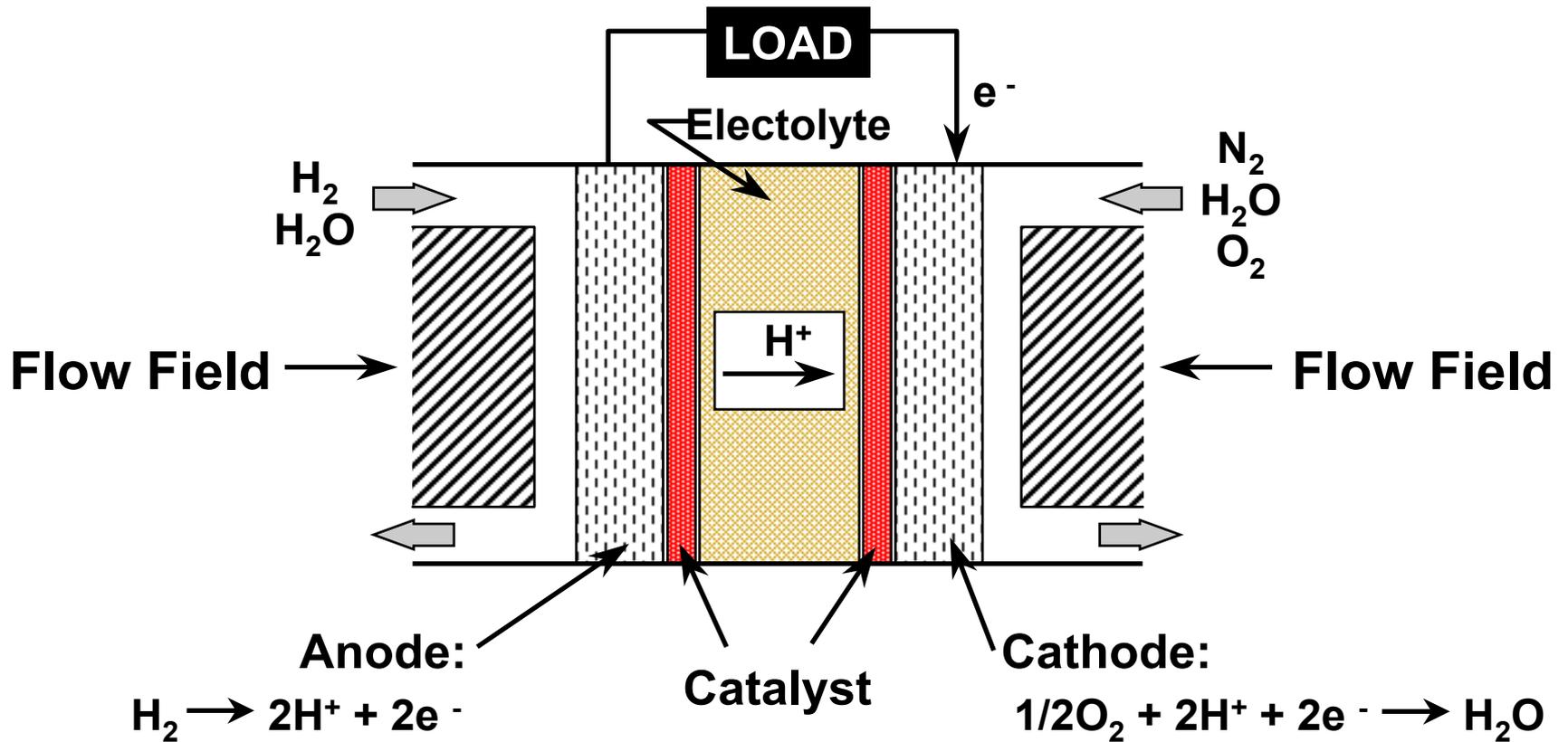


Fuel Cell Testing at Argonne National Laboratory

D. J. Andrekus, I. Bloom, E. G. Polzin,
W. M. Swift and J. F. Miller

IEEE Vehicular Technology Conference
Birmingham, Alabama
May 6-9, 2002

A Fuel Cell Schematic



Overall Cell Reaction: $H_2 + 1/2O_2 \rightarrow H_2O$ (Cell Potential ≈ 1 V)



