APOLLO 14 MISSION REPORT

PLSS/OPS (EVA-1)

The PLSS/OPS performance during the first EVA was excellent, and the telemetry data obtained compares well to data generated during preflight ground testing. (Appendix II). Comparison of the amount of expendables consumed (oxygen and water usage) was good. Based on metabolic determination from oxygen consumption, feedwater usage and thermal balance, the CDR worked at an average rate of 750 BTU/hr while the LMP worked at 900 BTU/hr during this EVA. Both crewmen maintained a comfortable temperature and only the LMP had to change diverter valve positions. Tables I, II, III, and IV provide a listing of expendables used, metabolic rates, assumptions used for calculating metabolic rates, and possible errors and their effects on metabolic rate determination.

Communications Check 52 Minutes

(From power on at 113:08:08 LMP and CDR to fan on at 113:59:40 LMP and CDR). When the RCU switches were properly positioned, communications were good in all modes. The O_2 quantity as indicated on the RCU was 89% for the CDR and 92% for the LMP. Current and voltage readings were normal and all sensors were reading as expected.

The initial POS charge as indicated on telemetry was 1000 psia for the CDR and 1020 psia for the LMP. This compares favorably with pre-flight ground-data, which indicated a 1025 psia charge for the CDR and a 1023 psia charge for the LMP.

The communications check required about 52 minutes because there was confusion as to what position the LM and RCU switches were to be in.

Communications and the telemetry problems were resolved at 113:50:20, about 30 minutes longer than planned.

PLSS Start Up 26 Minutes

(Fan on to feedwater flag clear at 114:25:20 CDR and 114:24:50 LMP). After initial fan start up flow was verified. The PLSS pump of the CDR was started up at 114:13:00 and that of the LMP at 114:13:00. The current and voltage readings were normal during startup; the current stabilized at 2.58 amps for the CDR and 2.7 amps for the LMP. These values are .1 amps lower than those during SESL tests for the CDR and the same value as during SESL for the LMP.

Initial pressurization of the PGA's resulted in a 55 psia pressure drop in POS pressure for the CDR and a 65 psia drop for the LMP. These values are 3 psia and 21 psia higher respectively than data obtained during chamber testing. Initial cabin depressurization began at 114:17:00 and the hatch was opened approximately 4 minutes later. The CDR's low feedwater pressure warning flag deactivated 4 minutes after turning on the feedwater. It took 3 minutes and 30 seconds for the LMP's low feedwater pressure indicator to deactivate.

EVA 278 Minutes

(From feedwater flag clear to feedwater valve closed at 119:03:15 LMP and CDR.)

The CDR began the EVA at 114:26:30 with the diverter valve in the minimum cooling position. Throughout the EVA the CDR remained in minimum cooling. The LMP egressed the LM at 114:35:00 with the diverter valve at the minimum position. Throughout the EVA, the LMP switched between minimum and intermediate positions, making 2 diverter valve changes. The LMP ingressed the LM at 118:57:30 and the CDR was back in the LM at 119:02:00.

Oxygen consumed was 490 psi for the CDR and 725 psi for the LMP. Total EVA time was 4 hours 49 minutes for the CDR and the LMP. The higher oxygen consumption usage rate of the LMP was due to a leak in the system.

PLSS Shut Down 23 Minutes

(From feedwater valve closed to power off at 119:26:00 for the LMP, and for the CDR.)

Cabin repressurization and PLSS shut down went smoothly with no loss of cooling being reported or indicated on telemetry. The crewmen shut off their PLSS oxygen supplies when the cabin pressure reached 2.5 psia. The CDR's POS pressure dropped 40 psi during repressurization while that of the LMP dropped 15 psi. The cabin reached 3.5 psia at 119:08:00. Feedwater pressure dropped off normally, and fan and pump shut downs occured at 119:23:40 for the LMP and 119:23:55 for the CDR. The EVCS mode switch was turned to "O" at 119:26:00 for both crewmen.

PLSS Recharge and Feedwater Collection

The LMP's PLSS oxygen recharge began immediately after cabin repressurization.

