Characteristics of Different Types of Separators used in the Manufacture of Lead-Acid Battery

by P. V. VASUDEVA RAO, S. GHOSH AND H. V. K. UDUPA

Central Electrochemical Research Institute, Karaikudi

ABSTRACT

VARIOUS types of synthetic separators made out of plastic, rubber, fibres etc., are being used in the manufacture of lead-acid battery in the country in addition to the indigenous wooden separators. Brief account of the procedure adopted and the results obtained in the measurement of such properties of these separators as electrical resistance, life under accelerated test conditions, porosity, flexibility and tensile strength; iron, manganese and other impurities content, are presented. Attempts have been made to study the properties of these separators after their use in the battery. The lead salts included in the separator during use and their subsequent reduction to lead has been found to be one of the causes of short-circuit in a battery in service.

INTRODUCTION

Separators form one of the vulnerable parts of the lead-acid battery and more often than not, the failure of a battery can be attributed to the failure of the separator and especially so when wooden separators are used. To overcome this defect, synthetic separators made out of plastics, rubber and fibre are used in recent years with success. As most of the separators are proprietory, comparative data of the synthetic separators with the wooden ones are not available. The aim of this work is to present data on the five types of separators which are being used by the battery manufacturers in the country. To keep the propriety of the make, type is indicated only by the material of make of the separators viz., (1) Wooden, (2) Plastic I, (3) Rubber, (4) Fibre, (5) Plastic II. The following tests were carried out on the separators: (1) Electrical resistance, (2) Life under accelerated test, (3) Flexibility, porosity and tensile strength, (4) Mn, Fe, etc., content, and (5) Properties after use in the battery.

The different separators used in the study were obtained from the various manufacturers



Fig. 1: WOODEN SEPARATOR (foreign) X 150

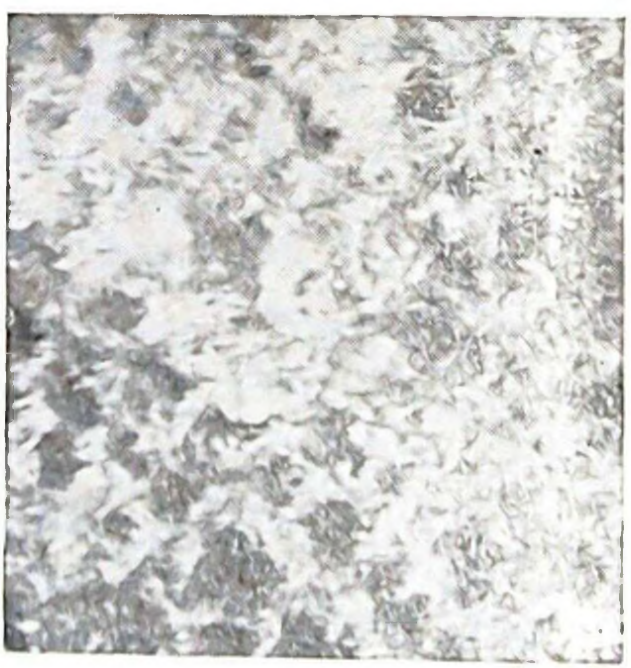


Fig. 2: WOODEN SEPARATOR (Indian) X 150



Fig. 3: FIBRE — SEPARATOR X 150

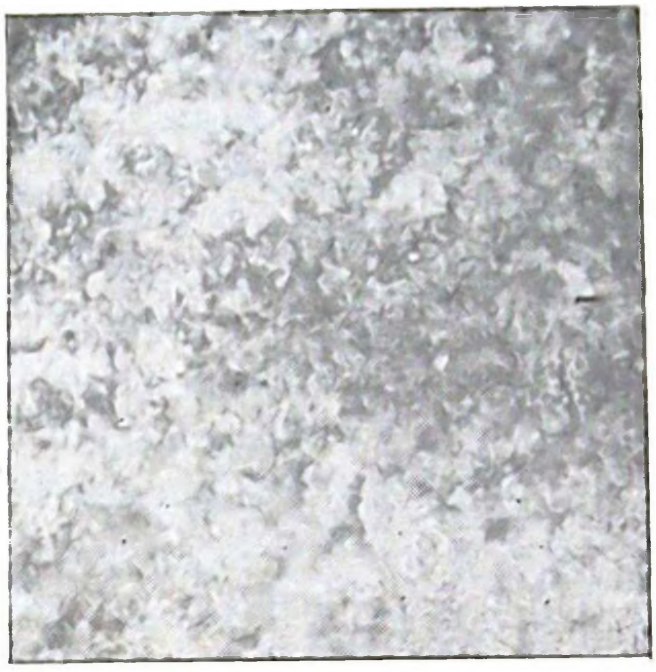


Fig. 4: RUBBER SEPARATOR X 150

and used separators were obtained from old batteries fitted with those separators.

