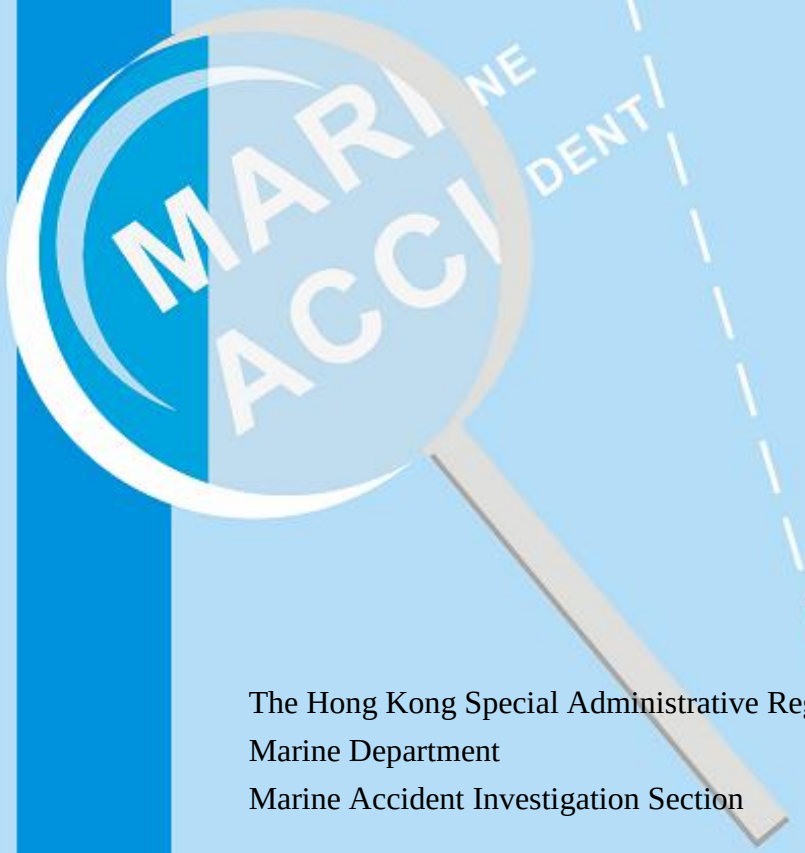
Report of Investigation into the explosion onboard the Hong Kong Registered chemical tanker *Liang Sheng* resulting one death and one injured in South China Sea off Shanwei, China on 12 July 2014



The Hong Kong Special Administrative Region
Marine Department
Marine Accident Investigation Section

15 December 2015

Purpose of Investigation

This incident is investigated in accordance with the Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (the Casualty Investigation Code) adopted by IMO Resolution MSC 255(84).

The purpose of this investigation conducted by the Marine Accident Investigation and Shipping Security Policy Branch (MAISSPB) of Marine Department, in pursuant to the Merchant Shipping Ordinance Cap. 281, the Merchant Shipping (Safety) Ordinance (Cap. 369), the Shipping and Port Control Ordinance (Cap. 313), or the Merchant Shipping (Local Vessels) Ordinance (Cap. 548), as appropriate, is to determine the circumstances and the causes of the incident with the aim of improving the safety of life at sea and avoiding similar incident in future.

The conclusions drawn in this report aim to identify the different factors contributing to the incident. They are not intended to apportion blame or liability to wards any particular organization or individual except so far as necessary to achieve the said purpose.

The MAISSPB has no involvement in any prosecution or disciplinary action that may be taken by the Marine Department resulting from this incident.

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1. Summary

1. On 12 July 2014, an accident happened on board the Hong Kong registered chemical tanker "*Liang Sheng*" (*the tanker*) when it was en route to Taiwan in the South China Sea after unloading a combustible cargo of Linear Alkyl Benzene (LAB) at Dongguan, China.

