ENCLOSED SPACE EQUIPMENT

Mines Rescue Marine

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Introduction

Over the last two years, the Mines Rescue Service has enhanced their enclosed space training and experience by exercising and practicing in a Marine environment. This has resulted in several of their training locations being adapted to simulate a marine environment and the formation of a new branch of the service named Mines Rescue Marine (MRM) with their own headquarters and specialised equipment section.

Apart from making use of their technical abilities and experience gained in the mining industry and focusing them on several of the most difficult 'on-board' enclosed space situations, they have also evaluated enclosed space equipment currently in use within the marine industry. Any such study is not helped by the fact that such equipment, which is recognised and legislated for ashore, is not recognised by any marine legislation.

To begin the study, MRM met with a number of manufacturers and tested various types of equipment in marine exercises. This resulted in MRM being able to define equipment which they regard as suitable and also suggest design changes to ensure the equipment was 'fit for purpose'.

It was interesting to note that in the majority of cases, enclosed space protection and rescue was wholly reliant upon equipment used for fire control. Case studies have shown that the use of such equipment, which is not designed for enclosed space use, has been instrumental in several deaths and accidents. For this reason the intention of this paper is to discuss the equipment necessary for the safe entry into and rescue from enclosed spaces, hopefully, to throw light on a subject which, certainly in industry ashore, is recognised as an essential part in the entry and rescue of persons from these spaces.

Enclosed space entries at sea are an inevitable part of life, the topic has and is being debated continuously with many wide and varying views on the subject. However, our focus has never changed. When looking at potential problems involving enclosed spaces we tend look at the safety aspects which involve

the personnel entering the space and of course in the event of something not going to plan, how we would be able to get those people safely out of that space. As an integral part of the ships management system a major part of that documented process is the selection and use of the correct equipment to assist those mariners doing the job. Hopefully, this paper will help somewhat to alleviate the dilemma faced by those involved in equipment selection.

Equipment

There are many manufacturers and suppliers of excellent equipment, designed to do whatever the buyer requires of it. But two main questions should be asked:

- Is it the correct equipment for the job
- Is the equipment 'Fit for Purpose' ?

To be able to answer these questions a high degree of subject knowledge is required. Undoubtly one of the main considerations will be cost, but the quality of the equipment, ease of use & maintenance and the safety of the people using it, should always be the main driver in this process.

Personal Protective Equipment (PPE)

Minimising the risk of accidents and protecting people must always be the primary concern and personal protective equipment seen as the last 'line of defence'. A review of PPE equipment used for enclosed space entry should always be part of the safety officers remit when persons are affecting an entry.

Individual PPE requirements will vary dependant upon the work in hand and any specific hazards identified on the appropriate risk assessment prior to entry, therefore this is an appropriate place to start.

Head Protection:

The requirement for a good quality, well fitting helmet which affords protection from side impact as well as from falling objects is essential. Accidents from bruised and split scalps are either minimised or eliminated entirely by ensuring that helmets are worn at all times when operating in an enclosed space. Chin straps are essential, they prevent the helmet falling off or indeed being blown away in heavy weather. Additional benefits are to be gained where fitments are available to accommodate a head torch or light on the helmet, essential for hands free operations. All helmets have a user life (see manufacturers recommendations) and are

normally date stamped inside the helmet this gives an indication to the safety officer when helmets should be replaced.

Eye Protection:

Various types of good quality eye protection are available on the market which meets current impact standards. These are an essential component of PPE they help to prevent accidents due to impact injury or foreign body's entering the eye. This type of protection may come in the form of glasses, goggles or helmet mounted visors and may be designed to meet your company's requirements and/or personal preference. A common problem with eye protection is misting up, if the wearer is working in a hot environment and sweating a lot this tends to happen. There are many proprietary anti-misting agents which if applied before use help to prevent misting up of the lenses.

Ear Protection:

As with eye protection, many forms of hearing protection are available for an individual to use. In any enclosed space area where the entrant is required to work in a noisy environment, ear protection is essential, indeed mandatory use may be required in some areas.
This protection falls into two main categories –

- Ear plugs which fit into the outer ear can afford a certain degree of protection, they may be separated pairs, or paired up and attached to a cord. These can then be shaped and fitted, indeed in certain instances moulds of the persons ears may be taken to ensure a comfortable fit.

