries (Intelec 2003)

Summary
Since April 2000 the IEC TC21 WG3 has the task to establish the relevant International IEC Standards for the testing (IEC 60896-21) and selection (IEC 60896-22) of VRLA batteries for Stationary applications. The work has advanced well and the status of the activities was regularly reported at the INTELEC Meetings in Phoenix 2000, Edinburgh 2001 and in Montreal 2002.The standardization work has now reached its final stage with the elaboration of the second Standard IEC 60896-22 in which the application related requirements for these batteries have been defined.

We will give an update on the status of the standardization work as per 1.7.2003 to the INTELEC community.

Real-time VRLA life test or how a small difference can have big effects (Intelec 2004)

Summary
Stationary lead acid batteries can experience temperature differences within a string especially when operated as 110V or 480V back-up batteries. In the present study the influence of a ~3°C temperature difference on the corrosion induced capacity loss of VRLA monoblocs during 7 and 9 years of float operation in a 5 tier rack installation is reported. Corrosion sensitive VRLA monoblocs can have residual capacity values ranging all the way from 3% to 110% in the same string due the cumulative influence of such minor temperature differences. VRLA cells and monoblocs, in which positive grid corrosion has been designed-out as main failure mode, show a much more robust performance under these adverse conditions.

Ground short phenomena in VRLA batteries (Intelec 2005)

Summary
All electrochemical energy storage systems can cause unsafe operating conditions when an uncontrolled current flow over an electrolyte path to ground occurs. The influences of different variables, intervening in such an event, have been explored with lead acid batteries of the VRLA/AGM type. The tests show that the ground short current ranges from 0.1 to ~50mA and that direct line of sight through the breached cell wall is needed to initiate energetic event causing arcing and charring of the plastic. Lower voltages can cause higher current flows as arcing at high voltages (+200VDC) may reduce or fully boil off the conducting path. Although no catastrophic events such explosions or a full fledged fire where noted no safe ground short conditions exist!

Do you want to know more? ï RFID tags on stationary batteries (Intelec 2006)

Summary
Stationary batteries provide essential power back-up storage in many industrial applications. These batteries are manufactured at multiple locations worldwide, must fulfill exacting criteria of reliability and traceability and pass commonly through several logistic centers and hubs before starting the operative life.

Reliability requires that for a qualified battery design key material and process parameters are known and within specs. If trouble arises in the field from deviations of the properties of these batteries, a rapid and watertight traceability where such units are, is an essential requirement to soothe the nerves of the battery end-user and to evaluate the extent of the intervention needed.

Many of such tracing actions rely on information resident on shipping papers, data codes stamped on battery cases, alphanumeric ID number labels or barcodes containing serial numbers. These scattered bits of data are then used for manual or semiautomatic information correlation. Many, if not all of above identification criteria rely on ñseeingò the battery and reading optically the key information, then turning back to the battery manufacturer and asking him ñ*shall I be concerned?*ò

IEC TC21, the technical commission of IEC dealing with standards for rechargeable batteries is proposing to initiate work on defining the physical aspects of battery compatible RFID tags, the data structure and information content embedded therein and the access to such information. This standardization effort will not delve with the electronics of the data storage and interrogation and be thus open to technical progress in this matter.

The envisaged RFID tags could, next to the sketched in-the-field tracking purposes, also act as depository of information for scheduling refreshing charges, the setting up the rectifier parameters, alerting for replacements and ultimately help in achieving a more homogeneous material sorting stream in the battery recycling process by storing key material type and quantity information. In the presentation practical examples of hardware for storing, reading and writing information as also some example of the information data string together with a possible schedule for establishing such an IEC standard will be presented.