2. After completion of tank cleaning, an able-bodied seaman (AB) and a deck cadet (DC) were assigned to conduct gas-free operations for cargo tanks. Following the connection of a ventilation pipe to a cargo pipe of a cargo tank, they went to the forecastle store room to switch on the force draft fan in order to purge the residue LAB from the cargo tanks. Shortly after switching on the fan, an explosion occurred and a fire subsequently broke out inside the store room. The AB was killed while the DC was seriously injured.

3. The store room and the equipment installed inside including electric control panels and cables, lights and escape hatch cover etc. were badly damaged.

4. The investigation into the accident revealed that the probable contributory factors to the accident were as follows:

a) The crewmembers did not follow the established procedures to use an explosion-proof fan for purging process. Instead, a non-explosion-proof fan was used that triggered the explosion.

b) Unauthorized installation of ventilation pipelines were connected to cargo lines leading the combustible LAB vapour spreading into and settling in the forecastle store room;

c) The ventilation in the forecastle store room was not effective as all its exhaust air suctions were installed at the ceiling. The LAB vapour, which is heavier than air, might have accumulated at the lower part of the store room; and

d) Although the two crewmembers sensed the smell of LAB upon their entry into the forecastle store room, they did not take any safety measure (such as test of the gas content) before switching on the fan.

2. Description of the Vessel

Name of the vessel:	*LIANG SHENG*
Flag:	Hong Kong, China
Port of Registry:	Hong Kong
IMO No.:	9526693
Call Sign:	VRKP8
Ship Type:	Oil / Chemical Tanker
Keel Laid:	2007
Gross Tonnage:	8,814
Deadweight:	13,968
Length Overall:	142.6 metres
Moulded Breadth:	20.8 metres
Main Engine:	6S35MC-MK7, 4440 KW
Ship Builder:	Ningbo Hengfu Ship Industry (group) Co., Ltd
Owner:	Liangsheng Shipping Ltd
Managers:	Shanghai Xuanrun Shipping Co., Ltd

Fig.1 *Liang Sheng*

3. Sources of Evidence

3.1 The management company of *Liang Sheng*.

3.2 The Maritime Safety Administration (MSA) of Guangdong, China.

4. Outline of Events

4.1 On 3 July 2014, the Hong Kong registered chemical tanker *Liang Sheng* (*the tanker*) departed Ulsan, Korea after loading 4606 tons of LINEAR ALKYL BENZENE (LAB) and proceeded to Yosu, Korea to load another 2000 tons of LAB. The cargo was loaded in 8 cargo tanks, namely 2P, 2S, 3P, 3S, 4P, 4S, 6P and 6S, the rest 4 cargo tanks 1P, 1S, 5P and 5S were empty. With the total cargo of 6606 tons of LAB, *the tanker* proceeded to Dongguan, China.

4.2 At about 1345 on 9 July 2014, *the tanker* arrived at Dongguan for discharging. At about 1630 on 11 July 2014, *the tanker* completed discharging her cargo and departed Dongguan on 12 July 2014.

4.3 *The tanker* was then in ballast condition and proceeded to her next port, Taichung, Taiwan.

4.4 At about 1800 on 12 July 2014, while *the tanker* was sailing in South China Sea off, Shanwei, China, cargo tank cleansing was commenced. According to the cargo tank cleansing plan, each cargo tank would be washed firstly by sea water then flushed by fresh water. When all cargo tanks washing were completed, all the hatch covers would be opened for gas-free. Gas-free operation would be done by mechanical ventilation. The purpose of the operation was for tank cleansing, inspection and subsequent loading of cargo at the next port of call.

4.5 At 2100 on 12 July 2014, the cargo tank washing was completed. In order to speed up the gas-free process, an able-bodied seaman (AB) and a deck cadet (DC) removed the blank flanges of the ventilation pipe and the cargo pipe on deck (Appendix 1 the ventilation pipeline diagram). A spool piece was connected in between the ventilation pipe and the cargo pipe. Thus the force draft ventilation fan in the forecastle store room could be used for the cargo tank gas-free operation. This had been the practice adopted by them for gas-free operation.

