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Fuel Cell Testing at the Argonne Fuel Cell Test Facility

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DOE Hydrogen Program Review

Washington, DC

May 2007

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FCP-3

Work sponsored by U.S. Department of Energy, Office of Hydrogen, Fuel Cells and Infrastructure Technologies

FreedomCAR & Fuel Partnership

U.S. Department of Energy

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Overview

Timeline

- Facility Planning: 1996
- Facility Commissioned: 1999
- End: Open - this is an ongoing activity to test/validate/document fuel cell performance as the technology continues to evolve and mature

Budget

- Total project funding: $300K/yr from DOE
- FY06: $300K
- FY07: $300K

Objectives

- To provide DOE with an independent assessment of DOE contract deliverables
- To benchmark commercial fuel cell technology developments

Collaborations

- FCTES^{QA} – International consortium (EU, Japan, US, etc) to develop standardized fuel cell test procedures
- FCTestNet Task Force
- USFCC

Approach

- Develop standardized test procedures for the evaluation of different stack technologies
- Characterize stack in terms of:
  - *Initial Performance*
  - *Durability: Accelerated aging test to yield a reasonable projection of life in a reasonable amount of test time*
  - *Low-Temperature Performance*
- Adapt Fuel Cell Test Facility as needed to accommodate the unique needs of different technologies
- Addresses Barriers
  - A. Durability
  - J. Start-up Time (future)

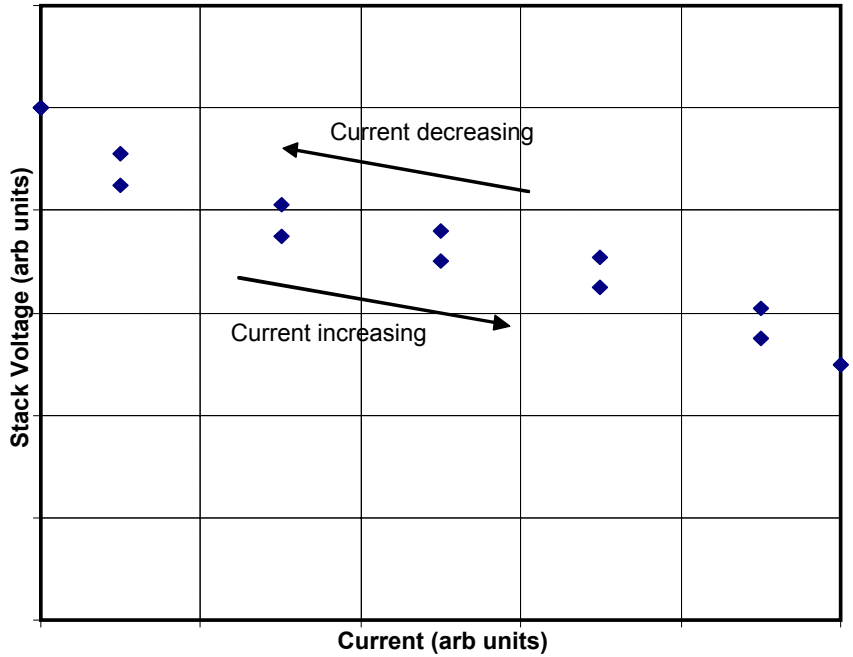
Technical Accomplishments: Progress and Results

- Characterized several fuel cell stacks and systems, ranging in size from 720 W to 85 kW

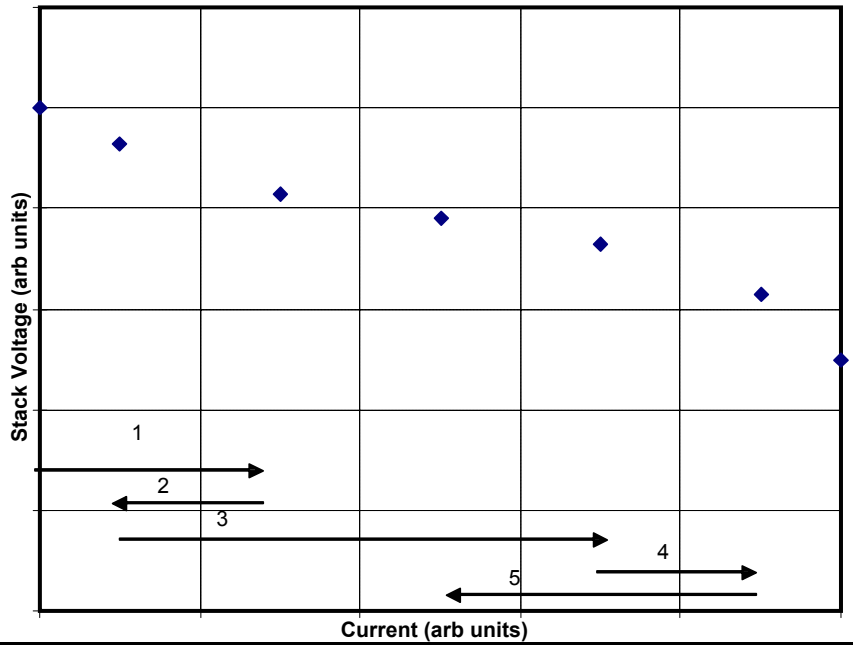
- FY07 Progress:
  - Characterized four 5 to 12-kW complete systems
  - Enhanced cooling system of the facility to handle high-temperature (130^{o}C), high-pressure coolant water

