EPL 74-1

ENVIRONMENTAL PHYSIOLOGY LABORATORY

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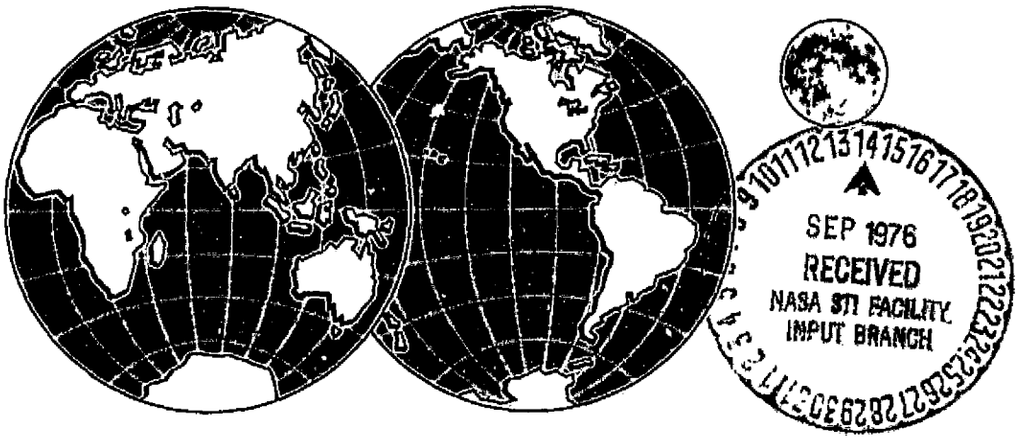

UNIVERSITY OF CALIFORNIA - BERKELEY

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RESULTS FROM THE EPL MONKEY-POD EXPERIMENT CONDUCTED AS PART OF THE 1974 NASA/AMES SHUTTLE CVT-II

Work performed under NASA Grant NGL 05-003-024

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TABLE OF CONTENTS

1. Introduction and Purpose of Report

This report documents the participation of the Environmental Physiology Laboratory (EPL) of the White Mountain Research Station, University of California, Berkeley, in the NASA/Ames Shuttle Spacelab Concept Verification Test II (CVT II) during the period 15-26 April 1974. Under NASA Grant NGL 05-003-024 to the University of California, Berkeley, Professor Nello Pace, Principal Investigator, and Dr. Bernard D. Newsom, NASA/Ames Scientific Monitor, a fiberglass pod system has been developed to house a 10-12 kg macaque monkey continuously in comfortable restraint for periods of 10 days or more under the weightless conditions of space flight. The monkey-pod system includes provisions for supplying food and water to the animal, for ventilating the upper and lower halves of the animal separately, for quantitative excreta collection, and for application of lower-body negative pressure (LBNP) to the animal as desired.

The monkey-pod system is adaptible for use in a variety of physiological experiments in which a sub-human primate can serve as the subject. The comfortable restraint feature permits the use of surgically prepared or instrumented animals, measurement of metabolic and energy balance, blood or excreta sampling, and the like. A decision was reached by NASA/Ames in the fall of 1973 to incorporate a prototype restrained-monkey experiment in CVT II, using the EPL monkey pod in a mockup of the Shuttle Spacelab.

The EPL Monkey-Pod Experiment was designed to incorporate a 10-12 kg pig-tailed monkey, *Macaca nemestrina*, into the pod and measure the respiratory gas exchange of the animal continuously during the 5-day run of CVT II, to be made in the spring of 1974. Arrangements were made by NASA/Ames to transfer a Perkin-Elmer SKYLAB physiological gas mass spectrometer from the NASA

Johnson Space Center so that measurement could be made of P_{O_2}, P_{CO_2}, P_{H_2O}, and P_{N_2} in the atmosphere entering and leaving the upper half of the monkey pod. The food and water intake of the animal was to be measured, and its heart rate monitored continuously by means of ECG electrodes applied to the torso under the restraint jacket. Once a day during the run, 15 torr LBNP was to be applied to the animal for 15 minutes, and the heart-rate response measured.

Four major elements were identified as comprising the EPL Monkey-Pod Experiment system, shown in Fig. 1. One was the fiberglass pod containing the monkey instrumented with skin ECG electrodes, a mechanical feeder to be operated to deliver a food pellet on demand by the monkey, and a suction-operated watering device again operated on demand by the animal.

The second element was an Inner Console to be placed in juxtaposition to the fiberglass pod and which housed the SKYLAB mass spectrometer, valving and electronic controls for the mass spectrometer, LBNP procedure, feeder and waterer, and a bottle of calibrating gas for the mass spectrometer. The Inner Console also housed a mass flowmeter and temperature sensor to monitor the exhaust gas from the monkey pod at the point where the gas was sampled for the mass spectrometer.

The third element was an umbilical complex passing through the wall of the Spacelab mockup, and comprising gas flow lines and electrical cabling between the Inner Console and an Outer Console located adjacent the Spacelab mockup. The Outer Console was the fourth element of the system, and in principle represented the experiment support to be provided from general spacecraft sources. These included 28-volt DC power and vacuum. Strip-chart recorders adjacent to the Outer Console were to be provided by NASA/Ames to read out the various channels of experiment data. Several

additional bottles of mass spectrometer calibrating gas were also located adjacent to the Outer Console to support the operation of the instrument. In an actual flight experiment, these bottles would be incorporated into the Inner Console.

The design of the EPL Monkey-Pod Experiment for CVT II agreed upon was that EPL personnel would monitor the physiological status of the animal and progress of the experiment continuously at the Outer Console station, whereas a NASA/Ames Payload Specialist would execute the daily activity schedule at the Inner Console station.

2. Applicable Documents

Semi-Annual Status Reports #18-#24
1 August 1970 to 31 January 1974
NGL 05-003-024

The Automated Primate Research Laboratory (APRL)
Final Report for Contract NSR 05-003-233 between NASA and the Regents of the University of California, EPL 72-1, 1 July 1972.

A Monkey Metabolism Pod for Space-Flight Weightlessness Studies.
N. Pace, D. F. Rahlmann, A. M. Kodama, R. C. Mains and B. W. Grunbaum. L.5.7 COSPAR 1973

EPL Documentation File for NASA/Ames CVT II Trials, 1974

EPL - NASA/Ames CVT II Test Log, 1974

Strip Chart Records derived from EPL Monkey Pod Experiment at NASA/Ames 15-18 April and 22-26 April 1974

3. Background

A copy of "Memorandum for Participants, Bioresearch Lab Breadboard for CVT II" (NASA-Ames LT: 239-18) dated 6 March 1974 and received shortly thereafter by Professor Pace, initiated the direct involvement of this laboratory with the scheduled activities at NASA/Ames. Dr. D. F. Rahlmann of EPL was assigned responsibility as EPL Monkey-Pod Experiment Coordinator, and was assisted during CVT II by Dr. A. M. Kodama, Mr. R. C. Mains and Mr. F. M. Vilao of EPL.

3.1 Meetings

One or more representatives of EPL/WMRS/UCB were present at NASA/Ames for the following meetings prior to, during and after the test runs.

Date	EPL Representatives	Remarks
12 Mar 1974	AMK, RCM, DFR, FMV	Introductory Form A submitted. Lab Mockup inspection.
20 Mar 1974	RCM, DFR	EPL experiment outline requirements and other NASA requested information submitted.
28 Mar 1974	NP, DFR	T.D.E.R. form submitted. Location for EPL exp. modules finalized.
3 Apr 1974	DFR	Forms C and D submitted. Finalization of shipping equipment to Ames from EPL. Inspection of lab facility modification.
12 Apr 1974	DFR	Final review of status and briefing for NASA/Ames CVT II test experimenters.
19 Apr 1974	DFR	Debriefing meeting. Submitted Evaluation Form of 15-18 Apr activities. Group picture.
26 Apr 1974	DFR	Debriefing meeting. Submitted Evaluation Form of 22-26 Apr activities.
29 Apr 1974	DFR	ESRO plans for Space Shuttle payloads.

3.2 Movement of EPL Major Equipment and Test Monkeys

Maps, as directional aids to EPL on the Berkeley Campus, were mailed to NASA/Ames on 29 Mar 1974. A complete monkey-pod experiment equipment list was submitted on 3 April 1974 and shipments were made to the test site as follows:

Date	Items	Carrier Type
4 Apr 1974	4 H size calibrated gas cylinders 1 Package vacuum pump oil	NASA/Ames truck on weekly scheduled run to UCB and return.
8 Apr 1974	Monkey Pod with feeder and waterer attached, couch and accessories within.	Contract, North American Van Lines

Date	Items	Carrier Type
	Inner Console	
	Outer Console	
	Coffin, metal (interfacing equip. inner to outer console, etc.)	
	Package containing vacuum pump	
	Package containing cryopump assembly	
	Package containing regulator controls for gas cylinders	
11 Apr 1974	2 male pig-tailed monkeys, individually caged in NASA/Ames supplied transport cages.	NASA/Ames van, on assignment to veterinarian.
	1 sack of 15% Protein Purina Monkey Chow	
	Ancillary monkey care container	
	Tool box	

Return of the above equipment to EPL by the same carriers was accomplished on the following dates: Major equipment and experimental monkeys, 29 April 1974, and gas cylinders with vacuum pump oil on 30 April 1974.

