Solid Oxide Fuel Cell Carbon Sequestration

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with Support of NiSource Energy Technologies

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Overview

- Timeline
  - Project Start: November 6, 2004
  - Project End: September 30, 2006
  - 5% Complete
- Budget
  - Total Project: $2,452,700
  - DOE Share: $1,962,155
  - Contractor Share: $490,545

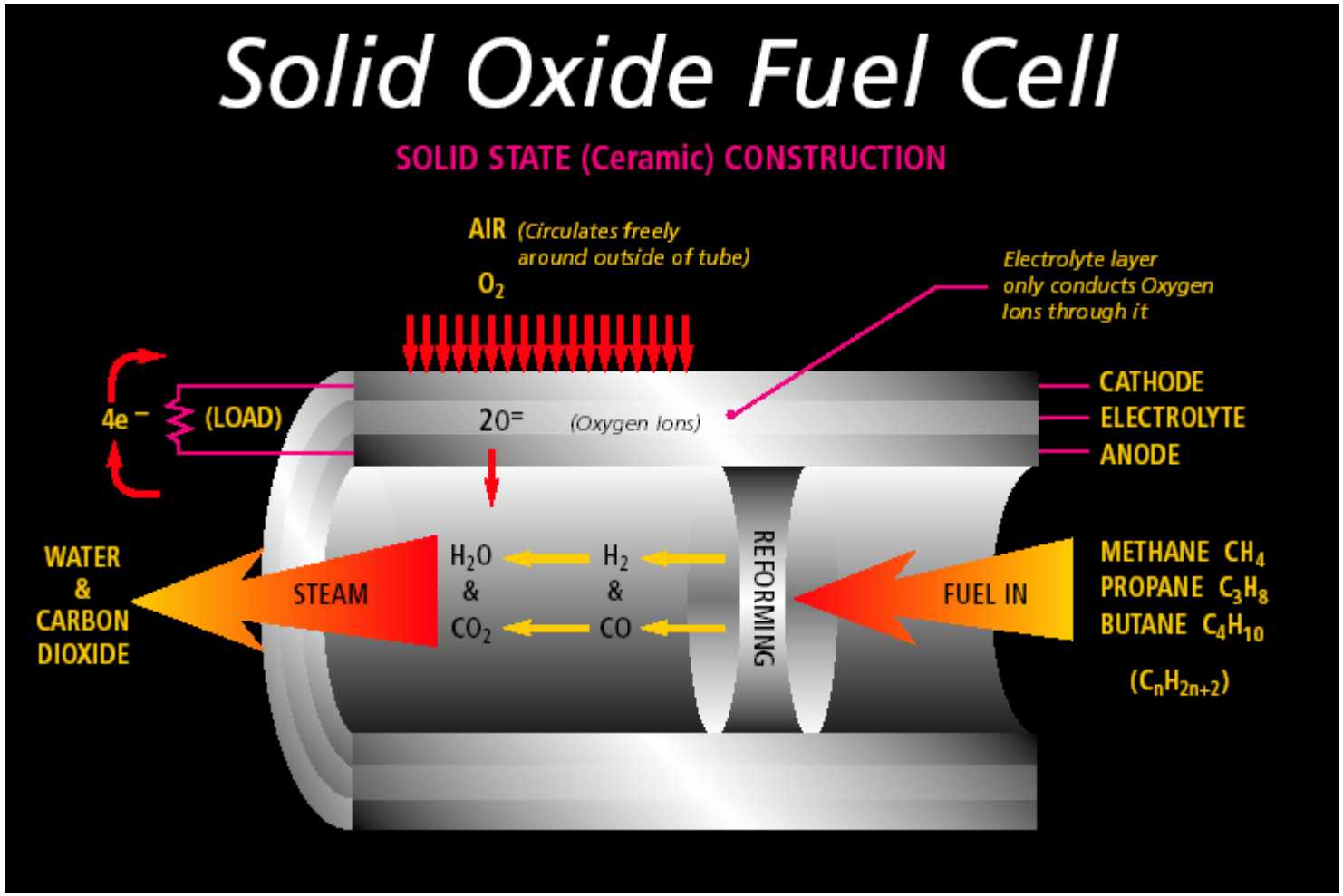
Project Objectives

- The objective of the project is to develop the technology capable of capturing all carbon monoxide and carbon dioxide from a natural gas fueled Solid Oxide Fuel Cell (SOFC) system.

