SMEAT FINAL REPORT

DTO 71 - 11

APPENDIX I - SPECIAL TESTS

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APPENDIX I

A. Breakout Cable/PDP 8-e Operation

An initial SMEAT 5 psia wet run occurred on July 10, 1972. Data from this test were difficult to interpret and raised questions regarding the performance of the metabolic analyzer. It became apparent that knowledge of metabolic analyzer transducer outputs was required to quantitatively describe performance of the metabolic analyzer. A breakout cable was installed on the SMEAT metabolic analyzer before the second 5 psia wet run. Table A-1 lists the variables that were then available to be monitored.

The breakout cable was connected to an electrical feedthrough in the chamber wall. The cable extended from outside the chamber to a platform immediately above the chamber. At this point the cable interfaced with a 24 channel calibration/buffer box. Each signal was buffered by feeding it through a high input, low output impedance unity gain amplifier. Twelve analog outputs were monitored on Brush 260 stripchart recorders. Additional analog signals were patched to a PDP 8-e digital computer.

The digital minicomputer (PDP 8-e) was used to check the computational accuracy of the Metabolic Analyzer (MA) analog computer. The use of a digital computer sampling analog signals allowed simultaneous calculation of gas exchange parameters using four different sets of equations describing mass balance. Two of these sets of equations are identical with the equations implemented in the MA for Mode 1 and Mode 2. The other two sets of equations are Mode 1 and Mode 2 calculations, but do not use the gas fraction of water measured by the mass spectrometer.

Instead, the temperature of the exhalation spirometer was monitored, and the water fraction was calculated by assuming the spirometer gas was saturated at that temperature. The calculated gas volume at standard temperature and pressure (STP) was then reduced to dry conditions by multiplying the STP volume by $(1-F_{H_2O})$. The Mode 1 and Mode 2 calculations were performed using dry gas volumes and dry gas fractions.

The accuracy and repeatability of the digital calculations were checked by monitoring the MA during an end-to-end calibration run using a known gas mixture and hand pump.

Simultaneous calculation of the four sets of equations using MA transducer data quantitated several sources of errors in the MS. The excessively high fraction of water measured by the mass spectrometer caused MA Mode 2 calculations of O_2 consumption and CO_2 production to be 4 - 5% low. This same error in water fraction caused Mode 1 O_2 consumption to be measured 10 - 20% high. In addition, correct Mode 1 operation was shown to be dependent on exact volume matching of inspired and expired volume spirometers.

B. Major Problem Areas

1. Quantitative Carbon Dioxide and Water Measurement.

The temperature of the exhalation spirometer was monitored concurrently with Mass Spectrometer (MS) water signal and no consistent relationship was demonstrated. Because partial pressure of water vapor is a function of temperature, a specific relationship between exhalation spirometer temperature and MS water signal was expected. We continually observed higher water readings than anticipated according to indicated spirometer temperature. Either the thermistor in the exhalation spirometer does not indicate true exhaled air temperature or the mass spectrometer is measuring water too high. Tests run on DVTU #2 verify that the spirometer thermistor is sufficiently accurate. Therefore, the mass spectrometer is measuring water too high, possibly due to an error in the water gain.

Carbon dioxide quantitation initially appeared to be interlocked with water measurement. MA data compared with Douglas bag data indicated that carbon dioxide was measured higher by the metabolic analyzer than by Douglas bags. In the laboratory, we have been unable to demonstrate a "loss" of carbon dioxide by the Douglas bags. This discrepancy between the MA and the laboratory standard is attributed to operation of the mass spectrometer in the SMEAT MA. Whether or not this problem is one of calibration or malfunction remains to be determined. However, data from the laboratory DVTU MA at sea level show carbon dioxide values similar to Douglas bag data.

Extensive post-SMEAT evaluation of the mass spectrometer is planned at Perkin-Elmer, Pomona, California. Resolution of the water/carbon dioxide measurement problem will await completion of these tests.

2. Variability in Hand Pump Calibration.

Initial hand pump calibrations showed large variability in computed data. The respiratory valves were suspect because they allowed blow-by due to their low cracking pressure. A study was performed in our laboratory to determine if the flight configuration crew valves were acceptable for end-to-end calibration of the MA. The report titled, The Effect of Different Valves on Calibration of the Metabolic Analyzer, by A. Paul Schachter, dated August 18, 1972, has been circulated to

MSFC and DE4 personnel. Briefly, it was concluded that crew valves were satisfactory for delivering known gas volumes to the MA if the pump was stroked slowly rather than rapidly.

Monitoring SMEAT hand pump calibrations demonstrated two additional sources of error; performance of sample and hold circuits for STP volumes and the trigger concept. STP sample and hold data were shown to correlate poorly with the raw spirometer volumes, e.g., 0.93 instead of the anticipated 1.0 correlation. Further investigation indicated that this problem may be unique to the SMEAT MA due to the "filter" capacitors used in the calibration voltage follower box. MA DVTU #2 consistently has shown a high correlation between STP and raw volumes (Figure A-1).

3. Trigger Circuit.

The trigger circuit design becomes problematic for two reasons; the trigger signal occurs at or near zero air flow, and there is no requirement that the next half of a breath cycle be initiated before the volume data from the preceding half are used for computation. Therefore, Mode 1 operation is impaired by normal human respiratory patterns such as coughs, slow air flow rates, etc.

A new trigger concept was studied briefly. It would make Mode 1 functional, but lower the overall reliability of the MA by making the dump of each spirometer dependent upon the other spirometer. Therefore, failure of any portion of the inspiration spirometer circuit or associated hardware would result in total loss of the MA data.

4. Ear Plethysmograph.

Ear plethysmograph performance has been the subject of extensive debate among crewmen. It appears that the ear plethysmograph measures heart rate reasonably well within the 60 - 120 beats/min. range. However, most data indicate that the plethysmograph heart rate is low relative to the VCG heart rate above the 120 beats/min. level. A comparison between VCG and plethysmograph heart rates for the three crewmen can be seen in Table A-2. Performance of this unit will be rechecked during post-SMEAT testing.

5. Dump Valve.

On SMEAT day 18, significant problems were encountered with the inspiration spirometer dump valve. Stripchart data indicate that the spirometer dump valve hung open during the run on SPT. The exact failure is uncertain, but most likely relates to either a temporarily clogged N_2 gas orifice or a seal that caused the ball valve to stick open.

6. Vital Capacity and Minute Volume Circuitry.

Starting with the SPT test on SMEAT day 27, the vital capacity and minute volume data were recorded to be approximately 60% high. On SMEAT day 30, the MA data were credible for the CDR at 1230 hours, but by 1600 hours when PLT was run, the data were again 40 - 60% high. SPT was run at 1745 hours and the data were again high. However, the data for SMEAT day 36 appeared "normal" for all crewmen. The next obvious failure occurred during PLT's special test on SMEAT day 43 at 1545 hours. Data for SPT on that date were also high by the 40 - 60% figure seen previously. For the remainder of SMEAT, the MA data for vital capacity and minute volume were credible.

In summary, an intermittent failure has been observed which produces high measurements for vital capacity and minute volume. It appears to be related to MA temperature. Fortunately the STP volume, required for computation of oxygen consumption and carbon dioxide production, is not affected by this anomaly. Post-SMEAT the failure was identified in a multiplier required to go from $V_{E_{STP}}$ to $V_{E_{STPD}}$.

7. Ergometer Failure.

The original SMEAT ergometer failed during a personal exercise period with SPT as subject. Examination indicated that 5 of 12 brushes had separated from the brush ring and the torque sensor had failed. At this time MSFC disclosed to us that we did not have a flight type ergometer as earlier stated. Apparently the only significant difference was in the type of brush ring, and in the fact that the DVTU armature turns "into" the brush ring rather than "away from" the brushes.

