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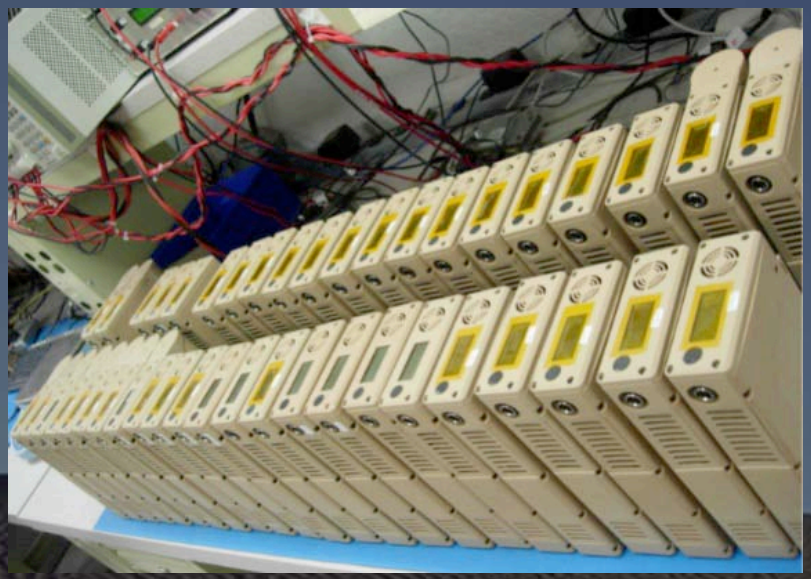
Pacific Northwest
NATIONAL LABORATORY

cts CINCINNATI TEST SYSTEMS

U.S. DEPARTMENT OF ENERGY

D.O.E. Program Review

Modular, High-Volume Fuel Cell Leak-Test Suite and Process



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May 12, 2011

Project ID # MN003

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Phase I
  Start: 09/01/2008
  End: 6/30/2011
- Phase II: TBD

Budget

- Total Phase I Project Funding (Actual)
  - DOE Share to UltraCell: $0.82M
  - DOE Share to PNNL: $0.63M
  - UltraCell Cost Share: $1.24M
  - Phase I Total: $2.69M
  - UltraCell Additional Cost Share: $0.68M
- Funding received in FY10
  - $285k (UltraCell)
  - $252k (PNNL)

Barriers

F: Low levels of Quality Control and inflexible processes

Partners

- UltraCell – Project lead
- PNNL – Fuel cell stack properties, method selection, quality metrics
- CTS – Leak-test suite design, fabrication, and installation

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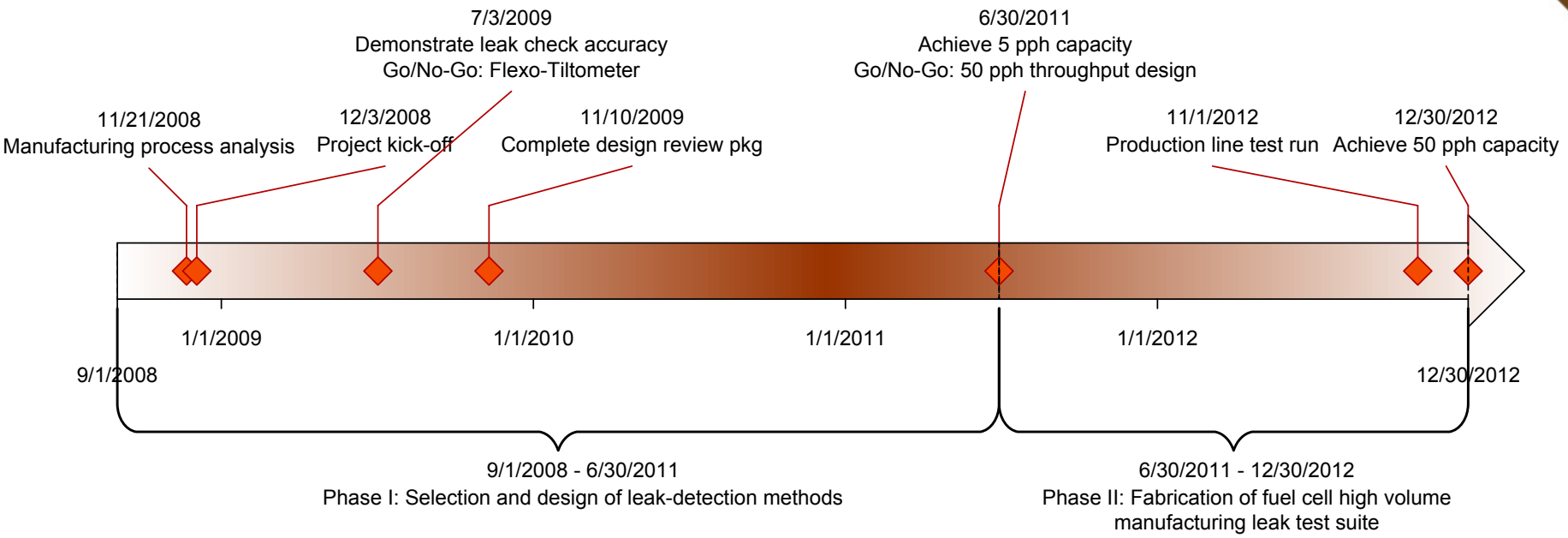
Objectives - Relevance

