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EVALUATION OF THE DIVING SYSTEMS INTERNATIONAL SUPERLITE 17B HE--ETC(U)

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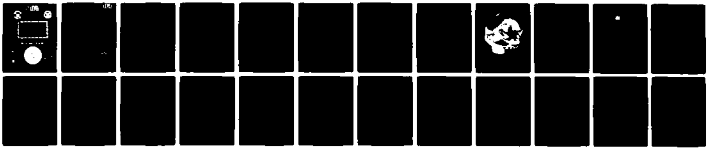

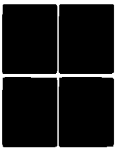

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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
Panama City, Florida 32407

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 9-79

# EVALUATION OF THE DIVING SYSTEMS INTERNATIONAL SUPERLITE 17B HELMET

JAMES R. MIDDLETON

NOVEMBER 1979

Approved for public release; distribution unlimited

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Breaths per minute (BPM)
Tidal volume

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Diving Systems International Superlite 17B helmet was tested by NEDU in accordance with MIL-R-24169A. Results of unmanned testing which evaluated breathing resistance, sideblock pressure drop and breathing work showed that the helmet meets or exceeds all mil spec requirements. The helmet is not recommended for inclusion on the list of equipment Authorized for Navy Use because the U.S.N. currently has no requirement for this type of equipment in addition to its own USN MK I Mod 0 Mask.

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# Table of Contents

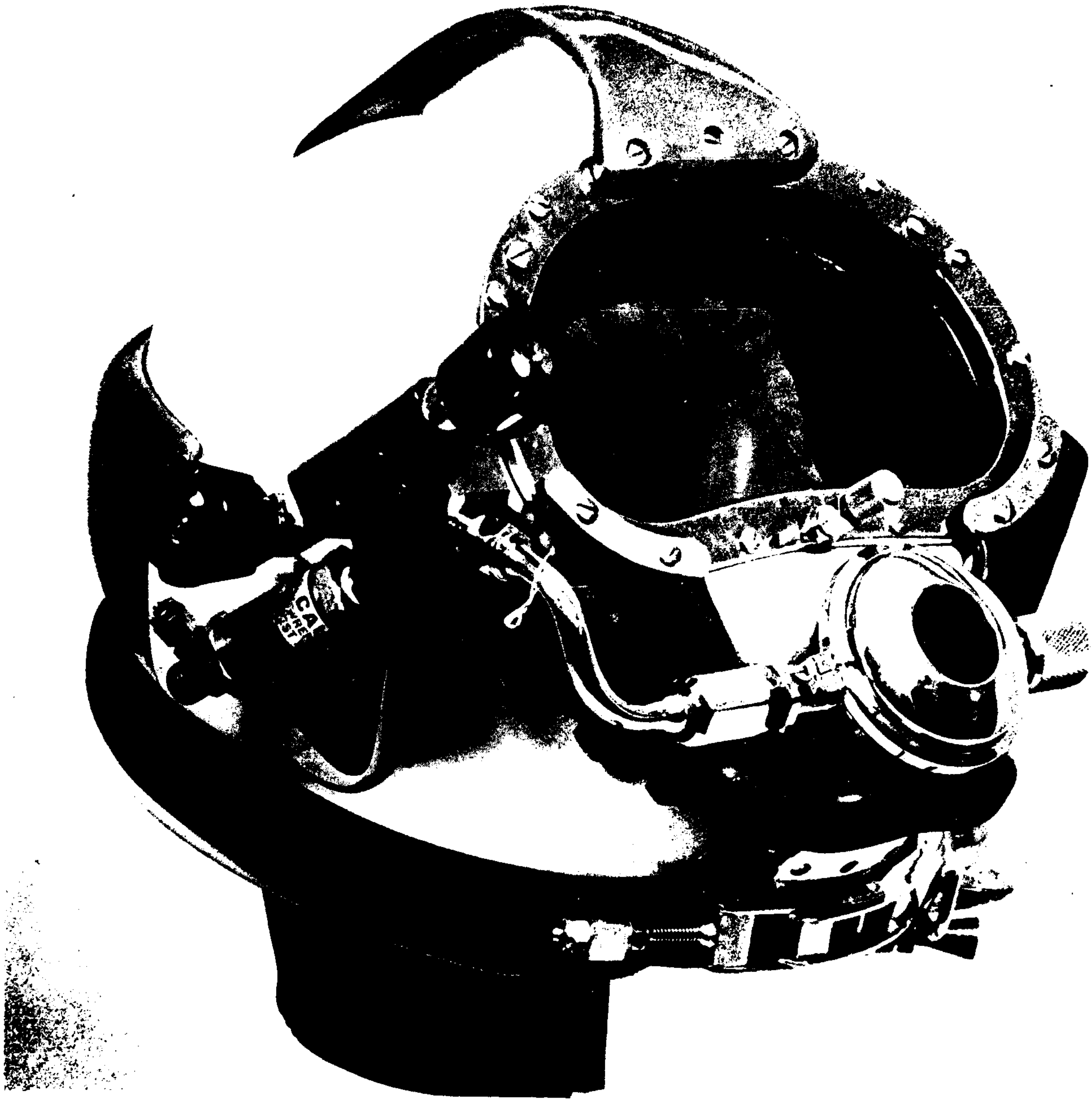
LIST OF ILLUSTRATIONS

## Glossary

| Abbreviation | Definition |
|---|---|
| BPM | breaths per minute |
| cm $H_2O$ | centimeters of water pressure (differential) |
| FSW | feet sea water |
| $HeO_2$ | helium-oxygen breathing gas |
| h.p. | high pressure |
| I.D. | inside diameter |
| kg.m/l | breathing work in kilogram meters per liter ventilation |
| LPM | liters per minute (flow rate) |
| mil spec | military specification MIL-R-24169A |
| NEDU | Navy Experimental Diving Unit |
| O/B | over bottom pressure |
| $\Delta P$ | pressure differential |
| psid | pounds per square inch differential |
| psig | pounds per square inch gauge |
| RMV | respiratory minute volume in liters per minute |
| USN | United States Navy |

## Abstract

The Diving Systems International Superlite 17B helmet was tested by NEDU in accordance with MIL-R-24169A. Results of unmanned testing which evaluated breathing resistance, sideblock pressure drop and breathing work showed that the helmet meets or exceeds all mil spec requirements. The helmet is not recommended for inclusion on the list of equipment Authorized for Navy Use because the U.S.N currently has no requirement for this type of equipment in addition to its own USN MK I Mod 0 Mask.



Diving Systems International Superlite 17B Helmet

## I. INTRODUCTION

In June 1979, NEDU tested the Superlite 17B, an umbilical supplied light weight helmet produced by Diving Systems International, 425 Garden Street, Santa Barbara, California, 93101.

The helmet was tested in accordance with MIL-R-24169A (reference 1) and other applicable standards. Various RMV's were used during the test to simulate light through extreme diver work rates. Pressure drop across the sideblock was monitored to give an indication of total system performance. Breathing work required to operate the helmet was also measured.

The test results show that the Superlite 17B helmet meets or exceeds all mil spec requirements.

## II. TEST PROCEDURE

### A. Test Plan

NEDU test equipment was set up as shown in Figure 1 and all testing of the helmet was done in accordance with applicable mil specs. The actual test plan is given in Appendix A. A breathing machine simulated diver inhalation and exhalation at various depths. The instrumentation and test equipment shown in Figure 1 is listed in Appendix B. Parameters controlled, measured, computed and plotted are listed below.