A flight configuration brush ring was installed in the SMEAT ergometer and the unit was recalibrated and returned to the chamber. Within approximately one week, the ergometer failed again. The characteristics noted were a loud grinding noise and a very high load after 29 min. at 300 watts. Inspection of the ergometer following its removal from the chamber failed to demonstrate the problem. A subsequent 36 min. run at 300 watts on a calibrator resulted in failure of the unit. Again, the failure was characterized by excessively high loads rather than unloading. In both cases, the failure was the torque sensor. This failure of the ergometer must be investigated and understood to prevent such occurrence inflight.

C. Special Tests

1. Extended hand pump calibration MA.

After installation of the breakout cable it was necessary to provide known transducer signals to calibrate the PDP 8-e digital computer. The SMEAT crewmen were given instructions to perform a hand pump calibration according to standard procedures, then to repeat the 1.5 liter and 2.5 liter steps twice, and finally, to perform the 3.5 liter step four times. Outside observers monitored each test and were able to judge the reproducibility of the pump stroke sizes in each case.' In all instances, it appeared that the spirometer potentiometer voltages (raw volume signals) were repeatable to better than 0.1 volt.

The results of the hand pump calibrations are summarized in Figures A-1 - A-7. In each case the MA or the PDP 8-e data were plotted as ordinates versus the data computed from the known inputs. Figures A-2 and A-3, respectively, show the reproducibility of $\dot{V}_{O_2}$ data from the MA and the PDP 8-e digital computer. Since both computers utilized the same input data, the data spread about the line of identity reflects the computational accuracy of each system. Similarly, $\dot{V}_{CO_2}$ data are shown in Figures A-4 and A-5, and minute volume data in Figures A-6 and A-7 for the MA and the PDP 8-e.

The computational accuracy of the PDP 8-e was demonstrated by these calibration tests. MA data variability is attributed primarily to variability of the sample/hold circuits for STP volume. Post-SMEAT, this variability was identified as resulting from a capacitor filter on each voltage follower channel of the calibration box. Switching the filters out eliminated most of the variability in the STP sample/hold circuits.

2. Metabolic gas samples via glass syringes.

Respiratory exchange ratio data indicated that carbon dioxide production was 10 - 20% higher on the SMEAT metabolic analyzer than previously measured for the crewmen. It was felt that this could be attributed to improper gas analysis by the SMEAT MA mass spectrometer. In order to check the mass spectrometer analyses of expired air, samples were obtained using 100 cc glass syringes. These samples were passed out the transfer lock and analyzed in duplicate for O_2 and CO_2 content by the micro-Scholander method.

Originally there were to be six sample syringes utilized. One was for a cabin air sample and the others were for exhaled air samples. Two syringes were broken before the experiment began. Of the remaining four syringes, the SMEAT crew filled two with cabin air and the other two with mixed expired air.

The procedures are given below. The results of Scholander analyses are tabulated in Table A-3.

M 171 SPECIAL PROCEDURE

I. PRELIMINARY STEPS

   A. Match syringe pistons and barrels

   B. Lubricate pistons with crytox and assemble syringes

II. IDENTIFICATION OF SAMPLING TIME

   A. Reference subject (i.e., - CDR), event time from ESS display and syringe number (i.e., - W7862)

   B. Voice record start of sampling period

III. SAMPLING PROCEDURE

A. Cabin air-flush syringe three (3) times, then fill to 100 cc mark and close luer stopcock valve

B. Mixed expired air samples

1. Attach metal sample probe

2. Insert probe as far as possible into end of exhaled air standpipe

3. Flush syringe three (3) times

4. Draw exhaled air sample into syringe and close luer stopcock to isolate syringe sample

IV. SAMPLING TIMES

A. Cabin air - before event time 21:00

B. Second workload - event time 12:00 to 11:00

C. Third workload - event time 7:00 to 6:00

V. SYRINGE TRANSFER

A. Pass out sample syringes in large garbage bag within three hours after last test, preferably at regularly scheduled transfer time.

In explanation, cabin air sample D-2500 may have been slightly diluted with ambient air (80% N_2, 20% O_2) as was exhaled sample W-7862. Neither of these is a reliable sample. Exhaled air sample W-7312 indicated that the sample syringe did not extend far enough up the exhalation dump tube. The oxygen and carbon dioxide fractions indicated a cabin air dilution of the mixed, exhaled air.

The lack of satisfactory results from these tests led to the initiation of a series of Douglas bag collections.

3. Douglas Bags

Douglas bag collections were planned for SMEAT using the following protocol for each subject:

Bag #	SAMPLE
1	20 pumps (3.5 l stroke) of cabin air
2	10 minute rest sample
3	Final 3 minutes at first work level
4	Final 3 minutes at second work level
5	Final 2 minutes at third work level

At least three sets of bags were obtained for each subject during the five inflight Douglas bag collections. The test dates were August 25 (238) and August 26 (239), 1972, and September 7 (251), September 13 (257) and September 18 (262), 1972. Twelve bags were available to the crew for each two-subject run. The extra bags were generally used to obtain an additional sample at each subject's last work level. During each run, the Crew Systems Division personnel were requested to hold chamber nitrogen level as stable as possible. This was necessary because of the sensitivity of the metabolic calculations to nitrogen levels. The data from the Douglas bag collections are summarized in Table A-4. The mean oxygen consumption values for each crewman fall near the middle of the 95% C.I. of his baseline data. The respiratory exchange ratio data were within normal limits, indicating that the high values noted from the SMEAT MA were incorrect.

4. Silica Gel Drier Test

Early in the development of the MA a silica gel drier was incorporated into the system to lower the dewpoint of the exhaled air. However, a negative aspect of silica gel was that it apparently adsorbed CO_2 on the trapped water. The CO_2 adsorption was expected to produce MA data that had low respiratory exchange ratios. With the exception of the rest data from the first subject (CDR), the respiratory exchange ratios were higher than perviously noted. Therefore, the cannister appeared to saturate with CO_2 long before it lost its capability to adsorb moisture. The data are summarized in Table A-5.

Water levels remained stable at 1.5% during the CDR's test, 1.8% during the PLT's test, and began to rise from 2.4 to 4.0% during the SPT's test. Therefore, in spite of the low water levels, CO_2 was still being measured higher than anticipated according to the Douglas bag technique. The implication is that the mass spectrometer CO_2 gain was being set too high. This may have been the summation of two separate problems: (1) the mass spectrometer CO_2 gain was adjusted for a gas thought to contain 14.3% CO_2 when, in fact, it contained only 14.0% CO_2, (2) the CO_2 gain is adjusted while some cabin air dilution is present in the gas being sampled.

5. Effect of short-term changes in cabin atmosphere on MA measurement of metabolic rate

Initial M 171 runs at altitude indicated oxygen consumption data were very sensitive to small changes in the quantity (fraction)of nitrogen in the chamber atmosphere. This computational sensitivity results from two facts: (1) The MA analog computer stores cabin air composition at the onset of each test. The implied assumption is that the cabin gaseous composition remains constant during the run;

(2) the computation of inspired volume is highly sensitive to small $F_{I_{N_2}}$ changes, thus an increase in $F_{I_{N_2}}$ during an M171 run will produce an apparent increase in $\dot{V}_{O_2}$. Conversely, a decrease in $F_{I_{N_2}}$ during an M171 run will produce a decrease in MA oxygen consumption. Two special SMEAT tests were run to document this point. In the first instance, the subject exercised at a steady state level of 180 watts as judged by no significant trend of increased heart rate during the 45-minute exercise period. Five minutes of $\dot{V}_{O_2}$ data were obtained with a stable cabin gas composition, followed by 30 minutes of $\dot{V}_{O_2}$ data during which time the $F_{I_{N_2}}$ was increased 0.005 per 10 minutes. A total $F_{I_{N_2}}$ increase of 0.015 resulted in an apparent $\dot{V}_{O_2}$ increase from 2.1 to 3.6 liters/min. On the second special test day a corollary test was performed wherein the $F_{I_{O_2}}$ was raised 0.015 while the same subject repeated the 45 min. ride at 180 watts. Because cabin CO_2 and H_2O levels remained relatively stable at 2.0% and 5.0% respectively, the increase in $F_{I_{O_2}}$ was reflected in a like decrease in $F_{I_{N_2}}$. M171 oxygen consumption data fell from 3.1 to 1.5 liters/min.