- **A fuel cell is an excellent leak-sensor: we use the manufactured part as part of the sensor network**
- **Project Objectives**
  - Design a modular, high-volume fuel cell leak-test suite capable of testing in excess of 100,000 fuel cell stack per year (i.e., 50 fuel cell stacks per hour).
  - Perform leak tests inline during assembly and break-in steps
  - Demonstrate improved fuel cell stack yield rate.
  - Reduce labor content.
  - Reduce fuel cell stack manufacturing cost.
- **Objectives for past year**
  - Test and evaluate leak-test suite prototype

Milestones – Relevance



- **End of Phase I: June 30, 2011.**
- **Phase II: TBD**

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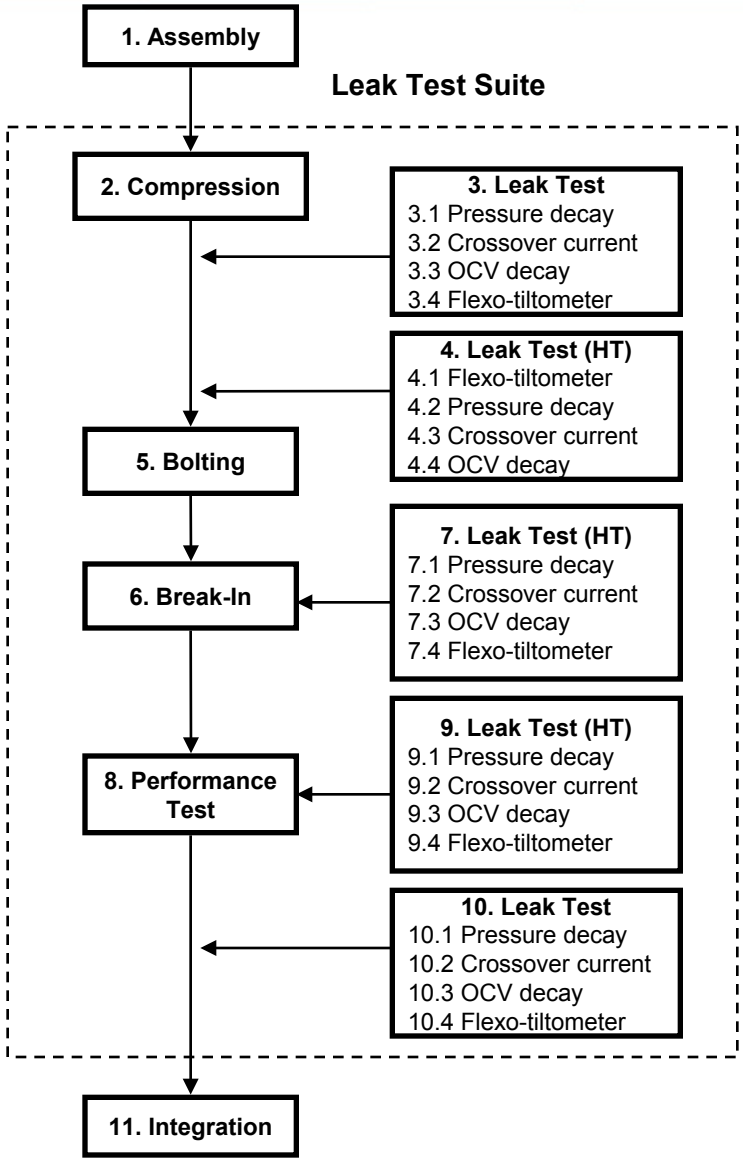
Approach


