

Fuel Cell Testing at the Argonne Fuel Cell Test Facility

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FCP24



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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
- FY05: \$300K
- FY06: \$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

- Standardized fuel cell stack test procedures have to be developed to aid the evaluation of different stack technologies
 - Characterize stack in terms of:
 - *Initial Performance*
 - *Durability: Accelerated testing to yield a reasonable projection of life in a reasonable amount of test time*
 - *Low-Temperature Performance*
- Adapt Fuel Cell Test Facility to accommodate the unique needs of different technologies
- Addresses Barriers
 - A. Durability
 - J. Start-up Time (future)

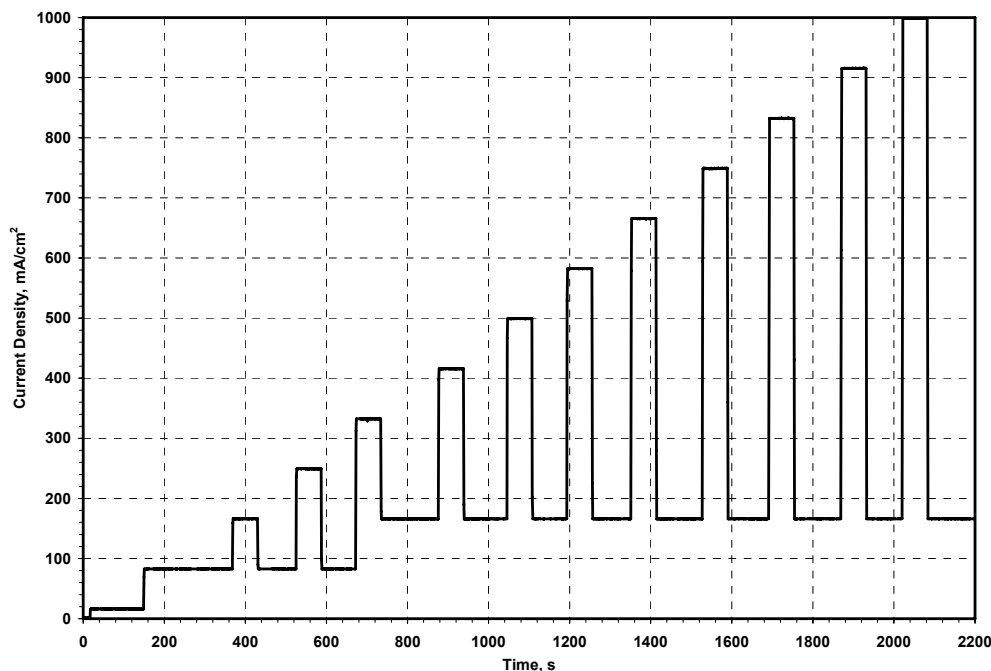
Technical Accomplishments: Progress and Results

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

- FY06 Progress:
 - Characterized two 7.5-kW stacks
 - Characterized reformer-only subsystem
 - Enhanced cooling system of the facility to handle 100 kW_t
 - Installed two 5-kW stacks for testing

Typical Results From Stack Test

- Pulsed-current testing is more representative of automotive applications than steady state, particularly at high powers
- Measure polarization behavior of 85-kW stack using current pulses
- Compare these results with those from a steady-state test
- Viable option when stack cannot be operated under steady loads

