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ATSB TRANSPORT SAFETY REPORT
Marine Occurrence Investigation No. 270
MO-2009-010
Final

Fatality on board the chemical tanker *Bow De Jin* at sea off New South Wales

24 November 2009

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Abstract

On 24 November 2009, the chief mate on board the Hong Kong registered chemical tanker *Bow De Jin* died after entering a cargo tank which contained hydrocarbon vapours and was deficient in oxygen.

The ATSB investigation was unable to determine why the chief mate, who had sailed on tankers for most of his seagoing career, did not follow industry standard and specific company safety procedures before he entered the cargo tank.

The investigation found that while enclosed space entry checklists were being filled out by the crew members on board the ship, the checklist system was not being used as a proactive means to ensure that the necessary safety requirements were being met prior to tank entries.

As a result of this incident and the ATSB investigation, *Bow De Jin*'s managers have taken action to improve the ship's enclosed space entry checklist system.

FACTUAL INFORMATION

Bow De Jin

Bow De Jin (IMO No. 9200598) was built in 1999 by Fukuoka Shipbuilding, Japan (Figure 1). It is 117.0 m long with a beam of 20.0 m and has a deadweight of 11,752 tonnes at its summer draught of 8.766 m. The ship's maximum depth is 11.2 m.

The ship is powered by a B&W 6L35ML/1 two-stroke, single acting diesel engine that delivers 3,884 kW. The main engine drives a single, fixed pitch propeller which gives the ship a service speed of about 13.5 knots[1].

At the time of the incident, *Bow De Jin* was owned by New Golden Shipping and managed by Fleet

Figure 1: ***Bow De Jin*** **departing Gladstone**

1 One knot, or one nautical mile per hour equals 1.852 km/hr.

Management, both of Hong Kong. It was on a time charter to Odfjell Tankers, Singapore, and classed with Nippon Kaiji Kyokai (Class NK).

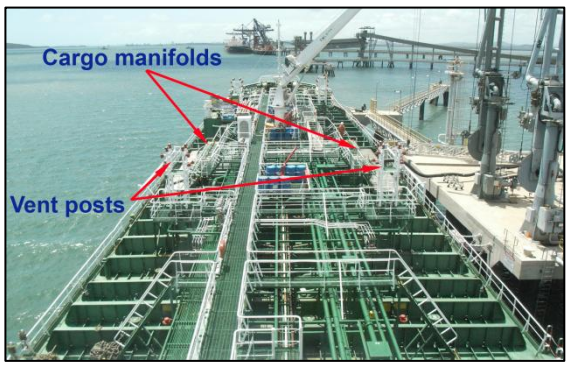
Bow De Jin's navigation bridge was equipped with navigational equipment consistent with SOLAS[2] requirements. The ship also carried a number of ultra high frequency (UHF) hand-held radios for internal shipboard communications.

The ship is a Type II and III chemical tanker and holds a 'Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk'. It has a cargo capacity of 12,292 m^3 (with tanks filled 98% by volume). Its 20 stainless steel cargo tanks are located forward of the accommodation superstructure; 10 tanks each on the port and starboard sides. Each tank is serviced by individual cargo pumps and lines. The cargo lines run above the main deck to a manifold located about amidships (Figure 2).

Access to each cargo tank is through a hatch located at the top of the tank, between the external frames of the cargo tanks and near the ship's centreline. The tanks are about 10 m deep and a ladder and stairway arrangement leads from the hatch opening to the bottom of each tank.

Gas freeing of the ship's cargo tanks is undertaken using a fixed fan system, with a capacity of 1,700 m^3/hr, to force fresh air through the cargo lines and into the required cargo tank(s). The air in the tank(s) is vented through vent posts on the main deck (Figure 2).

Figure 2: *Bow De Jin*'s foredeck



The ship carried a number of portable oxygen and gas detection units for testing tank atmospheres. This included three Dräger X-am 2000 personal gas detectors. At the time of the accident, all the gas testing equipment was calibrated as required by the manufacturers.

Bow De Jin's crew comprised 23 Chinese nationals. While at sea, three of the four mates maintained a traditional 4 hours on, 8 hours off watch keeping routine. Since the chief mate was responsible for gas freeing and tank cleaning operations, he was a day worker and did not keep navigational watches.