No damage to, or loss of, equipment was encountered as a result of these shipments.

On Tuesday, 9 April 1974, all EPL equipment less the experimental monkey was in place at the NASA/Ames Shuttle Spacelab mockup in Bldg. 239-A. By the end of that week several bioinstrumentation check-out trials had been conducted, and the fiberglass pod module was moved to Room 3-C, Bldg. 236, in preparation for the monkey insertion 15 April 1974.

3.3 Problem Areas

Requests for Ames supplied equipment was made by EPL at the scheduled dates. Generally these requests were fulfilled, although a full complement of compatible recording channels was not supplied. As a result, EPL

furnished a recording instrument for food and water activity data output, in addition to a reliable digital voltmeter.

There was a slippage of indicated shipping hours for equipment by the contract carrier from EPL to NASA/Ames.

Problems encountered relative to the actual test runs will be discussed in the following paragraphs.

4.0 Test Activity

A daily activity schedule was developed by EPL under date of 4 March 1974 and submitted to NASA/Ames. In addition a detailed step-by-step procedural protocol was prepared under date of 22 March 1974 on a NASA/Ames form entitled "Timing, Description and Equipment Requirements for each operation".

The procedural protocol from preparation to recovery, including the daily activity schedule, is shown as Appendix A. Appendix B contains the schedule involved for the twice daily (0800 and 1600 hr) calibration periods required for the respiratory gas exchange measurements. Operations for lower body negative pressure conducted once each day of the test runs are shown in Appendix C.

4.1 Schedule of EPL Monkey-Pod Experiment, 15-18 April 1974 (Trial A)

The candidate monkey selected for this trial was identified as #341, Philostrate. Insertion of the monkey into the pod was carried out in Room 3-C, Bldg. 236, at NASA/Ames starting at 0800 PST on 15 April 1974. The pod with monkey was transported to the test site in Bldg. 239-A, and interfaced with the balance of the experiment instrumentation. By 0940 hours PST continuous data flow was being recorded and continued until 1300 hours PST on 18 April 1974.

The daily activity schedule within the Spacelab mockup, and external monitoring at the Outer Console, during this test were performed by EPL personnel. Photographic sequences were taken during test activity within the

Spacelab mockup. A test log book was kept on site at all times. A test conductor was not present during the nighttime hours.

4.2 Schedule of EPL Monkey-Pod Experiment, 22-26 April 1974 (Trial B)

The candidate monkey for this trial was identified as #337, Simple. Insertion, transportation to test site, and interfacing were accomplished as in paragraph 4.1. Photographic documentation was made of the insertion and removal sequences on 22 and 26 April 1974.

Dr. S. Tom Taketa of NASA/Ames acted as the Shuttle Payload Specialist for the Experiment during this test, and under supervision of the EPL personnel carried out the daily activity schedule within the Spacelab mockup. EPL personnel monitored the test continuously during the day at the Outer Console. A test log book was kept on site at all times. A test conductor was not present during nighttime hours.

5.0 Test Results

An attempt was made to perform all procedures as outlined under the proposed schedule during both trials A and B. Despite some interruptions on the test site with mechanical and electrical additions being made and of the presence of photographers within the laboratory, all designated milestones to pod access were met.

5.1 Monkey Insertion Procedures

At 0800 hrs PST on 15 April 1974, monkey #341, Philostrate was injected intramuscularly with 70 mg of Ketaset(R) plus added atropine sulfate solution. Following the induction of tranquilization, a body weight of 11.61 kg was determined for the subject. The preparation of the test animal was carried out by two EPL personnel with assistance from Dr. R. Simmonds of NASA/Ames.

All insertion procedures were carried out according to schedule. However, the Eaton-Dikeman blotting paper inserted into the lower pod had

extended over the front lower port opening. An attempt was made to correct this problem without removing the couched monkey. The adequacy of correction remained in doubt and a decision was made to disconnect the couched monkey module and make the appropriate folds in the paper, thus clearing the lower pod intake and outlet gas ports. This ameliorative action was accomplished with the detachment of compression and retainer rings, followed by removal of the couched monkey and other associated instrumentation. After the paper was properly positioned, the balance of the insertion procedures was carried out without further delay.

The vehicle provided for initial transportation of the pod assembly with the monkey did not allow upright positioning in transit. Therefore, the individual accompanying the assembly had to maintain it in a tilted mode approximately 20° from the normal vertical. For the return trip from mockup site, and the test initiated on 22 April, the transfer vehicle was large enough to alleviate this situation; however, the assembly was tilted for clearance when loaded or unloaded.

Insertion of the test monkey #337, Simple, weighing 12.41 kg, by EPL personnel and Dr. Simmons proceeded according to schedule on 22 April 1974. The initial tranquilizing injection of the monkey commenced at 0640 hrs PST, and the pod assembly with monkey emplaced in the Shuttle Lab mockup by 0815 hrs on the same day.

In all cases, transit times from insertion area to test site and return were of short enough duration that a forced air flow provision was not necessary for maintenance of physiological integrity of the animal.

5.2 Monkey Condition and Nutrient Intake

Both test subjects completed the 3.25 and 4.08 trial days without injury from related restraining and instrumental apparatus. The only skin markings

found on the monkeys were several slight areas of erythema in the axillae.

Nutrient intake was adequate with the first trial monkey and below normal for the second trial. Extraneous noise levels and an erratic light:dark schedule within the Spacelab mockup undoubtedly contributed to this variance.

Food was continuously available to the monkeys *ad libitum*, while water was limited to an offering of 1,000 ml at 0730 hrs PST each day.

Tables 1 and 2 show the number of tablets which were counted by the light emitting diode in the feeder device and tabulated by the counter mounted on the Inner Console. A comparison of the counter with the total number of tablets consumed during each trial indicates an accuracy of 0.4% in the "dry run" and 1.8% in the "wet run". Assuming that this small deviation was randomly distributed throughout the trials, an average rate of food and water intake was also calculated.

5.2.1 Body Weight Changes

Table 3 shows the body weights of both test monkeys at the initiation and conclusion of each test period. The changes in body weight, a slight gain in the case of #341, Philostrate, are reflected in a daily food consumption which was double that of #337, Simple who exhibited a decline in weight.

The commercially available supplies of Purina Monkey Chow Tablets 5040 were not of the best quality in terms of individual consistency and conformation. As a result, a hand selection of food tablets was made prior to the test. These "selected" tablets were stored within the Spacelab mockup and used to resupply the feeder on a twice-daily basis. An accurate count of added tablets was made and recorded. The number of tablets offered, less those remaining in the feeder and any in the upper pod, was considered as a total number consumed during the trial period. Despite the need to remove the upper pod on 15 April between 1230 and 1330 hrs PST for an electronic

deficiency check of the feeder, #341, Philostrate consumed food at a maintenance level throughout the trial. However, the monkey #337, Simple was apparently disturbed by the action of an adjacent experiment, namely a time-lapse camera in operation during the night of 22 April. Possible additional factors which may have contributed to his performance have been mentioned in paragraph 5.2.

5.2.2 Metabolism in Relation to Energy Intake and Body Weight

In Table 4 the average weight of each test subject was determined as the mean of the insertion and removal weight. Further, a metabolic body size and an estimated resting metabolic rate were determined from the relationship $M = 72\ W^{0.75}$, where W = the animal weight, in kilograms, and M = the resting metabolic rate in kcal per 24 hrs. From previous determinations made at EPL, each gram of the food (5040 PMC Tablets) used for these trials contained 3.49 kcal. In the case of #341, Philostrate, his food intake provided adequate energy to supply his total metabolic requirements. #339, Simple, however, did not consume enough food to meet his resting metabolism and the resultant weight deficit relates a utilization of body energy stores.

5.2.3 Food and Water Intake Activity

A continuous data output in regard to food and water intake was obtained on an Esterline Angus recorder with a strip chart speed of 3.81 cm per hour. As in previous trials in the EPL laboratory, a rating score based on a scale of 0 to 3 was given to each hour of the CVT II tests as follows:

0 = no intake of food or water

1 = food or water intake at one interval of less than 1 minute duration

2 = food or water intake at two separate intervals, each interval not exceeding a one-minute duration.

3 = three or more individual food or water intake periods, or at least one continuous period in excess of a one-minute duration.

Table 5 contains an hourly summary of nutrient intake activity, together with 6 and 24 hour means. The major portion of the activity occurred during 0600-1800 hrs PST which encompasses the time of greatest amount of attendant human access to the laboratory interior.

