NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 6-88

SUPERLITE 17B/HELIOX 18B TESTING

DAVID G. KIRBY

AUGUST 1988

Navy Experimental Diving Unit

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVSEA Task 86-44A

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Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

ADA206349

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY N/A 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU Report 6-88	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZ. Navy Experimental Diving Unit 6b. OFFICE SYMBOL (If applicable) NEDU	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Navy Experimental Diving Unit Panama City, Florida 32407-5001	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Sea Systems Command 6b. OFFICE SYMBOL (If applicable) NAVSEA	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Naval Sea Systems Command Department of the Navy Washington, DC 20362-5101	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO. 86-44, 86-44A | WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Superlite 17B/Heliox 18B Testing

12. PERSONAL AUTHOR(S)
David G. Kirby, LT(N), CF

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year,Month,Day)	15. PAGE COUNT
Final	FROM_______ TO_______	August 1988	128

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Diving Systems International; DSI Navy 350 Regulator; Gas Services Offshore Limited; GSOL Ultra Flow 500 Regulator; Heliox 18B/NS; Superlite 17B/NS; SL-17B/NS MOD 0; SL-17B/NS MOD 1; Surface Supplied Diving; Saturation Diving; DSI-18B/NS

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

The Navy Experimental Diving Unit evaluated the SL-17B/NS MOD 0 diving helmet, SL-17B/NS MOD 1 diving helmet, and DSI-18B/NS (ex Heliox 18B) diving mask for surface supplied air and mixed gas diving using a gas supply pressure of 135 pounds per square inch over bottom pressure. The evaluation consisted of unmanned objective work of breathing testing, manned subjective evaluation, manned objective evaluation and system compatibility studies. The SL-17B/NS helmets and DSI-18B/NS mask proved to be extremely good diving systems. The SL-17B/NS MOD 1 was chosen for surface supplied diving while the SL-17B/NS MOD 0 and DSI-18B/NS were chosen for saturation diving. Under most conditions of operation, there was no substantial difference in performance between the two SL-17B/NS helmets. The fit of the head cushion/liner, oral nasal and neck dam

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT [ ] UNCLASSIFIED/UNLIMITED [x] SAME AS RPT. [ ] DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL NEDU Technical Librarian	22b. TELEPHONE (Include Area Code) 904-234-4351 22c. OFFICE SYMBOL

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

BLOCK 19 CONTINUED

were identified as critical components in ensuring proper operation and comfort. Recommendations were made concerning issue and procurement of these items. Although the safety locking pin for the SL-17B/NS is adequate it was recommended that the manufacturer be encouraged to develop an alternative method. The Kinergetics breathing Gas Heater, model 3352 was identified as inadequate due to its gas pressure limit and recommended for replacement.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

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ABBREVIATIONS

Air Sat	Air Saturation Dive
CO_2	carbon dioxide
DDS	deep diving system
Deep Dive	deep saturation dive
DSI	Diving Systems International
FSW	feet of sea water
GSOL	Gas Services Offshore Limited
HeO_2	helium oxygen
MK	Mark
MOD	modification
NAVSEA	Naval Sea Systems Command
NMRI	Naval Medical Research Institute
NEDU	Navy Experimental Diving Unit
NS	Navy specifications
OSF	Ocean Simulation Facility
psig	pounds per square inch (pressure) gauge
PTC	personnel transfer capsule
RMV	respiratory minute volume
SL	Superlite
UF	Ultra Flow
USN	United States Navy
USS	United States Ship

ABSTRACT

The Navy Experimental Diving Unit evaluated the SL-17B/NS MOD 0 diving helmet, SL-17B/NS MOD 1 diving helmet, and DSI-18B/NS (ex Heliox 18B) diving mask for surface supplied air and mixed gas diving using a gas supply pressure of 135 pounds per square inch over bottom pressure. The evaluation consisted of unmanned objective work of breathing testing, manned subjective evaluation, manned objective evaluation and system compatibility studies. The SL-17B/NS helmets and DSI-18B/NS mask proved to be extremely good diving systems. The SL-17B/NS MOD 1 was chosen for surface supplied diving while the SL-17B/NS MOD 0 and DSI-18B/NS were chosen for saturation diving. Under most conditions of operation, there was no substantial difference in performance between the two SL-17B/NS helmets. The fit of the head cushion/liner, oral nasal and neck dam were identified as critical components in ensuring proper operation and comfort. Recommendations were made concerning issue and procurement of these items. Although the safety locking pin for the SL-17B/NS is adequate it was recommended that the manufacturer be encouraged to develop an alternative method. The Kinergetics Breathing Gas Heater, model 3352 was identified as inadequate due to its gas pressure limit and recommended for replacement.

KEY WORDS:

Diving Systems International
DSI Navy 350 Regulator
DSI-18B/NS
Gas Services Offshore Limited
GSOL Ultra Flow 500 Regulator
Heliox 18B/NS
Superlite 17B/NS
SL-17B/NS MOD 0
SL-17B/NS MOD 1
Surface Supplied Diving
Saturation Diving

I. INTRODUCTION

The Navy Experimental Diving Unit (NEDU) evaluated the SL-17B helmet and Heliox 18B mask both fitted with GSOL UF500 regulator and modifications, for saturation diving, per reference 1, as possible replacements for the USN MK 1 MOD S. It was recommended that the SL-17B with UF500 and modifications be evaluated for surface supplied diving in pursuit of common equipment for all types of umbilical supplied diving.

In September 1986, NEDU was tasked by NAVSEA to test and evaluate the SL-17B and DSI-18B (ex Heliox 18B) both fitted with GSOL UF500 regulator and modifications as possible replacements for the USN MK 1 MOD 0 for surface supplied air diving to 190 FSW and mixed gas diving to 300 FSW. The GSOL UF500 regulator optimal over bottom pressure of 185 psig is in excess of many USN LP air supply systems, so the task was amended to test the helmet and mask at 135 psig over bottom pressure for surface supplied air diving to 190 FSW.

For a variety of reasons that will be discussed in this report, the DSI Navy 350 regulator was identified by NAVSEA as a possible alternative to the GSOL UF500 regulator for surface supplied diving. The task was subsequently modified to include evaluation of the DSI Navy 350 regulator and modifications fitted into the SL-17B. After unmanned evaluation was completed and the results indicated that the DSI Navy 350 met established performance criteria, NAVSEA commenced procurement of helmets fitted with both regulators for separate purposes. For saturation diving the SL-17B and DSI-18B (ex Heliox 18B) both fitted with GSOL UF500 regulator and modifications were designated SL-17B/NS MOD 0 and DSI-18B/NS. For surface supplied diving, the SL-17B fitted with DSI Navy 350 regulator and modifications was designated SL-17B/NS MOD 1. Although these designations were established after unmanned evaluations were completed, they are used in this report to simplify identification.

II. FUNCTIONAL DESCRIPTIONS OF EQUIPMENT

A. SL-17B/NS MOD 0 HELMET

This system consists of the helmet shell, head cushion/liner, sideblock and bent tube assembly, regulator, oral nasal, and neck clamp/neck dam assembly (Figure 1).

The helmet shell is a close fitting, off-white fiberglass shell that provides head protection, dry interior and a foundation to mount component parts. Buoyancy is countered by brass weights distributed about the helmet to produce balanced neutral buoyancy when submerged.

A head cushion/liner is snapped into the helmet to provide protective cushioning, warmth, and firm oral nasal fit. The amount of padding in the liner can be varied for proper fit. The side block is the same as the regular SL-17B except that a special o-ring seal is used between the nonreturn valve and side block. There is a port for dry suit inflation. The bent tube assembly is of a special design, unique to the GSOL UF500 regulator.

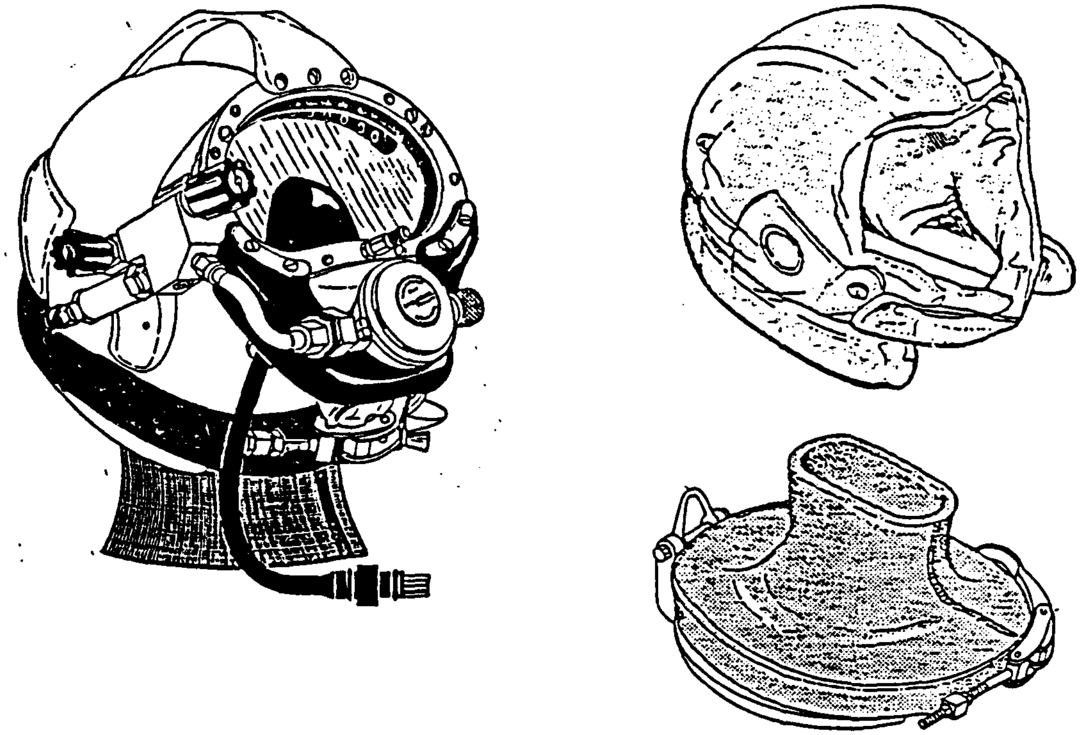

Figure 1. SL-17B/NS MOD 0 Helmet

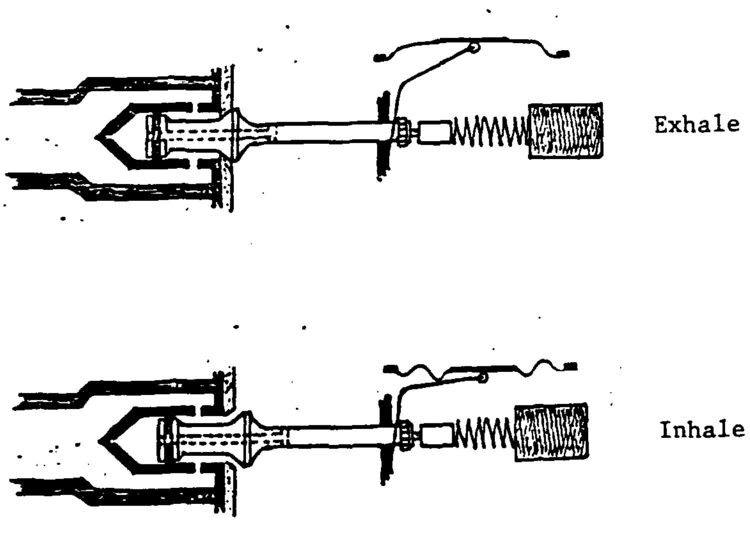

Figure 2. Operation of the GSOL UF500 Valve

The GSOL UF500 regulator is a balanced type demand regulator. A complete description is contained in reference 1. Figure 2 demonstrates the operation of the valve. As supply and ambient pressure are balanced by the special shape and construction of the valve, the only significant resistance to effecting flow is force applied by the dial-a-breath spring.

The divers mouth and nose fit into the oral nasal, held comfortably in place by the correct amount of padding in the head cushion/liner. The oral nasal differs from the standard SL-17B and USN MK 1 part by connecting to an exhaust valve mounted in the chin portion of the helmet. Originally intended as an easy attachment point for the GSOL gas recovery system, the oral nasal exhaust provides additional exhaust to the regulator exhaust for the SL-17B/NS. A water dump valve has been installed to the left of the oral nasal exhaust valve to vent water from the helmet interior.

The helmet is held in place on the divers head by the neck clamp assembly. A lever action on the assembly compresses a metal band around a small lip at the bottom of the helmet. The metal band latch is held shut by the lever's spring action, a latch catch mechanism (plunger) and a safety pin. Water is prevented from entering the bottom of the helmet by a foam neoprene neck dam attached to the neck clamp assembly. It functions in a manner similar to the MK 12 neck dam. An optional cold water neck dam may be obtained.

It is designed for use by working divers operating from a PTC for saturation diving only.

B. DSI-18B/NS

This bandmask system, Figure 3, looks similar to the USN MK 1. The hood and face seal is attached to the yellow mask in the same way as the MK 1. With the exception of the helmet shell, head cushion/liner, and neck clamp/dam assembly, its functional characteristics are identical to the SL-17B/NS MOD 0. It is designated for use by the standby diver in the PTC for saturation diving only.

C. SL-17B/NS MOD 1

This system is a yellow colored helmet, Figure 4, fitted with the DSI Navy 350 regulator, otherwise identical to the SL-17B/NS MOD 0.

The regulator is essentially the standard DSI Superflow regulator enhanced to provide increased flow of breathing gas (Figure 5). Breathing resistance can be altered by the dial-a-breath setting. The bent tube assembly is similar to the USN MK 1 bent tube. The SL-17B/NS MOD 1 is designated for surface supplied diving only.

III. TEST PROCEDURES

A. UNMANNED TESTING OF SL-17B/NS MOD 0 AND MOD 1

This evaluation commenced per the test plan of Appendix A1, using the procedures of reference 2. Task modifications to include the DSI Navy 350

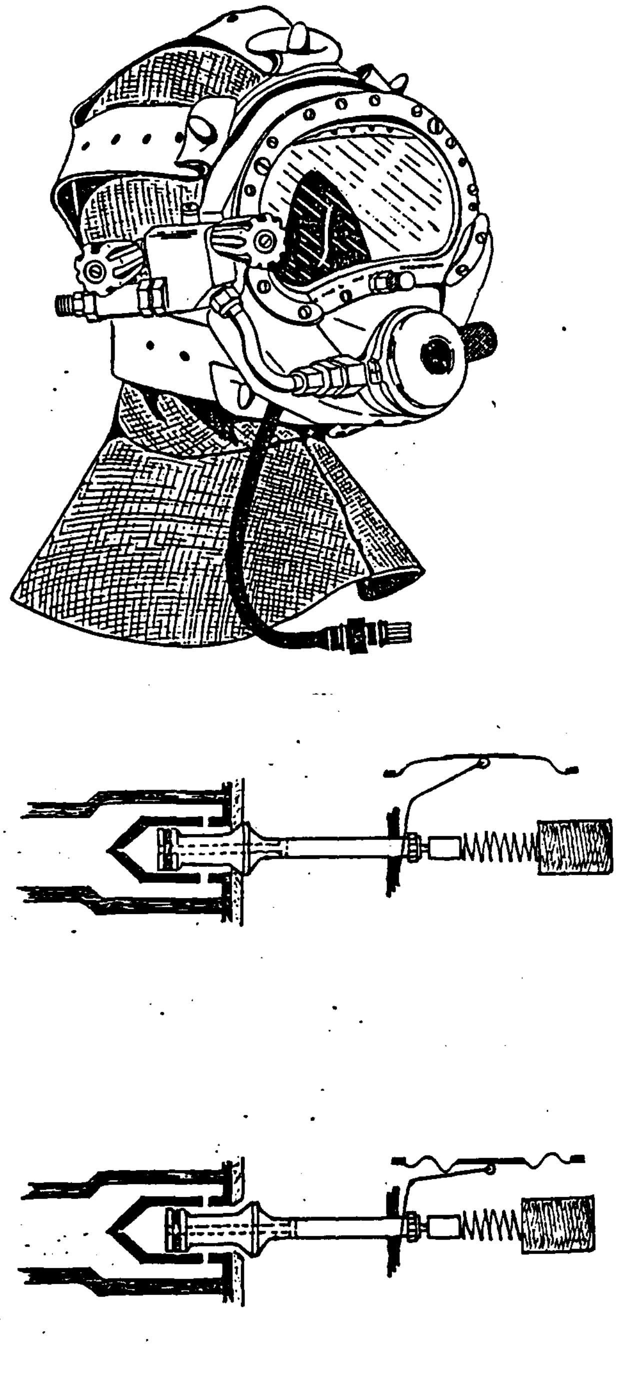

Figure 3. DSI-18B/NS and Operation of the GSOL UF500 Valve

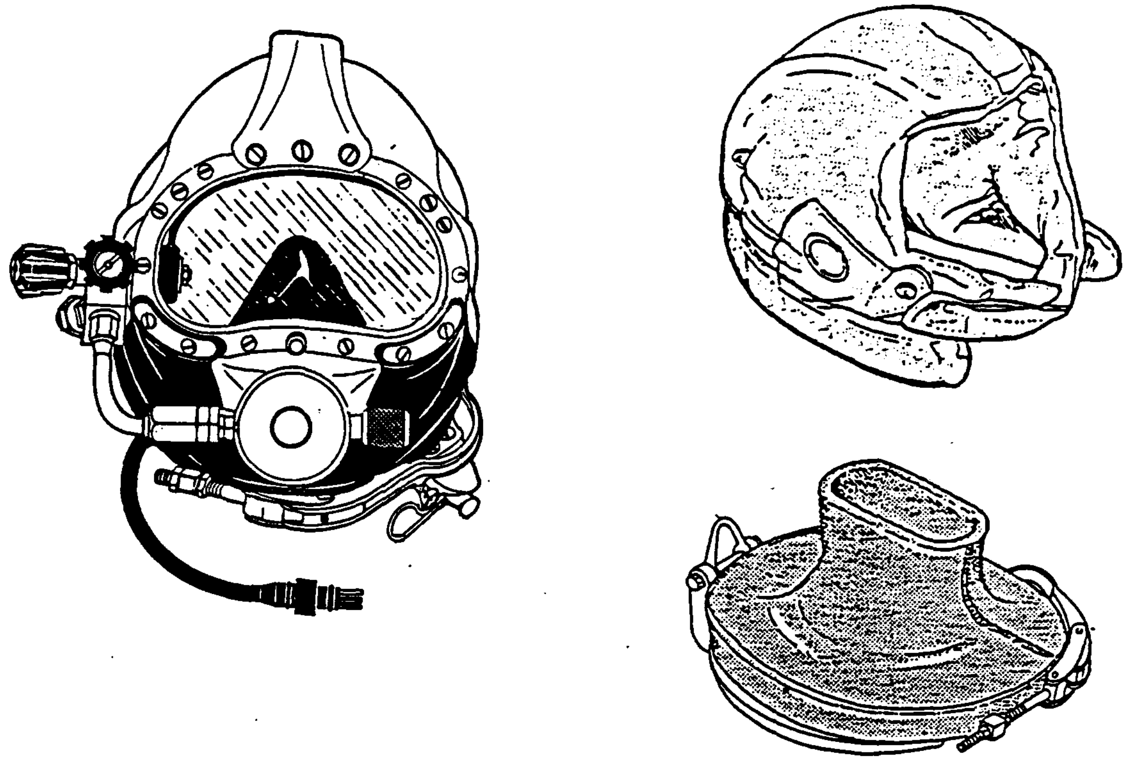

Figure 4. SL-17B/NS MOD 1

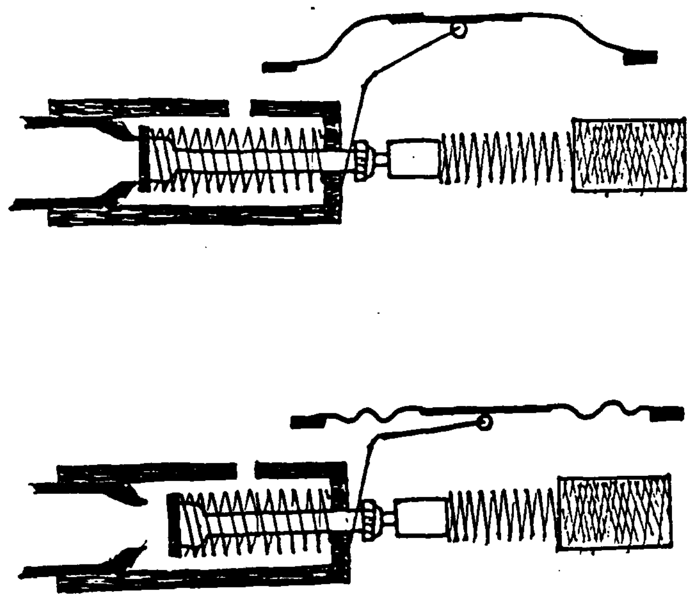

Figure 5. Operation of the DSI Navy 350 Regulator

regulator and lower the over bottom pressure to 135 psig changed testing significantly, so, a new test plan per Appendix A2 was conceived and conducted. The SL-17B/NS proved extremely difficult to mount correctly on the test apparatus. A seal could not be made against the oral nasal, so a DSI-18B/NS was utilized to mount both types of regulators. This was deemed acceptable because once a positive oral nasal seal was made, the breathing machine did not see a difference between helmet and mask. All tests included trial runs at 125, 135, and 145 psig over bottom air pressure via 600 feet of ½ inch divers' gas umbilical. Use of the ½ inch gas umbilical alone was deemed appropriate because it is currently the only size that may be used to supply the MK 1 MOD 0 to the maximum depth for air and mixed gas diving.

Upon completion of unmanned air tests, it was determined that unmanned HeO_2 testing would not be required. This determination was based upon comparative analysis with results reported in references 1 and 3 using a standard production SL-17B and DSI-18B. These indicated that a similar system (SL-17B/NS MOD 1) would meet requirements for HeO_2 to 300 FSW if the NEDU standards for air were met or exceeded. Notwithstanding, complete physiological manned testing, both air and HeO_2, was scheduled. Unmanned HeO_2 tests of the SL-17B/NS MOD 0 had already been conducted per reference 1. Although these had been completed with 100 foot umbilicals, the equipment performed so well that any increase in work of breathing induced by extra umbilical was considered to be insignificant at 300 FSW.

B. MANNED EVALUATION OF SL-17B/NS MOD 0 AND DSI-18B/NS FOR AIR DIVING TO 190 FSW

These open ocean subjective evaluations were conducted in and off Pensacola Harbor, Florida per Appendix B. Divers were required to complete human factors questionnaires after surfacing from working dives. These questionnaires were reviewed to obtain statistical information as well as comments or suggestions concerning comfort and safety. Specific items of interest were further investigated upon completion of the review. In addition, NMRI was requested to forward relevant information from their investigations.

C. SL-17B/NS MOD 0 TO MK 2 MOD 1 DDS COMPATIBILITY TRIAL

Manned dives were conducted onboard the USS ORTOLAN using the MK 2 MOD 1 DDS and standard surface supplied air procedures per Appendix C. System to system compatibility was assessed and divers were polled for observations and comments. Specific items of interest were further investigated.