Example Test Plan for a 5-kW System

- **Initial Characterization**
  - **Sequential Polarization Curve**

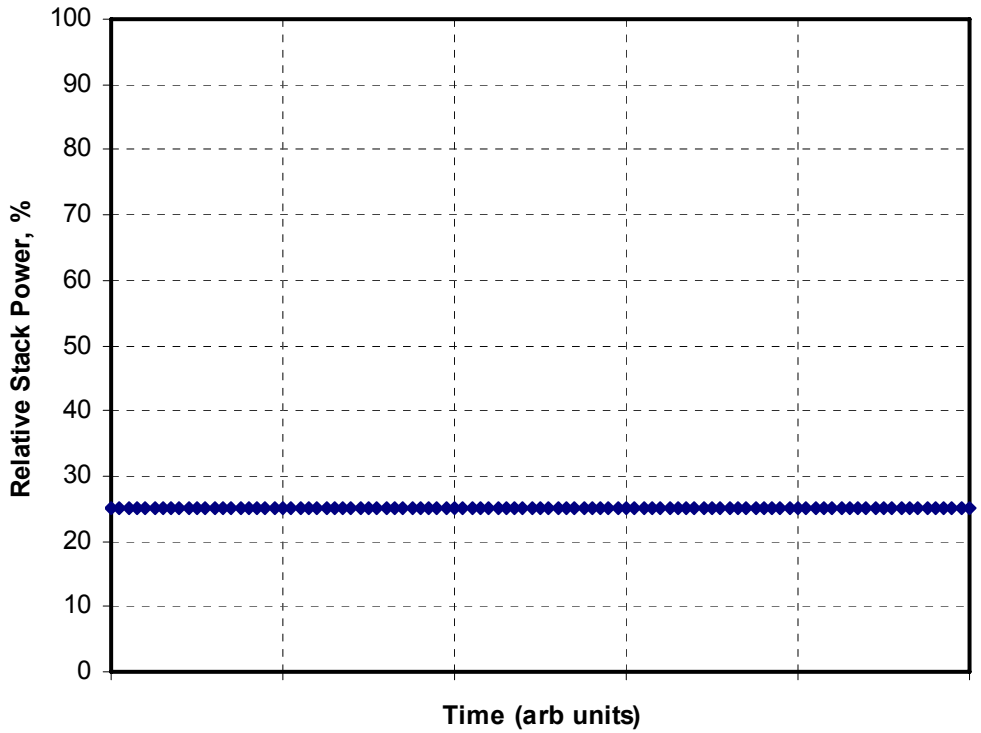


  - **Random Polarization Curve**
    - *Numbers and arrows on plot show sequence of current levels*



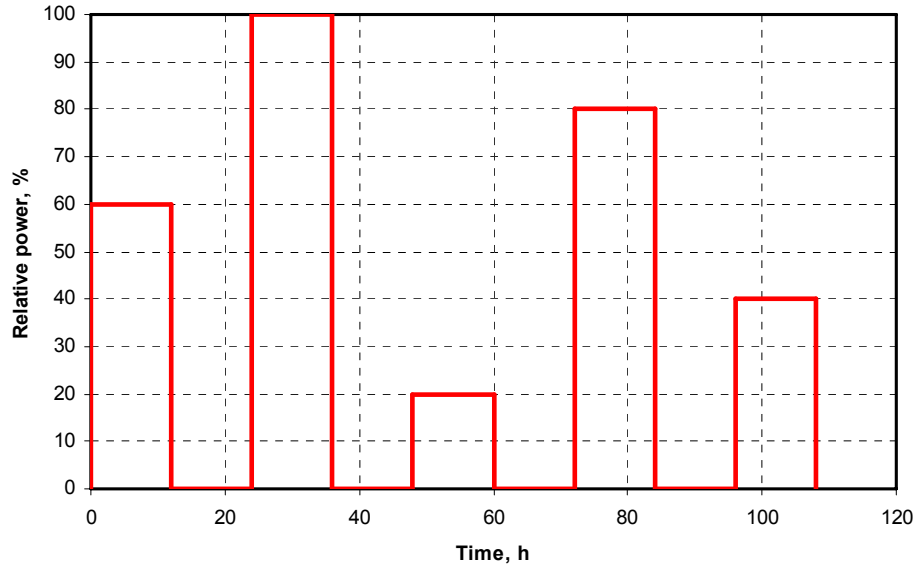
Example Test Plan (cont'd)

– Constant power (monitor cell/stack voltage and current)

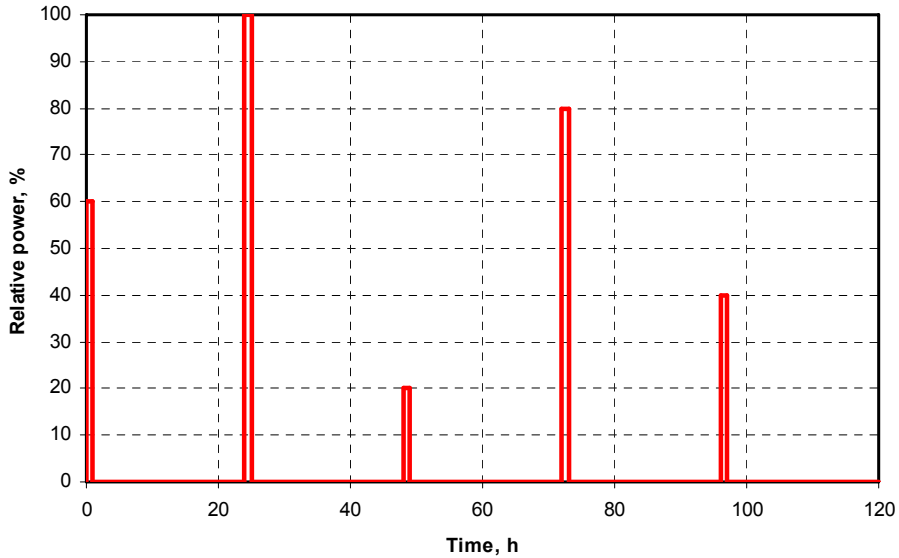


Durability Tests (1)

