Report 10-201: Bulk carrier TPC Wellington, double fatality resulting from enclosed space entry, Port Marsden, Northland, 3 May 2010

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Final Report

Marine inquiry 10-201
Bulk carrier TPC Wellington, double fatality resulting from enclosed space entry,
Port Marsden, Northland, 3 May 2010

Approved for publication: May 2011

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrence with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Important notes

Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

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Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

The *TPC Wellington* at Port Marsden

Source: mapsof.net

Location of accident

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Abbreviations

BC Code	Code of Safe Practice for Solid Bulk Cargoes
carbon dioxide	CO_2
carbon monoxide	CO
Commission	Transport Accident Investigation Commission
EEBD	emergency escape breathing device
IMO	International Maritime Organization
ISM Code	International Management Code for the Safe Operation of Ships and for Pollution Prevention
m	metre(s)
m^3	cubic metre(s)
MAIIF	Marine Accident Investigator's International Forum
MSC	Maritime Safety Committee
SMS	Safety Management System
SOLAS	International Convention for the Safety of Life at Sea 1974 as amended
UTC	co-ordinated universal time

Data summary

Vessel particulars

Name:	*TPC Wellington*
Type:	bulk carrier
Class:	SOLAS
Limits:	unlimited
Classification:	Korean Register KRS1 – bulk carrier ESP HC/E (hold Nos 2 & 4 may be empty) ENV(IOPP, IAPP, ISPP, IAFS) CHA LI KRM1
Length:	179.99 metres (m)
Breadth:	30.50 m
Gross tonnage:	23 257
Built:	Oshima Shipbuilding Company Limited, Nagasaki Japan, 1990
Propulsion:	one 6-cylinder Sulzer 6234 kilowatts diesel engine driving a single fixed-pitch propeller
Service speed:	14 knots
Owner: Operator:	TPC Korea Company Limited
Port of registry:	Panama
Minimum crew:	14

Date and time	Monday 3 May 2010, at about 1700[1]
Location	Port Marsden, Northland
Injuries	2 fatalities one minor
Damage	nil damage to vessel

[1] Times in this report are in New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24-hour mode.

1. Executive summary

Summary

1.1. On the afternoon of 3 May 2010, the bulk log carrier *TPC Wellington* was loading logs in Port Marsden, Northland. When the chief officer entered a cargo hold that was full of logs that had been loaded at a previous port, he rapidly lost useful consciousness (lost the ability to hold on to the ladder) and fell from the ladder onto the cargo below.

1.2. The ship's bosun had accompanied the chief officer to the cargo hold access and when the chief officer fell he alerted nearby deck crew before leaving to collect rescue equipment. One of the nearby crew members went to the hold access and on seeing the unconscious chief officer below, entered the hold with the intention of rescuing him. He too rapidly lost useful consciousness and fell from the ladder onto the cargo below.

1.3. The 2 crew members lost useful consciousness owing to the combined effects of an oxygen-depleted atmosphere and the likely presence of toxic gases, both consequences of the organic decomposition of the logs in the closed cargo hold. The oxygen levels in the cargo hold were as low as 1% to 3%, which would cause loss of effective consciousness within 3 to 9 seconds, and total unconsciousness very soon afterwards, followed by death within 5 minutes. Both crew members were pronounced dead at the scene after they had been rescued from the hold access.

1.4. The dangers of the organic decomposition of logs and other organic cargos in enclosed spaces are well known in the international maritime community, and were documented on board the *TPC Wellington*, but in spite of this the high risk this posed to the crew had not been identified, no specific training had been given to the crew members to heighten their awareness of the risk, and no emergency drills had been conducted in recent times for rescue from enclosed spaces.

1.5. The emergency response by the ship's crew to the accident was not well co-ordinated, which reduced the possibility of saving the lives of the 2 men in the cargo hold.

1.6. Internationally a disproportionately high number of deaths attributable to entry into enclosed spaces has prompted a review by the International Maritime Organisation of what can be done to improve safety in this area. The Commission has not been able to make any new and meaningful recommendations to address this well known safety issue. The Commission will, however forward this report to the IMO and invite the appropriate committee to note the contents of the report for any future programmes to improve awareness of the dangers associated with entry into enclosed spaces.

Key lessons

- Enclosed (confined) spaces can kill.
- Never enter an enclosed (confined) space unless you have checked the atmosphere.
- Always follow the correct procedures for entering enclosed (confined) spaces.
- Manuals and written procedures alone will not prevent accidents, but training and audit that ensures they are understood and are followed, probably will.

2. Conduct of the inquiry

2.1. On 3 May 2010 at about 1830, the Commission were notified by Maritime New Zealand that the accident had occurred at about 1700 the same evening on board the *TPC Wellington* while berthed at Port Marsden, Northland.

2.2. The circumstances reported were that the vessel had been loading a cargo of logs and 2 of the crew had died when they entered a cargo hold that was full of logs. A third crew member had nearly succumbed during the attempted rescue of the first 2.

2.3. As the accident fell into the category of a "very serious accident" as defined in the IMO's casualty investigation code, which requires states to conduct investigations under the code, the Commission opened an inquiry into the occurrence.

2.4. The Commission contacted the flag state of the vessel, Panama. The Commission and the Panama Maritime Authority agreed that the Commission would investigate the occurrence and would produce a report as part of a joint investigation into the occurrence. Once the final report had been produced by the Commission, Panama would present the report to the IMO.

2.5. On 4 May 2010, an investigator from the Commission travelled from Wellington to Port Marsden. On arrival the investigator was met and briefed by Maritime New Zealand investigators, the New Zealand Police, the Coroner and a member of the port's management team. That same day the investigator examined the scene of the accident.

2.6. During the next 2 days the investigator interviewed witnesses who had been involved in the rescue and in the events leading up to the accident. Others involved in the operation of the vessel were also interviewed.

2.7. Following the first phase of the investigation data was sourced from national and international agencies regarding the carriage of logs and their effect on the atmosphere when stowed in enclosed spaces. The Commission also received the post-mortem autopsy reports for the 2 deceased crew members.

2.8. On 24 March 2011, the Commission approved the circulation of a draft final report to interested persons.

2.9. The draft final report was sent to 16 interested persons with a request that submissions be forwarded to the Commission no later than 18 April 2011. Submissions were received from the Korean Maritime Safety Tribunal and the Panama Maritime Authority and Maritime New Zealand.

2.10. On 26 May 2011, The Commission approved the publication of the final report

3. Factual information

3.1. Narrative

3.1.1. On 26 April 2010 at about 0654, the *TPC Wellington* arrived in Napier after a voyage from Korea. The vessel was a 5-hold "handy size" bulk carrier equipped to carry logs. The vessel commenced loading logs at about 0900 until about 1830 on 28 April 2010. The vessel sailed for Tauranga at about 1945 that evening.

3.1.2. While the vessel was in Napier the vessel's agency statement of facts noted that number 5 cargo hold was worked between 0700 on 27 April and 1830 on 28 April. The statement of facts also noted showers (of rain) between 1900 on 27 April and 0700 on 28 April. While in Napier the *TPC Wellington* loaded a total of about 13 991 cubic metres (m^3) of logs of which about 4184 m^3 were loaded in number 5 cargo hold.

3.1.3. The *TPC Wellington* arrived in Tauranga during the morning of 30 April and cargo operations commenced at about 0700. The vessel's Agency statement of facts noted that cargo was worked in number 5 cargo hold from 0700 on 30 April until about 1530 on 1 May when number 5 cargo hold was full and the hatch lids were closed. Cargo work continued until 2200 on 1 May. The weather was reported as being fine throughout the vessel's stay in Tauranga. While in Tauranga the *TPC Wellington* loaded a total of about 13 091 m^3 of logs, of which about 963 m^3 were loaded in number 5 cargo hold and 2369 m^3 of logs were loaded on the deck at number 5 cargo hatch.

3.1.4. On the morning of 2 May 2010, the *TPC Wellington* sailed from Tauranga for Port Marsden and arrived in Port Marsden in the evening of the same day. Cargo operations commenced at about 2200 on 2 May 2010. The vessel was due to load about 11 476 m^3 of logs none of them being loaded at number 5 cargo hatch.

3.1.5. The logs were to be fumigated on passage to China. On 3 May at about 1530, the Marsden fumigation supervisor for a fumigation company and a work colleague boarded the vessel to carry out a pre-inspection of the cargo holds and ship to ensure that the ship was compliant for the on-voyage fumigation and there were no health and safety issues for the crew.

3.1.6. At about 1640, the Marsden fumigation supervisor and the work colleague reported to the master on the results of the fumigation pre-inspection. The Marsden fumigation supervisor reported that:

> Hatches 3F, 4F, 2F and 1F had excessive amounts of water visible in them which needed to be removed before fumigation could take place. Also the [rubber] seal on No.5 aft access door needed to be replaced.

3.1.7. The master called the chief officer to his cabin and a discussion followed on what could be done to remove the moisture from the hatches. The master then spoke to the chief officer in their native tongue (Korean), after which the chief officer left the master's cabin. The master later said that he:

> … didn't know where he [the chief officer] was going or what he [the chief officer] was planning to do. We hadn't made any decisions, and I hadn't given him any orders.

3.1.8. The chief officer was next seen at the port gangway station by some crew members. The chief officer asked the bosun, who was assisting with adjusting the gangway, to go with him to number 5 cargo hold access, which was located nearby on the forward face of the accommodation block (see Figure 1).

3.1.9. The bosun followed the chief officer towards the aft access door for number 5 cargo hold. The bosun said that on the way to the hold access he asked the chief officer what they were doing. The bosun said later that the chief officer replied that he wanted to go down the hold as there was water in the cargo hold; the bosun said he asked him twice not to go down because "the smell was no good".

