



NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

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EVALUATION OF PORTABLE RECOMPRESSION SYSTEM (PRS):
Life Support, Schedule Adequacy, and Human Factors

by

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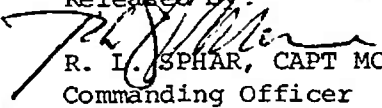
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SUMMARY

The Portable Recompression System (PRS), a single-place treatment chamber under consideration as a primary recompression unit for diving casualties, was evaluated in terms of its life-support adequacy, safety, and habitability. Thirty U. S. Navy divers were exposed to one of three theoretical treatment scenarios, all involving use of modified or unmodified Treatment Table I-A Schedules, singly or with one replication after a brief surface interval.

The data obtained indicated that the PRS unit functioned well, providing adequate life support and reasonable patient comfort. The various treatment scenarios appeared to be both safe and tolerable. Experimental subjects uniformly expressed confidence in use of the PRS in emergency situations.

Several problem areas were noted, which included a) need for clearly-defined medical management procedures for use by diving personnel in the absence of on-site medical expertise; b) inadequacies in the PRS communication system in diver-to-topside mode; c) consistent decreases in PRS oxygen percentages during treatments; and d) temperature/humidity stress on subjects that could adversely affect patient safety in tropical and sub-tropical environments.

INTRODUCTION

The Portable Recompression System has been designed for emergency recompression treatment of a diver and, if feasible, for transportation to a larger facility while the diver is undergoing recompression treatment. The system is a small, single lock, one-man, air-operated chamber lacking oxygen treatment capability and is, therefore, severely disadvantaged compared to Navy double-lock treatment chambers. The advantage of the PRS is that it can be located at remote dive sites or operations not supported by larger on-board or shore-based chambers. Therefore, the compromised treatment mode would be partially offset by immediate, on-site recompression treatment.

Because of the inability to administer oxygen and to gain access to the injured diver once pressurized, it has been proposed that all diving accidents treated with the PRS utilize the shortest air-only treatment table available, Table 1A(1). Review of the past use of this table in other situations indicates that its effectiveness is acceptable (2). Used in this manner, the PRS would be intended to provide definitive initial treatment and could serve to transport the injured diver, while undergoing treatment, to a Navy double-lock recompression chamber.

The purposes of these evaluations were a) to determine whether the PRS would provide adequate life support and reasonable patient comfort for the duration of the schedule (6 hrs., 20 mins.), b) to determine the safety and feasibility of performing a surface-decompression procedure

(as might be required to transfer the patient from the PRS to a larger chamber prior to completion of the treatment schedule), and c) to determine the safety and feasibility of performing two complete treatment schedules with a 30 min. surface interval between (as might be required if the patient had residual or worsening symptoms).

EXPERIMENTAL SUBJECTS

All experimental subjects were qualified U. S. Navy divers. They ranged in age from 20 to 43 years, with a mean of 29.5 (S.D. 6.87). The group was composed of 24 enlisted personnel and 6 officers. Further demographic information can be found in Table 1.

Because of the very limited confines of the PRS chamber, the subjects were carefully measured using a variety of standard anthropometric indices. Measurements of those indices selected as being most meaningful are shown in Figs. 2-5.

EXPERIMENTAL DESIGN

The treatment schedule (Treatment Table I-A) selected for use in conjunction with the PRS, although infrequently used, has enjoyed a good success rate in the past (2). However, it had not been used in a single-place chamber, and as a result, its safety under such conditions was unknown. Additionally, because access to the PRS subject is limited, it was decided to perform all PRS testing within a larger chamber possessing prolonged saturation capability. By compressing the saturation complex to PRS depth, test subjects could be removed from the PRS at any time complications might develop.

Physical Arrangement:

Two complete PRS systems were mounted within the NSMRL Chamber #1, which is a 1500 ft³ double-lock chamber with a pressure capability of 350 FSW and a life-support system capable of handling at least four men for indefinite periods. (See Fig. 1). Hatches remained open but ready to be closed if pressurization was necessary. Testing was performed with both PRS chambers simultaneously. Although placed within the saturation complex, the two PRS chambers were supplied with compressed air from adjacent scuba cylinders (twin 72 ft³ tanks for PRS #1, twin 90 ft³ tanks for PRS #2), rather than from other available air sources. This enabled an estimation of gas consumption to be expected in the normal operating mode.

Dive procedures:

Three basic dive procedures were tested. Protocol A) First, an uninterrupted Treatment Table I-A (PRS Table) was conducted on ten men. Protocol B) A second ten men were exposed to a protocol in which the PRS table was completed through the 40 ft. stop; the PRS was then brought to the surface, the subject was removed and transferred to the NSMRL No. 2 chamber, placed on 100% oxygen, and that chamber was compressed to 60 FSW. The interval between leaving 40 FSW in the PRS and reaching 60 FSW in the No. 2 chamber was less than 5 minutes in all cases. After reaching 60 FSW, the subject continued to breathe 100% oxygen and was decompressed to the surface on a Treatment Table 5 (1). Protocol C) A third ten men were exposed to an uninterrupted PRS Table (6 hrs., 20 min.). Thirty minutes after surfacing, those men reentered the PRS for a second PRS Table.

Because of changes seen in oxygen levels during Protocols A) and B) mentioned above, it was decided to assess the effect of venting the PRS during treatment. Therefore, during protocol C), five of the subjects

received one of two arbitrary venting schedules, (Protocol C₁), while a second five men received the other (Protocol C₂). These vents were performed only in the second of the two PRS exposures, so that the initial exposure for a subject could serve as a reference for his expected oxygen and carbon dioxide levels.

Environmental Evaluations:

Ambient temperature surrounding the PRS chambers was maintained at 78-80° F. Ambient temperatures within each PRS were measured using a YSI Series 400 Model 15-176-30 air temperature probe and a YSI Model 42-SF Tele Thermometer (Yellow Spring Instruments, Yellow Springs, OH). Ambient humidity within the PRS chambers was not measured. Oxygen and carbon dioxide were measured on a Medspect II medical mass spectrometer (Chemitron, St. Louis, MO), which alternately sampled for 20 seconds from each PRS chamber. The mass spectrometer sampling tubes were fixed at a point directly above the subject's forehead in the exhaust stream of the CO₂ scrubber system. This point was felt to be representative of the gas mixture being respired by the subject.

Human Factors Evaluations:

A questionnaire was developed that addressed a variety of factors dealing with habitability of the PRS. Each subject completed this questionnaire at the completion of his exposure(s). Figure 6 is a sample of that questionnaire.

Physiological and psychological evaluation of stress:

In order to determine whether or not exposure in the PRS presented undue stress, we measured each subject's pulse rate and blood pressure prior to and immediately following the exposure. These values were compared to baseline values obtained on previous days. Similar comparisons were made for parotid fluid α -amylase secretion. All three measures reflect general autonomic nervous system activity and are related to real or perceived stress(3). In addition, subjects completed several standard questionnaires regarding mood and anxiety/arousal. These were also administered in the baseline, pre-dive, and post-dive periods.

RESULTS

Life support system:

Oxygen

Figures 7 through 10 present respiratory gas measurements obtained during PRS dives. Figures 7, 8, 9a, and 10a show data obtained during unmodified PRS table exposures. The data show that ambient oxygen levels fell steadily at approximately 1% per hour during the first two hours of the dive. After that time, oxygen levels stabilized between 18.5% and 19.0% and remained relatively constant. These data demonstrate that the life support system can provide more than adequate oxygen to the subject, for the time required, since even at the lowest oxygen percentage (18.5%) the partial pressure of oxygen would be 0.24 ATA (182 mm Hg) at the 10 ft. stop.

Carbon dioxide:

Again referring to Figs. 7, 8, 9a and 10a, carbon dioxide levels were maintained within acceptable ranges, generally 0.10 to 0.15% (< 5 mm Hg at 100 FSW). This is well below the "1% surface equivalent" maximum set for Navy diving operations.

Temperature:

Ambient temperatures recorded in the PRS during normal operation ranged from 81.0° to 84.0° F. with a mean of 82.7° F. The maximum upon reaching the bottom was 86.0° F. Fig. 11 is a graphic representation of observed temperatures and indicates a gradual increase as the dives progressed.

Humidity:

Although humidity could not be measured, comments from the subjects and frequent clouding of the ports (without increased CO₂), suggested that the PRS atmosphere was totally saturated with water, or very nearly so. Therefore, for human factors and safety purposes it would be reasonable to assume a humidity of 95-100%.

Gas consumption:

PRS No. 1 was supplied by twin sets of 72 ft³ steel scuba cylinders charged to 2250 psi. PRS No. 2 was supplied by twin sets of 90 ft³ aluminum scuba cylinders charged to 3000 psi. During complete uninterrupted PRS Tables, total gas consumption averaged approximately 240 ft³, indicating that under these conditions the entire procedure could be conducted with two fully-charged sets of 90 ft³ cylinders or three fully charged sets of 72 ft³ cylinders.

Venting procedures:

As noted above, oxygen levels were observed to fall progressively to 18.5-19% during the course of these exposures. Although there was no question about adequate oxygen supply, the investigators felt that the efficiency of the treatment might be decreased. As the oxygen level fell, there would necessarily be a concomitant increase in nitrogen levels, from approximately 79% to 81-81.5%, decreasing the outward gradient favoring nitrogen elimination. Whether this would affect a real treatment remains conjecture, but in order to test practical methods of maintaining normal oxygen levels (therefore normal nitrogen levels), two arbitrary schedules of venting with air were devised. These venting schedules were tested in the second of the back-to-back PRS table exposures, so that the first exposure could serve as a reference for each man. The schedule for the first vent protocol (designated C₁) was as follows:

Upon reaching	30 FSW	2 min
Upon reaching	20 FSW	2 min
Upon reaching	10 FSW	2 min
1 hr. after reaching	10 FSW	2 min

The schedule for the second vent protocol (designated C₂) was as follows:

Upon reaching	60 FSW - 1 min
Upon reaching	50 FSW - 1 min
Upon reaching	40 FSW - 1 min
Upon reaching	30 FSW - 2 min
Upon reaching	20 FSW - 2 min
Upon reaching	10 FSW - 2 min
1 hr. after reaching	10 FSW - 2 min

Each of the one minute vents at 60, 50, and 40 FSW supplied an average of 17.7 ft³ of fresh air, while the two minute vents at 30, 20 and 10 FSW supplied an average of 19.4 ft³ each. Incorporating either venting schedule, total gas supply needed rose from two sets of twin 90's to three, and from three sets of 72's to four.