- In addition, the technology to electrochemically oxidize any remaining carbon monoxide to carbon dioxide will be developed.

- Success of this R&D program would allow for the generation of electrical power and thermal power from a fossil fuel driven SOFC system without the carbon emissions resulting from any other fossil fueled power generation system.

How Acumentrics Fuel Cells Work

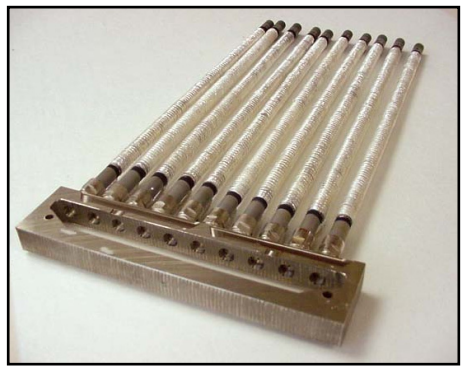


Acumentrics Fuel Cell Evolution

Stack Design Attributes

- Anode support tubes
- Brazed seals
- Stackable design
- Welded electric connections
- Low thermal mass
- Withstands heat expansion

Stackable Single Chamber Manifold design

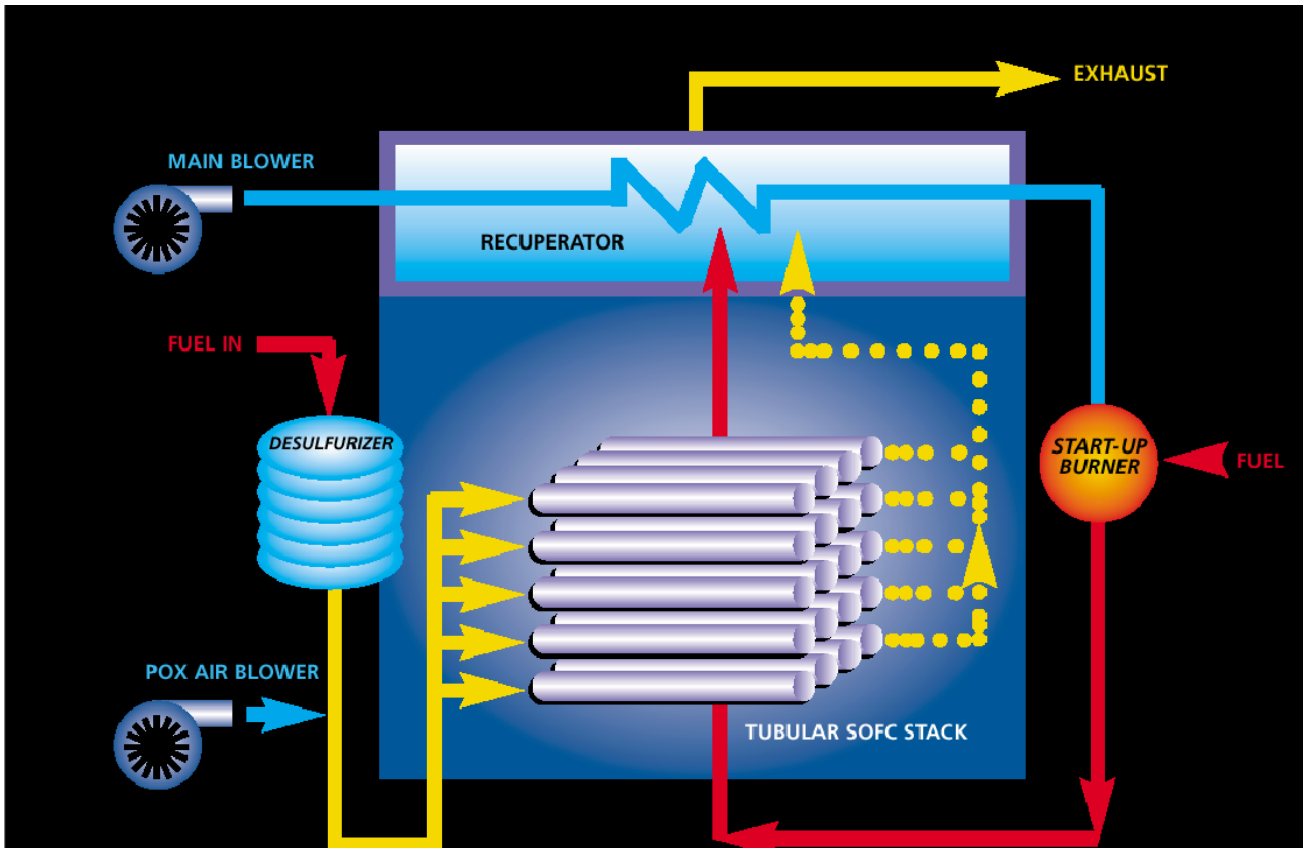


5 Watt
Tubes
Q2 2002

High Power Anode Tubes

20 Watt
Tubes
Q3 2003

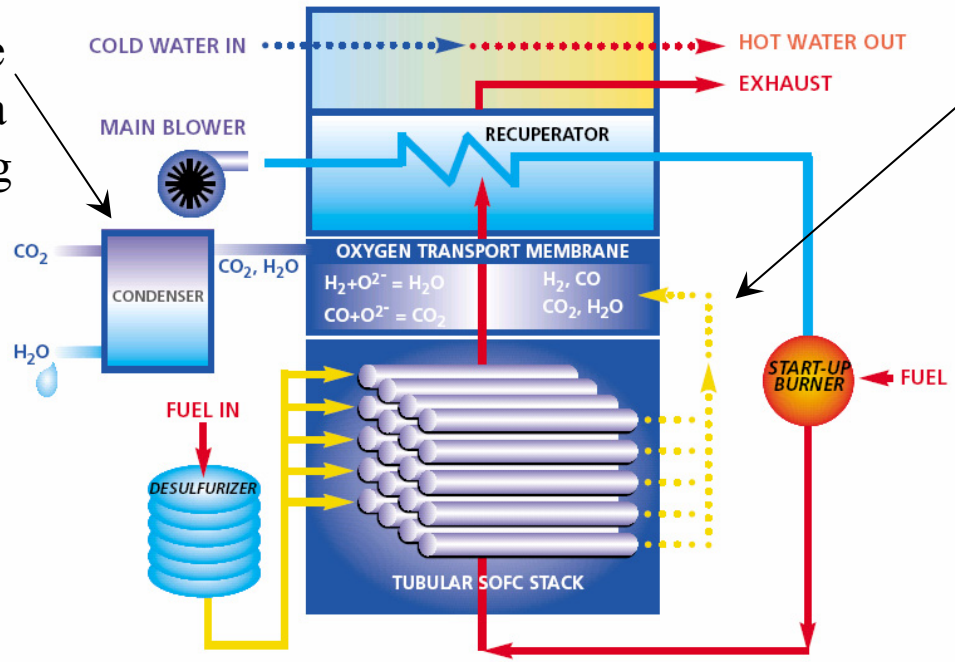
