Component Benchmarking

Subtask Reported: *Establishing a Standardized Single Cell Testing Procedure through Industry Participation, Consensus and Experimentation*

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May 2005

Project ID# FCP27

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The Institute for Hydrogen and Fuel Cell Research

Industry Contributors

- David Lane, W.L. Gore and Associates

- Eric Teather, DuPont Fuel Cells

- Dawn McNeil, Teledyne Energy Systems

- Ross Bailey, Greenlight Power Technologies

- Michael Pien, ElectroChem, Inc.

Overview

- Timeline
  - Start: 10/03
  - End: ongoing
  - % complete: N/A
- Budget
  - Part of a larger task "Technical Assistance to Developers" funded at $250K/y
    - DOE share: 100%
    - Contractor share: N/A
  - Most DOE-directed effort under the parent task generates proprietary data
  - FY04 funding: $250K
  - FY05 funding: $250K

- Barriers

  Standardized testing resulting in confidence in MEA and component performance is essential to overcoming Fuel Cell Barriers
  - A. Durability
  - B. Cost
  - C. Electrode performance
- Partners, Collaborators
  - USFCC Materials and Components Working Group
  - USFCC Members

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Single Cell Task Force

Objective

To provide the PEM Fuel Cell industry with a standard test protocol outlining a consistent, repeatable method for conducting a single cell test and generating a polarization curve

U.S. Fuel Cell Council

- An industry association dedicated to fostering the commercialization of fuel cells in the United States

- Materials and Components Working Group
  - **Mission**

    To address the issues in production, reliable supply, specification, and standardization of materials and components for fuel cell stacks
  - **Membership**

    Fuel cell industry leading companies, universities, government laboratories, and individuals
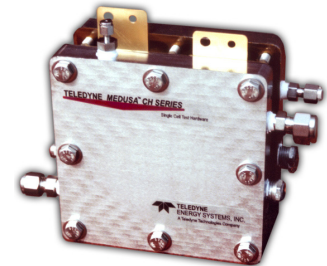
Single Cell Test Protocol

- ## Intent
  - – To enable publishing of test results of a material or component in a consistent, verifiable manner
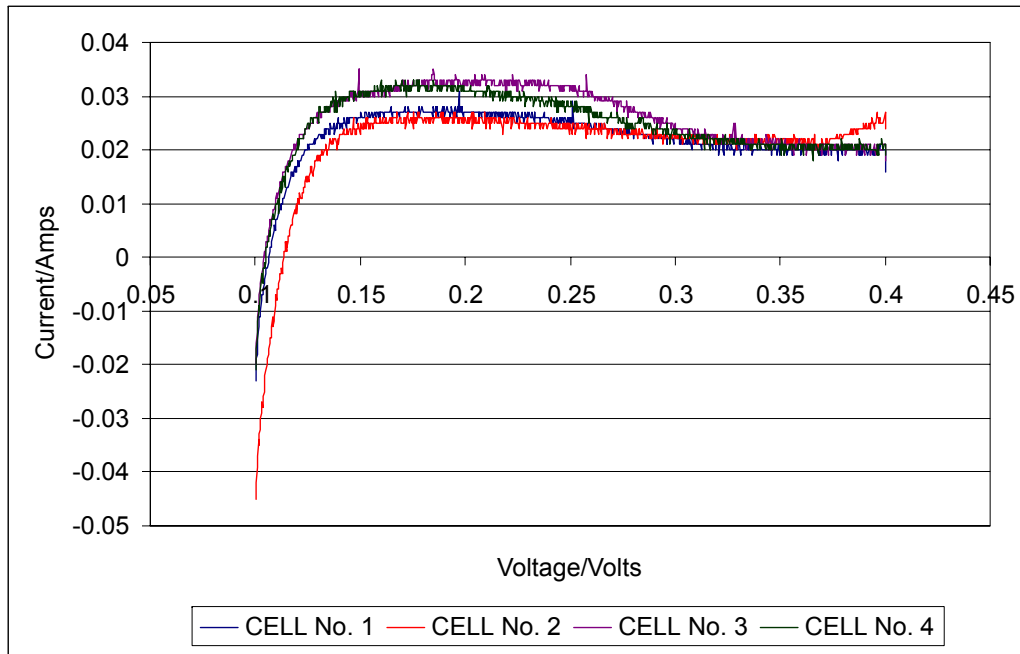
- ## Method
  - – Use of baseline hardware and materials with standard protocol for leak check, break-in, conditioning and polarization curves

Standard Hardware

- Teledyne Energy Systems Fuel Cell Hardware consisting of POCO graphite and co-flow configuration triple serpentine flow fields

- Saint-Gobain Performance Plastics Silicone Coated Fabric

- Dupont Nafion® 1135 Membranes

- DeNora ETEK V2 Diffuser Cloth

- Pressure testing performed to:
  - Verify proper hardware sealing
  - Determine a gross crossover leak rate
  - Electrochemically determine hydrogen crossover

H₂ Cross-Over Measurements

Gas Flows:

    A: H_2 (1.5 stoich at 1 A/cm^2)

    C: N_2 (30 L/h)

