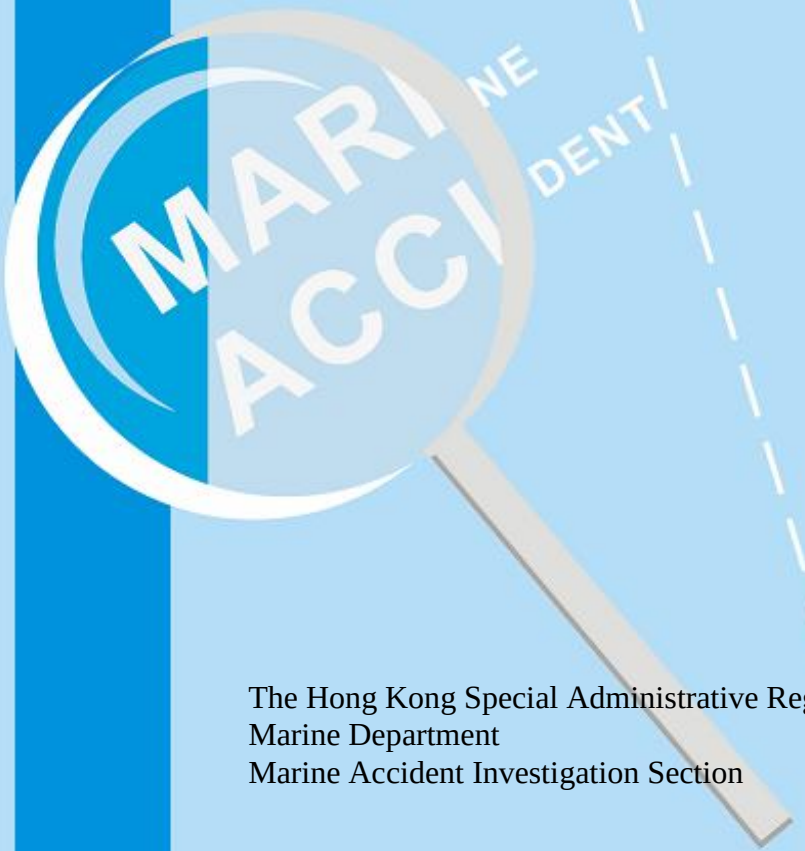
# Report of investigation into the explosion on board oil/chemical tanker "*NO.3 HEUNG-A PIONEER*" in waters off Penang, Malaysia on 18 April 2016




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

20 July 2018

**Purpose of Investigation**

The purpose of this investigation conducted by the Marine Accident Investigation and Shipping Security Policy Branch (MAISSPB) of Marine Department 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.

It is not intended to apportion blame or liability towards 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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## Glossary of Terms and Abbreviations

| | |
|---|---|
| kW | kilowatt |
| n.m. | nautical mile |
| m | Metre |
| GMT | Greenwich Mean Time |
| | |
| C/O | Chief Officer |
| AB | Able Bodied Seaman |
| AB1 | Able Bodied Seaman No.1 |
| AB2 | Able Bodied Seaman No.2 |
| AB3 | Able Bodied Seaman No.3 |
| OS | Ordinary Seaman |
| OS1 | Ordinary Seaman No.1 |
| OS2 | Ordinary Seaman No.2 |
| AO | Apprentice Officer |
| OL1 | Oiler No.1 |
| OL2 | Oiler No.2 |
| | |
| COT | Cargo Oil Tank |
| No.x P | No. x Port Side |
| No.x S | No. x Starboard Side |
| P&S | Port Side and Starboard Side |

## Time Notation in 24 hours

e.g. 1234 : 12 - hour 34 - minute

$1234_{56}$ : 12 - hour 34 - minute 56 - second

## 1. Summary

1.1 On 18 April 2016, at approximate position of 5°30.89'N, 99°56.90'E in Malacca Strait, whilst en route from Penang, Malaysia to Singapore, the Hong Kong registered oil/chemical tanker "NO.3 HEUNG-A PIONEER" (the *vessel*) exploded on her main deck during cargo oil tank cleaning operation. The explosion resulted in one death and five injuries of the crew members.

1.2 Before the accident, the *vessel* departed in ballast condition from Penang where she had completely discharged all the two grades of incompatible cargoes of nitric acid and acrylonitrile which would react violently if being mixed. After casting off from the terminal of Penang at 1730 hours on 18 April 2016, C/O held a cargo oil tank cleaning safety meeting with deck crew from 1800 to 1820 hours. During the preparation of the tank cleaning operation, an elbow spool piece was wrongly fitted to the port common manifold with the COT No. 8 P individual manifold. As a result, the acrylonitrile residue was able to creep through a leaky manifold cut-off valve of COT No. 8 P to mix with the nitric acid residue in the port common manifold.

1.3 At about 2015 hours, when cleaning of COTs No. 2 P&S and No. 8 P&S by water was carried out for about 8 minutes, a violent explosion occurred at the port common manifold on the main deck and injured 6 crew members on deck.

1.4 The *vessel* then returned to Penang and all the injured crew were sent ashore for treatment. One of them was certified dead in hospital on the same day.

1.5 The investigation had identified the following contributory factors to this accident:

a) carelessness of the crew resulted in the elbow spool piece being wrongly fitted to the port common manifold with COT No.8 P individual manifold which violated the segregation requirements of two incompatible grades of cargoes;

b) the manifold piping arrangements at midship port and starboard sides were complex. But there were no conspicuous markings on the manifolds for the crew to identify the cargo grades inside the manifold; and

c) although the leaky manifold cut-off valve of COT No.8 P was noticed before the accident, no precautionary measure was taken before the commencement of the cleaning operation.

1.6 The investigation had also found the following safety factors:

a) no preventive measure was in place to prevent wrong connection of an elbow spool piece which violated the segregation for incompatible cargo grades in the common manifold; and

b) the required procedure for verifying the proper connection and isolation of pipelines and hoses by the “line-up checklist” before tank cleaning operation had not been carried out.

## 2. Description of the vessel

### 2.1 The *vessel* (Fig. 1)

#### 2.1.1 Particulars

| | | |
|---|---|---|
| Ship name | : | "NO.3 HEUNG-A PIONEER" |
| Flag | : | Hong Kong, China |
| Port of registry | : | Hong Kong |
| IMO No. | : | 9438925 |
| Type | : | Oil/Chemical Tanker |
| Year built, shipyard | : | 2008, Nokbong Shipbuilding Co.,Ltd., Geoje, South Korea |
| Gross Tonnage | : | 8,271 |
| Net Tonnage | : | 3,642 |
| Deadweight | : | 12,395 metric tonnes |
| Length | : | 116.45 metres |
| Breadth | : | 20.4 metres |
| Engine power, type | : | 4,440 kW, one set of STX MAN B&W 6S 35MC |
| Classification society | : | Korean Register of Shipping |
| Registered owner | : | Eight River Shipping SA. |
| Management company | : | PTS Co. Ltd. |
| No. of Crew | : | 21 |

2.1.2 The *vessel* was an oil/chemical tanker classed with Korean Register of Shipping. It had 16 cargo oil tanks including the port and starboard slop tanks (also referred to as COTs No. 8 P&S). The manifold systems of the tanker were placed on port and starboard side main deck midship. A common manifold was installed within each manifold system.


Fig. 1 - The *vessel*

## 3. Sources of evidence

a) The statements of the master, officers and crew of the *vessel*

b) Information provided by the ship management company of the *vessel*

c) Death certificate of the deceased.

## 4. Outline of events

(All times were local time GMT + 8 hours)

4.1 The *vess*el loaded with two incompatible grades of chemical cargoes from two ports in South Korea to discharge in ports of Malaysia. One grade cargo was about 6800 metric tonnes (mt) of nitric acid (less than 70% in content) loaded at Yeosu in COTs No. 4 P&S, No. 5 P&S and No. 6 P&S. The other grade cargo was about 2000 mt of acrylonitrile loaded at Ulsan in COTs No. 2 P&S and No. 8 P&S. Details of their distribution are listed in Table 1.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **No.1 S**<br>**Empty** | *No.2 S*<br>*Acrylonitrile*<br>*683.9 mt* | **No.3 S**<br>**Empty** | No.4 S<br>Nitric Acid<br>1021.4 mt | No.5 S<br>Nitric Acid<br>1356.1 mt | No.6 S<br>Nitric Acid<br>1020.7 mt | **No.7 S**<br>**Empty** | *No.8 S*<br>*Acrylonitrile*<br>*280.7 mt* |
| **No.1 P**<br>**Empty** | *No.2 P*<br>*Acrylonitrile*<br>*676.5 mt* | **No.3 P**<br>**Empty** | No.4 P<br>Nitric Avid<br>1015.0 mt | No.5 P<br>Nitric Acid<br>1364.1 mt | No.6 P<br>Nitric Acid<br>1021.9 mt | **No.7 P**<br>**Empty** | *No.8 P*<br>*Acrylonitrile*<br>*279.8 mt* |

Table 1 Cargo distribution

4.2 After arrival at Port Kelang, Malaysia, the *vessel* berthed by her port side to the terminal. All cargo of nitric acid was discharged at Port Kelang through the port common manifold. The discharge was completed on 17 April 2016. Six elbow spool pieces remained in position and connected the port common manifold with the port individual manifolds of COTs No. 4 P&S, No. 5 P&S and No. 6 P&S.

4.3 The *vessel* then sailed and arrived at the port of Penang in early morning on 18 April 2016. All cargo of acrylonitrile was discharged through the starboard common manifold. Four elbow spool pieces were used to connect the starboard common manifold with the starboard individual manifolds of COTs No. 2 P&S and No. 8 P&S. During discharging of Acrylonitrile at Penang, the crew discovered that the cut-off valve of the port individual manifold of COT No. 8 P was leaky and reported it to C/O.

4.4 The *vessel* departed from Penang in ballast condition at about 1730 hours on 18 April 2016. After dropping off the pilot at 1815 hours, the *vessel* sailed at full speed to Singapore.

4.5 After the *vessel* was casted off from the terminal of Penang, C/O held a safety meeting of cargo oil tank cleaning in tally room from 1800 to 1820 hours with deck crew members, consisting of the bosun, A/O, AB1, AB2 and AB3, OS1 and OS2. During the meeting, C/O briefed the attendees on safety issues and their duties in the tanks cleaning operation. The tank cleaning plan including the cleaning sequence was also introduced.

The first group of tanks to be cleaned would be COTs No. 2 P&S and No. 8 P&S. Then, the second group of tanks would be COTs No. 4 P&S, No. 5 P&S and No. 6 P&S.

4.6 Subsequently, at 1820 hours, the crew went to the main deck to arrange the cargo pipelines for cleaning COTs No.2 P&S and No.8 P&S. In the meantime, as instructed by C/O through portable radio, AB1 connected the COT No.8 P individual manifold with the port common manifold by using an elbow spool piece. As such, the port common manifold was virtually linked up with COT No. 8 P, and segregated only by the leaky manifold cut-off valve.

4.7 At about 1945 hours, upon completion of the pipeline preparation, the crew members assembled again in tally room for a tool box meeting. Two additional members, OL1 and OL2 from engine room department, joined the tool box meeting. C/O assigned tasks to each crew member before commencing the cleaning of the cargo oil tanks No.2 P&S and No. 8 P&S. Afterwards, all the 9 crew members went to their respective locations on the main deck for further instructions from C/O. C/O assigned the tasks to the crew members as follows: (i) AB1 and OS 2 on COT No. 2 P, (ii) AB2 on COT No. 2 S, (iii) the bosun and A/O on starboard manifold, (iv) OS1 and OL1 on COT No. 8 P, (v) AB3 and OL2 on COT No. 8 S.

4.8 After all crew members reported their position, at about 2002 hours, C/O instructed A/O to check and confirm all cargo oil tank individual manifold cut-off valves were closed. After a short while, A/O confirmed to C/O through portable radio that all individual manifold cut-off valves (both sides) were closed. At about 2007 hours, after confirming the valves and washing machines ready with the local deck crew, the cleaning of COTs No. 2 P&S and No. 8 P&S commenced by supplying sea water to the respective fixed cargo oil tank cleaning machines. While the cleaning of the cargo oil tanks was going on, the cargo oil pumps of COTs No. 2 P&S and No. 8 P&S were started to strip the washing water from the cargo oil tanks and discharged it overboard through vessel's stripping line.

