Report 10-203: *Marsol Pride*, uncontrolled release of fire-extinguishing gas into engine room, Tui oil and gas field, 27 May 2010

Final Report

Marine inquiry 10-203
Marsol Pride, uncontrolled release of fire-extinguishing gas into engine room, Tui oil and gas field, 27 May 2010

Approved for publication: August 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 occurrences 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.

Ownership of report

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.

Photograph courtesy of Ministry of Economic Development

The *Marsol Pride*

Source: mapsof.net

Location of accident

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Abbreviations

ABS	American Bureau of Shipping
CO_2	carbon dioxide
Commission	Transport Accident Investigation Commission
DP	dynamic positioning
FPSO unit	floating production, storage and offloading unit
IMO	International Maritime Organization
kg	kilogram(s)
m	metre(s)
Quest Integrity NZL	Quest integrity NZL Limited
ROV	remotely operated underwater vehicle
Unimar	Unimar Limited
UTC	co-ordinated universal time

Glossary

bar	the bar is a unit of pressure equal to 100 kilopascals, and roughly equal to the atmospheric pressure on Earth at sea level.
dynamic positioning	a computer controlled system that automatically maintains a vessel's position and heading by using its own propellers and thrusters. Position reference sensors, combined with wind sensors, motion sensors and gyro compasses, provide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position.

Data summary

Vehicle particulars

Name:	*Marsol Pride*
Type:	offshore support, towing and fire fighting vessel
Class:	American Bureau of Shipping (ABS)
Limits:	unlimited
Classification:	✠A1, Towing Vessel, Fire Fighting Vessel Class 1, Offshore Support Vessel AH, (E), ✠AMS, ✠DPS-1
Length:	60 metres (m)
Breadth:	16 m
Gross tonnage:	1829
Built:	2004, Jiujiang Xin Xing Shipbuilding Company Limited, China
Propulsion:	2 Yanmar medium speed 6EY26m diesel engines each producing 1920 kilowatts and each driving a controllable-pitch propeller through a reduction gearbox
Service speed:	12 knots
Owner	Marine Logistics Solutions (MARSOL) LLC
Operator:	UNIMAR Limited (Unimar)
Port of registry:	Panama

Date and time	23 May 2010, at about 2318[1]
Location	Tui oil and gas field
Persons on board	33
Injuries	nil
Damage	nil

[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

1.1. On 23 May 2010 the general-purpose oilfield support vessel *Marsol Pride* was conducting underwater operations within the Tui oil and gas field off the west coast of New Zealand. The *Marsol Pride* was fitted with a fixed carbon dioxide (CO_2) fire smothering system for its engine room. Late that night a valve on one of the CO_2 pilot cylinders developed a leak and charged the system ready for release. A second leak in the main control valve then caused the entire system to activate resulting in an uncontrolled release of CO_2 gas into the engine room.

1.2. An automatic alarm in the engine room had warned the duty engineer there of the impending release so he had left the engine room to investigate the reason for the alarm. The incident caused one of the 2 main propulsion engines to shut down due to air starvation; other than that there was no damage to the vessel and no one was injured.

1.3. An uncontrolled or inadvertent activation of an engine room fixed CO_2 gas fire smothering system is a serious event because the CO_2 gas displaces any air in the space so that it cannot sustain human life, and it can immobilise the ships propulsion and generator systems at a critical part of an operation.

1.4. The lessons learned from this incident were:

- any component in a fixed CO_2 gas fire-fighting installation, the failure of which can cause serious harm or immobilise a vessel, should be inspected and tested often enough to detect any deterioration in performance so that remedial action can be taken to avert a failure
- the conditions under which control valves or any other component in a fixed CO_2 system are tested should be the same as or greater than the normal operating conditions for the system.

1.5. A safety recommendation was made to the Director for Maritime New Zealand to forward this report to the International Maritime Organization (IMO) and the International Association of Classification Societies so that they can draw on the lessons learned from this incident and consider amending the current guidelines that currently only suggest an inspection of control valves only once every 5 years.

2. Conduct of the inquiry

2.1. On 24 May 2010, Maritime New Zealand notified the Transport Accident Investigation Commission (the Commission) of an incident involving the *Marsol Pride* that had occurred at about 2330 on 23 May 2010.

2.2. The *Marsol Pride* was registered in Panama and was operating outside New Zealand's territorial waters but within New Zealand's exclusive economic zone. The operator was a New Zealand based company and the majority of the crew were New Zealand citizens.

2.3. The Commission notified the Panama Maritime Authority of the incident and monitored the investigation by the vessel operator. On 26 May the Commission opened an inquiry under section 8(e) of the Transport Accident Investigation Commission Act, on behalf of the Panama Maritime Authority.

2.4. On 27 May 2010, the Commission's investigator travelled to New Plymouth, where he was met and was briefed by the company's marine superintendent. The same day the investigator examined the on-board scene of the incident and interviewed the crew involved on board the vessel.

2.5. The investigator spoke with the ABS surveyor who was overseeing the refilling of the CO_2 cylinders in Auckland, and with the company responsible for refilling the cylinders. The Commission seized all the cylinder valves for further examination. The investigator also drew on information provided by the company that designed the fire extinguishing system (Tetra Fire Engineering Pte. Limited.).

2.6. On 2 June 2010, the investigator travelled to Nelson, where the operator of the vessel was based and interviewed company staff and staff from the company that had last maintained the CO_2 fire extinguishing system.

2.7. Three valves, 2 pilot valves and one boost valve were examined by the industrial research and inspection company Quest Integrity NZL Limited on behalf of the Commission to establish the condition of the valves and why they might have failed.

2.8. Data was sourced from national and international agencies regarding the design, installation and use of fixed fire extinguishing systems on board vessels.

2.9. On 22 June the Commission approved a draft final report for circulation to interested persons.

2.10. The draft final report was sent to 13 interested persons with a request that submissions be forwarded to the Commission no later than 15 July 2011. No written submissions were received by the Commission. One verbal submission was received from Maritime New Zealand indicating that it would be willing to accept the safety recommendation to forward the report to the IMO and the International Association of Classification Societies.

