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**EVALUATION OF DUI
"WING" BUOYANCY
COMPENSATOR**

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19. ABSTRACT: NEDU was tasked to conduct a survey of commercially available buoyancy compensators (BCs), and perform testing to determine which BC perform satisfactorily. Buoyancy compensator evaluation was conducted in three phases. Phase I, receipt inspection of the buoyancy compensator, technical review of the manufacturer supplied documentation (instructions / repair manuals), diver orientation, and Test Pool Evaluation (BC surface floating attitudes if used as a Life Jacket). No failure mode analysis was conducted. Phase II consisted of buoyancy / lift capacity testing in the Test Pool at 15 fsw. Phase III consisted of manned dives in the Gulf of Mexico to test diver buoyancy control and operational characteristics.				
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INTRODUCTION

Navy Experimental Diving Unit (NEDU) is tasked¹ to conduct surveys of commercially available buoyancy compensators (BCs), and perform testing to determine which BCs perform satisfactorily in accordance with references (2) and (3). All BCs that meet the above requirements will be candidates for recommendation to the Authorized for Navy Use (ANU) list. The purpose of this technical report is to determine if the DUI "Wing" BC meets those requirements.

METHODS

GENERAL

Each BC was tested and evaluated in three different environments Phase I (Bench Test), Phase II (Controlled Environment (Test Pool/Ocean Simulation Facility (OSF))), and Phase III (Open Ocean Diving). While bench testing, each BC was evaluated by two qualified U.S. Navy divers for completeness and adequacy of maintenance manuals and technical documentation, skill level required to perform routine repair and maintenance, operation of the integrated weight belt and the operation of all BC components. In a controlled environment, each BC was tested and evaluated for buoyancy and lift capability. While performing open water dives, each BC was used and evaluated by qualified U.S. Navy divers in a single SCUBA tank configuration to a minimum of 30 fsw (9.4 msw).

EXPERIMENTAL DESIGN AND ANALYSIS

All BCs tested were off the shelf items; the "Wing" BC is available in one adjustable "fits all" sizes. The Task Leader or assigned representative was present during the set-up and post-dive procedures on all BCs.

Phase I testing:

- Each model BC was evaluated by two qualified U.S. Navy divers for ease of operation and maintenance procedures.
- Average cost, from five different suppliers was acquired.

Specific comments from evaluators were compiled and documented.

Phase II testing:

- All BCs were tested to 15 fsw (4.7 msw) utilizing the Test Pool. Each BC was fully inflated and the average lift capacity recorded.

Phase III testing:

Each BC was evaluated during open water dives. A series of evaluation dives were conducted to a minimum depth of 30 fsw. Divers completed a human factor questionnaire after each dive. A set of descriptive statistics of the responses and specific comments were compiled.

EQUIPMENT AND INSTRUMENTATION

No special or proprietary tools were required to perform routine maintenance or repair on the BCs.

- a. Phase I: During bench testing, the following equipment was used:
 - (1) Fully charged SCUBA bottle and an approved regulator
(used to supply low-pressure air to perform equipment checks)
 - (2) Manufacturer's instructions and maintenance manual
 - (3) Miscellaneous hand tools and adapter fittings
 - (4) Weights (soft or molded)
- b. Phase II: During Test Pool testing the following equipment was used:
 - (1) Calibrated Viking spring scale model 895, 0 to 50 pounds (0 to 22.7 kg)
manufactured by Hanson in Shubuta, Mississippi.
 - (2) Lanyards, spinnaker shackles, and weight as appropriate to anchor BCs to
deck in test pool.
 - (3) Fully charged SCUBA bottle and an approved regulator (used to supply
low-pressure air)
 - (4) Personnel as required
 - (5) Weights
- c. Phase III: During at sea testing, the following equipment was used:
 - (1) Fully charged SCUBA bottle, approved regulator and all other personnel diving
equipment needed to perform a SCUBA dive
 - (2) Personnel as required
 - (3) At sea diving platform

PROCEDURES

BC evaluation was conducted in three phases: (1) receipt inspection and technical review of manufacturer supplied documentation, (2) Test Pool evaluation (buoyancy/lift capacity at 15 fsw), and (3) open water dives to test buoyancy control and operational characteristics.

- a. Phase I testing began with a review of the following:
 - (1) Completeness and adequacy of the maintenance manuals and technical
documentation
 - (2) Requirements for special or proprietary tools
 - (3) Skill level required to perform routine repair and maintenance
 - (4) Operation of integrated weight system
 - (5) Operation and activation of all BC components
 - (6) Ease of assembly in single tank configuration
 - (7) Unit price

A technical documentation and operational function worksheet was completed by each qualified diver assigned, and returned to the Task Leader.

b. Phase II Testing: Buoyancy/lift capacity of the units was tested in the Test Pool at a depth of 15 fsw. All divers participating in the study were required to familiarize themselves with the contents of the user's manual, to include location of controls on the BC and donning procedures.

A calibrated Viking spring scale model 895 was attached to the deck via a 100lbs. clump in the Test Pool to measure buoyancy. Each BC tested was attached to the scale and tested in the Test Pool at 15 fsw. The buoyancy was measured and documented; at a minimum, each BC was required to provide 10 lbs. of positive lift as outlined in reference (2). The BC was also tested for leaks at depth.

c. Phase III Testing: Manned open water dives were conducted to a minimum depth of 30 fsw to determine each BC's swim characteristics. Results were documented using a diver's questionnaire.