These tests established the requirement to maintain cabin atmospheric composition as stable as possible during M171 tests.

The data from the two tests are tabulated in tables A-6 and A-7.

6. Evaluation of MA mass spectrometer gas analysis

All preceding tests indicated the MA mass spectrometer was measuring carbon dioxide too high. This test was designed to provide a series of saturated gas samples to be introduced to the mass spectrometer at 5 psia. Essentially, the mixed gas samples were analyzed by the MA mass spectrometer using both the cabin air and the exhaled sample inlet ports. At the completion of this portion of the testing, the

Douglas bags were passed out of the SMEAT chamber and brought to the Environmental Physiology Branch for analysis using an S.R.I. MEDSPECT respiratory mass spectrometer. The data are shown in Table A8.

The results of these analyses indicated the SMEAT mass spectrometer was measuring CO_2 approximately 25% high and O_2 5% low. Analyses made via the cabin air and exhaled sample ports showed no appreciable differences.

7. Mass Spectrometer calibration gain adjust

The final regularly scheduled M171 test was used to check the impact of mass spectrometer gain adjusts on MA data. The CO_2 gain was set at 11.4%, instead of a nominal 14.3%, and water gain was similarly reduced from 24 to 18%. Otherwise, the protocol for M171 was that normally employed. The data obtained are shown in Table A9. Essentially, the $\dot{V}_{O_2}$ data appear normal, but $\dot{V}_{CO_2}$ are somewhat low relative to the Douglas bag data. This indicates that the CO_2 gain may have been reduced too much. The R.E.R. data reflect the CO_2 gain adjust by having numeracal values somewhat less than 1.0.

TABLE A1.

VARIABLES MONITORED BY PDP-8e

CHANNEL SMEAT	DVTU-2	VARIABLE	BOARD	PIN #	GROUND
1	15	$\dot{V}$ min (T/M)	XA-14	6	19, 20
2	8	Temp (E)	XA-19	29, 30	19, 20
3	9	Pressure	XA-19	13, 14	19, 20
4	7	Temp (I)	XA-20	29, 30	19, 20
5	5	$\dot{V}_I$ (Pot)	XA-21	Q	J, K
6	6	$\dot{V}_E$ (Pot)	XA-21	I	J, K
7	16	$\dot{V}_{O_2}$ (Br) Mode II	XA-24	P, Q	J, K
8	1	O_2 (BR)	XA-2	11, 12	19, 20
9	3	N_2 (BR)	XA-2	13, 14	19, 20
10	4	H_2O (BR)	XA-2	25, 26	19, 20
11	2	CO_2 (BR)	XA-2	29, 28	19, 20
12	19	O_2 (Cabin)	XA-3	P, Q	J, K
13	20	N_2 (Cabin)	XA-3	D, E	J, K
14	10	% O_2	XA-3	T, U	J, K
15	12	% N_2	XA-3	F, G	J, K
16	21	CO_2 (Cabin)	XA-4	P, Q	J, K
17	22	H_2O (Cabin)	XA-4	D, E	J, K
18	11	%CO_2	XA-4	T, U	J, K
19	18	%H_2O	XA-4	F, G	J, K
20	17	$\dot{V}_{O_2}$ (BR) Mode I	XA-8	1	19, 20
21	13	$\dot{V}_E$ STP	XA-9	P, Q	J, K
22	14	$\dot{V}_I$ STP	XA-9	D, E	J, K

TABLE A2

VCG - PLETHYSMOGRAPH HEART RATE COMPARISON

	CDR		PLT		SPT	
EVENT TIME	VCG	PLETHYS-MOGRAPH	VCG	PLETHYS-MOGRAPH	VCG	PLETHYS-MOGRAPH
25	60			-		-
24	59			72		56
23	59			71		52
22	60			75		52
21	60	62		72		50
20	66			78		55
19	78			103		120
18	76			95		110
17	70			95		95
16	78	80		97		112
15	76	85		97		105
14	90			112		110
13	94			115		115
12	93			115		118
11	94	93		108		120
10	98	93		110		115
9	110			125		131
8	114			125		133
7	124			122		138
6	119	111		128		139
5	121	110		130		136
4	71	75		73		92
3	60			65		80
2	62	70		70		70
1	61			72		71
0	67	66		68		71

TABLE A3

SCHOLANDER ANALYSES OF METABOLIC GAS SAMPLED BY GLASS SYRINGES

SYRINGE #	CABIN AIR	$\%O_2$	$\%CO_2$
D-2500	CABIN AIR	69.3 69.3	1.7 1.6
G-1722	CABIN AIR	71.4 71.4	1.9 1.9
W-7862	EXHALED AIR	36.0 36.1	3.8 3.9
W-7312	EXHALED AIR	65.6 65.6 65.6	4.9 4.9 4.9

TABLE A4

SUMMARY OF PHYSIOLOGICAL DATA OBTAINED FROM
SMEAT 5 PSIA DOUGLAS BAG COLLECTIONS

EXERCISE LEVEL	CDR				PLT				SPT			
	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_E$	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_E$	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_E$
1	.971	.724	.745	23.4	1.063	.850	.799	30.8	1.277	1.012	.792	39.3
	.862	.680	.788	21.3	1.097	.833	.759	28.1	1.370	1.143	.834	43.6
					.979	.887	.906	30.6	1.467	1.403	.956	48.8
									1.294	1.235	.954	43.0
MEAN	.916	.702	.766	22.4	1.046	.856	.821	29.8	1.352	1.198	.884	43.7
±SD	.077	.031	0	1.5	.054	0	.070	1.5	.083	.161	.077	3.9
2	1.424	1.242	.872	33.1	1.638	1.367	.835	44.9	2.098	1.986	.947	70.5
	1.309	1.196	.913	33.0	1.598	1.383	.865	42.0	2.325	2.198	.945	81.8
					1.465	1.453	.991	44.4	2.198	2.206	1.003	70.8
									2.195	2.075	.945	68.6
MEAN	1.366	1.219	.892	33.1	1.567	1.401	.897	43.8	2.204	2.116	.960	72.9
±SD	.077	.031	0	.07	.089	.031	.083	1.6	.089	.100	0	6.0
3	1.974	1.763	.893	47.6	2.294	1.937	.844	60.0	2.712	3.034	1.119	114.4
	1.786	1.765	.988	43.4	2.068	2.049	.99	60.3	3.025	2.686	.887	99.3
	1.924	1.905	.990	46.0	2.092	2.087	.997	61.4	3.539	3.145	.888	125.3
									2.914	3.258	1.118	111.6
									3.070	3.168	1.031	113.0
									2.700	3.079	1.140	103.3
MEAN	1.894	1.811	.957	45.7	2.151	2.024	.943	60.6	2.993	3.061	1.030	111.2
±SD	.089	.077	.054	2.1	.122	.070	.083	.736	.306	.197	.114	9.1