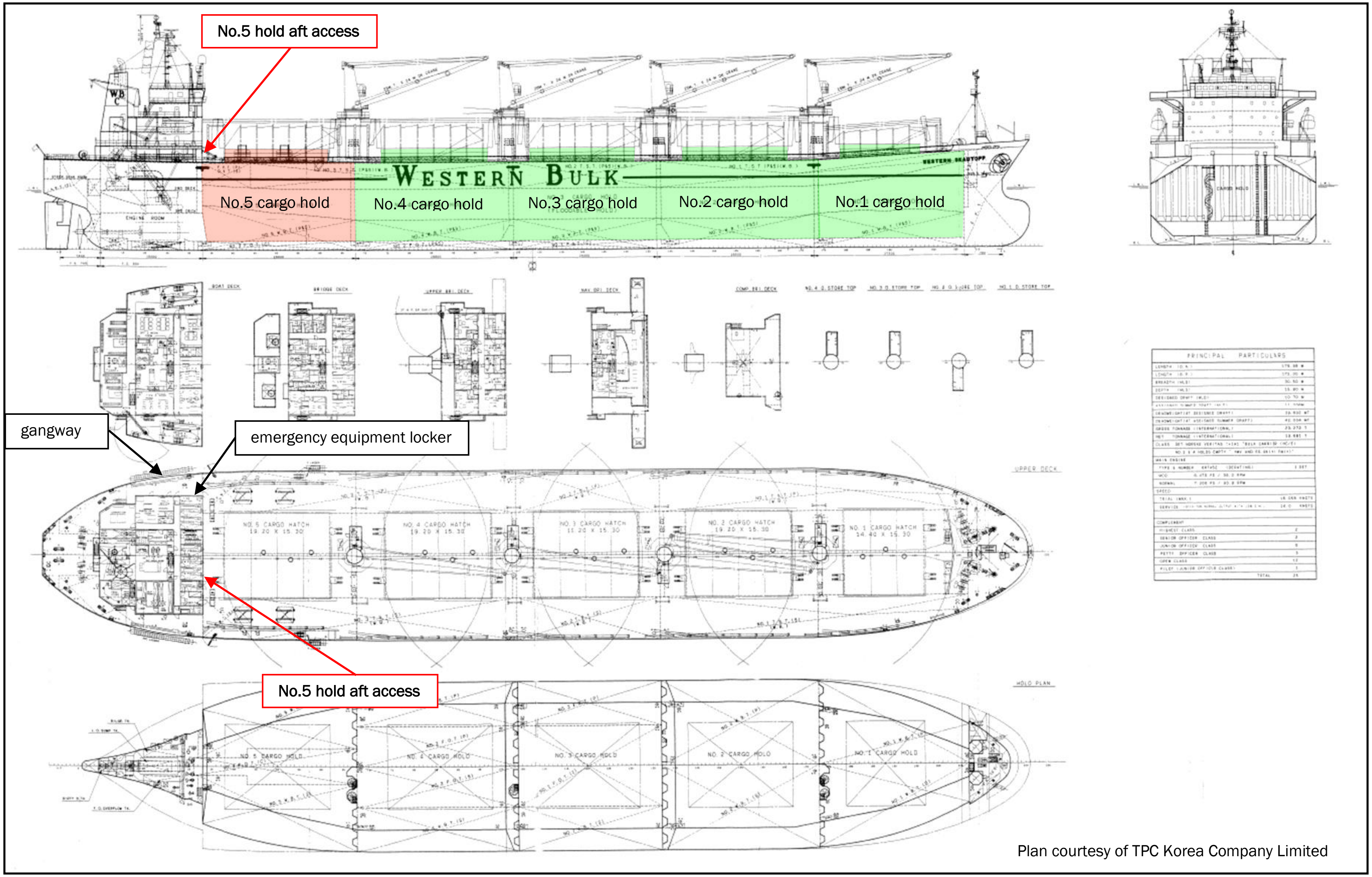

Figure 1
Plan of the *TPC Wellington*

3.1.10. The chief officer and bosun opened the access hatch, then the chief officer took his torch and climbed on to the ladder to make his way down into the hold. The bosun said that the chief officer said "OK, no problem" and started to descend. The bosun made an attempt to follow him into the hold but after the chief officer had descended only a short distance, estimated to be about 5 or 6 steps down the ladder he fell onto the logs below that were protruding into the access way.

3.1.11. The bosun immediately shouted for help from the crew members at the gangway (see Figure 1) that the chief officer had fallen down the hold. Once he had got the attention of the crew at the gangway the bosun made his way to the aft mooring station to get a rope suitable for hauling the chief officer out of the hold access.

Figure 2
Entrance door to No.5 Cargo Hold aft

Rescue phase

3.1.12. The second officer, who was at the gangway, on hearing the bosun's shouts for help alerted the captain by using his portable radio transceiver. One of the deck crew at the gangway ran into the accommodation to raise the alarm verbally. The third officer who was working in the ship's office heard the deck crew member shouting the alarm, and tried to follow him to the accident site; however, the crew member had disappeared from view, so the third officer made his way to the main deck and went to the port side of number 4 cargo hatch as he was unsure where the accident had occurred.

3.1.13. The bosun, after finding a rope suitable for the rescue, returned to number 5 cargo hold aft access. When he got there he found that the crew member (who had shouted into the accommodation) was already climbing down the access trunk into the hold and another crew member was about to follow him. The bosun managed to grab the latter by the collar and pulled him back from the access and told him not to go down. Just after the bosun had pulled the crew member away from the access he heard the sound of the other crew member falling down the access. The bosun then looked down the access and saw him lying on top of the chief officer in what appeared to be an unconscious state.

3.1.14. The master on receiving the radio message from the second officer left his cabin and went to the main deck to see what had happened. He went first to the starboard side of number 4 cargo hatch but, not finding anyone there he went to the port side where he met the third officer. On their way back to the accommodation they both heard over the radio from the second officer that the accident had occurred at number 5 cargo hold aft access. The master and third officer then made their way there.

3.1.15. When the master and third officer arrived at the scene they found the bosun and a crew member looking down into the access. The master looked down the access hatch and could see 2 bodies lying over the logs below. The master then instructed the third officer to bring the breathing apparatus to the accident scene and for the bosun and crew member to raise the alarm.

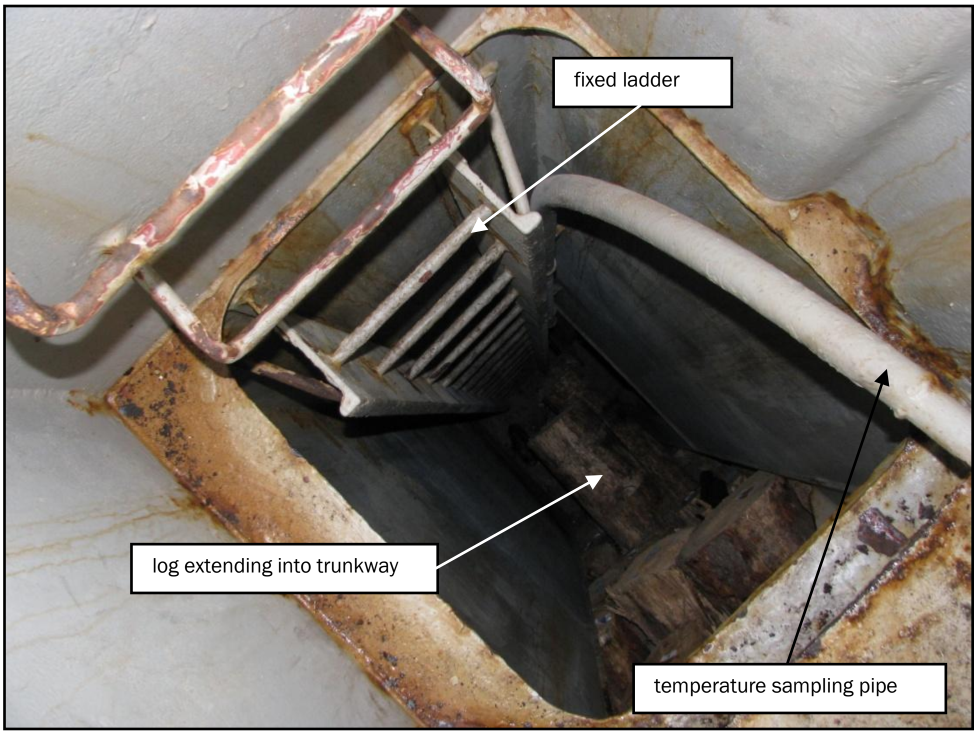

Figure 3
No.5 aft hold ladder from inside hold entrance door

3.1.16. The second officer after alerting the master went to the emergency equipment locker (see Figure 1) on the main deck, retrieved a breathing apparatus set and took it to the accident scene. The third officer arrived at the emergency equipment locker and took another breathing apparatus set to the accident scene. The second officer then made his way to the ship's hospital where he readied the oxygen therapy set for use and then took it to the accident scene.

3.1.17. The master then made his way back to his cabin where he informed the Marsden fumigation supervisor of the accident, then to the wheelhouse, stopping on the way to inform the chief engineer of the accident. On arrival in the wheelhouse the master activated the general emergency alarm to muster the vessel's crew.

3.1.18. The Marsden fumigation supervisor called the emergency services on his mobile telephone and asked for an ambulance. He then telephoned the staff at Port Marsden security gate house to advise them of the accident and requested that they also telephoned the ambulance service to confirm the message and details of accessing the Port Marsden wharves. The staff at Port Marsden security gate house also telephoned the Marsden Point refinery emergency services and requested their assistance. After making his telephone calls the Marsden fumigation supervisor and his colleague went to the main deck to see what assistance they could render.

3.1.19. At about 1701, the Police Northern Communications Centre logged the call from the Marsden fumigation supervisor and routed his call to the St. John Ambulance Service. The St John Ambulance Service assigned the first unit at about 1705 and the ambulance was en route from Whangarei at 1707. The St. John Ambulance Service notified the Fire Service at about 1706 and the Police Northern Nommunications Centre at about 1707. The Fire Service alerted its station at Ruakaka at about 1707 and the first appliance was enroute at about 1711. The St John Ambulance Service requested the Police to attend at about 1713 when it had established from its telephone conversation with the Marsden fumigation supervisor that one of the "patients" was not breathing. The Police dispatched its first unit, which was the Waipu Police unit, at about 1716.

3.1.20. The third officer on arrival back at the number 5 cargo hold aft access donned one of the breathing apparatus sets and tied the rescue rope the bosun had found around his waist. He then entered the access and climbed own the ladder to where the chief officer and crew member were lying. He initially tried to tie the rope around the crew member, but the body slipped further down and under a log; so the third officer tied the rope around the chief officer. The crew members on the deck then started to haul the chief officer out of the access as the third officer pushed from below.

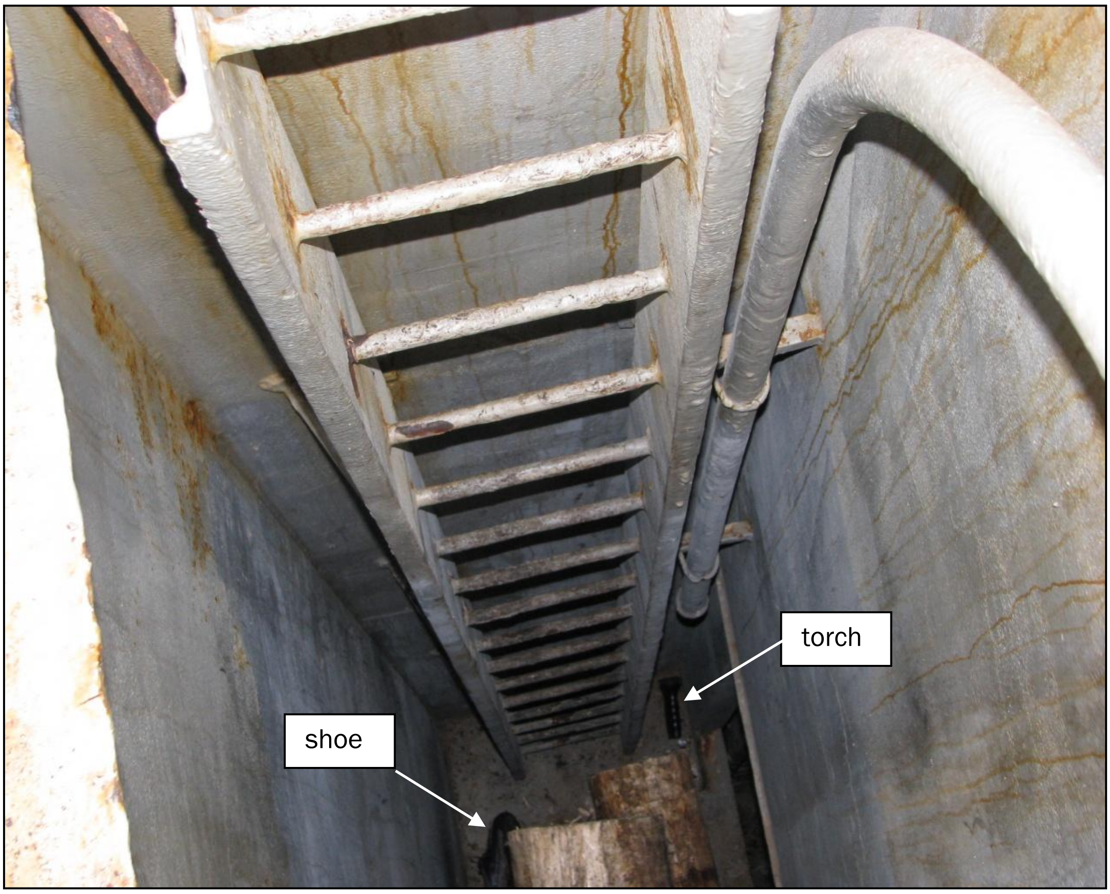

Figure 4
No.5 hold aft access showing shoe and torch unable to be recovered due to foul atmosphere

3.1.21. When the chief officer was hauled out of the hold access the crew members took him to the starboard side of the vessel where the Marsden fumigation Supervisor commenced cardiopulmonary resuscitation. The third officer on exiting the access was too exhausted to return and attempt to rescue the crew member so removed his breathing apparatus.

