

A Technical Note

A Cylindrical R-20 Size Zinc-Air Primary Cell*

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Summary

The design of primary zinc-air cells is described. Performance characteristics are presented for R-20 size cylindrical cells. The cells tested have been made from thermally hardened air cathodes prepared from a mixture of additionally activated active carbon and polytetrafluoroethylene, zinc anodes of pressed, amalgamated zinc powder, interelectrode separators, and 30% aqueous KOH solution electrolyte.

The cells when fresh, and after a period of storage, have satisfactory voltage-time characteristics at a maximum permissible current capability of 25 mA/cm².

Introduction

Our study of the construction of zinc-air cells is based on the earlier publications of Espig and Porter [1], with special attention being given to the development of an efficient production technology, bearing in mind that the costs of the materials used and the production costs are decisive in determining the market for the cells.

In this paper we will provide data on a high efficiency, R-20 size zinc-air cell with an alkaline electrolyte which can be used instead of the same size zinc-manganese dioxide cell.

*Based on a paper presented at the 28th meeting of the International Society for Electrochemistry, Varna, Bulgaria, September 1977.

Construction of the cell

The cell consists of the following elements:

(1) Porous carbon-plastic cathode [2], prepared from a mixture of catalysed active carbon [3], colloidal liquid PTFE-TF 5034-Hostafion, and a porophore for the active layer, and a mixture of active carbon, PTFE-TF 5034-Hostafion, and a porophore as the hydrophobic layer.

The active and hydrophobic layers were pressed together on a nickel grid and then hardened at 280 °C. Finally, this assembly was mounted as the cathode of a cell.

The porosity of this carbon-plastic cathode was 60 - 65%.

(2) Porous zinc anode, prepared from amalgamated zinc powder (more than 6% mercury) pressed in a mould of appropriate shape in order to obtain open-ended, barrel-shape anodes with internal current collectors.

The porosity of the anodes made in this way was greater than 35%.

(3) Electrolyte: this consisted of an aqueous solution of potassium hydroxide thickened with carboxymethyl cellulose.

Characteristics of the construction of the cell [4, 5]

As can be seen from Fig. 1, the carbon-plastic cathode, 4, forms a cylindrically-shaped container for the cell. The porous, cylindrical zinc anode, 5, mounted on the perforated, barrel-shaped current collector, is placed inside the cathode. The interior of the current collector and the space between the electrodes is filled with plastic separators saturated with alkaline electrolyte, 6. This construction ensures that electrolyte is in contact with both faces of the cylindrical anode and also increases the amount of electrolyte in the cell. The top of the cell is closed with a cover on which an insulating gasket, 3, is located, which also isolates the cap which is connected to the cathode, 4. A non-return valve, 2, is fitted axially in the cover and gasket. This valve permits release of gas and excess electrolyte from the cell, and between the gasket and the cap there is a material to absorb electrolyte. The base of the cell is similarly closed with a cover, 9, and an insulating gasket, 3, through which a connector passes connecting the anode current collector with the

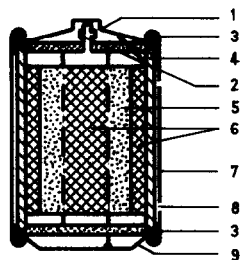


Fig. 1. R-20 Zinc-air cylindrical cell — cross section.

1, cathode cap; 2, non-return valve; 3, insulator-gasket; 4, air diffusion carbon cathode; 5, zinc anode; 6, separator saturated with KOH; 7, steel tube; 8, breathing holes; 9 cover.

cover, 9. The complete cell assembly is placed in a steel tube, 7, in which there are air breathing holes, 8. Between the steel tube, 7, and the cathode, 4, there are distance sleeves at the top of the cell.

Electrical tests

The R-20 zinc-air cell described above has been tested according to ISE and Polish Standards for this size of cell. The test parameters were:

Discharge resistance (R)	5 ohms
Final on-load voltage (V_k)	0.75 volts
Daily discharge time	30 min
Total discharge life	11.5 h
Storage time of the cells	6 months at 18 °C in sealed polyethylene containers.

In addition, continuous discharge tests, 24 hours per day, were carried out with a discharge load of 5 ohms, but with all the other parameters of the Standards unchanged.

In Table 1 the results of comparative tests on R-20 size zinc-air cells and manganese dioxide cells are given. Tests were carried out with cells when new and after 6 months storage, and on intermittent and continuous discharge.

In Fig. 2 the discharge curves for the R-20 size MnO_2 and zinc-air cells on intermittent discharge, and in Fig. 3 the curves for the continuous dis-

TABLE 1

Comparative test results for R-20 size zinc-air- and manganese dioxide cells

Test parameters	Unit	Test conditions: Room temperature, 5 ohms							
		Intermittent 30 min/day				Continuous 24 h/day			
		New cells		Cells after 6 months storage		New cells		Cells after 6 months storage	
		MnO_2	Zn-air	MnO_2	Zn-air	MnO_2	Zn-air	MnO_2	Zn-air
Voltage	V	1.5	1.24	1.5	1.24	1.5	1.24	1.5	1.24
Discharge duration	h	16	36	11	18	13	82	11	44
Output	A h	2.6	8.8	1.8	4.6	2.1	20	1.8	11
Volume	l	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Weight	kg	0.09	0.10	0.09	0.10	0.09	0.10	0.09	0.10
Specific output	A h/kg	29	88	20	46	23	200	20	110
	A h/l	52	176	36	92	42	400	36	220
	W h/kg	43	110	30	57	36	250	30	136
	W h/l	78	220	54	114	64	500	54	270