### B. Controlled Parameters

(1) Breathing Rate / Tidal Volume / RMV / Simulated Work Rate

(a) 15 BPM / 1.5 liters / 22.5 LPM / Light

(b) 20 BPM / 2.0 liters / 40.0 LPM / Moderate

(c) 25 BPM / 2.5 liters / 62.5 LPM / Moderately Heavy

(d) 30 BPM / 2.5 liters / 75.0 LPM / Heavy

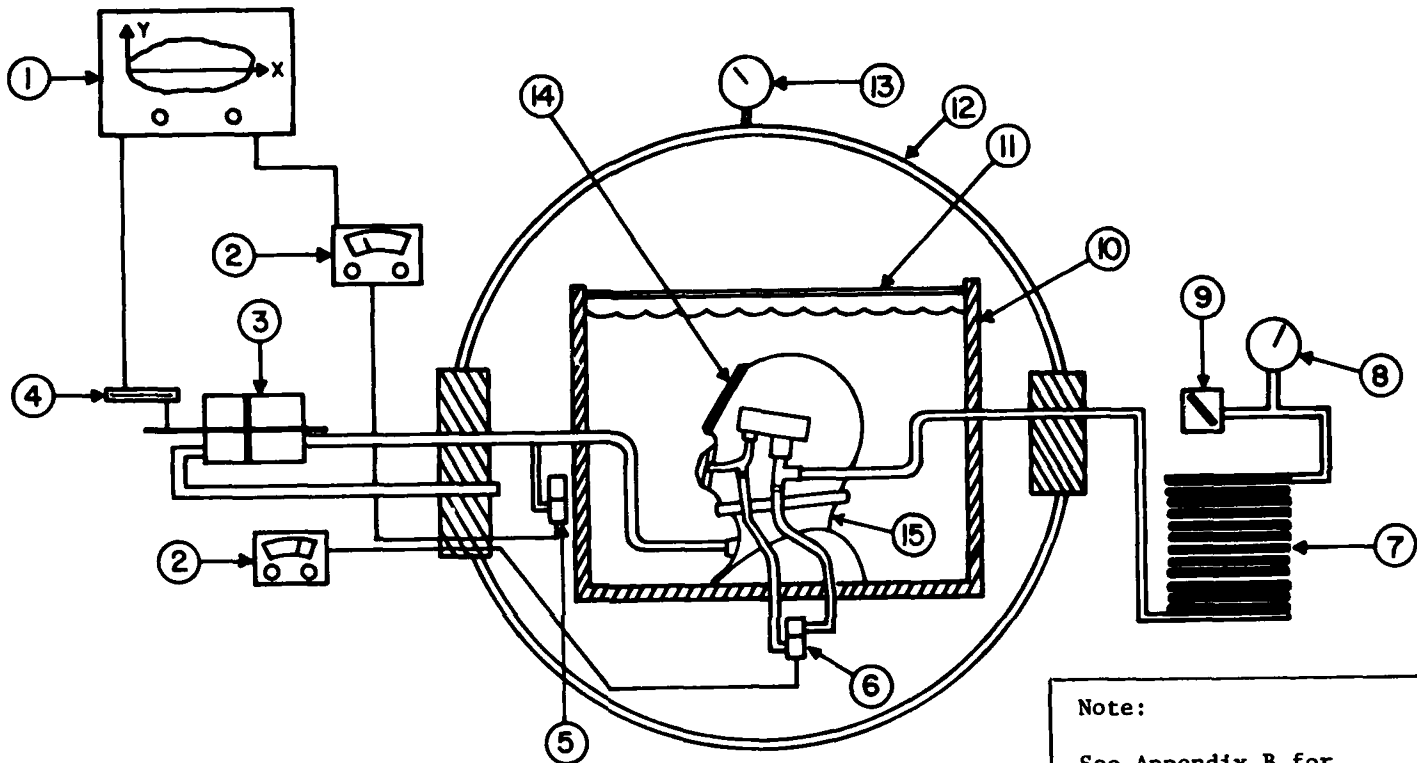
(e) 30 BPM / 3.0 liters / 90.0 LPM / Extreme

(2) Exhalation/Inhalation time ratio: 1.00/1.00

(3) Breathing waveform: sinusoid

(4) Umbilical supply pressure: 165 psig O/B at all depths

(5) Supply gas: air




Note:

See Appendix B for
Test Equipment Description

1. X-Y Plotter
2. Transducer Readout
3. Breathing Machine
4. Piston Position Transducer
5. Pressure Transducer (1.00 psid)
6. Pressure Transducer (20.0 psid)
7. 400' 3/8" I.D. Umbilical
8. Air Supply Gauge
9. Dome Loader
10. Wet Test Box
11. Bubble Dampening Mat
12. Chamber Complex
13. Chamber Depth Gauge
14. Superlite 17B Helmet
15. Mannikin

Figure 1. Test Setup

(6) Supply gas mode: Umbilical only

(7) Depth stops: 0 to 198 FSW in 33 FSW increments; and 300 FSW following 198 FSW

(8) "Dial-A-Breath" position: The second stage adjustment knob was set for minimum breathing resistance at the over bottom supply pressure used during the test (i.e., the knob was backed out until a free flow condition occurred and turned back in just enough to stop the free flow).

C. Measured Parameters

The following parameters were measured on the Superlite 17B test:

(1) Inhalation maximum $\Delta P$

(2) Exhalation maximum $\Delta P$

(3) $\Delta P$ vs. tidal volume plots

(4) Dynamic pressure drop across sideblock

D. Computed Parameters

Respiratory work is computed from $\Delta P$ vs. tidal volume plots

E. Data Plotted

The following data are plotted in this report:

(1) Inhalation maximum $\Delta P$ vs. depth at each RMV tested

(2) Exhalation maximum $\Delta P$ vs. depth at each RMV tested

(3) Respiratory work vs. depth at each RMV tested

(4) Dynamic pressure drop across sideblock vs. depth at each RMV tested

## III. RESULTS AND DISCUSSION

A. Description

The Superlite 17B helmet is a lightweight, open circuit diving helmet which is designed for surface supplied or saturation umbilical diving. The helmet has the capability of operating in either the demand or free flow mode.

The demand mode incorporates a "Dial-A-Breath" valve which allows a diver to maintain low breathing resistance regardless of gas supply pressure. The "Dial-A-Breath" valve is also used to create a free flow mode through the demand regulator. The diver's exhaled gas is vented through the exhaust valve in the demand regulator or through a supplemental exhaust valve located beneath the demand regulator housing.

A gas supply umbilical connects to the sideblock assembly on the right side of the helmet. The sideblock houses a non-return valve in the umbilical supply port and also incorporates a separate gas supply valve and connector for an emergency gas supply. The emergency supply normally consists of a standard scuba tank and first stage regulator assembly which is worn on the diver's back. In addition, the sideblock houses a defogging valve which may be used to supplement normal demand/free flow operation or to keep the face plate clear by directing a continuous flow of gas across the lens.

The helmet system consists of two pieces: the neck dam-yoke and the hat. The diver slips on the neck dam and swings the attached yoke into place. The neck clamp on the neck dam-yoke is then slipped onto the hat and locked. The lock system seals the neck dam to the hat and also secures the front of the yoke. The purpose of the yoke is to securely jock the helmet to the diver's head. The helmet is constructed by hand lay-up of fiberglass.

All of the hardware on the forward part of the helmet is interchangeable with the U.S. Divers Corp. KMB-9 and KMB-10 Band Masks.

## B. Breathing Resistance Tests

Breathing resistance was measured at five RMV's to simulate light through extreme diver work rates. Light work was simulated at 22.5 RMV, moderate work at 40 RMV, moderately heavy work at 62.5 RMV, heavy work at 75.0 RMV and extreme work at 90.0 RMV. The mil spec (reference 1) calls for 40 RMV only. The other RMV's were measured, however, to indicate the full range of helmet performance.

