Fuel Cell Balance of Plant Reliability Testbed

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Presenters:

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Stark State College of Technology

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Lockheed Martin MS2

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DOE Project Officer: Greg Kleen **Project ID # FC075**

Overview

Timeline

- Start - Aug 2008
- Finish – July 2011
- 54% Complete

Budget

- Total project funding
  - DOE $787,200
  - Contractor $196,800
- Funding received in FY08
  - $1,113.25
- Funding for FY09
  - DOE $264,031
  - Contractor $69,618

  2 of 3 testbeds built
- Funding for FY10
  - DOE $262,400
  - Contractor $73,731

  Build third test bed & equipment purchase plus operational testing for all 3 test beds

Barriers

- Technology Validation: Project will generate a reliability database for candidate PEM fuel cell balance-of-plant components
- Education: Project will enhance the education of technical workforce trained in PEM fuel cell system technology

Partners

- Lockheed Martin
  - Location of 1 of 3 testbeds and design
- Stark State College of Technology
  - Project Lead & location of 2 testbeds built by students

Relevance

- BOP (Balance-of-Plant) - to have hydrogen used in fuel cell products, systems need to be engineered for:
- Reliability
- Mean time between failure
- Training of Technicians for maintaining Fuel Cell Systems.

Approach

- Development of test beds to address the challenge to the fuel cell industry for the durability and reliability of components that comprise the complete system (Balance of Plant).
- Development of the test plan to address the candidate balance-of-plant components and basic test bed design for long term operation.
- Utilization of collaborations with component manufacturers to develop and enhance final product performance.
- Develop statistical models for extremely small sample sizes while incorporating manufacturer validation data for future evaluation of candidate components.
- Real-time, in-situ analysis of critical components' key parameters to monitor system reliability.
- Utilizing the test beds to enhance the education of the technical workforce trained in PEM fuel cell system technology.

Approach

Task Number	Project Milestones	Task Completion Date				Progress Notes
		Original Planned	Revised Planned	Actual	Percent Complete	
1	Test Bed Design	3/31/09			100%	
2	Renovation of College Facility	3/31/09	9/30/09		98%	Renovations are almost all completed by the contractor. The space has been okayed for occupancy and testbeds is being worked on in this area.
3	College Test Bed Fabrication & Test	6/30/09			48%	The first test bed is built. Pump failures need to be addressed and temperature control components need to be specified and purchased yet. LabVIEW instrumentation & control software is being used in testing. The second test stand frame work has been ordered and the building and testing will follow this Spring and Summer semester.
4	Parallel Test Bed Fabrication & Test	6/30/09	5/30/10		87%	Revised date due to pump failures. Progress continuing on test bed assembly and operational control logic programming.
5	Reliability Analysis	6/30/11				
6	Failure Analysis	6/30/11				
7	Consulting	6/30/11				
8	Project Management & Reporting	4/30/11	6/1/09		98%	The Hydrogen Safety Plan is turned in and is under review by the DOE.

Technical Accomplishments and Progress

- With last year report none of the test beds were built and operational.
  This year 2 Test-beds have been assembled and the third is under development.
- Several test parts have been identified, looking for others to test.
- Students are being trained on the construction, programming and operation of the test bed.
- The Hydrogen Safety plan has been implemented to ensure safe operation of the testbeds with hydrogen.