TABLE A5

MA SILICA GEL DRIER TEST DATA

		CDR			PLT			SPT		
EXERCISE LEVEL	EVENT TIME	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.
1	16	.827	.781	.944	.866	.942	1.088	1.373	1.415	1.031
	15	.922	.932	1.010	.771	.872	1.131	1.421	1.465	1.101
2	11	1.271	1.454	1.143	1.482	1.786	1.205	2.280	2.681	1.176
	10	1.212	1.585	1.307	1.336	1.636	1.225	2.278	2.611	1.146
3	6	1.838	2.248	1.223	1.940	2.530	1.304	3.003	3.877	1.291
	5	1.998	2.258	1.113	2.020	2.580	1.277	2.496	3.193	1.278

TABLE A6

NITROGEN INJECTION INTO CABIN ATMOSPHERE
M171 Special Test #7
Subject: Thornton (180 Watts)

9/9/72
Julian 253
SMEAT Day 46

INITIAL CABIN AIR

F_{O_2}	.6921		
F_{N_2}	.2445		
F_{CO_2}	.0198		
F_{H_2O}	.0456		

EVENT TIME	MA CO_2	MA O_2	MA RQ	MA MV	CABIN AIR FRACTIONS F_{O_2}	F_{N_2}	F_{CO_2}	DEWPOINT
44	1.310	1.228	1.094	42.6				
43	2.500	2.167	1.198	78.0				
42	2.490	2.151	1.202	76.5				
41	2.480	2.117	1.219	73.2				
40	2.400	2.093	1.189	72.7				
39	2.440	2.148	1.183	68.4	.709	.220	.0183	50°F
38	2.620	2.236	1.220	74.2				
37	2.430	2.060	1.225	74.2				
36	2.490	2.187	1.185	74.6				
35	2.730	2.360	1.205	80.3	.704	.222	.0184	50.5°F
34	2.68	2.410	1.159	80.2				
33	2.65	2.43	1.130	82.5				
32	2.69	2.522	1.112	80.4				
31	2.76	2.601	1.105	80.6	.702	.225	.0186	51°F
30	2.65	2.541	1.088	80.8				
29	2.57	2.516	1.063	78.5				
28	2.72	2.712	1.045	82.1				
27	2.66	2.689	1.032	81.0				
26	2.69	2.749	1.017	80.0	.699	.227	.0188	51.5°F
25	2.52	2.634	.998	77.7				
24	2.74	2.858	.998	81.5				
23	2.54	2.728	.967	78.3				
22	2.50	2.691	.968	75.9				
21	2.75	2.994	.958	81.9	.697	.229	.0191	52°F
20	2.68	2.958	.946	81.7				
19	2.77	3.058	.945	83.7				
18	2.39	2.742	.908	74.5				
17	2.65	3.033	.912	78.2				
16	2.51	2.891	.904	72.4	.694	.231	.0195	52°F
15	1.83	2.145	.884	57.3				
14	2.74	3.218	.887	86.0				
13	2.61	3.154	.861	79.7				
12	2.58	3.160	.850	78.1				
11	2.76	3.354	.858	78.4	.690	.233	.0198	52°F
10	2.72	3.372	.841	79.6				
9	2.75	3.375	.850	82.7				
8	2.72	3.439	.825	78.0				
7	2.71	3.450	.818	80.1				
6	2.59	3.330	.810	77.7	.688	.234	.0202	52°F
5	2.64	3.427	.802	78.4				
4	2.81	3.629	.806	83.4				
3	2.56	3.382	.787	78.2				
2	2.59	3.462	.781	75.8	.689	.234	.0205	52.5
1	2.60	3.658	.796	79.9	.689	.234	.0207	52.5
0	2.77	3.647	.792	84.7	.689	.233	.0208	52.5

OXYGEN INGECTION INTO CABIN ATMOSPHERE
M171 Special Test #7
Subject: Thornton (180 watts)

9/15/72
Julian 258
SMEAT Day 51

INITIAL CABIN AIR

F_{O_2}	.6821
F_{N_2}	.2495
F_{CO_2}	.0224
F_{H_2O}	.0482

H.R.	EVENT TIME	MA CO_2	MA O_2	MA RQ	MA MV	CABIN AIR FRACTIONS F_{N_2}	F_{O_2}	F_{CO_2}	D.P. °F	TIME
112	44	1.06	.968	1.119	36.0	.2550	.697	.0203	52	1755
110	43	2.490	2.296	1.129	77.5					
105	42	2.390	2.136	1.163	73.8					
104	41	2.480	2.230	1.156	68.7	.2550	.696	.0207	52	1802
107	40	2.240	2.060	1.129	64.8					
105	39	2.460	2.253	1.136	67.1					
105	38	2.410	2.175	1.153	67.9					
104	37	2.52	2.192	1.193	69.6					
104	36	2.57	2.230	1.200	71.0					
103	35	2.46	2.085	1.225	70.0	.253	.700	.0210	52	1807
105	34	2.38	2.027	1.218	63.1					
88	33	2.39	1.999	1.245	69.3					
107	32	2.64	2.181	1.260	71.8					
108	31	2.56	2.099	1.268	71.6	.250	.702	.0210	52	1812
109	30	2.40	1.965	1.267	70.8					
105	29	2.49	1.990	1.301	71.2					
105	28	2.56	2.035	1.308	72.					
105	27	2.73	2.169	1.309	73.6	.249	.703	.0212	52	1817
107	26	2.510	1.979	1.320	72.9					
102	25	2.53	1.949	1.349	75.9					
105	24	2.55	2.031	1.304	71.1					
107	23	2.53	1.970	1.331	71.7					
102	22	2.73	2.084	1.361	73.4	.247	.704	.0210	52	1822
107	21	2.57	1.959	1.361	72.8					
107	20	2.57	1.951	1.366	70.3					
109	19	2.63	1.948	1.400	77.5					
105	18	2.48	1.851	1.389	72.0					
110	17	2.66	1.984	1.392	74.0					
109	16	2.64	1.923	1.427	74.6					
108	15	2.78	2.008	1.440	73.5					
110	14	2.57	1.836	1.451	72.6	.243	.707	.0217	52	1829
104	13	2.70	1.861	1.508	76.5					
110	12	2.80	1.908	1.525	78.9					
107	11	2.36	1.683	1.458	70.1					
109	10	2.66	1.847	1.496	71.8					
109	9	2.79	1.867	1.550	75.4					
110	8	2.69	1.815	1.539	74.1	.242	.710	.0215	52	1835
110	7	2.63	1.768	1.545	70.8					
109	6	2.53	1.659	1.582	75.7					
110	5	2.64	1.717	1.597	74.3					
114	4	2.60	1.717	1.569	71.3					
109	3	2.82	1.775	1.647	74.8					
110	1	2.84	1.762	1.673	76.0					
112	0	2.65	1.636	1.680	76.0					

TABLE A8

DOUGLAS BAG GAS ANALYSIS AT 5 PSIA

SAMPLE	SMEAT MASS SPEC						SRI		
	CABIN AIR PORT			EXHALED SAMPLE PORT			MEDSPECT		
BAG #	F_{O_2}	F_{CO_2}	F_{N_2}	F_{O_2}	F_{CO_2}	F_{N_2}	F_{O_2}	F_{CO_2}	F_{N_2}
1	.5267	.2097	.2635	.5270	.2083	.2647	.5559	.1632	.2800
2	.6044	.1348	.2607	.6032	.1355	.2613	.6138	.1089	.2763
3	.6370	.1010	.2620	.6354	.1022	.2624	.6567	.0816	.2613
4	.6697	.0740	.2562	.6686	.0750	.2564	.6844	.0608	.2545
5	.6828	.0582	.2591	.6808	.0596	.2595	.6994	.0470	.2533