The breathing resistances plotted in the figures are the maximum values measured, excluding cracking pressure, during one complete inhalation-exhalation cycle at a given depth and RMV. On plots where data is incomplete, the test was terminated due to excessive breathing resistance. Typical recorded pressure-volume loop and breathing cycle data are shown in Figures 2 and 3.

The following table lists equivalent depth densities for air versus $HeO_2$ down to 200 FSW on air. This provides a means of comparing mask performance on $HeO_2$ mixes at depths greater than 200 FSW.

| Air Depth (FSW) | Equivalent $HeO_2$ Depth (FSW) |
|---|---|
| 50 | 300 |
| 100 | 730 |
| 150 | 1100 |
| 200 | 1500 |

(1) Inhalation Characteristics

The inhalation resistances plotted are the maximum pressures recorded, except for cracking pressures, at all RMV. Maximum flow resistance always occurred at the point of peak flow rate during the inhalation and exhalation cycles. "Dial-A-Breath" position was set as previously described for minimum breathing resistance at a specific O/B pressure and left for the duration of the test.

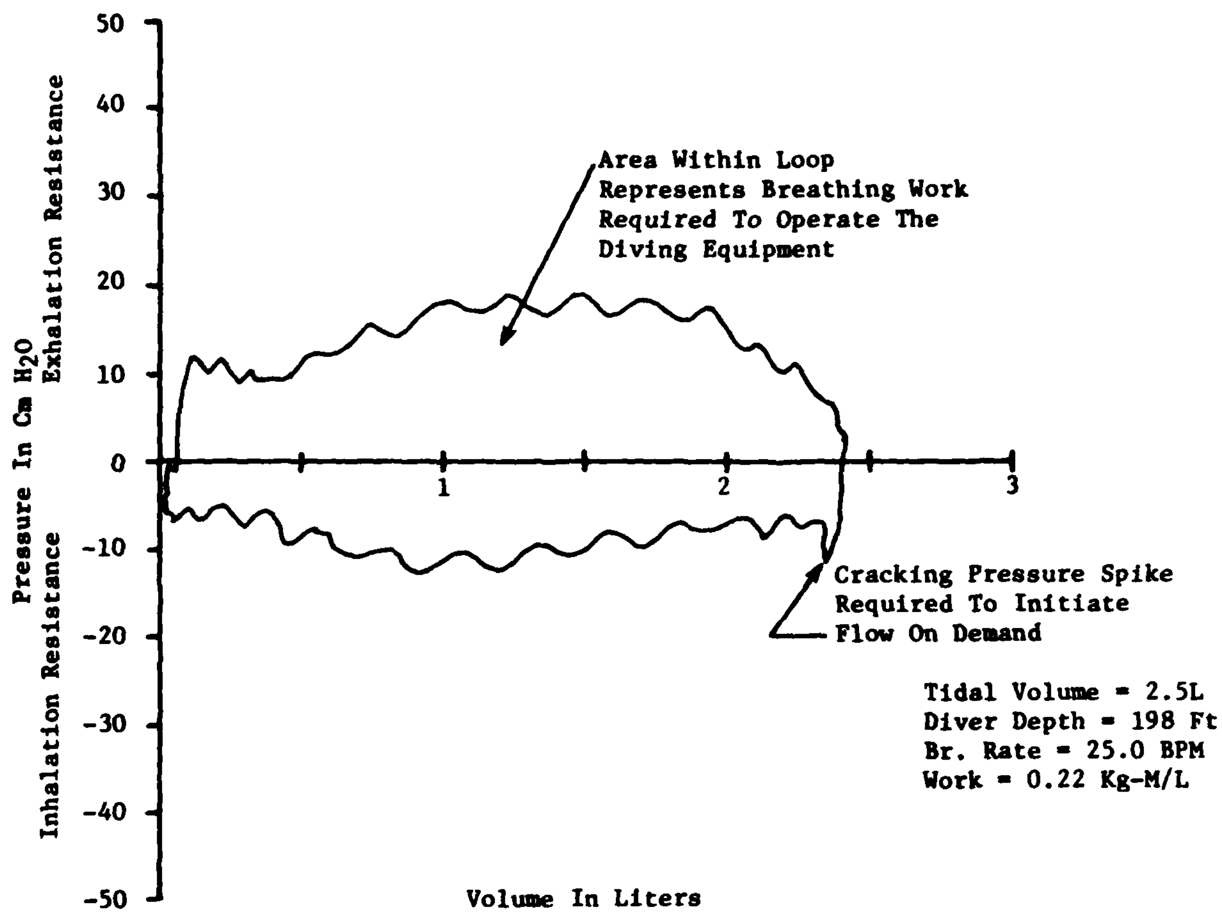
The cracking pressure of the Superlite 17B was very low and accompanied by smooth flow.

This initial pressure spike required to initiate flow on inhalation represents very little breathing work and is ignored when it exceeds peak flow differential pressures. The reason for high pressure differentials to initiate flow in a demand regulator is usually an incorrectly adjusted diaphragm linkage assembly. This represents no threat to the diver's life support system or its overall performance. Typical pressure-volume data is represented in Figures 2 and 3.

Inhalation resistance at 165 psig O/B supply pressure remains almost constant at 22.5 (Figure 4) and 40 RMV (Figure 5) regardless of depth, never exceeding 14cm $H_2O$. These values are very low and represent easy breathing even at 300 FSW.

At 62.5 RMV (Figure 6) inhalation effort increases to a maximum of 17.3cm $H_2O$ at 198 FSW. This is still within the mil spec limit for a moderately working diver and is considered satisfactory at this moderately heavy work rate.

Seventy-five RMV (Figure 7) inhalation effort did not increase substantially over 62.5 RMV until 165 FSW. At this point resistance jumped to 30cm $H_2O$. However, 75 RMV represents heavy diver work and the helmet's performance under these conditions is excellent.




