BMMD URINE MASS MEASUREMENT
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The following test was done to allow comparison of urine volumes by lithuim tracer, by onboard displacement measurement, and by mass determination. On days 258, 257 and 260 all urine samples were measured for mass on the BMMD. It was intended that each bag be separately measured, but this was done only on the last day. Good data was obtained on 8 of 9 samples. There was an obvious and gross (order of Kgms.) error in recording or transcription of one BMMD period reading for which it has not been possible to get the proper value.

Methodology - After removal of the sample bag from the urine bag, the three bags with one sheet metal bag container and its volume determination plate was taken to the BMMD with two C clamps and a single 900 gram cal. mass.

C clamps box and cover plate were attached to the BMMD, and a tare mass reading was obtained. Next the cal. mass was added to obtain a second point on the cal. curve. This was removed, and the three bags were supposed to be added one at a time and measured. The crew accomplished the impossible, and on the first two days added them all to one box.

Analysis - The cal curve is extremely linear and of the form:

$$Mass_x = K\left(T_x^2 - T_{tare}^2\right) \quad \text{where } T = \text{BMMD Period}$$

such that a simple ratio of cal mass period to urine mass period could be used:

$$\frac{\text{Cal mass (900 gm)}}{\text{Mass (Urine)}} = \frac{K\,(\text{Period}^2(\text{Cal})}{K\,(\text{Period}^2(\text{Urine})}$$

$$\text{Mass, Urine, Gms} = \frac{900\ \text{Period}^2(\text{Urine})}{\text{Period}^2(\text{Cal})}$$

Thus, to calculate mass the period of the urine sample was squared and tare period^2 subtracted. This was converted to mass. Since it was necessary to remove the sample, this sample mass had to be added (this sample is routinely measured on return), and the empty bag mass was subtracted. A figure of 390 $\pm$10 gms was given for this value and 390 gms used. The resulting mass was corrected for specific gravity from values routinely obtained on the ground.

Table 1 gives the raw data used in tabulation, while the results and variations in methods are shown in Table 2. The major source of error is probably the $\pm$10 gm variation limit on the urine bag.

This is rather good agreement between two indirect measurements, and both lends increased assurance to the tracer method, and once again

demonstrates that the MMD is a practical method for urine volume determination. Approximately 20 mins/day of a crewman's time would be required for all three determinations after the initial setup; i.e., C clamps, etc. left nearby. A daily tare mass should be taken, but the single cal mass need only be measured every week or so and less as the mission progressed; i.e., only four periods would be recorded.

TABLE 2

DIFFERENCES IN URINE VOLUME DETERMINATIONS ON SL-3

BAG NUMBER	VOL. BY UVMS ONBOARD ML.	VOL. BY LITRACER ML.	VOL. BY MMD ONBOARD ML.	DIFFERENCE IN Li VOL MASS VOL. ML.	% DIFFERENCE
315	1980	1551.	1570.	-19.	1.2
313	1200	1248.	1241.	+7.	0.56
774	820	984.	967.0	+17.	1.8
330	1470	1415.	1409.	+6.	0.4
272	1600	1441.	1467.	-26	1.8
320	930	1041.	1019.	+22	2.1
280	1050	1082.	1075.	+7	0.7
285	1680	1459.	1460.	-1	0.0

S.D. = 1.4% difference
Major error is probably ± 10 gm. variation in urine bag.

BAG #	BMMD PERIOD^2 SEC^2	RAW MASS GM	-BAG MASS (390 gm)	÷	S.G.	+	SAMPLE =	URINE VOL ML
257:								
Tare	8.54861	--						
900 gm Cal	.42878	--						
315	9.44407	1879.6	390		1.024		115	1569.6
315+313	10.18459	1551.4			1.021		103	1240.5
315+313+774	10.78406	1261.2			1.022		115	967.4
258:								
Tare	8.54619	--						
900 gm	.432247	--						
330	9.37431	1724.3			1.021		102	1408.9
272+330	10.23026	1782.2			1.026		110	1466.9
260:								
Tare	8.56306	--						
	.428722							
320	9.18933	1314.7			1.021		113	1018.7
280	9.22003	1379.1			1.022		107	1075.4
285	8.991782	1765.17			1.024		117	1459.9