TABLE A9

SMEAT MA METABOLIC DATA SUMMARY

CAL ADJUST TEST

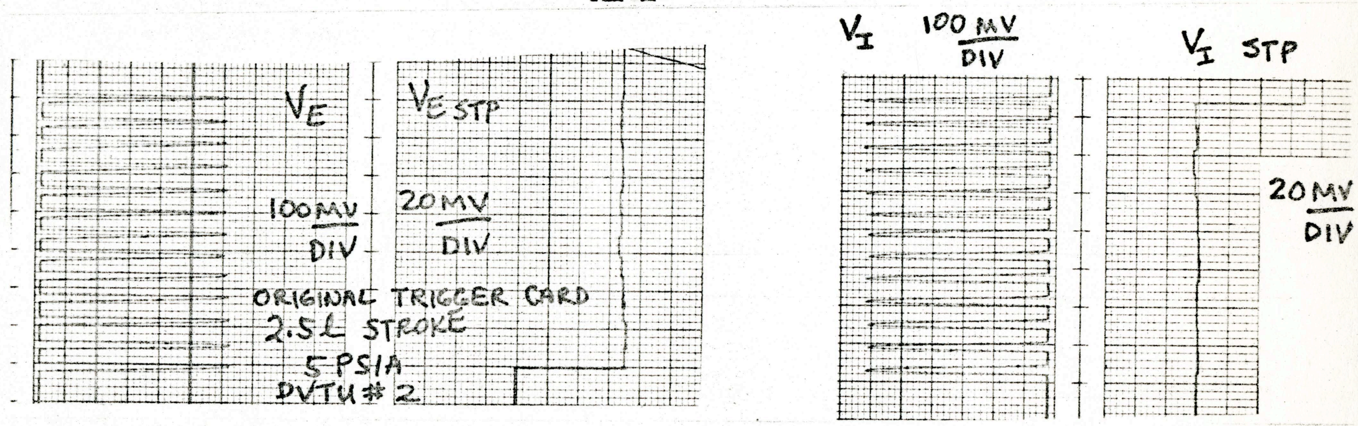
	CDR				PLT				SPT			
EXERCISE LEVEL	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_E$	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_E$	$\dot{V}_{O_2}$	$\dot{V}_{CO_2}$	R.E.R.	$\dot{V}_E$
LEVEL 1	.661 .894	.550 .761	.832 .851	22.7 22.3	.810 .793	.691 .691	.853 .871	26.9 27.4	1.405 1.328	1.083 1.083	.771 .816	45.4 46.6
LEVEL 2	1.480 1.506	1.324 1.344	.895 .892	31.6 33.1	1.290 1.329	1.183 1.224	.917 .921	46.0 44.1	2.286 2.247	1.947 1.917	.852 .853	78.6 77.9
LEVEL 3	2.067 1.978	1.947 1.877	.984 .949	46.6 46.2	2.017 2.007	1.887 1.867	.936 .930	63.2 63.9	3.164 3.185	2.942 2.892	.930 .908	123.3 121.7

FIGURE A1

HAND PUMP CALIBRATION

Examples of volume potentiometer outputs and resultant sample and hold values for STP volume. Both inspiration (V_I) and expiration (V_E) data are shown. Figure A1-1 demonstrates the stability of STP volumes obtained from DVTU #2. This is in contrast with the highly variable STP volumes obtained in the SMEAT calibration test A1-2.