Test Beds

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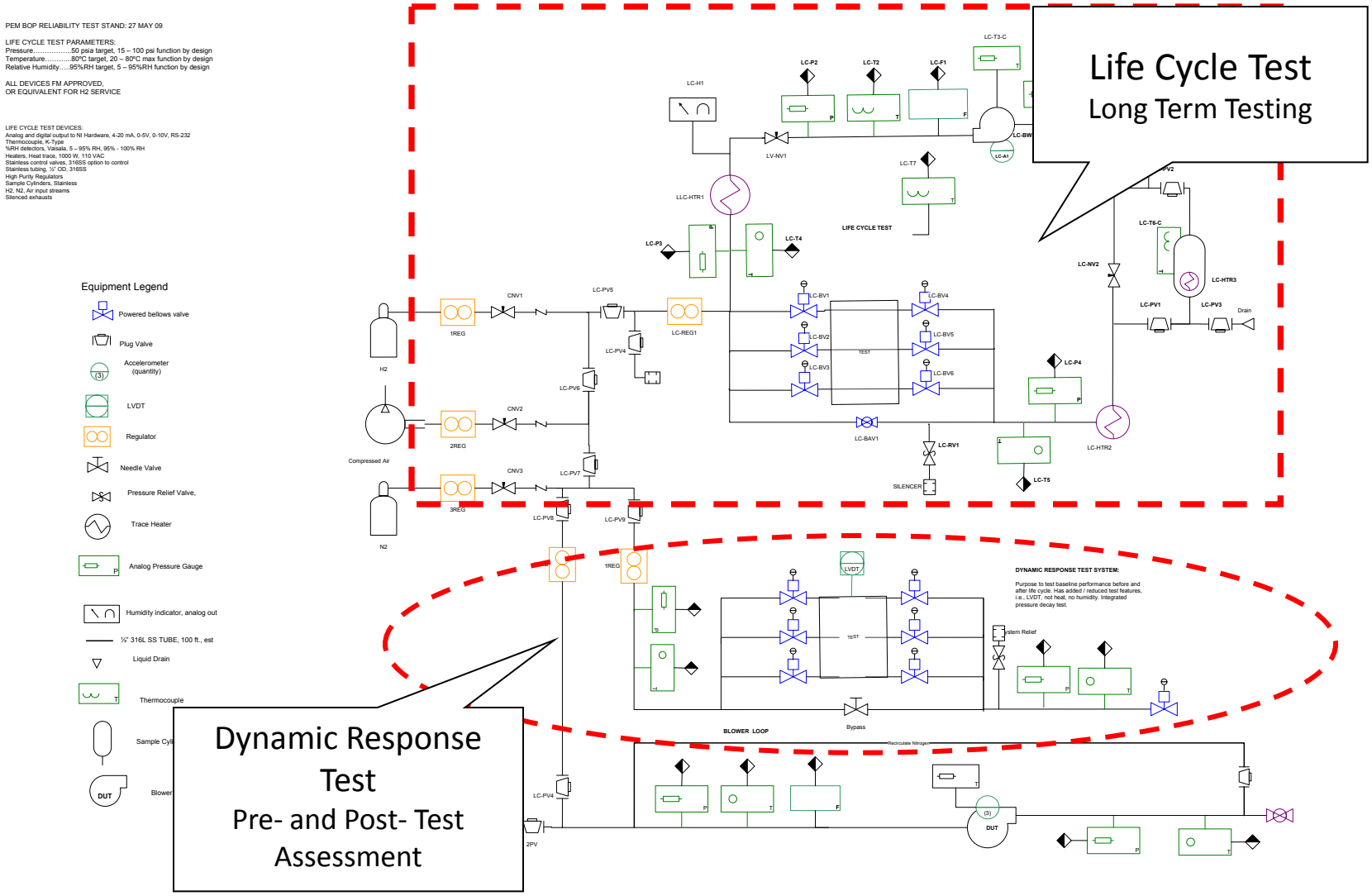
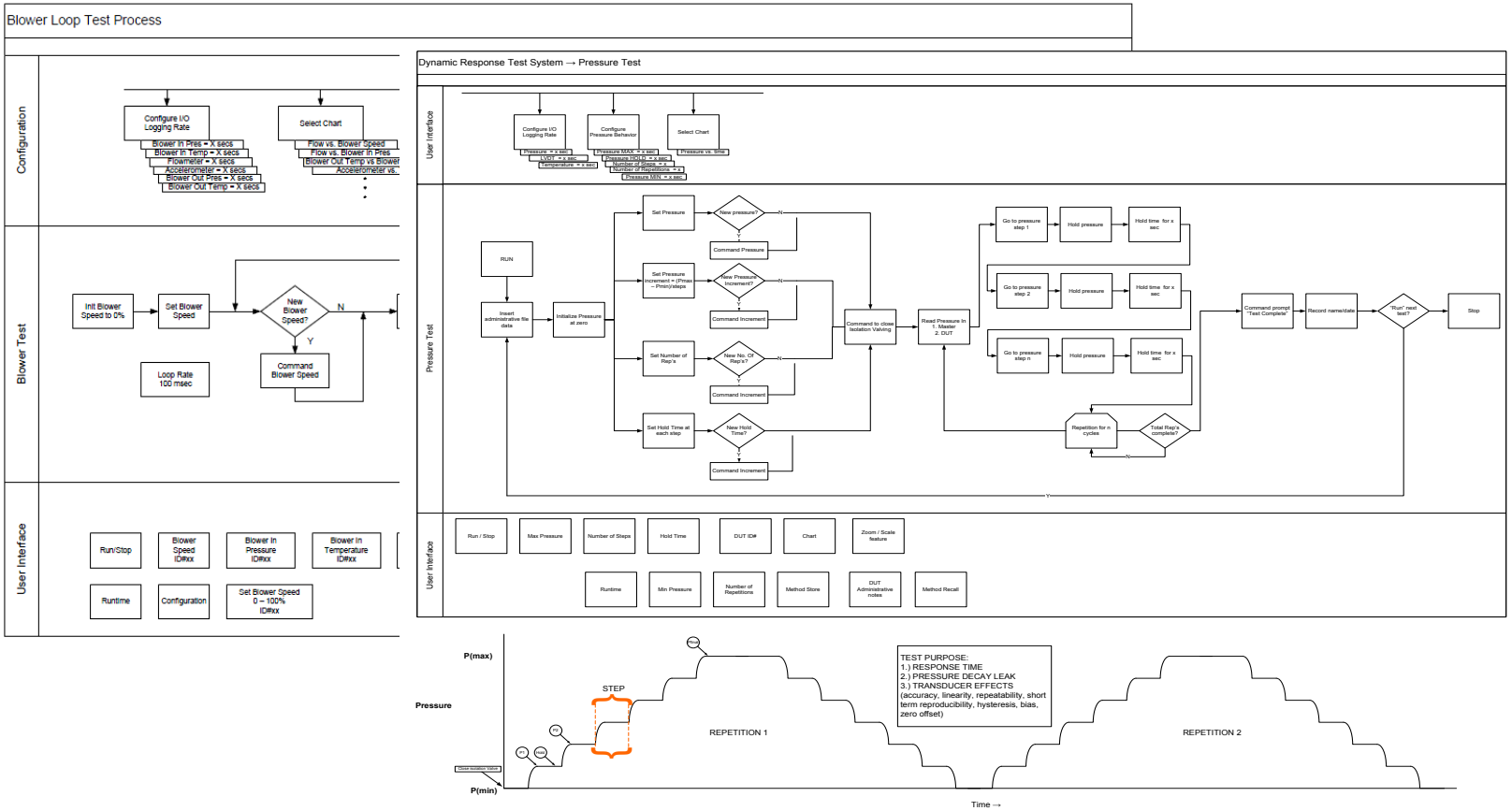
Testbed Design-Hydrogen Recycle

