Journal of Power Sources, 19 (1987) 211 - 214

LEAD/ACID BATTERIES FOR SOLAR (PHOTOVOLTAIC) SYSTEMS

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Introduction

Although the price of oil currently remains low in every country of the world, considerable research and development efforts are being focused on solar power systems as a means of utilizing renewable energy sources. Photovoltaic devices have great potential for a wide range of applications in small-scale to large-scale units With this interest in the solar area, the market demand for batteries for use in photovoltaic systems is increasing rapidly

Initially, conventional batteries were universally applied in solar-based energy systems. However, it rapidly became clear that such batteries do not match the required performance criteria The author's company has therefore paid special attention to the development of lead/acid batteries for electricity storage from photovoltaic arrays Commercial production of such batteries was achieved in 1979 and since that time efforts have been devoted to increasing the product range and keeping pace with the wide diversity of customers' requirements.

Key parameters for photovoltaic batteries

Cycle life

In practice, photovoltaic batteries have a daily cycle of charge during sunlight hours and discharge during the night and even in daytime. The same cycle is required on cloudy days, however, on a smaller scale The batteries must have a service life of more than 10 years

Self-discharge characteristics

Depending on the conditions of sunlight at the installation site and the system design, the batteries may be in a partially discharged state for three months or more In this case, the charge deficit and self-discharge loss must be covered by increasing the battery capacity For this reason, it is essential to limit the self-discharge rate to 5% per month, or less In order to reduce battery size and to shorten the period of inadequate charging, however, there has been a recent move towards a greater scale-up of the solar cell arrays. Under these conditions, self-discharge characteristics are less critical

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Maintenance

Photovoltaic systems are often situated in remote areas, *e g* , on mountain tops, islands, or at sea. This causes problems with watering maintenance, charging, repairing and servicing of the batteries Thus, it is most important for the batteries to be as fully maintenance-free as possible, especially in regard to "topping up" Ideally, the interval between water additions should be more than one year

Economics

Technological improvements have resulted in a dramatic reduction in the price of solar cell arrays Indeed, the other required components now constitute a higher proportion of the total cost of the solar system. Thus, a similar reduction in the cost of the batteries is keenly sought

Classification of photovoltaic batteries

Two categories of photovoltaic batteries have been developed by the author's company a shallow-cycle type (PS-TL) and a deep-cycle type (CSL), see Table 1 The respective performance characteristics are given in Fig 1

TABLE 1

Lead/acid batteries developed for photovoltaic systems by The Furukawa Battery Co Ltd

Class	Shallow-cycle service (Type PS-TL)	Deep-cycle service (Type CSL)
Voltage (V)	2	2
Capacity (A h)	50 - 2600 (C/500)	130 - 2000 (C/10)
Intended specific applications	• Repeatedly shallow cycle discharged at small currents • Long periods of partial charge • For system engineering approach involving periods of five days or more darkness and inclement weather Examples Radio relay stations, railroad signalling	• Repeatedly deep cycle discharged at high currents • For system engineering approach involving less than five days darkness and inclement weather Examples Solar photovoltaic power station, power supply for high loads
Features	• Extremely good efficiency when discharged at small currents • Less self-discharge capacity • Long interval between water additions	• Extremely long-lived when deep cycle discharged • Long interval between water additions
Self-discharge	< 3% per month	< 15% per month
Interval between water additions	3 - 5 years	3 - 5 years
Life	~10 years, when cycled to 10% DOD/day	~10 years, when cycled to 25% DOD/day

