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USABC and PNGV Battery Testing

A number of unique tests have been developed for testing rechargeable batteries for propulsion application in electric and hybrid vehicles. These tests are providing an unbiased measure of battery performance, life, and abuse tolerance based on the goals of the U.S. Advanced Battery Consortium (USABC) and the Partnership for a New Generation of Vehicles (PNGV) Programs. These in turn have been standardized as "recommended practices" by the Society of Automotive Engineers, Warrendale, Pa.

As a result of many years of experience, battery testing has largely been developed by a team of engineers and scientists at the U.S. Department of Energy's national laboratories in collaboration with General Motors Corporation, Ford Motor Company, and DaimlerChrysler Corporation. Test results, using benchmarking procedures based on defined vehicle requirements for full-size, multi-cell battery assemblies, can provide invaluable insight for improving battery design.

USABC Testing ...Moving Toward High-Energy Performance for Electric Vehicles

The USABC Test Procedures Manual defines procedures to evaluate the performance of high-energy batteries for electric vehicles against the USABC requirements. These tests are used to characterize the core battery performance including: self discharge loss, power capability, cycle life, and calendar life. The two key test procedures are the peak power test and the life cycle test. The peak power value that is calculated at 80% depth of discharge (DOD) is critical because it serves as the basis of comparison between derived power and the power goal for the given battery technology. The life cycle test is used to determine the electrical performance of a battery under charge and discharge cycling. End-of-discharge is defined when the net capacity removed (in ampere-hours) is 80% of the rated capacity.

PNGV...Moving Toward High-Power Performance for Hybrid Vehicles

The PNGV Test Manual defines procedures to evaluate the performance of high-power batteries for hybrid vehicles against the PNGV requirements. PNGV energy storage goals are outlined for both the "power-assist" and "dual mode" engine vehicles. Specific tests include: static capacity, hybrid pulse power characterization (HPPC), operating set point stability, self discharge, life cycling, thermal performance, energy efficiency and calendar life. A key procedure for PNGV goals is the HPPC test, which determines dynamic power capability over a battery's useable state-of-charge (SOC) range.

Battery Life Prediction

For reasonable accuracy, predicting battery life typically requires testing of full-size battery systems over several years. The configuration of EV batteries typically require 100 or more electrochemical cells in series. Separate test regimes are defined for laboratory cells, battery modules or full size cells, and complete battery systems.

- *Laboratory cell testing is intended primarily for an early assessment of electrochemical systems under consideration.*
- *Module testing is intended to verify that scale-up to the full size cell or module level was successful and subsequently to evaluate the overall full size cell or module.*
- *Battery systems testing is intended to predict or verify overall battery pack performance, as required, to insure acceptable in-vehicle performance.*

Electrochemical Storage System Abuse Testing

Understanding the abuse tolerance characteristics of high energy and high power batteries is vital to the successful integration of such batteries into electric vehicles. A comprehensive array of tests have been developed, which will, when utilized to characterize cells, modules and battery packs, provide vehicle developers with the necessary tools to make sound engineering decisions. These include the suitability of a particular battery technology for use in a particular application; the need for protective packaging, either mechanical or thermal; and the controls required for a responsible energy storage system integration. The future of battery powered electric and hybrid vehicles is dependent on the safe, reliable utilization of these new energy systems, ideally in the earliest test vehicles and definitely by the time the first retail consumers are using these advanced vehicles. Listed below are the principal test categories and some procedures for each:

- ***Mechanical Abuse Tests*** *- includes mechanical shock, drop, penetration, rollover, immersion, and crush tests. The outcome of these tests may dictate the type of packaging and preferred orientation of the cells or modules in the vehicle.*

- ***Thermal Abuse Tests*** *- includes radiant heat, thermal stability, compromise of thermal insulation, overheat, shock cycling, elevated temperature storage, and extreme cold temperature test. These tests are designed to determine how a battery technology responds to a wide range of temperature variations and other thermal conditions that may occur in vehicle applications.*

- ***Electrical Abuse Tests*** *- includes short circuit, partial short circuit, overcharge and overdischarge, and AC current exposure tests. Overcharge is one of the most important abuse tests in the overall sequence since failure in any of a number of systems can result in excessive overcharge.*

- ***Vibration Tests*** *- includes cyclical tests of varying magnitudes, which simulate the exposure that components in automotive applications experience. These tests characterize the effect of long term, road induced, vibration and shock on the performance and service life of battery technologies.*

Sources for Additional Information

Several battery test manuals provide well-rounded descriptions of the performance requirements for the largest public EV and HEV development programs in the United States. These include the USABC Electric Vehicle Battery Test Procedures Manual, Rev 2, DOE/ID-10479, January 1996; PNGV Battery Test Manual, Rev.2, DOE/ID-10597, August 1999; and the Sandia National Laboratories Electrochemical Storage System Abuse Test Procedure Manual, SAND99-0497, July 1999. They represent international industry standards and have been adopted by the Society of Automotive Engineers as recommended practice.

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