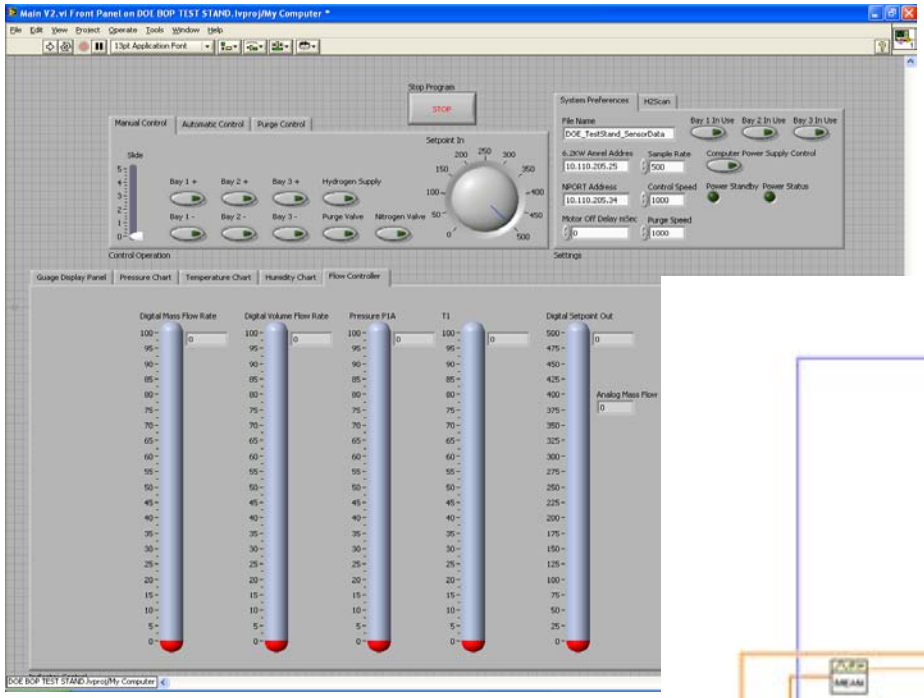


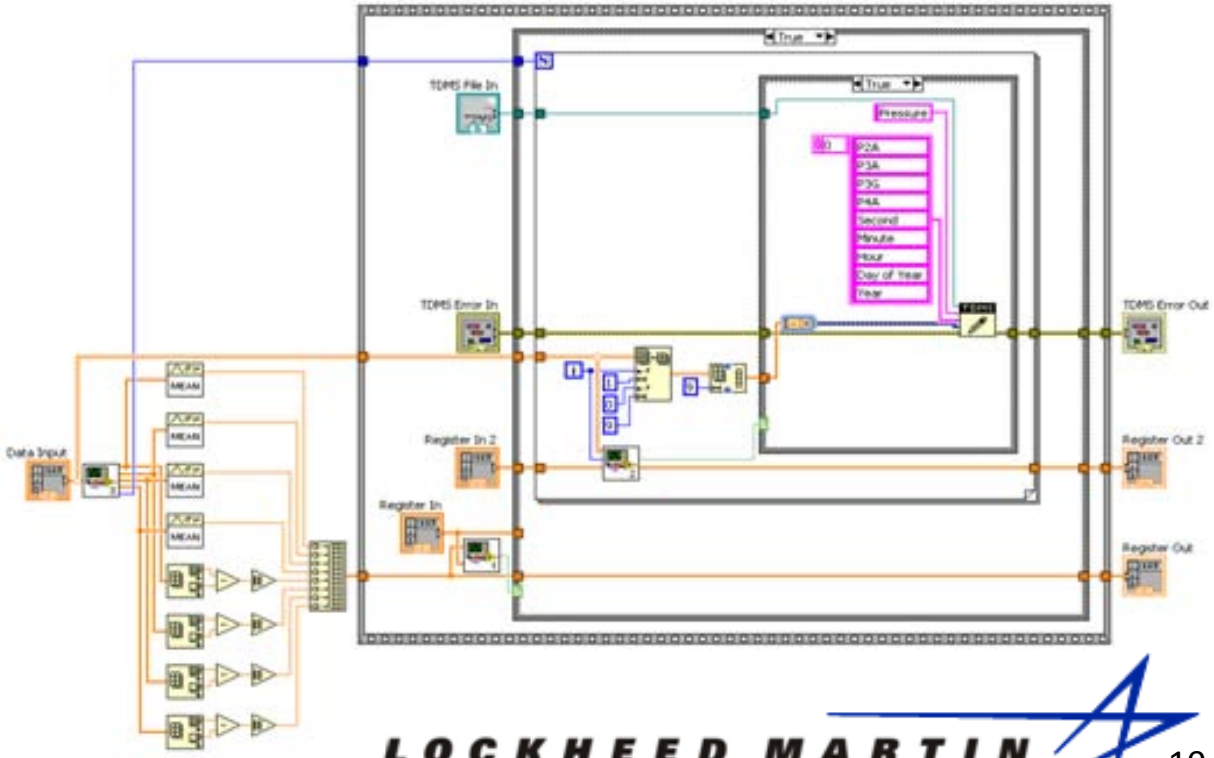
Testbed Design-Hydrogen Recycle



Logic Processes for test bed development