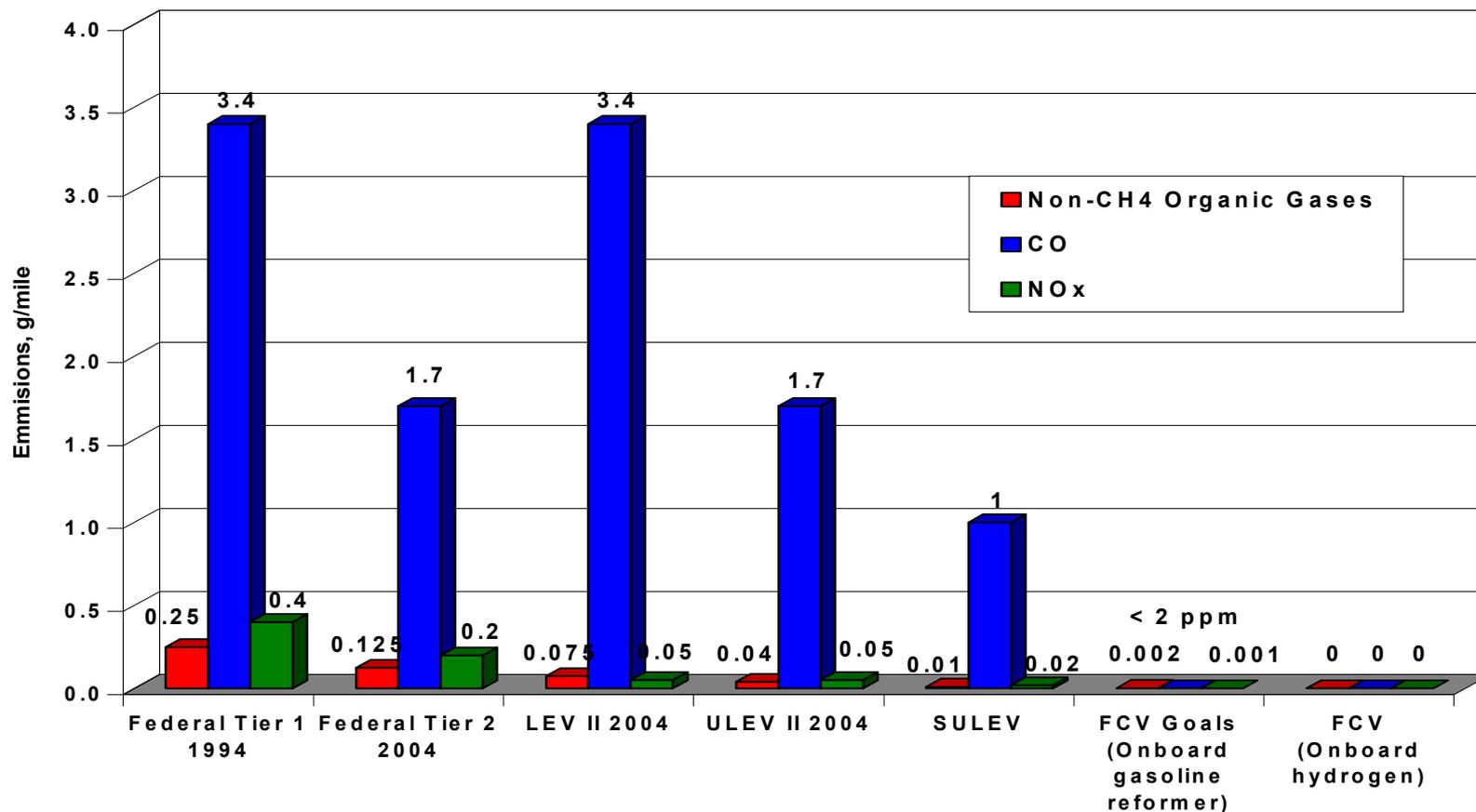
Fuel Cells for Automotive Applications

- More efficient use of chemical energy than an ICE
 - Emits little to no pollution
- No moving parts/solid state design
- Quiet
- PEM fuel cells
 - “Mature” technology
 - Compact
 - Rugged
 - Low operating temperature