LiOH cartridges and batteries were replaced on both PLSS's. Measurements of the feedwater bags were performed similar to those on Apollo 12. When the scale was zeroed, one RCU with a known earth weight was weighed to provide a conversion from lunar kilograms to earth pounds.
Using this factor, the lunar weights of the feedwater, and the initial charge of feedwater, the amount of feedwater used was calculated and a metabolic rate established to compare to rates calculated by the thermal balance method and the oxygen consumption method. Lunar weights of feedwater collected was 0.25 KG and 0.19 KG for the CDR and LMP respectively.
Topping off the PLSS POS was then performed. The POS pressure at the start of the second EVA was 980 psia on both PLSS units, verifying that a full charge had been accomplished.

PLSS/OPS (EVA-2)

Preparation for the second EVA progressed more smoothly than it did for the first EVA, and the actual EVA was completed without EMU problems. Generally, the second EVA was a repeat of the first, with good correlation between telemetry data and chamber test data.
The amount of oxygen and water consumed compared well during this EVA also.
Based on metabolic determinations from O_2 consumption, and

thermal balance, the CDR worked at a rate of 900 BTU/hr and the LMP worked at a rate of 1050 BTU/hr.

Communications Check 8 Minutes

(From power on at 131:36:54 CDR and LMP, to fan on at 131:45 CDR and LMP).

No problem occurred during this portion of the pre-egress activities and communications were good in all modes. The CDR had 85% oxygen and the LMP 85% as indicated on their oxygen quantity gauges. Telemetry indicated 980 psia for the CDR and the LMP.
Current and voltage readings were again normal and warning tones and flags performed properly.

PLSS Startup 8 Minutes

(From fan on to feedwater flag clear at 131:54:00 LMP and CDR.) Fan and pump startups were normal, and the current eventually stabilized at .1 amps lower than ground level tests. Actual current values were nearly the same as those during the first EVA.

Oxygen was turned on at 131:43:15 for the CDR and the LMP. The POS pressure drop during suit pressurization was 65 psi for the CDR and 60 psi for the LMP. These values compare with those during the first EVA quite well; 55 psi for the CDR and 65 psi for the LMP. Cabin depressurization began at 131:47:40, and the hatch was opened about 5 minutes later.

Elapsed time from feedwater on to feedwater flag clear was 3 minutes 26 seconds for the CDR and 3 minutes 26 seconds for the LMP.

EVA 270 Minutes

(From feedwater flag clear to feedwater valve closed at 136:20:50 LMP, and 136:24:00 CDR).

The CDR egressed the LM at 131:53:50, and the LMP followed at 132:00:00. The CDR began the EVA with the PLSS diverter valve in the minimum cooling position, as did the LMP.
Throughout the EVA, the CDR switched between minimum and intermediate cooling. The LMP also changed diverter valve positions between minimum and intermediate cooling.
The LMP ingressed the LM at 136:06:00, and the CDR ingressed at 136:16:30. Oxygen consumption was nominal for the time period with 450 psi being used by the CDR and 680 psi by the LMP.

PLSS Shut Down 6 Minutes

(From feedwater valve closed to power off at 136:30:10 CDR and LMP).

Cooling performance was good from feedwater off to cabin repressurization at 136:23:50. The POS pressure loss during cabin repressurization was 40 psi for the CDR and 20 psi for the LMP. The CDR and LMP shut off their oxygen valves at 136:23:00.

Feedwater pressure dropped off properly, and voltage and current data was normal during fan and pump shutdown. The Mode selector switches were placed in the "O" position at 136:30:10.

MITCHELL

EVA I	AMOUNT PRE EVA	AMOUNT USED			AMT. USED TOTAL	AMOUNT REMAINING	USE RATE DURING EVA	TIME USED (HR)	TIME REMAINING (HR)	TIME AVAILABLE (TOTAL HOURS)
		PRE EVA	EVA	POST EVA						
Oxygen (PSIA)	1020	65	725	15	805	215	157.7 psi/hr	4.88	0.64	5.52
Feedwater (lb.)	8.66	.42	5.23	-	5.65	2.05 usable	1.12 lb/hr	4.69	1.83	6.52
LiOH	-	-	-	-	-	-	-	5.40	4.60 plus	11.00 plus
Power (watt hours)	279	32	217	11	260	19	44.6 watts	6.27	.43	6.70
EVA II										
Oxygen (PSIA)	980	60	670	20	750	230	154.8 psi/hr	4.65	0.74	5.39
Feedwater (lb.)	8.96 (assumed)	.28	6.53	-	6.81	1.32 usable	1.43 lb/hr	4.56	.92	5.48
LiOH	-	-	-	-	-	-	-	5.00	3.00 plus	8.00 plus
Power (watt hours)	279	20	206	< 1	226	53	44.0 watts	5.20	1.20	6.40

TABLE II.