T_{Cell} : 29 °C
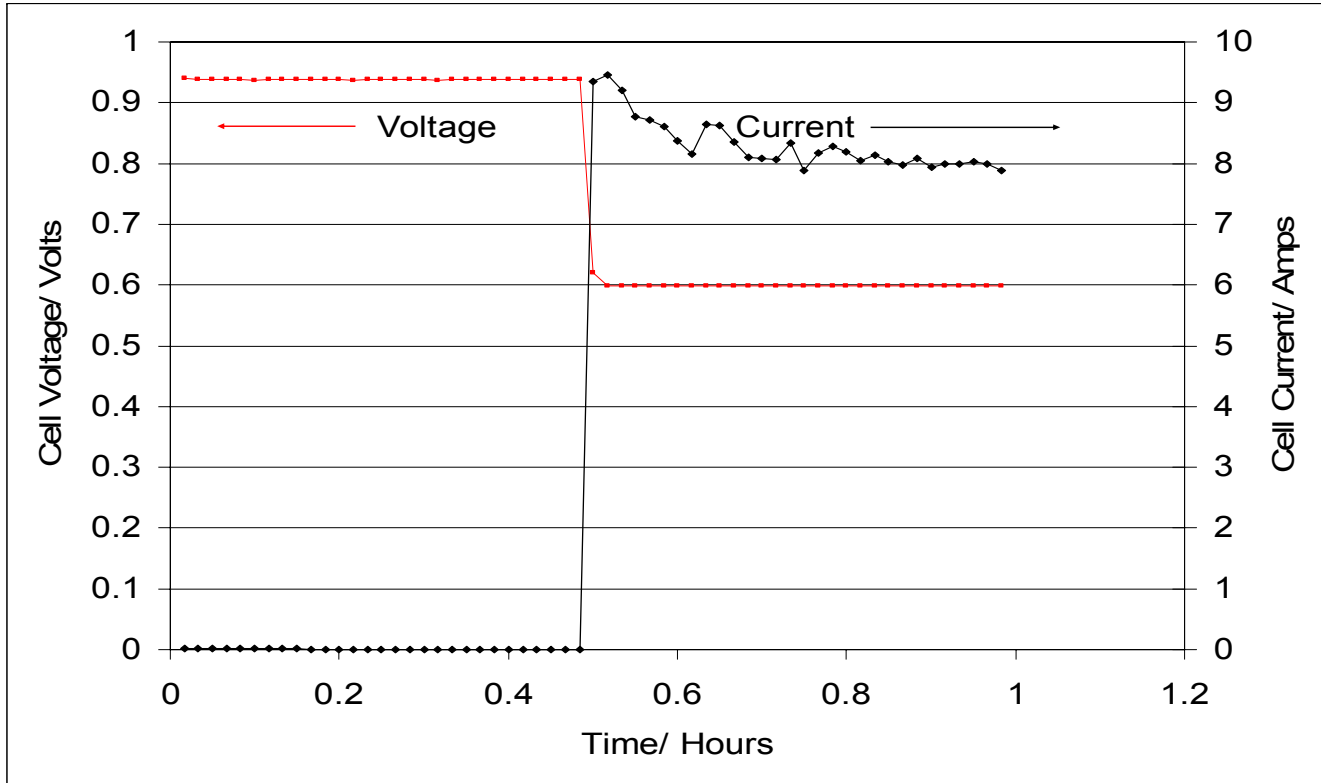
Back pressure : 3.7 psig (at LANL)

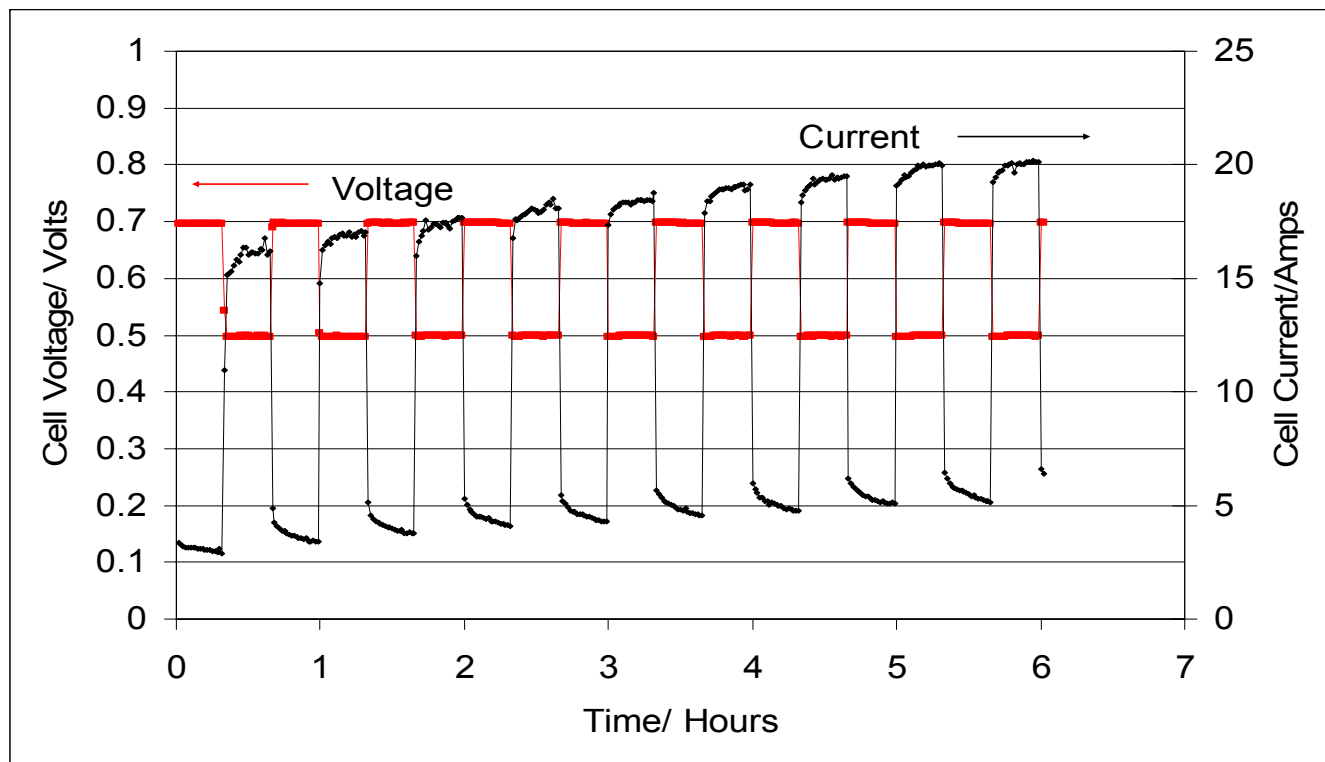**Scan Rate:** 2 mV/s

Potential range: 100- 400 mV

Break-In

- ## First Stage
  - Voltage Cycling at 30 minutes per setting (0.94V to 0.60V at 10 Stoich, 10 Amps)

