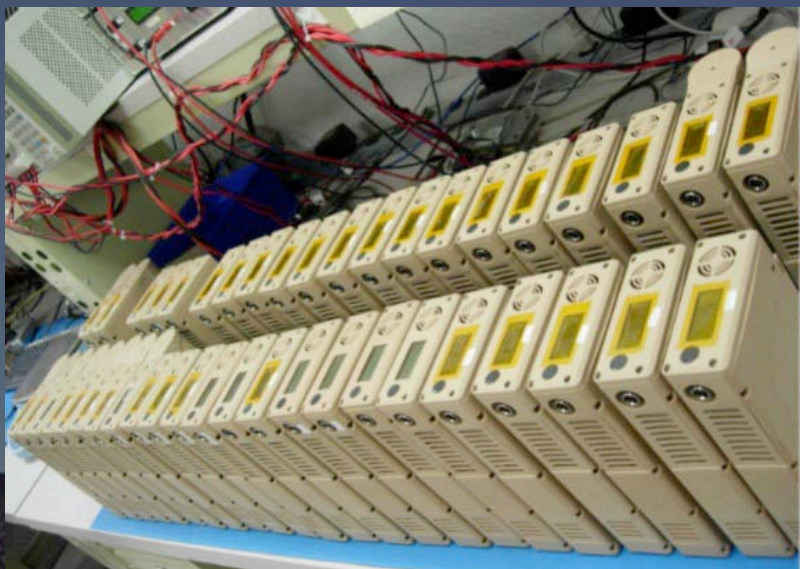


D.O.E. Program Review

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



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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