4.9 In order to clean other pipes of the cargo oil tanks by washing water, at about 2010 hours, C/O instructed the bosun and the A/O to link up the starboard common manifold by opening the starboard individual manifold cut-off valves of COTs No. 2 and NO. 8 P&S and their respective dropping valves. It would allow the washing water to fill into the cargo pipes and return to the COTs through starboard common manifold and respective cargo oil pipes by consequently opening the drop valves of each tank.

4.10 At about 2015 hours, when the *vessel* was sailing in approximate position of 5°30.89'N, 99°56.90'E in Malacca Strait, the OS1 together with OL1 went to open the drop valve of COT No. 8 P to allow washing water to pass through the drop line to the COT No. 8 P for cleaning the pipe lines. Suddenly a violent explosion occurred at port common manifold (Fig. 2).

Fig. 2 - Damage of the port manifold

4.11 After the accident, the master immediately ordered the third officer (who was on duty with the master on the bridge) to go down to the main deck to assess the situation and check if there were any injuries. In the meantime, the master contacted Penang Port Control (PPC) for emergency assistance. According to the PPC's, at about 2058 hours, the master began to turn the *vessel* back to Penang Pilot Station.

4.12 As the result of explosion, 6 out of the 9 crew members on the main deck were injured. The other 3 crew members (i.e. AB1, AB2 and OS2) on the forward deck at the COTs No. 2 P&S were not injured. Their locations on deck at the time of explosion are shown in Fig. 3. At about 2359 hours, the *vessel* arrived and berthed at Penang. At about 0005 hours on 19 April 2016, the shore paramedics arrived on board. The six injured crew members were sent to Seberang Jaya Hospital. However, OL1 was certified dead in the hospital on the same day. The other 5 injured crew members recovered in the hospital and one of them was able to resume his duty on board before the *vessel*'s departure.

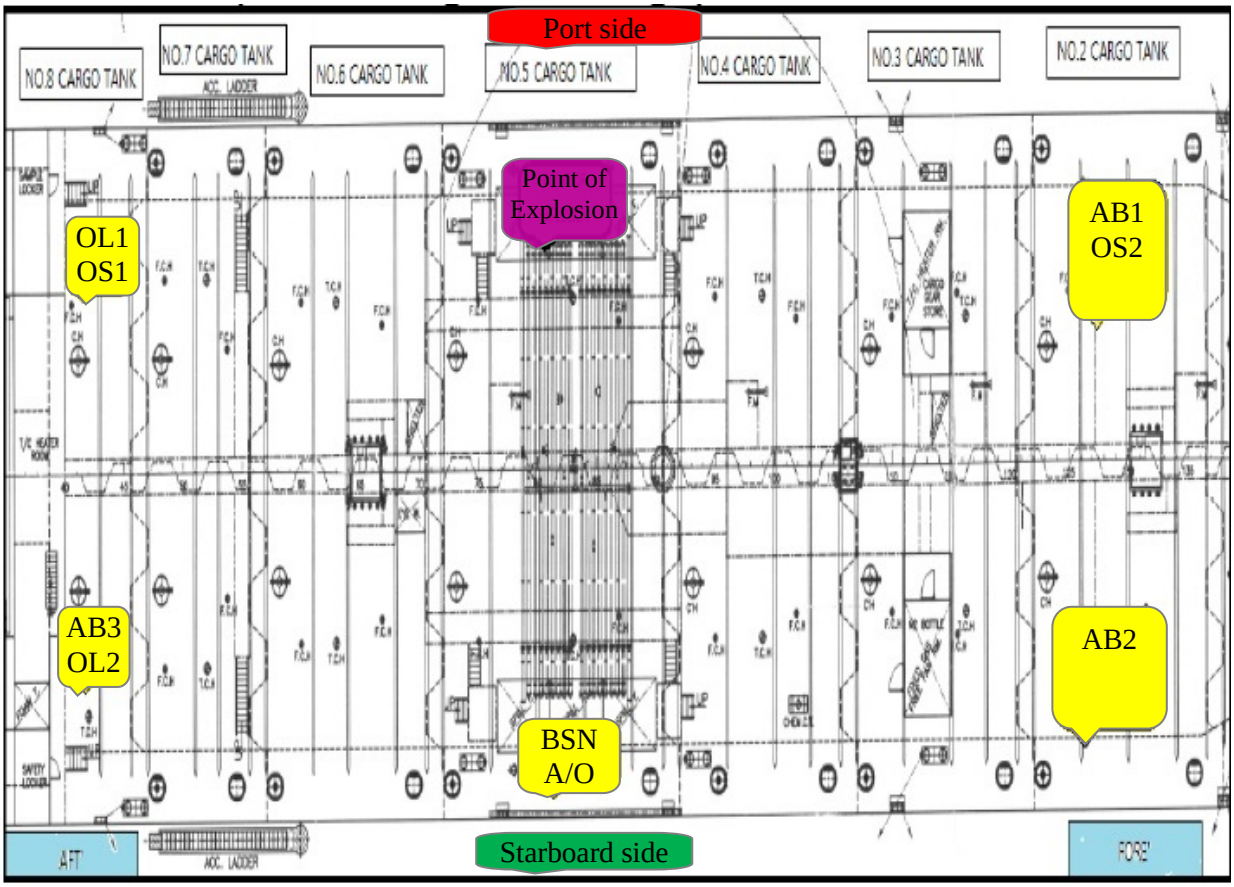



Fig. 3 - Locations of the crew members on deck at the time of explosion

4.13 Due to the violent explosion, the main deck and attachments, outfitting, accommodation bulkhead and miscellaneous fittings / equipment were damaged to various extents. It was observed that the explosion caused most of the metallic debris flown to the aft of the *vessel*. Not much damage was found on the forward part. Some of the damages were reported as follows:

(i) The port common manifold was blown to pieces, leaving only a short piece of the aft end at its location. It was obvious that the explosion centre was in the port common manifold (Fig. 4);

(ii) The main deck and attached structures underneath the port spill tray were buckled (Fig. 5);

(iii) Windows on the forward bulkhead of the accommodation were holed or shattered (Fig. 6);

(iv) The forward bulkhead of the accommodation was scattered with holes and mainly on the top part, e.g. the chief engineer's cabin on Captain Deck (Fig. 7); and

(v) In the COTs No. 5 P&S under the manifold, extensive pitting damage to the bulkhead and bottom plate was found. Furthermore, there was also extensive damage to the heating coils (Fig.8, Fig.9).

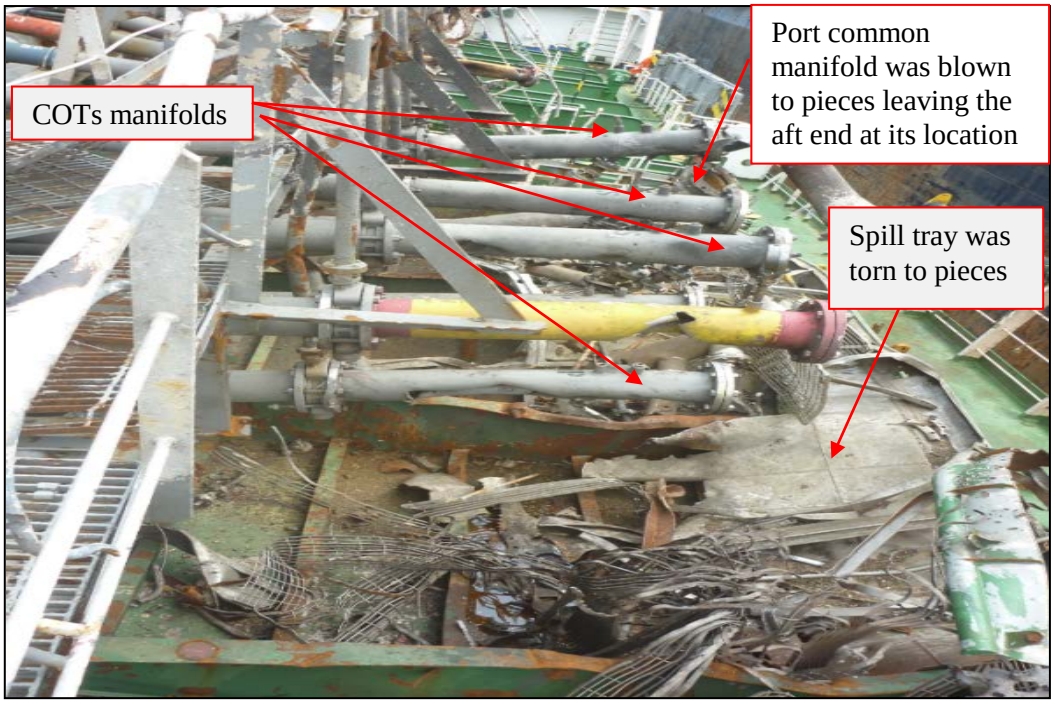



Fig. 4 - Port COTs manifolds at midship after explosion

Fig. 5 - Main deck underneath port spill tray


Fig. 6 - Windows on the accommodation forward bulkhead


Fig. 7 - Accommodation forward bulkhead in Chief Engineer's Cabin on Captain Deck

Fig. 8 – Damage on heating coils of COTs No.5 P&S

Fig. 9 – Pitting damage on bulkhead and bottom plate of COTs No.5 P&S

## 5. Analysis

### Certification and manning of the *vessel*, and crew members' working experience

5.1 The statutory trading certificates of the *vessel* were valid and in order. The *vessel* was manned by 21 crew members including the master and they came from South Korea or Myanmar.

5.2 The tanker endorsements and experience of the crew members involved in the incident are shown in Table 2 below.

| Rank | Nationality | Tanker endorsements | Years with company | Year with Rank | Years on chemical tanker | Years on all type of tankers | Months on board |
|---|---|---|---|---|---|---|---|
| Master | Korea | Oil/Chemical | 0.5 | 6.5 | 11.3 | 12.2 | 5.5 |
| C/O | Korea | Oil/Chemical | 7.3 | 2.5 | 5.4 | 5.4 | 6.5 |
| Bosun | Myanmar | Oil/Chemical | 0.5 | 10.4 | 4.9 | 11.4 | 5.6 |
| AB(1) | Myanmar | Oil/Chemical | 1.7 | 3.0 | 3.8 | 3.8 | 9.5 |
| AB(2) | Myanmar | Oil/Chemical | 6.0 | 0.5 | 3.5 | 3.5 | 1.7 |
| AB(3) | Myanmar | Oil/Chemical | 1.0 | 0.1 | 2.1 | 2.1 | 0.6 |
| OS(1) | Myanmar | Oil/Chemical | 0.5 | 3.6 | 1.4 | 1.4 | 6.2 |
| OS(2) | Myanmar | Oil/Chemical | 0.3 | 1.7 | 1.7 | 1.7 | 3.1 |
| Oiler (1) | Myanmar | Oil/Chemical | 0.8 | 5.9 | 3.0 | 4.0 | 9.5 |
| Oiler (2) | Myanmar | Oil/Chemical | 0.1 | 3.1 | 0.8 | 0.8 | 1.7 |
| A/O | Korea | Oil/Chemical | 0.6 | 0.6 | 0.6 | 0.6 | 7.7 |

Table 2 Tanker endorsements and working experience of crew members involved in the accident

5.3 The master, C/O and all ratings involved in the accident held certificates of competency or certificates of proficiency appropriate to their respective positions on board the ship. They were all experienced in the oil/chemical tanker operations. A/O had joined the ship for more than 7 months for training purpose, and was under the supervision of the bosun during the cleaning operation.

### Working hours and alcohol abuse

5.4 After the accident, all crew members on board had undergone alcohol test by using shipboard test kits by the master at 0400 hours on 19 April 2016. The results were all negative. C/O stated that he had a rest period of 10 hours and a work period of 8 hours during the day, and it was same for the deck crew members. No evidence was found

during the investigation to show that C/O and other crew members involved were affected by either fatigue at work or alcohol and drug abuse.