Although some biological differences in regard to biorhythms would be expected to exist between both monkeys, a examination of the feeding and watering patterns indicate that the peak hours of feeding and watering were shifted in the case of #337, Simple. These data would tend to support the idea that this monkey was influenced by the environmental perturbations previously noted in paragraphs 5.2 and 5.2.1.

5.2.4 Feeding, Duration and Efficiency

An average weight of 0.79 g has been determined for each 5040 PMC tablet. Thus food intake in terms of weight is shown in Table 6 in conjunction with relationships of time spent in feeding.

The duration of feeding was determined from examination of each 10-minute interval of the strip chart recording. For example, #341, Philostrate completed a total test time of 78 hours or 468 ten-minute periods, of which 33, or 7.05% of the total, were involved with feeding. A figure of 5.5 hours for feeding time is derived by multiplying the total test time in hours (78) by .0705.

Feeding efficiency is also indicated in Table 6 in terms of grams of feed per hour of total test time and per hour of feeding activity. Both monkeys spent approximately the same number of hours in feeding time (5.5 vs 5.8) despite the overall total test difference of 20 hrs. However #341, Philostrate consumed 40% more food per hour of feeding than #337, Simple.

5.2.5 Water Consumption, Duration and Efficiency

The water intake data was treated in a similar fashion as the food data analysis explained in paragraph 5.2.4 and the results are shown in Table 7.

In this comparison #337, Simple consumed over twice as much water during each hour of actual drinking time than #341, Philostrate. The latter monkey tended to sip on the water dispenser throughout a greater portion of the day.

5.3 Cardiovascular Data

The electrical activity of the heart was monitored on a Brush Recorder. Miniature ECG electrodes (I.M.I., Division of Becton Dickinson and Company) were placed on the thorax of the test subjects during the insertion procedures. The lead wires were led out through a small aperture in the mid dorsal line of the restraint jacket and secured to a binding post on rear of nylon mesh hammock. In turn, a shielded electrical wire from the binding post was brought out through upper pod port and connected to a biotachometer with its associated universal preamplifier on a Brush recorder. For the major portion of the recording time the average heart rate mode was used and the chart speed set at 0.1 mm/sec; for the ECG mode the speed was increased to 10 mm/sec.

The complete strip chart records were removed following each test run and an average heart rate determined on an hourly basis. Changes in heart rate were also examined in relationship to the application of lower body negative pressure.

5.3.1 Heart Rate and Electrocardiographic Data Output 15-18 April 1974

A summary of average heart rates for #341, Philostrate is presented in Table 8. Data during the first few hours following installation of the pod in the Shuttle Spacelab mockup and when the hood was removed on 15 April (see paragraph 5.2.1) have been omitted from the compilation. Intermittent ECG recordings were made between the hours of 0700 and 1600 hrs PST and the resultant heart-rate count plus recorder calibration indicated that reliable average heart rates could be determined throughout the test. An ECG recording trace made just prior to the removal of the monkey on 18 April revealed a

prominent R wave with minimal base line signal noise. A diurnal rhythmicity is apparent with consideration of average hourly values. The mean 24-hr rate of 117 beats/minute was somewhat below those recorded in previous trials with this monkey. Repeated pod trials may have conditioned this test subject. During the CVT II trial heart rates in excess of 200 beats per minute were recorded when disturbances occurred within the Spacelab mockup. However, the monkey appeared to adjust within 2 to 3 minutes following the onset of this unusual environmental influence.

Respiration rates were estimated from the ECG tracings whenever feasible and ranged from 21 to 29 breaths per minute.

A report of heart changes related to LBNP is considered under paragraph 5.5.1.

5.3.2 Heart Rate and Electrocardiographic Data Output 22-26 April 1974

A summary of average heart rates of #337, Simple is presented in Table 9. In contrast to the previous week's trial, reliable average heart rates could not be determined from the signal output after 0700 hrs on 24 April. ECG recordings were made during the daylight hours. An R wave was still prominent in these recordings, and the heart rate thus obtained was used as an average for that hour of observation. Probable causes for this malfunction in signal output may have been in the electrical connection to the inner console or a decline, with time, in the conductivity of the contact paste, "EKG Sol^{R}", used in the initial application of the surface electrodes. A more predictable answer to this difficulty should be elucidated by further testing.

Although the mean 24-hr heart rate of #337, Simple, 101 beats per minute, was lower than previous tests on this individual and other monkey subjects, a diurnal rhythmicity is apparent, despite the previously mentioned ambient perturbations (paragraph 5.2).

5.4 Respiratory Gas Measurements

Respiratory gas exchange measurements were carried out on the test animals by monitoring the air outflow from the upper pod with a mass spectrometer. A flight-qualified mass spectrometer provided by NASA/JSC was incorporated into an instrumentation console and received its first extensive trials as an integral part of the EPL Monkey-Pod System during the CVT II at NASA/Ames.

5.4.1 Operational Performance - Mass Spectrometer

As will be seen below, excellent performance was obtained from the Skylab Mass Spectrometer during the tests. Unfortunately, the continuous strip chart recording of the signal outputs from the mass spectrometer was not totally satisfactory, owing to fluctuations in the inlet pressure in the sample line external to the mass spectrometer proper. The mass spectrometer used is of a Skylab configuration and is designed to operate at 5 p.s.i.a. instead of the ambient pressure of a ground laboratory. As a result, a vacuum pump and a system of valves are used to control the pressure presented to the molecular leak at the sample inlet of the mass spectrometer. Inasmuch as the mass spectrometer measures the partial pressure of the gases in the sample, the results are very sensitive to changes in the total inlet pressure. Periodic inspection of the inlet pressure monitor, and drifts in the strip chart records, indicated sufficient fluctuations during the course of the CVT II so as to discourage any attempt to compute the continuous hour-by-hour respiratory gas exchange in the subject monkey as has been routinely carried out in the laboratory.

The problem is, however, expected to be temporary and should be largely corrected before the CVT II at NASA/MSFC. Several solutions have been suggested by NASA/JSC and the most practical at this time appears to be the

use of an inlet pressure regulator in the sample line to compensate for "upstream" variations in flow and pressure. Such a regulator has been acquired by NASA/JSC and is currently being bench-tested in Houston prior to installation at EPL/UCB.

5.4.2 Data Output

The above difficulties notwithstanding, useful data was obtained during the CVT II at NASA/ARC primarily demonstrating the excellent performance of the mass spectrometer. Representative measures of respiratory gas exchange were also obtained indicating the nature of the data to be collected on a continuous basis during an actual experiment. During the scheduled twice-a-day calibration periods, direct readings of the mass spectrometer signal outputs were obtained on a digital voltmeter for samples of cabin air and pod air following adjustment of the inlet pressure to its nominal value. The measurement of ΔF_{CO_2} and ΔF_{O_2} together with the flow rate of air passing through the upper section of the monkey pod permitted the computation of typical $\dot{V}_{CO_2}$ and $\dot{V}_{O_2}$ values for the test subjects, and the results are shown in Table 10.

5.4.3 Reliability and Calibration

As verification of the reliability of the mass spectrometer measurements of the respiratory gases, the sum of partial pressures of the gases obtained above was compared with the total barometric pressure read from a mercury barometer. As can be seen in Table 11, when the inlet pressure was maintained at the nominal value, there was very good agreement between the sum of partial pressures for samples of cabin and pod air and the total barometric pressure. The mean difference of approximately 0.8% is presumably due to the presence of argon in the atmosphere. The stability of the mass spectrometer can be seen in Table 12 which shows the results of repeated measurements of the partial pressures of O_2, CO_2, and N_2 in three calibration gas mixtures.

5.5 Lower Body Negative Pressure

Lower body negative pressure (LBNP) tests were conducted on both monkeys once each day for the first four days of the CVT II dry and wet runs. All but one of the LBNP tests were conducted between 1500 and 1600 hrs PST, which was also the time of day allotted for the mass spectrometer calibration sequence. The LBNP tests were conducted by an EPL co-investigator during the dry run and by the CVT II Payload Specialist during the wet run.

The procedure followed for conducting each LBNP test is contained in the document "LBNP Operations Sequence for NASA/Ames CVT II" dated 17 April 1974. This document describes the air pressure transducer calibration sequence and the LBNP test operations sequence consisting of 15 minute control, LBNP and recovery periods.

The usual LBNP test procedure is done with the pod tilted to horizontal so that the monkey is in the seated-supine position, thus simulating the blood distribution which would exist during weightlessness. This portion of the procedure had to be abandoned due to the impracticality of tilting the pod when installed in the Spacelab mockup. The standard supine LBNP test used in our laboratory consists of 15 minutes of 40-60 torr LBNP. Because this test had to be conducted in the upright position for the CVT II, the protocol was changed to 15 minutes of 15 torr LBNP so as not to stress the monkey unduly by the effects of LBNP being added to the normal postural blood redistribution. It is anticipated that monkey-pod tilt capability can be provided for ground control LBNP testing outside the Spacelab mockup when required.

