Chapter 7 – The Principals of Emergency Breathing Systems (EBS) for Helicopter Underwater Escape

by

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INTRODUCTION

Due to the fact that breath-holding ability in water below 15°C is considerably reduced [7]. The average breath-holding ability of a typical group of offshore workers is about 40 seconds [5], and the time for total clearance of 18 people from a typically fully loaded Super Puma helicopter is between 23 and 92 seconds [2, 3]. It is essential now to have some form of supplemental air for every crew and passenger on board a helicopter flying over water. For a detailed discussion about the implementation of an EBS system into service, please refer to Brooks and Tipton's AGARDograph AG-341 [4] and Coleshaw [6].

Over the past two decades, the three types of Emergency Breathing Systems have been increasingly put into service with helicopter operators for crew and passengers. Military helicopter aircrew very successfully pioneered the equipment. Anecdotal evidence such as the following statement has become common: "Without my emergency breathing system, I would not be here today".

With the increase in oil exploration, helicopter passenger flights over the sea and the media attention when one helicopter ditches and lives are lost, helicopter operators and oil companies are striving to make flight in these machines as safe as possible. The successful track record of these systems, the increase in safety training and safety technology has now made it possible for passengers to carry these systems. It is very important for everybody who may be involved in the implementation of a system that they understand the differences and limitations of each type. The object of this paper is to broaden your knowledge and understanding of these systems.

TYPES OF SYSTEMS

There are three types of systems which can be used for helicopter underwater escape. These are compressed air, a rebreather and finally a hybrid rebreather.

A Compressed Air System

A compressed air system is based on a well proven self-contained underwater breathing apparatus, which most people know as a SCUBA set. This system is a scaled down SCUBA set and operates on exactly the same principal. A high-pressure aluminum cylinder normally charged to 3000 psi or 206 bars of compressed air (21% O_2 + 79% N_2). The pressurized gas is then fed into a step down regulator called a first stage regulator normally found on the top of the aluminum cylinder. The gas pressure is stepped down from 3000 psi to approximately 130 psi. From there, it is fed via a low-pressure hose to a second stage regulator known as a demand valve. This senses the ambient pressure and therefore the user can demand air from the system with little or no resistance. The only resistance experienced is caused by having to inhale against a small pre-set valve, which allows air into the demand valve or mouthpiece. This type of breathing apparatus is classed as an open circuit demand system. This means that when the user breathes out, the exhaled air leaves the demand valve and enters the water. None of the expelled air is collected and reused again, as in the case of a closed circuit demand system.

System Specification

Working pressure between 1800 psi – 3600 psi
Air volume between 42 litres – 80 litres of air
Weight is approximately 3 lbs.
Duration approximately 21 breaths @ 21 feet deep.

The duration of the equipment is based on a starting pressure of 3000 psi and a breathing rate of 10.5 breaths per minute. (Max depth 45 feet)

A Rebreather System

The second system is a rebreather, which is based on exhaling and rebreathing your own air. Because the exhaled air contains un-metabolised oxygen, it can be rebreathed many times before the oxygen is used up. The air, which has been collected at atmospheric pressure (the surface), can be inhaled and exhaled into a bag known as a counter lung when the user is unable to hold their breath anymore.

System Specification

Air for the system is breathed at atmospheric pressure. (Max depth 12 feet)
Breathable air volume = Lung volume
System weight = Approximately 2.25 lbs
Contains an activating device to shut the counter lung off from the atmosphere
Mouthpiece and nose clip
Flexible hose
Counterlung

A Hybrid Rebreather

This system works on the same principle as a rebreather, but it also contains a six-inch 3.5-litre cylinder of compressed air fitted to the counterlung. This air cylinder can be activated by a salt water activated automatic inflator or manually using an emergency manual inflator pull cord. The compressed air is supplied to the counter lung before immersion in the water. The reason for the additional source of air is to provide some air for those who did not get a breath of air before going underwater. Pre-filling the counterlung also has the advantage that it helps make the system easier or more comfortable to breathe in and out underwater.

System Specification

The specifications are the same as a rebreather except for an automatic inflator and a compressed air cylinder.

