MA2013-4

MARINE ACCIDENT
INVESTIGATION REPORT

April 26, 2013

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Norihiro Goto
Chairman,
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

MARINE ACCIDENT INVESTIGATION REPORT

Vessel type and name:	Chemical tanker KYOKUHO MARU NO.2
Vessel number:	137077
Gross tonnage:	388 tons
Accident type:	Fatality of a crewmember
Date and time:	February 7, 2012, about between 12:26 to 12:29
Location:	Sakai-senboku Section 7, Hanshin Port Near 204° true, 2,600 m from the south lighthouse at the south breakwater at Yamato River, Sakai-senboku, Sakai City, Osaka, Japan (Approximately 34°34.6'N, 135°23.1'E)

March 28, 2013
Adopted by the Japan Transport Safety Board

Chairman	Norihiro Goto
Member	Tetsuo Yokoyama
Member	Kuniaki Shoji
Member	Toshiyuki Ishikawa
Member	Mina Nemoto

SYNOPSIS

<Summary of the Accident>

The chemical tanker KYOKUHO MARU No.2 left Komatsu Wharf, Izumi-otsu Port, Izumi-otsu City, Osaka Prefecture, with the master, the second officer and other three crewmembers onboard. On her way northward to the Umemachi Terminal in the Section 1 of Hanshin Port, at about 12:29 on February 7, 2012, the chief engineer found the second officer collapsed in the port No.1 cargo tank.

The second officer was rescued but had been disabled to breathe by the inhaled gas, and died in oxygen deficiency.

<Probable Causes>

It is probable that this accident occurred as the second officer entered the port No.1 cargo tank, where the wash water had remained with a smell of gas, and inhaled the chloroform gas when checking the inside of the tanks while the chemical tanker was heading north to the Umemachi Terminal, because AST Inc. had not made the crew well accustomed to taking careful actions when entering the cargo tank, including measurement of oxygen and other gas concentration, and also because the company had not manifestly established tank cleaning

procedures in case of wash water found remaining in the cargo tank.

<Recommendations and Remarks>

Recommendations

(1) Recommendations to the Minister of Land, Infrastructure, Transport and Tourism

It is probable that this accident occurred as the second officer entered the port No.1 cargo tank where the wash water had remained and chloroform gas odor had been in its atmosphere, and inhaled the gas while the chemical tanker was heading north to the Umemachi Terminal, because AST Inc. had not made the crew well accustomed to taking careful actions when entering the cargo tank to check its condition, including measurement of oxygen and other gas concentration, and because AST Inc. had not manifestly established the tank cleaning procedures including the treatment of wash water remaining after tank cleaning.

Since 1989, there have been 17 accidents caused by oxygen deficiency or gas poisoning, in 14 cases of which no oxygen and other gas concentration measurement had been made when entering into the enclosed spaces.

For the purpose of preventing the recurrence of similar accidents, the Board recommends the Minister of Land, Infrastructure, Transport and Tourism based on the result of this accident investigation, pursuant to Paragraph 1, Articles 26 of the Act for Establishment of the Japan Transport Safety Board, as follows:

The Minister should give directions to coastal chemical tanker operators to ensure that they take the following measures:

1) give their tanker crew instructions in the measurement of oxygen and other gas concentration when entering in enclosed spaces so as to make sure they implement it, and regularly visit their tankers to check that the measurement of oxygen and other gas concentration is carried out without fail;
2) instruct their masters to keep record of the measurement of oxygen and other gas concentration and, if a gas detector is used in the gas measurement, also keep record of the number of detector tubes purchased, used, and remaining, and regularly visit their tankers to check the record of gas concentration measurement and the detector tubes to ensure that the measurement and the recording are carried out without fail;
3) develop, in a simple form easy for their crew to understand, specific tank cleaning procedures, including check of wash water remains, removal of the remainder by stripping, and drying and gas-freeing operation as stated in the coastal tanker safety guidelines and P&A manual, and post them at places easy to see on work site; and
4) being aware of the importance of avoiding taking actions impulsively or on the crewmember's own judgment in an emergency, provide education and training to their crew regularly in responding to accidents and other emergencies.

In addition, the Minister should, when inspecting tankers, give their crew necessary instructions concerning 1) through 4) above and check their detector tube record to see if the measurement of oxygen and other gas concentration is properly performed, and make sure, by auditing the operators, that they have been active in the effort of assuring transportation safety and improving shipping operations.

(2) Recommendations to AST Inc.

It is probable that this accident occurred as the second officer entered the port No.1 cargo

tank where the wash water had remained and chloroform gas odor had been in its atmosphere, and inhaled the gas while the chemical tanker was heading north to the Umemachi Terminal, because AST Inc. had not made the crew well accustomed to taking careful actions when entering the cargo tank to check its condition, including measurement of oxygen and other gas concentration, and because AST Inc. had not manifestly established tank cleaning procedures including the treatment of wash water remaining after tank cleaning.

AST Inc. had had two similar accidents on the tankers they operated. After each of such accidents, AST Inc. gave education and training to its crew to make sure they practice oxygen and other gas concentration measurement, but the crewmember did not practice it properly as instructed and trained, to result in this accident.