The effect of Protocol C₁ on O₂ and CO₂ is shown in Fig 9b (Fig 9a shows the same subjects with no vents). Each vent increased the oxygen by 1/2-3/4%, and even though levels continued to fall after each vent, oxygen was maintained at significantly higher levels than were observed without vents (Fig 9a). Fig. 10b shows the effect of Protocol C₂ on O₂ and CO₂ (Fig. 10b shows the same subjects without vents). Again, each vent increased oxygen levels significantly, with the net result of oxygen averaging 1% or more above that seen without vents, even in the latter part of the dive.

Figs. 9b and 10b show another interesting finding. Carbon dioxide levels increased after each vent and, in general, remained at higher levels during the vented dives. One plausible explanation is that the vents were causing better mixing of the chamber atmosphere and eliminating "pocketing" of gas, especially in areas beneath the cot. It should be emphasized, however, that even these increased CO₂ levels were still well within acceptable ranges.

Fig. 12 shows the effect of the venting procedures on PRS ambient temperature. Temperature averaged 0.7° F. less than was observed in dives without vents. In addition, there was no tendency toward increasing temperature as the dives progressed.

Human Factors Evaluation

Figure 13 presents a summary of the subjects' responses on the human factors questionnaire (Fig. 6). The scores for each question were averaged to obtain the histograms shown. Although most factors received positive ratings, the data indicate several areas that the subjects felt to be less than satisfactory. Only factors receiving an average score less than 3.0 (satisfactory) will be discussed.

Communications:

Subjects reported no difficulty in understanding communications from outside operators, but were often requested to repeat what they had said. This indicates that the in-chamber microphone is not adequate for diver-to-operator communications. Whether this was a defect in design of the microphone, its poor functioning in these warm, humid conditions, or in its location within the PRS was not clear.

Temperature and Humidity:

Most subjects commented on one or both of these factors, some saying that the combination of the two was very uncomfortable. No effort was made to cool the PRS in any way, and under those (probably ideal) conditions PRS temperatures were generally 4-5° F. above temperatures outside. The venting procedures tested in Protocol C, although reported to be beneficial by the subjects, only resulted in an average fall of 0.7° F. (Figs. 11 and 12). Therefore, their subjective impressions may have been more related to decreased humidity and/or psychological effects. In view of the absence of provisions for controlling these two parameters, use of this system may be limited in extreme environments, especially tropical climates. For example if the ambient environmental temperature was 95° F. (not unusual in the tropics, PRS temperature might be expected to be 4-5° F. higher, as seen in these dives. Because the PRS

atmosphere is saturated with water vapor (or nearly so), normal physiologic mechanisms for maintaining thermal homeostasis (e.g. sweating) would be ineffective. Available data indicate that the maximum tolerance time for exposure to 100% humidity and 95-100° F. temperatures is in the range of two to four hours (3), which is far short of the 6 hr. 20 min PRS Treatment Schedule.

Lighting:

Lighting within the PRS was judged slightly less than satisfactory. However, most of the lower scores came from men in the lower chamber (see Fig. 1), and because of its location, less light was available. The investigators did not feel that light levels presented a significant problem.

Front-to-Back Movement:

All subjects reported turning over at least twice during their exposure. There was considerable variation in the ease with which they accomplished the maneuver, but no subject was unable to perform it. It is felt that the restrictions of movement are not sufficient to warrant increased PRS shell diameter, since this would require not only a major redesign effort but also increased air supply.

Comfort of Cot:

Subjects rated the PRS cot as providing slightly less than desirable comfort in view of the relatively long time they had to spend on it. Most responses indicated that there was insufficient cushioning on the aluminum sheeting forming the bottom surface. Also noted was the inflexibility of the cot, resulting in a lack of "give" for heavier parts of the body.

Urination:

Subjects were provided with a condom catheter attached to a flexible polyethylene tube leading to a standard one-liter urine collection bag.

This system was chosen in order to minimize accumulation of ammonia and hydrocarbons from an open collector such as a urinal. Most men chose not to position the catheter prior to the dive, but instead waited until urination was necessary. The restrictions of movement and inability to visualize positioning once inside led to incomplete seals and significant urine leakage in some cases. Therefore, lower scores were obtained. However, the investigators felt that had the condom catheters been applied prior to the dive, the system would have been adequate.

Defecation:

Responses to this question were not obtained from all subjects. Only those who felt the need to defecate commented, and, since there was no provision made for this, the lower scores are understandable. In view of the 6 hr. 20 min. duration of the PRS table, major modifications along these lines would not seem warranted.

Two additional questions were asked dealing with sleep and hunger. Average reported sleep times were: Protocol A: 2.23 hours; Protocol B: 0.4 hours; Protocol C: 4.70 hours. Sixty percent of the subjects reported hunger during their exposure.

Evaluation of Induced Stress

Mood and anxiety questionnaires were administered several days before (pre-dive 1) and immediately before (pre-dive 2) the PRS dives, as well as immediately after (post-dive 1) and several days after (post-dive 2) these dives. The data show that neither self-reported moods nor self-reported anxiety varied significantly across these test periods either for the 30 divers as a group or for any of the three separate groups (Protocols A, B, C, and C₂). The moods of activity and happiness (general satisfaction) were

found to be at moderate levels, while the moods of anger, depression, fear, and fatigue were extremely low. (The results for fatigue are interesting in view of the long exposure experienced by the divers in Protocol C). Self-reported anxiety was at a level typical of other groups which are not experiencing unusual stress. Substantial variability was found among the divers for these measures, which indicates that they were completing the questionnaires in an unbiased manner. In addition, substantial overall differences were found between the three groups, but none of these differences could be attributed to the dives. These differences more than likely represent sampling error which happened to place the most anxious and moody divers into a single group. Again, the divers in this group differed from divers in the other two groups across the four testing sessions, not just immediately before or after the dive.

Heart rate (HR) and blood pressure (BP) measurements were also taken during these four testing sessions. The most consistent findings are for heart rate, which rose significantly for each of the three groups immediately prior to the dive, and then fell to normal levels immediately after the dive. For subjects in Protocols A and C, both systolic and diastolic BP rose before the dive, with systolic BP returning to normal levels immediately after the dive. Diastolic BP remained elevated immediately after the dive for both groups, returning to pre-dive levels only for subjects in Protocol A several days later. Diastolic BP for the Protocol C groups was still at elevated levels during post-dive 2 testing. In Protocol B, systolic and diastolic BP remained normal or fell slightly just before and after the dive. These data appear to indicate that the three groups did experience some pre-dive anticipatory stress (as shown

by the elevated heart rates). The extent of this anticipatory stress, however, may have varied across the three groups because of the type of dive that was being made, as well as some underlying psychological differences between the groups. This latter interpretation is indicated by the variable diastolic and systolic BP measurements found across the three groups, as well as the mood and anxiety differences previously described.

In the subjects on Protocol A, pre-exposure parotid fluid α -amylase levels were significantly higher than post-dive levels ($F=10.75$; $df\ 1,9$; $p < .01$). The pre-dive increase in α -amylase secretion suggests increased autonomic nervous system (ANS) activity attributable to psychological factors (e.g. anticipation). The post-exposure decrease suggests that the 6 hr. 20 min. PRS exposure did not produce a significant physical stress effect. No significant physical stress effect. No significant difference was found in pre- and post-exposure α -amylase level in the "surface decompression" group (Protocol B). ($F=0.92$; $df=1,9$; $p > .1$). This suggests that minimal ANS activation occurred in the group. In the groups exposed to two PRS Tables (Protocols C and C₂), the post-exposure amylase level was higher than the pre-exposure value although the difference was not significant ($F=3.10$; $df=1, 7$; $p > .05$).

These results also may be interpreted as indicating that the elevation in amylase secretion in the subjects on Protocol A was related to anticipatory stress from being the initial group exposed to these novel hyperbaric conditions. Other data for blood pressure (BP) and heart rate (HR) at least partially confirm this interpretation. The BP and HR data,

however, show more anticipatory stress among the other two groups (elevated pre-dive responses). Perhaps some psychological or situational (being the initial group) characteristic differed between Group I and Groups II and III which mediated the ANS component of anticipatory stress among the members of Group I.

Overall, these psychologic and physiologic measurements indicate that the dives were not physically stressful, nor was the psychological stress sufficient to impair normal psychological defenses (as shown by the consistent mood and anxiety scores across pre- and post-dive conditions).

Statistical analyses

Pearson product-moment correlational analyses were performed on variables most likely to have some logical relationship. The variables subjected to these analyses are shown in Table 2. No statistically significant correlations could be demonstrated, indicating that differences seen could not be attributed to body size, induced stress, or psychological factors.

DISCUSSION

The data obtained during these evaluations demonstrated that when used under these (somewhat ideal) conditions, the PRS functioned very well. It did provide adequate life support and reasonable patient comfort for the duration of the schedule. Its use in performing a surface-decompression chamber transfer maneuver appeared to be both feasible and safe. Performing two complete PRS schedules separated by a brief (30 min.) surface interval appeared to be feasible, safe, and tolerable for the subject. Although the subjects recognized certain deficiencies in the system, they uniformly stated that they would have no reservations regarding its use as a treatment mode were they, themselves, involved in a casualty that required recompression therapy.

However, the investigators recognized several problem areas associated with use of the PRS which must be addressed prior to Fleet-wide recommendation:

A. Patient access. All single-man chambers limit access to the patient once treatment has begun. This precludes the use of even basic resuscitative measures or ancillary therapies (e.g. intravenous fluids, pharmacologic agents, oxygen administration, and so forth) that might be required in serious cases. In addition, operators may not have access to Medical Department personnel and may be quite unsophisticated at patient evaluation or monitoring. The ability to rapidly institute recompression therapy partially offsets these inadequacies. However,

careful attention should be given to writing a PRS medical manual which would specify steps to be taken in case of emergencies. This PRS medical manual should be written in clear, non-technical language and should enable diving personnel and supervisors to manage casualty treatment in the PRS in the absence of medical personnel. For example, what should be done if the subject loses consciousness, or vomits, or has a seizure, or panics? What specific questions could be asked of the patient or steps be taken by outside operators that would give information regarding his status and the progress of the treatment?

