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# CURRENT TECHNOLOGY OF SEPARATORS FOR SEALED (RECOMBINATION) LEAD/ACID BATTERIES

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## Growth of sealed lead/acid market

The sealed lead/acid battery (SLA) was first patented by the Gates Company in the U.S.A more than 10 years ago. Licensees of the Gates technology commenced the manufacture of commercial batteries starting with small cells. The SLA has, as its name indicates, the unique property of being completely sealed. This was made possible through the recombination of hydrogen gas and oxygen gas in the cell (hence such lead/acid batteries are known as recombination systems). The most suitable separator for this system is glass microfibre mat without a binder.

Figure 1 shows the worldwide trend in the usage of glass-fibre separators. Taking usage in 1986 as 100, the level in 1980 was only 20. Before that year, the increase was minor From the early 1980s onwards, the consumption rose markedly. Battery manufacturers hold the opinion that usage in the next several years will increase dramatically It is most likely that a 30% annual increase will occur in the next three years so that consumption will be double the present figure in 1989.

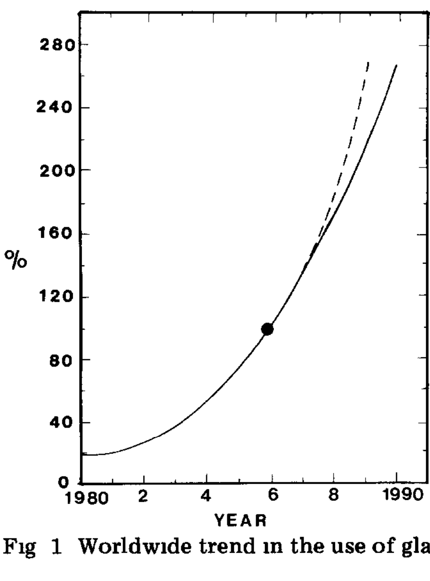


Fig 1 Worldwide trend in the use of glass-fibre separators (normalized to 1986)

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Until the early 1980s, the application of SLA systems was limited mostly to smaller cells that were used for stand-by lights, toys, miners' cap lamps, etc Between 1981 and 1986, the market was extended to medium and large sizes of batteries for motorcycles, marine batteries, video cassette/tape recorders, emergency lights, computer back-up, modular telephones, various industrial applications, etc. The third stage of development (from 1986 onwards) will involve an expansion of the established applications together with use of SLA technology in automotive and aeroplane batteries Major automotive battery manufacturers have completed technical studies on the application of SLA systems The concern is no longer associated with technical issues, but rather with economic issues

The numbers of battery manufacturers with respect to the size of the SLA business are given in Table 1 Here, large is defined as using more than 200 tonnes of separator material per year, medium is more than 50 tonnes, and small is less than 50 tonnes It can be seen that business has been expanded in the number of companies involved with SLA technology as well as in the size of production

TABLE 1

Numbers of manufacturers producing sealed (recombination) lead/acid batteries

| Year | Business volume | | |
|---|---|---|---|
| | Large | Medium | Small |
| 1980 | 1 | 2 | 4 |
| 1986 | 5 | 13 | >15 |
| 1990 (projection) | 10 | 18 | ? |

## Separator technology

In order to deliver performance in SLA systems, separators with the following properties must be used

Quick electrolyte absorption
High electrolyte retention
Acid resistance
Low internal resistance
Fine pore size (recombination, dendrite prevention)
No gas generation other than hydrogen and oxygen

Glass microfibre mat satisfies all these requirements

Most of the separators used in the commercial production of SLA batteries consist of a combination of several grades of glass fibres The latter are classified in terms of fibre diameter (Table 2) The 100-series are older grades than the 200-series, which have been developed recently as economy grades The control of fibre diameter is better for the 100-series and the mean diameter is a little smaller It is considered that the 200-series are satisfactory for battery separators The cost of the 200-series is lower

TABLE 2

**Types of glass fibre used as separator material for sealed (recombination) lead/acid batteries**

| Code | Average diameter (μm) |
|---|---|
| 104 | 0 7 |
| 106 | 0 8 |
| 108 | 0 9 |
| 110 | 2 4 |
| 112 | 3 9 |
| 206 | 0 9 |
| 208 | — |
| 210 | 2 9 |
| 212 | 4 1 |

Blends of glass fibres determine the separator grade. Table 3 gives examples of typical percentages of fibre blend. The blend determines the average fibre diameter and pore size in the separator, both these parameters are important in determining battery performance.

Typical physical properties of separators (*e g* , basic weight, thickness, tensile strength, density, air permeability, etc ) are presented in Table 4. Figure 2 shows the trend of each property with respect to the series of separator grade

A special mention must be made concerning the method of measuring the thickness of separators. Several methods (or instruments) are available at present (Table 5). Normally the separator is placed between the plates of the thickness-testing instrument under 15 - 25% compression above the stage of free compression. Since results depend, however, on the size of the anvil area, pressure, dwell time, speed of anvil drop, etc., it is extremely important that a standard for the test method be developed. In the meantime, customers specify a thickness and its method of measurement.