Emissions Advantage

Fuel Cells Emissions are Negligible



Automotive Applications of Fuel Cells

DaimlerChrysler Passenger Vehicles



**Necar 1
(Compressed H₂)**



**Necar 2
(Compressed H₂)**



Necar 3 (Methanol)



Necar 4 (Liquid H₂)



**Jeep Commander
Concept Vehicle
(Methanol)**



More Automotive Applications

Other OEM Passenger Vehicles



Nissan (methanol)



**Mazda Demio
(hydrogen)**



**Ford P2000
(hydrogen)**



**Toyota RAV4
(methanol)**



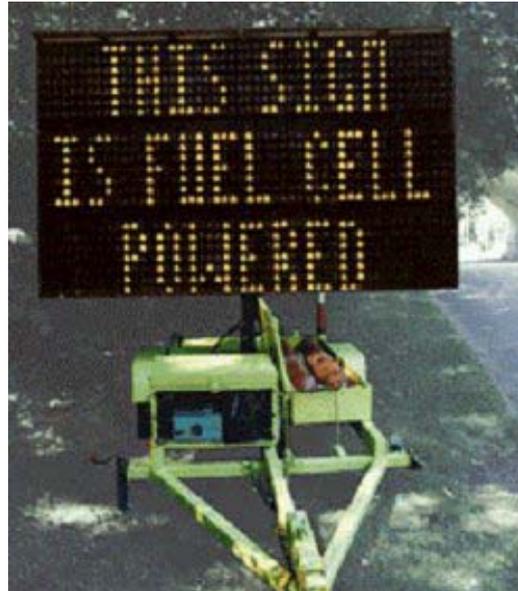
**Opel Sintra
(hydrogen)**



Non-Automotive Fuel Cell Applications



Plug Power
7hW
Residential
PEM FC



H-Power FC
Powered Highway
Road Sign



Ballard 250kW
PEM FC



Ballard FC for
Laptop

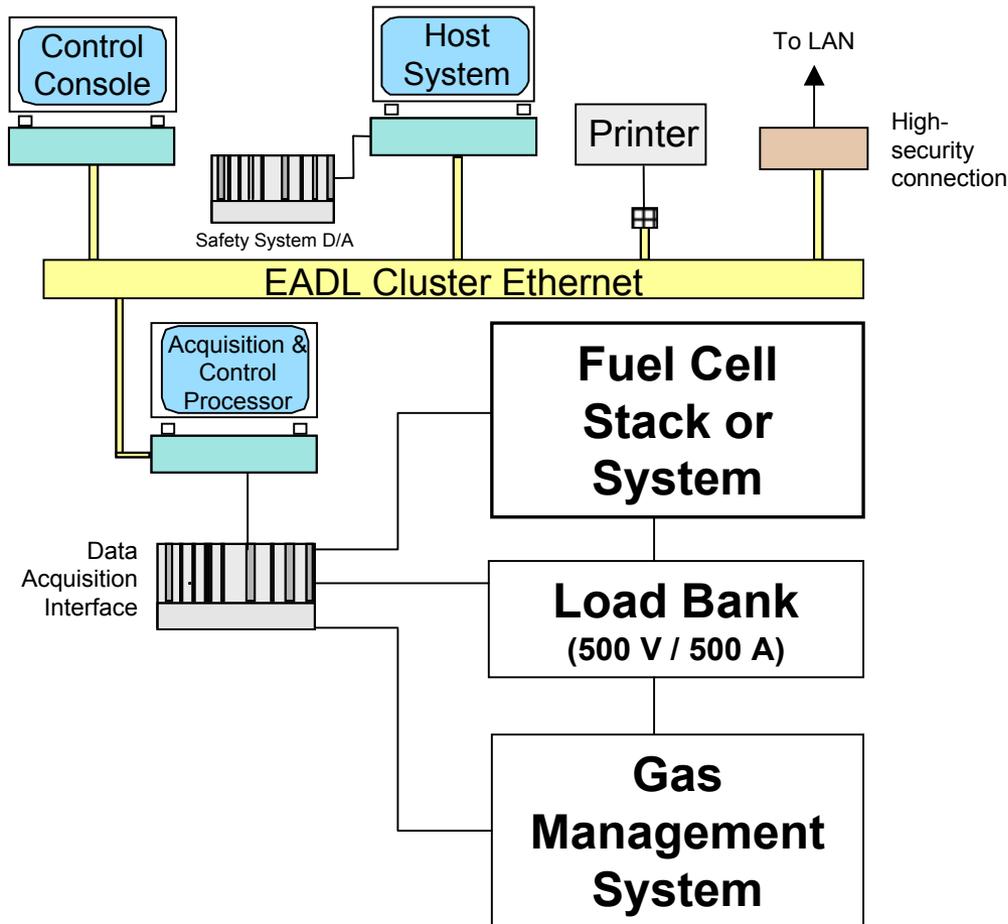


Argonne's Role In Fuel Cell Testing

- Argonne National Lab's Fuel Cell Test Facility (FCTF) was established by the US DOE to provide an unbiased assessment of fuel cell technologies under development for transportation applications
- The FCTF draws on Argonne's extensive experience in the electrochemical evaluation of batteries and battery test equipment
- Tests are independent and standardized
 - Provides a true measure of progress in fuel cell technology
 - Allows accurate comparison between developers



Versatile, Computer-based Test Laboratory



- Programmable current, power or resistance profiles with up to 0.1 sec resolution
- Constant Current, Power or Resistance
- Data-Acquisition rates up to 10 samples / second
- Control System Analysis (full systems)