B. Communications system. The current system does not appear to provide satisfactory communications from the diver to the outside operator. Reasons for this were not clear, but possibilities considered were mal-positioning of the in-chamber microphone, defective microphone manufacture/design, or decreased microphone performance due to environmental conditions (excess heat and humidity). In order to give the system maximum reliability and eliminate dependence on a battery power source, sound powered systems should be considered.

C. Oxygen levels. As currently designed, the PRS was unable to maintain oxygen levels above 19% unless periodic vents were inserted into the treatment schedule. The decreases seen could not be related either to body dimensions or to physiological and psychological measurements of anxiety and stress. The effect of the decreased oxygen (therefore increased nitrogen) levels on the efficacy of Treatment Table I-A in a casualty situation is unknown, but its significance should be investigated.

C. Thermal stress. As noted previously, with outside air temperature of 78-80° F., the PRS was unable to maintain temperature/humidity profiles that were comfortable for the subject. The investigators felt that this was, by far, the most serious problem seen. The subject provides a continuous source of heat and humidity, and these evaluations indicated that PRS temperatures 4-5° F. above ambient and humidities approaching 100% could be expected. Available data (3) indicate that use of the PRS without cooling or dehumidifying capability in tropical climates (85-95° F.) could be extremely hazardous. A diver could be subjected to a thermal stress much more dangerous than a delay in recompression therapy for his diving-related casualty. Although the venting protocols (C₁ and C₂) subjectively ameliorated this problem, objective changes were minimal, and the divers' comments may have been more related to psychology than physiology. At any rate, this problem requires considerable attention before the PRS can be approved for unlimited Fleet use.

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TABLE 1

Demographic Characteristics of Subjects

AGE	# MEN	RANK/RATE	# MEN	DUTY STATION	# MEN
43	1	CDR (MC)	1	Navy Experimental Diving Unit	5
40	2	LCDR (MSC)	1	Escape Training Dept., NavSubScol, NLon	10
37	2	LCDR	1	Naval Submarine Medical Research Laboratory	4
36	4	LT (MC)	1	USS FULTON (AS-11)	7
35	1	LT (MSC)	1	USS SUNBIRD (ASR-15)	2
34	2	LT	1	Submarine Support Facility, NLon	2
30	1	HTCS	1		
29	1	BMC	1		
28	1	HMC	1		30
27	3	HTC	1		
26	1	MMC	2		
25	2	BML	2		
24	2	MM1	2		
23	1	MR1	1		
22	2	SW1	1		
21	2	BM2	1		
20	2	EN2	1		
	30	HM2	1		
RANGE: 20-43		HT2	2		
MEAN: 29.5 years		MM2	3		
S.D.: 6.87		HT3	3		
		SM3	1		

TABLE 2

CORRELATIONAL ANALYSES PERFORMED ON PRS DATA

Mean O ₂ percentage vs.	Anthro indices (ht.,wt.,shld.,bd.,abd.cir.)
Mean CO ₂ percentage vs.	Body surface area
	Psychological indices (pre & post)
	Systolic BP (pre & post)
	Diastolic BP (pre & post)
	Pulse pressure (pre & post)
	Heart rate (pre & post)
	Parotid α -amylase (pre & post)
Head movement vs.	Height
Leg movement vs.	Weight
Arm movement vs.	Shoulder breadth
Front to back movement vs.	Abdominal circumference
Comfort of cot vs.	Body surface area
Parotid α -amylase (pre) vs.	Systolic BP (pre & post)
Parotid α -amylase (post) vs.	Diastolic BP (pre & post)
	Pulse pressure (pre & post)
	Heart rate (pre & post)

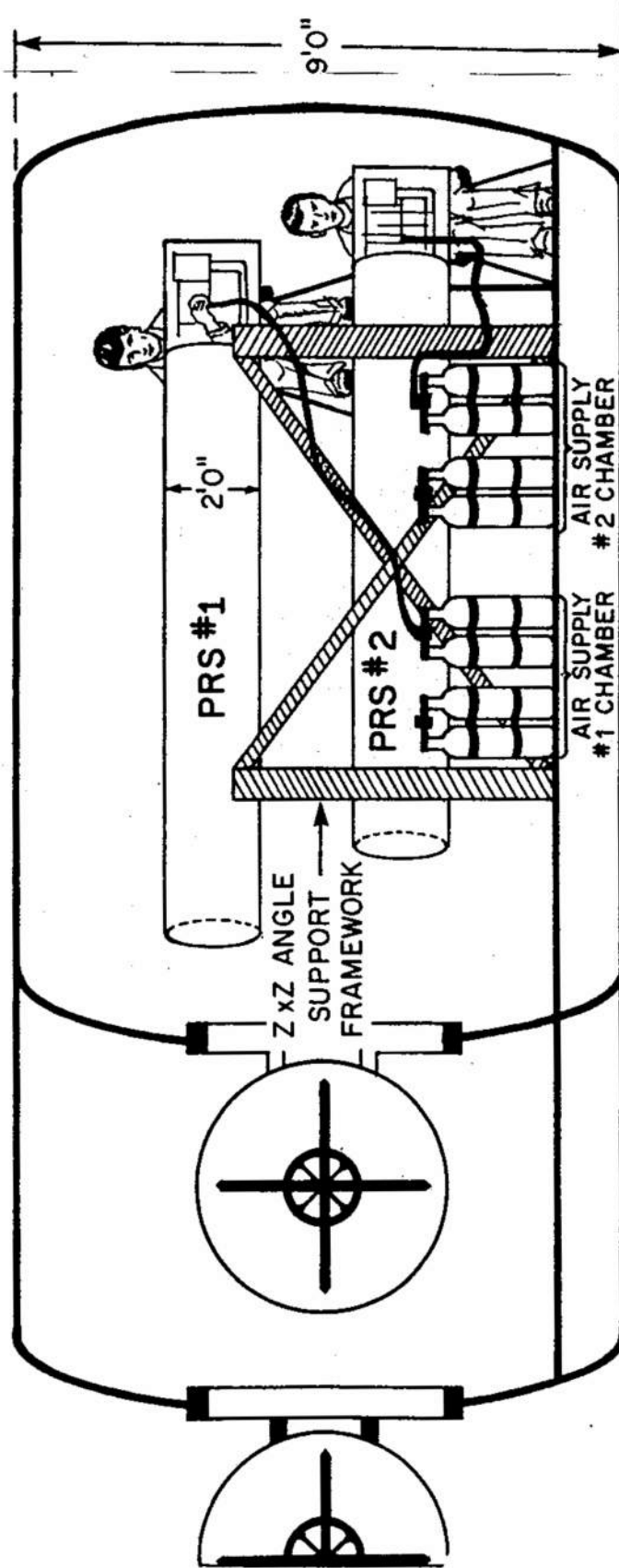


Fig. 1: Schematic representation of physical arrangement of PRS chambers within NSMRL saturation complex.

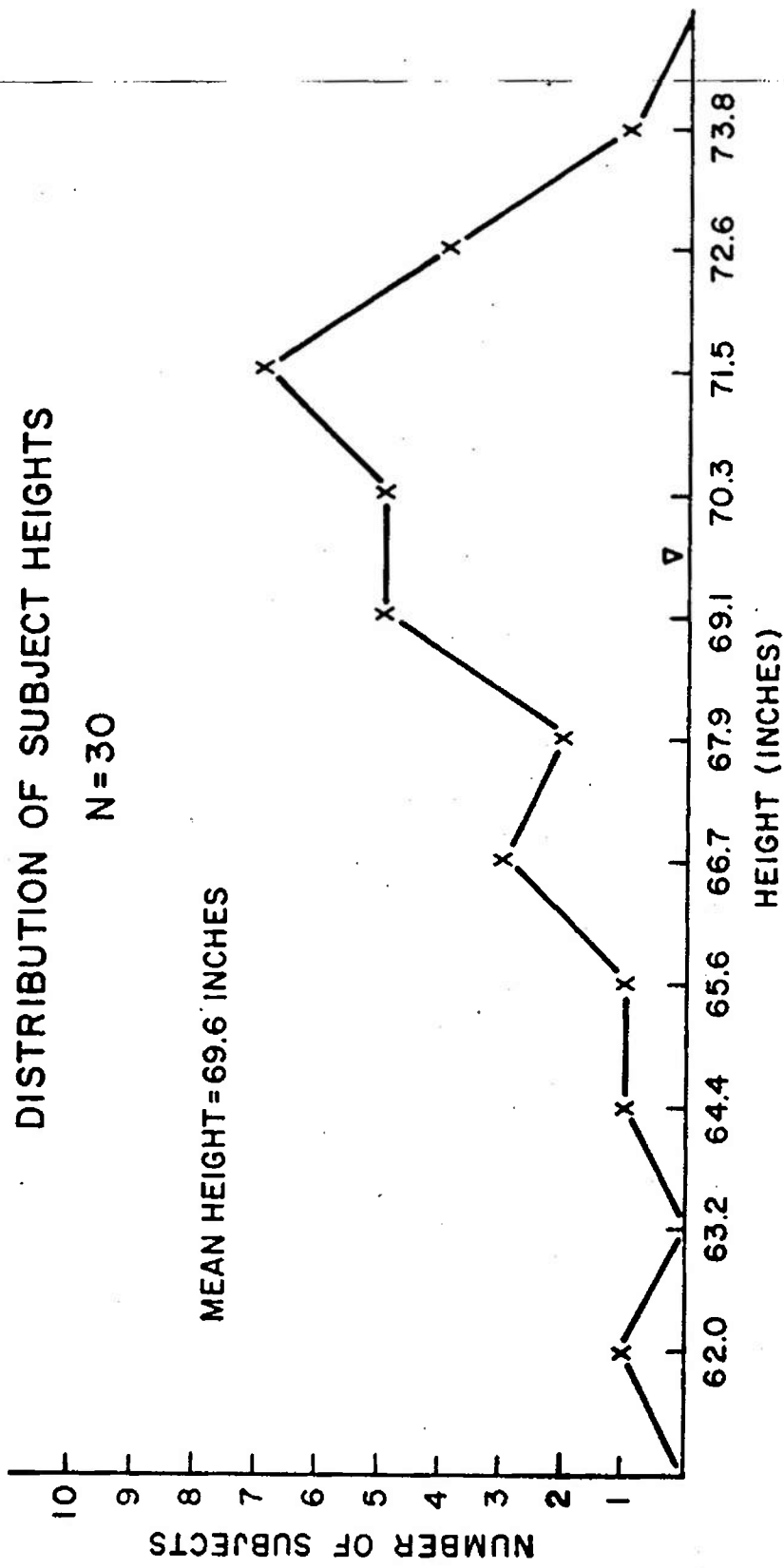


Fig. 2: Anthropometric indices: distribution of subject heights.

