AVESTOR™ Lithium-Metal-Polymer Batteries Deployed throughout North America

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Abstract

Over the last 25 years AVESTOR has developed a revolutionary design for stationary Lithium-Metal-Polymer (LMP) batteries. Through extensive research and development, AVESTOR's efforts have resulted in a battery that offers a new level of high energy density, reliability and long life under the most extreme environmental conditions.

Since 2004, LMP-technology batteries have been deployed in volume by various North American telecommunications operators in existing applications as well as in new ones. Despite the price difference with VRLA batteries, service providers are finding multiple applications where it makes economic sense to use LMP batteries. The high energy density of the LMP batteries allows the telecommunications operators to increase their back-up time without having to add on to their infrastructure. The wide operating temperature range of the LMP batteries offers the flexibility to install the LMP batteries in harsh environments without the use of external climate control equipment and still assure a long life. Furthermore, the alarming features integrated in LMP batteries give the telecommunications operators the ability to have an efficient back-up power system.

The paper will describe, from the Service Providers' point of view, the applications where they have found it makes sense to use LMP batteries and what impact it has on their day-to-day operations. Specifically how does the usage of LMP batteries affect their maintenance, installation and engineering activities as well as the resource allocations to those activities. In addition, this paper will describe what criteria the service providers used in their decision process to deploy LMP batteries in specific applications and the results versus initial expectations.

1 Introduction

The unique electrochemistry, design and operating characteristics of the LMP battery makes it ideally suited for numerous telecommunication applications. This 48-volt mono-bloc was specifically designed for 48-volt DC power systems. The unique features of the LMP battery allow telecommunications providers, engineers and installers to "think outside the box" of traditional backup power solutions. When applying LMP batteries, a number of very specific modifications can be made to provisioning, installation and operating practices.

2 Environmental conditions

The LMP battery's internal heating and intelligence maintain the electrochemistry at 42.5°C, which is required for efficient energy exchange throughout its -40 to +65°C operating temperature range, without any external infrastructure support. The battery case insulation minimizes heat transfer between the battery and its environment**.** In cabinets, CEVs or huts, cooling capacity can be eliminated for the battery compartment, reducing ambient air-cooling infrastructure investment and operating cost**.** In fact, diverting cooling or ventilation away from the batteries and positioning the LMP batteries side-by-side without any gap between them will optimize their performance by reducing heat loss.

2.1 Hot environment

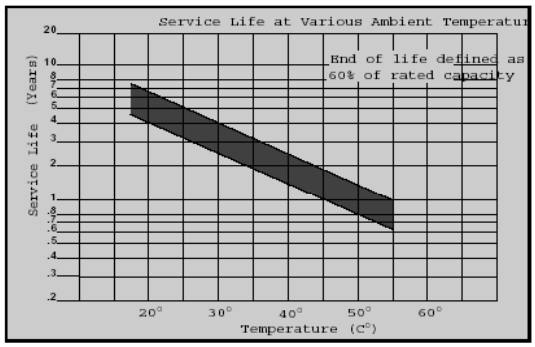
The LMP battery is very tolerant of high temperature environments and is designed to operate normally in ambient temperatures reaching 65ºC. Compared to other technologies for which life expectancy is reduced at ambient temperatures above 25ºC, the LMP battery is designed to and always operates at high internal temperatures, independent of the ambient temperature.

The unique concept of the lithium-metal-polymer technology involves an all-solid, rechargeable,

electrochemical generator made from two reversible electrodes physically separated by a dry solid polymer. The result is an electrochemical cell which is in a totally solid state, having neither liquid nor gel component, in which near 100 % of the mass is comprised of electrochemically active, heat tolerant materials.

That's why LMP batteries are warranted for 10 years non prorated over the entire temperature range from –40 to +65°C and up to 75 °C in storage, contrary to other technologies, which limit their warranties for warm environments.

Figure 1: VRLA service life vs. temperature



Several of our customers have selected LMPs for warm environments to reduce infrastructure cost and their total cost of ownership. Before, these customers routinely replaced VRLA batteries every 12-24 months.

