MEMBRANES
SPACE MANUFACTURING
REDUCED GRAVITY
PERMEABILITY
POLYMERIC FILMS
PHASE TRANSFORMATION

REVERSE OSMOSIS
FILTRATION
ELECTRODIALYSIS
COMPOSITE MATERIALS
MORPHOLOGY
DENSITY (MASS/VOLUME)
CASTING

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THE CASTING OF SEMI - PERMEABLE MEMBRANES IN A MICRO GRAVITY ENVIRONMENT

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I. Introduction

The National Electric Company of Venezuela, C.A.D.A.F.E., is sponsoring the development of this experiment which represents Venezuela's first scientific experiment in space. The experience can be classified as an educational one which could add knowledge to the fundamental study of polymeric membranes.

Presently, semi-permeable membranes are being manufactured from several different kind of polymers all over the world and specific applications have been identified in fluid separation processes such as reverse osmosis, ultrafiltration and electrodyalisis.

Although, the ultrastructure of asymetric and composite membranes have been under intensive study, still there are many questions about the factors affecting this structure and their degree of correlation. Nevertheless, there is indication that the entire morphological structure of polymeric membranes could be affected by the differences in specific gravity between the cast solution and the coagulation liquid, normally used in the membranes preparation process.

The casting of semi-permeable membranes in space might help to identify the effect of gravity upon the structure of these membranes.

It is important to recognize that the casting process involves changes of states (liquid-gas, liquid-solid) and that in a micro gravity environment, there will be a reduction on buoyancy-driven natural convection and density gradients

II. Experiment Description

A schematic of the experiment concept is presented in Figure 1 , along with the desired sequence. The experiment will be conducted in one-half of a longitudinal cylinder (5 cubic feet) as shown by the sketch of figures 2 and 3. An engineering layout of the experiment mechanism is presented in Figure 4. The experiment will contain several solenoid valves, a motor, several actuators, a roller mechanism, and a reservoir for both water and the polymer solution to be cast. The payload has an active heating subsystem. The plan to maintain the temperature requirements of 0 to 10/30 degrees celsius is simply to allow the ambient thermal conditions in the Orbiter bay to drive the temperature down near 0 oC passively. If the temperature of the payload drops below 0 oC, a thermostat will activate strip heaters to elevate the temperature until 10 oC or 30 oC is reached at which time another thermostat will de-activate the heater.

The sequence after experiment activation is simply to activate a valve to open the polymer solution dispenser and simultaneously force the solution on to the roller device. The roller device is then linearly translated to coat the flat plate glass with a 10 mil thickness of the polymer. Sixty seconds after the linear traversal of the polymer dispenser has been completed, the timer will activate a valve which will flush the polymer with cold water (0-10oC). The experiment is complete at this time and will be de-integrated in the above condition. The membrane casting experiment has an absolute limit of 30 oC. Temperatures higher than this level will invalidate the experiment.

III. Integration and Tests

The membrane casting apparatus will be flown in the large 5 cubic feet cannister that corresponds to the GAS Payload No. 559, reserved by the National Electric Company of Venezuela, C.A.D.A.F.E. A secondary experiment of the Bio-processing Research Center of the Philadelphia University Center will also be integrated in the same cannister. This protein crystal growth experiment will share with the membrane casting experiment the large ITA standarized Experiment Module (ISEM) which has been modified to provide maximum linear flat plate distance to maximize the membrane yield as shown in Figure 5. Figure 5 also shows a small volume allocated to payload 3. This space will contain (if possible) photographic equipment to provide optical data on the membranes and protein experiments.

The modified ISEM will be fabricated of standard aircraft aluminun of the grade and quality shown in Figure 6, and will be analyzed and tested to the launch shuttle environment as is the standard ISEM. The modified design will have a structural margin greater than 1.5 which will be verified by test.

The avionics package to support both experiments, will consist of a power supply, recorder, programmer sequencer, heaters and thermostats, and instrumentation (pressure, temperature and accelerometers).

The whole system with the experiments, structure and avionics will be subject to acceleration, vibration and thermal-vacuum tests and results will be reported at a latter time.The acceleration and vibration tests will be as specified in the July 1984 issue of the NASA GAS Handbook (page 57).

IV. Special Design Considerations

Special design considerations were taken in order to ensure the construction of an apparatus which could handle, in a successful way the fluids involved in this experiment.

One of the major design concerns was the elimination or reduction of Air Bubbles in the surface of the membrane, at the time when the casted membrane is submerged in water. The solution to minimize bubble formation was to provide space for the water to filter through two screen areas as shown in Figure 3.