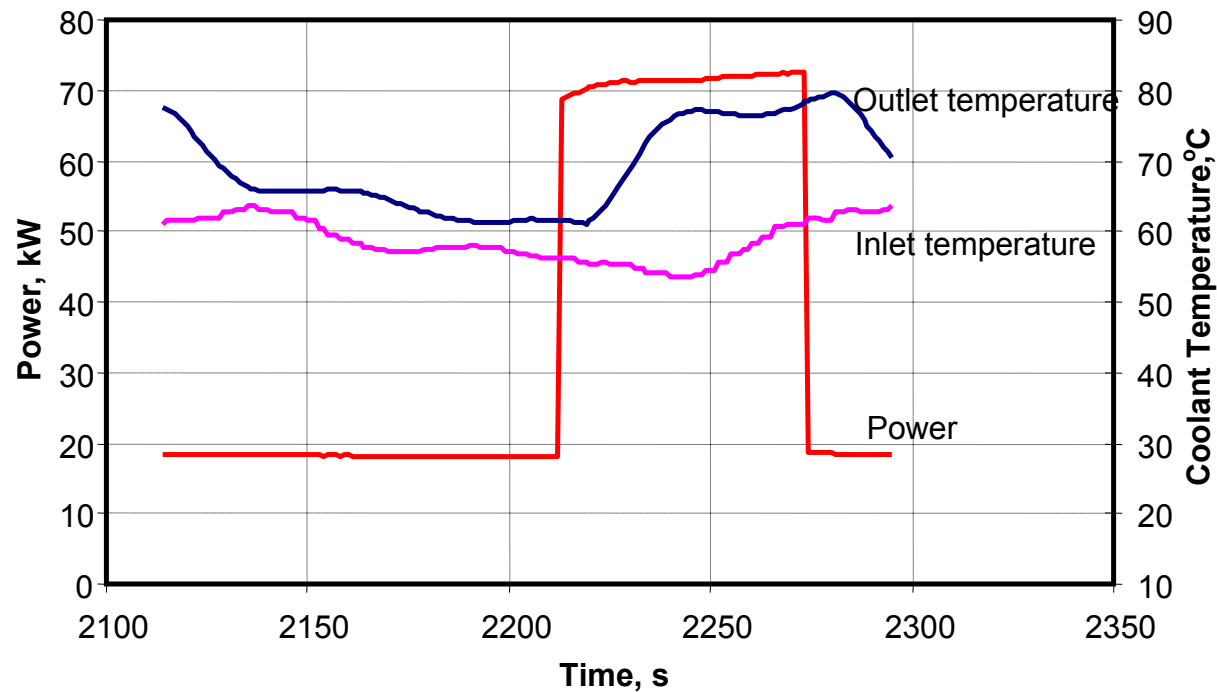


Sample pulsed-current profile

Pulse width = 1 min

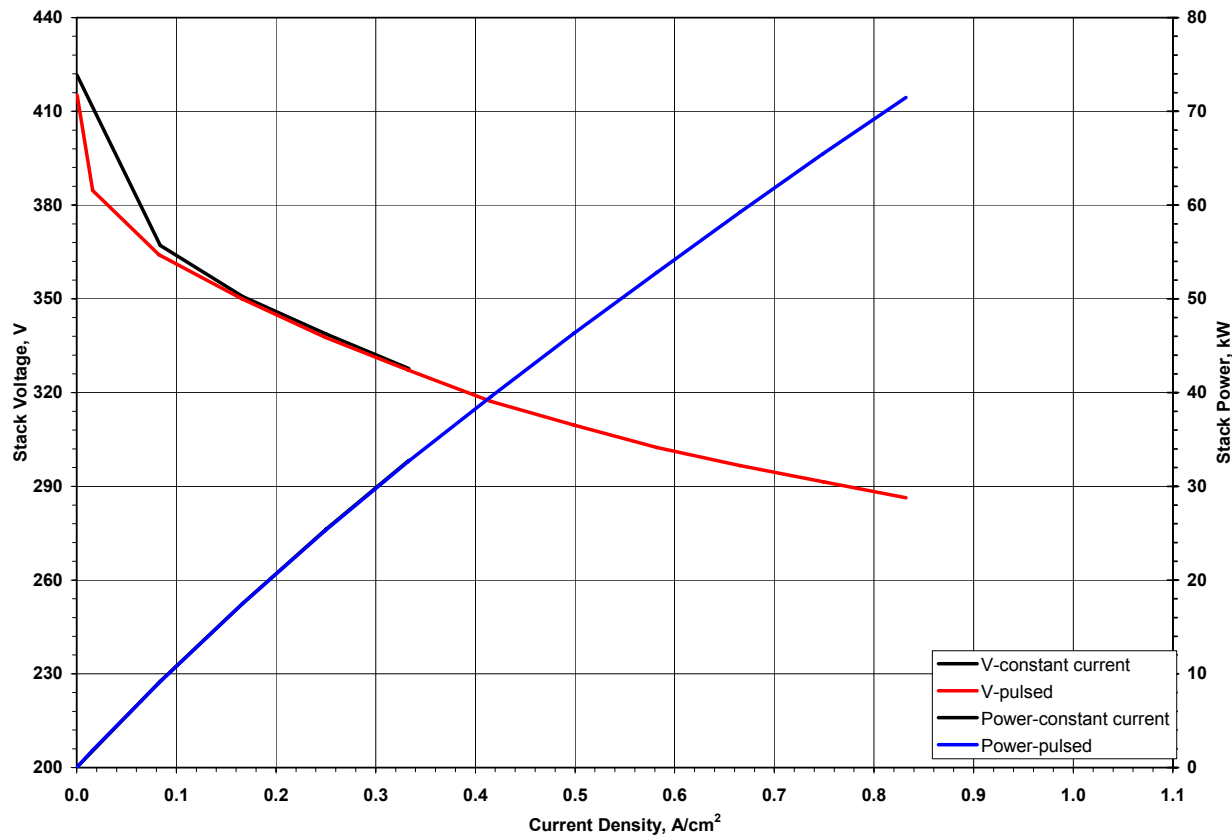
Pulsed-current Test Shows Heat-Response Characteristics of Stack

- With pulse testing, observe thermal transients in the stack
- Thermal transients have to be accommodated in an automobile



Constant- vs. Pulsed-Current Polarization Curves

- At current densities greater than $\sim 0.1 \text{ A/cm}^2$, observe very little difference in the polarization curves



Stack Durability Testing

■ Helped develop fuel cell durability test protocol to include:

- Characterization
 - *Polarization curves (sequential and random)*
 - Establishes baseline performance and serves as reference point for aging experiments
 - *Hydrogen cross-over measurements*
- Sensitivity testing of fuel, air and water stoichiometries

- *Example sensitivity matrix:*

		Air Stoichiometry			
		1.2	1.4	1.6	1.8
Fuel Stoichiometry	1.2	N	N	Y	Y
	1.4	N	Y	Y	Y
	1.6	N	Y	Y	Y
	1.8	N	Y	Y	Y
	2.0	N	Y	Y	Y

Y= met design-point power

N = did not meet design-point power

- Aging
 - *Constant power for 500+h*
 - *Potential cycling for 1000+h*
 - Cycle stack for a period of time then repeat characterization tests

Stack Durability Testing (2)

- Continuously perform test profile for a fixed number of cycles
- Characterize change by performing polarization curve and H₂-crossover measurements