The master had 22 years of seagoing experience. He obtained his Chinese master's certificate of competency in 2002 and had sailed as master for about 7 years. Since 2005, he had worked for Fleet Management and this was his second assignment on board *Bow De Jin*, having joined it on 26 May 2009. He had about 10 years of experience sailing on chemical tankers, as both chief mate and master.

The chief mate was 41 years of age. He held a Hong Kong class one licence with valid oil and chemical tanker endorsements, which was issued on 15 June 2009 in recognition of his Chinese certificate of competency. He began his seagoing career in 1993, initially as a seaman. He had sailed as a ship's officer since November 1995 and first sailed as chief mate in September 2003. He joined *Bow De Jin* in Singapore on 26 May 2009.

The chief mate had previously spent most of his seagoing career on oil and product tankers. This was his first time on board a chemical tanker. As this was also his first assignment on a Fleet Management ship, he initially sailed as a supernumerary to understudy the chief mate and become familiar with company procedures and chemical tanker operations. He took over as chief mate on 28 August 2009.

The accident

At 0930[3] on 22 November 2009, *Bow De Jin* berthed in Port Botany, New South Wales, following a voyage from Melbourne, Victoria. The

2 The International Convention for the Safety of Life at Sea, 1974, as amended.

3 All times referred to in this report are local time, Coordinated Universal Time (UTC) + 10 hours (Queensland) and + 11 hours (New South Wales).

ship was to discharge a cargo of various chemicals which had been loaded in Singapore.

By about 0600 on 23 November, the cargo had been discharged. Two of the cargo tanks, five port (5P), with a capacity of 909.7 m^3, and seven starboard (7S), with a capacity of 903.9 m^3, were still inerted[4] with nitrogen gas. These two tanks had carried Hexene-1[5].

At 0645, a harbour pilot boarded *Bow De Jin* and by 0712, the ship's mooring lines had been let go and the ship proceeded out of the port. Its next port of call was Gladstone, Queensland, where it would load a cargo of caustic soda for discharge in New Zealand.

Soon after the ship departed Port Botany, the crew commenced tank cleaning operations. They worked a 6 hours on/6 hour off routine so that the tank cleaning could take place throughout the day and night. Before work began, the chief mate explained the various stages of tank cleaning to relevant crew members at a pre-cleaning conference. He then supervised the operation, assisted by the boatswain (bosun) and the pumpman.

Between 0300 and 0400 on 24 November, 5P was washed with sea water. The tank was then rinsed with fresh water for 15 minutes, in accordance with the ship's tank cleaning instructions for Hexene-1. Ventilation was also started, with the fixed ventilation fan used to force fresh air into the tank.

At about 0500, the pumpman, who was leading the tank cleaning crew at the time, thought he could smell a 'petrol-like' odour coming from 5P. At 0600, he passed this information onto the bosun.

At about 0600, as the ship made its way up the northern New South Wales coast, tank washing was finished. The chief mate and the bosun met in the ship's cargo control room to discuss the next stage of the tank cleaning process. During the discussion, the bosun told the chief mate about the odour coming from 5P.

All the tanks had to be inspected to ensure they were free of previous cargo residue, so the chief mate filled out the enclosed space entry checklists for the tanks he intended to enter that morning. No enclosed space entry checklist was filled out for 5P.

Between 0600 and 0700, other crew members saw the chief mate in the ship's accommodation and, just after 0800, he was seen putting his plate in the galley after he had finished his breakfast.

At about 0845, the master received an email from the ship's Gladstone agent regarding its arrival draughts. The master needed to discuss the requirements with the chief mate so he telephoned his cabin. When the master's call went unanswered, he used the ship's public address (PA) system to make a broadcast, asking the chief mate to contact the master.

When the chief mate did not respond, the master went to the cargo control room and then the ballast pump room in an attempt to find him. On his way, the master asked deck crew in the area if they knew where the chief mate was. They told the master that they had not seen him. After checking the pump room, the master asked the bosun if he had seen the chief mate. The bosun said that he had not.

The master and the bosun then had a look around the ship's main deck but they did not see the chief mate. At about 0855, concerned about the chief mate, the master asked the bosun to begin looking in the port cargo tanks, moving from aft to forward, while he looked in the starboard tanks.