- ## Second Stage
  - Voltage Cycling for 6 hours at 20 minutes per setting (0.70V to 0.50V)

- ## Third Stage
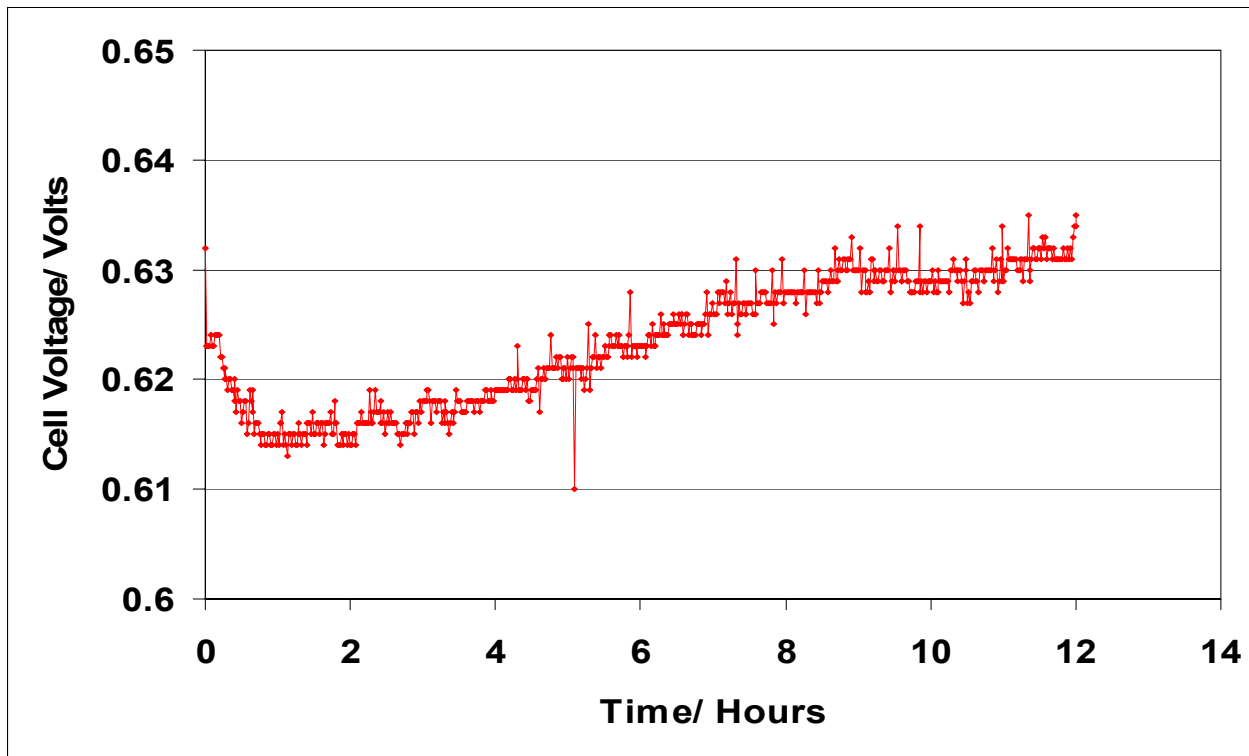 - Constant Current (10A) for 12 Hours

Stage 1: Initial Break-in

Stage 2: Initial Break-in
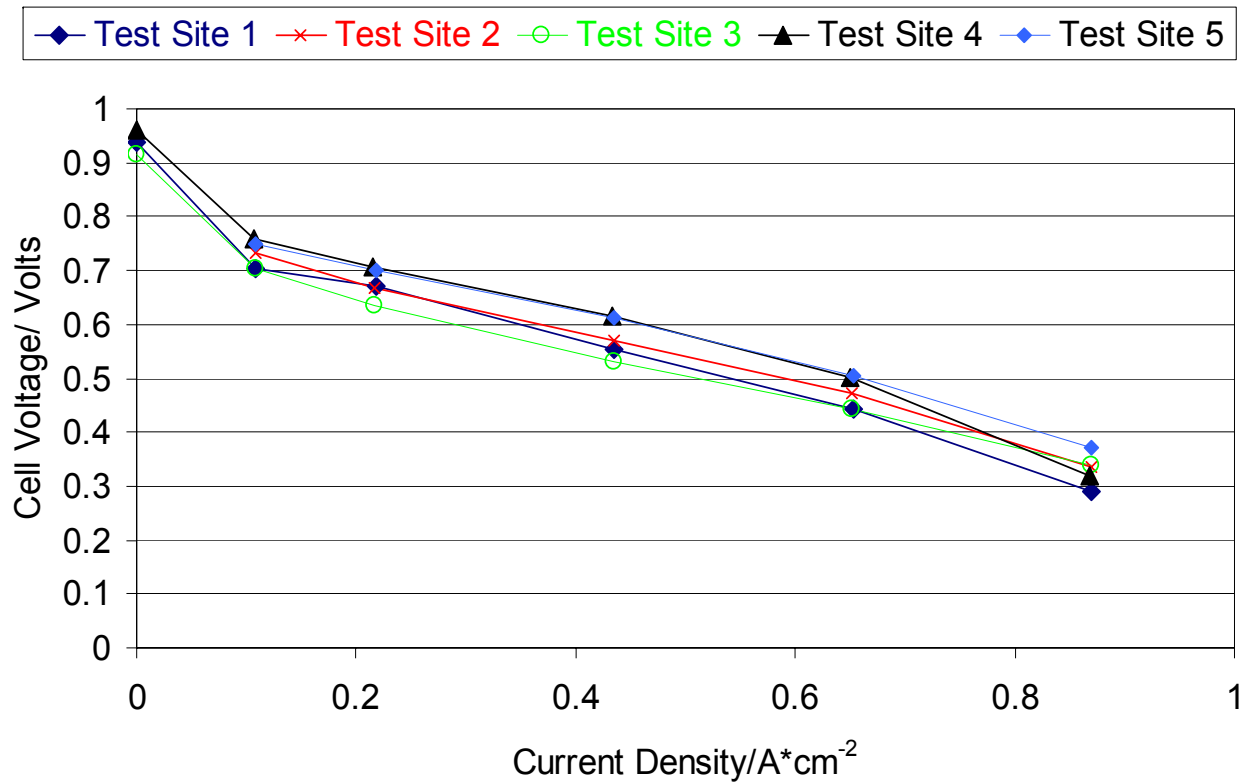
Stage 3: Initial Break-in