- **Start/Stop Cycling**
  - Long duration: 12 h on and 12 h off for 250 h

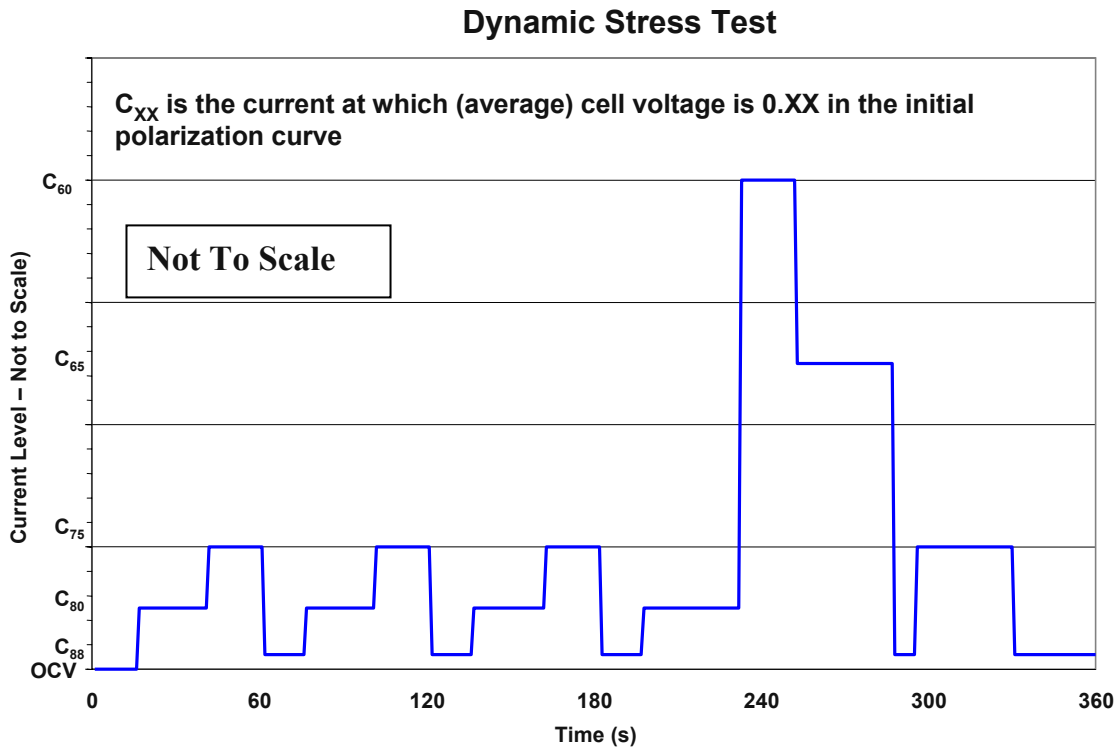


  - Short duration: 1 h on and 23 h off for 250 h



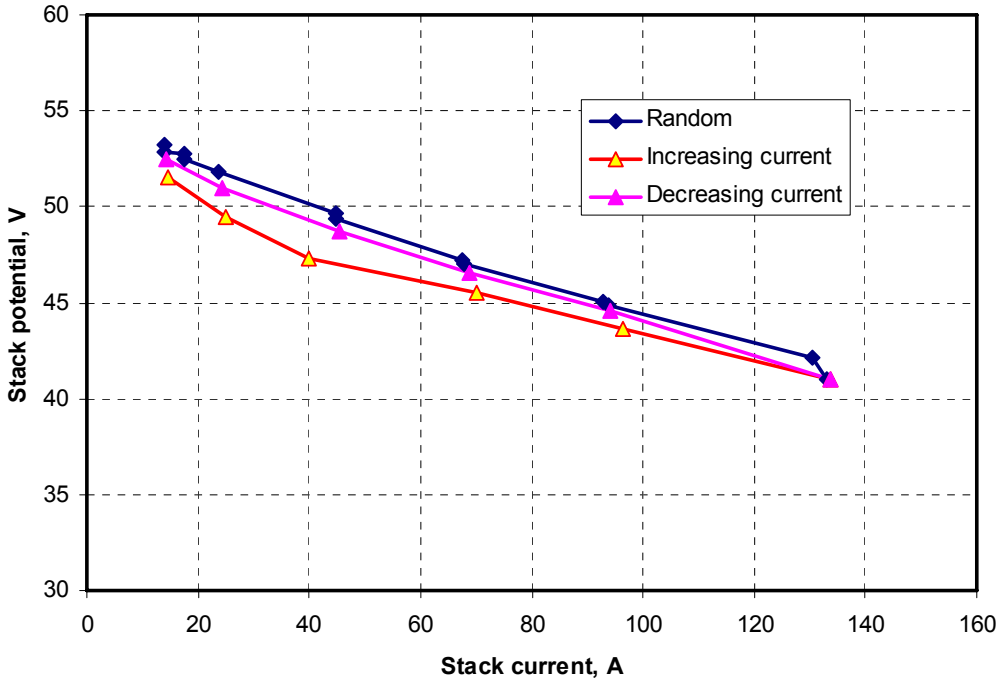
Durability (2)

- **Driving Duty Cycle (DST)**



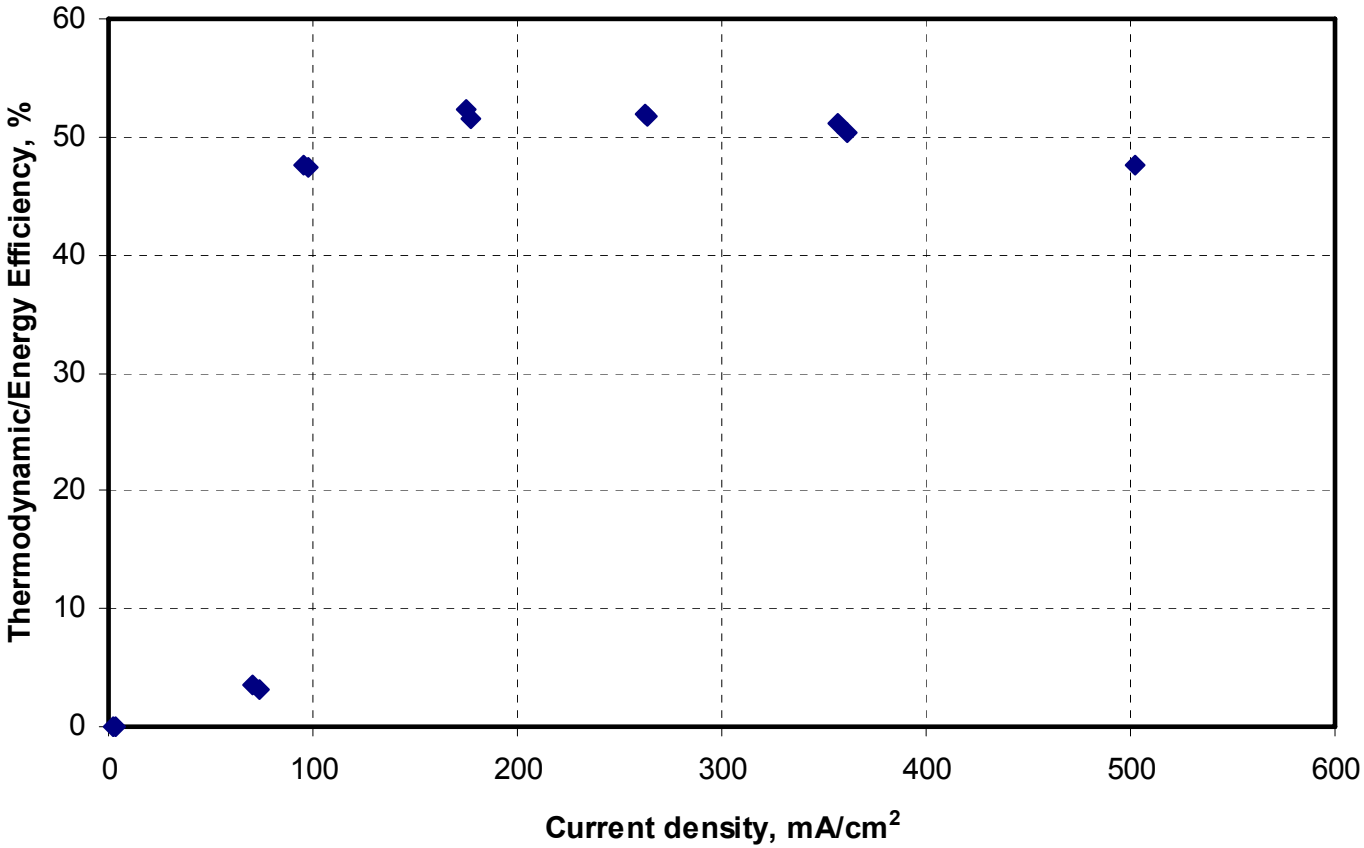
- **Reference Tests**
  - The reference tests will consist of one sequential polarization curve test. These tests are conducted before the aging process begins and after every 100-120 h of operation.