1. Assembly
Leak Test Suite
2. Compression
3. Leak Test
3.1 Pressure decay
3.2 Crossover current
3.3 OCV decay
3.4 Flexo-tiltometer
4. Leak Test (HT)
4.1 Flexo-tiltometer
4.2 Pressure decay
4.3 Crossover current
4.4 OCV decay
5. Bolting
6. Break-In
7. Leak Test (HT)
7.1 Pressure decay
7.2 Crossover current
7.3 OCV decay
7.4 Flexo-tiltometer
8. Performance Test
9. Leak Test (HT)
9.1 Pressure decay
9.2 Crossover current
9.3 OCV decay
9.4 Flexo-tiltometer
10. Leak Test
10.1 Pressure decay
10.2 Crossover current
10.3 OCV decay
10.4 Flexo-tiltometer
11. Integration

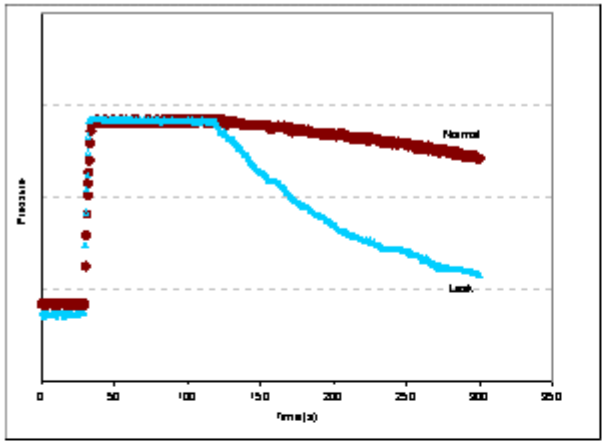
Approach

Features

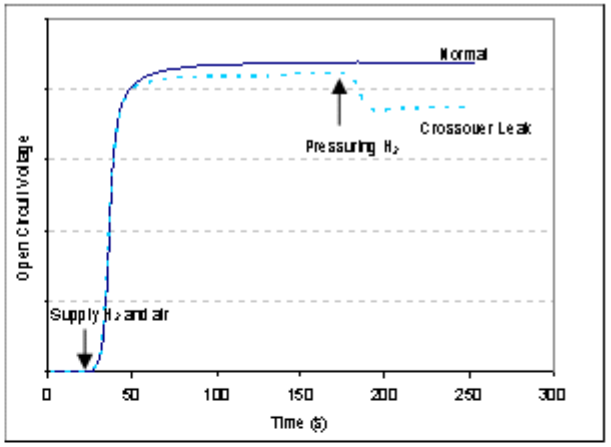
- ✓ Fully automated
- ✓ Inline leak-test during stack manufacturing
- ✓ Multi-functions: combined leak tests, compression, break-in and power performance in one system
- ✓ Diagnostics
- ✓ Safety feature

