3.3 Experiments M074/M172. Specimen and Body Mass Measurements

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These experiments were devised to demonstrate and validate the theoretical characteristics of a nongravimetric method of mass determination, and through daily crew and food and fecal measurements make possible, for the first time, a study of mass variations of men exposed to weightlessness.

Method

Experiment M074 uses two specimen mass measurement devices (SMMD) each of 1 kg capacity, to measure all individual food residues and defecations. Experiment M172 has a 100 kg body mass measurement device (BMMD) for daily nude[1] mass determination of each crewman; this measurement is taken immediately after sleep and after initial morning void. Since the devices are an integral part of the same study and are fundamentally similar, they will be described together.

Hardware Operation

The SMMD and BMMD are low frequency mass dependent mechanical oscillators. Determination of mass depends upon comparison of oscillation periods produced by sample masses to those produced by accurately known calibration masses. Although a proper set of calibration masses were available for the SMMD's, it had not been possible to get such a set of masses on board for the BMMD. Rather, various onboard pieces of equipment such as food trays and batteries were brought in to use. Unfortunately, no adequate methods had been provided for holding some of these items to the BMMD in weightlessness. As a result, the crew spent in excess of two hours in futile efforts to secure these items on the first calibration attempt. Finally, onboard straps and pads of unknown mass were used as a measure of expedience. On second attempt the following day, usable values were obtained with the use of onboard tape. In view of the difficulties, two additional scheduled calibrations were sacrificed for much shorter troubleshooting procedures to improve the validity of greatly restricted calibration data. Daily usage of the BMMD was simple, requiring 5 minutes of each crewman's time.

Calibration of the SMMD's was routine with the adequate onboard standards available. On the second day the electronics package of the Waste Management Compartment (WMC) unit was found to have failed. The crew was given the option of making all specimen measurements in the Ward Room (WR)

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[1] Nude earth-equivalent-weight in space was obtained by subtracting the weight of clothing worn during mass measurement plus other small corrections such as buoyancy. Clothing worn was based on post flight shipboard reports.

or changing the WR SMMD electronics to the WMC and making all measurements there. They chose the latter course but several days of fecal mass data were missed in the interim. After this, all specimen measurements and calibrations were routinely performed on the WMC unit.

Results

Specimen measurements. - To summarize briefly, overall errors with solid calibration masses are on the order of 0.1%. While several sources of error make it impossible to reach the desired accuracies for investigation of the methodology, for "operational" use the major sources of error will be linked to information of number of wipes used and items of this nature. Errors from the SMMD itself should not exceed 2 to 3% on samples of 100 g or more. In analysis of fecal data, the bag tare weights and number of wipes used were unknown, so an assumed tare weight was used. All defecation masses, except for the period of WMC SMMD failure are shown in table and in figure .

Only three food residues early in the mission were left, and thereafter all food opened was completely consumed. This is likely to be the in-flight pattern.

Crew Body Measurement. - During BMMD ground calibrations there was a marked drop to the curve at higher weights which was felt to be associated with gravitational deformation. This was apparently the case since the in-flight curve closely approximates the theoretical linear curve - to a fraction of a percent for solid masses. A higher order experimentally derived curve which fits even more closely was used for BMMD crew mass data reduction. Although calibration difficulties prevented accuracies for in-depth analysis of the machine, relative, i.e., repeated or day-to-day, measurements are felt to be $\leq +0.1$ pound to judge from one set of repeated measurements. Absolute measurements are dependent upon how well the normally nonrigid mass of man is coupled to the BMMD. A restraint system required to accomplish this under weightlessness had never been completely tested and any inadequacy would result in a greater apparent mass. Judging from post flight data and personal previous experience with the equipment, it is felt that this could be in the range of +0.25 to in excess of +1.0 pounds. Table shows all recorded crew body masses while figures are plots, of each crewman's weight or equivalent weight before, during, and after the mission. The total period of measurements reflected in the graphs coincides with the period the crewmen were maintained on the Skylab diet. Unfortunately the data for four days after orbital insertion was lost since the Skylab cluster was not activated.

All graphs have common features such as each crewman losing 1-1/2 to 2% of initial body weight during the preflight diet period. A small hump is present in all curves beginning a week prior to actual launch possibly coinciding with changes in activity occasioned by the 10-day launch delay.

1 - A three day sliding average was used to smooth this data yet allow major variations to appear

The CDR and SPT showed a more or less steady in-flight loss at a slightly increased rate. The CDR and SPT showed sharp drops and recovery associated with times of EVA. All three have an increased rate of loss near the mission end, possibly associated with increased activity. Only the SPT showed an initial rapid weight loss on exposure to weightlessness but based on a projected average rate of loss during this initial period the end result would be the same as that for the last six preflight days.

In the post flight period, there was a time of relatively rapid gain in mass of the SPT and PLT followed by a more or less stable period, while the CDR showed a rapid overshoot followed by return to a lower stable value. Physical activity was reduced in this period. Although the preflight loss is relatively small, if one simply projects this rate it will intercept the post flight weights at some 10 days post flight in the CDR's and PLT's case and some 20 days in the case of the SPT.

Future Action

Skylab 3 will carry some partial fixes to remedy the BMMD calibration mass problem. Spring clips will secure the food tray lids. Spring loaded clamps will allow rapid and, hopefully, rigid installation of batteries used for calibration masses. Unfortunately this eliminates one food tray such that only 150 lb total calibration range is covered requiring a 40 lb extrapolation of questionable validity to cover the Pilot's weight.