5.5.1 Performance

The requirements for low noise level and no monkey visual contact with humans during LBNP tests described in the LBNP Operations document, 17 April 1974, were not met for at least half of the LBNP tests. Useful data can be

collected during LBNP tests only by increasing the isolation of the monkey pod and/or preventing the occurrence of these environmental disturbances.

The LBNP control and pressure transducer calibration systems were located in the console outside the Spacelab mockup. These systems performed satisfactorily throughout the dry and wet runs. On day 1 of the wet run it was inadvertently discovered that because of the long air hose line and associated valves required to reach from the lower half of the monkey pod to the outer console, the lower pod air inlet resistance was too high and some air was being pumped from the upper pod to the lower pod. The effect of this occurrence was to invalidate the upper pod flow rate data. The solution to this problem was to disconnect the inlet air hose from the lower pod. This necessitated using a rubber cork to close the lower pod air inlet port on the pod during LBNP. This procedure was included as part of the LBNP operations for the duration of the wet run and worked satisfactorily.

The effect of 15 minutes of 15 torr LBNP on heart rate when applied in the upright position is shown in Table 13. These data provide an indication of the degree of variability in response between and among monkeys. The mean heart rate increased by 14 beats/min for monkey #341 and by 20 beats/min for monkey #337 during LBNP. The variability in response day to day is not dissimilar from LBNP data from novice human subjects. This variability would no doubt decrease with fewer environmental disturbances during these tests and repeated LBNP testing during pod conditioning trials.

Several modifications of the LBNP instrumentation are planned as a result of these tests. In order to facilitate the integration of the LBNP test and the mass spectrometer calibration sequence all LBNP control and calibrate functions will be moved to the Inner Console. Power and vacuum will still be supplied by the Outer Console, and lower pod air will still

exhaust at the Outer Console.

An air pressure gauge will be mounted on the Inner Console to indicate the differential pressure between the upper and lower pod both during lower-pod ventilation and negative pressure modes. It is hoped that the differential pressure in these two chambers can be kept at zero so that the movement of air from upper to lower pod when in the ventilation mode can be prevented. Eventually, a digital meter display of heart rate whose input is the cardio-tachometer output can be provided to monitor heart rate from inside the Spacelab mockup during LBNP tests.

A possible solution to the problem of the effects of environmental disturbances on monkey behavior during LBNP tests would be to provide closed circuit television monitoring of the monkey inside a sound-deadening enclosure. Additional problems related to the interaction of payload experiments have been mentioned earlier in this report.

An investigation is underway in our laboratory on the possible causes of ECG lead problem with monkey #337 described earlier in this report. It is hoped that increased reliability of this signal can be provided by modifications of the electrical connections and/or the ECG paste used in this system.

5.6 Monkey Removal

At 1315 hrs PST 18 April 1974, separation of the pod with #341, Philostrate from the metabolic analyzer was initiated. Ten food tablets were left in the plastic reservoir. The pod was transported to Room 3-C in Bldg. 236 and removal procedures commenced with upper pod hood separation. The monkey was examined and then tranquilized with Ketaset. The food tablet dispenser contained 28 tablets. One additional tablet was found in the upper pod on the right side of the jacket skirt. Thus, a total count of 39 tablets

was subtracted from the precisely known amount of food offered during the trial. With the exception of distilled water and spatula cleansing of the lower portion of the couched monkey, the instrumentation attached to the test subject was removed in reverse order from the scheduled insertion procedure. The monkey was then examined, weighed, and placed in a holding cage at 1400 hrs. As previously mentioned, #341, Philostrate maintained his weight during the trial and only slight skin reddening was evident on the neck and axilla. His behavior in the cage was judged to be normal by visual observation later in the day and on the following morning of 19 April 1974.

Removal of #337, Simple was initiated at 0840 hrs on 26 April 1974, and procedures followed in the same manner as those discussed for #341, Philostrate. Still and motion cinematography documented this action. A food tablet count of 69 in the plastic tube and 28 remaining in the dispenser was noted. This monkey completed his trial at weight of 11.70 kg, showing a net loss of 0.71 kg. No edema was present and skin discoloration in the axilla and ventral abdomen was minimal. Post-trial cage behavior was observed as being normal.

5.7 Excreta Collection

Immediately following the separation of the couched monkey from the lower pod by lifting of the plastic waste template support plate, a cleansing of the lower portion of the couch was made with a rubber spatula and distilled water dispensed from a plastic wash bottle. Additional cleansings were conducted on the lower couch and the monkey after removal of the restraint and divider instrumentation. All of the washings were contained with the absorbent paper within the lower pod. The absorbent paper was removed from the lower pod and placed in a storage container. The remaining fluid was then poured into the container through the lower front port. Two separate cleansings of the interior walls of the lower pod, are done with the resultant washed material

poured into the storage container.

The container for the excreta used in the first trial was a plastic bag. A 6-gallon wide mouth plastic jar measuring 45 cm high and 34 cm in outer diameter was used for excreta collection at the conclusion of the second trial. For the more efficient handling, storage and shipment when fluids are involved, it would appear that the plastic container is the preferable choice.

6. Summary and Conclusions

The feasibility of the EPL monkey pod system as a potential flight experimental entity on Shuttle Spacelab was demonstrated during the CVT II at NASA/Ames during the weeks of 15-19 April and 22-26 April 1974. Continuous quantitative physiological data were derived and tabulated. A single alternating current source of 110 volts/30 amps adequately supplied all the power requirements for the experimental package, including 2 strip chart recorders. Within the limits of the CVT II preparatory time, a modular concept was developed and fabricated. All aspects of the bioinstrumentation can be considered as conceivably qualifying for flight worthiness within the time schedule for the U.S. Space Shuttle program. Improvements and modification toward achieving this goal are ongoing.

The EPL monkey pod system also offers the possibility of a variety of protocols with minimal decrement to experimental integrity. For example, the action of removal and replacement of the upper pod hood during the course of these trials was accomplished with minimal impact on the total experiment. It is, therefore, conceivable, in this operational mode, for blood samples to be withdrawn from an arm vein while in flight. (Refer to EPL Semi-annual Status Report #20, p. 25,26.) Urine may possibly be separated from feces

with the use of a silicone collection tube and collected on a 24-hr basis. (Refer to EPL Semi-annual Status Report #21, p. 14.) Both of these concepts have had some preliminary testing at EPL. Further investigation of these and other conceptual modifications would be desirable.

7. Figure, Tables and Appendices

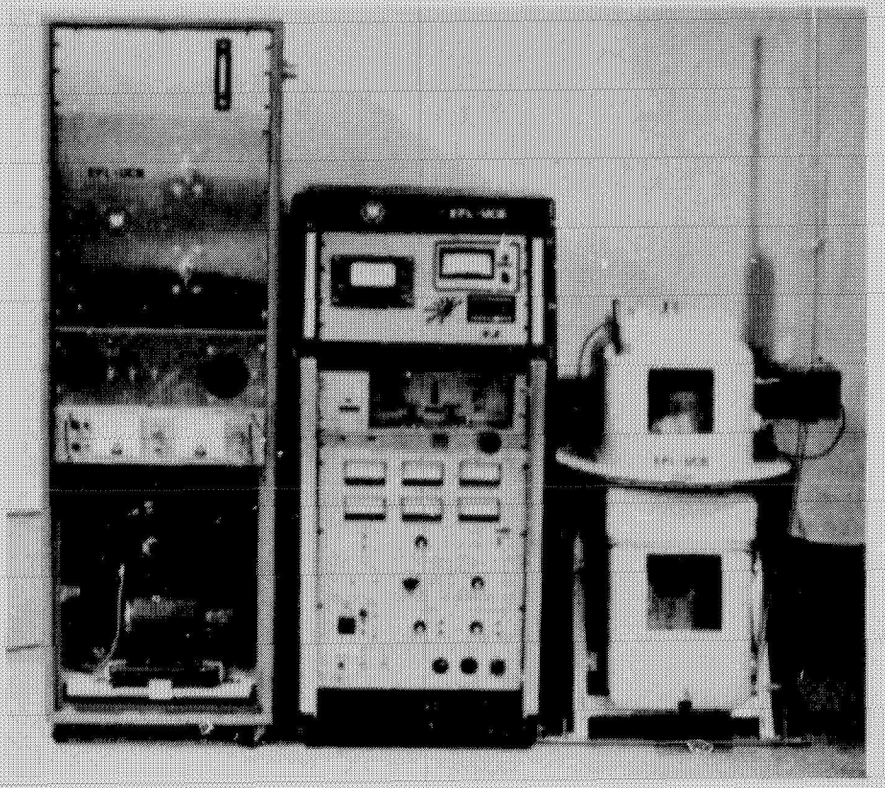


Fig. 1. The EPL monkey-pod experiment system used in the 1974 NASA/Ames Shuttle CVT II. The Outer Console housing vacuum pumps and 28 V DC power supply, is at the left. The Inner Console, housing the SKYLAB mass spectrometer, is in the center. The fiberglass monkey pod is at the right.