2.11. On 25 August 2011 the Commission approved the publication of the final report.

3. Factual information

3.1. Narrative

3.1.1. The *Marsol Pride* was a steel hulled DP-1 multi-purpose vessel with an overall length of 60 m and a breadth of 16 m.

3.1.2. The *Marsol Pride* was built by the JiuJiang Xin Xing Shipbuilding Company Limited of China in 2005. The vessel was owned by Marine Logistics Solutions (MarSol) LLC of Dubai, and chartered to and operated by Unimar Limited of Nelson New Zealand. The vessel was registered in Panama and had valid certificates issued by the Panamanian Government and by the ABS.

3.1.3. On 23 May 2010 the *Marsol Pride* was conducting an underwater pipeline survey in the Tui oil and gas field. The vessel was operating in the vicinity of the *Umaroa* floating production, storage and offloading (FPSO) unit. There were 33 technicians and crew on board.

3.1.4. At about 1800, the night-master took control of the vessel from the master and continued manoeuvring the vessel in dynamic positioning (DP) mode to facilitate the operation of a remotely operated underwater vehicle (ROV) near the sea bed.

3.1.5. By about 2300, the weather conditions had deteriorated, so the night-master stopped the underwater operations and the ROV was recovered on board. The weather conditions reported on board the vessel at the time were a north easterly wind of about 28 knots, cloudy skies and an air temperature of 15 degrees Celsius. The height of the waves was about 4 m, which was commensurate with the wind speed.

3.1.6. The third engineer was on duty in the engine room, where he was required to be when the vessel was operating in DP mode (see Figure 1). At about 2320, he entered the engine control room and as he did the CO_2 alarm sounded and the warning light started to flash. This meant that CO_2 gas from the fixed fire-smothering system was about to be released into the engine room. He picked up a portable radio transceiver and vacated the engine room.

3.1.7. Once the third engineer had vacated the engine room he contacted the night-master using the radio to advise him that the CO_2 alarm had been activated and he was going to investigate the cause. He then made his way to the CO_2 remote control cabinet (see Figure 3) that was located outside the CO_2 room.

3.1.8. When the third engineer got to the cabinet, he found it locked as it should have been. Opening the door to the control cabinet normally released a microswitch that sounded the CO2 alarm in the engine room. The microswitch had in the past developed a fault that erroneously sounded the CO_2 alarm, even though the door was closed, so he unlocked the cabinet to see if he could find any fault with the alarm microswitch. At this time the chief engineer arrived and together they could not find any fault with the switch. The chief engineer retrieved the key for the CO_2 room and opened the door so they could inspect the CO_2 installation.

3.1.9. On entering the CO_2 room they noticed that the pressure gauge for the CO_2 manifold was registering a pressure of about 30 bar [3 megaPascals]. They also found that the discharge hose on the number one (No.1) pilot cylinder was covered with condensation and frosted (see Figure 3). The chief engineer then opened the air/shore connection ball valve in an attempt to vent the gas in the manifold to atmosphere and reduce the pressure on the line. The pressure initially reduced, but the escaping CO_2 iced up and blocked the ball valve, and the pressure in the manifold began to rise again.