Round Robin Testing

- Four single cells tested at four different facilities using established Single Cell Testing Protocol
- Conditioning to re-hydrate cell at each new test site
  - 20A load for 4 hours, considered complete when voltage equilibrates
- Protocol Fourth Stage
  - Two sets of polarization curves were run 3 times with a 10 minute period between run until stabilization (less than 5mV deviation at 40A)
  - Protocol I (60°C, ambient pressure)
  - Protocol II (80°C, 25 psig)
- Cells were returned to original test-site for final testing

Polarization Curve Steps

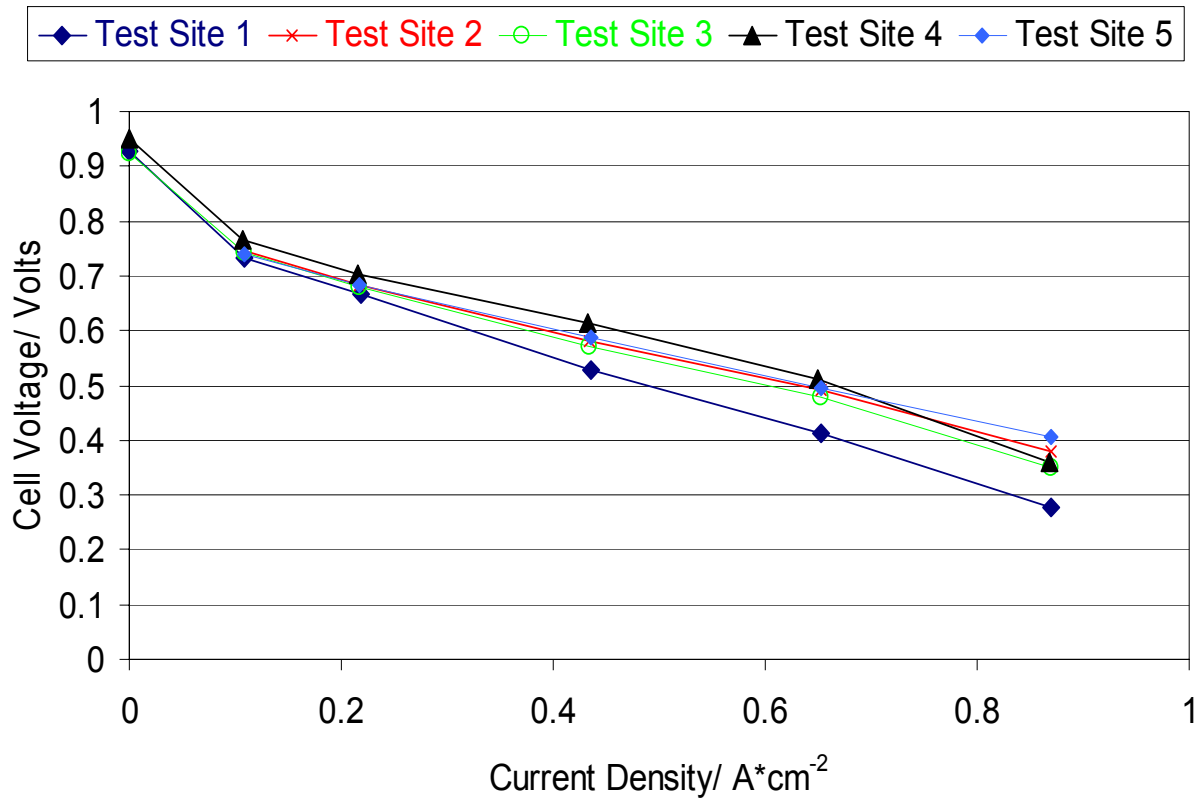| Sequence steps	Current Set point (Amps)	H2 Flow Rate (SLPM)	Air Flow Rate (SLPM)
0(< 1 minute)	0	0.042	0.166
1	5	0.042	0.166
2	10	0.084	0.332
3	20	0.167	0.663
4	30	0.251	0.995
5	40	0.334	1.327
6	50	0.418	1.658
7	60	0.501	1.990