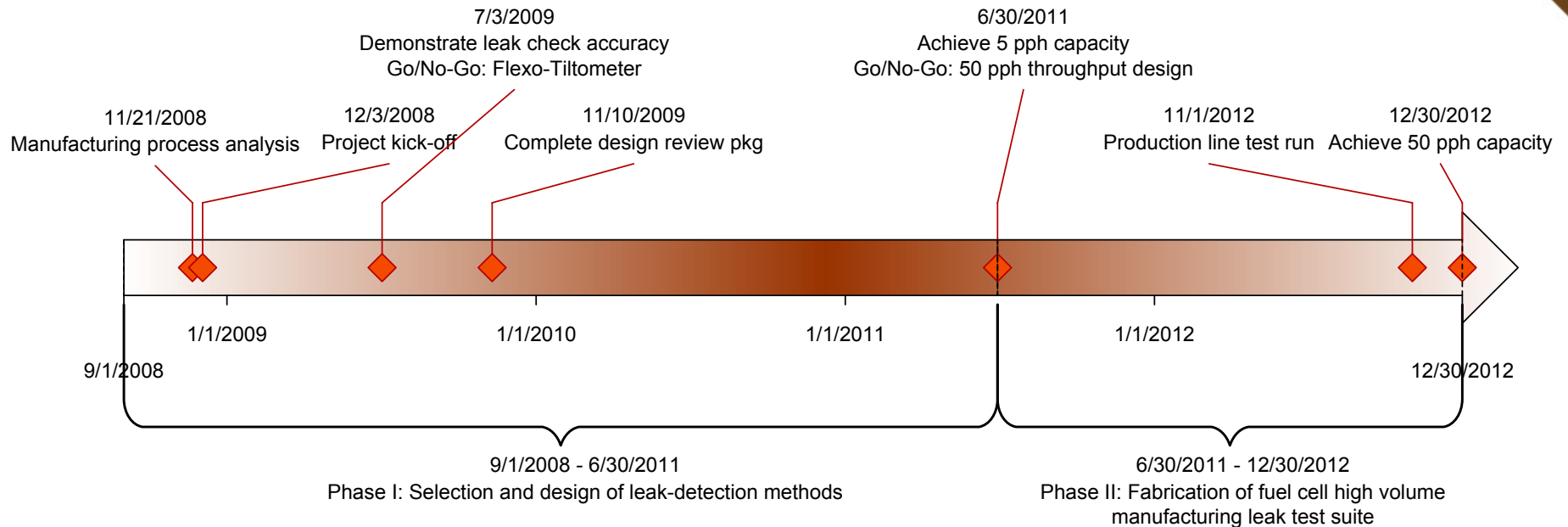
Partners

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

Objectives - Relevance

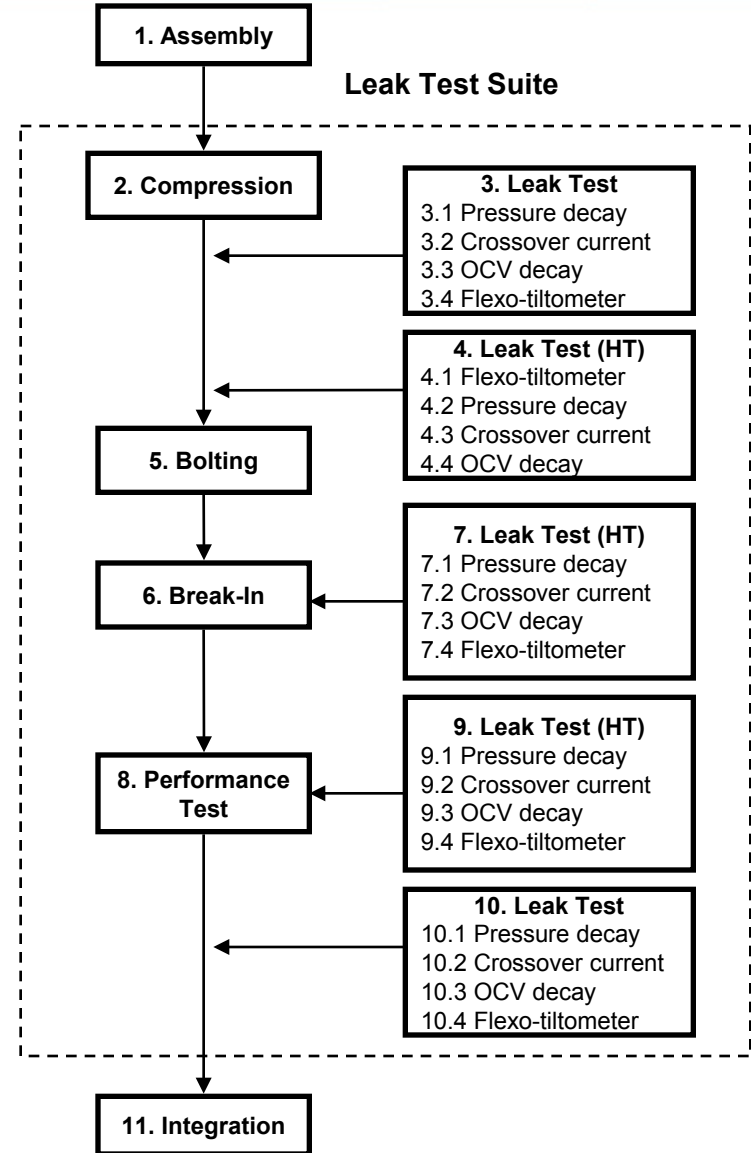
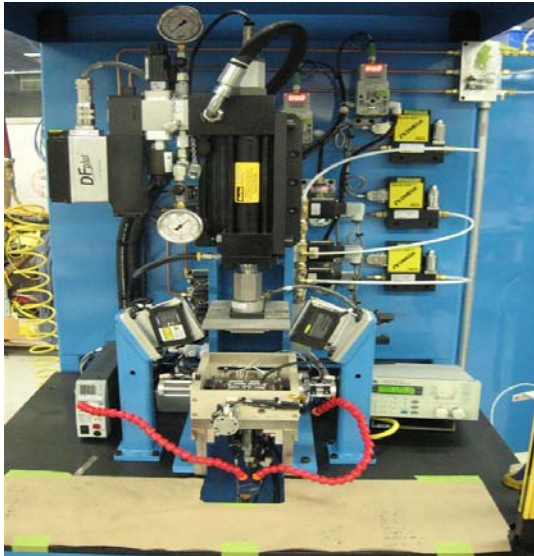
- **A fuel cell is an excellent leak-sensor: we use the manufactured part as part of the sensor network**
- **Project Objectives**
 - Design a modular, high-volume fuel cell leak-test suite capable of testing in excess of 100,000 fuel cell stack per year (i.e., 50 fuel cell stacks per hour).
 - Perform 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