For the purpose of preventing the recurrence of similar accidents, the Board recommends AST Inc. based on the result of this accident investigation, pursuant to Paragraph 1, Article 27 of the Act for Establishment of the Japan Transport Safety Board, as follows:

AST Inc. should take the following measures for the prevention of similar accidents:

1) give their tanker crew instructions in the measurement of oxygen and other gas concentration when entering in enclosed spaces so as to make sure they implement it, and regularly visit their tankers to check that the measurement of oxygen and other gas concentration is carried out without fail;
2) instruct their masters to keep record of the measurement of oxygen and other gas concentration and, if a gas detector is used in the gas measurement, also keep record of the number of detector tubes purchased, used, and remaining, and regularly visit their tankers to check the record of gas concentration measurement and the detector tubes to ensure that the measurement and the recording are carried out without fail;
3) develop, in a simple form easy for their crew to understand, specific tank cleaning procedures, including check of wash water remains, removal of the remainder by stripping, and drying and gas-freeing operation as stated in the coastal tanker safety guidelines and P&A manual, and post them at places easy to see on work site; and
4) being aware of the importance of avoiding taking actions impulsively or on the crewmember's own judgment in an emergency, provide education and training to their crew regularly in responding to accidents and other emergencies.

1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

The chemical tanker KYOKUHO MARU No.2 left Komatsu Wharf, Izumi-otsu Port, Izumi-otsu City, Osaka Prefecture, with the master, the second officer and other three crewmembers onboard. On her way northward to the Umemachi Terminal in the Section 1 of Hanshin Port, at about 12:29 on February 7, 2012, the chief engineer found the second officer collapsed in the port No.1 cargo tank.

The second officer was rescued but, having been disabled to breathe by the inhaled gas, died in oxygen deficiency.

1.2 Outline of the Accident Investigation

1.2.1 Setup of the Investigation

The Japan Transport Safety Board appointed an investigator-in-charge and another investigator to investigate this accident on February 7, 2012.

1.2.2 Collection of Evidence

February 8 and 9, 2012: On-site investigations and interviews

February 10, 11 and 20, March 19, April 10, 25 and 27, May 8, 9, 30 and 31, June 4 to 6, 11 and 14, and October 23, 2012: interviews

1.2.3 Comments from Parties Relevant to the Cause

Comments were invited from parties relevant to the cause of the accident.

1.2.4 Cooperation in the Investigation

(1) Concerning this accident, the Board obtained advice and cooperation of Professor Hiroshi Matsumoto, Department of Legal Medicine & Alcohol Medicine, Legal Medicine course in Medicine Faculty, Graduate School of Sapporo Medical University, for the effects of ethanol intake on human's olfactory function.

(2) Concerning this accident, the Board obtained advice and cooperation of Director Takeshi Morita, Safety Information Department, National Institute of Health Sciences for the characteristics and properties of chloroform.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

According to the statements of the master, the chief officer, the chief engineer and the engine rating of KYOKUHO MARU No.2 (hereinafter referred to as "the Ship", except Chapter 6), and the information from Sakai Coast Guard Station (hereinafter referred to as “Sakai Station”), and also the reply to the questionnaire by the hospital to which the second officer had been sent, events leading up to the accident were as follows.

2.1.1 Operations Made before the Date of the Accident

The Ship, with the master, the second officer and other three crewmembers onboard, and loaded with approximately 350 tons of chloroform*1 in her No.1 and No.3 cargo tanks and approximately 150 tons of methylene chloride*2 in her No.2 cargo tank, left Section 1 of Tokuyama-kudamatsu Port, Yamaguchi Prefecture at about 16:10, February 4, 2012, and called at Marugame Port, Kagawa Prefecture, where some foods were purchased. Then the Ship proceeded toward the Kobayashi Terminal of AST Inc. (hereinafter referred to as "Company A", except Chapter 6) in the Osaka Section 3 of Hanshin Port.

(Photo 2.1-1 The Ship (viewed from port bow))

At around 8:30 on February 6, two days later, the Ship came alongside the Kobayashi Terminal and was completely unloaded. For the cleaning of the cargo tanks, the Ship left the terminal at around 14:05 and had the inside of all of the cargo tanks cleaned, No.1 through No.3 in sequence, by a Butterworth washer*3 and with fresh water of approximately 0.6 m^3 per tank. While this cleaning operation was in progress, the cargo tank pump was operated, and the wash water containing chloroform (hereinafter referred to as "chloroform wash water") and the wash water containing methylene chloride which were collected in the suction well*4, were sucked up through a stripping*5 pipe and transferred into a slop tank*6.

After the transfer of the chloroform wash water of the port No.1 cargo tank into the slop tank, the chief engineer visually made sure that no chloroform wash water was remaining in the suction well.

At around 16:55, the Ship came alongside the Komatsu Wharf to wait there until "the item, time and place of the next cargo loading" (hereinafter "the next navigation schedule") were decided.

---

*1 "Chloroform" is a clear, colorless, volatile liquid, and its vapor smells sweet. It is mainly used as a raw material for chemicals, e.g., as a raw material for fluoric refrigerant and fluorine resin, and as a solvent or extraction solvent for pharmaceuticals (disinfectants), rubber and wax. Chemical name: trichloromethane. Formula: $CHCl_3$.

*2 "Methylene chloride" is a clear, colorless, nonflammable liquid. Its vapor smells sweat. Mainly used for degreasing metal machines. Chemical name: dichloromethane. Formula: CH_2Cl_2.

