Chapter 8

ALKALINE BATTERIES, SILVER-ZINC TYPE

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. Silver-zinc batteries differ considerably from conventional alkaline batteries both in construction and operating characteristics, and consequently in servicing procedure. A silver-zinc battery is relatively light, being about one third of the weight and volume of a lead-acid battery of equivalent capacity. It can be discharged at sustained high discharge rates without any serious loss of capacity, and shows no tendency to boil or change its characteristics at high altitude or low pressures.

2. These batteries are not yet used in military aircraft, but may be met in experimental guided missiles. A list of the main types likely to be encountered, with relevant data, is given in Table 1.

Table 1

List of silver-zinc batteries

Type	Nominal capacity	Nominal voltage	Weight (oz.)	Overall dimensions (in.)	Max. current drain normally permissible for continuous discharge (amp.)
HO75	0·75 a.h. at 10 hour rate	1·5	$\frac{3}{4}$	$\frac{9}{16} \times 1\frac{1}{8} \times 1\frac{1}{2}$	5
CGW	0·5 a.h. at 3 hour rate	1·5	$\frac{3}{4}$	$\frac{9}{16} \times 1\frac{1}{8} \times 1\frac{1}{2}$	10
H105	1·5 a.h. at 10 hour rate	1·5	$1\frac{1}{8}$	$\frac{5}{8} \times 1\frac{1}{8} \times 2$	7·5
DGW	1 a.h. at 3 min. rate	1·5	$1\frac{1}{8}$	$\frac{5}{8} \times 1\frac{1}{8} \times 2$	20
SH4	5 a.h. at 10 min. rate	1·5	$3\frac{3}{4}$	$\frac{51}{64} \times 1\frac{21}{32} \times 3\frac{5}{16}$	30
SH705	5 a.h. at 10 min. rate	1·5	$4\frac{1}{2}$	$\frac{13}{16} \times 2\frac{1}{16} \times 2\frac{15}{16}$	30
H10	10 a.h. at 10 hour rate	1·5	$8\frac{3}{4}$	$2\frac{1}{4} \times 1\frac{3}{32} \times 3\frac{1}{8}$	30
SH10	10 a.h. at 10 hour rate	1·5	10	$2\frac{1}{4} \times 1\frac{3}{32} \times 3\frac{1}{8}$	60
SH20	12·5 a.h. at 6 min. rate	1·5	12	$\frac{53}{64} \times 3\frac{21}{32} \times 3\frac{7}{8}$	125
H20S	20 a.h. at 10 hour rate	1·5	13	$2\frac{1}{32} \times 1\frac{23}{32} \times 4\frac{1}{4}$	50
SUH20	20 a.h. at 10 hour rate	1·5	13	$2\frac{1}{32} \times 1\frac{23}{32} \times 4\frac{1}{4}$	150
MH40	40 a.h. at 10 hour rate	1·5	28	$2\frac{31}{32} \times 1\frac{5}{8} \times 5$	100
SH40	40 a.h. at 10 hour rate	1·5	28	$2\frac{31}{32} \times 1\frac{5}{8} \times 5$	200
SZ6	9 amp. min. at 3 min. rate	6	$2\frac{1}{4}$	$1\frac{7}{32} \times 1\frac{1}{16} \times 1\frac{3}{4}$	6
SZ6/12	60 amp. min. as 12V battery	12	22	$4\frac{25}{32} \times 1\frac{25}{32} \times 2\frac{3}{8}$	30
	or				
	120 amp. min. as 6V battery at 3 min. rate	6			

DESCRIPTION

Construction

3. A cut-away view of a typical cell of this type is illustrated in fig. 1. The cells are normally assembled in polystyrene cases in which the plate and separator systems are maintained under lateral pressure, thus preventing the shedding of active material unless the case itself is damaged.

4. The positive plate consists of pure silver treated to form a thin, porous plate. The negative plate is prepared from zinc, and silver leads from both plates are soldered to steel terminals. The separator material consists mainly of a special cellulosic film completely enclosing the negative plates, and the electrolyte is potassium hydroxide with specific gravity of 1·45.

5. A simple vent system is incorporated in the cell, which gives protection against spillage of electrolyte. As gassing is so slight, and most of the electrolyte is held in the plate and separator system, it is not necessary to remove vent plugs during charging.