Approach



Approach

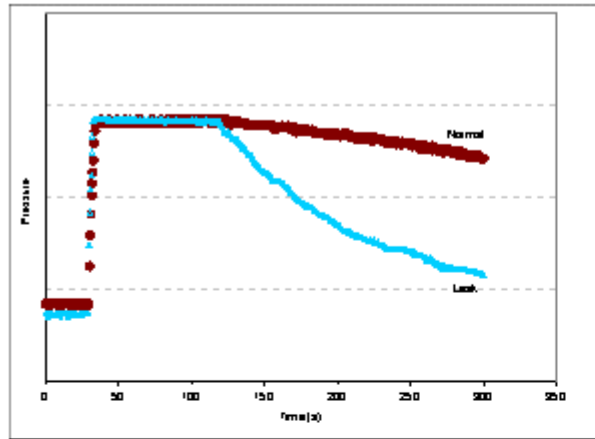
Features

- ✓ 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

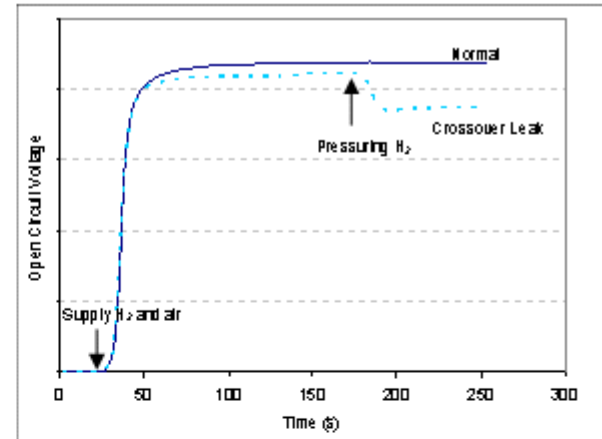


Approach

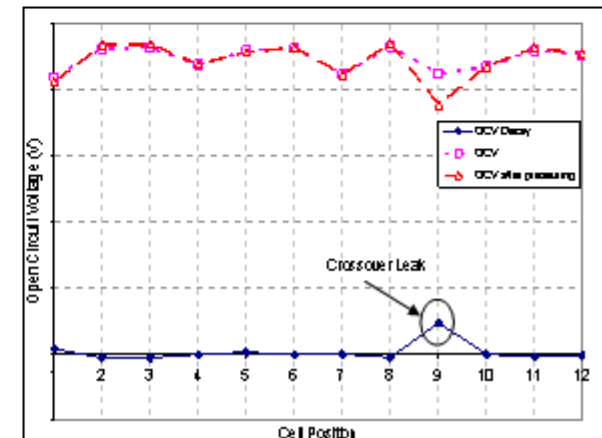
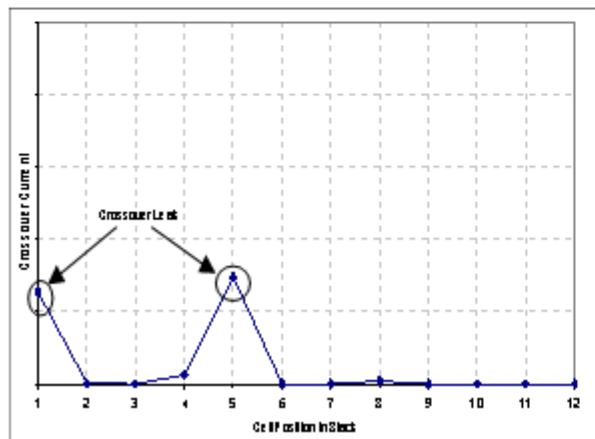
Pressure Decay Test