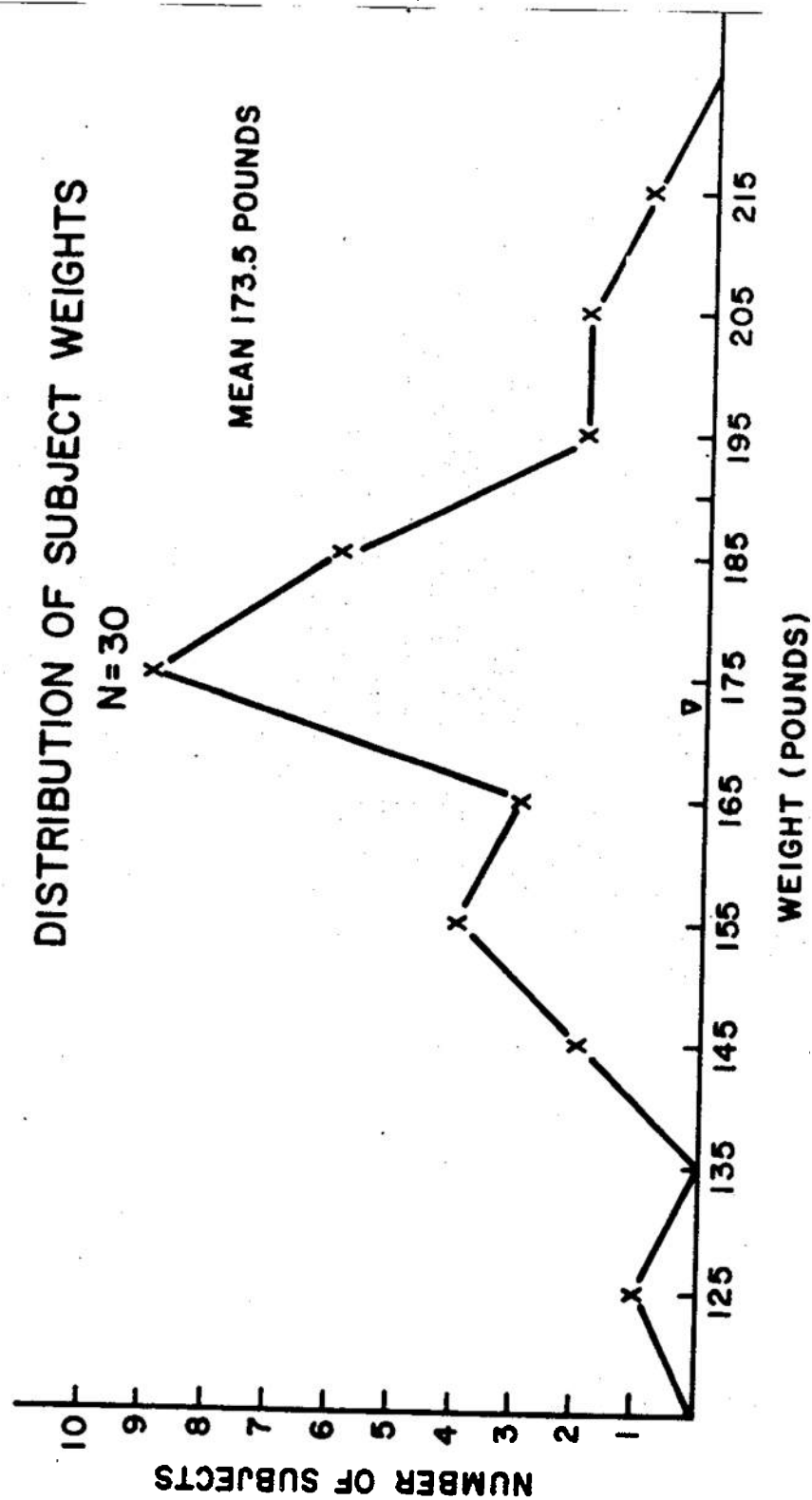


Fig. 3: Anthropometric indices: distribution of subject weights.

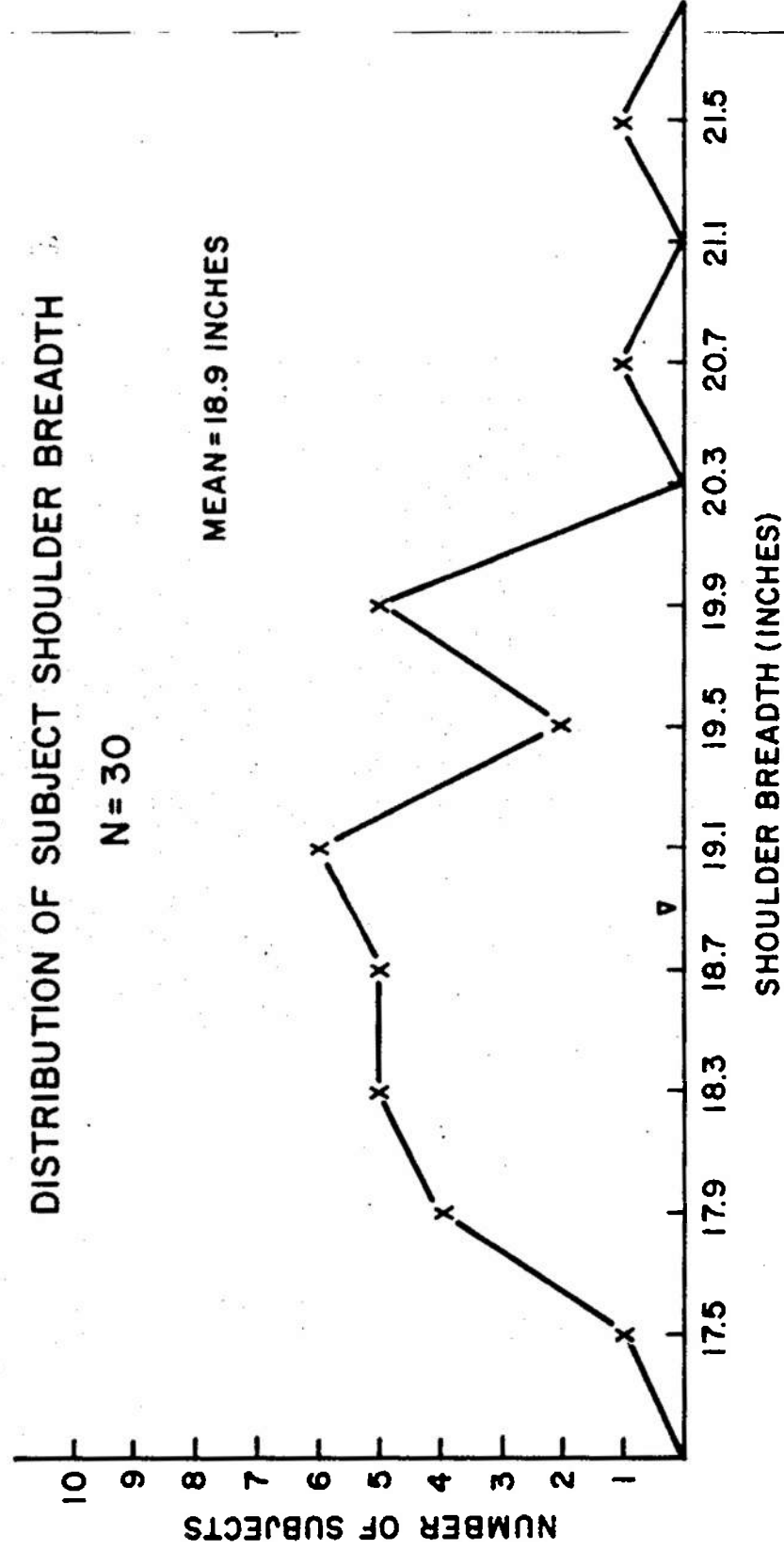


Fig. 4: Anthropometric indices: distribution of subject shoulder breadths.