- Ear defenders are the second means of protection, they may have an integral adjustable head band which make them independent of the user or have a fitment which attaches to a helmet. In either case, they are colour coded indicating the attenuation (loudness) levels for which they afford protection.

Full Body Protection:

At sea, coveralls are widely used, they prevent contaminants coming into contact with the body and exposed skin surfaces. In the main, poly/cotton coveralls are sufficient for day to day use. However, there may be circumstances where additional protection may be required, an example of this being where the person may come into contact with absorptive or corrosive contaminants. In such cases it may be more beneficial to wear sacrificial paper over-suits, or indeed PVC or other non penetrative suits to give added protection to the entrant when operating in the enclosed space. Heat retention and preventing the body temperature to self regulate, should always be a consideration when deciding to use non penetrative suits as a total barrier.

Hand Protection:

Is always advisable when operating in an enclosed space, it helps to minimise injury due to minor cuts, abrasions and contamination. Light hand protection is preferable to ensure dexterity is not impaired, whilst protection against liquid contaminants may be achieved with barrier creams, inner gloves or gloves made from liquid repellent materials.

Foot Protection:

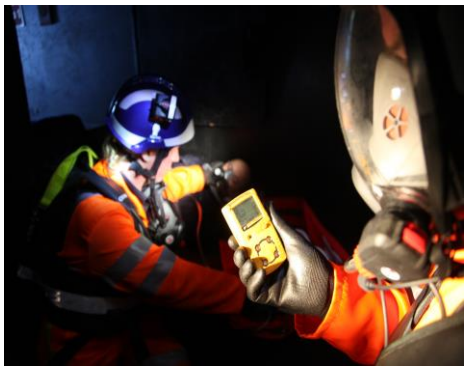
In most, if not all workplaces, foot protection is a mandatory requirement and may take the form of shoes or boots. Numerous proprietary brands of foot protection are available, however, our preference is to wear a leather lace up boot with internal steel toe protection and composite sole. They are lightweight, flexible and with the additional benefit of giving support to the ankle joint thereby helping to avoid sprains and strains.

Enclosed Space 'Entry' Equipment

On shore, the 'Confined Space Regulations' deal with specific equipment issues ensuring the safety of entrants into an enclosed space, whereas at sea SOLAS make recommendations for all on board equipment. At present, SOLAS does not take into account the specific equipment requirements for the safe entry into and rescue from enclosed spaces at sea.
In an endeavour to address this issue some individual marine companies prescribe their own equipment lists for safe entry and rescue however all too often this equipment is supplied by third parties or ordered from catalogues with those making the recommendations knowing little about the equipment or the environment it will be used in.

In many cases the type and design of a ship or platform will dictate the equipment required, however, consideration should be given to the following before making that decision.

Gas Detection Equipment:



Apart from the many dilemmas faced by the purchaser, there are a plethora of manufacturers who will supply and distribute gas detection equipment for use in enclosed spaces. So how do you choose?
In the first instance, you should be guided by your risk assessment. This will highlight the hazards and help in the selection of the correct type of monitor to use in relation to the gases likely to be encountered. As an enclosed space should always be checked prior to entry, it is preferable that the equipment comes with a means of remote sampling such as a length of tubing and internal pump or aspirator in order to pull the air sample out of

the space to a place of ‘fresh air’. Only when a determination of safe breathable air is confirmed should an entry into the enclosed space take place. Other beneficial considerations would be that it is lightweight, portable, water resistant, monitors continuously, and the instrument is intrinsically safe (carries ATEX approval). In addition to remote sampling and as an added safety feature personal gas detectors should always be carried into the space to monitor the entry and work area continuously thereby helping to safeguard the entrant.

Lighting:

Inevitably, most enclosed spaces encountered on-board a ship or installation are dark with no means of natural or artificially installed lighting. In order to overcome the problem, artificial light needs to be introduced into the space, this can be achieved in one of several ways:

- Permanently installed fixed lighting installations are probably the best solution to this problem, but they are expensive to install & maintain and therefore in most cases, not a viable option.