OCV Decay Test



Crossover Current Test



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

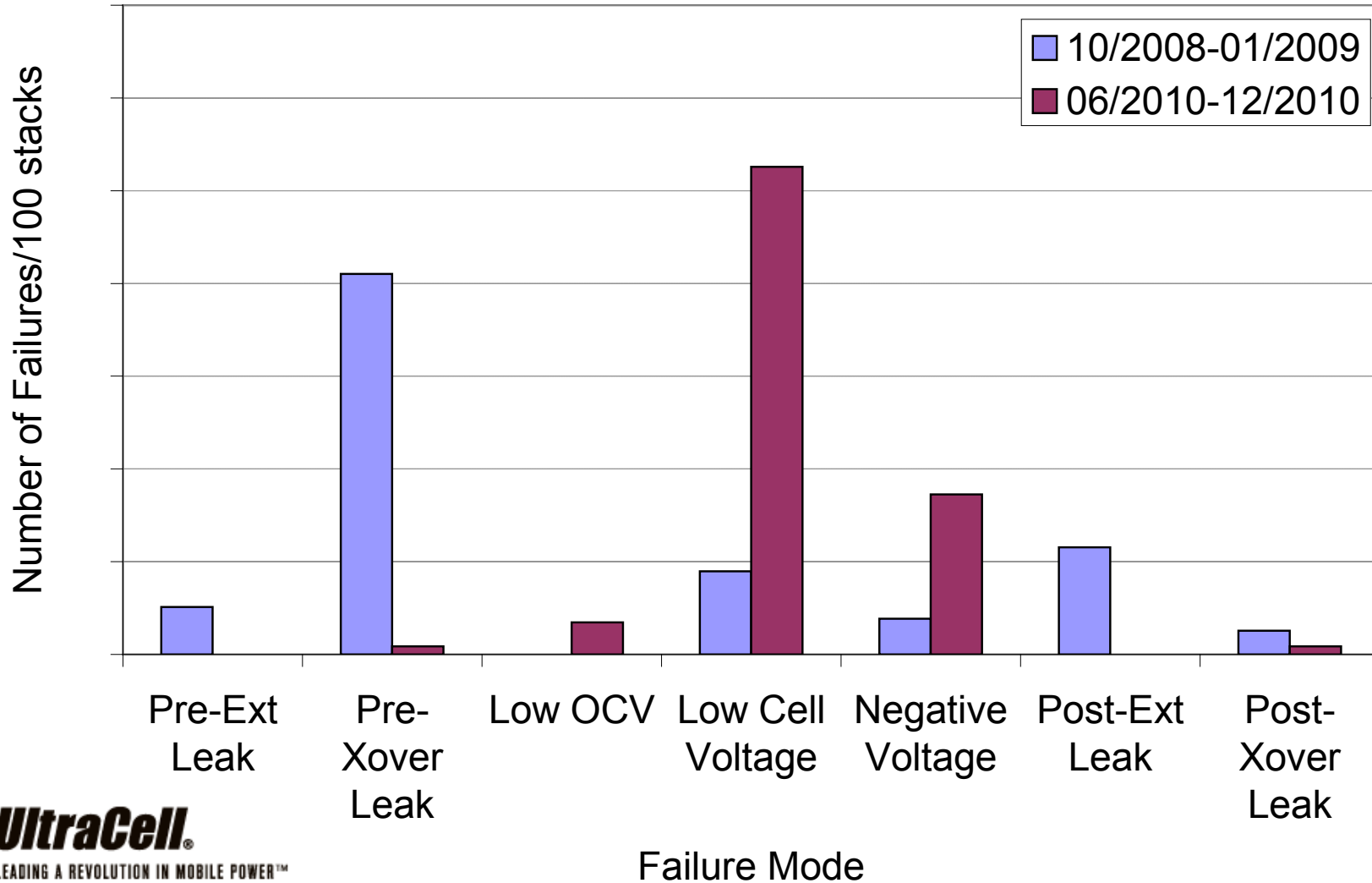


Leak Tester Process Steps	Time (minutes)
Stack connection	1
Start test	0.1
Stack disconnection	1
Total:	2.1



