The initial ISOA phase consists of determining the inter-relationship of 32 variables in flat plate batteries. Ninety-six three cell batteries have been built and given electrical tests. Performance goals of greater than 40 W h/kg and 100 W/kg have been attained with some combinations. Life cycling is in progress.

The second ISOA phase is directed toward a study of 32 variables in a new type of tubular lead–acid cell. One hundred and twenty eight, three-cell batteries have been built and these are being electrically tested as well as life cycled.

Phase I of the major subcontract with Battelle Columbus Labs. has resulted in the development of mathematical models for rectangular and radial grid designs. The cutting of molds to produce radial grids of improved conductivity and performance is in progress.

Installation of automatic-computer controlled test equipment has been completed and debugged and is being used for both electrical and life cycling.

Advanced battery development efforts are directed toward determining the feasibility and performance of a pile-type lead–acid battery. In addition, component evaluation will continue in an effort to obtain increased yields from positive plates, negative plates, and cells by utilizing more effective materials and reducing component weights.

Recent publications

1 G. S. Hartman and E. A. Rowland, Evaluation of battery performance for an electric vehicle with regenerative braking, *Proc. 5th Int. Electric Vehicle Symp., Philadelphia, PA, October 2 - 5, 1978.*
2 G. S. Hartman and D. L. Beals, Evaluation of battery performance using computer controlled test equipment, *14th IECEC, Boston, August 8, 1979.*
3 First Annual Report, September 1, 1978, *ANL Contract 31-109-38-4207* (in preparation).

RESEARCH, DEVELOPMENT AND DEMONSTRATION OF LEAD–ACID BATTERIES FOR ELECTRIC VEHICLE PROPULSION

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The objective of this project is to develop and demonstrate improved and advanced lead–acid battery systems for electric vehicles. Key technical goals for the Improved State-of-the-Art (ISOA) battery are a specific energy of 40 W h/kg at the 3 h discharge rate, a specific peak power of 100 W/kg

when 50 percent. discharged, a life of 800 cycles at an 80 percent. depth of discharge, and a volume price of $50/kW h. The corresponding numbers for the advanced lead–acid battery key technical goals are 60 W h/kg, 150 W/kg, 1000 cycles, and $40/kW h.

The major effort initially is on the development of the ISOA battery. This effort concentrates on design of the electrodes to minimize electrical resistance losses yet reducing the amount of lead required; development of an improved separator; and the development of a reliable, simple system for circulating electrolyte within each cell. An intensive R&D effort was also initiated to improve the active material utilization with particular emphasis given to finding a better expander material for use in the negative electrode. The advanced battery technology will utilize the results of this effort in addition to more refined electrode designs.

In early April, 1979, the first ISOA cells were constructed and submitted to the National Battery Test Laboratory (NBTL) for characterization and life-cycle testing. Results from both NBTL and Globe–Union have been encouraging. These first cells have exceeded the ISOA performance objectives for energy density (42.5 W h/kg demonstrated) and peak power (118 W/kg demonstrated). Life cycle tests are underway. Concurrent with the ISOA cell development, there has been extensive basic research into the expander for the negative electrode. The goal is to identify the active compound of the expander's lignosulfonate and better to understand its structure and mechanism. Once this compound is identified, the task will be to produce a synthetic material which will improve the active material utilization and life. A microelectrode testing technique has been developed which allows continuous testing of a large number of expander materials under varying operating conditions.

Future work will consist of continuing research in the characterization of the lignosulfonates and the correlation of the microelectrode testing technique with actual cell results. This research will yield new synthetic lignosulfonates of an optimized concentration that will be used in the battery development.

Further optimizations of all the battery components and processes will be pursued. Computer optimization/design of the electrodes for the advanced battery will be completed. This design will incorporate the lead-plate electrode composite for weight reduction. Active material efficiency improvement will also be addressed in the Advanced Battery design.

Recent publications

1 C. E. Weinlein, Lead–acid electric vehicle battery development, *Abstracts of Papers, ACS/CSJ Chemical Congress, Honolulu, April 1 - 6, 1979, Abs. INDE-45.*