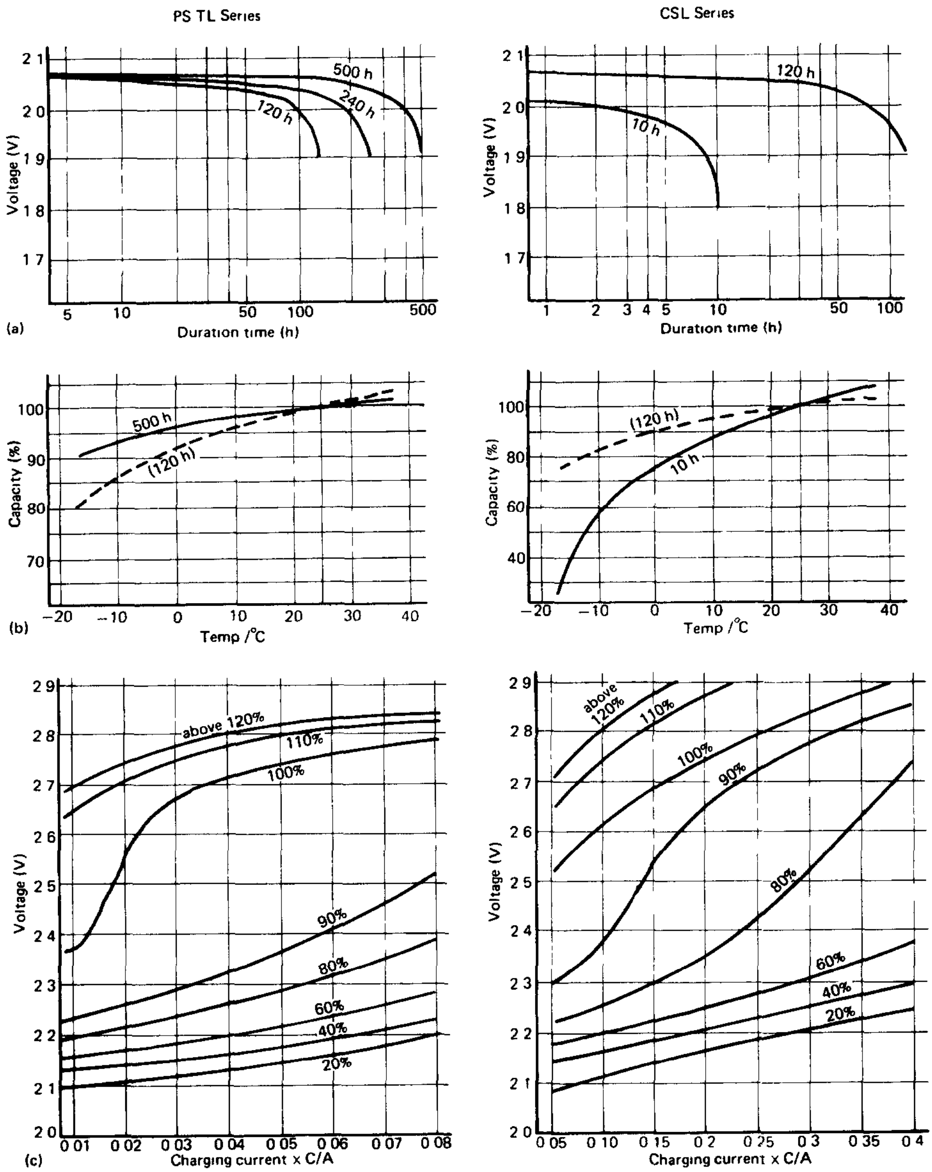

Fig 1 Performance of PS-TL and CSL series lead/acid batteries for solar applications (a) discharge characteristics, (b) dependence of capacity on temperature, (c) charge characteristics

The self-discharge capacity of type PS-TL batteries is reduced to one fifth that of conventional lead/acid batteries Also, the energy density is about twice that of conventional batteries when discharged at a low rate The latter is due to improved active-material utilization and an increased amount of electrolyte Type PS-TL batteries are best suited to sites where charging is low over long periods of time because of low insolation levels

The CSL batteries use a tubular, positive-plate construction The grid alloy is specially compounded to give good corrosion resistance and provide the batteries with long cycle lives These batteries are appropriate for locations with high insolation levels

Future developments

The future market expansion of solar photovoltaic systems depends heavily on economic considerations. Recent technological breakthroughs have reduced the cost of solar-cell arrays, but it is considered that further savings will prove difficult

The lead/acid battery is a mature technology and it is therefore to be expected that price reductions will only arise through higher volume production It is unlikely that alternative battery systems will replace the lead/acid battery in economic terms in the near future Closer attention should be directed towards minimizing the required battery capacity for remote-area, stand-alone, solar applications through improved systems engineering