TestBeds LabVIEW Programming





Technical Accomplishments and Progress

Reliability Testbed

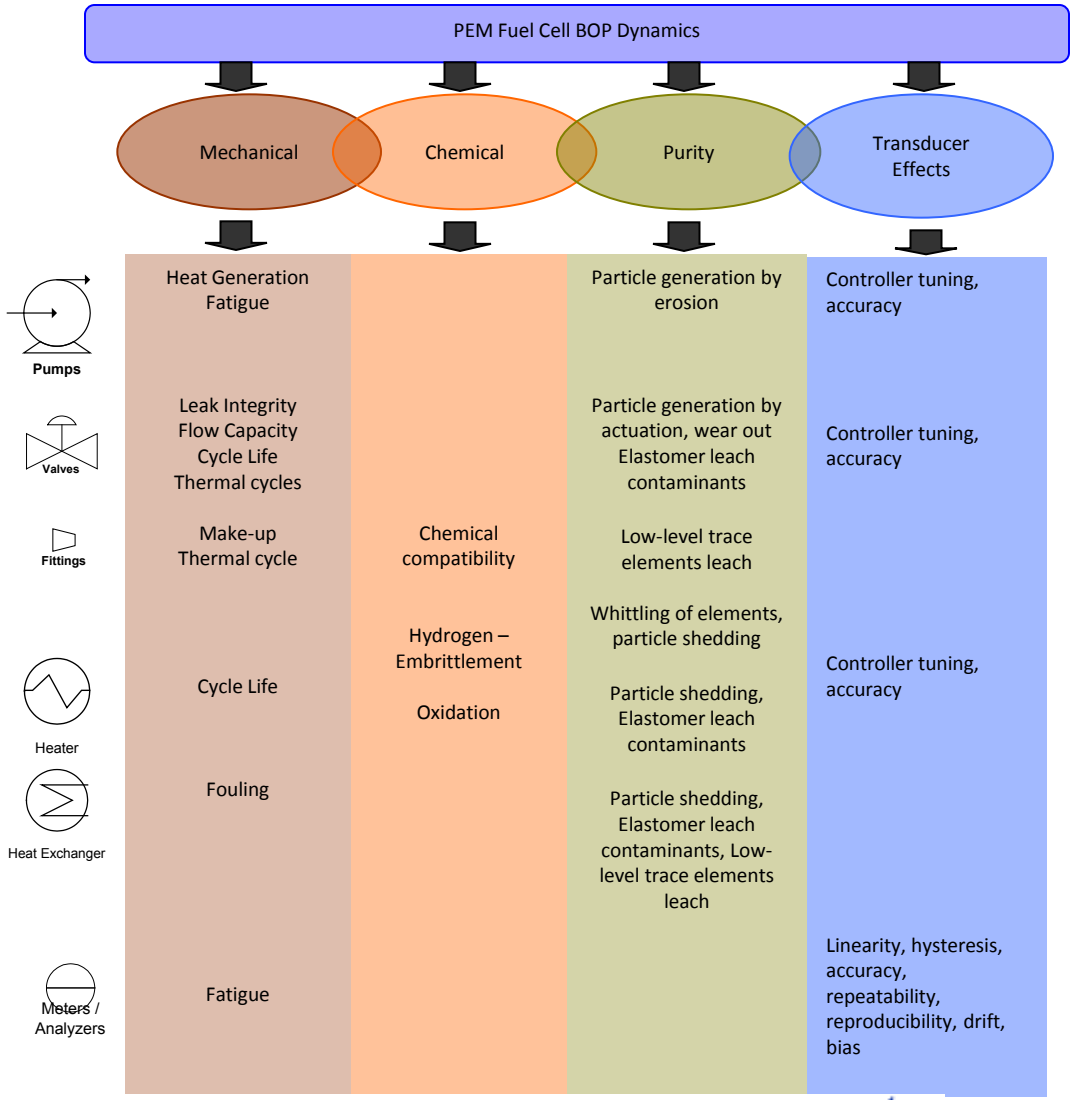
What is Reliability?

