Ergonomics of the Naval Diving Tower

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1. Introduction

The twenty metre naval diving tower was completed at HMAS Stirling in 1987 for seventeen and a half million dollars. Its purpose was to give Oberon Submarine personnel between the ages of 17 and 35, practical training every three years in escaping in submarine escape emergency suits and by free ascent from disabled submarines underwater. Prior to this date, training was completed overseas. The tower is also used for specialised SAS training. Two compression chambers and a doctor specialising in diving accidents provide back up services.

2. Submarine Escape Tower

2.1 Function

The tower permits submariners to enter at the base through a lock and to swim or float to the surface while releasing air from their lungs to prevent embolisms. If the submarine emergency escape suits are used, breathing may be possible as air escapes from the buoyancy vest into the hood reservoir.

A lock in a submarine being flooded provides 47 seconds to equalise one's ears to the increased air pressure. Burst ear drums often occur. The locks in the escape tower take longer and the equalisation process may be stopped at any time by hitting the wall with a wooden mallet to remove personnel with equalisation difficulties.

Air breathed within the lock is compressed inside the body by the weight of the 60 ft column of water. As the submariner rises through the water, this weight decreases linearly and the volume of air expands geometrically. Embolism or a burst lung may result. Consequently, the swimmer must exhale air continually as he or she rises. To ensure this is done, the swimmer is accompanied by two instructors, who are interchanged at different depths. The instructors would punch the swimmers in the stomach if they did not exhale.

The instructors must monitor their depths and times to ensure that they do not exceed the decompression table limitations. Otherwise, decompression is necessary to prevent nitrogen dissolved in the blood from forming bubbles and lodging in joints, the heart or the brain, causing bends, a possible stroke and death. Instructors receive six months training prior to appointment to ensure their competence.

2.2 Physical Environment

The tank is located in the centre of the building and is serviced by stairways and a large lift. Office space surrounds the tower. Access into the pool is via two submarine locks situated at the base, a large ten man lock half way up the tower or from the top via a submergible bell.

The sixty foot depth was chosen over 100 feet depth used in England because of the reduced risk of accidents. There is little point in subjecting personnel to skills at some risk, if they may never need these skills.

Television cameras and monitors service each entrance and are used for monitoring by the diving officer and training purposes. Video taped displays, for instance, illustrate mistakes of colleagues to ehance performance.

This environment is made as attractive and relaxing as possible to counter the fear involved in using the tower. Chlorinated clear fresh water is used, heated by 216 solar hot water heaters supplemented by gas heating. The warm water relaxes participants, improves visibility and lengths the time that instructors may remain in the water without discomfort. Six exit ladders are provided and clothes pegs with warm robes are immediately available. The room is brightly light, well painted and is cheerful in atmosphere.

Light reflecting mauve and pink tile sides and spot lights mounted on the roof provide maximal visibility.

White lines painted on the floor provide a monitoring assessment of medical state following a dive by the request to stand stationery on the line for four minutes.

Outside the pool soft pastel colours and carpet provide a quiet relaxing atmosphere, similar to an attractive home. This design represents a deliberate effort to reduce stress on the trainees.

Safety is facilitated by non-slip floor materials and red painting to warn of steps and grates. The lift is built to accommodate stretcher trolleys.

Maintenance is facilitated by colour coding and labelling all pipes and valves. Valves are stainless steel to avoid rust and are large to permit leverage and better turning. A movable platform may be lowered within the tower when it is empty of water to permit painting or tile replacement.

2.3 Simulation

Escape locks are built to simulate those of submarines. The identical escape suits are worn. Beyond this, the coldness, pressure, salt and dark murkiness of the water is not reproduced. This lack of realism is justifiable in terms of safety.

2.4 Psychological Concerns

It is difficult for humans to remember information or to act rationally in conditions of extreme stress caused by a life threatening situation. Overcoming these concerns is aided by relaxing the swimmers and providing overlearning of crucial points via repetition and warnings. Instructors provide emergency aid in case of forgetfulness. Selection and training processes for submariners is essential to ascertain those with a psychological readiness for this type of requirement.

3. Decompression Chamber

There are two six man decompression chambers. One is located at the tower top, immediately accessible to the pool. The other is on the ground floor. Separation speeds access and removes the need for a change in altitude which might affect the bends problem.

The chamber is divided into two compartments. The outer department is a lock permitting entry or exit during decompression. As the decompression may take five hours or longer, this is essential, particularly because the doctor usually accompanies the patient in the chamber. Below 18 meters oxygen toxicosis is a risk and mixed gases using helium must be administered. Highly pitched voices are characteristic of this medium.

A removable slide access has been built to allow a stretcher to enter the chamber quickly. The stretcher table may be tilted at any angle.

An EEG permits monitoring of the patients condition. All data concerning times and depths is recorded automatically onto computer disks with hard copy printouts. TV cameras, telephone and an emergency sound powered telephone permit communications. Windows also provide visual communication such as use of written notes. A small airlock allows drugs to be passed in quickly.

3.1 Control Panels

The control panel arrangement is not ideal. The upper controls are beyond the reach of shorter humans. Knobs are positioned in an identical pattern so that a change in position of any knob is clearly visible.

Pressure valves are located next to the dump valve and both valves are circular in shape. Such proximity could cause an error in the use of valves for contrasting purposes. Pressure could be released when it should be increased. This danger is offset by varying the size (smaller) and metal texture of the pressure valves.

VDU screens lack sufficient brightness to be readily visible on a bright day.

Carbon dioxide must be monitored and scrubbed periodically. This system receives prominence on the control panel. All gas lines for oxygen, helium and carbon dioxide are clearly labelled and traced to facilitate maintenance. Scales are large and easy to read, using needles over fixed scales. Such scales indicate direction of needle movement well.

Narcosis or a state similar to drunkenness with errors in judgment may occur at greater pressures.Controls for different machines are the mirror image of each other. This could cause user confusion and error.

4. Conclusion

The naval diving tower imposes psychological stresses on submarine personnel as well as direct, potentially life endangering risks. These risks are overcome by selection of suitable candidates, extensive training, use of skilled instructors and provision of decompression equipment and trained doctors.

The environment is relaxing and attitudes of personnel professional, positive and encouraging. Consequently, no loss of life has yet been experienced.