FINAL REPORT

PHASE II

PARAMETRIC STUDY OF FLIGHT-INDUCED PULMONARY PATHOLOGY

LS-66-0013

January 28, 1966

Prepared for
National Aeronautics and Space Administration
Ames Research Center
Contract NAS 2-1597

GARRETT
AIRESEARCH MANUFACTURING DIVISION
Los Angeles, California

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FOREWORD

This report was prepared in the Department of Life Sciences, AiResearch Manufacturing Company, Los Angeles, California by

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ABSTRACT

The extent of pulmonary pathological response of four selected subjects breathing a conditioned atmosphere and then being centrifuged was investigated. Pre- and posttest data consisting of chest X-rays and pulmonary function measurements were collected from each subject after conditioning to three test atmospheres with total pressures of 380, 380, and 194 mm Hg abs and oxygen partial pressures of 180, 367, and 180 mm Hg, respectively. Nitrogen was the diluent in the first 380 mm Hg pressure test; the rest of the atmosphere was water vapor and carbon dioxide. Two test durations, three hours and eight hours, were investigated, and at the end of the conditioning the subjects were exposed to a 6-g transverse acceleration ($+ a_x$) for two minutes.

Statistically significant results cannot be deduced because of the wide variation in measured parameters and the statistically inadequate number of subjects tested. Atelectasis did occur, and the severity appears to be a complex function of all variables studied.

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SECTION I

INTRODUCTION

This is the final report, prepared by AiResearch Manufacturing Company, a division of The Garrett Corporation, for the National Aeronautics and Space Administration on the Phase II effort and the results obtained under Contract NAS 2-1597, a parametric study of flight-induced pulmonary pathology.

Phase II of this contract consisted of the completion of monitoring and biological instrumentation, the adaptation and mating of the Phase I equipment to the University of Southern California's human centrifuge and the tests of human subjects as outlined in the statement of work. A detailed description of the primary equipment developed during Phase I is given in AiResearch Manufacturing Company Report LS-134. A summary description of the equipment and instrumentation is presented in Section 4 of this report. The experimental design and a summary of a typical testing sequence are presented in Section 2. Subject selection and training are discussed in Section 3. Actual data and typical illustrations of the tests appear in Section 5. A discussion of the results and deviations is presented in Section 6. Conclusions and recommendations are presented in Section 7. The appendix presents the operating, calibrating, and testing procedures in further detail, and tables of all the reduced data are included.

The occurrence of demonstrable changes in the respiratory system of pilots following exposure to acceleration after breathing oxygen was first demonstrated in 1958. During World War II, flight surgeons had occasionally noted some coughing and slight decrease in breathing ability in pilots who had flown high-performance aircraft breathing 100 percent oxygen, but had assumed that this was probably due to a transient irritation from the dryness of the gas alone, and had not been able to observe any changes in the lung fields on X-rays. These periods of respiratory irritation seemed to be self-limited in duration and there were virtually no pilots with substernal distress or coughing the day following such a flight, so intensive investigation into the cause of the symptoms was not undertaken.

During 1958 to 1959, Ernsting[1], of the RAF, first demonstrated the occurrence of patchy atelectasis in certain pilots after they had been exposed to 100 percent oxygen and g forces. He first published these findings in 1960, and, shortly thereafter, estimates of the occurrence of atelectasis in Hawker fighter pilots ranged as high as 80 percent.

Hershgold[2] at the USAF Aero Medical Laboratory demonstrated marked chest deformation radiographically on subjects undergoing transverse acceleration ($+g_x$) and published his interpretation of these in late 1959. Shortly following this, Langdon and Reynolds [3] confirmed postflight atelectasis in United States Air Force tactical fighter pilots and estimated there was a 25-percent occurrence of one degree or another of lung changes. In 1962 Levy[4] et al. outlined 10 additional cases among eight pilots with similar findings after g and oxygen flights and suggesteed the term aeroatelectasis to describe the sympton complex.

More thorough research under laboratory conditions rather than operational conditions was initiated in 1962, and the various investigators uniformly confirmed the occurrence of loss of some degree of function within the respiratory tree after exposure to transverse acceleration ($+g_x$). These investigators included Smedal[5], Hyde[6], Reed[7], and Banchero[8]. In all of these studies, transverse g was consistently used. Most of the studies did not combine careful control of breathing gas or gases prior to acceleration. The synergetic effect, however, of transverse acceleration ($+g_x$) and 100 percent oxygen breathing has been agreed to in theory by most investigators.

There was at one time considerable discussion regarding whether the occurrence of the loss of pulmonary function could be described from breathing oxygen alone. Certain investigators, for example, Comroe[9] in 1945, and Michel[10] in 1960, have demonstrated some loss in pulmonary function due to exposure to hyperoxic atmospheres. However, these changes have not been demonstrable until the first or second day of the test situation, and area changes seen in subjects exposed to transverse acceleration can be demonstrated in minutes.

In summary, then, there has been some excellent isolated work on separate facets of the phenomena which indicated the need for combining several of the responsible factors into one experiment to more adequately understand the effect of combined stressors. Consequently, the experiment undertaken by this program is an effort to carefully control the breathing atmosphere and systematically vary the total pressures and the composition of breathing gases before centrifugation, and to provide two separate conditioning times. As a result of this program, conclusions could well be reached for predicting the effects of environmental factors in the likelihood of atelectasis or some similar loss of pulmonary function.

REFERENCES

1. Ernsting, J. "Some Effects of Oxygen Breathing." Proceedings of the Royal Society of Medicine. 53:96, 1960.

2. Hershgold, E. J., "X-Ray Examination of the Human Subject During Transverse Accelerations." (abst.) Aerospace Medicine, 30:187-188, 1959.

3. Langdon, D. E. and Reynolds, G. E. Aerospace Medicine, 32:713, 1961.

4. Levy, P. M., Jaeger, E. A., Stone, R. S., and Doudna, C. T., Aerospace Medicine, 33:988-993, 1962.

5. Smedal, H. A., Rogers, T. A., Duane, T. D., Holden, G. R., and Smith, J. R., Jr., "The Physiological Limitations of Performance During Acceleration." Aerospace Medicine, 34:48-55, 1963.

6. Hyde, A. S., "The Physiological Effects of Forward Acceleration on Respiration and Protection Measures." NATO-AGARDograph No. 48, Chap. IX in Bio-assay Techniques for Human Centrifuges and Physiological Effects of Acceleration. Permagon Press, 1961.

7. Reed, J. H., Jr., Burgess, B. F., and Sandler, Harold, "Effects on Arterial Oxygen Saturation of Positive Pressure Breathing During Acceleration." Aerospace Medicine, 35:238-243, 1964.

8. Banchero, N., Cronin, L., Nolan, A. C., and Wood, E. H., "Blood Oxygen Changes Induced by Forward ($+g_x$) Acceleration." Aerospace Medicine, 36:608-616, 1965.

9. Comroe, J. H., Dripps, R. D., Dumke, P. R., and Deming, M., "Oxygen Toxicity--The Effects of Inhalation of High Concentrations of Oxygen for 24 Hours on Normal Men at Sea Level and at a Simulated Altitude of 18,000 Feet." J.A.M.A., 128:710, 1945.

10. Michel, E. L., Langevin, R. W., and Gell, C. F., "Effect of Continuous Human Exposure to Oxygen Tension of 418 mm Hg for 168 Hours." Aerospace Medicine, 31:138, 1960.

SECTION 2

TEST PROCEDURES

EXPERIMENT DESIGN

These experiments were conducted to determine what environmental conditions induce pulmonary pathology, more specifically atelectasis. The variables investigated were total pressure, gas composition, and the duration of breathing at the test conditions. At the end of each test condition the subject was centrifuged to 6 g with the resultant g vector normal to the spine (+ax). Baseline tests were conducted using ambient atmospheric conditions (sea level). The durations of breathing at each controlled atmosphere were 3 hr and 8 hr. The atmosphere composition is presented in Table 2-I. The methods and equipment associated with attaining these atmospheric conditions are described in Sections 3 and 4.

The methods used to determine the extent of pathological response were chest X-rays and pulmonary function tests by means of a spirometer. The chest x-rays were taken pre- and post- as described in the test sequence below. The following volumes were obtained.

TABLE 2-I

Total Pressure	O_2 Partial Pressure	N_2 Partial Pressure	H_2O Partial Pressure	CO_2 Partial Pressure
380	180	187	8	5
380	366	1	8	5
194	180	1	8	5

Functional residual capacity (FRC)

Expiratory reserve volume (ERV)

Residual volume (RV)

Vital capacity (VC)

Inspiratory capacity (IC)

Total lung capacity (TLC)

Timed vital capacity (TVC)

Tidal volume (TV)

Maximum voluntary ventilation (MVV)

Minute oxygen (consumption) (MO_2)

TESTING SEQUENCE

The electrodes were placed on the subject for the electrocardiogram and the pretest pulmonary function was determined. Upon completion of the pulmonary function test, the pretest physical examination and chest X-ray were taken. These procedures were accomplished with the subject in the structural chair used for centrifugation and in the position in which the posttest examinations would be conducted. At the conclusion of these tests the remainder of the bioinstrumentation was attached to the subject and the subject was installed in the capsule. The bioinstrumentation and all other necessary connections were made and checked out for proper operation.

The capsule was sealed and conditioning of the atmosphere was initiated. Measurement of the duration at test conditions was begun when the composition and total pressure were as prescribed by that particular day's test. During the conditioning, the subject was allowed to divest himself of the bioinstrumentation harnesses and to eat, drink, read, or sleep as he chose. One-half hour before centrifugation, the subject was instructed to don his instrumentation and to secure all loose equipment or objects. The instrumentation was checked out and final calibration completed just prior to centrifugation.

The subject was centrifuged to 6 g for 2 min. At the end of the centrifugation, the capsule was repressurized and the subject was removed and placed in position for X-rays and pulmonary function tests. During this latter period, the subject did not exert himself in any way, and talking was permitted only as necessary.

The sequence of chest X-rays and pulmonary function data collection was as follows after placing of the subject.

a. First X-ray

b. Pulmonary function test for FRC, MO_2, and TV

c. Second X-ray

d. The rest of the pulmonary function test

e. Third and final X-ray

A posttest medical examination was made and the remaining instrumentation was removed, concluding the test sequence.

Deviations from the above sequence occurred in the baseline tests and in tests at 194 mm Hg total pressure. In the baseline tests, two posttest X-rays were taken, the intermediate one not being necessary. Prebreathing of 100 percent oxygen for 2 hr before decreasing the total cabin pressure below 380 mm Hg was required to prevent dysbarism.

Figures 2-1 through 2-12 are illustrative of a typical testing sequence.

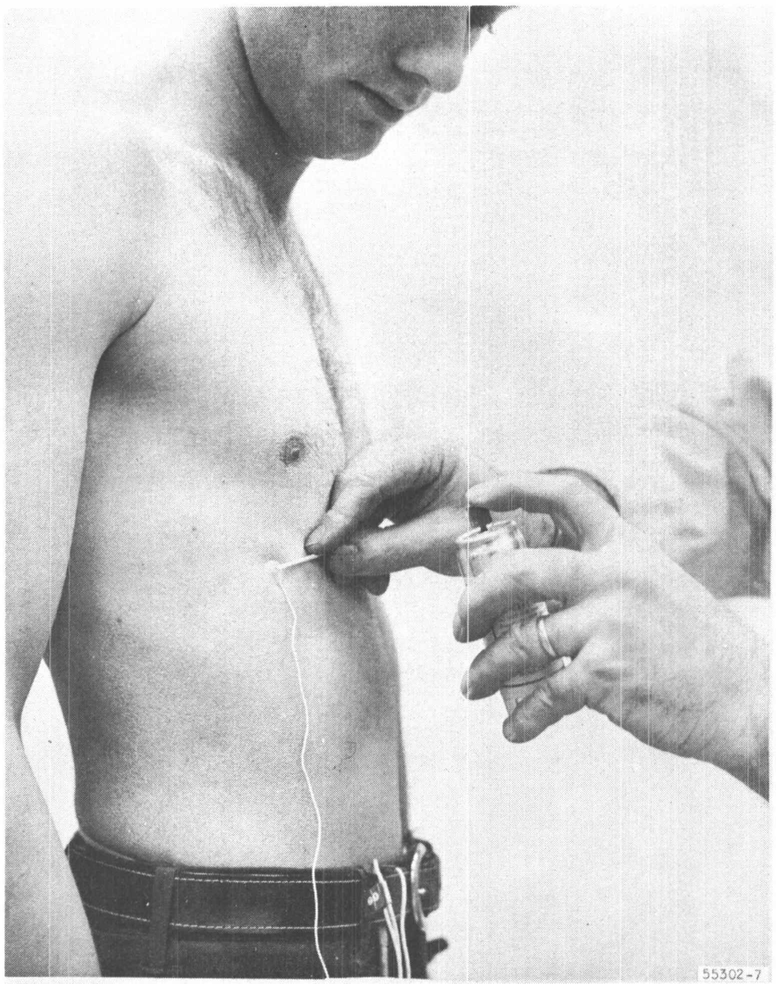

Figure 2-1. Placement of ECG Electrodes

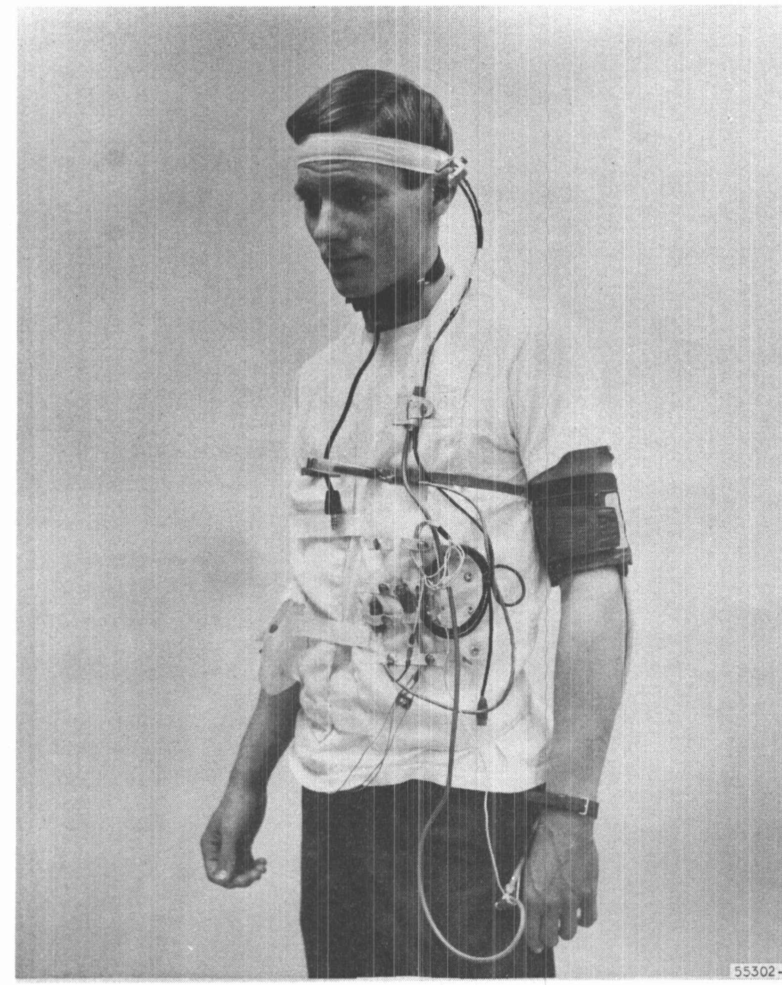

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Figure 2-2. Applied Bioinstrumentation Harness

Figure 2-3. Pre- and Posttest X-Ray Position

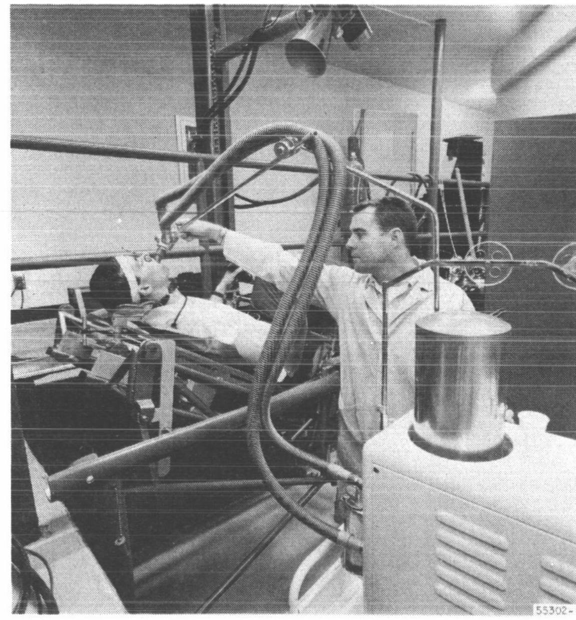

Figure 2-4. Pretest Pulmonary Function Testing

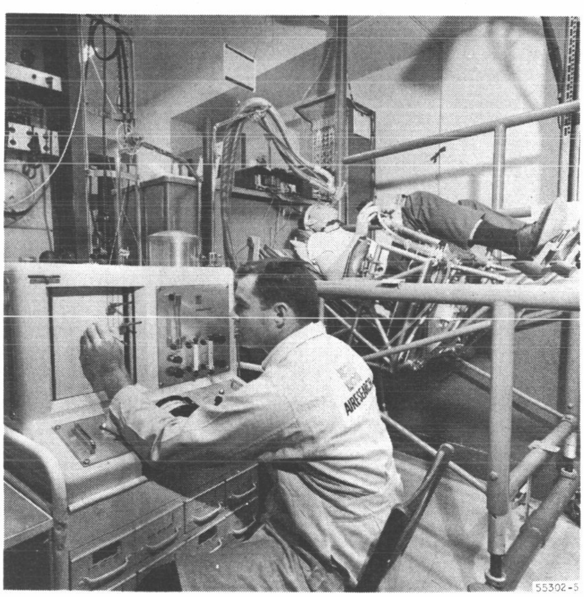

Figure 2-5. Posttest Pulmonary Function Testing

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Figure 2-6. Installation of Subject

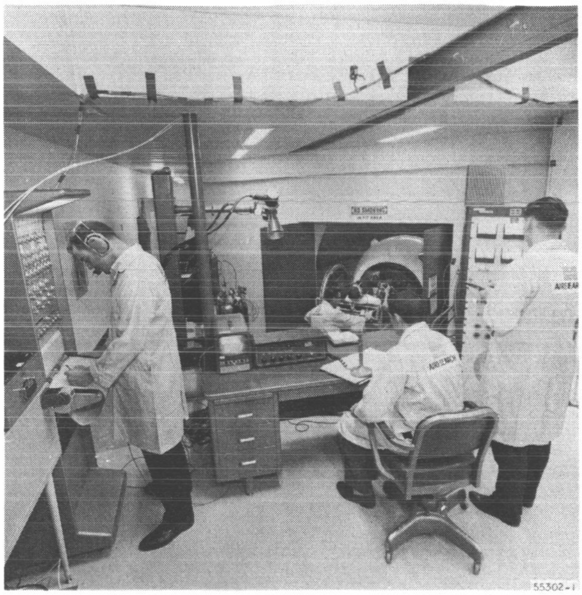
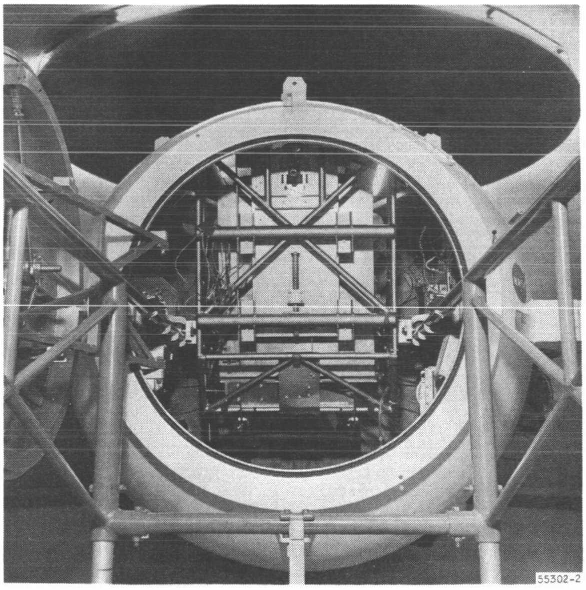


Figure 2-7

Figure 2-8



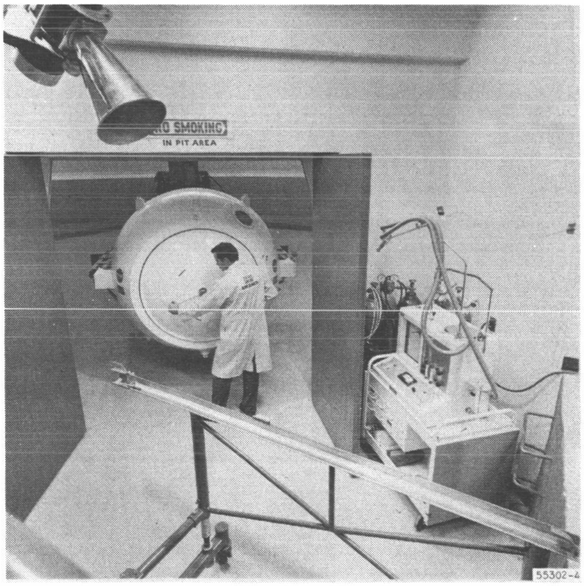


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Figure 2-9

Figure 2-10

Installation Operation Sequence

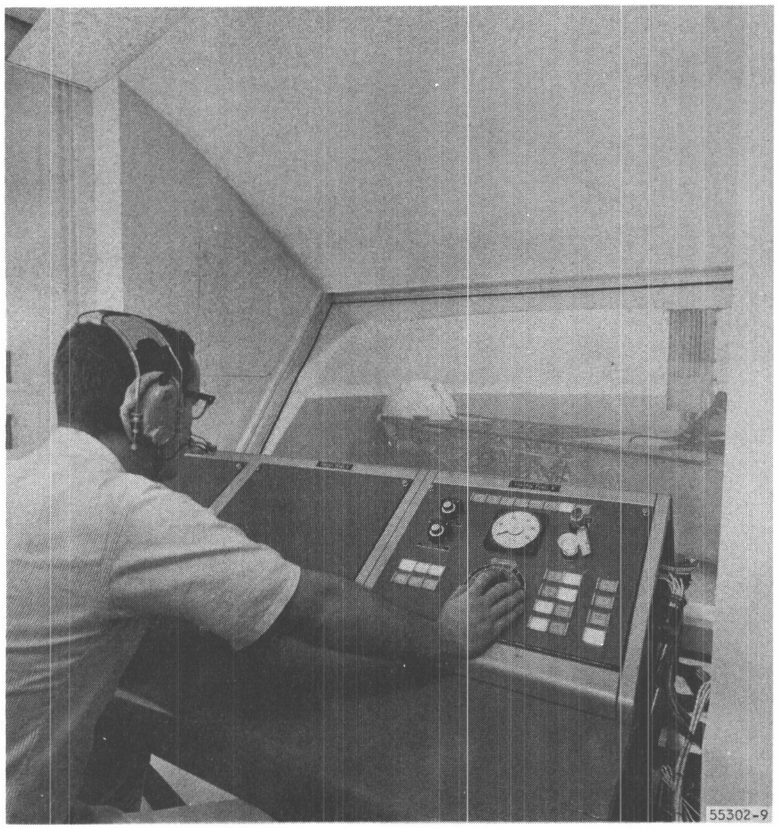

Figure 2-11. Centrifuge Control Room

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Figure 2-12. Centrifuge, Capsule, and Support Equipment

SECTION 3

SUBJECTS

SUBJECT SELECTION

Five subjects were selected for the initial training program. The qualifications demanded in the screening process, in order of significance, were

A strong interest in the tests and a desire to participate

Previous experience in similar tests

Training in high-performance aircraft

Altitude chamber experience

Experience in tests of similar complexity and duration

The prospects were briefed on (1) the nature of the tests, (2) the basic parameters being investigated, (3) expected durations, (4) the number of tests and conditions, and (5) the potential hazards. When each prospective subject had a thorough understanding of the tests and satisfied the above criteria, and was judged to be a candidate subject, a medical examination to determine his physical qualifications was conducted.

The subjects selected through the screening process are described in Table 3-1.

TABLE 3-1

Subject	Age yr	Height cm	Weight kg	BSA* sq m
1. MG	21	178	68.0	1.84
2. GR	42	170	72.5	1.83
3. LR	23	169	72.5	1.82
4. WS	32	176	79.8	1.94
5. FS	21	175	68.9	1.80

*From Dubois and Dubois nomogram

SUBJECT TRAINING

Some aspects of the pulmonary pathology study had a potential for creating a state of stress in the subjects. It was believed that this potential could be reduced by appropriate orientation and training to a level where the physiological responses associated with stress would not unduly influence the data.

Indoctrination training by a medical doctor was used to orient the subjects. The first step consisted of lectures and training at reduced pressure in an altitude chamber, acquainting the subject with the physiological responses to reduced pressure, its effect on the human body, and the precautions required. Secondly, the subjects were oriented as to the quantity and effect of X-ray radiation they would be exposed to.

The following phase of orientation and training of the subjects for this program was (1) isolation in a sealed, reduced-pressure capsule, (2) centrifuge acceleration and exposure to the resulting g forces. Adverse response to being locked in a reduced-atmosphere capsule was averted largely by the selection of subjects who had previously participated in reduced-pressure chamber studies. In addition, all these subjects had had prior training in the use of pressure suits and had participated in studies that required the simultaneous use of pressure suit and reduced-pressure chamber.

During the early part of the pulmonary pathology study, each subject experienced at least four baseline capsulations and training runs. During these baseline runs, the subjects were thoroughly oriented to the system's operation and were instructed in their duties and in control within the capsule. By the time the training runs were completed and the capsule was installed on the centrifuge, each subject had identified with the program and his concern had shifted from an emphasis on system performance, safety, emergency procedures, and the physiological aspects of reduced pressure to a concern for personal comfort in the capsule. Consequently, it was believed that the potential anxiety associated with reduced pressure of the capsule, had been alleviated. At this time, the four subjects to be used in further testing were selected. These were numbers 1 through 4 of Table 3-1. Following the installation of the capsule on the centrifuge, each of the program monitors and operators was centrifuged before the subject's training rides were begun. It was believed that the subjects would respond with a favorable attitude to the centrifuge testing program knowing that all the program participants had been subjected to and had approved the system in an actual duplication of the test condition to which the subject would be exposed.

The actual centrifuge training of the subjects was conducted with the subject directing the centrifuge control-operator via an intercommunication system. In this manner the subject could experience various g loads, with the acceleration and deceleration determined by his choice of forces rather than preselected by the conductors. It was exceedingly reassuring to the subject to know not only that he controlled speeds of the centrifuge but also that he was a controlling participant in the system.

During the training program, each subject was interviewed following each training ride. The interview was conducted informally, with the interviewer acting as a coparticipant sharing the physiological and subjective responses experienced during the training rides. It was anticipated that this would promote a free exchanger of subjective responses among the subjects and that anxiety resulting from the stress of centrifugation would more likely be verbalized. Verbalization of the subjective responses of the subjects was believed essential in ascertaining the causative factors of any potential anxiety. Also, it was thought that verbalization of the stress conditions would help to alleviate anxiety as well as enable the test conductor to detect in a subject any excessive response that might make him unsuitable for the study. The interview procedure adopted was apparently very satisfactory, since there was a considerable amount of discussion and exchange of experiences by the subjects both with the informal interviewer and among themselves. Each subject was centrifuged a minimum of six times prior to actual initiation of the test modes.[1] It was quite apparent that as the training runs progressed, the subjects became more secure and capable. By the fourth centrifugation, all subjects had stabilized their breathing rhythm during the 2-min 6-g centrifugation without gasping for breath and could talk over the inter-communication link with relative ease and comprehension. During the first runs the intelligibility of the subjects' speech was degraded under high g forces. These two aspects, breathing and the ability to speak during centrifugation, were most frequent topics of conversation by the subjects during the centrifugation training. By the completion of the sixth run, the subjects' concern had shifted from the difficulty associated with breathing and speaking to an emphasis on their personal comfort during the centrifuge tests. One factor of interest was to determine how much pressure in the seat and back bladders provides the best cusion during the 6-g ride. Perhaps the most beneficial service performed by the interview procedure was to disseminate the techniques learned by the subjects for reducing the stress of centrifugation. These techniques included body positioning and easing the difficulty encountered in breathing.

This training program is believed to have eliminated the greater part of the anxiety manifested by the subjects before and during the early phases of training. There were, of course, risks that the subjects were exposed to, and a certain amount of anxiety is inevitably associated with these risks. When high acceleration forces are dealth with, the consequences of failure can be severe. Our objective was to place the risk on a rational level for the personnel involved. The subjects' behavior during the study substantiates that this was accomplished.

Figures 3-1 through 3-4 illustrate the equipment as it was used in the training for familiarization and additional altitude training. Figure 3-1 shows the instrument console and the major portions of the environmental control system. Figure 3-2 through 3-4 illustrate the sequence of lecture and installation of the subject in the capsule.

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[1]The last two runs were used to establish the baselines for the subjects.

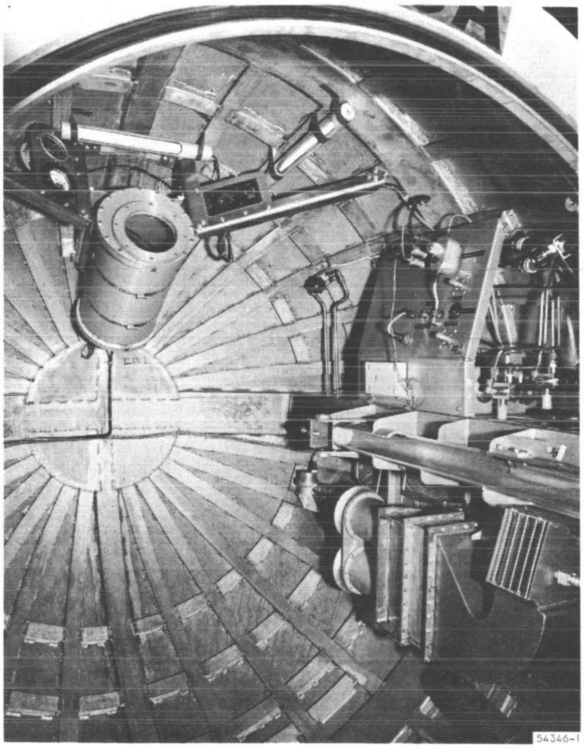

Figure 3-1. Instrument Console and ECS

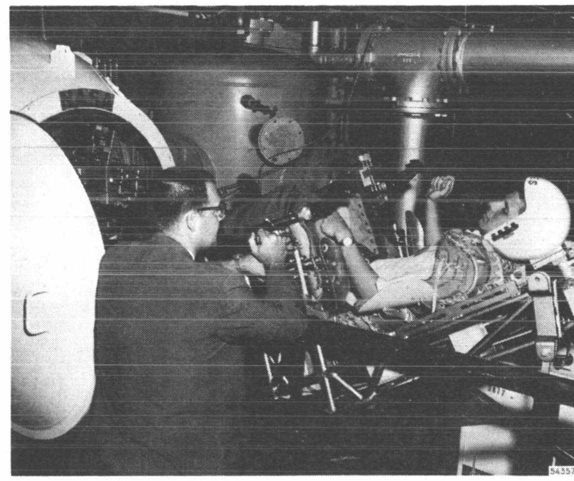

Figure 3-2. Familiarization Lecture

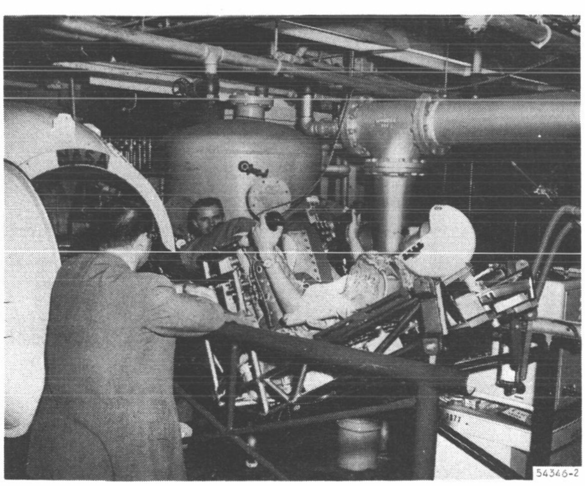

Figure 3-3. Installation of Subject

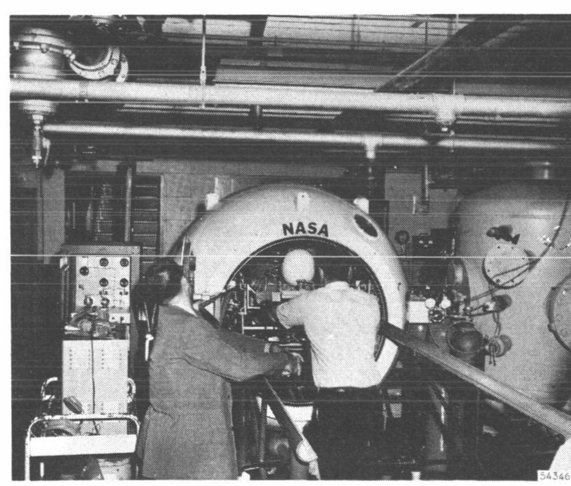

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Figure 3-4. Preparation for Altitude Training

SECTION 4

FACILITIES, EQUIPMENT, AND INSTRUMENTATION

FACILITIES

The facilities used in this phase of the program were the AiResearch research and development laboratories and the University of Southern California centrifuge, located in Los Angeles. The principle facility was the human centrifuge in the department of physiology. The facility was recently modified and expanded. A new drive system for the centrifuge and additional laboratory space were provided. The modification included accommodations for the study reported here. The facility was made available to AiResearch on October 6, 1965. Figure 4-1 shows the overall installation of the centrifuge.

The centrifuge consists of an electric drive and braking system that drives a boom providing a radial length of 23 ft at the mounting point and an overall radial clearance of approximately 27 ft. The centrifuge drive system is capable of accelerating this system at a constant rate of 5 revolutions per sec. During this program, the acceleration profile was as shown in Figure 4-2. The photographs in Section 2 show other parts of the centrifuge facility. Figures 2-11 and 2-12 provide an overall view of the centrifuge system. The altitude tank in the research and development laboratory at AiResearch was used in the subject's training program.

EQUIPMENT

The principal equipment used in this program and illustrated in Figures 2-1 through 2-12 are

1. Environmental capsule
2. External support and handling gear
3. Environmental monitoring system
4. Biological instrumentation and equipment

A summary of each of these items is presented below. Detailed information on the structure, the handling gear, and the environmental control system is included in the Phase I final report (AiResearch Report LS-134, Parametric Study of Flight-Induced Pulmonary Pathology, August 27, 1964.)

Environmental Capsule

1. Structure

The capsule is a 6-ft-diameter sphere of all-welded construction using 6061-T6 aluminum alloy. The primary load-carrying structure consists of ring frames and a box structure to which the seat truss and trunnions are attached.

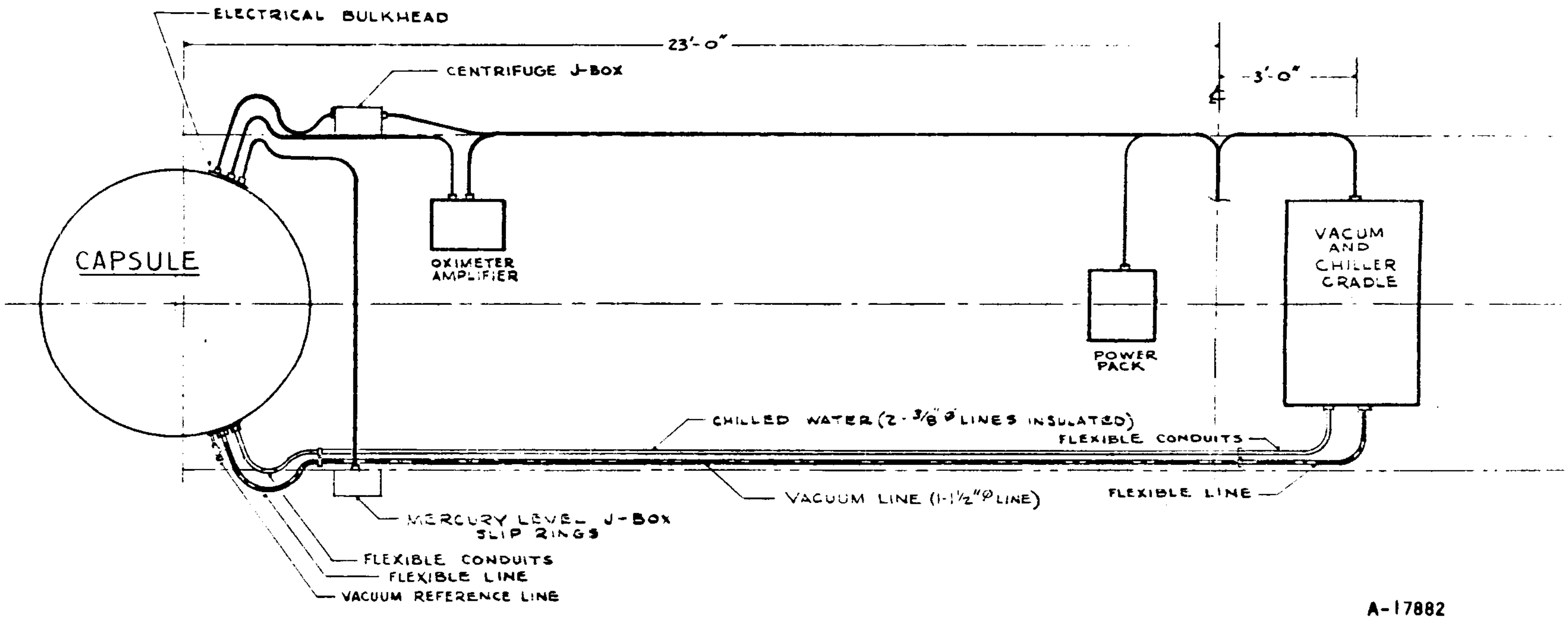


Figure 4-1. Plumbing and Electrical Instrumentation Lines on Centrifuge

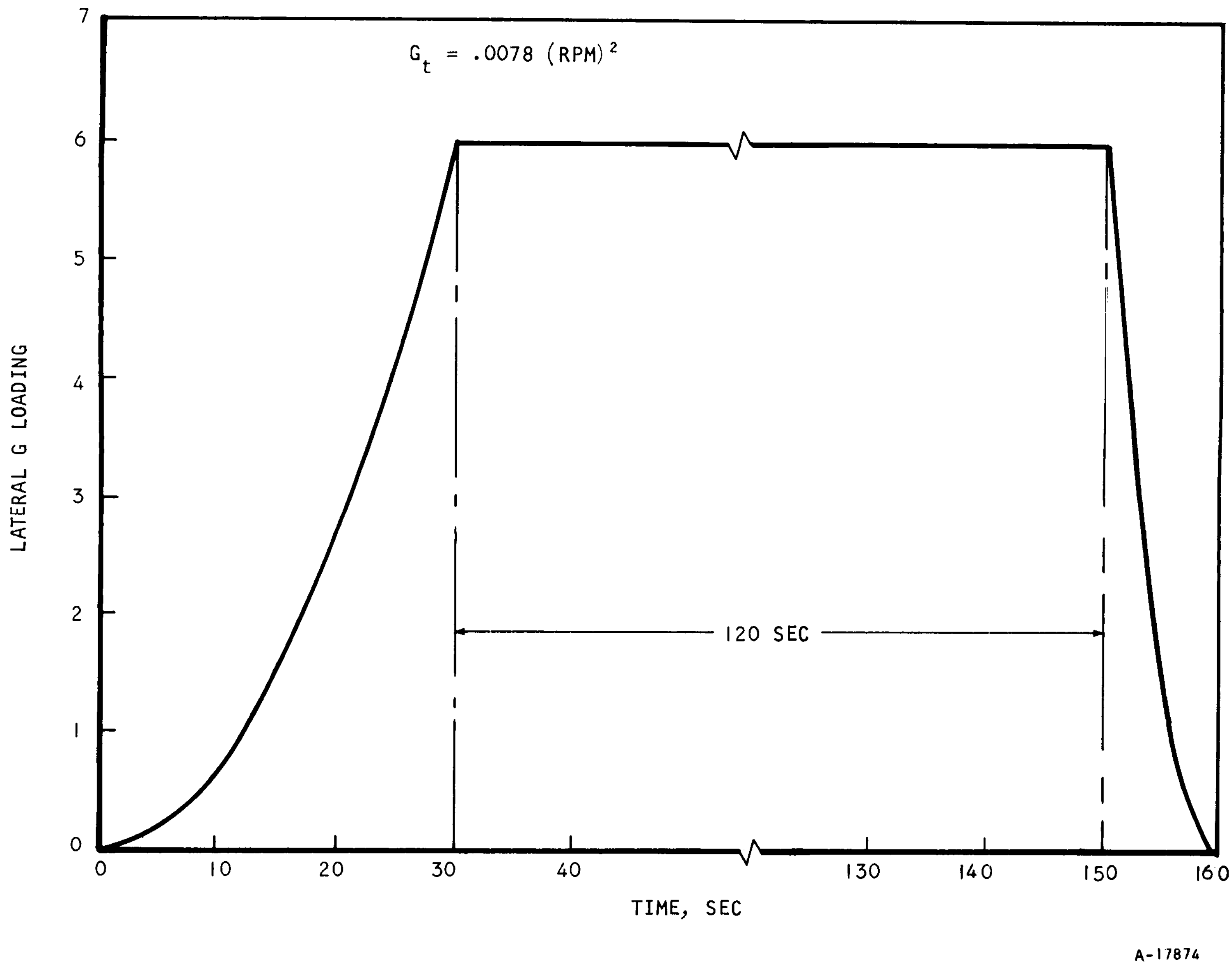


Figure 4-2. Acceleration Profile

The spherical shell is 1/8-in. thick reinforced with H stringers to withstand a collapsing pressure of 1 atm. The box structure is extended through the shell providing the structure for attachment to the centrifuge. Two 8-in.-diameter windows are provided in the upper portion, 180 degrees from each other. Two 8-in.-diameter bulkheads were used, one for electrical and instrumentation and one for pneumatic and liquid feedthroughs. The door opening is 42.5 in. in diameter, allowing free access for the intended use. The door is latched inside with three dogs actuated by rotating an external handle. The door is sealed with an inflatable and a mechanical seal. Bulkheads, windows, and feedthroughs are sealed with o-rings.