(See pages 11 and 12 for methods of determining expendables data.)

TABLE III.

Summary

EVA I

Shepard

	No Heat Leak No Suit Leak			With Heat Leak (-140BTU/hr) and Suit Leak		
Gas Inlet Temp. D.P. (°F)	68	64	60	68	64	60
Thermal Balance	870	788	717	973	881	810
O_2 Consumption [1]	780	780	780	743	743	743
Feedwater Consumption	628	628	628	740	740	740

Mitchell

Gas Inlet Temp. D.P. (°F)	73	69	65	73	69	65
Thermal Balance	895	795	710	988	888	803
O_2 Consumption [2]	1220	1220	1220	900	900	900
Feedwater Consumption	777	777	777	889	889	889

EVA II

Shepard

	No Heat Leak No Suit Leak			With Heat Leak (+135 BTU/hr) and Suit Leak		
Gas Inlet Temp. D.P. (°F)	71	67	63	71	67	63
Thermal Balance	1017	916	839	927	826	749
O_2 Consumption [3]	1080	1080	1080	900	900	900
Feedwater Consumption	Not Avail.			Not Avail.		

Mitchell

Gas Inlet Temp. D.P. (°F)	73	69	65	73	69	65
Thermal Balance	1268	1168	1082	1178	1078	992
O_2 Consumption [4]	1210	1210	1210	1050	1050	1050
Feedwater Consumption	Not Avail.			Not Avail.		

1. Assumed leakage used is that during PIA
2. Assumed leakage = 300 scc/min
3. Assumed leakage = 175 scc/min
4. Assumed leakage = 150 scc/min

TABLE IV

METABOLIC DETERMINATION ASSUMPTIONS

O_2 Consumption

Assumptions - R.Q. = 0.85 (input from Humbert)

Feedwater

Assumptions:

% heat generated by CO_2/LiOH = 0.276 (metabolic)
For EVA I: Heat Leak = -140 BTU/hr

Thermal Balance

Ventilation Loop + Liquid Transport Loop

Assumptions:

Ventilation flow - Based on PLSS/PGA PIA performance data corrected for LiOH cartridge and wet system.
Liquid flow - Based on PLSS/LCG performance data corrected for temperature.
EVA I: Heat Leak = -140 BTU/hr EVA II: Heat Leak = 135 BTU/hr

Possible Errors

O_2 Consumption

PGA leakage	- 1 cc/min	1 BTU/hr
R.Q.	- 0.01 change	2 BTU/hr
O_2 pressure	- 1 psi	2 BTU/hr

Feedwater

EVA II - 0 - 0.6# H_2O remaining in the sublimator - 0-130 BTU/hr

Heat leak - 100 BTU (neg)/hr 80 BTU/hr increase

Heat storage - 0-100 BTU 20 BTU/hr

Thermal Balance

Heat Storage	- 0-100 BTU	20 BTU/hr
Flow (liquid)	- 0.1#/min	6 BTU/hr
Delta T	- 0.1°F	25 BTU/hr
Vent Flow	- 0.1# 1 hr	4 BTU/hr
Dew Point	- 1°F	20 BTU/hr

EMU HEAT LEAKS

EVA	Condition[a]		Heat leak, Btu/hr
	Sun angle, deg	EMU	
1	12	Clean	-140
2	25	Partially dirty	+135

[a]Rough lunar plane.