DISTRIBUTION OF SUBJECT ABDOMINAL CIRCUMFERENCES

N = 30

MEAN = 34.4 INCHES

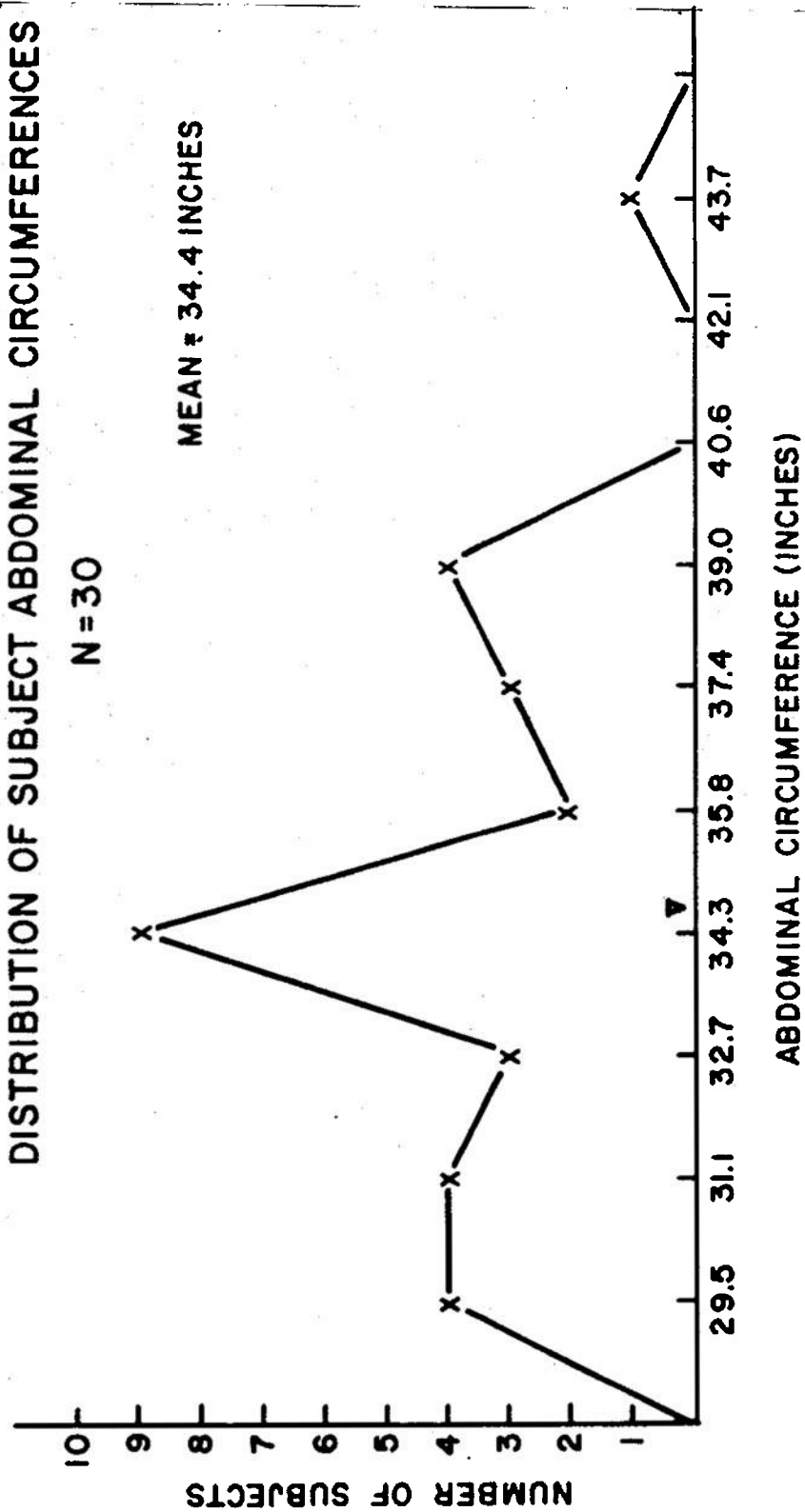


Fig. 5: Anthropometric indices: distribution of subject abdominal circumferences.

Human Factors Questionnaire for the Portable Recompression System (PRS)

Name _____ Date _____ PRS Treatment Used _____ Which chamber were you in? _____ Top _____ Bottom _____

Instructions

In rating the factors listed below for the PRS, make your judgments in relation to some pre-determined ideal standard that is correct for you. This standard should be based on the recompression treatment conditions that you think are necessary to provide maximum comfort and convenience. Take a few moments now to think about this standard.

Read through the list of factors below and form an initial, preliminary opinion about each one. Then go back and fill in the rating number that best represents your final opinion. Use the "comments" section on the other side to write a few words about your judgments.

Here is a definition of each rating category which can serve as a guide in making your judgements. Place the rating number that best represents your judgment next to each factor.

- Rating # 1 = Unsatisfactory: Long periods of severe discomfort/inconvenience.
 2 = Barely Satisfactory: Short periods of severe and/or long periods of moderate discomfort/inconvenience.
 3 = Satisfactory: Short periods of moderate and/or long periods of mild discomfort/inconvenience.
 4 = Outstanding: Only short periods of mild discomfort/inconvenience (or none at all).

Remember, only your honest, straightforward answers and comments will help to correct problems before the PRS is sent to your shipmates in the fleet.

<u>Rating #</u>	<u>Factors</u>	<u>Rating #</u>	<u>Factors</u>
_____	Method used to enter/exit chamber (make some allowances if you were in the top chamber)	_____	Head Movements
_____	Noise (Inside)	_____	Whole-body movements (moving from front to back side)
_____	Noise (Outside)	_____	View through the ports
_____	Communications	_____	Confinement (being separated from the outside only; do not include restriction of movements)
_____	Temperature	_____	Comfort of cot
_____	Humidity	_____	Urination (was condom catheter adequate)
_____	Ventilation or Circulation (include CO2 problems)	_____	Defecation
_____	Lighting	_____	Ease of equalizing ears/sinuses
_____	Leg Movements	_____	Adequacy of water bottle
_____	Arm Movements	_____	How much sleep did you get? _____ hrs.
		_____	Did you get hungry? Yes _____ No _____

Do you have any other comments about the living, treatment, or safety/life support conditions of the PRS or how you think the fleet will like it? _____

Fig. 6: Human factors questionnaire completed by each subject after exposure(s).

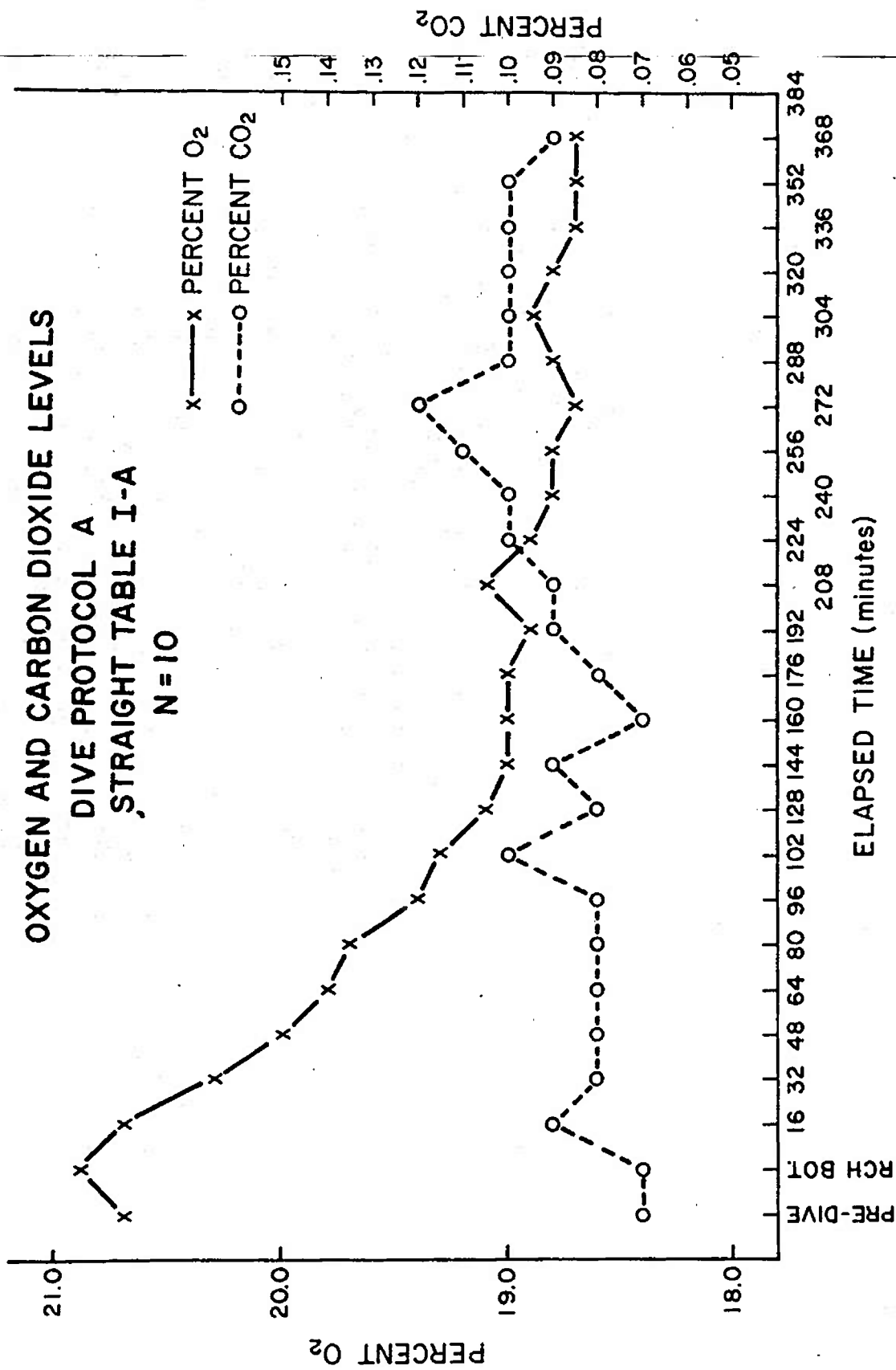


Fig. 7: Respiratory gas measurements during Protocol A (uninterrupted I-A).

