

## THE LEAD/ACID BATTERY INDUSTRY IN CHINA

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### Introduction

The founding of The Traffic Battery Factory (Nanking) in 1911 marked the beginning of the Chinese battery industry. In this factory, dry cells, wet cells and storage batteries were made. Then, for almost forty years, China was in turmoil with a succession of civil conflicts and wars of resistance. As a consequence of these events, the progress of the battery industry was seriously hindered, for example, the annual lead consumption for battery making was only 400 T in 1949. In addition, alkaline batteries were not made at that time.

Around 1949, the protracted wars abated and national reconstruction began. From 1950 onwards, technologies and equipment were imported from the U.S.S.R., and a number of new battery factories were built. Thus, from 1950 to 1958, lead/acid battery production increased at an average annual rate of 60% and the lead consumption rose to 28 000 T. The first alkaline battery factories were commissioned in 1955 and the manufacture of silver/zinc batteries started in 1958.

At present, there is at least one comprehensive lead/acid battery factory in each province, giving more than 50 factories, each with over 100 staff. There are also more than 1000 small workshops or mills scattered throughout the country. The annual output of the large factories is shown in Table 1.

TABLE 1

Lead/acid battery production in China

Output (kV A h/year)	No. factories
300000 - 500000	3
100000 - 300000	11
50000 - 100000	10

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In 1987, the total production of lead/acid batteries was 4 765 000 kV A h, among which were about 4 500 000 SLI batteries (6 or 12 V). The largest units were a 6000 A h traction battery and a 3000 A h stationary battery. There are also four large and about 20 small alkaline battery factories producing units ranging in size from 0.05 A h button cells to 1000 A h pocket cells.

Since the battery industry is closely related to the car industry, it is appropriate to consider the status of the latter in China. The first car factory was built in 1951, and up until 1979 the car output was 134 340 trucks annually (with a very small number of passenger cars). Since then, passenger car production has increased markedly. Equally, since 1980, motorcycle output has expanded. At present, there are six car production centres (including the well known First Car Factory and the Second Car Factory) and a number of small car factories. Vehicle development in China is shown in Tables 2 and 3.

TABLE 2

Vehicle output in China (unit  $\times 10^4$ )

	Year						
	1979	1981	1985	1987	1988	1990	2000
Trucks	13.15	20	31	39.65	59	55	115.1
Passenger cars	0.264	1.0	1.2	2.04	5.4	15	95
Tractors	4.5	5	5.5	6	—	7.2	9
Motorcycles	—	—	—	77.5	—	130	250

TABLE 3

Vehicle population in China (unit  $\times 10^4$ )

	Year					
	1979	1981	1985	1987	1990	2000
Trucks	380	400	430	450	550	1080
Passenger cars	10	18	28.3	45	80	400
Tractors	70	29.2	99.2	110	135	175
Motorcycles	—	—	—	400	700	1200

### Battery production

According to the statistics of the 11 major battery producers, the average annual increasing rate of batteries of different categories is as follows:

7.4% SLI

4.8% stationary

TABLE 4

Forecast of lead/acid battery production in China (unit  $\times 10^4$  kV A h)

	Year		
	1987 <sup>a</sup>	1990	2000
SLI	370	463	982
Traction	30.87	36.8	66.7
Stationary	18.6	21.4	34.2
Railway	7.63	9.5	19.5
Motorcycle	7.2	11	18
Miners' cap lamp	32	40	64
Others	10.2	12	20
Total	476.5	593.7	1204.4

<sup>a</sup>140 000 SLI batteries imported, 300 000 kV A h of SLI batteries exported.

TABLE 5

Forecast of alkaline battery production in China (unit  $\times 10^4$  kV A h)

	Year	
	1987	2000
Ni-Cd pocket	4	4.5
Ni-Cd	0.1	1.0
Ni-Cd sealed	0.5	5.0
Ni-Fe	0.5	10
Ag-Zn	0.5	0.5
Total	5.6	21

6.1% traction

7.5% railway

The forecasts for 1990 and 2000 are given in Tables 4 and 5 for lead/acid and alkaline batteries, respectively; these figures are in keeping with the Government's long-term industrial development projects.

### Battery technology

All batteries are made according to the national standards of China (GB).

#### SLI batteries

SLI batteries range in size from 36 to 225 A h. Some are made according to DIN, BS, JIS, BCI or GOCT standards if requested. The majority of batteries still use ebonite containers and medium thickness plates (positive =

2.4 mm, negative = 1.8 mm), although polypropylene containers and thin plates are expected to prevail. Grid alloys usually contain 5 to 7.5 wt.% Sb, but some factories have already used low-antimony alloys. Only one factory uses Pb-Ca-Sn alloy. The vast majority of the products are dry charged and only one factory makes wet-charged batteries with U.S.A. technology (Globe). The separators are of the microporous rubber type.

Annual export of SLI batteries is about 300 000 kV A h; approximately 150 000 batteries are imported from Japan and South Korea.

#### *Traction batteries*

Traction battery types range in size from 250 to 550 A h and use ebonite containers. Tubular plates are used with an inside tube diameter of 8 - 9.5 mm. The mine-explosive proof versions are made with polypropylene containers and are fitted with a flame-retarding vent plug. A new series of batteries employing tubes of diameter 8 - 6 mm and polypropylene containers are being developed with a capacity range from 100 to 805 A h (61 types). The largest traction battery ever made has been the 6000 A h type for naval vessels.

#### *Stationary batteries*

Stationary batteries are produced in 25 types from 30 to 3000 A h. They all employ tubular plates, flame-retarding plugs, thermometers and hydrometers. The containers are made of transparent resin. Catalytic plugs are supplied on request. In earlier times, Planté and pasted plate batteries were also manufactured, but this practice has been abandoned. Nevertheless, it is expected that flat pasted plates will again be produced to meet the requirements of high performance batteries. One factory in northern China manufactures batteries with German technology and produces units according to DIN standards.