2. Environmental Control System

The environmental system (ECS) consists of total pressure control, oxygen makeup, carbon dioxide removal, air cooling, and water removal.

Total pressure is controlled through the total pressure control head, which has a reference to external ambient pressure and to a vacuum source. The control head consists of a high quality bellows working against a variable spring-loading mechanism. The spring loading is varied to obtain the desired cabin pressure. The difference between the external pressure load and the spring tension load acting on the bellows will open or close a valve in the control head to a vacuum source. The ambient pressure reference line is restricted by a small orifice, so that the control head provides a nearly constant reference pressure well within the specifications of the program. This provides the inflow and the outflow valves with the desired pressure within the capsule. The inflow or outflow valves are referenced to cabin pressure and control head pressure and the difference between these pressures will actuate either valve pneumatically. The inflow valve opens if there is a deficiency, allowing the gas for maintaining total pressure to enter, and the outflow valve opens if there is an excess pressure. The system can be used as a two-gas or a one-gas (oxygen only) system. The total pressure is made up by the introduction of the diluent when the system is used in the two-gas mode and by oxygen in the one-gas mode. These gases are fed into the capsule through a regulated on-board high-pressure system.

The oxygen partial pressure is controlled by total pressure and/or minimum partial pressure through the oxygen partial pressure control system. This system consists of a polarographic sensor which provides a signal to an amplifier. The amplifier produces a signal for the actual partial pressure sensed and compares the sensed pressure with a preset minimum pressure. If the sensed pressure is less than the desired pressure, a signal is generated that is used to operate a solenoid valve to introduce oxygen from the on-board supply.

Carbon dioxide partial pressure is controlled by the introduction of carbon dioxide if the pressure is low or by the removal of carbon dioxide by the carbon dioxide absorbent bed if the pressure is high. The absorbent bed is a canister of soda lime with an activated-charcoal section. The charcoal section is provided for removal of odors and contaminant traces.

Cabin cooling and water vapor content are controlled by circulating the cabin air through a water-cooled heat exchanger and collecting the excess water condensed in the cooling process. Under normal operation, the partial pressure of water vapor in the cabin is slightly above that of the water-saturated air leaving the heat exchanger. All test conditions require cooling, and the cooling required, along with water vapor partial pressures, is maintained by coolant flow and temperature and by cabin air volume circulation. The coolant flow is adjusted with valves operated by the subject and the temperature is adjusted on the ECS support assembly. The cabin airflow is adjusted from the monitor's panel.

External Support and Handling Gear

1. External Support

The external support required by the capsule is the vacuum source, the chilled water supply, the gas supply, and the gas purging system. A vacuum pump, a water chiller, and a water pump were packaged into a cradle system mounted on the centrifuge (Figure 4-1). The cradle is used so that the resulting rotational and normal gravity forces will act perpendicular to the usual base of the equipment and commercially available equipment may therefore be used. The vacuum pump's capacity is 15 cu ft per min and is nearly constant through the pressure range of this program. The water chiller has a rating of 3/4 ton of refrigeration. The water pump circulates the chilled water to the capsule for atmosphere conditioning. Gas supplies and purging lines are attached by quick-disconnects as required through the mechanical bulkhead from high-pressure bottles, as shown schematically in Figure 4-3.

Shrouds are used to envelope the areas that are most prone to leakage from outside. The shrouds are used over the capsule door and door seal valve. The shrouds are purged with carbon dioxide so that any leakage would be carbon dioxide rather than nitrogen from the ambient atmosphere. Carbon dioxide can be easily removed, whereas nitrogen is difficult to remove.

A block and tackle system of pulleys and nylon ropes was utilized to rotate the capsule so that the capsule could be rotated to place the subject in a more comfortable position during long-duration tests. The stabilizing bar which rigidly supports the capsule is attached with pins that may be easily removed. These pins were removed and the capsule was rotated approximately 15 degrees. Before centrifugation, the capsule was rotated and fixed in the desired centrifuge position.

2. Handling Gear

The equipment used for handling the subject and capsule consists of the restraint system, extension rails, capsule dolly, and lifting cross. The restraint system supplied by NASA/Ames had been developed as a universal pilot restraint for research at high g loads in any direction. The structural portion of this system was modified for this program. Bearing structures with rollers and quick disconnect attachments were provided for the chair trunnions for ease of installation and handling. Since the direction of the resultant

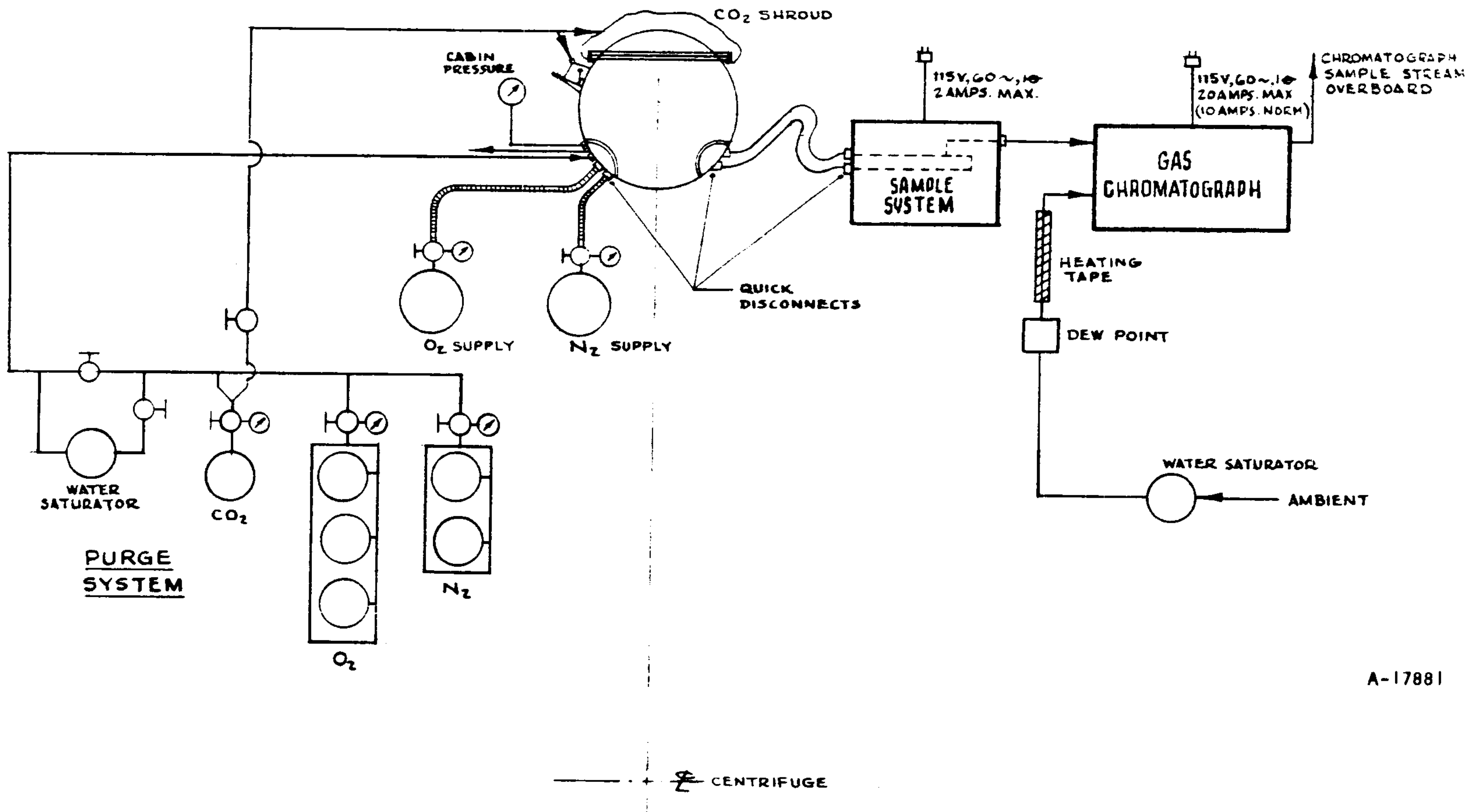


Figure 4-3. Gas Sampling, Purging, and High-Pressure Supply Schematic

acceleration vector was normal to the spine in the sagittal plane (eyeballs in) the entire restraint system was not required. Further, the formed back and thigh pieces were replaced by flat plates and the bladders were attached to the plates for cushioning and comfort. This was done so that the chest X-ray cassettes could be placed with a minimum of effort on the subject's part. It also provided more freedom for the comfort of the subject during the long testing durations. The restraint system is inserted and removed from the capsule on rails, as shown in the figures. Extension rails with casters are attached to the capsule internal fixed rails. The restraint system is then disconnected, positioned, and rolled out. The extension rails can then be detached and wheeled into position for the post-centrifugation physiological testing. A wheeled dolly and lifting cross are attached to the capsule for handling the capsule when it is not attached to the centrifuge.

Environmental Monitoring System

The environmental monitoring system consists of indications of the oxygen and carbon dioxide partial pressures, the temperature of the cabin, the temperature of the recirculated gas leaving the cabin cooling system, and the total absolute pressure of the capsule. Controls for fan speed and indicators of operating subsystems were also displayed on the console for primary control. These indications were continually displayed and were periodically recorded during tests, as shown in Table 4-1.

The recording of these data is required to assure that the composition of the atmosphere is correct and that the subject is in no danger. In the example shown, the temperature of the air leaving the heat exchanger is high until the 1300 reading, because neither the vapor pressure of water nor the cabin temperature was high enough to start the chilled water circulation. It was also necessary to purge the capsule continuously with oxygen and carbon dioxide at very low flows in order to maintain the nitrogen content below 1 percent. Differences between the monitor reading and the chromatograph reading are attributable to the slow response and low accuracy of the polarographic systems and to the periodic sampling of the chromatograph sampling system.

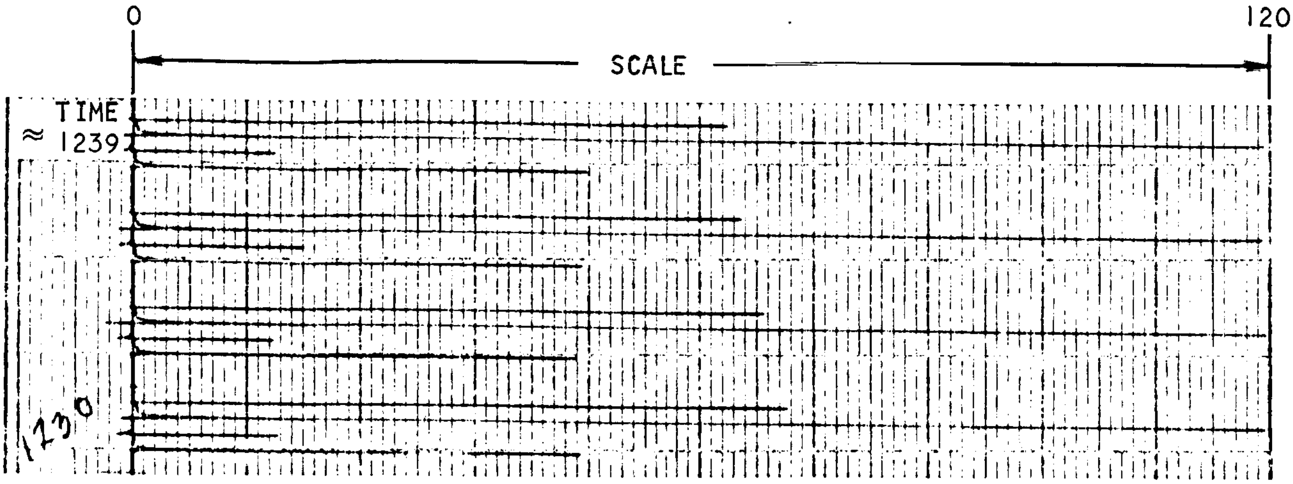
The chromatograph is a modified Beckman 320D process analyzer which analyzes the gas samples at 100 mm Hg absolute pressure at a time rate of approximately 3 min. A presentation of the analysis is shown in Figure 4-4. The scale indications starting from the bottom are those for water vapor, carbon dioxide, oxygen, and nitrogen in volume percent for each group analysis. These indications are corrected by referral to a calibration curve which was obtained by analysis of known gas samples.

The gas sample acquisition system, shown in Figures 4-5 and 4-6, is used to periodically trap a sample from a continuously circulating stream for possible future analysis. The pump has a Teflon diaphragm, allowing a stream to be pumped through the system without contaminating the gas. The sample stream may be returned to the system. The stopcocks on the sample burettes are opened and the stream allowed to purge through it. When a sample is desired, the stopcocks are closed. This system provides four samples before the sample burettes need replacing.

TABLE 4-1

TYPICAL RECORDING OF ATMOSPHERIC CONDITIONS

Test 380, Pure O_2							December 29, 1965
Time	1130	1200	1230	1300	1330	1400	1425
Control Panel							
pO_2, mm Hg	368	369	368	374	373	369	365
pCO_2, mm Hg	5.10	5.35	5.15	4.95	5.0	6.10	5.10
HX temperature in	74.5	74.7	74.6	72.3	70.5	70.0	69.8
HX temperature out	62.5	63.5	63.6	47.2	48.2	46.5	46.5
Cabin fan speed	30	30	30	30	30	30	30.0
CO_2 fan speed	0	0	0	0	0	0	0
Total press., in. Hg	14.85	14.89	14.78	14.77	14.87	14.90	14.78
Chromatography							
H_2O vapor %	1.10	2.60	2.95	2.20	2.15	2.15	2.10
CO_2 %	1.50	1.25	1.28	1.30	1.55	1.55	1.12
O_2 %	98.00	97.65	97.65	98.00	98.25	98.25	98.00
N_2 %	0.65	0.60	0.41	0.36	0.89	0.89	0.91
Total volume %	101.25	102.20	102.29	101.86	102.84	102.84	102.13



CONSTITUENT	VOLUME PERCENT	CORRECTED VALUE (APPROX)*
N_2	0.578	0.410
O_2	99.7	97.65
CO_2	1.28	1.28
H_2O	3.93	2.95

	SCALE	PRESSURE EQUIVALENT (MM HG)
N_2	0 TO 1	0 TO 1.9
O_2	0 TO 100	0 TO 194
CO_2	0 TO 10	1 TO 10
H_2O	0 TO 10	0 TO 5

TEST CONDITIONS

380 MM HGA — SUBJ: G.R.

367 MM HG O_2 PARTIAL PRESSURE — DATE: 29 DEC 1965

*REFER TO TABLE 4-1 FOR RECORDED ENTRY.

Figure 4-4. Chromatograph Analytical Presentation

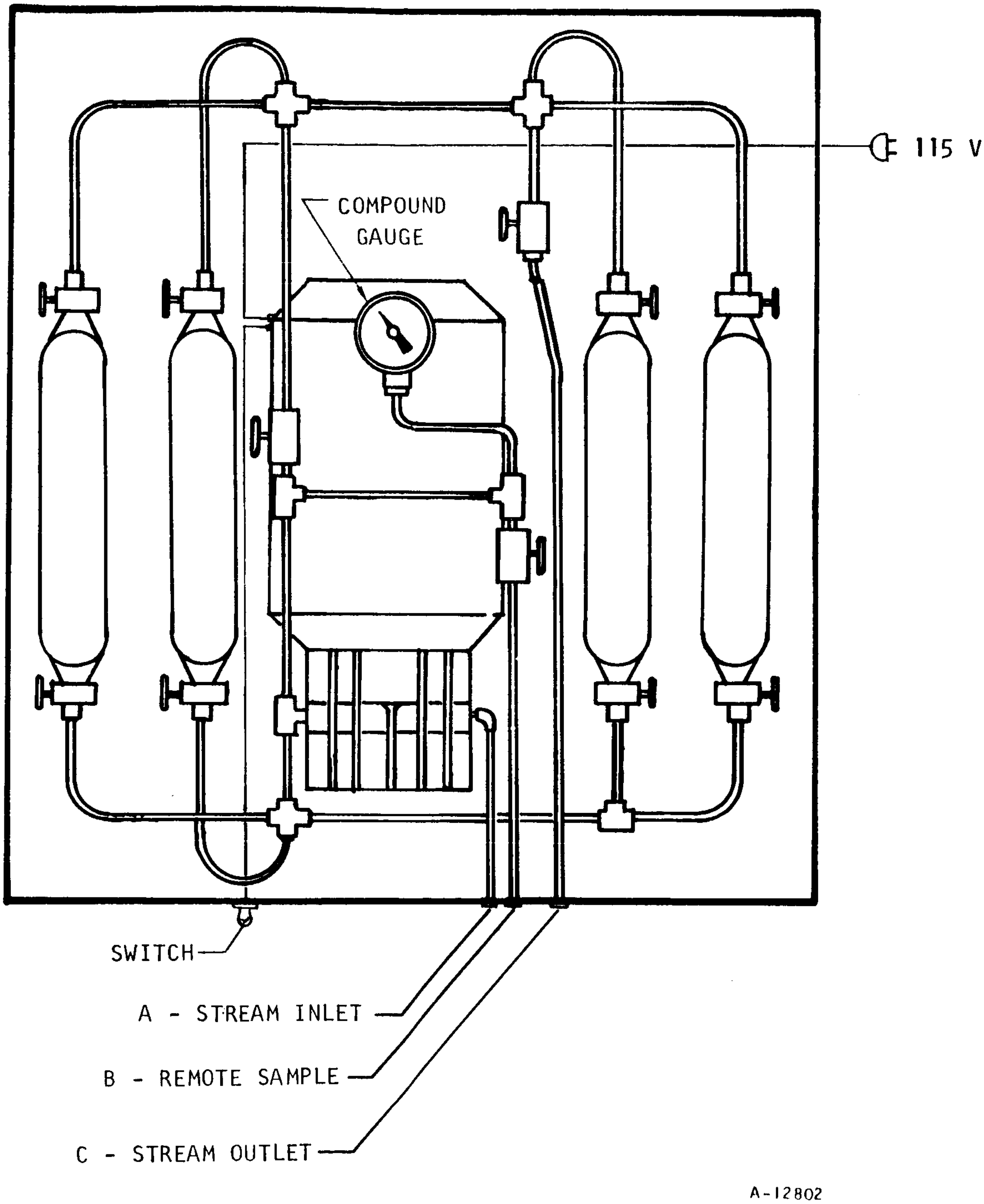


Figure 4-5. Gas Sample Acquisition Device

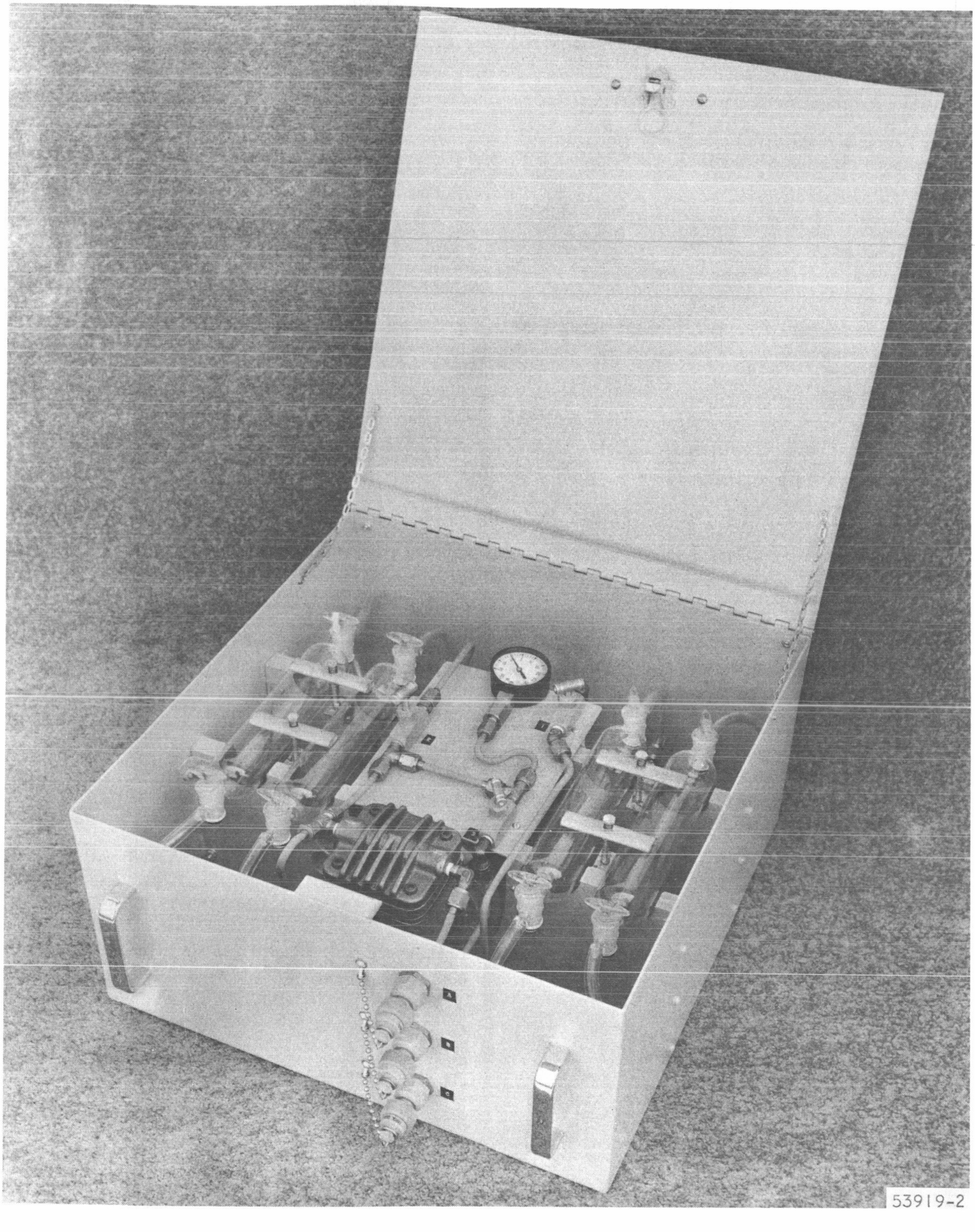


Figure 4-6. Gas Sample Acquisition Device

Biological Instrumentation and Equipment

The principal instruments used in this program to collect data for determination of the existence and amount of atelectasis were the X-ray machine and the pulmonary spirometer. A clinical X-ray machine was used. A Godart Model No. PNT/59005 Pulmonet Spirometer was used for the pulmonary function tests. The rest of the instrumentation, used primarily for monitoring purposes, includes intercommunication, television, a tape recorder, electrocardiogragh respiration rate recorder, pressure cuff and microphone, and an ear oximeter. The intercommunication consisted of a cabin speaker and a throat microphone for the subject. The television camera was positioned so that the subject's face could be watched during centrifugation. The tape recorder was used to record breathing noises and coughing during centrifuge testing.

The remainder of the measurements were recorded on an eight-channel Dynograph Offner recorder. ECG was monitored by two electrodes placed roughly in line with the heart's electrical axis. The anterior electrode was located over the sixth intercostal space directly below the nipple, and the posterior electrode was located over the lower border of the right scapula. A ground electrode positioned on the abdomen eliminated system noise. A simple strain-gauge belt attached around the girth of the chest was used for respiration rate. A standard clinical blood pressure cuff and microphone was used primarily for calibration of the ear oximeter. Due to the vibrations during centrifugation, the information was noisy and unstable. The ear oximeter, supplied by NASA, is a modified Waters oximeter. This device is used to obtain blood oxygen saturation, pulse, and pressure. Various procedures were tried to obtain useful data with this system, but the system was so unstable that the data could not be used.

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SECTION 5

PHYSIOLOGICAL PARAMETERS

DATA ACQUISITION AND PRESENTATION FORMAT

The pulmonary function data were recorded in a sequence that allowed the less rigorous measurements (FRC and ERV) to be made first and the more severe measurements (IC, VC, TVC and MVV) to be made last so that sensitivity to small changes in lung volume may be detected before rigorous breathing masked these effects. A typical record of the pulmonary function tests is seen in Figure 5-1 which presents the normal respiratory function as observed during baseline and pretest measurements. The precentrifuge trials were identical to postcentrifuge trials in procedure so that any effect on a specific measurement induced by a previous measurement would be held constant throughout the program.

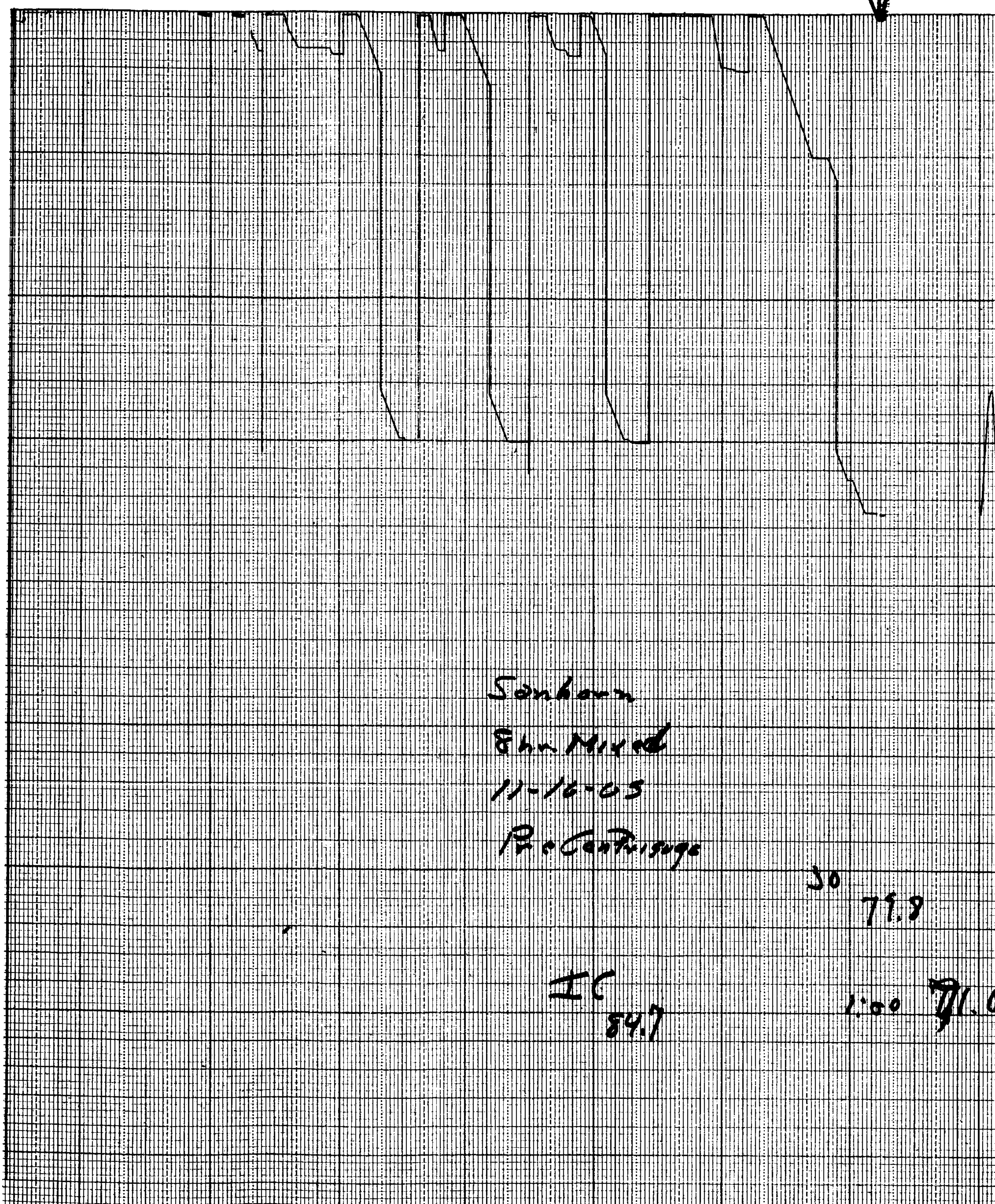
The pulmonary function data acquired is presented in Table 5-1 and arranged in order of apparent severity of test conditions, i.e., (baseline) occurs first and the most severe test (8 hr, 190 mm Hg) occurs last. In general the experiments were run in this fashion, as seen by the dates heading the columns. The first measurement in each column is for the precentrifuge value (ATP) of a parameter and the second figure for the postcentrifuge value (ATP) of that parameter. The asterisk behind a number indicates coughing during that measurement. All measurements, are in cubic centimeters except for Maximum Voluntary Ventilation (MVV) and it is in liters per min. The Timed Vital Capacity is the value measured for one second. The Residual Volume (RV) was obtained by subtracting the Expiratory Reserve Volume (ERV) from the Functional Residual Capacity (FRC). The total Lung Capacity (TLC) was obtained by addition of the Functional Residual Capacity and the Inspiratory Capacity (IC). The Tidal Volume (TV) was measured during the helium dilution phase of FRC measurement. The minute oxygen consumption (MO_2) was recorded from the spirometer system stabilization flowmeter. The MVV was obtained through the use of a volume integrator provided as a feature of the spirometer.

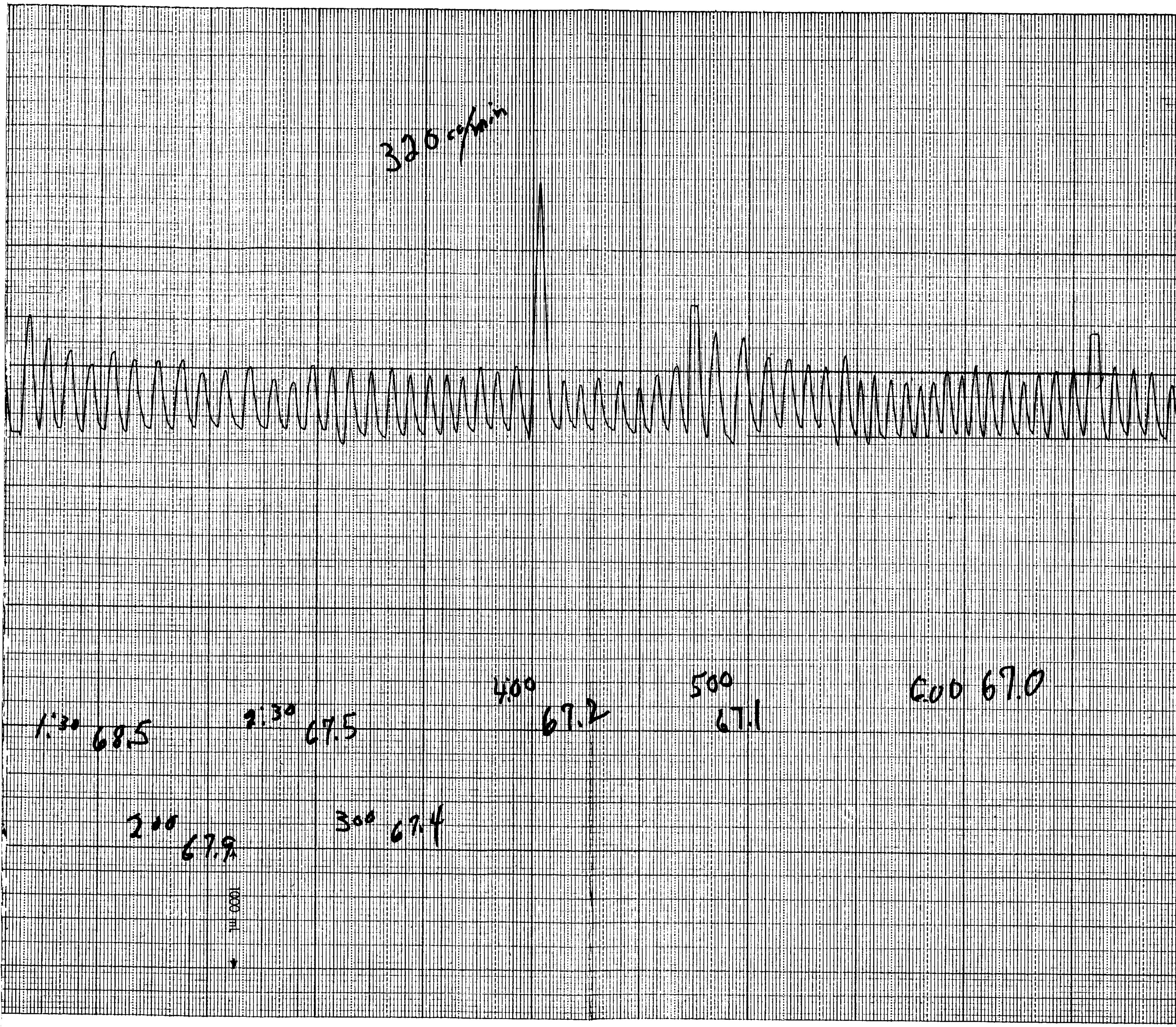
All measurements were made utilizing standard spirometric methods as detailed in the Appendix, listed as Pulmonary Function Procedures and Checklist.

RESULTS OF PULMONARY FUNCTION TESTS

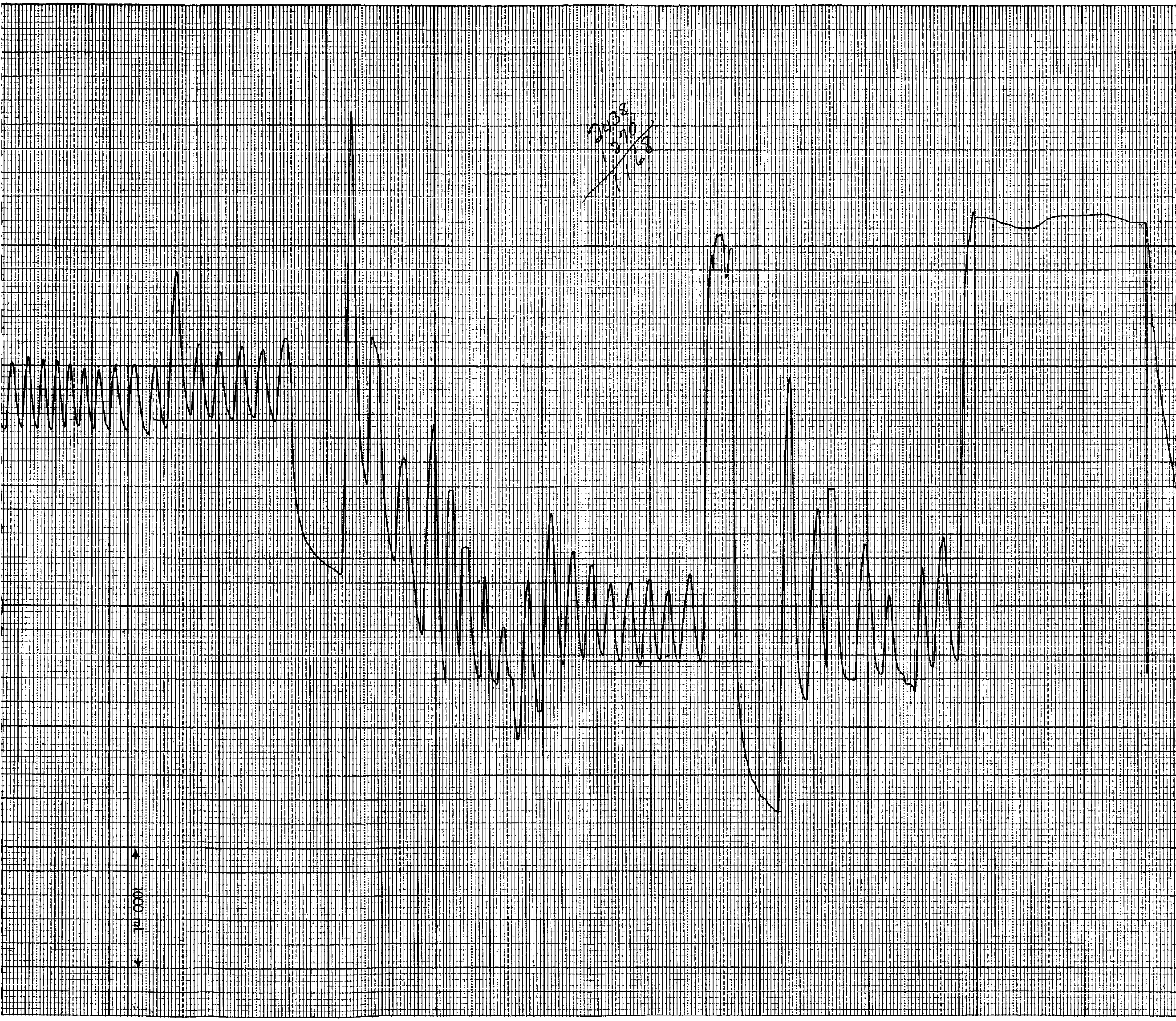
The data presented in Table 5-1 indicate that negligible changes occurred due to baseline conditions and that only certain lung volumes were altered by the combination of 100 percent oxygen and reduced barometric pressure.

The effect of being centrifuged at sea-level pressure while breathing air is small. The mean ERV for the group was reduced slightly and the mean IC was increased by essentially the same amount indicating that only the level of tidal breathing changed.