Stage 4: Polarization Curves
Test Cell No. 1/Protocol I
60°C, ambient pressure
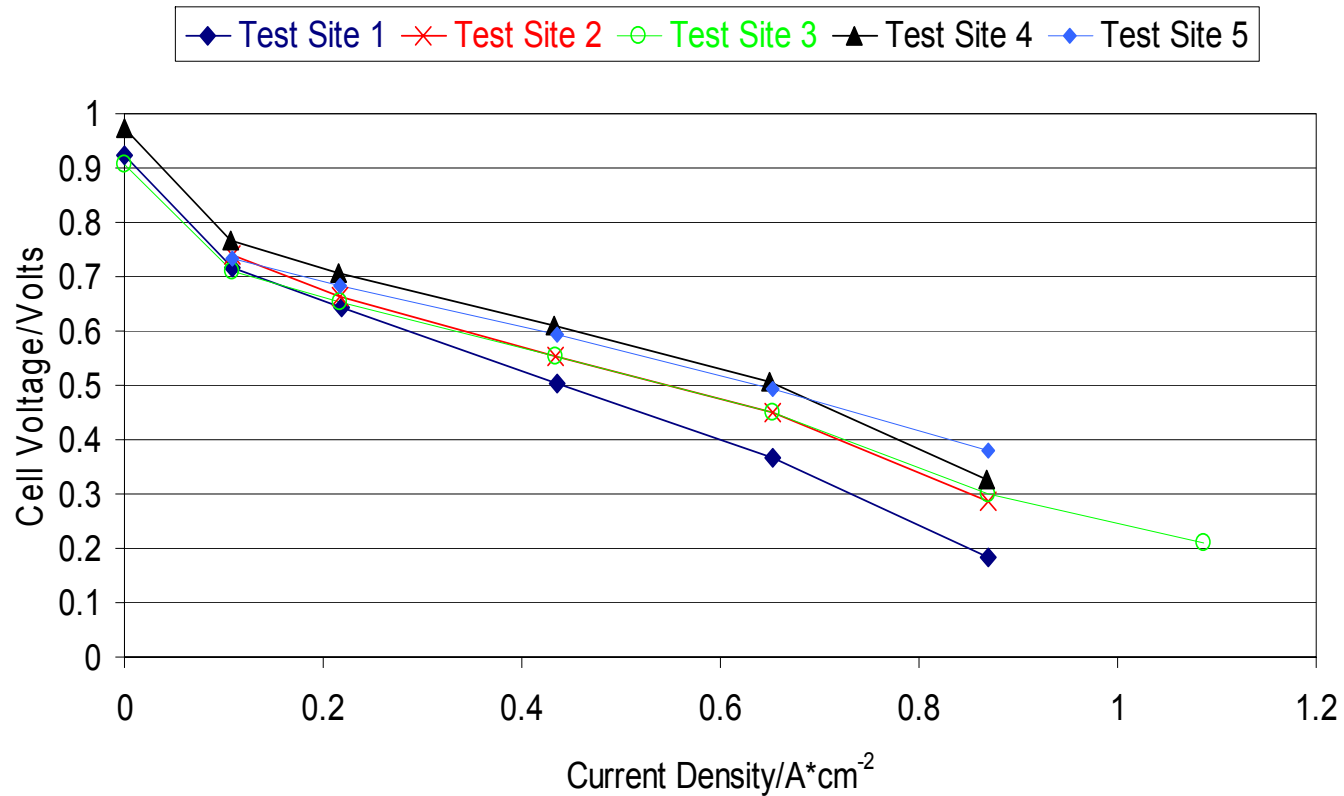
Stage 4: Polarization Curves
Test Cell No. 2/Protocol I
60°C, ambient pressure

Stage 4: Polarization Curves
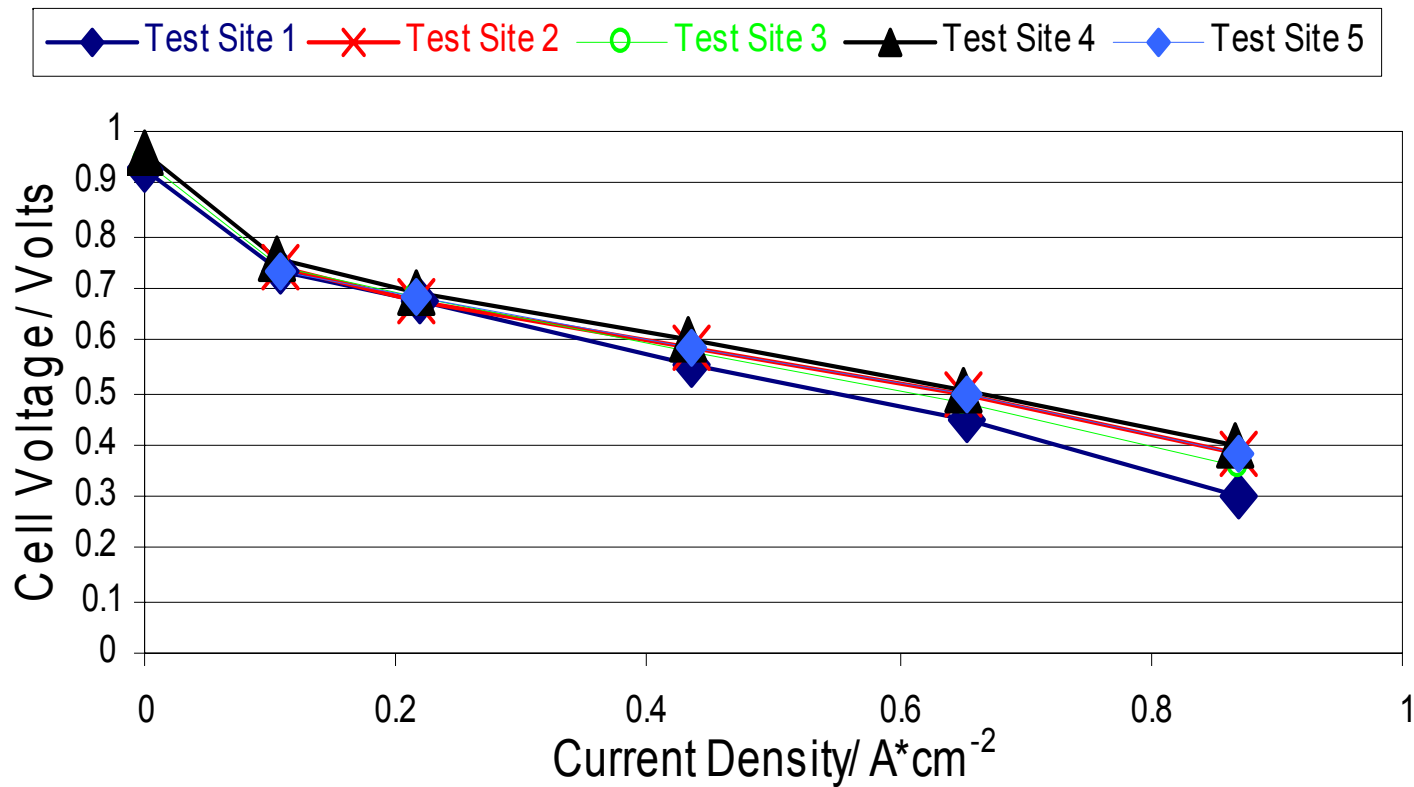## Test Cell No. 3/Protocol I
60°C, ambient pressure