*3 "Butterworth washer" is a washing machine provided in a cargo tank, and is used for washing the tank inside by jetting, while rotating itself, high-pressure water streams upon all over the tank inside. (See Photo 2.5-4 Butterworth Washer, etc.)

*4 "Suction well" denotes a depressed area provided on the stern side in a cargo tank to facilitate efficient suction of cargo and washing water, and is equipped with cargo and washing water suction piping.

*5 "Stripping" means to completely remove all unnecessaries by sucking up cargo and washing water remaining in a cargo tank and the cargo piping.

*6 "Slop tank" is a storage tank installed in the tanker to store used oil-mingled water resultant from cargo tank washing.

The master confirmed with the operator Company A that the Ship had no scheduled duty yet until a notice was given from Company A on the following day, and had the inside of the No.1 through No.3 cargo tanks dried by the operation of the turbofans seeing that the chloroform wash water in the cargo tanks had been cleaned out[*7]. At the same time, the master kept ventilating the tanks for about 13 hours till the following day to render them gas-free[*8].

2.1.2 Events during Departure from Komatsu Wharf till Occurrence of the Accident

At around 10:30 on February 7, the master was told by Company A to prepare for departure from the port, and transmitted the information to the Ship's crew.

At about 12:00, the master was told by Company A to depart from the port toward the Umemachi Terminal for the present, because the next navigation schedule would be decided at about 13:00. Then the master stationed himself at the bridge, the chief and the second officers at the bow, and the chief engineer and the engine rating at the stern, respectively.

The Ship left the Komatsu Wharf at about 12:10, and headed to the Umemachi Terminal at a ground speed of approximately 11 knots, with her course set at approximately 350° at about 12:17 at a point 047° (true bearing, hereinafter, too) and nearly 1,500 m from the south lighthouse at the Senboku-otsu south breakwater, Izumi-Otsu City, Osaka Prefecture.

Sitting on a seat, the master maneuvered the Ship assuming that the crewmembers were engaged in the preparations for the Ship's arrival at the Umemachi Terminal.

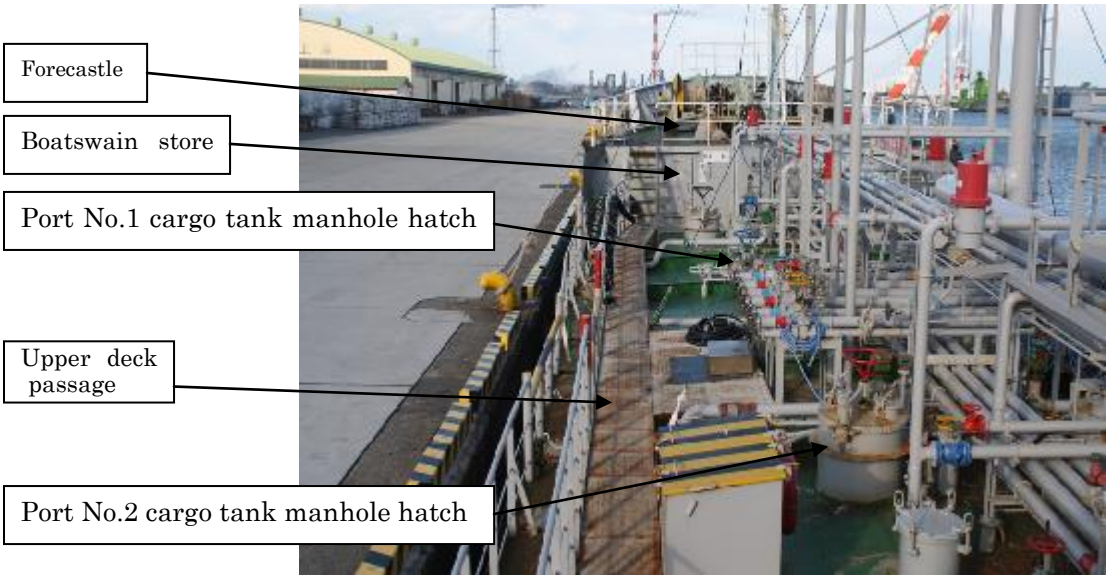
The chief and the second officers finished their preparations for the Ship's arrival at the terminal on the forecastle deck and, for the inspection of the cargo tank inside condition, allocated the duty for the starboard cargo tanks to the chief officer, and for the port cargo tanks to the second officer, respectively.

After finishing preparations for the Ship's berthing alongside the terminal, the chief engineer and the engine rating took a rest at the mess room. After that, when the chief engineer was checking the scuppers[*9] on the upper deck, he passed by the second officer and had a few words with him near the port No.3 cargo tank, feeling nothing unusual of him, and returned to the mess room. The engine rating was storing a bicycle to a proper place on the poop deck.

*7 The wording "clean out" places emphasis on thoroughly removing all unnecessaries.

*8 "Gas-free" means a cargo tank inside condition, freed of gas by replacing it with fresh air blown into the tank after the tank cleaning.

