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PERFORMANCE CHARACTERISTICS OF MAGNESIUM-LEAD CHLORIDE BIPOLAR BATTERY

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Magnesium-lead chloride batteries are suitable for some selected underwater applications like passive Sonobuoy. This cell system possesses constant steady voltage, quick activation time and long shelf life. In this paper, the performance characteristics of magnesium-lead chloride bipolar batteries consisting of different numbers of cells and the effect of temperature on the battery capacity are presented.

Key words: Activated, bipolar, shelf-life

INTRODUCTION

Magnesium sea water activated batteries are used in a wide range of underwater applications such as sonobuoy, life raft, lifebuoy, torpedo and other underwater detecting devices. These cell systems are characterised by long shelf life and quick activation time. A number of materials like silver chloride, cuprous chloride, lead chloride and copper oxalate have been used as cathodic depolarisers in magnesium reserve cell systems. Among these, magnesium-silver chloride system has been widely used because of high stability and low solubility of silver chloride. This system is more reliable and has other favourable electrochemical characteristics. The high cost of silver and the poor chemical stability of cuprous chloride led to the development of an activated battery system employing the cheap and stable lead chloride as cathode material. Hence, magnesium-lead chloride battery can be a suitable substitute for magnesium-silver chloride for some of the underwater applications.

The performance characteristics of magnesium-lead chloride multicell batteries have been reported [1,2,3]. Lead chloride possesses almost the same chemical stability, material efficiency and ampere hour capacity as that of silver chloride. The open circuit voltage of magnesium-lead chloride is 0.5V less than that of magnesium-silver chloride system.

The performance characteristics of 1.0V/3Ah magnesium-lead chloride single cells in which the cathodes consisted of lead chloride blended with graphite and binder and pressed on a grid were reported earlier[4]. In the present paper, the discharge data of magnesium-lead chloride bipolar batteries of different voltages viz. 2V, 3V, 5V and 10V and each cell containing 20 gms of lead chloride are presented.

EXPERIMENTAL

Magnesium alloy (Az31) sheets of dimensions 7.8cm x 5.8 cm x 0.15cm are used as anodes. The lead connection is provided to the anode by means of metallic rivets fixed on the magnesium plate. The cathode is presented by hot pressing 20gms of lead chloride over a copper grid. Thin plastic wires are used as spacers.

Each bipolar unit consists of magnesium plate on one side and lead chloride electrode on the other side, the two being connected by a metallic foil. The edges of each bipolar cell are coated with non-conducting materials to avoid the contact of the electrolyte with the inter-electrode junction. The battery is encased in plastic containers provided with holes both at the top and the bottom of the battery. These holes are provided for the free flow of electrolyte when the battery is activated and for the removal of waste corrosion products formed during discharge of the battery. Bipolar batteries exhibit a loss of electrical energy capacity due to the leakage current. This is minimised by proper sealing of the edges of the cells and suitable cell design. The battery is activated by immersing in 3.3% sodium chloride solution. Each battery was discharged at a constant current of 330 mA and the discharge continued till the battery voltage reached 90% of the initial voltage.

RESULTS AND DISCUSSION

The discharge behaviour of magnesium-lead chloride batteries consisting of 2, 3, 5 and 10 cells connected in series is shown in Fig.1. The battery voltage remains almost constant throughout the period

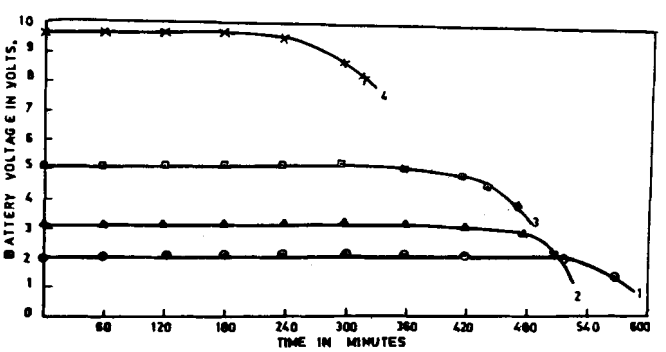

Fig.1: Discharge of Mg-$PbCl_2$ bipolar battery at 330 mA drain

⊙ – ⊙ ⊙ – *Two cells pack*
▲ – △ – △ *Three cells pack*
□ – □ □ *Five cells pack*
× – × – × *Ten cells pack*

