# NEAR-TERM ELECTRIC VEHICLE BATTERIES

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This project is directed toward the development of near-term battery technology for electric vehicles in support of Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976, P.L. 94 - 413. The majority of the funding for this project supports eight industrial subcontracts for research and development on lead–acid, nickel/zinc, and nickel/iron batteries. The project also includes verification testing of the improved cells and batteries by the ANL National Battery Test Laboratory, development of supporting technologies such as separators and charging techniques, and battery/vehicle integration tasks directed to accelerating application of the batteries.

During the first half of FY 1978, battery R&D subcontracts were given to ELTRA Corporation, ESB Inc., and Globe–Union, Inc. in the lead–acid area, to Yardney Electric Corporation, Energy Research Corporation and Gould Inc. in the nickel/zinc area, and to Westinghouse and Eagle–Picher Industries in the nickel/iron area. The contracts extend for periods of three to four years. All contracts call for the production of cells, modules, and prototype batteries. The subcontract with Yardney Electric Corp. was terminated on May 31, 1979 at the end of the Phase I effort. On April 15, 1979, ESB Inc. began a three-year subcontract for R&D on a nickel/zinc electric vehicle battery incorporating a vibrating zinc electrode.

The battery R&D efforts by the industrial contractors during this period were directed toward achieving the interim performance objectives established for FY 1979. These objectives are: (1) lead–acid — energy density of 39 W h/kg, peak power density of 90 W/kg, and a cycle life of 300 cycles; (2) nickel/iron — energy density of 58 W h/kg, peak power density of 110 W/kg, and a cycle life of 800 cycles; (3) nickel/zinc — energy density of 65 W h/kg, peak power density of 130 W/kg, and a cycle life of 200 cycles. The energy and power density objectives have been achieved on cells and modules in tests conducted by the contractors and at the Argonne National Battery Test Laboratory (NBTL). Life cycle testing has to be completed before cycle life can be demonstrated.

The NBTL was established to provide a facility for the independent testing and evaluation of various batteries as they are developed under the near-term battery program. As of June 1979 the laboratory was capable of the simultaneous testing of 13 cells or modules and one full-size (30 - 40 kW h) battery under a broad range of test conditions including simulated vehicle driving. Further expansion of NBTL test capabilities is underway. Since testing of cells and modules commenced in the NBTL in June 1978, tests have been completed on 39 nickel/zinc modules and six lead–acid

modules. Ongoing tests as of June 1979 include eight nickel/zinc cells and seventeen lead–acid cells.

The testing program at NBTL has shown that the temperature rise of a nickel/zinc module during discharge is directly proportional to the specific energy of the module. For all nickel/zinc modules tested the ratio is ~0.35 °C kg/W h, which suggests that the temperature rise of nickel/zinc batteries is intrinsically related to the specific energy, and any improvements in specific energy will require increased attention to thermal management. A similar, but less pronounced, effect is observed with lead–acid modules. A simplified EV battery load test profile was developed at NBTL which permits laboratory testing of batteries under load conditions representative of actual vehicle use.

The internal ANL support research program is directed toward the development of experimental and analytical data on the behavior of near-term battery systems which can be used to provide direction to the R&D effort. The studies performed thus far include the mathematical modeling of the thermal behavior of the nickel/zinc cells, an experimental investigation of polarization effects in the nickel/zinc system, and the analysis of stibine and arsine evolution from a lead–acid electric vehicle battery during vehicle use. In the battery/vehicle integration area battery application models are being developed which portray battery static/dynamic electrical and thermal behavior. These can be used in the design of electric vehicle systems. Electrical models have been derived for a lead–acid battery and two nickel/zinc batteries. In addition, this project is providing battery system support to the Upgraded Demonstration Vehicle (UDV) Program-related test and demonstration activities of the Jet Propulsion Laboratory (JPL). Three near-term full-size batteries (two nickel/zinc, and one nickel/iron) have been delivered to JPL for in-vehicle evaluation. In addition, identical modules are undergoing performance verification testing at NBTL.

The industrial contracts for the development of near-term battery technology will continue throughout 1980. This effort will give greater emphasis to the development of prototype electric vehicle batteries which will be delivered to the NBTL for verification testing. In addition, improved cells and modules will continue to be tested at NBTL using standardized procedures. These data will form the basis for the selection of R&D paths, the selection of the most promising battery types, and for the battery/vehicle interface assessment and modeling activities. The project will also continue to provide strong support to the DOE Upgraded Demonstration Vehicle program in order to accelerate application of the near-term battery technology.

## Recent publications

1 N. P. Yao, F. A. Ludwig and F. Hornstra, Overview of near-term battery development, *Proc. 5th Int. Electric Vehicle Symp., Philadelphia, October 2 - 5, 1978.*

2 F. Hornstra and N. P. Yao, Test methods and facilities at the National Battery Test Laboratory, *Extended Abstracts, Electrochem. Soc. Meeting, Pittsburgh, October 15 - 20, 1978, 78 - 2,* (102) (1978) 272 - 274.

3 A. R. Landgrebe and N. P. Yao, Batteries for electric vehicle applications: an overview, *Abstracts of Papers, ACS/CSJ Chemical Congress, Honolulu, April 1 - 6, 1979, Abs. INDE-44.*

## NEAR-TERM BATTERY SUPPORT

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The objective of this program is: (1) to provide a facility for testing cells and batteries at various stages of development in accordance with contractural requirements with DOE battery developers, (2) to provide a centralized and independent facility for characterizing, quantifying, and comparing the performance of various brands and types of batteries under the same operating conditions, (3) to verify performance of batteries under simulated operating conditions prior to application demonstrations, (4) to provide data for battery analysis and modeling, (5) to perform charging studies, (6) to provide battery support research on topics of fundamental interest to battery developers, and (7) to provide organizational and logistic support to the National Battery Advisory Committee (*ad hoc*).

During 1978 the National Battery Test Laboratory (NBTL) became operational to accommodate the testing program in support of the Near-Term Battery Development Program. Testing activity for the period from January 1978 through June 1979 included:

| Developer | System | Number of cells |
|---|---|---|
| ERC | Ni/Zn | 19 |
| Gould | Ni/Zn | 12 |
| Yardney | Ni/Zn | 16 |
| ESB | Lead–acid | 12 |
| Globe–Union/GE | Lead–acid | 6 |
| Globe–Union | Lead–acid | 5 |

Ranges of results obtained for the above tests were as follows:

| System | Specific energy (W h/kg) | Energetic efficiency (%) | Cycle life (cycles) |
|---|---|---|---|
| Lead–acid | 35 - 41 | 72 - 87 | 32 - TBD |
| Ni/Zn | 32, 62, 64 | 73 - 80 | 14 - 120 |