INFLUENCE OF SEPARATORS, EXPANDERS AND ELECTROLYTE PURITY ON THE PERFORMANCE OF MAINTENANCE-FREE LEAD/ACID BATTERIES

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Introduction

Water consumption is an important parameter used to estimate the performance of a maintenance-free lead/acid automotive battery, *i.e.*, the weight loss after constant-voltage charging at 14.4 V for 21 days at 40 °C. The water loss is expressed in terms of $g\,(A\,h)^{-1}$ for a 12-V battery [1]. Water consumption depends upon the purity of the electrochemical system, foremost on the composition of the grid alloys. The effects of the other battery components are known but the data are less available.

Experimental

The batteries under examination were 12 V/40 A h/180 A Type L1-W units [1] with a grid thickness of 1.4 mm. The composition of the grids for both positive and negative plates is given in Table 1. Since with the tank formation process the electrolyte gradually becomes contaminated, especially with antimony compounds, the test batteries were formed either in electrolyte prepared from analytical grade sulphuric acid or in a common operational electrolyte. For comparison purposes, batteries were also prepared by the container formation method. The basic composition of the electrolyte is given in Table 2.

Two types of expander were used in the negative paste. The first contained 0.2 wt.% of the Czechoslovakian expander SE 201 [2] and the second [3] was a mixture of 0.17 wt.% SE 201 and 0.13 wt.% Soviet expander BNF (note, wt.% is related to the weight of the dry oxides).

The effect of the choice of separator on battery characteristics was examined using: (i) Czechoslovakian separator AKUPOR (which is based on sintered PVC powder); (ii) DARAK ARMORIB (Grace); (iii) Czechoslovakian non-woven fabric VIATEX PSE 120L with PVC-pipe spacers.

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TABLE 1

Composition of grid alloy (wt.%)

Antimony	2.66	Silver	0.0091
Arsenic	0.138	Bismuth	0.0186
Copper	0.00397	Cadmium	0.0002
Selenium	0.0236	Nickel	0.0004
Tin	0.037	Zinc	0.0001

TABLE 2

Electrolyte impurities (wt.%)

Number of electrolyte	Type	Density (g cm^{-3})	Impurities	
			Type	Wt.%
1	Analytical grade (Czech. standard) used after dilution	1.839	Cl	0.00005
			NH_4	0.0003
			As	0.000003
			Fe	0.00008
			Se	0.0003
			heavy metals (Pb)	0.0003
			Substances oxidized by permanganate	0.0005
			Residue on ignition	0.0005
2	Filling, technical grade	1.28	Cl	0.0008
			Fe	0.0023
			Mn	0.00002
			Cu	0.00002
			Substances oxidized by permanganate	0.003
3	Operational	1.10	Sb	0.00012
4	Operational	1.10	Sb	0.00018

Results

Water consumption data according to tank- and container-formed batteries are given in Tables 3 and 4. The results obtained with different types of separators are presented in Table 5. The latter also contains measurements of the rapid discharge (cold cranking) parameters and the internal resistance at −18 °C.

Discussion

The powerful influence of electrolyte composition can be seen in the case of tank formation. For example, use of analytical grade electrolyte

TABLE 3

Influence of electrolyte purity on water consumption
L1-W batteries: tank formation.

Electrolyte[a]			
Formation (sp. gr. 1.10 g cm^{-3})	Filling (sp. gr. 1.28 g cm^{-3})	Expander	Water consumption (g (A h)$^{-1}$)
1 AG	1 AG	SE 201	6.6
1 AG	2 TG	SE 201	7.0
3 OP	2 TG	SE 201	7.4
4 OP	2 TG	SE 201	7.75
1 AG	1 AG	SE 201 + BNF	5.5
1 AG	2 TG	SE 201 + BNF	6.1

[a] See Table 1 for reference number.
AG = Analytical grade; OP = Operational; TG = Technical grade.

TABLE 4

Influence of electrolyte purity on water consumption
L1-W batteries: container formation.

Electrolyte[a] (density 1.24 g cm^{-3})	Expander	Water consumption (g (A h)$^{-1}$)
2 TG	SE 201	8.2; 8.6
1 AG	SE 201	8.6
2 TG	SE 201 + BNF	6.3
1 AG	SE 201 + BNF	7.8

[a] See Table 1 for reference number.
AG = Analytical grade; TG = Technical grade.

TABLE 5

Influence of separator type on performance of L1-W batteries

Separator type	C_{20} capacity (A h)	Cold cranking discharge time to 6 V[a] (min)	30-s voltage (V)	Internal resistance at −18 °C (mΩ)	Water consumption (g (A h^{-1}))
AKUPOR	42.0	2.72	9.09	12.8	6.5
DARAK-ARMORIB	42.2	2.53	8.93	13.0	2.65
VIATEX PSE 120L	42.3	2.52	9.62	9.3	8.4

[a] 180 A at −18 °C.