Acumentrics Tubular SOFC System Overview



In the existing generator design, the non-electrochemically used fuel is combusted with the air and exhausted to the atmosphere

Conceptual layout of a CO_2 Sequestered SOFC Generator

The CO_2 & H_2O are then passed across a condensor removing the water leaving a pure CO_2 stream



In the conceptual design, the non-electrochemically oxidized fuel is passed to a set of ceramic membranes which fully oxidize the remaining fuel.

Approach

- There are two key developments needed to successfully complete this research:

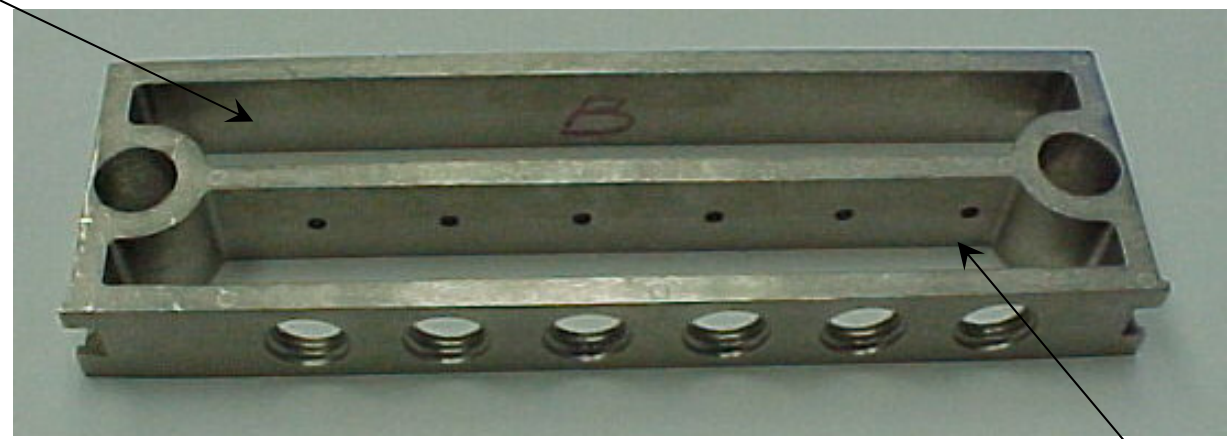
1. Develop the capability to capture the electrochemically utilized fuel gas.
2. Complete the oxidation of the spent fuel to result in an exhaust stream containing only carbon dioxide and steam.