D. HUMAN FACTORS TESTING OF SL-17B/NS MOD 1

These manned evaluations of the helmet were conducted during Air Sat 88A per Appendix D. Using information gained from previous manned testing of the SL-17B/NS MOD 0, specific diver positions were assumed and human factors information collected. Both the dive supervisor and diver completed questionnaires to assess real time subjective information with what the diver remembered upcn completion of the excursion. Specific items of interest were further investigated.

E. PHYSIOLOGICAL EVALUATION OF SL-17B/NS MOD 1 AT 300 FSW

Manned objective studies of the SL-17B/NS MOD 1 were conducted in the OSF at 300 FSW using HeO_2 per Appendix E during Deep Dive 88. Inhalation and exhalation effort, end-tidal CO_2 levels and dyspnea (air hunger) were measured with water temperature at 35°F. HeO_2 gas was supplied at 135 psi over bottom pressure through 600 feet of ½ inch umbilical. Specific items of interest were further investigated.

IV. TEST RESULTS

A. UNMANNED TESTING

The number of test runs conducted at each over bottom pressure for each helmet is listed in Table 1. The breathing loops generated were computer processed to produce tables of data. From these tables, the graphs of Appendix F were made for each over bottom pressure. These results have been summarized in Figure 6, which represents the range of 75% of collected data for 125-145 psig over bottom pressure.

The SL-17B/NS MOD 0 met the NEDU standards of reference 2 at the tested over bottom pressures. As over bottom pressure increased, inhalation resistance gradually decreased. The induced pressure drop measured at the side block was 2-3 times that measured for the SL-17B/NS MOD 1. Despite premission and predive set up per the manufacturers instructions, spontaneous free flow and extremely high breathing resistance were infrequently encountered. No cause for these occurrences could be demonstrated although contamination, the density of air vice HeO_2 and extreme sensitivity to the rather vague regulator set up procedure were advanced. As these occurrences were not reported in reference 1, they were identified for further study. They also prompted the evaluation of the DSI Navy 350 regulator as an alternative to the GSOL UF500 for air diving.

The SL-17B/NS MOD 1 met the NEDU standards of reference 2 at the tested over bottom pressures. As over bottom pressure increased, inhalation resistance and work of breathing graphs became more linear. Exhalation resistance appeared high, especially compared to the SL-17B/NS MOD 0. As the exhaust valves are identical on each helmet, the exhalation resistance values were expected to be similar. Reference 1 had found that if a regulator was free flowing, then exhalation resistance would increase. The video tapes of the unmanned tests were reviewed but the helmet did not appear to be free flowing prior to data recording. This phenomena was identified for further evaluation. From Figure 6 it can be seen that inhalation resistance was not significantly greater than for the SL-17B/NS MOD 0, except for 75 and 90 RMV (Appendix F). Work of breathing was not significantly higher either, except for 75 and 90 RMV.

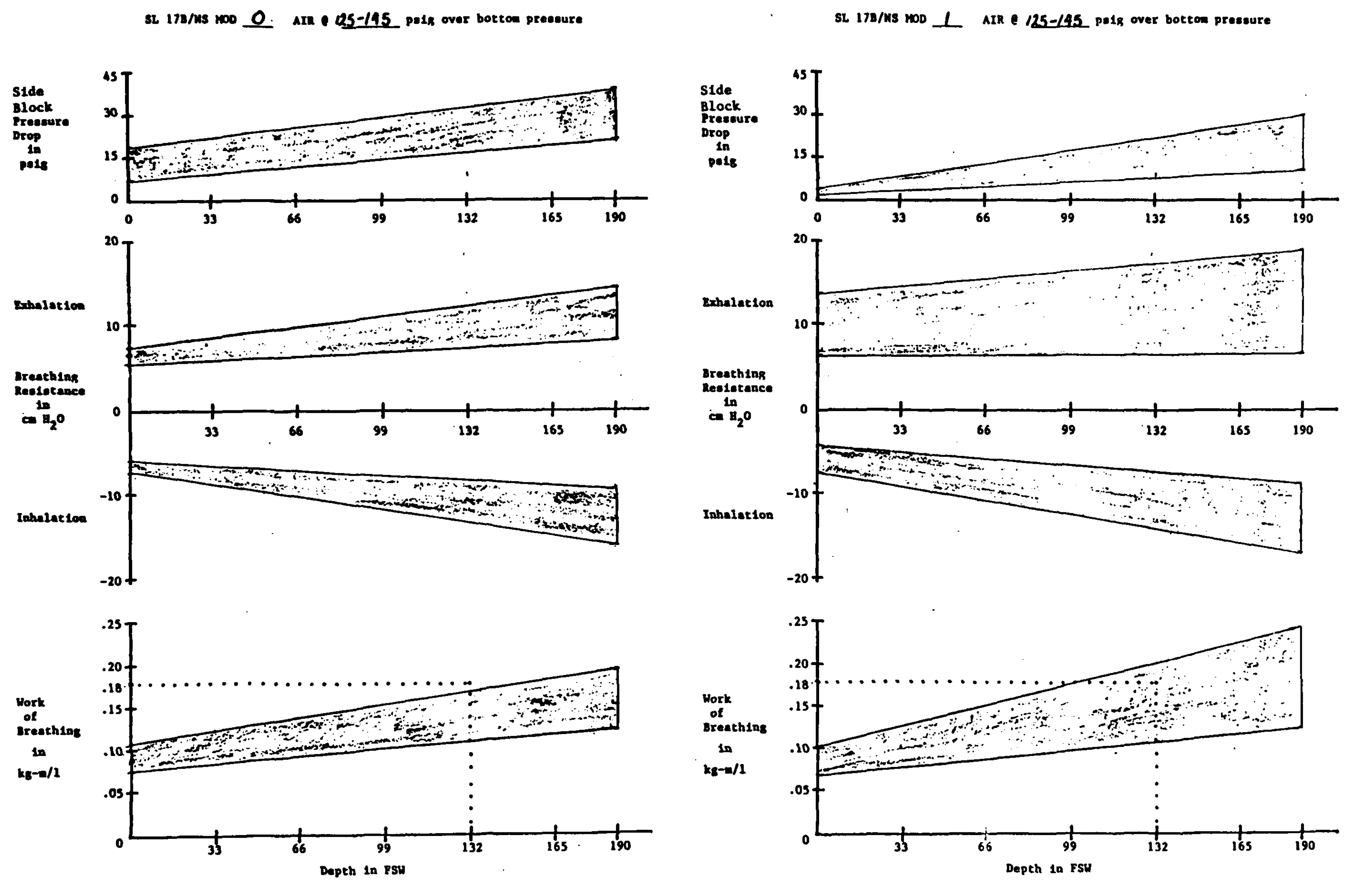

Figure 6. COMPARISON OF SL17B/NS UNMANNED TEST DATA FOR 75% OF ALL RMV'S AT TESTED OBP'S

Over Bottom Pressure in psig	Helmet Tested and Runs	
	SL-17B/NS MOD 0	SL-17B/NS MOD 1
125	1 run	2 runs
135	5 runs	3 runs
145	3 runs	2 runs

Table 1. Unmanned Test Runs Completed

B. MANNED AIR EVALUATION OF THE SL-17B/NS MOD 0 AND DSI-18B/NS

The combined results of the questionnaires completed by the divers is contained in Appendix G. Both the helmet and mask were described as significantly better than the USN MK 1. Particular observations that stimulated further study in later evaluations included:

1. Most divers reported that the oral nasal mask was too big, however, only 25% reported that it was uncomfortable.

2. Half of the divers reported incorrect head cushion/liner padding was used. This caused some oral nasal discomfort and loose fit. Experience was required to properly assess the amount of padding necessary.

3. The neck dam fit appeared critical. Poor fit allowed water entry and caused free flow.

4. There was some water entry into the oral nasal, the source of which could not be identified.

5. The neck clamp, plunger and safety locking pin for the helmet were identified as the major weak points of the assembly.

6. The band mask exhibited significant umbilical pull to the right.

The request for information from NMRI resulted in a letter, Appendix G2. Of specific interest was the recommendation that several sizes of helmet liners/cushions and neck dams be provided to ensure diver comfort.

C. COMPATIBILITY TRIAL, USS ORTOLAN

The SL-17B/NS proved to be compatible to the systems fitted onboard the ship, with the exception of the PTC diver communications umbilical connection. A conversion whip was produced although it suffered frequent flooding. Many of the divers reported water entry into the oral nasal. This was found to be caused by entrapment of the oral nasal exhaust valve by the valve cover. A manufactured dent in the cover (to clear the metal band of the DSI-18B) obstructed the normal movement of the rubber valve. Increased stiffness of the valve compared to the regular SL-17B did not allow it to flop past the obstruction and reseat. The valve is much stiffer than the regular SL-17B to stop free flow induced by helmet attitudes that result in the oral nasal exhaust being above the regulator exhaust. There is no oral nasal exhaust in the regular SL-17B. The manufacturer and configuration manager were consulted and a design change has been executed to eliminate the problem.

The Kinergetics Breathing Gas Heater, Model 3352, currently used during saturation diving and cold water diving using HeO_2 was identified as being unsuitable for use with the SL-17B/NS. The maximum gas over bottom pressure the heater is capable of withstanding is 150 psig. It requires 20 psig over the desired regulator over bottom pressure be applied to counter induced pressure loss. The SL-17B/NS MOD 0 has an optimum over bottom pressure of 185 psig. The SL-17B/NS MOD 1 has an optimum over bottom pressure of 135 psig. If the heater is used, the manufacturers specification is exceeded, unless sub-optimal helmet supply pressures are used. In addition the manufacturer no longer produces the model 3352.

During the trial the question was posed, "to what degree could the dial-a-breath counter excess over bottom pressure induced when two divers were at significantly different depths?" A SL-17B/NS MOD 0 and SL-17B/NS MOD 1 were set up at their respective optimum over bottom pressures of 185 psig and 135 psig and the dial-a-breath adjusted to just stop free flow. Supply pressure was increased without adjusting the dial-a-breath to simulate a companion diver, descending and supplied correct over bottom pressure. The SL-17B/NS MOD 0 withstood a pressure of 380 psig before a slight free flow occurred. The SL-17B/NS MOD 1 immediately began to free flow, but, dial-a-breath adjustment could stop induced free flow at pressures in excess of 300 psig.

During the post-mission of the SL-17B/NS MOD 0, it was discovered that some of the regulator parts would not mate correctly to some replacement parts. These difficulties, as well as some other observations (Appendix H), were brought to the attention of the manufacturer. Further investigation revealed that DSI was producing parts for the USN contract helmets, under slightly different specifications than the GSOL produced test units at NEDU. NEDU SL-17B/NS MOD 0 helmets were altered to the same parts as contracted for USN supplied systems. No further problems were encountered.

D. HUMAN FACTORS TESTING OF THE SL-17B/NS MOD 1

The complete results of the evaluation is contained in Appendix I. This study confirmed the findings of the SL-17B/NS MOD 0 manned evaluations, namely, that proper head cushion/liner fit and neck dam fit is highly individual and critical for diver comfort. The fit of these foam rubber parts varied slightly with depth. Poorly fitted neck dams almost always induced free flow of the helmet and caused flooding. Several divers reported umbilical pull to the right, similar to the DSI-18B/NS. Altering diver position did not affect breathing resistance on exhalation significantly, but resistance of inhalation decreased as the divers moved from upright, through prone toward 45° head down. Significant problems were encountered with the safety locking pin for the neck clamp plunger. All divers indicated an improved arrangement was required.

E. PHYSIOLOGICAL STUDIES, SL-17B/NS MOD 1 AT 300 FSW

The results of this study (Appendix J) proved to be so significant that they are to be part of a future report. Generally, the helmet performed very well under actual diver work of 200 watts inducing greater than 75 RMV. There appeared to be an increase in CO_2 retention when the diver was in an upright position with head looking down. Although the increase was minimal, this aspect of the SL-17B/NS MOD 1 will be further studied during manned 190 FSW evaluations to be conducted in late 1988.

V. DISCUSSION

Both the SL-17B/NS MOD 0 and the MOD 1 met the NEDU standards for work of breathing with 135 psi over bottom pressure supplied. Significant differences were obvious only when the breathing rate was increased to 75 and 90 RMV, whence the SL-17B/NS MOD 0 provided superior performance. The probable cause of the unexpected high exhaust resistance of the SL-17B/NS MOD 1 during unmanned testing may be oral nasal exhaust flooding as noted in manned evaluation. If a small amount of water entered the oral nasal because the valve became entrapped by the valve cover, exhaust resistance could increase. The other possible reason could be that the DSI Navy 350 regulator free flowed during the tests; however, this was ruled out when video of the tests were reviewed. With the suspected reason tentatively identified and the manufacturer eliminating the cause, any future unmanned evaluations should determine if the theory is correct.

The infrequent free flows and very high work values infrequently experienced during evaluation of the SL-17B/NS MOD 0 warranted further study. The identification of GSOL UF500 parts that were manufactured to different specifications could have caused the problem. In addition, the regulator set up was not very specific and it was possible to pre-mission the helmet, have it function on the bench, then not operate properly at depth. Either of these problems could have contributed to poor unmanned performance. Once these factors were eliminated, no further occurrences were observed. The problems are considered corrected; spontaneous free flows and very high work values should not occur.

The fit of the head cushion/liner is highly individual. The liner is a single size and fit is accomplished by inserting padding into pockets built into the liner. As support for the helmet is the diver's head, proper fit is essential to avoid discomfort and irritation. Also, the fit of the oral nasal is, in part, dependent upon proper head cushion/liner preparations. Determining the correct amount of padding to ensure proper fit takes time and experience. It would be best if each diver were issued a liner so he/she could pad it as appropriate, ready to snap into place when required. Such issue could be temporary; returned and re-issued as divers move from command to command.

The fit of the oral nasal is somewhat individual as well. The helmets and mask are normally fitted with a size LARGE oral nasal which seems to suit the majority of divers. Size SMALL and MEDIUM are also available under the same part number as the LARGE by specifying size when ordering from DSI. The SMALL is very small and more suitable for children than adults. The MEDIUM is suitable for thin faced divers or those much smaller than normal. When divers first use the SL-17B/NS or DSI-18/NS they should use the normal size LARGE to determine if it is too big before trying size MEDIUM. Diving commands may choose to procure a size MEDIUM if a diver has considerable problem with the size LARGE oral nasal.

The fit of the neck dam proved important to control water entry into the helmet and prevent free flow of the regulator. As supplied, the neck dam is too long for some divers to wear comfortably. As the neck dam is conical in shape, care must be taken when shortening the neck dam that the hole does not become so large that a proper neck seal cannot be made. The result of excessive trimming is that almost no diver will get a proper neck seal and will experience water entry and free flowing in a head-down position. Individual issue of the neck dam part of the assembly is not practical. A neck dam and clamp assembly together cost in excess of $300. It takes sometime to remove and replace the rubber neck dam from the assembly, especially if the optional cold water neck dam is used. Also, NEDU experience has shown that two different sizes were adequate for a dive team. Two or three neck dams of slightly different lengths should be produced at diving commands to allow all divers to obtain a good fit and proper seal. Some customizing of fit could be done by personnel experienced at wet suit repair and fitting.

The neck clamp locking arrangement, figure 7, was consistently recommended for change. The original safety locking pin frequently lost shape and fell out. Pins of a more resilient material have been identified to solve the problem, but the requirement for a pin should be addressed to obviate the need for it. The plunger can be depressed, under certain conditions, by the diver's shoulder. The safety locking pin prevents the plunger from moving. The current design sometimes results in the pin being knocked out by the diver's shoulder as well. Normally, depression of the plunger should not cause a problem. When properly adjusted, the neck clamp tends to stay closed. Thus, if the plunger is operated, the neck clamp does not open spontaniously. If the neck clamp tension is not properly adjusted (too tight) it tends to spring open when the plunger is depressed; releasing the helmet from the neck dam assembly. The best method of providing safe and secure locking of the assembly is to properly adjust the neck clamp tension and redesign the plunger/latch catch body to require two movement operation. The most obvious method would be a turn-then-push operation, keyed to adequate visual clues of alignment to aid the tender.

Although a divers' breathing gas heater is not required for surface supplied diving, the evaluation found the Kinergetics gas heater (model 3352) inadequate for saturation diving due to gas pressure limitations. A replacement for the model 3352, capable of operation at helmet gas delivery pressure of 185 psig over bottom pressure should be identified.

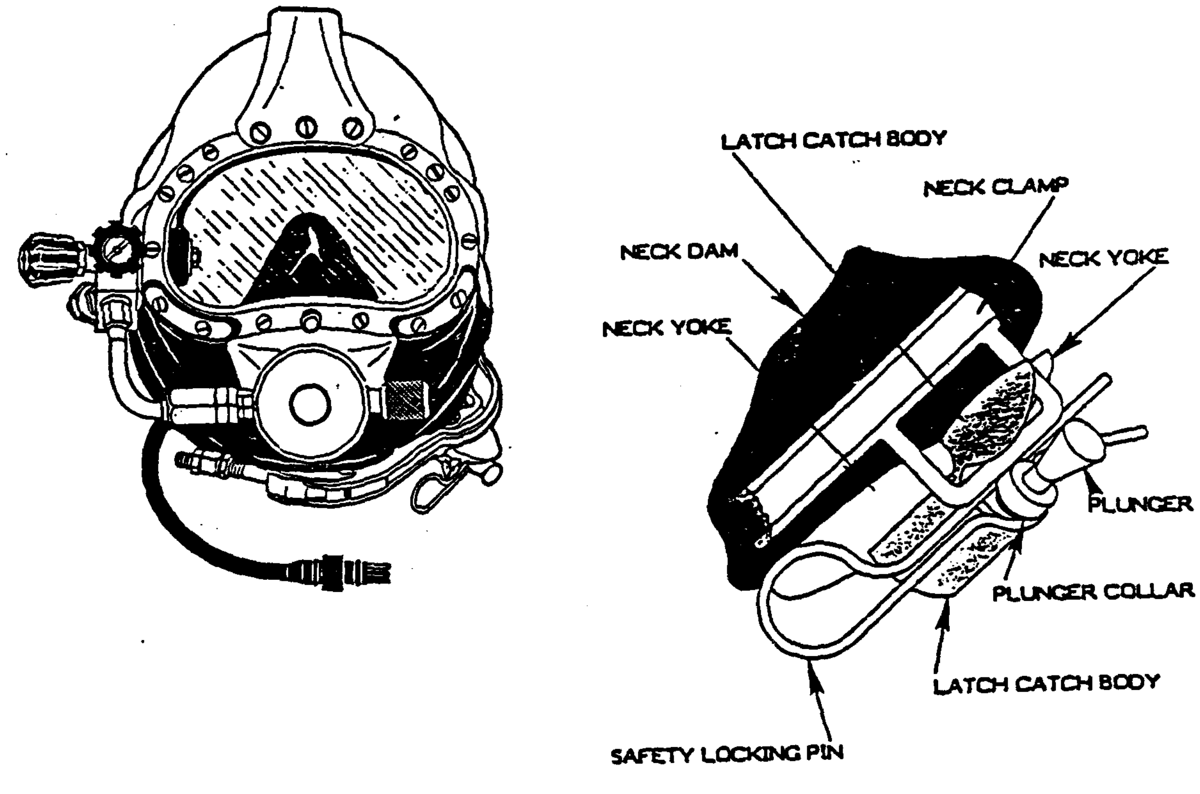

Figure 7. Neck Clamp Locking Arrangement

VI. CONCLUSIONS AND RECOMMENDATIONS

The SL-17B/NS and DSI-18B/NS proved to be extremely good diving systems that were highly praised by the test and evaluation divers. They are recommended for their intended uses. Specific comments are:

A. SL-17B/NS MOD 0

The proper fit of the helmet on the diver's head is solely dependent on the amount of padding inserted into the head cushion/liner. This is a highly personalized function. It is recommended that each diver in a command be issued a personal liner, to be custom padded by the diver.

The size of the oral nasal may be too large for a few divers. Alternative sizes are available. It is recommended that if commands determine any of their divers cannot comfortably use the standard size oral nasal, they procure the appropriate size.

The fit of the neck dam is instrumental in controlling water entry into the helmet and induced free flow of the regulator. Alterations must be done carefully, taking into account the conical shape of the neck dam and the resulting changes when the length is shortened. Individual issue, however, is not deemed necessary. It is recommended that commands produce two or three sizes, clearly labeled, to suit their divers.

Although the safety locking pin that will be supplied to the fleet is adequate, a better method of preventing accidental movement of the plunger can be found. It is recommended that the manufacturer be encouraged to develop such a method; that it be tested; and, if found acceptable, that it be retrofitted to the helmet by the appropriate commands.

The Kinergetics Breathing Gas Heater, model 3352 currently in use but no longer manufactured, will not support the helmet at the optimum over bottom pressure. It is recommended that a replacement be identified and supplied.

B. DSI-18B/NS

The above recommendations concerning replacement of the Kinergetics Gas Heater and oral nasal sizing apply to this mask as well.

C. SL-17B/NS MOD 1

This helmet met the NEDU unmanned performance specifications of reference 2. It is recommended for use in surface supplied and mixed gas diving to 190 and 300 FSW respectively at 35°F. Future evaluation is required to determine performance at 29°F.

The above recommendations concerning individual issue of head cushion/liners, oral nasal sizing, neck dam sizing, and development of an alternative plunger locking arrangement apply to this helmet as well.

VII. REFERENCES

1. Christopher J. Tarmey, LCDR, RN, "Unmanned Evaluation of Various Umbilical Supplied Open Circuit Demand UBA for PTC Diving," NEDU Report 11-86, September 1986.

2. James R. Middleton, Edward D. Thalmann, CDR, MC, USN, "Standardized NEDU Unmanned UBA Test Procedures and Performance Goals," NEDU Report 3-81, July 1981.

3. James R. Middleton, "Evaluation of the Diving Systems International Superlite 17B Helmet," NEDU Report 9-79, November 1979.

APPENDIX A1

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

STANDARD TEST PLAN

UNMANNED EVALUATION OF THE SUPERLITE 17NS AND HELIOX 18NS FOR SURFACE SUPPLIED AIR DIVING TO 190 FSW AND MIXED GAS DIVING TO 300 FSW

TEST PLAN NUMBER 86-34

NOVEMBER 1986

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References.

(a) NEDU Report 11-86
(b) NEDU Technical Memorandum TM86-10
(c) NAVSEA Task 86-44

1. Introduction. The DSI Superlite 17B and Heliox 18B fitted with the GSOL open circuit Ultraflow 500 demand regulator modification have been tested to 1000 FSW using appropriate HeO_2 mixtures for saturation diving. The results were reported in references (a) and (b). This configuration, now known as the Superlite 17NS and Heliox 18NS (Naval specification), was recommended for approval for open circuit saturation diving from PTCs.