Results from Tests – Types of Polarization Curves

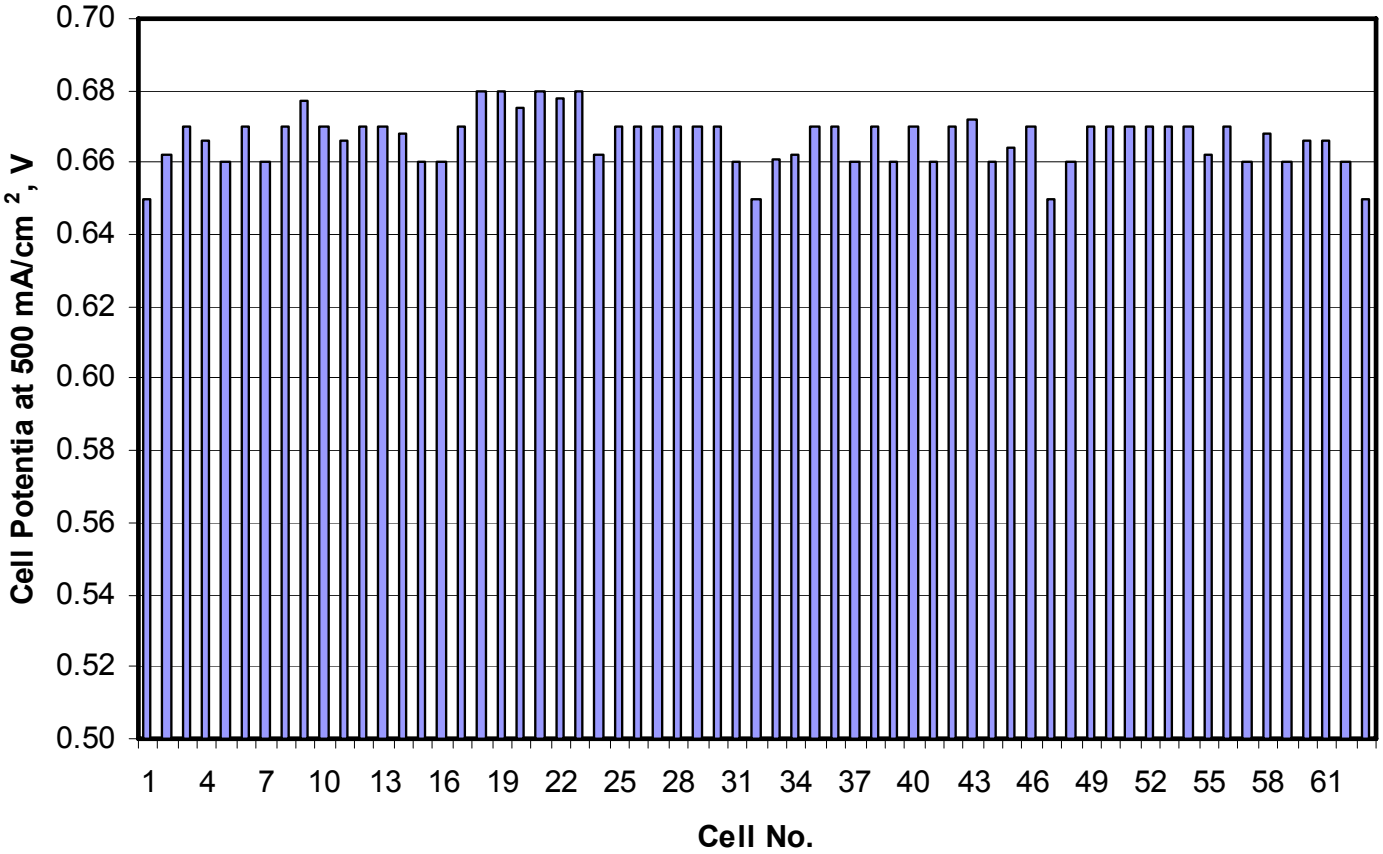


Rated maximum power: 5 kW
Measured maximum power: 5.5 kW

Thermodynamic Energy Efficiency at Characterization



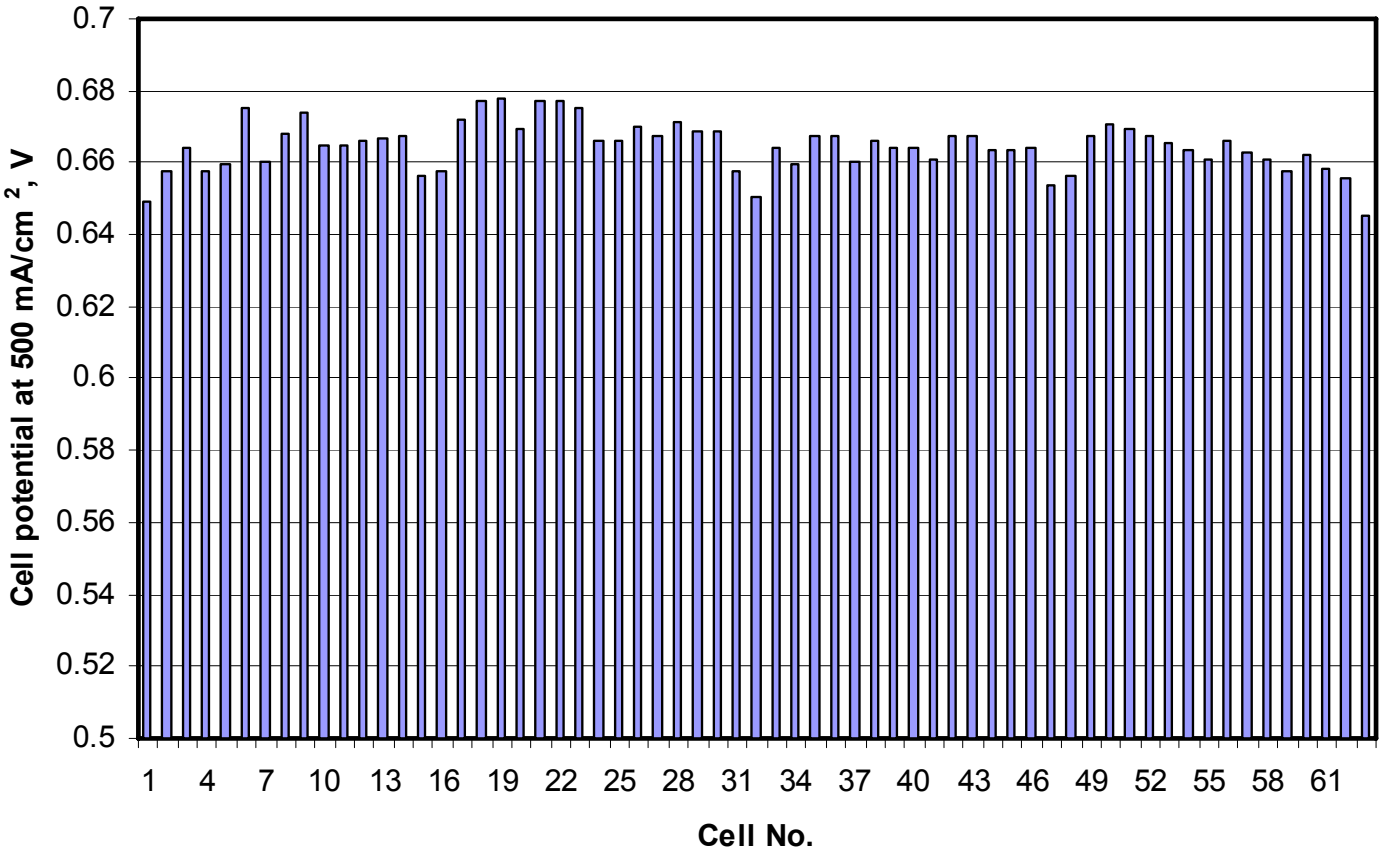
Cell Distribution at 500 mA/cm^2 at Characterization