When the bosun got to 5P, he looked down the open hatch and saw the chief mate at the bottom of the tank, near the base of the ladder (Figure 3). He immediately called the master who came over. The master noted that the chief mate was lying face down and was not moving.

The master told the bosun to get the crew to bring the emergency tank entry equipment (breathing apparatus (BA), stretcher, rope and oxygen equipment) to the tank hatch.

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4 The process of introducing inert gas into a tank so as to reduce the oxygen content to a level which renders the tank atmosphere non-flammable (oxygen content less than 8% by volume).

5 Also known as 1-Hexene, 1-Hexylene and Butyl Ethylene; it is extremely flammable, is colourless and has a slight petrol-like smell.

At about 0900, the master went to the bridge and, using the PA, told all non-duty crew to go to 5P to provide assistance.

The bosun and a seaman donned BA sets and carried out tank entry checks. They noted that the atmosphere inside the tank contained 16% oxygen at the bottom of the tank and 12% in the middle section. When they were satisfied that everything was OK, the master gave them permission to enter the tank. Additional BA sets were readied in case they were required.

Figure 3: Re-enactment of the chief mate's position in the tank

By about 0915, the chief mate had been brought out of the tank on the stretcher and laid on deck. He was unconscious, so the crew gave him oxygen and then started CPR[6] in an attempt to revive him.

At 0920, the master went to the bridge and contacted Fleet Management and the ship's Gladstone agent. At 0945, the agent contacted the Rescue Coordination Centre (RCC) in Canberra to request medical advice. The RCC contacted the Royal Flying Doctor Service (RFDS)[7] and a RFDS doctor then spoke to *Bow De Jin*'s master. At 1025, the doctor told the RCC that the chief mate should be taken off the ship at the earliest opportunity.

The RCC began coordinating a medical evacuation (medivac) by helicopter. A Brisbane based helicopter was tasked with the medivac.

Meanwhile, the crew continued their attempts to revive the chief mate.

At about 1245, medical personnel from the helicopter were winched onto *Bow De Jin*'s foredeck walkway. They immediately began evaluating the chief mate's condition and, at 1306, informed the ship's crew that the chief mate was deceased.

At about 1330, the helicopter departed without the chief mate's body. After a period of consultation with Fleet Management, the master resumed the ship's passage to Gladstone.

The chief mate's body was moved to the ship's hospital and then, because of the transit time to Gladstone, was moved into the cold provisions storage area.

At 2015 on 25 November, a Gladstone harbour pilot boarded *Bow De Jin* and by 2315, the ship was all fast alongside its berth at Fisherman's Landing.

Shortly after the ship berthed, officers from the Queensland Police Service boarded and at about 0400 on 26 November, they took the chief mate's body ashore.

ANALYSIS

The accident

At about 0900 on 24 November 2009, the chief mate was found lying at the bottom of 5P cargo tank. His reasons for entering the tank are not known. However, it is possible that he entered it to carry out a wall wash test (WWT) to determine whether the tank was free of cargo residue.

6 Cardio pulmonary resuscitation – a combination of chest compressions and artificial respiration, which is used to maintain sufficient circulation to produce brain function until specialised treatment is available.

7 The RFDS provide the Australian tele-medical advice service to ships at sea.

The chief mate did not tell anyone that he was entering the tank, there was no enclosed space entry checklist completed for the tank and there was no evidence that the atmosphere in the tank was tested before he entered it.

An autopsy determined that the chief mate did not fall and that he died as a result of asphyxiation[8] (oxygen deficiency).

Post mortem toxicology tests detected 'low molecular weight aliphatic hydrocarbons' in his blood. This substance is consistent with vapours produced by Hexene-1, the last cargo carried in the tank, and indicates that he inhaled a quantity of the vapours.

It could not be determined why the chief mate, someone experienced in tanker operations, did not follow established industry standards and company specific safety procedures covering potentially dangerous operations before he entered the cargo tank.