Sanborn
8hr Mixed
11-16-65
Pre Centrifuge
30
79.8
IC
84.7
1:00


320 cc/min
1:30 68.5
2:00 67.9
2:30 67.5
3:00 67.4
4:00 67.2
5:00 67.1
6:00 67.0
1000 mL

5-2-2



5-2-3

5-2-4

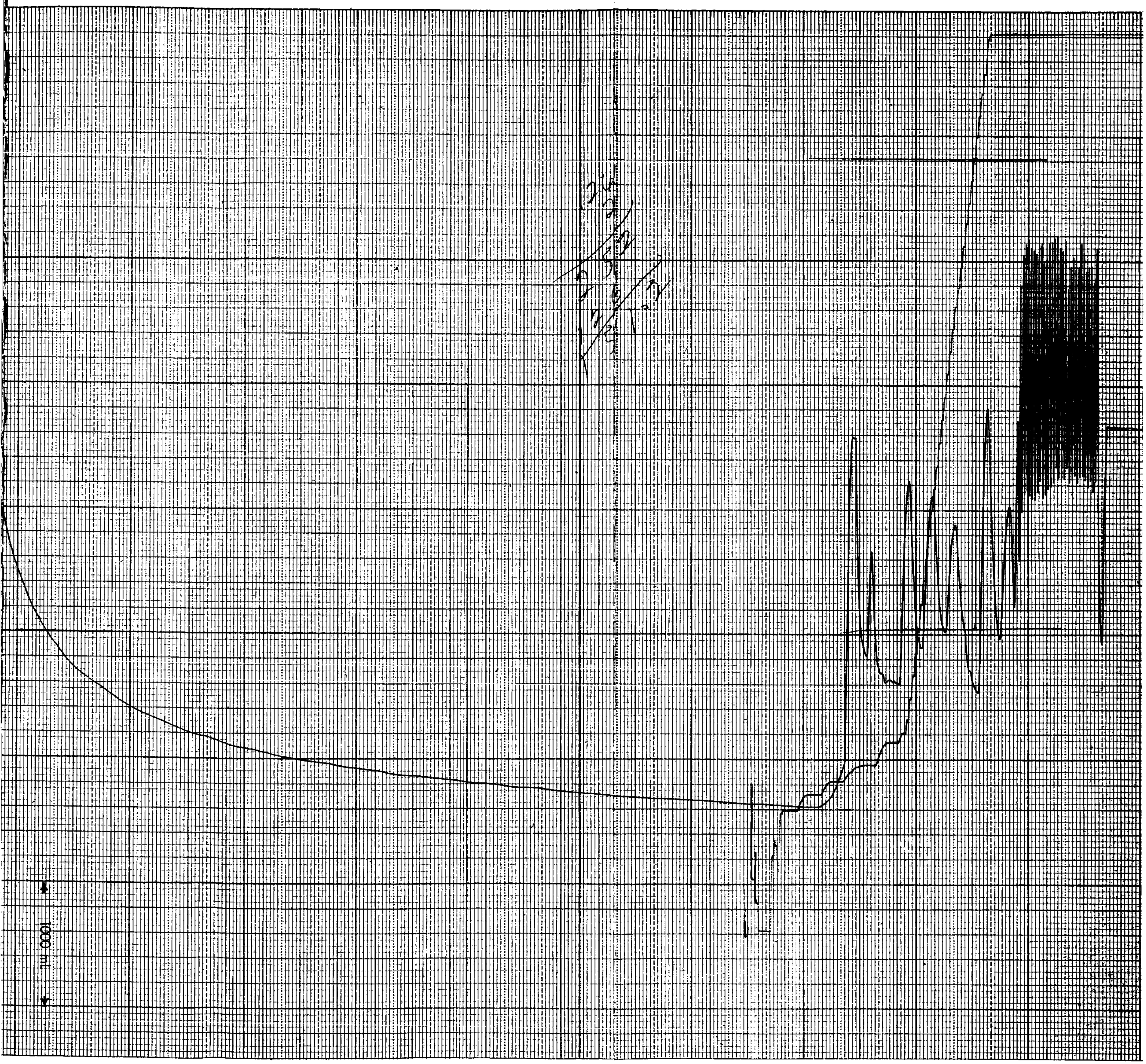


Figure 5-1. Pulmonary Function Test Data, Precentrifuge, 8-hr Mixed Mode, Subject WS

TABLE 5-1

PULMONARY FUNCTION DATA

Subject		Baseline 11-3 B Pre	Baseline 11-3 B Post	Baseline 11-4 B Pre	Baseline 11-4 B Post	11-12 3 hr Mixed Pre	11-12 3 hr Mixed Post	11-19 8 hr Mixed Pre	11-19 8 hr Mixed Post	12-3 3 hr O_2 360 Pre	12-3 3 hr O_2 360 Post	12-10 8 hr O_2 360 Pre	12-10 8 hr O_2 360 Post	12-17 3 hr O_3 180 Pre	12-17 3 hr O_3 180 Post	12-28 8 hr O_2 180 Pre	12-28 8 hr O_2 180 Post
MG	FRC	2920	2900	2845	2795	3140	2830	2842	2494	1733	1984	2978	2674	2875	2476	3032	2698
	ERV	1140	1080	1225	1120	1100	1280	1370	1305	1205	1000	1365	1160	1315	1160	1400	1130
	RV	1780	1820	1620	1675	2040	1550	1472	1189	528	984	1613	1514	1560	1316	1632	1568
	VC	4630	4615	4555	4570	4470	4625	4575	4480	4470	4615*	4600	4615*	4580	4800	4570	4555*
	IC	3550	3465	3445	3550	3395	3555	3385	3400	3250	3380	3250	3290*	3455	3245*	3210	3100*
	TLC	6470	6365	6290	6345	6535	6385	6227	5894	4983	5364	6228	5964	6330	5721	6242	5798
	TVC	3685	3435	3615	3320	3645	3400*	3600	3380*	3590	3450*	3880	3175	3525	3415	3530	3220
	TV	580	550	590	435	480	560	420	450	705	470	480	475	500	525	450	400
	MVV	133.2	152.4	148.8	142.8	124.8	133.2	135.0	124.5	119.0	124.8	120.0	120.2	115.5	151.5	117.6	126.2
	MO_2	280	220	325	320	240	240	260	280			260	280	280	280	260	260
												Heavy Coughing				Heavy Coughing	
WS	FRC	2385	2335	2725	2580	2210	2085	2438	2482	2545	2423	2554	2216	2433	2060	2352	2240
	ERV	1255	1000	1270	1130	1240	1180	1270	1055	1150	1140	1165	1230	1085	1080	1365	1285
	RV	1130	1335	1455	1450	970	905	1168	1427	1395	1283	1389	986	1348	980	787	955
	VC	4645	4635	5050	4845	4795	4650	4800	4665	4795	4505*	4840	4400*	4605	4515	4570	4545
	IC	3600	3670	3745	3820	3610	3600	3545	3750	3925	3610*	3670	3595	3470	3650	3550	3510
	TLC	5985	6065	6170	6400	5820	5685	5983	6232	6470	6033	6224	5811	5903	5710	5902	5780
	TVC	3075	3045	3330	3325	3015	2945	3175	3050	3130	2830*	3195	2495	3075	2900	3200	3050
	TV	400	440	480	410	500	520	535	330	485	525	585	440	450	420	455	450
	MVV	138	136.8	157.2	154.8	141.0	139.2	151.2	148.8	147.6	116.6*	154.2	115.8*	143.5	135.6	147.1	141.6
	MO_2	260	240	320	320	320	260	320	260	300	300	280	300	320	320	300	300
												Coughing with congested feeling in lungs		Moderate Coughing		Heavy Coughing	
LR	FRC	1832	1740	1880	1601	1703	1449	2050	1891	1584	1968	1762	1568	1803	1746	1617	1665
	ERV	720	780	900	840	735	775	1005	880	985	900	840	800	730	735	815	860
	RV	1112	960	880	761	968	674	1045	1011	599	1068	922	768	1073	1011	856	805
	VC	5000	5080	5150	5225	5150	5190	5055	5050*	5190	4260*	5240	3520*	5260	3450	5085	3395
	IC	4435	4400	4375	4650	4480	4495	4175	4350	4350	3745*	4395	2900	4510	3040*	4420	2875**
	TLC	6267	6140	6255	6251	6183	5944	6225	6241	5934	5713	6157	4468	6313	4786	6091	4540
	TVC	3375	3250	3275	3140	3395	2950*	3190	3200*	3280	2455*	3130	1735*	3300	2090	2985	1680
	TV	680	675	830	680	775	640	745	790	985	675	860	675	985	1040	645	625
	MVV	112.8	96.0	91.2	106.8	114.0	103.2	85.2	104.8	106.8	106.8	99.6	72.0*	97.2	88.4	91.4	46.9*
	MO_2	240	240	300	280	260	240	300	280	280	280	260	260	280	280	270	280
										Heavy Coughing		Heavy Coughing		Heavy Coughing		Heavy Coughing large TV at g onset	
GR	FRC	1790	1862	1868	1625	1753	1708	2065	1780	2029	1964	2082	1465	2023	2246	1887	1354
	ERV	820	795	1060	750	820	700	915	810	860	865	1110	820	930	845	800	765
	RV	970	1067	808	875	933	1008	1150	970	1169	1099	972	645	1093	1401	1087	580
	VC	4155	4140	4135	4070	4165	4030	4150	4000	4210	4165	4050	3645*	3980	3720	4165	3745
	IC	3450	3470	3200	3365	3485	3275	3370	3320	3350	3420	3040	3065	3225	3300	3400	3355
	TLC	5240	5332	5068	4990	5238	4983	5435	5100	5379	5384	5122	4530	5248	5546	5287	4709
	TVC	3520	3400	3200	3430	3525	3150	3335	3055*	3525	3290	3475	3105	3490	3295	3265	3285
	TV	680	555	675	600	865	600	730	520	915	640	940	600	730	500	585	590
	MVV	106.8	124.8	124.8	123.0	145.2	147.6	157.8	152.4	174.0	176.88	144.0	142.3	137.0	160.0	150.0	168.0
	MV_2	340	340	340	320	380	350	300	320	300	300	320	280	350	260	300	300
												Minor Coughing Resp. Rate Change		Minor Coughing		Minor Coughing	

C-663

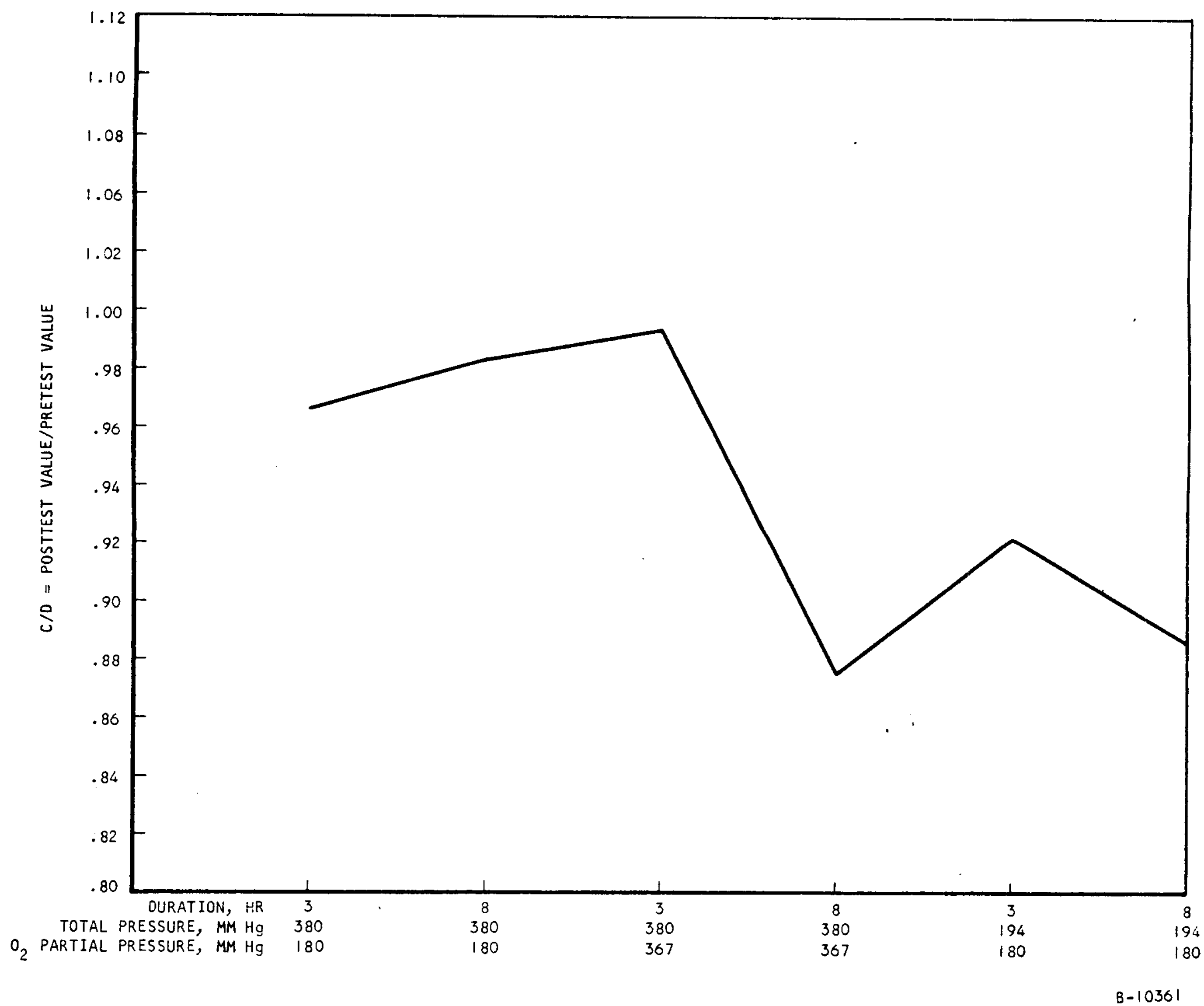


Figure 5-4. Total Lung Capacity $\overline{X}$

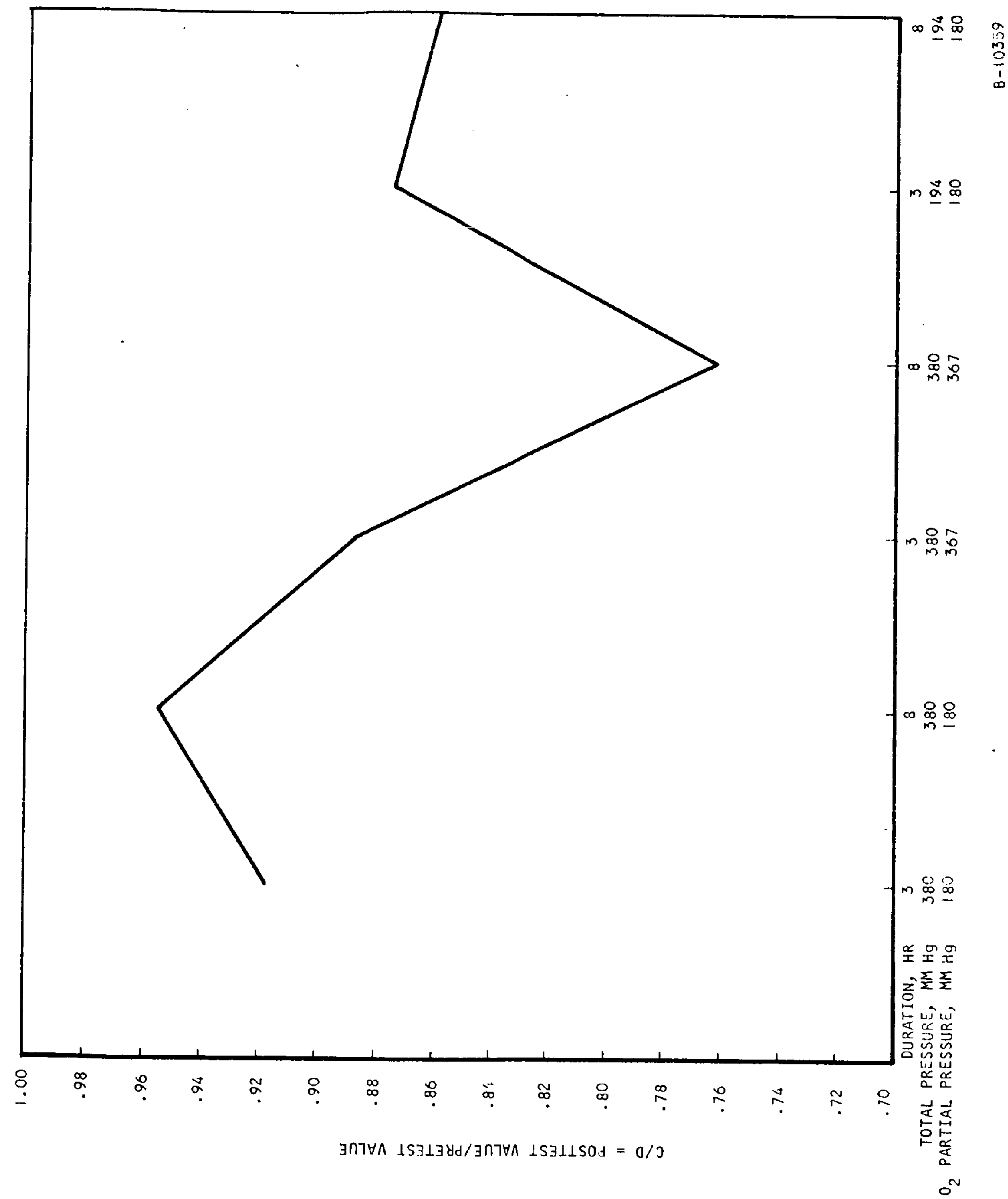


Figure 5-3. Timed Vital Capacity $\overline{X}$

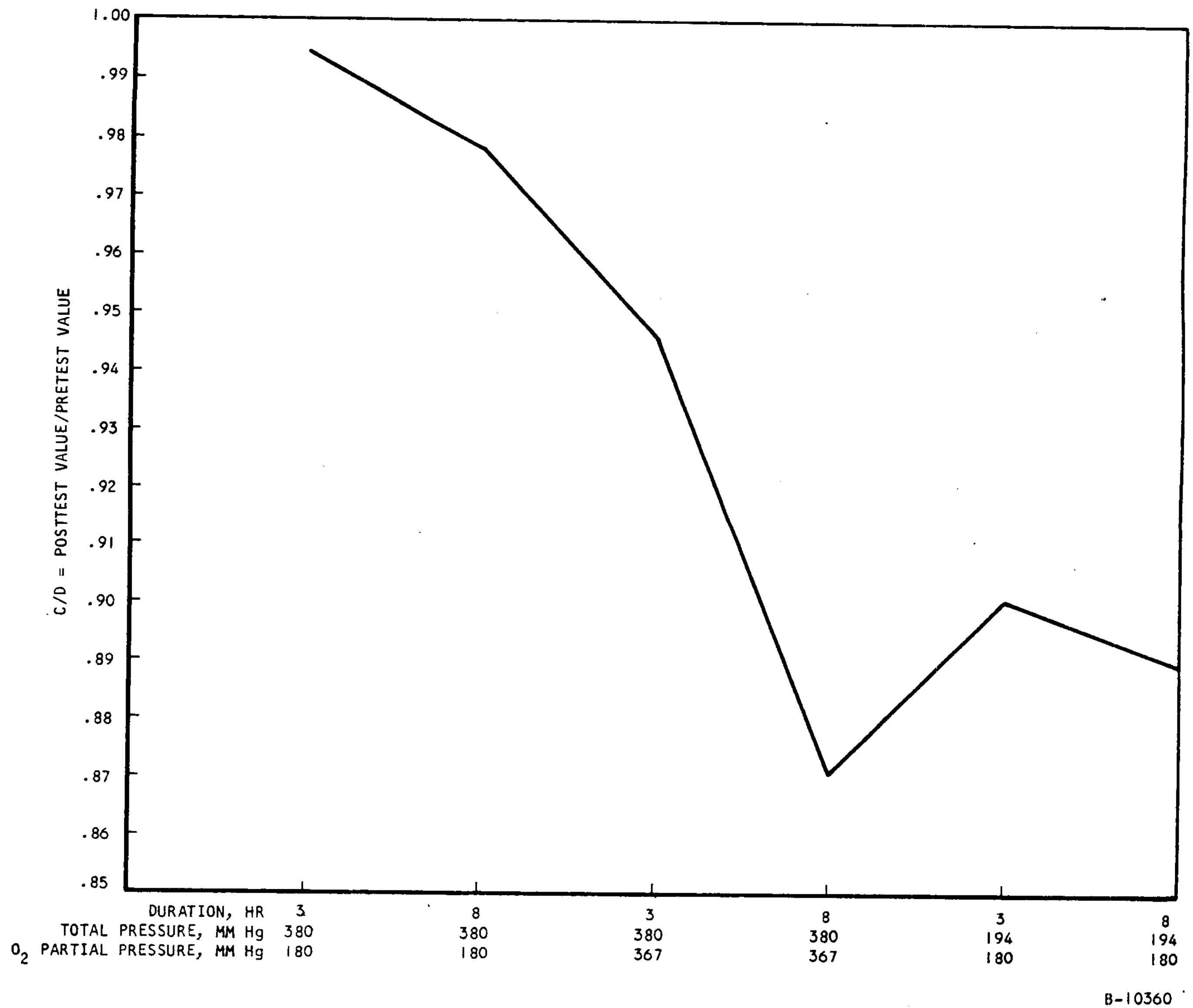


Figure 5-2. Vital Capacity $\overline{X}$

It is felt that oxygen, time, and reduction of pressure all contribute to respiratory difficulty. This is verified by the fact that significant changes in measured volumes occur where the combination of these parameters is the greatest. A reduction in postcentrifuge vital capacity, timed vital capacity, inspiratory capacity and total lung capacity occurs progressively as the severity of the exposure is increased. These changes may be seen more easily in Figure 5-2 through 5-5 where the mean values for the four subjects are computed as a ratio in order to show the incidence of volume changes. The ratio is C/D where C is the postcentrifuge value and D is the precentrifuge value. The number is normally less than 1 and is reduced as the severity of exposure is increased indicating a greater loss in respiratory measurements at reduced pressure and 100 percent oxygen.

The reduction in vital capacity, timed vital capacity, and total lung capacity may be explained by a reduction in inspiratory capacity for the mixed gas and three hour oxygen test and also by a reduced FRC in the 8 hr oxygen tests. Table 5-2, which presents the mean reduction in volume after centrifugation, shows that the inspiratory capacity ranges from being slightly hyperinflated (+148) at baseline to a reduction (-435) after 8 hr oxygen at 190 mm Hg.

TABLE 5-2

$\overline{X}$ REDUCTION IN VOLUME AFTER CENTRIFUGATION*

	IC	RV	VC	TLC	TVC	FRC
Baseline	+148	+23	17	+10	86	109
3 hr Mixed, 380	19	193	23	195	284	186
8 hr Mixed, 380	+87	59	97	78	154	187
3 hr, O_2, 380	180	+186	280	68	375	+112
8 hr, O_2, 380	376	246	637	739	793	364
3 hr, O_2, 190	357	91	485	508	395	66
8 hr, O_2, 190	435	163	537	677	437	246

*All values in cu cm.

The Residual Volume varies throughout the experimental series but does not show a trend except during the 8 hr oxygen tests. This reduction indicates that there is a significant interaction with oxygen at longer durations. The Functional Residual Capacity shows similar results with the largest reductions occurring at the 100 percent oxygen tests. This fact would also hint at

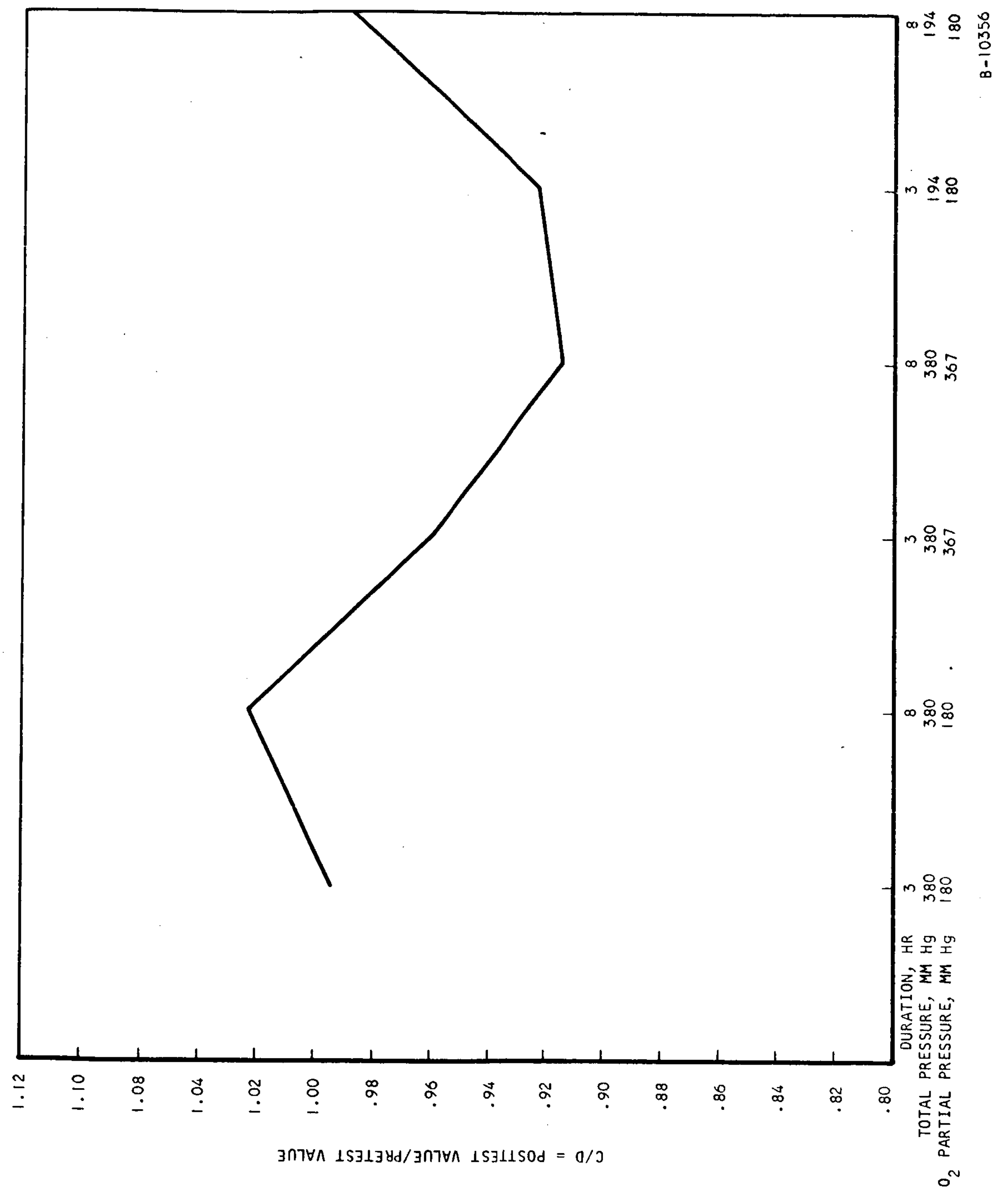


Figure 5-5. Inspiratory Capacity (F) $\overline{X}$

a physio-chemical change within the lung due to oxygen. This will be discussed in regard to the theory of surfactant degradation in Section 6.

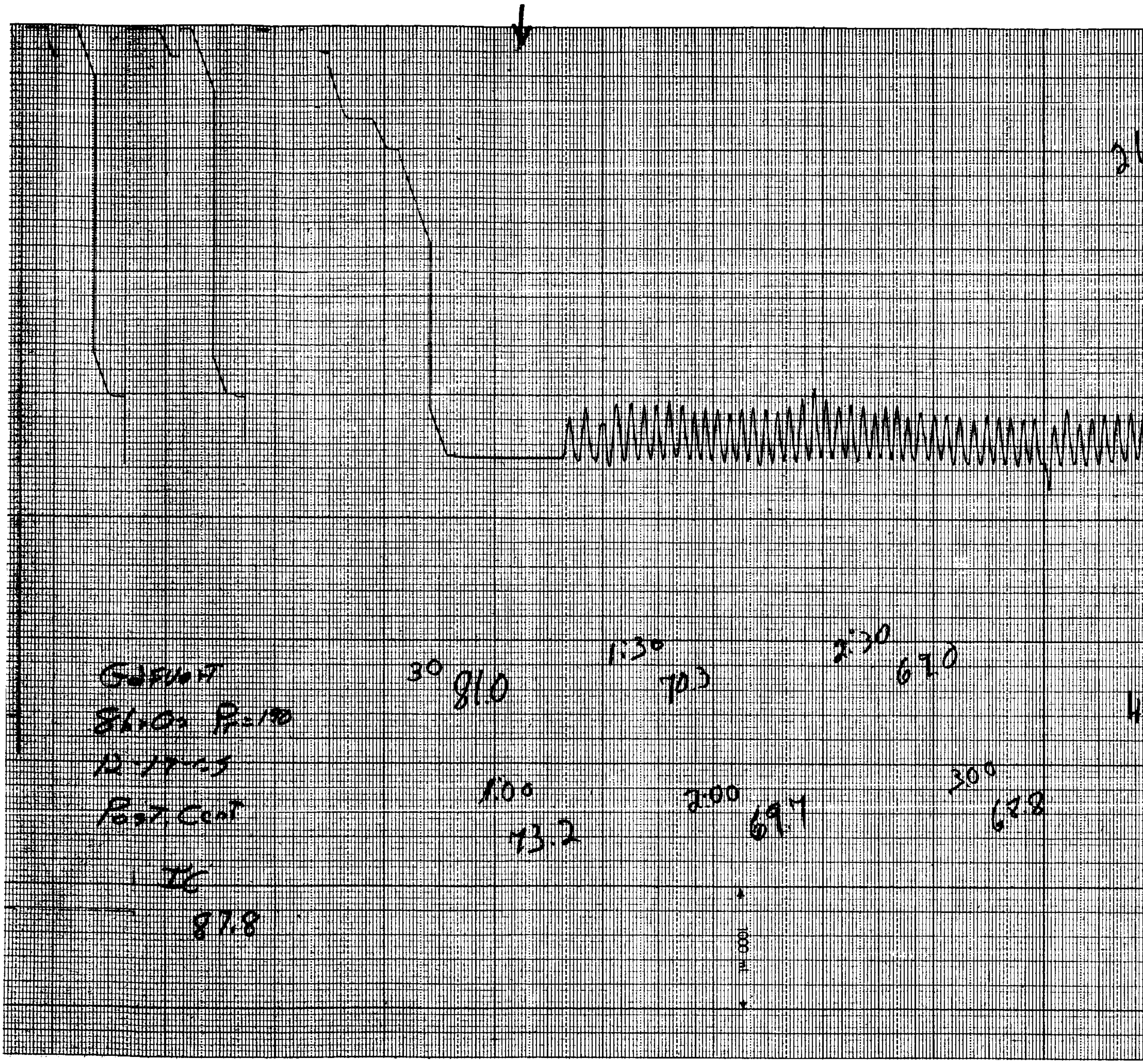
There was a high incidence of coughing that occurred after centrifugation the severity of which varied between individuals and test conditions. The coughing started almost immediately when the centrifuge stopped and lasted up to two hours later. The note below each test on Table 5-1 notes the level of coughing that occurred after centrifugation. The FRC and ERV were completed in all tests without coughing or difficulty. Attempts to perform the inspiratory portion of the vital capacity measurement did, in many cases result in an uncontrollable cough. The incidence of coughing during the respiratory measurements is noted by an asterisk in Table 5-1. When coughing occurred the subject resumed normal breathing until told to attempt the measurement again. A typical example of a record in which coughing occurred may be seen in Figure 5-6. Attempts were repeated until a satisfactory vital capacity measurement was made. The volume where an uncontrollable cough occurred was determined and recorded sequentially as IC_1, IC_2, IC_3, etc., and the final value was noted as IC_F. The values of IC for each individual when coughing occurred may be seen in Table 5-3. Each cough increases the respiratory capacity by a significant amount until the normal capacity is reached.

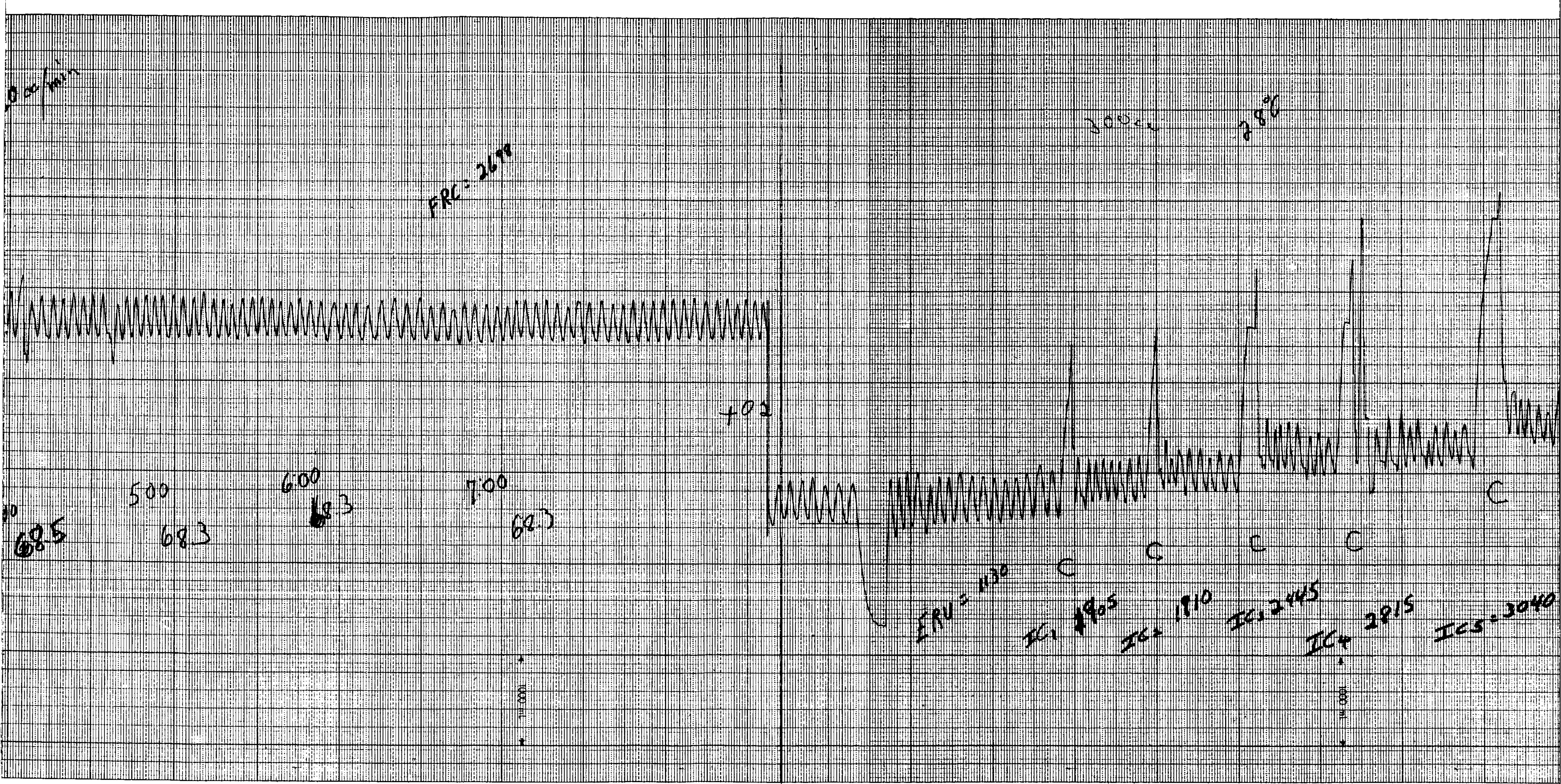
The effect of each experimental mode on the inspiratory capacity may be seen in Table 5-4. Here the first trial (IC_1) is listed along with precentrifuge value (IC_{pre}) and the final capacity (IC_F). The experiments are listed with the least severe (3 hr mixed) presented first and the most severe (8 hr oxygen at 190 mm Hg) last. Only these experiments where coughing occurred at a lower Inspiratory Capacity the more severe the test. The mean values for the first cough were plotted as a ratio C/D against severity of exposure in Figure 5-7. Here C is the postcentrifuge mean value and D is the precentrifuge mean value. The actual values range from a minor change on mixed gas to a significant value at 8 hr oxygen 190 mm Hg.

Attempts to utilize ear oximetry were unsuccessful in obtaining reliable quantitative data although it was extremely useful in noting the degree of unsaturation during centrifugation subjectively. It was also helpful in evaluating the well-being of the subject during and immediately after centrifugation.

X-RAY DATA AND FINDINGS

The radiological investigation of the problem was carried out concurrently with, but independently of the pulmonary function testing. Standard sized 14 in. x 17 in. chest films were taken with Radelin par speed screens and Kodak "Blue Brand" film. In order to avoid exertion on tbe part of the subject however, all films were taken with the subject seated in the chair in the same position pre- and postcentrifugation. The cassette was placed behind him, and all films were therefore AP films. All films were shot using a 200 ma Keleket machine 1/20th sec exposure, and the appropriate kv determined for each subject and kept constant throughout the test series. In order to further standardize the films, all were developed in a Kodak automatic X-ray processor, thus eliminating a human variable in the processing.


30 81.0
1:30 70.3
2:30 67.0
1:00 73.2
2:00 69.7
3:00 67.8
IC
87.8



500
6:00
7:00
68.5
68.3
68.3
68.3
+O2
ERV = 1130
IC3 2445
IC4 2815
IC5 = 3040

5-10-2

5-10-3

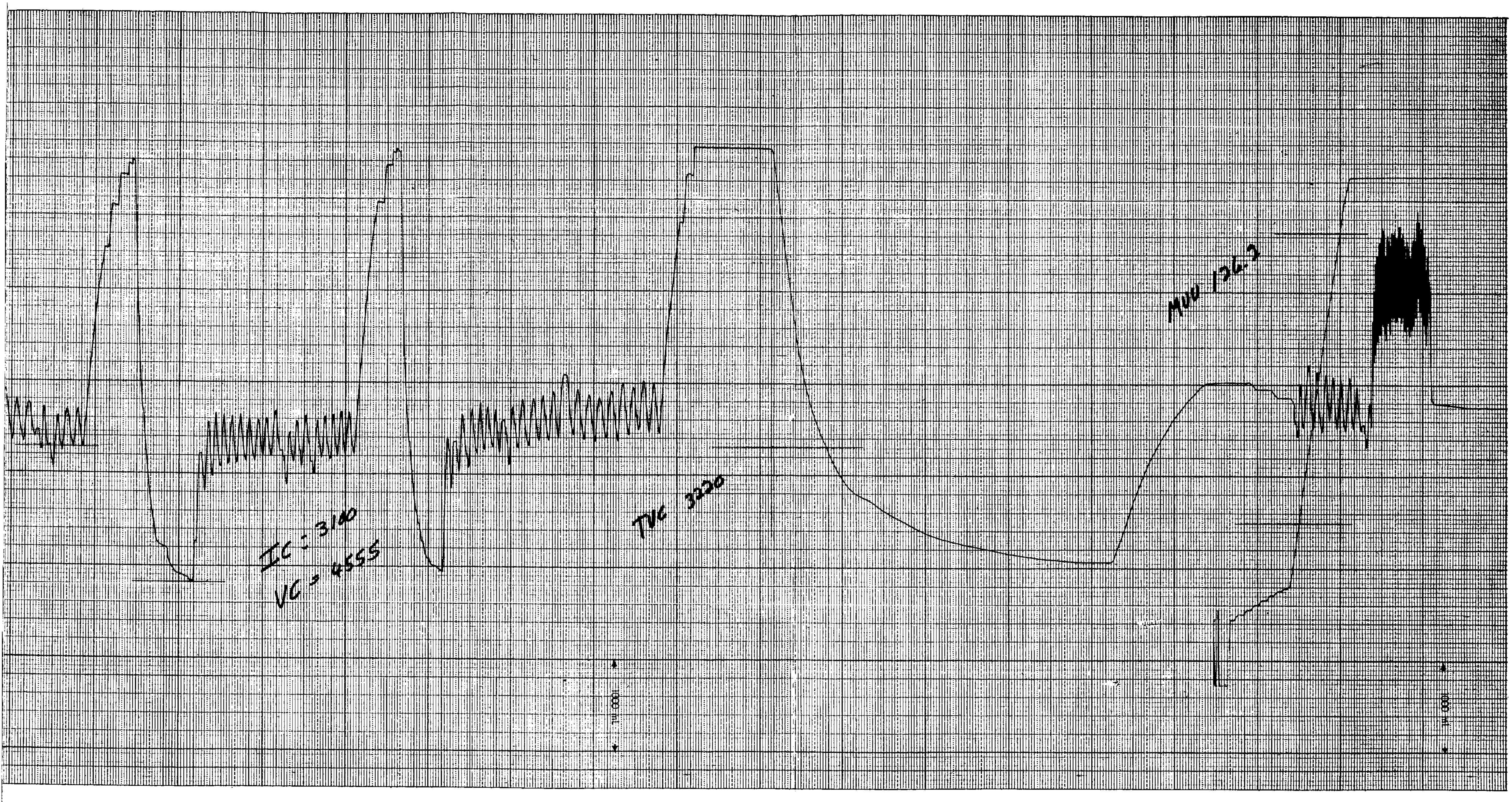


Figure 5-6. Pulmonary Function Test Data, Including Effects of Coughing, Postcentrifuge, 8-hr P_T = 190 Mode, Subject MG

TABLE 5-3

CHANGES IN INSPIRATORY CAPACITY DUE TO COUGHING

Subject MG	Subject LR	Subject WS
	3 hr, Mixed $IC_1 = 3190$ $IC_2 = 4050$ $IC_F = 4485$	
	8 hr, Mixed $IC_1 = 3010$ $IC_2 = 3225$ $IC_3 = 3425$ $IC_F = 4345$	
3 hr, O_2, $P_T = 380$ $IC_1 = 2960$ $IC_2 = 2730$ $IC_F = 3380$	3 hr, O_2, $P_T = 380$ $IC_1 = 2715$ $IC_2 = 3090$ $IC_3 = 3685$	3 hr, O_2, $P_T = 380$ $IC_1 = 3445$ $IC_2 = 3685$ $IC_F = 3625$
8 hr, O_2, $P_T = 380$ $IC_1 = 2810$ $IC_2 = 3055$ $IC_F = 3290$	8 hr, O_2, $P_T = 380$ $IC_1 = 1810$ $IC_2 = 2375$ $IC_F = 2490$	
3 hr, O_2, $P_T = 190$ $IC_1 = 2230$ $IC_2 = 2375$ $IC_3 = 2565$ $IC_4 = 3040$	3 hr, O_2, $P_T = 190$ $IC_1 = 2500$ $IC_2 = 2830$ IC $IC_F = 3040$	
8 hr, O_2, $P_T = 190$ $IC_1 = 1905$ $IC_2 = 1910$ $IC_3 = 2445$ $IC_4 = 2815$ $IC_5 = 3040$ $IC_F = 3100$	8 hr, O_2, $P_T = 190$ $IC_1 = 1685$ $IC_2 = 1815$ $IC_3 = 2000$ $IC_4 = 2405$ $IC_5 = 2700$ $IC_F = 2875$	8 hr, O_2, $P_T = 190$ $IC_1 = 2880$ $IC_2 = 3275$ $IC_F = 3510$

TABLE 5-4

EFFECT OF EXPERIMENTAL MODE ON INSPIRATORY CAPACITY

Subject MG	IC_{pre}	IC_1	IC_F
3 hr, O_2 P_T = 380	3250	2960	3380
8 hr, O_2 P_T = 380	3250	2810	3290
3 hr, O_2 P_T = 190	3455	2230	3245
8 hr, O_2 P_T = 190	3210	1905	3100
Subject LR			
3 hr, mixed	4480	3190	4485
8 hr, mixed	4175	3010	4345
3 hr, O_2, P_T = 380	4350	2715	3685
8 hr, O_2, P_T = 380	4395	1810	2490
3 hr, O_2, P_T = 190	4510	2500*	3040
8 hr, O_2, P_T = 190	4420	1685	2875
Subject WS			
3 hr, O_2, P_T = 380	3925	3445	3625
8 hr, O_2, P_T = 190	3550	2880	3510

*Delay in return to sea level due to ear blockage (28 min longer than normal).