One of our customers used special external cooling cabinets to keep the batteries cooler than the outside temperature, thereby extending the life of the battery. This cabinet cost several thousand dollars to engineer, furnish and install and required yearly maintenance. Additionally the cabinet took valuable real estate next to the remote terminal with the service providing equipment.

This customer realized immediate savings deploying LMP batteries because the initial cost difference between LMP batteries and VRLAs was offset by this external cooling cabinet cost difference.

Another customer's payback wasn't up front, but came within several years by eliminating the cost of yearly change out of VRLA batteries. This customer also elected to remove their external cooling cabinets and replace them with revenue generating cabinets, without having to increase the cost of real estate.

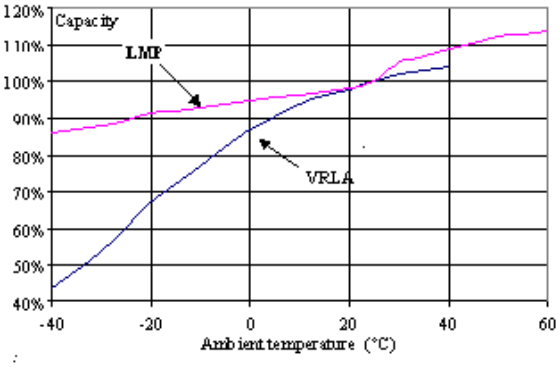
Figure 1 above indicates the expected life of VRLA batteries exposed to high ambient temperatures. Even in locations that only get very hot during the summer, LMP batteries may prove cost effective over a relatively short period of time. Also some uncontrolled premises applications with electronics equipment that generate lots of heat are good candidates for LMP batteries.

2.2 Cold environment

At -40ºC, the LMP battery will not freeze since it is made of entirely solid materials and its casing will not crack. During an extended outage, even with the external temperature at -40ºC the LMP battery will resume normal operation and recharge when AC power returns.

In outdoor applications in cold environments, it is common to oversize battery capacity to compensate for the degraded performance of traditional batteries. Figure 2 shows LMP and VRLA capacity over the operating temperature range. The LMP battery will use less than 15% of its capacity at -40°C, to maintain its optimum internal operating temperature with its integrated heating system. By comparison, traditional battery technologies, if still operational at this low temperature, will exhibit more than 50% loss of capacity.

Figure 2: Capacity vs. temperature



A customer of ours located in Alaska selected LMP batteries for its cold weather energy density. In this case they would have had to double the size of the cabinet selected for their network if they would have used VRLA batteries, exacerbating the task of obtaining scarce rights-of-way. Additionally they avoided the cost of heat pads, which are inefficient and occasionally have thermostat malfunctions, damaging the batteries they are supposed to protect.

3 High Density

At 1 Ah per pound, the LMP battery is less than 25% the weight of typical lead-acid or nickel-cadmium batteries. For telecommunications engineers, this means significant reduction in floor loading.

Figure 3 details floor loading for three LMP solution configurations: (1) a regular 7-foot, 23-inch telecommunication rack, (2) a special LMP battery frame and (3) a battery half-frame with a 42" power equipment rack (estimated at 200 lbs) mounted on top. For comparison purposes, an example of a typical 125Ah VRLA battery frame solution is included in the table. In all cases, the calculation for floor loading uses the front and rear spacing and/or aisle width as specified by Telcordia GR-63-CORE.

The chart clearly shows that you can get as much as 50% more energy, at less then half the weight, and in a smaller footprint than with VRLA and flooded LEAD acid batteries.

Figure 3: Floor loading information

Solution	Seismic rating	# batt	Total Ah	Shadow Area	Weight (lbs)	Floor Loading (lbs/ft^2)	
						Against Wall	w/ rear aisle
23" rack	4	16	1008	24.4"W 16.5"D	1345	439	422
	4	12	756		1037	338	326
LMP frame	4	18	1134	27.5"W 16.5"D	1628	471	453
Battery & power	4	9	567	27.5"W 16.5"D	1023	296	285
VRLA (125Ah) Frame Example		24	750	27.5"W 23"D	3638	775	753

3.1 Space Constraint

Finding enough space to install the necessary amount of batteries to support additional loads without having to go through extensive building redesign can be quite a challenge these days.

