



## 21<sup>st</sup> Century Locomotive Technology: Quarterly Technical Status Report 13 DOE/AL68284-TSR13

This is the quarterly status report for the 21st Century Locomotive Technology project, DOE Award DE-FC04-2002AL68284. This report covers activities performed January 2006 to March 2006.

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## Task 1: Advanced Fuel Injection

### Objective

Develop and demonstrate an advanced fuel injection system to minimize fuel consumption, while meeting Tier 2 emissions levels.

### Progress since last report

As scheduled, the first quarter has been spent performing upgrades and calibrations on the single cylinder engine. The work is complete and we are producing a baseline dataset using GE Evolution engine hardware, including the production unit pump fuel system (UPS). The baseline data includes operating conditions representative of the current GE Evolution Locomotive notch definitions.

#### **Calibration and maintenance support data quality for advanced fuel injection study**

Calibration and maintenance have been performed throughout the test facility, including the following devices:

- Fuel balance for fuel consumption measurement
- Engine dynamometer for engine load application
- Air flow meter for measurement of total air flow through engine
- Humidity sensor for measurement of intake air humidity
- Sensors and meters in the facility auxiliary systems for engine subsystem control

#### **Hardware modifications give greater flexibility for advanced fuel injection study**

- The single cylinder engine exhaust system has been upgraded to allow for more flexibility in engine exhaust pressure and temperature.
- The exhaust piping mounting has been changed to improve vibration management and lengthen component life.
- Static pressure instrumentation has been added on the engine manifolds.

#### **Baseline engine performance data collection for comparison with advanced fuel injection**

- A procedure to match SCE performance to MCE at each notch condition is being performed.
- Data collected will be used to identify differences between the advanced fuel injection and production unit pump system.



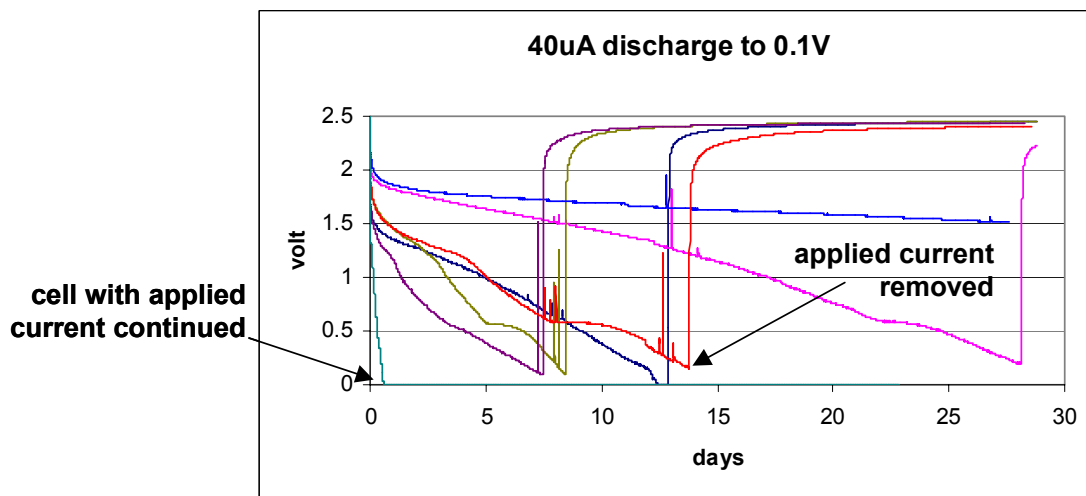
## Planned activity for next quarter

Over the next quarter, the baseline data will be collected and experiments with the high pressure common rail fuel system will begin. Previously we had explored HPCR at notch 4 and notch 8 conditions. We will assess more notch conditions to obtain an understanding of a duty cycle impact of HPCR. In addition to comparing the standard performance parameters, we will compare the details of the fuel injection event between the two system, such as comparing the fuel pressure profile in both fuel systems and the effect on PM, NO<sub>x</sub>, and fuel consumption.



## Task 3: Hybrid Energy Storage

Long-term 40-microamp constant current testing of room-temperature cells was completed. Figure 1 shows that a 40-microamp discharge current will drive cells to an ultimately negative terminal voltage, although the spread of time intervals for this to happen is significant, ranging from one day to more than 28 days. These cells were subsequently tested at operating temperature and the only cell damaged was where the applied current was continued after cell voltage reversed. The initial conclusion is that there is a lot of variability in room-temperature cell behavior, and further that system-imposed discharging currents extracting more than 1mAh must be avoided.



**Fig. 1: Battery cell behavior at room temperature with applied low discharging current.**

A review of the battery vendor's ongoing detail design of the locomotive battery was held with GE Transportation. The battery vendor is continuing major battery assembly redesign and analysis activities to address robustness. The project testing activity will begin when the vendor supplies redesigned batteries.

## Task 5: Demonstrate hybrid locomotive concept with full-scale storage modules, and fuel optimizer

An energy storage battery model and additional capability to determine charging and discharging events were added to the fuel optimizer. Studies have validating these enhancements. Significant "productization" activities will be performed on the fuel optimizer platform outside this project to meet commercial requirements over the next several months. It is planned for the Task 5 work on the hybrid optimization to resume in September 2006.