Chemical reaction

6. During the charge cycle the positive plate is first oxidized to argentous oxide and finally to argentic oxide. On discharge the argentic oxide is discharged first to argentous oxide and then to silver. This gives the cell the two-step characteristic at low and medium rates of charge and discharge which is typical of the silver-zinc battery. As in a conventional alkaline battery, the electrolyte does not participate in the reaction, and remains at a constant specific gravity of 1·45.

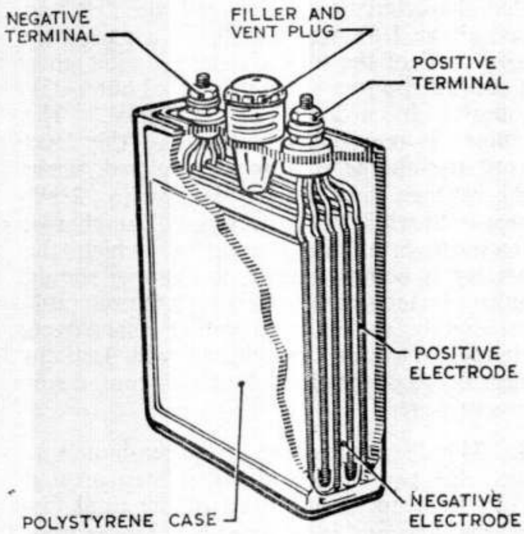

Fig. 1. Cut-away view of typical cell

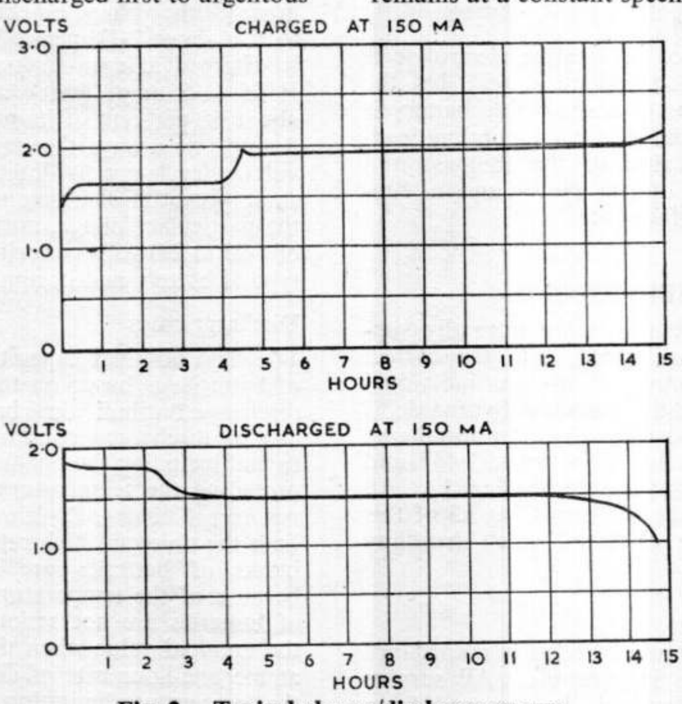

Fig. 2. Typical charge/discharge curves

7. The charge/discharge characteristics of a typical silver-zinc battery, the H105, are shown in fig. 2. In the charge curve the two-step characteristic is illustrated, the first step just above 1·6V which lasts for a period up to a third of the total charging period, then a sudden rise to a short peak at about 1·95V followed by a long step at 1·93V. The voltage is reasonably constant at this level until the charge is nearly completed, when the voltage rises fairly steeply to 2·1V, measured while the battery is still on charge. Irrespective of the current at which the battery is being charged, the charge should always be terminated at 2·1V. It is preferable to slightly undercharge rather than overcharge, since an overcharge will lead to electrolysis of the electrolyte with consequent loss of water.

8. The discharge curve at the ten-hour rate has also two stages; the first step around 1·8V lasts up to one third of the total discharge time, and is followed by a longer, very flat stage between 1·5V and 1·55V, the actual voltage depending on the type of battery. The falling off of voltage from the higher step to the lower is rapid, and also the final falling off of voltage at the end of discharge, and therefore it is advisable to terminate the discharge of a battery of several cells when the voltage falls to 1·2V multiplied by the number of cells.