Approach

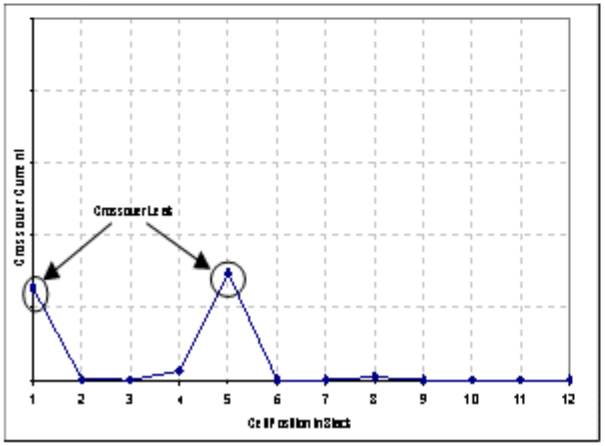
Pressure Decay Test

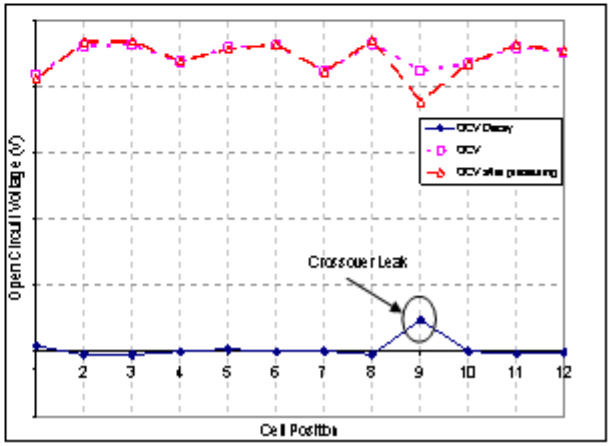


OCV Decay Test



Crossover Current Test





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Approach

- **Milestones**
  - Achieve 5 pph capacity on prototype leak test suite
  - Complete validation of prototype leak test suite

- **Progress**
  - Test and evaluate leak-test suite prototype.
  - Demonstrate that the prototype can accurately detect leaks in 20 stacks with known leak.
  - Demonstrate that the prototype does not cause any new failure modes in 5 stacks.
  - Demonstrate that the prototype does not cause any new failure modes in 3 systems.

Technical Accomplishments

The Leak Test Suite Reduces Stack Test Labor Time from 2.4 Hours to ~2 Minutes

Existing Process Steps	Time (minutes)
Leak Check	5
Stack Enclosure Assembly	5
Start up	5
Flow/Voltage Checks	24
H2 Test	10
H2 Pump	5
Performance Test	60
Shutdown	5
Leak Check	5
Remove test enclosure	5
Data Logging	15
Total:	**144**

Leak Tester Process Steps	Time (minutes)
Stack connection	1
Start test	0.1
Stack disconnection	1
Total:	**2.1**

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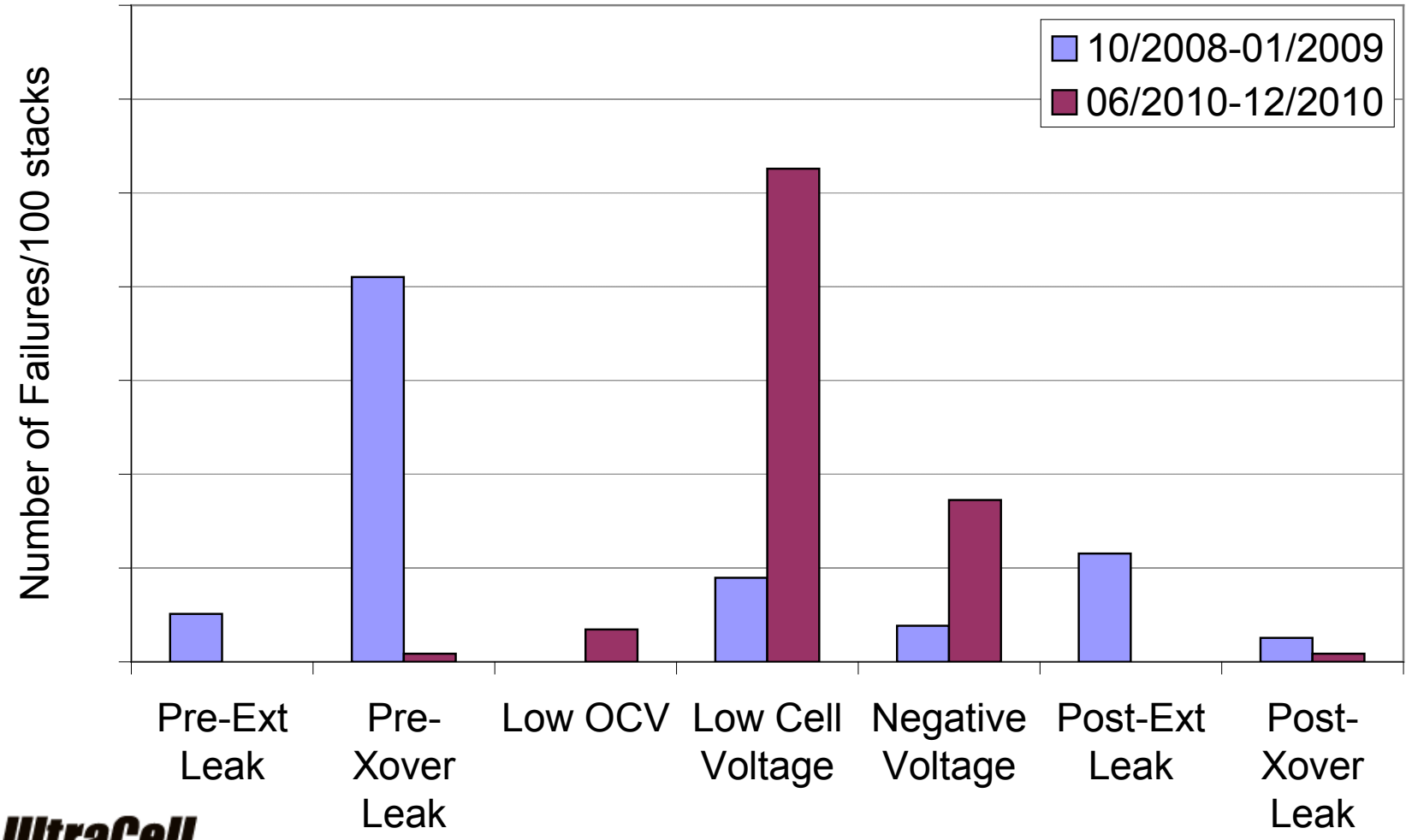
Technical Accomplishments