EXPERIMENTAL AND RESULTS

1. Electrical resistance—

The electrical resistance measurements were carried out according to I. S. Specification 652-1955. A Philips conductivity meter, which corresponds to the circuit given in the specifications for the measurement of resistance, was used as the a.c. bridge. Measurements of resistance were made on separators which were immersed in sulphuric acid of sp. gr. 1.280, immediately and after fourteen days of immersion time. The resistance value of the synthetic separators were not found to change whereas the resistance of wooden separators came down slightly after fourteen days. This is due to the extraction of the ligneous material from the separator, due to which the acid becomes brownish after the immersion period is over.

The resistance of the separators is an important property because it is one of the factors contributing towards the internal resistance of the cell. All the separators were found to pass the test as specified by Indian Standards Institution. But the resistance after it has been used in a battery was found to increase tremendously as seen from Table I. This is perhaps due to inclusion of lead salts in the pores of the separator as was found out by actual analysis.

2. Life under accelerated test condition—

This test gives the comparative performance of the different types of separators under the same accelerated testing conditions.

TABLE I

Electrical resistance of separators

Type	*Electrical resistance (ohm/sq. in.)*		*Life under accelerated test* (hours)*
	New	*Used*	
Wooden	0·03	0·276	70
Plastic I	0·027	7·000	109
Rubber	0·030	**	171
Fibre	0·0027	**	85
Plastic II	0·003	**	149

* Average of five tests

** Used separators not available for test

The set-up used for the same is given in Fig. 9. The separator under test is interposed between two lead blocks kept in sulphuric acid (sp. gr. 1·280) and connected to the positive and negative terminals of a direct current source respectively. The lead blocks were stopped off except for the portion which was in direct contact with the separator. Few more lead blocks are kept on the top block to impress a pressure of 20 kgm/dm². on the separator; a kilowatt meter was connected in series in the circuit to record the total current passed and to calculate the number of hours of life under constant current conditions. A constant current of 5 amp was passed (current density, 20 amp/dm²) between the two lead blocks. When the separator failed, the lead blocks were short-circuited and the voltage across the separator dropped nearly to zero. This voltage difference was taken account of by an electronic relay which put off the d.c. The conditions under which the test was carried out simulates more or less the conditions under which a separator functions in a battery. Table I shows the results obtained with the different types of separators. The lead salts included in the pores of the separator got reduced to lead filaments stretching from the negative plate to the positive and thereby led to shorting. The lead filament formation was observed by examining the thicknesswise section of the separator after shorting, under the metallurgical microscope (Fig. 8).

3. Tensile strength, porosity and flexibility

Tensile strength :—The tensile strength of the separators was measured by loading a known-cross section of the separator and noting the weight at the breaking point. This gave approximately the ultimate tensile stress and measurement was carried out to compare the strength of the separators before and after use in a battery. The figures given in Table II are for new separators. Cells were assembled with these separators and as soon as their life was over, the used separators from them will be taken up for further measurements. The data collected here, more or less indicate the order of strength of the various synthetic materials of which the separators are made of, but this will not give an indication of the order of their life in a battery. This factor depends upon how the separator material is affected by the environment inside the battery.

The porosity is an important factor which determines the amount of acid that can diffuse through the separator. Plastic I has very good porosity as seen from Table II. At the same time, too high a porosity may not prove advantageous as the chances of lead salts being included, leading to short-circuiting is increased. Photomicrographs of the cross-section of the separators are given in Figs. 1 to 7.

The flexibility of the separators is dependent upon the nature of the material of which it is made. From Table II, it can be noted that plastic separators have very high flexibility, probably due to the cross linkages in the polymer of which they are made. Rubber has a low flexibility due to poor bonding of the particles as can be seen from the photomicrographs. The flexibility of other separators are also to be explained as due to same reasons as above.



Fig. 5: RUBBER SEPARATOR WITH GLASS WOOL SUPPORT X 150



Fig. 6: PLASTIC I — SEPARATOR X 240

TABLE II

Tensile strength, porosity and flexibility of separators made of different materials

Type	*Porosity %*	*Flexibility*	*Tensile strength (lb/sq. in.)*
Wooden	52·5	Flexible	130*
Plastic I	79·0	Highly flexible	279·00
Rubber	45·5	Fragile	507·00
Fibre	53·5	Fragile	796·00