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of discharge. From the figure, it is clear that the capacity of the battery decreases as the number of cells in series increases. The battery consisting of 10 cells has given only 5 hours of service life at 330 mA current drain whereas the battery consisting of 2 cells has given 8½ hours of service life at the same current drain.

The effect of temperature on the performance of 10V battery is shown in Fig.2. It may be observed from the figure that the

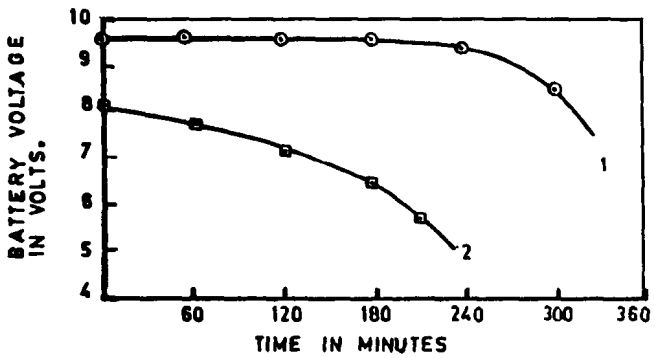

Fig. 2: Discharge of 10V Mg-$PbCl_2$ bipolar at 330 mA drain
⊙–⊙–⊙ *30°C*
–⊡–⊡–⊡ *0°C*

battery discharged at 273K shows a lower potential plateau and has given only 50% of the capacity of the battery discharged at 303K.

Fig.3 illustrates the variation of the battery capacity with the number of cells in series. It is evident from the figure that as

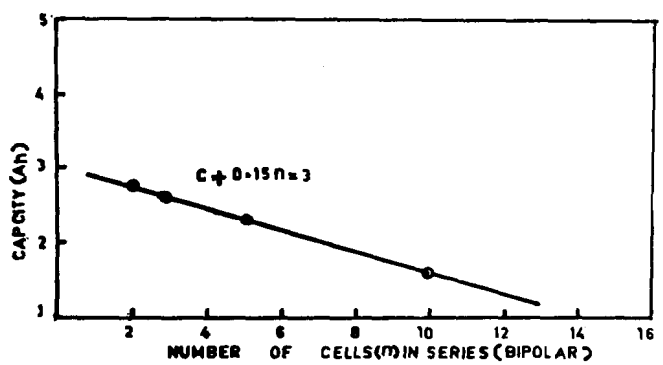

Fig.3: Capacity vs number of cells

the number of cells increases, the battery capacity decreases. This is due to the fact that the leakage current associated with bipolar cells increases with the number of cells resulting in the loss of capacity. The curve shown in Fig. 3 is a straight line depicted by the following equation.

$$C + 0.15\,n = 3$$

where 'C' is the capacity of the battery and 'n' is the number of cells in the battery connected in series. The above equation indicates that addition of each cell results in a loss of 0.15Ah capacity for a particular design of the battery which is reported here. The parameter 0.15 may get altered for a set of batteries of changed design.

TABLE-I: 10V/1.6Ah Magnesium-lead chloride bipolar battery

Size	5.9 x 5.9 x 7.8 cm
Weight	430 gms
Working voltage	9.5V - 8.5V
Time of activation	Less than 10 secs.
Current drain	330 mA
Duration	5 hours

CONCLUSION

From the results obtained, it may be concluded that both decrease in temperature and increase in the number of cells in series decrease the battery capacity. Magnesium-lead chloride system may be used as an alternative to magnesium-silver chloride battery for some specific applications like passive Sonobuoy.

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