- Temporarily installed fixed lighting such as, string lights are often used and are a very good means of illumination. They light up the travel route and immediate work area but are prone to damage, leaving the possibility of exposed electrical contact from cables, fittings and lamps as an added hazard.

- Portable lighting such as hand lanterns and torches are the most common form of lighting taken into enclosed spaces. The benefits of this method being that they illuminate the immediate travelling route and at the work place give a concentrated light source for detailed examination of equipment or chambers.
  The problem with lanterns or touches is that they normally have to be carried thereby impairing movement when climbing ladders or moving through tight spaces. This can be overcome by fitting the torch or light to the entrants helmet, thus making the operation ‘hands free’, improving safety and has the added advantage of being able to point a beam of light in the direction of travel at all times without the need to stop and re adjust the light source.

Helmet Mounted Light

Communications:

Having an effective means of contacting the entry guardian in order to pass information or raise the alarm in the case of an emergency is an essential requirement for any enclosed space entry team.

Communications come in many forms, from basic systems such as: tugs on a rope, air horns or whistles which are dependant on pre determined signals, to more sophisticated methods employing radios or hard wire systems. The latter two being preferable as the entrant has direct voice contact with the entry guardian and can have the added advantage of being 'hands free'.

Of the two main electronic methods, (radios and hard wire), radios are lighter and more portable than hard wire systems, however the signal may be lost due to black spots in the ship thereby reducing the effectiveness of the system, whereas hard wire systems, although cumbersome to run out, ensures continuity of voice communication. An added advantage being that the hard wire system doubles as a guide line and in some instances may be illuminated giving an additional safety feature.

Illuminated Guideline Communication System

<u>Escape Respiratory Protection:</u>

May be carried into the enclosed space by entrants as part of their personal safety equipment should the risk assessment identify the need. Known as EEBD's (emergency escape breathing devices) they provide the wearer with an independent breathable air supply for a short duration, usually 10 to15 minutes, enabling the entrant to get back to the entry point safely if the air quality deteriorates.

The most common EEBD used is the compressed air type but alternatives such as a chemical type are available. Whatever the preferred option, it must be remembered that EEBD's are designed for escape purposes only.

Compressed air EEBD's fall into two main types:

Constant Flow *(or Hood type)* - when activated, delivers a constant flow of air from the cylinder to a hood which is pulled over the wearers head. This is the easiest type to wear as it requires very little training or knowledge to use, simply open the bag which activates the cylinder valve, take out the hood and pull it over your head. A constant flow of air is then delivered to the wearer. The disadvantages of this type being that your vision is partially impaired because of the hood, it's a bit noisy due to the air feed into the hood and some wearers may get a feeling of claustrophobia.

Positive Pressure *(or Facemask type)* - this type of EEBD uses a facemask in place of the hood. When activated, and the facemask donned, air is delivered to the wearers facemask 'on demand'. This type requires a little more technical ability to use as the seal is made only when the facemask is in position and secured in place by a head strap.

Both types are similar in size and weight and can be carried either by a loop strap or worn as a jacket for added comfort and 'hands free' operation.

Chemical EEBD's - have the advantage of being smaller and lighter than their compressed air counterparts but requires to be stored in sealed containers which when opened and used must be returned to the manufacturer for re-servicing. They operate on the principle of a chemical reaction i.e. the CO2 and moisture from your exhaled breath activates the chemical (KO2) which in turn produces Oxygen for the wearer to breathe. Operational durations vary dependant on the model purchased and can range from 30 to 90 minutes usage.

Harnesses:

The wearing of a harness for entry into an enclosed space on a ship, whilst part of shore legislation in many countries, is a relatively new concept for those at sea. The need of such equipment is apparent when the rescue of a person is to be attempted. If a harness is already worn by the casualty, essential minutes are saved by clipping the harness onto the hoist and evacuating the person quickly.

Harnesses come in many designs and are normally worn to act as part of a fall restraint system. The type of harness which should be worn are 'rescue harnesses'. They are specifically designed to ensure that during vertical extrication operations the person will lean not more than 10 degrees from the vertical axis, ideal when winching through restrictive openings such as those encountered on board a vessel. Although they may be awkward to wear in an enclosed space, they have the added advantage of giving robust lifting points for manhandling a person during horizontal extrication.

