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NASA/DOD FLIGHT EXPERIMENTS TECHNICAL INTERCHANGE MEETING

ELECTROLYSIS PERFORMANCE IMPROVEMENT AND VALIDATION EXPERIMENT

Life Systems, Inc.

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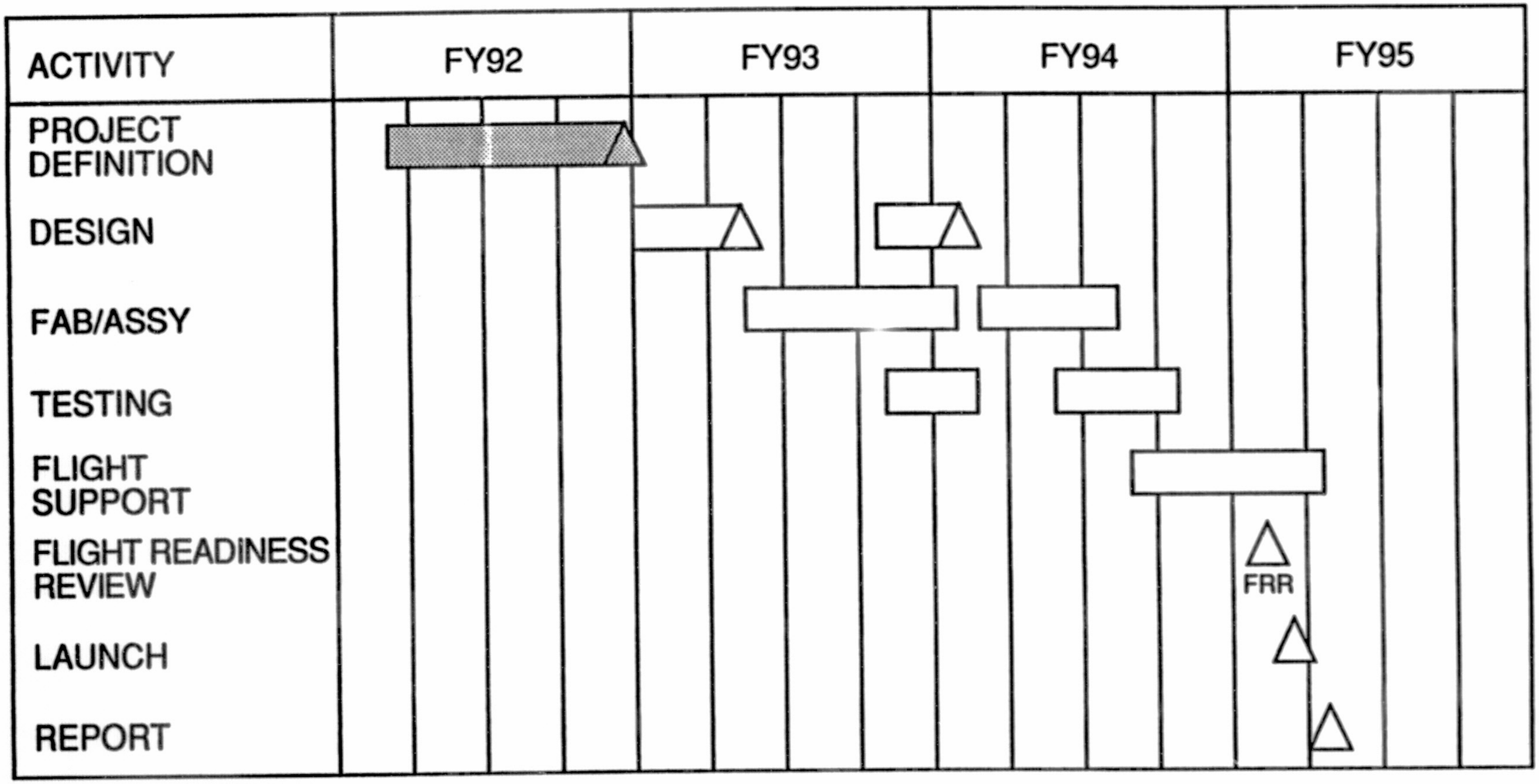
October 5-9, 1992
Monterey, California

OVERALL SUMMARY

- Phase B (Project Definition) Study has shown:
  - Experiment objectives are achievable
  - Safety requirements are satisfied, no "showstoppers" identified
  - Phase C/D schedule satisfactory for November 1994 launch