4.6 The AB and the DC went to the forecastle store room together to switch on the force draft fan. After switching on the fan, they left the store room and walked towards the entrance door. The DC was walking in front and followed by the AB. At about 2110 when the DC was just passing through the entrance door, an explosion occurred inside the store room.

4.7 The explosion occurred just about 30 seconds after the fan was started. The duty officer on the bridge saw a flame with black smoke emerging from the forecastle entrance door and extending over the foremast.

4.8 The fire alarm was sounded immediately and crewmembers were mustered to put off the fire. When the fire team arrived at the forecastle, the DC was found injured with skin burns over 40 % of his body. A severed leg of the AB and pieces of his clothes were found on deck at about 1 metre away from the entrance door of the store room. The fire fighters sprayed sea water through the escape hatch into the store room. About 10 minutes later, the fire was extinguished. Search and rescue was conducted but the body of the AB could not be found.

4.9 First aid was applied to the injured DC and the incident was reported to the local port authority, the MSA of Shantou, the People's Republic of China.

4.10 The search lights on the bridge wings and all deck lights were switched on in order to search for the AB at sea, but in vain. Finally, the master of *the tanker* declared that the AB was killed in the explosion.

4.11 The store room was badly damaged. About 90% of electric cable inside the room was damaged. All electric control panels were burnt. All lights were broken and the escape hatch cover was sheared and blown overboard (Fig. 2 & 3).

4.12 *The tanker* was steered on a course of 091°at a speed about 13 knots. The weather was fine and the sea was slight with southwesterly wind of force 3 on the Beaufort scale.

Fig.2 Left - the escape hatch cover blown away. Right - electric control panels deformed and burnt

Fig. 3 - Left – 90% of electric cable burnt. Right – all lights broken and damaged

5. Analysis

Certification of the vessel and crew

5.1 *Liang Sheng* was registered in Hong Kong and classed by Classification Society the Nippon Kaiji Kyokai. All her statutory and classification certificates were valid at the time of incident.

5.2 The master held a valid certificate of competency (COC) as a ship master and an advanced chemical tanker endorsement for working on board a seagoing chemical tanker. He started his seafarer career in year 1996 and was promoted to chief officer in year 2009. On 23 February 2014, he joined *Liang Sheng* as training captain and took over the command as a master on 17 April 2014. His working experience on board the vessel was considered adequate.

5.3 The chief officer held a valid COC as a ship master and an advanced chemical tanker endorsement for working on board a seagoing chemical tanker. He had worked as a chief officer on 5 chemical tankers since 2007 and he joined *Liang Sheng* on 7 March 2014 as a chief officer. His working experience on board chemical tanker as a chief officer was considered adequate.

5.4 The AB (the deceased) held a valid COC as an AB and an advanced chemical tanker endorsement for working on board a seagoing chemical tanker. He was a trainee onboard *Liang Sheng* from 17 April 2013 to 24 February 2014. He joined *Liang Sheng* again on 7 March 2014 as an AB until the incident. He had only about 14 months' seagoing experience.

5.5 The DC just joined *Liang Sheng* as a seafarer trainee on 19 June 2014.

Material Safety Data Sheet (MSDS) of LAB

5.6 According to the MSDS, LAB is a colourless, combustible liquid with a flash point of 139°C. Empty containers retaining product residue (liquid and / or vapour) can be dangerous. To pressurize, cut, weld, braze, solder, drill, grind, or expose such containers to heat, flame, sparks, static electricity, or other sources of ignition, may cause explosion.

5.7 The vapour density of the LAB to air is 8.47. Thus the LAB vapour is much heavier than air and it could accumulate in the lower part of the store room for a long period of time.