Reliability- The ability of an item to perform the required function, under stated conditions, for a period of time.

Candidate Balance-of-Plant Components

COTS – Commercial Off The Shelf Components.

- High production products such a piping, fittings, etc. where past history is available.
  - Use Weibull and Weibayes Analysis for those components with previous history. This procedure incorporates test and field data (vendor reliability and quality analysis) to demonstrate the component product meets the reliability target at the desired confidence level.
- Low production units with no manufacturer reliability data.
  - End of life component data and Forensic Failure Analysis will be the most important test data.



Hydrogen Recirculation Pump

- Hydrogen Recycle pump chosen for COTS (Commercial-Off-The-Shelf) Capability

  Parker Univane

  Rated for hydrogen operation and operation conditions $8K

- Recycle pump search identified the following issues:
  - Reliability of limited production components.
  - Materials compatibility, special order necessary for 316 SS with sealed operation.
  - Development costs required for hydrogen blower.
  - Components with delta pressure too low or low temperature rating.
  - Industrial size hydrogen compressors.
  - No DC motor.
  - Off the shelf not capable of service pressure.
  - High Development Cost.

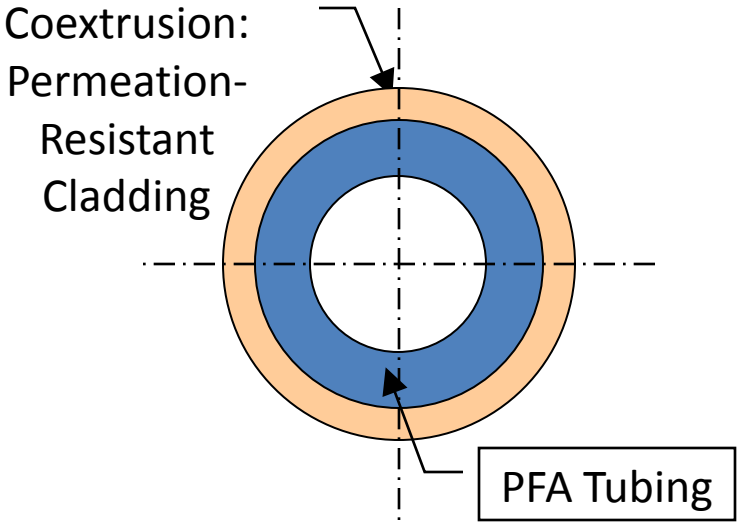
Search for Low Cost, Low Power, Low Weight Component.

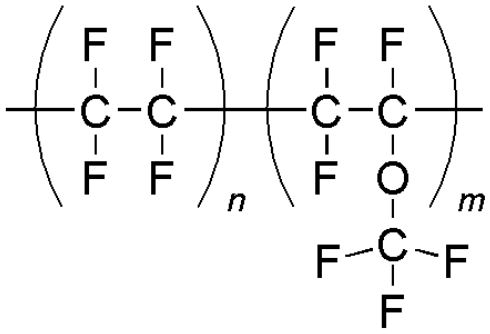
Fuel Cell Tubing

Component	Comments
316 Stainless Steel Tubing	**DI water compatible**
Coextrusion PFA Tubing	**DI water and chemical resistance, corrosion resistance, light weight**

- Alternate Tubing Choice
  - Performance tubing with greater resistance to permeation Zeus® Perme-Shield™ high-purity PFA. Perme-Shield™ demonstrates exceptional barrier properties and significantly defends against gas permeation and chemical leaching through the tubing walls used in wet chemical processing.