Oxygen deficiency

With regard to oxygen deficiency, ISGOTT[9] states:

> Symptoms indicating that an atmosphere is deficient in oxygen may give inadequate notice of danger. Most persons would fail to recognise the danger until they were too weak to be able to escape without help. This is especially so when escape involves the exertion of climbing.
>
> While individuals vary in susceptibility, all will suffer impairment if the oxygen level falls to 16% by volume.
>
> Exposure to an atmosphere containing less than 10% oxygen content by volume inevitably causes unconsciousness. The rapidity of onset of unconsciousness increases as the availability of oxygen diminishes, and death will result unless the victim is removed to the open air and resuscitated.
>
> An atmosphere containing less than 5% oxygen by volume causes immediate unconsciousness with no warning other than a gasp of air. If resuscitation is delayed for more than a few minutes, irreversible damage is done to the brain even if life is subsequently saved.

Before the BA-equipped team entered the tank to rescue the chief mate, they checked the atmosphere in the tank, noting that it contained 16% oxygen in the bottom section and 12% in the middle section.

The toxicology results indicate that the tank atmosphere also contained a quantity of Hexene-1 vapours. Hexene-1 vapours are three times heavier than air and will therefore be found at greater concentrations at the bottom of a tank. These vapours are narcotic in high concentrations and can act as an asphyxiant[10]. They affect the human central nervous system; irritate the eyes, the skin and the respiratory tract.

The evidence indicates that the chief mate collapsed at the bottom of the tank due to the lack of oxygen in the atmosphere; becoming unconscious and, consequently, was unable to help himself. He also breathed in a quantity of Hexene-1 vapours. This may have occurred as he descended into the tank, or after he had collapsed at the bottom of the tank.

Gas freeing

Following the discharge of the Hexene-1 in Port Botany, 5P remained inerted with nitrogen. Therefore, the tank had to be gas freed by introducing sufficient fresh air to lower the level of flammable, toxic and inert gas to that required for entry.

The cargo record book entry made by the ship's master indicates that 5P tank cleaning operations were carried out in the early hours of 24 November. The record book entry notes that during this process, 5P was ventilated for a period of 4 hours using a single fixed ventilation fan.

However, there are no records that indicate whether the atmosphere inside 5P was tested at the completion of ventilation to ensure that it contained not less than 21% oxygen and not more than 1% lower flammable level (LFL) of hydrocarbons. There are also no records to indicate whether any calculations or estimates were made to determine the amount of ventilation

8 A severe condition caused by the lack of oxygen and excess of carbon dioxide in the blood.

9 International Safety Guide for Oil Tankers & Terminals, Fifth edition (p 19).

10 Material Safety Data Sheet for Hexene-1, supplied by Sasol Chemicals Pacific, Singapore, for the cargo.

that was necessary to ensure the displacement of the Hexene-1 vapours and nitrogen in the tank.

Therefore, there are no records that indicate that 5P was gas free at the completion of the tank cleaning and ventilation process. The readings taken when the chief mate was removed from the tank (16% oxygen at the bottom of the tank and 12% in the middle section) and the fact that the chief mate died from asphyxiation, indicate that the tank was not fully gas free.

Tank entry

Bow De Jin's safety management system (SMS) contained extensive instructions and guidance regarding entry into tanks and enclosed spaces. This guidance was incorporated into an enclosed space entry checklist that was to be used by the ship's crew as an aide-memoire while carrying out the task and as a record for future auditing purposes. The checklist was to be signed by the person in charge of the enclosed space entry, checked and countersigned by either the chief mate or the chief engineer and further countersigned by the master before entry into the tank could be made.

The checklist required the person in charge to confirm that, amongst other things, the space was thoroughly ventilated; pre-entry and ongoing atmosphere testing was carried out; rescue and resuscitation equipment was ready for immediate use; a responsible person was standing by; the officer of the watch was notified before any entry was made; communication systems were agreed upon and tested; emergency and evacuation procedures were established and understood; and there was a system of recording who was in the space.

The SMS also contained the requirement for a three tiered 'tank tagging system' to be used at the entrance to cargo tanks, ballast tanks and void spaces. These tags were used to indicate whether the space was suitable for entry or not:

- DANGER - DO NOT ENTER
- NITROGEN OR INERT GAS – DO NOT ENTER
- SAFE CONDITION

On 24 November, the chief mate did not follow any of these procedures. Not only did he not complete an enclosed space entry checklist for 5P, he did not implement any of its requirements. There was no portable gas/oxygen detection equipment found at the entrance to, or in, the tank; the chief mate was not wearing a personal gas/oxygen detector; there was no rescue and resuscitation equipment setup nearby; there was no one standing by outside the tank; and no one knew the chief mate was entering the tank.