Internal resistance

9. The resistance of alkaline electrolyte is higher than that of sulphuric acid, but the internal resistance of a silver-zinc battery is often less than that of a corresponding lead-acid battery because of the thinness and close proximity of the plates and a consequent large surface area.

SERVICING

10. Silver-zinc batteries are normally supplied dry and uncharged, with the correct amount of electrolyte in an individual ampoule. If solid potassium hydroxide is used, it should be mixed in the normal way to a specific gravity of between 1·445 and 1·450 at room temperature (60 deg. F). All precautions as laid down in Chap. 3 of this section must be observed when handling electrolyte.

Initial filling

11. Each cell should be filled in accordance with the maker's instructions. All surplus liquid should afterwards be removed from the vent system, and liquid spilt on cell lids be cleaned off as it may otherwise result in the formation of leakage paths. With certain types of battery, it is necessary to fit sealing discs or vent tubes after filling; sealing solution is supplied with these batteries. It is important that batteries should stand after being filled for at least the minimum period of 12 hours before charging is commenced.

Initial charge

12. Initial charging instructions are issued with each battery. For most normal applications it is necessary to charge the battery once only before use. It is not, however, advisable to discharge the normal range of batteries at currents higher than the five-hour rate on the first discharge, e.g., the Type H105 (1·5 amp. hour) should not be discharged at more than 0·3 amp. on its first discharge.

Charging rate

13. Charging is normally carried out at the ten-hour rate based on the nominal capacity as quoted in Table 1, the manufacturer's instructions being the guiding factor; in an emergency, however, this can be considerably speeded up, particularly for the H range. Most types can be charged at rates up to the two-hour rate, providing (1) there is sufficient current available for charging; (2) great care is taken to see that the batteries do not overheat; (3) the voltage on charge is not allowed to rise above 2·1V per cell. Some types can be charged at even higher rates, e.g., Type H105 (1·5 amp. hour) can be charged to about 85 per cent of its nominal capacity at 5 amp.; as always the temperature rise and voltage levels are the limiting factors. Constant potential charging may also be used, the particular voltage, normally in the range of 1·93 to 2·0 volts per cell, depending on the type of battery and its application.

Discharge rates

14. The nominal capacity of the H range of batteries is based on the ten-hour rate of discharge, but individual batteries of this type can be discharged continuously at rates up to and including the one-hour discharge rate, providing the temperature of the case does not exceed 60 deg. C. It may be necessary to limit the time of a high rate discharge, where banks of batteries are being discharged, because of the temperature rise. Capacities of batteries are not seriously reduced from the nominal value when they are discharged at the one-hour rate of discharge; provided the temperature limitation is always adhered to, batteries can be discharged at rates in excess of the one-hour rate. Certain batteries of various capacities have been specially designed for very high rates of discharge; these batteries have, however, a limited life dependent on the duty, which may not exceed ten cycles.

15. If batteries are to be used at comparatively high discharge rates (such as the two -hour rate) for several consecutive cycles, it is advisable to charge and discharge at a low rate (such as twenty-hour rate) every fifth or sixth cycle, or alternatively to finish each discharge at the twenty-hour rate. With very high rates of discharge, of the order of the 15-minute rate or greater, it is advisable to drain each battery at the ten-hour rate every cycle, otherwise it will be found that the capacity and voltage characteristics deteriorate fairly rapidly.

Topping up

16. Sufficient electrolyte is held in the plate and separator system for normal working of the batteries; free electrolyte indicates only that the plate system is saturated. All batteries are supplied with instructions indicating the correct height of electrolyte; in general it will be found that the smaller batteries, e.g. H075, H105 and H705, are not more than a quarter to half full, and that larger sizes, e.g., H25 and above, are a half to three quarters full. The electrolyte level should never be above the top of the visible plates, and in no circumstances should it reach the top of the separators in any condition of the battery.

17. If the liquid level is below the minimum stated to that particular battery, it should be topped up with potassium hydroxide solution of S.G.1·165 in temperate zones and distilled water in hot zones. If potassium hydroxide is not available distilled water may be used for topping up, but under no circumstances may anything else be used. To facilitate filling and topping up, some of the larger cells are fitted with a screw in the lid, which should be removed before topping up the cell through the vent system; the screw should be replaced carefully at the end of the operation. It is important to keep the vent system and the small hole in the stopper clean, as there is a tendency for potassium hydroxide to block up the hole.