- Ready to begin Phase C/D

EPICS EXPERIMENT PROGRAM SCHEDULE



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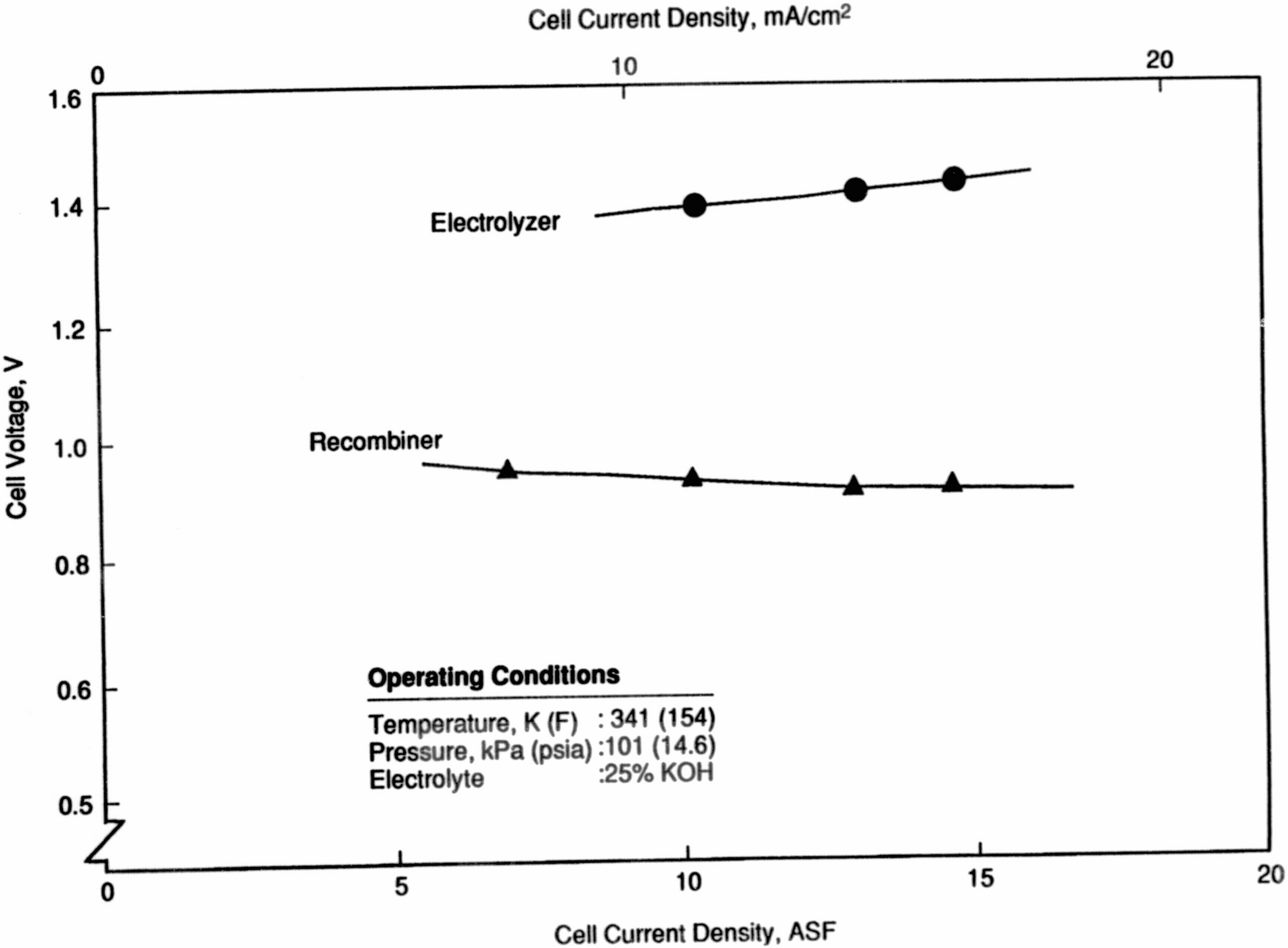
EPICS SCHEDULE

- Authorization to Proceed with Phase C/D Anticipated for November 1992 Start
- Unit Available for Launch in Late CY 1994 or Earlier

ELECTROLYZER/RECOMBINER CONCEPT TEST



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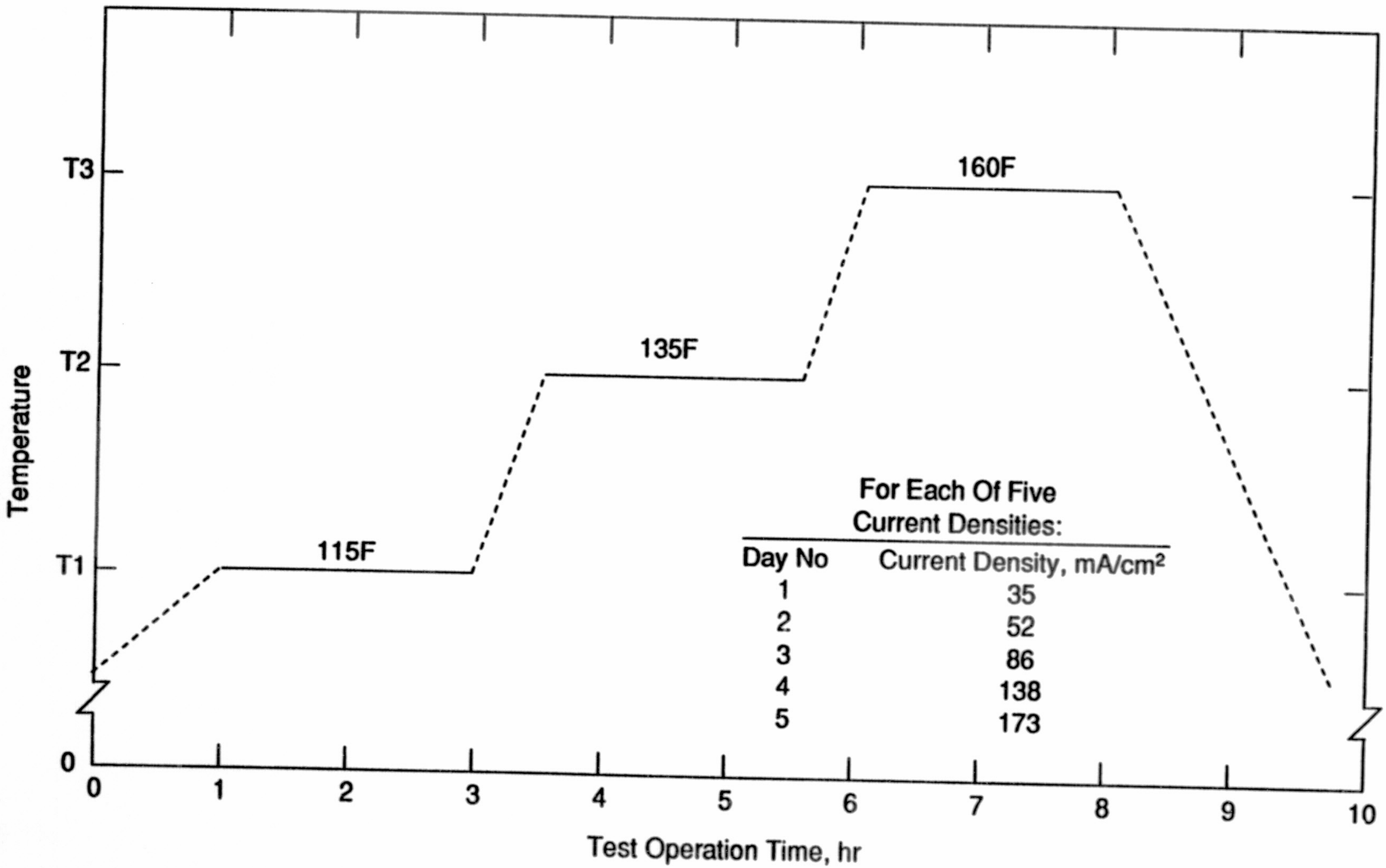
EPICS EXPERIMENT TEST SEQUENCE



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TEST SEQUENCE

Each Electrolysis Unit is Tested at a Combination of Three Temperatures and Five Current Densities