A1-1



A1-2

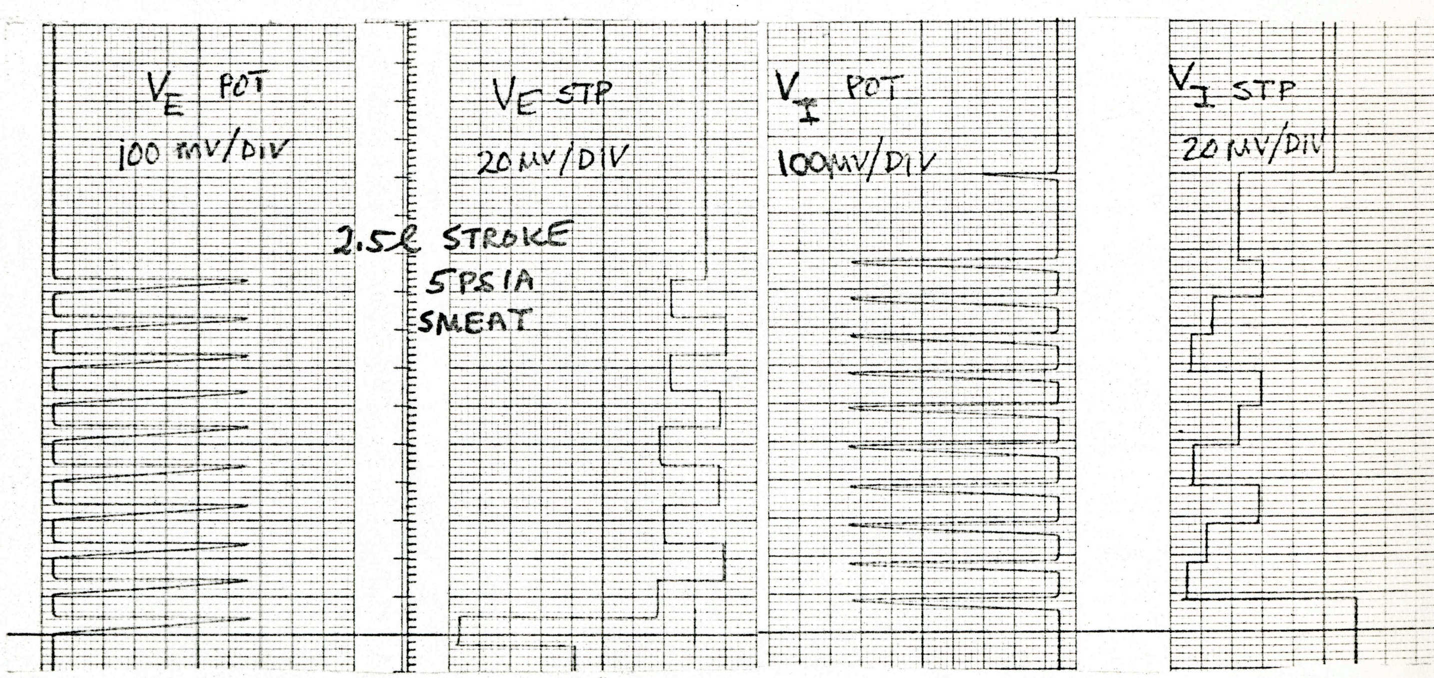


FIGURE A2

SMEAT - M171

PUMP CALIBRATION MODE 2 8-2-72

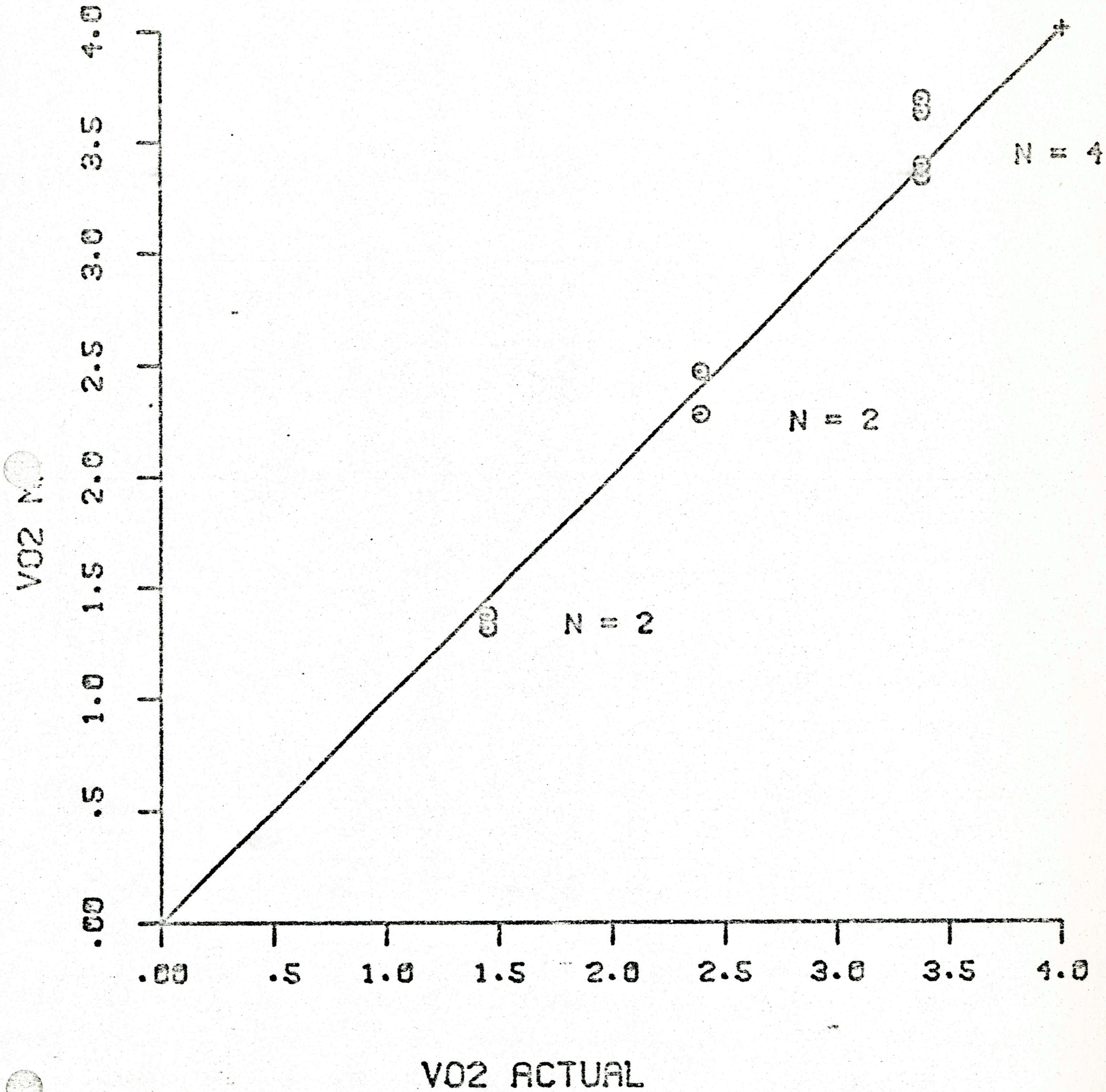


FIGURE A3

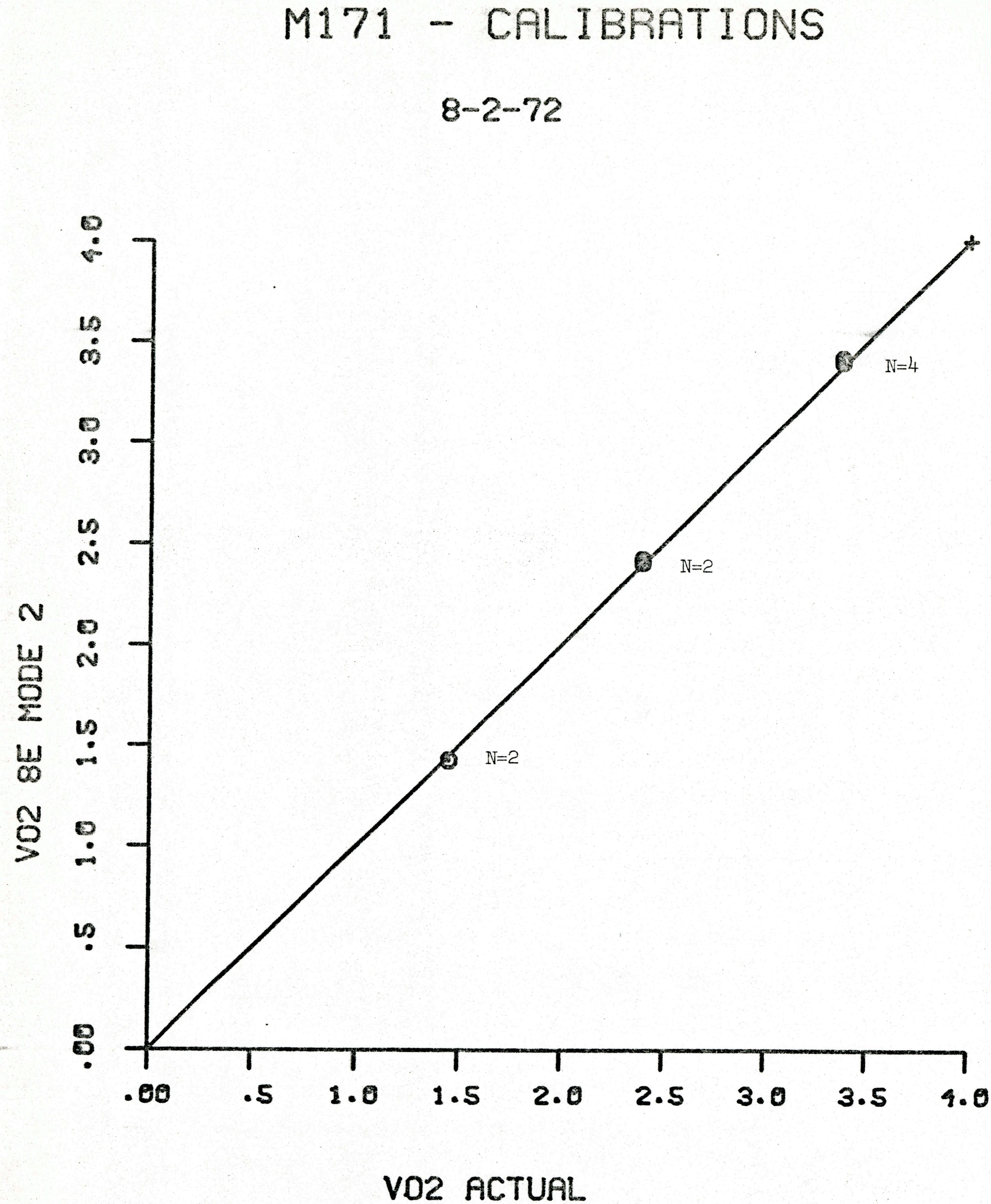

M171 - CALIBRATIONS
8-2-72
VO2 8E MODE 2
.00
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
N=2
N=2
N=4
VO2 ACTUAL