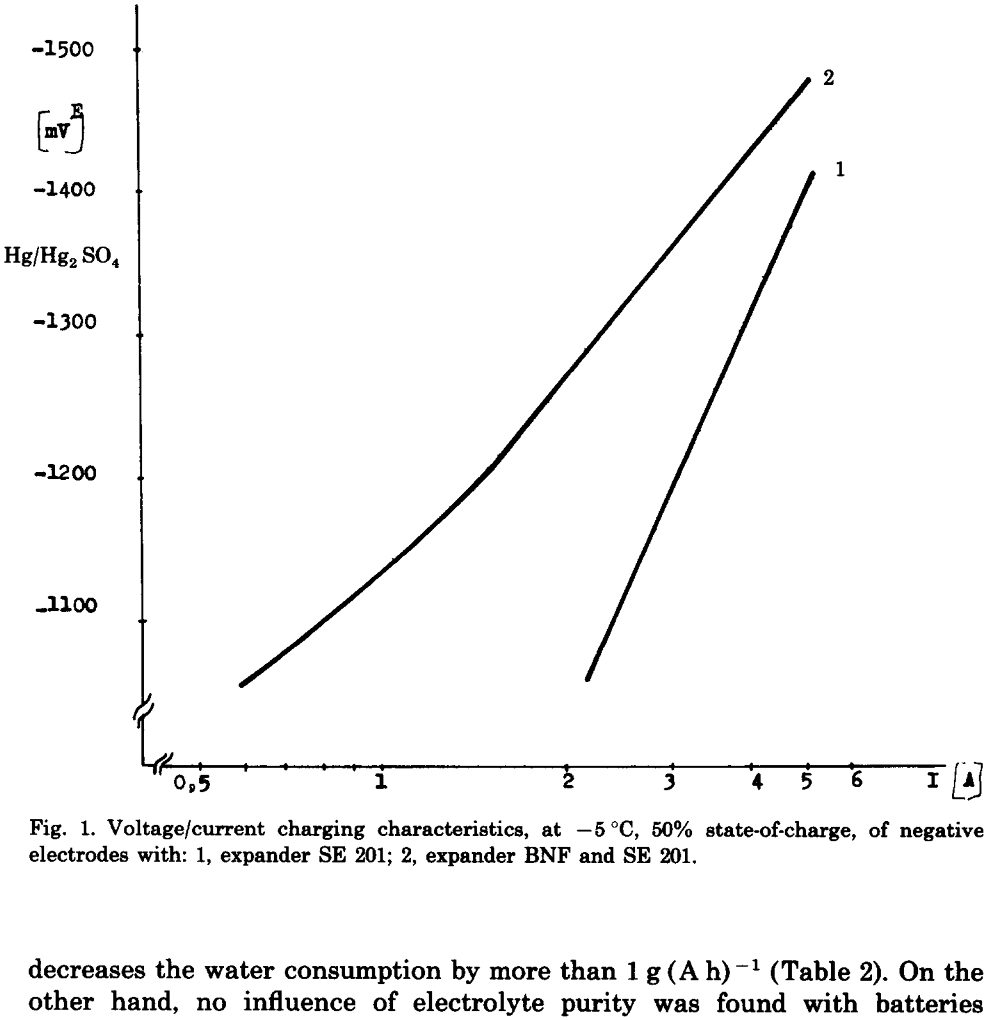

Fig. 1. Voltage/current charging characteristics, at −5 °C, 50% state-of-charge, of negative electrodes with: 1, expander SE 201; 2, expander BNF and SE 201.

decreases the water consumption by more than 1 g (A h)$^{-1}$ (Table 2). On the other hand, no influence of electrolyte purity was found with batteries prepared by the container formation procedure (Table 4). Any effect may be masked by other factors, *e.g.*, the formation temperature.

Studies using different expander types provided some interesting results. In particular, it was discovered that the blending of SE 201 and BNF expanders gave rise to a decrease in the water consumption of ~1 g (A h)$^{-1}$ [1]. The current flowing through the battery was always ~10% less with blended expander than with SE 201 expander alone. Figure 1 shows the voltage/current charging characteristics of negative electrodes using either type of expander at a temperature of −5 °C and a 50% state-of-charge. It can be seen that the observed decrease in the water consumption is related to a retardation in both the charging ability and the evolution of hydrogen.

Investigations also revealed that the separator type exerted a significant effect on battery performance. The observed differences (Table 5) cannot be equated with differences in either the pore size or the electrolytic resistance of the separators. In other published work [4], it has been shown that the passage of antimony from the positive to the negative electrode is markedly dependent upon the pore size of the separator, but the observed water consumption in this work is independent of the latter. It is concluded that PVC separators are chemically inert and the measured water-consumption values are equivalent to the rate of antimony transport taking place in the system studied here. In the case of DARAK ARMORIB separators, the low water consumption is probably caused by the selective absorption of organic compounds on the antimony particles that are deposited on the surface of the negative electrode [5].

References

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