METHODS OF DETERMINING EXPENDABLES DATA

Oxygen

A). Amount Pre EVA: For both EVA I and II, this is the quantity of O_2 each crewman had prior to turning on the O_2 valve

B). Amount Used Pre EVA: This is the amount of oxygen used to pressurize the PGA

C). Amount Used - EVA: This is the amount of oxygen used during the actual EVA, time span being from after initial suit pressurization to before cabin repressurization. This is the time period used to calculate the oxygen use rate

D). Amount Used - Total: This is the amount used during EVA and pre EVA

E). Amount Remaining: This is the amount of oxygen remaining just before cabin repressurization

F). Use Rate During EVA: This is the amount of oxygen used during EVA di ided by the time discussed in section G

G). Time Used: This is the time period where the usage rate is stable - from after suit pressurization to before cabin repressurization

H). Time Remaining: This is calculated using the use rate during EVA and the usable amount remaining. The usable amount remaining is that amount remaining just before cabin repressurization less 135 psi

I). Time Available: This is the time used plus the time remaining. Time used is from O_2 on to O_2 off

Feedwater

A). Amount Pre EVA: For EVA I this is the delta weight of the PLSS when charged for flight at KSC. For EVA II it is the same weight as EVA I (assumed) plus .30 lb. assumed to be left in the line to the sublimator

B). Amount Used Pre EVA: This is the amount of feedwater used to dissipate heat built up prior to turning the pump on

C). Amount Used - EVA: For EVA I, this is determined by taking the amount of pre EVA feedwater (corrected for hose expansion) and subtracting the amount collected using feedwater collection bag weights (corrected for slave water and bag weight). From this number is subtracted the amount of feedwater used in pre EVA. For EVA II, it is calculated using a metabolic rate based on O_2 consumption

D). Amount Used - Total: This is the amount used during EVA plus the amount used to dissipate heat built up prior to EVA

E). Amount Remaining: For EVA I, this is the amount collected by the feedwater collection bag less the bag weight. For EVA II it is calculated using a metabolic rate based on O_2 consumption

F). Use Rate During EVA: This is the amount of feedwater used during EVA divided by the time from feedwater ON to feedwater OFF

G). Time Used: This is the feedwater ON to feedwater OFF time

H). Time Remaining: This is calculated using the use rate during EVA and the amount remaining (usable)

I). Time Available: This is the time used plus the time available or the total EVA time before the feedwater would have been depleted

LiOH

The -6 PLSS LiOH expendable curve was used to determine the time remaining.

Power

Although 279 watt hours is the specification minimum pre EVA power available, PLSS batteries have always exceeded this and the lowest ever recorded was 282 watt hours.

APPENDIX I

Appendix I METABOLIC DETERMINATIONS

Metabolic rates were determined by thermal balance, oxygen consumption, and feedwater consumption.

Thermal balance consists of adding the heat absorbed by the Transport Water Loop and the Oxygen Vent Loop to obtain the total amount of heat generated by the crewman. The metabolic rate exerted upon the Transport Water Loop is equal to the LCG ΔT multiplied by the LCG Flowrate. The LCG ΔT is obtained from the actual EVA data, and the LCG flowrate is obtained from the preflight PIA data. The metabolic rate is then multiplied by the time span involved to determine the total amount of heat input by the crewman to the Transport Water Loop.

Heat Load on the Oxygen Vent Loop is determined by calculating the change in enthalpy of the vent loop from sublimator gas outlet to gas inlet. Various gas inlet dew point temperatures are assumed. The Vent Loop flowrate is then determined from the intersection of the curves of the PLSS fan ΔP vs Flowrate and PGA ΔP vs Flowrate. The PLSS fan ΔP is corrected for LiOH cartridge and wetted loop, while the PGA ΔP is corrected for altitude and flowrate. Multiplication of enthalpy change and the Vent Loop flowrate yields the total heat load output of the crewman to the Vent Loop.

The time period used for the oxygen consumption method is that where the usage rate stabilized to a nearly constant rate. The equation used is an empirical one. Knowing starting and final POS pressures over this given time span, the weight of oxygen used is calculated using the Universal Gas Law, $P = \rho zRT$, where P is pressure, T is temperature, ρ is density, and z is the compressibility factor. Compressibility factors are obtained from references stated in "Compressibility Factors for Oxygen for Temperatures from 490°R to 620°R and for Pressures from 200 psia to 3600 psia", Report No. 5-2940-2-HOU-980 (CSD), April 8, 1970, by R.V. Monzingo. The weight of oxygen consumed is then used in the empirical equation, and metabolic rate is determined.