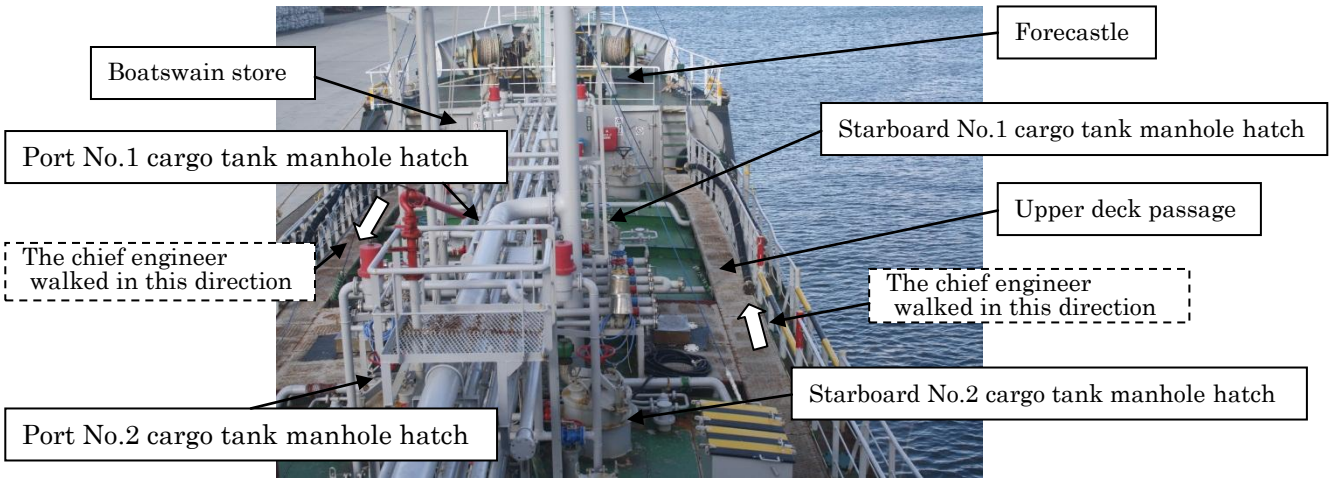
*9 "Scupper" is a drain port on each side of the deck.



(Photo 2.1-2 On Upper Deck of the Ship (Viewed from Bridge toward Port Bow)

At around 12:25, the chief officer, near the starboard No.1 cargo tank, directed the second officer, who was near the port No.1 cargo tank, to open the manhole hatch of the cargo tank. When the second officer was opening the manhole hatch, the chief officer smelt chloroform and cautioned the second officer against entering the cargo tank to avoid chloroform gas inhalation, and saw the second officer nodded in assent.

While opening the starboard No.2 and No.3 cargo tanks in sequence, the chief officer walked toward the accommodation space in order to get in hand a "portable oxygen and gas concentration detector" (portable gas monitor, Model GX-8000, Type F (see Photo 2.5-6 Portable Detector) made by Riken Keiki Co., Ltd. (hereinafter referred to as "the portable detector")) and a "pocketable oxygen and gas concentration detector" (pocketable gas monitor, Model GX-2009, Type A (see Photo 2.5-7 Pocketable Detector), made by Riken Keiki Co., Ltd., (hereinafter referred to as "the pocketable detector")). After having them in hand, he measured oxygen concentrations in the starboard No.1 and then the No.2 cargo tanks using the portable detector. When so measuring, he did not see the second officer and thought the second officer might be in the boatswain store*10 or elsewhere.



(Photo 2.1-3 On Upper Deck of the Ship (Viewed from Bridge toward Bow)

*10 Boatswain store" is a warehouse to store rigging, tools, etc. and is usually situated at bow.

With a view to see how work was being done on the upper deck, the chief engineer went out of the accommodation space, and walked along the upper deck passage from the starboard side via the bow side to the port side, when he peeped into the port No.1 cargo tank as the manhole hatch was open, and saw there a bucket lying, and the second officer, wearing gloves and an organic solvent mask, collapsed as if leaning against the bulkhead near the suction well.

※ This Photo 2.1-4 shows a situation where the second officer was found collapsed. Reproduced with the help of the Ship's crew at the on-site investigation.

(Photo 2.1-4 Situation where second officer was found)

When the chief engineer saw the second officer collapsed, he thought that, as the inside of the port No.1 cargo tank smelled of gas and seeing that the chloroform wash water remained in the suction well which had been dried the day before, the wash water might have been remaining in the portion of the piping through which both the cargo and the blown air run in common and have been forced back when ventilating.

Avoiding himself entering the port No.1 cargo tank, the chief engineer repeated shouting for the second officer, who showed no reaction. He then hastened to the bridge to report to the master and, on his way to the bridge, he told the chief officer, who had been measuring oxygen concentration in the starboard No.3 cargo tank, of the collapse of the second officer in the port No.1 cargo tank, went on to the bridge, and reported the situation to the master.

Based on the statement of the chief officer, the marine accident investigator reproduced the situations of this accident, to find as a result that it took the chief officer approximately one minute to go to the accommodation space to have in hand "the portable detector and the pocketable detector" (hereinafter "the both detectors") and start the measurement of the oxygen concentration in the starboard No.1 cargo tank, and that it was approximately three minutes after he started the measurement of oxygen concentration in the cargo tank that he received the information of the collapse of the second officer in the port No.1 cargo tank from the chief engineer.