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EPICS INTERFACES

Interface Requirements	Source
Water Supply	Self-contained in experiment
Coolant (air cooled)	Space Shuttle Cabin
Electrical Power	Space Shuttle
Data Acquisition/Storage	Self-contained in experiment
Crew Involvement	Single activation of experiment by operator.
Tools	No tools required

EPICS OPERATING CONDITIONS

Vehicle Conditions	
Middeck Total Pressure, kPa (psia)	101.3 ± 1.4 (14.7 ± 0.2)
Middeck Temperature, K (F)	292 to 300 (65 to 80)
Nominal Operating Conditions	
Number of Units	3
Current Density mA/cm² (ASF)	34 to 171 (32 to 160)
Operating Pressure, kPa (psia)	108.3 ± 1.4 (15.7 ± 0.2)
Operating Temperatures, Nominal, K (F)	319, 331 and 344 (115,135 and 160)

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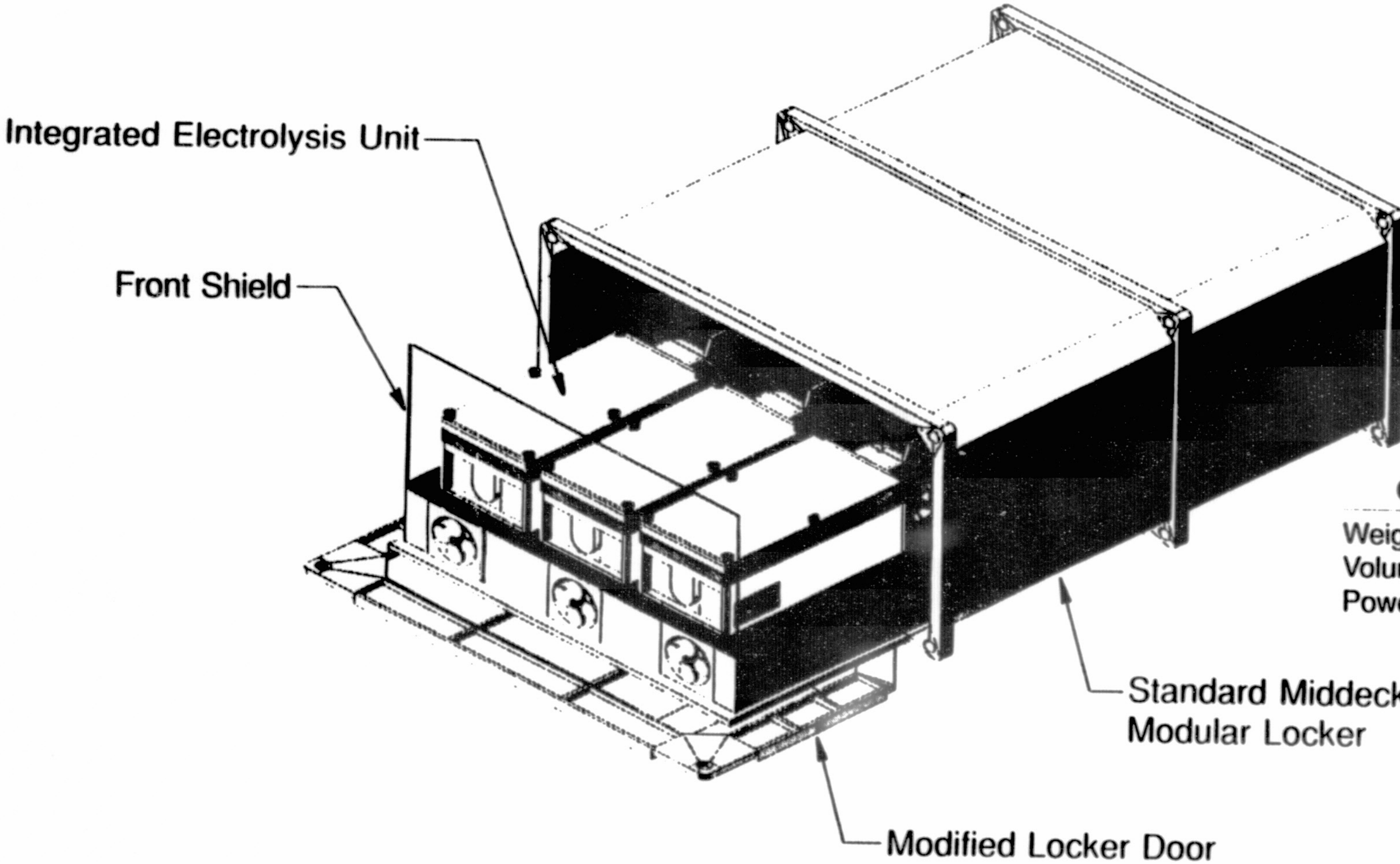
EPICS[a] EXPERIMENT PACKAGING CONCEPT
(IN LOCKER)



Characteristics

Weight, kg (lb)	: 20 (45)
Volume, dm^3 (ft^3)	: 45 (1.6)
Power, W	: 111 Max.

(a) Electrolysis Performance Improvement Concept Studies

EXPERIMENT HARDWARE

- Packaged in One Shuttle Orbiter Middeck Locker
- Simple Operational Requirements
- Minimum Interfaces