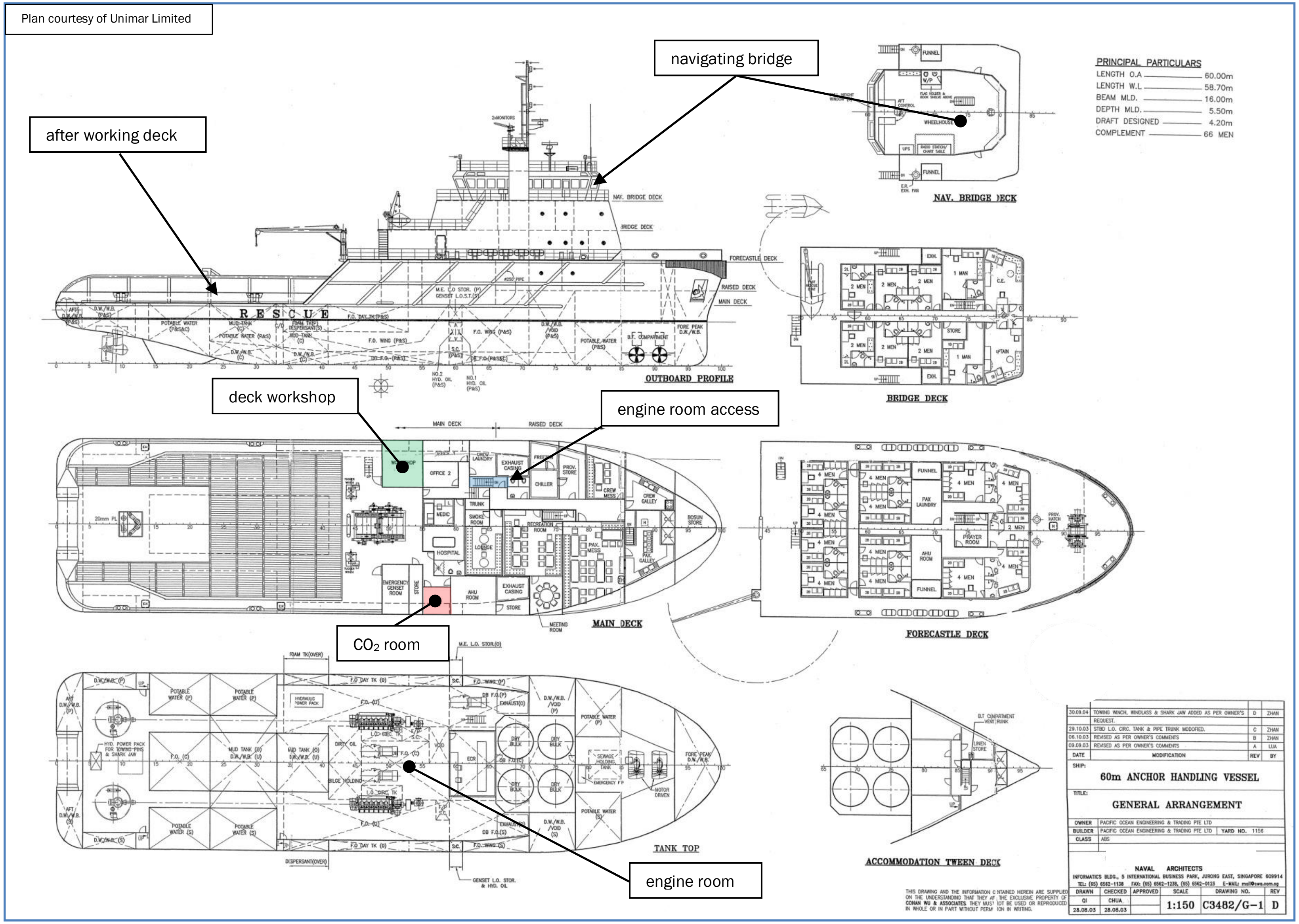


Figure 1
General arrangement plan of the Marsol Pride

3.1.10. The chief engineer then decided that the best course of action was to disconnect No.1 pilot cylinder from the system. He and the third engineer both went to the deck workshop to get the necessary tools. On their return they heard a series of tapping sounds followed by a louder bang which was the sound of the CO_2 system automatically firing and releasing the main charge of CO_2 into the engine room.

3.1.11. Opening the control cabinet door and setting off the CO_2 alarm was designed to shut down the engine room air supply fans, which had happened when the alarm first sounded. The combined effect of the fans stopping and the CO_2 gas displacing some of the air in the engine room caused the port propulsion engine to stop, but the starboard engine and 3 diesel generators continued to run. The fire alarm sounded at about this time.

Recovery phase

3.1.12. The master arrived in the wheelhouse shortly after the fire alarm sounded. He thought the fire alarm was real because he had noticed what he thought was thick smoke over the working deck. The night master handed control of the ship to the master and transferred the engine and navigation controls from the DP control unit at the aft end of the wheelhouse to the normal navigation position at the forward end of the wheelhouse.

3.1.13. The master manoeuvred the vessel away and downwind from the *Umaroa* FPSO unit and advised *Umaroa* control of the emergency. While he was doing this the night master made an emergency muster roll call and all crew and other personnel were accounted for by about 2336.

3.1.14. At about 2356 the chief and second engineers entered the engine room wearing self-contained breathing apparatus to check if there had been a fire. They found no fire so they re-started the engine room fans to clear the CO_2 gas and restarted the port main engine.

3.1.15. By about 0024 the master had control of both main engines, at which time he took the *Marsol Pride* back to the port of New Plymouth, arriving there at about 0810 on 24 May 2010.

3.2. Fixed fire extinguishing system

Description

3.2.1. The fixed CO_2 fire-extinguishing system on board was designed and manufactured by Tetra Fire Engineering Pte Limited of Singapore. It was an installation approved by the ship's classification society ABS and complied with standards set by the International Maritime Organization (IMO) (International Maritime Organization). The CO_2 gas that was released into the engine room displaced the air, thus literally starving the fire of oxygen.

3.2.2. The system on board the *Marsol Pride* comprised twenty 45 kilogram cylinders filled with CO_2 gas, all connected to a common manifold. Two of those 20 cylinders were the pilot cylinders. Referring to Figure 2, the system works as described below.

3.2.3. The operator goes to the remote CO_2 release cabinet, unlocks it and opens the door (item No. 13 shaded purple). Opening the door releases a micro-switch that activates the CO_2 alarm in the engine room and switches off the engine room air supply fans. The alarm serves to warn all persons to evacuate the engine room and the fans are stopped to prevent the CO_2 gas being displaced by fresh air. Inside the cabinet are 2 handles, of which one is mechanically connected to the valves on the 2 pilot cylinders inside the CO_2 room. Pulling this handle opens the pilot cylinder valves and CO_2 gas fills and pressurises the CO_2 manifold (item No. 17). If the engine room CO_2 alarm had not already been activated, a pressure switch installed on the manifold would activate it then (item No. 8).

3.2.4. No CO_2 gas has been released into the engine room at this point, and neither should it until the second handle is pulled. This second handle opens the boost valve (item No. 9 shaded in green). Opening this boost valve achieves 2 things; the first is it uses the CO_2 pressure in the manifold to activate a "gang release" mechanism that opens the valves of the other 18 CO_2 cylinders and CO_2 from those cylinders is open to the pressure manifold. The "gang release" mechanism is not shown in Figure 4.