**Weather and sea conditions**

5.5 On 18 April 2016, the weather was cloudy with south gentle breeze of force 3 on the Beaufort Wind Scale and slight sea condition of about 1 metre waves. The visibility was good (about 10 nautical miles) at the material time. The weather and the sea conditions did not contribute to the accident.

5.6 Although it was already dark when the cleaning operation commenced, all crew members had torches and deck illumination was provided. No difficulty was reported in the operation. The illumination on deck was not considered as a contributory factor to the accident, but the darkness might reduce the alertness of the crew member on the risk of cleaning operation.

**Death Certificate**

5.7 The death certificate of OL1 issued by the local authority concluded that his dead was caused by penetration injury over left lung. It was most probably due to the flying metallic debris passing through his left lung.

**Loading and discharging of nitric acid and acrylonitrile and its segregation requirement**

5.8 The Material Safety Data Sheets (MSDS) for both grades of cargo were available on board. According to the MSDS:

- Nitric acid (less than 70%, CAS No.: 7697-37-2) is extremely hazardous due to its corrosive, reactive, strong oxidizing and toxic properties. The nitric acid is fully soluble in water and may react violently upon contact with water with the evolution of heat, fumes and spattering. Although it is not combustible, its strong oxidizing characteristic together with the heat from reaction with water and combustible materials may cause ignition upon contact with combustible material, and can accelerate the burning of combustible materials. A contact with metals may generate to flammable hydrogen gas. Besides, a contact with combustible materials may lead to an explosion (Appendix 2); and
- Acrylonitrile (CAS No.: 107-13-1) is highly flammable with moderate explosion hazard. Although the vapor of acrylonitrile is heavier than air, it may travel a considerable distance to a source of ignition and flash back. Acrylonitrile reacts rapidly with strong acid, strong base or oxidizing agents (Appendix 3).

5.9 The approved shipboard "Cargo Operating Manual" described that nitric acid and acrylonitrile belonged to cargo group numbers of 3 and 15 respectively. The details of cargo compatibility between nitric acid and acrylonitrile were shown in the approved "Procedures and Arrangements Manual". The cargo compatibility chart in this manual indicated that the two cargoes were incompatible and would readily react with each other in a hazardous manner. The reaction of mixing of both cargoes would generate gas such as hydrogen and create large amount of heat, then cause explosion if the reaction was contained in a limited space.

5.10 In accordance with International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk (IBC Code), Chapter 3, paragraph 3.1.3.1, incompatible cargoes should be segregated from each other by means of a cofferdam, void space, or empty tank. In the cargo operating manual, it was also stated that the cargoes expected to result in a hazardous chemical reaction should not be loaded in the tanks adjacent to each other. The principle of the segregation aimed to prevent any possibility of mixing of incompatible cargo due to leakage. This was implemented by the loading and stowage arrangement in the loading ports in South Korea before proceeding to Port Kelang on 17 April 2016 (Fig. 10). The cargo oil tanks in yellow were loaded with nitric acid at Yeosu and those in blue were loaded with acrylonitrile at Ulsan. It segregated two incompatible cargoes by empty tanks in between.

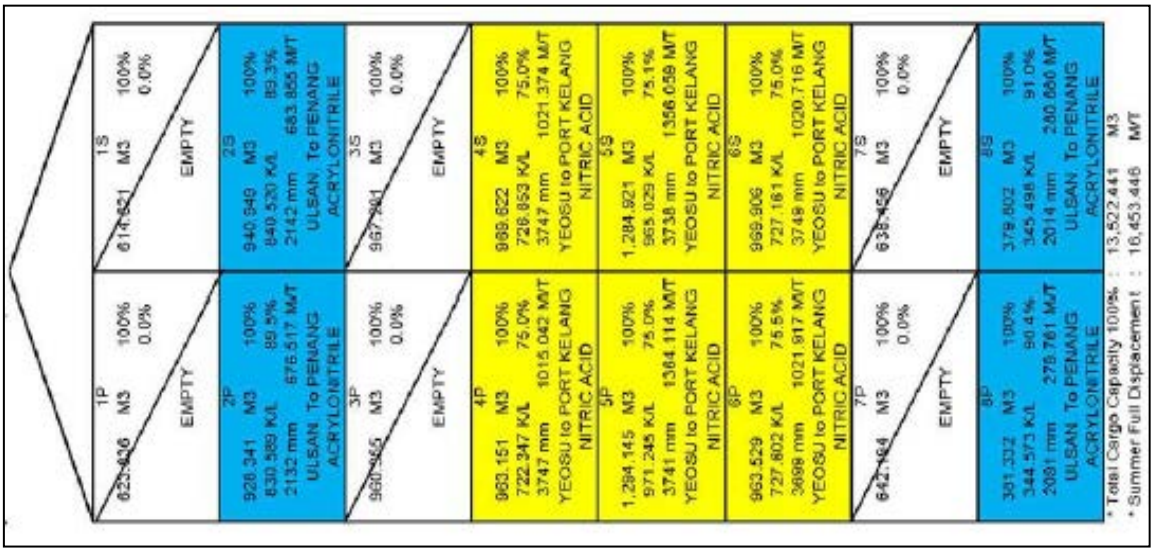


Fig. 10 - Cargo stowage plan with nitric acid in yellow and acrylonitrile in blue

5.11 This principle of segregation was also complied with during the discharging operation. The nitric acid was discharged via port individual manifolds and the port common manifold. The Acrylonitrile was discharged via starboard individual manifolds and the starboard common manifold.

**The arrangements of cargo piping system and manifold on main deck** (Fig.11)

5.12 The *vessel* was a type 2 oil/chemical tanker under the IBC Code with 16 segregated cargo oil tanks made of stainless steel (SUS 316L). Each cargo tank has individual outlet connections at midship and on each side of the main deck. Each outlet connection manifold consisted of a cut-off valve, a short piece of pipe with a pressure gauge and a drain tube to the spill tray. The cut-off valves were butterfly valves which were controlled manually on local platform. For loading and discharging cargo of one individual tank, the individual outlet manifold could be used by connecting with shore manifold, and be controlled by the individual cut-off valve (Fig. 12, Fig. 13, Fig. 14)

5.13 In addition, a common manifold was installed at midship and on each side of the main deck. It was constructed with 16 flange connections, which could be connected to any individual manifold outlet of each tank by an elbow spool piece. This combined the outlet cargo into one common connection with shore system. In the common manifold, two spectacle blank plates were provided to separate it into two parts if necessary, such as when segregation of incompatible cargo was required.

5.14 There were specific elbow spool pieces on board the *vessel* for each individual manifold marked with the tank number (Fig. 15). There were also elbow spool pieces designated and provided on board for connecting individual manifold with each other without using common manifold. The elbow spool pieces and their typical connections were shown in Fig. 16.

5.15 The manifold pipeline arrangement for the 16 tanks was quite complex and required extreme caution to avoid any mistake when linking up the desired cargo oil tank manifolds with the shore connection. Therefore, any operations on the midship cargo manifolds required good communication between the crew at the manifolds and C/O who was the person in charge staying in the cargo control room. Particular caution should be drawn by the crew members operating the common manifold by using the elbow spool pieces and/or spectacle blanks. The crew's knowledge on the piping system was another critical safety factor. Any miscommunication or negligence of the crew would cause mistake in linking up pipe lines at midship cargo manifolds. Special precaution should be paid to comply with the segregation requirement between incompatible grades of cargo.