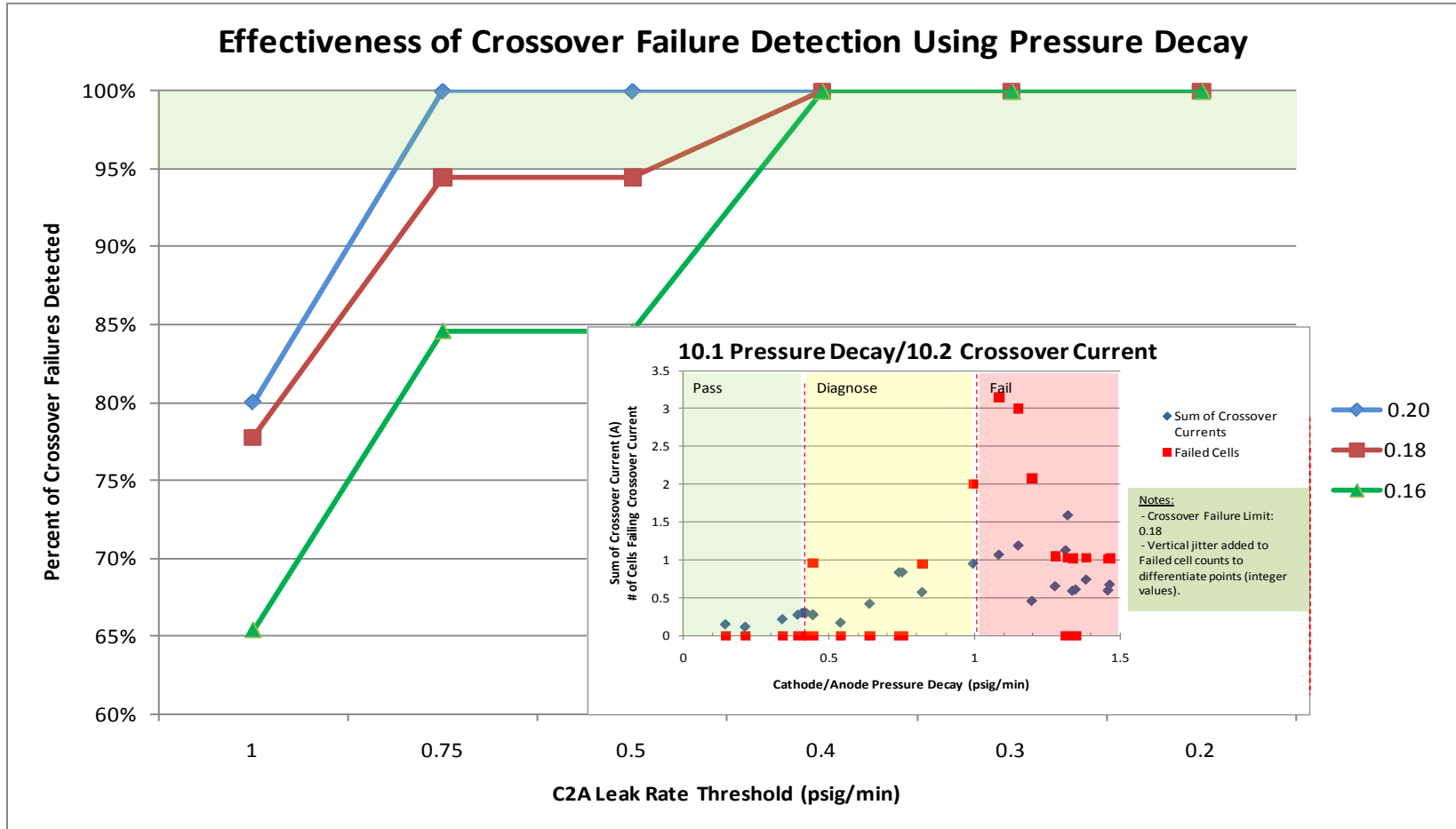
Technical Accomplishments

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



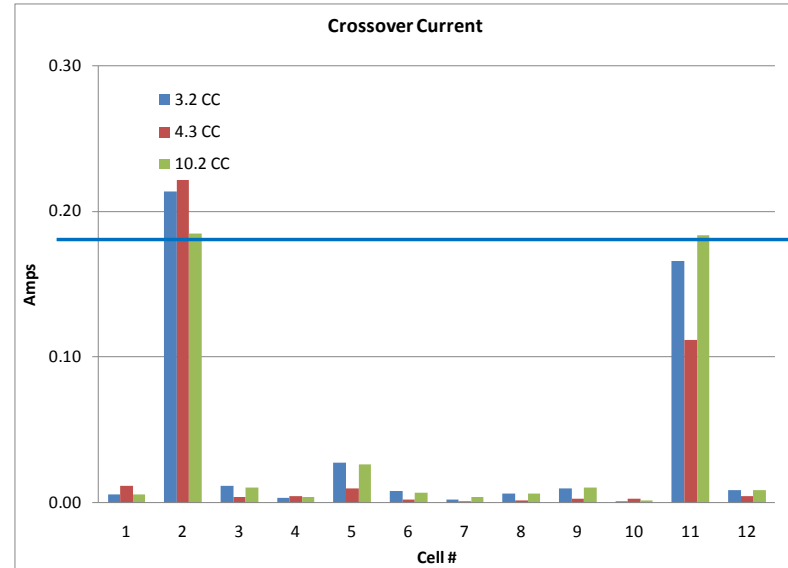
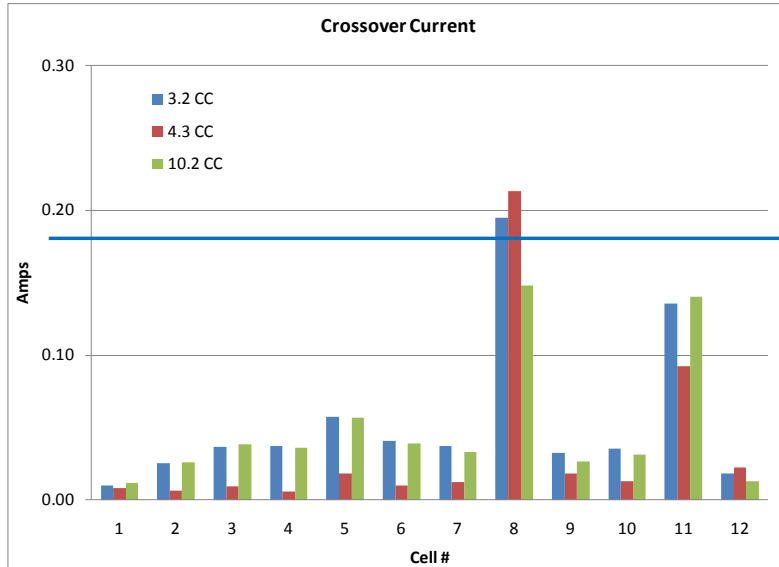
Technical Accomplishments