Failures due to leaks decreased from >70% down to 2%



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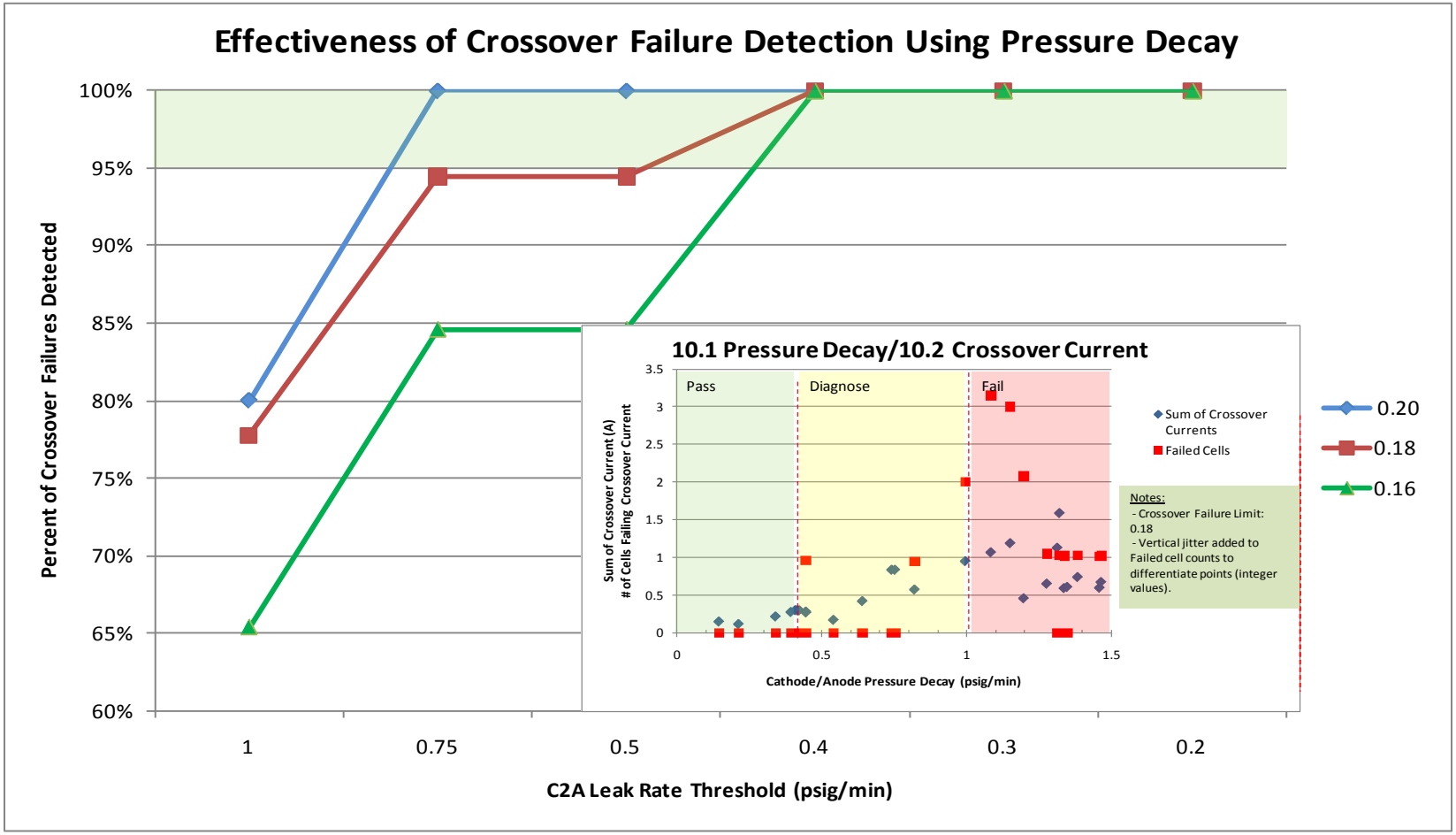
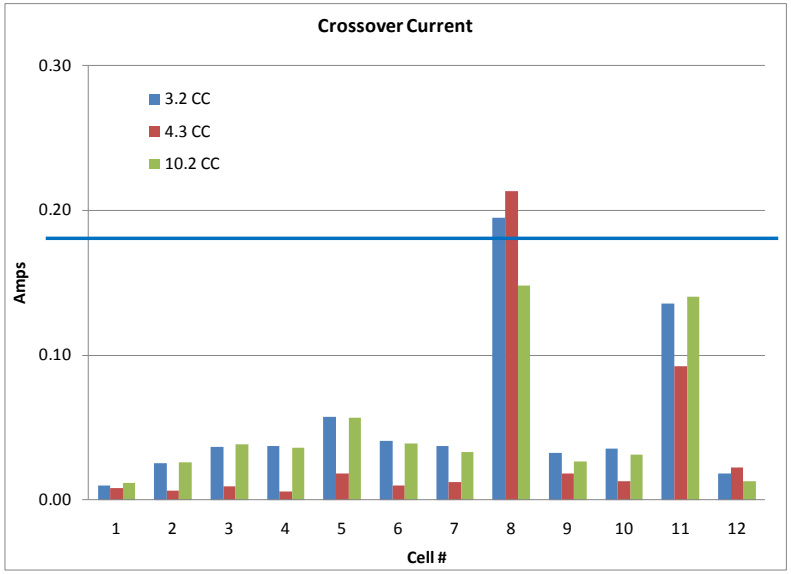
Technical Accomplishments