Table 1. Periodic nutrient intake of #341, Philoctrate as determined by the food tablet counter, number of tablets added to the feeder, and water volume measurement.

	Time Period				Duration of Period (hrs)	Food Consumed PMC 5040 Tabs			Water Consumed	
	Start		End			Total on counter	Per hr	No. added to feeder	Total (ml)	Per hr (ml)
	Hr	Day-Mo	Hr	Day-Mo						
I	0800	15 Apr	1600	15 Apr	8	72	9	166	380	47
II	1600	15 Apr	0800	16 Apr	16	147	9	53	310	20
III	0800	16 Apr	1600	16 Apr	8	110	14	100	800	100
IV	1600	16 Apr	0800	17 Apr	16	151	9	105	200	12
V	0800	17 Apr	1600	17 Apr	8	130	16	123	850	106
VI	1600	17 Apr	0800	18 Apr	16	34	2	100	150	9
VII	0800	18 Apr	1400	18 Apr	6	102	17	141	1,000	167
	Totals				78	746		788 -39* 749	3,690	

* 10 Tabs left in plastic tube
28 Tabs left in metal tube
1 Tab found in upper pod
39

Number of tablets consumed exceeded number of tablets indicated on counter by 3.

Therefore, counter accuracy of 0.4% if random.

Table 7. Periodic nutrient intake of #337, Simple as determined by the food tablet counter, number of tablets added to the feeder, and water volume measurement.

	Time Period				Duration of Period (hrs)	Food Consumed PMC 5040 Tabs			Water Consumed	
	Start		End			Total on counter	Per hr	No. added to feeder	Total (ml)	Per hr (ml)
	Hr	Day-Mo	Hr	Day-Mo						
I	0700	22 Apr	1600	22 Apr	9	89	10	160	220	24
II	1600	22 Apr	0800	23 Apr	16	131	8	75	780	49
III	0800	23 Apr	1600	23 Apr	8	51	6	180	450	56
IV	1600	23 Apr	0800	24 Apr	16	61	4	50	550	34
V	0800	24 Apr	1600	24 Apr	8	52	6	57	400	50
VI	1600	24 Apr	0800	25 Apr	16	47	3	15	600	37
VII	0800	25 Apr	1600	25 Apr	8	72	9	49	410	51
VIII	1600	25 Apr	0800	26 Apr	16	33	2	70	590	37
IX	0800	26 Apr	0900	26 Apr	1	13	13			
			Totals		98	549		667 -108* 559	4,000	

* 80 Tabs left in plastic tube
28 Tabs left in metal tube
108

Number of tablets consumed exceeded number of tablets indicated on counter by 10.

Therefore counter accuracy of 1.8%, if random.

Table 3. Body weight changes and nutrient consumption of 2 adult male pig-tailed monkeys.

Monkey No. and Name	Inclusive Dated of Test (Duration)	Body Weight at Insertion (kg)	Body Weight at Removal (kg)	Nutrients Consumed Food (No. PMC 5040 Tabs)	Nutrients Consumed Water (ml)
341, Philostrate	15-18 April 1974 (78 hr or 3.25 da)	11.61	11.65	749	3,690
337, Simple	22-26 April 1974 (98 hr or 4.08 da)	12.41	11.70	559	4,000

Table 4. Metabolism in relation to energy intake and body weight.

Monkey No. and Name	Average Wt During Trial (kg)	Metabolic Body Size Wt $^{0.75}$ (kg)	Resting Metabolic Rate (M)* (kcal/24 hr)	Kcal** Intake/ 24 hrs	Diff. kcal Intake -M/24 hr	Av. Wt. Gain or Loss (kg/24 hr)
341, Philostrate	11.63	6.30	454	637	+183	+0.012
337, Simple	12.06	6.47	466	312	-154	-0.174

* Calculated as $M = 72\ Wt^{0.75}$.

** Caloric value of 5040 PMC Tablets = 3.49 kcal/g.

Table 5. Comparison of food and water intake activity for 2 adult male pig-tailed monkeys in the EPL/UCB MK3 pod - CVT II tests at NASA/Ames.

Time Period (PST)	Food Intake Activity Rating Hourly Mean 341,Philostrate (15-18 Apr 74)	337, Simple (22-26 Apr 74)	Water Intake Activity Rating Hourly Mean 341,Philostrate (15-18 Apr 74)	337, Simple (22-26 Apr 74)
0000-0100	0.00	0.25	0.00	0.50
0100-0200	0.00	0.00	0.33	0.50
0200-0300	0.00	0.75	0.00	0.00
0300-0400	0.00	0.00	0.33	0.00
0400-0500	0.00	0.75	0.00	0.00
0500-0600	0.00	0.75	0.00	0.00
0600-0700	1.00	0.50	3.00	0.00
0700-0800	1.50	0.00	2.25	0.00
0800-0900	1.50	1.20	2.00	1.00
0900-1000	1.50	1.00	2.25	0.50
1000-1100	0.75	0.00	1.50	1.50
1100-1200	0.50	1.50	0.75	0.75
1200-1300	0.00	1.50	0.75	1.50
1300-1400	0.50	1.50	1.75	0.75
1400-1500	2.00	1.50	2.00	1.50
1500-1600	3.00	1.00	3.00	0.75
1600-1700	1.00	1.25	1.00	2.25
1700-1800	0.00	1.50	0.67	1.50
1800-1900	0.00	0.00	0.75	1.50
1900-2000	0.00	0.75	0.33	1.00
2000-2100	0.00	0.00	1.33	0.75
2100-2200	0.00	0.75	0.00	0.25
2200-2300	0.00	0.00	0.66	0.00
2300-2400	0.00	0.00	0.00	0.75
6 and 24-hr Means				
0000-0600	0.00	0.42	0.11	0.17
0600-1200	1.12	0.70	1.96	0.62
1200-1800	1.08	1.62	1.53	1.37
1800-2400	0.00	0.25	0.51	0.71
24-hr Mean	0.55	0.75	1.03	0.72

Table 6. Feeding duration and efficiency during CVT II tests at NASA/Ames.

Monkey No. and Name	Food Intake (g)*	Total Test Time (hr)	Duration of Feeding (hr)	% of Total Test Time Feeding	Feeding Efficiency	
					gms/total test time hr	gms/hr of feeding
341, Philostrate	591.7	78	5.5	7.05	7.6	107.6
337, Simple	441.6	98	5.8	5.95	4.5	76.1

* Average weight of 5040 PMC Food Tablets = 0.79 g.

Table 7. Water intake duration and efficiency during CVT II Test at NASA/ Ames.

Monkey No. and Name	Water Intake (ml)	Total Test Time (hr)	Duration of Water Intake (hr)	% of Total Test Time Consuming Water	Water Intake Efficiency	
					ml/total test time hr	ml/hr of water intake
341, Philostrate	3,690	78	12.5	16.02	47.3	295.2
337, Simple	4,000	98	6.3	6.16	40.8	645.2

Table 8. Heart rate summary of the adult male pig-tailed monkey #341, Philostrate during CVT II at NASA/Ames, 15-18 Apr 1974.

Observation Period (PST)	No. of Data Days Considered	Mean Heart Rate beat/min	S.E.
0000-0100	3	105	3
0100-0200	3	107	6
0200-0300	3	110	3
0300-0400	3	113	4
0400-0500	3	115	3
0500-0600	3	118	2
0600-0700	3	125	3
0700-0800	3	140	5
0800-0900	3	135	6
0900-1000	3	125	6
1000-1100	3	120	6
1100-1200	3	127	9
1200-1300	3	130	10
1300-1400	3	130	8
1400-1500	3	127	4
1500-1600	3	130	1
1600-1700	3	123	6
1700-1800	3	120	5
1800-1900	3	112	4
1900-2000	3	108	2
2000-2100	3	100	3
2100-2200	3	100	8
2200-2300	3	98	4
2300-2400	3	98	7

24-hr mean $\pm$ S.E. = 117 $\pm$ 3

6-hr means $\pm$ S.E.	0000-0600	111 $\pm$ 2
	0600-1200	129 $\pm$ 3
	1200-1800	127 $\pm$ 2
	1800-2400	103 $\pm$ 2

Table 9. Heart rate summary of the adult male pig-tailed monkey #337, Simple during CVT II at NASA/Ames, 22-25 April 1974.