Per reference (c) NEDU has been tasked to further evaluate both the Superlite 17NS and Heliox 18NS for surface supplied air diving to 190 FSW and mixed gas diving to 300 FSW. This will be achieved by unmanned testing in the NEDU EDF. Experience gained during previous testing has shown that the most consistent test results are obtained by testing the Ultraflow 500 in the bandmask rather than helmet [references (a) and (b)]. Accordingly, only the Heliox 18NS will be tested during this evaluation and the results will be considered representative of worst case Superlite 17NS diving.

The purpose of this test is to measure the breathing resistance and work of breathing of the Heliox 18NS through different umbilical sizes and lengths and to determine the best supply overbottom pressure for air and HeO_2 diving.

2. Personnel Requirements

a. LCDR C.J. Tarmey, RN is the Task Leader. He will be available throughout the test period.

b. EMC(DV) C.W. Clackley, USN will provide the bandmask to be tested and will ensure that it is properly fitted to the manikin.. He will have fully prepared it for testing in accordance with the manufacturers operation and maintenance manual, ensuring that the demand regulator is set up to the supply pressure to be tested. He will also provide the following:

(1) 300 ft. 3/8 in. ID divers umbilical.

(2) 300 ft. 1/2 in. ID divers umbilical.

(3) 600 ft. 1/2 in. ID divers umbilical.

(4) 600 ft. 3/8 in. ID divers umbilical.

(5) MK 1 adaptor whip.

EMC(DV) Clackley will be available throughout the test period.

c. Task personnel will instrument the helmet/mask to be tested.

d. Mr. Bill Mesplay, the manufacturers representative, may witness the testing.

3. Test Parameters

a. Equipment to be used:

(1) "C" breathing machine.

(2) EDF "C" chamber ark.

(3) EDF "C" chamber complex.

(4) Validyne pressure transducer w/1.00 psid diaphragm for inhalation/exhalation ΔP (1 ea).

(5) Validyne pressure transducer w/50 psi diaphragm for umbilical pressure drop.

(6) X-Y plotter.

(7) Gould strip chart recorder 3 channel:

(a) Channel 1 umbilical pressure drop.

(b) Oral ΔP.

(8) EDF bottlefield gas supply - 84/16 HeO_2
- Air

(9) EDF console gas supply regulator.

(10) EDF console "C" depth gauge.

(11) Test bandmask: Heliox 18BNS (DSI Heliox 18B with GSOL Ultraflow 500 conversion).

(12) Breathing machine piston position transducer.

(13) Bubble dampening mat.

(14) EDF HP 1000 breathing resistance computer program.

(15) Remote control actuator for adjustment of dial-a-breath at depth.

b. Logistic support:

(1) Bandmask to be tested.

(2) 300 ft. 3/8 in. ID umbilical and fittings.

(3) 300 ft. 1/2 in. ID umbilical and fittings.

(4) 600 ft. 1/2 in. ID umbilical and fittings.

(5) 600 ft. 3/8 in. ID umbilical and fittings.

(6) MK 1 adaptor whip.

(7) Air supply for chamber pressurization and air test runs.

(8) HeO_2 supply: 84/16 for mixed gas test runs to 300 FSW.

c. Parameters to be controlled:

(1) Breathing rate / tidal volume / RMV

(a) 15 BPM / 1.5 liters / 22.5 RMV

(b) 20 BPM / 2.0 liters / 40.0 RMV

(c) 25 BPM / 2.5 liters / 62.5 RMV

(d) 30 BPM / 2.5 liters / 75.0 RMV

(e) 30 BPM / 3.0 liters / 90.0 RMV

(2) Exhalation/inhalation time ratio: 1.00/1.00.

(3) Breathing waveform: sinusoid.

(4) Divers gas supply pressures: 145 psig and 185 psig overbottom.

(5) Incremental descent stops:

(a) Air test: 0 to 198 FSW in 33 FSW increments then 250 and 300 FSW.

(b) HeO_2 test: 0 to 198 FSW in 33 FSW increments then 250 and 300 FSW.

(6) Ark water temperature: ambient.

d. Parameters to be measured:

(1) Inhalation peak ΔP in CmH_2O.

(2) Exhalation peak ΔP in CmH_2O.

(3) ΔP vs. volume plots breathing work in Kg·m/ℓ.

(4) Umbilical pressure drop in psig.

e. Parameters to be computed: respiratory work from pressure vs. volume plots.

f. Data to be printed:

(1) Inhalation max pressure at each depth and RMV.

(2) Exhalation max pressure at each depth and RMV.

(3) Respiratory work at each depth and RMV.

(4) Umbilical pressure drop at each depth and RMV.

4. Test Procedure. Air testing will be conducted using 300 ft. 3/8 in. ID, 300 ft. 1/2 in. ID, and 600 ft. 3/8 in. and 1/2 in. ID umbilicals at both 145 and 185 psig overbottom supply pressures. Mixed gas testing will be conducted using a 600 ft. 1/2 in. ID umbilical at both 145 and 185 psig overbottom supply pressure. The following procedure will be followed for each test:

a. (1) Ensure that bandmask is set to specification and is working properly. Ensure good oral nasal seal on manikin head.

(2) Chamber on surface.

(3) Calibrate transducers.

(4) Open divers gas supply valve to regulator and set required supply overbottom pressure.

(5) Adjust dial-a-breath to a slightly positive free flow then back off until 1 psid pressure diaphragm (oral ΔP) indicates 0 psig.

(6) Adjust breathing machine to 1.5 liters tidal volume and 15 BPM and take data.

(7) Adjust breathing machine to 2.0 liters tidal volume and 20 BPM and take data.

(8) Adjust breathing machine to 2.5 liters tidal volume and 25 BPM and take data.

(9) Adjust breathing machine to 2.5 liters tidal volume and 30 BPM and take data.

(10) Adjust breathing machine to 3.0 liters tidal volume and 30 BPM and take data.

b. Pressurize chamber to 33 FSW and repeat steps (a)(5) to (a)(10).

c. Data is then to be taken at 33 FSW increments to 198 FSW and at 250 FSW and 300 FSW.

5. Program. Testing is scheduled to be conducted as soon as possible after the 1986 EDF overhaul. Six days (two runs per day) of testing are needed.

6. Safety Rules. As specified in the EDF Operating Manual.

7. Report Production. All data will be reduced and an NEDU report will be written by the Task Leader upon completion.

APPENDIX A2

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

STANDARD TEST PLAN

UNMANNED TESTING OF SUPERLITE 17B/NS

TEST PLAN NUMBER 87-27

OCTOBER 1987

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Ref: (a) NAVSEA Task 86-44
(b) NEDU Test Plan 86-34
(c) NEDU Test Plan 87-16
(d) NAVSEA Task 86-44A
(e) NEDU Test Plan 3-81

1. Introduction

a. Reference (a) requires that the Superlite 17B/NS and DSI 18B/NS be tested for use in surface supplied diving to 190 FSW in air and 300 FSW in HeO_2. It had been planned that the following schedule would be adhered to:

March 87 -	Unmanned testing to 190 FSW breathing air and 300 FSW breathing HeO_2.
Aug 87 -	Manned testing to 190 FSW during a series of archeological dives in Pensacola.
Sep 87 -	Immediately on return from Pensacola unmanned testing to confirm that there wasn't appreciable deterioration performance after four weeks in the field.
Apr 88 -	Umbilical supplied diving to 300 FSW breathing HeO_2 during Deep Dive 88.

b. The unmanned testing during March [reference (b)] uncovered an anomaly in that the rig appeared to breath better off the 3/8 inch diameter hose than it did off the ½ inch diameter hose.

c. Both the manned test [reference (c)] and the unmanned testing during September suggested that under certain conditions and workloads the rig had a tendency to force air to the diver, especially if the dial a breath was set incorrectly.

d. The high overbottom pressure recommended by the manufacturer rendered the rig incompatible with existing USN air sources and so NEDU was further tasked [reference (d)] to test the rig at a lower over bottom pressure (135 psi).

e. Consequently it has been decided to run a further series of unmanned tests to determine the optimum over bottom pressure and to investigate the effect on the work of breathing of adjustments to the "dial-a-breath."

f. In addition to this unmanned testing further manned tests have been scheduled for November/December 1987.

2. Personnel Requirements. As per EDF departmental orders.

3. Test Parameters. As per reference (e).

4. Instrumentation. As per reference (e).

5. Test Procedure

a. Unmanned testing is to be conducted in accordance with standard NEDU procedures [reference (e)]. Work of breathing is to be measured for light, medium and heavy work at depths to 190 FSW using 125, 135, and 145 psi over bottom pressure.

b. The effect of detuning the balanced regulator is to be investigated. The optimum over bottom pressure is to be determined with the regulator set up as per the manufacturers instructions. The dial-a-breath is then to be turned two, four, and eight turns in both directions. At each setting, work of breathing will be measured at 0, 33, 66, 132, and 190 FSW during light, moderate and heavy workloads.

6. Preliminary Arrangements. One 18B/NS bandmask and 600 ft. of ½ inch diameter umbilical to be prepared and delivered to EDF.

7. Program. Testing to be conducted in accordance with EDF program and priorities.

8. Safety Rules and Emergency Procedures. As per reference (e).

9. Report Production. Manned testing will be the subject of a separate test plan and a report combining all testing will be produced.

APPENDIX B

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

STANDARD TEST PLAN

MANNED EVALUATION OF THE SUPERLITE 17B-NS AND HELIOX 18B-NS FOR SURFACE SUPPLIED AIR DIVING TO 190 FSW AND VALIDATION OF THE OP'S AND EP'S OF THE SUPERLITE 17B-NS, HELIOX 18B-NS AND AGA DIVATOR MK II

TEST PLAN NUMBER 87-16

JULY 1987

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Appendix A1	Premission Maintenance Checklist - SL-17B/NS	A1-1 thru A1-3
Appendix A2	Predive Setup Checklist (First Dive) - SL-17B/NS	A2-1 thru A2-3
Appendix A3	Predive Setup Checklist (Repeat Dive) -SL-17B/NS	A3-1 thru A3-3
Appendix A4	Diving Supervisor's Checklist - SL-17B/NS	A4-1 thru A4-5
Appendix A5	Postdive Maintenance Checklist - SL-17B/NS	A5-1 thru A5-3
Appendix A6	Emergency Procedures SL-17B/NS- DSI-18B/NS	A6-1 thru A6-4
Appendix B	Pensacola OP ORD	B-1 thru B-5
Appendix C	Training Memo	C-1 thru C-3
Appendix D	Human Factors Questionnaire	D-1 thru D-7

References

(a) NAVSEA Task 86-44
(b) NEDU Test Plan 83-60
(c) NEDU ltr Ser 032/476 of 11 Sep 86
(d) NEDU Test Plan 86-11
(e) NEDU Technical Memorandum TM86-10
(f) NEDU Test Plan 86-34
(g) NAVSEA Task 86-62

1. Introduction. Reference (a) directed NEDU to evaluate the Superlite 17B-NS and Heliox 18B-NS for surface supplied air diving to 190 FSW and surface supplied HeO_2 diving to 300 FSW.

The Superlite 17B and Heliox 18B (not fitted with Gas Services Ultraflow 500 regulator) had been evaluated for HeO_2 diving to 1000 FSW [reference (b)]. Incorporation of the Ultraflow 500 regulator affected only rig breathing resistance, reference (c). Additional testing therefore was limited to unmanned.

Reference (d) tested the 17B-NS and 18B-NS for HeO_2 saturation diving to 1000 FSW. Reference (e) reported that both rigs performed within NEDU specifications for saturation diving and were subsequently presented for certification.

Unmanned testing of the 17B-NS and 18B-NS with both 3/8 inch and 1/2 inch supply hoses, to 190 FSW on air and 300 FSW on HeO_2 was successfully completed in March 1987 [reference (f)]. This completes testing in the HeO_2 mode. The requirements of reference (a) will therefore be met upon completion of manned testing to 190 FSW in the air mode.

In addition reference (g) requires that NEDU validate the OP's, EP's, and supervisors check off sheet of the MK 17B-NS, 18B-NS and AGA Divator MK II, Enclosed Space Diving System (ESDS) as written under contract by Matrix Marine (APPENDIX A).

NEDU has been further tasked to conduct a series of exploratory dives on 13 objects in the Pensacola area suspected of being of archeological interest. These dives will take place over a period of 4 weeks beginning early August 1987.

Although the maximum depth in the area is approximately 60 FSW, it is considered that the number of dives and the variation of currents and conditions encountered will be such that any equipment used will be given a rigorous evaluation. Therefore the opportunity will be taken to combine the three tasks.

2. Safety, Personnel, Responsibilities, and Routines will be covered in APPENDIX B (Pensacola OP ORD).

3. Training. All divers will be trained in the use of the equipment in accordance with APPENDIX C (Training Memo) prior to the dives.

4. <u>Data and Validation</u>. OPs and Supervisor Check List (Appendix A for Superlite 17B/NS and DSI 18B/NS) validation will be conducted by assigned Diving Officers, Master Divers, Diving Supervisors, and divers. The validation will include hands on walk thru and actual pre/post mission and pre/post dive procedures. Discrepancies and recommended changes will be annotated on working copies of the OPs, signed by the individual making changes and turned over to the project officer for compilation. The project officer will ensure that all changes are compiled into a single working copy, re-verified and incorporated into the finished report.

OPs and Supervisor Check List for AGA Divator MK II are found in the O&M Manual which will be provided by NCSC Code 3410. The same procedures discussed in the paragraph above will be followed in verifying the AGA O&M manual.

EP validation will be conducted with scenarios given by the project officer. These scenarios will be walked thru (dry) to ensure that actions listed in the EPs can be accomplished, give the desired results and are safe. All EPs will be annotated by Projects Officer, Diving Officer, Master Diver, Diving Medical Officer, and divers. These recommended changes will be compiled into a single working copy, re-verified and incorporated into the finished report.

All divers will be instructed in completing the diver questionnaire, Appendix D. This questionnaire will be completed after each dive by the diver and compiled by the Project Officer.

5. <u>Report Production</u>. Conclusions from the manned testing will be combined with the results of the unmanned testing [reference (f)] in a single report.

APPENDIX A-1
PREMISSION MAINTENANCE CHECKLIST — SUPERLITE-17B/NS

Date	Helmet No.
Excursion - Dive No.	Umbilical No.
Diver Name	Color Code
EGS Cylinder No.	

STEP/ACTION	COMMENTS	INITIALS
INVENTORY		
Inventory Superlite-17B/NS and ancillary equipment to be sure all component assemblies are complete and on hand.	Helmet____ Neckdam/Yoke_____ Umbilical____ Comm Set_______ Emer Cyl________	
HELMET ASSEMBLY		
CAUTION: DO NOT overtighten any binder head capscrews on faceplate retainer. If found loose, tighten until snug.		
1. Inspect for loose, damaged, or missing parts. DO NOT overtighten screws and nuts.		
2. Inspect helmet shell, and faceplate for gouges, chips, and deep scratches. If scratches are 1/32 inch deep and more than 1 inch long, replace part or select alternate helmet.		
3. Visually inspect the exterior and interior of the helmet for good condition.		
4. Ensure screws and fasteners on handle and weights are sealed with RTV.		
5. Inspect the bent tube assembly for dents or other damage.		
6. Inspect the oral-nasal assembly to ensure it is positioned on the regulator mount nut properly.		
7. Be sure neck clamp/yoke assembly and latch catch mechanism are clean and undamaged. Check neck clamp for smooth operation and positive seal of shell. Lubricate neck clamp with approved lubricant.		
8. Remove foam from head cushion and inspect head cushion to be sure cap, strap, and foam are clean, intact and in good condition.		

APPENDIX A-1
PREMISSION MAINTENANCE CHECKLIST — SUPERLITE-17B/NS - Continued

STEP/ACTION		COMMENTS	INITIALS
HELMET ASSEMBLY - Continued			
9.	Inspect microphone, earphones, wires, and communication connectors to be sure they are clean and undamaged. Perform communications check.		
10.	Perform air train check (Para 2-3.1.1._). Clean as necessary.		
11	Lubricate sliding O-rings and exhaust valves.		
12.	Perform one-way valve check (Para 2-3.1.1._).		
13.	Check demand regulator, defogger control valve, EGS knob, and nose block device knob to ensure smooth and proper operation.		
14.	Ensure protective caps are installed on air/gas inlet and EGS valve.		
EGS CYLINDER ASSEMBLY			
1.	Inspect for loose, damaged, or missing parts.		
2.	Inspect harness straps, buckles, and fasteners for wear or damage.		
3.	Ensure EGS cylinder is fitted with a regulator which reduces gas pressure to less than 220 psi overbottom pressure. Regulator must have a minimum of two low pressure ports: one for EGS hose and a second for over-pressure relief valve. Adjust regulator to required overbottom pressure (Para 2.3.1.2._).		
4.	Perform leak check on EGS cylinder using leak detector solution.		
HOT WATER SUIT OUTFIT OR OTHER THERMAL PROTECTION SUIT			
1.	Inspect for cuts, tears, and abrasion of materials.		
2.	Diver - Ensure suit fits.		

PRELIMINARY DRAFT

APPENDIX A-1
PREMISSION MAINTENANCE CHECKLIST — SUPERLITE-17B/NS - Continued

STEP/ACTION	COMMENTS	INITIALS
HOT WATER SUIT OUTFIT OR OTHER THERMAL PROTECTION SUIT - Continued		
3. Inspect fasteners for dirt and damage. Lubricate zipper with approved lubricant.		
4. Inspect manifold control or inlet valve for dirt, debris, or damage.		
5. Check operation of dump valves/exhaust valves.		
UMBILICAL ASSEMBLY		
1. Inspect hoses and fittings for date of manufacture/testing and for damage or extensive wear.		
2. Inspect all umbilical lashing and taping for cuts or fraying.		
3. Inspect strain relief shackle for proper locking/unlocking function.		
4. Inspect electrical cable and connectors for damage, dirt, and debris. Ensure insulation is intact.		
ANCILLARY EQUIPMENT		
1. Inspect test and tool kits for completeness.		
2. Inspect boots, swim fins, gloves, dive knife, and dive light for damage or serviceability.		

PERFORMED BY: ______________________
Name and Signature

NOTED AND CHECKED BY: ______________________
Diving Supervisor's Signature

05

APPENDIX A-2
PREDIVE SETUP CHECKLIST (First Dive) — Superlite — 17B/NS

Date	Dive Depth FSW
Excursion - Dive No.	Chamber Depth FSW
Diver Name	Gas Mix Air or He %O_2 %
Color Code	Emer Gas Mix Air or He %O_2 %
Helmet No.	Umbilical No.
NOTE: See Table 2-3 of manual for detailed procedures.	

STEP/ACTION	CHECK/READING
1. Fill in data required in upper portion of form.	
2. Ensure Premission Maintenance Inspection is completed.	
3. Visually inspect exterior helmet shell for cracks or damage. Check faceplate retainer screws for snugness. Do not overtighten. Inspect faceplate.	
4. Inspect neckdam for tears or deterioration of seams.	
5. Visually inspect demand regulator cover.	
6. Visually inspect bent tube assembly.	
7. Inspect oral-nasal mask for tears or deterioration. Ensure it is properly seated on the regulator mount nut.	
8. Visually inspect interior of helmet. Inspect head cushion. Ensure communication wires are connected properly.	
9. Inspect neck clamp assembly. Ensure latch catch mechanism properly seals neck dam against helmet.	
10. Check all moving parts (defogger control valve, EGS valve, nose block device, demand regulator).	
11. Test one-way valve for proper operation.	
12. Connect umbilical to gas source.	
13. Hold open end of umbilical. Open umbilical gas supply valve and blow through to clear umbilical.	
14. Close umbilical gas supply valve.	
15. Connect umbilical hose and communications cable to helmet. CAUTION: When connecting umbilical to helmet, use two wrenches. Do not use excessive force. Connection between hose and helmet should only be snug.	

PRELIMINARY DRAFT

APPENDIX A-2
PREDIVE SETUP CHECKLIST (First Dive) — Superlite — 17B/NS - Continued

STEP/ACTION	CHECK/READING
16. Perform communications check.	
17. Pressure check EGS cylinder and ensure proper cylinder mix.	_____psig _____%Mix
18. Close defogger valve.	
19. Connect EGS hose to EGS valve.	
20. Open EGS cylinder valve and EGS valve open demand regulator valve until a slight steady flow is received.	
21. Close EGS valve and EGS cylinder valve.	
22. Close demand regulator. Turn on umbilical gas. Open regulator valve until a slight steady flow is received.	
23. Check breathing gas flow. Adjust defogger valve, demand regulator, press purge button. Turn off umbilical gas.	
24. Adjust nose block fully outward.	

APPENDIX A-2
PREDIVE SETUP CHECKLIST (First Dive) — Superlite — 17B/NS - Continued

List any deficiencies in Superlite-17B/NS found during predive setup:

ATTACH CYLINDER LABEL HERE

Serial Number: ____________________
Filled By: ____________________
Checked By: ____________________
Date Filled: ____________________
Mix %: - ____________________
Manifold PSIG: ____________________

(If label is illegible, record information.)

SET UP BY: ____________________
Name & Signature

NOTED AND CHECKED BY: ____________________
Diving Supervisor

APPENDIX A-3
PREDIVE SETUP CHECKLIST (Repeat Dive) — Superlite — 17B/NS

Date	Dive Depth FSW
Excursion - Dive No.	Chamber Depth FSW
Diver Name	Gas Mix Air or He %O2 %
Color Code	Emer Gas Mix Air or He %O2 %
Helmet No.	Umbilical No.
NOTE: See Table 2-3 of manual for detailed procedures.	

STEP/ACTION	CHECK/READING
1. Fill in data required in upper portion of form.	
2. Rinse equipment thoroughly.	
3. Visually inspect exterior helmet shell for cracks or damage. Check faceplate retainer screws for snugness. Do not over-tighten. Inspect faceplate.	
4. Inspect neckdam for tears or deterioration of seams.	
5. Visually inspect demand regulator cover.	
6. Visually inspect bent tube assembly.	
7. Inspect oral-nasal mask for tears or deterioration. Ensure it is properly seated on the regulator mount nut.	
8. Visually inspect interior of helmet. Ensure communication wires are connected properly.	
9. Inspect neck clamp assembly. Ensure latch catch mechanism properly seals neck dam against helmet.	
10. Check all moving parts (defogger control valve, EGS valve, nose block device, demand regulator).	
11. Pressure check EGS cylinder and ensure proper cylinder mix. Check data on cylinder predive label and attach label to end of checklist.	______psig ______%Mix
12. Close defogger valve.	
13. Connect EGS hose to EGS valve.	
14. Open EGS cylinder valve and EGS valve. Open demand regulator valve until a slight steady flow is received.	
15. Close EGS valve and EGS cylinder valve.	

APPENDIX A-3
PREDIVE SETUP CHECKLIST (Repeat Dive) — Superlite — 17B/NS - Continued

STEP/ACTION	CHECK/READING
16. Close demand regulator. Turn on umbilical gas. Open demand regulator valve until a slight steady flow is received.	
17. Check breathing gas flow. Adjust defogger valve, demand regulator, press purge button. Turn off umbilical gas.	
18. Adjust nose block knob fully outward.	