5.8 The Shipboard Operation Manual stipulates when carrying chemical products, the MSDS of the cargo should be obtained in order to understand the characteristic of

the cargo. The master should ensure that all crewmembers are familiar with the characteristics, hazard, chemical action and emergency response etc. However, at the material time, no evidence showed that the master had ensured their crewmembers familiar with the chemical property of the LAB. Furthermore, it was the first time *the tanker* loading such cargo. The master had not even obtained the MSDS of LAB prior to loading. Therefore the master and other crewmembers did not know the characteristics of LAB and no safety measure had been taken prior to the cargo operations, tank cleansing and gas-free.

LAB vapour accumulated at the forecastle store room

5.9 The crewmembers did not feel any irritating gas when entering into the forecastle store room in the past voyages. However, the DC felt dizzy upon his entry into the forecastle store room before the incident. The LAB vapour had already accumulated inside the store room at the time of the incident.

5.10 The LAB vapour could enter the forecastle store room by the following means:

a. The fixed ventilation pipelines and a fan for gas-freeing cargo tanks had been installed since the delivery of the vessel on 30 July 2010. However, no pipelines diagram was available to explain the purpose of the ventilation pipelines. The ship owner made a sketch of the ventilation pipelines as shown in Appendix 1. It showed that two ventilation pipelines could be connected to the cargo pipelines on deck at the manifold on port and starboard side by the spool piece with a length of 300mm. In this incident, the two ventilation pipelines had been connected to the cargo lines before the fan was started. Through these ventilation pipelines, the LAB vapour might have spread into the forecastle store room. The Shantou Fire Department reported that there was a trace of continuous burning marks at the end of the ventilation pipe at the ventilator. It indicated that after the explosion, combustible gas continuously emerged from the ventilation pipelines, to support the combustion.

b. The mechanical ventilation system of the forecastle store room was so designed that all the air suctions were at the top of the store room (Fig. 4). Thus the air at the lower part of the store room was exchanged ineffectively. Investigation revealed that the access door of the forecastle store room was kept opened throughout the voyage, including the time when the cargo tank cleansing and gas-free operation were being conducted. The mechanical ventilation system of the store room was maintained at all times, thus, the air was continuously introduced into the store room. Furthermore, the wind was

blowing from the stern of *the tanker* and the crewmembers stated that they sensed a peculiar smell when conducting tank washing on deck. The cargo tank washing and gas-free operation would discharge a lot of LAB vapour. Therefore, it was possible that the LAB vapour would be sucked into the forecastle store room and accumulated at the lower part of the store room due to its density heavier than air.