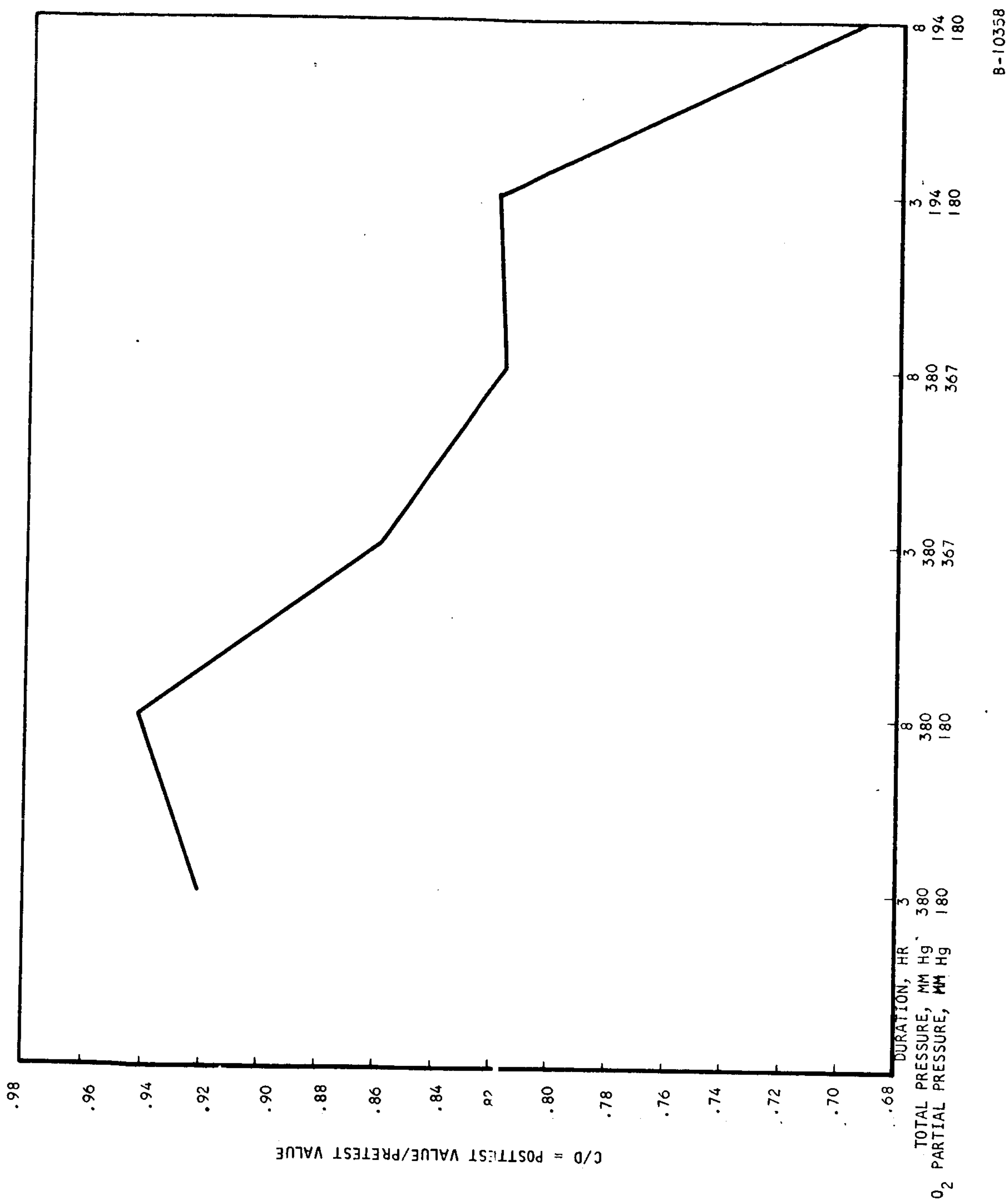


Figure 5-7. Inspiratory Capacity (I) $\bar{X}$

All films were inspiration films. The subjects were remarkably consistent in the level of inspiration reached as shown by the films taken before each run. The fact that the depth of inspiration reached immediately after centrifugation varies significantly is therefore related to the test procedure rather than subject variation. The films were reviewed by a clinical radiologist with extensive research experience in chest diseases, an internist, and physician specializing in aerospace medicine. The reviews were independent and all reached approximately the same conclusion regarding the films, however, to eliminate additional variables, only the classification of the radiologist is reported on the data sheets.

Each subject served as his own control in a preliminary set of films. The test procedure was followed except that no altitude exposure was included. A sample set of these films is shown as Figures 5-8 through 5-11. Figure 5-8 is a film taken before any centrifugation or altitude exposure of any kind. Figure 5-9 is a film taken under the same circumstances, but at the end of a tidal expiration. This film was taken in an effort to determine any relationship between the atelectasis patterns which later developed and the normal expiration patterns of the lung. Figure 5-10 was a film taken as soon after centrifugation as possible, Figure 5-11 is the last of the control films taken after the subject had been centrifuged and undergone the complete pulmonary function battery.

All films were classified on an arbitrary scale with a range from 1 to 5. These were defined at the outset as follows:

Grade 1	No demonstrable change of pulmonary tissue
Grade 2	Changes in tissue noted but not positively identified as atelectatic in character
Grade 3	Changes in tissue noted of a minimal nature and which could definitely be identified as atelectatic in character
Grade 4	Changes in tissue noted of a moderate nature atelectatic in character
Grade 5	Changes in tissue noted of an advanced nature atelectatic in character

It should be noted that the increased vascularity seen immediately after centrifugation is not included in the above classification. The grading results are shown in Table 5-5.

The actual tests included four films on each subject for each experimental condition. The first film, an example of which is shown as Figure 5-12, was taken immediately before the subject was rolled into the capsule for the test. This served as an additional control for the remainder of the films taken during the day. The next exposure, shown as Figure 5-13, was taken as soon as possible after centrifugation. The time interval averaged around twelve minutes, since this time was required to return the capsule to sea level ambient conditions, remove the subject still in his special chair, and position him in front of the X-ray tube. However, as will be noted from the

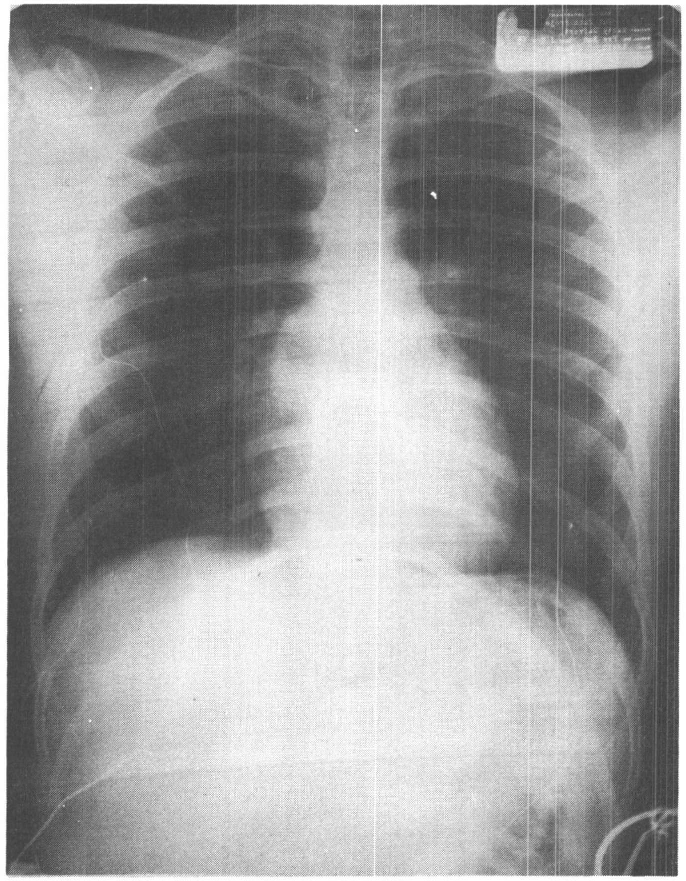
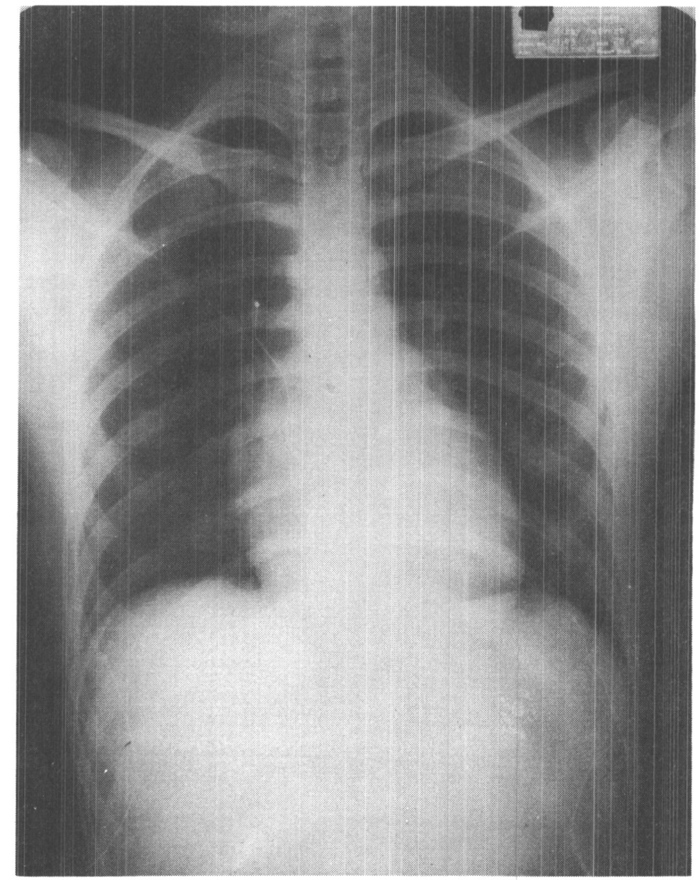


Figure 5-8. Initial control film, Subject MG prior to centrifugation. No altitude exposure.



F-3450

Figure 5-9. Initial control film, Subject MG, end tidal expiration, prior to centrifugation. No altitude exposure.

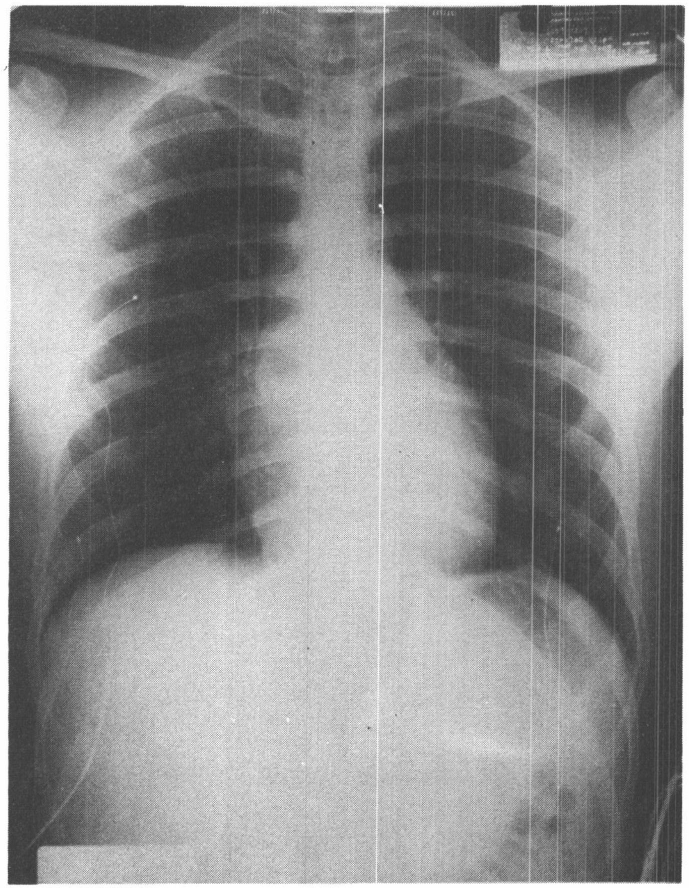
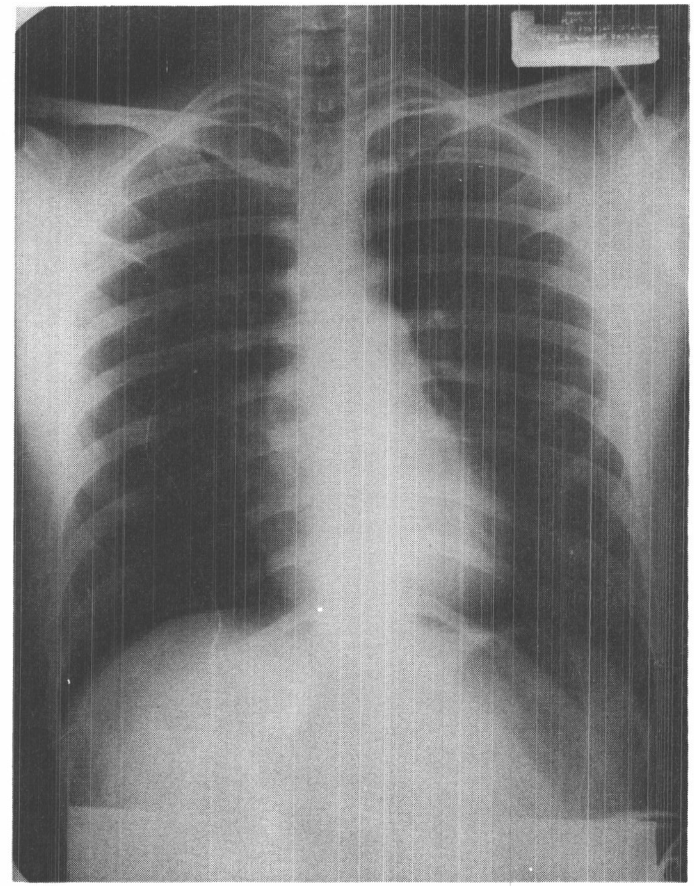


Figure 5-10. Control film, Subject MG 5 min after centrifugation but before pulmonary function testing. No altitude exposure.



F-3451

Figure 5-11. Control film, Subject MG 23 min after centrifugation and after pulmonary function testing. No altitude exposure.

TABLE 5-5

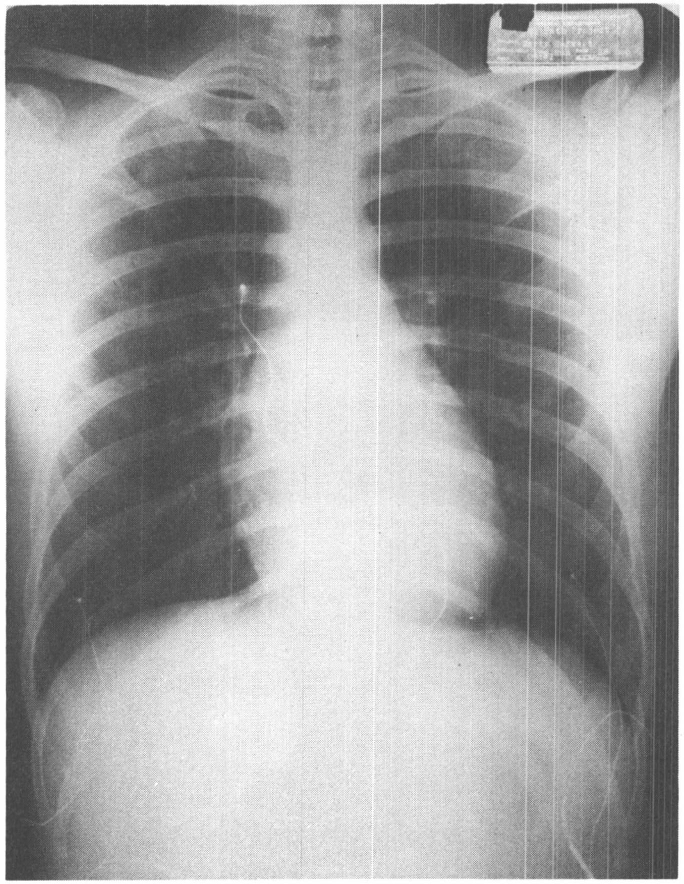
X-RAY DATA SUMMARY

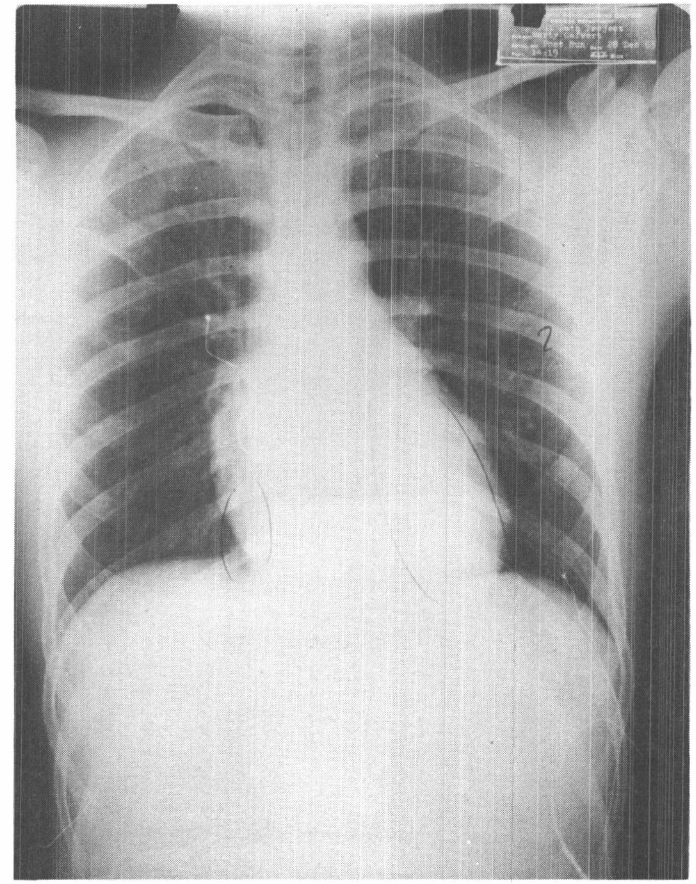
Program	Subject MG Time	Subject MG Result	Subject GR Time	Subject GR Result	Subject LR Time	Subject LR Result	Subject WS Time	Subject WS Result
BASELINE NUMBER 1								
Control Prerun	0930	-	1330	-	0820	-	0950	-
Centrifugation	1000		1347		0828		1010	
Control Postrun	1005	1	1353	1(a)	0835	2	1015	1
Control Postrun and Postfunction Test	1020	1	1410	1	0857	1	1030	1
BASELINE NUMBER 2								
Control Prerun	1410	-	1520	-	1134	-	1445	-
Centrifugation	1421		1529		1149		1456	
Control Postrun	1431	2	1535	1	1157	1	1505	1
Control Postrun and Postfunction Test	1448	1	1550	1	1215	1	1520	1
3-HOUR EXPOSURE P_T 380 mm Hg pO_2 180 mm Hg								
Control Prerun	0844	-	0845	-	0821	-	0940	-
Centrifugation	1230		1250		1330		1342	
Postrun	1309	3	1303	2	1238	1(b)	1358	1
Postrun	1320	3	1314	1	1249	1	1410	1
Postrun	1328	1	1320	1	1257	1	1416	1
8-HOUR EXPOSURE P_T 380 mm Hg pO_2 180 mm Hg								
Control Prerun	0848	-	0845	-	0835	-	0857	-
Centrifugation	1745		1730		1720		1738	
Postrun	1755	3	1739	2	1728	2	1750	1(b)
Postrun	1807	3	1751	2	1741	2	1801	1
Postrun	1812	2	1759	2	1748	1	1807	1
3-HOUR EXPOSURE P_T 380 mm Hg pO_2 367 mm Hg								
Control Prerun	0940	-	0959	-	0858	1	0851	1
Centrifugation	1559		1433		1433		1502	
Postrun	1608	2(c)	1439	4(c)	1450	3	1512	3(b)
Postrun	1628	2	1451	4	1459	3	1522	3
Postrun	1638	1	1458	1	1510	1	1530	1
8-HOUR EXPOSURE P_T 380 mm Hg pO_2 367 mm Hg								
Control Prerun	0844	-	0847	-	0830	-	0848	-
Centrifugation	1801		1631		1750		1830	
Postrun	1811	3(b)	1840	1(b)	1800	1	1839	3(b)
Postrun	1822	3	1852	1	1816	1	1852	3
Postrun	1830	1	1858	1	1829	2(d)	1859	1
3-HOUR EXPOSURE P_T 194 mm Hg pO_2 180 mm Hg								
Control Prerun	0941	-	0904	-	0915	-	0901	-
Centrifugation	1354		1400		1357		1333	
Postrun	1419	3	1413	3	1429	4	1342	4
Postrun	1431	2(e,g)	1431	3	1441	4	1353	3
Postrun	1442	2	1439	1	1450	3(f)	1358	1
8-HOUR EXPOSURE P_T 194 mm Hg pO_2 180 mm Hg								
Control Prerun	0858	-	0920	-	0858	-	0903	-
Centrifugation	1842		1858		1847		1845	
Postrun	1852	3	1910	2	1905	3	1851	3
Postrun	1905	3	1924	2	1921	3	1906	3
Postrun	1917	1	1933	1	1930	1(g)	1915	1

(a) Diameter of larger vessels increased by a measured 40 percent.
(b) Marked generalized increase in pulmonary vascularity.
(c) Definite wedging of pulmonary segments noted.
(d) Questionable blip noted.
(e) Particularly prominent "Tyrolean Brush" markings.
(f) Prominent residual markings in final film.
(g) Slight residual markings in final film.

Results Code

1 No change
2 Questionable changes
3 Definite minimal atelectasis
4 Moderate atelectasis
5 Major atelectasis





F-3452

Figure 5-12. Prerun control film, Subject MG. Test conditions, 3 hr exposure, P_T 194 mm Hg, pO_2 mm Hg.

Figure 5-13. Postrun film, Subject MG, 23 min after centrifugation. Test conditions as in Figure 5-12.

data sheet, there were several occasions where this time interval was quite lengthy. These delays occurred when the repressurization of the capsule had to be slowed due to ear blocks experienced by the subjects.

The third film of the day, Figure 5-14, was made approximately 10-15 minutes after the immediate post centrifugation film. At this time, the subject had been sitting quietly in his chair breathing for determination of tidal volumes, functional residual capacity, and the other "passive" pulmonary function tests. Following this third film, the subject was then put through the "active" pulmonary function tests which included maximum breathing capacity, timed vital capacity, vital capacity, etc., as mentioned elsewhere in this report. A fourth and final film of the day, shown as the example in Figure 5-15, was then taken to determine if the subject had returned to normal as compared with control film first taken before the day's activities.

Figures 5-16 through 5-25 are discussed in Section 6.

Figure 5-26 is illustrative of the mean grade average of atelectasis occurring among the four subjects for the 3- and 8-hr tests.

CLINICAL FINDINGS

Each subject was examined by a physician before and after the experimental procedures. The examination included palpation, percussion, and auscultation of the chest as well as a brief check of the nose and throat. Comments by the subjects on their physical condition were solicited before, during, and after each run. In only one case was a run postponed because of a subject's condition. In that instance, the subject was apparently the victim of a "flu" type of illness, and he did not feel well enough to report for work. In another case, a subject had had an episode of a "flu-like" syndrome several days previous to the experiment. However, there were no physical findings present other than a mildly inflamed nasopharynx. The subject reported slightly more difficulty than usual in clearing his ears during the descent from altitude, but there were no other apparent effects of his recent illness.

In all cases, following the centrifugation, there was a slight decrease of breath sounds anteriorly over the chest. However, this appeared to be only transitory in nature and may well have been related to the lack of positional activity on the part of the subject. Auscultation after the completion of the pulmonary function tests revealed no changes from the condition of the subject prior to the test.

In only one instance was there any demonstrable change upon physical examination. Following the three hour run with a P_T of 194 mm and a pO_2 of 180 mm, subject WS was found to have a small circumscribed area of expiratory rales anteriorly at about the mid axillary line at the 5th left interspace. This cleared after the active pulmonary function tests involving deep breathing exercises.

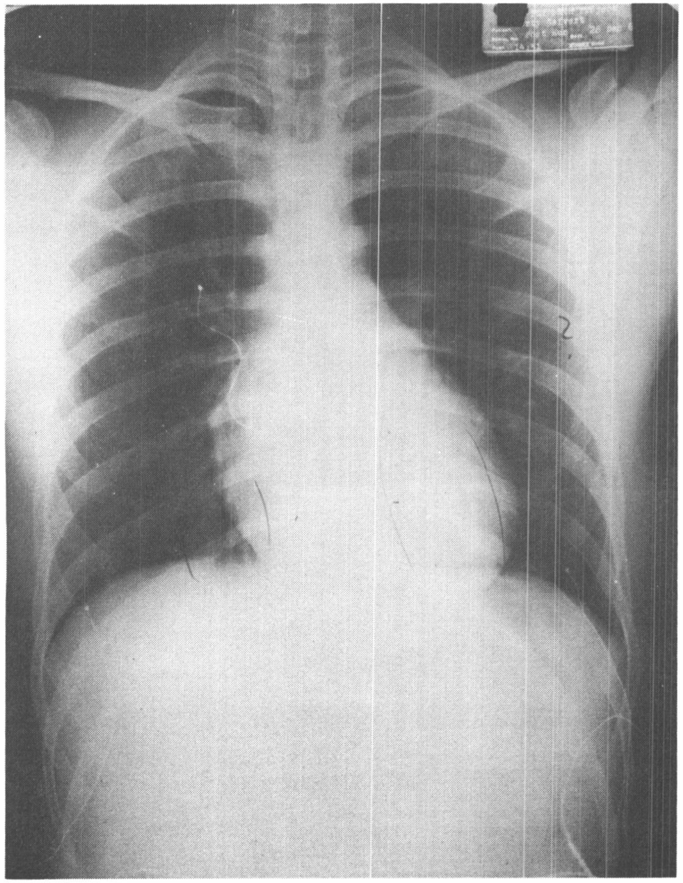
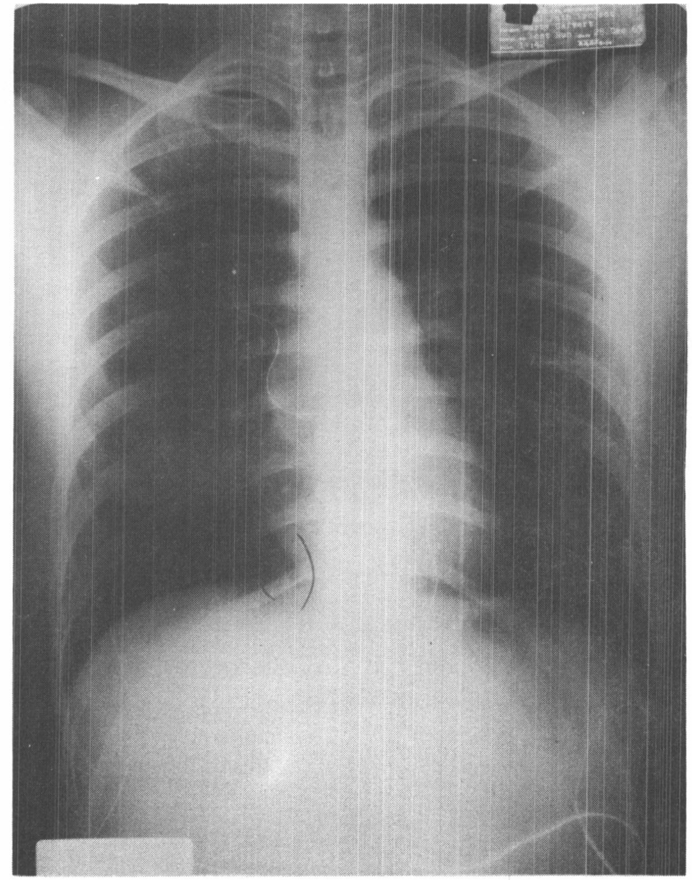


Figure 5-14. Postrun film, Subject MG, 35 min after centrifugation and after passive tidal breathing. Test conditions as in Figure 5-12.



F-3453

Figure 5-15. Postrun film, Subject MG, 46 min after centrifugation and after active pulmonary function testing. Test conditions as in Figure 5-12.

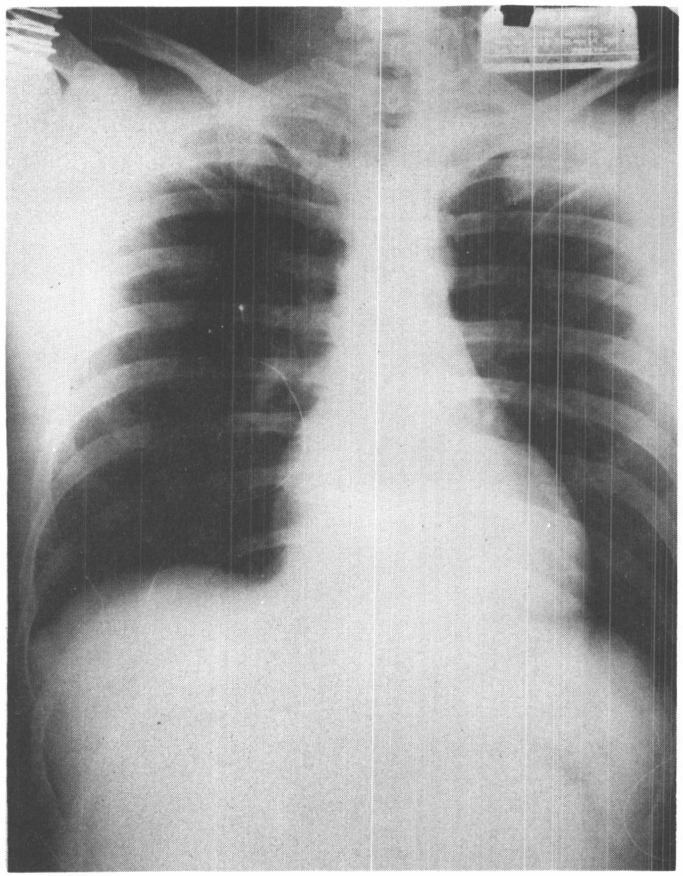
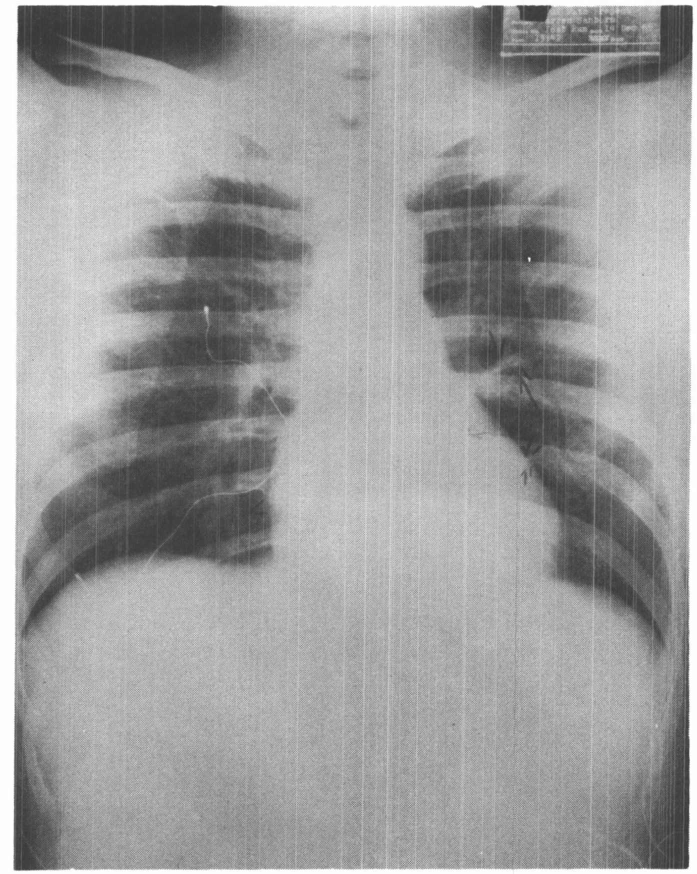


Figure 5-16. Prerun control film, Subject WS. Test conditions, 3 hr exposure, P_T 194 mm Hg, pO_2 180 mm Hg.



F-3454

Figure 5-17. Postrun film, Subject WS, 9 min after centrifugation. Test conditions as in Figure 5-16.

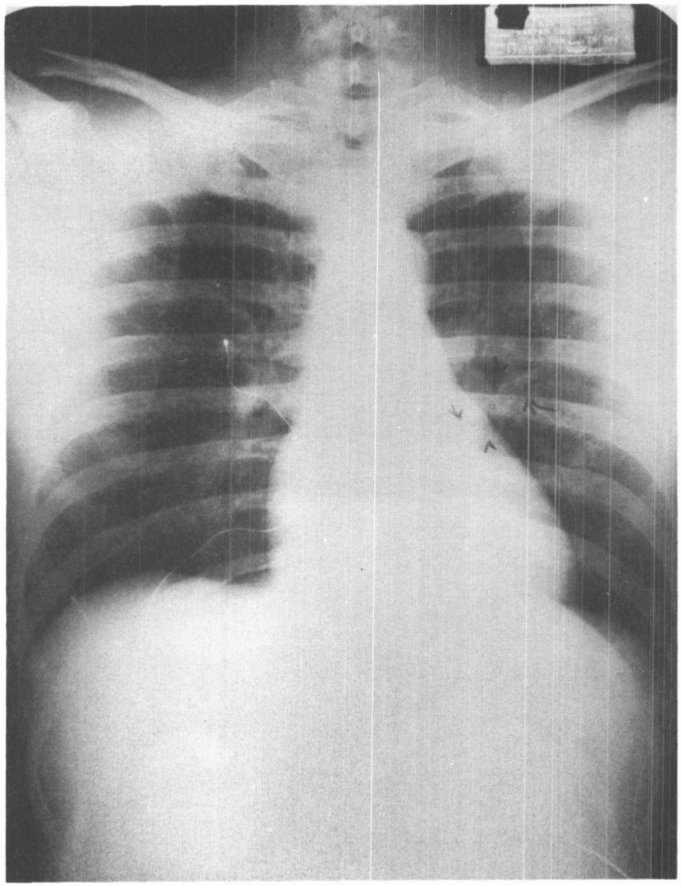
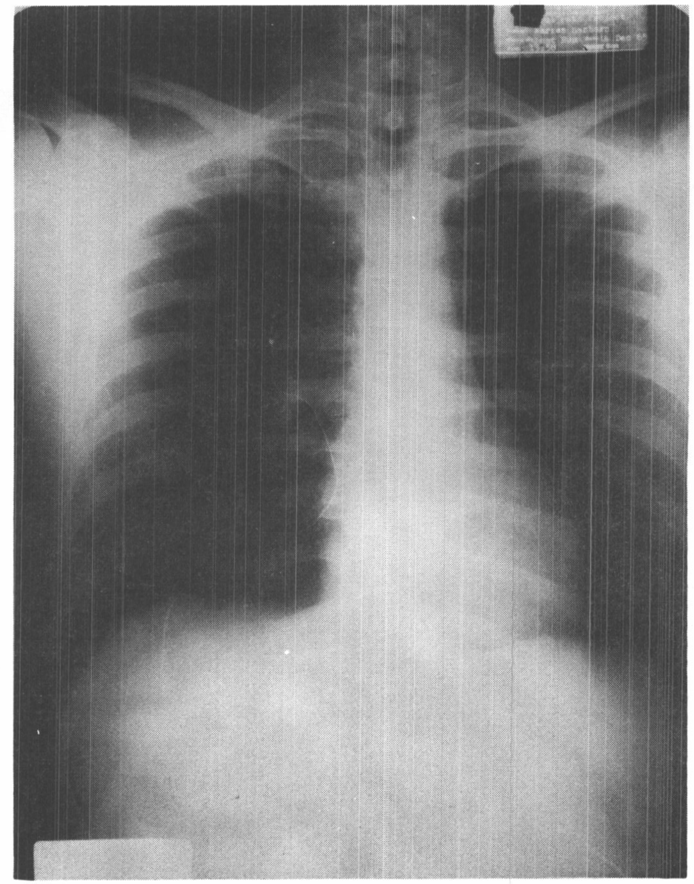


Figure 5-18. Postrun film, Subject WS 20 min after centrifugation and after passive tidal breathing. Test conditions as in Figure 5-16.



F-3455

Figure 5-19. Postrun film, Subject WS 25 min after centrifugation and after active pulmonary function testing. Test conditions as in Figure 5-16.

