ELSEVIER

Journal of Power Sources 67 (1997) 121–123

JOURNAL OF POWER SOURCES

Field experience with maintenance-free battery designs that incorporate thin tubular positives during electric-vehicle use

Klaus-Dieter Merz

CMP Batteries Ltd., PO Box 1, Salford Road, Over Hulton, Bolton, BL5 1DD, UK

Received 20 August 1996; accepted 20 December 1996

Abstract

The Classic 25 cell and the 3ET205 monobloc are two of the most used lead/acid batteries for electric buses and vans. Both products are of thin tubular positive-plate design, developed in 1988 and since then used in hundreds of electric vehicles (EVs). The excellent specific energy and the relatively low weight makes it an ideal product for EVs. Eight years field experience in various applications has proven the good performance and the superior cycle life. Encouraged by the positive field experience of this thin tubular plate technology, CMP Batteries started the development of valve-regulated lead/acid batteries with this design. This paper describes, briefly, the construction and design of the cells and monoblocs and compares some technical data. After the first production of Classic 25 MF, some tests have been carried out in the laboratory and in the field. The outcomes of these tests are presented and discussed. © 1997 Published by Elsevier Science S.A.

Keywords: Lead/acid batterries; Field tests; Electric vehicles; Tubular positive plates

1. Classic 25

The Classic 25 is a lead/acid cell that uses thin positive tubular plates. This plate has been developed for electric vehicles (EVs) to achieve a higher specific energy, whilst maintaining a good cycle life. The first battery incorporating thin positive plates was manufactured by CMP Batteries in 1984. This was a 6 V monobloc for electric vans and trucks.

The Classic 25 was developed 1988 and since then used in hundreds of electric vans, trucks and buses. Table 1 shows some technical data of the Classic 25 cell and the monobloc 3ET205, in comparison with the standard traction cell Classic (DIN-size cell).

Both thin-plate products have been proven in the field for more than ten years, in over 700 (EVs) and the 3ET205 monobloc is still the lead/acid battery with the highest specific energy for deep-cycling applications. The latter include the G-Van and shuttle buses in Santa Barbara, Chattanooga, and other cities.

Today, the largest electric bus project, in which Classic 25 batteries are in use is in Florence: 22 electric buses are operating in the inner city and 20 of them are using Classic 25 batteries. The longest field experience has been achieved in Santa Barbara, however, where 12 buses have been powered by the Classic 25 battery for almost six years.

The data in Table 2 are taken from the four-year report of the Santa Barbara Metropolitan Transit District and confirms the excellent performance of the thin tubular plate technology.

In some applications, flooded systems do not find acceptance and maintenance-free valve-regulated lead/acid (VRLA) products are required. VRLA batteries are available, both in gelled and absorptive glass mat (AGM) technology, but either the specific energy is not high enough or the cycle life is not very encouraging. Therefore, CMP started to develop a VRLA cell which incorporated thin tubular plate and AGM technology. Both technologies have been manufactured by CMP for many years and the combination of these two designs appeared to be relatively easy.

2. Classic 25 MF

Based on the good experience with the Classic 25 cell in EV applications, the decision was made to develop a maintenance-free Classic 25 cell using thin positive tubular

0378-7753/97/$17.00
PII S0378-7753(97)02504-4

Table 1
Development of high specific energy electric-vehicle batteries

Battery designation	Standard performance: Classic	High performance: Classic 25	Advance EV 3ET205
Acid gravity (g cm^{-3})	1280	1300	1320
Plate pitch (mm)	15.9	13.5	11.4
Number of tubes	19	24	30
Tube diameter (mm)	7.5	6.2	4.9
Spine diameter (mm)	3.2	2.3	1.85
Specific energy (C_5/5 rate) (Wh kg^{-1})	28	36	40
Cycle life	1500	1000	800

Table 2
Battery usage history in Santa Barbara buses (battery: Chloride 216-V, S32Y11)

Battery number	Date placed in service	Miles driven	Driving cycles
1	19.12.90	27668	639
2	10.04.91	25083	531
3	21.01.92	27961	766
4	21.01.92	36151	884
5	15.02.92	32992	921
6	27.02.92	20797	607
7	15.05.92	26738	708
8	15.05.92	27839	572
9	09.04.93	13749	358
10	20.05.93	20597	528
11	05.08.94	4918	102
12	05.08.94	4045	104
Total		268538	6720

plates and the AGM technology. Table 3 compares the design parameters of the Classic 25, Classic 25 MI and MII and the expected performance.

Work started with the Mark I design because of the availability of the tooling. The first cell types to be made were the S32Y11 (DIN-size cell: 5PzS 320) and the S36Y11 (DIN-size cell: 5PzS 350).