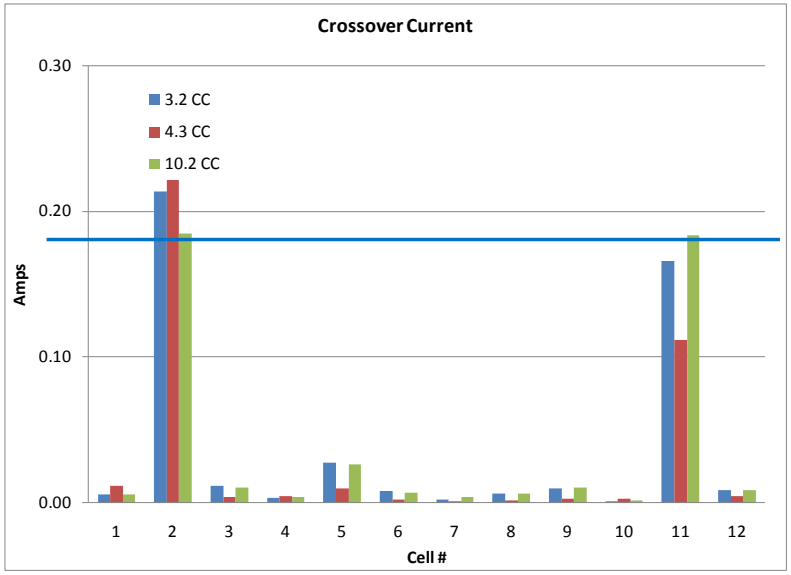
- Using PD criteria > 0.4 psig/min identifies >95% of crossover failures



Technical Accomplishments

Swapping or inserting both good and bad cells is easily detected





1) Good cell 2 and bad cell 8 are swapped
2) PD correctly identifies failed cell
3) Failed cell 8 and good cell 2 correctly identified on retest

1) Parts from 6 original stacks were used to build 23 stacks
2) 11 stacks were retested without rebuilds
3) 12 stack were rebuilt with new or swapped cells

	YES	NO
PD correctly predicts failed cell	19	4
CC correctly detects failure	15	0
OCV correctly detects failure	15	0
CC/OCV correctly detects swap	0	

95% of leaks correctly identified.