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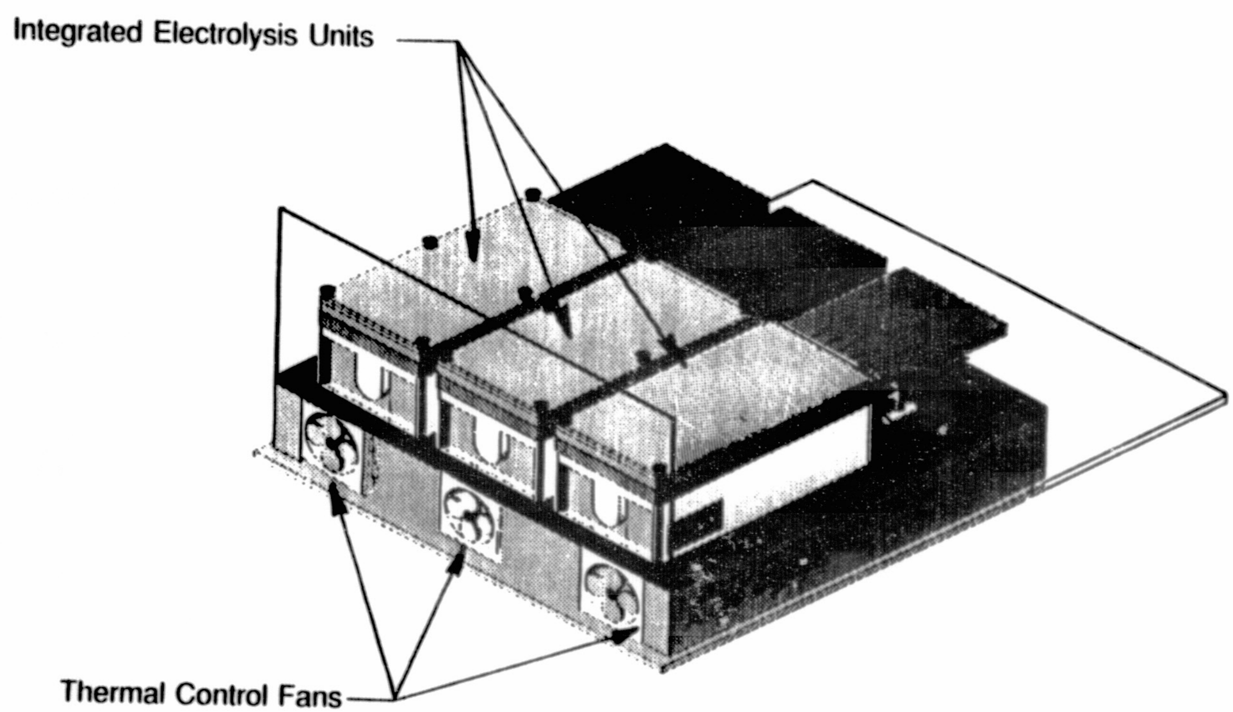
INTEGRATED ELECTROLYSIS UNIT (IEU)
CELL CONFIGURATIONS

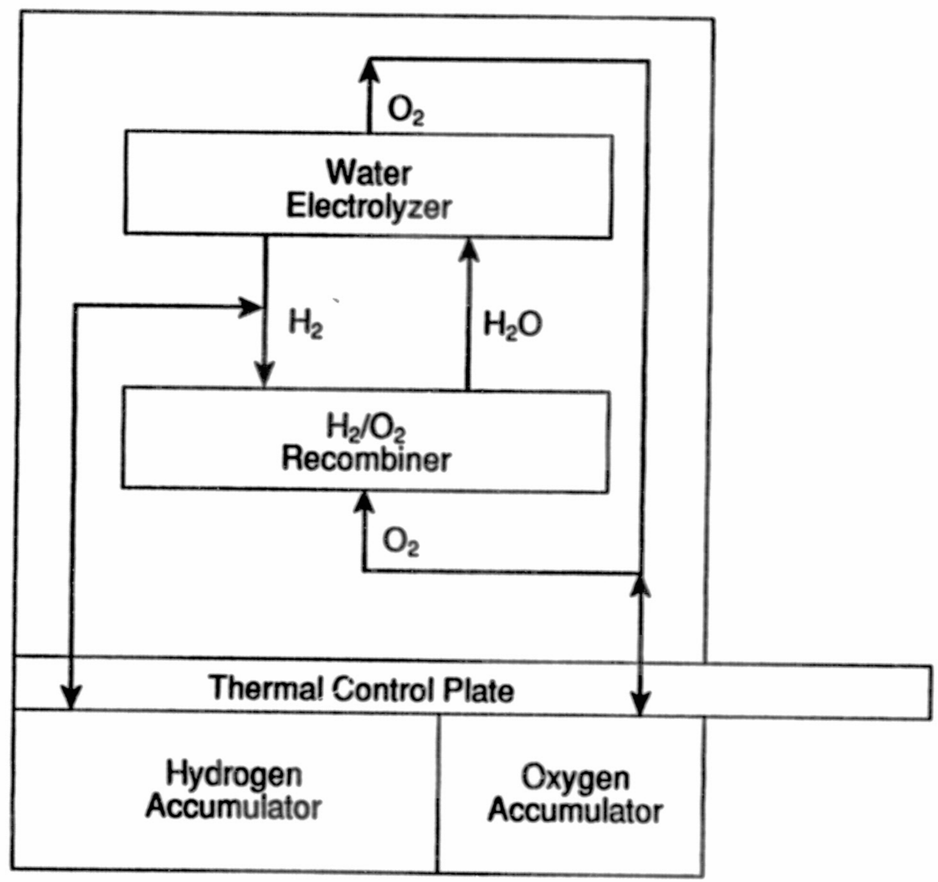
Parameter	IEU No. 1	IEU No. 2	IEU No. 3
Matrix Thickness[a]	Baseline	0.010 inch	Baseline
Electrode Thickness[b]	Baseline	Baseline	Baseline
Pore Size[c]	Baseline	Baseline	15 to 20 micron[e]
Porosity[d]	Baseline	Baseline	85-90[e]

(a) Baseline matrix thickness is 0.015 inch
(b) Baseline electrode thickness is 0.030 ±0.002 inch
(c) Baseline pore size is 10 to 12 micron
(d) Baseline porosity is 80 to 85%
(e) Actual pore size to be determined by manufacturer's capability

EPICS MECHANICAL/ELECTROCHEMICAL ASSEMBLY



FUNCTIONAL SCHEMATIC OF IEU



EPICS EXPERIMENT APPROACH

- Safety is Key
  - Use fuel cell based recombiner to consume H_2 and O_2 immediately after generation
- Enhance Experiment Success
  - Design EPICS with Three Independent Integrated Electrolysis Units (IEU) For Redundancy
  - Build and test engineering model before finalizing flight unit
- Increase Technology Base in Key Microgravity Impacted Areas
  - Include multiple combinations of electrode/separator (matrix) configurations