Feedwater consumption method is used to determine the metabolic rate by the amount of feedwater used during the EVA. The time period used is from feedwater on to feedwater off. This method was not used for EVA II because no feedwater collection was made after this EVA.

The feedwater used to dissipate heat prior to EVA is determined by calculating the heat load built up by the system prior to EVA. The system builds up heat from helmet on to feedwater on. Sources of the heat are the crewman, $LiOH/CO_2$ reaction, electrical load, and the formation of ice in the sublimator. It was assumed that the crewman built up heat at a rate of 600 BTU/hr and that 0.6 lb. of water freezes in the sublimator during the time from helmet on to feedwater on.

Final Metabolic Rates

EVA I

Shepard

There is excellent correlation between metabolic rates based upon feedwater consumption and oxygen consumption. The O_2 consumption method using no oxygen leakage shows that the maximum metabolic rate at which the CD worked is about 780 BTU/hr. Assuming an O_2 leak rate the same as during preflight PIA data gives a metabolic rate of 743 BTU/hr. This agrees with the feedwater consumption method which produces a metabolic rate of 628 BTU/hr assuming no heat leak, and a rate of 740 BTU/hr with a heat leak of -140 BTU/hr. This value of the heat leak is gotten from the Apollo EMU Performance Data Book.

From these two results, it is likely that the CDR's metabolic rate was about 750 BTU/hr.

The results of the thermal balance method do not agree with this result. However, the thermal balance method is the least accurate of the three methods. As is shown in Table IV, there are many sources of error involved in this method. It is possible that neither Transport Water flow nor Oxygen Vent Flow were as expected by preflight PIA data. The ΔT readout may have been in error, and the gas inlet dewpoint is unknown.

It is reasonable to assume that the thermal balance method does not dispute the results determined by the other two methods, and that the CD 's metabolic rate was 750 BTU/hr.

Mitchell

Feedwater consumption shows that the LMP worked at a metabolic rate of 859 BTU/hr, including heat leak. From this result, it is likely that the metabolic rate was about 900 BTU/hr during this EVA. Oxygen consumption with zero O_2 leakage yields a metabolic rate of 1220 BTU/hr. However, the LMP did have a high oxygen leakage rate. It is reasonable to assume that the leakage was about 300 scc/min, which would make the metabolic rate 900 BTU/hr, which agrees with the feedwater consumption method.

In addition, thermal balance method with a gas inlet dewpoint of 69°F shows a metabolic rate of 888 BTU/hr, including the -140 BTU/hr heat leak. Tests run at MSC show that this is a reasonable dewpoint temperature. Despite errors involved, thermal balance method in this case substantiates well the result gotten from the feedwater consumption method.

<u>EVA II</u>

<u>Shepard</u>

No feedwater measurement was made after EVA II, so feedwater used is unknown. Results obtained from the thermal balance and O_2 consumption methods give a range of metabolic rates from 800 - 1000 BTU/hr. It can be concluded that the CDR worked at an average metabolic rate of 900 BTU/hr. An O_2 leakage of 175 scc/min would result in a metabolic rate of 900 BTU/hr. It is not unlikely that the leakage rate for the CDR during this EVA would be on that order. Heat leak during EVA II was +135 BTU/hr. This value of the heat leak is gotten from the Apollo EMU Performance Data Book.

<u>Mitchell</u>

As for the CDR, no feedwater collection was taken for the LMP after this EVA, so no exact metabolic rate can be pinpointed. However, results obtained show that the metabolic rate was between 850 and 1250 BTU/hr. Using the same O_2 leakage as in EVA I gives a metabolic rate of 900 BTU/hr by the Oxygen Consumption Method. Thermal balance calculations give metabolic rates of up to 1200 BTU/hr.

The only conclusion which can be drawn is that the metabolic rate was between 900 and 1200 BTU/hr, or about 1050 BTU/hr.

