

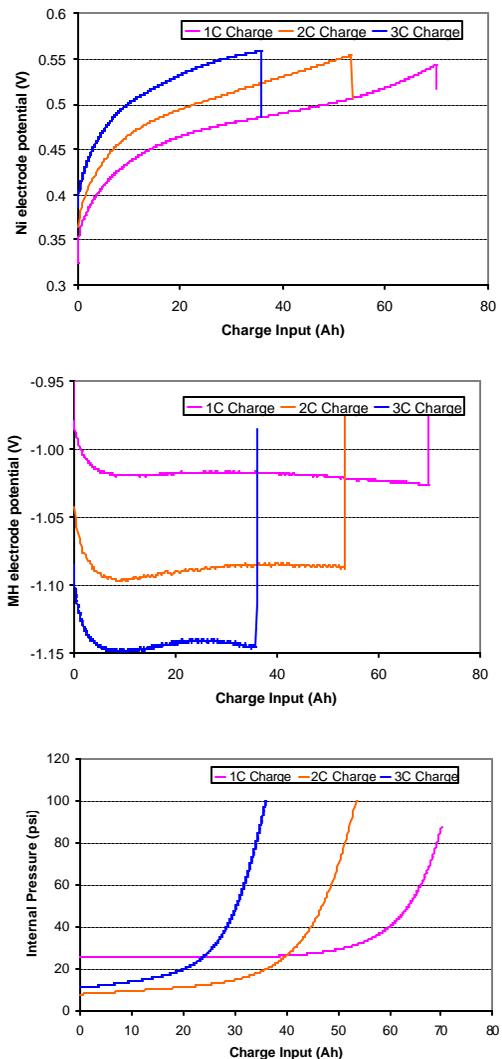
# IN-SITU ELECTROCHEMICAL ANALYSIS OF NICKEL-METAL HYDRIDE BATTERIES UNDER FAST CHARGING

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Electric and hybrid vehicles (EHVs) pose much reduced emissions, high fuel economy, and lowered maintenance costs. However, the high power and sporadic usage of the battery pack and its effect on battery performance remain a great concern for automakers and have a direct impact on consumers' acceptance. As for pure electric, there is an additional demand for high power fast charging, where the most prevailing fast charge terminations for the Ni-Cd and Ni-MH batteries are often based on the temperature acceleration ( $\frac{dT}{dt}$ ) and peak voltage detection. Recently we proposed a new fast charge technique for the Ni-MH traction batteries by detecting the internal pressure built-up. Pressure-control-based fast charge technique is more sensitive and reliable than the conventional temperature or/and voltage detection approaches because of the direct monitoring of the gas evolution and recombination. The disadvantage of the temperature detection comes from the inherent large heat capacity of the battery that makes the detectable temperature acceleration insensitive until the battery is substantially overcharged with severe gassing. Repeated overcharging is hazardous to battery cycle life. On the other hand, the peak voltage determination for full charge is hindered by aging and inhomogeneous electrode reaction. Both deficiencies could cause local overcharge, dry-out and shortened battery life.

This paper will discuss 'what's happened to the Ni-MH battery under fast charge regimes?' We conducted in-situ analysis and investigated an 85 Ah Ni-MH battery under 1C to 3C fast charge regimes. We found that the residual pressure after each charge cycle (with 1C charge and C/3 discharge) increased by about 30 psi. It implies that the excess gas produced during the fast charge process was not completely eliminated by subsequent recombination or the discharge reaction. We also found that the slopes of the pressure-time profiles at the end of the fast charges are the same among three tests under the same rates. It implies that the same gas evolution reoccurred in each cycle but was not completely reversible.

Figure 1 shows a different behavior between the working potentials of the nickel and metal hydride electrode. Under a fast charge, the potential of the nickel electrode increased smoothly with the charge input. The potential of the metal hydride electrode, in contrast, showed an interesting pattern during the same charge process. The MH potential dropped sharply in the beginning of the charging process, but then bounced to the positive direction to reach a maximum before descending at the end of the charge. This "unusual" potential excursion seems to link to the internal pressure built-up. We believe that the shift to the positive direction of the MH potential is an indication of the oxygen recombination at the MH electrode in the middle of the fast charge process. At the end of the charge, the descending of the MH potential seems to relate to the internal pressure build-up as the result of the hydrogen generation at the MH electrode.



**Figure 1.** Comparison among 1C, 2C and 3C fast charge regimes with respect to the internal pressure built-up and the potential of the individual electrode.

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