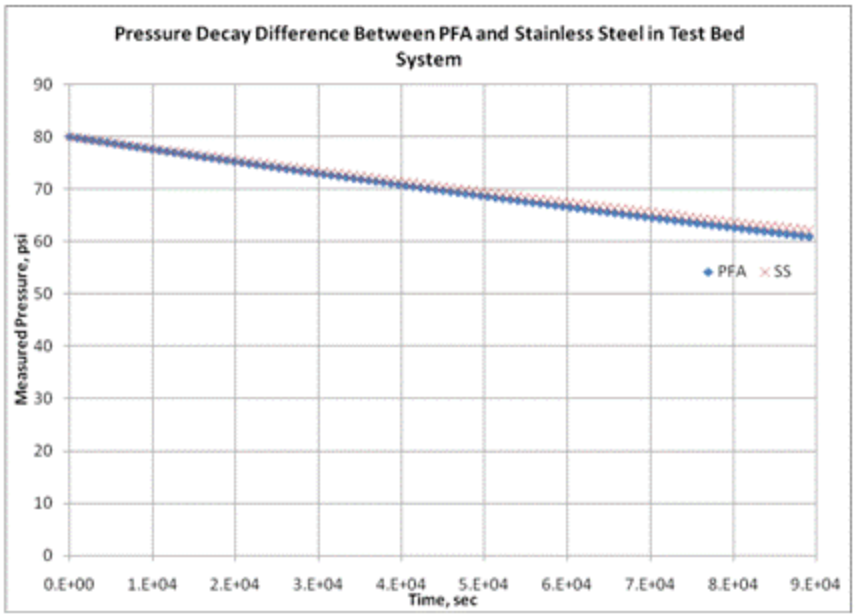
Zeus® PFA Tubing

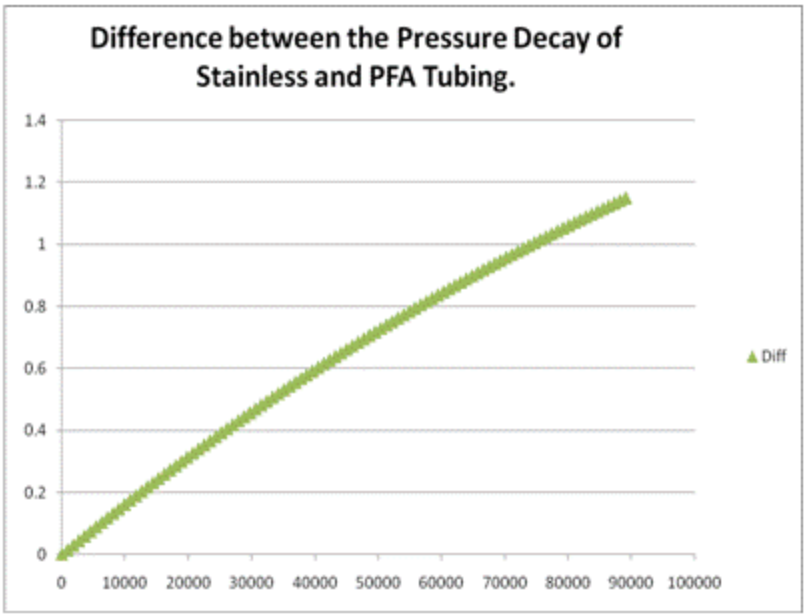




PFA- Perfluoroalkoxy polymer

PFA vs. Stainless Steel





- Pressure decay method used to test feasibility of PFA tubing.
- In the process of higher temperature and long term exposure to PEM environment testing.

Collaborations

- Lockheed Martin
  - Subcontract
  - Initial Test Bed Design
  - Parallel Test Bed Construction
  - Failure Analysis
  - Reliability Analysis
- Industry Dialogue
  - Parker
  - Swagelok
  - National Instruments
  - Omega Dyne
  - Rockwell Automation
  - Microchip
  - National Semiconductor
  - Zeus
  - Thomas
  - Buzmatics
  - Newport
  - BELLOFRAM
  - BelGAS
  - Proportional-air
  - SI Pressure
- Industry Dialogue (cont.)
  - SMC
  - AMREL
  - BALLARD
  - Brisk Heat
  - Fluke
  - H2Scan
  - Keithley
  - Keyence
  - Kikusui
  - Roxtec
  - Vaisala
  - Clippard
  - Omega
  - Ameritrol
  - ATEX
  - Intek
  - Asmeblon
  - Sandia Labs
  - McMaster-Carr
  - Auto Zone
  - Fluidtrol
- Industry Dialogue (cont.)
  - Alicat
  - Ametek
  - Fox Valve
  - EBZ
  - EXAIR
  - Pfizer
  - Airgas Great Lakes
  - NoShock
  - Summit Instruments
  - Mound Technical Solutions
  - Agilent
  - Neteon
  - Praxair
  - Item America
  - 8020
  - Rexel
  - Texas Instruments
  - Prosoft
  - Tektronix
  - Comsol
  - Piedmont Plastics
  - OFCC