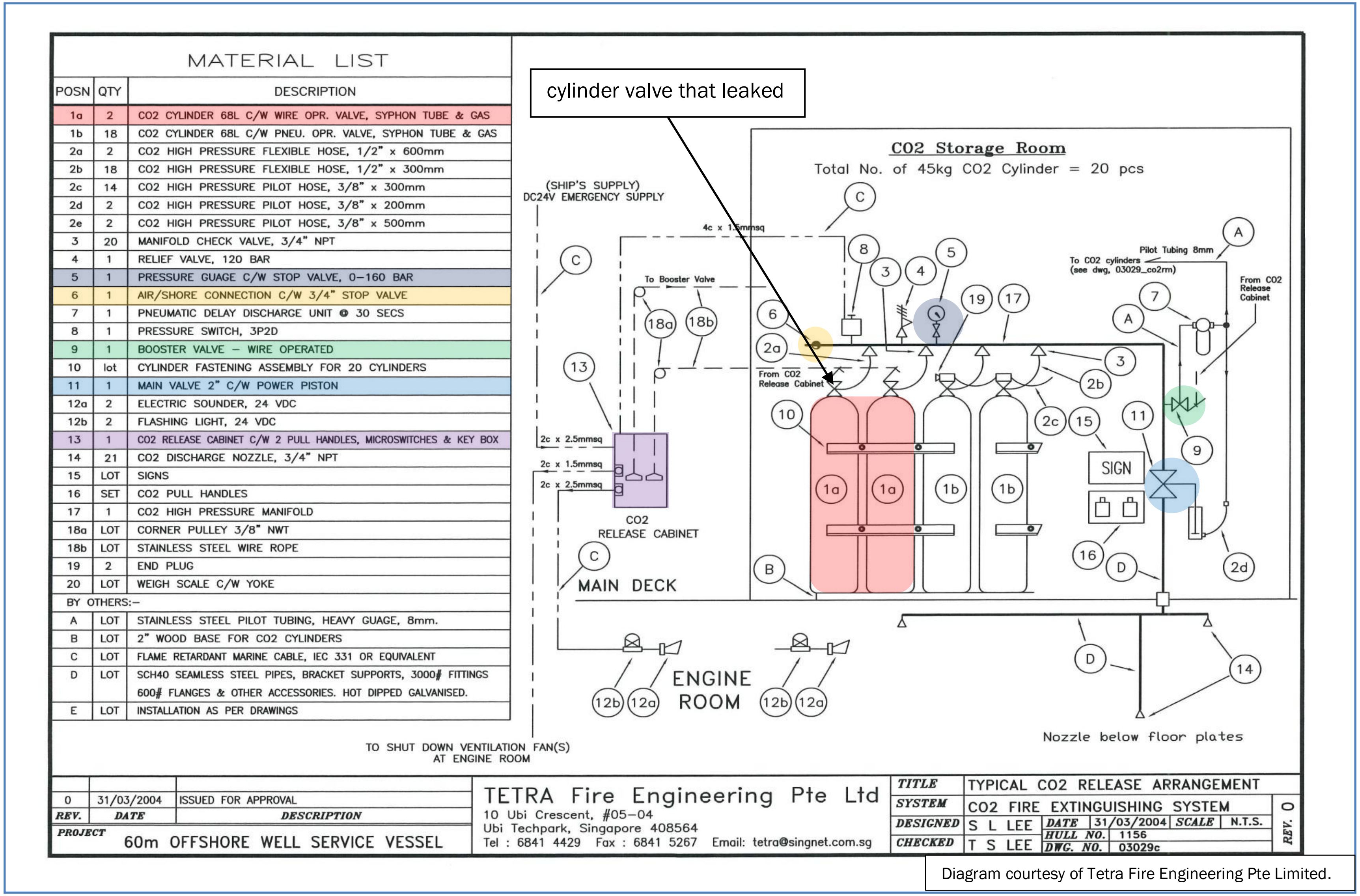


Figure 2
Diagram of CO_2 system on board the *Marsol Pride*

3.2.5. The second thing that opening the boost valve achieves is that 30 seconds after the 'gang release' opens the remaining 18 cylinders, CO_2 from the pressure manifold is used to open the main valve (item No. 11 shaded in blue). Once this main valve has been opened CO_2 gas from the pressure manifold is released into the engine room through a series of branch lines and strategically placed discharge nozzles. The 30-second delay is achieved through a pneumatic delay discharge unit (item No. 7), which was designed to allow all of the CO_2 cylinders to be charged to the system before the gas was released to the engine room.

3.2.6. The system could if necessary be activated manually from within the CO_2 room. In this case the valves on the pilot cylinders and the boost valve could be opened manually and then the system worked as described above.

3.3. Inspection, testing and refilling of the CO_2 system

Pre-incident

3.3.1. When the *Marsol Pride* had been chartered to Unimar, Unimar employed a fire protection company to carry out a service and certification of all fire appliances. On 15 May 2010, the following was carried out on the fixed fire extinguishing system:

- liquid level checked on 20 x 45 kg CO_2 cylinders
- alarms checked for operation
- ventilation shutdown checked for operation
- pull cables checked and adjusted as necessary
- CO_2 lines blown through with compressed air.

3.3.2. Before the CO_2 pipelines were blown through with compressed air, the engineer from the fire protection company disconnected the boost valve from the firing circuit as a safety precaution. The pressure of the compressed air applied to the manifold to blow through the pipelines was enough to register on the manifold pressure gauge before the main valve was manually activated, but was considerably less than the pressure applied to the manifold by the leaking cylinder.

3.3.3. The engineer from the fire protection company said later that while the boost valve was disconnected from the circuit he pulled the pull cable to the boost valve and the valve was found to be working with air coming out. When the valve was reset and checked the valve was not leaking against the reduced test pressure from the external air supply. The valve was not, however, tested under normal operating pressure.

Post incident

3.3.4. After arrival in New Plymouth the chief engineer noted that the 2 pilot cylinders on the CO_2 system had not discharged, and that the No. 1 cylinder was still leaking CO_2. He and the master decided that for safety's sake the 2 pilot cylinders should be discharged through the system. The engine room was evacuated, the 2 cylinders were discharged and entry to the engine room was prohibited until the CO_2 gas had been dispersed to the atmosphere by the engine room fans.

3.3.5. To discharge the 2 cylinders the chief engineer operated the remote pull from the CO_2 cabinet outside the CO_2 room, then operated the remote pull for the booster valve. This allowed the gas to discharge through the main valve into the engine room.

3.3.6. Once the 2 cylinders had been discharged, they were disconnected from the manifold and sent ashore where they were transported to a company in Wanganui for refilling. The company was recommended by the company that had last overhauled the fixed fire-extinguishing system in Nelson.