2.1.3 Rescue Operation

Upon receipt of the chief engineer's report, the master dropped anchor at approximately 34º 34'N, 135º 23'E, directed the chief engineer to stay in the bridge, and went to the port No.1 cargo tank. He joined the chief officer who had been near the port No.1 cargo tank, dropped the portable detector hose to the tank bottom near a vertical ladder attached in the cargo tank, and measured the oxygen concentration. The display of the portable detector indicated 20.9%. Then he put the pocketable detector into near the suction well to measure the oxygen

concentration, and the detector gave out a warning sound indicating that the oxygen concentration was below 18.0 vol%*11. He judged that, although the gas was partially present, oxygen was also still remaining and it would be possible to enter the cargo tank.

The master stepped down the ladder into the port No.1 cargo tank. He did not smell gas at the tank bottom beneath the ladder, but did smell it as he approached the second officer who had been fallen near the suction well and, feeling danger of the gas, he came back out of the cargo tank. The time he was in the cargo tank was approximately thirty seconds.

The master, on calculating that bringing the second officer away from the suction well to a place as high as possible would subject him less to the effect of the gas, returned into the port No.1 cargo tank, attempted to carry up the second officer onto a stage which was used for unloading latex and which was 1.5 m high from the tank bottom (hereinafter referred to as "the stage") but, under the menace of the smell of the gas, left the cargo tank in about 30 seconds.

Again, the master attempted together with the chief officer to carry up the second officer onto the stage, but the deadly unconscious body was too heavy even for the two men, and to avoid the danger of the gas they retreated from the cargo tank in about 30 seconds.

The master reported the accident to Company A. At around 12:47, he dialed 118 by a maritime mobile radiotelephone and asked rescue.

Even after this, in the attempt of carrying the second officer up onto the stage, the master again entered the port No.1 cargo tank, wearing a self-contained breathing apparatus and carrying on his back an oxygen cylinder, but he could not well adjust the oxygen feed rate, overconsumed the oxygen in a short time and was obliged to retreat from the cargo tank under the menace of the chloroform gas, leaving the second officer not on the stage.

By the arrangement made by the Ship to dry up her port No.1 cargo tank inside and to render gas-free by ventilating the tank before the arrival of the Japan Coast Guard, the cargo tank was ready to be entered when the patrol boat SHIGIKAZE of Sakai Station arrived.

At around 13:43, the patrol boat SHIGIKAZE of Sakai Station met the Ship and her officers set about rescuing the collapsed second officer in the port No.1 cargo tank; at around 13:55, carried the second officer out of the cargo tank; and at around 14:13, entrusted the second officer to the fire and rescue service at the Sakai Station base.

The second officer was conveyed on an awaited ambulance to a hospital in Sakai City, given resuscitation treatments, but died at about 15:43.

This accident occurred at 12:26 to 29, February 7, 2012 at about 2,600 m, 204° from the south lighthouse at the south breakwater of Yamato River, Sakai-senboku. (See Figure 1 Accident Location Map)

2.2 Fatality Information

The findings according to the forensic corpse examiner's report and the information from the Sakai Station on the corpse of the second officer include as follows.

Referring to the chloroform concentration in the blood and the organs of the second officer, 25.08 μg/mℓ were detected in the blood, 48.42 μg/mℓ in the gastric contents, and 4.68 μg/mℓ in the urine. The cause of the death*12 was determined to have been oxygen insufficiency due to

*11 "vol%" is a unit to represent volume concentration. The rate of a substance occupying a volume in a certain volume is expressed in percentage. Usual oxygen concentration in the air is 20.9 vol%.

*12 "Cause of death" means a disease, injury or syndrome that irreversibly terminates the living functions of a

disabled breathing as a result of chloroform inhalation. Alcohol concentration of 1.12 mg/mℓ was also detected in the dead body.

2.3 Damage to Vessel

The Ship had no physical damage.

2.4 Crew Information

(1) Gender, Age, Certificate of Competence, etc.

1) Master: male, 33

Fourth grade maritime officer (navigation)

Date of issue: December 28, 2006
Date of revalidation: January 13, 2012
Date of expiry: December 27, 2016

2) Chief Officer: male, 26

Fourth grade maritime officer (navigation) (with limitation on duties)

Date of issue: October 16, 2006
Date of revalidation: July 26, 2011
Date of expiry: October 15, 2016

3) Second Officer: male, 56

Fifth grade maritime officer (navigation)

Date of issue: September 21, 1979
Date of revalidation: February 8, 2011
Date of expiry: May 22, 2016

4) Chief Engineer: male, 35

Sixth grade maritime officer (engineering) internal combustion (with limitation on duties)

Date of issue: July 6, 2007
Date of expiry: July 5, 2012

5) Safety General Manager: male, 59

(2) Sea-going Experience

1) Master

According to the statements and the seaman's book of the master, his experience was as follows:

a) Main sea-going experience

He worked as a deck hand on a fishing boat in July 1994, and since then had a seaman career for about 14 years. In July 2008 and on, he worked as the chief officer of the Ship; in April 2010, he belonged to Shinto Kisen Co. (hereinafter referred to as "Company B") as a seaman and continued to work onboard the Ship. He held through the seaman's career as a junior chief officer since November 27, 2011, as the chief officer since January 8, 2012, and as the master of the Ship since January 13, 2012.

b) Condition of health

He was in good health.

2) Chief Officer

---

living body. It is broadly classified into death from disease and death of external origin.

