A Pocket Guide To

Safe Confined Space Entry Onboard Ships

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Confined or enclosed spaces on ships are restricted places with limited openings for entry and exit, unfavorable or negligible natural ventilation and not designed for continuous working.

Confined space entry is a matter of great discussion in the maritime industry as several seafarers, shore workers, and surveyors have lost their lives in these restricted areas.

All maritime professionals must be aware of the dangers associated with entering and working in enclosed spaces. They must also have the necessary knowledge and training to enter confined spaces without putting their lives at risk.

Some of the common confined spaces on board ships are cargo holds, cargo tanks, pump rooms, cofferdams, engine crankcases, boiler chamber, sewage tanks, fuel and lube oil tanks, double hull spaces, duct keels, compressor rooms, paint lockers etc.
The atmosphere of any enclosed space on board ship is potentially dangerous as there may be lack of oxygen or it may contain trapped toxic and flammable gases.

However, it is also to note that sometimes a place might not technically fall under the "confined space" category, but if there is deficiency of oxygen or loss of ventilation in there, it should be considered as a dangerous place for work.

A risk assessment of all enclosed and dangerous working spaces is mandatory before planning and commencing any kind of work so that appropriate measures can be taken to protect those whose lives may be at risk.

Some of the main reasons for confined space accidents are:

- Underestimating the dangers of a confined space
- Failure to recognize a confined space
- Incorrect safety procedures
- Attempting to rescue crewmembers
- Relying more on physical senses than safety equipment
A confined space on board ships can have several dangerous hazards, especially if it has been kept closed for a long time.

Some of the main dangerous of enclosed spaces are:

1. Toxic Vapors

Enclosed spaces such as ship's fuel or cargo tanks can have trapped hydrocarbon gases, which are flammable as well as toxic. Such toxic gases can be present in areas such as duct keel, cofferdams, cargo tanks, pump rooms, ballast tanks etc. Benzene and hydrogen sulphide are some of the most dangerous components which are found in the vapors of oil cargoes.
Other dangerous gases on ships include nitrogen dioxide, nitric oxide, Sulphur dioxide, carbon monoxide etc. Leakage of chemicals in enclosed spaces, especially on board chemical and gas tanker or other packaged dangerous goods, can lead to trapped toxic vapors.

<table>
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<th>Gas</th>
<th>Limit 8 Hour work shift [ppm]</th>
<th>Limit 15 min working [ppm]</th>
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<tr>
<td>Benzene (C₆H₆)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Hydrogen Sulphide (H₂S)</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO₂)</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Nitrogen Monoxide (NO)</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Sulphur Dioxide (SO₂)</td>
<td>2</td>
<td>5</td>
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Toxins are measured in parts per million (PPM). Under no circumstances should a person enter a confined space exceeding the limits specified above. Different testing bodies throughout the world may, however, have different acceptance limits.

For vessels with inert gas systems, trace amounts of various toxic gases may increase the hazard of exposure for personnel. Normally, a steady 21% by volume of oxygen reading will be sufficient to dilute these gases to below their “Threshold Limit Value” (TLV).
2. Oxygen Deficiency

Oxygen in an enclosed space might have been reduced especially if the confined space is kept closed for a long time. Some more reasons for depleting oxygen can be rusting, oxygen absorbing cargo or chemicals, or displacement of oxygen by carbon dioxide, inert gas or hydrogen.

Any atmosphere with less than 20.8% (± 0.2%) oxygen by volume should not be entered.

3. Flammable Vapors

As mentioned earlier, flammable gases can be present in enclosed spaces which contained oil, chemical or gas cargoes. Sometimes cofferdams and other places adjacent to the cargo tanks can also contain flammable vapors in case there is a leakage. Vapors from paints, cleaning chemicals, or tank coatings can also be extremely harmful.

Enclosed spaces not only contain toxic vapors but sometimes they also have contaminants which can be absorbed through the skin.

Some contaminants in gas and chemical tankers are irritant or corrosive when they come in contact with skin.
Enclosed space with an atmosphere with more than 1% of the “Lower Flammable Limit” (LFL) or “Lower Explosive Limit” (LEL), on a combustible gas indicator should not be entered. The Flammability indicator shows the percent within a safety range of 0-10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%.

Combustible gas detectors have normally two measuring ranges 0-100% LEL and 0-10% LEL.

Note: Do not trust your own senses to determine if the air in a confined space is safe to enter! Many toxic gases and vapors can neither be seen nor smelled, nor can the level of oxygen be determined without using the right equipment.
Risk assessment is to be carried out of an enclosed space by a competent person before commencing the work.

Risk assessment mainly includes identifying possible hazards, jobs that needs to be done, making procedures for entry and exit, carrying out of important checks, planning rescue operations etc.