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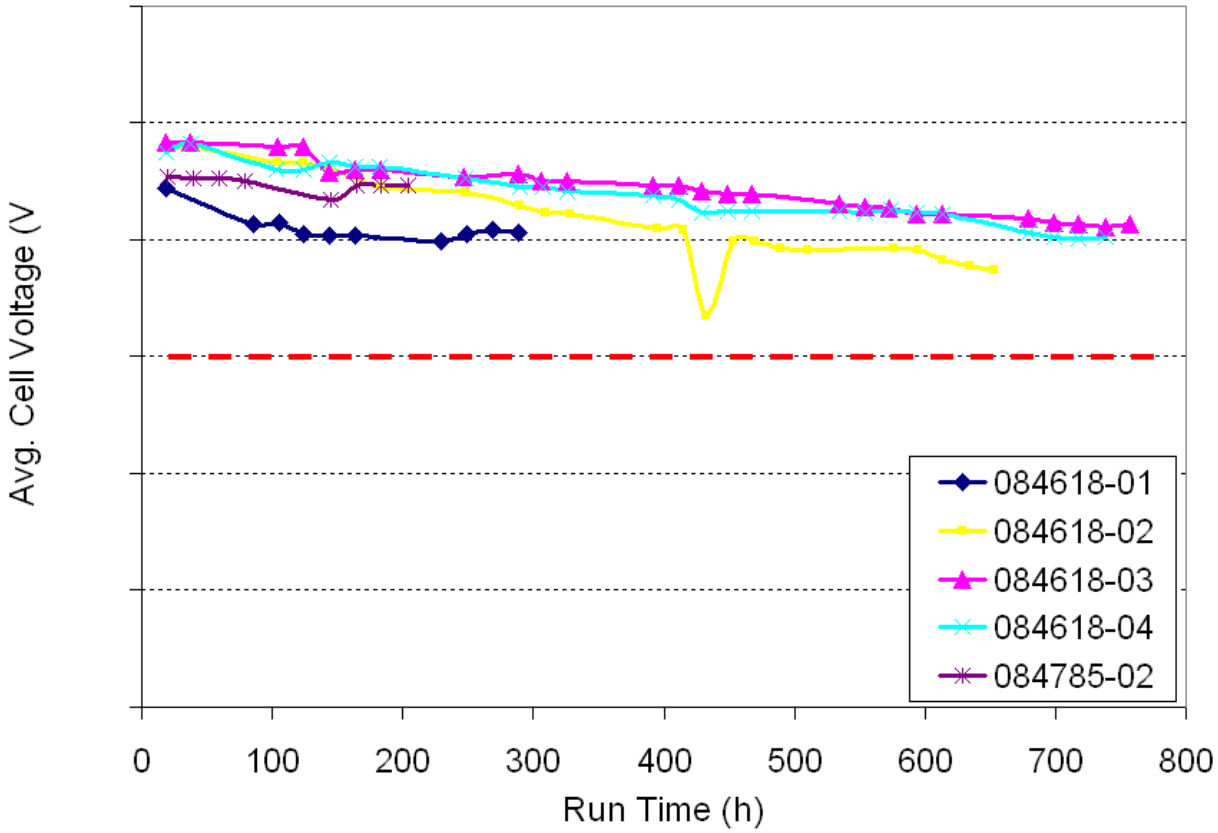
Technical Accomplishments



Two stacks finished 30-day test as of April 1st, 2011.
All stack tests will be finished by April 22nd, 2011