Another important concern was that the fluids have to be kept in a range of temperatures between 0 oC and 30 oC. According to data available of the more likely internal temperatures to be experienced by the GAS containers, temperatures below 0 oC should be expected during the space mision. Therefore, heaters were needed to ensure temperatures above this limit at all times. The probability of high temperatures (above 30 oC) are only expected some time after the landing of the Space Shuttle. However, the payload will have been cold prior to entry (0 oC to 10 oC) and the thermo-time lag in conjuction with the air conditioning equipment provided by NASA should eliminate this risk of high temperatures.

V. Important Observations

The GAS program of NASA presents certain requirements and limitations, some of which were important to recognize previous to the development of this experiment:

1. A minimum of 13 months is usually necessary for the completion of all the documentation, safety procedures and integration of the experiment.
2. It was necessary to ensure that the fluids involved in this experiment could stand the minimum of two months specified by NASA at the launching site, without losing chemical consistency and without allowing organic growing.
3. The internal temperature profiles that the container will probably experience were carefuly studied in order to ensure that the experiment could be successfuly performed.

Consultations

The following organizations-persons provided guidance, recommendation and encouragement:.

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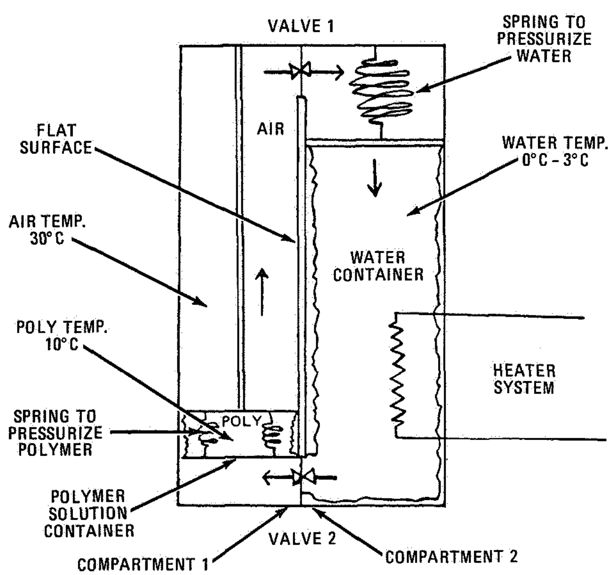

SEQUENCE

1) Motor will move polymer container across flat surface. At the same time pressurized system will force polymer solution out of container, casting membrane on flat surface.

2) After one minute Valve 1 and Valve 2 will open and water will be forced to go through Valve 2 to Compartment 1, while air will be forced to go through Valve 1 to Compartment 2.

3) Once water has been transferred to Compartment 1 and air to Compartment 2 Valve 1 and Valve 2 will close.