Breathing Pressure Versus Tidal Volume Loop

Figure 2. Sample Pressure-Volume Loop

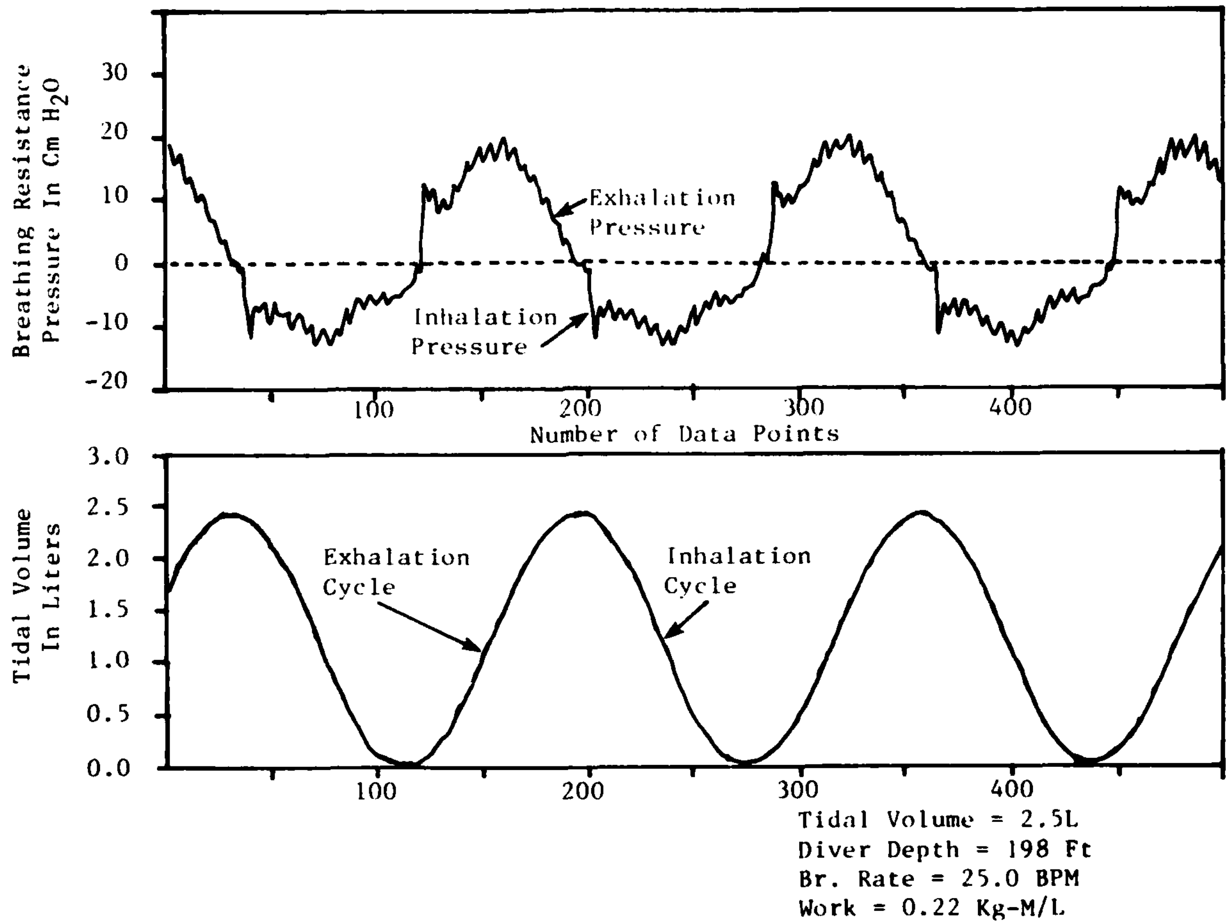



Figure 3. Sample Breathing Cycle Data

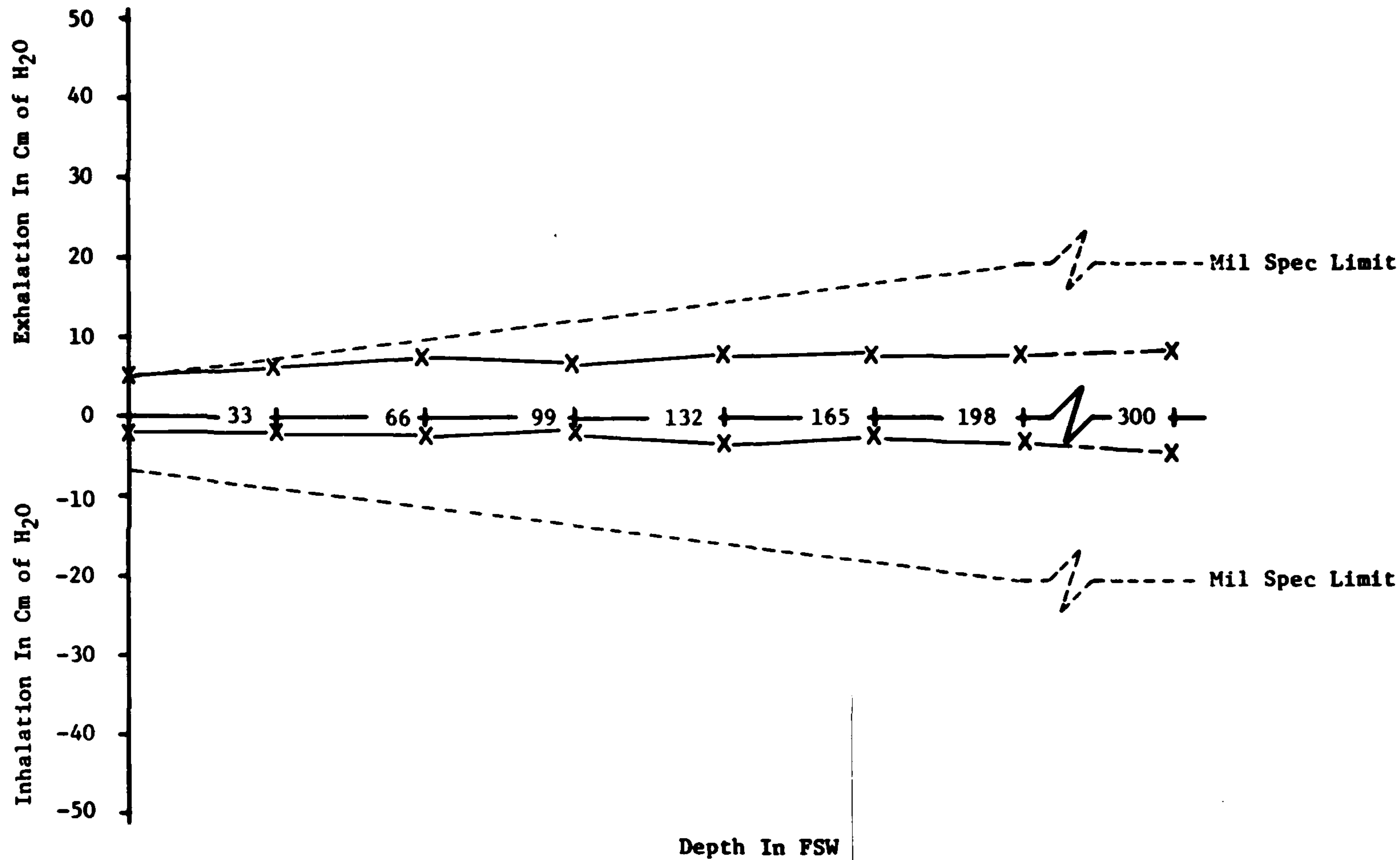



Figure 4. Breathing resistance vs. depth
165 psig O/B supply pressure
22.5 RMV

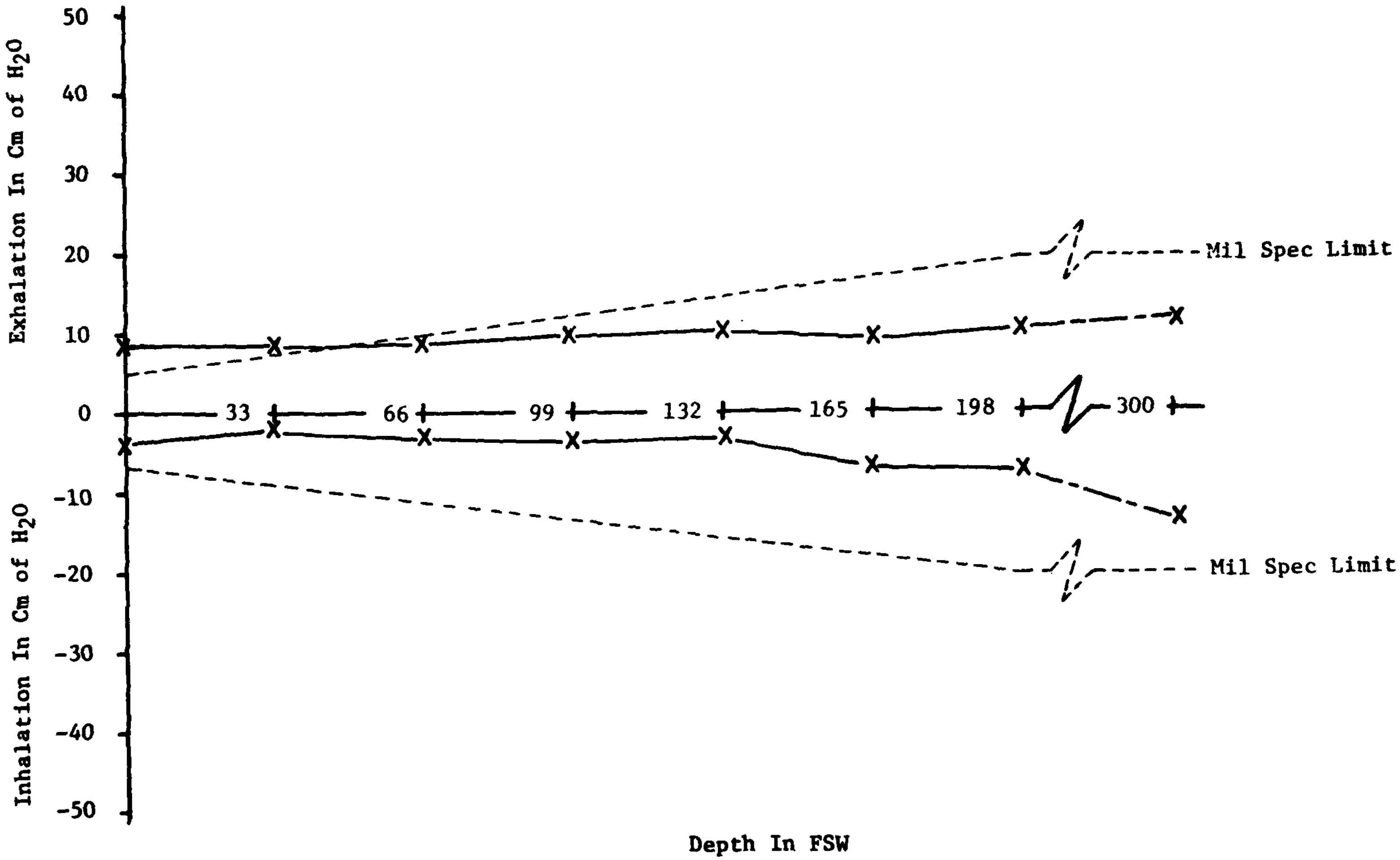



Figure 5. Breathing resistance vs. depth
165 psig O/B supply pressure
40 RMV

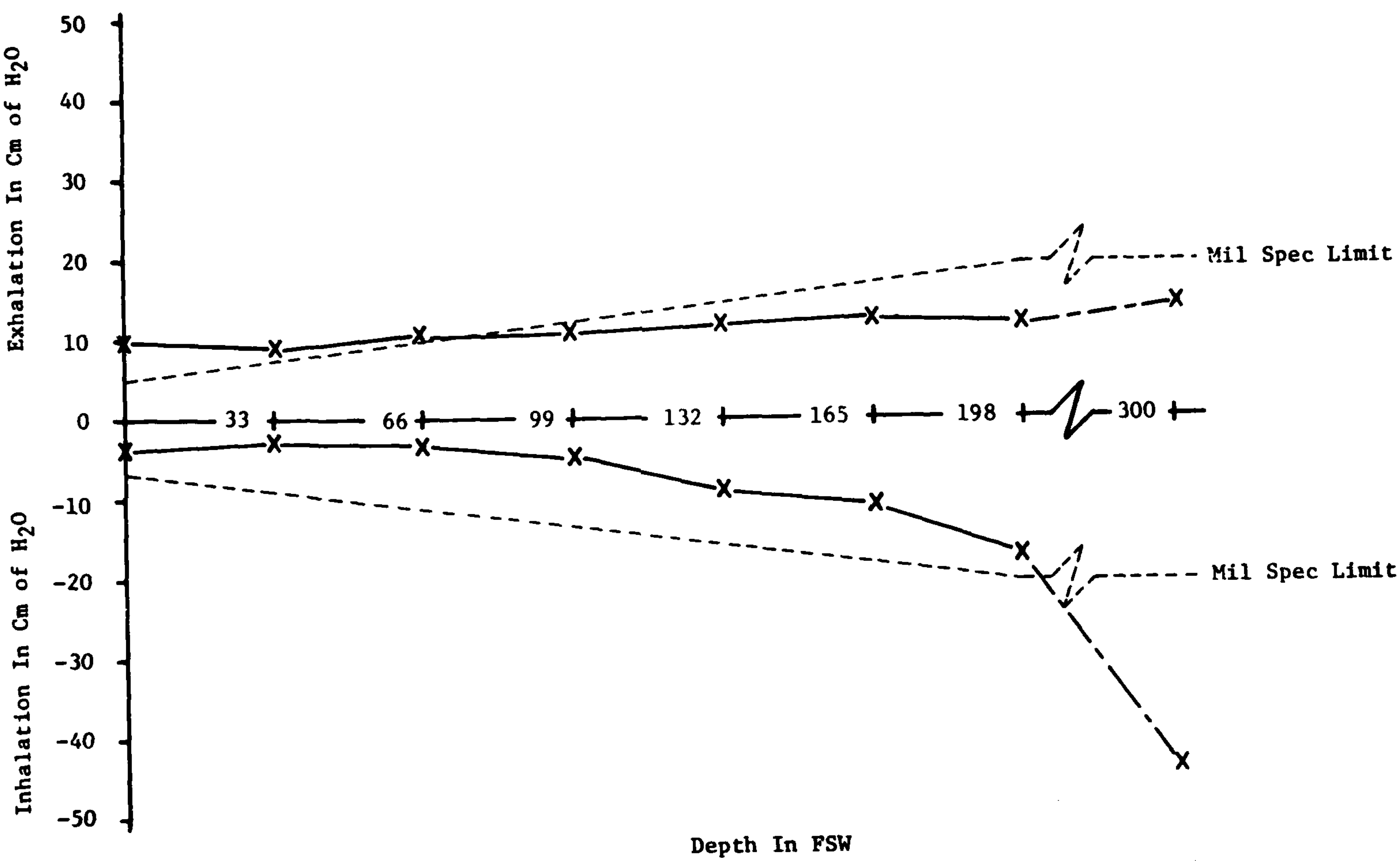



Figure 6. Breathing resistance vs. depth
165 psig O/B supply pressure
62.5 RMV

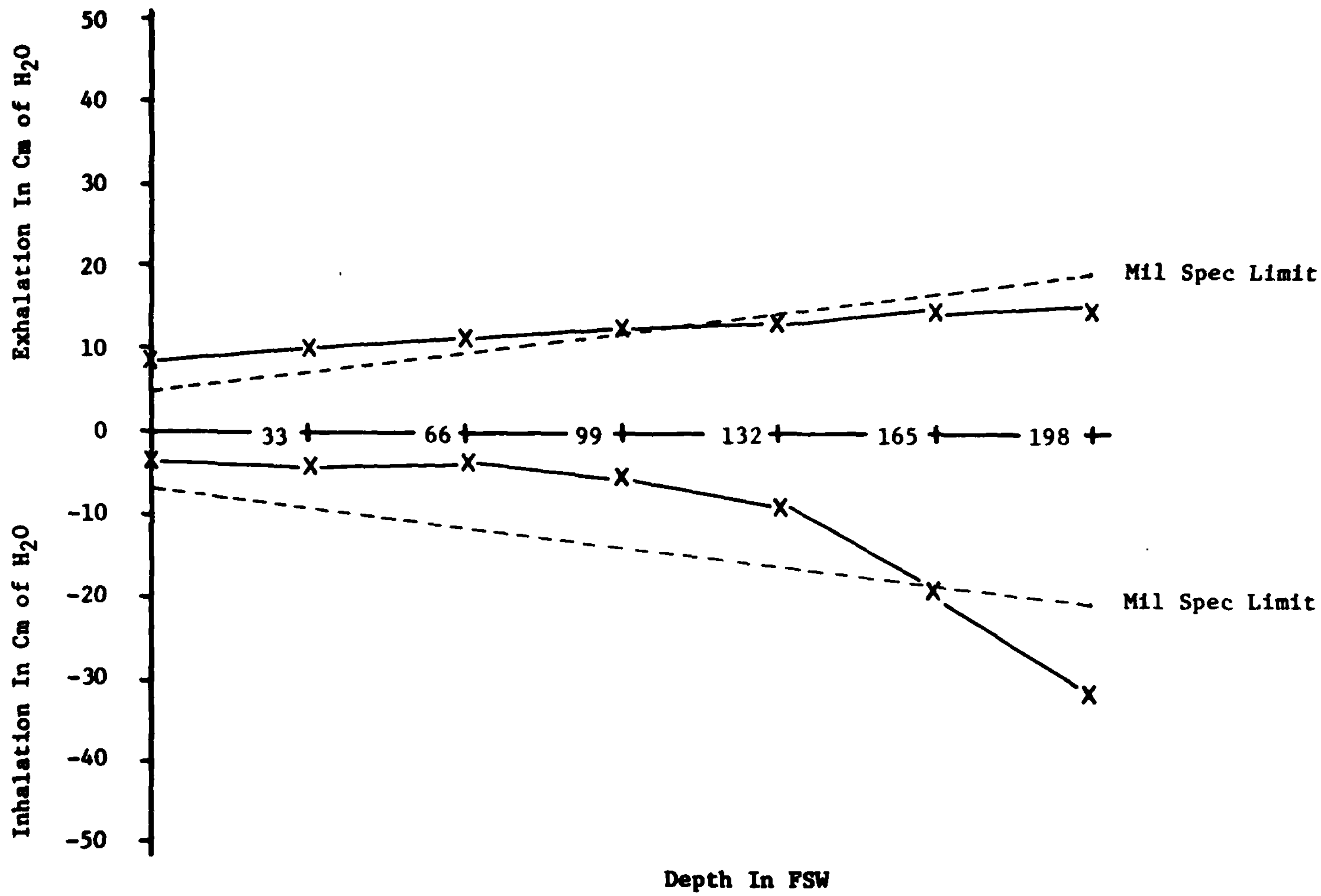



Figure 7. Breathing resistance vs. depth
165 psig O/B supply pressure
75 RMV

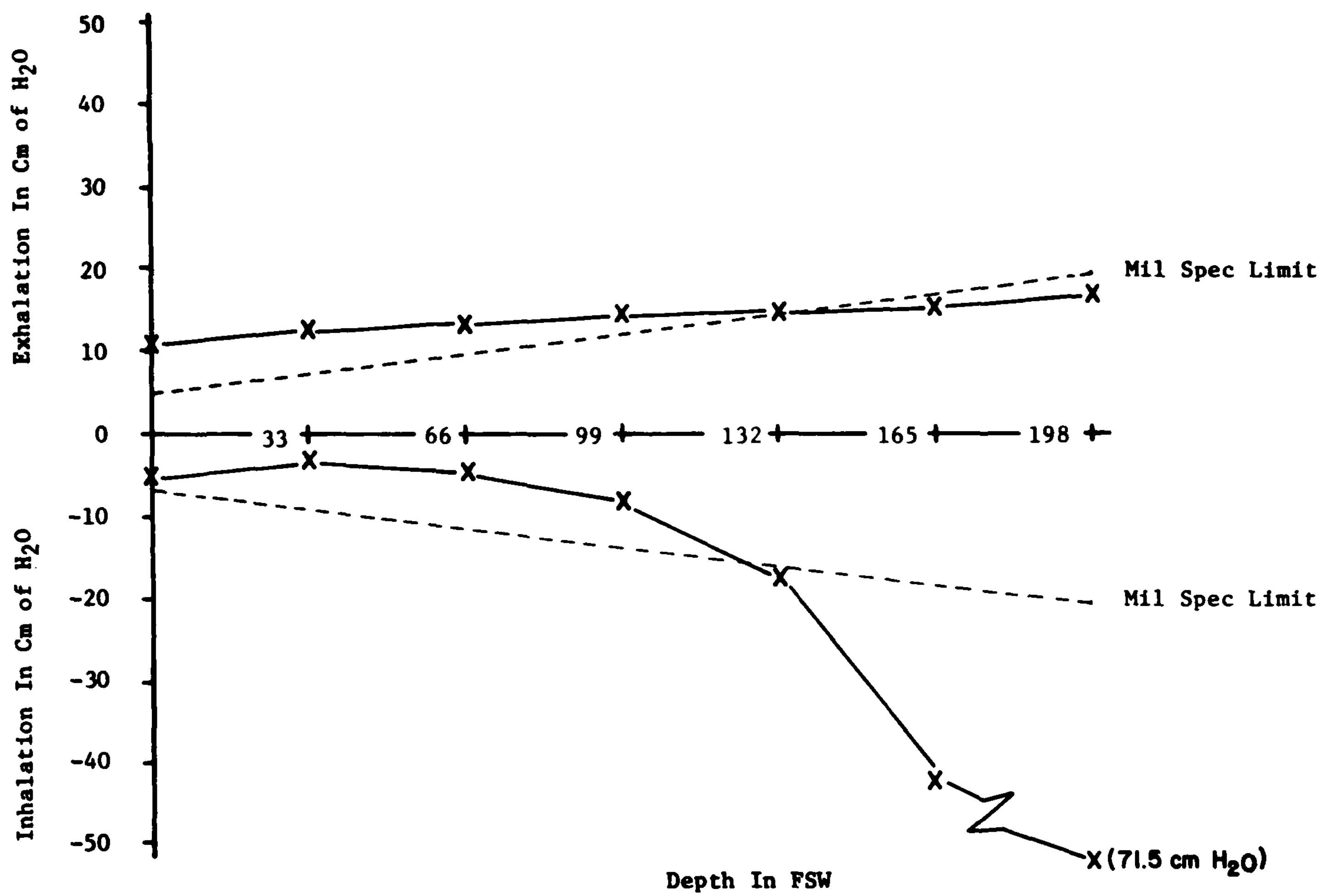



Figure 8. Breathing resistance vs. depth
165 psig O/B supply pressure
90 RMV

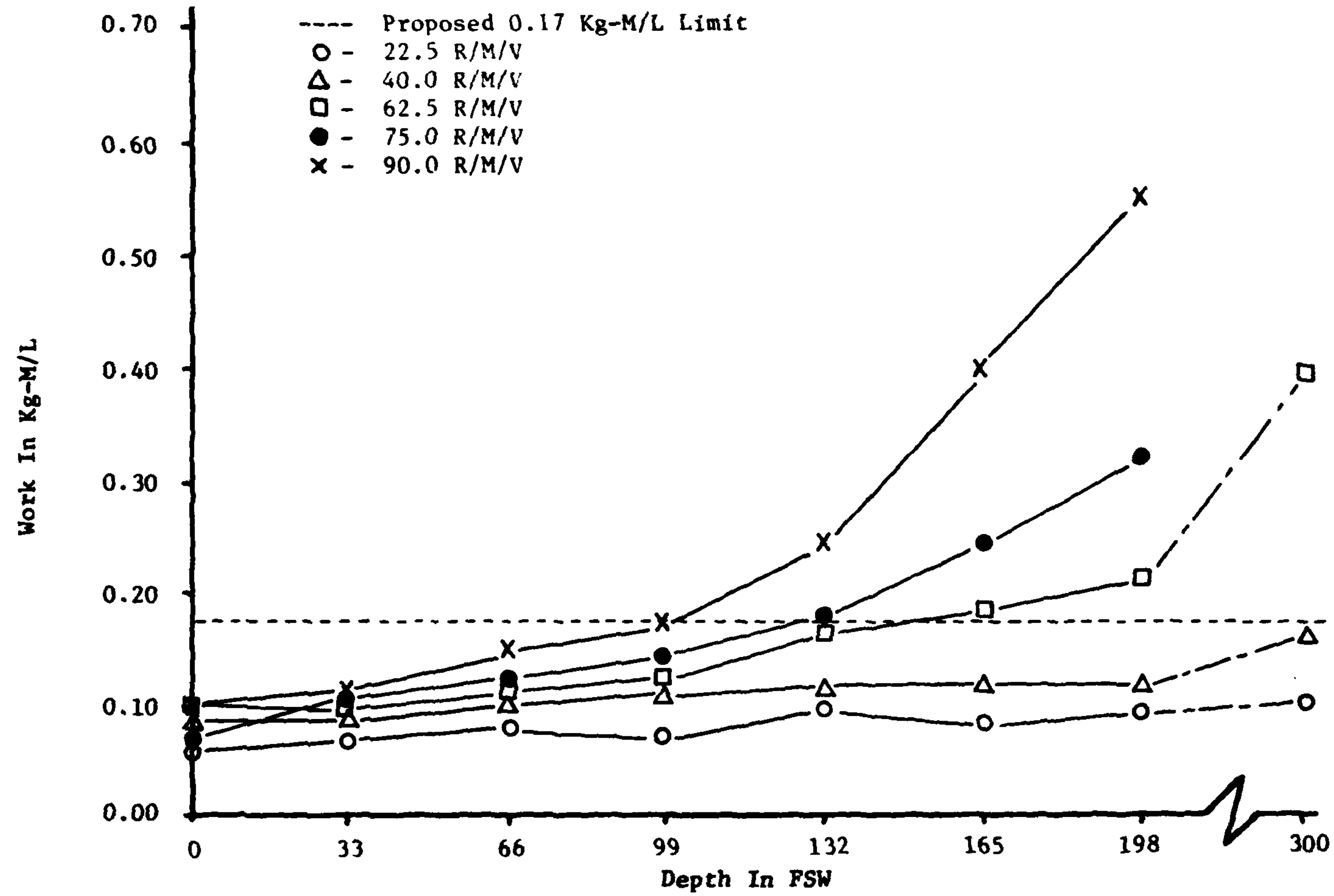



Figure 9. Breathing work vs. depth
165 psig O/B supply pressure

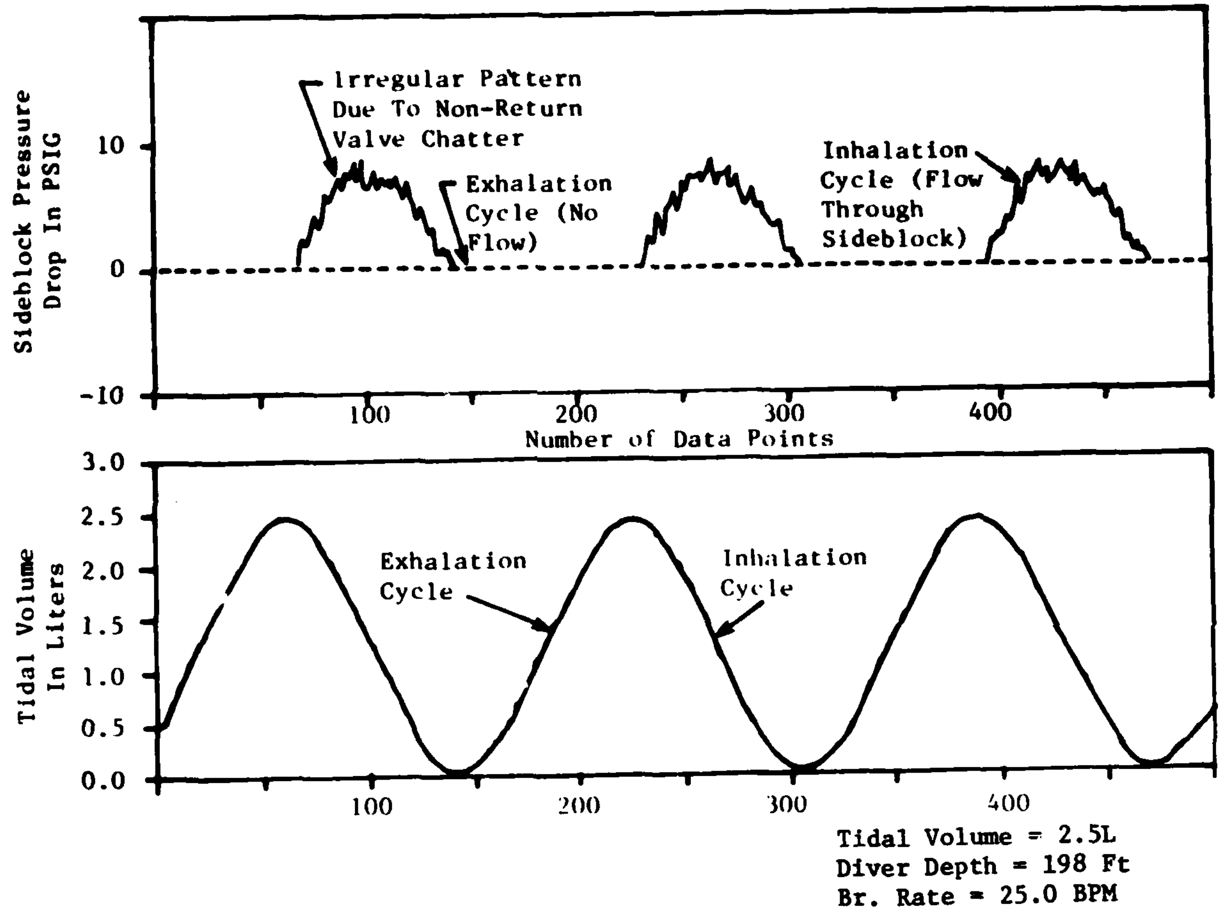



Figure 10. Superlite 17B Sample Sideblock Breathing Cycle

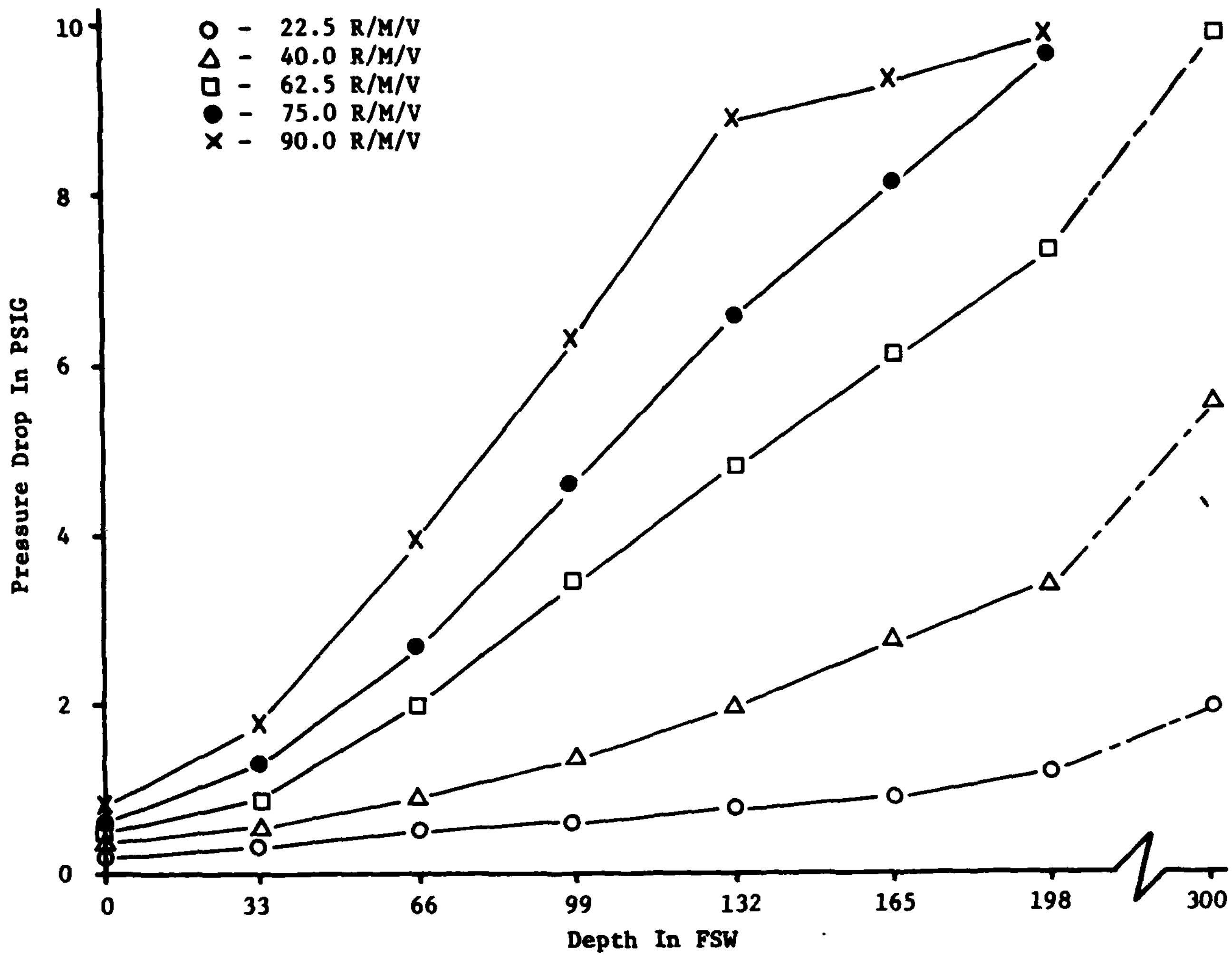



Figure 11. Sideblock pressure drop vs. depth
165 psig O/B supply pressure

The extreme work rate of 90 RMV (Figure 8) produced acceptable breathing resistance at depths down to 132 FSW. It should be noted that this work rate can be sustained by a diver for only very short periods of time and is an extreme performance level for any type of diving equipment.