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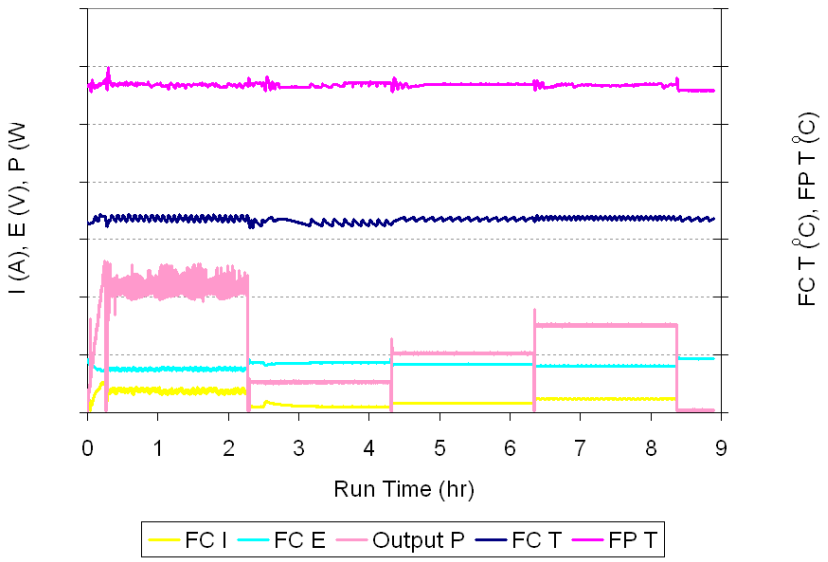
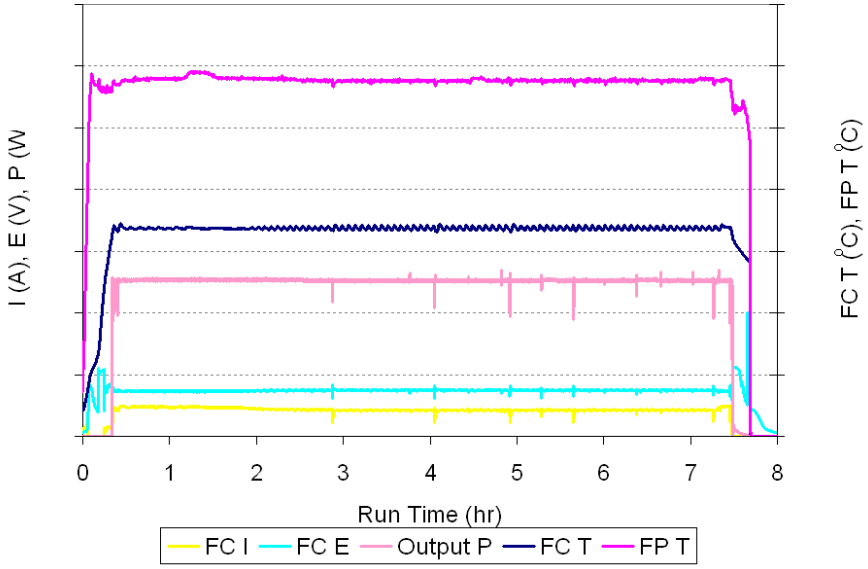
Technical Accomplishments





- One system finished test as of April 1st, 2011.
- All system tests will be finished by April 15th.

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Collaborations

- **UltraCell Corporation**
  Project lead.
  Leading producer of fuel cell systems for remote or mobile devices.
- **Pacific Northwest National Laboratory**
  Stack properties, method selection, quality metrics
- **Cincinnati Test Systems**
  Leak-test suite design, fabrication, and installation

Future Work

- Fabricate, integrate, test and evaluate high volume leak-test suite
- Modify pilot production line to accommodate leak test suite
- Test run pilot production line with leak-test suite
- Validate leak-test suite

Summary

- **Objectives**
  - Design and build a modular, high-volume fuel cell leak-test suite and develop processes to
  - Perform leak tests inline during assembly and break-in steps
- **Progress**
  - Tested and evaluated leak-test suite prototype.
  - Achieved 5 pph leak test rate on the prototype.
  - Demonstrated that the prototype can accurately detect leaks in stacks with known leak.
  - Demonstrated that the prototype does not cause any new failure modes in fuel cell stacks. (Completed by April 22nd, 2011)
  - Demonstrated that the prototype does not cause any new failure modes in fuel cell systems. (Completed by April 15th, 2011)
- **Future Work**
  - Fabricate, integrate, test and evaluate leak-test suite
  - Test run pilot production line with leak-test suite