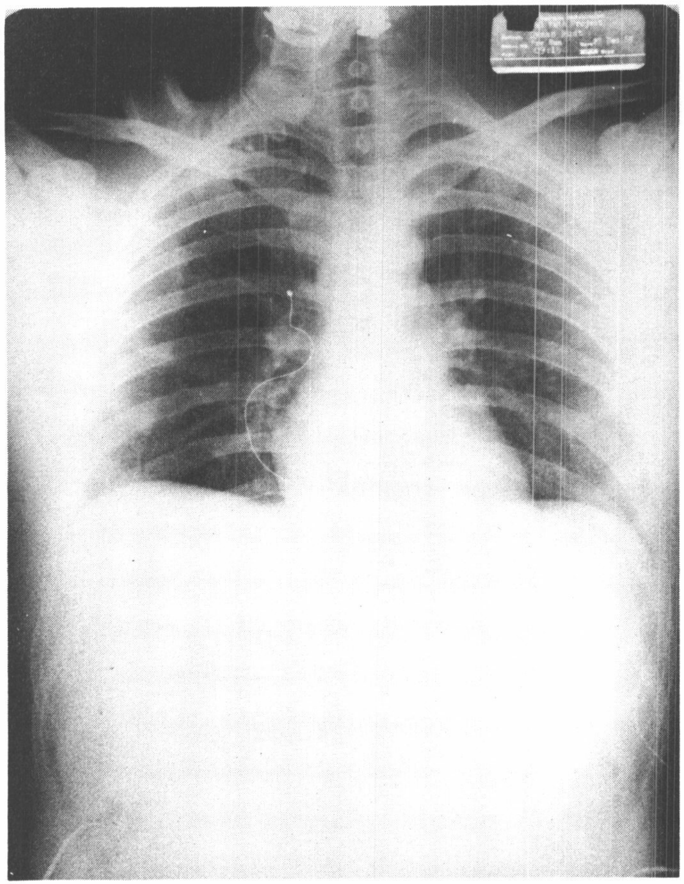
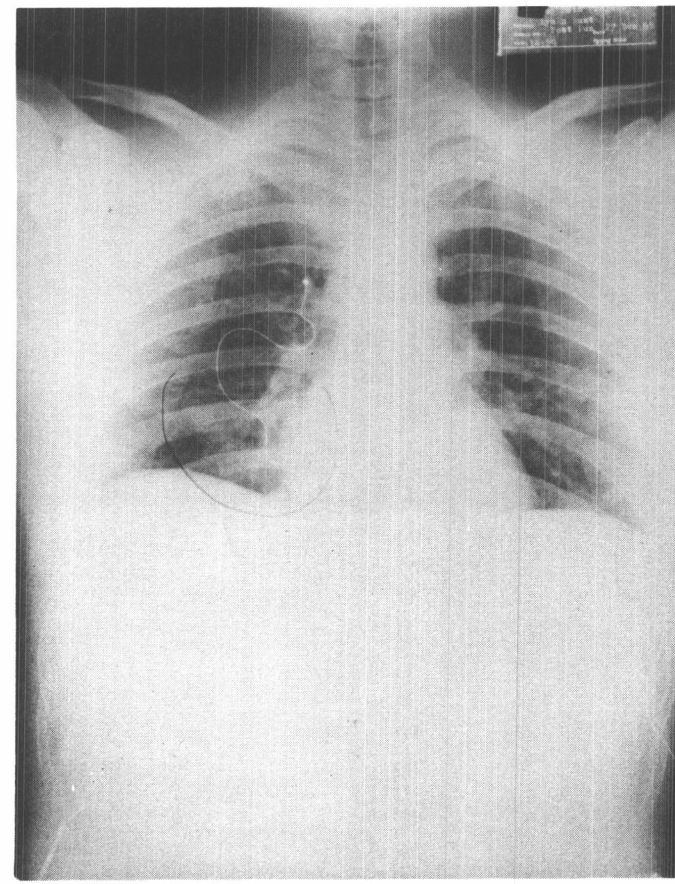


Figure 5-20. Prerun control film, Subject LR. Test conditions 3 hr exposure, P_T 194 mm Hg, pO_2 180 mm Hg.



F-3456

Figure 5-21. Postrun film, Subject LR 32 min after centrifugation. Test conditions as in Figure 5-20.

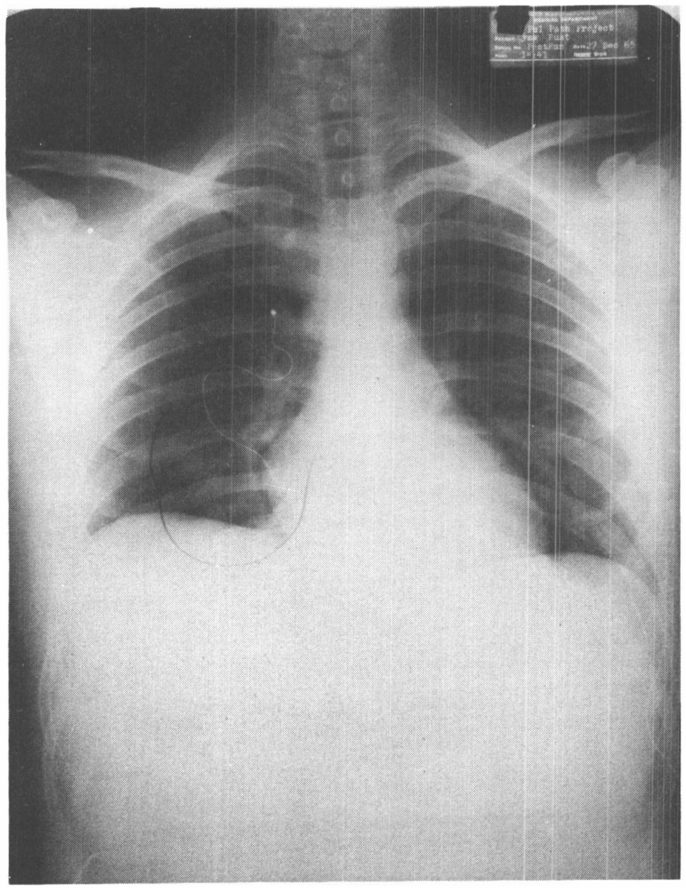
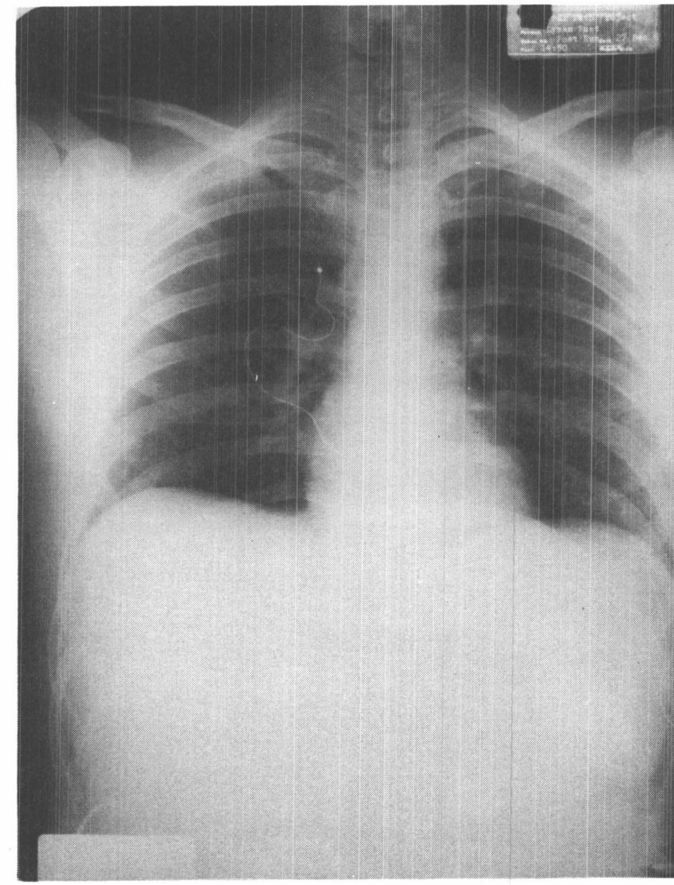


Figure 5-22. Postrun film, Subject WR 44 min after centrifugation and after passive tidal breathing. Test conditions as in Figure 5-20.



F-3457

Figure 5-23. Postrun film, Subject LR 53 min after centrifugation and after active pulmonary function testing. Test conditions as in Figure 5-20.

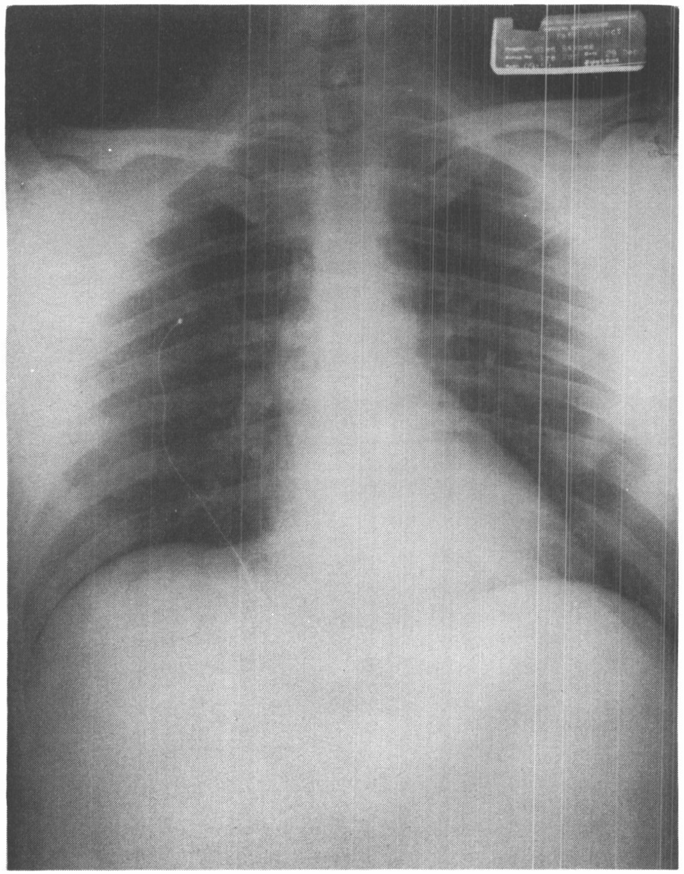
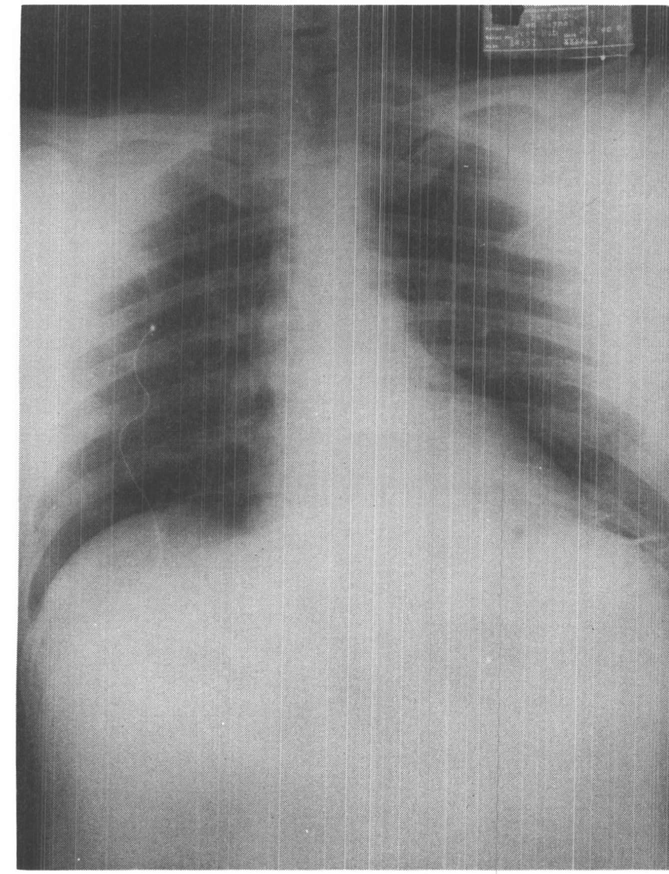


Figure 5-24. Prerun control film, Subject GR. Test conditions, 3 hr exposure, P_T 194 mm Hg, ρO_2 189 mm Hg.



F-3458

Figure 5-25. Postrun film, Subject GR 18 min after centrifugation and after passive tidal breathing. Test conditions as in Figure 5-24.

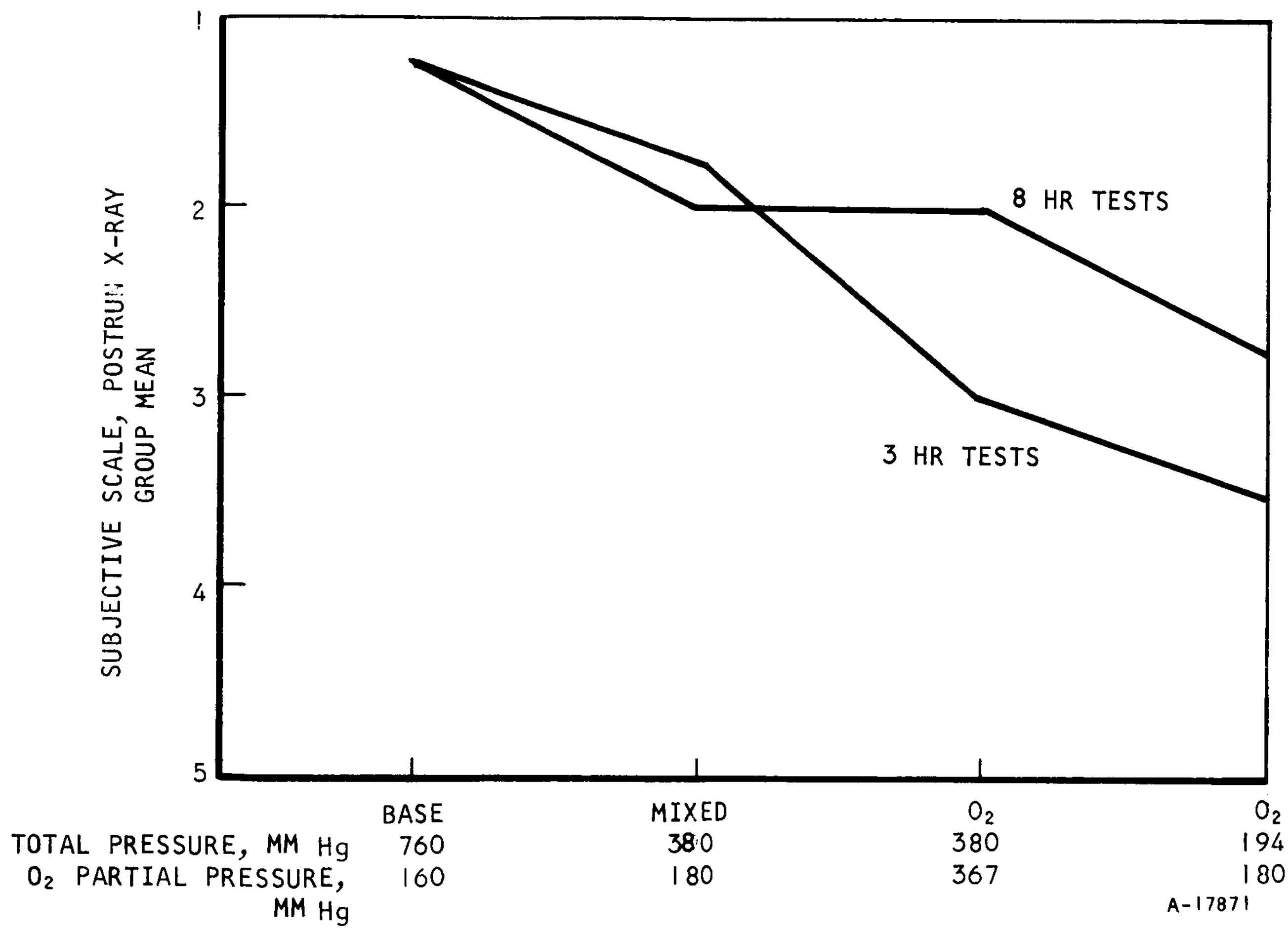


Figure 5-26. X-Ray Mean Group Average

Subjectively, the subjects did not find the test severe. Comments about their opinions of the various test atmospheres will be found in the section concerning the pulmonary function tests. A universal complaint was the lack of room to stretch and move about. Most of the complaints concerned the inability in the restricted quarters to extend the knee completely and thus straighten the leg. A sense of boredom was experienced by some subjects, but this was largely alleviated by allowing them to take any desired reading material into the cabin for the test. Of interest from the psychological standpoint was the difference in response to the test situation of the four subjects. All were reasonably intelligent and alert individuals. However, the most alert appeared to become the least so during the test, and the most phlegmatic of the group became the most interested in any unusual noises or sounds during the actual test in the opinion of the observers. This was not objectively documented,however.

In the entire test program, there were two cases of aeroembolism. These occurred, as might be expected, during the tests at P_T 194 mm Hg. Each of the subjects was required to prebreathe 100 percent oxygen at sea level for one hour before ascending to an altitude equivalent to less than a P_T of 360 mm Hg. Subject WS experienced a mild case of "bends" in his hand and ankle during his first trial above this altitude for a three hour test. The following day, subject GR also developed a mild case of "bends" in a knee under the same conditions. A leak in the regulator used for prebreathing was suspected but never proven by subsequent testing. However, the regulator was changed, and the subjects required to breathe for approximately 1.5 hr before the test. No further aeroembolism was noted during the remainder of the tests.

SECTION 6

DISCUSSION OF RESULTS

DISCUSSION OF PHYSIOLOGICAL PARAMETERS

The results of the pulmonary function data indicate that atelectasis did occur to some extent in three of the four subjects. The incidence of occurence varied as a function of oxygen partial pressure, total pressure and exposure time. It was found that complete reinflation of the lung did occur as a result of the cough reflex.

One of the mechanisms of atelectasis which would occur from this experimental procedure is the absorption type in which alveolar gas is absorbed into the blood when the airway is blocked by mucus, fluid or mechanical deformation. The possibility of the occurrence of surfactant degradation which would contribute to the total atelectasis is also indicated by the data. These two mechanisms will be discussed separately.

The incidence of absorption atelectasis is evident by the reduced inspiratory capacity, vital capacity, timed vital capacity and total lung capacity. In addition to the results shown in Table 5-1 this reduction in capacity is indicated by the graphs of Figures 5-2 through 5-5. Here the mean values for the group ($N = 4$) are plotted for the ratio C/D where the postcentrifugation value is (C) and the pre-centrifugation value is (D). The changes in this ratio indicate that a reduction in post-centrifuge volume occurs as a function of oxygen partial pressure, total pressure and time. One would expect the effects of total pressure utilizing the present theory of absorption atelectasis during mechanical deformation of the lung while breathing oxygen at reduced barometric pressure. This is supported by the incidence of a greatly reduced inspiratory capacity with a progressive increase in capacity over a short time as a result of the cough reflex (Table 5-3, in previous section). The volume at which the first cough occurs (Table 5-4, in previous section) for each exposure also supports the thesis that an absorption type atelectasis occurs.

It may be pointed out that the Inspiratory Capacity measurements were made approximately 24 minutes after the centrifuge was stopped and that in many cases heavy coughing preceeded this measurement.

Not all of the data in Figures 5-2 through 5-6 can be explained by an absorption type of atelectasis. It is shown in Figures 5-2 through 5-5 that in every case the 8-hr, 380-mm-Hg, 100-percent oxygen exposures is the most severe. This is demonstrated by Figure 6-1 in which the vital capacity data from Figure 5-2 is plotted independently of time, with the solid lines representing the 3-hr exposure and the broken line the 8-hr exposure. The 3-hr exposure indicated the probable operation of a simple absorption type of atelectasis where the vital capacity is reduced as a function of the mass of oxygen in the lung during deformation. The data following oxygen-nitrogen mixtures show no significant reduction probably because nitrogen is present in the lungs and acts as a brake. The data for 367-mm-Hg oxygen shows a

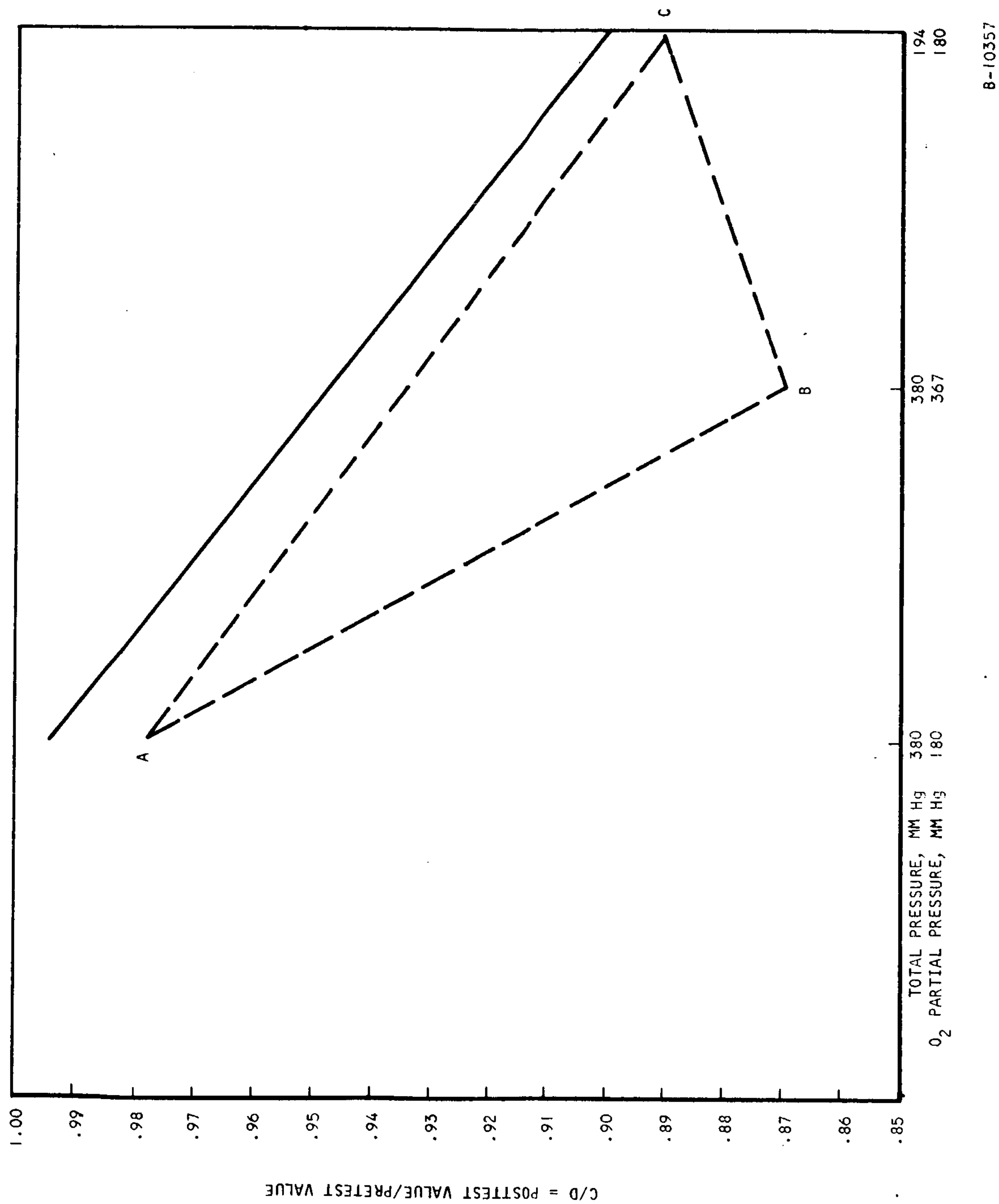


Figure 6-1. Vital Capacity $\overline{X}$

significant reduction from baseline; however, since a significant mass of oxygen is present, the absorption process during centrifugation takes longer than with 180-mm-Hg oxygen, where the mass of oxygen in the lung is the least.

The 8-hr exposures, however, do not appear to result in only a simple type of absorption atelectasis. With reference to Figure 6-1 again, the greatest reduction in mean vital capacity occurs at the second data point (B) where the oxygen partial pressure (367-mm-Hg) and the mass of oxygen in the lung is the greatest in the series of experiments. At point C, however, the partial pressure of oxygen is 180, as in (A) but no nitrogen is present to act as a brake. Theoretically, if only absorption atelectasis occurred, a reduction in mean vital capacity would occur along line AC.

The only environmental difference between point B (PO_2 = 367) and C (PO_2 = 180) is the mass of oxygen in the lung since the exposure time is the same. The amount of oxygen in the lung then apparently increases the extent of atelectasis during 8 hr of exposure. This observation may be explained by the loss of surfactant type of atelectasis. In this mechanism oxygen at high partial pressures destroys or inactivates the lipoprotein material lining the alveoli that contributes to the total elasticity of the lung. It may be that the critical closing pressure of the lung alveoli has been reduced before centrifugation allowing some areas of the lung to become atelectic before centrifugation or a greater reduction in mean vital capacity to be caused during centrifugation. The former was suggested by the subject's respiratory sounds (recorded on tape) prior to, during and after centrifugation. There was a moderate incidence of coughing and throat clearing prior to centrifugation especially on subject LR. This is supported by the reports of subjects GR and WS of "a tightness in the chest making it hard to breathe," and "congestion in the chest similar to that felt on a very smoggy day." When it was suggested that it may be similar to the congested feeling after an intense physical workout subject WS agreed that the feeling was identical.

Additional evidence of the possible effect of surfactant degradation is indicated by the data in Table 5-2. The Inspiratory Capacity (IC) is reduced inversely proportional to total pressure indicating an absorption effect. However, FRC and RV show a reduction specific to the 8 hr pure oxygen exposures.

Significant amounts of coughing, throat clearing, sighing, and yawning occurred during the exposure periods but whether this is due to a pulmonary reflex of some sort or just the normal response to boredom and inactivity in a confined space could not be determined.

DISCUSSION OF X-RAY DATA

A tabulation of the data obtained is shown as Table 5-5. In all cases, both control and experimental, the striking increase of vascularity in the lung fields should be noted. In one case, measurement of the diameter of a vessel positively identified in the serial radiographs indicated an increase in diameter of approximately 40 percent. This is not attributable to the test atmospheres since it occurred in the controls, and must therefore be related to the mechanical effects of the altered pulmonary circulation under centrifugation.

The first set of examples shown in Figures 5-12 through 5-15 were made during the 3-hr test at a total pressure of 194 mm of Hg with a pO_2 of 180 mm. Figures 5-13 and 5-14 both demonstrate areas of atelectasis at the lower right of the cardiac shadow which are not seen on the control film taken before the test. There is a small residual marking in this area seen on the final film as well. However, residual markings were rare, as noted on Table 5-5, being seen only three times in the 24 tests run. Of particular interest in this subject is the set of markings noted behind the left portion of the cardiac shadow. This gave the appearance of a small "Tyrolean brush" of the type worn in hats as decorations. This inverted brush appeared repeatedly in the films of only this particular test subject.

A second set of test films for the same conditions (i.e., 3-hr exposure at P_T 194 mm and pO_2 180 mm) but with a different subject is shown in Figures 5-16 through 5-19. Figure 5-17 shows moderate atelectasis to the left of the cardiac shadow together with some decay as seen in Figure 5-18 even though the subject had been breathing quietly during this short period of time. At the completion of the active pulmonary function tests as shown in Figure 5-19, the radiographic findings approximated those of the control film taken prior to testing.

A third set of films on still another subject during similar test conditions (i.e., 3-hr exposure at a P_T of 194 mm of Hg with a pO_2 of 180 mm) is shown as Figures 5-20 through 5-23. In this case, moderate atelectasis can be noted into the right of the cardiac shadow in both the immediate post centrifugation film and again 12 minutes later after passive tidal breathing tests. Following the active pulmonary tests (Fiqure 5-23) the lung has largely cleared, but some prominent residual markings are still present in the affected area.

Films of the final subject are shown as Figures 5-24 and 5-25. These were made during a three hour exposure to a P_T of 380 mm with a pO_2 of 367 mm of Hg. Definite plate-like atelectasis can be noted at the left costal margin in Figure 5-25 compared with the pretest film made that morning and shown as Figure 5-24. This particular film was the second made 18 minutes after centrifugation. Following the active pulmonary function tests, the film reverted to normal and is not shown with these examples.

SECTION 7

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Conclusions to be drawn from the data collected are not clearly discernible. The pulmonary function data do not agree in all cases with the radiological data. The conclusions herein therefore cannot be correlated between the two methods. The occurrence of atelectasis is confirmed by each major method of measurement. The degree of atelectasis seems to be a measure of the method used rather than a disagreement between the methods. One subject was only marginally affected, according to the pulmonary function tests, although his radiological data were similar to those of the other subjects. However, this subject did show a greater response in the radiological method than the other three subjects for the 3 hr, 380 mm Hg total pressure and 367 mm Hg oxygen. This may be attributed to the experience of this individual in pressure breathing from hyperbaric situations. Except in this case he showed the least response to the testing parameters. This may be related to the physical conditioning of this subject, to his anthropometric build, or to the test conditions. The significance of each of these variations can be much better analyzed by the addition of four more test subjects. Additional tests including some persons with experience in pressure breathing may help to identify the training effect as a function of the experimental conditions.

Since the major techniques of measuring the degree of atelectasis do not agree, the conclusions of each method are presented independently.

Pulmonary Function Conclusions

The pulmonary function studies indicate that atelectasis occurred, in general, as a direct function of the severity of exposure to oxygen, reduced pressure, and time. The smallest change occurred from breathing a 50/50 mixture of oxygen and nitrogen, while the greatest occurred after 8 hr of 100 percent oxygen at 380 mm Hg. The presence of atelectasis is indicated by a reduction in inspiratory capacity, vital capacity, total lung capacity, timed vital capacity and, in some cases, functional residual capacity and residual volume. The incidence of heavy coughing at reduced inspiratory capacity with a successive increase in that capacity with each cough indicated a reinflation phenomenon occurring after centrifugation.

Evidence for absorption-type atelectasis as well as an interaction of surfactant loss effect is presented and discussed in Section 6. This is an artifact that requires further investigation.

Radiological Conclusions

Inspection of the subjective radiological data obtained points to a number of possible generalizations. The first of these is that little or no problem will be encountered where appreciable amounts of a diluent gas (nitrogen in this case) are present, together with a sea-level oxygen partial pressure equivalent.

A distinction between essentially 100 percent O_2 atmospheres at a P_T of 380 mm Hg and 194 mm Hg is more difficult to uncover. However, based on the X-ray data alone, the P_T of 194 mm Hg appears to be slightly more productive of atelectasis. This is slight, and admittedly it is based on very limited data.

The effect of exposure time appears to be significant. In both test series with 100 percent oxygen, the findings after an eight-hour exposure were less marked than after the three-hour exposure. This difference is most easily noted at a pO_2 of 367 mm Hg, although it is still clearly seen at a pO_2 of 180 mm Hg. This finding would seem to indicate the presence of a compensatory mechanism which becomes active at some point between three and eight hours, although, with only two time points for comparison, the temporal limits are subject to speculation.

Finally, it can be stated that atelectasis does occur at least to a moderate degree following exposure to low total pressure and high concentrations of oxygen. This is of a moderate nature, and apparently a time function, 100-percent-oxygen ambient conditions. Further investigation should clarify these relationships.

In general, it can be said that the test procedures and results to date demonstrate that this research can produce significant data when a statistically adequate number of subjects are similarly exposed.

RECOMMENDATIONS

Significant results cannot be deduced from the data resulting from these tests because of large variances and the small number of subjects tested. As noted in the conclusions above, several areas may be clarified by testing additional subjects under precisely the same conditions as those of this program. In addition, if identical tests are conducted, a more thorough evaluation of each subject's previous training as it affects the respiratory function should be conducted.

Testing of subjects using the same techniques, conditions, and times without the centrifugation may further differentiate the effects of pulmonary deviations not entirely explainable by a dynamic stress. These tests could be conducted with less complexity and expense than previous tests.

Improvements in data collection methods could be accomplished by on-board instrumentation. These improvements are not suggested to obtain supplementary data for this program, because any additional data should be collected under identical conditions using identical methods. Most of the on-board pulmonary functions can be measured by minor modification (or adaptation) of existing spirometers. The radiological data would require considerable adaptation of the equipment used in this experiment.

In conclusion, it is recommended that at least four additional subjects be tested under identical conditions to provide statistically meaningful data as to the pulmonary response to the various conditions used in this program. Supplementary testing to support the overall findings may then be explicitly defined.

APPENDIX

OPERATING PROCEDURES, CHECKLISTS, AND CALIBRATION PROCEDURE

This appendix presents operating procedures, checklists, and calibration procedures. It should be noted that some procedures and checklists are incomplete in themselves and require complete familiarization with the equipment or the equipment operating manuals. Section 4 is the tabular results of the reduced data.

1. Atmosphere Control and Calibration Procedures

2. Systems Operating Checklists

3. Bioinstrumentation Procedures and Checklist

4. Analysis of Reduced Data

ATMOSPHERE CONTROL AND CALIBRATION PROCEDURES

ATMOSPHERE CONVERSION CHART

	mm Hg	in. Hg	psi	Volume %
Condition I				
Total pressure	194	7.59	3.73	
O_2	180	7.08	3.48	92.80
CO_2	5	0.197	0.097	2.57
N_2	1	0.04	0.019	0.52
H_2O	8	0.315	0.155	4.12
Condition II				
Total pressure	380	14.96	7.35	
O_2	366	14.43	7.08	96.3
CO_2	5	0.197	0.097	1.31
N_2	1	0.04	0.019	0.26
H_2O	8	0.315	0.155	2.13
Condition III				
Total pressure	380	14.96	7.35	
O_2	180	7.08	3.48	47.3
CO_2	5	0.197	0.097	1.31
N_2	187	7.37	3.62	49.25
H_2O	8	0.315	0.155	2.13
Condition IV				
Total pressure	750	29.52	14.5	
O_2	180	7.08	3.48	24.0
CO_2	5	0.197	0.097	0.67
N_2	557	21.9	10.78	74.3
H_2O	8	0.315	0.155	1.07

ATMOSPHERE CONTROL PROCEDURES

The atmosphere of the capsule will be purged for all conditions of testing including the baseline test at atmosphere conditions. Each atmosphere will require different procedures. These procedures vary slightly and are delineated separately for each purpose of operation. The conditions are

Condition	pO_2	pCO_2	pN_2	pH_2O	pTotal
A Baseline	180	5	557	8	750 ±5
B 380 mixed	180	5	187	8	380 ±5
C 380 pO_2	367	5	(1 maximum)	8	380 ±5
D 180 pO_2	180	5	(1 maximum)	8	193 ±5

NOTE: The identification of conditions is reference only.

The general procedures for each condition are delineated below but for each condition, adjustments will have to be made. Note that each condition requires more than normal oxygen pressure. (Refer to the purging schematic system setup.)

When all systems are "go," with subject installed, the following initial steps shall be followed:

Condition A Baseline

1. Place the manual dump valve in the open position.
2. Open oxygen purge supply valve to approximately 25 psig.

When the partial pressure of oxygen has reached approximately 220 mm Hg, shut off oxygen purge.

3. Turn on nitrogen purge until the oxygen partial pressure is approximately 180 mm Hg.
4. Introduce carbon dioxide into the cabin through a water saturator until the partial pressure of CO_2 is approximately 5 mm Hg. All gas introduced for adjustment should be run through the water saturator.
5. The gas chromatograph readings shall be within test condition tolerances for 10 min before testing. Therefore discrete adjustments may have to be made.
6. Turn on vacuum pump and make final adjustments.
7. When the atmosphere composition is as desired and the time for actual test is within 10 min, the following lines shall be disconnected and stowed.

    a. Gas purge lines

    b. Manometer lines

    c. CO_2 blanket lines

    d. High pressure O_2 and N_2 lines

8. When 7, above, is complete, the test may be conducted at the physiological monitor's discretion.

Condition B-380 Mixed, N_2 and O_2

1. Place the manual dump valve in the open position.
2. Open oxygen purge supply to approximately 25 psig and continue until the partial pressure of oxygen is approximately 380 mm Hg.
3. Turn on the vacuum pump.
4. Shut off oxygen purge.
5. Pump down to approximately 15 in. Hg total pressure.
6. Introduce CO_2 through purge system, with water saturator in line, to approximately 5 mm Hg.
7. Adjust O_2, N_2, and CO_2 to test conditions through the water saturator.
8. Maintain test conditions (until just before centrifugation) to 10 to 20 min.
9. Before centrifugation, disconnect

    a. Purge lines

    b. Manometer line

    c. CO_2 blanket lines

    d. High-pressure O_2 and N_2 lines

10. When item (9) above is complete, the test may be conducted if the physiological test conductor concurs and the conditions are met within the 10- to 20-min stabilization period.

Condition C-380 pO_2

This condition involves the elimination of nitrogen as a major constituent of the atmosphere. Therefore, the procedure is modified in that the pumping/purging operation is utilized to a greater degree. The procedure is as follows with this system set up:

1. Place the manual dump valve in the open position.
2. Turn on the pure oxygen purge supply valve.
3. When the oxygen partial pressure is between 380 and 420 mm Hg turn on the vacuum pump, close the dump valve and adjust the oxygen purge inflow to allow a slow decrease in cabin pressure. (Do not allow pO_2 to exceed 450 mm Hg.)

4. Reduce the cabin absolute pressure to 380 mm Hg.
5. Turn on the pure oxygen purge supply until the partial pressure of oxygen is approximately 360 mm Hg (maintaining approximately 380 mm Hg total pressure).
6. Turn the purge lines through the water saturator.
7. Continue oxygen flow through the water saturator until the partial pressure of oxygen is approximately 370 mm Hg.
8. Introduce carbon dioxide until it reaches approximately 5 mm Hg abs.
9. Adjust atmospheric composition to within test requirements.
10. If necessary during the test, the oxygen purge lines should be used to make up oxygen or water-vapor pressure.

Condition D-180 pO_2

This condition involves the elimination of nitrogen as a major constituent of the atmosphere. The procedure is as follows with this system set up:

1. Place the manual dump valve in the open position.
2. Turn on the pure oxygen purge supply valve.
3. When the cabin oxygen partial is between 360 and 400 mm Hg, turn on the vacuum pump.
4. Close the dump valve and shut off the oxygen flow to allow the cabin pressure to decrease at a rate of approximately 110 mm per min maximum. (If rate is too high, turn on the oxygen purge to reduce it.)
5. At approximately 1/2 atm, increase the oxygen flow to reduce the rate of depressurization to 10 to 50 mm Hg per min.
6. Maintain oxygen inflow until the oxygen partial pressure is above 180 mm Hg and below 200 mm Hg and the total pressure is approximately 230 mm.
7. Turn the oxygen purge supply through the water saturator. Continue for 2 min.
8. Turn off the oxygen purging supply and turn on the CO_2 purging through the water saturator.
9. When the CO_2 partial pressure approaches 5 mm Hg, shut off all supply gases.
10. Wait for 5 min, noting the variations in the major constituent gases and atmosphere conditions. It is most likely that oxygen will have to be supplied along with water makeup.
11. Continue to adjust atmosphere composition until 15 min of continuous readings, within tolerances, have been maintained.

12. Start test time as soon as item 11 is complete and total duration from item 3 is concurrent with the pre-set test duration.

Calibration of the Total Pressure Control Head

The total pressure control head is marked with pressures corresponding closely to the total pressures to be used. In order to adjust and calibrate to the specific pressure to be used for a test, the following procedures should be followed:

1. Disconnect control pressure reference line at the top of the control head.
2. Connect the reference port to a mercury manometer. (Corrected for barometric pressure), as shown in Figure A-1.
3. Place pressure selector to 750 mm position. Be sure center shaft is seated by pressing lightly.
4. Turn on vacuum pump.
5. Turn the selector knob to the position most nearly corresponding to the desired test pressure. Be sure the shaft and knob are seated.
6. If necessary, set the pressure desired by inserting a 3/32 inch Allen wrench through the holes in the knob into the screw. Adjust the opposing screw an equal amount.
7. Check the stability of the setting by moving the knob in and out and reseating. If the setting i not stable, one of the adjusting screws is probably not set in the proper position.
8. Pressure should be within 0.1 in. of mercury.

The pressure to be used in the tests are:

380 mm Hg - 14.96 inches Hg

259 mm Hg - 10.18 inches Hg

193 mm Hg - 7.62 inches Hg

Sea level (750 mm) will also be used but no calibration is necessary.

CARBON DIOXIDE SYSTEM CALIBRATION PROCEDURES

These procedures are written assuming that the calibration gas used is 1.32 percent by volume of carbon dioxide (10 mm Hg at 760 mm total pressure).

