Calendar Life Modeling Methodology for High-Power PNGV Saft Batteries

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The Partnership for a New Generation of Vehicles (PNGV) is a cooperative research and development program between the Federal Government and USCAR, whose members are Daimler-Chrysler, General Motors, and Ford Motor Company (1). A major goal of the program is to develop technologies for a new generation of hybrid electric vehicles with fuel economies up to three times (80 miles per gallon) the average 1994 family sedan. The investigation of energy storage devices has focused in recent years on high-power lithium ion, lithium polymer and nickel metal hydride batteries, all of which are being tested at the Idaho National Engineering and Environmental Laboratory.

The calendar life goal adopted by the PNGV and used by the Electrochemical Energy Storage Team is 15 years (2). The performance towards this goal is difficult to verify. However, modeling can assist in the prediction of the performance, but it must be developed for each technology. A calendar life model has been developed utilizing Saft HP-12, 12 Ah lithium ion cells.

Six Saft HP-12 cells (1999 Configuration) have been under test for 52 weeks using the PNGV calendar life test (2). Two cells each are being subjected to temperatures of 40°C, 50°C, and 60°C. Figure 1 shows the PNGV cell power over the course of the test at four-week reference-performance-test intervals. The PNGV cell power is determined from the power capability versus available energy graph from a Hybrid Pulse Power Characterization test (2). The PNGV cell power is the optimized power at which the PNGV 300 Wh energy goal can be met. Figure 2 shows the linear trend-lines for the average cell power at a particular test temperature. The trend-lines' slopes enable the extrapolation of the calendar life for each of the three test temperatures. This in turn allows extrapolation to nominal battery temperature of 25°C using an Arrhenius relation as shown in Figure 3. The graph plots the natural logarithm of the "Years to End of Life" versus the inverse temperature in Kelvin. Two cases are presented. The first case extrapolates calendar life based on the individual PNGV cell powers with their appropriate temperature-related power fade. The second case extrapolates calendar life based on the highest PNGV cell power correlated with their appropriate temperature-related power fade.

For case one, the calendar life model developed for the Saft HP-12, 12 Ah lithium ion cell predicts a calendar life of 6.3 years using the individual PNGV cell powers for the cells in a pack. The second case predicts a calendar life of 12.4 years assuming the highest PNGV cell power for every cell in a pack. Saft has since built HP-12 cells with improved component.

References

1. Review of the Research Program of the Partnership for a New Generation of Vehicles, 6th Report, National Academy of Sciences, 2000
2. PNGV Battery Test Manual, Revision 3, DOE/ID-10597, February 2001

Figure 1: Power Fade for Saft HP-12 Cells

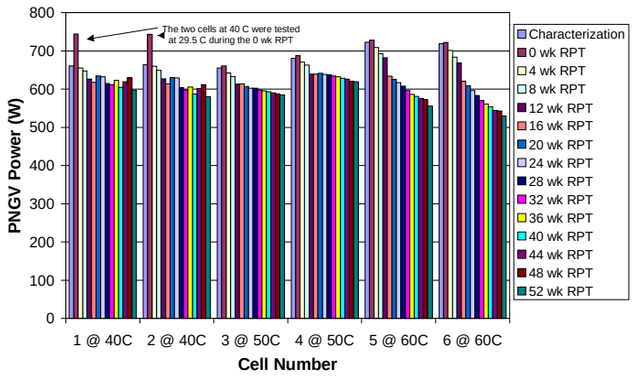

Figure 2: Chart of PNGV Power vs 4 wk Reference Performance Tests for Saft HP-12 Cells

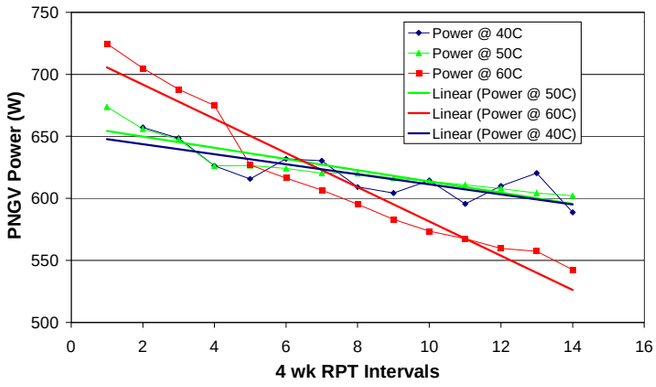

Figure 3: Arrhenius Plot of Calendar Life versus Temperature and Power Fade for Saft HP-12 Cells

Preliminary Results