APPENDIX A-3

PREDIVE SETUP CHECKLIST (Repeat Dive) — Superlite — 17B/NS - Continued

List any deficiencies in Superlite-17B/NS found during predive setup:

ATTACH CYLINDER LABEL HERE

Serial Number: ______________
Filled By: ______________
Checked By: ______________
Date Filled: ______________
Mix %: ______________
Manifold PSIG: ______________

(If label is illegible, record information.)

SET UP BY: ______________________
Name & Signature

NOTED AND CHECKED BY: ______________________
Diving Supervisor

APPENDIX A-4
DIVING SUPERVISOR'S CHECKLIST - SUPERLITE-17B/NS

Date - Time of Excursion		Chamber Depth	FSW
Excursion - Dive No.		Max Diver Depth	FSW
Water Temperature	°F	Supply Gas Regulator Setting	PSIG
	STANDBY	RED	YELLOW
Diver Name			
Tender Name			
NOTE: See Tables 2-4 thru 2-7 of manual for detailed procedures.			

STEP/ACTION	CHECK/READING	
DONNING PROCEDURES	RED DIVER	YELLOW DIVER
1. **Supervisor - Ensure completion of predive checks:** a. Premission Maintenance Checklist (Appendix A-1) ___. b. Predive Checklist (First Dive, A-2) ___.		
2. Don wet suit if appropriate.		
3. Don thermal protection suit if necessary.		
CAUTION - Do not use an aerosol spray on faceplate. 4. Diver - Apply a thin film of anti-fogging solution to the face plate with a soft cloth.		
5. Close demand regulator.		
6. Tender - Ensure umbilical is connected to side block assembly; activate breathing gas flow to umbilical.		
7. Open demand regulator and defogger control so gas flow will be steady.		
8. Tender - Assist diver with donning of EGS and adjust straps for fit.		
WARNING: Turn upper edge of neck dam UP and OUT. 9. Don neck clamp/yoke assembly. Pull neck dam down over head. Fold neck dam UP and OUT.		
10. Tender - Position helmet, upside down, with head cushion neck strap sticking out.		
11. Grasp neck strap, don helmet, and adjust until aligned and comfortable. Fasten head cushion neck strap.		
12. Pushing neck clamp/yoke rearward, place rear hinge tab on alignment sleeve. Pull neck ring forward and then up. Grasp handle and steady helmet, while pushing neck ring up into place. Swing clamp lever to left until it snaps closed locking ring on helmet.		

APPENDIX A-4
DIVING SUPERVISOR'S CHECKLIST - SUPERLITE-17B/NS - Continued

STEP/ACTION	CHECK/READING	
DONNING PROCEDURES - Continued	RED DIVER	YELLOW DIVER
13. Feel lever and latch catch mechanism to ensure it is correctly engaged and locked.		
14. Tender - Connect EGS hose to EGS valve on side block.		
15. Close EGS valve. Open cylinder valve to pressurize hose. Listen for sound of gas entering hose and for leaks.		
16. Tender - Connect umbilical strain relief shackle to diver's harness.		
17. Tender - Ask, BREATHING OK DIVER?		
18. Tender - Report DIVER ON GAS. Timekeeper record ON GAS time.		
EQUIPMENT CHECKS PRIOR TO ENTRY INTO WATER		
1. Diver - Checkout breathing system: Operate defogger demand regulator adjust valves to ensure proper operation. Check breathing resistance: breathe in and out. Press demand regulator purge button to check gas purge.		
2. Diver and tender - Perform communications check - sending and receiving.		
3. Check helmet connections for leaks with "snoop" or soapy water.		
4. Tender - Check accessories: boots/fins, knife, weights, diver tools, diver light, other.		
5. Diving Supervisor - Check STANDBY DIVER READY TO ENTER WATER.		
6. Tender - Check thermal protection suit.		
7. Tender - Check entire rig; latch catch mechanism, hose connections, harness, strain relief, gas flow to diver.		
8. Notify Diving Supervisor, DIVER READY.		
9. Tender - Assist diver into water. Timekeeper - Record IN WATER TIME.		

APPENDIX A-4
DIVING SUPERVISOR'S CHECKLIST - SUPERLITE-17B/NS - Continued

STEP/ACTION	CHECK/READING	
	RED DIVER	YELLOW DIVER
IN WATER CHECKS		
1. Divers - RIG BREATHING OK.		
2. Supervisor - Perform COMMUNICATIONS CHECK (all stations).		
3. Diver - Ensure helmet is watertight.		
4. Divers - Hold breath and check each other for leaks.		
5. Divers - Check partner's equipment.		
6. Adjust harness straps for in water fit.		
7. Divers - Report BUOYANCY OK.		
8. Divers - Report THERMAL PROTECTION SUIT OK.		
9. Divers - Report READY TO GO TO WORK SITE.		
10. Divers - Report when leaving surface (LS).		
11. Divers - Readjust demand regulator as required during descent.		
POSTDIVE CHECKS		
1. Divers - Report when leaving bottom, reaching decompression stops, and REACHING SURFACE (RS). Timekeeper - Record times as required.		
2. Diver - Exit water. Tender assists.		
3. Tender - Open latch catch mechanism and swing open neck clamp.		
4. Tender - Lift helmet forward and up to remove. Diver - After removal, hold helmet.		
5. Tender - Report OFF GAS. Diver - Report DIVER OK.		
6. Tender - Close valve on EGS valve cylinder.		

APPENDIX A-4
DIVING SUPERVISOR'S CHECKLIST - SUPERLITE 17B/NS - Continued

STEP/ACTION	CHECK/READING	
POSTDIVE CHECKS - Continued	RED DIVER	YELLOW DIVER
7. Tender - Turn off umbilical gas.		
8. Diver - Open EGS valve and defogger control valve to vent EGS hose.		
9. Tender - Disconnect EGS hose from side block.		
10. Tender - Disconnect umbilical strain relief from diver harness and set helmet aside.		
11. Tender - Remove EGS and harness from diver.		
12. Diver - Pull neck dam up and off head.		
13. Tender - Place neck clamp/yoke assembly with helmet.		
14. If last dive, proceed with checklist. If repeat dive, proceed with repeat dive procedure.		
15. Tender - Disconnect umbilical from helmet. Place protective caps over air inlet and EGS valve inlet.		
16. Tender - Inspect rig; rinse equipment thoroughly with fresh water.		
17. Perform postdive maintenance checklist. Clean and lubricate as necessary.		

APPENDIX A-4
DIVING SUPERVISOR'S CHECKLIST - SUPERLITE-17B/NS - Continued

STEP/ACTION	CHECK/READING		
DIVE STATISTICS SUMMARY	STANDBY DIVER	RED DIVER	YELLOW DIVER
Helmet Assembly No.			
EGS No.	Not applicable.		
Time Off Gas			
Time On Gas			
Total Gas Time			
Time Reached Surface (RS)			
Time Left Surface (LS)			
Total Time of Dive (TTD)			

List any deficiencies concerning helmet, EGS, thermal protection equipment, umbilical assembly, etc., found during predive, dive, or postdive equipment checks:

Diving Supervisor's Signature

Diving Officer's Signature

APPENDIX A-5
POSTDIVE MAINTENANCE CHECKLIST — SUPERLITE-17B/NS

Date	Excursion - Dive No.
Diver Name	Helmet No.
Color Code	EGS No.

STEP/ACTION	COMMENTS	INITIALS
INVENTORY		
Inventory Superlite-17B/NS and ancillary equipment to be sure all component assemblies are complete and on hand.		
MAINTENANCE ACTIONS REQUIRED		
Repair or replace all defective items prior to next excursion or dive.		
HELMET SHELL AND NECK CLAMP/YOKE ASSEMBLIES		
1. Inspect helmet assembly for damage, loose or missing parts, and dirt. Check all component screws for tightness.		
2. Inspect neck clamp/yoke assembly to ensure it operates smoothly and engages the latch catch assembly.		
3. Remove and inspect head cushion for tears, rips, or crumbling. Let air dry or replace if necessary.		
4. Remove, dry and store earphones.		
5. Inspect faceplate and helmet shell for gouges, chips, deep scratches, and cracks. If scratches are 1/32 inch deep and more than 1 inch long, replace faceplate or helmet shell.		
NOSE BLOCK DEVICE		
1. Remove the nose block device packing nut. Inspect for damage and repair as necessary.		
2. Lubricate the two O-rings and main shaft.		
3. Replace nose block device packing nut.		

APPENDIX A-5
POSTDIVE MAINTENANCE CHECKLIST — SUPERLITE-17B/NS - Continued

STEP/ACTION	COMMENTS	INITIALS
SIDE BLOCK ASSEMBLY		
1. Inspect one-way valve to ensure it is clean and undamaged.		
2. Inspect defogger control valve to ensure it is clean and undamaged.		
3. Open and close defogger control valve knob to ensure valve turns smoothly.		
4. Inspect EGS valve to ensure it is clean and undamaged.		
5. Open and close EGS valve knob to ensure valve turns smoothly.		
REGULATOR		
1. Visually inspect for dents or other external damage.		
2. Turn demand regulator valve fully in and then fully out.		
3. Press the purge button a few times to ensure the valve resets correctly.		
4. Remove rubber whisker and lubricate demand regulator exhaust valve. Replace whisker.		
EXHAUST VALVE		
1. Remove screws and exhaust valve cover.		
2. Inspect for any debris, dirt, or damage and clean. Repair as necessary.		
WATER DUMP VALVE		
1. Remove screws and exhaust valve cover.		
2. Inspect for any debris, dirt, or damage and clean. Repair as necessary.		

APPENDIX A-5
POSTDIVE MAINTENANCE CHECKLIST — SUPERLITE-17B/NS - Continued

STEP/ACTION	COMMENTS	INITIALS
EGS CYLINDER ASSEMBLY		
1. Visually inspect cylinder and first stage regulator.		
2. Check cylinder, record psig.		psig_____
UMBILICAL ASSEMBLY		
1. Flush exterior with fresh water.		
2. Inspect electrical cable and hoses for cracks or other damage. Inspect bindings and umbilical rings for wear and damage.		
3. Inspect swivel snap shackle for wear and damage.		
4. Inspect electrical connector to ensure it is clean and undamaged. Check O-rings.		
5. Inspect for loose hot water hose clamps.		
6. Inspect coupling nuts for thread damage preventing proper alignment or hookup.		
ANCILLARY EQUIPMENT		
1. Check light for intensity and leakage, repair as necessary.		
2. Inspect gloves, swim fins, dive knife, and boots for tears or deterioration.		

PERFORMED BY: ______________________________
Name and Signature

NOTED AND CHECKED BY: ______________________________
Diving Supervisor's Signature

2-5 EMERGENCY PROCEDURES

These procedures address actions to control mechanical problems of the diving equipment while it is in use. Medical emergency procedures are covered in the U.S. NAVY DIVING MANUAL. Emergency situations which involve the Superlite-17B/NS or the DSI-18B/NS demand immediate action by the diver and support personnel. In each situation, the dive partner must go to the aid of the diver experiencing the emergency.

WARNING

If any underwater emergency occurs notify dive station and dive partner immediately. Do not ditch the helmet. Failure to follow prescribed emergency procedures may result in injury or death to diver.

2-5.1 HELMET FLOODING. In the event of partial or complete flooding, the diver should perform the following actions.

a. Immediately assume an upright position with head tilted to the left.

b. Immediately open defogger control valve (turn knob outward - counterclockwise) or press demand regulator purge button.

c. Report condition.

d. After clearing water from helmet, check for additional leaks.

e. If helmet continues to take on water, fully open demand regulator valve.

f. Return to dive station without delay. (Dive partner accompanies diver to dive station.)

2-5.2 BREATHING DIFFICULTY - INHALATION RESISTANCE. If breathing becomes difficult because of increased breathing resistance, the diver should perform the following actions.

a. Open demand regulator valve for easier breathing - turn outward (counterclockwise).

b. Report breathing difficulty or present condition.

c. Topside/PTC operator - Check breathing gas supply overbottom pressure.

d. If inhalation resistance continues, press demand regulator purge button to obtain an increased flow of gas.

e. If gas flow is still inadequate, turn defogger control knob outward to open defogger valve.

f. If gas flow does not increase, turn EGS valve control knob outward (counterclockwise), admitting flow from EGS cylinder.

WARNING

Use of defogger control valve with emergency gas supply will accelerate expenditure of emergency gas.

g. Return to dive station without delay. *(Dive partner accompanies* diver to dive station.)

2-5.3 UMBILICAL GAS SUPPLY FAILURE. If breathing gas flow stops, the diver should perform the following actions.

a. Open helmet EGS valve by turning control knob outward (counterclockwise). (This will admit EGS flow to diver.)

b. Report loss of umbilical gas flow.

WARNING

Use of defogger control valve with emergency gas supply will accelerate expenditure of emergency gas.

c. If there is still no flow from demand regulator, turn defogger control knob outward to open defogger valve.

d. Return to dive station without delay. (Dive partner accompanies diver to dive station.)

e. When on surface and out of the water, remove helmet at once before emergency gas is expended.

2-5.4 DEMAND REGULATOR FREE FLOW. If the demand regulator is open and free flows, gas the diver should perform the following actions.

a. Adjust demand regulator knob inward (clockwise) to stop free flow condition.

b. Report demand regulator free flowing or other condition.

c. If free flow cannot be stopped, report your situation and return to dive station with dive partner.

2-5.5 FOULED OR PINNED UMBILICAL. If umbilical is entangled, the diver should perform the following actions.

a. Report situation and attempt to free entanglement (if possible).

b. If umbilical cannot be freed, await Diving Supervisor instructions and arrival of dive partner. (Dive partner assists diver throughout situation.)

c. With dive partner's assistance, attempt to free umbilical. If umbilical cannot be freed, request further insturctions from Diving Supervisor.

d. If ordered by diving supervisor to switch to EGS and to disconnect from the umbilical, perform steps e through g.

e. Check EGS cylinder submersible pressure gauge to confirm adequate supply of gas.

f. Open helmet EGS by turning control knob outward (counterclockwise).

g. Ensure rig is delivering breathing gas properly.

h. Dive partner or standby diver - Disconnect umbilical.

i. Return to dive station with dive partner.

2-5.6 SUMMARY OF EMERGENCY PROCEDURES. The emergency procedures described above in Paragraphs 2-5.1 through 2-5.5 are summarized in Table 2-16.

2-5.7 REPORTING CONSIDERATIONS. Circumstances of the emergency incident may dictate the completion of a Failure Inadequacy Report (FIR) and an Equipment Accident/Incident Report as specified in U.S. Navy Diving Manual, Volume 2, Appendix B.

APPENDIX B

PENSACOLA ARCHEOLOGICAL PROJECT OP ORD

SECTION 1. INTRODUCTION AND OBJECTIVES

A. Introduction. NEDU has been tasked to assist in the Underwater Archeological Survey in Pensacola in support of the Gulf Coast Homeporting Environmental Impact Statement. It has been decided that the opportunity would be taken to complete several NAVSEA Tasks at the same time.

B. Objectives. NEDU has been requested to survey fourteen contacts suspected of being of historic interest. To run concurrently with this task will be Task 86-44 (testing of Superlite 17 BNS and DSI 18 BNS Surface Supplied) and Task 86-62 (Validation of 17 BNS, 18 BNS and AGA Divator MK 11 OPs and EPs).

SECTION 2. ORGANIZATION: Personnel assignments are listed in APPENDIX C.

A. Projects Officer is responsible for:

1. Personnel Coordination

2. Equipment Coordination

3. Safety

4. Liaison with local authorities

5. Liaison with local Archeologist (Army Engineers Corps subcontractors)

B. Training Officer: Will be responsible for ensuring that all divers are properly trained in all equipments to be used during the project per the training memo, APPENDIX C.

C. Logistic Supervisor: The Logistic Supervisor will be responsible for the movements and transportation of all materials and equipment within the operation.

SECTION 3. ROUTINE: Diving will be conducted from the MV Paul Langevin III. The Langevin will berth at NAS Pensacola on a nightly basis. The times and frequency of the dives will be dependent upon sea and tidal conditions.

The dives will also be dependent upon the requirements of the on site archeologist, who will liaise with the Master Diver in charge of the side.

The Project Officer or his appointed assistant will be in charge of the divers at all times.

SECTION 4. DRESS: Dress each day will be UDT's, blue and golds, safety shoes. Dress to and from the work site each day will be civilian clothes. Dress when conducting any business within Naval Air Station will be Navy working uniform.

SECTION 5. MEDICAL EMERGENCY: Medical emergencies will be dealt with in accordance with existing Naval Air Station procedures (see Tables B-1, B-2).

SECTION 6. COMMUNICATIONS: VHF Marine Band Channel 16 is monitored by Port Operations Navy Pensacola Control (Table B-1).

SECTION 7. DATA GATHERING: Data on the contacts will be collected under the direction of the Project Archeologist. Data on Task 86-44 will be compiled by each diver filling out the Human Factors Questionnaire APPENDIX D.

SECTION 8. DIVING: All diving will be conducted in accordance with U.S. Navy Diving Manual Vol I. Superlite 17 BNS, DSI bandmask 18 BNS or AGA Divator MK II will be used for the dives using lightweight diving outfit MK I Mod 0 as the stand by equipment. The ROPER Cart will be used as a gas supply source during selected dives.

SECTION 9. PROGRAM: The Paul Langevin will arrive at NCSC Panama City early on 9 Aug 1987. On completion of loadout it will then proceed to its assigned berth at Pensacola. Dive teams as detailed will, on completion of loadout proceed to Pensacola, transporting the 25 foot NEDU craft and ROPER Cart by trailer.

Sunday 9 August

Ser #	Time	Events	Remarks
01	0600	Dive team as detailed muster at the SCUBA Locker.	
03	0630	Paul Langevin arrives NCSC. Berth alongside.	
05	o/c 03	Load out	
07	o/c 05	Paul Langevin departs NCSC for Pensacola. Dive team departs for Pensacola.	

Monday 10 August

Ser #	Time	Events	Remarks
01	TBD	Archeologist craft departs Pensacola.	Relocation of first dive site.
03	TBD	NEDU 25 FT craft accompanies the Archeological craft.	Loran settings to be lined up with those of Paul Langevin.

05 On successful relocation of 1st dive site NEDU divers to mark the site: Report position back to Paul Langevin. Paul Langevin sails.

07 Paul Langevin positions over the first dive site.

o/c 1st survey dive

While this dive is in progress the archeological boat will relocate the second and subsequent sites recording Loran coordinates and buoying as appropriate.

On completion of diving on Friday, 4 September, the Paul Langevin will be released to return to NCSC Panama City. It will berth alongside at 0600 on Saturday, 5 September, where dive team #4 as detailed will unload. Dive team #4 will vacate accommodations PM Friday, 4 September or early AM Saturday, 5 September and will return to NCSC to receive the Paul Langevin and offload.

Table B-1. Emergency Assistance Checklist

RECOMPRESSION CHAMBER
NAMI
Location
Divers 452-2141 After Hours: 452-4354
Contact
:05 minutes
Response Time

AIR TRANSPORTATION
HC-16
Location
Sea/Air Rescue Duty Desk: 452-2511
Contact
:15 minutes Mon-Sat/1:00 hr Sun
Response Time

SEA TRANSPORTATION
Port Ops NAS Pensacola
Location
Duty Watch: 452-2624/2625
Contact
:30 minutes
Response Time

HOSPITAL
NAMI
Location
Divers 452-2141 After Hrs: 452-4354
Contact
:30 minutes
Response Time

DIVING MEDICAL OFFICER
NEDU (Navy Experimental Diving Unit)
Location
Duty DMO AV 436-4351 Com (904)234-4351
234-4353
Contact 235-1668

Response Time

COMMUNICATIONS
Port Ops Navy Pensacola Control
Location
Marine Band Channel 16 (156.8 mhz)
Contact

Response Time

DIVING UNITS
NDSTC AV 436-4100 Com (904) 234-4011
Location 234-4100

NEDU AV 436-4351 Com (904) 234-4351
235-1668
Contact

Response Time

COMMAND
NAS Pensacola
Location
OOD/CDO 452-2353
Contact

Response Time

EMERGENCY CONSULTATION
24 Hours a Day

NEDU Duty Phone Numbers:

Commercial (904) 234-4351
AUTOVON 436-4351

NAVAL MEDICAL RESEARCH INSTITUTE

Commercial (202) 295-1839
AUTOVON 295-1839

Ambulance:

NAS Pensacola
452-4138
:15 minutes response time

Table B-2. Procedures for Diving Emergency

UPON NOTIFICATION OF DIVING EMERGENCY REMAIN IN RADIO CONTACT WITH DIVE BOAT AND FOLLOW GUIDELINES BELOW:

AIR TRANSPORTATION	SEA TRANSPORTATION
IF NEEDED, CONTACT HC-16 SEA/AIR RESCUE DUTY DESK AT 452-2511(2-2511) STATE EMERGENCY AND/OR TYPE ACCIDENT: LOCATION: BOAT USED:	IF NEEDED, MAN SMALL BOAT AND SEND TO LOCATION

(1) DUTY WATCH CONTACT NAS PENSACOLA BRANCH CLINIC AT 452-4238, STATE TYPE OF ACCIDENT ASSISTANCE GOING TO HC-16 HANGER IF USING AIR TRANSPORTATION OR TO PORT OPERATIONS IF USING SEA TRANSPORTATION.

(2) CONTACT NAMI DIVERS RECOMPRESSION CHAMBER AT 452-2141 DURING WORKING HOURS OR 452-4354 AFTER WORKING HOURS AND HOLIDAYS. STATE EMERGENCY AND ENSURE CHAMBER IS MANNED.

(3) CONTACT PORT OPERATIONS DEPARTMENT HEAD, COMMAND DIVING OFFICER, AND DUTY CHIEF. STATE EMERGENCY AND WHAT HAS BEEN DONE.

(4) CONTACT OOD OR CDO NAS PENSACOLA AT 452-2353. STATE EMERGENCY AND WHAT HAS BEEN DONE.

DIVING SUPERVISOR: ______________________________

DIVING OFFICER: ______________________________

APPENDIX C

10 July 1987

MEMORANDUM

From: NEDU Code 03A
To: Distribution

Subj: PENSACOLA SURVEY TRAINING

Encl: (1) Changes in Pensacola Watchbill

1. Personnel training and equipment preparation for Task 86-44 will take place between 20-31 July 1987.

2. Equipment. Teams as listed in enclosure (1) will be instructed in the following equipment:

a. Superlite 17B-NS
b. DSI Bandmask 18B-NS
c. AGA Divator MK 2
d. Air lift and fitting equipment
e. Underwater camera (as supplied by the archeologist)

3. Responsibilities.

a. HTCM(MDV) Buski - Coordinate training
b. BMC(DV) Cline - Provision and preparation of FADS equipment, air lift and fitting equipment
c. QMC(DV) Dietz - Provision and preparation of umbilicals, helmets and bandmasks
d. BMC(DV) Paauwe - Provision of all ancillary equipment required to support the training

4. Program

Week #1
Monday 20 July - 0630 group #1 muster at the Milvan. Set up dive station o/c commence training.