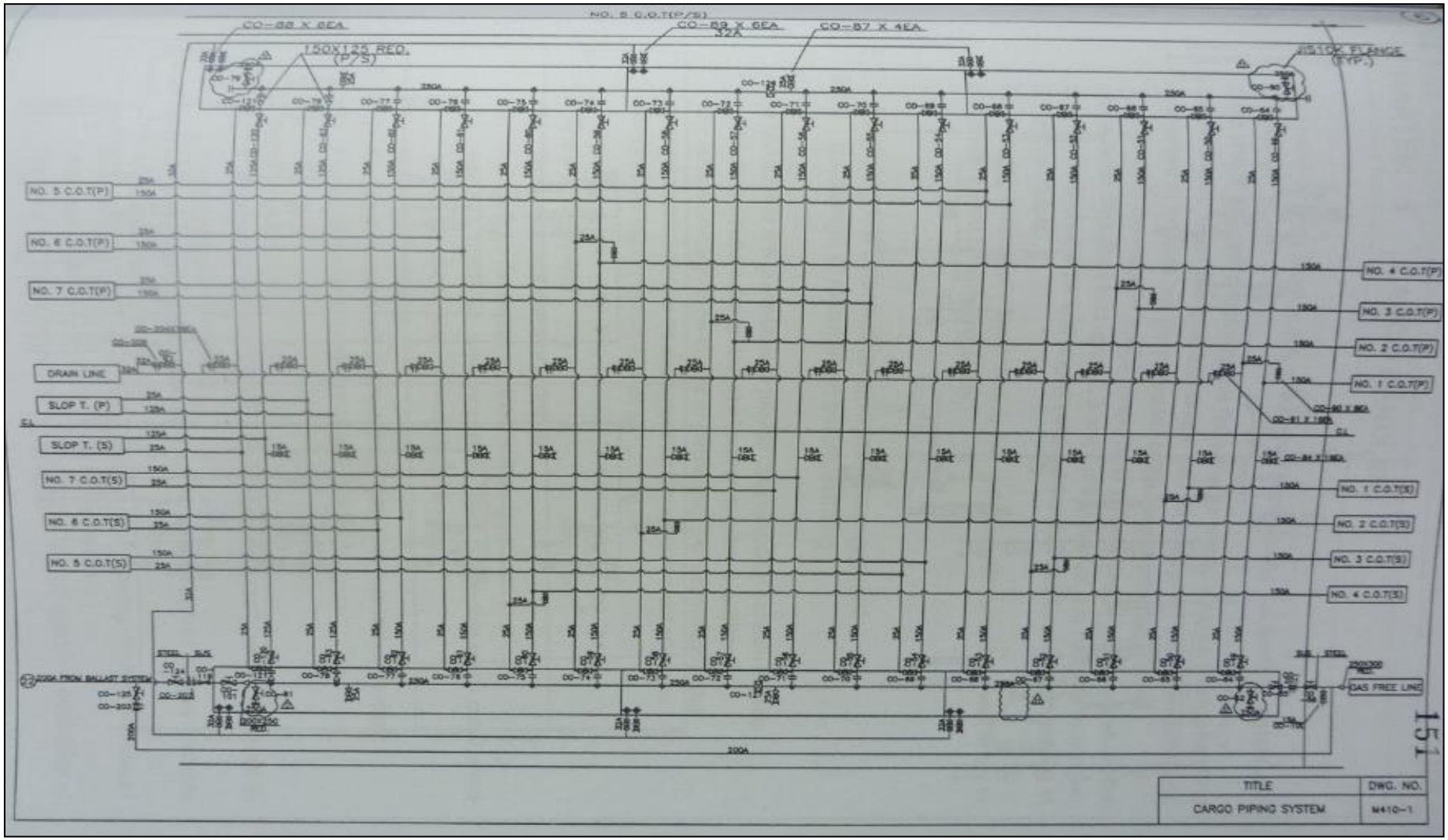



Fig. 11 - Pipe diagram of cargo pipe system on deck

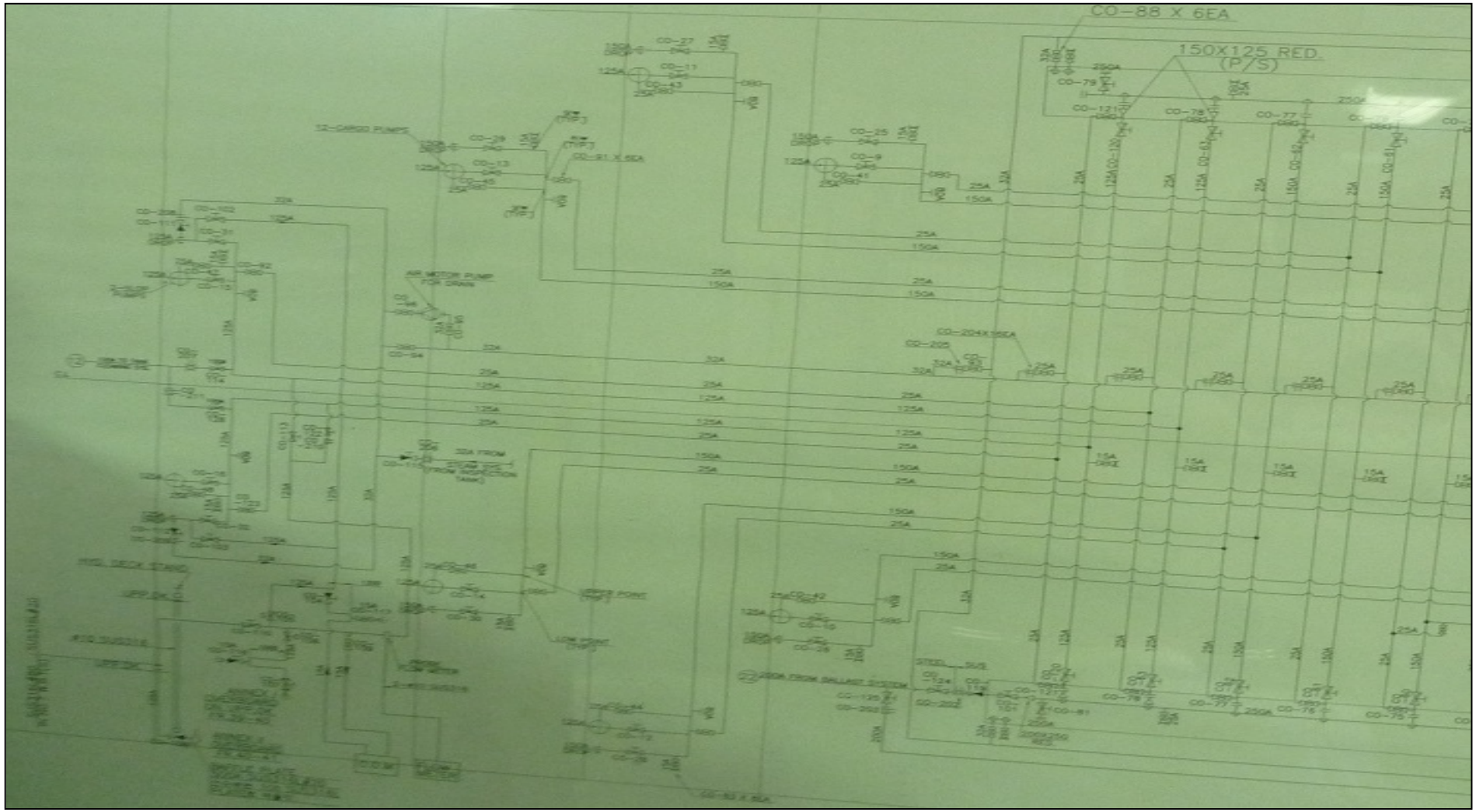



Fig. 12 - The cargo pipe diagram showing the COTs No. 5, 6, 7 and 8 (Slop) P&S

Fig. 13- Manifold arrangement (Starboard)

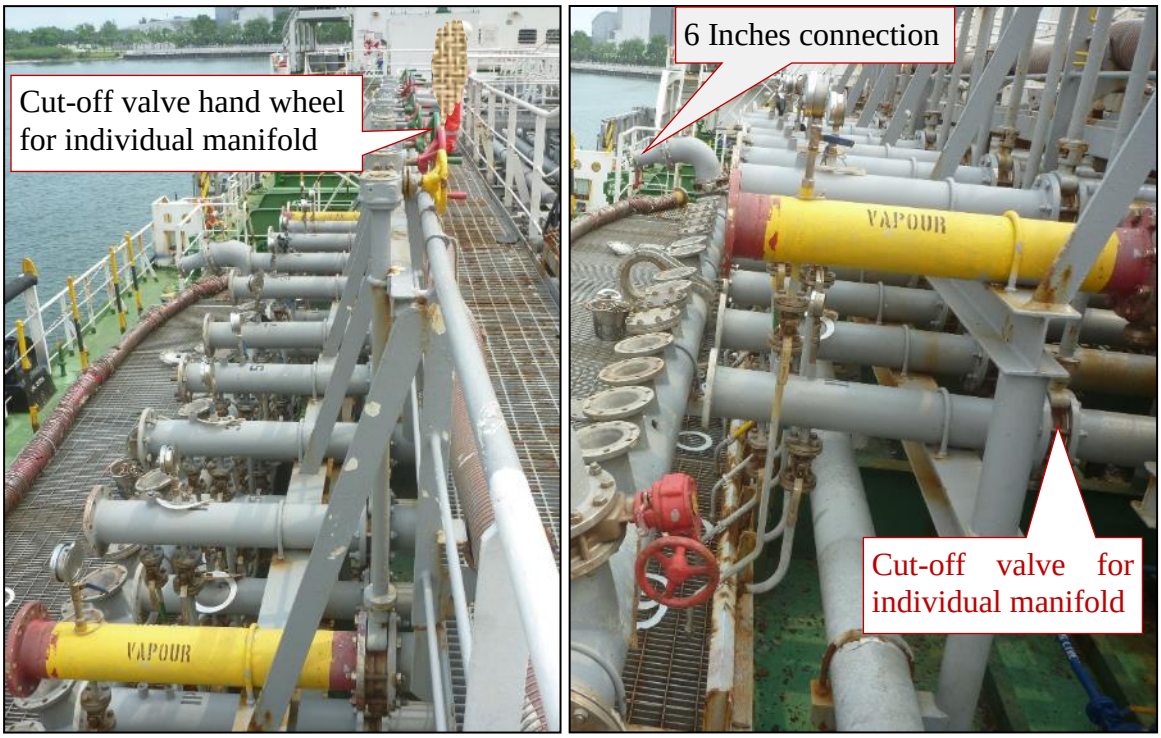



Fig. 14 - Manifold cut-off valve for each individual manifold

Fig. 15 - Elbow spool pieces for manifold connection.


Fig. 16 - Typical connection of manifold by elbow spool pieces

**The manifold connection for discharging cargo before the cleaning operation**

5.16 Upon arrival at her first discharge port, Port Kelang, on 17 April 2016, in accordance with the discharge plan, the *vessel* discharged nitric acid via port common manifold. Therefore the port individual manifolds of COTs No. 4 P&S, No. 5 P&S and No. 6 P&S were connected with the port common manifold by six elbow spool pieces for discharging the cargo ashore. The connections remained in place after discharging and the port common manifold contained nitric acid residue (Fig. 17).

5.17 After the *vessel* arrived at port of Penang on 18 April 2016, the remaining cargo grade of Acrylonitrile in COTs No. 2 P&S and No. 8 P&S were discharged via starboard common manifold. 4 elbow spool pieces were used to link the individual manifolds to the starboard common manifold. After discharging, the elbow spool pieces remained in place (Fig. 18). During discharging, the cut-off valve of the port individual manifold

of COT No. 8 P was found leaky by observing the pressure gauge fitted after the cut-off valve. Since there was no imminent need, C/O planned to replace the leaky valve after the cargo oil tank cleaning.

5.18 When AB1 used an elbow spool piece to connect the port individual manifold of COT No. 8 P with port common manifold as per the C/O's instruction, the port common manifold was connected with the individual manifold of No. 8P. Since the port side cut-off valve was leaky, any liquid in the individual manifold of COT No. 8 P and/or in the port common manifold could pass through the leaky valve and mix with each other.

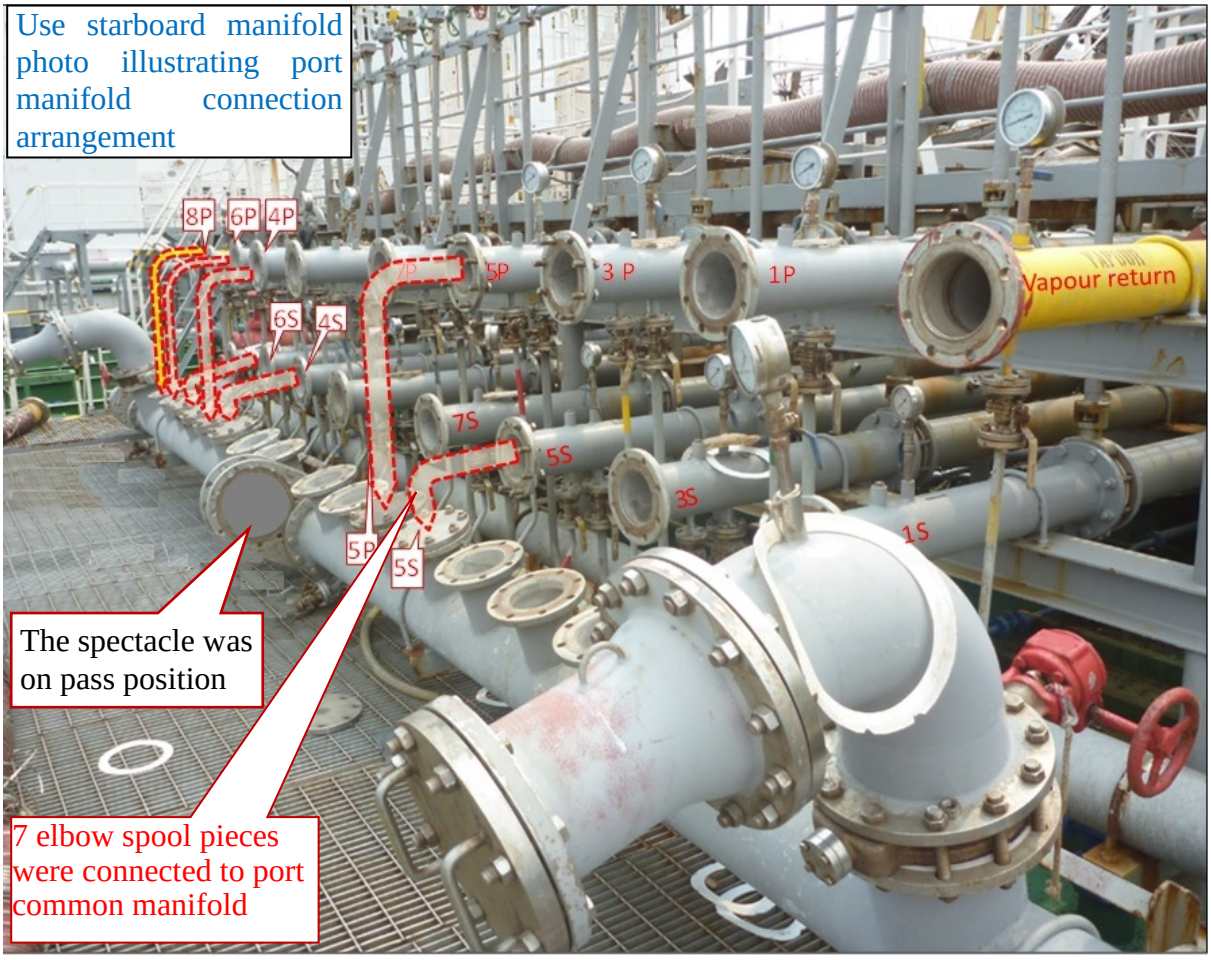



Fig. 17 - Illustration of the port common manifold in connection with the manifolds of COTs No. 8P, No. 6 P&S, No. 4 P&S, No. 5 P&S by elbow spool pieces