Technical Accomplishments- Spent Fuel Capture

- A double chamber manifold has been developed building on the single chamber design.
- An ability to close the normally open end of the cell has been proven by two concepts- brazing and isopressing.

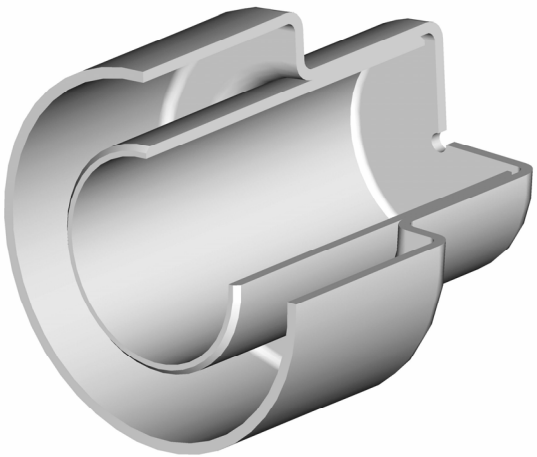
Double Chambered Manifolds

Fuel Inlet Cavity

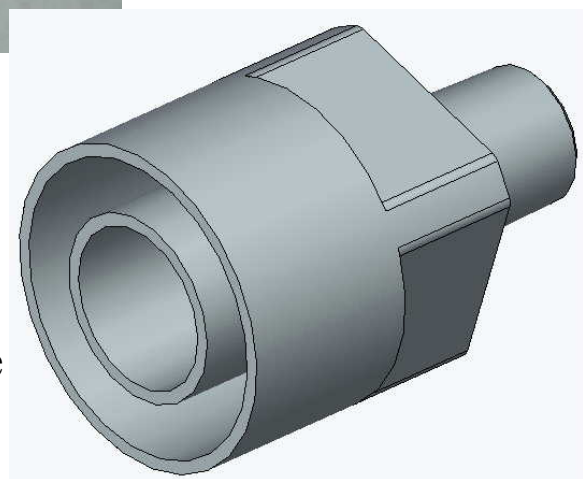


Spent Fuel Cavity

Cap Designs



The existing cap designs allow for fuel delivery through an injector tube while providing the negative connection for the fuel cell