Tuesday 21 July - 0630 group #1 muster at the dive site. Commence training.

Wednesday 22 July - Group #2 muster at the dive site. Commence training.

Thursday 23 July - Group #3 muster at the dive site. Commence training.

Friday 24 July - Group #4 muster at the dive site. Commence training.

Any additional personnel who are connected with the project and who wish to dive one or more of the rigs are invited to contact CPO(D) Stanley with the view to diving on Tuesday, 21 July 1987.

Week #2 (27 - 31 July) will be used to train individuals unable to attend training during week #1 and any guest divers from other units. Any questions, contact HTCM Buski or CPO Stanley.

Very respectfully,

M P Robinson

M. P. ROBINSON
LT, RN

Distribution:
00, 01,
Department Heads
HTCM Buski
BMC Cline
BMC Paauwe
MMC Ashton
QMC Dietz

PENSACOLA WATCH BILL

All personnel are to arrive on Sunday before start of working week.

Week of: 9 Aug - PM 15 Aug	Week of: 16 Aug - PM 22 Aug	Week of: 23 Aug - PM 29 Aug	Week of: 30 Aug- PM 5 Sep
			Medical Officer as assigned.
CPO Stanley	HTCM Buski	CPO Stanley	HTCM Buski
1. QMC Dietz	1. QMC Dietz	1. QMC Dietz	1. QMC Dietz
2. BMC Cline	2. BMC Cline	2. BMC Cline	2. BMC Cline
3. BMCM Stevens	3. HTCM Huss	3. HM2 Snelling	3. MMC Shattuck
4. MRC Pacelli	4. ENC Cuchens	4. HTCM Hink	4. BMC Bingham
5. CEC Anderson	5. ENC Velarde	5. ENC Clackley	5. MMC Ashton
6. BMC Paauwe	6. HT1 Gronbeck	6. ENC Wrenn	6. ENC Ellis
7. EN2 Jones	7. HT2 Wharton	7. BMC Siemiet	7. EN1 Cousins
8. CM1 Sloan	8. EN2 White	8. HT2 Rau	8. EM2 Kelly
9. EM2 Kelly	9. BM1 Stark	9. HTC Olson	9. ENC Krepp
10. HT2 Whitlow	10. HM2 Waltz/ HM2 Snelling	10. BM2 Greenwell	10. LT Couch
11. HM2 Waltz	11. Mr. Schmitt	11. ~~Mr. Cowgill~~	11. Mr. Boone
12. Mr. Pelton	12. Mr Barth	12. Mr. Schlegel	12. Mr. Briere
13. QMCS Griggs	13. HMCM Thomas	13. HT1 Lopez	13. MM1 Stokes
			14. BM1 Warner

Others involved will be: (Dates and times to be as required.)

LCDR Machasick
LT Robinson
HTCM(MDV) Buski
MC(MDV) Stanley

APPENDIX D

SUPERLITE 17B-NS HELMET HELIOX 18B-NS BANDMASK

AGA DIVATOR MK 2

NAME____ DATE______________

Ht_________ Wt_________ Length of Dive_________

How many previous dives in this rig?___________________

---

1. Extremely poor
2. Poor
3. Not quite adequate
4. Adequate
5. Very good
6. Excellent

Select the number indicating your response to the following questions:

1. How do you rate the ease with which you were able to don the rig you have just worn? _________

Comments or suggestions: ____

____

____

____

2. How do you rate the fasteners, fittings and valves provided on the Rig?___

Comments or suggestions: ____

____

____

____

3. How do you rate the fit of: comfort of:

Skull Cap __________ __________
Oral-Nasal __________ __________
Shell/Spider ________ __________

Comments or suggestions: ____

____

____

____

4. How would you rate:

Rig (Diver's) Visibility? __________

Comments or suggestions: ____

____

____

____

5. How do you rate the rig you tested for freedom of moving about the topside area or topside work before entering the water? __________

Comments or suggestions: ____

____

____

____

6. How do you rate the locations of the emergency valve on the rig you have worn? __________

Comments or suggestions: ____

____

____

____

7. How do you rate the ease of operation of the valve(s) on the rig you have worn? __________

Comments or suggestions: ____

____

____

____

8. How would you rate the communication system of the rig? __________

Comments or suggestions: ____

____

____

____

Circle Appropriate Answer

9. Was the rig comfortable during the dive(s)?

Very Uncomfortable	Uncomfortable	OK	Comfortable	Very Comfortable
(1)	(2)	(3)	(4)	(5)

If uncomfortable, explain: ______________________________

____

____

10. Did faceplate fogging occur?

YES (1) NO (2)

If so, when? ____________ And did it prevent you from completing your assigned task? ______________________________

____

11. During your dives did water enter the rig at any time?

YES (1) NO (2)

If so, describe (how much water, what caused it, did you have to surface, did it flood out, were you able to clear it): ______________________________

____

____

12. Wh .: using the communication system, were you understood clearly and were you able to understand clearly when others talked to you?

YES (1) NO (2)

Explain: ______________________________

____

____

____

Select the most appropriate answer below for the following questions:

1. Heavy
2. Moderate
3. Tolerable
4. Minimal

13. How would you rate the breathing resistance of the rig in the up-right position? During Inhalation ____________ During Exhalation ____________

Comments or suggestions: ____

____

____

____

14. How would you rate the rig's breathing resistance in the 45° head-up position? During Inhalation ____________ During Exhalation ____________

Comments or suggestions: ____

____

____

____

15. How would you rate the rig's breathing resistance in the prone position? During Inhalation ____________ During Exhalation ____________

Comments or suggestions: ____

____

____

____

16. How would you rate the rig's breathing resistance in the 45° head-down position? During Inhalation ____________ During Exhalation ____________

Comments or suggestions: ____

____

____

____

17. Did you have any difficulty swimming? YES ______ NO ______

If YES, please explain: ____

____

____

____

18. Did you have any difficulty walking? YES ______ NO ______

If YES, please explain: ____

____

____

____

19. What part of the pre-dive check list would be the easiest to overlook?

____

____

____

20. In general, how would you rate the performance of the rig?

Unsatisfactory	Poor	Fair	Good	Excellent
(1)	(2)	(3)	(4)	(5)

21. In general, how was the rig balanced for comfort?

a. On the surface?

Unsatisfactory	Poor	Fair	Good	Excellent
(1)	(2)	(3)	(4)	(5)

b. At depth? (In all positions)

Unsatisfactory	Poor	Fair	Good	Excellent
(1)	(2)	(3)	(4)	(5)

Additional comments on balance: ____________________________________

____

____

____

22. Did the neck dam fit properly?

YES (1)   NO (2)

23. Did the neck dam leak?

YES (1)   NO (2)

General comments on the neck dam: ____________________

____

____

____

24. What about the balance of the umbilical against the rig, did it tend to pull the rig to one side?

a. On the surface?

YES (1)   NO (2)

b. At depth?

YES (1)   NO (2)

25. Did you use the nose clearing device?

YES (1)   NO (2)

If yes, how well did it work?

Unsatisfactory	Poor	Fair	Good	Excellent
(1)	(2)	(3)	(4)	(5)

<u>SUPERLITE ONLY</u>

1. Did the helmet liner fit snugly?

YES (1)   NO (2)

<u>SUPERLITE ONLY</u>
(Continued)

2. Was the helmet liner comfortable?

a. On the surface?

YES (1) NO (2)

b. At depth?

YES (1) NO (2)

3. Did the helmet liner place your face snugly into the oral-nasal mask?

YES (1) NO (2)

4. What pieces/parts of the SL 17B appear to lack durability or sturdiness if it was subjected to Fleet use?

APPENDIX C

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

STANDARD TEST PLAN

SL 17 B/NS MOD 0 TO MK 2 MOD 1 DDS
COMPATIBILITY TRIAL

TEST PLAN NUMBER 88-07

MARCH 1988

Submitted:

D.G. KIRBY
LT(N), CF
Fleet Support Projects

Reviewed:

R.T. MACHASICK
LCDR, USN
Senior Projects Officer

(acting)
H.J.C. SCHWARTZ
CDR, MC, USN
Senior Medical Officer

J.C. DEVLIN
CDR, USN
Executive Officer

Approved:

J.D.M. HAMILTON
CAPT, USN
Commanding Officer

DISTRIBUTION: Codes 00, 01, 02, 03, 036, 04, 07
Original to Technical Library

RECORD OF CHANGES

Except as provided for herein, changes will be made only on the authority of the Commanding Officer, NEDU. A dark vertical line in the left-hand margin indicates the coverage of change.

CHANGE NO.	AUTHORITY	INSERTION	SECTION	INITIAL

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References

(a) NAVSEA Task 86-44
(b) NAVSEA Task 88-05

1. Introduction. The SL-17B-N/S MOD 0 has been selected to replace the Navy MK 1 MOD S for saturation diving with the MK 2 MOD 1 Deep Diving System (DDS). Prior to system certification, it must be ensured that the SL-17B-N/S MOD 0 will be compatible in all respects with the MK 2 MOD 1 Personnel Transfer Capsule (PTC) systems and that proper procedures are developed for deployment from the PTC. In addition, an introduction of the helmet to fleet users will provide useful feedback for generation of introduction and training documentation.

To meet these requirements, NEDU proposes a trial fit-up of the SL-17B-N/S MOD 0 onboard USS ORTOLAN in Charleston, S.C. Diving will be conducted by shipboard divers trained by NEDU personnel in accordance with this test plan.

2. Test Procedures. A team from NEDU will travel to the USS ORTOLAN and install the SL-17B-N/S MOD 0 onboard the PTC. They will ensure correct electrical and umbilical connections and identify stowage requirements. Pre and post-dive checks and PTC egress and entry procedures shall be in accordance with standard ships operating procedures. If it is deemed safe and, when authorized by the Commanding Officer, USS ORTOLAN, a dive from the PTC at a depth not greater than 30 FSW using air or a suitable HeO_2 gas mixture will be conducted to validate the proposed procedures.

3. Test Parameters. All maintenance, set up, and dive procedures shall be conducted per the current SL-17B-N/S MOD 0 Operations and Maintenance (O&M) Manual and the U.S. Navy Diving Manual. Maximum dive depth will not exceed 30 FSW. MK 2 MOD 1 DDS will be set up using USS ORTOLAN Operating Procedures (OPs).

4. Equipment and Instrumentation. Three SL-17B-N/S MOD 0 helmets will be supplied by NCSC by 7 March 1988 and are to be cleaned per the NEDU cleaning procedure prior to 11 March 1988. The NEDU team technician will provide all set up and test equipment necessary to insure proper performance of the helmet. All required training material will be prepared prior to team departure. The SL-17B-N/S MOD 0 will not be instrumented.

5. Safety Rules and Emergency Procedures. All diving will be conducted in accordance with the U.S. Navy Diving Manual. USS ORTOLAN Emergency Procedures (EPs) will be augmented where applicable with EPs from the SL-17 O&M Manual. EPs unique to the SL-17 will be documented as an annex to this test plan.

6. Termination Criteria. The trial may be terminated at the discretion of Commanding Officer, USS ORTOLAN, Team Leader, or Diver-Subjects.

7. Personnel Requirements. The crew of the USS ORTOLAN will be used as required by the Commanding Officer, USS ORTOLAN. NEDU will assemble the following team:

Team Leader: CDR J. C. Devlin, USN

Project Director: LT(N) D. G. Kirby, CF

Team Member: LCDR R. T. Machasick, USN

Team Technician: MMC(DV) M. D. Cox

Team members will coordinate travel and accommodation requirements through department heads.

8. Program. The following program will be followed:

a. Helmets cleaned: 11 March 1988.

b. Team departs NEDU: 4 April 1988.

c. Tests commence onboard USS ORTOLAN: 4 April 1988.

d. Training and dives: 5 April 1988.

e. Team departs USS ORTOLAN: 8 April 1988.

9. Report Production. A letter will be drafted documenting results of the trial. It will be incorporated into the final report of the SL-17B-N/S MOD 0 by the Project Director.

APPENDIX D

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

OSF DIVE PROTOCOL

NITROGEN-OXYGEN 1988 (AIR SAT)

TEST PLAN NUMBER 88/01

JANUARY 1988

Submitted:	Reviewed:	Approved:
for M.P. ROBINSON LT, RN Operations Officer	R.T. MACHASICK LCDR, USN Senior Projects Officer	J.D.M. HAMILTON CAPT, USN Commanding Officer
	H.J.C. SCHWARTZ CDR, MC, USN Senior Medical Officer	
	J.C. DEVLIN CDR, USN Executive Officer	

ANNEX A3

HUMAN FACTORS TESTING OF SUPERLITE 17B/NS HELMET MOD 1

1. Introduction/Objectives. The SL 17B/NS is a commercially available open circuit helmet with an oral-nasal mask and demand regulator. The helmet has been previously tested during Deep Dive 82 and Deep Dive 84 as a possible replacement for the USN MK 1 MOD S Mask. Unmanned testing of the DSI Navy 350 regulator in place of the previously trialed Superflow regulator has been conducted. This test will provide the manned evaluation of the Navy 350 regulator using air within the air diving range and validation of the O&M Manual.

The fitting of the Navy 350 created changes in the oral-nasal that could alter the previous human factors study results. Primarily, an additional exhaust port was created that joined the chin portion of the oral-nasal to the bottom of the helmet. This may restrict the movement of the oral-nasal and create discomfort or improper fit. In addition, there have been some changes in the neck dam assembly that warrant human factors analysis at 50 FSW and 24 FSW in 18°C(65°F) water.

2. Instrumentation Recording Dive Parameters

a. SL 17B/NS setup: the helmet will be supplied with air at 135 psig overbottom pressure.

(1) The diver subject will wear a personal wet suit.

(2) The air supply will pass through a 650 ft. umbilical which will be immersed in the wet pot.

(3) Electrically braked bicycle ergometer.

b. Instrumentation: The SL 17B/NS will be instrumented as per ANNEX A-4 but will not be used at the 50 and 24 FSW tests. The test lead will not be attached to the helmet.

(1) The bicycle ergometer RPM and wattage will be monitored.

c. Recording: All human factors records will be completed by hand.

d. Calibration: Special equipment calibration is not required for the human factors studies.

e. Data Recording:

(1) The supervisor will complete the Supervisors Human Factors Questionnaire three times during the exercise sequence of the dive.

(2) The diver-subject will complete the Diver-Subject Human Factors Questionnaire upon completing the diving day.

(3) During the study appropriate comments will be made concerning the following:

Date
Diver Name & Number
Starting & Stopping Work
Incidents during the dive

3. Procedures

a. General

(1) Complete dive supervisor and SL 17B/NS checklists.

(2) Don diving rig.

(3) Adjust Dial-A-Breath to free flow, then back off slightly to comfort level.

(4) Enter water and commence exercise sequence.

(5) Exit water and complete post dive checklist.

b. Exercise sequence.

(1) Once the diver is squared away, the supervisor will commence the following:

(a) Complete Supervisor Human Factor Questionnaire Part 1.

(b) Diver mounts ergometer.

(c) Start exercize for 5 minutes at 50 watts.

(d) Diver dismounts.

(e) Complete questionnaire Part 2.

(f) Diver mounts ergometer and completes 5 minutes at 100 watts.

(g) Diver dismounts.

(h) Complete questionnaire Part 3.

(i) Diver returns to surface when instructed.

4. Termination Criteria. The test may be terminated by the Dive Watch Officer, on recommendation of the Dive Watch Medical Officer, the Dive Supervisor, or by the diver-subject. Among causes for termination will be excessive regulator free flow or helmet flood out.

5. Risks/Benefits. Modifications have been made to the faceplate of the SL 17B/NS helmet to accomodate medical electronics. No additional risks to those entailed in normal diving are expected.

DIVE SUPERVISOR HUMAN FACTORS QUESTIONNAIRE

PART 1/2/3 DIVER NAME ______________________ DATE __________

Instruct the diver to assume each position listed. For each position read the given questions and record the divers response in the block provided.

Scale:	Heavy (1) Poor	Moderate (2) Not Quite Adequate	Tolerable (3) Adequate	Minimal (4) Very Good

QUESTION	DIVER POSITIONS			
How would you rate:	Upright	45° Head Up	Prone	45° Head Down
Breathing resistance during inhalation?				
Breathing resistance during exhalation?				
Fit of the Oral nasal for comfort/effectiveness?				
Answer Yes/No:	Upright	45° Head Up	Prone	45° Head Down
Does water enter the helmet? If yes, describe.				
Does the dial-a-breath effectively control the gas flow? If no, describe.				

Comments: ____

APPENDIX A

SUPERLITE 17B-NS HELMET

NAME____ DATE ______________

Ht ______________ Wt____________ Length of Dive ___________

How many previous dives in this rig?____________________

Answer the following questions by selecting the appropriate number from the scale below.

Extremely Poor	Poor	Not Quite Adequate	Adequate	Very Good	Excellent
(1)	(2)	(3)	(4)	(5)	(6)

1. How do you rate the fit of: comfort of:

	fit	comfort
Head Cushion	________	________
Oral-Nasal	________	________
Neck Dam	________	________
Face Seal	________	________
Shell	________	________

Comments or suggestions: ______________________________________

____

____

____

2. Did you use the nose clearing device?

   YES (1) NO (2)

   If yes, rate how well it worked: ___________

3. Did the helmet liner place your face snugly into the oral-nasal mask?

   YES (1) NO (2)

4. Did faceplate fogging occur?

YES (1)   NO (2)

If so, when? ____________ And did it prevent you from completing your assigned task? ____________

5. Did the neck dam leak?

YES (1)   NO (2)

General comments on the neck dam: ____________

6. Did the head cushion foam insert get wet during the dive.

YES (1)   NO (2)

7. During your dives did water enter the rig at any time?

YES (1)   NO (2)

If so, describe (how much water, what caused it, did you have to surface, did it flood out, were you able to clear it): ____________

8. In general, how was the rig balanced for comfort in the water (in all positions)?

Unsatisfactory	Poor	Fair	Good	Excellent
(1)	(2)	(3)	(4)	(5)

9. Did you have any problems with the balance of the helmet while submerged?

YES (1) NO (2)

If yes, describe the problem ____________________

____

____

10. In general, how would you rate the performance of the rig?

Unsatisfactory	Poor	Fair	Good	Excellent
(1)	(2)	(3)	(4)	(5)

11. Are there any changes or improvements you would like to make on this rig? Comments or suggestions: ____________________

____

____

____

APPENDIX E

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407-5001

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

OSF DIVE PROTOCOL

DEEP DIVE 88 ALPHA

TEST PLAN NUMBER 88/08

MAY 1988

Submitted:

M.P. ROBINSON
LT, RN
Operations Officer

Reviewed:

R.T. MACHASICK
LCDR, USN
Senior Projects Officer

Approved:

J.D.M. HAMILTON
CAPT, USN
Commanding Officer

H.J.C. SCHWARTZ
CDR, MC, USN
Senior Medical Officer

J.C. DEVLIN
CDR, USN
Executive Officer

ANNEX A5

PHYSIOLOGICAL EVALUATION OF SUPERLITE 17 B/NS MOD 0 AND DSI 18 B/NS AT 1000 FSW AND SUPERLITE 17 B/NS MOD 1 AT 300 FSW

1. INTRODUCTION

a. Superlite 17 B/NS Mod 0

The Superlite 17 (SL-17) B/NS Mod 0 is a commercially available dry helmet with an oral-nasal mask and a demand regulator manufactured by Diving Systems International (DSI) (425 Garden Street, Santa Barbara, CA). This helmet has recently been equipped with a newer design regulator, the Gas Services Offshore Ltd. (GSOL) Model 500 previously called the Ultraflow 500. (Gas Services Offshore, Ltd., address: 7 Westhill Industrial Estate; Westhill, Aberdeen; Scotland AB36TQ). This Superlite 17 B/NS Mod 0 has been unmanned tested with heliox (HeO_2) to 1000 FSW (NEDU Report 11-86). These results presently are being re-evaluated but indicate that the GSOL 500 may have adequate breathing characteristics to support at least moderate work in a diver in the upright position to 1000 FSW. It should be noted that the recirculator to reclaim exhaled helium was not evaluated. This circuit may also increase the resistance for exhalation and decrease the regulator performance if future testing is done.

The previous version of the Superlite 17 B/NS used an older regulator, the Diving Systems International (DSI) Superflow 250. This regulator has been manned tested to at least 850 FSW (NEDU Reports 4-83 and 1-86). Out of nine graded exercises performed at 856 FSW (NEDU Report 1-86) one diver stopped work during a moderate work load (100 watts) and six divers failed to complete the heavy work load (150 watts). The reasons for failure of seven out of nine graded exercises performed was reported as severe air hunger, known as dyspnea. The differential pressures generated at the divers' mouth from inhalation to exhalation (ΔP) also suggested a very high degree of pulmonary stress being imposed upon the diver by this regulator (DSI Superflow 250).

One purpose of this Annex is to man-test this newer regulator, the GSOL 500, with graded exercise at 1000 FSW. The reason 1000 FSW was chosen is that the Personnel Transfer Capsule's (PTCs) deepest attainable depth is 850 FSW and with the deepest downward excursion of the PTC diver to 150 FSW, 1000 FSW is the diver's maximum exposure.

b. DSI 18 B/NS

The Band mask version of the SL-17 B/NS Mod 0, called the DSI 18 B/NS or Heliox 18 B/NS, uses the same GSOL 500 regulator. It also must be man-tested at 1000 FSW, since it is the rig that can be donned and doffed single-handedly by the standby diver remaining back in the PTC.

c. Superlite 17 B/NS Mod 1

For shallower HeO_2 diving to 300 FSW and air diving to 190 FSW, the Superlite 17 B/NS Mod 1 using the DSI Navy 350 regulator must be manned tested. The DSI Navy 350 is not to be confused with the GSOL 350 of similar design. After decompressing to 300 FSW from 1000 FSW the SL-17 B/NS Mod 1 in its only configuration, a helmet, will be man tested on HeO_2. Unmanned testing of the SL-17 B/NS Mod 1 at 190 FSW on air showed actable performance. Therefore, it is believed to be safe to conduct manned testing without previous unmanned testing of the SL-17 B/NS Mod 1 to 300 FSW on HeO_2. This same helmet will also be man tested using air at 190 FSW in separate air bounce dives tentatively planned later this year. Previous manned testing using only two divers at 190 FSW on AIR SAT 88A was inconclusive due to technical reasons and inappropriate use of the helmet.

d. Physiological Evaluation

Unmanned evaluation of regulators and advanced underwater breathing apparatuses (AUBA) has measured the volume averaged pressure in units of kg•m/ℓ as a reference to assess the work of breathing. This is a measure of the external work imposed on a diver who must also overcome the internal work of moving dense gas in and out of his lungs. The simultaneous measurement of both pressure (P) and volume (V) to determine the P-V loop area in manned testing is technically difficult due to inducing further resistance into the breathing circuit by using standard flow probes. Recently, it has also been suggested that dividing the P-V loop area by the diver's tidal volume, hence volume averaged pressure, may not truly represent the work of breathing in manned testing anyway (1). A complete review of this literature will appear on the final NEDU report supporting this task.