(2) Exhalation Characteristics

At 22.5 (Figure 4) and 40 RMV (Figure 5) exhalation resistance was extremely low, never exceeding 11cm $H_2O$. Resistance at 62.5 (Figure 6) and 75 RMV (Figure 7) was almost identical and still well within the mil spec limit for 40 RMV. Ninety RMV (Figure 8) exhalation pressures increased over the 75 RMV values but not significantly. In general, the exhalation breathing characteristics were impressive even at high diver work rates.

C. Work of Breathing

Breathing work (Figure 9) required for the D.S.I. Superlite 17B was very low at 22.5 and 40 RMV, reaching a maximum of only 0.16kg.m/l at 300 FSW. At 62.5 RMV breathing work did not significantly exceed the proposed limit until a depth of 300 FSW was reached. Work rates increased rapidly beyond 132 FSW at work rates of 75 and 90 RMV. Beyond 132 FSW at 75 and 90 RMV breathing work reached levels considered safe only in emergency conditions.

It is important to note that these values are using air as the breathing gas and these values using $HeO_2$ correspond to much greater depths for the same work rates.

D. Sideblock Performance

The dynamic pressure drop across the helmet sideblock was measured. Monitoring pressure drop between the inlet and outlet of the sideblock gave information as to how much affect sideblock pressure loss contributed to breathing resistance. By correlating this information with breathing resistance plots, changes in work performance can be traced.

Figure 10 is an example of the dynamic pressure drop plots that were made during the test. The Superlite 17B helmet has an extremely well designed sideblock in that pressure losses never exceeded 10 psig even at 90 RMV and 300 FSW, (Figure 11). Consequently, the porting of this sideblock is adequate to handle any type of diver work rate without affecting breathing resistance. In addition, as can be seen in Figure 10, the operation of the sideblock non-return valve was relatively smooth with low cracking pressures.

## IV. CONCLUSIONS AND RECOMMENDATIONS

The D.S.I. Superlite 17B is considered to be a safe and effective diver life support system. The helmet is not recommended for placement on the list of equipment authorized for Navy use because the U.S.N. MK I Mod 0 Mask currently meets all fleet needs for this type of equipment.

Breathing resistance was low even at heavy diver work rates at all depths down to 198 FSW. Results indicated low cracking pressures on the demand regulator with smooth even flow through the breathing cycle.