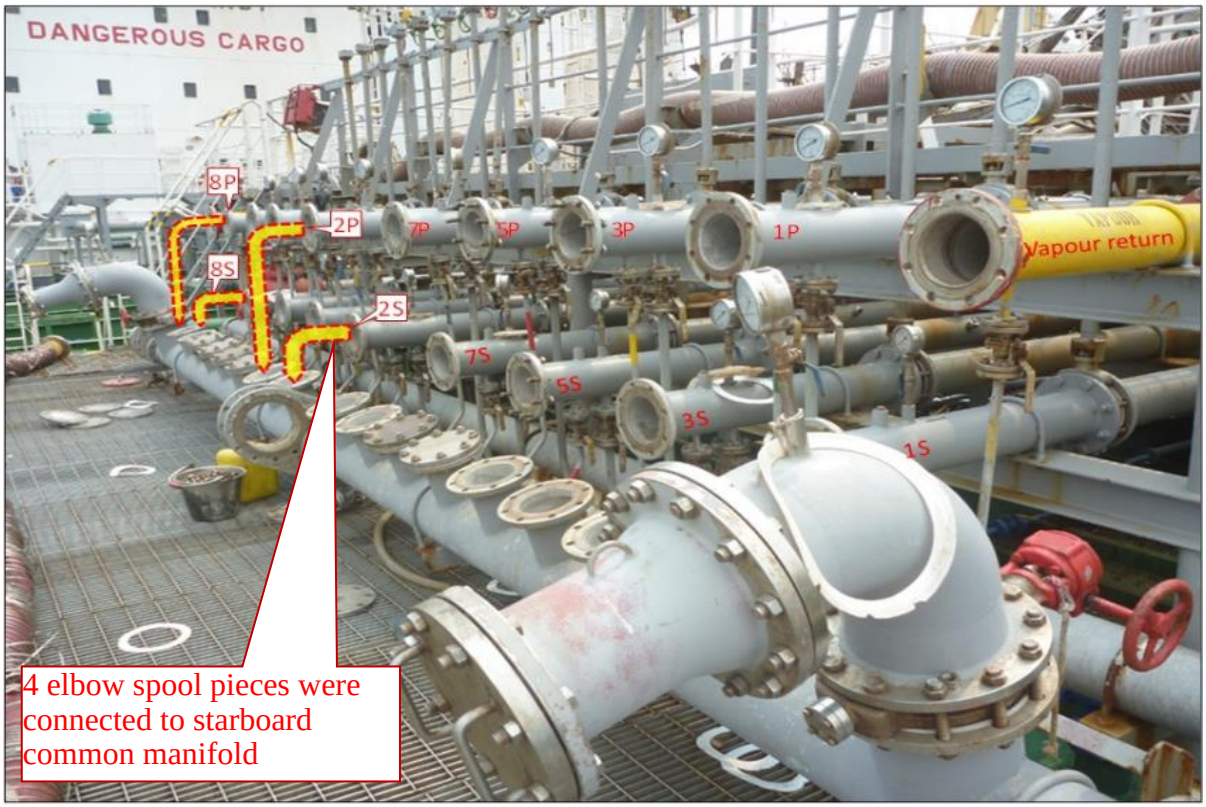



Fig. 18 - Illustration of the COTs No.2 P&S and No.8 P&S manifolds in connection with the starboard common manifold

**Tank washing and stripping operation and cargo pipe flushing**

5.19 The tank washing system was separated from the cargo system. The sea water was pressurized and delivered to the washing pipe system on deck by a tank cleaning pump. The pressurized water drives the tank cleaning machine (Fig. 19) and jets into the cargo tank to clean the tank inner surface.

5.20 During the cleaning operation, the washing water mixed with cargo residue and accumulated in the bottom of the tank. Then the cargo oil pump (Fig. 20) would be used to strip the water through the stripping line and discharge it overboard through a valve in compliance with MARPOL Annex II requirements. (Figs. 21 and 22)

5.21 After lining up the washing system, C/O started the tank cleaning pump at about 2007 hours. After confirming all washing machines running satisfactory, C/O started the cargo pump for each tank to strip the washing water and discharge it overboard. As the operation was being conducted smoothly, C/O instructed the deck persons to open the drop valves to let the stripped washing water from cargo tanks to pass the drop pipes and return to the cargo tanks in order to flush the drop pipes. During the washing and stripping operation, the washing pipe system and the cargo pipe system of COTs No. 2 P&S and No. 8 P&S were filled with sea water and the stripped washing water with acrylonitrile residue respectively.

5.22 At about 2015 hours after about 8 minutes of cleaning operation, an explosion occurred on the port common manifold. It was deduced that the washing water mixed with acrylonitrile filled up the individual manifold pipe of COT No.8 P, leaked from the leaky cut-off valve, passed through the wrongly connected elbow spool piece, entered into the port common manifold, and mixed with the cargo residue of nitric acid. The mixture of the acrylonitrile and nitric acid reacted violently in the limited enclosed space of the common manifold and resulted in a violent explosion thereafter. It occurred so sudden that no crew member could even hear any abnormal noise or vibration caused by the boisterous reaction of the mixture before the explosion.

Fig. 19 - Fixed tank cleaning machine on deck


Fig. 20 - Deep well cargo pump on deck

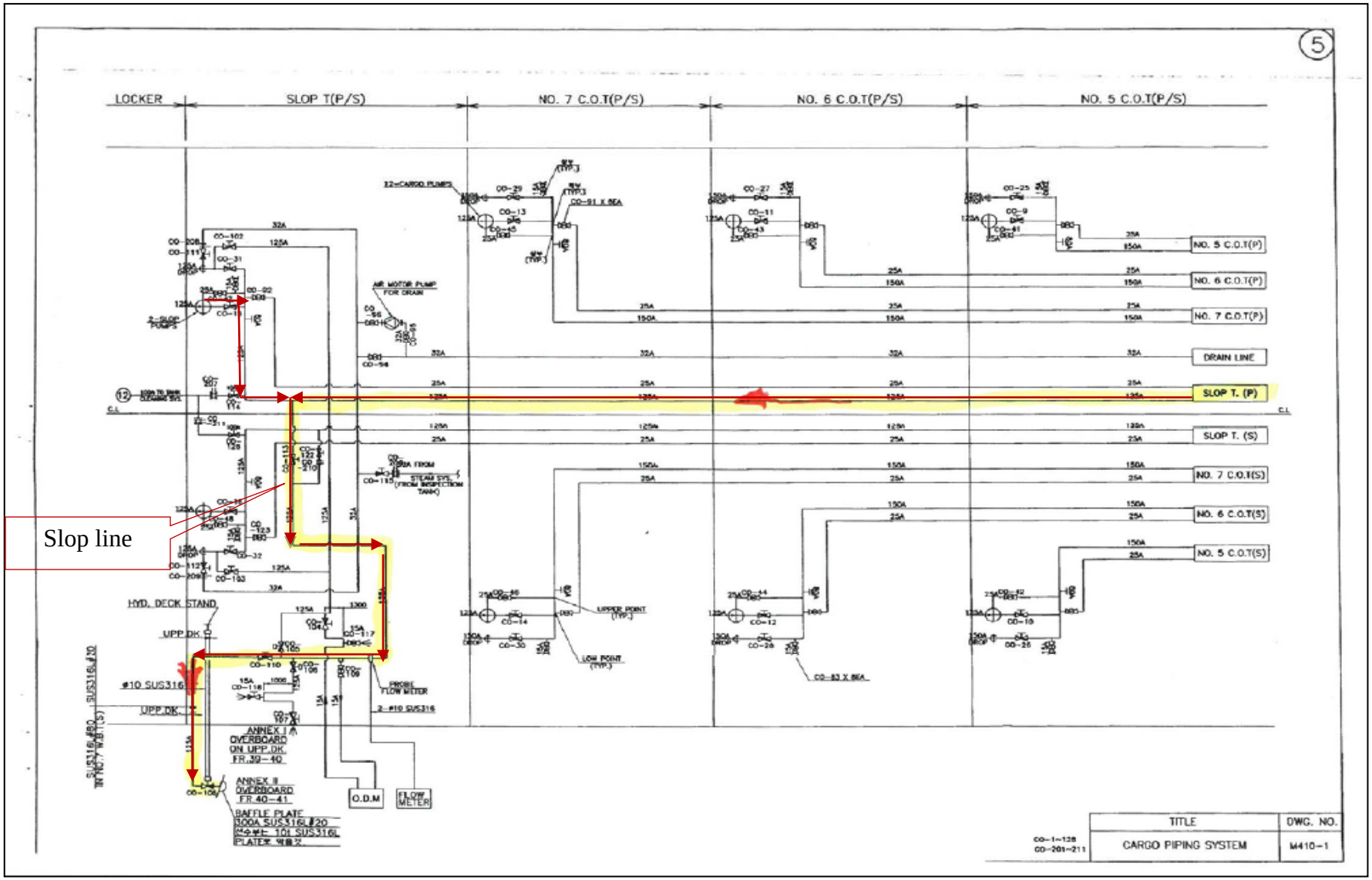



Fig. 21 - Diagram of Discharging stripped washing water from COT No.8 P

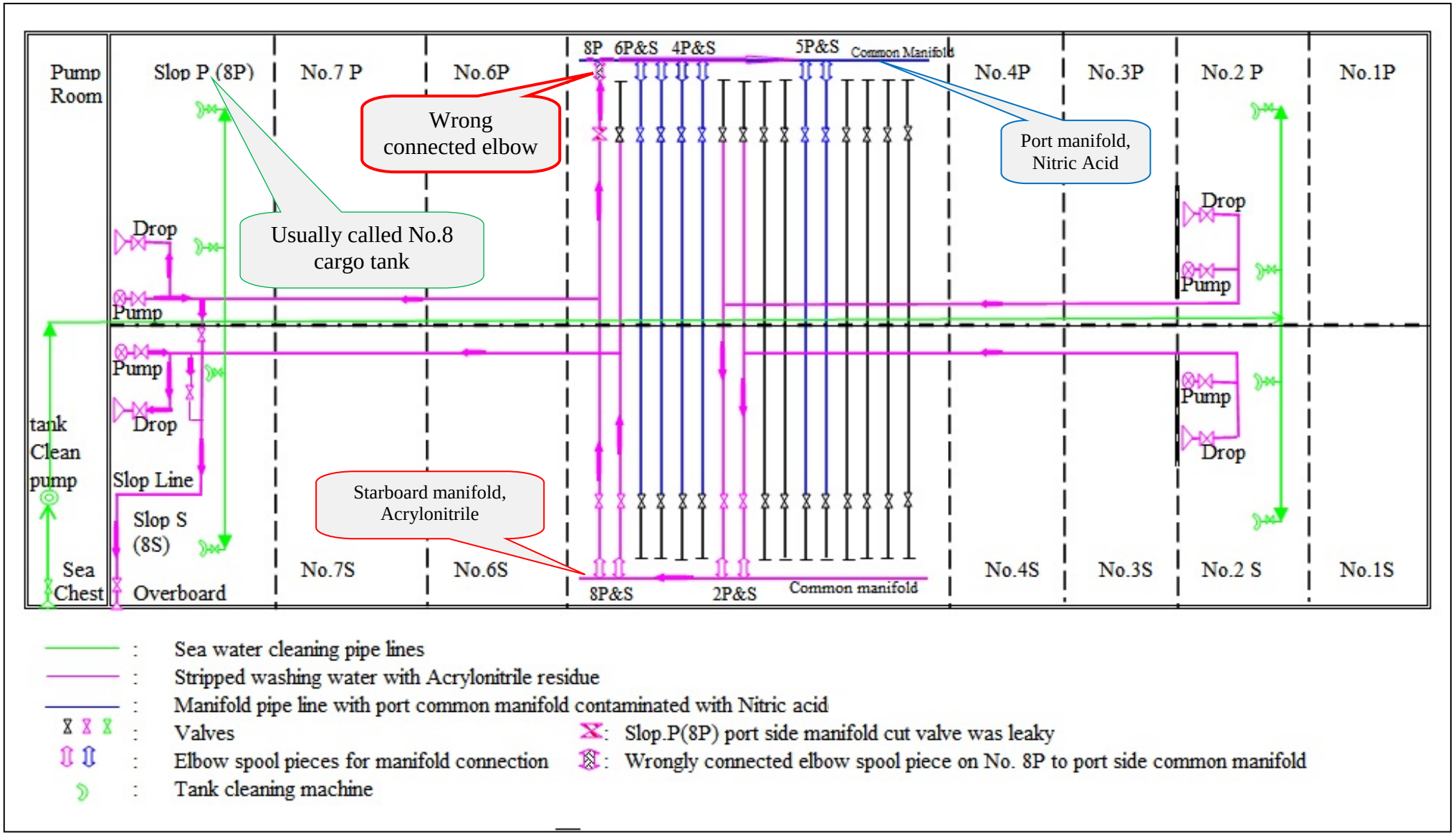



Fig. 22 - Diagram of tank cleaning water flow and stripped washing residue flow during the tank cleaning operation of COTs No. 8 P&S and No. 2 P&S

**Identification of manifold connection and malfunction of the manifold cut-off valve**

5.23 After the accident, an examination into the manifold found that there were no distinguishable markings on the manifolds to identify different cargoes in the pipelines. Therefore, it was very easy to make mistakes when linking up the manifolds by the elbow spool pieces in the congested piping area. The port individual manifolds of COTs No.8 P&S and No. 2 P&S were not marked or secured by lashing seal, chain lock or other barriers to prevent them from being wrongly connected to the port common manifold once it was left with cargo residue of nitric acid.