Following points should be noted while carrying out a proper risk assessment:

- Potential hazards and any other possible dangers are to be identified
- Opening and securing the enclosed space entry is to be done properly
- Precautions should be taken to check if the opening of enclosed space is pressurized or not
- All fire hazard possibilities should be minimized if hot work is to be carried out. This can be done by emptying the fuel tank or chemical tank nearby the hot work places
➢ The confined space has to be well ventilated before entering and other procedures for entering should be planned out.

➢ The space has to be checked for oxygen content and other gas contents with the help of oxygen analyzer and gas detector.

➢ “Permit to work” should be procured.

No one should enter the enclosed space until a thorough risk assessment has been carried out by a responsible and competent official.

The entry should be made only after an enclosed space entry permit is issued by the master or concerned authority and necessary checklists are filled.
The competent officer responsible for the enclosed space work should be able to make an informed assessment of the dangerous atmosphere and must have sufficient theoretical knowledge and practical experience to identify the hazards and decide what necessary precautions needs to be taken in order to carry out the work.

Important duties of a responsible officer in charge includes:

- Identifying potential hazards related to the confined space on basis of the risk assessment
- Considering potential dangers from neighboring or connected spaces
- Securing and well illuminating the place
- Testing atmosphere at various levels
- Making proper communication systems for carrying out the work safely
- Discussing the hazards related to trips and falls, and from obstructions such as pipes, coils, girders etc.
Based on the risk assessments, he should make procedures and guidelines to enter the dangerous space, considering there is minimum risk to the life or health of the person entering the space.

The procedures planned should be on the basis of the assessments, which would be either:

a. there is minimal risk to the life or health of the person then or in future time.

b. there is no immediate risk but a risk can arise in future during the course of work.

c. there is immediate risk to life and health.

The responsible officer would then get all safety equipment ready and make necessary arrangements to check the atmosphere inside the enclosed space.

He should then ensure that the permit to enter is ready, authorizing the entry.
The enclosed space needs to be tested for both oxygen content and flammable gases before making an entry.

An oxygen content monitor is used to check the oxygen level, which should be at least 21% by volume. If possible, oxygen testing should be done remotely. If this is not possible, the person entering the space should use a breathing apparatus along with other personal safety equipment.

The number of people entering the space should be kept minimum and the testing should be carried out at different levels as concentration of toxic gases might vary.

For testing the amount of flammable gases or vapor in the enclosed space, a combustible gas indicator or explosimeter is to be used.

The instrument used for testing must provide accurate reading even at low concentrations.

As most of the combustible gas detectors are calibrated on a standard gas, when testing other gases and vapors, references should be made to the calibration curves supplied with the instrument.
It is to note that combustible gas indicator and oxygen content monitor are two different equipment tools with different purposes and they should never be used as substitute for each other.

When checking for combustive gases using combustible gas indicator, usually a "nil" reading is desired but if the readings are steady, up to 1% of lower flammable limit is sometimes also accepted.

It is also to note that sometimes it’s difficult to measure the exact quantities of components such as hydrocarbons and hydrogen, and therefore specialized equipment and trained personnel should be arranged to carry out these process.
A confined space cannot be entered without using the right personal protective and safety equipment.

Crewmembers entering the enclosed space should never enter the same without wearing proper breathing apparatus.

The breathing apparatus would usually comprise of a continuous supply of air from outside the confined space and a self-contained supply which would enable a person to escape in case of failure of the continuous supply or during an emergency.

The arrangement should be such that in order to change over to the self-contained supply, no part of the personal protective clothing needs to be removed.
It should be noted that the self-contained breathing apparatus is of an approved type and additionally tested for use with other breathing air systems. Moreover, the breathing airline apparatus should also be approved from a standard authority and should be of demand valve type.

The capacity of the self-contained apparatus should be sufficient to escape to a safer area. It should also be considered that in emergency condition, the wearer's breathing rate is higher than normal breathing rate of 40 liters per minute.

The responsible officer should ensure that the breathing apparatus are properly checked before use. He should also note the following:

- The supply airline from outside the enclosed space should be continues and used only by those working in the space. Notices should be placed at the right areas to ensure that they are not used for other purposes.

- The pumps and hoses supplying the air should be secured in such a way that the air supply is not interrupted.

- The air pumped into the lines should be filtered and fresh.

- Notice of enclosed space entry indicating tank location to be displayed in ECR and bridge.
The pump used for the airlines should be constantly monitored for working condition.

Before using the pipes and hoses, they must be thoroughly blown to remove moisture and other contaminants.

The engineer on watch must be informed about the compressor supporting the airlines so that it is not stopped by mistake and is monitored continuously.

Those wearing breathing apparatus must know how to use it properly.

All checks should be made to ensure that the breathing apparatus is donned according to the procedures recommended in the manufacturer's guidelines.
The officer should check the pressure, low-pressure alarms, fitting of the facemask, the amount of air coming inside the mask, airtight seal between the person's face and facemask etc.