As a result, the chief mate entered a tank that was not gas free and he asphyxiated before he could be found and rescued.

While *Bow De Jin* was the first chemical tanker the chief mate had served on, most of his seagoing career had been spent sailing on board oil and product tankers, including more than 3½ years as chief mate.

Enclosed space entry requirements are the same for chemical tankers as they are for oil and product tankers. Consequently, the chief mate would have been able to use the knowledge he had acquired on oil and product tankers and apply it directly to chemical tanker operations.

The chief mate had also completed a specialised chemical tanker safety course, the syllabus of which included atmospheric testing and tank entry requirements[11].

However, on 24 November, the chief mate chose to disregard all this experience and training when he accepted the risks associated with entering the tank, risks that most seafarers would consider unacceptable.

The chief mate had met with the bosun earlier that morning to discuss the day's work. Consequently, the bosun was aware that the chief mate would be entering a number of tanks that day to carry out wall wash tests. However, the bosun was not asked to prepare the necessary equipment for the tank entries or to assign a crew member to assist the chief mate; and he did not offer any assistance.

When the chief mate did not respond to the master's announcement on the public address system, the master went looking for him. The master looked in all the areas on board the ship that he thought the chief mate might have been and he asked the bosun and a number of other crew members if they had seen him. When they

11 STCW Code Section A-V/1, paragraphs 16-21.

advised they had not, the master concluded that the chief mate might be in a cargo tank and hence he and the bosun started looking in the tanks.

This evidence indicates that the bosun was aware that the chief mate was intending to enter tanks that day and that no one had been assigned to assist him and that the master considered that it was conceivable that the chief mate was in a cargo tank even though he had not advised anyone that he was doing so.

This suggests that the bosun and the master both considered that the chief mate may have entered a tank alone and without following well defined procedures.

Enclosed space entry checklist system

The intent of any enclosed space entry checklist system is to ensure that the necessary preparations are made immediately before a space is entered. By doing so, the system ensures that all equipment and procedures are in place, and that the information gathered concerning hazards for that specific space (such as oxygen and toxic/hazardous gas content) are known, immediately before the space is entered.

On board *Bow De Jin*, there was no enclosed space entry checklist filled out for 5P for any entry into the tank on 24 November. However, seven checklists had been filled out for that morning. A comparison between these and earlier checklists indicates that they were all probably filled out by the chief mate well in advance of tank entry and 'signed off' by other crew members later in the day, after the tanks had been entered (Figure 4).

The hand writing on all seven checklists matched that of previous checklists that had been filled out and signed by the chief mate. However, he could not have completed the checklists at that time on 24 November because he was seen elsewhere on the ship at that time. Therefore he probably filled out the checklists some time earlier.

The indicated time of signing by the person in charge of the entry team, the responsible person supervising the entry, the master and the completion of work were the same on each of the seven checklists: 0550, 0550, 0600 and 0700 respectively. This was not possible because neither the master nor the bosun were aware that any tank had been entered before breakfast on 24 November.

