SKYLAB MEDICAL EXPERIMENTS ALTITUDE TEST

## Detailed Test Objective

I. Experiment/Operational System

    A. Title

        M171 Metabolic Activity

    B. Principal Investigator and Principal Coordinating Scientist

        E. L. Michel

II. Purpose and Background

    A. Purpose of Experiment

        1. To determine if man's metabolic effectiveness in doing mechanical work is progressively altered by the simulated space environment.

        2. To determine the metabolic cost of identical operation activities when man is deprived of the benefits of normal earth atmosphere as compared to the cost in the normal earth atmosphere.

        3. Secondary purpose is to evaluate the bicycle ergometer as an exercisor.

    B. Justification for Experiment

Metabolic measurements have been limited to carbon dioxide production on previous U.S. space programs. This experiment will measure transitory (peak) energy expenditures associated with performance of calibrated work in space. The data provides information on metabolic heat production (an index of the rate of conversion of chemical energy into mechanical energy) during various phases of the mission; i.e., rest and exercise. Oxygen utilization, carbon dioxide production and respiratory quotients

**B.** Justification for Experiment (Cont'd)

will be compared at various periods throughout the mission. Changes in work capacity will be assessed as a function of mission duration.

Several ground studies have attempted to predict metabolic activity using reduced gravity simulators. The 56 day mission monitors metabolic activity with the crew living at 1/3 normal atmosphere. Data will provide baseline information of a Skylab simulated mission, except for weightlessness for comparison with baseline laboratory tests and future Skylab missions.

III. Participants

    **A.** Number of Crewmen Required

        Three crewmembers

    **B.** Function of Each Crewman

        1. Two crewmen are required for each experiment; one as the subject, the other as observer.

        2. The Scientist Pilot is the observer for the other crewmembers. When the Scientist Pilot is the subject, one of the other crewmen acts as observer.

IV. Functional Objectives

    F01 Perform the calibrated exercise (by all 3 crewmen) on the ergometer.

V. Test Conditions

    **A.** Environmental Requirements

        1. During the experiment, the temperature shall be maintained at $70° \pm 5°F$.

A. Environmental Requirements (Cont'd)

2. Air motion control maintained from 50 ft/min to 100 ft/min.

3. Humidity will be maintained at 8mm to 12mm Hg $H_2O$.

B. Crew Constraints

1. Each crewman's experimental period should be scheduled at the same time on all experimental days.

2. Experiment should not be done until 2 hours after heavy exercise.

3. Experiment should be scheduled at least 3 or 4 hours after eating.

4. Experiment should not be performed until at least 1/2 hour has elapsed since venipuncture.

VI. Hardware Requirements

A. Identification and Purpose of Hardware

| Identification | Purpose |
|---|---|
| 1. Breathing Apparatus | - provides unidirectional flow of inspired and expired air. |
| 1.1 Nose Clip | - ensures all gases pass through the mouthpiece. |
| 1.2 Mouthpiece | - provides the interface and flow path between the subject and the valve assembly. |
| 1.3 Absorption Cartridge | - ensures saliva will not impair the check valves in the valve assembly. Saliva Cartridge is changed after each test. |
| 1.4 Valve Assembly | - contains inspired and expired check valves to direct the flow of air. The inspired check valve filter prevents particles from being inhaled. |
| 1.5 Breathing Hoses | - permit gases to flow to and from the subject via the valve assembly. |