I. Thermal Balance Method (Zero Heat Leak)

A. Transport Water Loop
Shepard EVA I

MR = LCG T x LCG F/R
ML = MR x t

Time Period	t	T	LCG Av. T	LCG F/R (PPM)	LCG F/R (PPH)	MR (BTU/hrs)	HL (BTU)
114:19 to 115:32	1:13 1.217	1.50	81	4.30	258	387	471
115:32 to 119:08	3:36 3.6	2.02	73.8	4.38	263	531	1910

Total ML = 2381 BTU

Mitchell EVA I

Time Period	t	T	LCG Av. T	LCG F/R (PPM)	LCG F/R (PPH)	MR (BTU/hrs)	HL (BTU)
114:19 to 114:32	:13 .217	1.0	85.5	4.03	242	242	52.5
114:32 to 117:24	2:52 2.867	1.75	76.9	4.35	261	456	1310
117:24 to 117:28	:04 .067	4.4	70.2	4.31	259	1140	76
117:28 to 119:08	1:40 1.67	1.7	75.6	4.35	261	443	740

Total ML = 2178.5 BTU

Shepard EVA II

Time Period	t	T	LCG AV. T	LCG F/R (PPM)	LCG F/R (PPH)	MR (BTU/hrs)	HL (BTU)
131:48 to 133:40	1:52 1.867	1.45	79.7	4.34	26 .5	378	705
	:02 .033	4	80	4.4	264	1057	35.2
	:02 .033	4	79	4.40	264	1057	35.2
	:07 .1166	5.6	75.8	4.45	267	1495	174
	1:02 1.0333	4.2	63.6	4.50	270	1134	1172
135:14 to 136:23	1:09 1.15	1.8	72.4	4.40	264	475	526
	:10 .167	2.0	81.3	4.33	260	520	86.5

Total ML = 2733.9 BTU

Mitchell EVA II

Time Period	t	T	LCG AV. T	LCG F/R (PPM)	LCG F/R (PPH)	MR (BTU/hrs)	HL (BTU)
131:48 to 133:26	1:38 1.633	1.7	76.4	4.29	257.5	437	713
133:26 to 134:08	:42 .7	4.8	61	4.58	275	1320	923
134:08 to 134:42	:34 .567	1.7	75.9	4.35	261	444	251.5
134:42 to 136:23	1:41 1.683	4.1	61.5	4.57	274	1123	1890

Total ML = 3777.5 BTU

B. O_2 Vent Loop

Shepard EVA I

Flow = 6.32 acfm = 8.08 pph

From psychrometric charts	h(42°F DP)	h(In. DP)	Δh
68°F inlet dew point and 42°F outlet D.P.	33	80.5	47.5 BTU/lb
64°F inlet dew point and 42°F outlet D.P.	33	70.1	37.1
60°F inlet dew point and 42°F outlet D.P.	33	61.1	28.1

Dry F/R = 8.08 (1-.022) = 7.90 pph
MR = 47.5 BTU/lb x 7.90 pph = 375 BTU/hr — 68°F D.P.
LM = 375 BTU/hr x 4.817 hr = 1808 BTU

MR = (37.1) (7.90) = 293 BTU/hr — 64°F D.P.
HL = (293) (4.817) = 1412 BTU

MR = (28.1) (7.90) = 222 BTU/hr — 60°F D.P.
HL = (222) (4.817) = 1070 BTU

Mitchell EVA I

Flow = 6.22 acfm = 7.95 pph

From psychrometric charts	h(47°F DP)	h(In. DP)	Δh
73°F inlet dewpoint and 47°F outlet D.P.	39.2	96	56.9 BTU/lb
69°F inlet dewpoint and 47°F outlet D.P.	39.2	83.4	44.2
65°F inlet dewpoint and 47°F outlet D.P.	39.2	72.4	33.2

Dry F/R = 7.95 (1-.0245) = 7.76 pph
MR = (56.9) (7.76) = 442
HL = (442) (4.817) = 2127

MR = (44.2) (7.76) = 343
HL = (343) (4.817) = 1651

MR = (33.2) (7.76) = 258
HL = (258) (4.817) = 1240

O_2 Vent Loop

Shepard EVA II

Flow = 6.32 acfm = 8.08 pph

From psychrometric charts	h(45°F D.P.)	h(In. D.P.)	Δh
71°F inlet D.P. and 45°F outlet D.P.	36.8	90.0	53.2 BTU/lb
67°F inlet D.P. and 45°F outlet D.P.	36.8	77.3	40.5
63°F inlet D.P. and 45°F outlet D.P.	36.8	67.5	30.7

Dry F/R = 8.08 (1-.022) = 7.90
MR = (53.2) (7.90) = 420
HL = (420) (4.583) = 1928