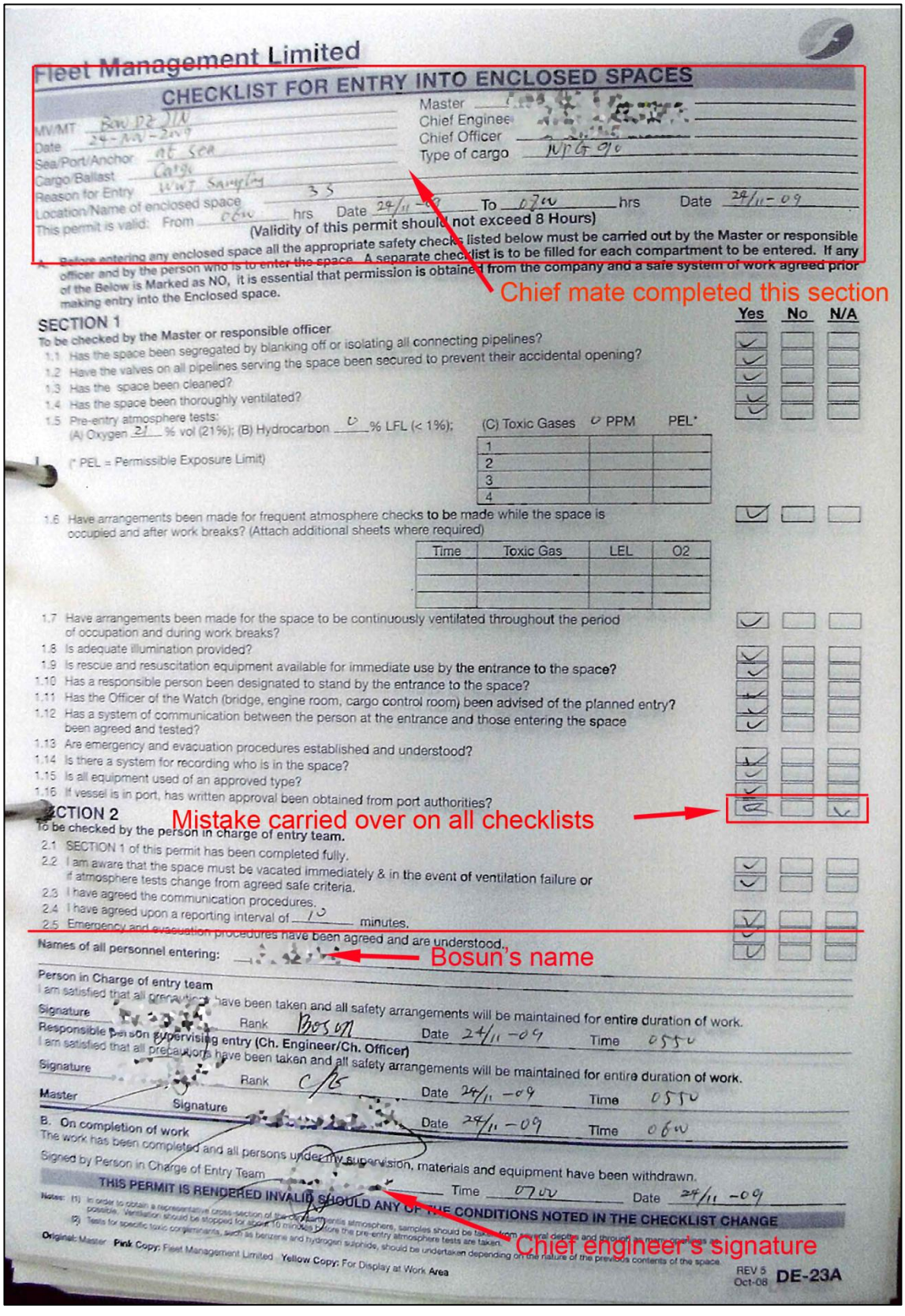
Finally, a similar mistake was made on all seven checklists. On each, a check box indicating that tank entry approval had been obtained from port authorities was mistakenly ticked and then crossed out. The ship was at sea so this was clearly a mistake carried through by someone 'ticking the boxes'.

All previous enclosed space checklists for cargo tanks on board were signed by the chief mate as both the person in charge and the supervising officer. On all seven checklists filled out on 24 November, the bosun signed as the person in charge and the chief engineer signed as the supervising officer. It is likely that this occurred because of the accident.

The completion of these checklists well in advance of enclosed space entry, and before the necessary checks had been carried out, indicates that the system was not being effectively implemented on board *Bow De Jin*. As a result, it was not being used as a proactive means to ensure that safety requirements were being met prior to tank entries.

It is possible that those responsible for carrying out this task on board *Bow Di Jin* did not have a proper understanding of the importance of each step of the system and that they were simply treating it as a compliance exercise.

Figure 4: A completed tank entry checklist for 24 November (crew member names have been pixilated out)



Errors, mistakes and violations

The chief mate was highly regarded and well liked on board *Bow De Jin*. He was said to be happy with no known personal problems. This indicates that it is improbable that he deliberately entered the oxygen deficient tank with the intent to cause himself harm. Therefore, for some unknown reason, he entered the tank without following well established and proven safety procedures.