A. Identification and Purpose of Hardware (Cont'd)

| Identification | Purpose |
|---|---|
| 2. Body Temperature Measurement System | - measures the temperature of the ear canal near the tympanic membrane. |
| 2.1 Probe | - consists of one 3 foot long cable with thermocouple at one end and a bridge completion network in the center of the cable. |
| 2.2 Ear Mold | - is individually fitted to the crewman's ear. The probe's thermocouple passes through it approximately 1/8 inch to continuously measure temperature. |
| 2.3 Signal Conditioner | - is contained within the SIB of M093 and conditions the signal for transfer to the ESS and telemetry. |
| 3. Ergometer | - operates like a bicycle with a seat, pedals and handlebars. The pedal force is controlled by a generator that may be automatically programmed for heart rate/time interval or manually set for a specific heart rate or a work rate in watts. |
| 3.1 Ear Heart Rate Sensor | - sensor fits on ear lobe and senses heart rate. Its wire connects into the ergometer panel ear sensor jack and is used for exercising. |
| 4. Metabolic Analyzer | - measures the quantities and partial pressures of the crewman's inspired and expired gases. It provides conditioned electrical signals for telemetry via the ESS. |
| 4.1 $H_2O$ Dryer | - removes water from the gases in the Expiration Inlet line prior to Mass Spectrometer Sampling. The Dryer canister is occasionally replaced as required by a specific test procedure. |
| 5. Automatic Blood Pressure Measurement System | - measures the systolic and diastolic pressures using the oscultatory method. |
| 5.1 BPMS Cuff | - fits on the subject's left arm and connects to the SIB. It inflates and senses Korotkoff sounds and deflating cuff pressures. |

A. Identification and Purpose of Hardware (Cont'd)

| Identification | Purpose |
|---|---|
| 5.2 BPMS Gas Umbilical | - provides $N_2$ gas from the ESS to the SIB/Cuff hose interface. |
| 5.3 BPMS Panel | - provides displays and controls and computes the systolic and diastolic pressure from the cuff sensor signals. |
| 5.4 Aneroid Gage | - provides a backup measure of instantaneous ABPMS gas pressure. |
| 6. Vectorcardiogram | - monitors heart rate and provides heart rate signals to the ergometer and the BPMS for M171. It simultaneously provides added data for M093 experiments (3 heart wave analog signals vx, vy, and vz). |
| 6.1 VCG Harness/Electrodes | - consists of cabling with 7 electrodes and a ground electrode to sense heart wave signals. |
| 6.2 Subject Interface Box | - contains 8 preamps for 7 sensors and ground, BTMS signal ground and connector, the BPMS cuff electrical connector, VCG harness electrical connector, the BPMS gas umbilical with aneroid gage, and the VCG electrical umbilical connectors. |
| 6.3 VCG Umbilical | - provides electrical wiring between the ESS and the SIB including: VCG wiring, BPMS wiring and BTMS wiring. |
| 6.4 VCG Panel | - provides controls and display for VCG operation and computes heart rate as well as conditioning 3 analog signals of the 3 VCG channels. |
| 6.5 Electrode Kit | - provides components for properly installing the VCG electrodes. |
| 7. ESS | - provides controls and displays for experiment power, data processing for VCG and BPMS electronics and transfers conditioned signals to telemetry. |
| 8. Chest Support | - for evaluating the ergometer as an upper body exercisor. |
| 9. Tool A | - provides proper torquing of the Mass Spectrometer Sample Inlet and Vacuum Valves. |

B.  Identification and Purpose of GSE

None

VII.  Chamber Interfaces

A.  Stowage Requirements

Provision for mounting and storing the following:

1.  The Valve Assemblies, Breathing Hoses, Mouthpieces, Absorption Cartridges, VCG components, Waist Belt, Ear Sensor, BPMS components, BTMS components and Tool A will be stowed in the Bio-Med Containers.

2.  Provision will be made to stow 1 spare dryer canister.

B.  Special or Unique Interfaces

This experiment requires 28 VDC electrical power.  The Mass Spectrometer vacuum requirements are TBD torr.  Nitrogen gas will be used for the ABPMS and to drive the Metabolic Analyzer valves.

VIII.  Crew Training

A.  Briefing Sessions Required

One briefing session of 1½ hours duration is scheduled for T-2 months.

B.  Training Sessions Required

Six training sessions of 1½ hours duration is scheduled for T-30, T-25, T-20, T-15, T-10 and T-5 days per crewman.

The M171 PI or his representative will determine when sufficient training has been achieved to take baseline data.