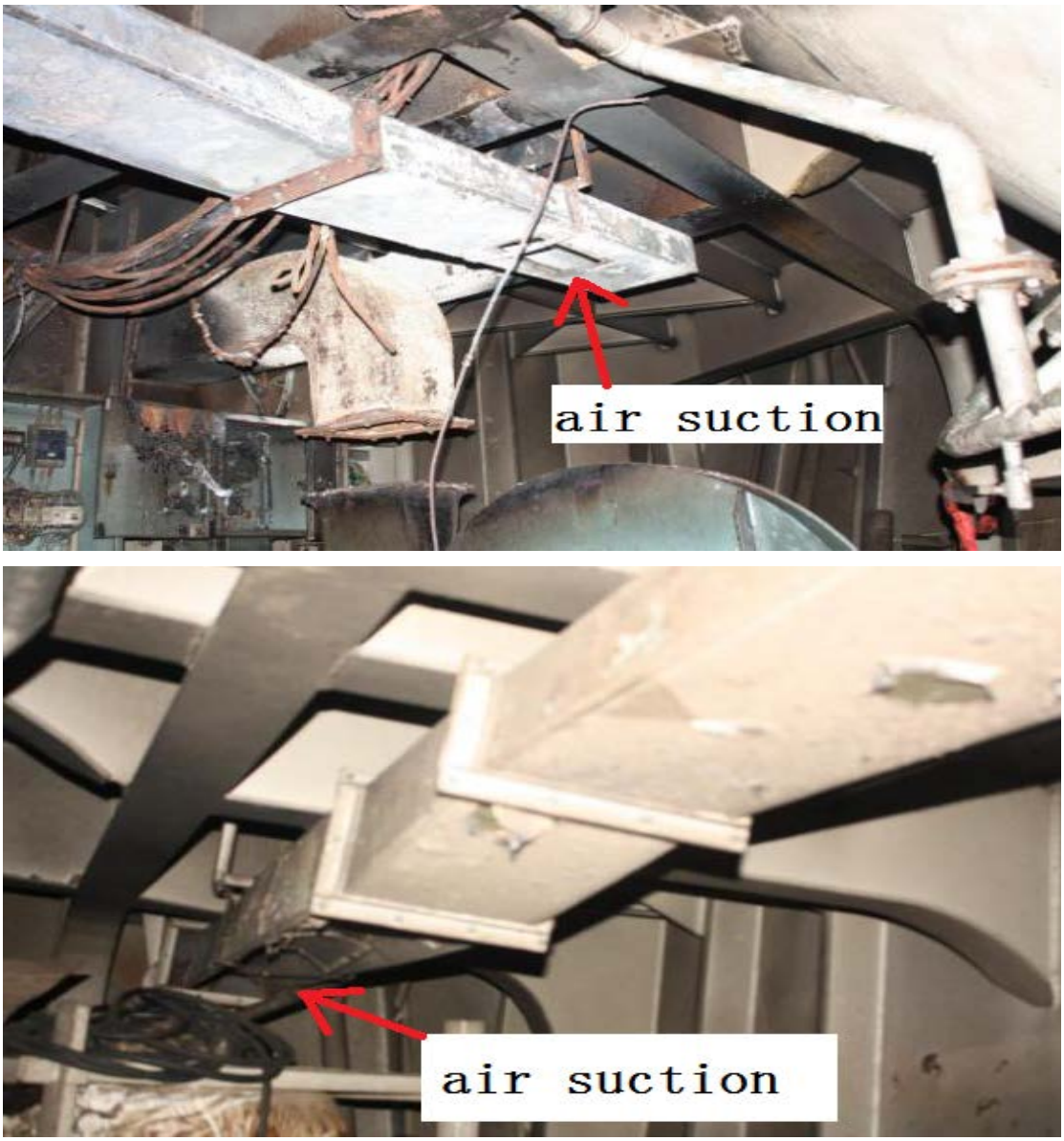

Fig. 4 - The air suctions were all at the ceiling of the store room.

5.11 If the air suctions of the ventilation system in the store room could be installed at different height levels, the ventilation in the store room would be more effective and the LAB vapour might not have accumulated in the store room.

5.12 In order to prevent the recurrence of the explosion, the air ducts in the forecastle store room and the emergency fire pump room had been modified to improve the ventilation after the incident.

The trigger of the explosion

5.13 The on scene inspection by the Shantou Fire Department revealed that the junction box of the force draft fan was found cracked. After opening the cover, some traces of black spurting carbon could be seen. According to the statement of the chief engineer of *the tanker*, the fan was a non-explosion-proof type. When the fan was switched on, after about 15 seconds, there was a secondary start-up of the fan which produced much higher electric current and heat. Therefore, overheating or even sparks generated in the junction box due to the starting of the fan was most likely the trigger of the explosion.

5.14 Other facts at the scene were found not likely to have triggered the explosion, for instance, the lights in the forecastle store room had been kept on all the time and it was not necessary for them to be switched on. Besides, it was impossible that the AB and DC had caused the fire as they both were non-smokers.

5.15 The DC sensed an irritating smell upon entry into the forecastle store room and it was believed that the deceased sensed the same as well. However, no safety measure (such as testing the gas content) had been taken. They continued entering the store room and switched on the fan that triggered the explosion.