In simple terms, a diving rig imposes external resistance (R_{ext}) upon the diver's own pulmonary system which has its own internal resistance (R_{int}). Measurement of the differential pressure at the mouth of the diver from peak inspiration to peak expiration (ΔP), does not help to quantify this overall total resistance load (R_{tot}) placed on the diver. The measurement of ΔP reflects only the respiratory drive the diver can generate to overcome this R_{tot}, and is influenced by the compliance of the AUBA breathing circuit whether it be a neck dam as in the SL-17 or a rebreathing bag and counter-lung, as in the EX 19 or EX 14.

It would be very helpful, therefore, to measure both pressure and flow to calculate this total resistance R_{tot}, based on Ohm's Law, equation (1), and equation (2):

$$V = I \bullet R \qquad (1)$$

where: V = voltage
I = current
R = resistance, electrical

$$\Delta P = \dot{V} \bullet R \qquad (2)$$

where: ΔP = pressure
$\dot{V}$ = gas flow
R = resistance, breathing

In a recent study, an ultrasonic pneumotachometer which does not impose a resistance was favorably evaluated (2). Such technology may be very useful here at NEDU and will possibly be evaluated for use in diving physiology research up at the Naval Medical Research Institute (NMRI) (3). A review of this type of ultrasonic pneumotachometer will be included in the NEDU report supporting this task.

The measurement of the ΔP or the peak-to-peak pressure differential has a great deal of intersubject variability as demonstrated during SL-17 B/NS Mod 1 preliminary studies at 50 FSW during Air Sat 88A, January 1988 (4). A more meaningful analysis of the pressure generated by diver subject would include mean inspiratory pressure (P_{insp}), mean expiratory pressure (P_{exp}), peak inspiratory pressure (P_{max}insp) and peak expiratory pressure (P_{max}exp) (1). These pressure measurements can better describe the physiological stresses imposed on both inspiratory and expiratory phases of the diver's respiration cycle. This will better help the engineers to improve the design of future regulators, helmets and AUBAs.

As a measurement of pulmonary performance of the diver, exhaled and inhaled CO_2 levels will be measured. The measurement of CO_2 at the end of a normal breath, called end-tidal, will be both in percent or fraction ($F_{ET}CO_2$) and in units of partial pressure ($P_{ET}CO_2$). A number of factors can cause a diver to "over breathe the rig." They may be dyspnea, respiratory muscle fatigue or insensitivity to higher and higher concentrations of CO_2. The $F_{ET}CO_2$ and $P_{ET}CO_2$ will be followed during the experimental dive for safety reasons to avoid complications of dizziness or loss of consciousness (5, 6). This data will also be analyzed to determine inspiratory and expiratory CO_2 ($P_{insp}CO_2$, $P_{exp}CO_2$) levels that are associated with declining diver performance at higher exercise levels. Also, the sensation of dyspnea will be subjectively determined on a scoring system to better predict and follow when the diver is being overstressed by the rig during graded exercise testing.

Diver-subjects will receive instructions to not purge their regulators during these studies because it does not vent the helmet. Purging the regulator will actually increase the stress placed on the diver by inducing a high positive pressure static load. This may increase the work a diver must do to exhale and which may increase dyspnea respiratory muscle fatigue leading to premature failure during heavy exercise.

Dyspnea or air hunger, was first favorably evaluated during graded exercise during Air Sat 88A, Annex A4, Superlite 17 B/NS Mod 1. Dyspnea will be subjectively evaluated by each diver-subject at the completion of each 6-minute exercise period or at anytime during exercise as directed by the Principal Investigator. Upon command requesting "Dyspnea Score", the diver will use hand signals to respond. The "OK" sign will mean no dyspnea, and one, two and three fingers will indicate mild, moderate and severe dyspnea, respectively. If a diver-subject decides to terminate an exercise period prematurely, he will be questioned as to the reason (fatigue, dizziness) and for his dyspnea score as well as any other symptoms.

2. RISKS/BENEFITS

The GSOL 500 regulator used in the SL-17 B/NS Mod 0 and DSI 18 B/NS has been unmanned tested and should present no unusual risk to the diver-subject. The main risk is a high inspired CO_2. Elevated inspired CO_2 may produce symptoms of headache, dizziness, tunnel vision and even loss of consciousness. This risk will be limited by constant monitoring of inspired Pco_2 ($P_{insp}CO_2$). The diver will be in a safety harness. If the diver does experience difficulty, he or the standby can open the free flow valve and the CO_2 level in the helmet can be brought to zero within a few seconds. Briefly breathing high levels of CO_2 does not cause permanent damage.

The SL-17 B/NS Mod 1 has not been unmanned tested with HeO_2 at 300 FSW. Limited manned testing at 190 FSW with only two divers is inconclusive. If the Superlite 17 B/NS Mod 0, DSI 18 B/NS and Superlite 17 B/NS Mod 1 are found acceptable, it offers the Navy diver the benefits of less breathing resistance, better head protection of a solid helmet, a dry environment for the head, and good communications.

The diver's heart rate and lead II EKG will also be monitored during underwater graded exercise for safety reasons.

The recommended minimum gas temperature derived from studies at NEDU in 1980 for 1000 FSW should be 22°C (72°F) (Piantadosi, 1980). Even though a breathing gas heater is not standard U.S. Navy issue with the SL-17B/NS MOD 0 or DSI-18B/NS, preliminary manned testing at 1000 FSW clearly demonstrated the need to heat the diver's breathing gas. Even though the risk of core hypothermia breathing cold HeO_2 at 1000 FSW is considered minimal for such a short duration of graded exercise wearing a hot water NRV suit, there are other complications of breathing cold gas at deep depths. These risks include a copious secretion of liquid and thick mucous in the respiratory tract which can foul a mouthpiece and may cause choking, gagging and induce pain in the upper respiratory tract (Goodman et al, 1971; Hoke et al, 1975). For these reasons, a breathing gas heater (Kinergetics, model 3375-2) will be necessary for the SL-17B/NS MOD 0, and MOD 1 plus the DSI-18B/NS studies.

3. INSTRUMENTATION, RECORDING

a. Superlite 17 B/NS Mod 0 and DSI 18 B/NS setup at 1000 FSW and Superlite 17 B/NS Mod 1 at 300 FSW using the Kinergetics Breathing Gas Heater Model 3375-2:

(1) Gas supply will be at 205 psig O/B pressure at 1000 FSW. A 100 foot umbilical will be used for 1000 FSW studies, which will be immersed in the wet chamber. The Kinergetics breathing gas heater (model 3375-2) has been successfully manned tested to depths ranging from 1120 to 1250 FSW on divers using a MK 1 MOD S mask who were performing extreme work on a bicycle ergometer in 40°F water (Middleton and Miller, 1978). Even though the operating gas pressure in the heater was reported by Middleton and Miller to be "150 psig O/B or greater," these studies were successfully done at 180 psig O/B pressure. Based on the professional opinion of NEDU's Hyperbaric Engineer, Mr. James McCarthy, and successful hydrostatic testing of the

Kinergetics heater to 350 psig for 30 minutes, this heater can safely be used at 205 psig O/B pressure for the SL-17B/NS MOD 0 and DSI-18B/NS studies at 1000 FSW. The water inlet temperature will be at 110°F, also specified by the manufacturer and tested here at NEDU (Middleton and Miller, 1980). The O/B pressure of 205 psig was chosen for the following reasons. The Kinergetics company recommends an additional 20 psig above the O/B pressure, due to an anticipated gas pressure drop across the heater. This pressure drop was measured to be 7 psig in NEDU Report 10-80 (Piantadosi, 1980). The operating manual for the SL-17 states the operating O/B pressures should be between 115 and 225 psig. Therefore, 205 psig is a very reasonable choice for the O/B pressure.

(2) The helmet will be adjusted per manufacturer's instructions and specifications prior to the dive. An inclinometer (angle indicator) will be used on all helmets to allow monitoring of a face forward or face down head attitude.

(3) The diver will wear a hot water suit, with temperature to comfort. He will wear a safety harness.

(4) The SL-17 B/NS Mod 1 at 300 FSW will use the 600 foot umbilical and will have an overbottom pressure of 135 psig.

b. Instrumentation:

(1) Electrically braked bicycle ergometer, RPM and wattage. Bike will be set up at 45°, relative to the diver's back.

(2) Gas samples from helmet, allowing adequate sampling at the mass spectrometer. Preliminary data from Air Sat 88A (4) demonstrates inaccurate and unreliable CO_2 measurements from the SL 17 B/NS Mod 1 at 190 and 50 FSW. These problems were due to the wrong sampling line used, improper sampling and modifications needed for our Perkin Elmer MGA 1100 mass spectrometer. These problems will need to be corrected before work up dives are completed.

(3) Differential pressure:

Oral-nasal pressure transducer

Validyne DP-9 with 0.8 psi (± 50 cm H_2O) diaphragm referenced to ambient water pressure as measured relative to the balloon at the diver's suprasternal notch (SSN). This will allow accurate and reliable pressures to be calculated relative to the pressure centroid in the chest. Positive connection will be to the mouth and negative to the reference balloon.

(4) Temperature of Wet Chamber will be 40°F.

(5) Eight-channel Strip Chart Recorder.

Channel Number	Function
#1	Oral-nasal PO_2
#2	Oral-nasal PCO_2
#3	Blank
#4	Oral-nasal pressure
#5	Spare
#6	EKG
#7	Spare
#8	Spare

(6) The Honeywell 101 Data Recorder will also be used for data storage and the Nicolet Digital Oscilloscope will be programmed to calculate $\bar{P}_{insp}$, $\bar{P}_{exp}$, $P_{max}insp$, $P_{max}exp$.

c. Calibration Procedures:

(1) The following calibration gases will be used:

Bottle No.	%O2	%CO2	Balance	Alternate Bottles
(a) 1000 FSW				
12	3.990	0.1505	He	None
14	1.6990	0.2909	He	57,66
57	1.3610	0.2474	He	17
69	0.8930	0.0192	He	58
(b) 300 FSW				
Ordered	0.9184	N/A	He	None
1	4.5030	0.0000	He	54
19	2.4000	0.6335	He	39
116	0.0000	0.4970	He	101,107

These cal gases were chosen to set up the strip chart for PCO_2 (dry) for a 0-75 mmHg range as per instructions in reference (7). These cal gases give PCO_2 of approximately 70 and 35 mmHg. The cal gases for O_2 are for a 0 to 0.5 ATA range.

(2) Mass Spectrometer:

(a) A full calibration will only be needed as per Perkin Elmer instructions, or as needed as per the Principal Investigators.

(b) For graded exercise, prior to each subject and at the completion of the graded exercise, full span and mid-range cal gases will be checked.

(c) The water vapor channel will be turned off.

(3) Pressure Transducers:

(a) Calibrate and adjust prior to each run, +25 and -25 cm H_2O full scale.

(b) Prior to each 6 minute exercise period, check baseline pressure by having the diver hold is breath (notate strip chart). A breath-hold (BH) for 5 seconds will reconfirm the baseline during exercise as per the Principal Investigators instruction.

(c) Method of oral-nasal transducer calibration using the Gould Strip Chart Recorder will be as follows: Remove reference balloon from transducer. Place helmet on deck and notify Medical Deck. Ensure that the transducer cable is plugged into umbilical to Medical Deck. The strip chart operator will electrically zero the transducer signal conditioner. The strip chart operator will adjust the pen to the center of the appropriate channel. The strip chart operator will tell the trunk tender to connect the water column manometer to the positive side of the transducer. The trunk tender will turn the position of the manometer until the water column reaches +25 cm H_2O. The trunk tender will inform the strip chart operator of the readings of the (+) and (-) columns. The strip chart recorder will be adjusted to correspond with the average manometer readings. Full scale deflection on the chart channel will be (-) 25 cm H_2O to the right. The strip chart operator will tell the trunk tender to return the columns to equal. The strip chart operator will check for zero on the strip chart. This calibration will be done in 10 cm H_2O increments, (+) and (-).

The trunk tender will turn the piston of the manometer until the water column reaches (-)25 cm. Calibration of the strip chart will be done for the positive (left) deflection as outlined above. Full scale deflection on the chart channel will be (-)25 cm H_2O to the left.

The trunk tender replaces the reference balloon upon completion.

d. <u>Data Recordings</u>. No notations will be made on or near any actual tracings. This will preserve all original tracings for photography purposes for the NEDU report and research articles.

(1) The following hand written records will be made on the 8-channel strip chart prior to each exercise sequence. Place on top page.

Purpose (Graded Exercise); Helmet Type
Date and Time
Diver Name and Number
Oral-nasal Sample Flow Rates (cc/min)
Cal Gas Bottle Numbers and Concentrations plus Equivalent Partial Pressure
Pressure Scale (-25 to +25 cm H_2O)
Wet Chamber Temperature
Diver Dress

(2) During the study, appropriate comments will be made concerning the following:

Inhalation (I) and exhalation (E)
Start and Stop Work and Work Rate in Watts (e.g. start 150 W)
Breath-hold (BH)
Cal Checks
Changes in amplifier settings
Notations explaining any aberations in the data, deviations from exercise procedure, or problems encountered.
Dyspnea Score (Dys 0, 1, 2, 3)

(3) Following completion of the study, note a general indication of the diver's physical condition and comments concerning the diver.

(4) Fold all strip chart paper by using the perforated edges of individual sheets. All experimental data information should be on top page for easy reference.

4. PROCEDURES

a. General:

(1) Calibrate transducers as required. Apply EKG leads to diver.

(2) Complete Dive Supervisor and SL-17 B/NS Mod 0, Mod 1 & DSI 18 B/NS Checklists. Ensure Kinergetics breathing gas heater is connected properly.

(3) Don instrumented rig.

(4) Adjust sample gas flow rates.

(5) Adjust Dial-A-Breath to free flow, then back off slightly to comfort level.

(6) Enter water and mount ergometer. Position head either face forward or face down, as appropriate.

(7) Readjust Dial-a-Breath in either face forward or face downward attitude and do not readjust, unless directed by the Principal Investigator. Do not open steady flow valve, except briefly to defog faceplate and notify medical deck. Do not use steady flow valve to vent the helmet.

(8) Complete exercise sequence as indicated below.

(9) Exit water and complete post dive checklist.

b. Graded Exercise Sequences:

(1) After all equipment is calibrated the EKG is properly recorded and the diver dressed, the diver will enter the water and mount the bicycle

ergometer. The standby diver will enter the water if it is necessary to help with the instrumentation.

(2) After direction of the diver is given to the Medical Deck, the Medical Deck Supervisor will begin the following exercise sequence:

Time	Work Rate	Duration
0-4	Rest	4 min
4-10	50 watts	6 min
10-14	Rest	4 min
14-20	100 watts	6 min
20-24	Rest	4 min
24-30	125 watts	6 min
30-34	Rest	4 min
34-40	150 watts	6 min
40-42	Rest	2 min

The reason for the additional 125 watts is that failures due to dyspnea and fatigue are anticipated from 100 to 150 watts for most divers at 1000 FSW. Also, human performance data with graded exercise at 1000 FSW is too limited to better predict these failures. The diver will be coached to keep his speed between 55-60 RPM.

Just before beginning each exercise period and after 2 minutes following the graded exercise, the diver will be instructed to exhale, inhale and hold his breath for 5-10 seconds, then breathe. This will enable a no-flow oral-nasal pressure to be established and chart record should be marked E, I, and BH, respectively.

(3) The strip chart recorder will be run continuously at 2 mm/sec during the entire work cycle. During the last minute of each exercise period, the chart speed will be increased to 10 mm/sec. The Honeywell 101 data recorder will run continuously during the graded exercise.

(4) Upon completion of the 150 watt cycle, the diver will be allowed to rest and when ready, will be instructed to surface.

(5) The wide variation seen in four diver-subjects during SL-17 B/NS Mod 1 testing at 50 FSW and two subjects at 190 FSW was remarkable (4). There is a great intersubject variability in pulmonary physiological responses to testing breathing circuits under pressure. The most important thing to remember is that even if the data measurements are accurate, without testing an adequate number of subjects, the data cannot be considered reliable unless reproducibility has been verified. Therefore, all divers must make one run (40 mins) with either the helmet face forward or helmet face down, on separate days. Only one graded exercise per day will be allowed for any diver-subject.

By facing down, it is expected that it will be much more dificult to exhale, severely limiting the diver during moderate to heavy work (4). If a diver develops too much dyspnea or pressure and CO_2 measurements indicate the diver is overstressed, the Principal Investigator or cognizant Medical Officer will order the diver to face forward and terminate the experiment.

In all experiments the diver's back will be held constant at 45° (i.e., leaning forward 45° from erect). Encouragement to keep the divers butt down during heavy exercise will be needed by the control room or medical deck as appropriate. The diver's legs should never fully extend on the ergometer. This can lead to overstressing the knees during underwater bicycle ergometery. What is recommended is a slight bend in the knee (15-20°) at maximal leg extension (BMC Siemiet, personnel communication).

(6) Dive Schedule:

(a) 1000 FSW

DAY 3	SL-17 B/NS Mod 0, Face forward, all divers
DAY 4	SL-17 B/NS Mod 0, Face down, all divers
DAY 5	DSI 18 B/NS, Face forward, all divers
DAY 6	DSI 18 B/NS, Face down, all divers

(b) 300 FSW

DAY 19	SL-17 B/NS Mod 1, Face forward, all divers
DAY 20	SL-17 B/NS Mod 1, Face down, all divers

5. TERMINATION CRITERIA

The test may be terminated by the Dive Watch Officer, on recommendation of the Dive Watch Medical Officer, the Dive Supervisor, or by the Diver-Subject. Among the causes for termination will be excessive CO_2 in the oral-nasal mask as determined by the cognizant Medical Officer.

6. DIVER SAFETY

Beyond adequate 1 ATA work-up dives and standard emergency procedures (EP) and operating procedures (OP), special emergency drills actually managing the diver's airway and performing mouth-to-mouth resuscitation in the trunk will be done for all trunk tenders. This will be supervised by Dr. Sterba. This will ensure our maximal preparedness to properly treat the unconscious diver with respiratory arrest or a blocked airway. The Principal Investigator can ask for "dyspnea" or "OK Red?" to the diver at anytime during the exercise period as needed.

All divers will have both EKG (Lead II) and heart rate monitored during underwater bicycle ergometry.

7. REFERENCES

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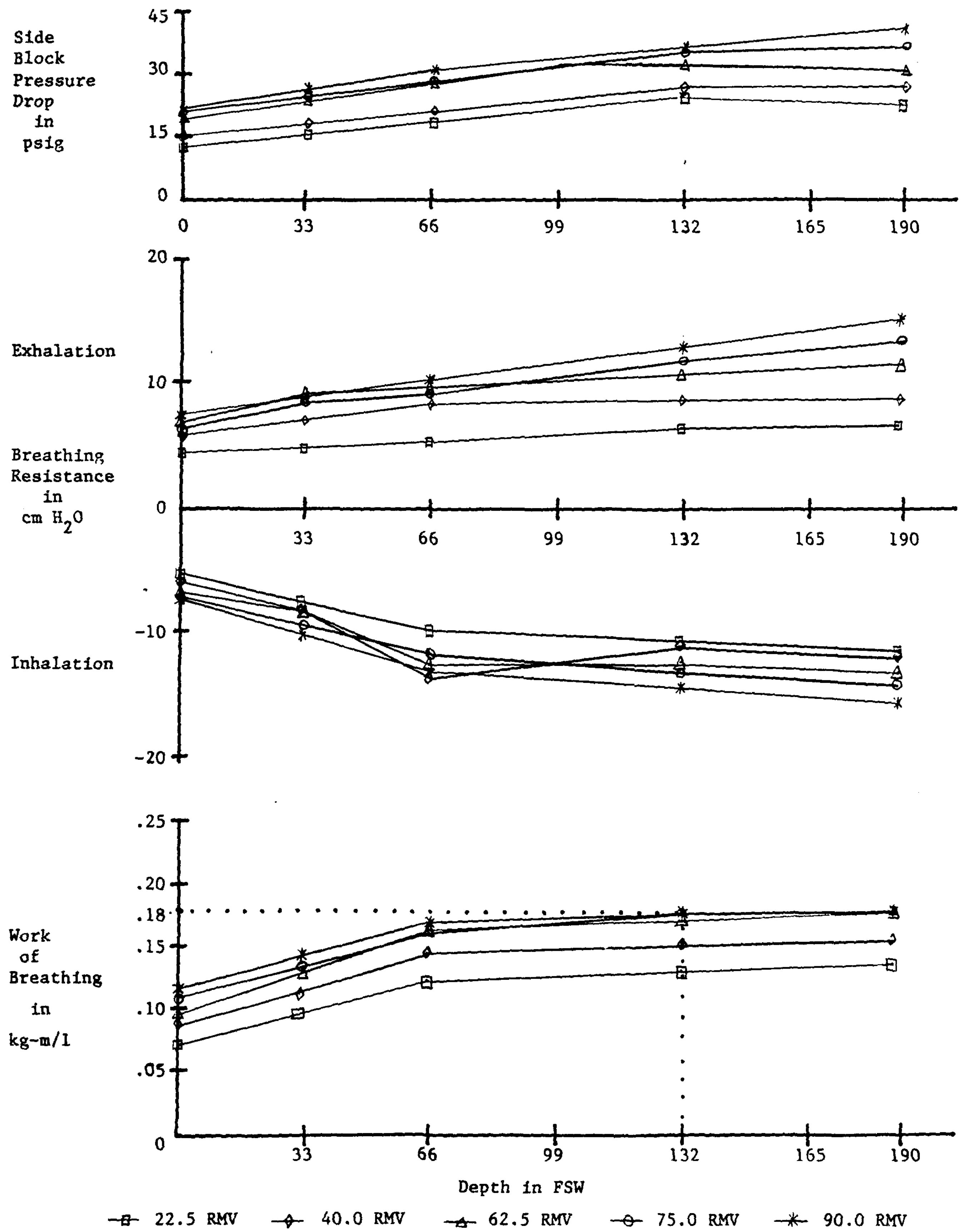
APPENDIX F