Rescue Harness

Enclosed Space 'Rescue' Equipment

The worst case scenario during any enclosed space entry is to have to effect a rescue of casualties. To ensure this happens quickly and efficiently dedicated rescue equipment is essential. In selecting rescue equipment, three key features should be considered:

1. Is it 'fit for purpose'
2. Can it be easily operated
3. Can it be easily maintained

Identifying the correct equipment for the job is the difficult part. Once selected, an adequate programme of training in its use is the next link in the 'chain of

competency'. Having the correct equipment and people trained in its use are the main keys to success.

Winching Arrangements:

Almost every case of enclosed space entry on board a ship will involve ascending or descending through restrictive entries into a tank or chamber. Where a vertical entry is being made, extrication equipment should be set up prior to entry in order to enable an effective rescue to be implemented immediately. Removing someone with a rope and pulley is strenuous, time consuming and carries a serious risk of injury to the casualty.

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Currently on many ships and installations chain blocks, rope & pulley systems or indeed man handling are accepted methods of rescue. These methods should be replaced, where possible, by using mechanical man riding winches. Dependant on the manufacturer, these man-riding winches have varying design features such as those which are dependant on a tripod / quad pod arrangement or others which can operate independently.

Man access into a 'Barge Tank'

Man-Riding Winch (in use)

Mechanical winches drastically reduce the need for manual handling and make casualty extrication less onerous on the rescuers. Man-riding winches can effect casualty retrievals from varying depths and are certified to lift up to 150kg on the man-riding mode.

Winches of whatever type depend on an effective anchorage point. These anchorage points may be of the fixed type such as eye bolts, lifting beams and certified cross members or mobile anchorage points such as davit arms, tripods, girder clamps or strops & shackles. Whatever type of winching arrangement chosen, forethought should always be given to the location and adequacy of anchorage points.

Fall Arrest Units:

By definition, fall arrest units are safety devices which are attached to a suitable anchorage point and harness in order to prevent serious injury due to a fall. In practice, they limit the vertical distance dropped should that person slip whilst ascending or descending a ladder thereby preventing serious injury. They come in various types, rope lengths and designs. The most common

type act on the ‘inertia reel principle’ which is similar to the operation of a car seat belt.
Many of the ‘inertia reel’ type, also incorporate the use of a handle for retrieval purposes, in other words if the unit is activated the handle will allow the person to be wound to safety, they are not specifically designed for man-riding purposes.

Stretchers:

Moving a person through and out of an enclosed space is always difficult. The most common method is to man-handle the person using their clothing, a board or such other device. Where space allows, it is always preferable to move a casualty on a stretcher for two reasons. It is a stable structure which is more comfortable for the casualty and it gives the rescuer a rigid lifting platform to work with. There are many types of stretchers, each with their own advantages (and disadvantages). When choosing the type for enclosed space rescue the following should be considered:

- Can it get in and out of the space
- Is it lightweight
- Does it have the necessary rigidity required
- Are there adequate lifting points
- Can it perform both horizontal and vertical rescues
- Is it compatible with a winch

Internal access between compartments in a tank

Entrance to a ‘Coffer Dam’

Respiratory Protection:

S.C.B.A. - For rescue, a working BA differs significantly from that required by enclosed space entrants in so far as they need an extended usage time and training in there use. Normal working BA has a duration of around 20 to 40 minutes, dependant on the wearers stature, temperament, nature of the space encountered and work activity. The nature of the space will have a limiting effect on the ability of the wearer to operate effectively as the physical size and weight of the BA will impair task achievement. Too often Fire Fighting BA sets are used for enclosed spaces and case studies have shown

that due to their physical size and weight, they have limited or indeed even prejudiced attempts at rescue.

It is essential that the BA sets chosen for enclosed space rescue meet the criteria for enclosed space rescue, with attention paid not just to duration but also to its' physical size, weight and comfort when worn.

Compact 'Jacket Type BA' in use

Matching these exacting requirements is difficult, but there are BA which employ slim-line 4.7ltr lightweight cylinders, having 300 bar capacity for extended use and fit into a jacket arrangement around the wearer for comfort. These BA are designed for use in restricted spaces and have an added advantage of enabling an airline to be connected to them to extend their working duration further.