Average=

0.660 ± 0.005 V

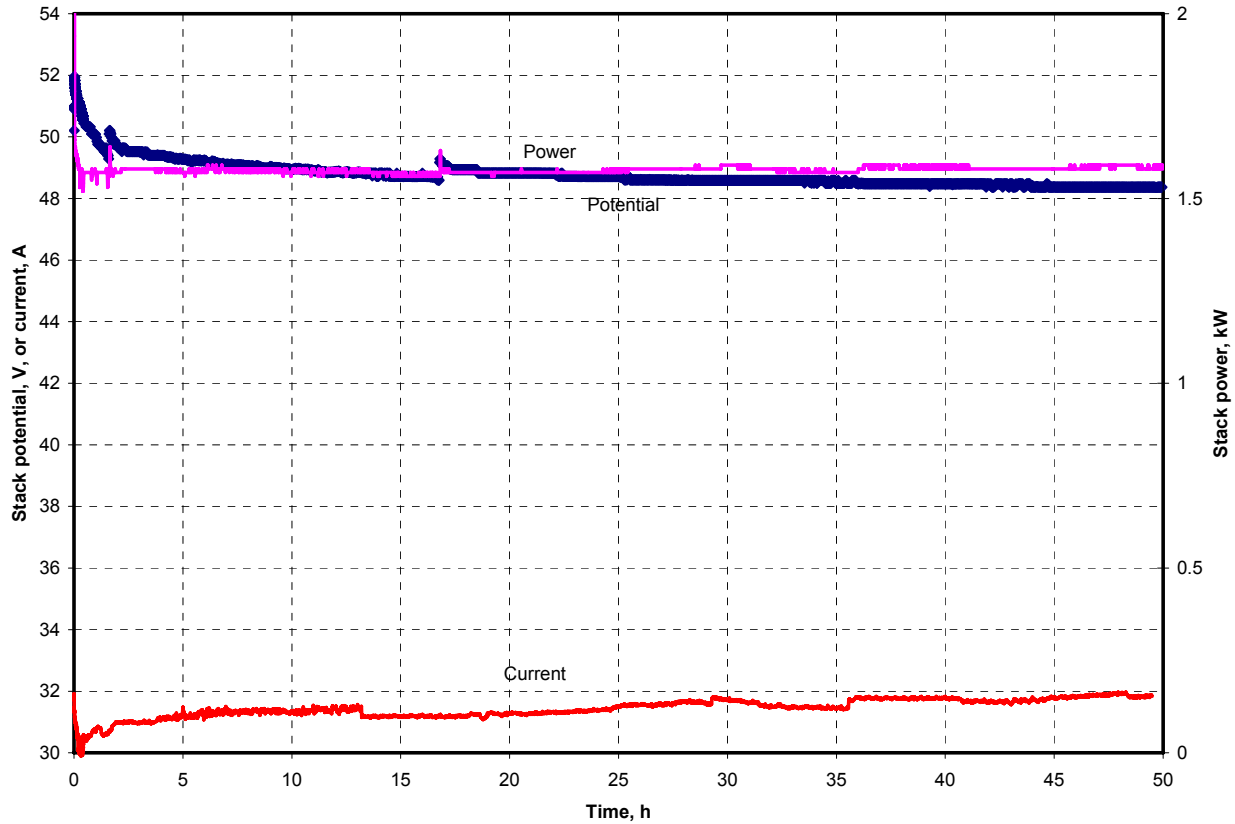
Uniformity of Cell Potentials From Random Polarization Curve