FIGURE A4

SMEAT - M171

PUMP CALIBRATION MODE 2 8-2-72

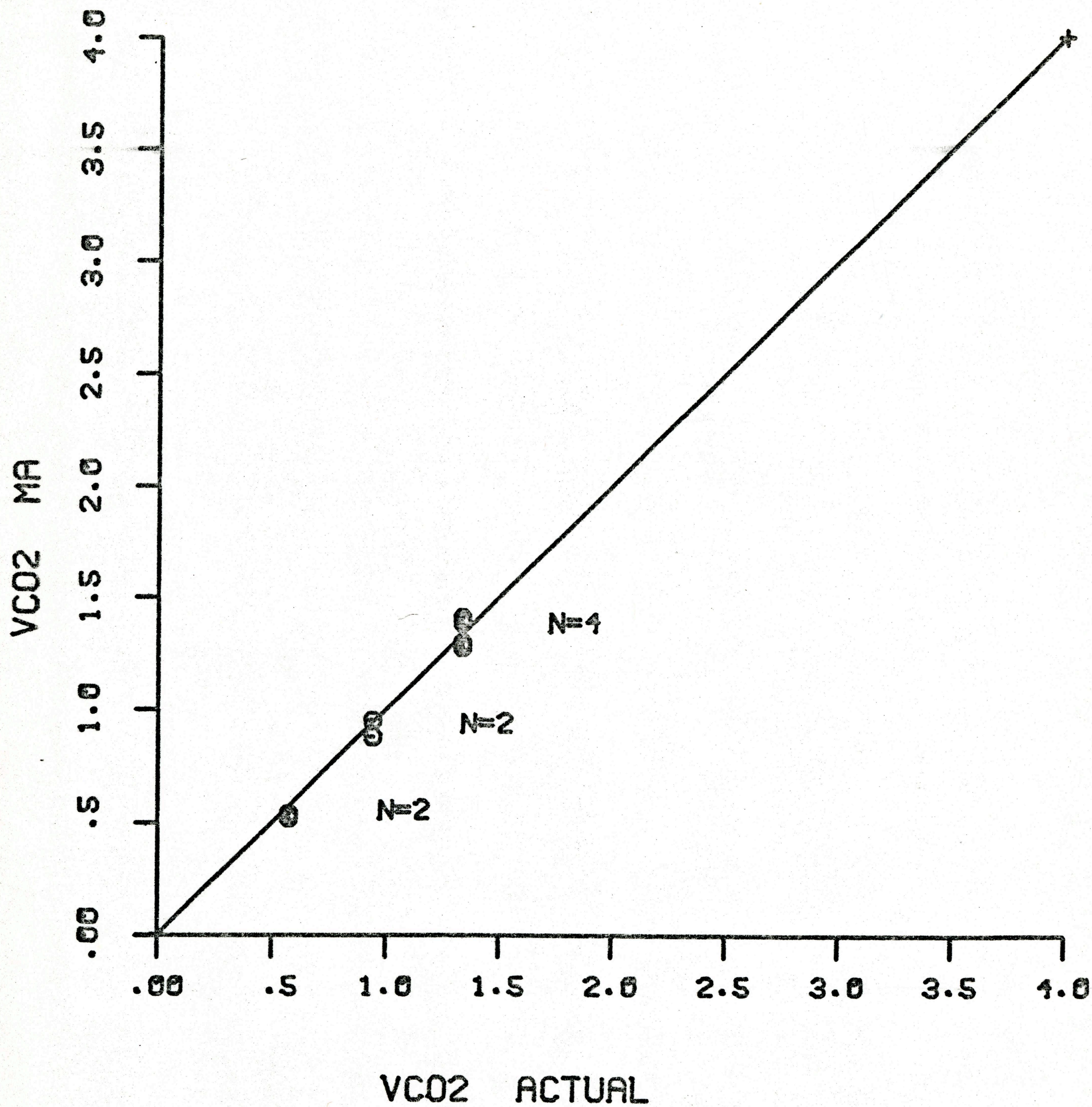


FIGURE A5

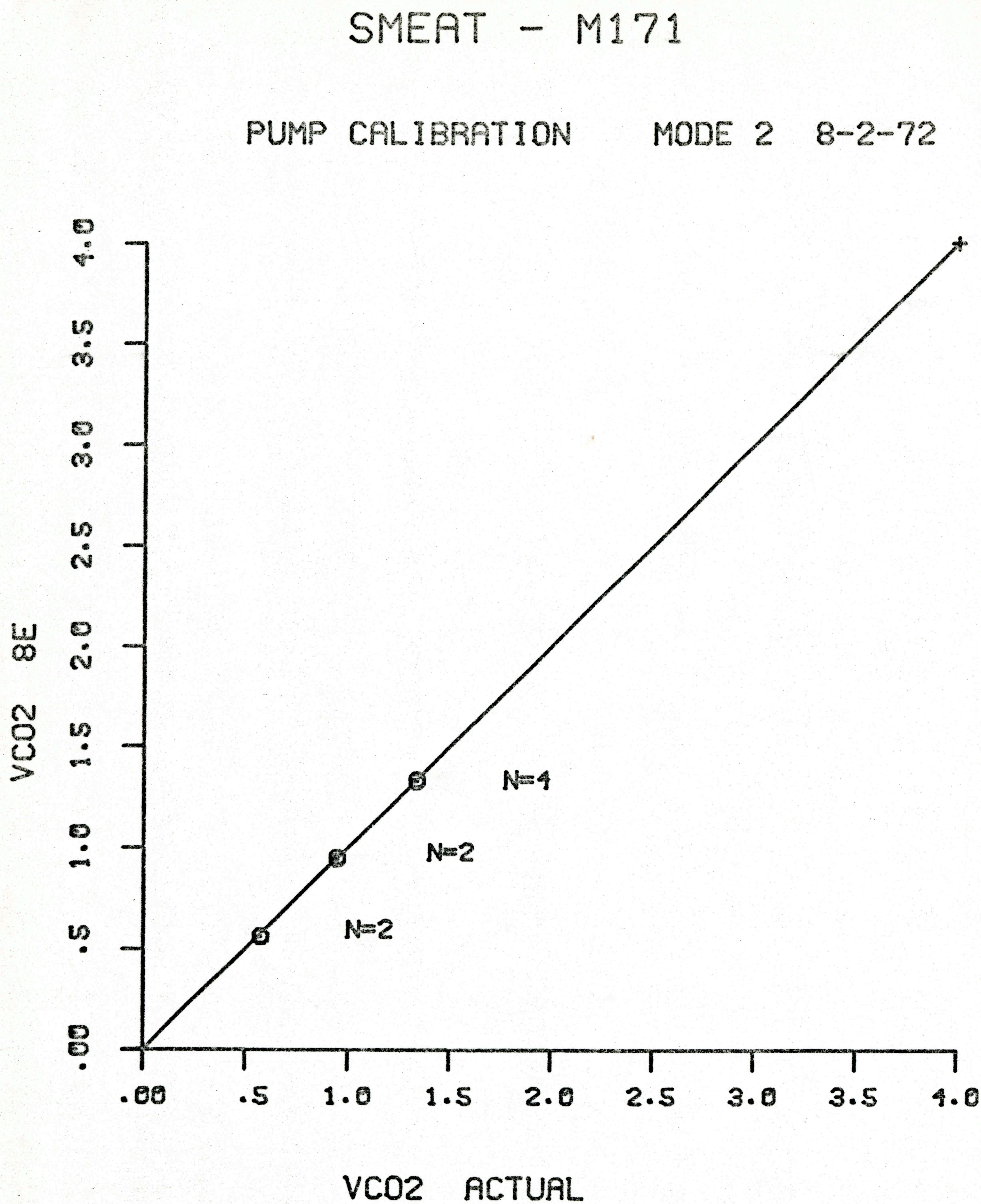

SMEAT - M171
PUMP CALIBRATION MODE 2 8-2-72
VCO2 8E
VCO2 ACTUAL
.00
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
N=4
N=2
N=2