IX. Scheduling Requirements

A. Number of Performances

1. In-chamber days are consistent with M092 testing.

| Day | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crewman | | 1 | 3 | | 2 | | | 1(2,3) | | | 1 | 2 | 3 | | | 1 | | 2 | 3 | |

| Day | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crewman | | (1,2) | | 3 | | | | | | | 1 | 2 | | 3 | | 1(2,3) | | | 1 | 2 |

| Day | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crewman | 3 | | | 1 | | 2 | 3 | | | (1,2) | | 3 | | | | |

2. Post Chamber

| T + Days | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | XX every third day until baseline levels are reached | | | | | | | | | |

NOTE: The chamber test schedules are planned for the M092-M171 serial testing as performed on the Skylab Missions.

X.  Data Requirements

    A.  Experiment Measurement List

        1.  $O_2$ Consumption

        2.  $CO_2$ Production

        3.  Minute Volume

        4.  Ergometer Work Load

        5.  Ergometer RPM

        6.  Heart Rate

        7.  Body Temperature

        8.  Vital Capacity

        9.  Respiratory Exchange Ratio

      10.  Ambient Temperature (ESS)

      11.  Ambient Pressure (ESS)

      12.  Subject/Experiment ID (ESS)

      13.  Blood Pressure, Diastolic

      14.  Blood Pressure, Systolic

      15.  VCG - $V_x$ (RT-LT)

      16.  VCG - $V_y$ (UP-DN)

      17.  VCG - $V_z$ (FR-BK)

      18.  Time

    B.  Unique Measurement List for SMEAT

        None

C. Data From Other Experiments

    1. Experiment M071 - Mineral Balance and M073 - Bio-Assay of Body Fluids

       Basic energy inputs/outputs to subjects (food, drink and waste products).

    2. Experiment M172 - Body Mass Measurement

       Daily assessment of each crewman's weight.

D. Other Requirements

    1. Logs - Comments and data will be recorded in the Medical Experiments Log.

    2. Voice Recordings

       a. Real Time

          Voice Link - It is a requirement that the real-time chamber voice link be available at the consoles whenever required.

       b. Post Real Time

          Typed transcriptions of voice communications relating to M171 will be provided. Transcripts will identify speakers and will include GMT time annotations accurate to $\pm 1$ second for each speaker.

    3. Computer Programs

       a. Summary

          1. Metabolic Activity Software

             a. General description. This set of programs must

                (1) assimilate all data from the metabolic activity experiment during all three mission phases,

**D.** Other Requirements (Cont'd)

(pre, in, and posttest) as well as all relevant data from other experiments (e.g., VCG data), (2) provide continuous output of raw data when desired, (3) compute continuous and discrete derived variables, (4) perform statistical analysis of derived variables, (5) output all information or derived variables and statistical analyses of changes due to testing.

Unique programs for M171 are

Continuous derived variable program

(METAB 1)

Discrete derived variable program

(METAB 2)

Applicable systems software for M171 are:

Conversion (AD)

Conversion (DA)

Plot (T-PLOT)

Editing (EDIT)

Statistical Analysis (STAT)

Output (OUT)

**b.** Detailed Requirements

**1.** Computer Programs

**a.** Raw Data Computer Program - A program is required to take raw data and compute derived variables for statistical analysis 24 hours after experiment performance. All variables to be used in statistical

D.  Other Requirements (Cont'd)

analyses will be written on a tape to be designated "Basic Statistical Analysis Tape". Raw variables are:

1.  Blood pressure (systolic and diastolic)

2.  Oxygen consumption

3.  $CO_2$ production

4.  Minute volume

5.  Body temperature

6.  ECG (for heart rate)

7.  Work load

8.  RPM

9.  Ambient temperature

10. Ambient pressure

Derived variables are:

A.  Least squares slopes from regressions of:

1.  $O_2$ consumption vs. heart rate

2.  $CO_2$ production vs. heart rate

3.  Blood pressure (systolic) vs. heart rate

4.  Blood pressure (diastolic) vs. heart rate

5.  $O_2$ consumption vs. work load

6.  $CO_2$ production vs. work load

7.  Minute volume vs. $O_2$ consumption

B.  Specified values estimated from above regression lines:

1.  $O_2$ consumption at heart rate of 160

2.  $CO_2$ production at heart rate of 160

D.  Other Requirements (Cont'd)

3.  Minute volume at 1 liter of $O_2$ consumption

4.  $O_2$ consumption at 100 watts work load

5.  ($O_2$ consumption at heart rate of 180)/Body weight

b.  <u>STAT Computer Program</u> - A program to be called STAT is required to take data from the Statistical Analysis Tape and perform statistical analyses of that data 48 hours after experiment performance.  The program shall consist of two main sections, each with a specific task.