Gas Management System



Interfaced with
computer system

Reformate
Mixer

Test Station

Humidifier

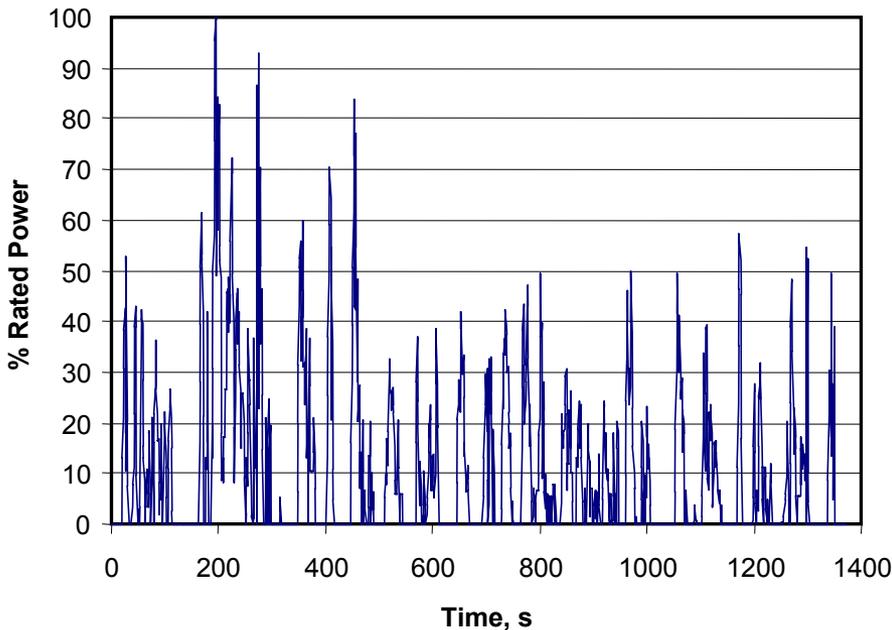


Electrochemical Technology Program

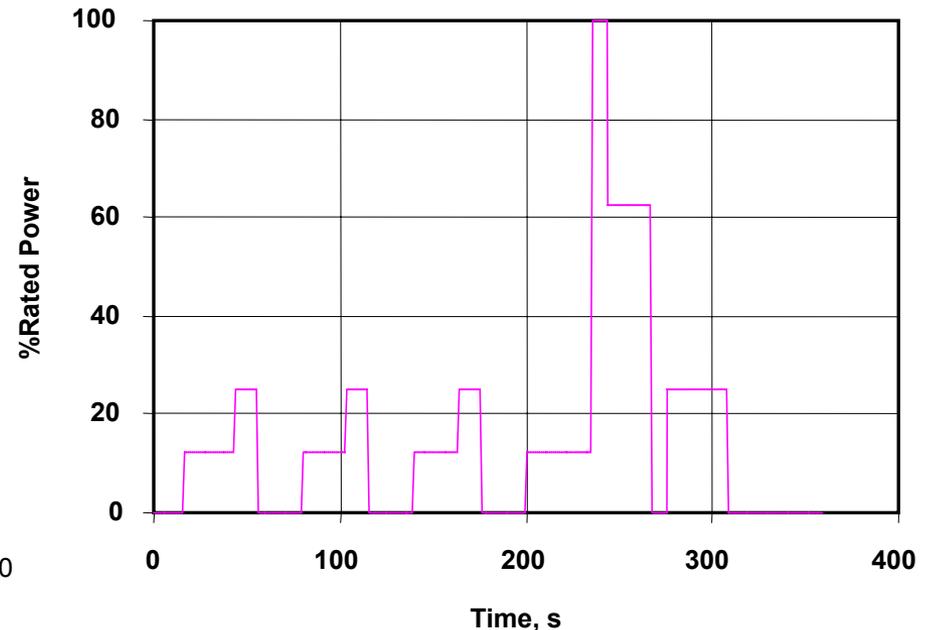
Argonne National Laboratory

Examples of Dynamic Loads

- Fuel cell-compatible profiles
 - Modified USABC battery profiles
- Other profiles can be easily implemented