Dynamic Stress Test

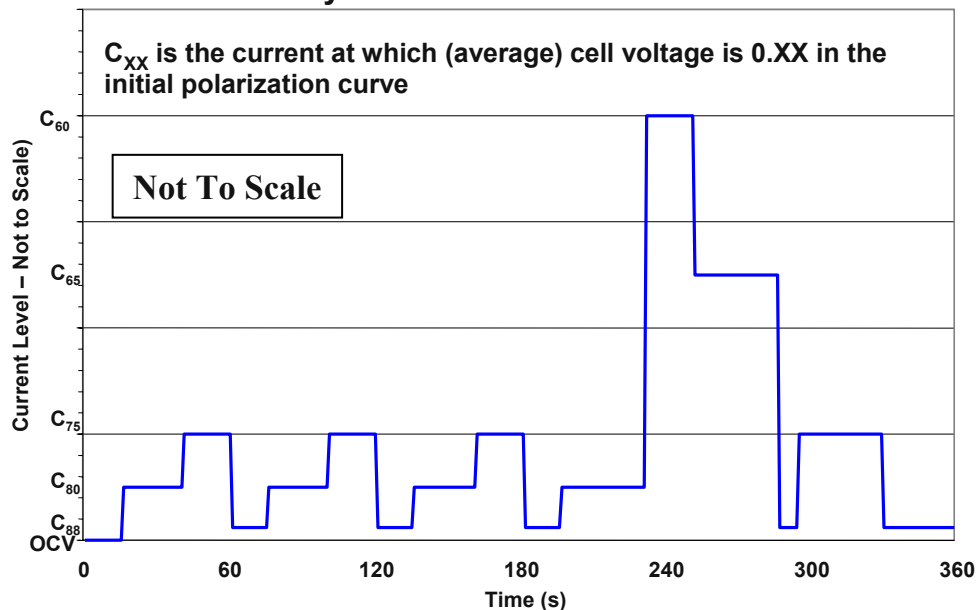


Table 1 – Current Density vs Time for the Cycle Profile

Step	Duration n sec	C _{XX}		Step	Duration sec	C _{XX}
1	15	OCV		9	20	C ₇₅
2	25	C ₈₀		10	15	C ₈₈
3	20	C ₇₅		11	35	C ₈₀
4	15	C ₈₈		12	20	C ₆₀
5	24	C ₈₀		13	35	C ₆₅
6	20	C ₇₅		14	8	C ₈₈
7	15	C ₈₈		15	35	C ₇₅
8	25	C ₈₀		16	40	C ₈₈

Experience Gained During Stack Durability Testing Will Be Leveraged By Participation in FCTes^{QA}

- The goal of FCTes^{QA} is to evaluate single-cell test procedures that are currently being used in the EU, Japan, the US, etc.
- The EU, Japan and US have their own test procedures. Harmonizing the procedures will facilitate communication and understanding of results, helping to accelerate fuel cell development.
- Head-to-head comparisons will be made regarding quality of the data obtained, ease of use, and reproducibility by using similar test hardware and fuel cells.
- All the test procedures will be discussed during the initial meeting of FCTes^{QA} on May 15, 2006. From the discussion, the group will select which procedures from those presented should be evaluated further.

Facility Upgrades and Enhancements: Enhanced Cooling to 100 kW_t

- Future testing of large stacks in the facility will not be limited by cooling constraints



**100-kW cooling system being
installed in the Fuel Cell Test
Facility**

Designed and Built a Low-Pressure Chiller for a Fuel Cell Stack Test

- Safely removes any hydrogen that may be in the stack coolant



Plans for Future Work

- Fuel cell and stack testing
 - Expecting three 5-kW commercial stacks and systems for benchmarking before the end of FY06
 - Expecting a DOE contract deliverable for evaluation in 1st quarter of FY07
- Testing at sub-ambient pressures
- Facility upgrades and enhancements
 - Add capability to perform fast gas transients
 - Add capability to perform low-temperature (-30°C) tests

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.
- Acquire and benchmark commercial fuel cell stacks to provide DOE with information regarding the maturity of the technology.
- FCTF is responsive to the needs of the sponsors, fuel cell developers, and end users.

Response to Reviewers' Comments from FY05

- Reviewers stated that there was little or no collaboration with other testing facilities, etc.
 - *Collaboration with USFCC, FCTestNet Task Force, and FCTes^{QA} should aid the development of standard protocols for evaluating fuel cells. Other test sites, such as LANL, are part of these groups*
 - *Leveraging their experience and ours*
- One reviewer was not sure about the need for independent testing to advance the “state-of-the-art”
 - *Independent evaluation and benchmarking provide clear insights about the maturity of the developer’s technology and the technology in general. This helps DOE focus its limited resources on areas where development is needed.*