Collaborations
Educational Institution Dialogue

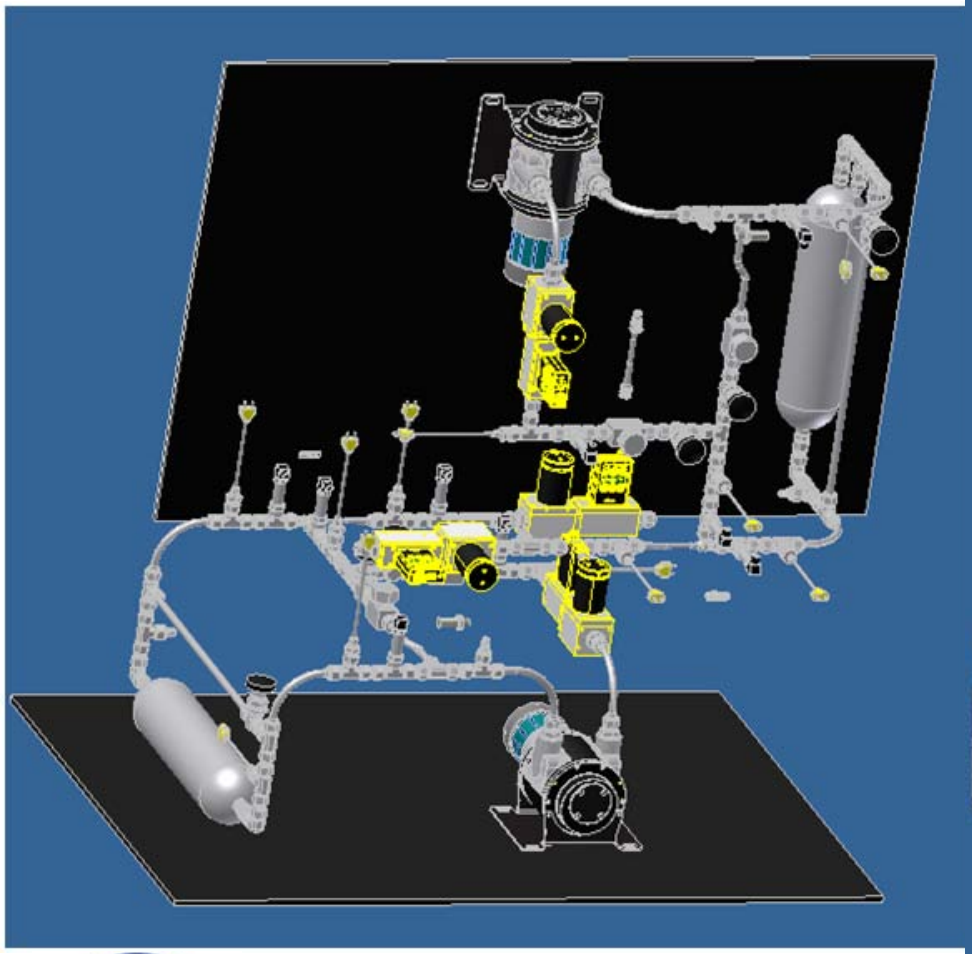
- NSF Great Lakes Fuel Cell Education Partnership State Coordinators
  - Indiana
    Vincennes University
    Rose Hulman Institute of Technology
  - Michigan
    Kettering University
    Lansing Community College
  - New York
    Rensselaer Polytechnic Institute
    Hudson Valley Community College
  - Ohio
    University of Akron
    Stark State College of Technology
  - Pennsylvania
    Penn State University