- 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



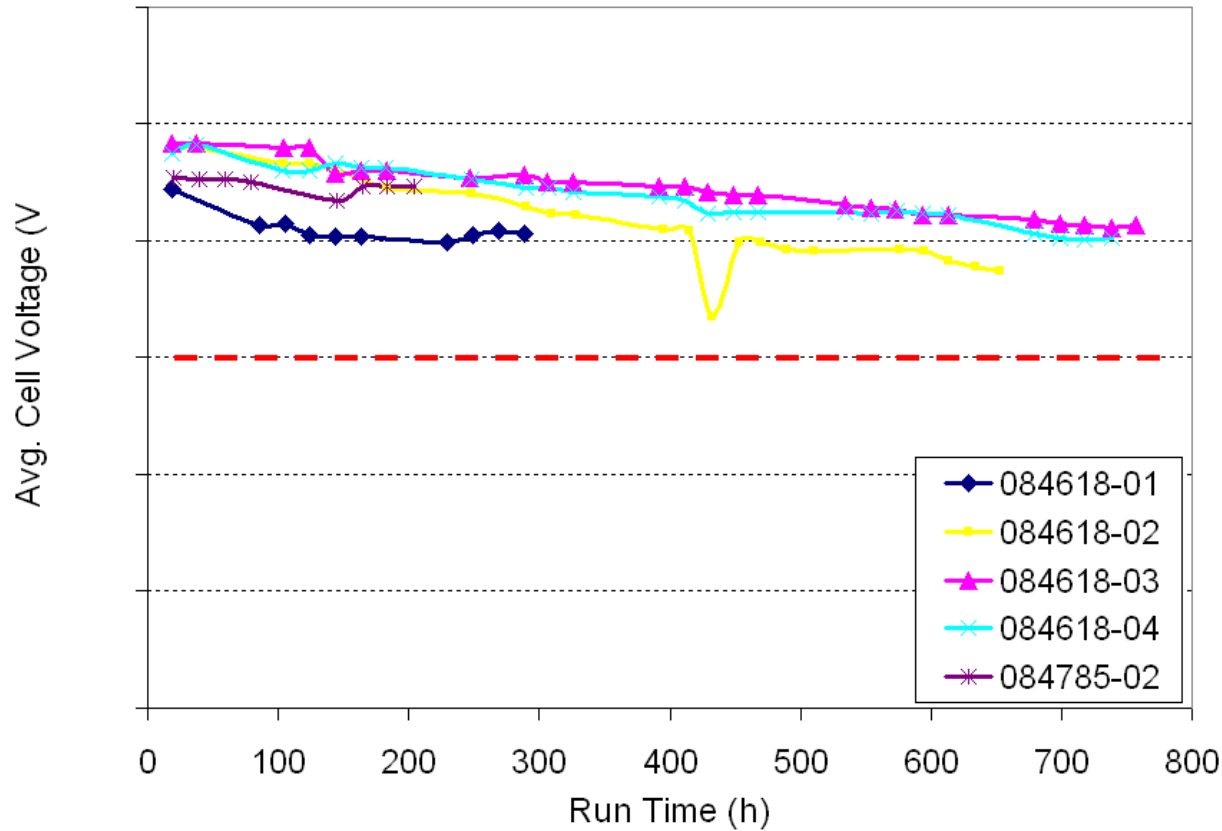
- 1) Good cell 2 and bad cell 8 are swapped
- 2) PD correctly identifies failed cell
- 3) Failed cell 8 and good cell 2 correctly identified on retest