* From literature



Fig. 7: PLASTIC II — SEPARATOR X 150

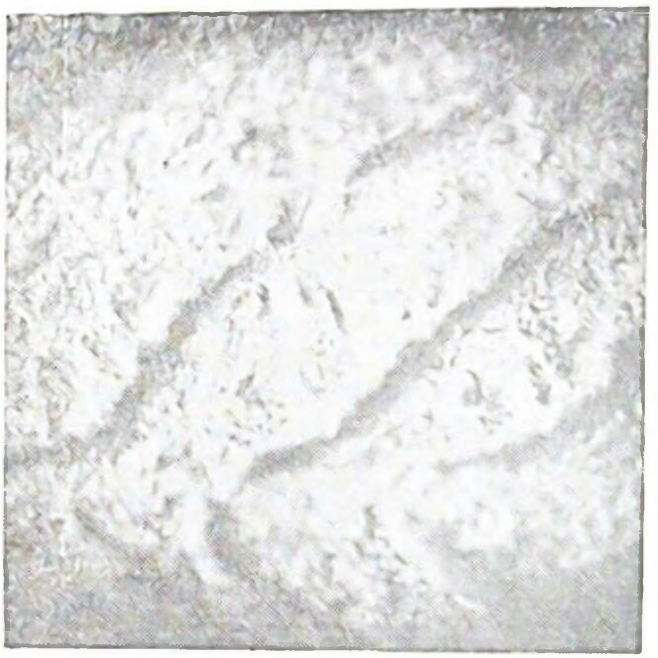


Fig. 8: CROSS SECTION SHOWING FILAMENT OF LEAD, AFTER USE IN A BATTERY X 150

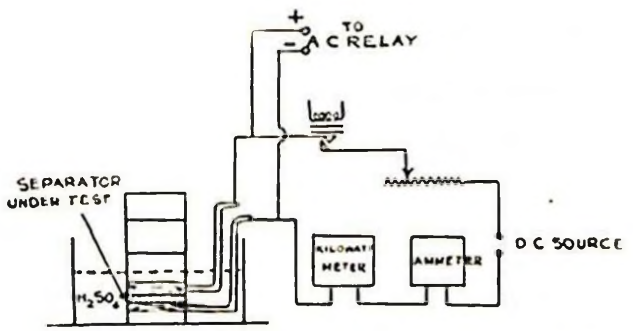


FIG 9 ARRANGEMENT FOR ACCELERATED TESTING OF LIFE OF DIFFERENT TYPES OF SEPARATORS

4. **Manganese, iron, chloride and other impurities before and after use of the separators—**

The wooden separators contain manganese and iron and they are removed while processing to a limit admissible according to I. S. specification. It was found that out of four different samples of separators of indigenous wood tested, all passed the test for manganese but two of the samples did not pass the test for iron. The results of test carried out are given in Table III. As iron is a very undesirable impurity due to its redox nature, proper steps have to be taken by manufacturers to see that iron is more or less completely eliminated. Complete elimination of iron by the usual methods is difficult to achieve as the Indian wood used for the manufacture contains considerable amount of iron absorbed from the ferruginous soils. Special methods of processing, therefore, will have to be adopted to see that this defect is overcome. In the case of synthetic separators, it was observed that certain samples gave considerable amount of chloride before use in the battery. This chloride might have come from the fillers which have probably not been completely removed. The separators were found to con-

tain lead salts included in them after use as shown in Table IV. The amount of inclusion was found to vary according to the porosity of the separators, and the resistance of the separators increased during use as could be seen from the table. This inclusion of lead salts in the separators and its subsequent reduction to lead filaments was found to be one of the reasons of short-circuits occurring in a battery in service.

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TABLE III

Results of testing wooden separators (Indian) as per I.S. Specification 652-1955

Sample No. obtained from different manufacturers	*Dimension tolerance*	*Electrical resistance**	*Manganese content** mg/100 g of even dry sample*	*Iron content*	*Remarks*
1.	Passed the test	Passed the test	Passed the test	Passed the test	Finish is good. 20 to 40% break on bending test.
2.	—do—	—do—	—do—(0·031)	Not passed the test	Not satisfactory. 20 to 40% break on bending test.
3.	—do—	—do—	—do—(0·033)	Passed the test	—do—
4.	—do—	—do—	—do—(0·035)	Not passed the test	Good. 20 to 40% break on bending test.

* Should not be more than 0 07 ohm/sq. in of face area.

** Should not exceed 1·5 mg per 100 g of even dry separator.

TABLE IV

Chloride content of separators and data on inclusion of lead salts in separators after use

Type	*Manganese and iron content (New)*	*Chloride content %*		*Lead salts after use in a battery expressed as $PbSO_4$ (g/cm²)*
		New	*Used*	
Wooden	Passed for Mn content, few samples did not pass for Fe.	Nil	Nil	0 0026
Plastic I	Nil	0·78	0·38	0·00256
Rubber	,,	0·10	Nil	0·0052
Fibre	,,	0·021	,,	0·063
Plastic II	,,	Nil	,,	0·035