3.1.22. The first engineer on hearing the general emergency alarm started to make his way to his emergency station in the engine room, but on his way there he heard people on the starboard side of the upper deck, so he went to investigate. That was about the time the chief officer was hauled out. When the first engineer heard that one other crew member was still trapped in the hold he donned the other breathing apparatus and entered the access. But the breathing apparatus prevented him manoeuvring past a log that was protruding into the access. The first engineer exited the hold and took off the breathing apparatus, then found and donned an emergency escape breathing device[2] (EEBD) that was of smaller dimensions.

3.1.23. The first engineer then re-entered the hold access and climbed down to the crew member. When he got to him he noted what he thought were signs of life, so he took off his EEBD mask and placed it momentarily on the unconscious crew member in an attempt to revive him. The first engineer then replaced his mask and managed to manoeuvre the crew member out from where he had slipped and attach the rescue rope to him. The crew members on deck then hauled the crew member out of the access as the first engineer pushed from below. When the first engineer was nearing the top of the access ladder he started to run out of compressed air in the EEBD, but was able to be hauled from the access by the crew on deck. When he reached the upper deck at about 1737, he was suffering from and showing the signs of asphyxia.

3.1.24. At about 1716, the first ambulance arrived at Port Marsden and its crew were on board the vessel by about 1719. The first ambulance was joined within minutes by the Marsden Point refinery emergency services, 2 fire appliances from Ruakaka and a Police unit.

3.1.25. The ambulance staff tried to resuscitate the chief officer and the crew member, however both the chief officer and crew member were pronounced dead at the scene. The ambulance staff also administered oxygen to the first engineer. Meanwhile a further ambulance, Police unit, fire appliance and 2 fire command units had arrived at the scene. Owing to the condition of the first engineer and the distance to the nearest hospital an emergency medical evacuation helicopter was used to transport the first engineer to hospital in Whangarei. The first engineer was discharged from hospital later that evening and returned to the vessel.

Testing of hold access atmosphere

3.1.26. At about 2215 on the day of the accident, the atmosphere in number 5 hold access was tested by a member of the Marsden Point refinery operations team in the presence of 2 Maritime New Zealand investigators. The Marsden Point refinery employee was using a ITX gas monitor, which had been calibrated on 22 April 2010 and was valid until 21 July 2010, in preference to the vessel's oxygen meter. A normal reading is 20.95% oxygen by volume in the atmosphere; the alarm on the monitor sounds at 19% oxygen in the atmosphere. The results were as shown:

Oxygen readings			
Date	Time	Position	Oxygen reading
03/05/2010	2215	At second rung down on vertical ladder	1%
	2220	At 1m back from entrance in cross breeze	20.7%
	2220	At head level in hold access entranceway	20.95%
	2220	At first rung down on vertical ladder	19.5%
	2230	At second rung down on vertical ladder	18.8%
	2230	At third rung down on vertical ladder	2%

Table 1
Oxygen readings of atmosphere in No.5 cargo hold entrance 3 May 2010

The access door was then closed and was not opened until the next day, when at 1435 the door was reopened and the atmosphere tested again by a Marsden Point refinery employee in the presence of the Maritime New Zealand investigators and the Commission's investigator. The results were as follows:

[2] Limited capacity breathing apparatus designed to assist evacuation from machinery and other spaces.

Oxygen readings			
Date	Time	Position	Oxygen reading
04/05/2010	1435	At chest level in hold access entranceway	16%
	1435	At deck level in entranceway	8%
	1435	At second rung down on vertical ladder	14.5%
	1435	At 3 metres down on vertical ladder	3%

Table 2
Oxygen readings in atmosphere in No.5 cargo hold entrance 4 May 2010

Time of useful consciousness under reduced inspired oxygen conditions

3.1.27. Time of useful consciousness is defined as the amount of time in which an individual is able to perform flying duties efficiently in an environment of inadequate oxygen supply (Dehart & Davis, 2002). It is the period of time from the interruption of the oxygen supply or exposure to an oxygen-poor environment to the time when useful function is lost, and the individual is no longer capable of taking proper corrective and protective action. It is not the time to total unconsciousness. The time of useful consciousness was also known as effective performance time (Wikipedia).

% Oxygen at sea level	Partial pressure of oxygen in millimetres of mercury	Time of useful consciousness at rest
21%	160	Infinite
10%	78	20 – 30 minutes
7.7%	60	3 – 5 minutes
6%	47	1 – 2 minutes
4.9%	38	30 – 60 seconds
3.8%	30	15 – 20 seconds
3.3%	26	9 – 12 seconds
2.3%	18	9 – 12 seconds
1%	8	9 – 12 seconds

Griffiths R, 2011, adapted from Fundamentals of Aerospace Medicine 4th Edition 2008

Table 3
Time of useful conciousness under reduced inspired oxygen conditions

3.2. Vessel information

3.2.1. The *TPC Wellington* was built by the Oshima Shipbuilding Company Limited of Nagasaki, Japan in 1990. The vessel was owned by Wellington Maritime S.A. of Panama City, Republic of Panama and operated by TPC Korea Company Limited of Seoul Korea. The vessel was registered in Panama and had valid certificates issued by the Panamanian Government and by Korean Register classification society

3.2.2. The *TPC Wellington* was a steel hulled bulk carrier with an overall length of 179.99 m and a breadth of 30.50 m. The vessel had an international gross registered tonnage of 23 257.

3.2.3. The vessel's cargo carrying spaces were divided into 5 holds. Number 5 hold had a capacity of about 9,822 m^3 and the other 4 holds had capacities ranging between 8830 m^3 and 11 344 m^3 giving a total capacity of about 52 145 m^3. Each cargo hold was covered by segmented steel hatch covers. When closed the hatch covers provided a weathertight covering to the cargo hold.

3.2.4. The cargo holds were capable of being naturally ventilated by vents located at the forward and aft ends of the cargo holds. These vents were capable of being sealed shut by a hinged metal covers with rubber sealing strips attached to the outsides of the vents.

3.2.5. With the exception of number 1 cargo hold, which only had one access, each cargo hold could be entered via 2 fixed arrangements from the weather deck. One was to use a vertical ladder mounted either in a recess of the corrugated bulkhead or in an enclosed trunk. The second was to use a fixed steep spiral staircase with platforms usually located at the opposite end of the hold from the vertical ladder. Each hold access was covered by an access lid or dogged door that could be sealed weathertight using dogs[3].

3.2.6. The *TPC Wellington* was equipped with the standard range of navigational equipment. As an internationally trading vessel the *TPC Wellington* was required to comply with the provisions of the International Convention for the Safety of Life at Sea 1974 as modified by the protocol of 1998 (SOLAS) with regard to fire and life-saving appliances.

3.3. Personnel information

3.3.1. The master of the *TPC Wellington* was a 50-year-old Korean male. He had been a master for about 4 years and had sailed on a variety of vessels. He had been master on board the *TPC Wellington* for the previous 5 months.

3.3.2. The chief officer of the *TPC Wellington* was a 56-year-old Korean male. He had been chief officer for several years and was experienced in the carriage of bulk cargoes including logs. He had been on board the vessel for about one month.

3.3.3. The chief officer's work hours for the previous 3 days were obtained from the computer records on the vessel, which showed that he had worked the following:

Date	Times	Hours worked	Total Hours
30 April 2010	0800 – 0930	1.5	
	1530 – 1730	2.0	
	1800 – 1900	1.0	
	2000 – 2400	4.0	8.5
1 May 2010	0945 – 1400	4.25	
	1630 – 1930	3.0	
	2230 – 2400	1.5	8.75
2 May 2010	0000 – 0430	4.5	
	1600 – 2000	4.0	8.5

Table 4
Chief officer's hours of work preceeding 3 days

The hours the chief officer worked after the *TPC Wellington* arrived in Port Marsden until the time of the accident had not been entered. These were estimated to be 2 hours until cargo work commenced at 2200 on 2 May then approximately 8 hours from 0800 on the morning of 3 May until 1700, the approximate time of the accident allowing for breaks.

3.3.4. The first engineer of the *TPC Wellington* was 35-year-old Korean male. He had been on board the vessel for about 2.5 months. He had sailed on a variety of vessels for about 6 and a half years.

3.3.5. The third officer of the *TPC Wellington* was a 23-year-old Korean male. He had been on board the vessel for about 5 months. The *TPC Wellington* was his first appointment at sea.

3.3.6. The bosun of the *TPC Wellington* was a 46-year-old Myanmar male. He had been on board the vessel for about one month. He had first gone to sea in 1998 and had sailed on a variety of vessels.

3.3.7. The able bodied seaman who died was a 33-year-old Myanmar male. He had been on board the vessel for about 5 months. He had served as a seaman at sea for several years.

3.3.8. The deceased seaman's work hours for the previous 3 days were obtained from the vessel's computer records which showed that he had worked the following:

[3] A wedged handle used for securing a door within its frame against a suitable seal to make it water or weather-tight.

Date	Times	Hours worked	Total Hours
30 April 2010	0400 – 0800	4.0	
	1600 – 2000	4.0	8.0
1 May 2010	0400 – 0800	4.0	
	1600 – 2000	4.0	
	2230 – 2400	1.5	9.5
2 May 2010	0400 – 0800	4.0	
	1600 – 2000	4.0	8.0

Table 5
ABC's hours of work preceeding 3 days

The hours the able bodied seaman had worked after the *TPC Wellington* arrived in Port Marsden until the time of the accident. Were estimated to be 4 hours from 0400 to 0800 on 3 May then one hour from 1600 until 1700 the approximate time of the accident.

3.4. Injuries

3.4.1. The autopsy report found that the cause of the chief officer's death was consistent with asphyxia due to oxygen deprivation. The autopsy report found that the chief officer was suffering from focal atherosclerosis of the coronary arteries which may have increased his vulnerability to hypoxia. A toxicological examination revealed no findings of significance.

3.4.2. The autopsy report for the deceased seaman found that the cause of his death was consistent with asphyxia due to presumed oxygen deprivation. A toxicological examination revealed a blood alcohol content of 32 milligrams per 100 millilitres which equates to about 40% of the legal blood alcohol limit for a New Zealand driver 20 years or over.

3.4.3. The first engineer suffered from mild hypoxia and was taken to Whangarei Hospital for treatment but was released later the same evening.

3.5. Organisational and management information

3.5.1. In 1993, after some fine tuning of the system, the IMO adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code); and in 1998 the ISM Code became mandatory. The ISM Code established safety management objectives and required a safety management system (SMS) to be established by the company, which was defined as the ship owner or any person, such as the manager or bareboat charterer, who had assumed responsibility for operating a vessel. The company was then required to establish and implement a policy for achieving these objectives, including providing the necessary resources and shore-based support. The procedures required by the ISM Code were to be documented and compiled in a safety management manual, a copy of which was to be kept on board.

3.5.2. TPC Korea Company Limited, the operator of the *TPC Wellington*, was audited by Class KR under the authority of the Government of the Republic of Panama and was found to comply with the requirements of the ISM Code. The owner was issued with a document of compliance certificate, which was renewed, after verification of continued compliance, at regular intervals.

3.5.3. On 14 September 2008, the *TPC Wellington* had been audited and the vessel's SMS had been found to comply with the requirements of the ISM Code. The vessel had been issued with a safety management certificate on 14 September 2008, which remained valid, subject to periodic verification, until 13 September 2013.

3.5.4. A part of the ship's SMS on board was the vessel procedures manual in which the operating company laid out the procedures to be followed to operate the vessel. The manual was broken down into eight sections namely:

- shipboard duties
- shipboard training and drills
- navigation management

- shipboard safety work
- environmental protection
- shipboard maintenance
- ship operation,
- cargo Handling

Shipboard duties included the duties and responsibilities of the master and crew, including the chief officer. Shipboard safety work included reference to enclosed space work, the personal protective equipment required should emergency entry into an enclosed space be required, and an entire chapter on the procedure for enclosed space entry (see Appendix 3). Section one of the ship operation manual included a requirement for the master to ensure that cargo information was obtained, in accordance with the IMO's Code of Safe Practice for Solid Bulk Cargoes (BC Code), including any hazard that might occur from the transportation of the cargo and the management of dangerous cargoes. Cargo handling included a chapter on log handling.

3.6. Cargo information and properties

3.6.1. The *TPC Wellington* was chartered to transport logs, predominantly Monterey pine (*Pinus radiata*) from New Zealand to Korea and China.