Figure 1. EXPERIMENT CONCEPT

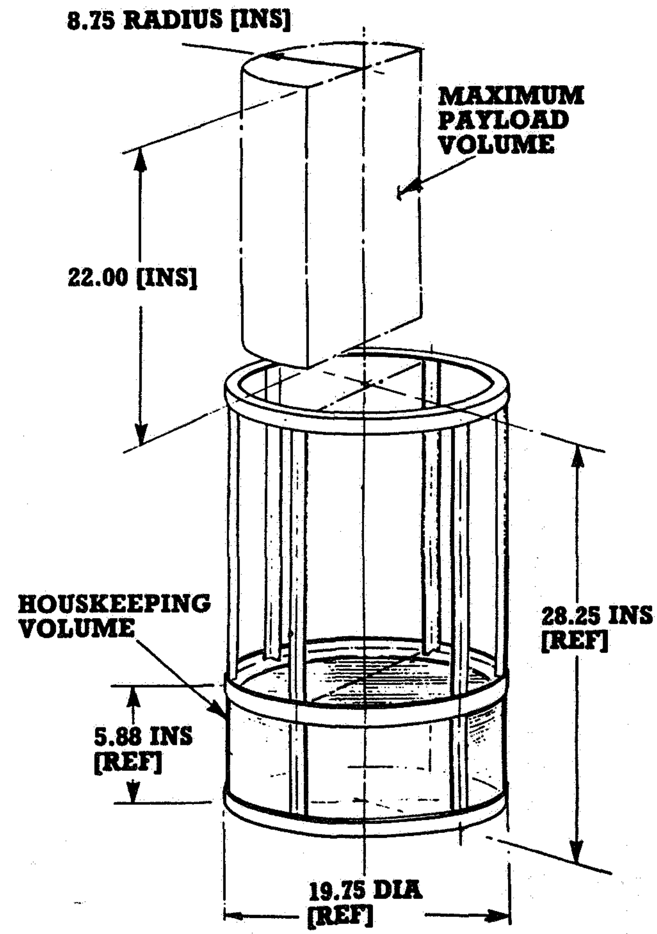

Figure 2. LONGITUDINAL CYLINDER

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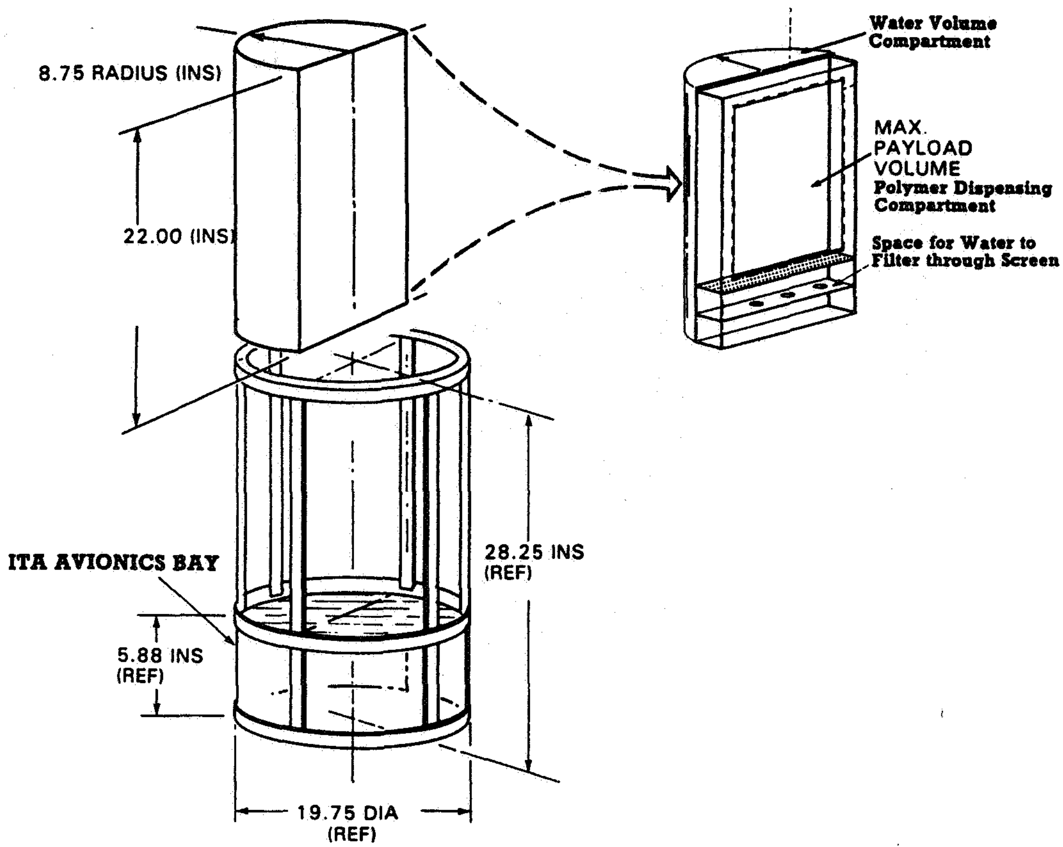