The unauthorized ventilation pipelines and ventilation fan

5.16 According to the shipowner, *the tanker* was originally owned by an European shipowner who could not take delivery of *the tanker* due to a financial problem. *The tanker* had been laid up for almost 3 years until the current shipowner took over it. The fixed ventilation pipelines (Fig. 5 & 6) and the non-explosion-proof fan for gas-free of cargo tanks had been installed at the time of delivery of the vessel on 30 July 2010. However, neither drawings nor operation procedures of such system was available. There was a cargo tanks gas-free procedure which used a portable type blower for gas-free of cargo tanks. The blower should not generate any spark during the operation, i.e explosion-proof type fan. In fact, such procedure was not applicable to the existing unauthorized ventilation pipelines and fan. Furthermore, no crewmember following such requirement in the cargo tanks gas-free procedure. The Safety Management System was not effectively implemented.

5.17 The starting of the non-explosion-proof electric motor could generate sparks

which could ignite the combustible LAB vapour.

5.18 The ventilation pipelines and fan had not been submitted to the classification society for review and approval.

5.19 After the incident, the non-explosion-proof fan in the forecastle store room had been removed and an explosion-proof fan was installed in a new fan room and the ventilation pipelines were modified during dry docking. The revised General Arrangement was then approved by Classification Society the Nippon Kaiji Kyokai. A copy of "Instruction For Cargo Tank Gas Free Fan" was provided to *the tanker*.

5.20 The investigation also revealed that according to the witness statement, the flammable gas content had not been checked prior to the tank washing operation. It was not consistent with the record in the tank cleansing plan.

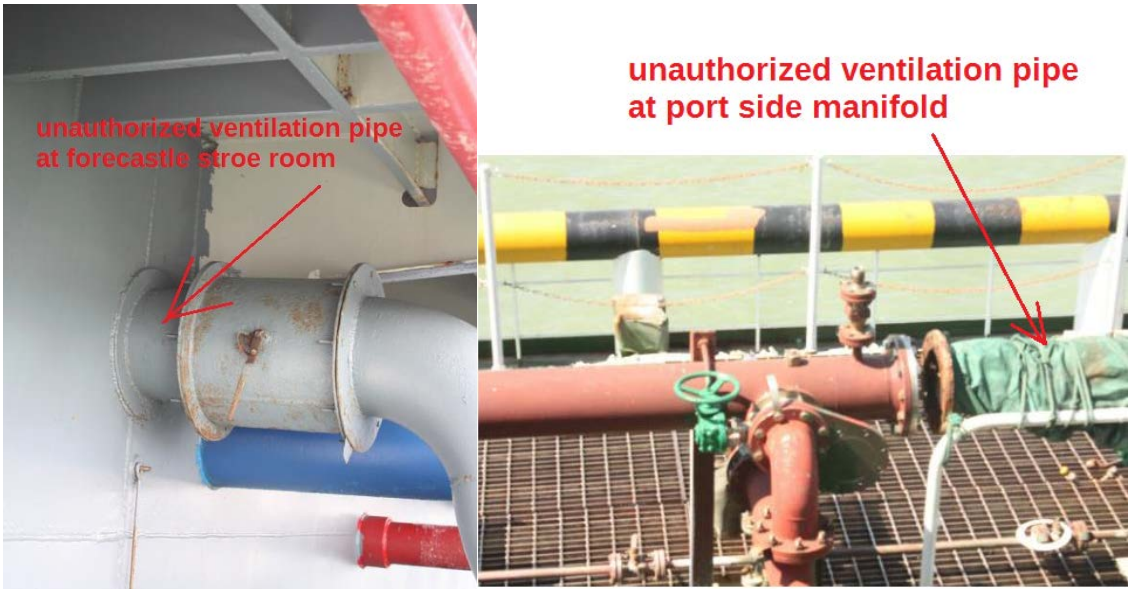

Fig. 5 - the unauthorized ventilation pipelines (ends at forecastle store room and manifold).