FIGURE A6

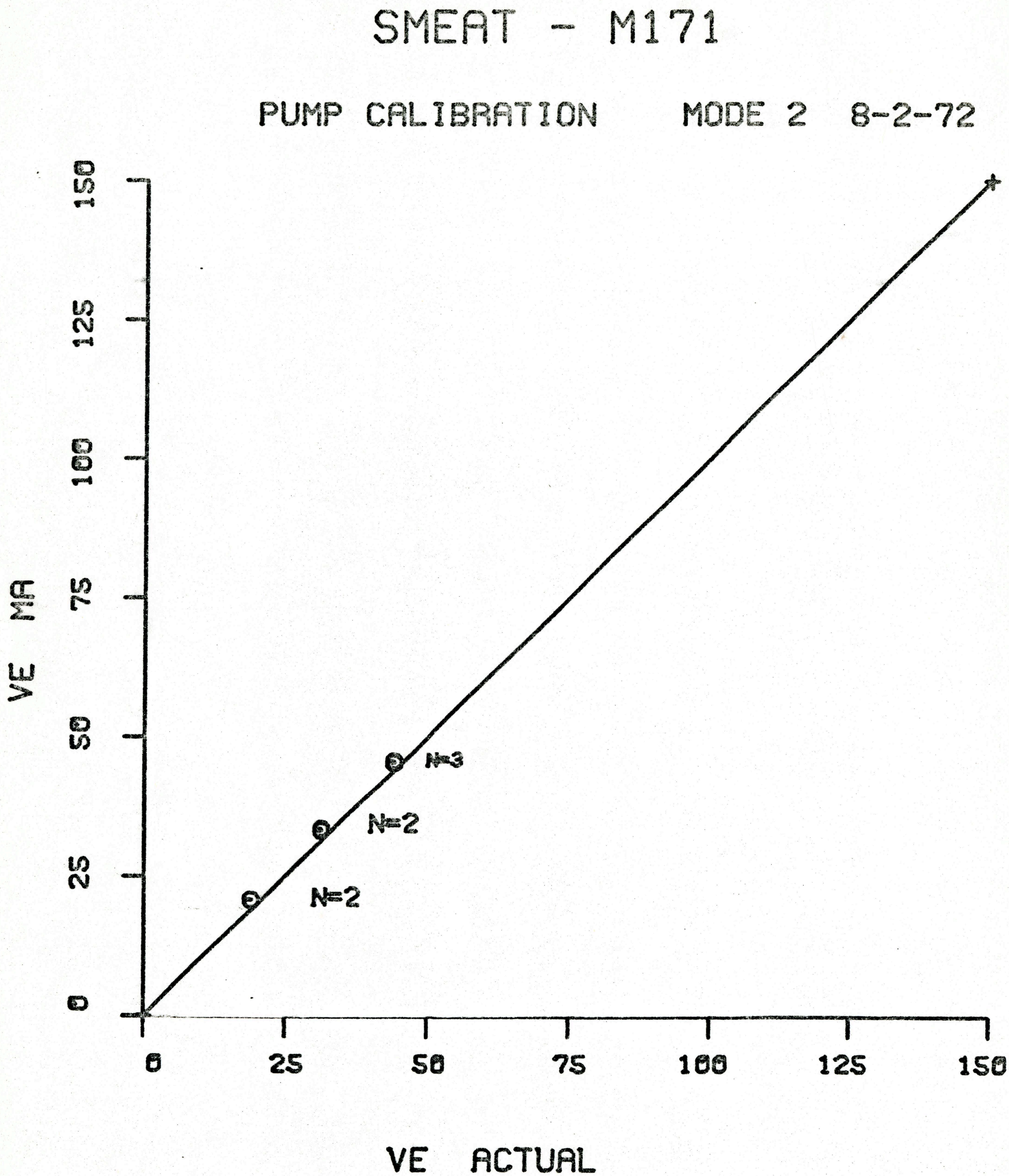
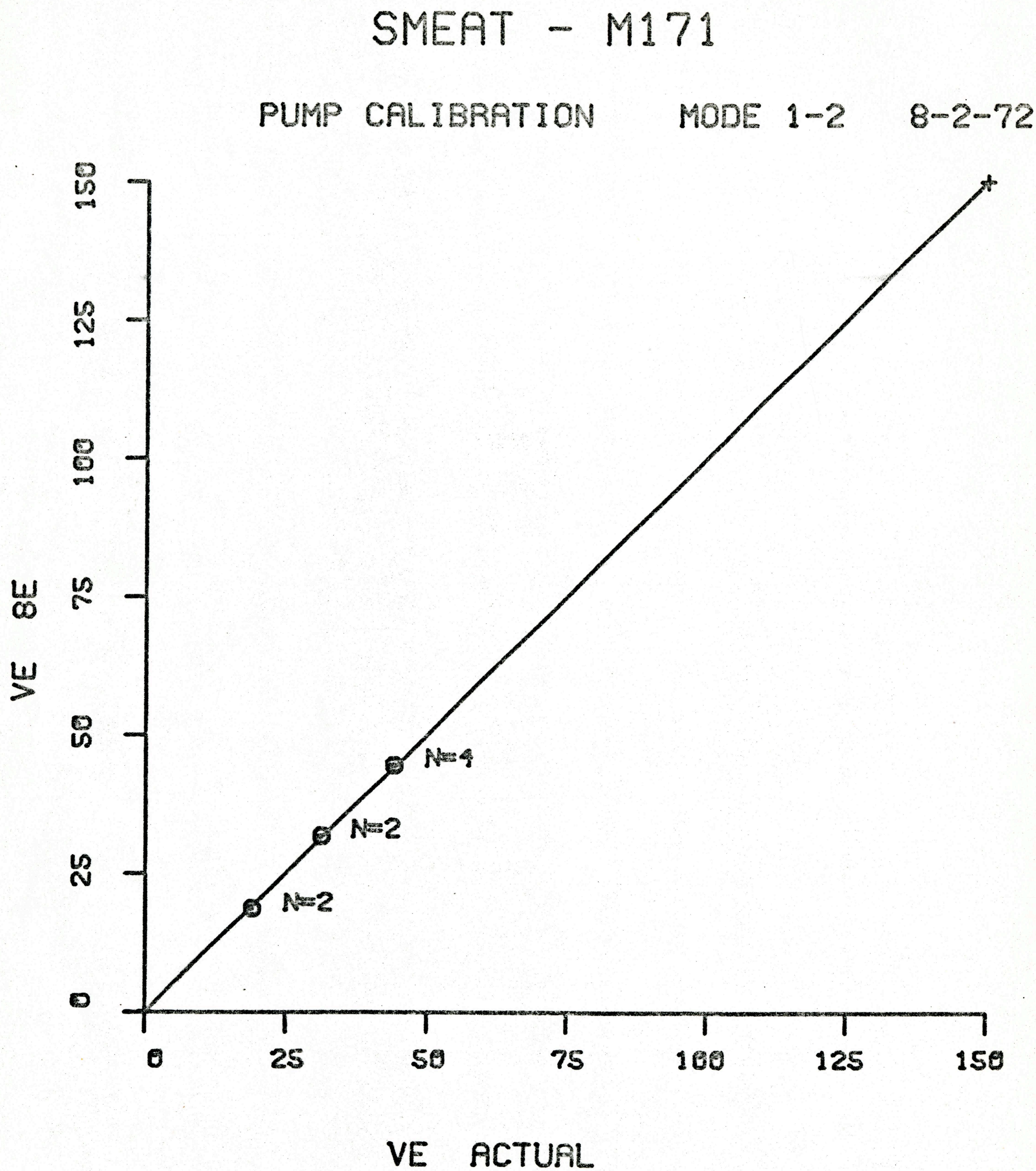

SMEAT - M171
PUMP CALIBRATION MODE 2 8-2-72
VE MA
VE ACTUAL
0
25
50
75
100
125
150
N=3
N=2
N=2

FIGURE A7


SMEAT - M171
PUMP CALIBRATION MODE 1-2 8-2-72
N=4
N=2
N=2
0
25
50
75
100
125
150
VE 8E
VE ACTUAL