3.6.2. The carriage of logs at sea and in bulk was covered in the IMO's BC Code which was first published in 1965. The Code had been revised and republished several times since then.

3.6.3. Section 3 of the BC Code was concerned with the safety of personnel and ships and gave general information on the safety precautions to be taken and information to be passed to the master before the commencement of loading (see Appendix 1). Section 3 also referred to the general precautions to be taken when an enclosed space was entered which were contained in Appendix 7 of the BC Code (see Appendix 2). Paragraph 3.2.4 of the BC Code specifically mentioned timber logs and stated:

> 3.2.4 Many cargoes frequently carried in bulk are liable to cause oxygen depletion in a cargo space or tank; these include most vegetable products, grains, timber logs and forest products, ferrous metals, metal sulphide concentrates and coal cargoes.

3.6.4. Organic materials are subject to decomposition over time, principally due to either microbiological (anaerobic or aerobic) or autoxidative processes. Various gaseous products are then formed, including carbon monoxide (CO), carbon dioxide (CO_2), hydrogen sulphide (H_2S) and hydrocarbons. When organic materials are stored in confined spaces, these decomposition products will accumulate in the air and may eventually reach toxic levels. Oxygen depletion will occur simultaneously (Urban Svendberg, 2009).

3.6.5. The deck cargo was destined for Korea and was to be fumigated at a shore-based facility in Korea after discharge from the ship. The cargo in the holds was destined for China and was to be fumigated during the sea passage between New Zealand and Korea.

3.6.6. Fumigating the holds required the holds to be sealed as airtight as possible and a fumigant to be introduced into the holds by a suitably qualified person, who would then ensure that a sufficiently high concentration of the fumigant was contained within the hold for a sufficient period to achieve the desired result.

3.6.7. Fumigation of cargo was conducted under the Recommendations for the safe use of pesticides in ships produced by the IMO in circular MSC.1/Circ.1358 which stated in its introduction:

> … Account has been taken of existing recommendations of the World Health Organization (WHO), the International Labour Organization (ILO), and the Food and Agriculture Organization (FAO) of the United Nations, in regard to pesticide residues and occupational safety.

3.6.8. The Marsden fumigation supervisor for the fumigation company was on board the vessel to ensure that the ship was fit to be fumigated and to provide documentation and explanation to the master on the fumigant to be used, the hazards involved and the precautions to be taken. The colleague who accompanied him was to travel with the ship to conduct the fumigation.

3.6.9. The fumigant that was to be used was phosphine gas (PH_3) which was introduced into the cargo holds as Aluminium phosphide in pellet form. Aluminium phosphide reacted exothermically[4] with water sufficiently that it was possible to ignite the cargo, which was why the supervisor commented on the amount of water in the holds. His task was to inspect the ship and to provide the master with a gas suitability statement detailing areas that required sealing or other remedial works to ensure that the vessel was suitable for in-transit fumigation. If the vessel was found to be unsuitable or not capable of being made suitable during the loading period the fumigator-in-charge would recommend rejection of the vessel. The Marsden fumigation supervisor was in the process of filling out the gas suitability statement with the master when the accident happened.

[4] A reaction that evolves heat

4. Analysis

4.1. Introduction to the issues

4.1.1. Death by entry into enclosed spaces on ships is not a new phenomenon; in fact for decades it has been one of the most talked-about and well documented risks facing crews in the maritime industry.

4.1.2. The Commission now discusses why the 2 crew members died in this case, the inherent dangers created by the carriage of log cargoes at sea, and the procedures that should have been followed to avoid the 2 deaths in this case.

4.1.3. Also discussed are the survivability aspects of this accident; that is, could the 2 crew members have been saved? It is not the purpose of this report to ascribe blame, but sometimes that inference is unavoidable if the lessons are to be learned. Without detracting from the sincere efforts some crew members made to save the 2 colleagues collapsed in the hold, some important lessons are discussed that could benefit other mariners reading this report.

4.2. Why the crew members died

4.2.1. The accident sequence started when the chief officer entered an enclosed cargo space without checking that the atmosphere was suitable for entry and without following the appropriate safety precautions. In this case, there was insufficient oxygen in the hold to sustain life for more than a few minutes. The presence of other toxic gases such as CO and H_2S would of themselves have been likely to cause similar incapacitation through intoxication. However, the effects of such severe hypoxia would be supervening in a short time period. With such a rapid onset of loss of useful consciousness, the crew would have been unlikely to recognise the effects of hypoxia in time to self-rescue from the oxygen-depleted area.

4.2.2. The Commission was unable to determine why the chief officer who was second in command on the vessel, had sailed on bulk carriers carrying logs often during his career, was considered by his peers to be a competent officer and in part was responsible for the safe working practices of the deck crew, would enter an enclosed space without taking well documented precautions.

4.2.3. Ironically number 5 cargo hold was not one mentioned by the master as having excess water in it, so there was no purpose for his going down there. The master did refer to the rubber seal on number 5 hold access door needing replacing, but this should have been easily checked from the deck. It is possible that he mixed up the tasks associated with each cargo hold. Delays for ships engaged in any kind of charter can be costly, so the possibility that the ship would be rejected as suitable for in-transit fumigation would have been a strong driver to remedy the problems identified by the fumigation provider, possibly at the expense of taking appropriate precautions.

4.2.4. The reasons for the deck crew member choosing to enter the enclosed space are easier to rationalise. He was not at the access door when the chief officer entered the cargo hold, but only heard the bosun shout that the chief officer had fallen. The deck crew member then entered the accommodation to raise the alarm before proceeding to the access. The deck crew member might not necessarily have been aware that the chief officer had collapsed from asphyxiation, a possible slip/trip/fall scenario being quite feasible. On arrival at the hold access there was nobody else there, the bosun having gone to get a rescue line. Like the chief officer, it could not be established what training the deck crew member had received for entry into enclosed spaces filled with log cargos, so it could not be ruled out that his action to help the chief officer was a knowledge-based mistake, one possibly heavily influenced by a strong emotional motivation to assist a colleague, so close and visibly in obvious distress.

4.2.5. In 1990, James Reason in his book Human Error distinguished between 3 main groups of error, namely slips, lapses and mistakes. He described knowledge-based mistakes as:

> Knowledge-based thinking involves evaluating an unfamiliar or unusual situation and deciding on a course of action. Ideally, operational personnel would make decisions by following a carefully reasoned process involving considering all the

> options and weighing up the risks of various courses of action. In reality however, things are not that simple. Sometimes we do not consider all of the alternatives or we take mental short cuts to arrive at a solution. Or under the pressure of having too little time and too much to do, thinking becomes "short circuited" and we end up deciding on an unsuitable course of action. Emotional factors also exert a powerful influence on decisions, and despite the most thorough training, no one is immune to such pressures (Reason, 1990).

The scenario where the rescuer has succumbed to the same fate as the person being rescued has been all too common in the maritime industry, and there are many examples of this included in the IMO statistics, which are discussed in more detail below.

Finding

According to the autopsy reports, the chief officer and the deck crew member died from asphyxia due to oxygen deprivation, which was consistent with the depleted (about 3%) level of oxygen in the cargo hold they had entered immediately before collapsing.

4.3. Dangers created by log cargos in enclosed spaces

4.3.1. In 2009, total log exports from New Zealand were provisionally recorded as being in excess of 9 million m^3 of which over 50% was destined for China (DANA Limited, 2010). To transport this amount of logs would require more than 200 shipments on vessels of a similar size to the *TPC Wellington*. No record could be found in the previous 10 years of a similar occurrence happening in a New Zealand port.

4.3.2. Organic cargoes such as logs were known to deplete oxygen in enclosed atmospheres. The depleted oxygen is often replaced by other gases injurious to the health, or fatal in sufficient quantities, such as CO, CO_2, H_2S and hydrocarbons (Urban Svendberg, 2009). CO and CO_2 are colourless and odourless. H_2S is colourless and, although known as the "rotten egg smell" at concentrations over 100 parts per million causes paralysis of the olfactory nerve and thus seems to be odourless and is extremely toxic (Lewis, 1996). The main hydrocarbon emitted by logs as they decompose is a monoterpene, α-pinene, which would have accounted for the strong pine smell in the hold. The chief officer would not have been able to detect the presence of 3 of the toxic gases produced by the logs, but would have been able to smell the presence of the monoterpene. He would also have been unable to detect, without the aid of an oxygen meter, the reduced oxygen content of the atmosphere within the hold. His first indication that something was "wrong" would have been as he started to succumb to the lack of oxygen and the possible presence of the other toxic gases, which as discussed above would have happened rapidly.

4.3.3. The organic cargo, logs, in cargo hold number 5 had depleted the amount of oxygen available in the access trunk to the hold, as measured after the event, to such a degree that anyone entering the hold without wearing breathing apparatus would have been affected virtually as soon as they entered the hold. The Occupational Health and Safety Administration in the United States of America has a standard of 20.8% to 21.0 % as the normal oxygen level in the atmosphere, and 19.5% or below is considered a low oxygen level. The National Institute for Occupational Safety and Health in the United States of America produced a technical report on respiratory protection that noted the following signs and symptoms were observable when a human body experienced oxygen deficiency (see below):

Oxygen % in atmosphere	Symptoms
16% to 12%	Deep breathing, accelerated heartbeat, impaired attention, impaired thinking, impaired coordination.
12% to 10%	Very faulty judgment, very poor coordination, rapid fatigue from exertion that may cause permanent heart damage, intermittent breathing.
10% and below	Nausea, vomiting, inability to perform vigorous movement or loss of all movement, unconsciousness followed by death.
Less than 6%	Spasmodic breathing, convulsive movements, death in minutes.

Table 6
Observable symptoms of oxygen deprivation on the human body

4.3.4. The initial reading of 1% at the second rung down could have been representative of the hold access atmosphere before the exterior atmosphere mixed with it, hence the reading at the third rung down some 15 minutes later being 2%.

4.3.5. Similar tests conducted the following day showed a level of 3% at a depth of 3 m into the hold. The time of useful consciousness at this level would have been in the range of 9 to 12 seconds from the time of inhaling air at between 1% and 3%, this time being the average time for oxygen de-saturated air to circulate to the brain. After 9 to 12 seconds the chief officer and the deck crew member would have become rapidly confused, poorly co-ordinated and unable to hold on to the ladder, so falling to the logs below. Complete loss of consciousness would have followed rapidly, and death within 5 minutes. The range of 1% to 3 % therefore was critically low and could not sustain life for more than a few minutes.

Findings

On entering the cargo hold with a 3% level of oxygen, the chief officer and deck crew member would have had 9 to 12 seconds of useful consciousness to maintain a hold on the access ladder; total unconsciousness rapidly following and death within 5 minutes.

Oxygen levels in the cargo hold would have been depleted by the organic decomposition of the logs and toxic gases such as CO, CO_2 and H_2S may also have been present, phenomena well known to the shipping industry and one that were documented in the cargo handling procedures on board the *TPC Wellington*.

4.4. Entry into enclosed spaces

4.4.1. An enclosed space was defined by the IMO as being a space that had any of the following characteristics; limited openings for entry and exit, unfavourable natural ventilation, and not being designed for continuous worker occupancy. Enclosed spaces on ships such as cargo holds, fuel and ballast tanks, void spaces, and cofferdams had been a source of accidents and increased scrutiny by regulatory and safety authorities.

4.4.2. In 1997 the IMO introduced recommendations for entering enclosed spaces and these superseded the recommendations already contained in Appendix F to the bulk carrier code, which later became Appendix 7 of the bulk carrier code that was current at the time of the accident.

4.4.3. Despite the introduction of the recommendations on entry into enclosed spaces by the IMO in 1997, accidents continued to happen and became a subject of concern to the Marine Accident Investigators International Forum (MAIIF). In 2009 it submitted a document to the IMO calling for a revision of the procedures and citing at least 101 enclosed space incidents resulting in 93 deaths and 96 injuries since the recommendations had been adopted (Marine Accident Investigator's International Forum, 2009). In 2009, Maritime NZ issued Safety Bulletin Issue 21 – September 2009, Enclosed and Confined Spaces Can Kill highlighting to the maritime industry the dangers of enclosed spaces (see Appendix 4).