One of our customers needed to free-up space inside a walk-in cabinet (small shelter) to meet co-location requirements. They had two options to choose from. One was to remove the batteries from the main building and install LMP batteries outside in an uncontrolled environment cabinet mounted on the outside wall of the building. The other solution was similar to the first one except they would deploy VRLA batteries in a bulkier cabinet equipped with an environmental control unit on a concrete pad. The customer elected to go with the first solution, because they were able to save costs by not having to engineer and pour a concrete pad. Not having to acquire additional real estate was a key factor in their decision, and having LMP batteries installed in an uncontrolled environment cabinet reduced the cost of maintenance as well as the AC utility cost.

Several other customers have opted for LMP batteries for remote cabinet installations. These customers have added more power consuming DSL equipment to their POTS line cards to expand services to their customers. Many cabinets weren't designed with enough space to place the additional batteries needed to provide the extra backup power, so these customers have installed LMP batteries to provide the energy they need. The new 80 Ah LMP battery in the same footprint as the 63 Ah battery is approximately 3 times as dense as typical VRLA batteries. Because of this, for most of our customers, the limitation is now no longer the battery space, but the ability of the cabinet environmental systems to dissipate the heat from all the equipment.

3.2 Weight Limitation

The LMP technology provides a high-energy battery that's 1/4 the weight of a lead acid battery, which is a significant advantage when the customer needs to increase their backup capacity in areas where floor loading is an issue.

Adding battery backup to customer premises locations, particularly those situated in older buildings, could necessitate among other things, the reinforcement of the floor to support the battery's weight, a new cooling and ventilation system and possibly spill containment. These infrastructure upgrades are costly to the customer not only in terms of money, but also in term of time and efficiency.

One of our customers who provides long distance services needed to increase the transmission capacity of their network at certain locations. Adding more flooded lead acid batteries became impossible without a major floor reinforcement, which proved much more expensive than deploying LMP batteries in small, light, compact frames.

In older huts, floor loading is a major issue, and customers have deployed the LMP technology in this environment because of their light weight. One of our customers was able to increase their back-up time without going through the expensive process of upgrading the building infrastructure to accommodate the extra batteries. If the customer had decided to go the traditional lead-acid approach, they would have incurred a significant cost to lift the hut to reinforce the existing floor. Moreover, this couldn't have been done without disrupting services from the existing, live equipment within the building.

Having decided to go with the LMP technology, not only did the customer save money on the floor loading aspect of the project, he also saved money by

not having to upgrade the existing ventilation system that would have been required to support the extra lead acid battery hydrogen emissions. The LMP battery facilitated a very simple, quick and cost effective solution to a potentially very complex and expensive challenge. Because of this, our customer has standardized on LMP batteries for this application.

4 Installation, Maintenance and Remote Monitoring

LMP batteries are uniquely different than existing lead acid and nickel cadmium batteries in the way they are installed, maintained and monitored. These differences have allowed our customers to save money and increase network reliability.

Unlike VRLA and Ni-Cd batteries, LMP batteries have an electronics board called a Module Control Unit (MCU) to monitor, control and optimize the battery's performance. The MCU regulates the battery's internal temperature, balances and equalizes cells, prevents overcharging and over-discharging, measures the battery voltages and current, and exchanges information with external devices. It will also calculate its own State-of-Health (SOH), State-of-Charge (SOC), and perform self-diagnostics. All of this would need to be manually performed with VRLA or Ni-Cd batteries, and not nearly with the same accuracy.

The status of the LMP battery is automatically reported through green and red light emitting diodes (LED) mounted on the front of the battery. A green light means that the battery is operational with more than 80% of its rated capacity. A red light means that the battery needs to be replaced because of capacity fade or a major component fault.