3. Test programme for Classic 25 MF

Sufficient cells have been made to conduct intensive bench tests and assemble at least one complete battery for an electric bus. Some S32Y11-type cells have been assembled with different separation in order to make them suitable for gel filling, see Table 4. These cells have been finished in a German battery plant and put on test.

Table 3
Design data of Classic 25 MF cells

Battery parameter	Classic 25	Classic 25 MF Mark I	Classic 25 RE Mark II	Advanced EV 3 ET 235 MF
Acid gravity (g cm^{-3})	1.300	1.300	1.310	1.320
Plate pitch (mm)	13.5	13.5	13.5	11.4
Number of tubes	24	24	27	30
Tube diameter (mm)	6.2	6.2	6.2 × 5.4	4.9 × 3.8
Spine diameter (mm)	2.3	2.3	2.15	1.85
Separator type	polyethylene	glass microfibre	glass microfibre	glass microfibre
Tube shape	round	round	rectangular	round
Specific energy (C_5/5 rate) (Wh kg^{-1})	36	33	35	43
Cycle life	1000	> 600	> 700	650

Table 4
Comparison of technical data of Classic 25 MF and standard flooded cells

Battery parameter	DIN 4PzS 280	S32Y11 MF	DIN 4PzS 320	S36Y11 MF
Acid gravity (g cm^{-3})	1.280	1.310	1.280	1.310
Weight (kg)	19.1	19.3	21.7	21.9
Capacity	280	329	320	360
(C_3/3 rate) (Ah)	245	288	280	360
Specific energy (C_5/5 rate) (Wh kg^{-1})	28.7	33.4	28.9	316
(Wh l^{-1})	76.2	78.4	52.3	32.2
DOD (%)	80	60	80	60
Cycle life	1500	in test	1500	in test

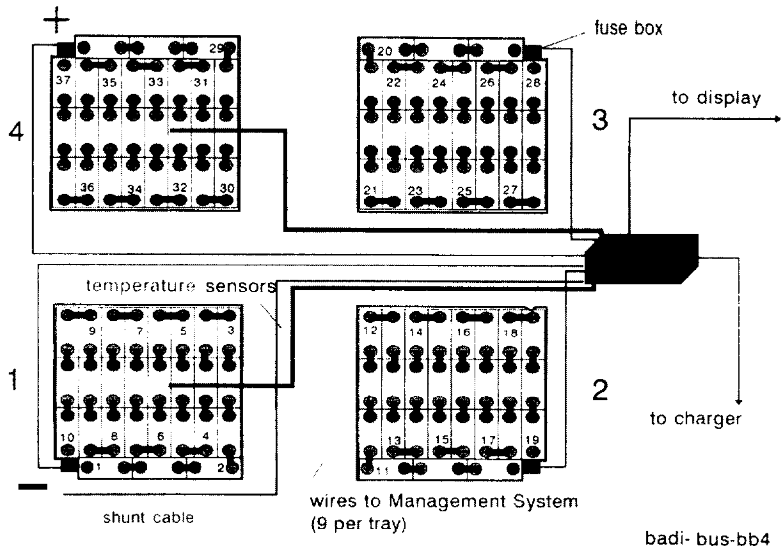

Fig. 1. Four-tray layout for 22 ft bus, 54 V (27 cells) BDA 000019.

3.1. Field test

Two batteries were made for electric buses: one for a Santa Barbara bus, the other for CARTA in Chattanooga. Both batteries are for the same application and the electric buses are similar, although the battery layout is slightly different. One is a three-tray layout, the other battery is assembled in four trays. The four-tray layouts is shown in Fig. 1. It is a 216 V battery (108 cells) composed of S36Y9 300 Ah type cells. As is shown in Fig. 1, a management system is used for this electric bus battery. Although all VRLA batteries are maintenance free, whether they are of a gel or AGM design, they need to be controlled in cycling applications. VRLA batteries are more sensitive to depth-of-discharge (DOD) and temperature and must be charged under controlled conditions.

During CMP's long-term experience with maintenance-free batteries in EV applications (particularly high-voltage arrangements), it has been found to be absolutely essential to have a good and reliable system to manage the battery. For these test batteries, a Badicheq system is used. CMP's knowledge and experience in battery charging and monitoring went into this development and good experience has been obtained with this system. The latter controls parameters such as: DOD; temperature; cycles; energy consumption, and charging regime. A specific feature is the selective charging of a maximum of four battery circuits during the main charging phase to equalize weak cells or blocs.

Returning to the battery layout, three cells are connected to form a 6 V unit. In total, 36 cables lead to the management system and are managed as a 6 V bloc battery. Two temperature sensors transmit the battery temperature in order to adjust the charging voltage and to calculate the battery capacity.

3.2. Test results

The batteries were put in operation recently and results are not available yet. First test results will be discussed at 5ELBC.