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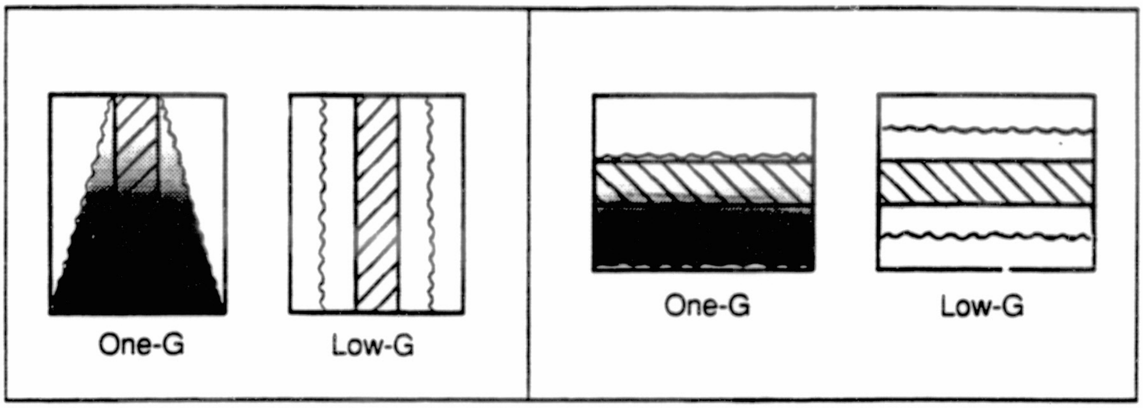
EPICS EXPERIMENT DESCRIPTION

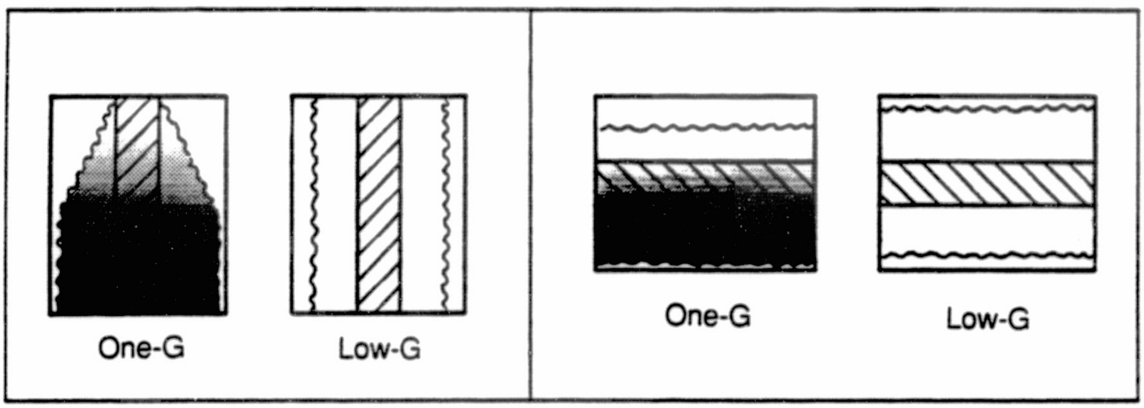
- Approach
- Hardware
- Test Sequence
- Schedule

MAGNIFICATION OF GRAVITY EFFECTS ON ELECTROLYTE DENSITY DISTRIBUTION

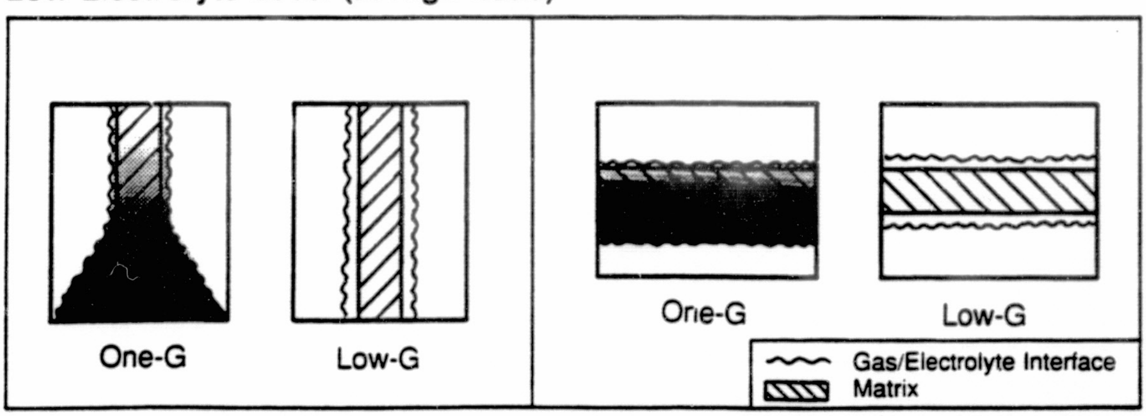
Nominal Electrolyte Level (at Nominal Load)



Increased Electrolyte Level (at Low Load)



Low Electrolyte Level (at High Load)