These major and minor alarms can be sent via a Battery Alarm Kit over the cabinet alarm system. Built-in, accurate, self-diagnostic alarming that can be transmitted remotely is the key to a truly maintenance free battery. The other key component is the physical integrity of the battery, which doesn't require periodic inspection or maintenance. With the LMP battery there is no corrosion at the terminal connections, no electrolyte leaks or seepage and no case cracking. This is because it's a completely solid battery with no liquid or gel electrolyte. Leakage is therefore impossible and all the electrochemical materials and cells are enclosed in a completely sealed 0.16-inch thick aluminium case, isolating the components from the external environment. Unlike VRLA batteries that can swell and crack their casing, possibly causing electrolyte leakage and resultant corrosion, LMP batteries will not swell. LMP cells are compressed by an internal spring loaded pressure system that compensates for any cell volume variation within this hermetically sealed aluminium case.

The major reason that terminal posts and connections must be inspected and cleaned with VRLA batteries is because the electrolyte can move up the posts from the inside of the batteries and corrode the posts. Furthermore VRLA posts are typically made out of lead, which is a soft metal requiring regular re-torquing. The LMP battery has copper terminal posts and brass fasteners, having no inter-metallic reaction between them. This is the same type of material combination used for cabinet busbar connections. Testing has confirmed that even with vibration and temperature variations, the terminal connections are truly maintenance free and do not require any re-torquing. Overall, battery plant reliability is improved by integrating control and intelligence functions of the battery plant into each individual battery module, providing redundancy.

Installation of LMP batteries is also easier than VRLA or NiCd batteries. LMP batteries are shipped fully charged and can be stored without a recharge for up to 2 years. Voltage matching during installation is not required because the initial current inrush after installation goes to the LMP battery, which is a purely resistive load, thus avoiding excessive arcing or sparking. Also the terminals are "dead front" until the storage plug is removed, so the installation can be finished before the circuit is energized. The battery has built-in short circuit and reverse polarity protection that automatically disconnects the battery from the circuit, notifies the installer of the faulty installation via a flashing red LED, and confirms the fault is cleared before resuming normal operation.

The LMP battery is a truly a zero-maintenance battery that will notify the customer if it needs to be repaired or replaced. Several of our customers, who have remote cabinets that are difficult to access, particularly during the winter, have chosen LMP batteries for this reason. Periodic maintenance visits are very expensive, and having a battery that can accurately report faults is of tremendous value for these customers. Another large customer focused on LMP technology primarily because there was no more need for quarterly and year maintenance visits that are typical of flooded lead acid installations. By adding the cost of this maintenance over the life of the installation, the customer concluded that LMP batteries, while initially more expensive, paid for itself over time and actually saved the customer manpower and money.

5 Conclusion

Our customers have chosen LMP batteries for a number of their applications because they can take advantage of one or more of the several major benefits the technology has to offer. It was for this reason that a large customer of ours selected LMP batteries for their large, state of the art, Voice Over IP (VOIP) network. They chose lithium-metal-polymer batteries for their long guaranteed lifetime, no matter how extreme the climate. They chose it to eliminate "truck rolls" to maintain and check the batteries, taking advantage of the maintenance free aspect of the battery and also the accurate, remote monitoring that allows on-site checks only if the battery requires and calls for one. They plan to grow the network over time, and the LMP technology allows them to add new LMP batteries next to already installed batteries as new services and power demand increases. They chose to provision their new network not only with the latest communications equipment, but also with the latest and greatest backup battery technology that offered them the most cost effective and reliable backup power system available today.

At our customers' request, we have started working more closely with power and cabinet equipment manufacturers to integrate the alarm and monitoring features of the LMP batteries with their smart rectifiers and to facilitate the design of smaller, simpler, and more cost effective cabinets that maximize the space and infrastructure for revenue producing equipment in these cabinets.

Our customers are leading the way in applying the unique LMP battery technology to the many, varied and often challenging applications for which they have to provide reliable, cost effective backup power in their networks.

6 Literature

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