Breathing work required to operate the mask was generally low and would not inhibit a diver's ability to perform useful work except in extreme cases.

Pressure and flow characteristics of the helmet sideblock were exceptional. Pressure losses were extremely low and smooth non-return valve operation was observed throughout the tests.

In general, the D.S.I. Superlite 17B is an exceptionally well built, easy to use and maintain helmet. It should provide the working diver with a high performance piece of life support equipment under even the most demanding conditions.

## V. REFERENCES


1. Department of the Navy Military Specification MIL-R24169A, Regulator, Air, Demand, Single Hose, Nonmagnetic, Divers, 22 March 1967.

2. Navy Experimental Diving Unit Report 23-73, U.S.N. Procedures for Testing the Breathing Characteristics of Open-Circuit Scuba Regulators, by S. D. Reimer, p. 5, 11 December 1973.

3. Navy Experimental Diving Unit Report 19-73, Proposed Standards for the Evaluation of the Breathing Resistance of Underwater Breathing Apparatus, by S. D. Reimer, p. 36, 30 January 1974.

## APPENDIX A

## TEST PLAN

1. a. Insure that regulator is set to factory specifications and is working properly.

   b. Chamber on surface.

   c. Calibrate transducers and then zero transducer after water is added to arc.

   d. Open air supply valve to test regulator and set supply pressure at 165 psig O/B.

   e. Adjust breathing machine to 1.5 liters tidal volume and 15 BPM and take data.

   f. Adjust breathing machine to 2.0 liters tidal volume and 20 BPM and take data.

   g. Adjust breathing machine to 2.5 liters tidal volume and 25 BPM and take data.

   h. Adjust breathing machine to 2.5 liters tidal volume and 30 BPM and take data.

   i. Adjust breathing machine to 3.0 liters tidal volume and 30 BPM and take data.

2. a. Pressurize chamber to 198 FSW in 33 FSW increments and repeat steps 1d-1i at each stop.

   b. Pressurize chamber to 300 FSW and repeat steps 1d-1i.

## APPENDIX B

## TEST EQUIPMENT

(Note: Equipment corresponds to that in Figure 1)

1. X-Y plotter
2. Validyne CD-23 transducer readout (2 ea.)
3. Breathing machine
4. Breathing machine piston position transducer
5. Validyne pressure transducer w/1.00 psid diaphragm
6. Validyne pressure transducer w/20.0 psid diaphragm
7. 400 ft. of 3/8" I.D. Umbilical
8. External air supply pressure
9. Dome loader
10. Wet test box
11. Bubble dampening mat
12. EDF chamber complex
13. Chamber depth gauge
14. Test helmet: D.S.I. Superlite 17B