Average=
0.660±0.007 V

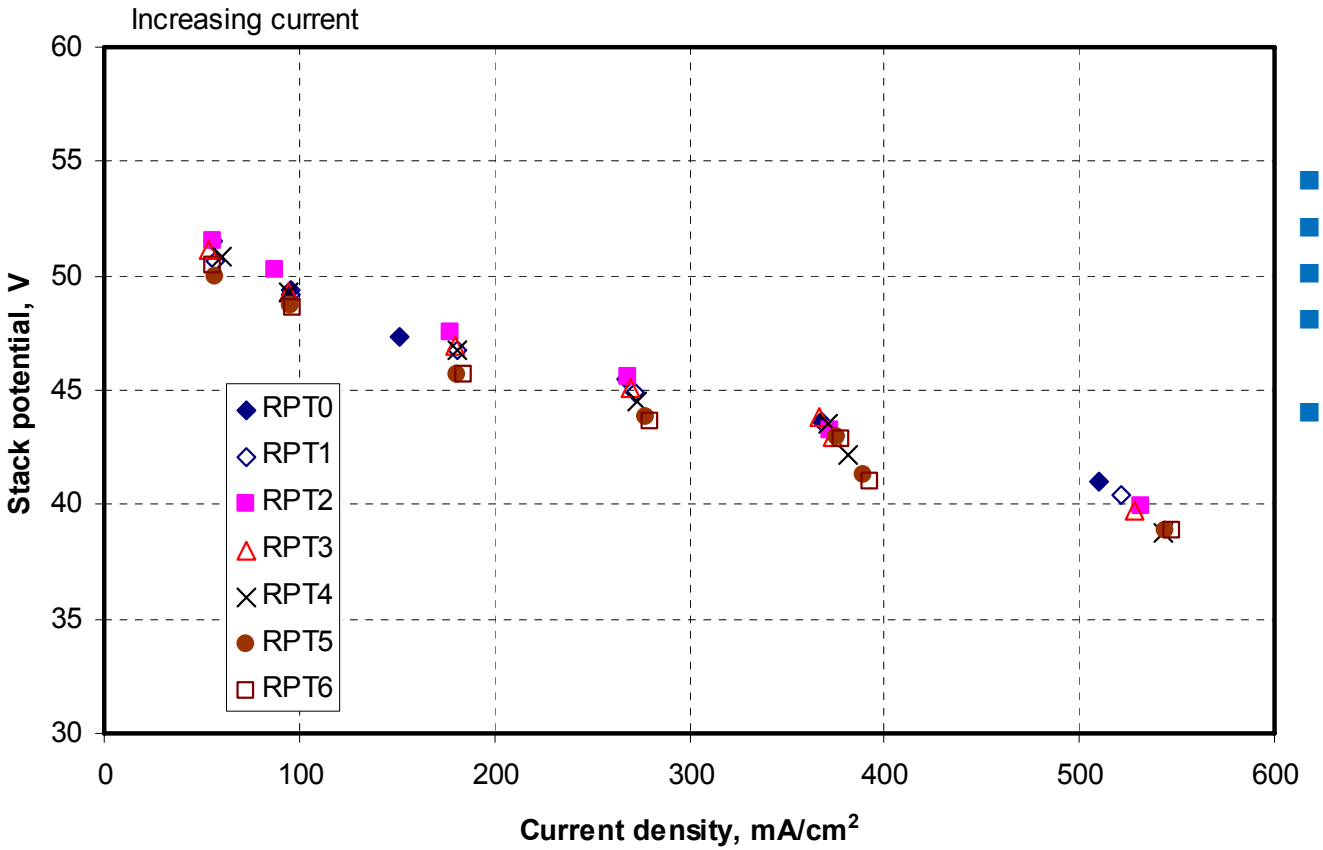
Results From Tests – Constant Power

- Constant Power for 50 h



Rate of voltage decline = ~20mV/h over the course of 44 h

Results From Long-Term Durability Tests

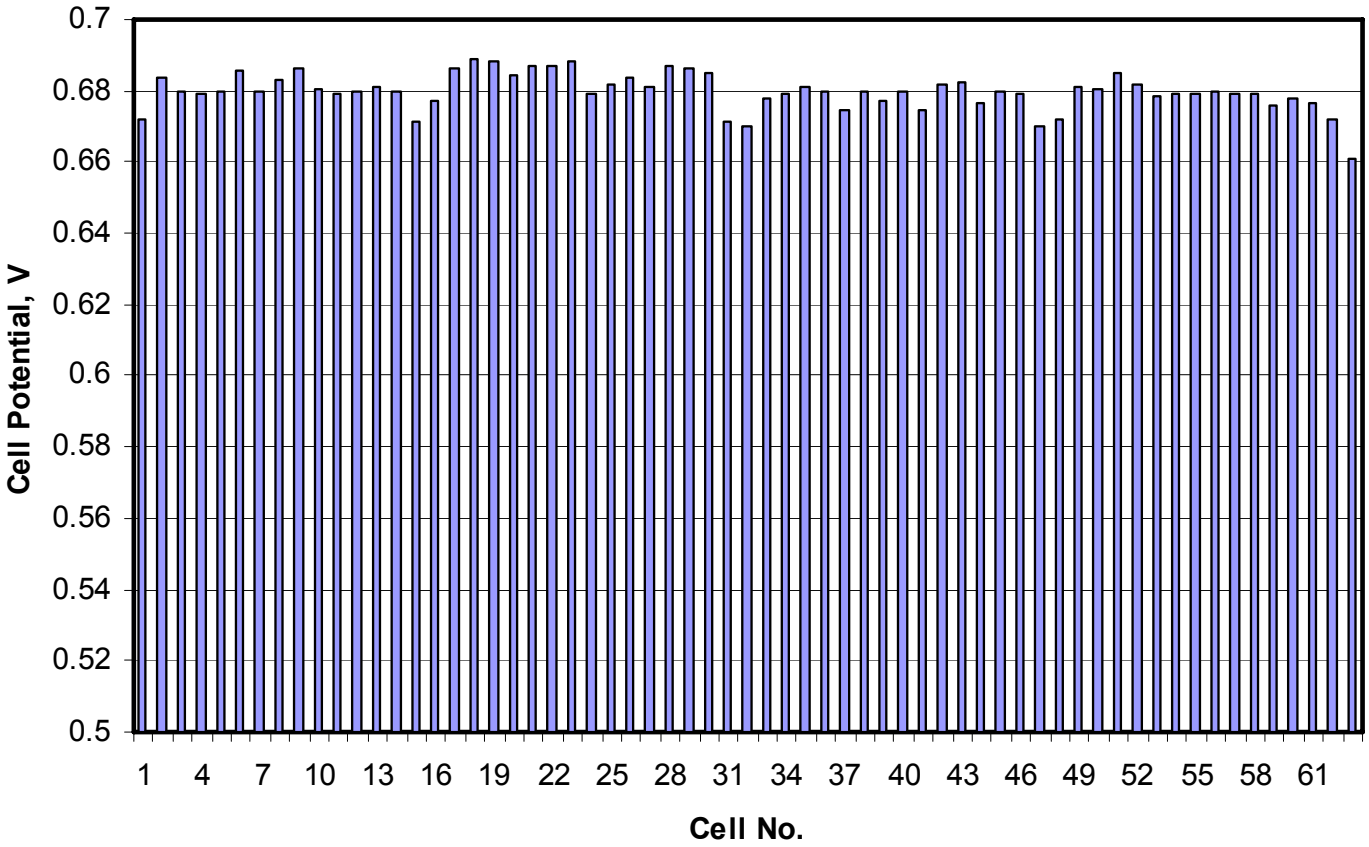


- RPT0 = start; no aging
- RPT1, RPT2= 1h on/23 h off
- RPT3, RPT4= 12 h on/12 h off
- RPT5, RPT6 = DST duty cycle