THE ADVANTAGES AND DISADVANTAGES OF COMPRESSED AIR SYSTEMS VICE REBREATHER SYSTEMS

Compressed Air System

The advantage of a compressed air system is that once the demand valve is placed in the mouth, it will supply the user with an instant supply of air at any stage of the ditching on the surface or underwater. It works well under any orientation of the body and down to a depth of more than 45 feet. The duration of these systems can vary from 2 minutes to 6 minutes depending on the size of the cylinder; the volume of air; the working pressure of the unit; and most important, the breathing rate of the person using it. There are several types available from reputable companies that make and supply diving equipment. Several of these systems have already been successful in saving lives in ditching accidents.

There are only two disadvantages of a compressed air system. First, very rarely, especially in the scenario of helicopter underwater escape or escape training, the user can suffer some form of pulmonary over-inflation injury if it is not used correctly [1]. This type of injury is caused by the air in the lungs or any space in the body increasing in volume due to a decrease in pressure on ascent (Boyle's Law). If the user does not exhale on the way to the surface, or does not breathe normally when using this equipment, it can cause this type of injury. Second, the system will run out of air without warning.

Rebreather and Hybrid Rebreather System

The positive features of a rebreather is that it is somewhat simpler in design, but with the addition of a compressed air cylinder which converts it into a hybrid system, another layer of complexity related to use and maintenance is added. In either system, the main disadvantage is that it requires a number of steps to make it operational during a critical part of flight. The system, currently the most popular used in North Sea, requires the human to physically perform up to six separate steps after the impact phase of a helicopter ditching to make it work. If these procedures are not carried out the system is rendered inoperable and the survivor could drown.

The system must be activated before immersion as there is no purge capability and it cannot be operated underwater. As technology advances, it may be possible to operate a rebreather underwater if some form of automatic shut off valve is used to stop water entering the mouthpiece or breathing tube. This type of automatic shut of valve is being investigated by some of the major survival suit manufactures. Unlike the compressed air system, which senses ambient pressure and gives the survivor the ability to demand air at any depth, the rebreather does not have that feature. As depth and orientation changes it becomes more difficult to exhale and rebreathe from the counter lung. This becomes particularly noticeable if the helicopter is sinking and the survivor's body is not aligned with the counter lung and the air contained within it. It is not easy to learn to control exhalation and inhalation compared to a compressed air system. The tendency is to breathe quickly, which causes you to hyperventilate and it needs a great presence of mind to control the breathing rate. A rebreather is designed to operate above 12 feet. However, the survivor may be as deep as 30 feet or more particularly, if the helicopter has inverted and sunk rapidly and is floating only by an air pocket trapped in the tail section. Then, if a hybrid rebreather is used, the hazards of pulmonary over inflation injuries are identical to that of a compressed air system. With a rebreather or hybrid rebreather, as you rebreathe your own air, the build up of carbon dioxide rapidly causes the survivor to hyperventilate, with the potential of losing consciousness. This is at a time when a survivor must be in full control of his or her mental faculties.

TRAINING AND MAINTENANCE REQUIREMENTS

All of these systems require training. This training should consist of classroom theory training, and because none of these systems are universal in their use, it also requires specific practical pool training specific to the unit. This must be done before doing practical egress training in a suitable helicopter simulator. Regular practical wet refresher training is essential so the operator retains the skills to use the equipment quickly and efficiently. Both in training and operations, the latest models of compressed air systems are relatively cheap to service and maintain. The author has no experience of servicing or maintenance of the rebreather in operations, but for training, it is considered more expensive to use. With the spread of infectious diseases and the difficulty of sterilizing the counter lung, a new or totally sterilized counter lung must be used each time.

INTEGRATION WITH OTHER SURVIVAL EQUIPMENT

This type of equipment is often designed as an add-on to a major part of survival equipment. If not carefully thought out, it can be detrimental to its performance and usability and also cause problems with other life support equipment. There are many different types of these systems and they can only be placed in few positions. The positions are the aviation lifejacket, the flying suit or survival suit, or finally mounted in the helicopter. Whatever position is selected, it is imperative that skilful human engineering is used to match the system to the equipment and the aviation environment. Otherwise it can be detrimental to the performance of the system and catastrophic to the user.

CONCLUSION

In the 21st century, it has now become clear from scientific work and anecdotal evidence from helicopter ditchings, that to prevent the crew and passengers drowning through inability to breath-hold while making either a simple or complex escape, some form of supplemental air is required, especially in water below 15°C.

Currently there are three systems available for operators. The pro's and con's of each system have been described in order that they will work as advertised, a caution has been added concerning the importance of implementing practical wet training and requirement for ensuring an extensive human engineering integration.

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