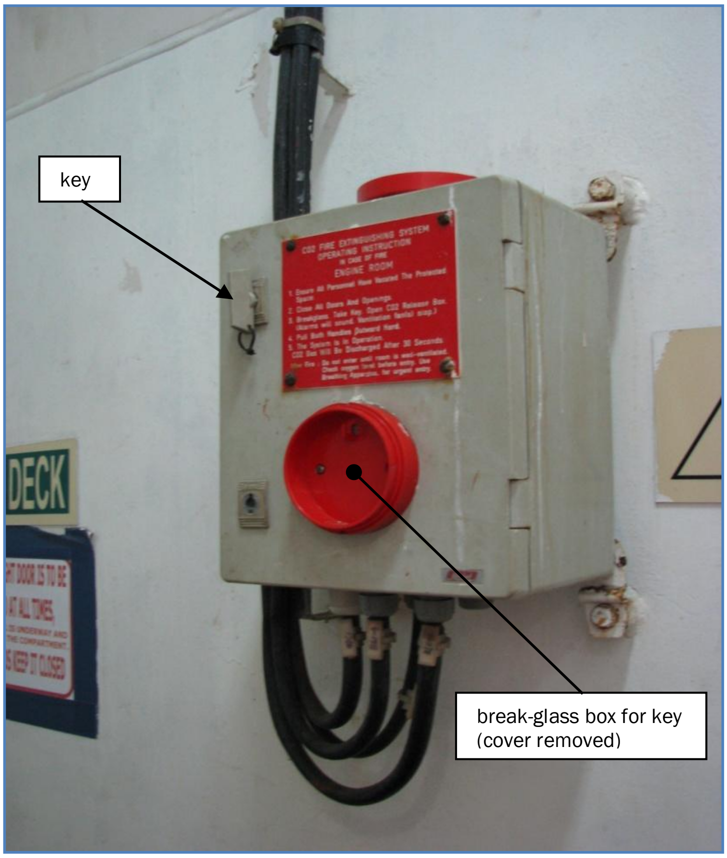


Figure 3
CO_2 system remote release box

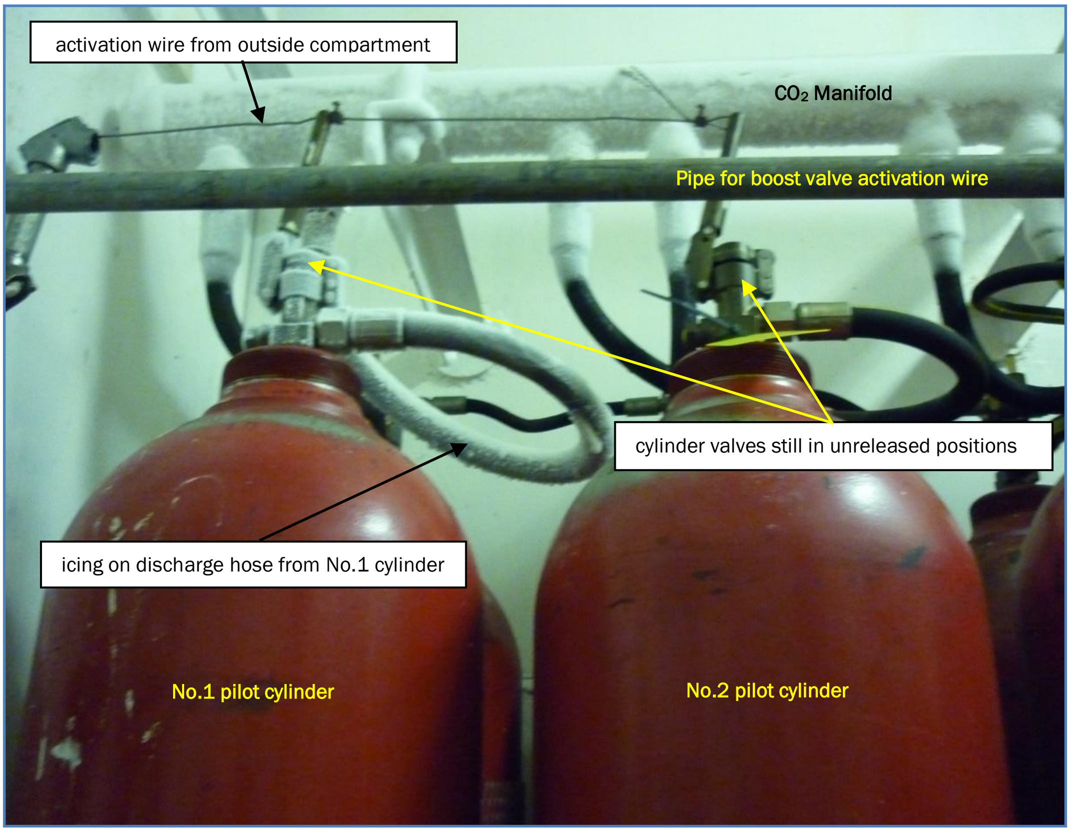


Figure 4
CO_2 pilot clylinders after release, one showing tell-tale icing

3.3.7. The company in Wanganui hydrostatically tested and certified the cylinders, refilled them and confirmed that all valves were 100% leak free with special attention being paid to the 2 pilot cylinder valves which it found to be free of foreign bodies and defects. The cylinders were then returned to the vessel in New Plymouth.

3.3.8. When the cylinders were returned to the vessel in New Plymouth the vessel's managers were in contact with a surveyor from ABS, the classification society for the *Marsol Pride.* The surveyor informed them that the company in Wanganui was not certified by ABS, so the cylinders were required to be sent to an ABS-certified company in Auckland. The surveyor also advised the vessel's managers to contact the manufacturers of the CO_2 system for information on reinstating the fixed fire-suppression system.

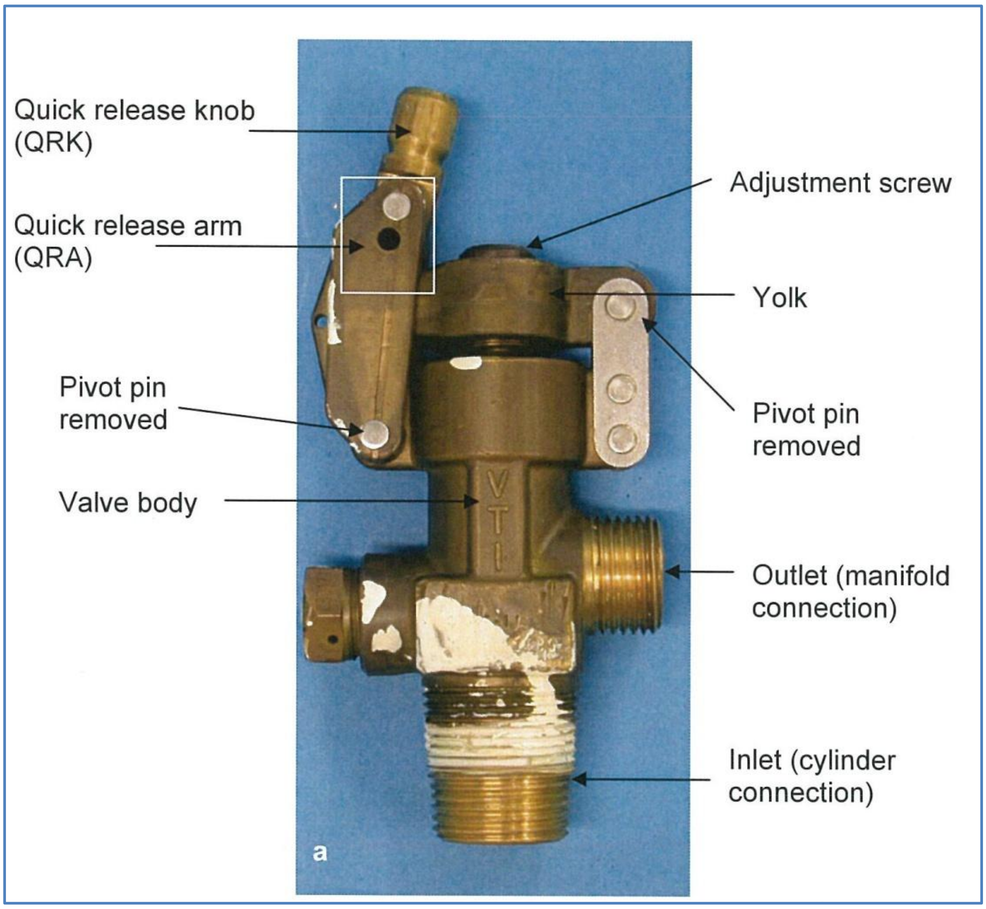
3.3.9. The manufacturer recommended that owing to the age of the system, certain parts of the valves on each cylinder be replaced. The cylinders were removed again from the vessel and transported to an ABS-certified company in Auckland. This company discharged the gas out of the cylinders, refilled the cylinders and fitted them with new valves. The companysupplied a new boost valve.