4.4.4. Having rules, regulations and guidelines does not in itself ensure compliance with them, nor does simply repeating the rules and regulations in on-board documentation ensure compliance. The responsibility for ensuring compliance with legislation and company operating procedures firstly rests with the ship owner or operating company, then with senior staff on board who have the responsibility for ensuring compliance on board, then lastly with the crew who are performing the procedure. It is this chain of responsibility that is espoused in the ISM Code, and if the chain is broken in some way the crew who are most likely to encounter an enclosed space scenario are at higher risk of having an accident.

4.4.5. The *TPC Wellington*'s shipboard management manual and systems had been audited and approved by Korean Register under the ISM Code. The manual contained references to the requirements to be followed when loading log cargoes, the dangers associated with the cargo and procedures to be taken if entry into an enclosed space was required. However, TPC Korea Company Limited, although identifying the need for education and training onboard for emergency response training and drills in the vessel procedures manual had not identified the need for an enclosed space rescue drill in the ship's emergency response drill matrix.

4.4.6. The SSM failed to mitigate what was known to be a high-risk to the crew. No record could be found of specific training for the crew to highlight the danger of entering enclosed cargo holds, nor had an enclosed space drill been held. Of the crew who had been made aware of the dangers, this awareness stemmed from shore-based training or training with other operators.

4.4.7. The bosun asked the chief officer twice not to enter the hold because he knew of the dangers. As previously mentioned, the Commission was unable to determine what training the chief officer had received; however, as the second most senior officer on board the vessel he should have been aware of the requirements on enclosed space entry and these would have been included in his certificated training (International Maritime Organization, 2005).

Findings

Being a dedicated log carrier, the risk of death by entering closed cargo holds containing logs and rescue from enclosed spaces should have been high on the ship's emergency response training programme, yet no evidence could be found in the vessel's records for the previous 3 months that such a drill or training had been performed.

It could not be established why the chief officer, a veteran of the sea, and senior officer on board would have ignored the warnings given by the bosun and entered the cargo hold, particularly as number 5 cargo hold was not one of those identified by the fumigator as needing water removed.

It could not be established what training the deceased deck crew member had received in the hazards of entering closed cargo hold, but he might not have been aware of why the chief officer was unconscious, or may simply have been overwhelmed by an emotional urge to perform the rescue in spite of the danger to himself.

4.5. Survivability

4.5.1. The way in which the crew responded to the emergency was indicative of insufficient knowledge and inadequate training on board the *TPC Wellington*. The response was unco-ordinated, with several different parties taking action independently of each other until the general alarm was raised approximately 8 minutes after the event.

4.5.2. When the chief officer collapsed on the cargo hold access ladder, the bosun immediately shouted to other members of the crew stationed at the gangway. Ideally, someone should have sounded the general alarm to ensure a co-ordinated response, leaving the bosun at the scene, who had the most knowledge of what had happened, to guard the scene and prevent a repeat occurrence.

4.5.3. The master, on receiving the call, rather than sounding the alarm, went to see what was happening, as did the third officer. Owing to a lack of proper communication, neither of them was sure where the accident had happened and they went independently to the wrong cargo hold access. This further delayed the rescue. Had the master taken appropriate control of the situation, sounded the alarm and contacted the shore authorities before going to the scene then the rescue may well have been expedited. Whether this could have saved the life of either of the victims is difficult to determine.

4.5.4. If the response had been instantaneous, and some thought been given to placing the second breathing apparatus on one of the victims in the cargo hold, it is remotely possible that one could have been saved. This would have given the rescuers more time to prepare for the retrieval in a co-ordinated way.

Figure 5 EEBD used in the rescue

4.5.5. Both breathing apparatus sets were brought to the scene and one set was used effectively by the third officer to recover the chief officer. The second set proved too bulky for its wearer to reach the second victim. The EEBD was only meant as an "escape" device so the first engineer using it to enter the hold, while laudable, was considerably risky. The air supply from the EEBD was luckily sufficient for the first engineer to carry out the retrieval of the deck crew member, but only just. The first engineer was on the point of collapse as he exited the hold and if he had not been close enough to the exit to be hauled clear by his colleagues he too could have become a casualty.

Finding

The rescue response from the vessel's master and crew was not well coordinated or practised, taking some 15 to 20 minutes to remove the bodies from the cargo hold and attempt resuscitation. Given the survival time in the cargo hold atmosphere, any rescue attempt would have had to be immediate and efficient for either of the deceased to survive, which would have been achievable if the entry into enclosed spaces procedure had been followed in the first place.

5. Findings

The following findings are not listed in any order of priority:

5.1. According to the autopsy reports the chief officer and the deck crew member died from asphyxia due to oxygen deprivation, which was consistent with the depleted (about 3%) level of oxygen in the cargo hold they had entered immediately before collapsing.

5.2. On entering the cargo hold with a 3% level of oxygen, the chief officer and deck crew member would have had 9 to 12 seconds of useful consciousness to maintain a hold on the access ladder; total unconsciousness rapidly following and death within 5 minutes.

5.3. Oxygen levels in the cargo hold would have been depleted by organic decomposition of the logs and toxic gases such as CO, CO_2 and H_2S may also have been present, phenomena well-known to the shipping industry and ones that were documented in the cargo-handling procedures on board the *TPC Wellington*

5.4. Being a dedicated log carrier the risk of death by entering enclosed cargo holds containing logs and rescue from enclosed spaces should have been high on the ship's emergency response training programme, yet no evidence could be found in the vessel's records for the previous 3 months that such a drill or training had been performed.

5.5. It could not be established why the chief officer, a veteran of the sea and a senior officer on board would have ignored the warnings given by the bosun and entered the cargo hold, particularly as number 5 cargo hold was not one of those identified by the fumigator as needing water removed.

5.6. It could not be established what training the deceased deck crew member had received in the hazards of entering closed cargo holds, but he might not have been aware of why the chief officer was unconscious, or may simply have been overwhelmed by an emotional urge to perform the rescue in spite of the danger to himself.

5.7. The rescue response from the vessel's master and crew was not well coordinated or practised, taking some 15 to 20 minutes to remove the bodies from the cargo hold and attempt resuscitation. Given the survival time in the cargo hold atmosphere, any rescue attempt would have had to be immediate and efficient for either of the deceased to survive, which would have been achievable if the entry into enclosed spaces procedure had been followed in the first place.

6. Safety actions

General

6.1. The Commission classifies safety actions by two types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation; and

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

6.2. The following safety actions are not listed in any order of priority.

(a) The Commission has forwarded this report to the IMO and invited the appropriate committee to note the contents of the report with a view to any future amendments to the procedures in the recommendations on entry into enclosed spaces.

(b) On 25 May 2011, Maritime New Zealand responded that:

> Over the last 12-18 months, MNZ has been working to educate the wider maritime community, including small boat operators, about the dangers of entering confined spaces. Following the initial development and distribution of Safety Bulletin No.21 in September 2009, we again highlighted the problem in three successive issues of MNZ's Lookout magazine — June 2010, September 2010 and March 2011. Lookout has a wide distribution within the commercial sector and, to a lesser extent, the recreational sector.
>
> In addition, MNZ highlighted the issue in its September 2010 surveyor newsletter and continues to raise it at Surveyor Seminars. In particular, MNZ has highlighted the fact that the risks apply to both small and larger vessels alike.
>
> The next step in widening the audience for this information, particularly those with small craft, could be to utilise the various sector publications that are available, including Professional Skipper and Seafood NZ, rather than reissue Safety Bulletin 21.
>
> To this end, MNZ will to develop an article for distribution to be used by these and other media outlets.

7. Recommendations

General

7.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether those safety issues are applicable to a single operator only or to the wider transport sector.

7.2. In the interests of transport safety it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

7.3. The Commission has not identified any new meaningful recommendations that could have prevented this accident that have not already been identified and widely taught both nationally and internationally through industry training organisations and nationally through Maritime New Zealand educational material (see Appendix 4). This occurrence report does, however, offer a number of lessons that can be useful to the maritime industry and the general public simply through its dissemination and readership.

8. Key lessons

8.1. Enclosed (confined) spaces can kill.

8.2. Never enter an enclosed (confined) space unless you have checked the atmosphere.

8.3. Always follow the correct procedures for entering enclosed (confined) spaces.

8.4. Manuals and written procedures alone will not prevent accidents, but training and audit that ensures they are understood and are followed, probably will.

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Appendix 1 – Section 3 of the Code of Safe Practice for Solid Bulk Cargoes (BC Code)

Safety of personnel and ship

3.1 General requirements

3.1.1 Prior to and during loading, transport and discharge of solid bulk cargoes all necessary safety precautions, including any appropriate national regulations or requirements, should be observed.

3.1.2 Advice on medical matters is given in the IMO/WHO/ILO Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG). A copy of the MFAG should be on board each ship.

3.2 Poisoning, corrosive and asphyxiation hazards

3.2.1 Certain solid bulk cargoes are susceptible to oxidation, which in turn may result in oxygen reduction, emission of toxic fumes and self-heating. Some cargoes may not oxidize but may emit toxic fumes, particularly when wet. There are also cargoes which, when wetted, are corrosive to skin, eyes and mucous membranes or to the ship's structure. In these cases, particular attention should be paid to protection of personnel and the need for special precautions and measures to be taken prior to loading and after unloading.

3.2.2 Therefore, it is important, that the shipper informs the master prior to loading as to whether chemical hazards exist. The master should also refer to the individual entry for the cargo involved and the necessary precautions, especially those pertaining to ventilation.

3.2.3 Shipmasters are warned that cargo spaces and adjacent spaces may be depleted in oxygen or may contain toxic or asphyxiating gases. An empty cargo space or tank which has remained closed for some time may have insufficient oxygen to support life.

3.2.4 Many cargoes frequently carried in bulk are liable to cause oxygen depletion in a cargo space or tank; these include most vegetable products, grains, timber logs and forest products, ferrous metals, metal sulphide concentrates and coal cargoes.

3.2.5 Entry of personnel into enclosed spaces should not be permitted until tests have been carried out and it has been established that the oxygen content has been restored to a normal level throughout the space and that no toxic gas is present, unless adequate ventilation and air circulation throughout the free space above the cargo has been effected. It should be remembered that, after a cargo space or tank has been tested and generally found to be safe for entry, small areas may exist where oxygen is deficient or toxic fumes are still present.

General precautions and procedures for entering enclosed spaces appear in Appendix 7. As much publicity as possible should be given to the hazards associated with entry into enclosed spaces. A poster on the subject should be produced. A specimen (reduced format) for such a poster for display on board ships in accommodation or other places, as appropriate, has been included in Appendix 7.

3.2.6 When transporting bulk cargo which is liable to emit a toxic or flammable gas, or cause oxygen depletion in the cargo space, an appropriate instrument for measuring the concentration of gas or oxygen in the cargo space should be provided.

3.2.7 It should be noted that a flammable gas detector is suitable only for testing the explosive nature of gas mixtures.

3.2.8 Emergency entry into a cargo space should be undertaken only by trained personnel wearing self-contained breathing apparatus and protective clothing and always under the supervision of a responsible officer.

3.3 Health hazards due to dust

3.3.1 To minimize the chronic and acute risks due to exposure to the dust of certain cargoes carried in bulk, the need for a high standard of personal hygiene of those exposed to the dust cannot be too strongly emphasized. The precautions should include, not only the use of appropriate protective clothing and barrier creams, when needed, but also adequate personal washing and laundering of outer clothing. Whilst these precautions are good standard practice, they are particularly relevant for those cargoes identified as toxic by this Code.

3.4 Flammable atmosphere

3.4.1 Dust created by certain cargoes may constitute an explosion hazard, especially while loading, unloading and cleaning. This risk can be minimized at such times by ensuring that ventilation is sufficient to prevent the formation of a dust-laden atmosphere and by hosing down rather than sweeping.