MR = (40.5) (7.90) = 320
HL = (320) (4.583) = 1468

MR = (30.7) (7.90) = 243
HL = (243) (4.583) = 1112

Mitchell EVA II

Flow = 6.22 acfm = 7.95 pph

From psychrometric charts	h(47°F D.P.)	h(In. D.P.)	Δh
73°F inlet D.P. and 47°F outlet D.P.	39.2	96	56.9 BTU/lb
69°F inlet D.P. and 47°F outlet D.P.	39.2	83.4	44.2
65°F inlet D.P. and 47°F outlet D.P.	39.2	72.4	33.2

Dry F/R = 7.95 (1-.0245) = 7.76 pph
MR = (56.9) (7.76) = 442
HL = (442) (4.583) = 2030

MR = (4.42) (7.76) = 343
HL = (343) (4.583) = 1572

MR = (33.2) (7.76) = 258
HL = (258) (4.583) = 1183

EVA I

Shepard

Assumed Gas I let Temp D.P.	68	64	60
ML (Vent)	1808	1412	1070
ML (T/W)	2381	2381	2381
Total ML (BTU)	4189	3793	3451

EVA time 4.817 hrs.

M/R (BTU/hr)	870	788	717
Av. M/R (BTU/hr)		792	

Mitchell

Assumed Gas Inlet Temp D.P.	73	69	65
ML (Vent)	2127	1651	1240
ML (T/W)	2179	2179	2179
Total ML (BTU)	4306	3830	3419

EVA time 4.817 hrs.

M/R (BTU/hr)	895	795	710
Av. M/R (BTU/hr)		800	

EVA II

Shepard

Assumed Gas I let Temp D.P.	71	67	63
ML (Vent)	1928	1468	1112
ML (T/W)	2734	2734	2734
Total ML (BTU)	4662	4202	3846

EVA time 4.583 hrs.

M/R (BTU/hr)	1017	916	839
Av. M/R (BTU/hr)		924	

Mitchell

Assumed Gas I let Temp D.P.	73	69	65
ML (Vent)	2030	1572	1183
ML (T/W)	3778	3778	3778
Total ML (BTU)	5808	5350	4961

EVA time 4.583 hrs.

M/R (BTU/hr)	1268	1168	1082
Av. M/R (BTU/hr)		1173	

II. O_2 Consumption Method

EVA I

Shepard

$$ML = \frac{O_2 \text{ used} - O_2 \text{ leaked}}{.0001648}$$, RQ = 0.85 (see page 26)

Time: 114:38 to 119:06 = 4:28 = 4.467 hrs.

At 114:38 POS pressure = 945 psia, O_2 Wt. = 1.190 lb.

At 119:06 POS pressure = 490 psia, O_2 Wt. = 0.615 lb.

O_2 used = 1.190 - 0.615 = 0.575 lb.

For zero O_2 leakage, O_2 used - O_2 leaked = 0.575 lb.

$$ML = \frac{0.575}{.0001648} = 3490 \text{ BTU}$$

$$ML = \frac{3490 \text{ BTU}}{4.467 \text{ hrs.}} = 780 \text{ BTU/hr}$$

For preflight PIA data, suit leakage was 147 scc/min

$$147 \times \frac{180}{740} = 35.8 \text{ scc/min at altitude}$$

O_2 leaked = 35.8 scc/min x 2.92 x 10^6 lb/scc x 268 min = 0.028 lbs.

O_2 used - O_2 leaked = 0.575 - 0.028 = 0.547 lb.

$$ML = \frac{0.547}{.0001648} = 3320 \text{ BTU}$$

$$ML = \frac{3320 \text{ BTU}}{4.467 \text{ hrs.}} = 743 \text{ BTU/hr}$$

Mitchell

Time: 114:30 to 119:06 = 4:36 = 4.6 hrs.

At 114:30 POS pressure = 960 psia, O_2 Wt. = 1.213 lb.

At 119:06 POS pressure = 235 psia, O_2 Wt. = 0.288 lb.

O_2 used = 1.213 - 0.288 = 0.925 lb.

For zero O_2 leakage, MR = 1220 BTU/hr

From preflight PIA data, suit leakage was 70 scc/min, 17.0 scc/min at altitude.