3.3.10. The Commission took control of the old valves to carry out further tests and examinations on them. The cylinders were then returned to the vessel in New Plymouth and refitted into the system under ABS supervision. Before the system was re-commissioned the CO_2 discharge nozzles in the engine room were removed and the system cleaned. Debris was found to be either blocking or impeding the gas flow of several of the discharge nozzles.

3.3.11. The Commission sent the 2 pilot cylinder valves and the boost valve to Quest Integrity NZL for independent examination and testing.

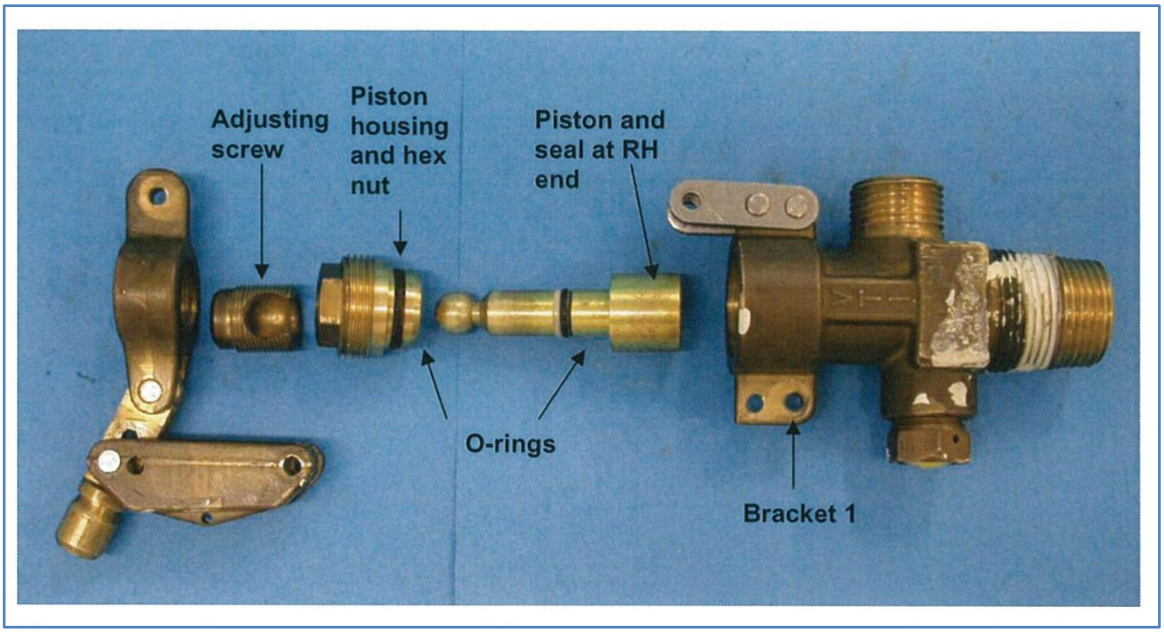
3.3.12. In report number 100565.01 (Part 2) Results of an examination of CO_2 valves, Quest Integrity NZL noted:

> Key findings from this examination include the following:
>
> - Considerable debris was found in the boost valve, including some in the recess beyond the valve seat. This debris is most likely to have been deposited when the valve was open or partially open, as may occur in a leaking valve. In contrast, the seals and recesses in the pilot valves were very clean.
> - The debris contained particles resembling brass swarf, corroded or oxidised brass, oxidised zinc, corrosion or oxidation products of iron-based material, fibres, dust/dirt particles and what appeared to be a liquid residue.
> - Microscopic assessment and chemical analysis confirmed that the brown areas on the boost valve piston and on the valve seat had suffered attack of the brass, in the form of de-zincification.
> - The boost valve seal had a raised rim whereas the pilot valve seals did not.
> - Brass particles were embedded in the boost valve seal.
>
> The following conclusions have been drawn from this examination
>
> - It is very likely that the boost valve leaked gas
> - It is most likely that the leak was caused by debris on the valve seat
> - The origin of the debris could not be precisely established but two possible sources have been identified and further investigation is recommended
> - It is likely that once leaking occurred, acidification of moisture around the seat and piston caused de-zincification. – this would have exacerbated the propensity for leaks