According to James Reason[12], people operate on three levels of performance:

- **Skill-based**, in which individuals conduct routine, familiar tasks, in a largely automatic way where there is little conscious thought.
- **Rule-based**, where the individual faces a task which is one they have encountered before, or have been trained for, or is covered by written procedures. At this level, the individual must apply some conscious thought.
- **Knowledge-based**, which requires the individual to use a large amount of conscious thought to come up with a solution to an unfamiliar task.

The chief officer was probably working at the rule-based level on the morning of 24 November.

In rule-based performance, the 'rules' are acquired as a result of experience and training and they are the 'stuff' of which expertise is made. However, this level of performance is associated with a variety of errors or mistakes.[13]

Rule-based errors, mistakes and violations can happen when an individual thinks they know what they are doing, as in dealing with what appears to be a 'trained for' problem. The errors come about as a result of misapplying a normally good rule; applying a bad rule; or failing to apply a good rule.[14]

The necessity to implement a series of precautions, including the checking of an enclosed space's atmosphere for oxygen content and hazardous gases before entry, can be considered to be a 'good rule'.

Rule-based violations/non-compliances

On 27 November 1997, the International Maritime Organization (IMO) adopted Resolution A.864(20) – Recommendations for entering enclosed spaces aboard ships. The continuing object of the 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.

The recommendations included the statement:

> 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 manner in which a set of rules are applied by a professional group (i.e. seafarers) has been the subject of a great deal of research. A review of literature has shown that there are a wide variety of reasons lying behind rule non-compliance[15]. These reasons include, a lack of knowledge of the regulations; a lack of surveillance and enforcement; taking a short-cut or getting the job done; a lack of acceptability of the legitimacy of the rules; a lack of trust where co-operation was required; a demonstration of a worker's professional skills; and regulations that could not cover all the circumstances.

The need for the implementation of a defined set of precautions prior to an enclosed space entry on board a ship is internationally accepted as a 'legitimate rule' and it is generally well covered in ships' SMS procedures, including *Bow De Jin*'s. Furthermore, the need to meet this requirement is well known on board ships and checks of enclosed space entry permit/checklist systems are included in most audits.

Since the chief mate was appropriately qualified and experienced and had demonstrated his professional skills to those around him since

12 Reason, J. (1990). *Human error*. Cambridge University Press.

13 Reason, J. (2008). *The human contribution – unsafe acts, accidents and heroic recoveries*. UK (p 14/15).

14 Ibid (p 37).

15 Belcher, P. (2007). *Rule following behaviour in collision avoidance – a study of navigational practices in the Dover Strait*. University thesis.

joining the ship, the only remaining reason as to why he may have not implemented what was recognised as a 'good rule' is that he might have been taking a short cut in an attempt to get the job done.

Rule-based errors and mistakes

Rule-based errors can occur as a result of: complacency; time pressure; distraction; fatigue; or training.

The chief mate was appropriately trained but he was completing a task that he had completed many times in the past. Furthermore, he had to ensure that all of the ship's cargo tanks were ready for loading when the ship arrived in Gladstone. However, there is no evidence that suggests that he was either fatigued or distracted from the task at hand.

Therefore, it is possible that, due to complacency or time related pressures, he made a mistake. For example, he may have mistakenly entered the wrong tank. However, regardless of whether he made such an error, he did so without implementing industry-recognised standards and company specific safety procedures.

Continuing concerns about enclosed space entry on ships

In October 2009, the Marine Accident Investigators International Forum (MAIIF) submitted a report to the IMO outlining the results of a member survey regarding the number of deaths and injuries reported since the introduction of Resolution A.864(20)[16].

In its report, MAIIF lists 93 deaths and 96 injuries as having occurred since the adoption of the resolution in 1997. Of those 93 deaths, 22 occurred on board tankers.

The report lists MAIIF's underlying areas of concern. They include the lack of knowledge, training and understanding of the dangers of entering enclosed spaces; personal protective equipment (PPE) or rescue equipment not being used, not available or in disrepair; inadequate or non-existent signage; inadequate or non-existent identification of enclosed spaces on board; inadequacies in safety management systems; and poor management commitment and oversight.

MAIIF also stated that the investigations carried out into these incidents show that it is evident that training was inadequate; and that the necessary drills were not carried out in the procedures for safe entry and safe rescue from enclosed spaces. At its 2010 annual meeting, MAIIF agreed to support the introduction of mandatory enclosed space drills on board ships.