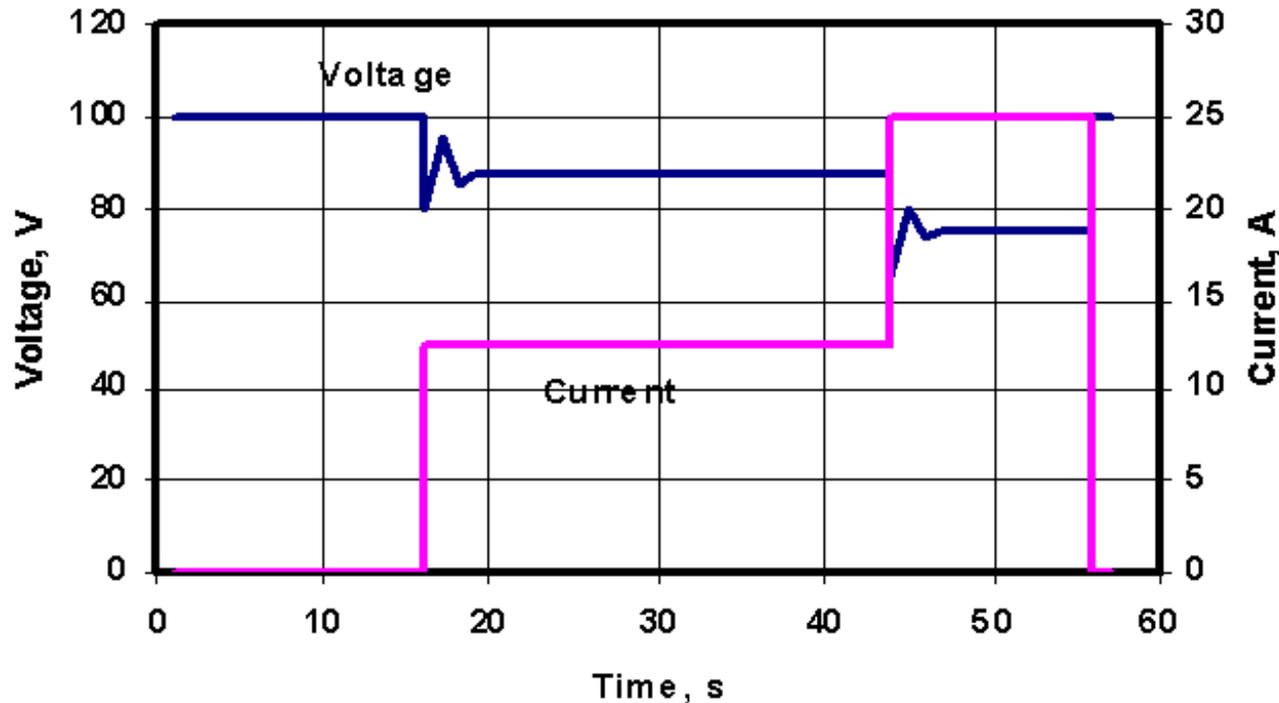
FUDS



DST



Load Following Ability



- System overshoot is approximately 10 V
- System took approximately 3 seconds to stabilize
- Underdamped system



Multiple Fuel Sources

- Fuels Currently Available
 - Hydrogen
 - Simulated Reformate
 - California Phase II Reformulated Gasoline
- Future Fuel Availability
 - Natural Gas (currently under construction)
 - Methanol
 - Diesel



Two Bulk Fuel Supplies



Hydrogen Storage Facility

1.18×10^6 L (42,000 ft³)



Gasoline Storage Facility

416 L (110 gals.)



Diverse Range of Deliverables Tested



Bare Stacks
(100 W_e to 50 kW_e)



Complete Systems
(100 W_e to 250 kW_e)