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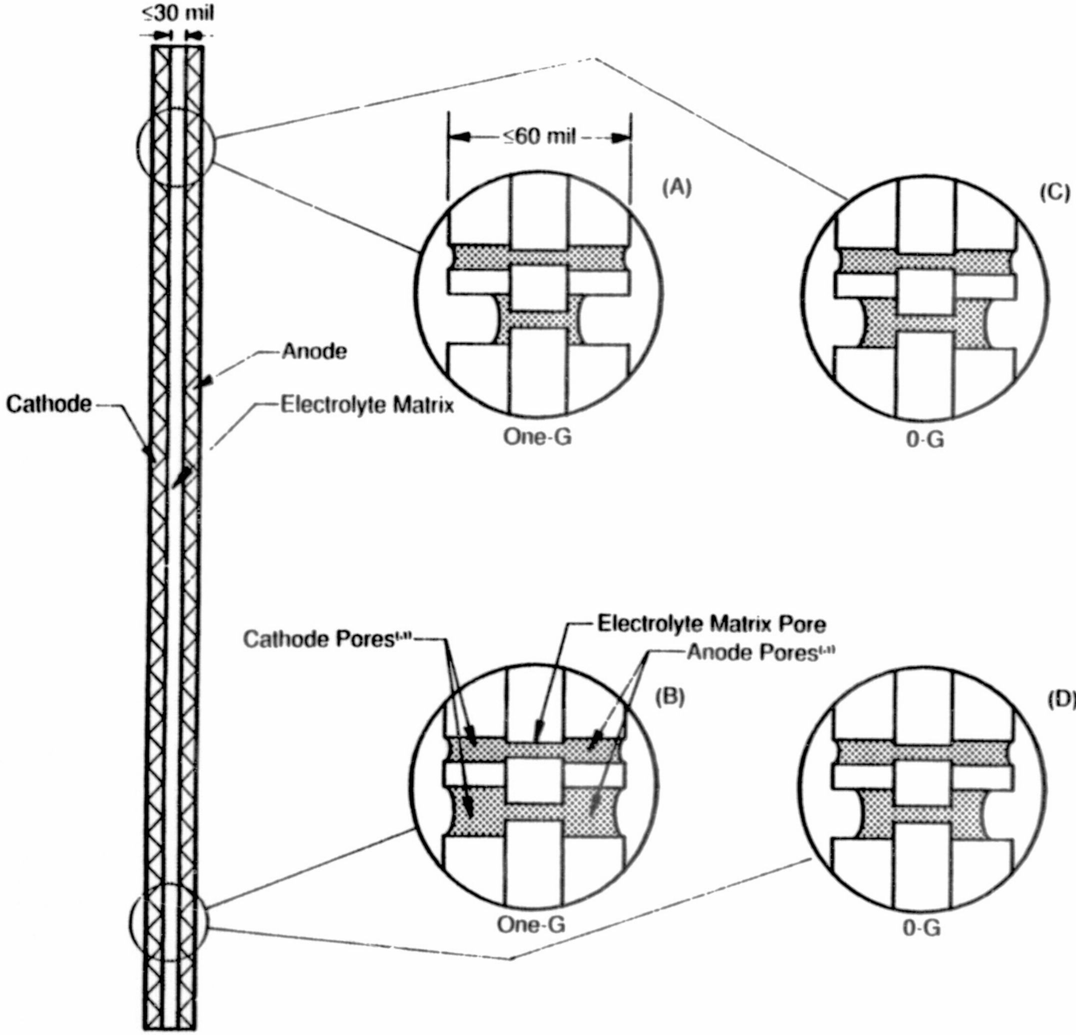
MAGNIFICATION OF GRAVITY EFFECTS ON GAS-LIQUID INTERFACE



NOTE:

1. Capillary effects in one-G are not strong enough to completely counteract gravity effects.
2. The smaller pores will have stronger capillary force, which may be able to completely counteract gravity.
3. There is a gravity force gradient, from top to bottom in one-G. Resulting in a liquid distribution gradient.
4. In 0-G the gravity gradient is eliminated and therefore the liquid will be distributed evenly.
5. The gravity force gradient will also result in a density difference.

(a) All pores will not be the same size.

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EPICS EXPERIMENT OBJECTIVES

- Demonstrate and validate the Static Feed Electrolyzer (SFE) concept in microgravity
- Investigate ways a microgravity environment may improve SFE process efficiency since "absence" of gravity will result in:
  - A more uniform electrolyte volume distribution governed primarily by capillary forces and surface tension
  - A more uniform electrolyte density distribution

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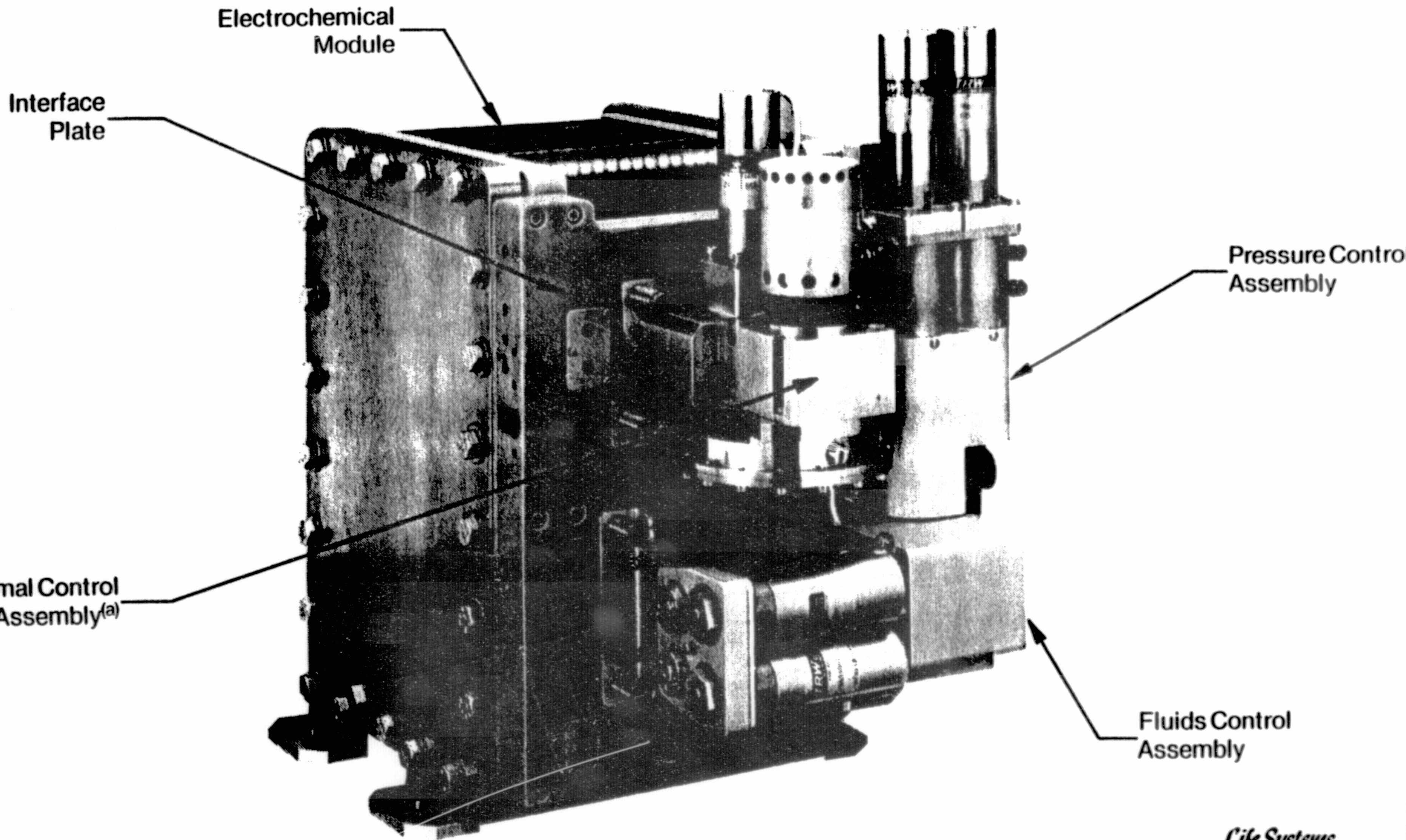
The Electrolysis Performance Improvement Concepts Study (EPICS) Has Two Objectives