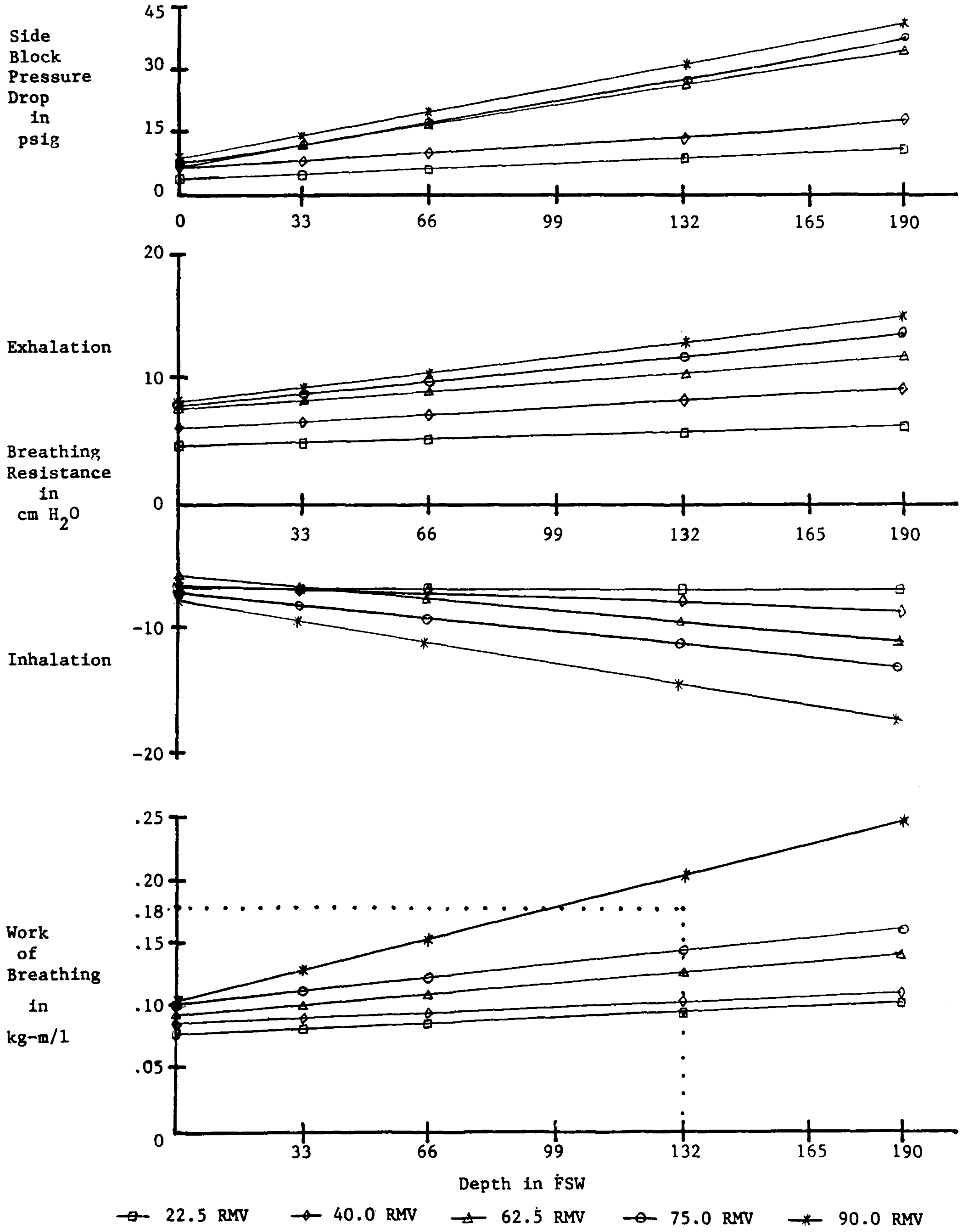
SL-17B/NS OVER BOTTOM PRESSURE GRAPHS

AUGUST 1988

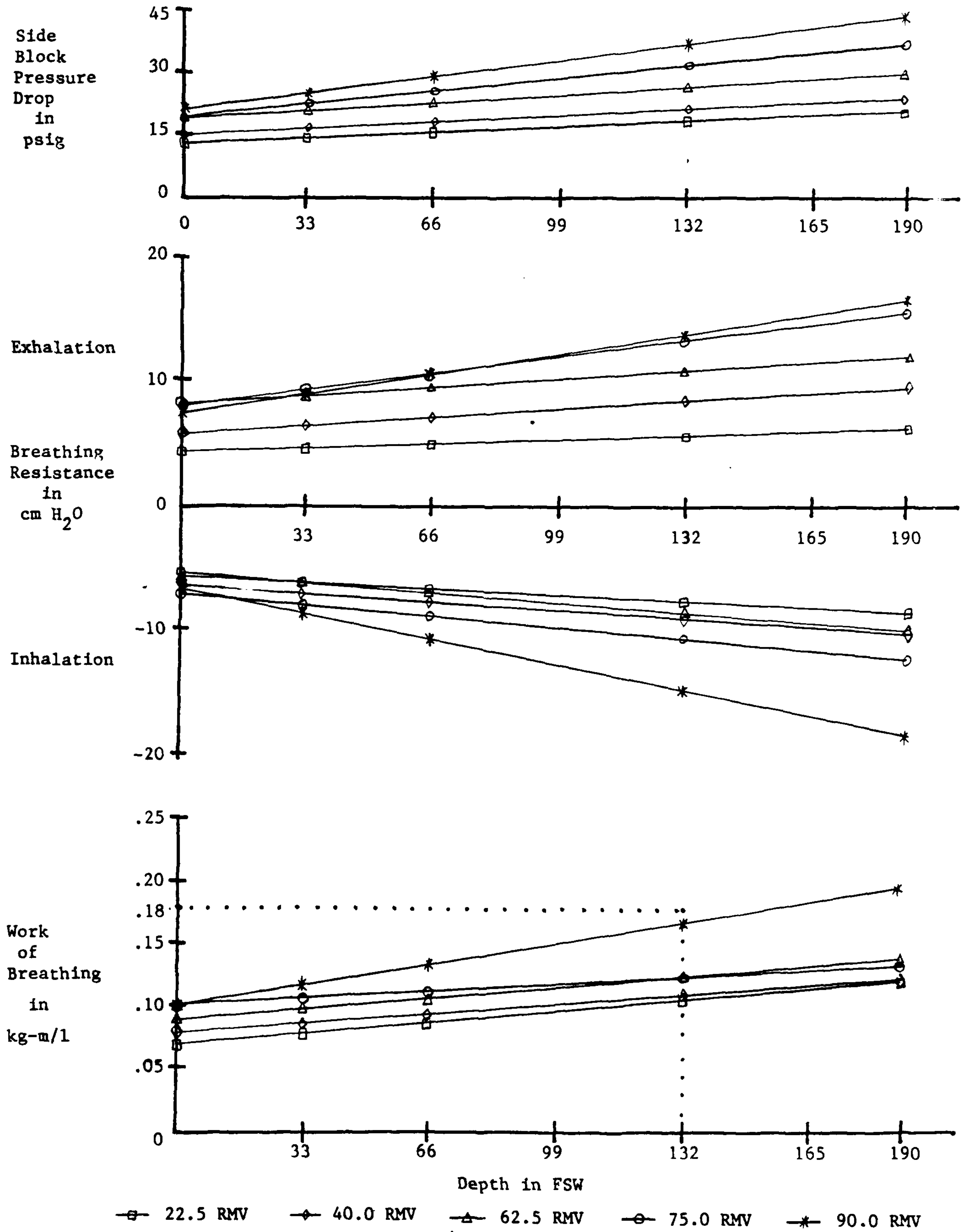
SL 17B/NS MOD 0 AIR @ 125 psig over bottom pressure



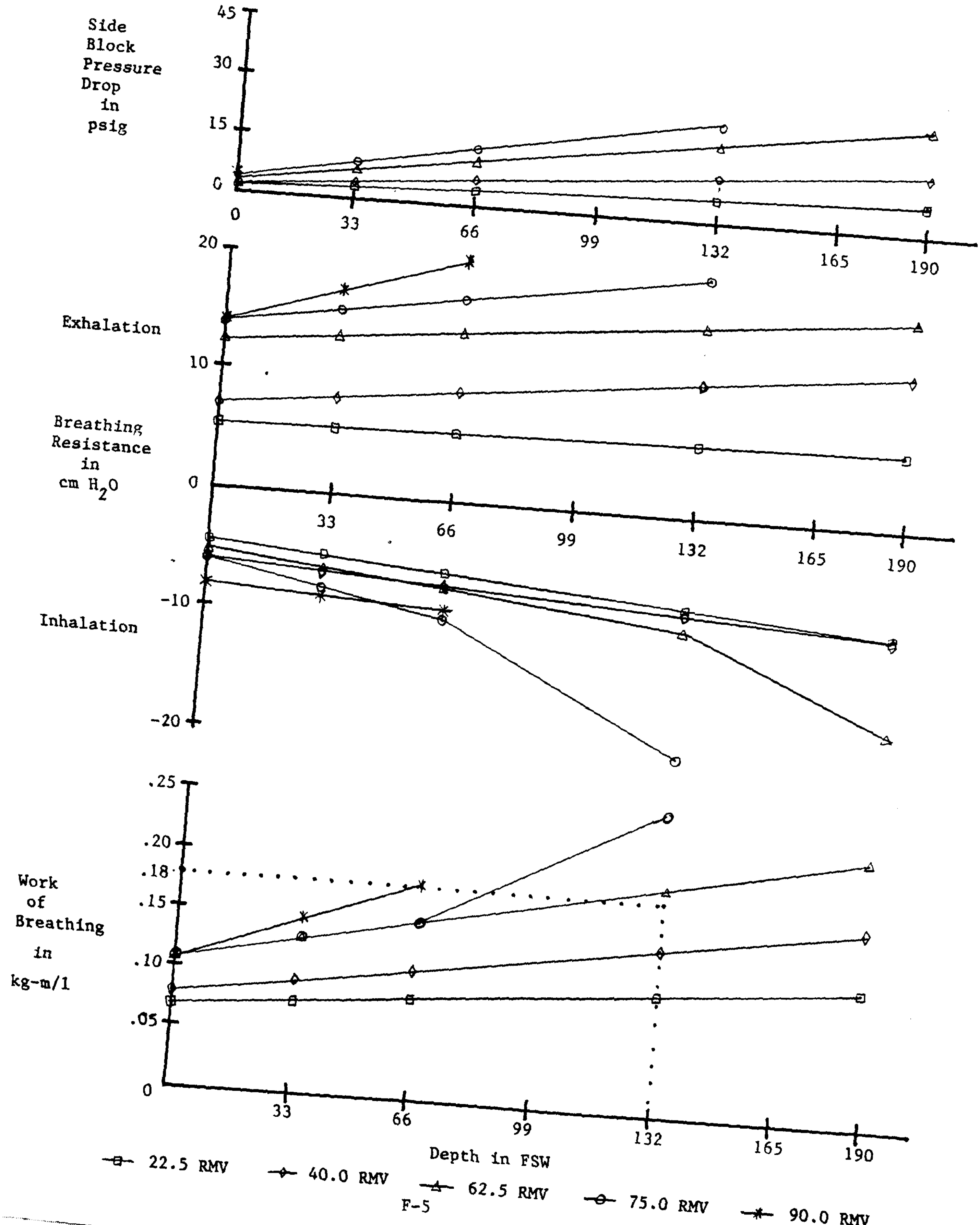
SL 17B/NS MOD O AIR @ 135 psig over bottom pressure



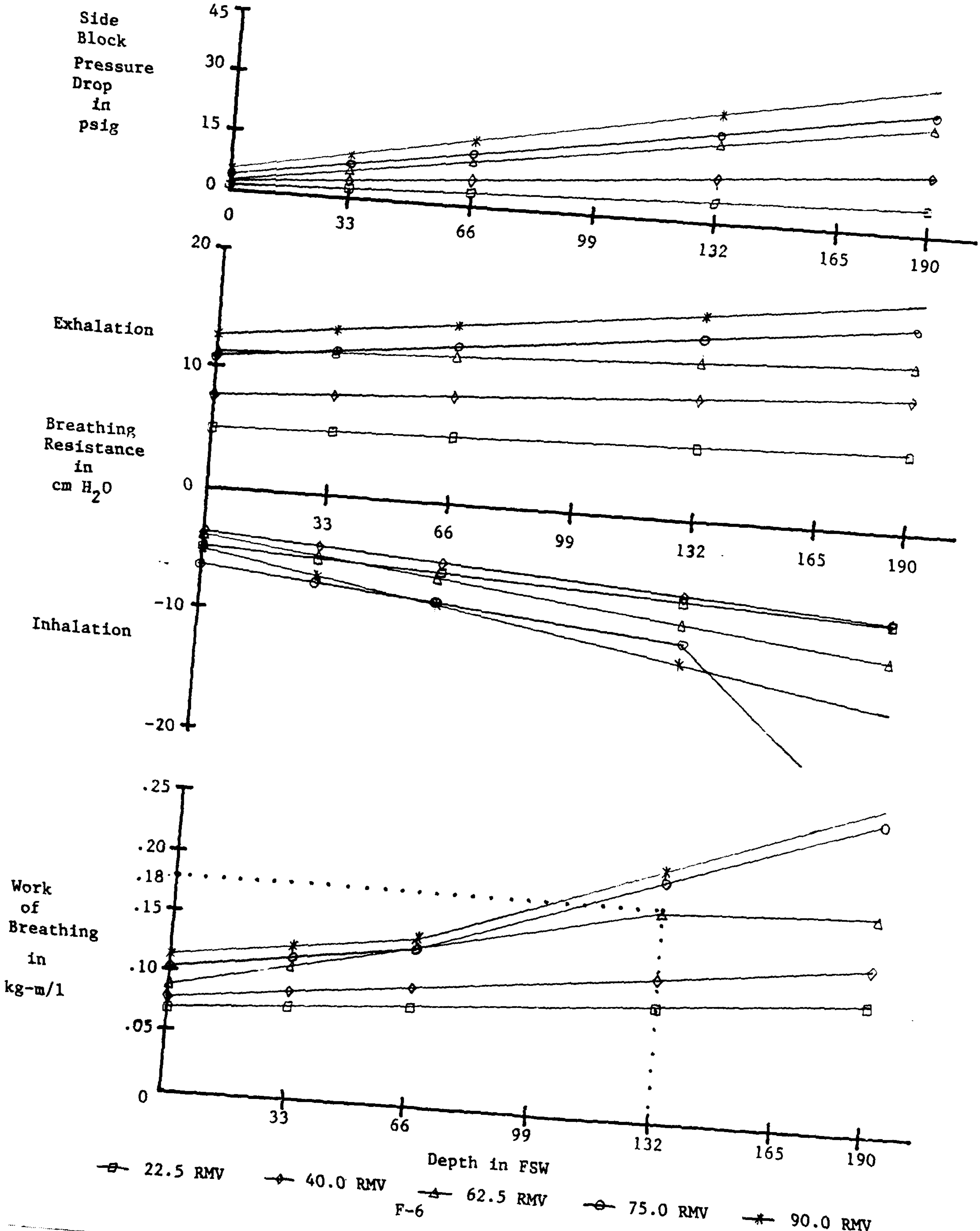
SL 17B/NS MOD O AIR @ 145 psig over bottom pressure



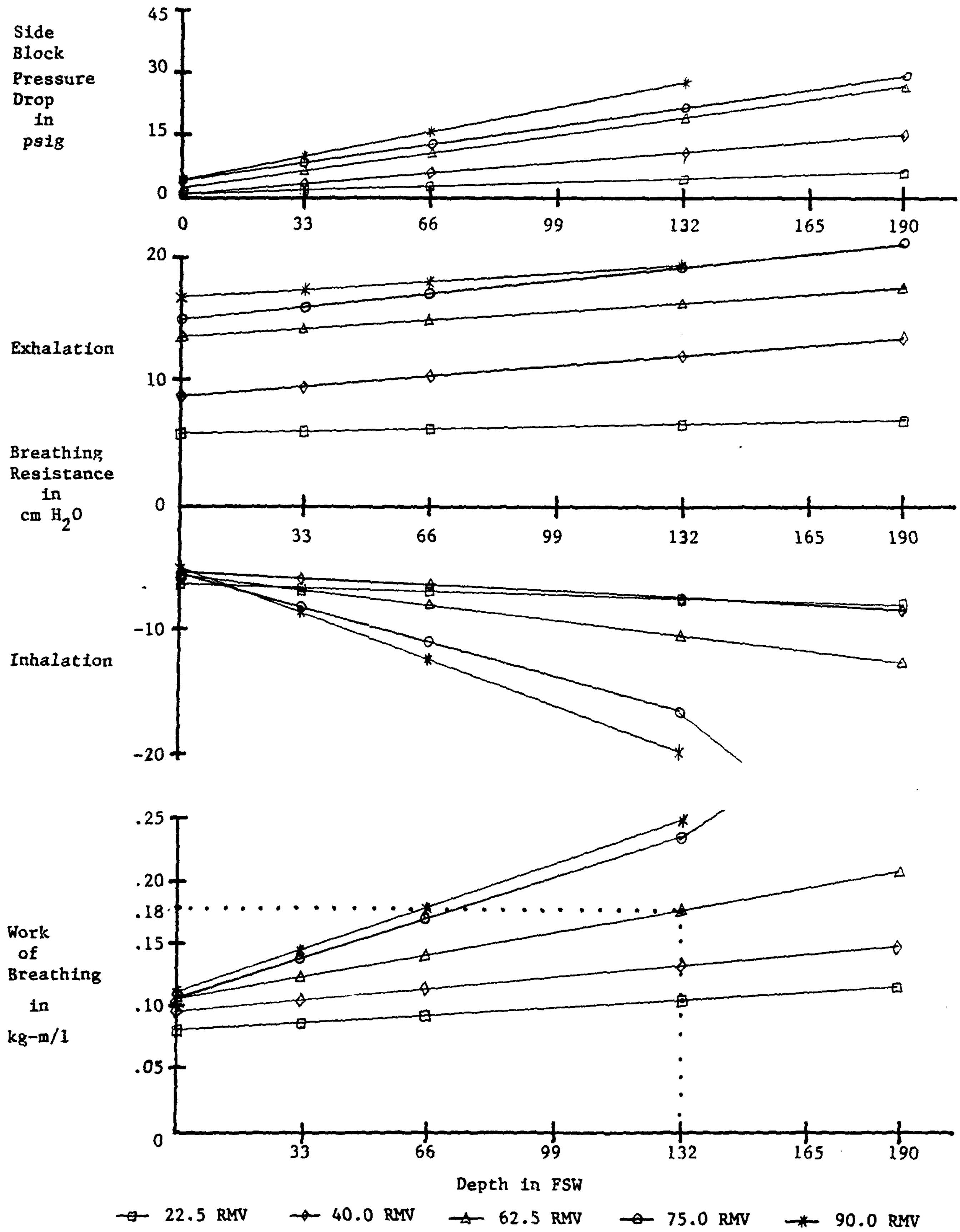
SL 17B/NS MOD 1 AIR @ 125 psig over bottom pressure



SL 17B/NS MOD 1 AIR @ 135 psig over bottom pressure



SL 17B/NS MOD 1 AIR @ 145 psig over bottom pressure



APPENDIX G1

RESULTS OF MANNED SUBJECTIVE TRIALS

PENSACOLA HARBOR

SUPERLITE 17-B/NS MOD 0

NAME 23 DIVES WITH 20 DIFFERENT DIVERS **DATE** SEPTEMBER 1987

Ht / **Wt** / **Length of Dive** :08-:70 AVERAGE :35

How many previous dives in this rig? 0 -> 20 AVERAGE 6

---

1. Extremely poor
2. Poor
3. Not quite adequate
4. Adequate
5. Very good
6. Excellent

Select the number indicating your response to the following questions:

1. How do you rate the ease with which you were able to don the rig you have just worn? ______ 8 ADEQUATE
11 VERY GOOD
4 EXCELLENT

Comments or suggestions:

10% SUGGEST PRACTICE MAKES THE JOB EASIER.

2. How do you rate the fasteners, fittings and valves provided on the Rig?___
10 ADEQUATE
9 VERY GOOD
4 EXCELLENT

Comments or suggestions:

25% SUGGEST BETTER DESIGN FOR NECK CLAMP LEVER LOCKING PIN AND SAFETY.

2% SUGGEST CLIPS FOR MICROPHONE WIRES TO CLEAR ORAL NASAL.

3. How do you rate the fit of: comfort of: POOR -> NOT QUITE/ADEQUATE +

	fit	comfort
Skull Cap	4/19	3/20
Oral-Nasal	3/18	5/16
Shell ~~Spider~~	0/22	2/19

Comments or suggestions:

70% FOUND ORAL NASAL TOO BIG

50% HAD INCORRECT LINER PADDING

10% EXPERIENCED CHIN ABRASION FROM RUBBING ON HELMET

4. **How would you rate:**

7 ADEQUATE
12 VERY GOOD
Rig (Diver's) Visibility? 3 EXCELLENT

Comments or suggestions:

20% FELT PROPER LINER FIT WOULD IMPROVE VISIBILITY

5. **How do you rate the rig you tested for freedom of moving about the topside area or topside work before entering the water?** 1 NOT QUITE
7 ADEQUATE
8 VERY GOOD
6 EXCELLENT

Comments or suggestions:

15% SUGGEST MINIMUM TIME ON SURFACE.

6. **How do you rate the locations of the emergency valve on the rig you have worn?**

2 ADEQUATE
12 VERY GOOD
9 EXCELLENT

Comments or suggestions:

7. **How do you rate the ease of operation of the valve(s) on the rig you have worn?**

2 ADEQUATE
11 VERY GOOD
8 EXCELLENT

Comments or suggestions:

8. **How would you rate the communication system of the rig?** 1 ADEQUATE
8 VERY GOOD
13 EXCELLENT

Comments or suggestions:

25% REPORTED BEST THEY HAVE EVER EXPERIENCED

Circle Appropriate Answer

9. Was the rig comfortable during the dive(s)?

Very Uncomfortable (1)	Uncomfortable (2)	OK (3)	Comfortable (4)	Very Comfortable (5)
4	4	2	6	6

If uncomfortable, explain:

75% FELT LOOSE LINER FIT ALLOWED TOO MUCH MOVEMENT WITHIN THE HELMET

10. Did faceplate fogging occur?

YES (1) 3   NO (2) 19

If so, when? DURING HARD WORK And did it prevent you from completing your assigned task?

NO - EASILY CLEARED BY STEADY FLOW

11. During your dives did water enter the rig at any time?

YES (1) 10   NO (2) 12

If so, describe (how much water, what caused it, did you have to surface, did it flood out, were you able to clear it):

20% ORAL NASAL FLOODING - UNKNOWN CAUSE

60% NECK DAM FLOODING - POOR FIT

12. When using the communication system, were you understood clearly and were you able to understand clearly when others talked to you?

YES (1) 22   NO (2) 0

Explain:

Select the most appropriate answer below for the following questions:

1. Heavy
2. Moderate
3. Tolerable
4. Minimal

13. How would you rate the breathing resistance of the rig in the up-right position? During Inhalation ___________ During Exhalation ___________

Comments or suggestions: 3 TOLERABLE 3 TOLERABLE
20 MINIMAL 20 MINIMAL

10% INDICATED IMPROPER DIAL-A-BREATH USED

14. How would you rate the rig's breathing resistance in the 45° head-up position? During Inhalation ___________ During Exhalation ___________

Comments or suggestions: 2 TOLERABLE 2 TOLERABLE
20 MINIMAL 20 MINIMAL

15. How would you rate the rig's breathing resistance in the prone position? During Inhalation ___________ During Exhalation ___________

Comments or suggestions: 6 TOLERABLE 4 TOLERABLE
16 MINIMAL 18 MINIMAL

5% INDICATED POOR ORAL NASAL FIT

16. How would you rate the rig's breathing resistance in the 45° head-down position? During Inhalation ___________ During Exhalation ___________

Comments or suggestions: 5 TOLERABLE 3 TOLERABLE
16 MINIMAL 18 MINIMAL

10% INDICATED NECK DAM LEAK INDUCED FREE-FLOW

17. Did you have any difficulty swimming? YES 7 NO 12

If YES, please explain:

45% HEAVILY WEIGHTED FOR STRONG CURRENT

18. Did you have any difficulty walking? YES 4 NO 19

If YES, please explain:

100% YES - STRONG CURRENT

19. What part of the pre-dive check list would be the easiest to overlook?

LEAVE THE SIDE BLOCK EMERGENCY VALVE OPEN

FORGET TO CHECK EGS BOTTLE PRESSURE BETWEEN DIVES

20. In general, how would you rate the performance of the rig?

Unsatisfactory (1)	Poor (2)	Fair (3)	Good (4)	Excellent (5)
1	2		11	8

21. In general, how was the rig balanced for comfort?

a. On the surface?