3.4.2 Some cargoes may emit flammable gases in sufficient quantities to constitute a fire or explosion hazard. Where this is indicated in the individual entries, the cargo spaces and adjacent enclosed spaces should be effectively ventilated at all times (see also 9.3.2.1.3 for requirements for mechanical ventilation). Also it may be necessary to monitor the atmosphere in such spaces by means of combustible gas indicators.

3.5 Ventilation

3.5.1 Where cargoes are carried which may emit toxic or flammable gases the cargo spaces should be provided with effective ventilation.

3.5.1.1 For the purpose of this Code, ventilation means exchange of air from outside to inside the cargo space to reduce any build-up of flammable gases or vapours to a safe level below the Lower Explosive Limit (LEL), or for toxic gases, vapours or dust to a level to maintain a safe atmosphere in a cargo space.

3.5.1.2 For ventilation requirements, the following definitions should be applied:

.1 natural ventilation means ventilation that is not power generated. An airflow is supplied by air ducts and/or other adequately designed openings;

.2 surface ventilation means ventilation only of the space above the cargo;

.3 mechanical ventilation means power generated ventilation; and

.4 continuous ventilation means ventilation that is operating at all times.

3.5.2 Recommendations on ventilation

.1 when continuous ventilation is required by the entry for the cargo in this Code or by the cargo information provided by the shipper, ventilation should be maintained while the cargo is in the hold; unless a situation develops where ventilation would endanger the ship;

.2 if maintaining ventilation endangers the ship or the cargo, it may be interrupted unless there is risk of explosion or other danger due to interruption of the ventilation;

.3 Holds intended for the carriage of cargoes for which continuous ventilation is required, should be provided with ventilation openings which may be kept opened when required. Such openings should comply with the requirements of the Load Line Convention as amended for openings not fitted with means of closure; and

.4 Ventilation should be such that any escaping hazardous gases, vapours or dust cannot reach living quarters. Escaping hazardous gases9, vapours or dust should not be able to reach work areas unless adequate precautions are taken (refer to Appendix 7).

3.6 Cargo under in-transit fumigation

3.6.1 Fumigation should be performed in accordance with the Recommendations on the Safe Use of Pesticides in Ships, set out in Appendix 8 of this Code.

Appendix 2 – Appendix 7 of the Code of Safe Practice for Solid Bulk Cargoes (BC Code)

RECOMMENDATIONS FOR ENTERING ENCLOSED SPACES ABOARD SHIPS

Preamble

The object of these recommendations is to encourage the adoption of safety procedures aimed at preventing casualties to ships' personnel entering enclosed spaces where there may be an oxygen-deficient, flammable and/or toxic atmosphere.

Investigations into the circumstances of casualties that have occurred have shown that accidents on board ships are in most cases caused by an insufficient knowledge of, or disregard for, the need to take precautions rather than a lack of guidance.

The following practical recommendations apply to all types of ships and provide guidance to seafarers. It should be noted that on ships where entry into enclosed spaces may be infrequent, for example, on certain passenger ships or small general cargo ships, the dangers may be less apparent, and accordingly there may be a need for increased vigilance.

The recommendations are intended to complement national laws or regulations, accepted standards or particular procedures, which may exist for specific trades, ships or types of shipping operations.

It may be impracticable to apply some recommendations to particular situations. In such cases, every endeavour should be made to observe the intent of the recommendations, and attention should be paid to the risks that may be involved.

1 Introduction

The atmosphere in any enclosed space may be deficient in oxygen and/or contain flammable and/or toxic gases or vapours. Such an unsafe atmosphere could also subsequently occur in a space previously found to be safe. Unsafe atmosphere may also be present in spaces adjacent to those spaces where a hazard is known to be present.

2 Definitions

2.1 *Enclosed space* means a space, which has any of the following characteristics:

.1 limited openings for entry and exit;

.2 unfavourable natural ventilation; and

.3 is not designed for continuous worker occupancy,

and includes, but is not limited to, cargo spaces, double bottoms, fuel tanks, ballast tanks, pump-rooms, compressor rooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases and sewage tanks.

2.2 *Competent person* means a person with sufficient theoretical knowledge and practical experience to make an informed assessment of the likelihood of a dangerous atmosphere being present or subsequently arising in the space.

2.3 *Responsible person* means a person authorized to permit entry into an enclosed space and having sufficient knowledge of the procedures to be followed.

3 Assessment of risk

3.1 In order to ensure safety, a competent person should always make a preliminary assessment of any potential hazards in the space to be entered, taking into account previous cargo carried, ventilation of the space, coating of the space and other relevant factors. The competent person's preliminary assessment should determine the potential for the presence of an oxygen-deficient, flammable or toxic atmosphere.

3.2 The procedures to be followed for testing the atmosphere in the space and for entry should be decided on the basis of the preliminary assessment. These will depend on whether the preliminary assessment shows that: .1 there is minimal risk to the health or life of personnel entering the space;

.2 there is no immediate risk to health or life but a risk could arise during the course of work in the space; and

.3 a risk to health or life is identified.

3.3 Where the preliminary assessment indicates minimal risk to health or life or potential for a risk to arise during the course of work in the space, the precautions described in 4, 5, 6 and 7 should be followed as appropriate.

3.4 Where the preliminary assessment identifies risk to life or health, if entry is to be made, the additional precautions specified in section 8 should also be followed.

4 Authorization of entry

4.1 No person should open or enter an enclosed space unless authorized by the master or nominated responsible person and unless the appropriate safety procedures laid down for the particular ship have been followed.

4.2 Entry into enclosed spaces should be planned and the use of an entry permit system, which may include the use of a checklist, is recommended. An Enclosed Space Entry Permit should be issued by the master or nominated responsible person, and completed by a person who enters the space prior to entry. An example of the Enclosed Space Entry Permit is provided in the appendix.

5 General precautions

5.1 The master or responsible person should determine that it is safe to enter an enclosed space by ensuring:

.1 that potential hazards have been identified in the assessment and as far as possible isolated or made safe;

.2 that the space has been thoroughly ventilated by natural or mechanical means to remove any toxic or flammable gases, and to ensure an adequate level of oxygen throughout the space;

.3 that the atmosphere of the space has been tested as appropriate with properly calibrated instruments to ascertain acceptable levels of oxygen and acceptable levels of flammable or toxic vapours;

.4 that the space has been secured for entry and properly illuminated;

.5 that a suitable system of communication between all partie s for use during entry has been agreed and tested;

.6 that an attendant has been instructed to remain at the entrance to the space whilst it is occupied;

.7 that rescue and resuscitation equipment has been positioned ready for use at the entrance to the space, and that rescue arrangements have been agreed;

.8 that personnel are properly clothed and equipped for the entry and subsequent tasks; and

.9 that a permit has been issued authorizing entry.

The precautions in .6 and .7 may not apply to every situation described in this section. The person authorizing entry should determine whether an attendant and the positioning of rescue equipment at the entrance to the space is necessary.

5.2 Only trained personnel should be assigned the duties of entering, functioning as attendants, or functioning as members of rescue teams. Ships' crews should be drilled periodically in rescue and first aid.

5.3 All equipment used in connection with entry should be in good working condition and inspected prior to use.

6 Testing the atmosphere

6.1 Appropriate testing of the atmosphere of a space should be carried out with properly calibrated equipment by persons trained in the use of the equipment. The manufacturers' instructions should be strictly followed. Testing should be carried out before any person enters the space, and at regular intervals thereafter until all work is completed. Where appropriate, the testing of the space should be carried out at as many different levels as is necessary to obtain a representative sample of the atmosphere in the space.

6.2 For entry purposes, steady readings of the following should be obtained:

.1 21% oxygen by volume by oxygen content meter; and

.2 not more than 1% of lower flammable limit (LFL) on a suitably sensitive combustible gas indicator, where the preliminary assessment has determined that there is potential for flammable gases or vapours.

If these conditions cannot be met, additional ventilation should be applied to the space and re-testing should be conducted after a suitable interval. Any gas testing should be carried out with ventilation to the enclosed space stopped, in order to obtain accurate readings.

6.3 Where the preliminary assessment has determined that there is potential for the presence of toxic gases and vapours, appropriate testing should be carried out using fixed or portable gas or vapour detection equipment. The readings obtained by this equipment should be below the occupational exposure limits for the toxic gases or vapours given in accepted national or international standards. It should be noted that testing for flammability does not provide a suitable means of measuring for toxicity, nor vice versa.

6.4 It should be emphasized that pockets of gas or oxygen-deficient areas can exist, and should always be suspected, even when an enclosed space has been satisfactorily tested as being suitable for entry.

7 Precautions during entry

7.1 The atmosphere should be tested frequently whilst the space is occupied, and persons should be instructed to leave the space should there be deterioration in the conditions.

7.2 Ventilation should continue during the period that the space is occupied and during temporary breaks. Before re-entry after a break, the atmosphere should be re-tested. In the event of failure of the ventilation system, any persons in the space should leave immediately.

7.3 In the event of an emergency, under no circumstances should the attending crew member enter the space before help has arrived and the situation has been evaluated to ensure the safety of those entering the space to undertake rescue operations.

8 Additional precautions for entry into a space where the atmosphere is known or suspected to be unsafe

8.1 If the atmosphere in an enclosed space is suspected or known to be unsafe, the space should only be entered when no practical alternative exists. Entry should only be made for further testing, essential operation, and safety of life or safety of a ship. The number of persons entering the space should be the minimum compatible with the work to be performed.

8.2 Suitable breathing apparatus, e.g. air-line or self-contained type, should always be worn, and only personnel trained in its use should be allowed to enter the space. Air-purifying respirators should not be used, as they do not provide a supply of clean air from a source independent of the atmosphere within the space.

8.3 The precautions specified in 5 should also be followed, as appropriate.

8.4 Rescue harnesses should be worn and, unless impractical, lifelines should be used.

8.5 Appropriate protective clothing should be worn, particularly where there is any risk of toxic substances or chemicals coming into contact with the skin or eyes of those entering the space.

8.6 The advice in 7.3 concerning emergency rescue operations is particularly relevant in this context.

9 Hazards related to specific types of cargo

9.1 Dangerous goods in packaged form

9.1.1 The atmosphere of any space containing dangerous goods may put at risk the health or life of any person entering it. Dangers may include flammable, toxic or corrosive gases or vapours that displace oxygen, residues on packages and spilled material. The same hazards may be present in spaces adjacent to the cargo spaces. Information on the hazards of specific substances is contained in the IMDG Code, the Emergency Response Procedures for Ships Carrying Dangerous Goods (EmS Guide) and Materials Safety Data Sheets (MSDS). If there is evidence or suspicion that leakage of dangerous substances has occurred, the precautions specified in 8 should be followed.

9.1.2 Personnel required to deal with spillages or to remove defective or damaged packages should be appropriately trained and wear suitable breathing apparatus and appropriate protective clothing.

9.2 Bulk liquid

9.2.1 The tanker industry has produced extensive advice to operators and crews of ships engaged in the bulk carriage of oil, chemicals and liquefied gases, in the form of specialist international safety guides. Information in the guides on enclosed space entry amplifies these recommendations and should be used as the basis for preparing entry plans.

9.3 Solid bulk

9.3.1 On ships carrying solid bulk cargoes, dangerous atmospheres may develop in cargo spaces and adjacent spaces. The dangers may include flammability, toxicity, oxygen depletion or self-heating, which should be identified in shipping documentation. For additional information, reference should be made to the Code of Safe Practice for Solid Bulk Cargoes.

9.4 Oxygen-depleting cargoes and materials

9.4.1 A prominent risk with such cargoes is oxygen depletion due to the inherent form of the cargo, for example, self- heating, oxidation of metals and ores or decomposition of vegetable oils, animal fats, grain and other organic materials or their residues.