SFE-1 ILLUSTRATION OF SFE SUBSYSTEM



(a) Not required for SFE-IV

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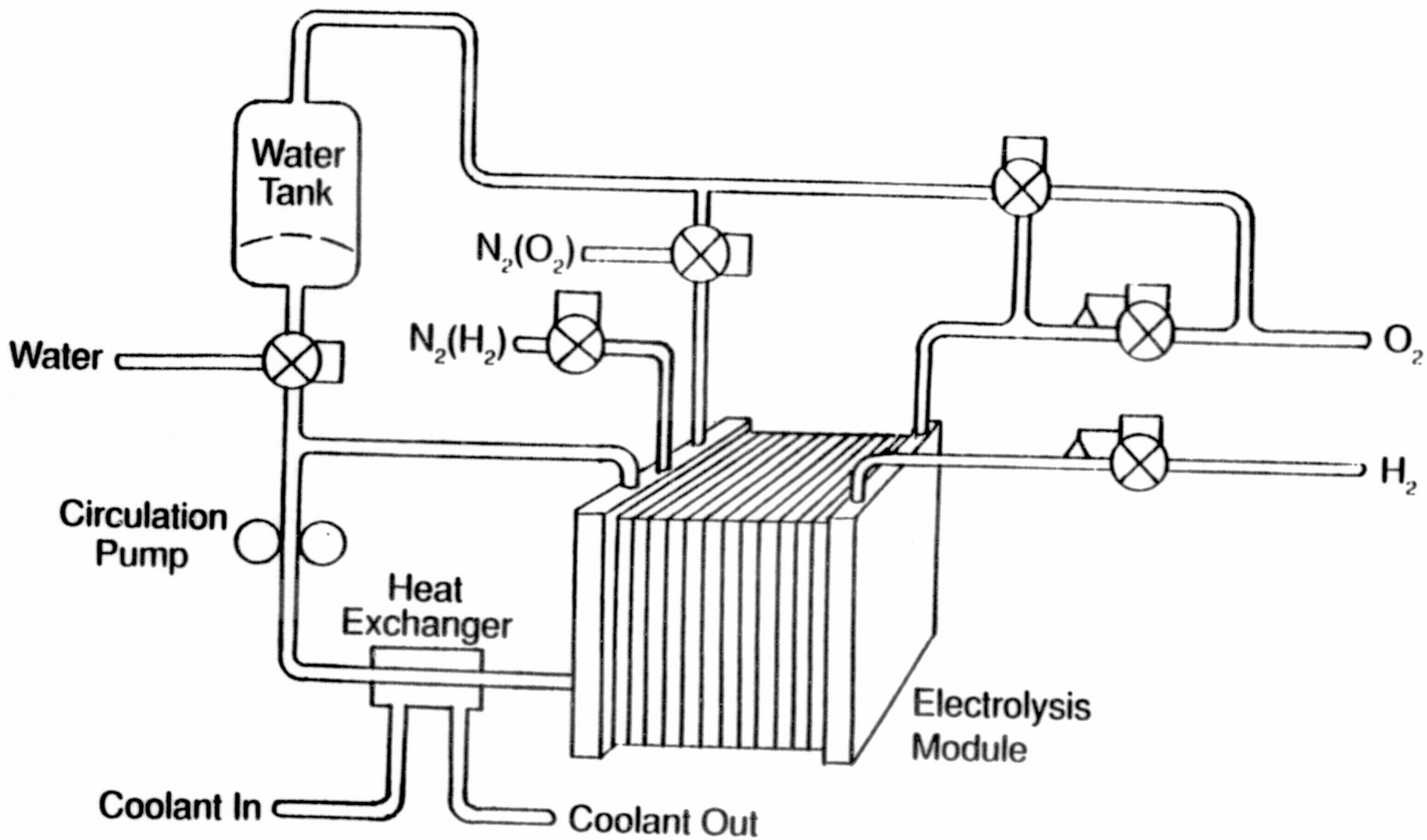
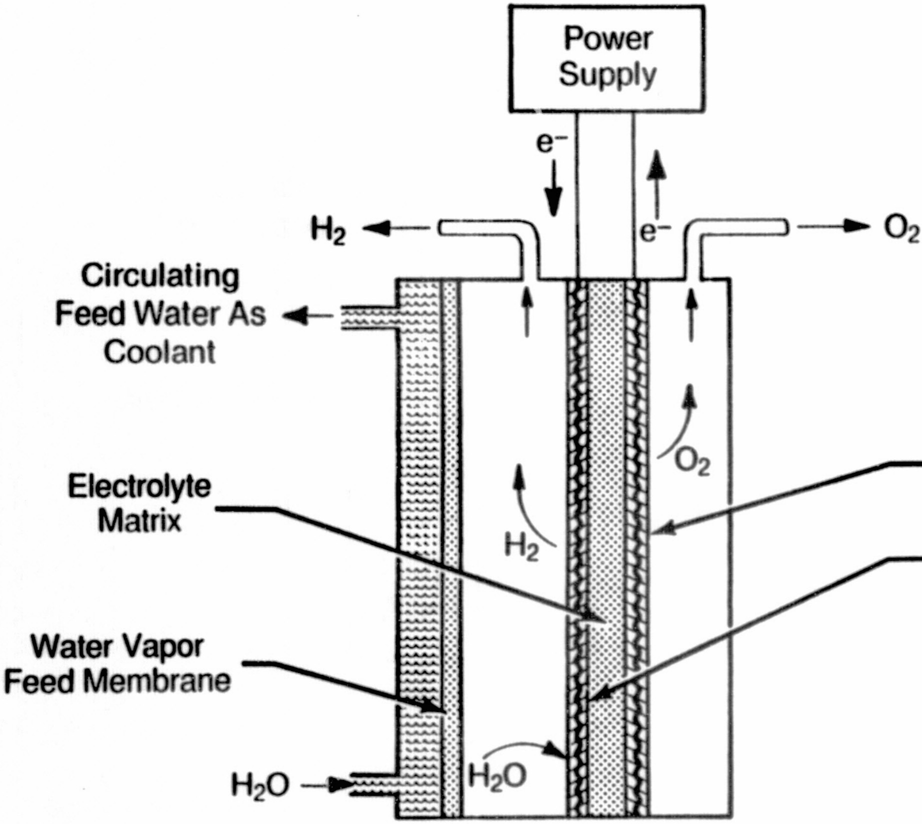
TYPICAL SFE PROCESS SCHEMATIC