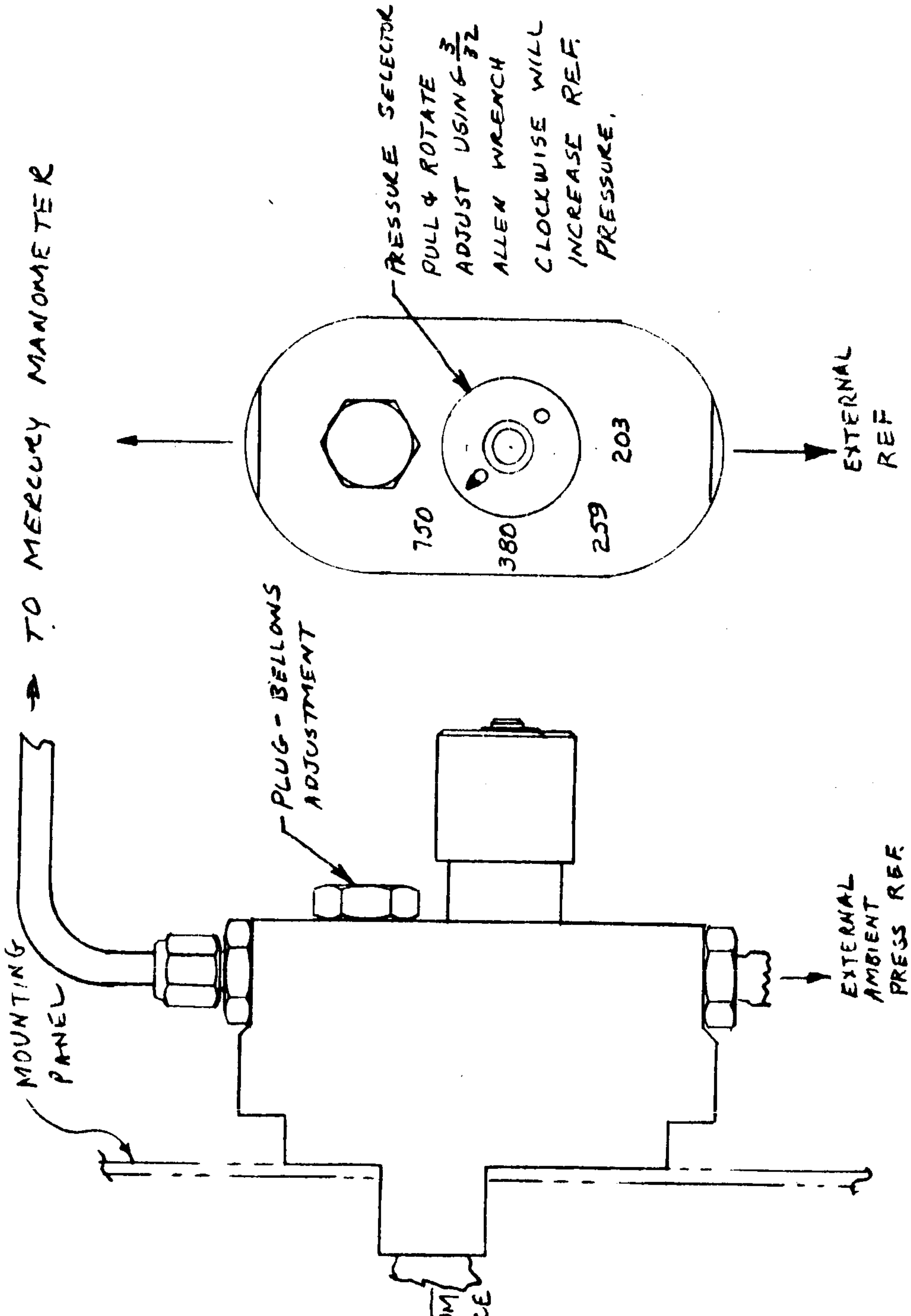


Figure A-1. Total Pressure Control Head

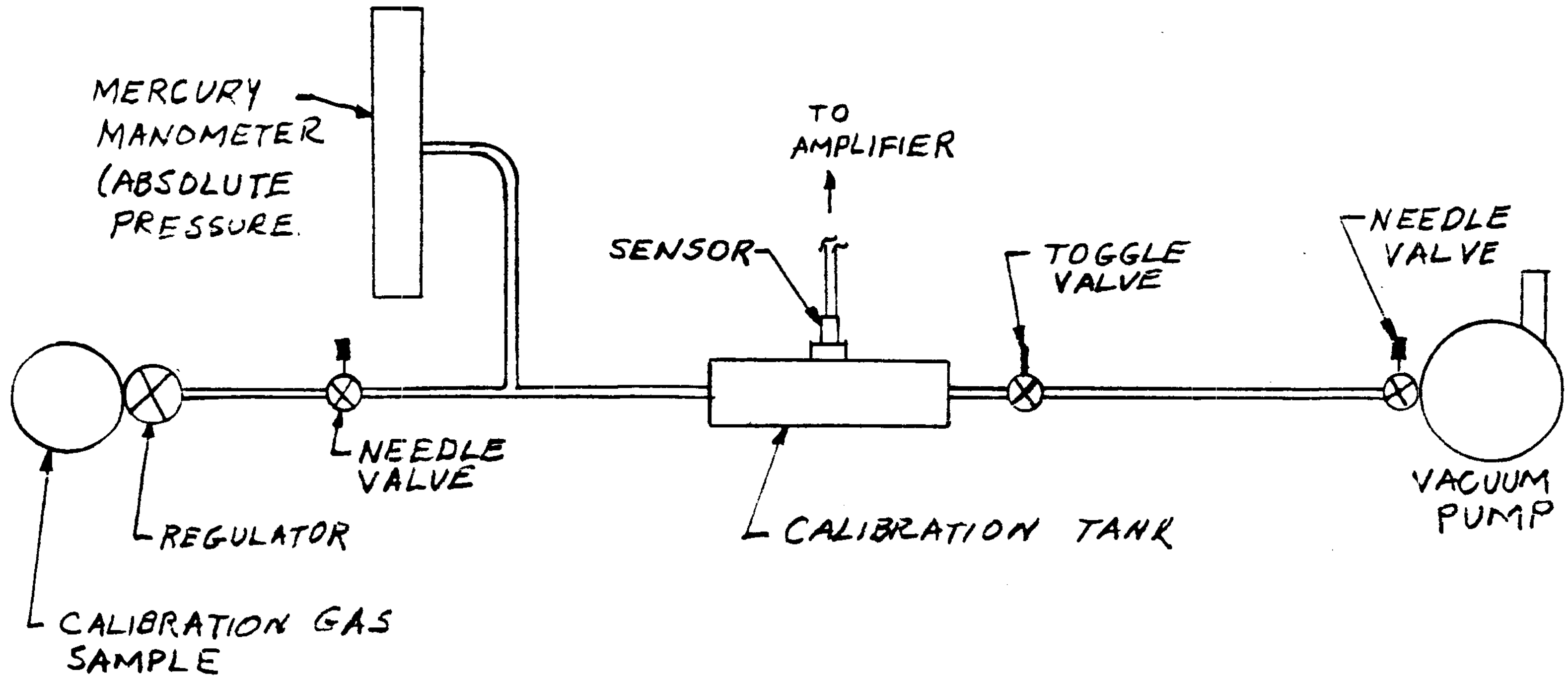


Figure A-2. Carbon Dioxide and Oxygen Polarographic Sensor Calibration Schematic

If any other sample percentage is used, the set pressures may be determined as discussed below.

1. The sensor should be charged and placed in the CO_2 system and allowed to stabilize for at least 30 min, and preferably longer, as noted in the recharging procedures.
2. Set up the system as shown in the schematic, with the carbon dioxide calibration gas as the sample gas. (See Figure A-2).
3. Evacuate the calibration tank to 0 in. Hg.
4. Shut off manual valve.
5. Increase pressure in calibration tank with calibration gas to 2.99 in. Hg A (76 mm Hg A). This is equivalent to a partial pressure of 1 mm Hg CO_2 using a gas 1.32 percent by volume.
6. Wait 3 min to allow the system to respond.
7. Set the cabin CO_2 indicator to read 1 mm Hg by adjusting the gain on the CO_2 amplifier.
8. Adjust the monitor panel to read 1 mm Hg by adjusting the pot in the rear of the console.
9. Increase the pressure in the calibration tank to 29.92 in. Hg A (760 mm Hg A).
10. Wait 3 min to allow system to respond.
11. Reset the zeros on the cabin and monitor panels if required.
12. Reevacuate the calibration tank to zero.
13. Shut off manual valve.
14. Increase pressure to 2.99 in. Hg A (76 mm Hg A).
15. Wait 3 minutes to allow system to respond.
16. Adjust indicators as required.
17. Increase pressure to 8.98, 14.96, 20.94 and 29.92 inches Hg A, respectively, recording the indicated partial pressures at each pressure. Allow 3 min at each pressure.
18. The readings obtained from the above procedures correspond to 1, 3, 5, 7, and 10 mm Hg partial pressure of carbon dioxide. If there is a marked deviation (±.5 mm Hg) from the readings, a correction curve should be constructed for the monitor's use.

Total Pressure Calculations

To determine the total pressure required to obtain the desired partial pressure of carbon dioxide using a given volume percent of CO_2 on the calibration gas the following equation is used:

$$\frac{pCO_2 \times 760}{\frac{\%VCO_2 \times 760}{100}} = P_T \text{ (Absolute)}$$

$$\frac{pCO_2 \times 100}{\%V_{CO_2}} = P_T$$

where pCO_2 = partial pressure of CO_2 desired

$\%V_{CO_2}$ = % by volume of CO_2 in the calibration gas

and P_T = Absolute pressure in the calibration tank

EXAMPLES OF TOTAL PRESSURE CALCULATIONS

	P_T, mm Hg (in. Hg)	
Partial Pressure Desired pCO_2	$\%VCO_2$ 1.32	$\%VCO_2$ 1.6
1	76(2.99)	62.5(2.46)
3	22.8(8.98)	287.5(7.38)
5	380(14.96)	312(12.3)
7	532(20.94)	438(17.23)
10	760(29.92)	625(24.62)

Recharging of the Carbon Dioxide Sensor

1. General

The major factor limiting sensor useful life is the impedance of the glass electrode. Experience indicates that the glass resistance increases slowly with age even when stored wet, but if stored dry the glass resistance increases rapidly and, to a degree, non-reversibly. As the impedance of the glass electrode increases, it may eventually exceed the limit permissible for the input of the Model 75202V* airborne amplifier. For practical purposes, the maximum allowable sensor impedance is approximately 150 megohms, while the minimum at time of shipment is about 80 megohms. It is therefore important that the CO_2 sensor be stored charged. When exposed to air from 20 to 95 percent RH during storage, recharging the sensor every two to three weeks should suffice. If prolonged storage is anticipated, the sensor should be in a sealed vessel containing a moist sponge, or equivalent.

2. <u>Charging Procedure</u>

1. Remove silicone rubber cap.
2. Using a clean tissue, such as a Kim-Wipe, wipe the excess electrolyte out of the rubber cap, and off of the sensor electrodes. Rinse the electrodes with distilled water and dry with a Kim-Wipe. If the old gel is hardened, soften with water and use a sharpened wood to scrape and then clean.
3. Apply gel electrolyte to the electrodes. Use a sharpened applicator stick to work bubbles out of crevices, especially adjacent to the silver wire electrode and across the front of the glass bulb.
4. Slide the rubber cap over the front of the sensor. Note the longitudinal slot in the sensor body, through which air and excess gel may escape. Pinch the rubber cap between thumb and forefinger so as to keep the vent slot open as the rubber cap is slowly slid into place.

   NOTE: With experience, it will become easy to apply the proper amount of gel to the sensor to avoid having a large excess escape from the vent. If too much gel has been applied to the sensor, gentle pressure on the rubber cap, coupled with proper pinching to keep the vent groove open, will force it out.

5. Clean away excess gel which has escaped from under the rubber cap. This is a very important step, because a bridge of electrolyte from the sensor to the stainless steel body would introduce a third electrode into the system, resulting in very erratic sensor behavior.

   A. Wipe off excess gel.

   B. Rinse the plastic sensor body (area between rubber and stainless body) with distilled water.

   C. Dry sensor body thoroughly with a clean tissue.

*Beckman Instruments part number.

A freshly charged sensor may drift between 2 and 10 percent of scale during the initial 4 to 20 hr. Following this initial drift, the typical sensor will be stable within ±3 percent of scale (for two-decade range) for 3 to 5 days on dry gas, and 10 to 30 days on gas at 95 percent RH. Marked deviations from this degree of stability are usually indicative of:

a. Incomplete charging with electrolyte

b. Accidental contamination of electrolyte

c. Accidental bridging of electrolyte to the stainless steel sensor body, thus forming a third electrode as discussed above.

POLAROGRAPHIC OXYGEN SYSTEM CALIBRATION AND USE PROCEDURES

The polarographic oxygen system is an adaptation of a hypoxia warning system* that is used to provide a signal when the partial pressure of oxygen is at or below a preset level. This signal is used to open a solenoid valve in the oxygen supply to introduce oxygen into the capsule when the partial pressure is below the preset level--i.e., the level specified for each test condition.

There are several modes of calibration, use and adjustments that can be used. These modes are explained further below.

System Calibration Procedure

1. Remove sensor from receptacle and set zero on the monitor oxygen panel. (Cabin indicator should read zero.)
2. Set up the system as shown in the schematic with oxygen as the sample gas.
3. Purge sample lines from gas supply to tank.
4. Evacuate the calibration tank to 0 in. Hg A as read on the mercury manometer.
5. Shut off vacuum source, using the manual valve.
6. Repressurize chamber with pure oxygen to 29.92 (760 mm) oxygen.
7. Adjust span on the monitor panel and capsule panel to read 760 mm Hg.
8. Evacuate tank to zero.
9. Shut off manual valve.
10. Increase the pressure in the tank to 3.15 in. Hg A (80 mm Hg A) and hold for 10 sec.
11. Read and record partial pressures indicated on meters.

*From Beckman Instruments Inc.

12. Repeat steps 11 and 12 for 6.3, 9.44, 12.6, 15.71, 18.89, 22.0, and 29.92 inches of mercury. (These pressures correspond to 160, 240, 320, 400, 480, 560, and 760 mm Hg, respectively.)

13. A correction curve from the data of steps 11 through 13 should be constructed.

14. This calibration shall be conducted at the beginning of each testing condition.

Operating Calibration (Daily and Specific Level of pO_2)

The specific level of oxygen partial pressure should be set in the oxygen system and a calibration curve constructed from this datum to provide more accurate readings during a test at about the pre-set level. (See Figure A-3). This procedure is outlined as follows:

1. Remove sensor, zero monitor indicator (necessary only after long duration shutdown or change of pO_2 sensor).
2. Set up system as shown in the schematic with oxygen as the sample gas.
3. Purge sample lines from gas supply to tank.
4. Evacuate the calibration tank to 0 in. Hg.
5. Increase pressure to the desired operating level (which will be specified).
6. Adjust span set on the cabin and monitors panel to read the desired pO_2. (Figure A-4).
7. Adjust the automatic control to a position just slightly below system sensitivity. (This level may require adjustments during the test. See next level adjustments.)
8. Once the above adjustment is made, the system should be calibrated within 50 mm Hg on either side of the datum to provide more precise references for correction.

Adjustments During Tests

There are a number of measurements that may require adjustments for nominal control during a test. These nominal measurements are monitored through an automatic gas chromatograph that may indicate an adjustment of the nominal settings. These adjustments will be read through the audio contact with the subject.

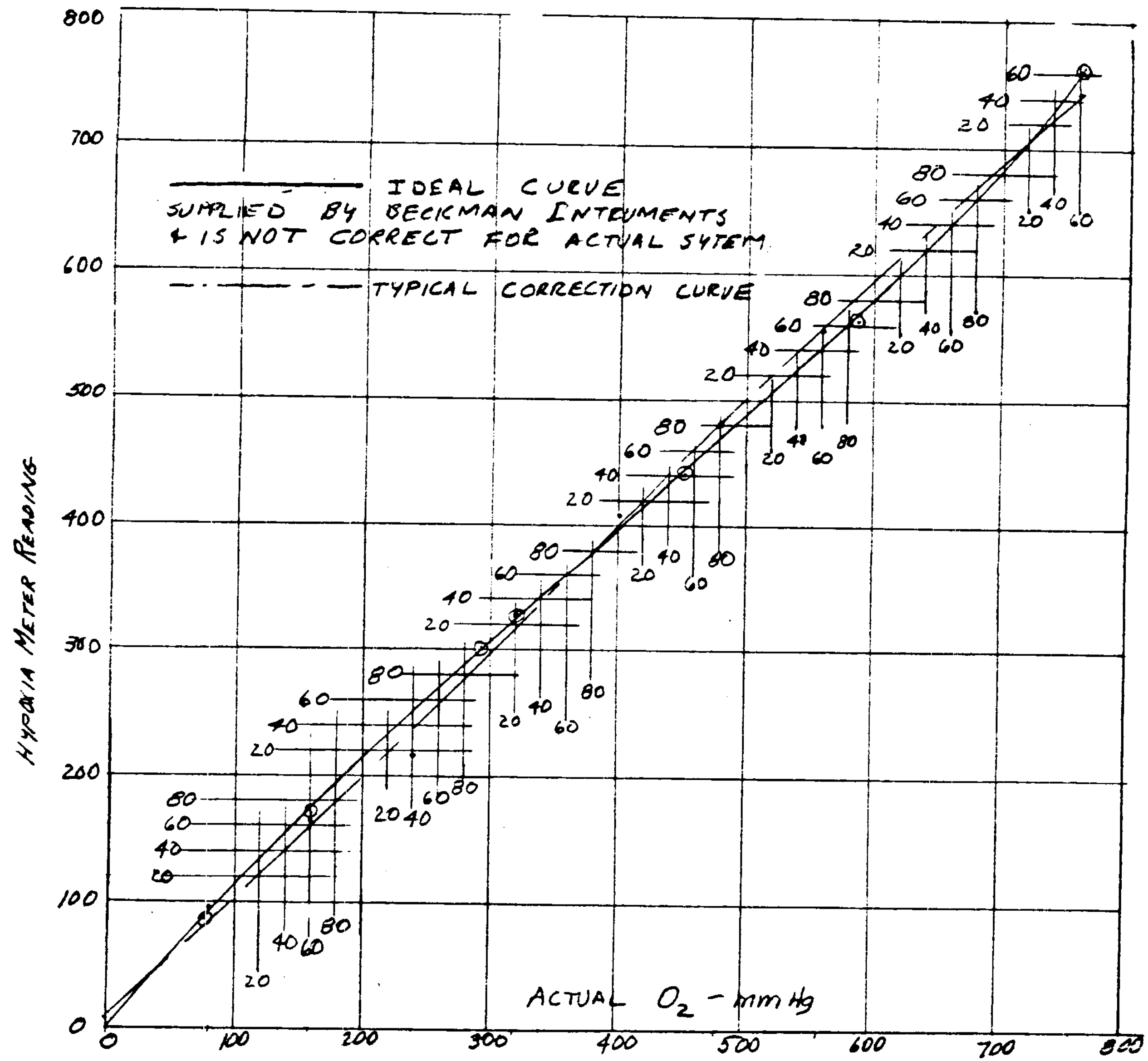


Figure A-3. Correction Curve, Oxygen Partial Pressure

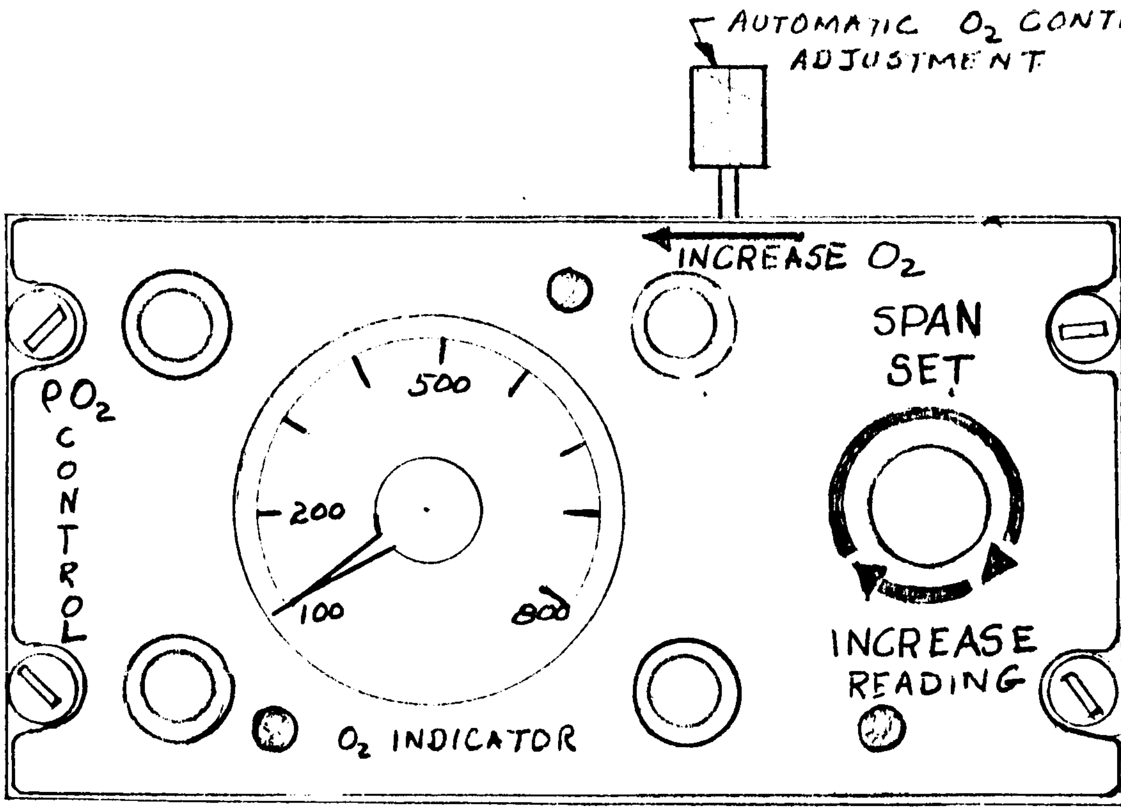


Figure A-4. Oxygen Partial Pressure Control Panel

TEMPERATURE SENSOR CALIBRATION

The temperature sensors are thermistors placed in the cabin ambient and in the outlet ventilation ducts. The accompanying curves are the calibration curves for each thermistor. The meter zeros and spans are set by placing these loads across them with a known resistance. The cabin outlet temperature is the most critical temperature and the meter should be set to read most accurately between 35° and 50°F. (See Figures A-5 and A-6).

To calibrate:

1. Set in the resistance corresponding to 30°F
2. Adjust the zero control until the meter reads 30°F
3. Set in the upper temperature resistance (70°F on the cabin ambient and 45°F on the ventilation outlet)
4. Adjust the span set to correspond with the upper temperature
5. Recheck the zero (30°F) set

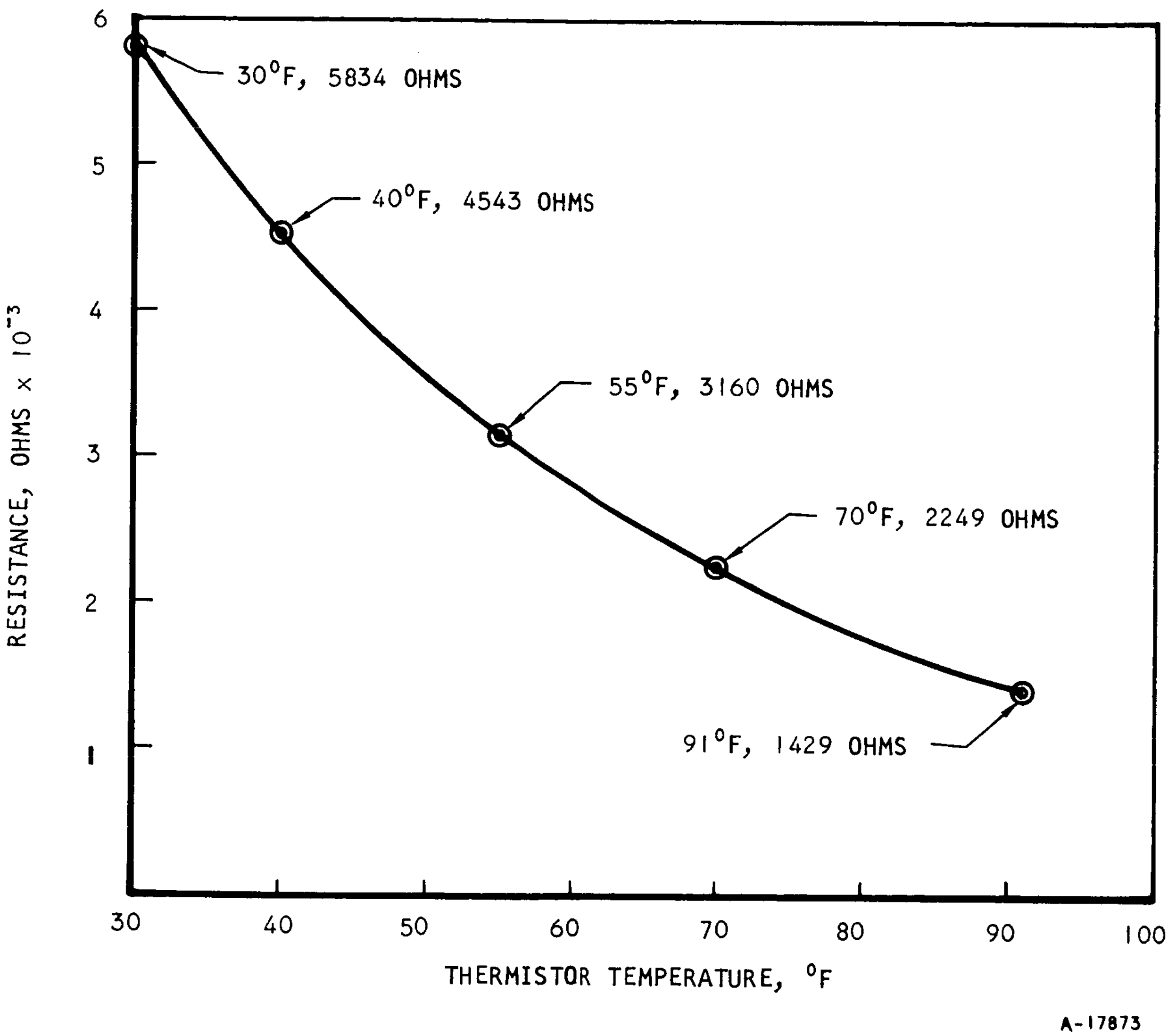


Figure A-5. Thermistor Unit 1, Cabin Outlet

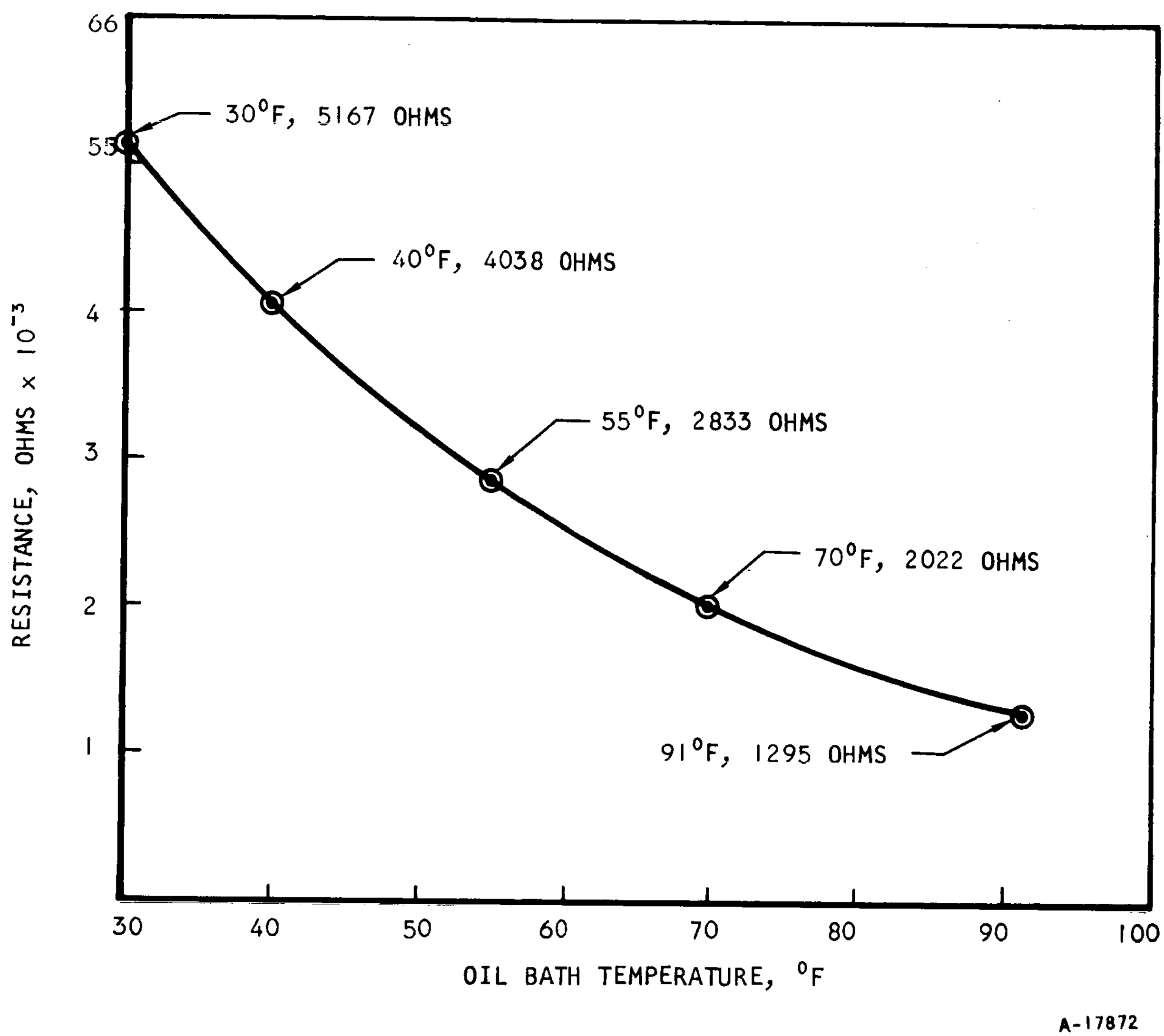


Figure A-6. Thermistor Unit 2, Cabin Inlet

SYSTEMS OPERATING CHECKLISTS

Walk-Around Inspection

Equipment Pretest Readiness

Subject Preemplacement Readiness

Control Panel Monitor and Recording Sheet

Capsule Purge and Steady State

Centrifuge Stage

Subject Removal

Systems Shutdown and Posttest

WALK-AROUND INSPECTION CHECKLIST, GENERAL INSTRUCTION SHEET

The walk-around inspection will be conducted as the first checklist procedure prior to all other operational procedures and prior to the use of other checklists. If no deviations from the checklist are found, it shall be noted at the end of the checklist and the inspector shall so inform the test conductor. Deviations from the checklist shall be noted and entered on the bottom of the checklist. The deviation shall be described in a short accurate narative specifying the item, fault, and deviation. The deviations found will be reported to the test conductor verbally as well as noted on the checklist. Noncompliance shall require correction under the direction of the test conductor before the test begins.

WALK AROUND INSPECTION CHECKLIST

Pre-subject emplacement - inspection of capsule and hardware.

	Remarks
A. Attachment points to centrifuge arm	
1. Visual inspection for stress cracks and structural integrity	______
2. Visual inspection for undue wear at locking pins and bolts	______
3. Visual inspection of stabilization arm for stress cracks	______
4. Visual inspection of stabilization arm for undue wear	______
B. Capsule shell exterior	
1. Visual inspection for stress cracks and structural integrity	______
2. Visual inspection of interconnections of lines through the gas bulkhead	______
3. Visual inspection of inter connections of lines through the electrical bulkhead	______
4. Visual inspection for structural integrity of windows and seals	______
C. Door mechanism and seal	
1. Visual and manipulation check of door hinges and movement	______
2. Visual inspection of door seals for defects in surface	______
D. Capsule interior	
1. Visual inspection of shell for structural integrity	______
2. Visual and manual inspection of lines and cables through bulkheads	______
3. Visual and manual inspection of security of equipment mounting to shells interior wall	______
4. Manually examine tubing support and integrity	______
5. Manually examine valve support and integrity	______
6. Manually examine electrical lines and connectors	______
7. Visually and manually examine capsule interior for cleanliness	______

E. Chair and rail units

1. Visual and manual inspection of rail unit for structural and functional integrity ______
2. Visual and manual inspection of chair unit for structural and functional integrity ______
3. Manual inspection of chair in locked position and of locking mechanism ______

F. Chiller-vacuum unit platform

1. Visual and manual inspection of platform connection to centrifuge for security, stress and wear ______
2. Visual and manual inspection of all equipment mounting to platform ______
3. Visual and manual inspection of all lines and tubing for security of mounting ______
4. Visual check of oil level of vacuum unit ______
5. Visual check of liquid coolant level (1/2 full or more) ______
6. Visual and manual check of connectors and connections ______
7. Visual and manual check of lines from platform to capsule ______

G. Gas supply source (bottles and lines)

1. Check O_2 supply bottles on manifold for adequate gas supply ______
2. Check N_2 supply bottles for adequate gas supply ______
3. Check CO_2 supply bottles for adequate gas supply ______
4. Visual and manual check of lines and connectors ______

Date ______ Conducted by ______

Remarks

EQUIPMENT PRETEST READINESS CHECKLIST GENERAL INSTRUCTION SHEET

This checklist shall follow the walk-around inspection checklist, and will be performed by the test conductor in conjunction with an operator. The checklist shall be the responsibility of the test conductor in communication with and directing the operator performing and verifying the individual tasks in sequence. Compliance and/or deviations from the checklist shall be so noted by the test conductor and entered on the checklist. Deviation shall require correction before the test begins.

EQUIPMENT PRETEST READINESS CHECKLIST

A. General

1. Enter ambient temperature ______
2. Enter barometric pressure ______
3. Enter relative humidity ______

B. System

1. Connect absolute pressure gage line ______
2. Remove O_2 sensor cover ______
3. Remove CO_2 sensor cover ______
4. Activate power supply switch ______
5. Activate communication power switch ______
6. Verify the power to and/or operation of:

    CO_2 canister soda lime verification ______
    Capsule TV camera (on/off) ______
    Capsule communication (on) ______
    Capsule lights (on) ______
    Capsule cooling fan (on/off) ______
    Capsule CO_2 fan (on/off) ______
    Chiller (on) ______
    Pump (on) ______
    Vacuum unit (on/off) ______
    Remove CO_2 canister plug (out) ______

7. Connect O_2 high pressure line ______
8. Connect O_2 purge line ______
9. Connect two atmosphere sample lines ______

C. Interior Capsule Verification

1. Functional operation of rail unit and capsule mating ______
2. Secure chair and seat operator ______
3. Position chair and roll operator into capsule ______
4. Functional lock up of chair, i.e., 4 pins ______
5. Connect and check out intercom ______

C. Interior Capsule Verification (continued)

6. Connect and check out trouble light ______
7. Connect bladder and inflate ______
8. Activate and verify TV transmittal ______
9. Verify internal capsule displays and functions:
   a. O_2 flow and N_2 flow ______
   b. Automatic dump valve operation ______
   c. Coolant liquid flow ______
   d. Vacuum capability ______
   e. O_2 (capsule) tank pressure ______
   f. N_2 (capsule) tank pressure ______
10. Visual and Functional verification of door operation ______
11. Remove operator:
   Place rails in position and lock in place ______
   Deflate bladder and disconnect ______
   Disconnect trouble light ______
   Disconnect intercom ______
   Remove lock pins on chair ______
   Tip handle on chair inward ______
   Lower and roll operator out of capsule ______
   Shut off O_2 in capsule ______
12. Notify test conductor that system readiness check is complete and satisfactory, or that a system hold is necessary due to checklist deviation. ______

Date ______ Conducted by ______

Remarks

SUBJECT PREEMPLACEMENT READINESS CHECKLIST GENERAL INSTRUCTION SHEET

This checklist shall follow the equipment pretest readiness checklist. This checklist procedure shall be performed by the test conductor in conjunction with an operator. The checklist shall be the responsibility of the test conductor in communication with and directing the operator performing and verifying the individual tasks in sequence. Compliance and/or deviations from the checklist shall be so noted by the test conductor and entered on the checklist. Deviation shall require correction prior to test initiation.

SUBJECT PREEMPLACEMENT READINESS CHECKLIST

A. Capsule readiness

1. Set pressure control head to test condition ______
2. Position pressure control valve at normal ______
3. Position capsule gas selector in correct position for test ______

B. Subject readiness (in chair for physiological functions)

1. Assist in adjusting chair to fit subject ______
2. Check chair support pins in base for proper tension to assure full locking ______
3. Roll in subject and secure in position with 4 lock pins ______
4. Connect intercom ______
5. Connect trouble light ______
6. Connect bladder supply ______
7. Connect body temperature ______
8. Connect Respiration rate ______
9. Connect ECG ______
10. Connect ear oximeter ______
11. Connect X.D. Pressure ______
12. Remove guide rails ______
13. Manual dump valve open ______
14. TV camera on ______
15. Turn on O_2 at capsule O_2 tank ______
16. Close and latch hatch ______
17. Inflate door seal ______
18. Install CO_2 shroud over door and cup over door-seal-valve ______
19. Verify subjects readiness to proceed with test ______

CONTROL PANEL MONITOR AND RECORDING SHEET

The control panel will be monitored continuously when a subject is in the capsule. Both the control panel and the capsule readouts will be recorded on the standard data sheets. These recording sheets will be kept with the test log. The monitoring function will be performed by a system operator under the direction of the test conductor. Data will be recorded at intervals of 30 min and more frequently if deemed necessary by the test conductor.

Test ______________ Date __________ Recorded by ________________

Control Panel MM pO_2					
Manometer In. Hg					
Control Panel MM pCO_2					
Control Panel Out HX Temp.					
Control Panel In HX Temp.					
Control Panel Cabin Fan Setting					
Control Panel CO_2 Fan Setting					

Capsule Panel MM Hg Total Press.					
Capsule Panel MM pO_2					
Capsule Panel MM pCO_2					

Chromatograph H_2O volume %					
Chromatograph CO_2 volume %					
Chromatograph O_2 volume %					
Chromatograph N_2 volume %					

CAPSULE PURGE AND STEADY-STATE CHECKLIST GENERAL INSTRUCTION SHEET

This checklist shall be kept by an operations team member and made available to the test conductor via the intercom and as recorded data. The checklist shall be submitted to the test conductor on the completion of the test. Out of tolerance, and sudden variations or deviation shall be reported immediately to the test conductor. The decision to hold, abort, or continue the test shall lie with test conductor.

(The checklist portion of the purge condition shall be directed toward monitoring the operations of the various functions involved. The emphasis will be placed on the in-tolerance performance of the system parameters. The actual purge procedure shall be performed under the authority of the test conductor to manipulate the system configuration to meet the test conditions. This procedural dichotomy provides supplementary support to each, i.e., the checklist providing periodic sequential data points to the test conductor and the test conductor's manipulation of the operations being reflected in the checklist data.

CAPSULE PURGE CHECKLIST

A. Subject-Panel Monitor-Test Conductor, System Verification Checklist

1. Power on ____________
2. Chiller on ____________
3. Water pump on ____________
4. TV camera on ____________
5. Cabin fan on ____________
6. CO_2 fan on ____________
7. Cabin manual dump open ____________
8. Communication (i.e., welfare of subject) ____________
9. Trouble light check ____________
10. Auto. dump check ____________
11. O_2 flow to capsule from purge reserve ____________
12. (If two gas test N_2 flow from system reserve) ____________
13. Open CO_2 valve ____________
14. Pressurize shroud with CO_2 ____________

B. Test conductor's parameters for the purge condition and steady state

1. O_2 partial pressure ____________
2. N_2 partial pressure (if two gas test) ____________
3. CO_2 level ____________
4. Water vapor pressure ____________
5. Capsule temperature ____________

(NOTE: Sequences and purge parameter read-outs shall be entered in the test log and/or recorded on the panel monitor's data sheet.)

CENTRIFUGE STAGE CHECKLIST

This checklist will be initiated following the steady state. The checklist will be recorded by the test conductor and performed under his direction. Under no condition will centrifugation of the subject take place without performing and verifying every checklist item.

CENTRIFUGE STAGE CHECKLIST

A. System Disconnects and Readiness

1. Deflate CO_2 shroud and remove ____________
2. Disconnect O_2 line at capsule and remove ____________
3. Disconnect N_2 line at capsule and remove ____________
4. Disconnect CO_2 line at capsule and remove ____________
5. Turn off gas at source ____________
6. Disconnect all non-centrifugation equipment 5 minutes prior to centrifuging ____________

B. Subject Checkout

1. Restraints secure on water bottle ____________
2. Restraints secure on waste bottle ____________
3. Subject check for loose objects in capsule ____________
4. Subject's restraint secure ____________
5. Trouble light check ____________
6. MD's instruction to subject ____________
7. Test conductor's instruction to subject ____________

C. Capsule/Centrifuge Connections

1. Test conductor verify disconnection and removal of non-centrifuging lines ____________
2. Verify vacuum source on ____________
3. Verify TV on ____________
4. Verify cabin O_2 source on ____________
5. Verify cabin N_2 source on (for two gas test mode) ____________
6. Verify water-glycol flow ____________
7. Verify CO_2 fan on ____________

D. Centrifugation Readiness

1. Check and verify each participating technician ready ____________
2. Check and verify MD ready ____________
3. Check and verify subject ready ____________
4. Authorize centrifuge operator to activate centrifuge ____________

D. Centrifugation Readiness (continued)

5. Authorize centrifuge operator to deactivate centrifuge ____________

6. Position centrifuge for unloading ____________

Date ______________________ Test Conductor ______________________

Remarks

SUBJECT REMOVAL CHECKLIST

This checklist will be initiated immediately following the deactivation of the centrifuge. The checklist will be under the direction and control of the test conductor and recorded by a system operator. Care must be exercised in performing this checklist to assure that the requirement for getting the subject into position for physiological testing as quickly as possible does not interfere with performing the checklist procedures in an orderly efficient manner.