Observation Period (PST)	No. of Data Days Considered	Mean Heart Rate beat/min	S.E.
0000-0100	2	95	5
0100-0200	2	90	5
0200-0300	2	92	2
0300-0400	2	92	2
0400-0500	2	92	2
0500-0600	2	102	12
0600-0700	2	105	15
0700-0800	4	107	6
0800-0900	5	111	7
0900-1000	3	109	3
1000-1100	3	104	5
1100-1200	3	112	6
1200-1300	3	107	6
1300-1400	4	102	7
1400-1500	3	100	5
1500-1600	3	123	10
1600-1700	3	108	7
1700-1800	2	100	10
1800-1900	2	100	10
1900-2000	2	100	5
2000-2100	2	90	5
2100-2200	2	90	5
2200-2300	2	100	5
2300-2400	2	90	15

24-hr mean $\pm$ S.E. = 101 $\pm$ 2

6-hr means $\pm$ S.E.	0000-0600	94 $\pm$ 2
	0600-1200	108 $\pm$ 1
	1200-1800	106 $\pm$ 4
	1800-2400	95 $\pm$ 2

Table 10. Respiratory gas exchange in monkey #337, Simple computed from spot-checks of NASA mass spectrometer signal outputs* during CVT II at NASA/Ames.

Date	Time	O_2 Consumption (liters/hr, STPD)	CO_2 Consumption (liters/hr, STPD)	Respiratory Quotient
22 Apr 74	1600	4.38	3.54	0.81
23 Apr 74	0900	4.02	3.59	0.89
23 Apr 74	1530	4.17	3.89	0.93
24 Apr 74	0856	3.96	3.28	0.83
24 Apr 74	1531	3.60	3.26	0.91
25 Apr 74	0845	3.45	2.84	0.82
25 Apr 74	1531	3.89	3.51	0.90
26 Apr 74	0830	4.06	3.25	0.80
Mean		3.94	3.40	0.86
S.D.		0.30	0.31	0.05

* Based on direct readings of voltage outputs on a digital voltmeter following adjustment of MS inlet pressure to nominal value.

3.94×24 hr = 94.6 liters O_2/24 hr

94.6×4.85 = 459 kcal/24 hr

Table 4 = 466 kcal/24 hr

Table 11. Sum of gas partial pressures measured by NASA mass spectrometer[1] compared with total barometric pressure measured by mercury barometer.

Date	Time	Gas Sample	P_{CO_2} (torr)	P_{O_2} (torr)	P_{N_2} (torr)	P_{H_2O} (torr)	P_{total} (torr)	P_B (torr)	Diff.[2] (torr)	% Diff.[3]
22 Apr 74	1[illegible]	Cabin	0	157.7	591.6	6.1	755.4	761.9	6.5	0.85
		Pod	6.2	146.5	583.2	17.3	753.2	761.9	8.7	1.14
23 Apr 74	0900	Cabin	0	157.6	591.4	6.1	755.1	760.1	5.0	0.65
		Pod	6.9	149.2	585.9	14.8	756.8	760.1	3.3	0.43
23 Apr 74	1530	Cabin	0	157.4	590.7	3.5	751.6	758.3	6.7	0.83
		Pod	6.4	148.7	584.4	13.4	752.9	758.3	5.4	0.71
24 Apr 74	0856	Cabin	0	157.9	593.0	5.2	756.1	762.0	5.9	0.77
		Pod	5.4	149.8	588.1	12.8	756.1	762.0	5.9	0.77
24 Apr 74	1531	Cabin	0	158.2	593.2	3.8	755.2	762.9	7.7	1.01
		Pod	5.4	151.3	590.7	11.6	759.0	762.9	3.9	0.51
25 Apr 74	0845	Cabin	0	159.1	597.7	2.8	759.6	767.0	7.4	0.96
		Pod	4.6	152.0	593.0	11.6	761.2	767.0	5.8	0.76
25 Apr 74	1531	Cabin	0	158.9	596.5	3.6	759.0	766.2	7.2	0.94
		Pod	5.5	151.6	592.4	11.0	760.5	766.2	5.7	0.74
26 Apr 74	0830	Cabin	0	158.9	595.6	7.1	761.6	768.0	6.4	0.83
		Pod	5.4	151.5	594.5	11.9	763.3	768.0	4.7	0.61
									Mean	0.79%

[1] Based on direct readings of voltage outputs on a digital voltmeter following adjustment of MS inlet pressure to nominal value.

[2] Diff. = $P_B - P_{total}$

[3] % Diff. = $100 (P_B - P_{total})/P_B$.

Table 12. Stability of NASA mass spectrometer as indicated by gas partial pressure measurements on calibration gas mixtures.[1]

Date	Time	Cylinder #1			Cylinder #2			Cylinder #3		
		P_{CO_2} (torr)	P_{O_2} (torr)	P_{N_2} (torr)	P_{CO_2} (torr)	P_{O_2} (torr)	P_{N_2} (torr)	P_{CO_2} (torr)	P_{O_2} (torr)	P_{N_2} (torr)
22 Apr 74	1600	7.3	153.8	600.2	10.4	149.5	601.7	14.5	147.2	600.5
23 Apr 74	0900	7.1	154.3	599.8	10.2	150.0	600.9	14.3	147.9	600.2
23 Apr 74	1530	7.1	154.1	599.8	10.2	149.9	600.1	14.3	147.5	600.9
24 Apr 74	0856	7.3	154.1	599.6	10.2	149.9	601.2	14.3	147.5	600.2
24 Apr 74	1531	7.1	154.0	599.8	10.2	149.7	600.9	14.3	147.4	599.8
25 Apr 74	0845	7.3	154.1	600.9	10.4	149.9	599.8	14.5	147.5	600.9
25 Apr 74	1531	7.1	154.1	599.8	10.4	149.9	600.9	14.3	147.5	600.2
26 Apr 74	0830	7.5	156.1	599.8	10.6	151.8	600.9	14.7	149.5	600.2
Mean		7.3	154.3	600.0	10.3	150.1	600.8	14.4	147.8	600.3
S.D.		0.1	0.7	0.4	0.1	0.7	0.6	0.1	0.7	0.4
C.V. (%)		1.4	0.5	0.1	1.0	0.5	0.1	0.7	0.5	0.1

[1] Based on strip chart readings following adjustment of MS inlet pressure to nominal value.

Table 13. Effect of 15 minutes of 15 torr LBNP on heart rate when applied to two monkeys in upright position.

	Heart Rate (beats/min)			
	Control	LBNP	Recovery	LBNP-Control
Monkey #341				
Day 1	120*	130	115	+ 10
2	110	120	120	+ 10
3	112	115	115	+ 3
4	125	160	120	+ 35
Mean	117	131	118	+ 14
Monkey #337				
Day 1**	95	110	100	+ 15
2	70	95	85	+ 25
Mean	83	103	93	+ 20

* All data shown were obtained during last 5 minutes of the control, LBNP and recovery periods.

** Data not available for days 3 and 4 due to poor EKG record.

CVT BIORESEARCH LAB BREADBOARD TEST II
TIMING, DESCRIPTION & EQUIPMENT REQUIREMENTS FOR EACH OPERATION

DFR/27 Mar 74

INVESTIGATOR: N.Pace, D.F.Rahlmann, A.M.Kodama, R.C. Mains and B.W.Grunbaum

ORGANISM: 2 - Adult Male Pig-tailed Monkeys *(M. nemestrina)* (8-14 kg body weight)

DATE: 22 March 1974

TEST TITLE: A Monkey Metabolism Pod for Space Flight Weightlessness Studies.

DAY	ELAPSED TIME (min) Per Step	Total	BRIEF DESCRIPTION OF EACH OPERATION (Step by Step)	EQUIPMENT/FACILITY REQUIREMENTS
T-TBD			Pod preparation prior to monkey insertion.	All pod parts
			Check cleanliness of lower and upper pod sections. Feeder secured in place and capable of being operated manually in upper pod.	(At monkey area)
			Remove blotting paper from plastic bag and insert in lower pod.	Pre-weighed - clean Eaton-Dikeman #320 Blotting Paper enclosed in plastic bag.
			Installation of inner console into Shuttle Lab.	
			Interface gas lines and electronic lines to outer console.	
			Connect data output electronics from outer console to recorders.	(At Shuttle Lab area)
			Check out of system w/o monkey.	
1	5 10	10	Selection of one test subject in individual colony squeeze cage on basis of physical condition, feeding and watering pattern and previous performance in pod configuration.	Log Book. Face mask. Colony entry clothing as required by NASA/Ames. Monkey Records.
	5 5	15	Test subject secured in squeeze cage. Single intramuscular (IM) injection of Ketamine Hydrochloride (4 to 6 mg/kg of body wt) and Atropine Sulfate (0.04 mg/kg of body wt).	3 ml syringe with 21 ga needle. Vinyl gloves. Leather gloves.

INVESTIGATOR: N.Pace, D.F.Rahlmann, A.M.Kodama, R.C.Mains and B.W.Grunbaum

ORGANISM: 2 - Adult Male Pig-tailed Monkeys *(M. nemestrina)* (8-14 kg body weight)

DATE: 22 March 1974

TEST TITLE: A Monkey Metabolism Pod for Space Flight Weightlessness Studies.