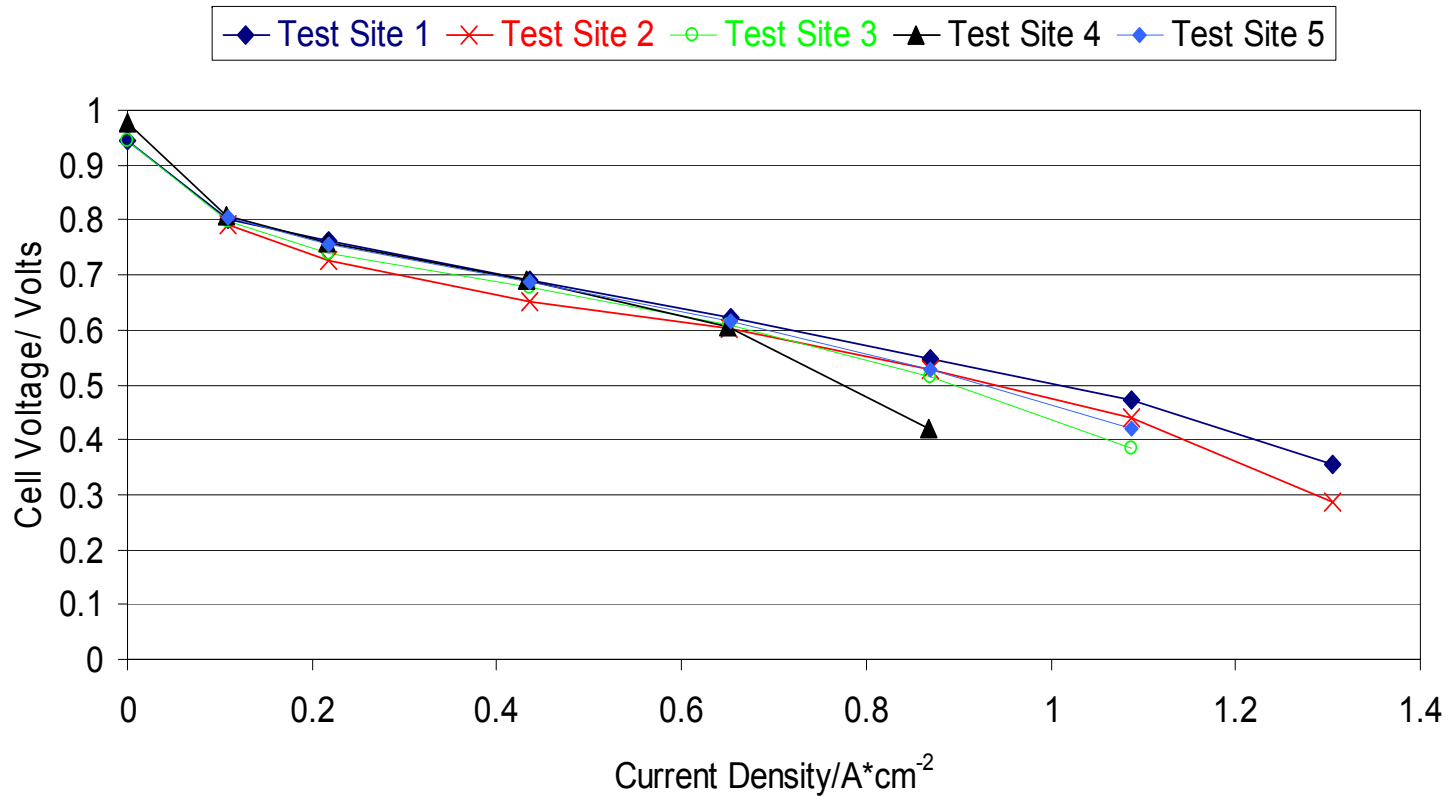# Stage 4: Polarization Curves
Test Cell No. 4/Protocol I
60°C, ambient pressure

Stage 4: Polarization Curves
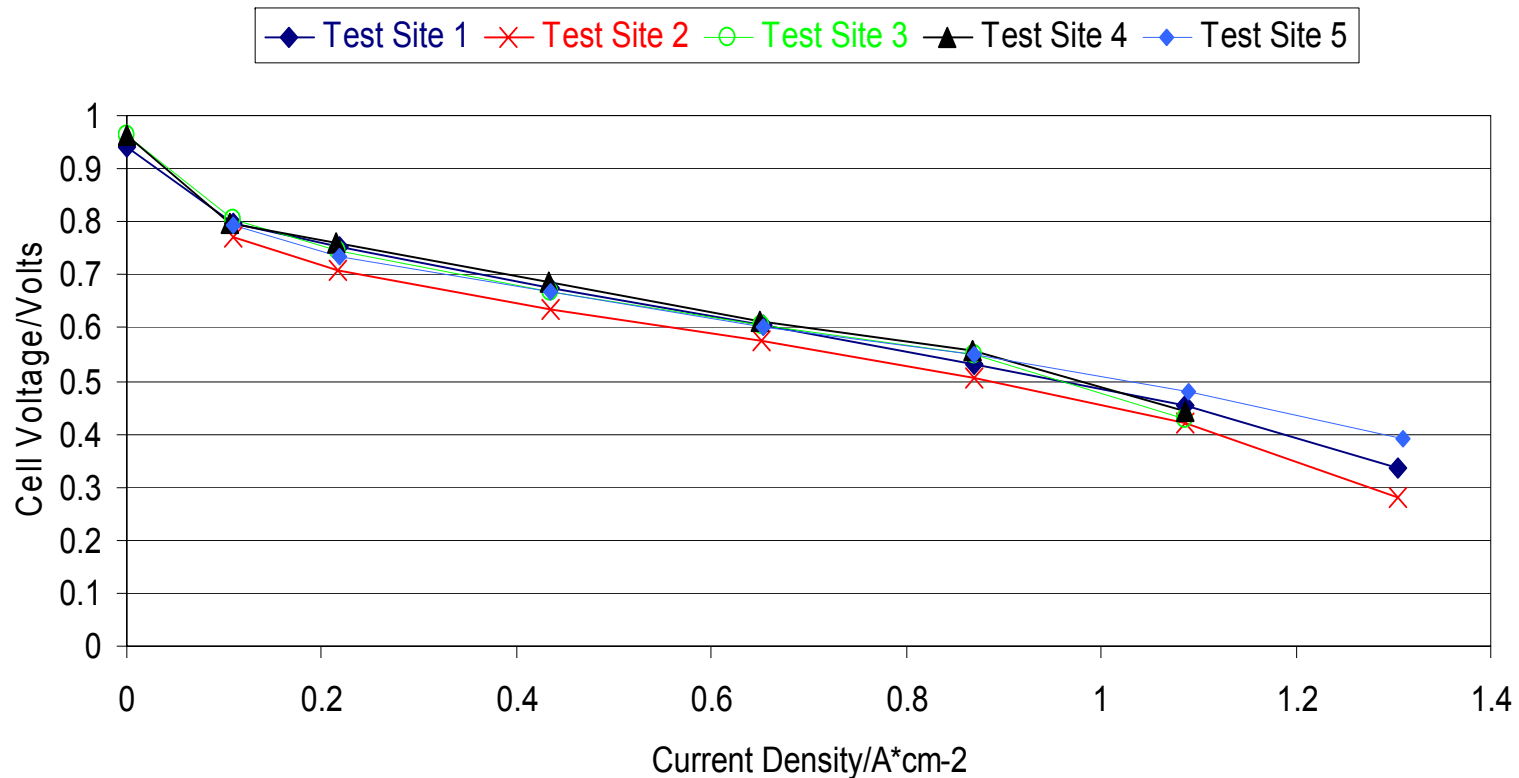## Test Cell No. 1/Protocol II
80°C, 25psig