5.24 Although the leaky cut-off valve was discovered before the accident, no particular safety or precautionary measure was implemented before the washing operation. The crew proceeded to wash in normal manner without noticing the deficiency. The AB1 followed the C/O's instruction and linked up the COT No.8 P individual manifold with the port common manifold using an elbow spool piece. C/O was busy in monitoring the 9 crew members in the operation and did not recognize that his instruction resulted in the violation of segregation requirement.

**Tank cleaning plan and risk assessment with safety check list**

5.25 According to the procedure of the Safety Management System (SMS) on board the ship, the tank cleaning plan was prepared by C/O and approved by the ship's master. Full risk assessment with checklist was completed by C/O. Safety meeting and tool box meeting were convened before the operation. Before tank cleaning, the checklist showed that the item "Are line and hoses connected properly and securely" was checked and confirmed. It was found during the investigation that this item was not adequate to identify the wrong connection of an elbow spool piece with the common manifold. After the accident, the company revised this checklist by adding a new item "Are lines and hoses connected or isolated properly by using 'line-up checklist'?" (Appendix 4).

5.26 Although a "line-up checklist" (Appendix 5) was provided on board as a part of the procedures of SMS system, it had not been used for the tank cleaning operation before the accident. In this checklist, verification of the elbow spool piece connection was not included.

**Safety meetings for the tank cleaning operation**

5.27 The two oilers (including the deceased) normally worked inside the engine room. They

did not attend the cargo oil tank cleaning safety meeting with the deck crew in tally room. They were only briefed by C/O in the tool box meeting with others before commencing the washing operation. The oilers might not have received sufficient safety briefing so as to be fully aware of the potential hazards involved in their jobs.

5.28 It was obvious that in the safety meeting, a thorough risk assessment on the leaky cut-off valve of the COT No.8 P individual manifold was ignored. In addition, the compliance with the segregation requirement was overlooked. As a result, AB1 followed the C/O's instruction and connected the elbow spool piece to port common manifold without hesitation and doubt. Moreover, although the instruction was given by walkie-talkie and all team members should have received it via walkie-talkie, nobody realized this wrong instruction and challenged it by double checking with C/O before AB1 connected the elbow spool piece.

## 6. Conclusions

6.1 On 18 April 2016, the *vessel* was in ballast condition en route from Penang, Malaysia, to Singapore. In approximate position of 5°30.89'N, 99°56.90'E in Malacca Strait, the port common manifold of the *vessel* exploded during cargo oil tank cleaning operation which resulted into the death of an oiler and injuries of five crew members.

6.2 The investigation had identified the following contributory factors to this accident:

a) carelessness of the crew members resulted in the elbow spool piece being wrongly fitted to the port common manifold with COT No.8 P individual manifold which violated the segregation requirements of two incompatible grades of cargo;

b) the manifold piping arrangements at midship port and starboard sides were complex. But there were no conspicuous markings on the manifolds for the crew to identify the grades of cargoes inside the manifolds; and

c) although the leakage of the manifold cut-off valve of COT No.8 P was noticed before the accident, no precautionary measure was taken before the commencement of the cleaning operation.

6.3 The investigation had also found the following safety factors:

a) no preventive measure was in place to prevent wrong connection of an elbow spool piece which violated the segregation for incompatible cargo grades in the common manifold; and

b) the required procedure for verifying the proper connection and isolation of pipelines and hoses by the "line-up checklist" before tank cleaning operation had not been carried out.

## 7. Recommendations

7.1 The ship management company of the *vessel* should:-

(a) inform all masters, officers and crew of the fleet on the findings of this accident investigation;

(b) issue safety instruction on handling leaky valves of cargo oil pipeline during operation;

(c) provide onboard familiarization training to crew of the cargo manifold piping arrangement;

(d) review the onboard procedures for handling incompatible cargoes, taking the following aspects into considerations:

- full risk assessment should be conducted for the tank cleaning operation;
- particular cautions should be highlighted when using the common manifold. The “line-up checklist” should include the use of elbow spool pieces to avoid any violation of the segregation requirement;
- procedures should be developed such as using warning signs, chain lock/seal or barrier on the individual manifold to prevent them from being wrongly connected to the common manifold which may contain incompatible cargo;
- cargo compatibility information should be readily available to all crew members for reference; and
- crew members involved in the cargo tank cleaning operation should attend all relevant safety and tool box meetings.

7.2 A Hong Kong Merchant Shipping Information Notice is to be issued to promulgate the lessons learnt from the accident.

## 8. Submission

8.1 The draft report was sent to the following parties for their comments:

a) the ship management company, master and C/O of the *vessel*; and

b) the Ship Safety Branch of the Marine Department.

8.2 No comment was received from the above parties at the end of consultation.

## 9. Appendices

### Appendix 1 - Photographs of port and starboard manifolds with elbow spool pieces

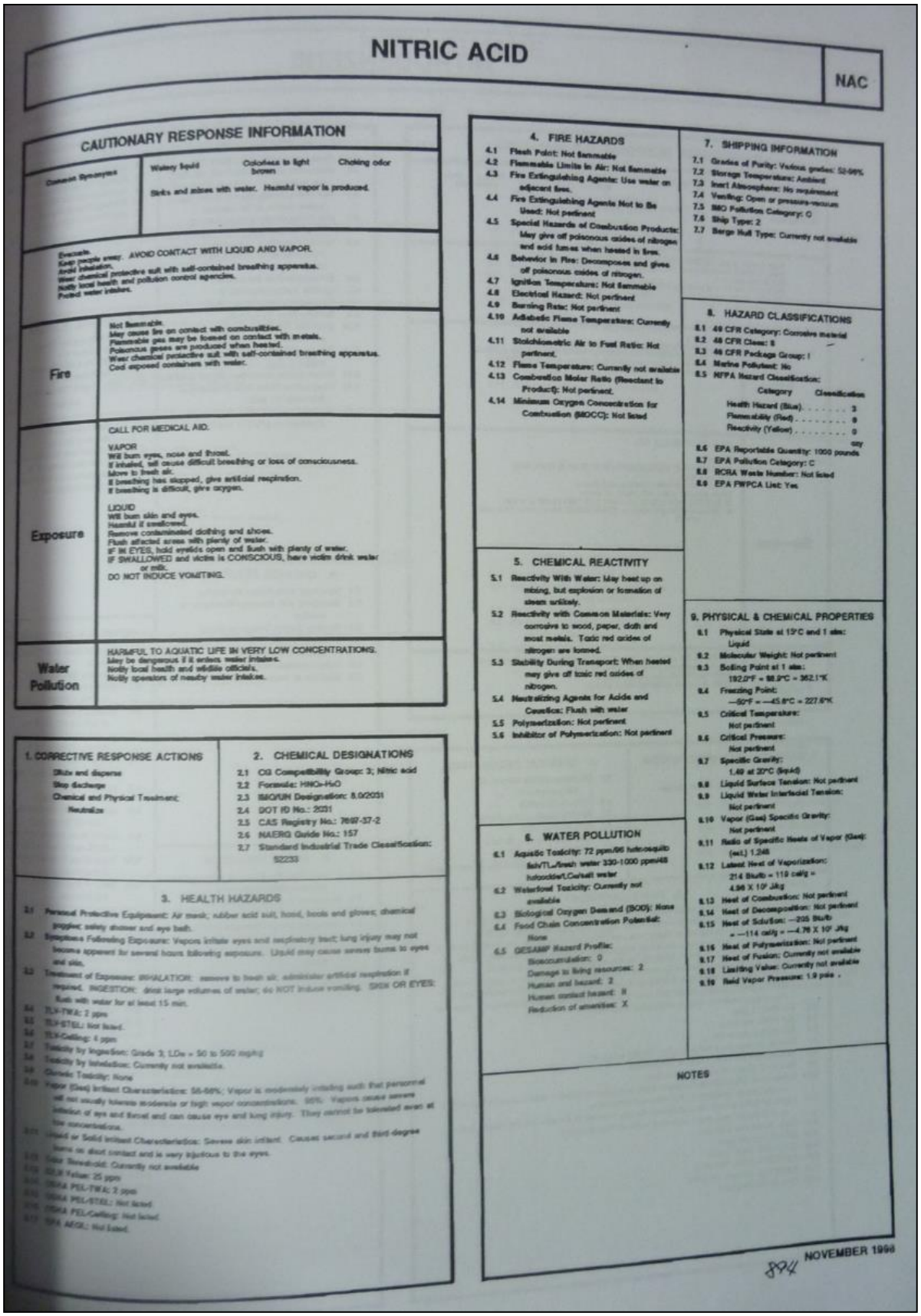
STARBOARD SIDE MANIFOLD





# PORT SIDE MANIFOLD

## Appendix 2 - Marine Safety Data Sheet of Nitric Acid



# NITRIC ACID

NAC

## CAUTIONARY RESPONSE INFORMATION

Common Synonyms: Watery liquid; Colorless to light brown; Choking odor

Sinks and mixes with water. Harmful vapor is produced.

Evacuate.
Keep people away. AVOID CONTACT WITH LIQUID AND VAPOR.
Avoid inhalation.
Wear chemical protective suit with self-contained breathing apparatus.
Notify local health and pollution control agencies.
Protect water intakes.

**Fire**

Not flammable.
May cause fire on contact with combustibles.
Flammable gas may be formed on contact with metals.
Poisonous gases are produced when heated.
Wear chemical protective suit with self-contained breathing apparatus.
Cool exposed containers with water.

**Exposure**

CALL FOR MEDICAL AID.

VAPOR
Will burn eyes, nose and throat.
If inhaled, will cause difficult breathing or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Will burn skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

**Water Pollution**

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

## 1. CORRECTIVE RESPONSE ACTIONS

Dilute and disperse
Stop discharge
Chemical and Physical Treatment:
Neutralize

## 2. CHEMICAL DESIGNATIONS

2.1 CG Compatibility Group: 3; Nitric acid
2.2 Formula: $HNO_3$-$H_2O$
2.3 IMO/UN Designation: 8.0/2031
2.4 DOT ID No.: 2031
2.5 CAS Registry No.: 7697-37-2
2.6 NAERG Guide No.: 157
2.7 Standard Industrial Trade Classification: 52233

## 3. HEALTH HAZARDS

3.1 Personal Protective Equipment: Air mask; rubber acid suit; hood; boots and gloves; chemical goggles; safety shower and eye bath.
3.2 Symptoms Following Exposure: Vapors irritate eyes and respiratory tract; lung injury may not become apparent for several hours following exposure. Liquid may cause severe burns to eyes and skin.
3.3 Treatment of Exposure: INHALATION: remove to fresh air; administer artificial respiration if required. INGESTION: drink large volumes of water; do NOT induce vomiting. SKIN OR EYES: flush with water for at least 15 min.
3.4 TLV-TWA: 2 ppm
3.5 TLV-STEL: Not listed.
3.6 TLV-Ceiling: 4 ppm
3.7 Toxicity by Ingestion: Grade 3; $LD_{50}$ = 50 to 500 mg/kg
3.8 Toxicity by Inhalation: Currently not available.
3.9 Chronic Toxicity: None
3.10 Vapor (Gas) Irritant Characteristics: 55-68%: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations. 90%: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations.
3.11 Liquid or Solid Irritant Characteristics: Severe skin irritant. Causes second and third degree burns on short contact and is very injurious to the eyes.
3.12 Odor Threshold: Currently not available
3.13 IDLH Value: 25 ppm
3.14 OSHA PEL-TWA: 2 ppm
3.15 OSHA PEL-STEL: Not listed.
3.16 OSHA PEL-Ceiling: Not listed.
3.17 EPA AEGL: Not listed.