DAY	ELAPSED TIME (min) Per Step		Total	BRIEF DESCRIPTION OF EACH OPERATION (Step by Step)	EQUIPMENT/FACILITY REQUIREMENTS
1 (contd.)	5	5	20	Monkey removed from cage when tranquilizer effective, examined and weighed to nearest 10 grams. Weight recorded.	General weighing scale (metric).
				Monkey placed on prep. table.	Table 75 cm high x 75 cm wide x 150 cm long.
	5	5	25	Monkey prepared for application of silver-silver chloride ECG electrodes by shaving thorax, scrubbing skin with gauze sponges and surgical soap followed by 70% alcohol wipe. Electrodes filled with paste, applied with double-stick washers and and covered with a foam adhesive disc.	ECG electrodes Contact paste Gauze sponges Phisohex Alcohol Wipes
				Minimum of 2 people required for following operations:	
	2	2	27	(1) Silicone divider seal passed over legs and positioned at iliac crest level.	
				(2) Elastic waistband applied to central sleeve of divider seal.	
				(3) Restraint jacket passed over head, velcro closure made and sewn with nylon cord.	Needle and nylon cord.
	5	5	44	(4) Lower Body Negative Pressure (LBNP) waist template assembled around waist with rubber gasket on edge of central hole.	
	1	1	45	(5) LBNP waist template support plate passed over legs and positioned at iliac crest level of monkey.	
	2	2	47	(6) Monkey placed in lower half of pod couch (sitting on table) and parts listed in steps 5, (oiled spacer bar "O" rings), 1, and 3 (in that order) passed over spacer bars of couch.	
	2	2	49	(7) Upper half of pod couch joined to lower half, and restraint jacket hammock secured to upper half of couch.	

CVT BIORESEARCH LAB BREADBOARD TEST II
TIMING, DESCRIPTION & EQUIPMENT REQUIREMENTS FOR EACH OPERATION

DFR/27 Mar 74

INVESTIGATOR: N.Pace, D.F.Rahlmann, A.M.Kodama, R.C.Mains and B.W.Grunbaum

ORGANISM: 2 - Adult Male Pig-tailed Monkeys *(M. nemestrina)* (8-14 kg body weight)

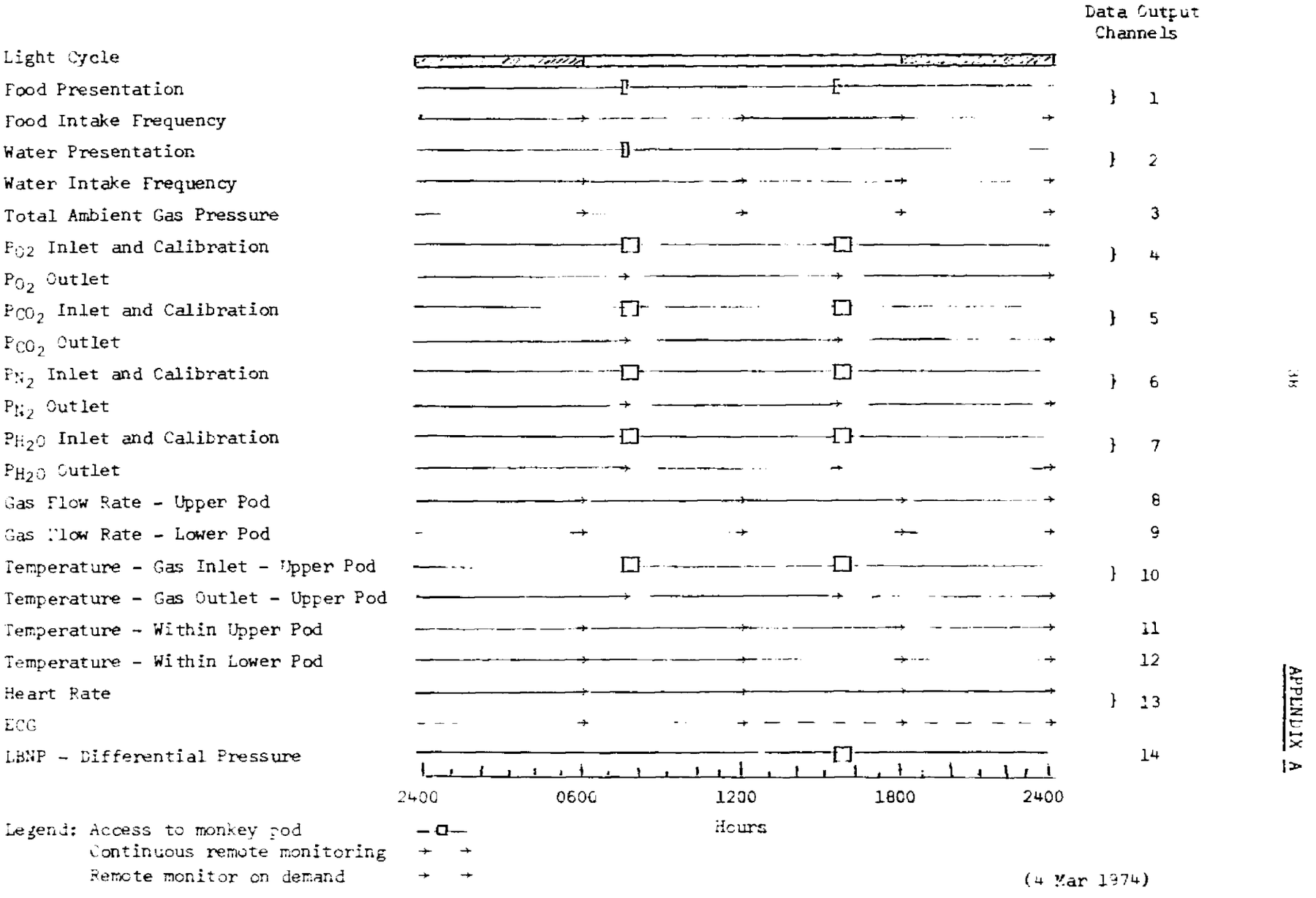
DATE: 22 March 1974

TEST TITLE: A Monkey Metabolism Pod for Space Flight Weightlessness Studies.

DAY	ELAPSED TIME (min) Per Step	Total	BRIEF DESCRIPTION OF EACH OPERATION (Step by Step)	EQUIPMENT/FACILITY REQUIREMENTS
1 (contd.)	2	51	(8) Upper and lower leg restraint bars positioned and secured.	
	1	52	(9) Entire couch/pod divider/monkey assembly passed into the lower pod by one person holding onto the upper couch, while second person directs the positioning through the window on lower pod.	
	1	53	(10) Waist template support plate pressed into position, compressing the silicone "O" ring seal.	
	5	58	(11) Divider seal and jacket skirt edges slid into the groove in the edge of the pod divider shelf and compression ring and retainer ring placed on the jacket skirt perimeter and secured with screws.	
	1	59	(12) Press rubber "O" rings into beveled seat on support plate.	
	2	61	(13) Upper/lower pod "O" ring placed in groove of the lower pod and the upper pod set in place.	
	2	63	(14) Barrel clamp placed over the edges of the upper and lower pod and the clamp tightened with bolt.	
	TBD		Transport of pod assembly to Shuttle Lab. If this step delayed, provision should be made for air flow through upper and lower pod.	Suitable transport vehicle - possible air flow provision.
			Tie down pod frame. Connect gas lines to inner console.	
			Install waterer and connect electronic lines from feeder and waterer to inner console.	
			Add 1,000 ml H_2O to waterer and 200 PMC 5040 food.	Fresh H_2O 5040 PMC Tablets
			Continuous data output -- refer to EPL-UCB Daily Activity Schedule dated 4 March 1974, copy attached.	Brush Recorders MK200

ENVIRONMENTAL PHYSIOLOGY LABOP'TORY, UNIVERSITY OF CALIFORNIA, BERKELEY
NASA/AMES CVT MONKEY POD EXPERIMENT
DAILY ACTIVITY SCHEDULE

DFR/27 Mar 7-



(4 Mar 1974)

APPENDIX A

CVT BIORESEARCH LAB BREADBOARD TEST II — DFR/27 Mar 74
TIMING, DESCRIPTION & EQUIPMENT REQUIREMENTS FOR EACH OPERATION

INVESTIGATOR: N.Pace, D.F.Rahlmann, A.M.Kodama, R.C.Mains and B.W.Grunbaum

ORGANISM: 2 - Adult Male Pig-tailed Monkeys *(M. nemestrina)* (8-14 kg body weight)

DATE: 22 March 1974

TEST TITLE: A Monkey Metabolism Pod for Space Flight Weightlessness Studies.