9.4.2 The materials listed below are known to be capable of causing oxygen depletion. However, the list is not exhaustive. Oxygen depletion may also be caused by other materials of vegetable or animal origin, by flammable or spontaneously combustible materials, and by materials with a high metal content:

.1 grain, grain products and residues from grain processing (such as bran, crushed grain, crushed malt or meal), hops, malt husks and spent malt;

.2 oilseeds as well as products and resid ues from oilseeds (such as seed expellers, seed cake, oil cake and meal);

.3 copra;

.4 wood in such forms as packaged timber, roundwood, logs, pulpwood, props (pit props and other propwood), woodchips, woodshavings, woodpulp pellets and sawdust;

.5 jute, hemp, flax, sisal, kapok, cotton and other vegetable fibres (such as esparto grass/Spanish grass, hay, straw, bhusa), empty bags, cotton waste, animal fibres, animal and vegetable fabric, wool waste and rags;

.6 fishmeal and fishscrap;

.7 guano;

.8 sulphidic ores and ore concentrates;

.9 charcoal, coal and coal products;

.10 direct reduced iron (DRI);

.11 dry ice;

.12 metal wastes and chips, iron swarf, steel and other turnings, borings, drillings, shavings, filings and cuttings; and

.13 scrap metal.

9.5 Fumigation

9.5.1 When a ship is fumigated, the Recommendations on the Safe Use of Pesticides in Ships, reproduced in Appendix 8, should be followed. Spaces adjacent to fumigated spaces should be treated as if fumigated.

10 Conclusion

10.1 Failure to observe simple procedures can lead to people being unexpectedly overcome when entering enclosed spaces. Observance of the principles outlined above will form a reliable basis for assessing risks in such spaces and for taking necessary precautions.

EXAMPLE OF AN ENCLOSED SPACE ENTRY PERMIT

This permit relates to entry into any enclosed space and should be completed by the master or responsible officer and by the person entering the space or authorized team leader.

General

Location/name of enclosed space	....	
Reason for entry	....	
This permit is valid	from : .... hrs	Date ....
	to : .... hrs	Date ....
		(See note 1)

Section 1 - Pre-entry preparation

(To be checked by the master or nominated responsible person)	**Yes**	**No**
• Has the space been thoroughly ventilated?	?	?
• Has the space been segregated by blanking off or isolating all connecting pipelines or valves and electrical power/equipment?	?	?
• Has the space been cleaned where necessary?	?	?
• Has the space been tested and found safe for entry? (See note 2)	?	?
• Pre-entry atmosphere test readings:	?	?
- oxygen .... % vol (21%) By:		
- hydrocarbon .... % LFL (less than 1%)		
- toxic gases .... ppm (specific gas and PEL) Time		
(See note 3)		
• Have arrangements been made for frequent atmosphere checks to be made while the space is occupied and after work breaks?	?	?
• Have arrangements been made for the space to be continuously ventilated throughout the period of occupation and during work breaks?	?	?
• Are access and illumination adequate?	?	?
• Is rescue and resuscitation equipment available for immediate use by the entrance to the space	?	?

• Has a responsible person been designated to be in constant attendance at the entrance to the space?	?	?
• Has the officer of the watch (bridge, engine-room, cargo control room) been advised of the planned entry?	?	?
• Has a system of communication between all parties been tested and emergency signals agreed?	?	?
• Are emergency and evacuation procedures established and understood by all personnel involved with the enclosed space entry?	?	?
• Is all equipment used in good working condition and inspected prior to entry?	?	?
• Are personnel properly clothed and equipped?	?	?

Section 2 - Pre-entry checks

(To be checked by the person entering the space or authorized team leader)	**Yes**	**No**
• I have received instructions or permission from the master or nominated responsible person to enter the enclosed space	?	?

• Section 1 of this permit has been satisfactorily completed by the master or nominated responsible person	?	?
• I have agreed and understand the communication procedures	?	?
• I have agreed upon a reporting interval of .... minutes	?	?
• Emergency and evacuation procedures have been agreed and are understood	?	?
• I am aware that the space must be vacated immediately in the event of ventilation failure or if atmosphere tests show a change from agreed safe criteria	?	?

Section 3 - Breathing apparatus and other equipment

(To be checked jointly by the master or nominated responsible person and the person who is to enter the space)	**Yes**	**No**
• Those entering the space are familiar with the breathing apparatus to be used	?	?
• The breathing apparatus has been tested as follows:	?	?
- gauge and capacity of air supply	------------------------	
- low pressure audible alarm	------------------------	
- face mask - under positive pressure and not leaking	------------------------	
• The means of communication has been tested and emergency signals agreed	?	?
• All personnel entering the space have been provided with rescue harnesses and, where practicable, lifelines	?	?

Signed upon completion of sections 1, 2 and 3 by:

Master or nominated responsible person .... Date.................. Time................

Responsible person supervising entry .... Date.................. Time................

Person entering the space or authorized team leader .... Date.................. Time................

Section 4 - Personnel entry

(To be completed by the responsible person supervising entry)

Names	**Time in**	**Time out**
--	----------------	----------------
--	----------------	----------------
--	----------------	----------------
--	----------------	----------------

Section 5 - Completion of job		
(To be completed by the responsible person supervising entry)	**Date**	**Time**
• Job completed	-------------------	-------------------
• Space secured against entry	-------------------	-------------------
• The officer of the watch has been duly informed	-------------------	-------------------

Signed upon completion of sections 4 and 5 by:

Responsible person supervising entry .... Date..................Time..................

THIS PERMIT IS RENDERED INVALID SHOULD VENTILATION OF THE SPACE STOP OR IF ANY OF THE CONDITIONS NOTED IN THE CHECKLIST CHANGE

Notes:

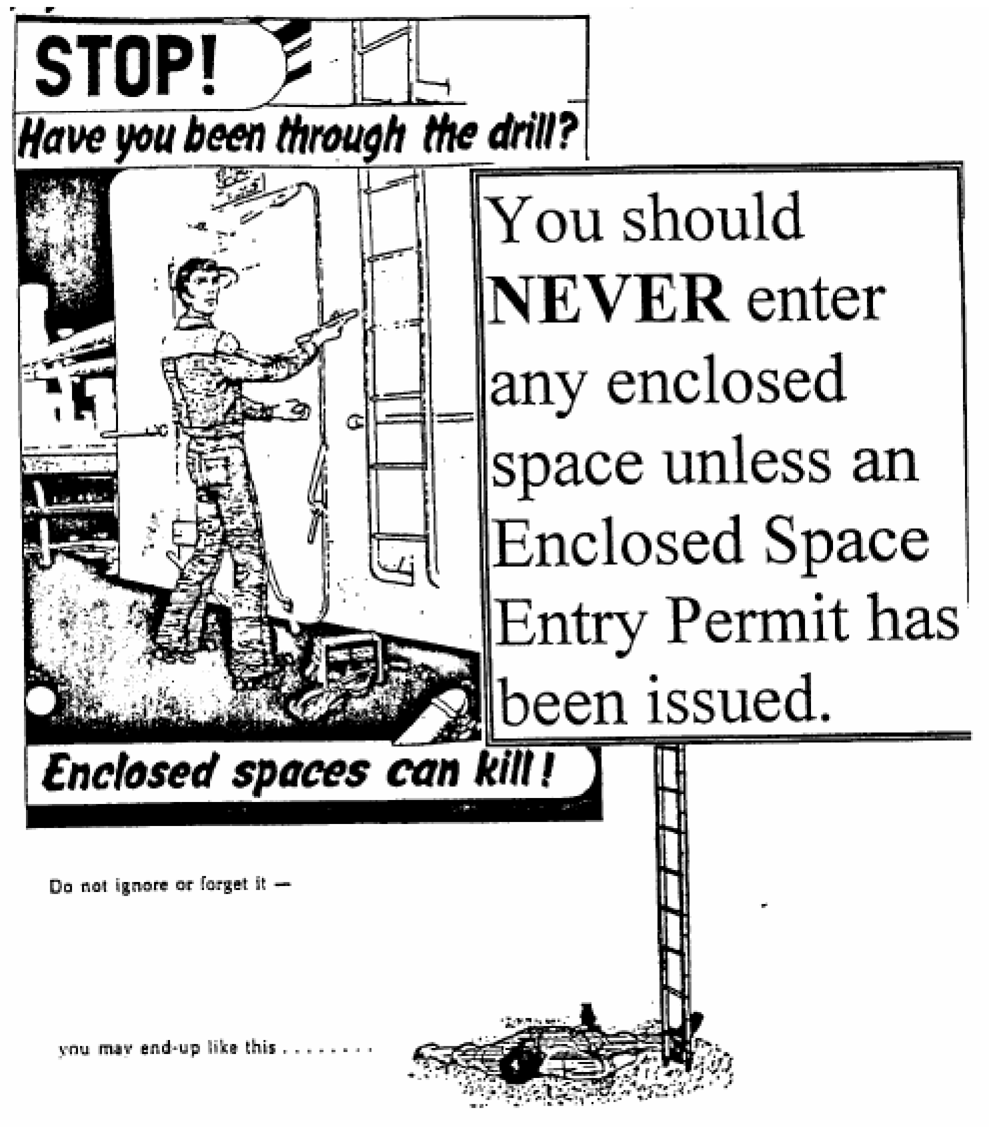
1 The permit should contain a clear indication as to its maximum period of validity.

2 In order to obtain a representative cross-section of the space's atmosphere, samples should be taken from several levels and through as many openings as possible. Ventilation should be stopped for about 10 minutes before the pre-entry atmosphere tests are taken.

3 Tests for specific toxic contaminants, such as benzene or hydrogen sulphide, should be undertaken depending on the nature of the previous contents of the space.

RECOMMENDED POSTER FOR DISPLAY ON BOARD SHIPS IN ACCOMMMODATION OR OTHER PLACES, AS APPROPRIATE

(reduced format)



Appendix 3 – Procedure for enclosed space entry and enclosed space entry permit TPC Korea Limited

TPC TRANS PACIFIC CARRIERS	SHIPBOARD SAFETY WORK ROCEDURES	Doc. No. : TSQ-V04-04 Page : 1/2
	Ch.-4 Procedure for Enclosed Space Entry	Rev. No. : 0 Enf. Date : 2006. 03. 01

1. Enclosed Space (also referred to as "Confined Space")
   Any space with restricted access that is not subject to continuous ventilation and in which the atmosphere may be hazardous due to the presence of hydrocarbon gas, toxic gases, inert gas or oxygen deficiency. This definition included cargo hold, ballast, fuel, water, lube oil, silo, sewage tanks, cofferdam, duct keels, void spaces and trunkings; and other items of equipment that are not routinely ventilated and entered such as boilers and main engine crankcases.

2. Possibility of Danger of Enclosed Space Entry
   (1) There is highly possibility of oxygen deficiency by oxidization action where heavy rusty area due to sea water ingress. (ex. Ballast Tank)
   (2) All cargo (regardless of their kind) laden in cargo hold of bulk carrier take a breathing, therefore there is still possibility of oxygen deficiency.
   (3) A space closed for a long time is possibility of existence of harmful gas due to volatilization of paint, concentration of combustible gas from oily steaming and corrosion of organic compound.

3. Procedure
   The Responsible officers shall be notified of any entry required into a enclosed space. They shall ensure the following precautions are taken prior to allowing any personnel to enter the space.
   (1) The enclosed space atmosphere must be thoroughly ventilated and tested immediately prior to entry to provide the following acceptable levels;
   ① Oxygen concentration is 20 % by volume
   ② Hydrocarbon vapor concentration is not > 1% LEL

   (2) Atmosphere tests must be performed at several depths and through as many deck openings as possible.

   (3) The atmosphere shall also be tested for toxic gases, when applicable, to ensure the acceptable PEL(Permissible Exposure Limits) is not exceeded.

   (4) The following emergency response and rescue equipment shall be available for immediate use at the entrance to the space.
   ① Lifelines and rescue harnesses
   ② Positive pressure breathing apparatus and resuscitation equipment.

   (5) Where possible, a separate means of access should be made available as an alternate escape route.

   (6) Responsible officer shall carry out safety check in compliance with "Hot Work Permit" and the approval of the Master/C/E shall be obtained prior to commence work.

   (7) The Responsible officer shall take a notice to the entrance of enclosed space including name of enclosed space, date and valid time.

