Enclosed Space Equipment

When looking at potential problems involving enclosed spaces, we tend to look at the safety aspects of entering the space, and of course in the event of something not going to plan, how we would be able to get people safely out of that space. A major part of that process is the selection and use of the correct equipment to assist those mariners doing the job.

In addition to focussing on several of the most difficult onboard enclosed space situations, Mines Rescue Marine has also evaluated the safety and effectiveness of enclosed space equipment currently in use within the marine industry.

It is interesting to note that in the majority of cases, enclosed space protection and rescue onboard ship 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. In discussing the equipment necessary for the safe entry into and rescue from enclosed spaces, we hope to throw light on a subject which is recognised as an essential part in the entry and rescue of persons from these spaces.

Selection criteria
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?

Answering these questions requires a high degree of subject knowledge. Undoubtedly one of the main considerations will be cost, but the quality of the equipment, ease of use and maintenance, and the safety of the people using it should always be the main driver in this process.

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 makes 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 marine companies prescribe their own equipment lists for safe entry and rescue. 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 selecting 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 it has been determined that the air is safe and breathable 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.

Lighting
Inevitably, most enclosed spaces onboard a ship or installation are dark. Artificial light can be introduced into the space in one of several ways:

- Permanently installed fixed lighting installations are probably the best solution to this problem, but they are expensive to install and 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 illuminate the immediate travelling route and at the work place give a concentrated light source for detailed examination of equipment or chambers. The problem 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 helmet. Helmet mounted lights have the added advantage of allowing users to direct a beam of light in the direction of travel at all times without the need to stop and re-adjust the light source.

Communications

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 dependent on pre-determined signals, to more sophisticated methods employing radios or hard wire systems. These are 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. Hard wire systems, although cumbersome to run out, ensure continuity of voice communication. An added advantage is that the hard wire system doubles as a guideline. In some instances, the wire may be illuminated, giving an additional safety feature.

Escape respiratory protection

This 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 (emergency escape breathing devices), they provide the wearer with an independent breathable air supply for a short duration, usually 10 to 15 minutes, enabling the entrant to get back to the entry point safely if the air quality deteriorates.

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

Compressed air EEBD fall into two main types.

● The constant flow (or hood type), when activated, delivers a constant flow of air from the cylinder to a hood which is pulled over the wearer’s head. This is the easiest type to wear as it requires very little training or knowledge. The user simply opens the bag which activates the cylinder valve, takes out the hood and pulls it over their head. A constant flow of air is then delivered to the wearer. The disadvantages are that 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.

● The positive pressure (or facemask type) 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 EEBDs have the advantage of being smaller and lighter than their compressed air counterparts but must be stored in sealed containers. Once opened and used, they 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 dependent on the model purchased and can range from 30 to 90 minutes’ usage.

Harnesses

Wearing a harness for entry into an enclosed space is part of shore legislation in many countries, but is still a relatively new concept for those at sea. The need for such equipment is apparent when a rescue is needed. If the casualty is already wearing a harness, 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 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 casualty during horizontal extrication.

Rescue equipment

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

● Is it fit for purpose?
● Can it be easily operated?
● 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.

Chain blocks, rope and pulley systems or indeed man handling are accepted methods of rescue on many ships and installations. These methods should be replaced, where possible, by using mechanical man-riding winches.

Man-riding winches can effect casualty retrievals from varying depths and are certified to lift up to 150kg on the man-riding mode.

Features will vary depending on the manufacturer, with some dependent on a tripod or a four-legged arrangement, while others can operate independently.

Mechanical winches drastically reduce the need for manual handling and make casualty extrication less onerous on the rescuers.

Winches of all types depend on having an effective anchorage point. These may be fixed anchorage points such as eye bolts, lifting beams and certified cross members or mobile anchorage points such as davit arms, tripods, girders clamps or slings and shackles. Whatever type of winching arrangement is chosen, consideration should always be given to the location and strength of anchorage points.

Fall arrest units
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 if the user slips. 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 devices also incorporate 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.

Stretcher
Moving a person through and out of an enclosed space is always difficult. The most common method is to manhandle 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?
- Are there adequate lifting points?
- Can it perform both horizontal and vertical rescues?
- Is it compatible with a winch?

Respiratory protection
Breathing apparatus (BA) for rescue operations differs significantly from that required for enclosed space entrance under routine conditions, in so far as it has an extended usage time, and demands specific user training. Normal working BA has a duration of around 20 to 40 minutes, dependent on the wearer's 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. All too often, firefighting BA sets are used for enclosed spaces. Case studies have shown that they have limited or indeed even prejudiced attempts at rescue due to their size and weight.

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

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. They have the added advantage that an airline can be connected to extend their working duration further.

Airline: This type of respiratory equipment is used on many ships. Essentially, it consists of a bank of two or four cylinders 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, helping to prevent the face mask being dislodged by movement.

The main advantages of this system are the extended usage time, and that it allows entry into spaces where a BA set may restrict the wearer.

The main disadvantages of the system are limited range, and some restriction of movement due to the need for hose handling, particularly if more than one person is using the system.

Oxygen resuscitation equipment
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 automatically changing from positive cycle mode, delivering set quantities of oxygen at precise intervals to the casualty when they are not breathing, to on demand mode when the casualty is capable of breathing for themselves. The unit should be independent, transportable, lightweight, easy to use and reliable, 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. 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 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. This is an excellent piece of equipment having distinct benefits to both the casualty and the rescuers when manoeuvring within the enclosed space.

**De-fibrillation equipment**
Automatic external defibrillators (AEDs) are life saving instruments which should be readily available and on hand outside the enclosed space. These AEDs 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.

**Mandating safety**
The combination of realistic training and dedicated equipment has protected mines rescuers throughout their history. This expertise has now been successfully implemented into many industries ashore. There is available equipment that can be recommended for use for the marine and the oil and gas industries and this combined with training in the use can provide a higher level of safety for workers in these spaces.

In consideration of the number of casualties which continue to occur in enclosed spaces onboard ship, there must come a time, in line with industry ashore, when enclosed space working and rescue equipment becomes mandatory.

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