SUBJECT REMOVAL CHECKLIST

A. Test conductor's control and direction to operators

1. Turn off vacuum source __________
2. Activate cabin dump to open __________
3. Control capsule pressurization by monitoring and manipulating: __________
   a. Monitor cabin pressure via absolute pressure gage
   b. Monitor cabin internal pressure via subject's display
   c. Control manual dump valve
   d. Control automatic dump valve
4. At one atmosphere verify pressure to subject and operator's __________
5. Deactivate door seal control __________
6. Open hatch __________
7. Position rail unit and engage lock pins __________
8. Disengage subject's lines and instrumentation:
   a. Bladder pressure connection __________
   b. Trouble light connection __________
   c. Intercom connection __________
   d. MIC - Body temperature __________
   e. Respiration rate __________
   f. ECG __________
   g. Ear oximeter __________
   h. XR Press. __________
9. Disengage 4 chair locking pins __________
10. Roll subject out and lock in position __________
11. Disengage rails from capsule __________
12. Position subject for physiological testing __________

Date __________ Signed __________

Remarks

SYSTEMS SHUTDOWN AND POSTTEST CHECKLIST

This checklist will be performed immediately following the placement of the subject for physiological testing. The test conductor will control the procedures and be informed of any deviations or faults found during the performance of this checklist.

SYSTEMS SHUTDOWN AND POSTTEST CHECKLIST

A. Capsule Interior and Control Panel Integration

1. O_2 manual valve at O_2 tank in capsule, off ______
2. Verify CO_2 fan off ______
3. Verify Cabin fan off ______
4. Verify TV off ______
5. Verify water chiller off ______
6. Verify CO_2 canister plug replaced ______
7. Shut off O_2 gas at supply bottles and manifold ______
8. Shut off N_2 gas at supply bottle ______
9. Shut off CO_2 gas at supply bottle ______
10. Shut off communication panel ______
11. Shut off water pump ______
12. Panel main power off ______
13. Verify all panel displayed systems off ______
14. Place O_2 and CO_2 covers over sensors ______

B. Gas Sample Bottles

1. Lable gas sample bottles in sampling unit ______
2. Remove sample bottles and store ______
3. Place new sample bottles in sampling unit ______

C. Capsule Interior

1. Remove subjects waste container, water collection tank and dispose of contents ______
2. Clean waste container and tank, sterilize and replace in capsule ______
3. Examine subjects and test conductor notes for corrective comment germane to the capsule interior (If any are noted, they shall be brought to the attention of the test conductor and procedures initiated to correct the condition under the test conductor's direction.) ______
4. Check with test conductor on adequacy of soda lime ______
5. Examine CO_2 removal unit mouting, lines, and connection for structural integrity ______

C. Capsule Interior (continued)

6. Examine subject monitoring displays for mounting integrity as well as lines and connectors ____________

7. Examine capsule ECS for mounting integrity as well as lines and connectors ____________

8. Vacuum the capsule interior ____________

9. Wipe capsule interior with a dampened cloth containing Turco 4988-1. Wipe capsule interior with a dampened cloth containing distilled water. (NOTE: item 9 will be performed at the direction of the test conductor as well as any additional cleaning procedures deemed necessary.) ____________

D. Equipment Palet

1. Verify adequacy of water/glycol level ____________

2. Verify adequacy of vacuum pump oil level ____________

3. Examine all equipment mounting to palet for mounting security, also check lines, tubing and connectors. ____________

4. Examine connecting points of palet to centrifuge arm ____________

E. Gas Supply System

1. Check O_2, N_2 and CO_2 and replace those bottles of inadequate pressure and mark pressure and date on bottle ____________

2. Check gas reserve and order bottles to maintain appropriate reserve ____________

3. Check gas lines and connectors for security of mountings and functional integrity. ____________

Date ____________ Signed ____________

Remarks

BIOINSTRUMENTATION CHECKLISTS AND PROCEDURES

Oximeter Donning and Calibration

Pulmonary Function Test

Loading and Supplies

OXIMETER DONNING AND CALIBRATION PROCEDURE AND CHECKLIST

1. Instruct subject to place oximeter on ear ____________
2. Turn on power to oximeter ____________
3. Run down thumb nut to clamp oximeter in place ____________
4. Turn on oscillograph ____________
5. Instruct subject to turn in thumbscrew until pulse wave disappears (1/4 turn intervals) ____________
6. Back off thumbscrew until pulse wave is maximal (approx. 1/4 turn) ____________
7. Place selector switch on IR and depress IR calibrate button ____________
8. Null meter with IR pot ____________
9. Place selector switch to SAT. ____________
10. Instruct subject to inflate cuff and earpiece to 200 mm Hg and hold the pressure ____________
11. Null R pot. Adjust the oximeter channel to indicate 100 percent saturation ____________
12. Allow the pressure to bleed at about 10 mm Hg/sec. ____________
13. Note systolic pressure by appearance of sounds on microphone channel ____________
14. Note ear pulse pressure by appearance of pulse waves on pulse channel. ____________

    (If this is not approximately 30 mm Hg less than systolic pressure then the earpiece is too tight or too loose and must be readjusted - repeat step 6.) ____________

PULMONARY FUNCTION TEST PROCEDURES AND CHECKLIST

A. Assessing System Volume

1. Start machine and let warm up for 30 min.
2. Flush out system.
3. Push bell to the bottom.
4. Zero helium analyzer.
5. Introduce 250 cc He and allow mixing.
6. Open mouthpiece, push bell to the bottom, close mouthpiece, and record He concentration (B).
7. Add air (V_n) to the system.
8. After mixing record final He concentration (C).
9. Calculate system volume.

B. FRC Determination

1. Flush out system and zero He analyzer.
2. Add 400 cc He to the system.
3. Allow mixing and then push bell to the bottom.
4. Add 1000 cc of O_2 to the system.
5. Add 2500 cc of air to the system.
6. Record the initial He concentration (C).
7. Apply noseclip to subject.
8. Connect subject to system at end of normal expiration.
9. Introduct O_2 at rate that facilitates a constant baseline.
10. Connect integrator.
11. Record He concentration every 30 sec for the first three minutes and each minute thereafter until the test is complete (Approx. 7 min.)
12. Perform ERV maneuver and resume normal breathing.
13. Perform VC determination and resume normal breathing.
14. Plot He concentration readings on prepared graph paper and extrapolate to initial concentration (C).

C. Timed vital capacity determination

1. Place bell in middle position.
2. Request subject to inspire maximally and hold breath.
3. Adjust recorder speed to 1200 mm/min.
4. Subject told to exhale maximally as rapidly as possible.

D. Maximum Breathing Capacity

1. Place bell in mid-position.
2. Adjust O_2 flow control to facilitate a constant baseline. Adjust recorder at 60 mm/sec.
3. Connect and lock integrator.
4. Subject is told to breathe for 15 sec as deeply as possible at the rate a 30 breaths/sec.
5. Calculate MBC

NOTE: Integrator factor 1 cm. = 300 cc vol.

LOADING AND SUPPLIES CHECKLIST

1. Place lunch in containers and place in capsule ____________
2. Fill drinking bottle and load into capsule ____________
3. Place clean wickie bottle into capsule ____________
4. Place subjects reading material into capsule ____________
5. Place waste container into capsule ____________
6. Check with subject for any additional supplies that he desires ____________

ANALYSIS OF THE REDUCED DATA

All of the respiratory function data were reduced in the form of ratios so that major deviations and progressive trends would be easily recognized. The ratios were determined for each subject and then means of the individual variations as well as means of the ratios were determined.

In the following data, mean values for given respiratory measurement (means of ratios computed for individuals) occur first. The ratios of the means for a respiratory measurement (ratios computed from the means of the parameters) occur second, with the individual variations following.

Symbols

A = average of the baseline postcentrifuge values

B = average of the baseline precentrifuge values

C = postcentrifuge value for a specific test

D = precentrifuge value for a specific test

E = mean value for all precentrifuge measurements

F = mean value for the postcentrifuge baseline measurements as well as the postcentrifuge mixed-gas values

TABLE 1A

C-post
D-pre

GROUP : SUMMARY
PARAMETER $\bar{X}$ VC

Mean of ratios computed for individuals

RATIOS	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 184 O_2 C	3 HR 184 O_2 D	8 HR 184 O_2 C	8 HR 184 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
A/B	.9958															
C/D			.9945		.9784		.9455		.8709		.9047		.8894			
C/A			.9942		.9785		.9492		.8760		.8933		.8804			
C/B			.9897		.9745		.9446		.8704		.8883		.8754			
D/B				.9958		.9960		1.0042		1.0024		.9855		.9862		
D/B / C/B			1.0067		1.0221		1.0654		1.1741		1.1420		1.1547			
A/B / C/D			1.0017		1.0177		1.0619		1.1710		1.1397		1.1521			
C/E			.9943		.9786		.9491		.8761		.8935		.8804			
C/F			1.0021		.9863		.9569		.8832		.9007		.8877			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ post base																

Ratios computed from means of (?) per rate

GROUP : SUMMARY

PARAMETER VC RATIO OF $\overline{X}$

TABLE IB

Ratios	$\overline{X}$ Baseline Post A	$\overline{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 187 O_2 C	3 HR 187 O_2 D	8 HR 187 O_2 C	8 HR 187 O_2 D	$\overline{X}$ Pre E	$\overline{X}$ Post Base & Post Mixed F
	4647	4664	4623	4646	4549	4645	4386	4666	4096	4689	4121	4607	4060	4597	4686	4671
A/B	.9963															
C/D			.9950		.9791		.9399		.8630		.8947		.8831			
C/A			.9948		.9786		.9438		.8704		.8868		.8736			
C/B			.9912		.9751		.9403		.8672		.8835		.8704			
D/B				.9961		.9959		1.0004		1.0049		.9875		.9856		
$\frac{D}{B} / \frac{C}{B}$			1.0049		1.0213		1.0639		1.1587		1.1177		1.1323			
$\frac{A}{B} / \frac{C}{D}$			1.0013		1.0175		1.0600		1.1544		1.1135		1.1281			
C/E			.9950		.9989		.9440		.8706		.8869		.8738			
C/F			1.0026		.9863		.9512		.8772		.8937		.8805			
C/$\overline{X}_g$ P.C.																
C/$\overline{X}_g$ Post Base																

A-47

C-post
D-pre

SUBJECT : LR

PARAMETER VG

TABLE IC

	$\bar{X}$ Baseline		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 19% O_2		8 HR 19% O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	5152	5075	5190	5156	5050	5055	4260	5190	3520	5240	3450	5260	3395	5085	5142	5136
RATIOS A/B	1.0151															
C/D			1.0065		.9990		.8208		.6717		.6558		.6676			
C/A			1.0073		.9802		.8268		.6832		.6696		.6589			
C/B			1.0226		.9950		.8394		.6935		.6798		.6689			
D/B				1.0157		.9960		1.0226		1.0325		1.0364		1.0019		
$\frac{D}{B} / \frac{C}{B}$			.9934		1.0010		1.2182		1.4888		1.5245		1.4978			
$\frac{A}{B} / \frac{C}{D}$			1.0085		1.0161		1.2367		1.5112		1.5478		1.5205			
C/E			1.0093		.9821		.8284		.6845		.6709		.6602			
C/F			1.0105		.9832		.8294		.6853		.6717		.6610			
C/$\bar{X}_3$ PRE																
C/$\bar{X}_8$ POST BASE																

REPORT IC

PAGE OF

C - POST
D - PRE

SUBJECT : MG

PARAMETER VC

REPORT 1D

PAGE OF

TABLE ID

	$\bar{X}$ BASELINE		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	4592	4592	4625	4470	4480	4575	4615	4470	4615	4600	4800	4580	4555	4570	4556	4572
A/B	1.0000															
C/D			1.0346		.9792		1.0324		1.0032		1.0480		.9967			
C/A			1.0071		.9756		1.0050		1.0050		1.0452		.9919			
C/B			1.0071		.9756		1.0050		1.0050		1.0452		.9919			
D/B				.9734		.9962		.9734		1.0017		.9973		.9952		
$\frac{D}{B} / \frac{C}{B}$			.9665		1.0211		.9685		.9967		.9541		1.0033			
$\frac{A}{B} / \frac{C}{D}$			.9665		1.0212		.9686		.9968		.9541		1.0033			
C/E			1.0151		.9833		1.0129		1.0129		1.0535		.9997			
C/F			1.0115		.9798		1.0094		1.0094		1.0498		.9962			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

A-49

C POST
D-PRE

SUBJECT : WS

PARAMETER VC

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 187 O_2 C	3 HR 187 O_2 D	8 HR 187 O_2 C	8 HR 187 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	4740	4047	4650	4795	4665	4800	4505	4795	4400	4840	4515	4605	4545	4570	4762	4678
A/B	.9779															
C/D			.9697		.9718		.9395		.9090		.9804		.9945			
C/A			.9810		.9841		.9504		.9282		.9525		.9588			
C/B			.9572		.9624		.9294		.9077		.9315		.9376			
D/B				.9892		.9903		.9892		.9935		.9500		.9428		
$\frac{D}{B} / \frac{C}{B}$			1.0334		1.0289		1.0643		1.1000		1.0198		1.0055			
$\frac{A}{B} / \frac{C}{D}$			1.0084		1.0062		1.0408		1.0757		.9974		.9833			
C/E			.9764		.9796		.9460		.9239		.9481		.9544			
C/F			.9940		.9972		.9630		.9405		.9651		.9715			
$C/\bar{X}_g$ PRE																
$C/\bar{X}_g$ POST BASE																

TABLE IE

REPORT IE

PAGE OF

A-10

C post
D - pre

SUBJECT : GR

PARAMETER VC

RATIOS	$\bar{X}$ BASELINE POST A	PRE B	3 HR 380 MIXED C	D	8 HR 380 MIXED C	D	3 HR 380 O_2 C	D	8 HR 380 O_2 C	D	3 HR 187 O_2 C	D	8 HR 187 O_2 C	D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	4105	4145	4030	4165	4000	4150	4165	4210	3645	4050	3720	3980	3745	4165	4126	4060
A/B	.9903															
C/D			.9675		.9638		.9893		.9000		.9346		.8991			
C/A			.9817		.9744		1.0146		.8879		.9062		.9123			
C/B			.9722		.9650		1.0048		.8793		.8994		.9034			
D/B				1.0048		1.0012		1.0156		.9770		.9601		1.0048		
D/B / C/B			1.0335		1.0375		1.0107		1.1111		1.0698		1.1122			
A/B / C/D			1.0235		1.0274		1.0010		1.1003		1.0595		1.1014			
C/E			.9767		.9694		1.0094		.8834		.9015		.9076			
C/F			.9926		.9852		1.0258		.8977		.9162		.9224			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ POST BASE																

TABLE IF

REPORT IF

PAGE OF

A-51

REPORT 2A
PAGE OF

TABLE 2A

GROUP : SUMMARY

PARAMETER $\bar{X}$ RV

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
A/B	1.0151															
C/D			.8673		.9600		1.3765		.7862		.9486		.8505			
C/A			.8397		.9700		.9646		.7830		1.0188		.7792			
C/B			.8556		.9774		.9700		.7875		1.0302		.7895			
D/B				.9929		1.0281		.8266		1.0669		1.0664		.9515		
D/B / C/B			1.1873		1.0688		.8120		1.2954		1.1015		1.2529			
A/B / C/D			1.1895		1.0853		.8421		1.3238		1.1171		1.2870			
C/E			.8648		.9933		.9773		.8119		1.0285		.8084			
C/F			.8807		1.0141		1.0027		.8257		1.0570		.8226			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

TABLE 2B

REPORT 2B
PAGE OF

GROUP : SUMMARY

PARAMETER RV RATIO OF $\overline{X}$

	$\overline{X}$ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 19.7 O_2		8 HR 19.7 O_2		$\overline{X}$ PRE	$\overline{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	1242	1219	1034	1227	1149	1208	1108	922	978	1224	1177	1268	977	1140	1178	1167
RATIOS A/B	1.0188															
C/D			.8427		.9511		1.2017		.7990		.9282		.8570			
C/A			.8325		.9251		.8921		.7874		.9476		.7866			
C/B			.8482		.9425		.9089		.8022		.9655		.8014			
D/B				1.0475		.9909		.7563		1.0044		1.0401		.9351		
$\frac{D}{B} / \frac{C}{B}$			1.2349		1.0513		.8321		1.2516		1.0772		1.1668			
$\frac{A}{B} / \frac{C}{D}$			1.2089		1.0711		.8477		1.2750		1.0976		1.1887			
C/E			.8777		.9753		.9405		.8302		.9991		.8293			
C/F			.8860		.9845		.9494		.8380		1.0085		.8371			
C/$\overline{X}_g$ PRE																
C/$\overline{X}_g$ POST BASE																

C-POST
D-PRE

SUBJECT : MG

PARAMETER RV

TABLE 2C

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	1747	1700	1550	2040	1189	1472	984	528	1514	1613	1316	1560	1568	1632	1530	1558
A/B	1.0276															
C/D			.7598		.8077		1.8636		.9386		.8435		.9607			
C/A			.8872		.6805		.5632		.8666		.7532		.8975			
C/B			.9117		.6994		.5788		.8905		.7714		.9223			
D/B				1.2000		.8658		.3105		.9488		.9176		.9600		
$\frac{D}{B} / \frac{C}{B}$			1.3162		1.2379		.5364		1.0654		1.1895		1.0408			
$\frac{A}{B} / \frac{C}{D}$			1.3524		1.2722		.5514		1.0948		1.2182		1.0696			
C/E			1.0130		.7771		.6431		.9895		.8601		1.0248			
C/F			.9948		.7631		.6315		.9717		.8446		1.0064			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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TABLE 2D

C-post
D-pre

SUBJECT : LR

PARAMETER RV

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	860	996	674	968	1011	1045	1068	599	768	922	1011	1073	805	856	931	851
A/B	.8634															
C/D			.6962		.9674		1.7829		.8329		.9422		.9404			
C/A			.7837		1.1755		1.2418		.8930		1.1755		.9360			
C/B			.6767		1.0150		1.0722		.7710		1.0150		.8082			
D/B				.9718		1.0491		.6014		.9257		1.0773		.8594		
$\frac{D}{B} / \frac{C}{B}$			1.4360		1.0335		.5609		1.2006		1.0613		1.0633			
$\frac{A}{B} / \frac{C}{D}$			1.2401		.8924		.4842		1.0366		.9163		.9181			
C/E			.7239		1.0859		1.1471		.8249		1.0859		.8646			
C/F			.7920		1.1880		1.2549		.9024		1.1880		.9459			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

TABLE 2E

REPORT 2E

PAGE OF

C POST
D PRE

SUBJECT : WS

PARAMETER RV

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 Hr 380 Mixed C	3 Hr 380 Mixed D	8 Hr 380 Mixed C	8 Hr 380 Mixed D	3 Hr 380 O_2 C	3 Hr 380 O_2 D	8 Hr 380 O_2 C	8 Hr 380 O_2 D	3 Hr 194 O_2 C	3 Hr 194 O_2 D	8 Hr 194 O_2 C	8 Hr 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base + Post Mixed F
	1392	1292	905	970	1427	1168	1283	1395	986	1389	980	1348	955	987	1229	1279
A/B	1.0773															
C/D			.9329		1.2219		.9197		.7098		.7270		.9675			
C/A			.6501		1.0251		.9216		.7083		.7040		.6860			
C/B			.7604		1.1044		.9930		.7631		.7685		.7391			
D/B				.7507		.9040		1.0797		1.0750		1.0433		.7639		
D/B / C/B			1.0718		.8185		1.0873		1.4087		1.3754		1.0335			
A/B / C/D			1.1547		.8818		1.1713		1.5177		1.4818		1.1134			
C/E			.9363		1.1611		1.0439		.8022		.7973		.7770			
C/F			.7075		1.1157		1.0031		.7709		.7662		.7466			
C/$\bar{X}$g P.U.																
C/$\bar{X}$g Pos. Base																

C - post
D - pre

SUBJECT : GR

PARAMETER RV

REPORT 2F

PAGE OF

TABLE 2F

	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 19% O_2 C	3 HR 19% O_2 D	8 HR 19% O_2 C	8 HR 19% O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
Ratios	971	889	1008	933	970	1150	1099	1169	645	972	1401	1093	580	1087	1022	980
A/B	1.0922															
C/D			1.0803		.8434		.9401		.6635		1.2817		.5335			
C/A			1.0381		.9989		1.1318		.6642		1.4428		.5973			
C/B			1.1338		1.0911		1.2362		.7265		1.5759		.6524			
D/B				1.0494		1.2935		1.3149		1.0933		1.2294		1.2227		
D/B / C/B			.9255		1.1855		1.0636		1.5069		.7801		1.8941			
A/B / C/D			1.0110		1.2949		1.1617		1.6461		.8521		2.0472			
C/E			.9863		.9491		1.0753		.6311		1.3708		.5675			
C/F			1.0285		.9897		1.1214		.6581		1.4295		.5918			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

L - Post
D - Pre

GROUP : SUMMARY

PARAMETER $\bar{X}$ ICF

REPORT 3A
PAGE OF

TABLE 3A

RATIOS	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base + Post Mixed F
A/B	1.0419															
C/D			.9946		1.0223		.9603		.9149		.9220		.9878			
C/A			.9794		.9759		.9390		.8589		.8843		.8595			
C/B			.9982		.9948		.9570		.8749		.9011		.7359			
D/B				1.0047		.9668		.9982		.9601		.9816		.9776		
$\frac{D}{B} / \frac{C}{B}$			1.0070		.9722		1.0474		1.1289		1.1190		1.1494			
$\frac{A}{B} / \frac{C}{D}$			1.0511		1.0207		1.0824		1.1743		1.1634		1.1954			
C/E			1.0120		1.0082		.9702		.8876		.9137		.8881			
C/F			.9905		.9870		.9498		.8686		.8944		.8695			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

TABLE 3B

REPORT 3B

PAGE OF

GROUP : SUMMARY

PARAMETER ICF Ratio of $\bar{X}$

	$\bar{X}$ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 19% O_2		8 HR 19% O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	3872	3724	3723	3742	3705	3618	3538	3718	3212	2588	3308	3665	3210	3645	3677	3756
RATIOS																
A/B	1.0397															
C/D			.9949		1.0240		.9515		.8952		.9025		.8806			
C/A			.9615		.9568		.9137		.8295		.8543		.8290			
C/B			.9997		.9948		.9500		.8625		.8882		.8619			
D/B				1.0048		.9715		.9983		.9634		.9841		.9787		
D/B / C/B			1.0051		.9765		1.0508		1.1169		1.1079		1.1355			
A/B / C/D			1.0450		1.0153				1.1614		1.1520		1.1806			
C/E			1.0125		1.0076		.9621		.8735		.8996		.8729			
C/F			.9912		.9864		.9419		.8551		.8807		.8596			
C/$\bar{X}_q$ P.I.C.																
C/$\bar{X}_q$ Post Base																

C-Post
D-Pre

SUBJECT : LR

PARAMETER ICF

TABLE 3C

	$\bar{X}$ Baseline		3 Hr 380 Mixed		8 Hr 380 Mixed		3 Hr 380 O_2		8 Hr 380 O_2		3 Hr 194 O_2		8 Hr 194 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios	4525	4405	4495	4480	4350	4175	3745	4350	2900	4395	3040	4510	2875	4420	4392	4473
A/B	1.0272															
C/D			1.0033		1.0419		.8609		.6598		.6740		.6504			
C/A			.9933		.9613		.8276		.6408		.6718		.6353			
C/B			1.0204		.9875		.8501		.6583		.6901		.6526			
D/B				1.0170		.9477		.9875		.9977		1.0238		1.0034		
(D/B) / (C/B)			.9966		.9596		1.1616		1.5155		1.4835		1.5375			
(A/B) / (C/D)			1.0238		.9858		1.1931		1.5568		1.5240		1.5793			
C/E			1.0234		.9904		.8526		.6602		.6921		.6545			
C/F			1.0049		.9725		.8372		.6483		.6796		.6427			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

AIRESEARCH MANUFACTURING DIVISION
Los Angeles, California

C-POST
D-PRE

SUBJECT : MG

PARAMETER ICF

TABLE 3D

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 187 O_2 C	3 HR 187 O_2 D	8 HR 187 O_2 C	8 HR 187 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	3509	3499	3555	3395	3400	3385	3380	3250	3290	3256	3245	3455	3100	3210	3367	3492
A/B	1.0028															
C/D			1.0471		1.0044		1.0400		1.0123		.9392		.9657			
C/A			1.0136		.9694		.9637		.9381		.9252		.8839			
C/B			1.0165		.9722		.9665		.9408		.9277		.8864			
D/B				.9708		.9677		.9298		.9293		.9879		.9179		
$\frac{D}{B} / \frac{C}{B}$			.9550		.9955		.9615		.9877		1.0646		1.0355			
$\frac{A}{B} / \frac{C}{D}$			.9576		.9984		.9642		.9906		1.0677		1.0384			
C/E			1.0058		1.0098		1.0038		.9771		.9637		.9209			
C/F			1.0180		.9736		.9679		.9421		.9292		.8877			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

REPORT 3D PAGE OF

C - POST
D - PRE

SUBJECT : WS

PARAMETER ICF

TABLE 3E

REPORT 3E

PAGE OF

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 Hr 380 Mixed C	3 Hr 380 Mixed D	8 Hr 380 Mixed C	8 Hr 380 Mixed D	3 Hr 380 O_2 C	3 Hr 380 O_2 D	8 Hr 380 O_2 C	8 Hr 380 O_2 D	3 Hr 194 O_2 C	3 Hr 194 O_2 D	8 Hr 194 O_2 C	8 Hr 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	3745	3672	3600	3610	3750	3545	3610	3925	3595	3670	3650	3470	3510	3550	3636	3910
A/B	1.0198															
C/D			.9992		1.0578		.9197		.9795		1.0518		.9887			
C/A			.9612		1.0013		.9639		.9599		.9746		.9372			
C/B			.9803		1.0212		.9831		.9790		.9940		.9558			
D/B				.9831		.9381		1.0688		.9994		.9449		.9667		
$\frac{D}{B} / \frac{C}{B}$			1.0028		.9186		1.0871		1.0208		.9506		1.0114			
$\frac{A}{B} / \frac{C}{D}$			1.0226		.9640		1.1088		1.0411		.9695		1.0314			
C/E			.9900		1.0313		.9928		.9887		1.0038		.9653			
C/F			.9703		1.0167		.9730		.9690		.9838		.9460			
$C/\bar{X}_g$ PRE																
$C/\bar{X}_g$ POST BASE																

A 62

C - post
D - pre

TABLE 3F

REPORT 3F

PAGE OF

SUBJECT : GR

PARAMETER ICF

RATIOS	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 19% O_2 C	3 HR 19% O_2 D	8 HR 19% O_2 C	8 HR 19% O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	3417	3325	3245	3485	3320	3370	3420	3350	3065	3040	3300	3225	3355	3400	3315	3349
A/B	1.1178															
C/D			.9311		.9851		1.0208		1.0082		1.0232		.9367			
C/A			.9496		.9716		1.0008		.9969		.9657		.9818			
C/B			.9759		.9984		1.0285		.9218		.9924		1.0090			
D/B				1.0401		1.0135		1.0075		.9142		.9699		1.0225		
D/B / C/B			1.0739		1.0151		.9795		.9917		.9773		1.0133			
A/B / C/D			1.2005		1.1347		1.0950		1.1089		1.0924		1.1328			
C/E			.9788		1.0015		1.0316		.9245		.9954		1.0120			
C/F			.9689		.9913		1.0212		.9151		.9853		1.0019			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ post base																

A-63

C - Post
D Pre

GROUP : SUMMARY

PARAMETER $\bar{X}$ TLC

TABLE 4A

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
A/B	1.0018															
C/D			.9666		.9822		.9931		.8753		.9214		.8855			
C/A			.9625		.9819		.9455		.8685		.9169		.8723			
C/B			.9630		.9839		.9481		.8704		.9191		.8746			
D/B				.9964		1.0023		.9592		.9942		.9974		.9875		
D/B / C/B			1.0346		1.0198		1.0096		1.1558		1.1014		1.1410			
A/B / C/D			1.0364		1.0214		1.0119		1.1571		1.1024		1.1420			
C/E			.9713		.9915		.9539		.8781		.9253		.8815			
C/F			.9753		.9960		.9588		.8814		.9302		.8852			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

C Post
D Pre

GROUP : SUMMARY

PARAMETER TLC RATIO OF $\bar{X}$

REPORT 4B
PAGE OF

TABLE 4B

	$\bar{X}$ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 184 O_2		8 HR 184 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base # Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios	5978	5968	5749	5944	5889	5967	5623	5691	5193	5932	5440	5948	5206	5883	5912	5892
A/B	1.0016															
C/D			.9671		.9869		.9880		.8754		.9145		.8849			
C/A			.9616		.9857		.9406		.8686		.9100		.8708			
C/B			.9633		.9867		.9421		.8701		.9270		.8723			
D/B				.9959		.9978		.9535		.9937		.9966		.9857		
$\frac{D}{B} / \frac{C}{B}$			1.0338		1.0132		1.0121		1.1422		1.0750		1.1300			
$\frac{A}{B} / \frac{C}{D}$			1.0356		1.0148		1.0137		1.1441		1.0952		1.1318			
C/E			.9724		.9961		.9511		.8782		.9201		.8805			
C/F			.9757		.9994		.9543		.8813		.9232		.8835			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

C-post
D-pre

SUBJECT: LR

PARAMETER: TLC

REPORT 4C

PAGE OF

TABLE 4C

Ratios	X̄ Baseline Post A	X̄ Baseline Pre B	3 Hr 380 Mixed C	3 Hr 380 Mixed D	8 Hr 380 Mixed C	8 Hr 380 Mixed D	3 Hr 380 O_2 C	3 Hr 380 O_2 D	8 Hr 380 O_2 C	8 Hr 380 O_2 D	3 Hr 19% O_2 C	3 Hr 19% O_2 D	8 Hr 19% O_2 C	8 Hr 19% O_2 D	X̄ Pre E	X̄ Post Base & Post Mixed F
	6195	6201	5944	6183	6241	6225	5713	5934	4468	6157	4786	6313	4540	6091	6178	6143
A/B	.9894															
C/D			.9613		1.0025		.9627		.7256		.7581		.7453			
C/A			.9594		1.0074		.9221		.7212		.7725		.7328			
C/B			.9493		.9968		.9124		.7136		.7644		.7251			
D/B				.9875		.9942		.9477		.9833		1.0083		.9728		
$\frac{D}{B} / \frac{C}{B}$			1.0402		.9973		1.0386		1.3779		1.3197		1.3416			
$\frac{A}{B} / \frac{C}{D}$			1.0292		.9869		1.0277		1.3635		1.3051		1.3275			
C/E			.9621		1.0101		.9247		.7232		.7746		.7348			
C/F			.9676		1.0159		.9300		.7273		.7790		.7390			
C/$\bar{X}_g$ Pos…																
C/$\bar{X}_g$ Pos Base																

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C-POST
D-PRE

SUBJECT: MG

PARAMETER TLC

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	6355	6380	6385	6535	5894	6227	5364	4983	5964	6228	5721	6330	5798	6242	6163	6247
A/B	.9960															
C/D			.9770		.9465		1.0764		.9576		.9037		.9288			
C/A			1.0047		.9274		.8440		.9384		.9002		.9123			
C/B			1.0007		.9238		.8407		.9347		.8967		.9087			
D/B				1.0242		.9760		.7810		.9761		.9921		.9783		
$\frac{D}{B} / \frac{C}{B}$			1.0234		1.0565		.9285		1.0442		1.1063		1.0765			
$\frac{A}{B} / \frac{C}{D}$			1.0194		1.0522		.9253		1.0401		1.1021		1.0723			
C/E			1.0360		.9563		.8702		.9677		.9282		.9407			
C/F			1.0219		.9434		.8586		.9546		.9157		.9281			
C/$\bar{X}_g$ P.C.																
C/$\bar{X}_g$ POST BASE																

TABLE 4D

REPORT 4D PAGE OF

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C-POST
D-PRE

SUBJECT : WS

PARAMETER TLC

TABLE 4E

	$\bar{X}$ Baseline Post	$\bar{X}$ Baseline Pre	3 HR 380 Mixed		8 Hr 380 Mixed		3 Hr 380 O_2		8 Hr 380 O_2		3 Hr 187 O_2		8 Hr 187 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	A	B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios	6202	6077	5685	5820	6232	5983	6033	6470	5811	6224	5710	5903	5780	5902	6057	6080
A/B	1.0205															
C/D			.9768		1.0416		.9324		.9336		.9673		.9793			
C/A			.9166		1.0048		.9727		.9369		.9206		.9319			
C/B			.9354		1.0255		.9927		.9562		.9396		.9511			
D/B				.9577		.9845		1.0646		1.0241		.9713		.9712		
$\frac{D}{B} / \frac{C}{B}$			1.0238		.9600		1.0724		1.0710		1.0337		1.0211			
$\frac{A}{B} / \frac{C}{D}$			1.0447		.9797		1.0944		1.0930		1.0549		1.0420			
C/E			.9385		1.0288		.9960		.9593		.9427		.9542			
C/F			.9350		1.0250		.9922		.9557		.9391		.9506			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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C post
D pre

Subject : GR

Parameter TLC

TABLE 4F

	$\bar{X}$ Baseline		3 Hr 380 Mixed		8 Hr 380 Mixed		3 Hr 380 O_2		8 Hr 380 O_2		3 Hr 194 O_2		8 Hr 194 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	Post	Pre														
	A	B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios	5161	5154	4993	5238	5100	5435	5384	5399	4530	5122	5546	5248	4709	5297	5253	5101
A/B	1.0013															
C/D			.9513		.9383		1.0009		.8844		1.0567		.8889			
C/A			.9655		.9881		1.0432		.8777		1.0745		.9124			
C/B			.9668		.9895		1.0446		.8789		1.0760		.9136			
D/B				1.0162		1.0545		1.0436		.9935		1.0182		1.0277		
D/B / C/B			1.0510		1.0656		.9990		1.1303		.9462		1.1248			
A/B / C/D			1.0525		1.0671		1.0003		1.1321		.9475		1.1264			
C/E			.9486		.9708		1.0249		.8625		1.0557		.8964			
C/F			.9768		.9998		1.0554		.8880		1.0872		.9231			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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GROUP : SUMMARY

PARAMETER $\bar{X}$ TVC

	$\bar{X}$ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 197 O_2		8 HR 197 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS																
A/B	.9757															
C/D			.9179		.9546		.8867		.7617		.8742		.8585			
C/A			.9442		.9636		.9104		.7939		.8851		.8497			
C/B			.9203		.9389		.8877		.7745		.8635		.8301			
D/B				1.0041		.9838		1.0006		1.0102		.9907		.9603		
$\frac{D}{B} / \frac{C}{B}$			1.0914		1.0486		1.1384		1.3561		1.1823		1.2290			
$\frac{A}{B} / \frac{C}{D}$			1.0650		1.0234		1.1108		1.3214		1.1509		1.1963			
C/E			.9261		.9454		.8924		.7778		.8677		.8338			
C/F			.9663		.9860		.9320		.8130		.9063		.8706			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

TABLE 5A

REPORT 5A PAGE OF

C POST
D PRE

GROUP : SUMMARY

PARAMETER TVC RATIO OF $\bar{X}$

	$\bar{X}$ BASELINE		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 197 O_2		8 HR 197 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	3293	3379	3111	3395	3171	3325	3006	3381	2627	3420	2952	3347	2808	3245	3358	3217
A/B	.9745															
C/D			.9163		.9536		.8890		.7681		.8819		.8653			
C/A			.9944		.9629		.9128		.7977		.8964		.8527			
C/B			.9206		.9384		.8896		.7774		.8736		.8310			
D/B				1.0047		.9840		1.0005		1.0121		.9905		.9603		
$\frac{D}{B} / \frac{C}{B}$			1.0913		1.0485		1.1246		1.3019		1.1338		1.1555			
$\frac{A}{B} / \frac{C}{D}$			1.0635		1.0219		1.0961		1.2687		1.1050		1.1261			
C/E			.9264		.9443		.8951		.7823		.8790		.8362			
C/F			.9670		.9857		.9344		.8165		.9176		.8728			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

TABLE 5B

REPORT 5B
PAGE OF

REPORT 5C

PAGE OF

C-POST
D-PRE

SUBJECT: WS

PARAMETER TVC

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O2 C	3 HR 380 O2 D	8 HR 380 O2 C	8 HR 380 O2 D	3 HR 19% O2 C	3 HR 19% O2 D	8 HR 19% O2 C	8 HR 19% O2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	3185	3202	2945	3015	3050	3175	2830	3130	2495	3195	2900	3075	3050	3200	3149	3091
A/B	.9946															
C/D			.9767		.9606		.9041		.7809		.9508		.9531			
C/A			.9246		.9576		.8885		.7833		.9105		.9576			
C/B			.9197		.9525		[illegible]		.7792		.9056		.9525			
D/B				.9415		.9915		.9775		.9963		.9603		.9993		
D/B / C/B			1.0237		1.0409		1.1060		1.2792		1.0604		1.0491			
A/B / C/D			1.0183		1.0353		1.1000		1.2736		1.0460		1.0435			
C/E			.9362		.9685		.8986		.7923		.9209		.9685			
C/F			.9527		.9867		.9155		.8071		.9382		.9867			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

C-post
D-pre

SUBJECT : LR
PARAMETER TVC

	X̄ Baseline		3 Hr 380 Mixed		8 Hr 380 Mixed		3 Hr 380 O_2		8 Hr 380 O_2		3 Hr 187 O_2		8 Hr 187 O_2		X̄ Pre	X̄ Post Base & Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios	3195	3305	2950	3395	3200	3190	2455	3280	1735	3130	2090	3300	1680	2985	3236	3135
A/B	.9667															
C/D			.8689		1.0031		.7484		.5543		.6333		.5628			
C/A			.9233		1.0015		.7683		.5430		.6541		.5258			
C/B			.8925		.9682		.7428		.5249		.6323		.5083			
D/B				1.0273		.9652		.9924		.9470		.9984		.9031		
$\frac{D}{B} / \frac{C}{B}$			1.1509		.9969		1.3360		1.8041		1.5778		1.7767			
$\frac{A}{B} / \frac{C}{D}$			1.1125		.9637		1.2916		1.7440		1.5264		1.7176			
C/E			.9116		.9888		.7586		.5361		.6458		.5191			
C/F			.9409		1.0207		.7830		.5534		.6666		.5358			
$C/\bar{X}_g$ Pre																
$C/\bar{X}_g$ Post Base																

REPORT 5E PAGE OF

C - post
D - pre

SUBJECT : GR
PARAMETER TVC

RATIOS	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	3415	3360	3150	3525	3055	3335	3290	3525	3105	3475	3295	3490	3285	3265	3416	3258
A/B	1.0163															
C/D			.8936		.9160		.9333		.8935		.9441		1.0061			
C/A			.9224		.8945		.9633		.9092		.9648		.9619			
C/B			.9375		.9092		.9791		.9241		.9806		.9776			
D/B				1.0491		.9925		1.0491		1.0342		1.0386		.9717		
D/B / C/B			1.1190		1.0916		1.0714		1.1191		1.0591		.9939			
A/B / C/D			1.1373		1.1094		1.0889		1.1374		1.0764		1.0101			
C/E			.9221		.8943		.9631		.9089		.9645		.9616			
C/F			.9668		.9376		1.0098		.9530		1.0112		1.0082			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ post base																

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SUBJECT : MG

PARAMETER IVC

C-POST
D-PRE

	$\bar{X}$ Baseline		3 Hr 380 Mixed		8 Hr 380 Mixed		3 Hr 380 O_2		8 Hr 380 O_2		3 Hr 194 O_2		8 Hr 194 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios	3379	3650	3400	3645	3380	3600	3450	3590	3175	3880	3415	3525	3220	3530	3633	3383
A/B	.9252															
C/D			.9327		.9388		.9610		.8182		.9687		.9121			
C/A			1.0068		1.0008		1.0216		.9401		1.0112		.9535			
C/B			.9315		.9260		.9452		.8698		.9356		.8821			
D/B				.9986		.9863		.9835		1.0630		.9657		.9671		
$\frac{D}{B} / \frac{C}{B}$			1.0720		1.0651		1.0405		1.2221		1.0321		1.0963			
$\frac{A}{B} / \frac{C}{D}$			.9919		.9855		.9627		1.1307		.9550		1.0143			
C/E			.9358		.9303		.9496		.8739		.9399		.8863			
C/F			1.0050		.9991		1.0198		.9385		1.0094		.9518			
C/$\bar{X}_q$ Pre																
C/$\bar{X}_q$ Post Base																

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TABLE 6A

GROUP : SUMMARY

PARAMETER $\bar{X}$ I C 1

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
A/B	1.0419															
C/D			.9218		.9420		.8583		.8160		.8189		.6931			
C/A			.9073		.9018		.8411		.7645		.7821		.6665			
C/B			.9242		.9187		.8573		.7787		.7978		.6801			
D/B				1.0047		.9736		.9960		.9601		.9816		.9776		
D/B / C/B			1.1090		1.0857		1.2047		1.3994		1.3203		1.6385			
A/B / C/D			1.1558		1.1304		1.2588		1.4510		1.3671		1.6936			
C/E			.9375		.9317		.8688		.7897		.8074		.6881			
C/F			.9485		.9413		.8773		.7908		.8158		.6913			
C/$\bar{X}_g$ P.C.																
C/$\bar{X}_g$ Post Base																

REPORT 6B
PAGE OF

GROUP : SUMMARY

PARAMETER IC 1 RATIO OF $\bar{X}$

TABLE 6B

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	3798	3724	3392	3742	3370	3618	3135	3718	2820	3588	2920	3665	2456	3645	3678	3590
A/B	1.0198															
C/D			.9064		.9314		.8431		.7859		.7967		.6737			
C/A			.8931		.8873		.8254		.7424		.7680		.6466			
C/B			.9108		.9049		.8418		.7572		.7841		.6595			
D/B				1.0048		.9715		.9983		.9634		.9841		.9787		
$\frac{D}{B} / \frac{C}{B}$			1.1832		1.0735		1.1859		1.2723		1.2550		1.4840			
$\frac{A}{B} / \frac{C}{D}$			1.1251		1.0949		1.2095		1.2976		1.2800		1.5137			
C/E			.9222		.9162		.8523		.7667		.7939		.6677			
C/F			.9448		.9387		.8732		.7855		.8133		.6841			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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C - POST
D - PRE

SUBJECT : LR

PARAMETER IC1

TABLE 6C

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 19.7 O_2 C	3 HR 19.7 O_2 D	8 HR 19.7 O_2 C	8 HR 19.7 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base + Post Mixed F
	4525	4405	3190	4480	3010	4175	2715	4350	1810	4395	*2500	4510	1685	4420	4392	3812
A/B	1.0272															
C/D			.7120		.7209		.6241		.4118		.5543		.3812			
C/A			.7049		.6651		.6000		.4000		.5524		.3723			
C/B			.7241		.6833		.6163		.4108		.5675		.3825			
D/B				1.0170		.9477		.9875		.9977		1.0238		1.0034		
$\frac{D}{B} / \frac{C}{B}$			1.4045		1.3869		1.6023		2.4286		1.8040		2.6232			
$\frac{A}{B} / \frac{C}{D}$			1.4426		1.4248		1.6458		2.4944		1.8531		2.6946			
C/E			.7263		.6853		.6181		.4121		.5692		.3836			
C/F			.8368		.7896		.7122		.4748		.6558		.4420			
C/$\bar{X}_g$ Post																
C/$\bar{X}_g$ Post Base																

* 28 MIN. DELAY IN DESCENT DUE TO EAR BLOCK.