Conducting routine drills of safety related activities has proved to be an effective training tool on board ships. Therefore, the introduction of such drills should effectively address MAIIF's underlying areas of concern by promoting on board awareness of the dangers associated with enclosed space entry and rescue.

At the time that this report was released, the IMO was reviewing and revising, as necessary, the 'Recommendations for entering enclosed spaces aboard ships'.

FINDINGS

Context

On 24 November 2009, the chief mate on board the Hong Kong registered chemical tanker *Bow De Jin* died after entering a cargo tank which contained Hexene-1 vapours and was deficient in oxygen.

From the evidence available, the following findings are made with respect to the accident. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing Safety Factors

- The chief mate did not follow industry standard and company specific procedures when he entered the cargo tank.
- The cargo tank was not gas free; it contained Hexene-1 vapours and was deficient in oxygen.
- The chief mate collapsed at the bottom of the cargo tank and asphyxiated.

16 International Maritime Organization. DSC 15/10, 7 October 2009.

- The chief mate did not inform anyone that he was entering the cargo tank and a responsible person was not standing by when he entered it. As a result, when he became affected by a lack of oxygen, there was no one who could provide him with assistance.
- While enclosed space entry checklists were being filled out by the crew members on board *Bow De Jin*, the checklist system was not being used as a proactive means to ensure that the necessary safety requirements were being met prior to tank entries. *[Significant safety issue]*

Other key findings

- The introduction of mandatory enclosed space drills should be an effective way of increasing on board awareness of the dangers associated with enclosed space entry and rescue.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Fleet Management

Enclosed space entry checklist/permit system

Significant safety Issue

While enclosed space entry checklists were being filled out by the crew members on board *Bow De Jin*, the checklist system was not being used as a proactive means to ensure that the necessary safety requirements were being met prior to tank entries.

Safety action taken by Fleet Management MO-2009-010-NSA-018

Fleet Management has advised the ATSB that the company has reviewed its SMS procedures with regard to enclosed space entry and found them to be adequate. However, the company also recognises that a serious failure occurred on board *Bow De Jin* as a result of non-compliance with company procedures.

Consequently, in order to ensure compliance with procedures and to heighten awareness of the enclosed space entry requirements fleet-wide, Fleet Management has initiated a number of short and long term preventative measures. These include:

- A fleet advisory notice regarding the accident on board *Bow De Jin.*
- Formal training for fleet superintendents, focusing on the permit to enter system and the checks they should carry-out during their audits.
- Enhancing warning signage at tank entrances, stating that the tank may by deficient in oxygen.
- Development and introduction of a 1 day training session on enclosed space entry for all officers and ratings joining the company's tankers.
- Revision of the SMS procedures covering:
  - Entry into enclosed spaced reclassified as a 'high risk' operation;
  - more effective monitoring and control by the duty officer of personnel entering the spaces; and
  - mandatory on board training drills for entry into enclosed spaces.
- The introduction of a new 'work permit module' on their ships' web based 'Planning and Reporting Infrastructure for Ships' (PARIS) software. Entry permits will be generated within the system and date/time stamps automatically generated for:
  - when the permit was created,
  - when it was approved by the master, and
  - when the task is completed.

With the new system, creating permits after the entry into the tank will not be possible.

- The introduction of a 'permit compliance verification' check for superintendents to verify dynamic elements of the permit to enter system. The check is to be used when the superintendent sails on a ship and compliance with various permits and associated SMS procedures will be thoroughly monitored.

ATSB assessment of the action

The ATSB is satisfied that the action taken by Fleet Management adequately addresses the safety issue.

SOURCES AND SUBMISSIONS

Sources of Information

The master, crew and managers of *Bow De Jin*

The Australian Maritime Safety Authority

The Queensland Police Service, Gladstone

The Gladstone District Coroner

References

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Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to *Bow De Jin*'s master and bosun, Fleet Management, the Australian Maritime Safety Authority (AMSA), the Queensland Police Service, the Gladstone District Coroner and the Marine Department of the Hong Kong SAR (MARDEP).

Submissions were received from *Bow De Jin*'s master and bosun, Fleet Management, AMSA, MARDEP, the Gladstone District Coroner and the Queensland Police Service. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.