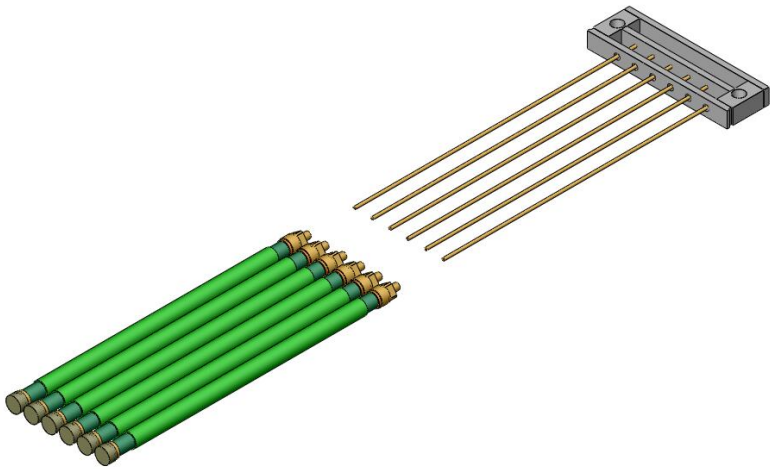


Injector Options

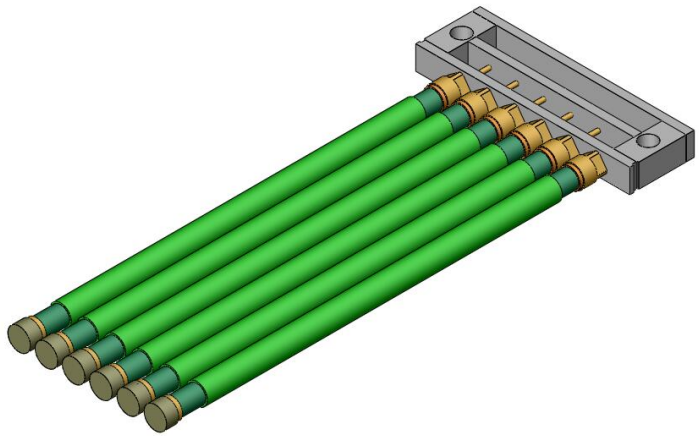
- Utilized to deliver fuel to the opposite cell end
- Contains an orifice for flow uniformity