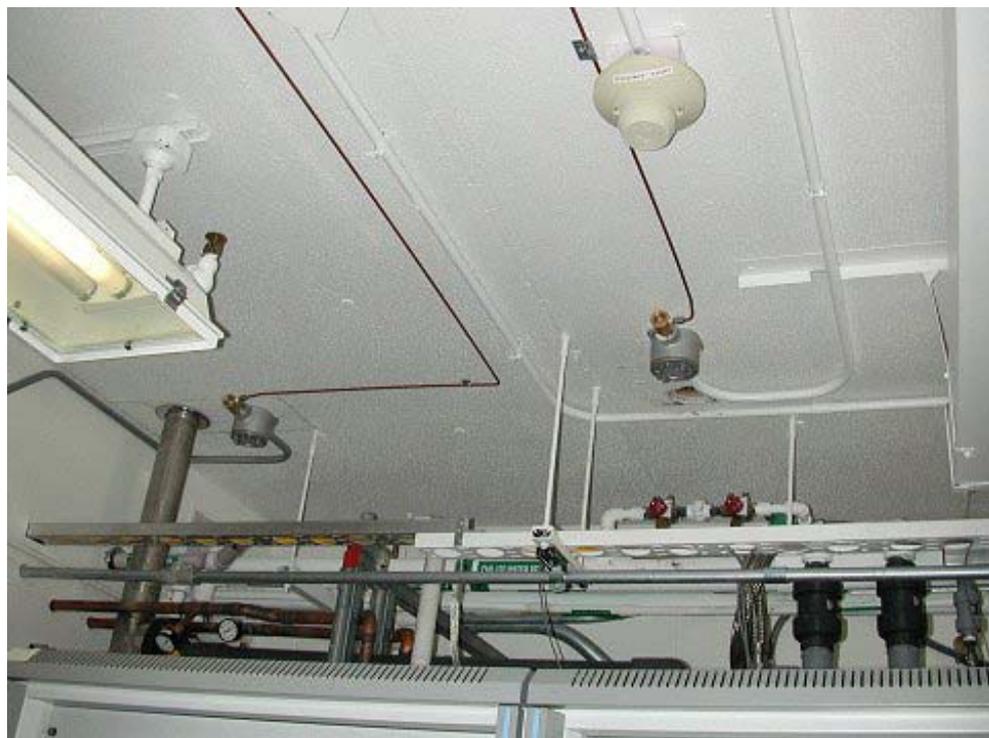


Electrochemical Technology Program

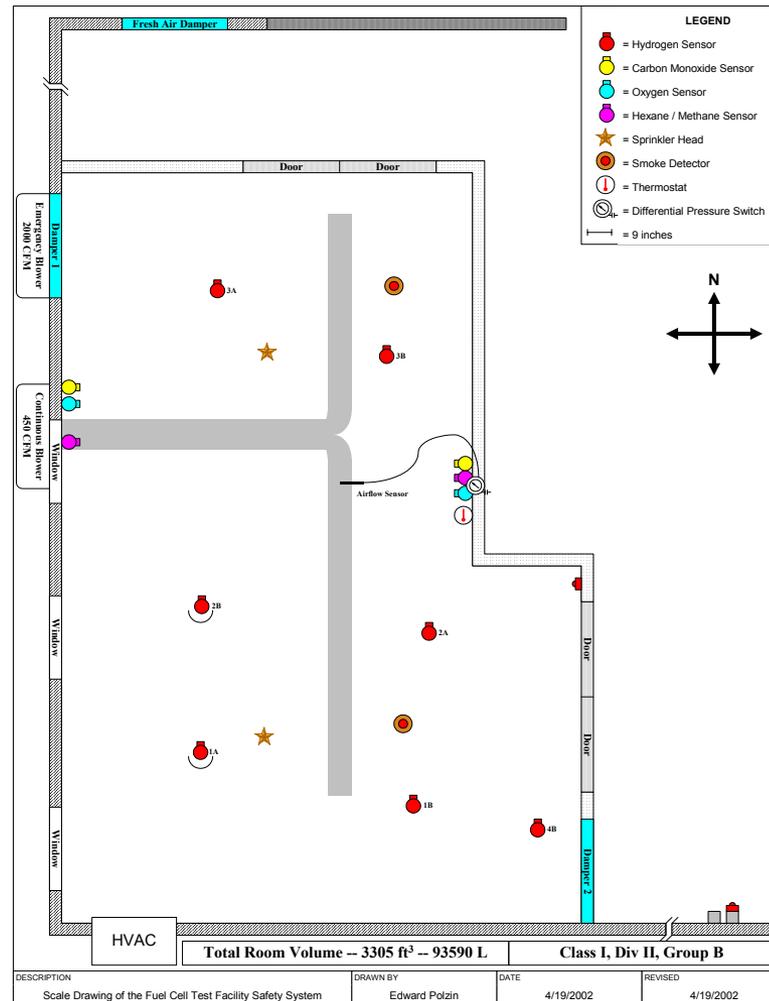
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Safety Is Very Important

- H₂ sensors
- CO, HC sensors
- O₂-depletion sensors
- Fire and smoke detectors
- Constant Room Ventilation



Sensors Are Placed At Key Locations



Summary

- The FCTF is operational and is being continuously upgraded to handle higher-powered stacks and diverse testing requirements.
- Testing started in August 2000 and we have tested stacks and complete systems from many developers.
- Together, the computer-operated load and the fuel supply systems offer tremendous flexibility.
- The FCTF hardware and software can easily adapt to almost any combination of conditions needed by a given developer.