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REPORT 6C

PAGE OF

REPORT 6D

PAGE OF

C-Post
D-Pre

SUBJECT : WS

PARAMETER I C 1

TABLE 6D

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 Hr 380 Mixed C	3 Hr 380 Mixed D	8 Hr 380 Mixed C	8 Hr 380 Mixed D	3 Hr 380 O_2 C	3 Hr 380 O_2 D	8 Hr 380 O_2 C	8 Hr 380 O_2 D	5 Hr 194 O_2 C	5 Hr 194 O_2 D	8 Hr 194 O_2 C	8 Hr 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	3745	3672	3600	3610	3750	3545	3445	3925	3595	3670	3650	3470	2880	3550	3639	3710
A/B	1.0198															
C/D			.9972		1.0578		.8777		.9795		1.0518		.8112			
C/A			.9612		1.0013		.9198		.9599		.9746		.7690			
C/B			.9803		1.0212		.9381		.9790		.9940		.7843			
D/B				.9831		.9654		1.0688		.9994		.9449		.9667		
$\frac{D}{B} / \frac{C}{B}$			1.0028		.9453		1.1393		1.0208		.9506		1.2325			
$\frac{A}{B} / \frac{C}{D}$			1.0226		.9640		1.1619		1.0411		.9695		1.2571			
C/E			.9892		1.0305		.9466		.9879		1.0030		.7914			
C/F			.9703		1.0107		.9285		.9690		.9838		.7762			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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C-POST
D PRE

SUBJECT : GR

PARAMETER IC1

TABLE 6E

RATIOS	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 187 O_2 C	3 HR 187 O_2 D	8 HR 187 O_2 C	8 HR 187 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	3417	3325	3225	3485	3320	3370	3420	3350	3065	3040	3300	3225	3365	3400	3316	3349
A/B	1.1178															
C/D			.9311		.9851		1.0208		1.0082		1.0232		.9867			
C/A			.9496		.9716		1.0008		.8969		.9657		.9818			
C/B			.9759		.9984		1.0285		.9218		.9924		1.0090			
D/B				1.0481		1.0135		1.0075		.9142		.9699		1.0225		
$\frac{D}{B} / \frac{C}{B}$			1.0739		1.0151		.9795		.9917		.9773		1.0133			
$\frac{A}{B} / \frac{C}{D}$			1.2005		1.1347		1.0950		1.1087		1.0924		1.1328			
C/E			.9788		1.005		1.0316		.9245		.9954		1.0120			
C/F			.9689		.9913		1.0312		.9151		.9853		1.0017			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

REPORT 6E
PAGE OF

AIRESEARCH MANUFACTURING DIVISION
Los Angeles, California

C - POST
D - PRE

SUBJECT : MG

PARAMETER ICl

REPORT	6F
PAGE	OF

TABLE 6F

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE / POST MIXED F
	3507	3499	3555	3395	3400	3385	2960	3250	2816	3250	2230	3455	1905	3210	3367	3492
A/B	1.0028															
C/D			1.0471		1.0044		.9107		.8646		.6464		.5934			
C/A			1.0136		.9694		.8440		.8012		.6358		.5431			
C/B			1.0465		.9722		.8464		.8035		.6376		.5447			
D/B				.9708		.9679		.9293		.9293		.9879		.9179		
D/B / C/B			.9550		.9955		1.0979		1.1565		1.5494		1.6851			
A/B / C/D			.9576		.9984		1.1011		1.1598		1.5537		1.6849			
C/E			1.0558		1.0098		.8791		.8345		.6623		.5657			
C/F			1.0180		.9736		.8476		.8046		.6386		.5455			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

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C - post
D - pre

GROUP : SUMMARY

PARAMETER X̄ FRC

Ratios	X̄ Baseline Post A	X̄ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 187 O_2 C	3 HR 187 O_2 D	8 HR 187 O_2 C	8 HR 187 O_2 D	X̄ Pre E	X̄ Post Base $ Post Mixed F
A/B	.9505															
C/D			.9174		.9199		1.0767		.8397		.9726		.8890			
C/A			.9225		1.0099		.9970		.9051		1.0136		.9082			
C/B			.8781		.9571		.9422		.8602		.9845		.8625			
D/B				.9575		1.0384		.8900		1.0300		1.0065		.9761		
D/B / C/B			1.0927		1.0914		.9407		1.2026		1.0372		1.1393			
A/B / C/D			1.0376		1.0378		.8953		1.1434		.9865		1.0879			
C/E			[illegible]		.9703		.9532		.8735		.9924		.8764			
C/F			.9386		1.0265		1.0119		.9213		1.0527		.9246			
C/X̄g pre																
C/X̄g post base																

TABLE 7A

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PAGE OF

AIRESEARCH MANUFACTURING DIVISION
Los Angeles, California

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REPORT 7A
PAGE OF

GROUP : SUMMARY

PARAMETER FRC RATIO $\bar{X}$

TABLE 7B

	$\bar{X}$ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 19⁷ O_2		8 HR 19⁷ O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	2171	2280	2018	2204	2161	2348	2084	1972	1980	2344	2217	2283	1989	2235	2243	2134
A/B	.9521															
C/D			.9156		.9203		1.0567		.8447		.9710		.8899			
C/A			.9295		.9953		.9599		.9120		1.0211		.9161			
C/B			.8850		.9478		.9140		.8684		.9723		.8723			
D/B				.9666		1.0298		.8649		1.0280		1.0013		.9802		
$\frac{D}{B} / \frac{C}{B}$			1.0922		1.0865		.9462		1.1837		1.0298		1.1236			
$\frac{A}{B} / \frac{C}{D}$			1.0398		1.0345		.9010		1.1271		.9805		1.0698			
C/E			.8996		.9634		.9291		.8827		.9884		.8867			
C/F			.9456		1.0126		.9765		.9278		1.0388		.9320			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

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C-POST
D-PRE

SUBJECT: GR

PARAMETER: FRC

REPORT 7B
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TABLE 7C

	$\bar{X}$ BASELINE		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	1743	1829	1708	1753	1780	2065	1964	2029	1465	2082	2246	2023	1354	1887	1937	1743
A/B	.9529															
C/D			.9743		.8619		.9679		.7036		1.1102		.7175			
C/A			.9799		1.0212		1.1267		.8405		1.2885		.7768			
C/B			.9338		.9932		1.0738		.8009		1.2279		.7402			
D/B				.9584		1.1290		1.1093		1.1383		1.1060		1.0317		
D/B / C/B			1.0263		1.1600		1.0330		1.4212		.9007		1.3938			
A/B / C/D			.9780		1.1059		.9845		1.3543		.8583		1.3280			
C/E			.8817		.9189		1.0139		.7563		1.1595		.6990			
C/F			.9799		1.0212		1.1267		.8405		1.2885		.7768			
C/$\bar{X}_g$ PLC																
C/$\bar{X}_g$ POST BASE																

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C- POST
D. PRE.

Subject : LR

Parameter FRC

TABLE 7D

	$\bar{X}$ Baseline Post	$\bar{X}$ Baseline Pre	3 Hr 380 Mixed		8 Hr 380 Mixed		3 Hr 380 O_2		8 Hr 380 O_2		3 Hr 187 O_2		8 Hr 187 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	A	B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	1670	1856	1449	1703	1891	2050	1968	1584	1568	1762	1746	1803	1665	1671	1785	1670
Ratios																
A/B	.8997															
C/D			.8508		.9224		1.2424		.8898		.9683		.9964			
C/A			.8676		1.1323		1.1784		.9389		1.0455		.9970			
C/B			.7807		1.0188		1.0583		.8448		.9407		.8970			
D/B				.9175		1.1045		.8534		.9493		.9714		.9003		
$\frac{D}{B} / \frac{C}{B}$			1.1752		1.0841		.8061		1.1236		1.0326		1.0036			
$\frac{A}{B} / \frac{C}{D}$			1.0574		.9753		.7241		1.0111		.9291		.9029			
C/E			.8117		1.0593		1.1025		.8784		.9781		.9327			
C/F			.8676		1.1323		1.1784		.9389		1.0455		.9970			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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C-POST } –
D-PRE

SUBJECT: WS

PARAMETER ERC

REPORT 7D

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TABLE 7E

	X̄ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		X̄ PRE	X̄ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	2457	2555	2085	2210	2482	2438	2423	2545	2216	2554	2060	2433	2240	2352	2455	2370
A/B	.9616															
C/D			.9434		1.0180		.9520		.8676		.8466		.9523			
C/A			.8485		1.0101		.9861		.9019		.8384		.9116			
C/B			.8160		.9714		.9483		.8673		.8062		.8767			
D/B				.8649		.9542		.9960		.9996		.9522		.9245		
D/B / C/B			1.0599		.9822		1.0503		1.1526		1.1810		1.0499			
A/B / C/D			1.0192		.9445		1.0100		1.1083		1.1358		1.0108			
C/E			.8492		1.0109		.9869		.9026		.8391		.9124			
C/F			.8797		1.0472		1.0223		.9350		.8691		.9451			
C/X̄g PRE																
C/X̄g POST BASE																

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C- POST
D- PRE

SUBJECT : MG

PARAMETER FRC

TABLE 7F

REPORT 7E
PAGE OF

	$\bar{X}$ Baseline		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 19% O_2		8 HR 19% O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	2847	[illegible]	2830	3140	2494	2842	1984	1733	2674	2978	2776	2875	2698	3352	2795	2754
A/B	.9878															
C/D			.9012		.8775		1.1448		.8979		.9655		.8898			
C/A			[illegible]		.8760		.6968		.9392		.9750		.9476			
C/B			.9819		.8653		.6884		.9278		.9632		.9361			
D/B				1.0895		.9861		.6013		1.0331		.9965		1.0520		
(D/B) / (C/B)			1.1095		1.1396		.8734		1.1134		1.0345		1.1238			
(A/B) / (C/D)			1.0960		1.1256		.8628		1.1001		1.0230		1.1101			
C/E			1.0125		.8923		.7098		.9567		.9932		.9652			
C/F			1.0275		.9055		.7264		.9709		1.0079		.9796			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

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C-Post
D-Pre

GROUP : SUMMARY

PARAMETER $\bar{X}$ ERV

TABLE 8A

	$\bar{X}$ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios																
A/B	.8989															
C/D			1.0058		.8860		.9351		.8991		.9424		.9439			
C/A			1.0334		1.0781		1.0527		1.0647		1.0196		1.0715			
C/B			.9298		.9720		.9451		.9539		.9108		.9624			
D/B				.9232		1.0048		1.0153		1.0739		.9730		1.0301		
$\frac{D}{B} / \frac{C}{B}$			1.0075		1.1313		1.0755		1.1818		1.0655		1.0730			
$\frac{A}{B} / \frac{C}{D}$			.8992		1.0155		.9708		1.0139		.9569		.9639			
C/E			.9149		.9556		.9339		.9418		.8987		.9499			
C/F			1.0041		1.0488		1.0287		1.0374		.9914		1.0441			
C/$\bar{X}_g$ P.M.																
C/$\bar{X}_g$ Post Base																

REPORT 8B
PAGE OF

TABLE 8B

C POST
D-PRE

GROUP : SUMMARY

PARAMETER ERV RATIO OF $\bar{X}$

RATIOS	$\bar{X}$ BASELINE POST A	PRE B	3 HR 380 MIXED C	D	8 HR 380 MIXED C	D	3 HR 380 O_2 C	D	8 HR 380 O_2 C	D	3 HR 194 O_2 C	D	8 HR 194 O_2 C	D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	936	1048	983	973	1014	1140	976	1050	1002	1120	955	1023	1010	1095	1062	967
A/B	.8931															
C/D			1.0102		.8894		.9295		.8946		.9335		.9223			
C/A			1.0502		1.0833		1.0427		1.0705		1.0202		1.0790			
C/B			.9379		.9675		.9312		.9561		.9112		.9637			
D/B				.9284		1.0877		1.0019		1.0687		.9761		1.0448		
D/B / C/B			.9898		1.1242		1.0759		1.1177		1.0712		1.0841			
A/B / C/D			.8840		1.0041		.9608		.9983		.9567		.9683			
C/E			.9256		.9548		.9190		.9435		.8992		.9510			
C/F			1.0165		1.0486		1.0093		1.0361		.9875		1.0444			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

REPORT	FC
PAGE	OF

C-POST
D-PRE

SUBJECT : WS

PARAMETER ERV

	$\bar{X}$ Baseline		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	1065	1262	1180	1240	1055	1270	1140	1150	1230	1165	1080	1085	1285	1365	1224	1091
A/B	.8438															
C/D			.9516		.8307		.9413		1.0557		.9953		.9413			
C/A			1.1079		.9906		1.0704		1.1549		1.0140		1.2065			
C/B			.9350		.8359		.9033		.9746		.8557		1.0782			
D/B				.9825		1.0063		.9112		.9231		.8597		1.0792		
D/B / C/B			1.0508		1.2038		1.0087		.9471		1.0046		1.0599			
A/B / C/D			.8867		1.0157		.8512		.7992		.8477		.8964			
C/E			.9640		.8619		.9313		1.0049		.8823		1.0498			
C/F			1.0815		.9670		1.0449		1.1274		.9899		1.1778			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

TABLE 8C

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REPORT 8D
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C - POST
D - PRE

SUBJECT : LR

PARAMETER ERV

TABLE 8D

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	810	810	775	735	880	1005	900	985	800	840	735	730	860	815	841	818
A/B	1.0000															
C/D			1.0544		.8756		.9137		.9523		1.0068		1.0552			
C/A			.9567		1.0864		1.1111		.9876		.9074		1.0617			
C/B			.9567		1.0864		1.1111		.9876		.9074		1.0617			
D/B				.9074		1.2407		1.2160		1.0370		.9012		1.0061		
$\frac{D}{B} / \frac{C}{B}$			.9484		1.1420		1.0944		1.0500		.9931		.9476			
$\frac{A}{B} / \frac{C}{D}$			.9484		1.1420		1.0944		1.0500		.9932		.9476			
C/E			.9215		1.0463		1.0701		.9512		.8739		1.0225			
C/F			.9474		1.0757		1.1002		.9779		.8985		1.0513			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

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C Post
D-Pre

SUBJECT : GR

PARAMETER ERV

REPORT 8E
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TABLE 8E

	$\bar{X}$ Baseline		3 HR 380 Mixed		8 HR 380 Mixed		3 HR 380 O_2		8 HR 380 O_2		3 HR 187 O_2		8 HR 187 O_2		$\bar{X}$ Pre	$\bar{X}$ Post Base & Post Mixed
	Post A	Pre B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
Ratios	772	940	700	820	810	915	865	860	820	1110	845	930	765	800	914	763
A/B	.8212															
C/D			.8536		.8852		1.0058		.7387		.9086		.9562			
C/A			.9067		1.0492		1.1204		1.0621		1.0945		.9909			
C/B			.7446		.8617		.9202		.8723		.8989		.8138			
D/B				.8723		.9734		.9148		1.1808		.9893		.8510		
D/B / C/B			1.1715		1.1296		.9941		1.3536		1.1005		1.0457			
A/B / C/D			.9620		.9276		.8164		1.1116		.9038		.8588			
C/E			.7658		.8862		.9463		.8971		.9245		.8369			
C/F			.9174		1.0615		1.1336		1.0747		1.1074		1.0026			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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C - POST
D - PRE

SUBJECT: MG

PARAMETER ERV

TABLE 8F

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 Hr 380 Mixed C	3 Hr 380 Mixed D	8 Hr 380 Mixed C	8 Hr 380 Mixed D	3 Hr 380 O_2 C	3 Hr 380 O_2 D	8 Hr 380 O_2 C	8 Hr 380 O_2 D	3 Hr 194 O_2 C	3 Hr 194 O_2 D	8 Hr 194 O_2 C	8 Hr 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	1100	1182	1280	1100	1305	1370	1000	1205	1160	1365	1160	1350	1130	1400	1269	1196
A/B	.9306															
C/D			1.1636		.9525		.8298		.8498		.8592		.8071			
C/A			1.1636		1.1863		.9090		1.0545		1.0545		1.0272			
C/B			1.0829		1.1040		.8460		.9813		.9813		.9560			
D/B				.9306		1.1590		1.0194		1.1548		1.1421		1.1844		
D/B / C/B			.8593		1.0498		1.2049		1.1768		1.1638		1.2389			
A/B / C/D			.7997		.9770		1.1214		1.0950		1.0831		1.1530			
C/E			1.0086		1.0283		.7880		.9141		.9141		.8904			
C/F			1.0702		1.0911		.8361		.9698		.9698		.9448			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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C - Post
D - Pre

GROUP: SUMMARY

PARAMETER $\bar{X}$ MVV

REPORT 9A
PAGE OF

TABLE 9A

RATIOS	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
A/B	1.0241															
C/D			.9940		1.0255		.9636		.8658		1.0834		.9172			
C/A			1.0165		1.0318		1.0313		.8967		1.0298		.9111			
C/B			1.0324		1.058[illegible]		1.0616		.8925		1.0598		.9409			
D/B				1.0523		1.0444		1.0978		1.0284		.9813		1.0050		
$\frac{D}{B} / \frac{C}{B}$			1.0095		.9871		1.0508		1.1812		.9440		1.2030			
$\frac{A}{B} / \frac{C}{D}$			1.0328		1.0133		1.0734		1.2039		.9626		1.2225			
C/E			1.0165		1.0280		1.0219		.8637		1.0312		.99[illegible]			
C/F			1.0018		1.0155		1.0099		.8525		1.0155		.8937			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

GROUP : SUMMARY

PARAMETER MVV RATIO OF $\bar{X}$

TABLE 9B

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 Hr 380 Mixed C	3 Hr 380 Mixed D	8 Hr 380 Mixed C	8 Hr 380 Mixed D	3 Hr 380 O_2 C	3 Hr 380 O_2 D	8 Hr 380 O_2 C	8 Hr 380 O_2 D	3 Hr 197 O_2 C	3 Hr 197 O_2 D	8 Hr 197 O_2 C	8 Hr 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base [illegible] F
	129.6	126.6	130.8	131.2	132.6	132.3	129.6	136.8	112.5	129.4	133.8	123.3	126.6	126.5	129.0	130.6
A/B	1.0236															
C/D			.9969		1.0022		.9473		.8693		1.0851		.9533			
C/A			1.0092		1.0231		1.0000		.8680		1.0324		.9305			
C/B			1.0331		1.0473		1.0236		.8886		1.0568		.9526			
D/B				1.0363		1.0450		1.0805		1.0221		.9739		.9992		
$\frac{D}{B} / \frac{C}{B}$			1.0030		.9978		1.0555		1.1502		.9215		1.0489			
$\frac{A}{B} / \frac{C}{D}$			1.0267		1.0213		1.0805		1.1774		.9433		1.0737			
C/E			1.0139		1.0279		1.0046		.8720		1.0372		.9348			
C/F			1.0015		1.0153		.9923		.8614		1.0245		.9234			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ post base																

C - POST
D - PRE

SUBJECT : WS

PARAMETER MVV

TABLE 9C

REPORT 9C

PAGE OF

RATIOS	X̄ Baseline POST A	X̄ Baseline PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	X̄ PRE E	X̄ POST BASE & POST MIXED F
	145.8	147.6	139.2	141.0	148.8	151.2	116.6	147.6	115.8	154.2	135.6	143.5	141.6	147.1	147.[illegible]	144.9
A/B	.9878															
C/D			.9872		.9841		.7899		.7509		.9449		.9626			
C/A			.9547		1.0205		.7997		.7942		.9300		.9711			
C/B			.9430		1.0081		.7899		.7845		.9186		.9593			
D/B				.9552		1.0243		1.000		1.0447		.9722		.9966		
D/B / C/B			1.0129		1.0160		1.2659		1.3316		1.6583		1.0388			
A/B / C/D			1.0006		1.0037		1.2505		1.3154		1.0454		1.0261			
C/E			.9443		1.0094		.7910		.7856		.9199		.9606			
C/F			.9606		1.0269		.8046		.7991		.9359		.9772			
C/X̄g PRE																
C/X̄g POST BASE																

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C-Post
D-Pre

Subject: LR

Parameter: MVV

TABLE 9D

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 Hr 380 Mixed C	3 Hr 380 Mixed D	8 Hr 380 Mixed C	8 Hr 380 Mixed D	3 Hr 380 O_2 C	3 Hr 380 O_2 D	8 Hr 380 O_2 C	8 Hr 380 O_2 D	3 Hr 194 O_2 C	3 Hr 194 O_2 D	8 Hr 194 O_2 C	8 Hr 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	101.4	102.2	103.2	114.0	104.8	85.2	106.8	106.8	72.0	99.6	88.4	92.2	46.9	91.4	99.8	102.7
A/B	.9921															
C/D			.9052		1.2300		1.0000		.7228		.9094		.5131			
C/A			1.0177		1.0335		1.0523		.7100		.8717		.4625			
C/B			1.0099		1.0254		1.0450		.7045		.8649		.4589			
D/B				1.1154		.8336		1.0450		.9746		.9510		.8943		
(D/B) / (C/B)			1.1046		.8129		1.0000		1.3832		1.0995		1.9487			
(A/B) / (C/D)			1.0960		.8065		.9921		1.3725		1.0909		1.9335			
C/E			1.0340		1.0501		1.0701		.7214		.8857		.4699			
C/F			1.0048		1.0204		1.0399		.7010		.8607		.4566			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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SUBJECT : GR

PARAMETER MUV

Gpost
D-pre

TABLE 9E

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 19% O_2 C	3 HR 19% O_2 D	8 HR 19% O_2 C	8 HR 19% O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE / POST MIXED F
	123.9	115.8	147.6	145.2	152.4	157.8	176.8	174.0	142.3	144.0	160.0	137.0	168.0	150.0	142.4	136.9
A/B	1.0699															
C/D			1.0165		.9657		1.0160		.9881		1.1678		1.1200			
C/A			1.1912		1.2300		1.4269		1.1485		1.2913		1.3559			
C/B			1.2746		1.3160		1.5267		1.2288		1.3816		1.4507			
D/B				1.2538		1.3626		1.5025		1.2435		1.1830		1.2953		
D/B / C/B			.9836		1.0354		.9841		1.0119		.8562		.8928			
A/B / C/D			1.0525		1.1079		1.0530		1.0827		.9161		.9552			
C/E			1.0365		1.0702		1.2415		.9992		1.1235		1.1797			
C/F			1.0781		1.1140		1.2923		1.0402		1.1695		1.2280			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

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C-POST
D-PRE

SUBJECT: MG

PARAMETER MVV

	$\bar{X}$ BASELINE		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	147.6	141.0	[illegible]	124.8	124.5	135.0	124.8	119.0	120.2	120.0	151.5	115.5	126.2	117.6	126.7	138.2
RATIOS A/B	1.0468															
C/D			1.0673		.9222		1.0487		1.0016		1.3116		1.0731			
C/A			.9024		.8434		.8455		.8143		[illegible]		.8550			
C/B			.9446		.8829		.8851		[illegible]		1.0744		.8950			
D/B				.8851		.9574		.8439		.8510		.8191		.8340		
$\frac{D}{B} / \frac{C}{B}$			.9370		1.0843		.9534		.9983		.7623		.9318			
$\frac{A}{B} / \frac{C}{D}$			.9807		1.1351		.9981		1.0451		.7981		.9754			
C/E			1.0573		.9826		.9850		.9486		1.1957		.9960			
C/F			.9638		.9008		.9030		.8697		1.0962		.9131			
$C/\bar{X}_g$ PRE																
$C/\bar{X}_g$ POST BASE																

REPORT 9F

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TABLE 9F

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GROUP : SUMMARY

PARAMETER $\bar{X}$ TY

C Pre-?
D Pre

TABLE 10A

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 18? O_2 C	3 HR 18? O_2 D	8 HR 18? O_2 C	8 HR 18? O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
A/B	.8889															
C/D			.9316		.8652		.7834		.7911		.9310		.9638			
C/A			1.0917		.9377		1.0741		1.0093		1.1144		.9543			
C/B			.9682		.8333		.9589		.8980		.9919		.8514			
D/B				1.0652		.9996		1.2408		1.1693		1.0650		.8804		
D/B / C/B			1.1180		1.2253		1.3281		1.2951		1.1077		1.0399			
A/B / C/B			.9909		1.0981		1.1702		1.1529		.9823		.9232			
C/E			.9232		.9771		.9109		.8563		.8494		.8071			
C/F			1.0909		.9326		1.0688		1.0037		1.1042		.9496			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ post base																

REPORT	10A
PAGE	OF

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REPORT 10B

PAGE OF

GROUP: SUMMARY

PARAMETER IV RATIO OF $\bar{X}$

TABLE 10B

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	542	614	580	655	522	607	577	772	547	721	621	666	516	533	649	546
A/B	.8827															
C/D			.8854		.8599		.7474		.7586		.9324		.9681			
C/A			1.0701		.9630		1.0645		1.0092		1.1457		.9520			
C/B			.9446		.8501		.9397		.8908		1.0114		.8403			
D/B				1.0667		.9885		1.2573		1.1742		1.0846		.8680		
D/B / C/B			1.1303		1.1628		1.3379		1.3181		1.0723		1.0329			
A/B / C/D			.9969		1.0265		1.1810		1.1635		.9466		.9117			
C/E			.8936		.8043		.8890		.8428		.9568		.8950			
C/F			1.0622		.9560		1.0567		1.0018		1.1373		.9450			
C/Xg Pre																
C/Xg Post Base																

C-POST
D-PRE

SUBJECT : WS

PARAMETER IV

REPORT	10C
PAGE	OF

TABLE 10C

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
	425	440	520	500	330	535	525	485	440	585	420	450	450	455	486	425
A/B	.9659															
C/D			1.0400		.6168		1.0824		.7521		.9333		.9890			
C/A			1.2235		.7764		1.2352		1.0352		.9882		1.0588			
C/B			1.1818		.7500		1.1931		1.0000		.9545		1.0227			
D/B				1.1363		1.2159		1.1022		1.3295		1.0227		1.0340		
$\frac{D}{B} / \frac{C}{B}$			.9614		1.6212		.9238		1.3295		1.0714		1.0110			
$\frac{A}{B} / \frac{C}{D}$			.9287		1.5659		.8923		1.2842		1.0349		.9766			
C/E			1.0699		.6790		1.0802		.9053		.8641		.9259			
C/F			1.2235		.7764		1.2352		1.0352		.9882		1.0588			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

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C-post
D-pre

Subject : LR
Parameter TV

TABLE 10D

Ratios	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	677	755	640	775	790	745	675	985	675	860	1040	985	625	645	813	696
A/B	.8966															
C/D			.8258		1.0604		.6852		.7848		1.0558		.9689			
C/A			.9453		1.1669		.9970		.9970		1.5361		.9231			
C/B			.8476		1.0463		.8940		.8940		1.3774		.8278			
D/B				1.0264		.9867		1.3046		1.1390		1.3046		.8543		
$\frac{D}{B} / \frac{C}{B}$			1.2109		.9430		1.4592		1.2740		.9471		1.0320			
$\frac{A}{B} / \frac{C}{D}$			1.0857		.8455		1.3085		1.1424		.8492		.9253			
C/E			.7872		.9717		.8302		.8302		1.2792		.7687			
C/F			.9195		1.1350		.9698		.9698		1.4942		.8979			
C/$\bar{X}_g$ Pre																
C/$\bar{X}_g$ Post Base																

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Cor-post
D-pre

TABLE 10E

SUBJECT : GR

PARAMETER TV

RATIOS	$\bar{X}$ Baseline Post A	$\bar{X}$ Baseline Pre B	3 HR 380 Mixed C	3 HR 380 Mixed D	8 HR 380 Mixed C	8 HR 380 Mixed D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 197 O_2 C	3 HR 197 O_2 D	8 HR 197 O_2 C	8 HR 197 O_2 D	$\bar{X}$ Pre E	$\bar{X}$ Post Base & Post Mixed F
	577	677	600	865	520	730	640	915	600	940	500	730	590	585	784	568
A/B	.8522															
C/D			.6936		.7123		.6994		.6382		.6849		1.0085			
C/A			1.0398		.9012		1.1091		1.0398		.8665		1.0225			
C/B			.8862		.7680		.9453		.8862		.7385		.8714			
D/B				1.2776		1.0782		1.3515		1.3884		1.0782		.8641		
D/B / C/B			1.4416		1.4039		1.4297		1.5666		1.4599		.9916			
A/B / C/D			1.2286		1.1964		1.2184		1.3353		1.2442		.8450			
C/E			.7863		.6806		.8376		.7853		.6544		.7722			
C/F			1.0563		.9154		1.1267		1.0563		.8802		1.0387			
C/ $\bar{X}_g$ pre																
C/ $\bar{X}_g$ post base																

REPORT 10E
PAGE OF

C-POST
D-PRE

SUBJECT : MG

PARAMETER IV

TABLE 10F

	$\bar{X}$ Baseline POST A	$\bar{X}$ Baseline PRE B	3 HR 380 MIXED C	3 HR 380 MIXED D	8 HR 380 MIXED C	8 HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 187 O_2 C	3 HR 187 O_2 D	8 HR 187 O_2 C	8 HR 187 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
RATIOS	492	585	560	480	450	420	470	705	475	480	525	500	400	450	525	498
A/B	.8410															
C/D			1.1666		1.0714		.6666		.9895		1.0500		.8888			
C/A			1.1382		.9146		.9552		.9654		1.0670		.8130			
C/B			.9572		.7692		.8034		.8119		.8974		.6837			
D/B				.8205		.7179		1.2051		.8205		.8547		.7692		
$\frac{D}{B} / \frac{C}{B}$			.8582		.9333		1.5000		1.0105		.9524		1.1250			
$\frac{A}{B} / \frac{C}{D}$			.7208		.7849		1.2616		.8499		.8009		.9462			
C/E			1.0666		.8571		.8952		.9047		1.0000		.7619			
C/F			1.1249		.9036		.9437		.9538		1.0542		.8032			
C/$\bar{X}_7$ PRE																
C/$\bar{X}_7$ POST BASE																

REPORT 10F

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C-Part
D-Pre

GROUP : SUMMARY

PARAMETER $\bar{X}$ MO₂

REPORT 11A

PAGE OF

TABLE 11A

RATIOS	$\bar{X}$ BASELINE POST A	$\bar{X}$ BASELINE PRE B	3HR 380 MIXED C	3HR 380 MIXED D	8HR 380 MIXED C	8HR 380 MIXED D	3 HR 380 O_2 C	3 HR 380 O_2 D	8 HR 380 O_2 C	8 HR 380 O_2 D	3 HR 194 O_2 C	3 HR 194 O_2 D	8 HR 194 O_2 C	8 HR 194 O_2 D	$\bar{X}$ PRE E	$\bar{X}$ POST BASE & POST MIXED F
A/B	.9360															
C/D			.9141		.9723		1.0000		1.0058		.9312		1.0092			
C/A			.9502		1.0030		1.0190		.9892		1.0114		1.0058			
C/B			.9023		.9504		.9844		.9369		[illegible]		.9536			
D/B				.9946		.9894		.9844		.9326		1.0242		.9444		
$\frac{D}{B} / \frac{C}{B}$			1.0999		1.0420		1.0000		1.0011		1.0865		.9910			
$\frac{A}{B} / \frac{C}{D}$			1.0426		.9879		.9663		.9487		1.0300		.9374			
C/E			.9223		.9728		.9778		.9571		.9968		.9723			
C/F			.9614		1.0450		1.0305		1.0027		1.0254		1.0181			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ POST BASE																

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GROUP : SUMMARY

PARAMETER MO_2 RATIO OF $\bar{X}$

TABLE 11B

RATIOS	$\bar{X}$ BASELINE POST	PRE	3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 197 O_2		8 HR 197 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	A	B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	285	300	272	300	285	295	293	293	280	280	285	307	285	282	293	281
A/B	.9500															
C/D			.9066		.9661		1.0000		1.0000		.9283		1.0106			
C/A			.9543		1.0000		1.0280		.9824		1.0000		1.0000			
C/B			.9066		.9500		.9766		.9333		.9500		.9500			
D/B				1.0000		.9833		.9766		.9333		1.0233		.9400		
D/B / C/B			1.1030		1.0350		1.0000		1.0000		1.0000		.9894			
A/B / C/D			1.0478		.9833		.9500		.9500		1.0233		.9400			
C/E			.9283		.9726		1.0000		.9556		.9726		.9726			
C/F			.9679		1.0142		1.0429		.9964		1.0142		1.0142			
C/$\bar{X}_g$ P.I.C																
C/$\bar{X}_g$ POST BASE																

REPORT 11B
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REPORT IIC
PAGE OF

SUBJECT : LR
PARAMETER MO₂

C - post
D - pre

TABLE IIC

	$\bar{X}$ Baseline		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
RATIOS	260	270	240	260	280	300	280	280	260	260	280	280	280	270	273	260
A/B	.9629															
C/D			.9230		.9333		1.0000		1.000		1.000		1.0370			
C/A			.9230		1.0769		1.0769		1.0000		1.0769		1.0769			
C/B			.8888		1.0370		1.0370		.9629		1.0370		1.0370			
D/B				.9629		1.1111		1.0370		.9629		1.0370		1.0000		
$\frac{D}{B} / \frac{C}{B}$			1.0833		1.0714		1.0000		1.0000		1.0000		.9643			
$\frac{A}{B} / \frac{C}{D}$			1.0432		1.0317		.9629		.9629		.9629		.9285			
C/E			.8791		1.0256		1.0256		.9523		1.0256		1.0256			
C/F			.9230		1.0769		1.0769		1.0000		1.0769		1.0769			
C/$\bar{X}_g$ pre																
C/$\bar{X}_g$ POST BAS.																

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C - POST
D - PRE

SUBJECT : MG

PARAMETER MO_2

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TABLE IID

	$\bar{X}$ Baseline		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		$\bar{X}$ PRE	$\bar{X}$ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	270	302	240	240	280	260	—	—	280	260	286	280	260	260	272	265
RATIOS A/B	.8852															
C/D			1.0000		1.0769				1.0769		1.0000		1.0000			
C/A			.8888		1.0270				1.0370		1.0370		.9629			
C/B			.7947		.9271				.9271		.9271		.8609			
D/B				.7947		.8609				.8609		.9271		.8609		
$\frac{D}{B} / \frac{C}{B}$			1.0000		.9285				.9285		1.0000		1.000			
$\frac{A}{B} / \frac{C}{D}$			.8852		.8219				.8219		.8852		.8852			
C/E			.8823		1.0294				1.0294		1.0294		.9558			
C/F			.9456		1.0566				1.0566		1.0566		.9811			
C/$\bar{X}_g$ PRE																
C/$\bar{X}_g$ POST BASE																

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C-POST
D-PRE

SUBJECT : WS

PARAMETER MO2

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TABLE IIE

	X̄ Baseline		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		5 HR 19% O_2		8 HR 19% O_2		X̄ PRE	X̄ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	280	290	260	320	260	320	300	300	300	280	320	320	300	300	302	270
RATIOS A/B	.9655															
C/D			.8125		.8125		1.0000		1.0714		1.0000		1.0000			
C/A			[illegible]		.9285		1.0714		1.0714		1.1428		1.0714			
C/B			.8965		.8965		1.0344		1.0344		1.1034		1.0344			
D/B				1.1034		1.1034		1.0344		.9655		1.1034		1.0344		
$\frac{D}{B} / \frac{C}{B}$			1.2307		1.2307		1.0000		.9333		1.0000		1.0000			
$\frac{A}{B} / \frac{C}{D}$			1.1883		1.1883		.9655		.9011		.9655		.9655			
C/E			.8609		.8609		.9933		.9933		1.0596		.9933			
C/F			.9629		.9629		1.1111		1.1111		1.1851		1.1111			
$C/\bar{X}_g$ PRE																
$C/\bar{X}_g$ POST BASE																

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C - Post
D - pre

SUBJECT : GR

PARAMETER MO₂

	X̄ Baseline		3 HR 380 MIXED		8 HR 380 MIXED		3 HR 380 O_2		8 HR 380 O_2		3 HR 194 O_2		8 HR 194 O_2		X̄ PRE	X̄ POST BASE & POST MIXED
	POST A	PRE B	C	D	C	D	C	D	C	D	C	D	C	D	E	F
	330	340	350	380	320	300	300	300	280	320	260	350	300	300	328	332
RATIOS A/B	.9705															
C/D			.9210		1.0666		1.0000		.8750		.7428		1.0000			
C/A			1.0606		.9696		.9090		.8484		[illegible]		.9090			
C/B			1.0294		.9411		.8823		.8235		.7647		.8823			
D/B				1.1176		.8823		.8823		.9411		1.0294		.8823		
$\frac{D}{B} / \frac{C}{B}$			1.0856		.9375		1.0000		1.1428		1.3461		1.0000			
$\frac{A}{B} / \frac{C}{D}$			1.0537		.9099		.9705		1.1091		1.3065		.9705			
C/E			1.0670		.9756		.9146		.8536		.7926		.9146			
C/F			1.0542		.9638		.9036		.8433		.7831		.9036			
C/X̄g PRE																
C/X̄g POST BASE																

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