RESULTS

PHASE I

The inspection of the manufacturers supplied documentation on the use, service, parts, technical aspects and exploded views/diagrams were excellent. Documentation fails to include a parts list or technical specifications within the supplied buoyancy compensator manual, but are available from the manufacturer upon request. There were no requirements for special or proprietary tools needed. Skill level required to perform routine maintenance should be at least a second class diver or above. The integrated weight system weights were secure and easy to operate the release mechanism. The operation and activation of all BC components were easy to operate. There were no problems assembling the single tank configuration, there was no twin tank configuration.

The average manufacturer's suggested price per unit is \$348.

PHASE II

The "Wing" BC in the single tank configuration averaged 48.6 pounds of positive lift (lbf) at 15 fsw (4.7 msw) (see Table 1). The measured buoyancy of the "Wing" BC was approximately 16.2% less than the 58 lbf quoted by the manufacturer. However, that difference might have been due to differing test conditions, procedures, or depth.

No twin tank configuration was tested. At time of testing, a twin tank configuration was not available from manufacturer.

PHASE III

During the manned evaluation of the DUI "Wing" BC, 11 divers tested the BC in a single tank configuration to depths ranging from 30 to 100 fsw. On a scale of 1 – 6 (4.0 being the minimum mark for an overall acceptable score), this BC scored a rating of 4.30 in the single tank configuration.

CONCLUSIONS

During testing, two major items of note were encountered. First, in accordance with manufacturer's technical manual and Maintenance Requirement Card (MRC) MIP 5921/023 R-1, the cylinder band strap must be wet prior to installation of the tank. If this was not done, the bottle had a tendency to slip down and out of the BC, which could lead to the loss of the diver's air supply. Second, approximately 30% of the divers reported there was not an attachment point for the low pressure (LP) inflation hose or octopus, making the LP inflation hose and octopus difficult to locate while diving.

RECOMMENDATIONS

Based on the testing and evaluation in accordance with reference (3) and reported in Tables (1) and (2), we recommend that the DUI Model name "Wing" (P/N: 290600) be authorized for Navy Use in single tank configuration. Prior to each diving day PMS MIP 5921/023 R-1 must be completed. No surface floating attitude testing was conducted as per manufacturer's supplied documentation on the use of the BC, therefore we do not recommend this BC be used as a life preserver.

Table 1. DUI "Wing" Buoyancy Compensator Pull Test Data Sheet

DUI "Wing" Single Tank Configuration				
NO.	NOMENCLATURE	BC #	BUOYANCY (LBF)	DEPTH
1	DUI "WING"	1	48 LBF	15 FSW
2	DUI "WING"	2	49 LBF	15 FSW
3	DUI "WING"	3	49 LBF	15 FSW
Average Buoyancy			48.6 LBF	
INFLATION METHOD				
			LP WHIP FROM SCUBA BOTTLE	
			LP WHIP FROM SCUBA BOTTLE	
			LP WHIP FROM SCUBA BOTTLE	

Table 1. Each size BC was tested to 15 fsw (4.7 msw) utilizing the Test Pool. Each BC was fully inflated three times in the single tank configuration, recording the average lift capacity.

Table 2. Human Factors Evaluation of the DUI "Wing" Buoyancy Compensator in Single Tank Configuration.

DUI "Wing" Single Tank Configuration										
QUESTIONNAIRE #	#8 Comfort	#9 Mobility	#10 Donning & Doffing	#11 Neutral Buoyancy	#12 Location of Controls	#13 Operating Controls	#14 Water Drag	#15 Feel Comfortable	#16 Overall Rating	AVERAGE
1	4	4	5	4	3	4	3	4	4	3.89
2	6	5	5	6	5	5	6	6	6	5.56
3	4	4	4	4	4	4	4	4	4	4.00
4	4	4	4	4	4	4	4	4	4	4.00
5	5	6	5	6	5	5	6	6	5	5.44
6	4	4	4	4	4	4	3	4	4	3.89
7	5	4	4	5	6	4	4	5	5	4.67
8	2	2	3	3	1	3	1	3	3	2.33
9	5	5	5	5	5	5	4	5	4	4.78
10	5	5	4	5	5	5	4	4	5	4.67
11	5	5	4	5	4	5	5	5	5	4.78
QUESTION AVERAGE	4.45	4.38	4.27	4.84	4.18	4.36	4.00	4.55	4.45	4.36
Overall Average										4.36

Table 2. A series of open water evaluation dives per tank configuration were conducted to a minimum depth of 30 fsw (9.4 msw). Divers completed a human factors questionnaire after each dive. A set of descriptive statistics of the responses and specific comments were compiled. The BCs scored on a scale of 1-6 scale (4.0 being the minimum mark for an overall acceptable score) (1 = poor, 4 = adequate, 6 = excellent).

REFERENCES

1. Commander, Naval Sea Systems Command, Task Assignment 98-10, *Commercial Diving Equipment Test and Evaluation*, Dec 97.
2. NAVSEA Ltr Ser: OOC32/3265 dated 21 July 1989
3. R. W. Mazzone, *Procedure for the Evaluation of Commercially Available Buoyancy Compensator's (Unmanned/Manned)*, NEDU TP98-01, Navy Experimental Diving Unit, January 1998.
4. Naval Sea Systems Command, *U.S. Navy Diving Manual, Vol. #5*, Rev. 4, NAVSEA SS521-AG-PRO-010, 20 Jan 99. Chapter 7-2.3.4, page 7-9.