According to the statements and the seaman's book of the chief officer, his experience was as follows:

a) Main sea-going experience

He worked as a deck hand on a fishing boat in March 2002, and since then had a seaman career for about 6 years and 4 months. In July 2008 and on, he worked onboard the Ship; in April 2010, he belonged to Company B as a seaman and continued to work onboard the Ship; since January 30, 2012, he was onboard the Ship as the chief officer.

b) Condition of health

He was in good health.

3) Second Officer

According to the statements of the master, the chief officer, chief engineer, and the president of Company B, and also to the seaman's book of the second officer, his experience was as follows:

a) Main sea-going experience

The second officer had a seaman's career working on chemical tankers for a total of about 30 years. In the absence of the master or the chief officer, he sometimes worked as his deputy. On this Ship, he worked as the second officer since February 4, 2012. At the same time, he was the senior managing director of Company B, was in a leader's position for crew education, and had a strong sense of responsibility.

b) Condition of health

On the day of this accident, the second officer appeared normal, showing no mental instability. When off duty, he drunk alcoholic beverage. He had no chronic illness.

4) Chief Engineer

According to his statements and the seaman's book of the chief engineer, his experience was as follows:

a) Main sea-going experience

The chief engineer became a seaman for Company B and worked onboard a chemical tanker. On the Ship, he worked for a total of some one year, worked as the second engineer since January 8, 2012, and as the chief engineer since February 3, 2012.

b) Condition of health

He was in good health.

5) Safety General Manager

According to the data of Company A, he joined a transportation company (now Company A) in March 1976, was the executive sales department manager for some time, assumed the office of the executive marine department manager in May 2004, and was installed as the safety general manager in October 2006.

(3) Manning

According to the statements of the master and the chief engineer, the day-off system for the work on board the Ship prescribed 5 crewmembers onboard the Ship for about 3 months including about 25 off-days. According to the system, the second officer was going to assume the post of the master in his place who was soon going to take days off.

(4) Work of Second officer

According to the statements of the master, the chief officer and the chief engineer, the second officer had much experience onboard chemical tankers, and had a tendency of performing cargo tank cleaning relying on his empirical sense.

2.5 Vessel Information

2.5.1 Particulars of Vessel

Vessel number	137077
Port of registry	Bizen City, Okayama Prefecture
Owner	Kishi Kisen Co., Ltd. (hereinafter referred to as "Company C")
Charterer	Company B
Operator	Company A
Gross tonnage	388 tons
L x B x D	53.71m x 8.90m x 4.40m
Type of vessel	Type II*[13]
Hull material	Steel
Engine	Diesel engine x 1
Output	735kW
Propulsion	Fixed pitch propeller x 1
Date of launch	April 28, 2001
Navigation area	Coastal

2.5.2 Load on the Ship

According to the statements of the master, the chief officer and the chief engineer, and also to the loading & stevedoring contract, the Ship was almost fully loaded with approximately 350 tons of chloroform and approximately 150 tons of methylene chloride, to a draught of about 3.10 m at the bow and 3.90 m at the stern.

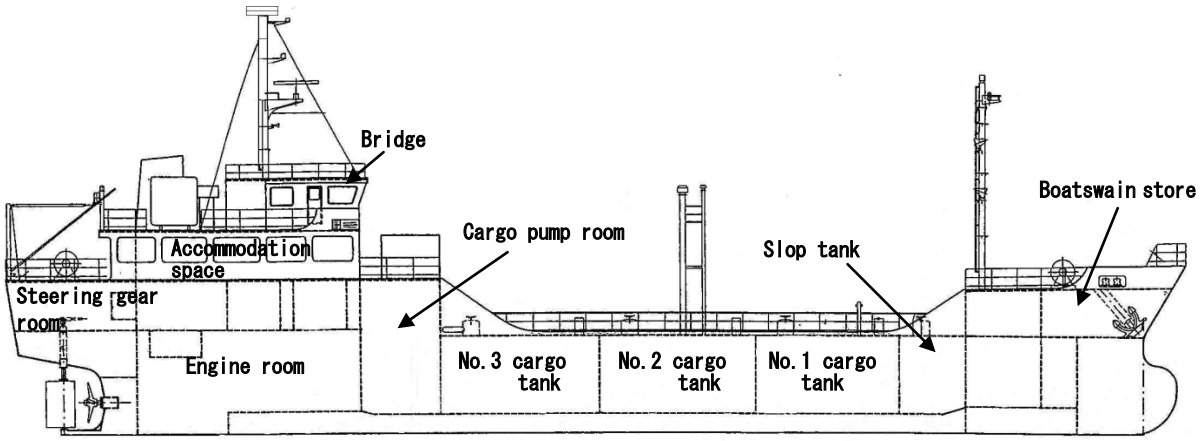
2.5.3 Other Information of the Ship

This Ship had been engaged in the domestic transportation of flammable liquids and liquid chemicals in addition to chloroform and methylene chloride.

(1) Constructional Arrangement

The Ship had a forecastle and a poop on the upper deck, and had a boatswain store on the forecastle, and a steering gear room, an engine room, and a cargo pump room, located in this order from stern to bow, at the poop. The cargo pump room was adjacent to the stern side of the No.3 cargo tank. The accommodation space was on the poop deck, and the bridge was above the accommodation space.