All safety equipment such as emergency escape breathing set, personal gas detector, portable radio, retrieval harness, emergency light / torch, emergency means of communication such as whistle etc. should be kept ready.

The users must know how to share the air supply with others who require it in case of extreme emergency.

The users must be aware that the self-contained supply should be used only when there is a failure of the continuously supply from outside.

Under any condition, the breathing apparatus should never be removed, unless it becomes imperative to save the person's life.

All the equipment should be inspected for correct operation before and after use.
**Procedure for Entering an Enclosed Space**

The following are the points that need to be followed before entering an enclosed space:

- The final results of the risk assessment of the enclosed space is to be discussed and necessary precautions are to be taken by the competent officer.

- A responsible officer should be appointed to take charge of the work and people required to assist him should be assigned.

- A list of work to be done should be made for the ease of assessment for e.g. welding to be carried out or some pipe replacement etc. This helps in carrying out the work quickly and easily.
Equipment such as breathing apparatus, lifelines, rescue harnesses should be checked for proper functioning.

The torches or lamps to be used should be approved of use in flammable atmosphere.

Space should be prepared and secured for safe entry.

The access to the space should be well illuminated and no source of ignition should be taken near the space until the responsible officer is satisfied that it is safe to do so.

Permit to work system should be ready and signed.

Means of hoisting an incapacitated person from the confined space should be kept ready and other necessary precautions for emergencies should be taken.

Suitable breathing apparatus, e.g. of the air-line or self-contained type, should always be worn, and only personnel trained in its use should be allowed to enter the space.

Persons entering enclosed spaces should be provided with calibrated and tested multi-gas detectors that monitor the levels of oxygen, carbon monoxide and other gases as appropriate.
At least one person should stay at the entrance and he must be aware of his duties.

A clear communication system should be agreed between the person entering the space and the one standing near the entrance. The officer on watch must also be clear on his communication system with those working in the enclosed space.

Lifelines to be used must be long enough and capable to attach firmly to the harness. The user should be able to remove them easily in case they get tangled or if need arise during emergencies.

Proper checks should be made to ensure that entry with breathing apparatus is possible in the confined space. All obstacles that can cause difficulty of movement should be removed from the space.
- The person going inside should carry oxygen analyzer with him and it should be ON all the times to monitor the oxygen content. In case the level drops, the analyzer should be able to sound alarm and the space should be evacuated quickly without any delay.

- No source of ignition has to be taken inside unless the master or competent officer is satisfied.

- The number of persons entering should be constrained to the adequate number of persons who are actually needed inside for work.

- The rescue and resuscitation equipment are to be present outside the confined space. Rescue equipment includes breathing air apparatus and spare charge bottles.

- The oxygen content should read 21% by volume. Percentage less than that is not acceptable and more time for ventilation should be given in such circumstances.

- Enough lighting and illumination should be present in the enclosed space before entering.
All necessary checklists and procedures are to be carried out to prevent any unfortunate accident inside the enclosed space.

Permit to work is valid only for a certain time period. This means that if time period expires, a new permit is to be issued and checklist is to be filled out accordingly.

Permit to work has to be checked and provided by the master of the ship or other recognized authority in order to work in the allowed confined space.
Proper signs and “men at work” sign boards should be provided at required places so no one starts an equipment, machinery or any operation related to the confined space, risking life of the people working inside.

Duty officer has to be informed before entering the enclosed space.

The checklist also has to be signed by the person involved in entry and by a competent officer.

One person must always be kept standby to communicate with those who have gone inside the enclosed space for work.
Once an entry is made, the space should be checked once again for flammable and toxic gases before commencing the work, especially hot work.

Throughout the working period, ventilation should continue, even during breaks. In case there is failure or interruption in ventilation system, the crew should leave the space immediately.

While the work is carried out, one person should periodically check the atmosphere for oxygen level. In case the condition deteriorates, he should immediately instruct to leave the space.

If during the work any unforeseen difficulties or hazards develop, the work should be stopped and evacuation should be made immediately so that the situation can re-assessed before recommencing the work.
If any emergency occurs, the general alarm should be sounded so that a rescue team reaches immediately for help.

No one should enter the space until the situation has been evaluated and the atmosphere has been checked for safe entry.

Once the “permit to work” expires, all personnel inside the enclosed space should make an evacuation and the entrance should be closed, until a new “permit to work” has been issued and the area is rechecked for safe entry.

After finishing the work and when the person is out of the enclosed space, the after work checklist has to be filled.

The permit to work has to be closed after this.
Precautions When working inside Enclosed Space

Precautions should be taken while carrying out enclosed space activities such as welding, cutting, brazing, painting, scraping, sand blasting and degreasing. Many processes create toxic gases which can be extremely harmful to people working in the enclosed spaces. For example, cleaning vapors from solvents can become very toxic in a confined space. It is also important to be aware that hot work carried out consumes oxygen.

