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EVALUATION OF SURFACE SUPPLIED GAS PANEL

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Executive Summary

Early in the 1980s, operational diving requirements arose which demanded a lightweight portable surface supplied (LWSS) capability, to bridge the gap between the heavy-duty fixed systems in the YDTs and HMCS CORMORANT and the basic CABA diving team. Over the next few years the operational concept of the LWSS evolved as CUMA entered service. Plans were made to minimize the number and variety of diver's gas consoles by broadening the capability of the LWSS system to permit Air, Heliox and SS CUMA operations from the same console. Thus it was hoped that one console would satisfy many requirements, saving money, training and maintenance effort.

A CUMA Surface Supplied Gas Panel (CUMA SSGP) designed by Fullerton Sherwood Engineering Limited (FSEL) was purchased and modified to support 3 divers in the open circuit diving mode, *i.e.*, either hookah, SL-17 or AGA full-facemask, as well as two divers using surface supplied CUMA. EDU was tasked to evaluate the reconfigured panel with the intention to determine if a single panel could be used to safely meet the needs of both open and closed-circuit light-weight breathing gas supply systems.

The reconfigured panel was evaluated for open circuit and semi-closed circuit surface supplied diving in May 95. This evaluation was conducted in 3 phases: (1) design review, (2) unmanned functional trials and (3) manned dives.

It became apparent during Phases 1 and 2 that the reconfigured gas panel had fundamental design flaws. Among the problems were: it was not light weight at 119 lb; valves could not be confirmed open or closed without a physical check; it was possible to supply pure oxygen to a diver at depths greater than 9 metres of sea water; and valves could be inadvertently operated. These problems and others would prove a hazard during diving operations, even under controlled conditions; consequently, it was decided not to proceed with the manned dives.

Although the components and manufacture of the reconfigured panel were of a high standard, the valves selected were not suitable for use throughout the surface supplied diving panel nor was sufficient consideration given to the ergonomics of the panel. It was concluded that any system with the capability of supporting Air, Mixed gas and CUMA surface supplied diving operations would be inherently complex if it used present technology and manufacturing procedures and thus unlikely to be portable or small enough to fit into a small inflatable boat.

DCIEM TECHNICAL MEMORANDUM 96-13

3752B-P51CD/CUMA (HPSD)

28 February 1996

EVALUATION OF SURFACE SUPPLIED GAS PANEL

Reference: A. Contract N0. W8472-1-MT07/-1-TOX.
B. Contract No. W7711-4-4607/01-TOX dated 17 May 94.
C. 3715B - P11XN (DRMPC 6-2) Dated 27 June 1994.
D. EDU Test Plan 3/95 dated 19 May 95 - Evaluation of the Design Specifications for the Proposed Surface Supplied Gas Panel.
E. DCIEM Human Factors Evaluation Guide.
F. B-GG-380-000/FP-003 Canadian Forces Diving Manual Volume 3 - Surface Supplied Breathing Apparatus.
G. MIL-STD 1472D.
H. DMEE 5-5-5 1190-5 dated 11 Dec 91.
J. FSEL Proposed CUMA Lightweight Surface Supplied Diving System Operating Manual.

Introduction

1. Early in the 1980s, operational diving requirements arose which demanded a lightweight portable surface supplied (LWSS) capability, to bridge the gap between the heavy-duty fixed systems in the YDTs and CORMORANT and the basic CABA diving team. Bottom endurance, safety of working inside confined spaces and lack of communications were, and remain, shortcomings of CABA which could not be overcome when the heavy-duty systems either could not access the dive site, or were beyond the needed response time.

2. Over the next few years the operational concept of the LWSS evolved as CUMA entered service. Plans were made to minimize the number and variety of diver's gas consoles by broadening the capability of the LWSS system to permit Air, Heliox and SS CUMA operations from the same console. (The CUMA requirement arises from the limited self-contained gas supply and lengthy decompression in dives in the region of eighty metres.) Thus it was hoped that one console would satisfy many requirements, saving money, training and maintenance effort.

3. In April 1987, trials on a Lightweight Surface Supplied Diving System were completed; however, deficiencies highlighted in the high pressure system resulted in the system being put into abeyance. In 1991 the USN tested a CUMA Surface Supplied Gas Panel (CUMA SSGP) designed by Fullerton Sherwood Engineering Limited (FSEL), and a rep-

lica of this panel was purchased (Ref. A) by DMEE under this "buy and try" program. DMEE proposed that the evaluation should investigate the potential of this new panel to support Surface Supplied CUMA (semi-closed circuit diving mode), air and heliox diving. Design and ergonomic deficiencies were identified with this panel and EDU, in consultation with DMEE funded FSEL's reconfiguration (Ref. B) of the Gas Panel. The reconfigured surface supplied (SS) panel was to be lightweight, capable of supporting 3 divers in the open circuit diving mode, i.e., SL-17 and AGA as well as two divers using SS CUMA.

4. EDU was tasked (Ref. C) to evaluate the reconfigured panel.

Purpose

5. To evaluate the FSEL Surface Supplied Gas Panel (SSGP). Specifically, the evaluation was to assess the design specification and ergonomics and test the theory that a single gas console could meet the criteria of being lightweight and capable of supporting both open circuit and semi-closed circuit diving.

Method

6. The reconfigured panel was evaluated (Ref. D) for open circuit and semi-closed circuit surface supplied diving in May 95. This evaluation was to be conducted in 3 phases:

Phase 1 - Design Review,
Phase 2 - Unmanned Functional Trials and,
Phase 3 - Manned Dives in the DRF.