DAY	ELAPSED TIME (min) Per Step	Total	BRIEF DESCRIPTION OF EACH OPERATION (Step by Step)	EQUIPMENT/FACILITY REQUIREMENTS
1 (contd.)			Recorder chart speed continuous at 0.05 mm/sec throughout trial except EKG wave form on demand. Control from outside lab mockup. Lights on at 0600 hrs.	
			At 0800:	
	1 5	5	Food presentation -- add known quantity of food tablets and record. Record number on tablet counter and zero.	5040 PMC Tablets
	1 5	10	Record volume of water left in waterer and add sufficient amount of water to bring up to 1,000 ml. Record volume of water added in terms of consumption of monkey from time of previous addition.	Fresh H_2O in clean container.
	5 60	70	Calibration of bioinstrumentation in regard to N_2, O_2, CO_2, H_2O and temperature (may not need total hours time within lab).	Calibration-Gas Mixtures Cyl. $\%O_2$ $\%CO_2$ $\%N_2$ $\%H_2O$ 1 21 0 79 0 2 20 1 79 0 3 19 2 79 0 4 0 0 98 2
			At 1600:	
	6 60	130	Calibration of metabolic instrumentation (same as 0800 hr) Lower body negative pressure (LBNF) (Monkey pod area should be free of extraneous sounds and traffic during this time)	
			At 1700 hrs:	
	1 5	135	Food added to feeder. Record number of tablets added. Do not zero counter but note and record number on indicator dial. Water consumption recorded but no additional water added.	5040 PMC Tablets
			At 1800 hrs: Lights off in lab area.	

Total time needed per day for pod and/or inner console access = 135 min.
This total does not include contingency time for possible remedial repair of any part of total experiment package.

Test Days	
2 through Recovery	Repeat Day 1 activities as applicable.

CVT BIORESEARCH LAB BREADBOARD TEST II
TIMING, DESCRIPTION & EQUIPMENT REQUIREMENTS FOR EACH OPERATION

DFR/27 Mar 74

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ORGANISM: 2 - Adult Male Pig-tailed Monkeys *(M. nemestrina)* (8-14 kg body weight)

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TEST TITLE: A Monkey Metabolism Pod for Space Flight Weightlessness Studies.

DAY	ELAPSED TIME (min) Per Step	Total	BRIEF DESCRIPTION OF EACH OPERATION (Step by Step)	EQUIPMENT/FACILITY REQUIREMENTS
R			Recovery	
			Record amount of food and water consumed.	
			Count all food tablets remaining in feeder.	
			Disconnect pod from inner console.	
			Release tie down from pod frame	
	TBD		Transport pod with monkey to animal recovery area.	Suitable transport vehicle.
			Remove upper pod.	
			Tranquilize monkey.	
			Remove debris and record number of uneaten food tablets which may be present.	
			Disassemble divider parts in reverse order of insertion procedure.	
			While removing couched monkey	
			Cleanse lower couch with distilled H_2O and clean spatula, allowing washings to be added to lower pod contents.	
			Remove monkey from couch.	
			Wash lower couch with distilled H_2O and spatula - washings to lower pod contents.	
			Wash lower portion of monkey body with distilled H_2O - washings to lower pod contents.	
			Determine body weight of test monkey and return to cage.	
			Remove lower pod contents and place in container for subsequent chemical analysis.	5 gallon polypropylene container with sealable lid.
			Wash lower pod interior with distilled H_2O and spatula - add washings to container.	
			Store container at -15°C.	Deep Freeze

APPENDIX B

OPERATIONS SEQUENCE FOR RESPIRATORY GAS EXCHANGE MEASUREMENTS DURING CALIBRATION PERIODS OF CVT II TRIALS AT NASA/ARC

1. Pre-set calibration gas cylinder flows at Outside Console to insure out-board leak in calibration gas line, and leave "zero" cylinder flow ON.
2. Enter Shuttle Mock-Up Laboratory to record "UCB Internal Instrumentation Console Data."
3. Record upper pod air flow rate and temperature from panel meters.

   In-line barometric pressure sensor not yet available. Obtain P_B from mercury barometer in adjacent laboratory.
4. Mass spectrometer operations.
   a. Place MS Output/DVM Switch to Voltage position and record MS inlet pressure transducer voltage on DVM.
   b. Adjust Sample Outlet Valve as needed to set above voltage between 3.490 and 3.510 volts.
   c. Place MS Output/DVM Switch to Current position and record MS ion pump current (measured as a negative voltage) on DVM.

      The nominal reading is between -20 and -10 millivolts.
   d. Place MS Output/DVM Switch to the CO_2, O_2, N_2, and H_2O positions and record MS signal outputs on DVM for CO_2, O_2, N_2, and H_2O respectively for pod air.

      During normal running mode, the MS sampling system will be set with the Sample Valve in the Pod position, and the Calibration Valve in the Cabin Air position.

e. Turn Sample Valve to Calibration position (activating Calibration Valve).

MS should now be sampling cabin air.

f. Place MS Output/DVM Switch to Voltage position and adjust Sample Outlet Valve as needed to set voltage between 3.490 and 3.510 volts.

g. Allow 5 minutes for stabilization of readings, then place MS Output/DVM Switch to the CO_2, O_2, N_2, and H_2O positions and record MS signal outputs on DVM for CO_2, O_2, N_2, and H_2O respectively for cabin air.

h. Turn Calibration Valve to Cylinder position.

MS should now be sampling from the "zero" calibration gas cylinder.

i. Place MS Output/DVM Switch to Voltage position and adjust Sample Outlet Valve as needed to set voltage between 3.490 and 3.510 volts.

5. Return to Outside Console for remainder of calibration procedures.

6. Adjust recorder base lines as needed with the "zero" calibration gas.

CO_2 5 div from left of chart

O_2 5 div from right of chart

N_2 Mid-scale (25 div)

H_2O 5 div from left of chart

(LBNP may be started)

7. Run calibration curves by connecting calibration gas line, in turn, to cylinders 1, 2, and 3.

Allow about 5 minutes for each cylinder.

8. Re-connect calibration gas line to "zero" cylinder.

9. Return to Inside Console in Shuttle Mock-Up Laboratory.

   a. Turn Calibration Valve to Cabin Air position.

   b. Turn Sample Valve to Pod position.

   c. Adjust Sample Outlet Valve as needed to set MS inlet pressure transducer voltage between 3.490 and 3.510 volts.

   If return to laboratory is delayed, e.g., because of LBNP run, disconnect calibration gas line at cylinders and allow MS to sample room (High-Bay) air until Steps 9a-9c can be completed.

10. Shut off main valves on calibration gas cylinders.

END of routine for respiratory gas exchange measurements during calibration periods of CVT II trials at NASA/ARC.

C A U T I O N

In the event of power failure in test facility or accidental loss of power to mass spectrometer during a CVT II trial, close MS Sample Inlet Valve (blue handle) fully clockwise and snug as soon as possible.

The mass spectrometer is protected against application of power out of normal sequence and will not return to operation upon restoration of power.

Procedures required to restore operation of mass spectrometer will depend on duration of power outage and time before closure of valve, and presumably need not be carried out by a "Payload Specialist" during a CVT II trial.

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APPENDIX C

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LBNP Operations Sequence for NASA/Ames CVT II

A. Calibrate pressure transducer

(1) Sensitivity set to OFF, set pen position to left margin.

(2) Increase sensitivity in steps and move pen back to base line with balance control.

(3) Set sensitivity to 10/DIV.

(4) Close leak valve and apply pressure to sphygmomanometer bulb to read 50 torr.

(5) Set pe on right-hand margin by adjusting the gain control.

(6) Reduce pressure to 0 mmHg and check base line; if changed, repeat steps A (1)-(5).

(7) Apply pressures of 50 and 25 mmHg to transducer and then open leak valve to ambient pressure.

B. LBNP Test

(1) Throughout test monkey should ideally not be exposed to noise (other than background) of human, other organism, or equipment origin. Monkey should not be able to observe human or other organisms through upper pod window.

(2) Control period:

Record heart rate and make notes of any monkey behavior which can be discerned, e.g. shaking pod.

(3) LBNP period:

Same as in B (2), then the following, in order.

(a) To initiate LBNP -- shut off lower pod air flow switch.

(b) Shut off air inlet valve to lower pod.

(c) Turn air outlet, lower pod valve to LBNP.

(d) LBNP switch to ON

(e) Increase voltage on LBNP control knob to give 15 mm Hg neg. press. as read from transducer channel on Brush recorder. Gradually increase voltage over period of about 15 seconds.

(f) Maintain pressure for 15 min.

(g) Decrease voltage on LBNP control knob to zero.

(h) LBNP switch to OFF.

(i) Turn air outlet, lower pod valve to Ventilation.

(j) Open air inlet valve to lower pod.

(k) Turn on lower pod air flow switch.

(4) Recovery period:

Same as in B (2).