## 4. FIRE HAZARDS

4.1 Flash Point: Not flammable
4.2 Flammable Limits in Air: Not flammable
4.3 Fire Extinguishing Agents: Use water on adjacent fires.
4.4 Fire Extinguishing Agents Not to Be Used: Not pertinent
4.5 Special Hazards of Combustion Products: May give off poisonous oxides of nitrogen and acid fumes when heated in fires.
4.6 Behavior in Fire: Decomposes and gives off poisonous oxides of nitrogen.
4.7 Ignition Temperature: Not flammable
4.8 Electrical Hazard: Not pertinent
4.9 Burning Rate: Not pertinent
4.10 Adiabatic Flame Temperature: Currently not available
4.11 Stoichiometric Air to Fuel Ratio: Not pertinent.
4.12 Flame Temperature: Currently not available
4.13 Combustion Molar Ratio (Reactant to Product): Not pertinent.
4.14 Minimum Oxygen Concentration for Combustion (MOCC): Not listed

## 5. CHEMICAL REACTIVITY

5.1 Reactivity With Water: May heat up on mixing, but explosion or formation of steam unlikely.
5.2 Reactivity with Common Materials: Very corrosive to wood, paper, cloth and most metals. Toxic red oxides of nitrogen are formed.
5.3 Stability During Transport: When heated may give off toxic red oxides of nitrogen.
5.4 Neutralizing Agents for Acids and Caustics: Flush with water
5.5 Polymerization: Not pertinent
5.6 Inhibitor of Polymerization: Not pertinent

## 6. WATER POLLUTION

6.1 Aquatic Toxicity: 72 ppm/96 hr/mosquito fish/TL$_m$/fresh water 330-1000 ppm/48 hr/oddish/Cal/salt water
6.2 Waterfowl Toxicity: Currently not available
6.3 Biological Oxygen Demand (BOD): None
6.4 Food Chain Concentration Potential: None
6.5 GESAMP Hazard Profile:
Bioaccumulation: 0
Damage to living resources: 2
Human and hazard: 2
Human contact hazard: X
Reduction of amenities: X

## 7. SHIPPING INFORMATION

7.1 Grades of Purity: Various grades: 52-99%
7.2 Storage Temperature: Ambient
7.3 Inert Atmosphere: No requirement
7.4 Venting: Open or pressure-vacuum
7.5 IMO Pollution Category: C
7.6 Ship Type: 2
7.7 Barge Hull Type: Currently not available

## 8. HAZARD CLASSIFICATIONS

8.1 49 CFR Category: Corrosive material
8.2 49 CFR Class: 8
8.3 49 CFR Package Group: I
8.4 Marine Pollutant: No
8.5 NFPA Hazard Classification:

| Category | Classification |
|---|---|
| Health Hazard (Blue) | 3 |
| Flammability (Red) | 0 |
| Reactivity (Yellow) | 0 |
| | qty |

8.6 EPA Reportable Quantity: 1000 pounds
8.7 EPA Pollution Category: C
8.8 RCRA Waste Number: Not listed
8.9 EPA FWPCA List: Yes

## 9. PHYSICAL & CHEMICAL PROPERTIES

9.1 Physical State at 15°C and 1 atm: Liquid
9.2 Molecular Weight: Not pertinent
9.3 Boiling Point at 1 atm: 192.0°F = 89.0°C = 362.1°K
9.4 Freezing Point: —50°F = —45.6°C = 227.6°K
9.5 Critical Temperature: Not pertinent
9.6 Critical Pressure: Not pertinent
9.7 Specific Gravity: 1.49 at 20°C (liquid)
9.8 Liquid Surface Tension: Not pertinent
9.9 Liquid Water Interfacial Tension: Not pertinent
9.10 Vapor (Gas) Specific Gravity: Not pertinent
9.11 Ratio of Specific Heats of Vapor (Gas): (est.) 1.248
9.12 Latent Heat of Vaporization: 214 Btu/lb = 119 cal/g = 4.98 X $10^5$ J/kg
9.13 Heat of Combustion: Not pertinent
9.14 Heat of Decomposition: Not pertinent
9.15 Heat of Solution: —205 Btu/lb = —114 cal/g = —4.76 X $10^5$ J/kg
9.16 Heat of Polymerization: Not pertinent
9.17 Heat of Fusion: Currently not available
9.18 Limiting Value: Currently not available
9.19 Reid Vapor Pressure: 1.9 psia

NOTES

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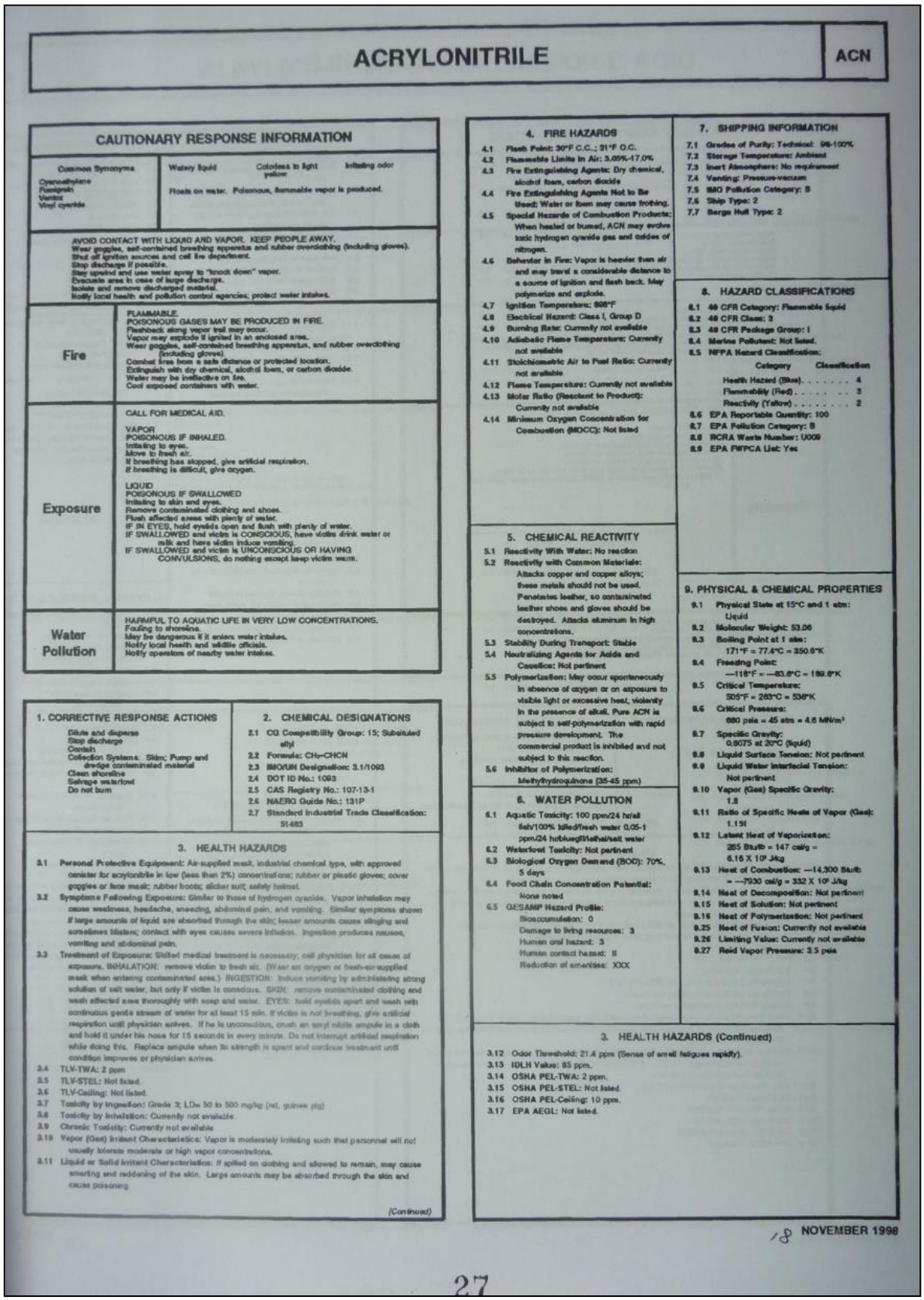
## Appendix 3 - Marine Safety Data Sheet of Acrylonitrile



# ACRYLONITRILE

ACN

## CAUTIONARY RESPONSE INFORMATION

Common Synonyms: Cyanoethylene, Fumigrain, Ventox, Vinyl cyanide

Watery liquid. Colorless to light yellow. Irritating odor. Floats on water. Poisonous, flammable vapor is produced.

AVOID CONTACT WITH LIQUID AND VAPOR. KEEP PEOPLE AWAY.
Wear goggles, self-contained breathing apparatus and rubber overclothing (including gloves).
Shut off ignition sources and call fire department.
Stop discharge if possible.
Stay upwind and use water spray to "knock down" vapor.
Evacuate area in case of large discharge.
Isolate and remove discharged material.
Notify local health and pollution control agencies; protect water intakes.

**Fire**

FLAMMABLE.
POISONOUS GASES MAY BE PRODUCED IN FIRE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Combat fires from a safe distance or protected location.
Extinguish with dry chemical, alcohol foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

**Exposure**

CALL FOR MEDICAL AID.

VAPOR
POISONOUS IF INHALED.
Irritating to eyes.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
POISONOUS IF SWALLOWED
Irritating to skin and eyes.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and have victim induce vomiting.
IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS, do nothing except keep victim warm.

**Water Pollution**

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
Fouling to shoreline.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

## 1. CORRECTIVE RESPONSE ACTIONS

Dilute and disperse
Stop discharge
Contain
Collection Systems: Skim; Pump and dredge contaminated material
Clean shoreline
Salvage waterfowl
Do not burn

## 2. CHEMICAL DESIGNATIONS

2.1 CG Compatibility Group: 15; Substituted allyl
2.2 Formula: $CH_2$=CHCN
2.3 IMO/UN Designation: 3.1/1093
2.4 DOT ID No.: 1093
2.5 CAS Registry No.: 107-13-1
2.6 NAERG Guide No.: 131P
2.7 Standard Industrial Trade Classification: 51483

## 3. HEALTH HAZARDS

3.1 Personal Protective Equipment: Air-supplied mask; industrial chemical type, with approved canister for acrylonitrile in low (less than 2%) concentrations; rubber or plastic gloves; cover goggles or face mask; rubber boots; slicker suit; safety helmet.
3.2 Symptoms Following Exposure: Similar to those of hydrogen cyanide. Vapor inhalation may cause weakness, headache, sneezing, abdominal pain, and vomiting. Similar symptoms shown if large amounts of liquid are absorbed through the skin; lesser amounts cause stinging and sometimes blisters; contact with eyes causes severe irritation. Ingestion produces nausea, vomiting and abdominal pain.
3.3 Treatment of Exposure: Skilled medical treatment is necessary; call physician for all cases of exposure. INHALATION: remove victim to fresh air. (Wear an oxygen or fresh-air-supplied mask when entering contaminated area.) INGESTION: Induce vomiting by administering strong solution of salt water, but only if victim is conscious. SKIN: remove contaminated clothing and wash affected area thoroughly with soap and water. EYES: hold eyelids apart and wash with continuous gentle stream of water for at least 15 min. If victim is not breathing, give artificial respiration until physician arrives. If he is unconscious, crush an amyl nitrite ampule in a cloth and hold it under his nose for 15 seconds in every minute. Do not interrupt artificial respiration while doing this. Replace ampule when its strength is spent and continue treatment until condition improves or physician arrives.
3.4 TLV-TWA: 2 ppm
3.5 TLV-STEL: Not listed.
3.6 TLV-Ceiling: Not listed.
3.7 Toxicity by Ingestion: Grade 3; $LD_{50}$ 50 to 500 mg/kg (rat, guinea pig)
3.8 Toxicity by Inhalation: Currently not available.
3.9 Chronic Toxicity: Currently not available
3.10 Vapor (Gas) Irritant Characteristics: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations.
3.11 Liquid or Solid Irritant Characteristics: If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. Large amounts may be absorbed through the skin and cause poisoning.