Airline – This type of respiratory equipment is used on many ships, essentially it consists of a bank of cylinders (2 or 4), attached to a manifold and first stage regulator. The air is transferred to the wearer through a fixed hose line which terminates at a face mask with demand valve arrangement similar to the BA, discussed earlier. As an added safety feature the air hoses are normally attached to a waist belt thereby helping to prevent the face mask being dislodged by movement.
The main advantages of this system is, - extended usage due to the 'bank of cylinders' arrangement extending the wearing time and it allows entry into spaces where a BA set may restrict the wearer.
The main disadvantages of the system are - limited range, movement and hose handling, particularly if more than one person is using the system.

Oxygen Resuscitation Equipment:

Oxygen is essential to keep the body alive, it therefore follows that when entering an enclosed space in order to rescue a person, an independent supply of oxygen is needed to support the casualty's respiration. One way of achieving this is to fit an 'Oxygen Powered Resuscitator' to the casualty. The unit should be capable of operation in both a 'Positive Cycle' mode (delivering set quantities of oxygen at precise intervals to the casualty when they are not breathing), whilst at the same time being capable of automatically changing to

an ‘On Demand’ mode (when the casualty is capable of breathing for themselves). The unit should be independent, transportable, lightweight,

Oxygen Resuscitator stowed in Carrying Pack

Oxygen Resuscitator ‘In Use’

easy to use and reliable, thereby allowing the rescue party to concentrate mainly on the task in hand, assured, that the resuscitation equipment is ‘doing its’ job’.

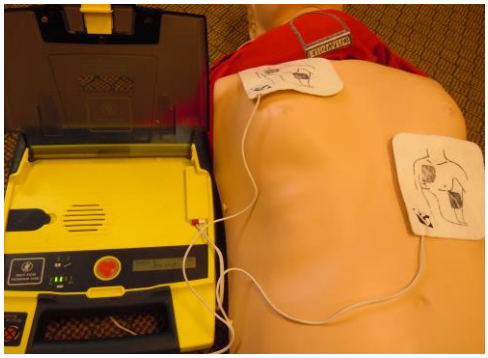
First Aid Equipment:

Basic Life Skills first aid should be a mandatory requirement for all rescue workers. The ability to prevent the casualty’s condition worsening, by stemming blood flow from a wound or immobilising a fracture before moving them, is a fundamental component of casualty management. In order to support the application of life saving first aid techniques, a well stocked first aid kit should be available for use by the rescue party at the enclosed space entry point.

Analgesic Gas Equipment:

The main function of analgesic gas is offer pain management. It is inhaled into the body and is self administered. In essence, the person taking the analgesic gas will continue to breathe in the analgesia until the pain eases.
It is carried in a self contained carry bag which includes a cylinder of ENTONOX gas, regulator, delivery hose and demand facility. It is an excellent piece of equipment used for pain management during the rescue process, having distinct benefits to both the casualty and the rescuers when manoeuvring within the enclosed space.

De-fibrillation Equipment



Automatic external de-fibrillators are life saving instruments which should be readily available and on hand outside the enclosed space. These AED's are predominantly used to shock the heart back into its normal rhythm should cardiac arrest occur. The earlier an AED is used, the greater the chance of casualty survival. Most modern units give voice prompts to the user, (available in various languages) and are supplied in either 'semi' or 'fully automatic' modes. These units are compact, portable, lightweight, battery operated and generally manufactured for ease of use, which benefits the rescuer.

Conclusion

In consideration of the number of casualties which continue to occur in enclosed spaces, there must come a time, in line with industry ashore, when enclosed space working and rescue equipment becomes mandatory. The continued use of Fire Fighting equipment for rescue from these spaces remains questionable as previous case studies have shown Fire Fighting equipment to be inadequate in some instances and indeed having fatal consequences in others.

Within the Mines Rescue Service, we fully understand the need for realistic training and dedicated equipment, it is this combination which has protected mines rescuers throughout their history, the benefits gained from this learning process can now be delivered into the marine industry in order to give your rescuers that same level of protection to which they are entitled.
Hopefully, if this paper stimulates further debate, it will focus attention, once again, on the extreme dangers associated with enclosed spaces in the marine industry.