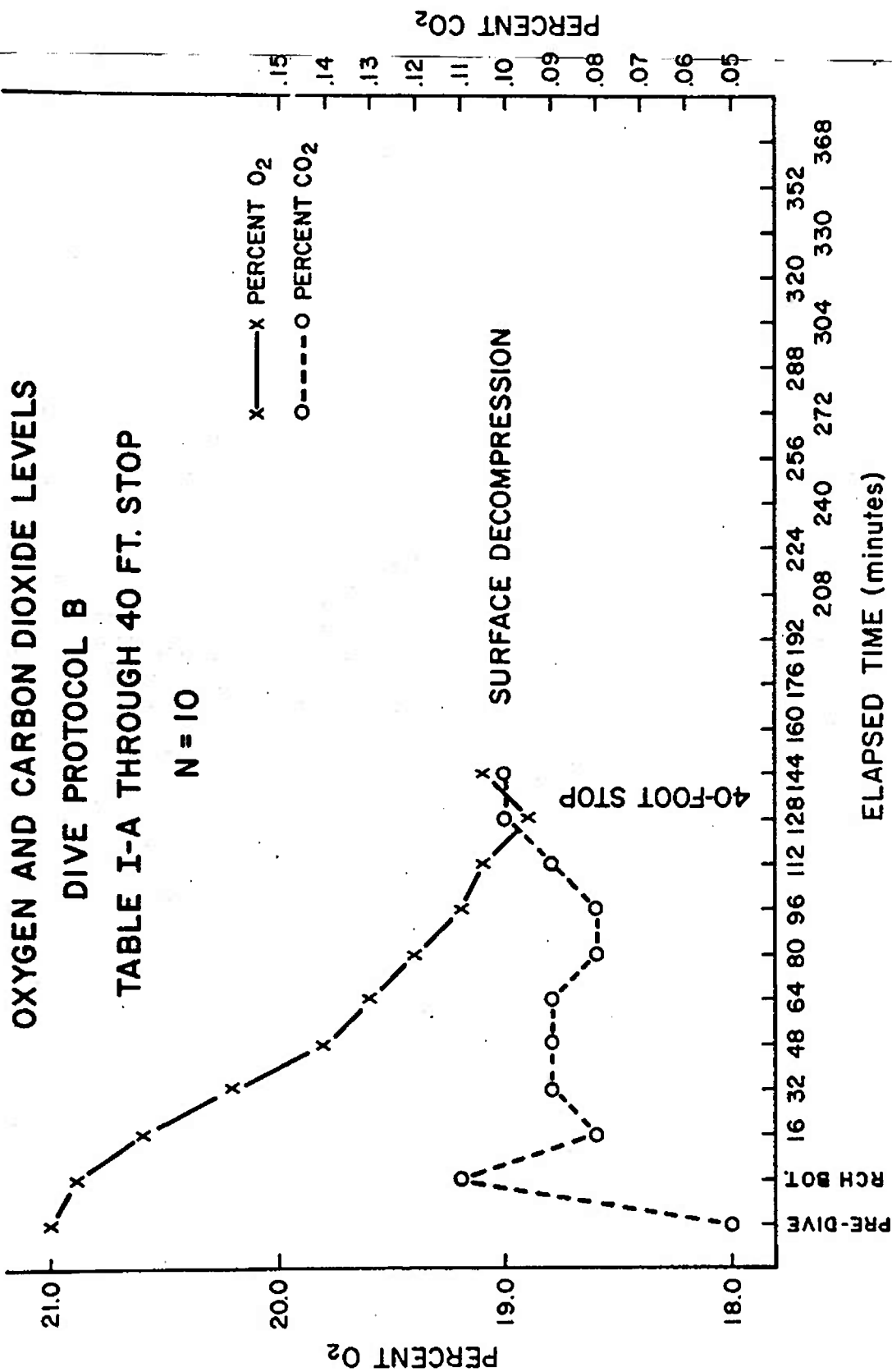


Fig. 8: Respiratory gas measurements during Protocol B (Table I-A through 40 ft. stop).

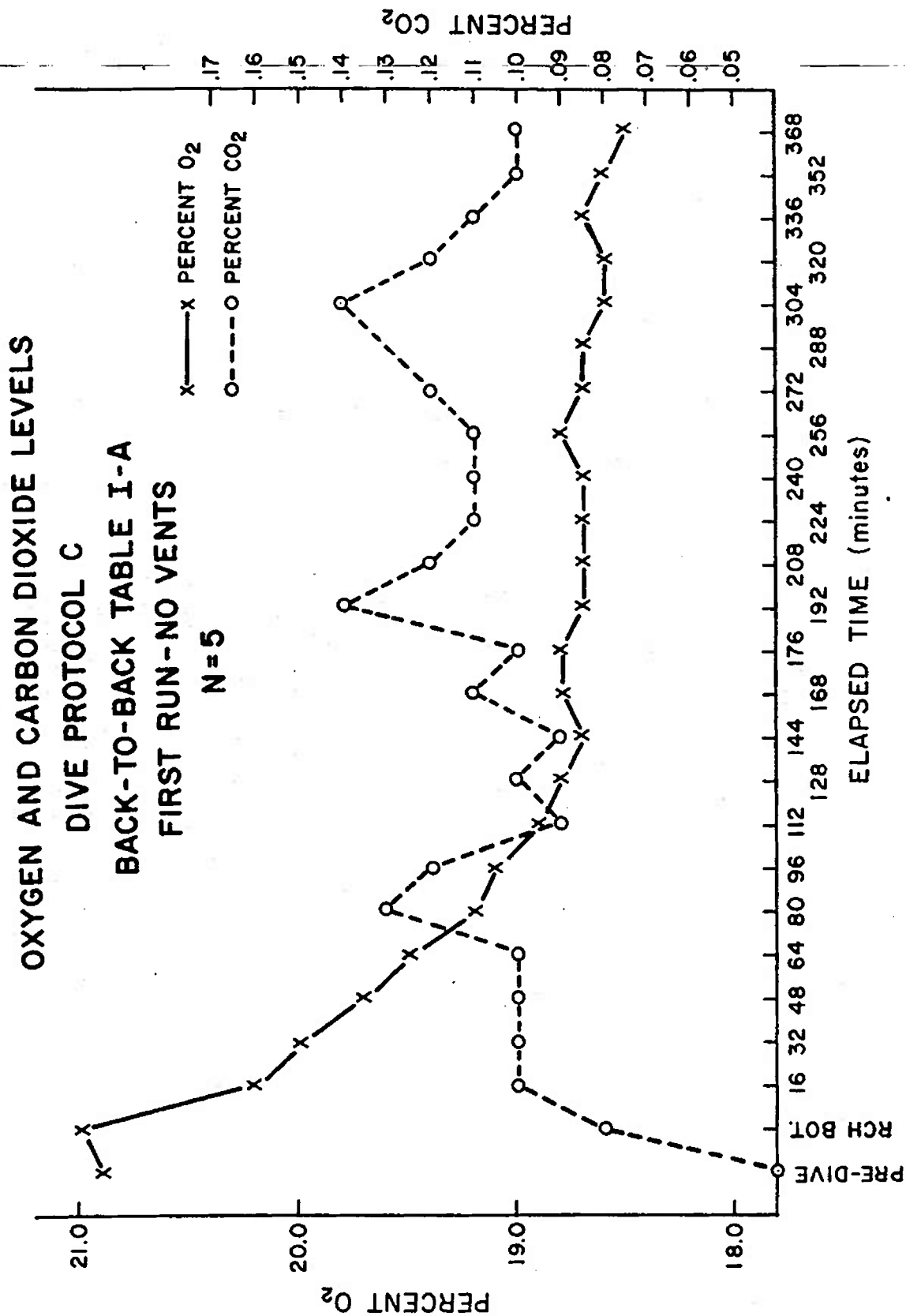


Fig. 9a: Respiratory gas measurements during Protocol C (first I-A exposure, uninterrupted).

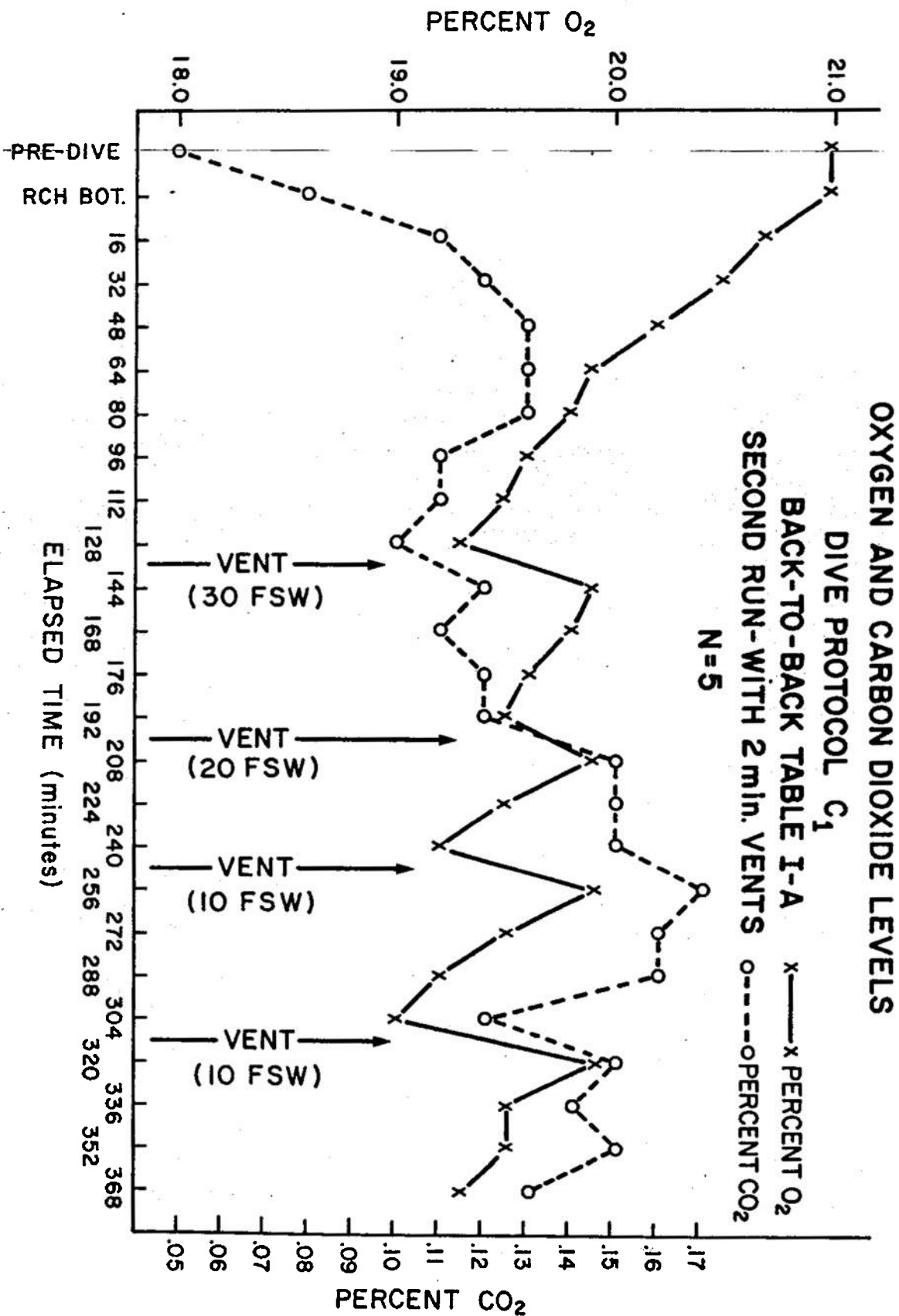


Fig. 9b: Respiratory gas measurements during Protocol C₁ (2 minute air vents as indicated).