Various methods are used to fill tubular plates with battery oxide:

- many factories employ the vibration fill technique
- a few factories use the paste injection method
- one factory uses granular oxide
- only one factory uses a pneumatic filler; this is a Chinese proprietary method that is a noiseless, low contamination and efficient process.

#### *Railway batteries*

Railway batteries consist of two kinds: (i) the T-Series for passenger coaches; (ii) the N-Series for diesel locomotives. They all are made with tubular plates and ebonite containers, and are equipped with level indicators.

#### *Motorcycle batteries*

Motorcycle batteries are made in the following sizes: 2, 4, 6, 8, 12, 16, 20 and 28 A h. The construction is the same as that of the imported original.

*Miners' cap lamp batteries*

The miners' cap lamp batteries comprise two types: the 7 A h/4 V and 8 A h/4 V systems. They are made with tubular plates and hard rubber containers.

*Sealed batteries*

Sealed batteries have been manufactured in sizes such as 3 A h/6 V, 9.5 A h/6 V and 10 A h/6 V.

*Alkaline batteries*

Alkaline batteries manufactured in China are mainly of the pocket Ni-Cd type. The largest capacity is 1000 A h. Sintered Ni-Cd versions are rapidly being developed. The smallest type is a 0.05 A h button cell. Four production lines for cylindrical sealed cells have been installed. Although their production is small in number, silver/zinc batteries are fabricated in a wide variety of sizes.

**Battery manufacturing equipment**

Before 1980, all the lead/acid battery manufacturing equipment was of domestic origin and productivity was rather low, for example, the casting speed was 7 panels/min and the pasting speed was 45 panels/min. Since 1981, however, a large amount of up-to-date equipment has been introduced. Some incomplete statistics are shown as follows

*SLI equipment*

76 casting machines	(32 Yuasa; 16 GS, 8 FS, 4 Varta, 10 Wirtz, 2 Singer, 4 Taiwan)
35 pasting machines	(19 Yuasa, 6 GS, 3 FS, 4 MAC, 2 Singer, 1 Taiwan, 1 Varta)
20 assembly lines	(7 Yuasa, 1 FS, 4 GS, 2 Globe, 3 Sovema, 1 Singer, 1 Taiwan, 1 Varta)
6 mixers	(3 Beardsley Piper, 3 Ox-Master)
2 cast-on strap machines	(1 Globe, 1 Singer)
2 dry charge driers	(Taiwan)

*Industrial battery equipment*

5 casting machines	(Hagen, Sovema, GS, Yuasa, Hadi)
1 oxide machine	(Linklater)
2 dry charge driers	(Sovema)
1 pellet former	(Hagen)
3 tubular plate fillers	(2 Sovema, 1 Hagen)
3 pasting machines	(Sovema, Hagen, GS)
2 flash driers	(Sovema, GS)

An innovation is the pneumatic filler for tubular plates which has been invented by Chongqing Batteries. In this machine, high pressure air drives oxide evenly into tubes within a fraction of a second.

The equipment used for the manufacture of alkaline batteries was originally of domestic origin. In recent years, however, four new production lines for sealed cylindrical cells were imported from the U.S.A. and the F.R.G.

## Parts and materials

### *Alloys*

Domestic lead production is estimated at 100 000 T/year. To date, battery factories have produced alloys in house. Now, at least two smelters have begun to supply Pb-Ca-Sn alloy. A further company supplies Ca and Ca-Al alloy. The nickel powder for alkaline batteries is obtained mainly from Canada.

### *Separators*

The large battery companies have their own rubber separator plants. In addition, there are at least four other factories that specially produce rubber separators.

In recent years, five PVC sintering machines have been bought from Jungfer with a total annual output amounting to  $2.5 \times 10^8$  pieces. By comparison, paper separator production is  $3 \times 10^8$  pieces, so the productivity of the introduced PVC equipment is not adequately utilized. Besides these developments, two institutes are investigating the manufacturing technique of polyethylene separators. The super fine glass-fibre mats required for sealed batteries have been made in Shanghai and Chongqing.

Separators for alkaline battery usage are mainly of the aceto-cellulose (silvered) type. A good quality radiation grafting film has been made in Shanghai.

### *Containers*

Large battery factories generally produce ebonite and polypropylene containers. There are also at least three other factories exclusively making containers.

### *Tubular-plate accessories*

Glass-fibre tubes are popular. There are two factories supplying gauntlet or synthetic fibre types.

## Battery research

The larger battery factories all have their own research departments. There are several important Battery Research Institutes, notably the Tianjin

No. 18 Research Institute and the Shenyang Storage Batteries Research Institute. At present, the prevailing research subjects are those related to alloys, utilization of active materials, sealed cells, new separators, fibre electrodes (alkaline), new battery systems, gelled-electrolyte cells, and high efficiency nickel/iron cells.

### **Future prospects**

It has been decided to accelerate the development of passenger car production and four manufacturing centres are undergoing construction. The expected output in 2000 will reach one million vehicles annually and the whole car fleet will be about 15 million. The motorcycle fleet will be even larger. Now there is a factory in the East using British (Chloride) technology to produce maintenance-free batteries with an annual capacity of 400 000 kV A h. Other factories intend to introduce new techniques to make their own maintenance-free batteries.

Sealed cells of 3, 9.5 and 24 A h have been made; larger sealed cells are under development in some factories. Negotiations for introducing sealed cell technology are also being held between Chongqing Battery and CEAC (France) and others.

In summary, the battery industry in China has very good prospects and opportunities for international cooperation are numerous.