Photograph courtesy of Quest Integrity NZL Limited

Figure 5
Boost valve in closed position



Photograph courtesy of Quest Integrity NZL Limited

Figure 6
Boost valve disassembled

Photograph courtesy of Quest Integrity NZL Limited

Figure 7
Boost valve seal in end of piston

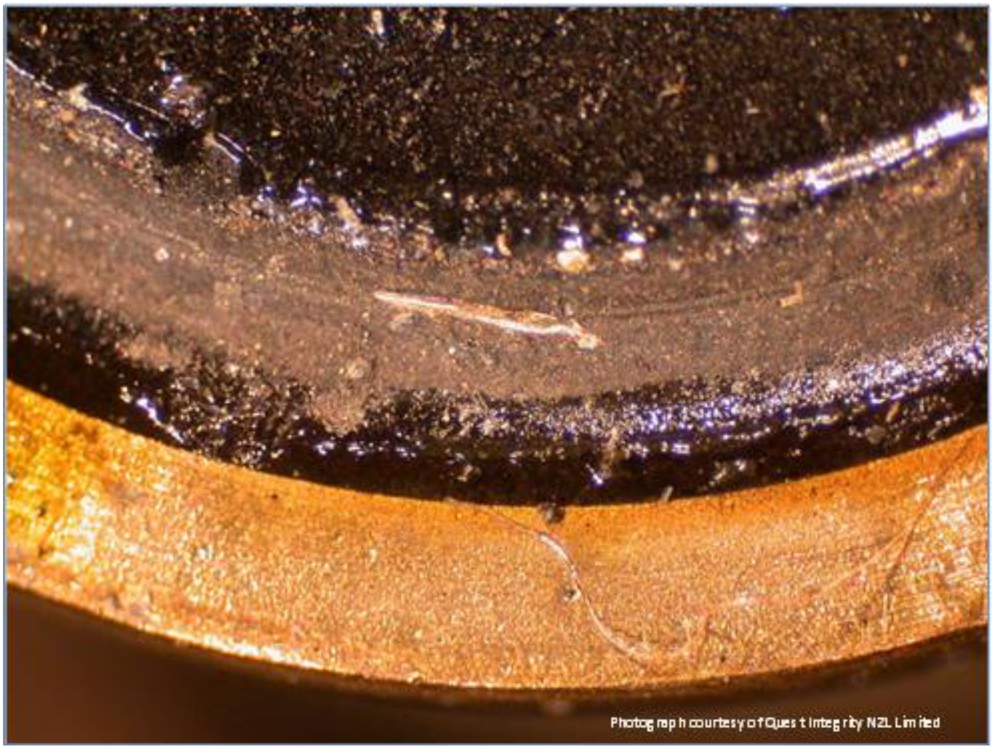


Figure 8
Boost valve, close-up of a portion of the seal

3.4. Personnel information

3.4.1. The master of the *Marsol Pride* held a New Zealand Class 1 Master Foreign Going, certificate of competency. His sea going career spanned some 22 years and he had been on board the *Marsol Pride* for about 10 weeks at the time of the incident.

3.4.2. The night master of the *Marsol Pride* held a New Zealand Class 1 Master Foreign Going, certificate of competency. His sea going career also spanned some 22 years and he was on his second voyage on board the *Marsol Pride* when the incident happened.

3.4.3. The chief engineer of the *Marsol Pride* held a Dutch Class 1 Engineer Foreign Going, certificate of competency. His sea going career spanned some 16 years and he was on his second voyage on board the vessel when the incident happened.

3.4.4. The third engineer of the *Marsol Pride* held a New Zealand certificate of competency as a marine engineer class 3. He was on his second voyage on board the vessel when the incident happened, and his sea going career spanned some 15 years.

4. Analysis

4.1. Introduction

4.1.1. Ships' engine rooms contain various machinery installations that provide sources of fuel and ignition for a fire; consequently the risk of a fire occurring is high. To mitigate that risk, regulations require fire-detection and fire-fighting systems to protect the vessel and its crew. The CO_2 fixed fire-smothering system on board the *Marsol Pride* was a safety-critical system designed to minimise the effects of a fire in the engine room.

4.1.2. Activating an engine room CO_2 fire-fighting system creates other risks. An engine room flooded with CO_2 cannot sustain human life because it displaces the air, and combustion engines cannot continue to operate without an adequate air supply. Any decision to activate a CO_2 system is made after considering the risks to crew who might be trapped in the engine room, and the risk of immobilising the propulsion and generator systems. An uncontrolled or inadvertent activation of the engine room CO_2 system is therefore a serious event.

4.1.3. Even though the fire alarm on board the *Marsol Pride* was activated during the event, there was no fire. Usually in the event of an on-board emergency, the crew response is examined for any lessons that can be shared, but because there was no fire and the crew response to the event was good, this report does not comment on these aspects other than to mention them now.

4.1.4. The following analysis only discusses how and why the CO_2 gas was released into the engine room, and because the maintenance of safety-critical systems is important it also comments on the maintenance and testing of the CO_2 system and how that might have contributed to the incident.

4.2. What happened

4.2.1. On the *Marsol Pride* an uncontrolled release of CO_2 gas from the fixed fire-smothering installation to the engine room could only have happened if there had been at least 2 points of failure. In this case the first was the release of CO_2 from the pilot cylinder into the manifold, and the second was the condition of the booster valve that allowed CO_2 gas under pressure to pass and activate the "gang release" mechanism and open the main valve.

4.2.2. The possibility of the system having been inadvertently activated by someone was considered and discounted as unlikely. The third engineer reported that the CO_2 remote control box was locked when he arrived there, and the CO_2 room was also locked. No maintenance was being performed on the CO_2 system at the time, and at 2300, no other maintenance was being conducted in or around the CO_2 room.

4.2.3. The No.1 pilot cylinder had been leaking. The frosting around its discharge valve and hose connection to the pressure manifold (Figure 4) was typical of what occurs when CO_2 gas is released under pressure.

4.2.4. The Commission has not been able to determine why the pilot cylinder leaked. The laboratory examination showed that the valve was in good condition with no defects. By the time the Commission took possession of the valve:

- it had been fully opened by the chief engineer on board to discharge the remaining CO_2 gas, then closed again,
- it had been opened and closed when the cylinder was refilled at Wanganui,
- it had been opened to discharge the CO_2 gas again then removed from the cylinder in Auckland.

4.2.5. Any foreign debris that might have been trapped between the valve and the valve seat could have been expelled, and any maladjustment in the valve setting could have been rectified during the refilling process. Why the valve on the pilot cylinder leaked is not as important as the second failure: the leaking booster valve.