MR = 1202 BTU/hr

EVA II

Shepard

Time: 132:12 to 136:20 = 4:08 = 4.133 hr.

At 132:12 POS pressure = 910 psia, O_2 Wt. = 1.150 lb.

At 136:20 POS pressure = 335 psia, O_2 Wt. = 0.415 lb.

O_2 used = 1.150 - 0.415 = 0.735 lb.

For zero O_2 leakage, MR = 1080 BTU/hr

Using preflight PIA leakage, MR = 1042 BTU/hr.

Mitchell

Time: 132:00 to 136:20 = 4:20 = 4.333 hr.

At 132:00 POS pressure = 920 psia, O_2 Wt. = 1.157 lb.

At 136:20 POS pressure = 250 psia, O_2 Wt. = 0.293 lb.

O_2 used = 1.157 - 0.293 = 0.864 lb.

For zero O_2 leakage, MR = 1210 BTU/hr.

Using preflight PIA leakage, MR = 1192 BTU/hr.

Empirical Equation for Metabolic Load by O_2 Consumption

$$\text{Metabolic Load} = \frac{O_2 \text{ used} - O_2 \text{ leaked}}{.0001708 - \frac{(RQ-0.707)}{(0.293)}(.0000123)}$$

For RQ = 0.85, the equation reduces to:

$$\text{Metabolic Load} = \frac{O_2 \text{ used} - O_2 \text{ leaked}}{.0001648}$$

III. Metabolic Rate Based on Feedwater Consumed

Shepard EVA I

RCU Earth Weight = 5.14 lb.
RCU Lunar Weight = 0.382 kg

$$\frac{5.14 \text{ lb.}}{0.382 \text{ kg.}} = 13.52 \text{ lb/kg}$$

Lunar weight of feedwater bag from Shepard's first EVA = 0.25 kg
Earth weight of dry feedwater bag = 0.47 lb.
Feedwater collected = (lunar weight x 13.52) - 0.47
= (0.25 kg x 13.52 lb/kg) - 0.47 lb.
= 2.91 lb.

Initial charge = 8.59 - .13 (due to hose expansion)
= 8.46 lb.

Feedwater used = Initial charge - (feedwater collected + 0.83 slave water)
= 8.46 - (2.91 + .83)
= 4.72 lb.

Feedwater used to dissipate heat built up prior to EVA =

$$\frac{(1.276)(600)(.361) + (182)(0.6) + 54.6}{1038}$$

= 0.42 lb.

Feedwater used during EVA = 4.72 - 0.42 = 4.30 lb.

$$\text{Metabolic Rate} = \frac{\text{Heat of Conversion x Weight - Electrical Load}}{(1.276)(4.7)}$$

NOTE: The constant 1.276 provided by HSD accounts for the percent of heat generated by the CO_2/LiOH reaction.

The cabin temperature prior to EVA I was 70°F (D. Boydston EC6)

$$MR = \frac{\text{Heat of conversion x Weight - Electrical Load}}{(1.276)(4.7)}$$

$$= \frac{[1075.8 - (T_{cabin} - 32)]\ 4.30 \text{ lb.} - 690}{6.00}$$

$$= \frac{(1037.8)\ 4.30 - 690}{6.00} = \frac{3770}{6.00} = 628 \text{ BTU/hr}$$

Mitchell EVA I

Feedwater used = 5.60 lb.

Feedwater used during EVA = 5.60 - 0.42 = 5.18 lb.

$$MR = \frac{(1037.8)\ 5.18 - 716}{6.00} = \frac{4654}{6.00} = 777 \text{ BTU/hr}$$

Electrical Load

Shepard EVA I

43 x 3.415 x 4.7 = 690 BTU

Mitchell EVA I

44.6 x 3.415 x 4.7 = 716 BTU

Feedwater used to dissipate heat prior to EVA

Heat Load due to crewman: (600)(.361) = 216.5 BTU
Heat Load due to Li●H/CO_2 reaction: (.276)(600)(.361) = 59.7
Heat Load due to ice formed in sublimator: .6[144 + (70-32)] = 109.1
Heat Load due to Electrical Load = 54.6
Total Heat Load = 439.9 BTU
Heat of Conversion = 1038 BTU/lb.