18. The liquid levels quoted are those in the discharged condition and topping up should preferably take place in this condition, though batteries may be topped up immediately after charge. In this instance, all that is necessary is to ensure that the liquid level is up to the lowest level specified by the manufacturer, e.g., H075, H105 and H705 are a quarter full at least. If for any reason the battery is hot, it should be allowed to return to room temperature before it is topped up. It should not be found necessary to top up cells more frequently than every few months, unless the battery has lost excessive water due to being seriously overcharged. Batteries which frequently reach temperatures above 40 deg. C, either due to frequent high rate charges or discharges or high ambient temperatures, may also need topping up rather more frequently.

State of charge

19. The open-circuit voltage of a fully-charged cell is between 1·85 and 1·87 volts irrespective of the rate of charge; cells which have been discharged for a third of their capacity or less normally show open-circuit voltages above 1·8 volts. Cells which are more than a third discharged show open-circuit voltages of approximately 1·61 volts; practically discharged cells will also show similar voltages. Any open-circuit voltage below 1·6 volts indicates that the cell retains no useful capacity. Batteries which have been completely drained may sometimes show open-circuit voltages of 0·2 volts in the negative direction; this is quite normal and does not necessarily indicate trouble.

Shelf life and storage

20. If batteries have been formed and used but are not required for immediate use, they should always be stored in the discharged condition and not in the charged or partially charged condition. Unlike other types of batteries it is not necessary to cycle them during storage. They should be discharged through a suitable load, such as a lamp load, down to zero volts, preferably individually, or, if as a battery, with a falling current load; the load should then be disconnected and the battery stored in a suitable cool, clean place. When cells are fitted with a screw in the lid, considerably improved storage life can be obtained by filling the cells to the tops of the separators with potassium hydroxide solution of S.G. 1·45 during the storage period. The level should be adjusted to the normal value before the batteries are returned to service.

21. The silver-zinc battery has a good charged shelf life; the larger the battery, the better is its shelf life. A small battery, such as the Type H075, will be quite satisfactory for all normal requirements after standing charged for three weeks; it will still be usable for many weeks after this, but for maximum efficiency it is desirable to give it a charge and discharge cycle (at the 10 or 20 hour rates) about once every three weeks.

22. It will be found that the charged shelf life of a battery will be better if the battery, particularly the lid, is kept quite clean, and if the electrolyte level is kept near to the maximum allowable. These conditions also apply to batteries stored in the discharged condition. Batteries should also be stored in a cool place, at a temperature preferably below 25 deg. C but above 0 deg. C; batteries stored in high ambient temperature, i.e., above 35 deg. C may be expected to lose their charge in a shorter period.

23. It will be found that some batteries which have been stored for lengthy periods have rather low voltages when first put on discharge; this is particularly noticeable if the discharge current is higher than the five hour rate. This " sluggishness " is a natural phenomenon, and it will be found that the normal voltage is attained fairly rapidly. If necessary, this can be speeded up by discharging the battery very rapidly for a few minutes prior to the actual discharge.

Overheating

24. If great distortion of the case of a battery has taken place this is nearly always due to the overheating of batteries by excessive currents and/or temperature condition. It has already been emphasized that great care must be taken during high rate charges and discharges to ensure that the batteries are not allowed to overheat, but it must also be remembered that despite their small size the silver-zinc batteries can deliver very high power outputs, and it is therefore important to ensure that no accidental short-circuit occurs. While a momentary short-circuit will cause no harm to the system, a sustained short-circuit will very rapidly cause the batteries to generate sufficient heat for the cells to distort. The distortion of the cell may become so great that the internal assembly itself is damaged. It is therefore essential that no piece of metal should be dropped between the terminals of one cell or adjacent terminals of a battery of cells. Risks of accidental short-circuits are obviously greater with small cells due to the very short paths between the terminals, and therefore great care must be exercised when using a voltmeter to check their voltage that the meter prods do not short two terminals.

25. Overheating caused by too high an ambient temperature, by discharge for too long at high rates, or other external conditions is characterized by general distortion of the battery, most emphasized at the base. Where a cell has been short-circuited externally, the polystyrene lid material may shrink away from the terminal, and the solder to the terminal itself may become blackened. It is, of course, not necessary for a dead short-circuit to take place; a very heavy current drain can cause the same damage.