Stage 4: Polarization Curves
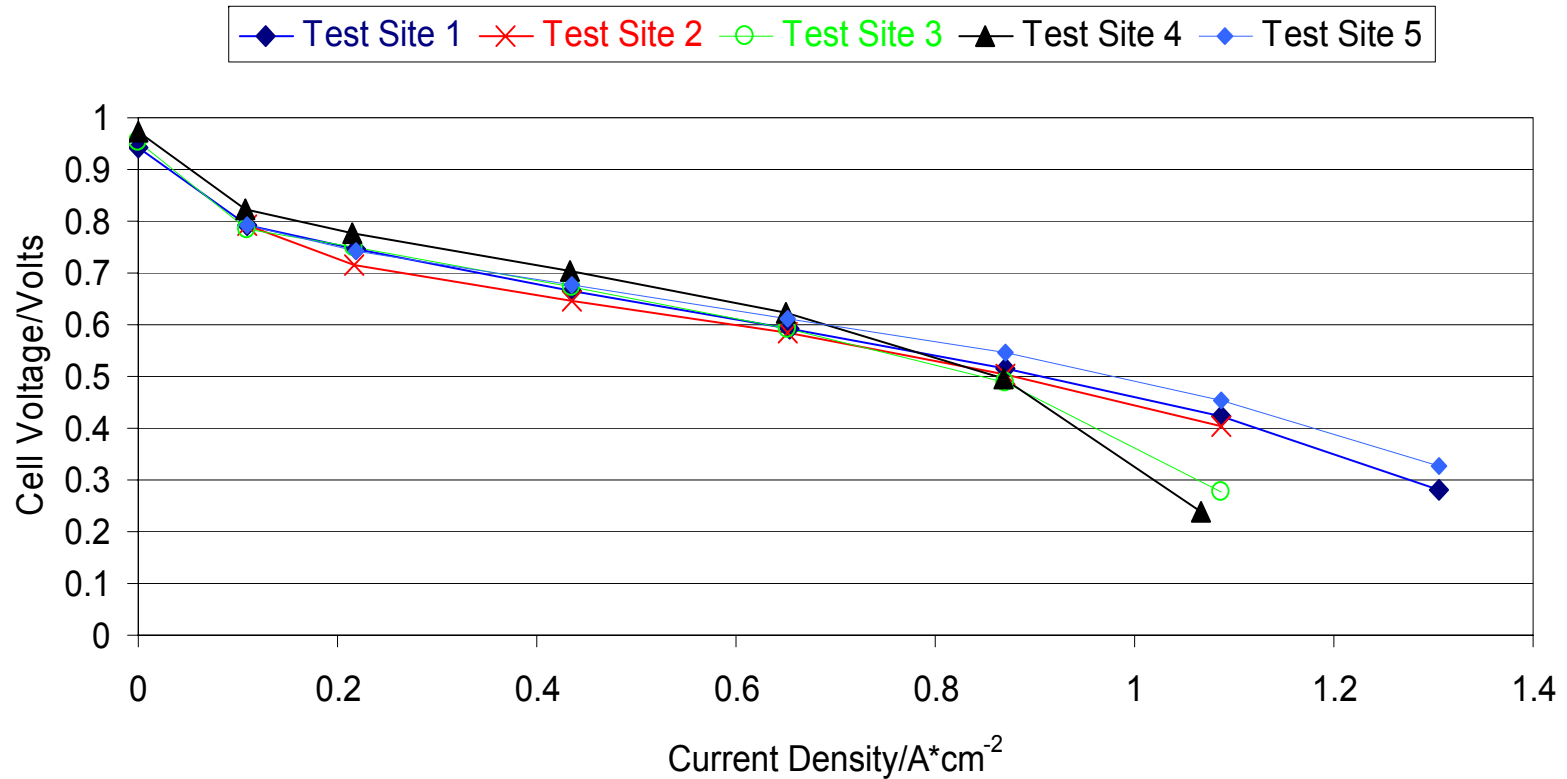## Test Cell No. 2/Protocol II
80°C, 25psig