Welding: Hot work on surfaces with coatings create gases which can be very toxic. This gas may come from hot work being carried out in a tank adjacent to the enclosed space. Care must be taken during such operations.

Coating: Special attention should be given when spray coating is carried out in an enclosed space area. Spray coating with small sized particles when mixes with air, leads to toxic components which can be extremely harmful.

Grinding: Grinding may cause miscellaneous compositions of dust. Absorption of metal dust into the body through inhalation is dependent on the physical and chemical properties and the size of the particles. Dust like this may cause metal fume fever and bronchitis.
**Sandblasting:** The dangers of sandblasting depends on the type of substance and the size and containment of the grit.

Several grits used for sandblasting contain carcinogenic substances such as quartz, nickel, lead and lead compound.

During sandblasting, containment of carcinogenic chemicals may increase depending on the surface of the sandblasted area. These are extremely toxic in nature.

**Hydro blasting:** Hydro blasting may create aerosols, which are dispersion of solid or liquid particles in air. These particles are small enough to stay in the air for a long period of time.

Aerosols may transport reactive chemicals deep into the lungs in a way that cause very high exposure. Aerosols may be produced from dust, dirt and cleaning chemicals from high-pressure cleaning of miscellaneous surfaces.

**NDT operations:** Chemicals from NDT operations may also be dangerous. Most ultrasonic thickness measuring equipment are not intrinsically safe. Proper care should thus be taken while carrying out such processes.
Personal protective and safety equipment such as lifelines, breathing apparatus, safety harness, resuscitation equipment etc. should be properly maintained and inspected at regular intervals of time.

The inspections are to be made by competent person or authority and a record should be kept for future references.

Testing equipment should be kept in good working condition and periodically serviced and calibrated.

Manufacturers guidelines and recommendations should always be present with the equipment.

Several accidents in ship’s enclosed spaces have also occurred because of equipment failure, which is caused mainly as a result of poor and infrequent maintenance procedures by the ship’s crew.
Slip, trips and falls are the most common types of accidents that a seafarer faces while working on ships and the same can happen while working in a confined space. The injury occurred due to trip and fall can be more severe if it takes place from a height or takes place in confined spaces or holds.

Crew members should have the necessary knowledge and experience to perform rescue operations in enclosed space emergencies.

There has been many cases in the past wherein the person who went to rescue a victim in a confined space became a victim himself/herself as proper precautions were not taken for such rescue operation.

It is therefore necessary that properly trained team is required to perform such rescue operations, as it will help to reduce the rescue time and also prevent any further incidents.
Following precautions and procedures are to be followed for quick and effective rescue operation supposing a victim to be rescued from an enclosed space.

- General emergency to be announced through the ship’s alarm.
- A responsible officer to be made in charge of the operation.
- Adequate man power to be present for the operation.
- Two trained persons to be ready with SCBA and PPE.
- All prior checks to be carried out on SCBA used in the operation.
- Life line to be used by the entry person.
- Communication equipment (walky-talky) to be given to all.
- Torch lights to be taken along.
- Extra ready breathing apparatus to be kept stand by.
- In charge of operation to be present at entry point coordinating the operation.
Breathing apparatus to be carried by rescuing party along with stretcher for the victim.

If not possible to carry SCBA, EEBD to be carried instead.

A life line to be tied out in the stretcher of the victim so that it can be guided and lifted out of the tank.

The three main types of rescue operations that are carried out on board ships are:

1. **Non-Entry Rescue** – The rescue which is contented without entry into the confined space. This is usually conducted using ropes or winches.

2. **Rescue by Others** – When crew members carry out emergency rescues. This is the most common rescue technique carried out at the sea.

3. **Rescue by Trained Personnel** – When specialized trained personnel carry out rescue operations. As this is not possible at the sea, such methods are only used during extreme emergencies at port or in dry-docks.
Rescuing a person from an enclosed space is not an easy task. 50% of the accidents that take place in enclosed spaces are during rescuing operations. The rescue operation must be carried out only under the supervision of a competent officer after taking all necessary safety precautions.

More people die or are injured in enclosed spaces than through any other onboard work activity. In spite of all the guidelines, safety procedures, manuals, and training, accidents in enclosed spaces continue to take place on ships.

These needless deaths and injuries need to be stopped immediately. Recognizing a confined space and dangers it represents is the key to eradicate these unfortunate incidents in dangerous places.

The procedures mentioned in this guide are not exhaustive in nature. The safety precautions to be taken for entering an enclosed space would depend on various other factors considering the type, size and design of the vessel. Company’s guidelines and procedures must be followed to carry out a safe and successful enclosed space work.

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