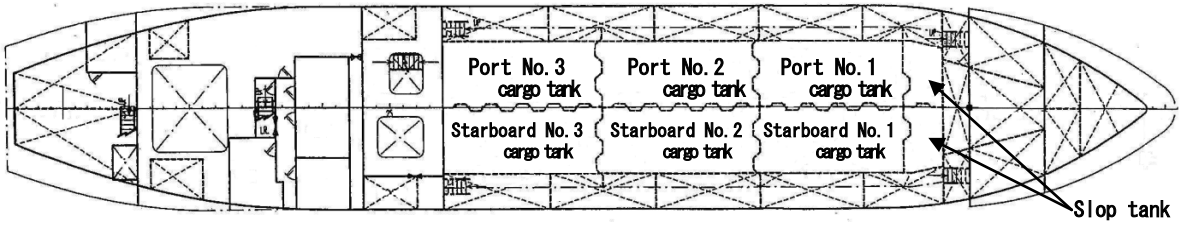
*[13] "Type II" is one of the Types prescribed in the IBC Code (international code for the construction and equipment of ships carrying dangerous chemicals in bulk). Any tanker of this Type is required to be equipped with high-level cargo outflow preventive measures to minimize risks to the environment and safety, and has a double hull construction to have the same preventive effect in the event of a stranding accident.



(Fig. 2.5-1　General Arrangement)

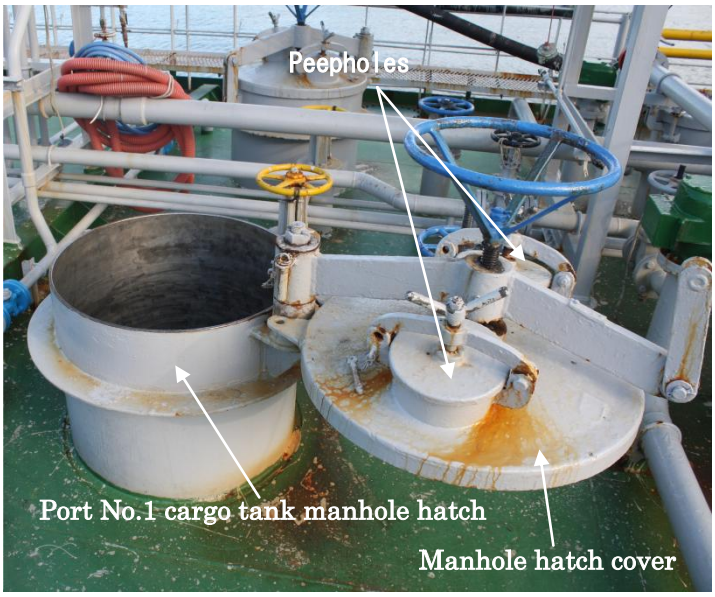
(2) Cargo Tanks

The ship had a double hull construction.　Below the upper deck were three cargo tanks, called No. 1, No. 2 and No. 3, arranged in this order from the bow side, on either side (port, starboard) of the longitudinal bulkhead extending along the centerline of the hull, 6 cargo tanks altogether.　Each of the tanks was fitted with a manhole hatch approximately 77.5 cm in diameter, and approximately 62 cm in height from the expansion trunk*14.



(Fig. 2.5-2　Cargo Tanks)

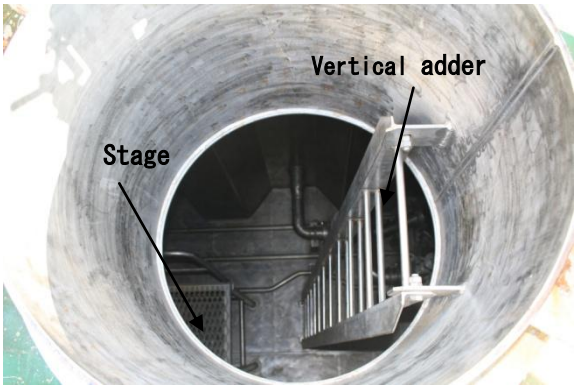
The hatch covers have two peepholes to observe liquid surface below.



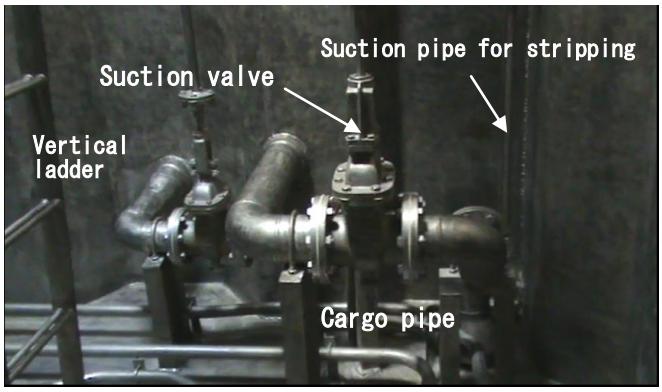
(Photo 2.5-1　Port No.1 Cargo Tank Manhole Hath)

*14 "Expansion trunk" is a space provided at the cargo tank top to minimize the danger of tank pressure rise due to cargo expansion and cargo gasification owing to temperature rise.