(Continued)

## 4. FIRE HAZARDS

4.1 Flash Point: 30°F C.C.; 31°F O.C.
4.2 Flammable Limits in Air: 3.05%-17.0%
4.3 Fire Extinguishing Agents: Dry chemical, alcohol foam, carbon dioxide
4.4 Fire Extinguishing Agents Not to Be Used: Water or foam may cause frothing.
4.5 Special Hazards of Combustion Products: When heated or burned, ACN may evolve toxic hydrogen cyanide gas and oxides of nitrogen.
4.6 Behavior in Fire: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back. May polymerize and explode.
4.7 Ignition Temperature: 898°F
4.8 Electrical Hazard: Class I, Group D
4.9 Burning Rate: Currently not available
4.10 Adiabatic Flame Temperature: Currently not available
4.11 Stoichiometric Air to Fuel Ratio: Currently not available
4.12 Flame Temperature: Currently not available
4.13 Molar Ratio (Reactant to Product): Currently not available
4.14 Minimum Oxygen Concentration for Combustion (MOCC): Not listed

## 5. CHEMICAL REACTIVITY

5.1 Reactivity With Water: No reaction
5.2 Reactivity with Common Materials: Attacks copper and copper alloys; these metals should not be used. Penetrates leather, so contaminated leather shoes and gloves should be destroyed. Attacks aluminum in high concentrations.
5.3 Stability During Transport: Stable
5.4 Neutralizing Agents for Acids and Caustics: Not pertinent
5.5 Polymerization: May occur spontaneously in absence of oxygen or on exposure to visible light or excessive heat, violently in the presence of alkali. Pure ACN is subject to self-polymerization with rapid pressure development. The commercial product is inhibited and not subject to this reaction.
5.6 Inhibitor of Polymerization: Methylhydroquinone (35-45 ppm)

## 6. WATER POLLUTION

6.1 Aquatic Toxicity: 100 ppm/24 hr/sil fish/100% killed/fresh water 0.05-1 ppm/24 hr/bluegill/lethal/salt water
6.2 Waterfowl Toxicity: Not pertinent
6.3 Biological Oxygen Demand (BOD): 70%, 5 days
6.4 Food Chain Concentration Potential: None noted
6.5 GESAMP Hazard Profile:
Bioaccumulation: 0
Damage to living resources: 3
Human oral hazard: 3
Human contact hazard: II
Reduction of amenities: XXX

## 7. SHIPPING INFORMATION

7.1 Grades of Purity: Technical: 98-100%
7.2 Storage Temperature: Ambient
7.3 Inert Atmosphere: No requirement
7.4 Venting: Pressure-vacuum
7.5 IMO Pollution Category: B
7.6 Ship Type: 2
7.7 Barge Hull Type: 2

## 8. HAZARD CLASSIFICATIONS

8.1 49 CFR Category: Flammable liquid
8.2 49 CFR Class: 3
8.3 49 CFR Package Group: I
8.4 Marine Pollutant: Not listed.
8.5 NFPA Hazard Classification:

| Category | Classification |
|---|---|
| Health Hazard (Blue) | 4 |
| Flammability (Red) | 3 |
| Reactivity (Yellow) | 2 |

8.6 EPA Reportable Quantity: 100
8.7 EPA Pollution Category: B
8.8 RCRA Waste Number: U009
8.9 EPA FWPCA List: Yes

## 9. PHYSICAL & CHEMICAL PROPERTIES

9.1 Physical State at 15°C and 1 atm: Liquid
9.2 Molecular Weight: 53.06
9.3 Boiling Point at 1 atm: 171°F = 77.4°C = 350.6°K
9.4 Freezing Point: —116°F = —83.6°C = 189.6°K
9.5 Critical Temperature: 505°F = 263°C = 536°K
9.6 Critical Pressure: 680 psia = 45 atm = 4.6 MN/m²
9.7 Specific Gravity: 0.8075 at 20°C (liquid)
9.8 Liquid Surface Tension: Not pertinent
9.9 Liquid Water Interfacial Tension: Not pertinent
9.10 Vapor (Gas) Specific Gravity: 1.8
9.11 Ratio of Specific Heats of Vapor (Gas): 1.151
9.12 Latent Heat of Vaporization: 265 Btu/lb = 147 cal/g = 6.16 X $10^5$ J/kg
9.13 Heat of Combustion: —14,300 Btu/lb = —7930 cal/g = 332 X $10^5$ J/kg
9.14 Heat of Decomposition: Not pertinent
9.15 Heat of Solution: Not pertinent
9.16 Heat of Polymerization: Not pertinent
9.25 Heat of Fusion: Currently not available
9.26 Limiting Value: Currently not available
9.27 Reid Vapor Pressure: 3.5 psia

## 3. HEALTH HAZARDS (Continued)

3.12 Odor Threshold: 21.4 ppm (Sense of smell fatigues rapidly).
3.13 IDLH Value: 85 ppm.
3.14 OSHA PEL-TWA: 2 ppm.
3.15 OSHA PEL-STEL: Not listed.
3.16 OSHA PEL-Ceiling: 10 ppm.
3.17 EPA AEGL: Not listed.

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## Appendix 4 - Revised "Checklist Before Tank Cleaning"

**<Company's revised "Checklist Before Tank Cleaning, P-06-F-30">**

### CHECKLIST BEFORE TANK CLEANING

| VESSEL : | DATE : | VOY. : |
|---|---|---|
| PREVIOUS CARGO : | NEXT CARGO : | |

| No | CHECK ITEM | RESULT | IF NO, WHY? |
|---|---|---|---|
| 1 | Did you make cleaning plan and made it known to crew well?<br>크리닝계획을 수립하고 선원이 숙지했는가?<br>Familiarization training date 크리닝 계획의 친숙화 교육 훈련일자 : (  ) | | |
| 2 | Did you post the cleaning plan in COC? 크리닝계획이 COC에 게시되었는가? | | |
| 3 | Did you consider effect of cleaning to the adjacent tanks?<br>인접탱크의 크리닝영향이 고려되었는가? | | |
| 4 | Did you check stock of F.W and detergents? 청수 및 세제의 재고를 점검하였는가?<br>How many is it kept? 얼마나 보유중인가?<br>Fresh Water 청수 : (  M/T), Detergent 세정제 : (  CAN) | | |
| 5 | Did you discuss cleaning plan with the engine department? When?<br>크리닝계획이 기관부와 협의되었는가? 언제 협의하였는가? (  ) | | |
| 6 | Did you make the properties(hazards) of unloaded cargo known to crew well?<br>양하한 화물에 대한 위험성을 선원이 잘 알고 있는가? | | |
| 7 | Did you make the properties (hazard, etc.) and safe using method of detergents known crew? 세제/용해제의 위험성/안전한 사용법을 선원들이 잘 알고 있는가? | | |
| 8 | Did you give precautionary knowledge to crew for safety?<br>안전에 관한 예방법을 숙지시켰는가? | | |
| 9 | Did you instruct crew to wear protective clothes and equipment?<br>보호복이나 보호장구의 착용법에 대해 교육했는가? | | |
| 10 | Did you test function of measuring equipment? (oxygen meter/combustible gas meter 각 종 계측기기를 점검하였는가?<br>Latest calibration date 마지막 교정 일자<br>Portable gas detectors (  ), Personal gad detector (  ) | | |
| 11 | Did you confirm eye washer and shower on upper deck to be functional?<br>eye washer 및 eye shower는 정상작동하는가? | | |
| 12 | Was communication system(Walkie-Talkie) confirmed to be functional?<br>통신장비(Walkie-Talkie) 상태는 확인되었는가? | | |
| 13 | Did you discuss and agree amongst crew procedures for emergency cases?<br>비상상황에 대한 절차가 선원들간 협의되고 인정되었는가? | | |
| 14 | Did you agree and instruct arrangement of personnel on the working spot?<br>각 개인간의 작업장소는 협의되고 교육되었는가? | | |
| 15 | Were all equipments to be used for cleaning tested and confirmed to be safe and functional? 크리닝 설비는 안전하고 사용가능한지 점검되었는가?<br>TANK CLEANING HOSE상태 및 BUTTERWORTH MACHINE 상태 점검<br>Check of condition of tank cleaning hose and butterworth machine etc. | | |
| 16 | Are lines and hoses connected or isolated properly by use "Line-up check list?<br>모든 라인 및 호스는 Line-up 점검표에 따라 적절하게 연결 또는 격리 되었는가?<br>마지막 Tank Cleaning Hose의 절연저항 점검일자 (  )<br>Latest checked date of insulation resistance for a tank cleaning hose to be used. | | |
| 17 | Are lines used for cleaning segregated properly from the others?<br>크리닝시 사용될 라인은 적절히 분리되었는가? | | |
| 18 | Are valves used for cleaning functional and in good condition?<br>크리닝시 사용될 밸브들은 정상적으로 작동하는가? | | |
| 19 | Are weather and other circumstances taken into consideration for cleaning operations? 날씨나 기상상황은 크리닝 계획에 고려되었는가?<br>Weather condition 기상 상태 (Swell 파랑:  m, Weather 기상 :  ) | | |
| 20 | Steaming included tank cleaning plan? Tank Cleaning 계획에 Steaming이 포함되었는 | | |
| 20-1 | If yes, Are LEL of all cargo tank checked and confirmed less than 1%?<br>만약 그렇다면 모든 화물탱크의 LEL이 1% 미만인지 점검하고 확인했는가? | | |
| 21 | Is precaution of steaming instructed to crew? Steaming주의사항을 교육하였는가? | | |

Prepared by C/O

Approved by Master

P-06-F-30/<Revised>2016.04.20 PTS CO.,LTD.

**Appendix 5 - "Line-up Check List"**

## LINE-UP CHECK LIST

| Vessel | | Voy No. | | Date | |
|---|---|---|---|---|---|

사관과 부원은 1항사의 지시에 따라 하역작업 전 라인업을 시행해야 한다. 1항사는 라인업에 대한 이중점검을 실시하여 휴먼에러를 방지해야 한다.

Primary line-up shall be carried out by officer & ratings as per chief officer's order and secondary line-up shall be carried out by chief officer prior to cargo operation for preventing human errors.

| | 1st | | 2nd | | | | 1st | | 2nd | |
|---|---|---|---|---|---|---|---|---|---|---|
| No.1 COT(P) | Open | Close | Open | Close | | No.1 COT(S) | Open | Close | Open | Close |
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| No.2 COT(P) | Open | Close | Open | Close | | No.2 COT(S) | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| No.3 COT(P) | Open | Close | Open | Close | | No.3 COT(S) | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| No.4 COT(P) | Open | Close | Open | Close | | No.4 COT(S) | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| No.5 COT(P) | Open | Close | Open | Close | | No.5 COT(S) | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| No.6 COT(P) | Open | Close | Open | Close | | No.6 COT(S) | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| No.7 COT(P) | Open | Close | Open | Close | | No.7 COT(S) | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| SLOP (P) | Open | Close | Open | Close | | SLOP (S) | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Drop Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Delivery Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * P/V Valve | ☐ | ☐ | ☐ | ☐ | | * P/V Valve | ☐ | ☐ | ☐ | ☐ |

| Port Manifold | Open | Close | Open | Close | | Stb'd Manifold | Open | Close | Open | Close |
|---|---|---|---|---|---|---|---|---|---|---|
| * Vapour Return Line V/V | ☐ | ☐ | ☐ | ☐ | | * Vapour Return Line V/V | ☐ | ☐ | ☐ | ☐ |
| * Com' Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Com' Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| * Cargo Line V/V with Cap | ☐ | ☐ | ☐ | ☐ | | * Cargo Line V/V with Cap | ☐ | ☐ | ☐ | ☐ |
| Remark | | | | | | Remark | | | | |

Officer _____ Rating _____ Chief Officer _____

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