4.2.6. The CO_2 alarm that the third engineer heard in the engine room would have been caused by the pressure switch detecting the rising pressure in the gas manifold as the pilot cylinder leaked. Had the rest of the system been intact, that should have been as far as this incident went. The main valve should have prevented the gas entering the engine room, and even if it too had leaked, the consequence would have been the loss of only one cylinder of CO_2 into the engine room with negligible risk to crew and machinery systems.

4.2.7. The laboratory inspection of the booster valve showed that it was not in good condition and that it was "very likely" that it had leaked gas. CO_2 gas leaking past the booster valve would and did eventually cause the "gang release" of the other 18 CO_2 cylinders, then 30 seconds later, opened the main valve, which then allowed the contents of the entire CO_2 system to discharge into the engine room.

4.2.8. If the CO_2 fire-smothering system had been used deliberately, the fans would have been stopped, either automatically by the system, or manually beforehand. The various fire shutters, doors and dampers around the engine room would have been closed to seal off the space before releasing the CO_2. In this case the supply fans were stopped automatically, but the engine room was not sealed off because there was no fire and it was not the crew's intention to activate the CO_2 system. The main propulsion and generator engines continued to run, drawing in outside air through the various engine room openings.

4.2.9. The engine room was designed to force-feed outside air to the combustion engines. Most of the engines were running at the time, so they would have struggled to maintain performance without the air supply fans operating, to the point where one of the main engines shut down owing to air starvation. A diesel engine that is starved of air produces thick black exhaust fumes, and it was probably this that the master noticed around the outside deck of the ship as he made his way to the bridge in response to the ship's fire alarm sounding. The exhaust smoke was probably what set off the automatic fire detection system.

4.3. Maintenance of critical systems

4.3.1. Leaks developing in valves can be expected from time to time for a number of reasons, so the possibility of one out of the 20 CO_2 cylinders developing a leak at some time was not remote. The possibility of 2 consecutive leaks in the same system was less likely.

4.3.2. As mentioned earlier, the consequence of a leak in a single CO_2 cylinder was not as significant as the consequence of a leak developing in the booster valve, because a leak there could cause the whole system to activate if pressure built up in the manifold for some reason, as happened in this case. That was why the procedure for clearing the CO_2 pipes to the engine room using compressed air recommended first isolating the booster valve from the pressure manifold, which the service technician said he had done when servicing the system 8 days before the incident.

4.3.3. The integrity of the booster valve was critical to the integrity of the complete system, so it was surprising that a physical check of this valve was not included in the maintenance procedure. The technician in this case had checked that the valve was opening and closing by pulling on the wire cable, but no inspection was made of the actual valve seating arrangement, nor was one specified.

4.3.4. The technician said that he had tested the booster valve for leaks, but he had used compressed air at below the normal operating pressure of the system. The valve may well have not leaked when tested at this lower pressure, but when the pilot cylinder leaked into the pressure manifold the booster valve would have been potentially holding against the full operating pressure of the system, causing it to then leak.

4.3.5. The Commission could not establish how long the booster valve had been leaking, nor could it establish how long the debris had been trapped within the valve seal. If the booster valve had blown through with compressed air, as had happened during maintenance 8 days before the incident, any debris within the pressure manifold could have passed through and lodged within the valve.

4.3.6. The laboratory examination revealed that the brass booster valve piston and valve seat had been attacked by corrosion in the form of de-zincification, a process where the zinc component in brass preferentially corrodes or oxidises. The report said also that CO_2 dissolving in moisture formed carbonic acid, a substance known to attack the zinc inclusion in standard brass.

4.3.7. The de-zincification around the valve seat would have exacerbated the propensity for the valve to leak past debris trapped within the valve seal. The condition in which this booster valve was found justifies a regular inspection and cleaning of the booster valve or any control valve in other fixed CO_2 systems that are critical to the integrity of the whole system.

4.3.8. The IMO guidelines say that control valves should be internally inspected at least every 5 years, which might be sufficient, provided that such valves are tested under operational pressure at more frequent intervals; annual inspections for example. In this way any early deterioration in the valve performance could be detected and lead to timely inspection and repair before an event such as this incident occurs.

5. Findings

5.1. An uncontrolled or unplanned activation of a ship's fixed CO_2 fire smothering system is a serious event because it can cause serious harm to crew members and could immobilise the ship at a critical time of its operation or voyage.

5.2. An uncontrolled release of CO_2 gas into the *Marsol Pride*'s engine room occurred owing to the successive and independent failure of 2 valves in the fixed CO_2 fire-fighting system.

5.3. The booster [control] valve was a critical component in the system that controlled the release of the CO_2 gas into the ship's engine room. The failure of the valve was caused by a combination of corrosion and debris entrapped within the valve seal.

5.4. The integrity of a fixed CO_2 fire-fighting system cannot be assured when the only requirement is to inspect control valves every 5 years, with no requirement to pressure test them periodically.

6. Key lessons

6.1. Any component in a fixed CO_2 gas fire fighting installation the failure of which can cause serious harm or immobilise a vessel should be inspected and tested often enough to detect any deterioration in performance so that remedial action can be taken to avert a failure.

6.2. The conditions under which control valves or any other component in a fixed CO_2 system are tested should be the same as or greater than the normal operating conditions for the system.

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 these safety issues are applicable to a single operator only or to the wider transport sector. In this case, recommendations have been issued to Maritime New Zealand, with notice of these recommendations given to.

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.

Recommendation

7.3. Critical components in a fixed CO_2 gas fire fighting system such as control valves can cause serious harm or immobilise a vessel if they fail. It is a concern that such components are only required to be internally examined every 5 years and are not required to be tested at the design operating pressure at all.

It is recommended that the Director of Maritime New Zealand forward this report to the International Maritime Organization and the International Association of Classification Societies so that they can draw on the lessons learned from this incident and consider amending the current guidelines to require a more robust examination and testing regime for such critical components. (019/11)

8. Citations

International Maritime Organization. (n.d.). *The International Code for Fire Safety Systems (FSS Code).* London: International Maritime organization.

Quest Integrity NZL Limited. (2010). *Part 2 - Discussion, Conclusions and Recommendations from an examination of CO2 valves.* Quest Integrity NZL Limited.

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