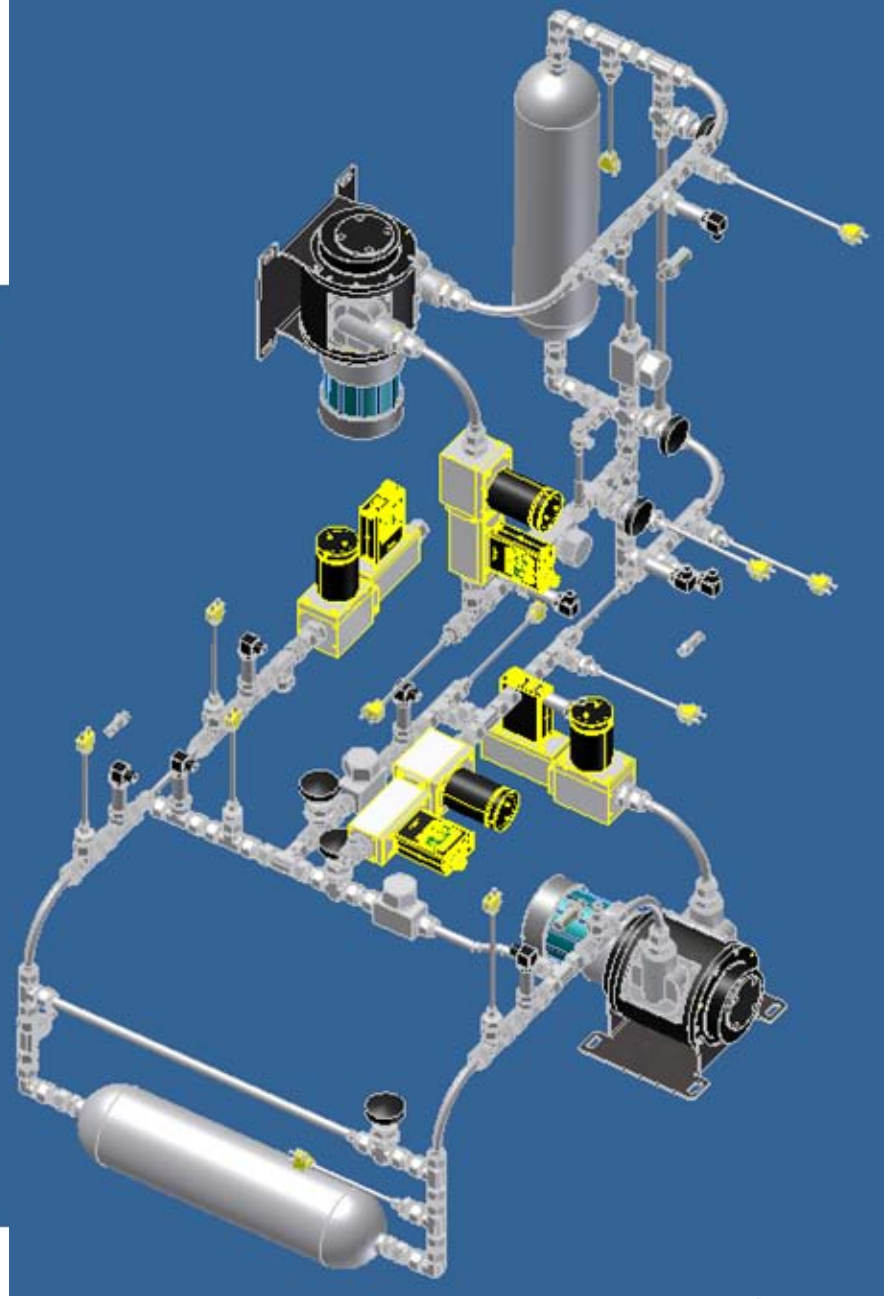
- Educational Institution Dialogue (cont.)
  - Early College course
    Alternative Energy and Fuel Cells
  - Engineering & Science Career Field Technical Fuel Cell Energy
  - Project Lead the Way Ohio Fuel Cell Option
  - Upward Bound Fuel Cell Course
  - Support for First Fuel Cell Contest teams
  - High School Student Science Projects
  - Ohio Energy Project

Proposed Future Work

- Identify additional parts to test.
- Acquire real time, in-situ data from the operation of the Test beds.
- Address failure analysis and reliability analysis as failures occur.

Proposed Future Work Test Bed 3





Acknowledgements

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- **Marcus Griffin, Lockheed Martin MS2**

- **DOE Managers:**
  Greg Kleen, Project Officer
  Kathi Epping, HQ Technology Manager

Project Summary

Relevance: BOP -to have hydrogen used in fuel cells, a balance needs to be engineered for reliability and technician training for fuel cell system.

Approach: Develop BOP testbeds, collaboration with component manufacturers to enhance product performance, and train technical workforce in PEM fuel cell systems.

Technical Accomplishments & Progress: Test Plan generation.
Students are being trained on the construction and operation of the test bed, and the Hydrogen Safety Plan has been implemented to insure safe operation of the testbeds with hydrogen.

Technology Transfer/Collaboration: Active partnership with Lockheed Martin and industry dialogue with Parker, Swagelok, National Instruments, Omega Dyne, and others ...

Proposed Future Work: Execute Test Plan; construct third reliability test bed with students; begin acquiring real time, in-situ data; address failure analysis and reliability analysis of BOP components.

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Supplemental Slides

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