- Time between RPTs = 120 h

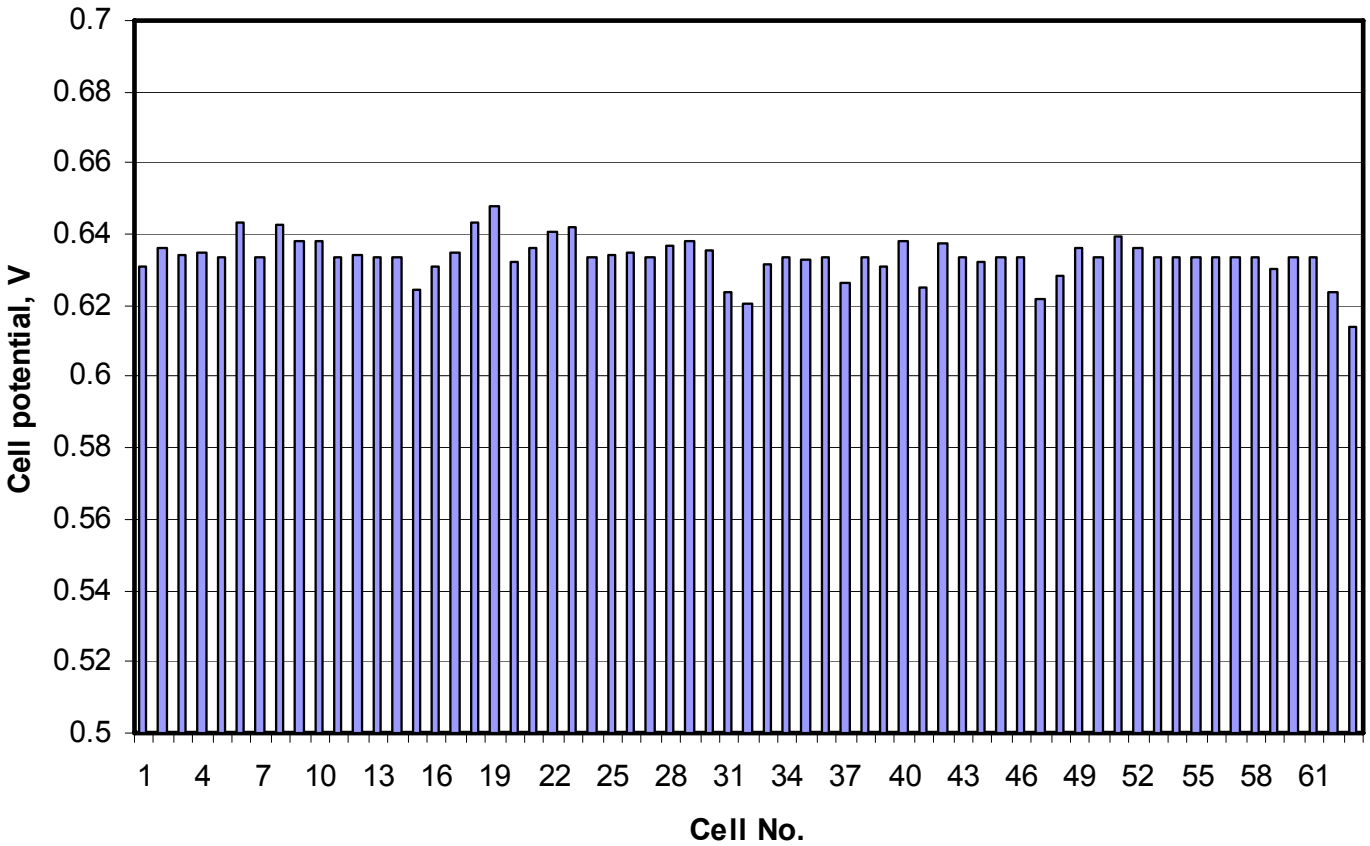
Uniformity of Cell Voltages After 12-h/12-off Cycling

- Current density = 500 mA/cm^2
- Average= 0.680±0.005 V



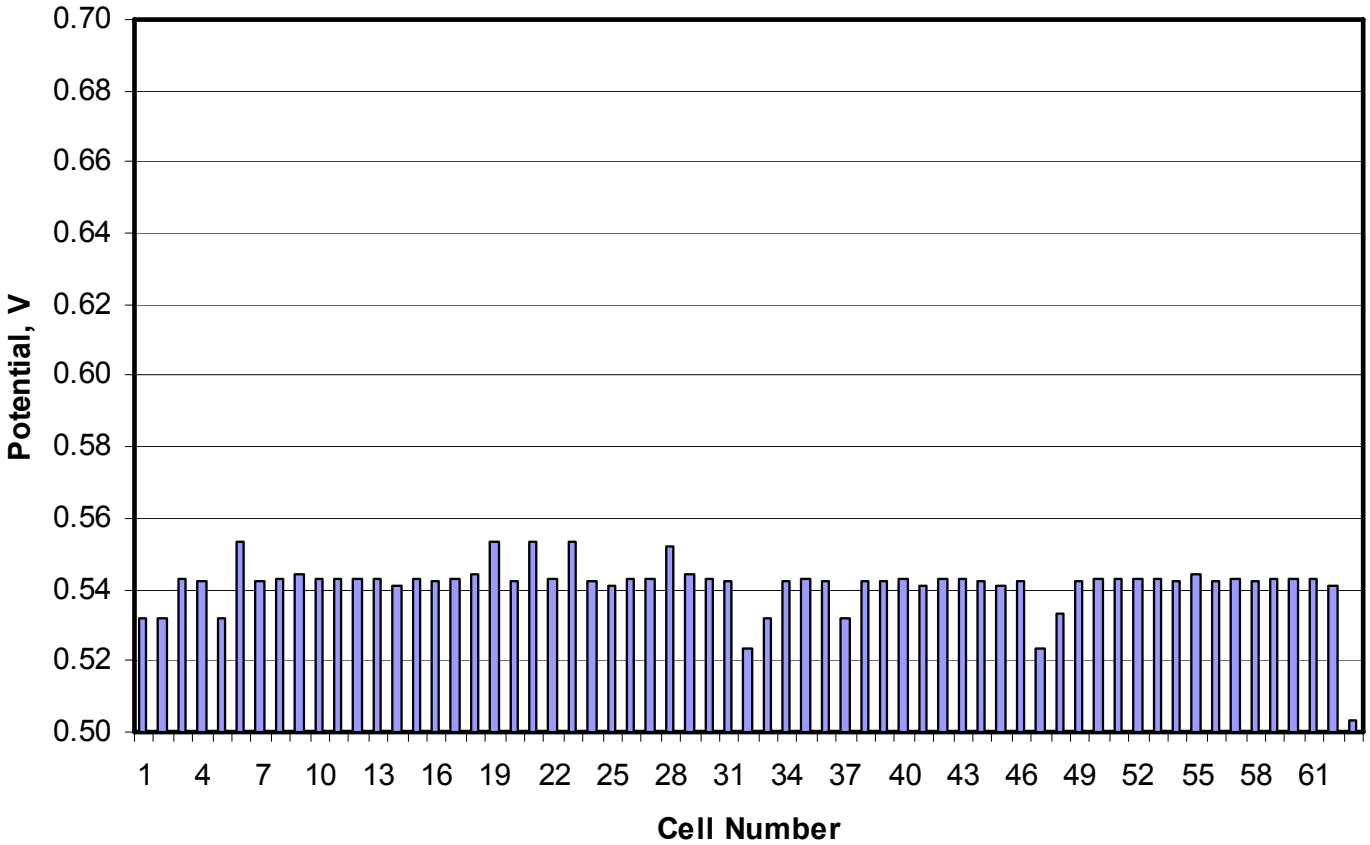
Uniformity of Cell Voltages After 1-h-on/23-h-off Cycling