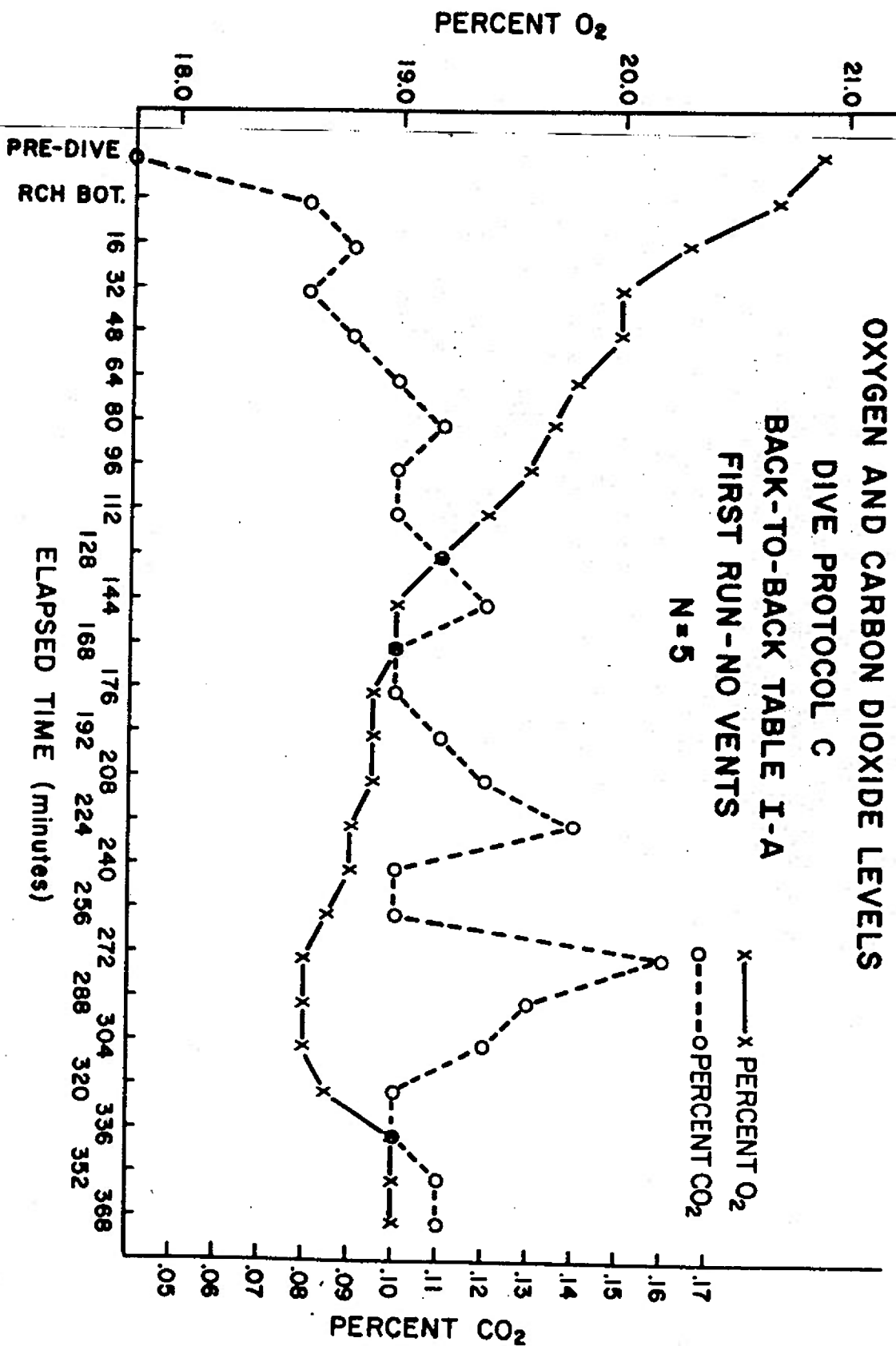


Fig.10a: Respiratory gas measurements during Protocol C (First I-A exposure, uninterrupted).

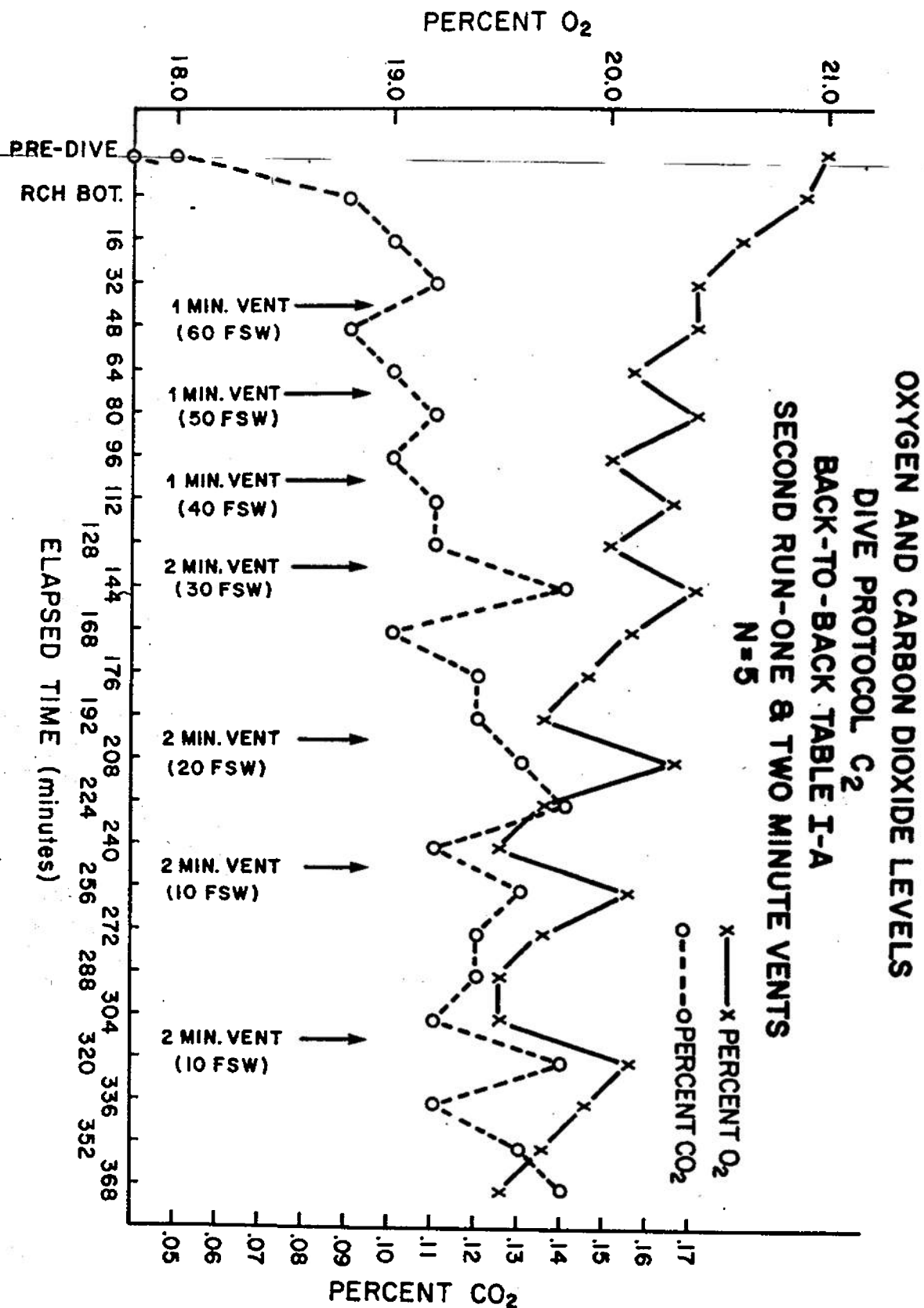


Fig. 10b: Respiratory gas measurements during Protocol C₂ (1 and 2 minute air vents as indicated).

