NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

February 14, 1973

REPLY TO
ATTN OF: CB

MEMORANDUM

TO: Whom It May Concern

FROM: CB/William E. Thornton

SUBJECT: Urine Volume Measurement by BMMD

The question of using mass to determine urine volume with the SL MMDs was recently raised. This has been advocated as a simple solution to the urine volume measurement problem since 1965. Even with poorly constrained bags with appreciable "slosh", accuracies of a few percent are possible and the original specifications for the BMMD required such accuracies.

If the urine is well constrained in rigid containers such as the present box and spring loaded cover of the UVMS, high accuracies can be obtained as was recently demonstrated.

For the demonstration, 3 urine bags were filled with differing quantities of water. These were placed in the UVMS box with the VD cover in place and held to the front of the 1G trainer BMMD by two SL 'C' clamps. BMMD periods were recorded for each of the three bags plus box and clamps, box and clamps alone for tare, and a single point 900 gm calibration point made using the SMMD cal masses. The calculation of the water mass was made as shown on the enclosure, and the masses compared with weights obtained by a Metlar gravimetric balance.

Liquid Sample	BMMD Mass/Gms	Gravimetric Mass/Gms	Error Gms	Error %
1	1837.6	1836.0	+1.6	.08
2	764.5	763.0	+1.5	.20
3	2825.5	2822.0	+3.5	.12

These are the order of mass errors one should expect with reasonable care. There appears to be a small system error present. The gravimetric balance was not checked against the calibration masses or this my represent a small amount of slosh.

The above errors must be added to those from variations in urine specific gravity. The average pooled daily specific gravities should be 1.005 ±.002. (Individual voids may vary more than this and in extreme illness one can get ranges of 1.020 to 1.000 though not for long). Using such a standard correction, one could reasonably expect errors of ±.2% from this source. If the sample bags were to be removed prior to mass measurement, then any variation in sample amount would produce an error. Temperature density variations are normally ignored. Urine bag variation would also have to be considered. I trust neither of these two items should be greater than a few grams.

The major concern at this time is not accuracy but crew time. If one crewman does all three measurements, it should add about 30 mins to the time line.

W. Thornton

William E. Thornton
PI, M074/172

Enclosure
Calculation of mass

CEK/WEThornton:fs

ENCLOSURE

Calculation of mass from BMMD period:

T = period of three cycles: secs

M = mass: gms

$K_{1,2}$ = constants

$T \approx K M^{-2}$ and $M \approx K_2 T^2$

Assuming: straight line form and taking zero point as BMMD period with tare wt. in place and the 900 gm cal mass as a second point on a straight line the slope is derived:

Sample -	T Sec	Av. T Sec	T^2
Zero mass	2.93452		
	38		
	48		
	53	2.93446	8.611055
	41		
Zero mass +900 gms	3.00545		
	545		
	41	3.00543	9.032609
	43		

Slope:

$$\frac{\text{Mass}}{T.^2 - T^2 900} = \frac{900}{9.03261 - 8.61141} = 2134.95 \text{ gm/sec}^2$$

Calculating masses: $K_2 T x^2 - K_2 T^{\circ 2} = K_2 T^2 x \frac{M}{T^2} = M$

Sample	T Sec	T Av Sec	T^2 Sec^2	BMMD Mass Gms
1	2.99488			
	492	2.994915		
	500		8.96952	765.30
	486			
2	3.07786			
	777			
	780	3.077762	9.472618	1839.39
	768			
	770			

2

Sample	T Sec	T Av Sec	T^2 Sec^2	BMMD Mass Gms
3	3.15216			
	199			
	214	3.152113	9.935816	2828.30
	216			

A small buoyancy correction must be made since gravimetric masses are increased by the amount they are buoyed up by air (∿ 1.3 gm/1000 cc) and this effect is not present in the MMD. After taking into account the relative air displacements of steel cal mass and water samples, a correction of approximately -.1% must be made. Making this correction, the weights are:

Sample	Mass
1	764.5
2	1837.6
3	2825.5