SODIUM–SULFUR BATTERY DEVELOPMENT, PHASE III

Ford Motor Company, P.O. Box 2053, Dearborn, MI 48121 (U.S.A.)

ERDA began supporting this effort in June, 1975. Phase IV of the program is being carried out with Ford Aerospace & Communications Corp. (FACC) and Ford Motor Co. as parties of a tripartite agreement with DOE.

The overall objectives of the program are to develop and demonstrate a large (~1 MW) sodium–sulfur battery for utility application and a battery for powering an electric vehicle. The Phase III work centered on development of cells with improved performance, reproducibility and durability. Improvements were required in cell design and materials and sealing technology. An additional goal was the definition of battery requirements for the electric vehicle application.

Design work led to demonstrating good performance with essentially complete reactant utilization for both load-leveling (~250 W h) and electric vehicle (~60 W h) cells. New seal designs were developed and work continued on the development of corrosion-resistant sulfur containers. (Efforts related to the demonstration of performance reproducibility for a larger number of load-leveling cells were carried out at FACC and are described in the report which follows.)

A packaging study of a Fiesta converted to an electric vehicle identified a front-wheel drive power-train arrangement with the battery located in the middle of the vehicle as the optimum configuration.

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Aeronutronic Division, Ford Aerospace & Communications Corp., Newport Beach, CA 92663 (U.S.A.)

The primary Phase III objectives were the development of the Mark I cell (~250 W h) and the demonstration of good, reproducible performance of a group of these cells. To accomplish these overall objectives, improvements in electrode design, container materials, and sealing technology were required.

During Phase III, more than 200 cells were assembled and tested to examine the effects of electrode geometry, seal configuration, and sulfur container material. In October 1978 a durability test of a group of 20 cells representing the best combination of variables was begun. Early in their life these cells delivered ~120 W h/kg at 90 mA/cm^2 at an efficiency of ~80%. Tests of these cells continued in Phase IV.

The Phase IV work encompasses continuing cell development leading to selection of a cell design for the pre-BEST Qualification Test which is to begin by the end of Phase IV. In this phase the overall designs and control systems will be developed for both systems.

More than 250 exploratory and Mark I cells utilizing a 34 mm dia., 250-mm long β''-alumina solid electrolyte have been built and tested in the last 18 months under the referenced Phase III and Phase IV contracts. Of these, presently 60 cells are undergoing electrical testing. Eleven of these have been operated for over 400 cycles. Discharged at 90 mA/cm^2 to 1.4 V and charged at 50 mA/cm^2 to 2.6 V, 46 cells of the improved Mark I design exhibited the following mean performance: energy, 208 W h; energy density, 109 W h/kg; capacity, 119 A h; utilization of sulfur ($S^0 \rightarrow NaS_3$), 86.7%; efficiency, W h_o/W h_i, 81.6%; discharge time, 5.0 h; overall cell impedance (ohmic resistance plus polarization), 10.6 mΩ.

During the remainder of 1979 and early 1980 an improved cell will be developed. A compact hermetic seal will replace the present bulky mechanical seal. A more durable sulfur container will be developed. Multicell tests will be continued. System analysis of conceptual batteries is being performed.

SODIUM–SULFUR BATTERY DEVELOPMENT, PHASE IV

Ford Motor Company, Engineering & Research Staff, Dearborn, MI 48121 (U.S.A.)

The Ford portion of this program has the following objectives: (1) the development and evaluation of advanced sodium–sulfur cells which offer increased volumetric energy density, improved cell safety, and improved freeze–thaw characteristics; (2) the analysis of EV battery requirements and coordination of EV battery design efforts; (3) the completion of sodium–sulfur battery technology transfer to Ford Aerospace and Communications Corporation, Aeronutronic Division. The program objectives will be achieved by conducting an on-going research effort in cell design, fabrication, analysis and evaluation and *via* system studies to determine EV battery requirements and characteristics.