ZINC–CHLORIDE BATTERY DEVELOPMENT PROJECT

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The objective of this contract is to continue the research and development of the zinc–chloride battery for electric vehicle applications. Battery performance characteristics, system operability, battery control, safety, and the study of high density chlorine hydrate storage were evaluated on a commercially-sized battery basis. The near-term goal of this program was to engineer the zinc–chloride battery from the present full-sized laboratory batteries into prototype commercial batteries for electric vehicles by December, 1981.

The major accomplishments on this program through June, 1979 were as follows:

(i) A nominal 50 kW h battery, of a mobile battery system design, was built for laboratory testing, to date, this battery has undergone 73 cycles. Maximum delivered energy was 43 kW h at the C/4 discharge rate. At 704 kg total battery weight, this represents a specific energy of 63 W h/kg. This battery is still on test.

(ii) A 500 A/150 V rectification and battery control system for simulated vehicle cycle testing of the above battery was designed and installed at EDA.

(iii) Battery test facility requirements were established, and battery testing procedure guidelines were instituted.

(iv) An anti-fouling technique to prevent hydrate blockage of the chiller heat exchanger was developed.

(v) A bench model of a mobile battery hydrate formation system was designed and fabricated. This system allows the ready manufacture of chlorine hydrate to evaluate advanced chlorine hydrate stores.

(vi) Chlorine storage density of greater than 0.2 g per ml of store volume using simple filtration techniques was demonstrated.

(vii) A modeling study on a zinc–chloride battery for electric vehicle application with emphasis on the matching of battery performance, with payload selection and mission requirements, was conducted.

The major program plan through 1980 is to design, fabricate, and finally demonstrate a vehicle compatible zinc–chloride battery in a selected electric vehicle. Prior to battery installation, an analytical study of the battery/vehicle operational characteristics under various driving cycles, together with an analysis of failure modes and safety, will be conducted. High chlorine storage density, without undue system complexity, remains a key goal for the zinc–chloride battery program as applied to EV applications. Programs to improve chlorine density from 0.20 g/ml to a commercial target of 0.26 g/ml of store volume will be pursued, as will programs to ensure the formation of $Cl_2 \cdot 6H_2O$, rather than the less dense $Cl_2 \cdot 8H_2O$.

Recent publications

1 P. Carr, Zinc–chlorine hydrate battery, *Second Annu. Battery and Electrochem. Technol. Conf., Arlington, VA, June, 1978.*
2 W. L. Pickwick, Test facility and test guidelines for the 50 kW h zinc–chloride battery, *Topical Report, Contract No. EY-76-C-02-2966, March, 1979.*
3 Chen H. Chi, Vehicle battery design — modeling of zinc–chlorine batteries for electric vehicles, *Topical Report, Contract No. EY-76-C-02-2966, June, 1979.*
4 H. K. Bjorkman, Chlorine hydrate store development, *Topical Report, Contract No. EY-76-C-02-2966* (currently being written).

DEVELOPMENT OF ZINC–BROMINE BATTERIES FOR UTILITY ENERGY STORAGE

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The goals of this program are to perform a cost and design study for an 80 kW h zinc–bromine stand-alone battery module and to build and test three 8 kW h submodules. These are intermediate milestones for a three year program whose overall goals are the construction and testing of an 80 kW h zinc–bromine BEST prototype module by August of 1981.

The design layout of the 80 kW h module is complete; there are to be 10 identical 8 kW h submodules of either monopolar or bipolar design (the decision between the two is to be made just prior to module construction) contained on a 4 ft. × 8 ft. skid. Two electrolyte circulation systems, one each for the negative and positive electrolytes, are connected to the cells in a series–parallel array. These, constructed of polypropylene pipe for chemical resistance, provide electrolyte and bromine flow to the cells, since most of the electrolyte and bromine are stored in external tanks.

Three 8 kW h submodules are under construction for design evaluation and performance testing. Two of them are monopolar submodules, comprising nonporous titanium negative electrode substrates, porous, flow-through titanium positive electrode substrates, and microporous separators in a filter press stack. Injection-molded polypropylene frames contain the electrodes and provide paths for electrolyte circulation in the stack. The third is of a bipolar design, in which carbon negative electrodes are pressed back to back with porous titanium positive electrodes in bipolar electrode pairs, also in a filter press stack.