Double Manifold Configuration

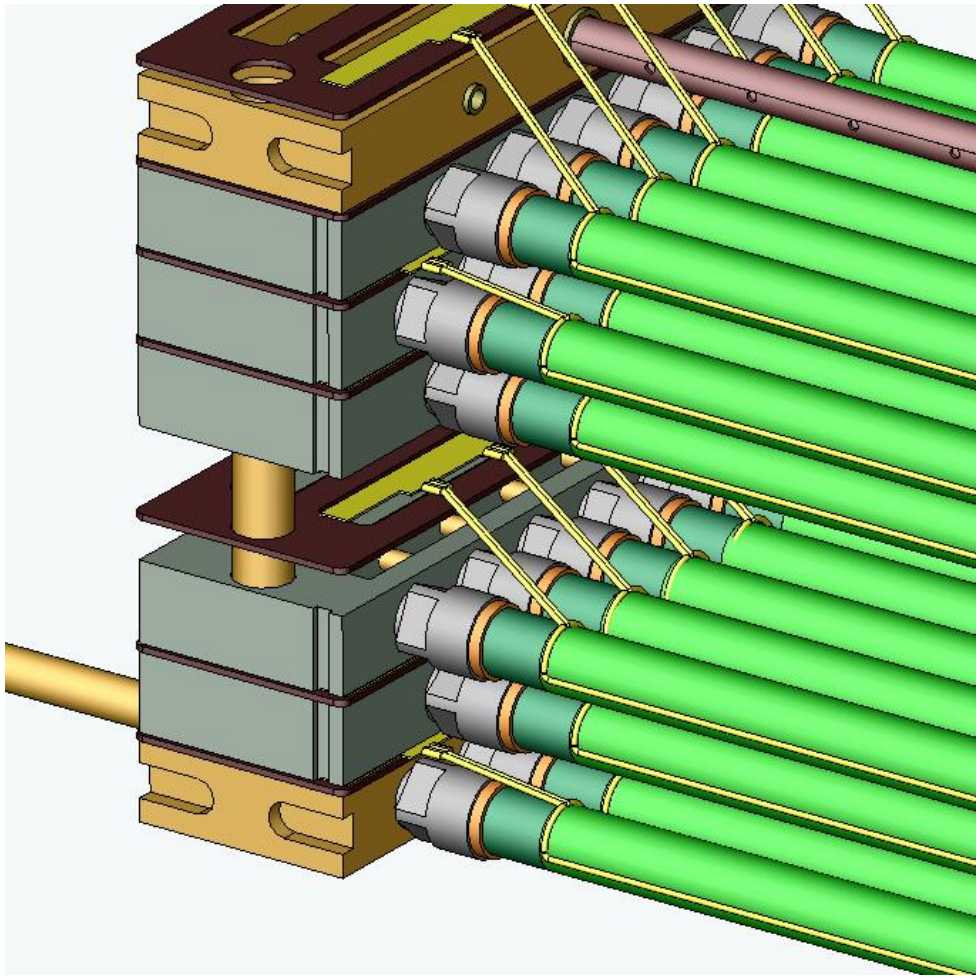
Injector Design



6 Cell Manifold Design



Double Manifold Stack Configuration



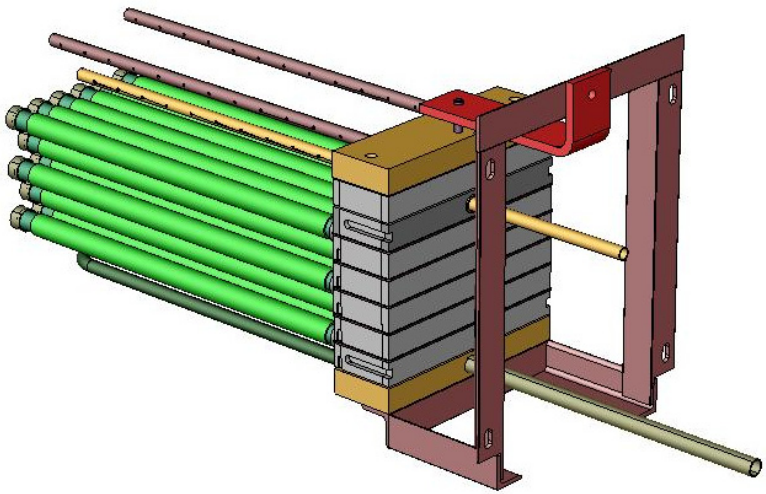
Closed End Formation - Braze Caps

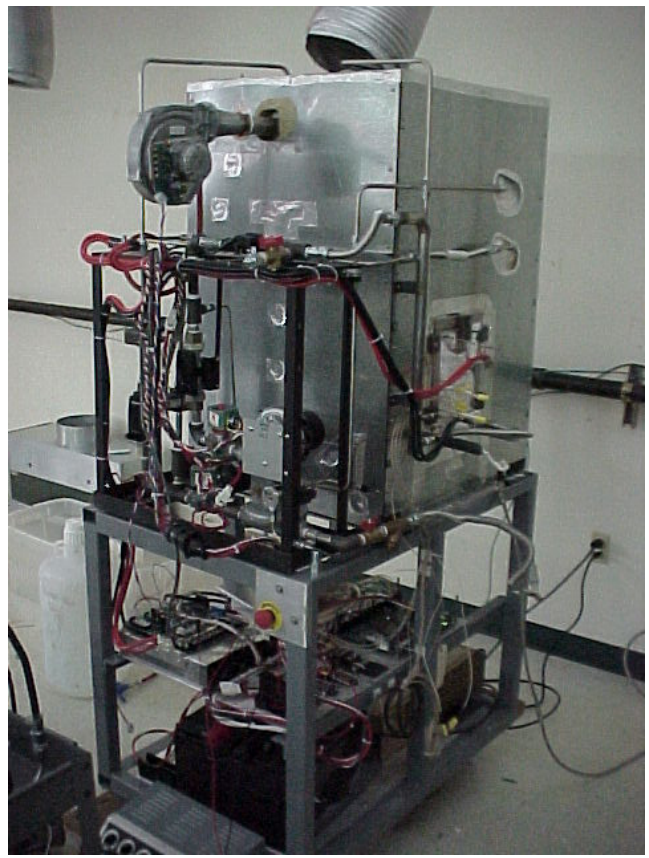
Closed End Formation - Isopressing

The tube has been manufactured by isopressing the anode powder in a mold with an integral closed end

Spent Fuel Capture Test Stands

- Manifolds and current interconnects can be tested in these devices.
- Up to six manifolds can be bundled together to form a mini stack





Technical Accomplishments – Spent Fuel Oxidation

- A literature search is underway to determine suitable materials to oxidize the spent fuel. They must be:
  - Stable at high partial pressures of oxygen.
  - Provide both ionic and electronic conductivity.
  - Mechanically and thermally compatible with other generator components.

Technical Accomplishments – Spent Fuel Oxidation

- Two general approaches can be taken to obtain the adequate material.

1. Utilize a single phase material which demonstrates both sufficient ionic and electronic conductivity in a single film
2. Deposit “bands” of films, switching between ionic and electronic, and then providing an electrical connection path.

Spent Fuel Oxidation Test Chambers

Future Plans

- Remainder of FY2005
  - Determine the 2-3 best mixed conducting materials capable of achieving the required oxygen flux.
  - Complete build of the test rigs for manifolds and mixed conducting materials.
- FY2006
  - Test and demonstrate the capability to capture all fuel effluent.
  - Demonstrate adequate oxygen flux on full scale tubes.
  - Complete the conceptual design of a carbon sequestered generator.
  - Complete a 2000 hour endurance test.