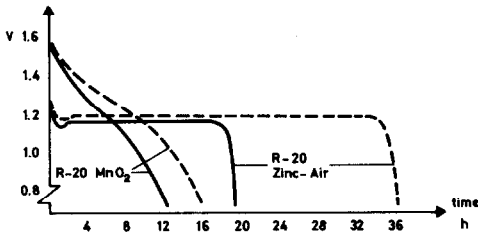


Fig. 2. R-20 MnO_2 and zinc-air cells. Discharge characteristics when new and after 6 months temperate storage. Test conditions: discharge through 5 ohm, 30 min/day at room temperature, ----- cells when new, ——— cells after 6 months storage.

charge are shown. From these curves it can be seen that the voltage of the zinc-air cells when new is constant, and only slightly below 1.2 V for the whole discharge time on both intermittent and continuous discharge. After storage the shape of the discharge curve is basically similar to that of new cells but the initial voltage drop and subsequent recovery is accentuated, and the discharge duration is only about half that of new cells.

The current-voltage relationships for R-20 size manganese dioxide and zinc-air cells are shown in Fig. 4, from which it will be seen that there is sufficient similarity in this characteristic for the two types of cell to be considered to be interchangeable for most applications.

Discussion

The results obtained from the electrical tests on the R-20 zinc-air cell lead us to the following conclusions on the construction and technology of the cells:

The construction provides means of increasing the amount of electrolyte, a possibility which has been previously overlooked [1, 6]. This increase is obtained by the use of a cylindrical anode, the interior of which acts as an electrolyte reservoir. This construction has the added advantage that on the

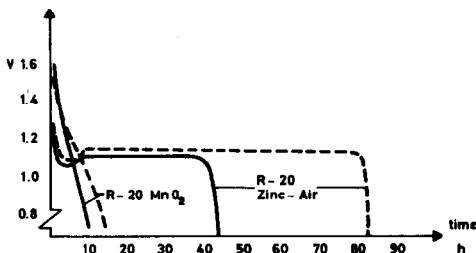


Fig. 3. R-20 MnO_2 and zinc-air cells. Discharge characteristics when new and after 6 months temperate storage. Test conditions: continuous discharge through 5 ohm, 24 h/day at room temperature, ----- cells when new, ——— cells after 6 months storage.

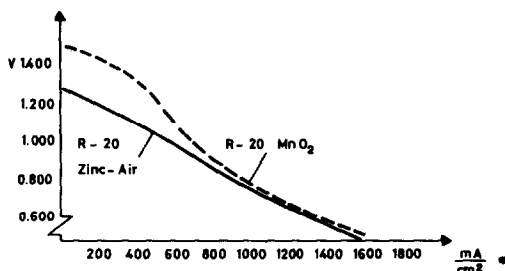


Fig. 4. R-20 MnO₂ and zinc-air cells. Voltage-current characteristics for cells when new. ---- MnO₂ cells, — zinc-air cells. The current density is referred to the geometric surface area of the carbon cathode of the zinc-air cell and the zinc can anode of the MnO₂ cell.

5 ohm discharge test about 90% utilization of the zinc is obtained at almost constant voltage.

Leakage of electrolyte is protected against in the present construction by a special valve. This form of cell closure appears to be effective, as no exudation of electrolyte has been observed during, or after, 6 months storage. Further, it can be seen from Figs. 2 and 3 that the use of an electrolyte thickened with carboxymethyl cellulose does not result in any increase in ohmic resistance of the cells when new or after storage.

The current-voltage characteristic of the cell is sufficiently similar to that of the same size of manganese dioxide cell for the two types of cell to be interchangeable for most applications.

The method of construction of the plastic-carbon cathodes for this cell is applicable to all cells in the R range, from R-6 to R-40, as well as to cells for watches and hearing aids.

The cathodes used in the cells were prepared from active carbon additionally activated, catalysed with 3 - 5% of silver, and thermally hardened.

We hope that this construction makes the cells fully interchangeable with other R-type cells.

References

- 1 R. E. Mick, J. W. Cretzmeyer and D. L. Douglas, in D. H. Collins (ed.), *Power Sources* 5, Academic Press, London, New York, 1973.
- 2 K. Appelt and L. Malanowski, P.R.L. Patent P - 171 153.
- 3 K. Appelt, J. Fica, L. Malanowski and K. Skoczowski, P.R.L. Patent P - 188 991 (23.04.1976).
- 4 K. Appelt, L. Malanowski and R. Koczorowski, P.R.L. Patent P - 185 139 (29.11.1975).
- 5 K. Appelt, L. Malanowski and R. Koczorowski, P.R.L. Patent - 197 198 (31.03.1977).
- 6 J. W. Cretzmeyer, H. R. Espig and R. S. Melrose, in D. H. Collins (ed.), *Power Sources* 6, Academic Press, London, New York, 1977.