Unsatisfactory (1)	Poor (2)	Fair (3)	Good (4)	Excellent (5)
		7	11	4

b. At depth? (In all positions)

Unsatisfactory (1)	Poor (2)	Fair (3)	Good (4)	Excellent (5)
1	3	3	9	5

Additional comments on balance:

25% SUGGESTED A MK 12 TYPE ATTITUDE STRAP TO CURE THE HELMET LIFTING

22. Did the neck dam fit properly?

YES	NO
(1)	(2)
17	5

23. Did the neck dam leak?

YES	NO
(1)	(2)
8	14

General comments on the neck dam:

WHEN YES REPORTED:

50% IMPROPER NECK DAM DIAMETER

50% LEAKED IN HEAD DOWN POSITIONS

24. What about the balance of the umbilical against the rig, did it tend to pull the rig to one side?

a. On the surface?

YES	NO
(1)	(2)
5	17

b. At depth?

YES	NO
(1)	(2)
3	19

25. Did you use the nose clearing device?

YES	NO
(1)	(2)
13	9

If yes, how well did it work?

Unsatisfactory	Poor	Fair	Good	Excellent
(1)	(2)	(3)	(4)	(5)
	2	1	10	

SUPERLITE ONLY

1. Did the helmet liner fit snugly?

YES	NO
(1)	(2)
13	9

SUPERLITE ONLY
(Continued)

2. Was the helmet liner comfortable?

a. On the surface?

YES	NO
(1)	(2)
21	1

b. At depth?

YES	NO
(1)	(2)
17	5

3. Did the helmet liner place your face snugly into the oral-nasal mask?

YES	NO
(1)	(2)
5	17

4. What pieces/parts of the SL 17B appear to lack durability or sturdiness if it was subjected to Fleet use?

NECK DAM

NECK CLAMP SAFETY PIN

LINER INSERTS

UF500 REGULATOR

HELIOX 18B-NS BANDMASK

NAME 14 DIVES WITH 12 DIFFERENT DIVERS **DATE** AUGUST 1987

Ht / **Wt** / **Length of Dive** :11-:82 AVERAGE :42

How many previous dives in this rig? 0 - 3 ALL HAVE PRIOR MK 1 EXPERIENCE

1. Extremely poor
2. Poor
3. Not quite adequate
4. Adequate
5. Very good
6. Excellent

Select the number indicating your response to the following questions:

1. How do you rate the ease with which you were able to don the rig you have just worn? ______

Comments or suggestions: 1 ADEQUATE
10 VERY GOOD
3 EXCELLENT

2. How do you rate the fasteners, fittings and valves provided on the Rig? ___

Comments or suggestions: 1 NOT QUITE ADEQUATE
10 VERY GOOD
2 EXCELLENT

3. How do you rate the *fit* of: *comfort* of: POOR → NOT QUITE/ADEQUATE +

	fit	comfort
Oral-Nasal	2/12	2/12
Shell/Spider	1/12	2/11

Comments or suggestions:

45% HAD WATER ENTER THE MASK

4. How would you rate:

Rig (Diver's) Visibility? ________

Comments or suggestions: 4 ADEQUATE
8 VERY GOOD
2 EXCELLENT

5. How do you rate the rig you tested for freedom of moving about the topside area or topside work before entering the water? ________

Comments or suggestions: 3 ADEQUATE
8 VERY GOOD
3 EXCELLENT.

6. How do you rate the locations of the emergency valve on the rig you have worn? ________

Comments or suggestions: 8 VERY GOOD
6 EXCELLENT

7. How do you rate the ease of operation of the valve(s) on the rig you have worn? ________

Comments or suggestions: 8 VERY GOOD
6 EXCELLENT

8. How would you rate the communication system of the rig? ________

Comments or suggestions: 1 POOR
1 NOT QUITE ADEQUATE
4 VERY GOOD
8 EXCELLENT

14% LOST COMMS IN THE WATER

Circle Appropriate Answer

9. Was the rig comfortable during the dive(s)?

Very Uncomfortable	Uncomfortable	OK	Comfortable	Very Comfortable
(1)	(2)	(3)	(4)	(5)
1	1	1	8	3

If uncomfortable, explain: ____________________

10. Did faceplate fogging occur?

YES	NO
(1)	(2)
2	12

If so, when? HARD WORK And did it prevent you from completing your assigned task?

NO-CLEARED EASILY USING STEADY FLOW

11. During your dives did water enter the rig at any time?

YES	NO
(1)	(2)
6	8

If so, describe (how much water, what caused it, did you have to surface, did it flood out, were you able to clear it):

WHEN YES:

30% WATER IN ORAL NASAL - UNKNOWN CAUSE 50% WATER IN MASK - LOOSE FIT OF FACE SEAL

12. When using the communication system, were you understood clearly and were you able to understand clearly when others talked to you?

YES	NO
(1)	(2)
12	2

Explain:

WHEN YES:

100% LOST COMMS IN WATER DUE TO WET COMM WHIP CONNECTOR

Select the most appropriate answer below for the following questions:

1. Heavy
2. Moderate
3. Tolerable
4. Minimal

13. How would you rate the breathing resistance of the rig in the up-right position? During Inhalation ____________ During Exhalation ____________

	During Inhalation	During Exhalation
	1 MODERATE	1 TOLERABLE
Comments or suggestions:	2 TOLERABLE	10 MINIMAL
	10 MINIMAL	

7% HAD TO ADJUST DIAL-A-BREATH TO GET DESIRED FLOW

14% DID NOT ADJUST DIAL-A-BREATH

14. How would you rate the rig's breathing resistance in the 45° head-up position? During Inhalation ____________ During Exhalation ____________

	During Inhalation	During Exhalation
Comments or suggestions:	2 TOLERABLE	2 TOLERABLE
	12 MINIMAL	11 MINIMAL

15. How would you rate the rig's breathing resistance in the prone position? During Inhalation ____________ During Exhalation ____________

	During Inhalation	During Exhalation
Comments or suggestions:	1 TOLERABLE	1 MODERATE
	12 MINIMAL	1 TOLERABLE
		10 MINIMAL

16. How would you rate the rig's breathing resistance in the 45° head-down position? During Inhalation ____________ During Exhalation ____________

	During Inhalation	During Exhalation
Comments or suggestions:	3 TOLERABLE	2 TOLERABLE
	9 MINIMAL	9 MINIMAL

17. Did you have any difficulty swimming? YES 3 NO 8

If YES, please explain:

WHEN YES:

65% STRONG CURRENT

65% EXTRA WEIGHT ADDED FOR WALKING

18. Did you have any difficulty walking? YES 5 NO 7

If YES, please explain:

WHEN YES:

60% STRONG CURRENT

19. What part of the pre-dive check list would be the easiest to overlook?

- THAT THE HOOD IS PROPERLY ATTACHED TO THE FRAME

- THAT THE EGS BOTTLE VALVE IS OPEN

20. In general, how would you rate the performance of the rig?

Unsatisfactory (1)	Poor (2)	Fair (3)	Good (4)	Excellent (5)
		1	8	5

21. In general, how was the rig balanced for comfort?

a. On the surface?

Unsatisfactory (1)	Poor (2)	Fair (3)	Good (4)	Excellent (5)
	2	5	2	5

b. At depth? (In all positions)

Unsatisfactory (1)	Poor (2)	Fair (3)	Good (4)	Excellent (5)
	1	2	7	4

Additional comments on balance:

15% REPORTED UMBILICAL PULLED MASK TO THE RIGHT

22. What about the balance of the umbilical against the rig, did it tend to pull the rig to one side?

a. On the surface?

YES	NO
(1) 8	(2) 6

b. At depth?

YES	NO
(1) 4	(2) 10

23. Did you use the nose clearing device?

YES	NO
(1) 9	(2) 5

If yes, how well did it work?

Unsatisfactory (1)	Poor (2)	Fair (3)	Good (4)	Excellent (5)
	1		4	4

APPENDIX G2

DEPARTMENT OF THE NAVY
NAVAL MEDICAL RESEARCH INSTITUTE
NAVAL MEDICAL COMMAND, NATIONAL CAPITAL REGION
BETHESDA, MD 20814-5055

IN REPLY REFER TO
4100
Ser DM2/6230
13 FEB 1987

From: Commanding Officer, Naval Medical Research Institute
To: Commanding Officer, Navy Experimental Diving Unit, Panama City, Florida 32401

Subj: SUPERLITE 17B DIVING HELMET

Ref: (a) NAVSEA 4100 Ser 00C3/1247 ltr of 07 Oct 1985

Encl: (1) Superlite 17B Questionnaires

1. From 4 September, 1986 to 28 November, 1986 the Diving Medicine Department of the Naval Medical Research Institute conducted a series of dives utilizing the Superlite 17B Diving Helmet. By reference (a), we were requested to provide your Command with information regarding the performance of the helmet. The information requested is forwarded herewith as enclosure (1).

2. During the dive series, the Superlite 17B was utilized in the open-circuit mode and with the Gas Services Helinaut valve in the closed-circuit mode. The following statements summarize the comments made by the divers:

a. The Superlite 17B communications is superior to the MK-1 and the MK-12 systems.

b. Maintenance requirements were minimal.

c. Some divers stated they felt "safer and more comfortable" than in either the MK-1 or the MK-12.

d. The Superlite 17B was uncomfortable for extended wear (maximum dive time was 8 hours) while utilizing the Gas Miser Helinaut valve.

e. Several sizes of headliners and neck dams would be beneficial for the personal comfort of the divers.

f. The Superlite 17B diving helmet got high marks for overall utility as a rig that would be a favorite for working dives.

3. Thank you for the opportunity to contribute to your evaluation of the Superlite 17B. Should you have questions concerning the enclosed, NMRI point of contact is LT David Balk, CEC, USN who may be reached at A/V 295-5875/5945 or commercial (202) 295-5875/5945

K. SORENSEN

Copy to:
NAVSEA 00C3

APPENDIX H

SL 17B/NS MOD 0 UF500 PROBLEM PARTS

The following parts, by name and part number, have been located in NEDU's supply of UF500 regulators/spares and display the following defects/discrepancies. Refer to diagrams, page 2.

1. Washer, MS 15795-805; the washer has indiscriminately appeared in several thicknesses from 0.55 to 0.30 mm.

2. Spacer, 592-6318272; the spacer has varied inside diameter to the point that 25% of the parts will not fit over the threaded section of the inlet valve.

3. Inlet valve, 592-6318266 and Body, 592-6318261; some inlet valves will not fit into some bodies. Eventually bodies and valves can be mated but interchangeability of parts is seriously reduced.

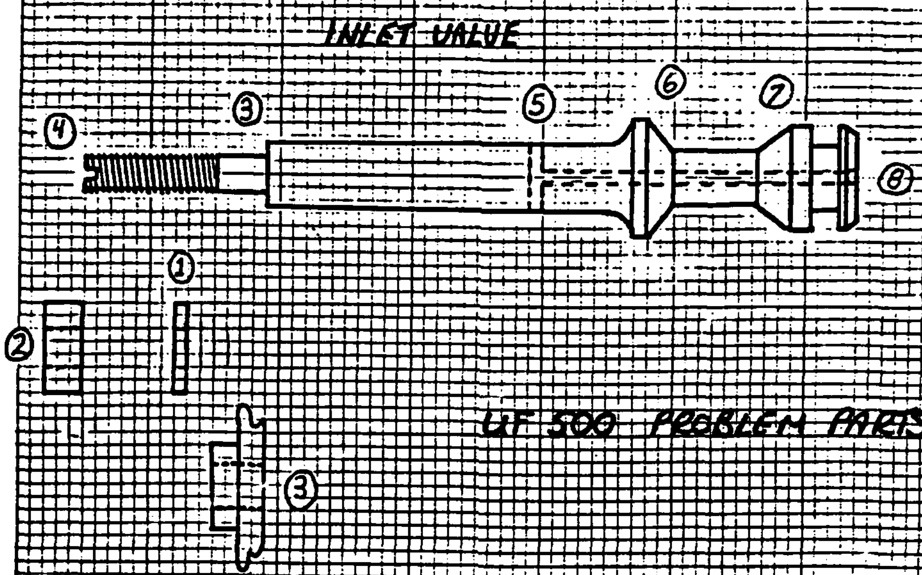
4. Inlet valve, 592-6318266; a valve 2 mm longer than an original UF500 conversion kit valve was found in a new SL 17B/NS MOD 0 received from DSI via NCSC. The extra length appeared to be the cause of uncontrolled free flow that required replacement of the valve.

5. Inlet valve, 592-6318266; the same longer valve from item 4. was found to be defectively machined. The hole at the position (5) was not completely drilled through. This could interfere with gas flow to the balancing chamber and degrade regulator performance.

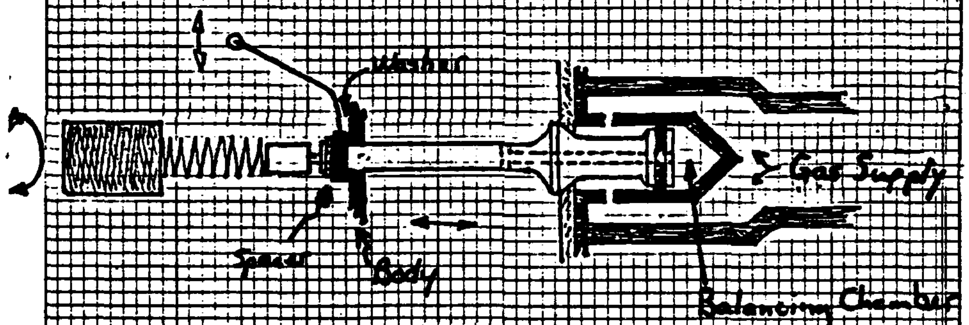
6. Inlet valve, 592-6318266; the shape of this portion of the valve varies from sample to sample. It forms a seal with the teflon valve seat.

7. Inlet valve, 592-6318266; the shape of this portion of the valve varies from sample to sample. It is unknown what effect the shape of this feature has on gas flow.

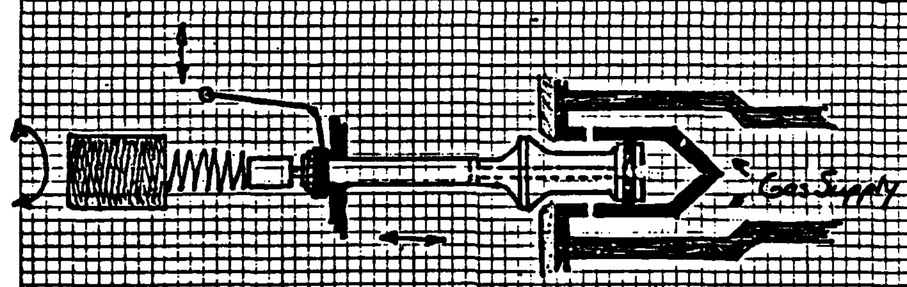
8. Inlet valve, 592-6318266; In a spare parts sample, the hole at position (8) was found to be completely clogged with turnings and would not pass gas to the balancing chamber. This would cause regulator failure at depth.



UF 500 PROBLEM PARTS



SHUT



OPEN

UF500 OPERATION

APPENDIX I

HUMAN FACTORS TESTING OF SL-17B/NS MOD 1

A post-dive questionnaire evaluating the Superlite 17B-NS helmet was completed by seven Navy divers. The divers ranged in height from 68.5 to 74 inches and weighed between 155 and 204 pounds. The average diver height and weight was 70.4 inches and 175 pounds. The forty-two dives in this test series were conducted during a five day air saturation dive performed in the Ocean Simulation Facility at the Navy Experimental Diving Unit with a simulated depth of 50 FSW. The actual depth of the water column for the divers was approximately six feet and water temperature was 65° F. Overall, the divers rated the rig performance as good during this dive series. The fit and comfort of the shell and head cushions were rated as adequate to excellent by all divers. The divers did comment that the fit and comfort of the head cushions changed somewhat with changes in the foam compression with depth. They felt that this factor could be taken into account when setting up the helmet with sufficient experience. Only one size oral-nasal mask was available for use with the helmet during these dives. Despite this, only one of the seven divers experienced consistent and significant problems with the fit and comfort of the oral-nasal mask. This diver also reported that the head cushions did not place his face snugly into the mask, although he rated their fit and comfort as adequate. A second diver reported some minor problems with the fit of the oral-nasal mask. The remaining five divers reported that the fit and comfort of the oral-nasal mask was either adequate or very good during the majority of their dives, with the helmet liner placing their face snugly into the oral-nasal mask.

Two different sizes of neck dam were available to the divers. Three of the divers reported an adequate fit, three reported the fit as between adequate to excellent and one diver reported a less than adequate fit. The comfort ratings for the neck dam closely paralleled the ratings for fit. The diver who was unable to get an adequately fitting neck dam had leaks at this location on all his dives. All other divers reported either no leaks or only an occasional leak occurring during their dives. Water entered the helmet at two locations during these dives. One location where leaks were reported was at the neck dam. In addition, small amounts of water were also reported entering through the regulator and nose clearing device by several divers.

With the relatively small water column on these dives, the nose clearing device was used by only three of the seven divers. It was rated as adequate on the majority of the dives on which it was used (12 of 14) and as very good on the remaining dives. Faceplate fogging was reported on 86% of the dives. This was a problem especially during the exercise periods on the bicycle ergometer, but also occurred throughout the dive on many of the dives. Repeated use of the free-flow control was required to keep the faceplate clear.

On the average, the balance of the helmet in the water was rated as good by the divers. The rig did, however, tend to be pulled to the right by the weight of the umbilical and several divers recommended additional counterweighting to eliminate this problem.

During thirty-four of the forty-two dives, the divers reported on rig breathing resistance, helmet leaks, oral-nasal mask fit, and dial-a-breath efficiency in each of four positions. The four positions used were upright, 45° head-up, prone, and 45° head-down. This was done three times for each dive: before, between, and after two short exercise periods on a bicycle ergometer. It was felt that the increased breathing rate immediately after each exercise period might influence the breathing resistance perceptions of the divers. Analysis of the information collected, however, showed no difference between these three sessions and the ratings were averaged for each dive prior to completing the remainder of the analyses.

The breathing resistance during inhalation was rated as minimal to tolerable by all divers. There was, however, a significant position effect with the reported breathing resistance improving as the divers moved from an upright position down toward a 45° head-down position. There was somewhat greater variability among the divers in the breathing resistance reported during exhalation with ratings from minimal to moderate. Reported breathing resistance during exhalation was not affected by diver position, however.

Ratings of the fit of the oral-nasal mask for comfort and effectiveness obtained from the in-water administered supervisor's questionnaire were slightly lower than those reported in the post-dive questionnaires for two of the seven divers, but remained adequate to very good for 75% of the dives. No effect of position was noted.

Significant gas flowing under the neck dam at the back of the neck was reported in the 45° head-down position. This gas flow was frequently too severe to be compensated for by the dial-a-breath and resulted in gas free-flowing in the helmet. All divers stressed the importance of using a custom fitted neck dam if this problem was to be eliminated. In addition, some stretching of the neck dam was reported with repeated use and this had a gradual effect on the fit. No follow-up study was conducted on the extent of this reported stretching. It may be self-limiting, or it may require that the neck dams be replaced on a regular schedule in order to maintain a good fit.

Communications worked well overall and the divers reported no difficulty understanding the instructions from the control room. However, the diver-to-surface communications had a definite tendency to break-up and become more difficult to understand in the 45° head-down position. This did not occur on all the dives, but was noted on a significant number of them. No question on this item was included in the original test plan and its occurrence only gradually became obvious as the series progressed. Therefore, the exact frequency with which it occurred is not known.

The dial-a-breath was reported to effectively control the gas flow in all positions, except when the diver was 45° head-down with excessive gas flow from the neck dam.

The locking pin on the breech ring frequently came loose while the divers were in the water. All locking pins provided were lost prior to the completion of the dive series and pins were improvised to allow completion of the dives. The divers felt that an improved locking pin was needed for the helmet.

APPENDIX J

August 8, 1988

MEMORANDUM

From: LCDR John A. Sterba, MC, USNR
To: LT David Kirby, CF

Subj: PRELIMINARY RESULTS OF MANNED EVALUATION OF SL-17 B/NS MOD 1 AT 300 FSW ON DEEP DIVE 88

1. The manned test and evaluation of the SL-17 B/NS Mod 1 at 300 FSW with six diver-subjects comparing helmet position facing forward to facing down revealed these results:

a. RESTING BREATHING. Comparing facing forward to facing down helmet position, there were no changes in end-tidal CO_2 tension (P_{ET} CO_2), which is very close to arterial CO_2 tension. Also, there were no changes in mouth pressure during inspiration and expiration. Therefore, there was no change in the peak-to-peak pressure with changes in helmet position at rest. This indicates helmet position at rest did not overstress the divers' cardiorespiratory system being there was no evidence of an increase in effort of breathing and no increase in CO_2 retention.

b. Heavy exercise. There was a mild increase in P_{ET} CO_2 (49.4 to 56.2) indicating a rise in arterial CO_2 with face down helmet position. In addition, face down helmet position increased the mouth pressures during exhalation, leading to an increase in peak-to-peak pressures with face down helmet position (15.5 to 21.8). Despite evidence of a mild increase in CO_2 retention and a moderate increase in breathing effort, the inspiratory and expiratory dyspnea scores subjectively assessing degree of breathlessness did not change in the diver-subjects.

2. In summary, SL-17 B/NS Mod 1 demonstrated excellent performance, physiologicially, in the facing forward position at high work rates of approximately 200 watts (150 watts indicated plus 50 watts for the non-return valve (NRV) suit). Although the divers did not report any increase in the degree of breathlessness, i.e., dyspnea, with face down helmet position, there were increases in CO_2 retention and effort of breathing that could possibly impair the diver during an emergency if extreme exertion would be needed.

3. The complete NEDU report of the manned T. and E. of the SL-17 B/NS Mod 1 at 300 FSW and Mod 0 at 1000 FSW is in preparation and will be called "Manned Evaluation of Superlite-17 B/NS Mod 0 at 1000 FSW and Mod 1 at 300 FSW during Deep Dive 88." You can reference this as (Sterba, J.A. "Manned Evaluation, etc." NEDU Report in preparation) in your report and references.

Very respectfully,

John A. Sterba

JOHN A. STERBA