TABLE 3

**Blends (%) of glass fibres used as separator materials in sealed (recombination) lead/acid batteries**

| Series | Code | | |
|---|---|---|---|
| | 106 (206) | 110 (210) | 112 (212) |
| A | 80 | 20 | — |
| C | 50 | 50 | — |
| G | 60 | 40 | — |
| E | 40 | 60 | — |
| F | 20 | 70 | 10 |
| H | 10 | 50 | 40 |

TABLE 4

Physical properties of glass-fibre separators

| Physical properties | Unit | (Grade no ) X8983 | Product range |
|---|---|---|---|
| Basic weight | g $m^{-2}$ | 200 | 60 - 350 |
| Thickness* | $\mu$m | 1430 | 400 - 3500 |
| Tensile | g (25 mm)$^{-1}$ MD | 1600 | 700 - 2500 |
| | CD | 800 | 300 - 1800 |
| Grain ratio | % | 50 | 50 - 75 |
| Density | g $cm^{-3}$ | 0 140 | 0 11 - 0 15 |
| Air permeability | l $min^{-1}$ (100 cm)$^{-2}$ | 22 | 8 - 55 |
| Internal resistance | m$\Omega$ $in^2$ | 2 6 | 0 6 - 7 0 |
| Maximum pore size | $\mu$m | 28 | 14 - 35 |
| BET fibre surface area | $m^2$ $g^{-1}$ | 1 2 | 0 6 - 2 4 |
| Void volume | % | 95 | 94 - 96 |
| Water absorption rate | s (25 mm)$^{-1}$ | 7 3 | 5 0 - 12 0 |
| Water retention | g $m^{-2}$ | 1480 | 400 - 3000 |

*Thickness measured by TMI 551M gauge with pressure 0 7 psi and anvil diameter 2 in

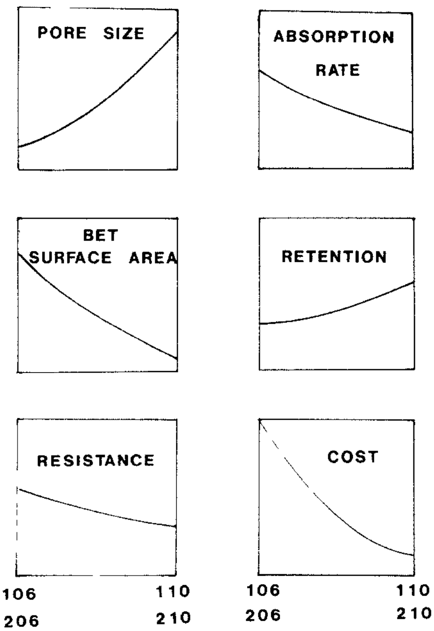


Fig 2 Trends in glass-fibre separator properties as a function of separator series (*i e*, from 106 to 110, and from 206 to 210)

## Cost of separators

The historical trend in separator cost (taking 1980 as 100%) is shown in Fig 3 Two major factors have contributed to the observed decline in cost,

TABLE 5

Methods of measuring the thickness of glass-fibre separators

| | Model name/Company | | | | |
|---|---|---|---|---|---|
| | TMI551M | TMI553M | 553M | 549 | JIS |
| Capacity (in ) | 0 - 0 250 | 0 - 0 50 | 0 - 0 50 | 0 - 0 040 | — |
| Sensitivity (in ) | 0 001 | 0 001 | 0 001 | 0 0001 | — |
| Anvil (foot) area ($cm^2$) | 20 25 | 20 25 | 6 46 | 0 2 | 100 |
| Anvil (foot) pressure (psi) | 0 70 | 0 70 | 1 5 | 7 3 | |
| ($g\ cm^{-2}$) | 49 | 49 | 105 | 511 | 200 |
| Total weight of anvil (g) | 1000 | 1000 | 682 | 1000 | 200 |
| Comment | Dexter Standard | | | TAPPI Standard | |

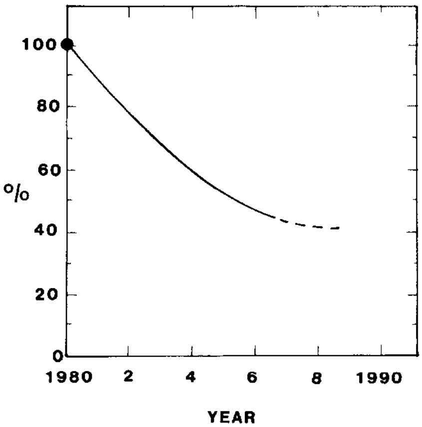


Fig 3 Trends in glass-fibre separator costs (normalized to 1980)

namely, the use of cheaper 200-series material and the change in the blend ratio of small to large diameter fibres At the beginning of SLA battery development, the A series (see Table 3) was used, gradually this has been replaced by the C, G, E and F series with concomitant improvement in battery performance

It is anticipated that the cost of glass-fibre separators will decrease if (a) lower energy costs are achieved, (b) cheaper, finer fibres become available, (c) a binder can be found to allow the use of a greater proportion of large-diameter fibre, (d) designs can be developed to replace some of the expensive series materials with cheaper ones, (e) lamination with microporous films becomes possible.