1.  Section one shall take each dependent variable for each individual, perform an analysis of variance, correlation and regressions.  This section shall have the capability to be used at any time, i.e., pretest, "chamber" or posttest, using all data collected up to that time.

2.  Section two, to be used after all data is collected, shall do analysis of variance, comparing differences, between pre- and posttest for the various crewmen, testing for interaction.

c.  <u>STOUT Computer Program</u> - A statistical output program to be called STOUT is required to prepare output of all processed data in 48 hours after experiment performance.

STOUT shall be capable of producing output in three distinct modes, any or all of which may be called for at any time.  These modes are:

D. Other Requirements (Cont'd)

       1.  Microfilm and hard copy plots of designated variables.

       2.  Tabular listings of data including descriptive statistics (e.g., means, standard deviations, etc.).

       3.  Results of statistical tests performed by STAT.

    d.  EDIT Computer Program - The program EDIT shall have the capability of taking the "Basic Statistical Analysis Tape" and striking out any data points designated as "bad", keeping track of the number of "good" or usable data points for each variable for each crewmember, experiment and time of experiment, and rewriting all "good" data on the "Statistical Analysis Tape" in a format to be used by the "Statistical Analysis Program."

2.  Tape Requirements

    a.  Analog Tape - An analog tape containing experiment data for each member of the crew will record VCG $V_x$, $V_y$ and $V_z$ data.

       Each analog tape shall have introductory annotations on the voice track prior to experiment performance identifying date, subject, and location.

    b.  Digital Tape - A digital computer-compatible tape will be generated from the M171 data. This data will be used to input data for further analytical and statistical processing, and a copy will be provided for archival storage purposes.

D.  Other Requirements (Cont'd)

The computer compatible tape shall contain the following parameters:

Experiment I.D.

Subject I.D.

**Time**

Biomed-Exp. M171, Vital Capacity

Biomed-Exp. M171, ERGM Work Rate

Biomed-Exp. M171, $O_2$ Consumption

Biomed-Exp. M171, Respiration VPM

Biomed-Exp. M171, $CO_2$ Production

Biomed-Exp. M171, Body Temperature

Biomed-Exp. M171, ERGM Heart Rate

Speed-Exp. M171, Ergometer RPM

Biomed-Exp. M093, VCG X Axis

Biomed-Exp. M093, VCG Y Axis

Biomed-Exp. M093, VCG Z Axis

Biomed-Exp. M092, Diastolic Press

Biomed-Exp. M092, Systolic Press

Press-ESS, Ambient

Temp-Ess, Ambient

Volt-ESS, 28 VDC Power Bus

Volt-ESS, 10 VDC Bus, Plus

Volt-ESS, 10 VDC Bus, Minus

c.  Displays

1.  <u>Alpha Numeric CRT</u> - will display the following parameters:

D. Other Requirements (Cont'd)

$O_2$ Consumption

$CO_2$ Production

Minute Volume

Ergometer Work Rate

Systolic Pressure

Diastolic Pressure

Heart Rate

Real Time

2. <u>Strip Chart Recorder</u> - The stripchart will contain the entire test profile beginning and ending with calibration data for:

VCG $V_x$

VCG $V_y$

VCG $V_z$

Time

XI. FDF Requirements

The Flight Data File will contain M171 procedures, the Medical Experiment Log and the SMEAT daily mission time line.

XII. Deviations from Approved Skylab Experiment

A. The triangle shoes will not be required.

B. The waist restraint will not be required.