ELECTROLYZER CELL SCHEMATIC AND REACTIONS



Reactions

Anode (+): $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

Cathode (-): $4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$

Overall: $2H_2O + \text{Power} \rightarrow 2H_2 + O_2$

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The Static Feed Electrolysis (SFE) Concept Was Developed For Space Application

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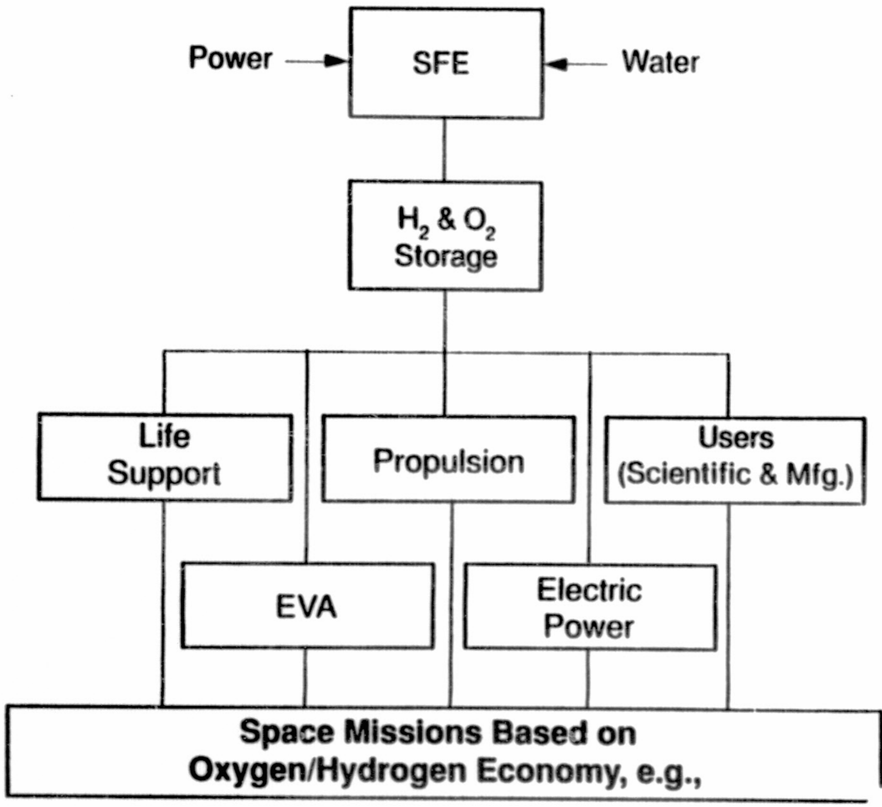
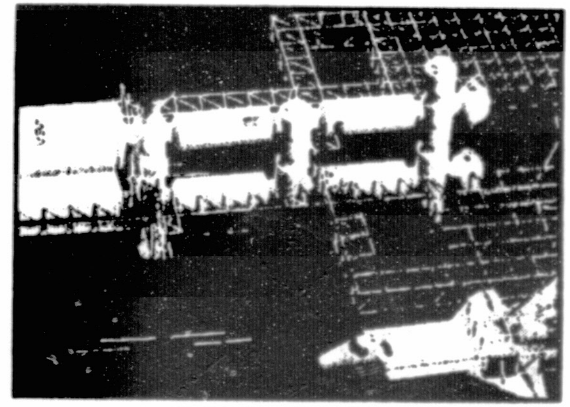
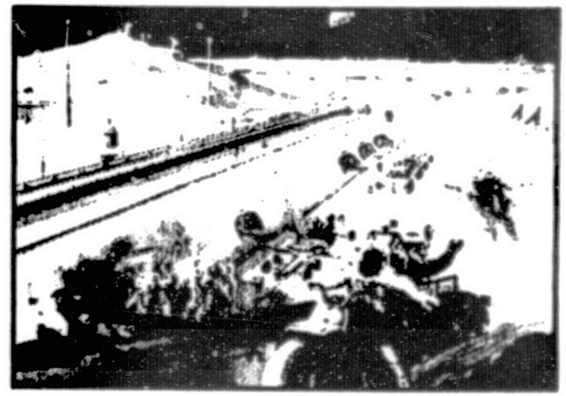
SFE APPLICATIONS MEET NASA MISSION NEEDS/GOALS



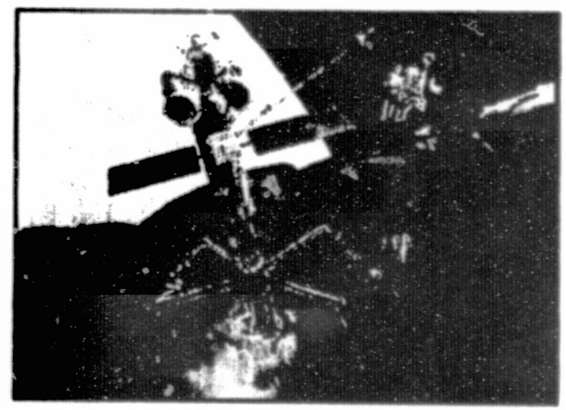
Space Station Freedom
- Propulsion
- Life Support
- EVA



Lunar Base
- Propellant Production
- Life Support
- Energy Storage
- EVA



Phobos Propellant Plant
- Propellant Production
- Life Support
- Energy Storage
- EVA



Water Electrolysis Will Play An Ever Increasing Role In Space Missions

PRESENTATION OVERVIEW

- Water Electrolysis: An ever increasing need/role for space missions
- Static Feed Electrolysis (SFE) Technology: A concept developed for space applications
- Experiment Objectives: Why test in microgravity environment
- Experiment Description: Approach, hardware description, test sequence and schedule
- Summary: Successfully completed Phase B, ready for Phase C/D