7. Phase 1 of the evaluation involved a Design Review of the FSEL SSGP using a team of qualified Canadian Forces Clearance Divers from the Experimental Diving Unit (EDU) and guidance from the DCIEM Human Factors Evaluation Guide (Ref. E). This included conducting in-house checks on all components of the panel to ensure parts and materials matched the schematic drawings of the reconfigured panel and assessing the panel's ergonomic characteristics.

8. Phase 2 of the evaluation involved a series of operational drills (Ref. F) on the panel and conducting a comparison of the reconfigured panel against the present in-service CF Surface Supplied Gas Panel (Ref. F) These drills involved operating the panels in a simulated dive and exercising a series of standard operational and emergency drills with the panel operator dressed with and without three finger leather mittens with a woolen liner. The purpose of this exercise was to examine the operation of the proposed SSGP with the operator dressed for cold weather. Records were made of the ease/difficulty of operation and any errors made in system operation. The proposed SSGP system was configured with the umbilical connected to a SL-17 helmet, with Air/O2/HeO2 supplied. The personnel selected to act as panel operators were selected from within EDU and included four experienced Canadian Forces Clearance Divers, one Royal Navy Clearance Diver, one civilian with surface supplied diving experience and one civilian with no surface supplied diving experience.

9. Phase 3 of the evaluation would involve using the panel to support manned diving in the controlled environment of the Diving Research Facility (DRF). During this phase the panel would be tested under the following conditions:

a. Surface supplied open circuit diving using AGA,
b. Surface supplied open circuit diving using SL-17,
c. Surface supplied semi-closed circuit diving using SS CUMA.

Results

10. During Phase 1 of the evaluation, the following design deficiencies were noted:

i. The reconfigured panel could not be considered lightweight at 119 lb. This would require 3 divers to lift safely (Ref. G) from ground level to a height of 3 foot. Further, the reconfiguration saved only 14 lb from the original panel weight (US Navy version) of 133 lb,

ii. Due to the design of the valves it was necessary to physically check a valve to confirm it was open or closed,

iii. The valves were difficult to operate because of their close proximity to each other and were susceptible to inadvertent operation when functioning an adjacent valve,

iv. It was possible to supply pure oxygen to a diver at depths greater than 9 metres of sea water (msw),

v. The panel connection for the umbilical was recessed into a confined space in the panel container, which meant that a special tool manufactured by FSEL had to be used to secure the umbilical. Furthermore, the design of the tool and space available did not permit the operator to get any purchase on the umbilical nuts when securing the umbilicals to the panel.

11. Phase 2 of the evaluation highlighted the following:

i. During the panel drills, and whilst operating a valve involved in the drill, an adjacent valve was inadvertently operated on 3 out of 7 occasions with the panel operator wearing gloves. Further, the panel operators were observed to continuously check the valve position as it was impossible to visually identify whether the valve was in the open orshut position. This problem would be further exacerbated during night time operations,

ii. On average it took 50% longer to conduct both standard operating drills and emergency drills (i.e., gas shifts, emergency procedures, system checks and cross connects) with the reconfigured panel when compared to the in-service CF Surface Supplied

Gas Panel.

iii. The position and size of the gauges were such that whilst operating the valves the panel operator often obscured the relevant gauge with his arm, making it awkward for the panel operator to monitor the respective gauges whilst operating either an associated valve or regulator.

iv. During the panel drills, the CF Clearance Divers committed 5 critical errors which would have led to a diving incident. The civilian with surface supplied diving experience was observed to make one error which could have led to a diver related incident. The civilian without any diving experience made no errors but took on average three times longer to conduct the operation when compared to an experienced Clearance Diver.

12. Since it became apparent during Phases 1 and 2 that the reconfigured gas panel had fundamental design flaws which would prove a hazard during diving operations, it was decided, on diver safety grounds, not to proceed with the Phase 3 - Manned Dives in the DRF.

Conclusions

13. The reconfigured Surface Supplied Gas Panel (Ref. B) was not considered safe for the conduct of surface supplied diving, nor was it considered "lightweight". It was concluded that any system with the capability of supporting Air, Mixed gas and CUMA surface supplied diving operations would be inherently complex and thus unlikely to be portable or small enough to fit into a small inflatable boat. Although the components and manufacture of the reconfigured panel were of a high standard, the valves selected were not suitable for use throughout the surface supplied diving panel nor was sufficient consideration given to the ergonomics of the panel.

14. This buy-and-try evaluation has led to an important conclusion regarding surface-supplied gas delivery. That is, the viability of designing and manufacturing a surface supplied panel with the combined functionality required to be light-weight; support air, heliox and CUMA surface supplied diving operations; and meet MCM non-magnetic standards for CUMA operations is still some way off. Consequently, it will be important for the CF to provide operational divers with equipment to fill the immediate need of a LWSS panel for air diving, outlined at para 1., and subsequently develop a separate panel for surface-supplied CUMA diving. However, the reasons for a light-weight, multi-function panel may still valid and, if technology arises to make it possible, it would be desirable to bring a panel like this into service.

Recommendations

15. It is recommended that DNR, in consultation with D Dive S, MARCOM and the Fleet Diving Units consider the future requirement for a Light-weight Surface Supplied Gas Panel capable of supporting air, heliox and CUMA operations before any further effort and money is expended.

16. If the requirement for such a system is still valid a Statement of Capability Deficiency should be raised and supported by a Statement of Requirement.

17. As mentioned above, the components of the LWSSGP were of a high standard and suitable for use within the Experimental Diving Unit (EDU) as spare parts for use in support of the research programme. It is recommended that the panel remains with EDU in order that the components may be utilized in support of EDU operations.

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AGA
SL-17

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