- 1) Parts from 6 original stacks were used to build 23 stacks
- 2) 11 stacks were retested without rebuilds
- 3) 12 stacks 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	

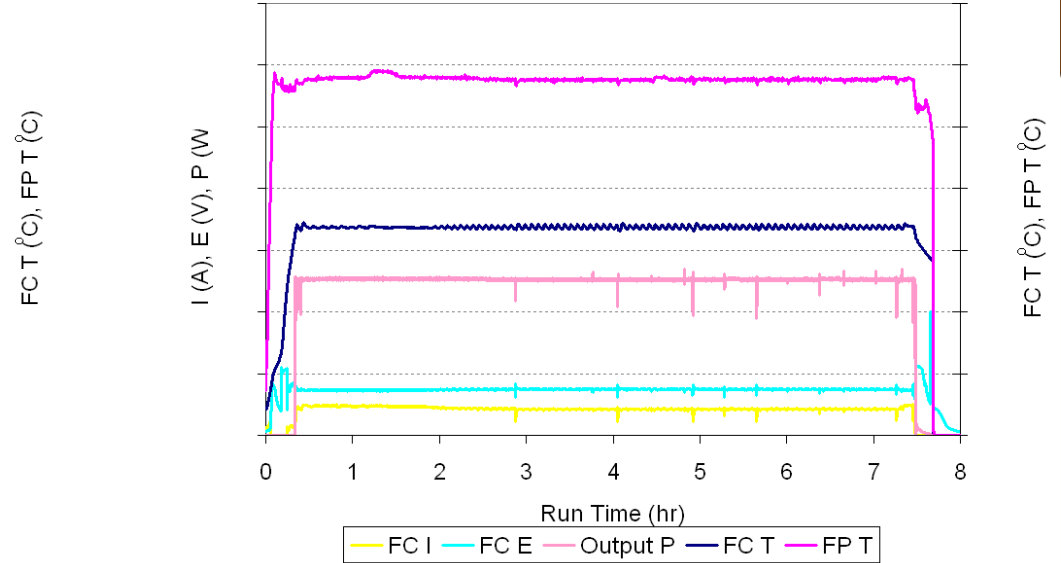
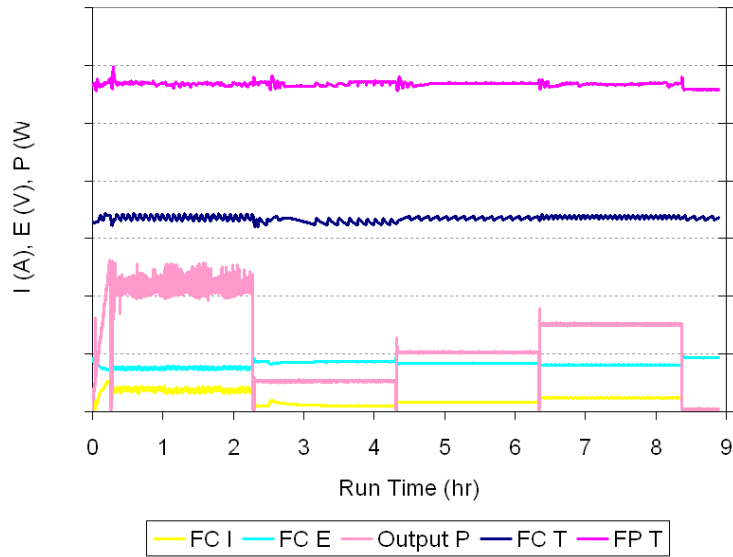
**95% of leaks
correctly identified.**

Technical Accomplishments



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

Technical Accomplishments



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

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