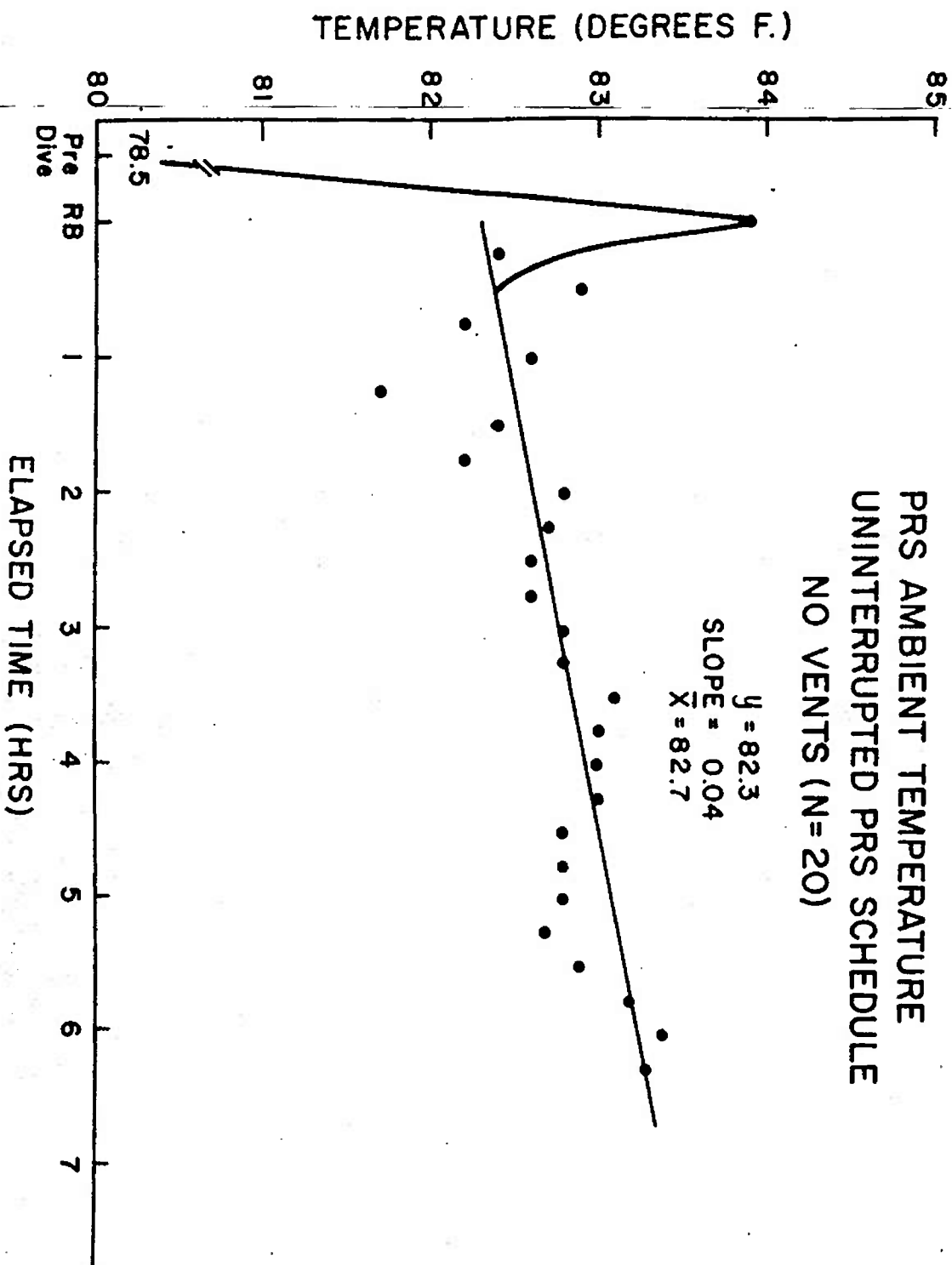


Fig. 11: Temperatures within the PRS chambers during uninterrupted Table I-A exposures. (Protocol A and Protocol C combined, N=20).

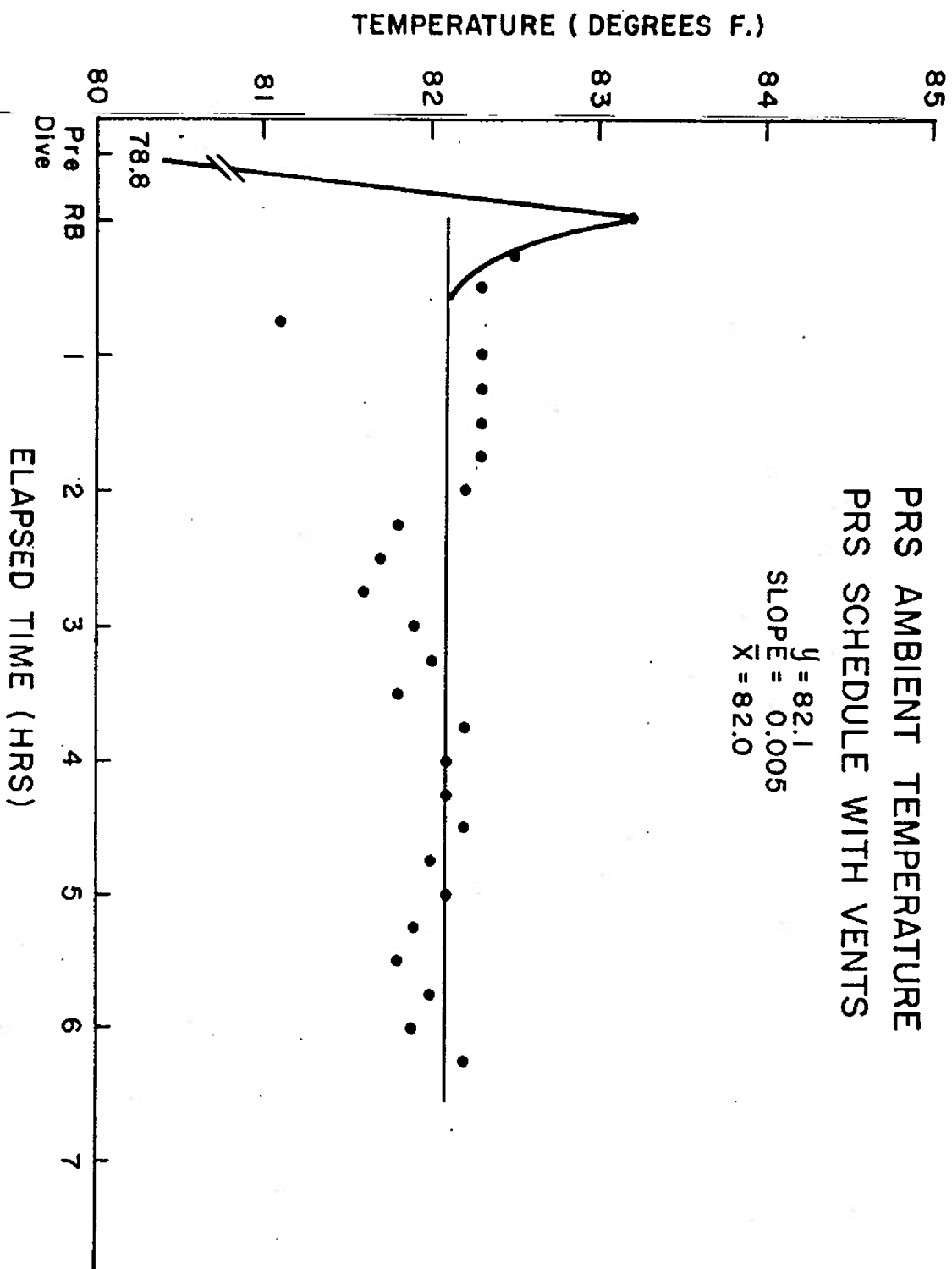


Fig. 12: Temperatures within the PRR chambers during vented Table I-A exposures. (Protocol C₁ and Protocol C₂ combined, N=10).

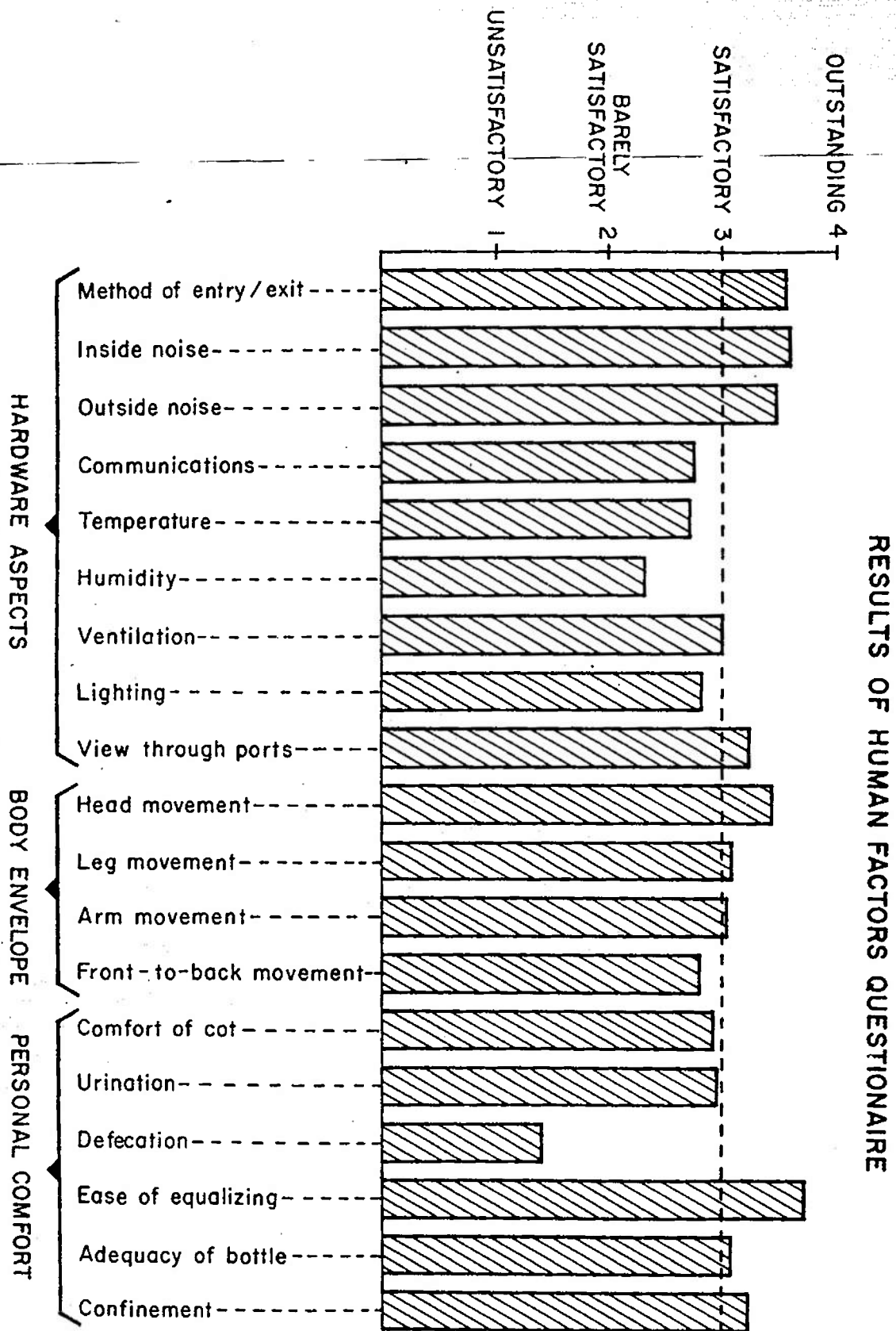


Fig. 13: Mean values of responses to items on human factors questionnaire.