- Current density= 500 mA/cm^2
- Average=0.630±0.006 V



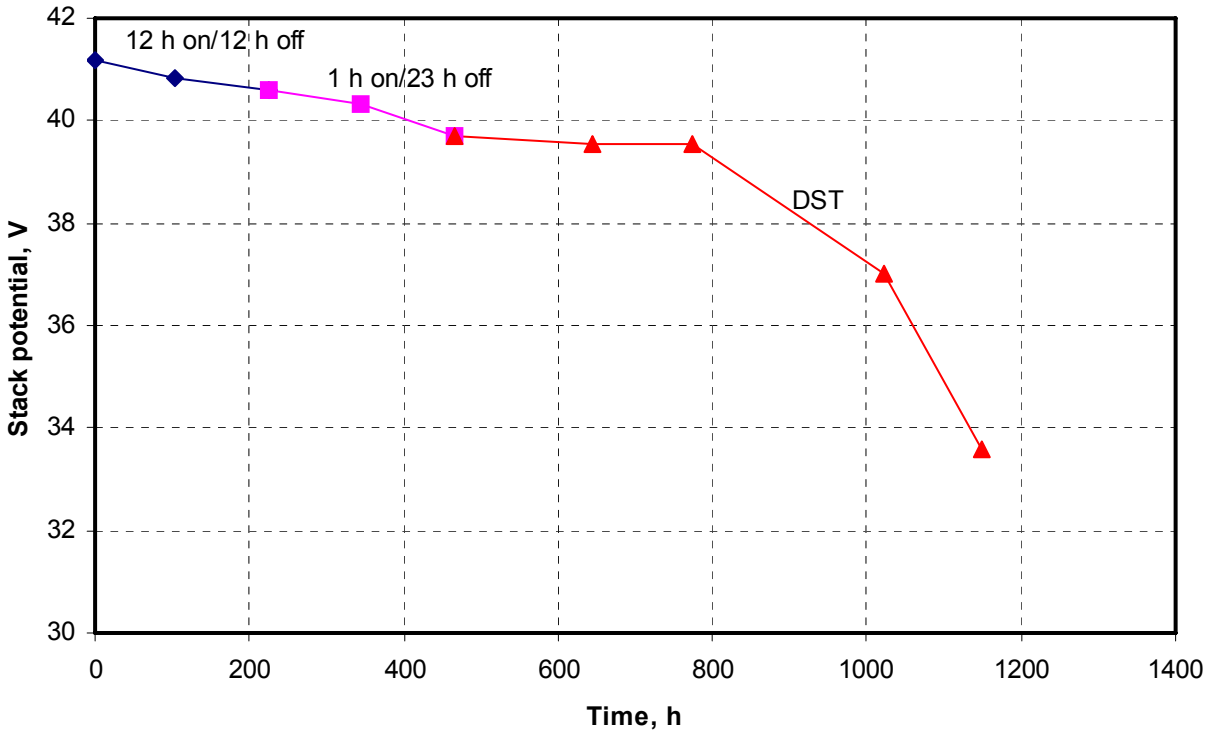
Uniformity of Cell Voltages After DST Cycling

- Current density=500 mA/cm^2
- Average=0.541±0.007 V



Rate of Voltage Degradation Depends on Test Type

- Stack voltage measured at 500 mA/cm^2
- Initial slope of curves appears to depend on time at high voltages ("idle" time). After 800 h of DST cycling, stack performance degraded rapidly

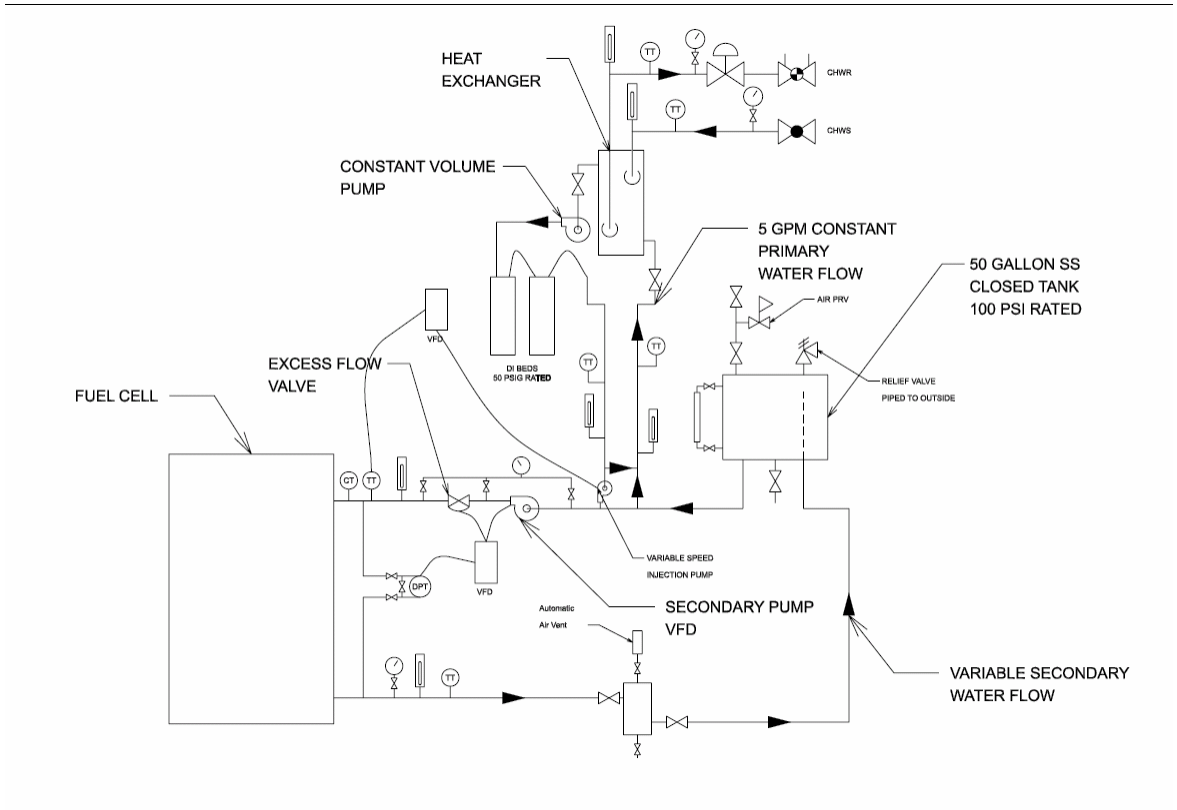


Rated lifetime: 1000 h

Measured lifetime: 1148 h

Facility Enhancements

- To accommodate DOE programs, upgrade cooling system to handle high-temperature deliverables (max. temperature = 130°C)



Summary

- FCTF has the ability to gauge development of fuel cell technology and is continuously upgrading capabilities (e.g., larger cooling capacity, fast gas transients, and low temperatures).
- Testing in FCTF is modeled after US standards. International standards would facilitate data exchange and, hence, technology validations. The FCTF is active in the proposal, evaluation and adoption of standardized test methods.
- FCTF acquires and benchmarks commercial fuel cell stacks to provide DOE with information regarding the evolution of the technology.
- FCTF is responsive to the needs of the sponsors, fuel cell developers, and end users.

Acknowledgment

This work was performed under the auspices of the US Department of Energy, Office of Hydrogen, Fuel Cells and Infrastructure Technologies, under Contract No. DE-AC02-06CH11357.