26. Good contact should always be made between terminals and bus-bars to avoid undue heating at these points when a high current is passed. Both the terminals and bus-bars should be kept clean so that there are no high resistance joints.

27. It is also possible to damage a cell either by charging with the wrong polarity, or by discharging a bank of cells for too long a period so that those cells with lower capacity than the others are reversed. Short periods at a low current in the wrong direction are unlikely to seriously damage the battery, but a lengthy over discharge, or a high current in the wrong direction, may cause irreparable harm. The battery may sometimes become overheated; the leads may become oxidized and so increase the internal resistance, or in extreme cases the leads will be burnt away and some or all of the plates become open-circuited. The capacity may be considerably reduced even if no other serious damage is caused. It is usually possible to tell when a cell has been driven backwards by the colour of the leads (where these can be seen in the plate), and by the plating of zinc on the positive plate.

Treatment of faults

Reduction of capacity

28. There is a slight decrease in capacity of silver-zinc batteries with cycling, but if the capacity of a cell falls very markedly, e.g., to 50 per cent of the nominal value, the electrolyte level should be checked immediately following a full discharge. If necessary, the cell should be topped up to the specified level and allowed to stand for 12 hours. The cell should then be given a slow cycle, e.g., at the 20 hour rate, of charge and discharge before being put back into use. The capacity often improves gradually after topping up. If a cell has been cycled repeatedly at high rates of charge or discharge, the capacity may deteriorate but will improve again after one or two low rate cycles.

29. A cell which has become partly self-discharged by standing for long periods in the charged condition may give a low discharge capacity because the cell will not take a good charge. The reason is that the positive plates have retained their charge, during storage in the charged condition, while the negative plates have been oxidized and so have lost all or part of their charge. When an attempt is made to charge a cell in this condition, the charge is limited by the positive plates which will take only a limited additional charge. It is sometimes possible to bring a cell in this condition back into service by very careful treatment. The battery should first be topped up to its maximum liquid level, and then charged at the forty-hour rate.

30. If the voltage of the cell rises rapidly to 3 volts or more, it is impossible to bring the cell back into serviceable condition. More often the voltage rises after a short period to a level over 2·0V but under 2·2V, and continues at that level for a very lengthy period. In these circumstances the voltage level can be allowed to rise to about 2·1V on charge, but immediately there is any sudden increase or the voltage reaches 2·2V, the charge must be stopped. It will be found that during the charging period between 2·1V and 2·2V some gassing takes place from the positive plate, but this is not violent. At the conclusion of charge the cell should be discharged at the ten or twenty-hour rate, and another low rate cycle of charge and discharge (e.g., 20-hour rate of charge and 10-hour rate of discharge) should be carried out. After this treatment a battery is often in a usable condition for all normal applications, although the capacity may be reduced from the nominal to some extent. It is sometimes possible to recognise a "self-discharged" cell visually as the positive plates (even in the discharged condition) are black, but the edges of the negative plates where they can be seen through the separator material are practically white.

31. Batteries which have been subjected to many cycles and have been allowed to stand for varying periods in the partially-charged condition may also show similar characteristics to those described above, and it will be found possible to improve their capacity by the same means. Great care must be taken in the use of the method; currents greater than the 40-hour rate must never be used, and the voltage must not be allowed to rise above 2·2V. It is advisable to top up with potassium hydroxide of S.G. 1·45 when this is available.

Internal short-circuits

32. A cell which has been seriously overcharged may develop a partial short-circuit due to the build-up of zinc paths over the top of the separators. In this instance the cell will seldom charge to 2·1V. There is no easy remedy for this fault.

33. Due to various causes a cell sometimes develops an internal short-circuit. This is sometimes due to continual overcharging, and sometimes to damage to the separator system caused by severe impact on the cell. It is often impossible to see from the outside of a cell where a short-circuit has taken place, but it sometimes shows as a localized spot on the edges of the plates, accompanied in some instances by a puncture on the case. Where a puncture has taken place there may also be some slight damage to an adjoining cell in a battery where the cells touch. It will practically always be found that the damage is very localized even in the cell in which the short-circuit has taken place.

(81154) Gp.375/1. D5299/Wt.45671/359280/L.P.S. Ltd. 3250/3/59


LTF
RAF BINBROOK