   (8) Responsible officer shall allow personnel to enter the space only after he has verified that they have proper personal protection equipment including;
   ① Appropriated cartridge or canister face mask if chemical contaminants are present
   ② Proper clothing including safety helmets, shoes and leather gloves
   ③ Approved flashlights

   (9) Once personnel have entered the space, the responsible officer shall ensure the following;
   ① Atmosphere tests are conducted at regular intervals

② Continuous ventilation is provided to the space
③ Two or more persons must be in the space and accounted for at all times
④ Adequate illumination of the space, ladders and entrance is provided

(10) The duty officer shall be informed of the names of persons entering the space, identification of space and estimated time of work completion. When the space involved is on the E/R, the duty engineer shall also be informed.

(11) A responsible member of the crew shall in constant attendance at eh entrance to the space, and in direct between with the duty officer or duty engineer.

(12) In the event of emergency, under no circumstances shall the attending crewmember enter the space before help has arrived and the situation has been evaluated.

(13) Communication method between personnel working in the space and the attending responsible crewmember shall be estimated and tested. Interval between communications shall not be exceed 30 minute. Emergency signals shall be established and agreed to by both parties.

4. Record
(1) Enclosed Space Entry Permit (TFM-V04-01)

5. Explanation of Terms by the Ministry of Commerce, Industry and Energy

Term	Explanation
ppb	Parts-Per-Billion (1ppm=1,000ppb)
ppm	Parts-Per-Million (1%=10,000ppm)
Vol%	Showing the concentration of gas as 1/100 unit
%LEL	Percent of lower explosive limit (%LEL).
LEL	The **Lower explosive limit** of a gas or a vapour, is the limiting concentration (in air) that is needed for the gas to ignite and explode
UEL	The **Upper explosive limit** of a gas or a vapour, is the limiting concentration (in air) that is needed for the gas to ignite and explode
Permissible Exposure Limits	legal limit for exposure of an employee to a substance or physical agent
Explosive Limit	Explosive limit of a gas or a vapour, is the limiting concentration (in air) that is needed for the gas to ignite and explode
TLVs	Threshold Limit Values : The concentration in air to which it is believed that most workers can be exposed daily without and adverse effect
TLV-TWA	Threshold Limit Value Time Weighted Average : average exposure on the basis of a 8h/day, 40h/week work schedule
TLV-STEL	Threshold Limit Short Term Exposure Limit : spot exposure for a duration of 15 minutes, that cannot be repeated more than 4 times per day
TLV-C	Threshold Limit Value Ceiling : absolute exposure limit that should not be exceeded at any time

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ENCLOSED SPACE ENTRY PERMIT

TPC DATE:

INSTRUCTION : See (TSQ-V04-04) for Enclosed Space Entry Procedure. The Chief Officer or 1st Engineer shall complete this permit and provide it to the Master for approval and validation. **Permit not valid until signed by Master.**

SPACE : **REASON FOR ENTRY :**

OPERATION TEAM (RANK / NAME) : (1) (2)	**ATMOSPHERE CHECKED BY (RANK / NAME) :**
(2) (3)	**WATCH MAN (RANK / NAME) :**
(4) (5)	**MEANS OF COMMUNICATION :**

ITEM TO CHECK AND THE RESULT [RESPONSIBLE OFFICER]	**YES**
Has the space been properly ventilated? 작업구역은 적절히 환기되었는가? Means of Ventilation : ____________	☐
Atmosphere testing performed at several locations and levels. 공기측정은 여러 위치와 여러 깊이에서 수행되었는가? TIME ______ OXIGEN _____% H_2S _____PPM COMBUSTIBLE _____%LEL IGS-CO _____PPM ※ **Reading limitation** 21≥ OXIGEN > 20% H_2S < 10PPM LEL < 1% IGS-CO < 35PPM	☐
Have arrangements been made to continue ventilation during occupancy of the space and at breaks? 작업중 및 휴식시간에 환기가 계속되도록 조치하였는가?	☐
Has the atmosphere been tested regularly during occupancy and at breaks? 작업중 및 휴식시간에 공기측정은 정기적으로 시행하였는가? TIME ______ OXIGEN _____% H_2S _____PPM COMBUSTIBLE _____%LEL IGS-CO _____PPM TIME ______ OXIGEN _____% H_2S _____PPM COMBUSTIBLE _____%LEL IGS-CO _____PPM	☐
Are rescue and resuscitation equipment available for immediate use at the entrance to the space? 밀폐구역 입구에 구조장비 및 응급처리기구를 즉시 사용할 수 있도록 준비하였는가?	☐
Have the watchmen been arranged to be in constant attendance at the entrance to the space? 밀폐구역 입구에는 감시자가 항상 대기토록 배치하였는가?	☐
Has a system of communication between the person at the entrance and those entering the spaces been agreed and tested? 밀폐구역 내 작업자와 감시자의 통신수단을 갖추고 시험하였는가?	☐
Are the workers skilled for or experienced in such operations? 작업자는 작업을 실시하기에 적절한 유경험자(숙련자)인가?	☐
Are the portable lights or other equipment of an appropriate type? 휴대용 전등 및 기타 장비는 안전한 형식의 것인가?	☐
Are access and illumination adequate? 내부의 조명은 적절한가?	☐

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ENCLOSED SPACE ENTRY PERMIT

TPC DATE:

[PERSON ENTERING THE ENCLOSED SPACE]	YES
Are you satisfied with the above mentioned items checked by the responsible officer? 상기 책임사관이 점검한 항목에 대해 만족하는가?	☐
Do you understand the arrangements for communication between yourself and the responsible person in attendance at the entrance to the space? 감시자와의 통신수단과 조치에 대해 이해하고 있는가?	☐
Are you aware you should leave the space immediately in the event of the ventilation problems or communication failure? 통풍/통신에 문제 발생시 즉시 밀폐구역을 떠나야 함을 숙지하고 있는가?	☐
[RESPONSIBLE OFFICER & PERSONNEL ENTERING THE SPACE]	**YES**
Are you familiar with the breathing apparatus to be used? 밀폐구역 입구에 비치한 자장식호흡구의 사용법을 알고 있는가?	☐
Has the apparatus been tested for the following: 준비된 자장식호흡구에 대한 다음 사항을 점검하였는가? (1) Adequacy of air supply (2) Low pressure audible alarm (3) Face mask: air supply and tightness	☐
Have the emergency signals and other emergency arrangements been agreed? 비상신호 등 다른 조치에 대해 사전약속이 되어 있는가?	☐

CONFIRMING AND SIGN

The undersigned confirm that all preventive measures have been taken and the safety measures will be maintained during the occupancy in the space.
본인은 모든 예방조치가 취해졌으며, 작업기간에도 안전조치가 유지될 것임을 확인하였습니다.

DATE : TIME :

RESPONSIBLE OFFICER :

SAFETY OFFICER (C/E) :

APPROVED : MASTER

VALID FROM[TIME] ~ TO[TIME] (permit valid maximum 24 hours)

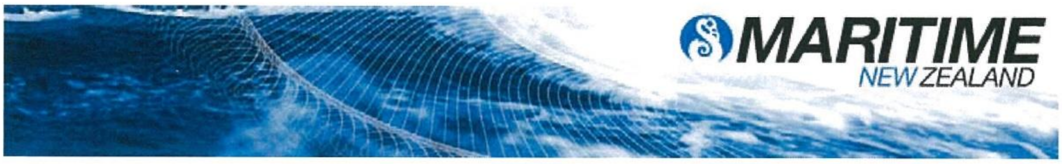
CONFIRMING COMPLETION OF THE OPERATION

The undersigned confirm that the operations have been completed and all personnel and equipment have been withdrawn under control of the undersigned.
작업이 완료되었고 본인의 감독하에 모든 인원과 장비가 철수 되었음을 확인합니다.

DATE : TIME :

RESPONSIBLE OFFICER :

Appendix 4 – Maritime New Zealand Safety Bulletin Issue 21 – September 2009 – Enclosed Spaces



Maritime New Zealand Guidelines

SAFETY BULLETIN ISSUE 21 – SEPTEMBER 2009

ENCLOSED AND CONFINED SPACES CAN KILL

This safety bulletin is for:

- New Zealand ship owners, masters and crew
- any contractors, ship builders or repairers working on board ships
- safe ship management companies and surveyors
- classification societies in New Zealand and class surveyors
- MNZ maritime safety inspectors.

Purpose

This bulletin is issued to highlight dangerous confined spaces onboard ships, some of the lethal hazards present, how best to reduce the risks involved and to alert people to the hazards of poorly planned rescue attempts.

Warning – risk of death

Life is risked every time someone enters an enclosed or confined space without following the correct procedures.

The space may be deficient in oxygen. Oxygen deficiency can be caused by:

- rusting steel or chain
- rotting organic matter
- drying paint or coatings
- motors/petrol pumps
- refrigerants and other gases
- hot work (torching or welding).

The space may also contain flammable or toxic fumes, gases or vapours. Carbon monoxide damages your ability to absorb oxygen and this effect can also accumulate for days after exposure. Hydrogen sulphide is highly poisonous, often lethal and can evolve from fuel tanks, pipes, sewage and organic decomposition.

Enclosed or confined spaces

A dangerous enclosed or confined space is a space with the following characteristics:

- severely limited natural ventilation
- capacity to accumulate or contain hazardous atmosphere
- exits that are not readily available
- designs that are not meant for continuous occupancy.

Examples of enclosed spaces are:

- cargo holds
- pump rooms
- fuel/bunker tanks
- chain lockers
- paint/chemical lockers
- sanitary/waste tanks
- pipe tunnels
- peak tanks
- any other poorly ventilated confined space
- battery lockers
- boiler furnaces
- ballast tanks
- void spaces
- fresh water tanks
- double bottom tanks
- engine crankcases
- cofferdams

Precautions and procedures

Familiarise yourself with the health and safety advice provided in the Maritime New Zealand *Code of Safe Working Practices for Merchant Seafarers*, the Department of Labour information sheets - *Safe Working in a Confined Space*, and IMO Resolution A.864(20). These documents describe how to establish procedures for entry into enclosed spaces and should be considered in addition to identifying all of the confined spaces on board that may pose a hazard. Procedures include examples of permit to work systems and the rationale on how to apply them on board for both the ship's crew, and importantly, all contractors working on board.

Before entry

The space should be assessed by a person with sufficient knowledge and experience to ensure that:

- the potential hazards of the space are identified
- the space is prepared for entry
- the space is secured for entry
- the atmosphere of the space is safe for entry, involving a test of the atmosphere whenever necessary.

On entry

On entering a dangerous space ensure that:

- you never carry out entry work alone
- you have a person assigned on safety standby for each entry
- the person on standby is equipped with the right equipment to be able to raise an emergency alarm, adequate protective clothing and sufficient equipment to initiate a rescue
- the space is well ventilated.

If things go wrong

If you see someone lying motionless, even if at the bottom of a ladder in an enclosed space, **DO NOT rush in to carry out a rescue by yourself.** Typically, personnel react by rushing into lethal atmospheres under the misconception that they will be able to save colleagues. But unplanned rescues are likely to end in tragedy.

When an emergency occurs the alarm should be sounded so that back-up is immediately available to the rescue team. Under no circumstances should the attendant enter the space before help has arrived and the situation has been evaluated. The safety of rescuers entering the space must be ensured.

Rescue procedures

Full consideration should be given to rescue procedures and specifically that:

- rescue procedures should be planned before entry and taken into account in any risk assessment.
- the rescue procedure should be specific for each type of dangerous enclosed or confined space.
- rescue equipment should be immediately available.
- breathing apparatus should be **self contained breathing apparatus (SCBA)** and **NOT** emergency escape breathing devices (EEBDs).
- any rescue procedure should be practised frequently enough to provide a level of proficiency that eliminates life-threatening rescue attempts and ensures an efficient and calm response to any emergency.

Further reading

Maritime New Zealand *Code of Safe Working Practices for Merchant Seafarers 2007*, Chapters 16 and 17. http://www.maritimenz.govt.nz/Commercial/Shipping-safety

Department of Labour *Safe Working in a Confined Space*
http://www.osh.govt.nz/order/catalogue/pdf/confined.pdf

IMO recommendations for entering enclosed spaces aboard ships, annex to Resolution A.864(20) adopted 27.11.97 http://www.imo.org/includes/blastData.asp/doc_id=10569/864(20).pdf

Further Information
For further information please contact our Wellington office:
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