Fig. 6 - The unauthorized ventilation pipes (one on port side, another on starboard side).

6. Conclusion

6.1 On 12 July 2014, after discharging the cargo of LINEAR ALKYL BENZENE (LAB), the Hong Kong registered chemical tanker *Liang Sheng* (*the tanker*) sailed from Dongguan, Guangdong and proceeded to Taichung, Taiwan in ballast condition.

6.2 At about 2110 local time on 12 July 2014 when *the tanker* was sailing in South China Sea off, Shanwei, Guangdong, an explosion occurred in the forecastle store room that resulted in one death and one injury when they went to switch on the force draft ventilation fan in the forecastle store room in order to ventilate the cargo tanks for gas-free.

6.3 The investigation into the accident revealed that the contributory factors to the accident were as follows:

a) The crewmembers did not follow the established procedures to use an explosion-proof fan for purging process. Instead, a non-explosion-proof fan was used that triggered the explosion.

b) Unauthorized installation of ventilation pipelines were connected to cargo lines leading the combustible LAB vapour spreading into and settling in the forecastle store room;

c) The ventilation in the forecastle store room was not effective as all its exhaust air suctions were installed at the ceiling. The LAB vapour, which is heavier than air, might have accumulated at the lower part of the store room; and

d) Although the two crewmembers sensed the smell of LAB upon their entry into the forecastle store room, they did not take any safety measure (such as test of the gas content) before switching on the fan.

6.4 The investigation also revealed the following safety issues:

a) No Material Safety Data Sheet (MSDS) was kept on board and no relevant information such as safety precautions and fire risks of the LAB, had been provided to the crewmembers;

b) The ventilation pipelines and fan in question were not approved by the concerned classification society;

c) No checking of flammable gas content had been performed in accordance with the tank cleaning plan; and

d) The crewmembers failed to observe the established gas-free and tank cleaning procedures, the effectiveness of the Safety Management System was in doubt.

7. Recommendations

7.1 The management company of *the tanker* should issue a safety circular informing all masters and navigation officers of the findings of this incident investigation.

7.2 An additional audit for Safety Management System shall be carried out to verify the effectiveness of the Shipboard Safety Management System. In particular:

(a) the crewmember should follow the procedures for gas-free procedures for cargo operation and tank cleaning concerning the safety of personnel and protection of the environment;

(b) gas measurements/monitoring should be carried out during the tank cleaning and gas freeing operations;

(c) to provide appropriate training and instructions for cargo operation and tank cleaning; and

(d) to obtain the MSDS of cargo to be loaded for the characteristics of such cargo and take necessary safety measures before cargo operations.

7.3 The management company should ensure that any installation or modification to ventilation pipelines or ventilation fans of *the tanker* should be carried out after obtaining the approval from the classification society.

7.4 A copy of the report should be sent to the classification society Nippon Kaiji Kyokai to draw their attention to the lessons learnt from this incident.

8. Submission

8.1 In the event that the conduct of any person or organization is criticized in an accident investigation report, it is the policy of the Marine Department that a copy of the draft report should be given to that person or organization so that they can have an opportunity to express their comments on the report or offer evidence not previously available to the investigating officer.

8.2 Copy of the draft report has been sent to the following parties for comments:

a) The management company, the Master of *Liang Sheng*.

b) Shipping Division (Ship Safety Branch) of Hong Kong Marine Department.

c) MSA Guangdong, China, as the coastal State of the incident.

d) The classification society Nippon Kaiji Kyokai.

8.3 Submissions were received from the classification society Nippon Kaiji Kyokai and the Shipping Division of Hong Kong Marine Department. The report was amended as appropriate.

Appendix 1 the ventilation pipeline diagram

(There was no drawing available, owner provided a sketch as following.)