Figure 3. IVAN VERA PAYLOAD CONCEPT IN THE MODIFIED ITA EXPERIMENT MODULE

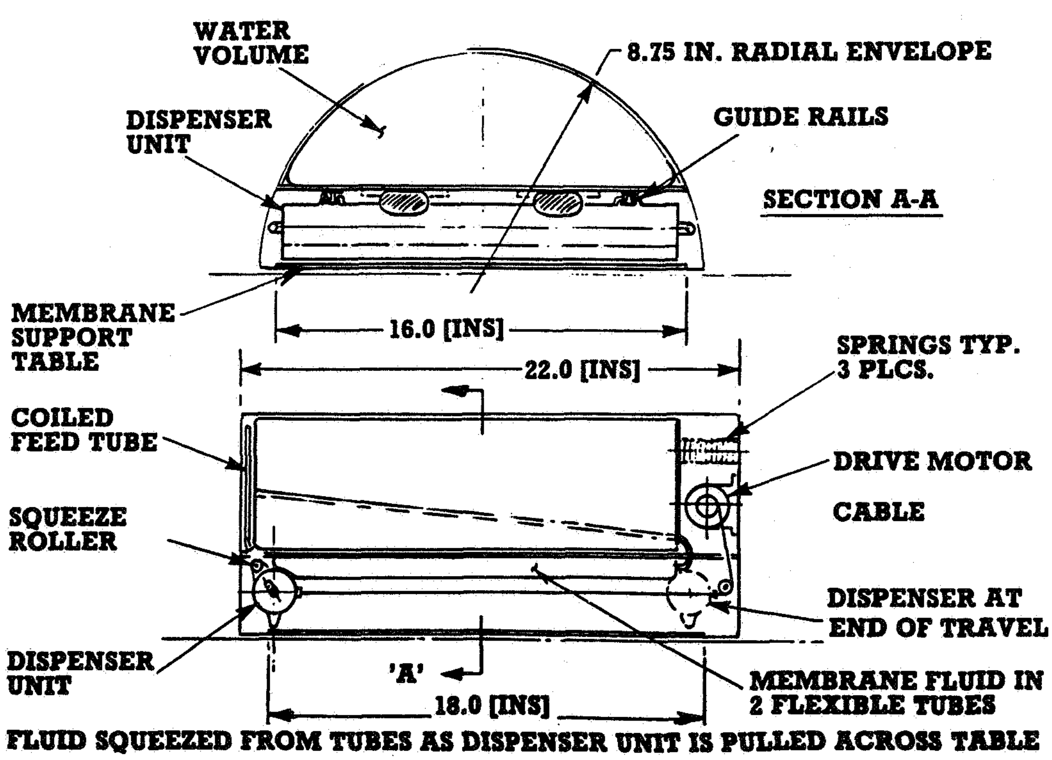

Figure 4. EXPERIMENT MECHANISM

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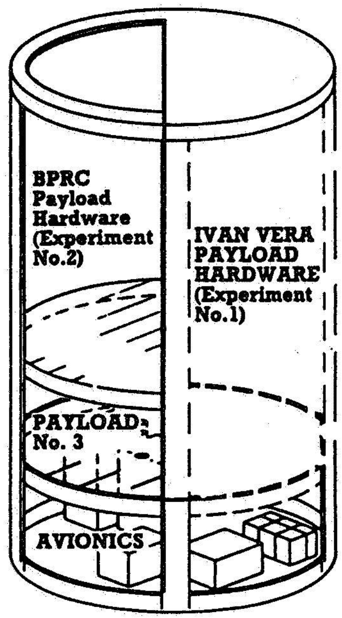
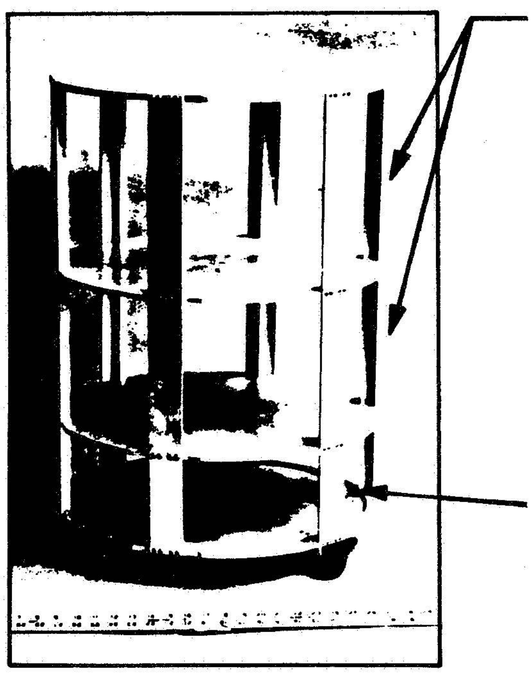


Figure 5. PRIME PAYLOAD NO. 1
IVAN VERA EXPERIMENT



Experiment bays tailored to client requirements

- Shuttle compatible for GAS program
- STRUCTURE - 6061 T6 A1 anodized
- Weight - 28 lbs. (for 5FT^3 model)
- Adjustable lateral support snubber design
- Fasteners - Aerospace CRES stainless steel
- Adjustable experiment deck height
- User Experiment Bays accommodate
  - Payload weight ~ 140 lbs.
  - Payload volume ~ 3.5FT^3

ITA Bay with Base-Line Avionics

- Power Supply
- Recorder
- Instrumentation
- Programmer/Sequencer

Figure 6. ITA STANDARDIZED EXPERIMENT
MODULE STRUCTURE CHARACTERISTICS