Stage 4: Polarization Curves
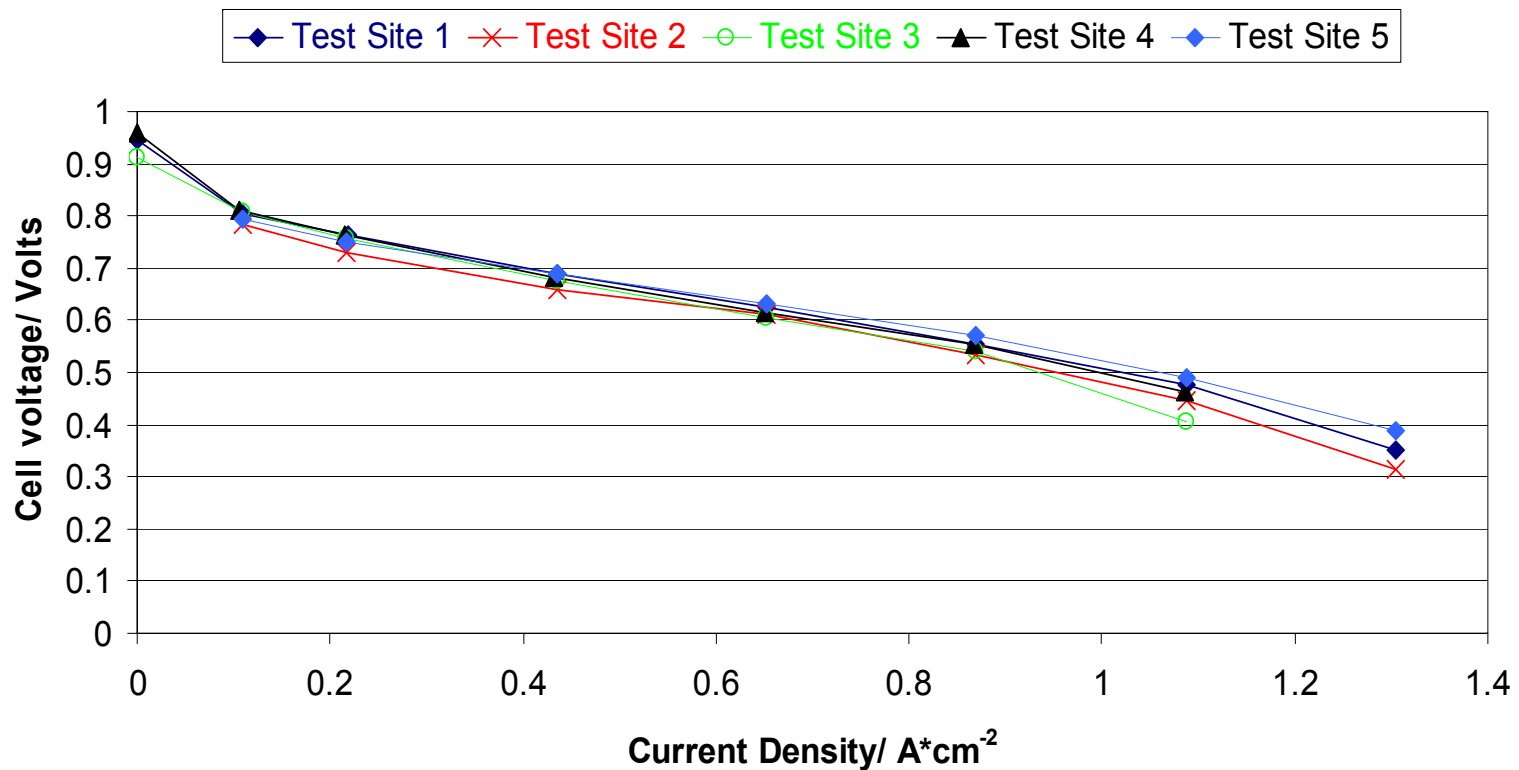## Test Cell No. 3/Protocol II
80°C, 25psig

Stage 4: Polarization Curves
Test Cell No. 4/Protocol II
80°C, 25psig

Summary

- Performance variations under conditions in Protocol I indicate cell break-in requires longer times at lower temperatures

- Comparable results using Protocol II also support longer break-in

- Variations in the test results led to discussions that helped identify and correct issues regarding testing equipment and calibration techniques used at the different sites

Future Plans

- To utilize lessons learned to improve the existing protocol

- To expand the testing protocol to include longevity and durability testing

- To define a calibration procedure for test stations running these types of measurements

Supplemental Slides

Publications and Presentations

- David Lane (W.L. Gore and Associates), Eric Teather (DuPont Fuel Cells), Tommy Rockward (Los Alamos National Laboratory - LANL), Francisco Uribe (LANL), Dawn McNeil, (Teledyne Energy Systems), Ross Bailey (Greenlight Power Technologies), Michael Pien (ElectroChem, Inc.), "Establishing a Standardized Single Cell Testing Procedure through Industry Participation, Consensus and Experimentation," Proc. 2004 Fuel Cell Seminar

- US Fuel Cell Council Report *In Preparation*

- *Proprietary letter reports to DOE and developer on DOE-directed Technical Assistance to Developers under parent task*

Hydrogen Safety

The most significant hydrogen hazard associated with this project is:

Hydrogen leak leading to accumulation in the test laboratory with ignition leading to an explosive event

Hydrogen Safety

Our approach, developed over >40 years of safe hydrogen handling, to deal with this hazard is:

- In labs with hydrogen supply from cylinder banks or from a hydrogen generator, hydrogen sensors have been installed and are interlocked with the hydrogen gas supply to block further H_2 inflow
- Two sensors are installed in every room for redundancy & coverage
- Sensors installed at ceiling level where accumulation is most severe
- H_2 sets off the alarm at 10% of Lower Flammability Limit (LFL)
- In rooms that use only bottled hydrogen, only a single cylinder is in the room at any given time and bottle sizes are limited to ensure being safely below the LFL of the confined space even with complete release of a full cylinder

Work has been reviewed and approved through Los Alamos National Laboratory's formal safety programs:

- Hazard Control Plan (HCP) - Hazard based safety review
- Integrated Work Document (IWD) - Task based safety review
- Integrated Safety Management (ISM)