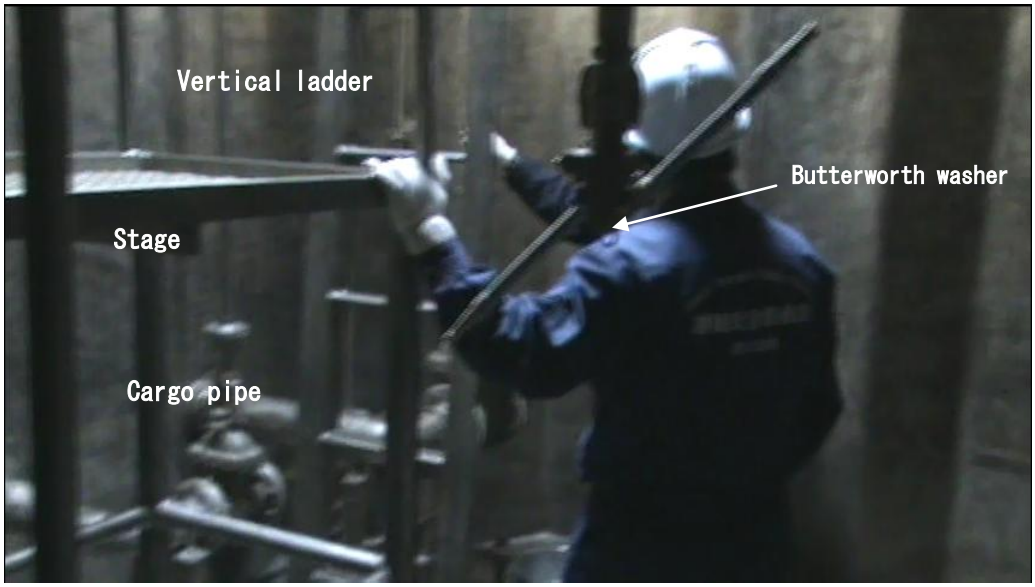
The port No.1 cargo tank was equipped with cargo piping, suction piping for stripping, and a Butterworth washer. At the place 2 m down from the top of a vertical ladder extending from the manhole hatch to the cargo tank bottom, was the stage. The length of the vertical ladder was approximately 3.5 m, and the distance from the ladder bottom end to the suction well was approximately 5 m.



(Photo 2.5-2 Vertical Ladder)



(Photo 2.5-3 Cargo Piping, etc.)



(Photo 2.5-4 Butterworth Washer, etc.)

(3) Tank Cleaning

According to the statements of the master, the chief officer, the chief engineer and the safety general manager, the operation of tank cleaning was as follows:

The usual tank cleaning operations on the Ship consisted of stripping while washing with fresh water after unloading, the transfer of the wash water to the slop tank, stripping again because the wash water comes back into the cargo tank and collects in the suction well, ventilating for at least 10 hours, and cleaning out the used wash water remainder by crewmember entering in the tank.

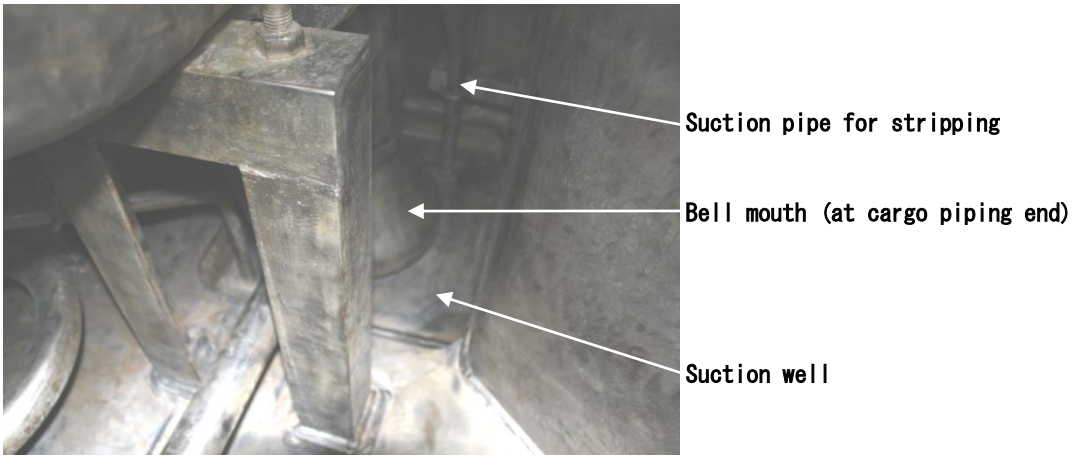
The master and the chief officer had many times experienced gas smelling when opening a manhole hatch to enter the tank after more than 10 hours of ventilation, and thought that the gas smell was due to the backflow of the used wash water remainder in the piping into the cargo tank forced by the airflow because the same piping was used for the

cargo transfer and the ventilation, and also due to the dampness which delayed drying.

Company A had not manifestly established tank cleaning procedures, including the treatment of used wash water if remained in the cargo tanks.

(4) Port No.1 Cargo Tank Capacity and Suction Well Capacity

According to the Procedure & Arrangement manual for equipment*15 (P&A manual), the Port No.1 cargo tank had a capacity of 80.164 m^3, and the suction well (44 x 38 x 6 cm) had a capacity of approximately 0.01 m^3.



(Photo 2.5-5 Suction Well, etc.)

(5) Gas-Free Device

According to the statements of the master, the chief officer and the chief engineer, the condition of the gas-free device was as follows:

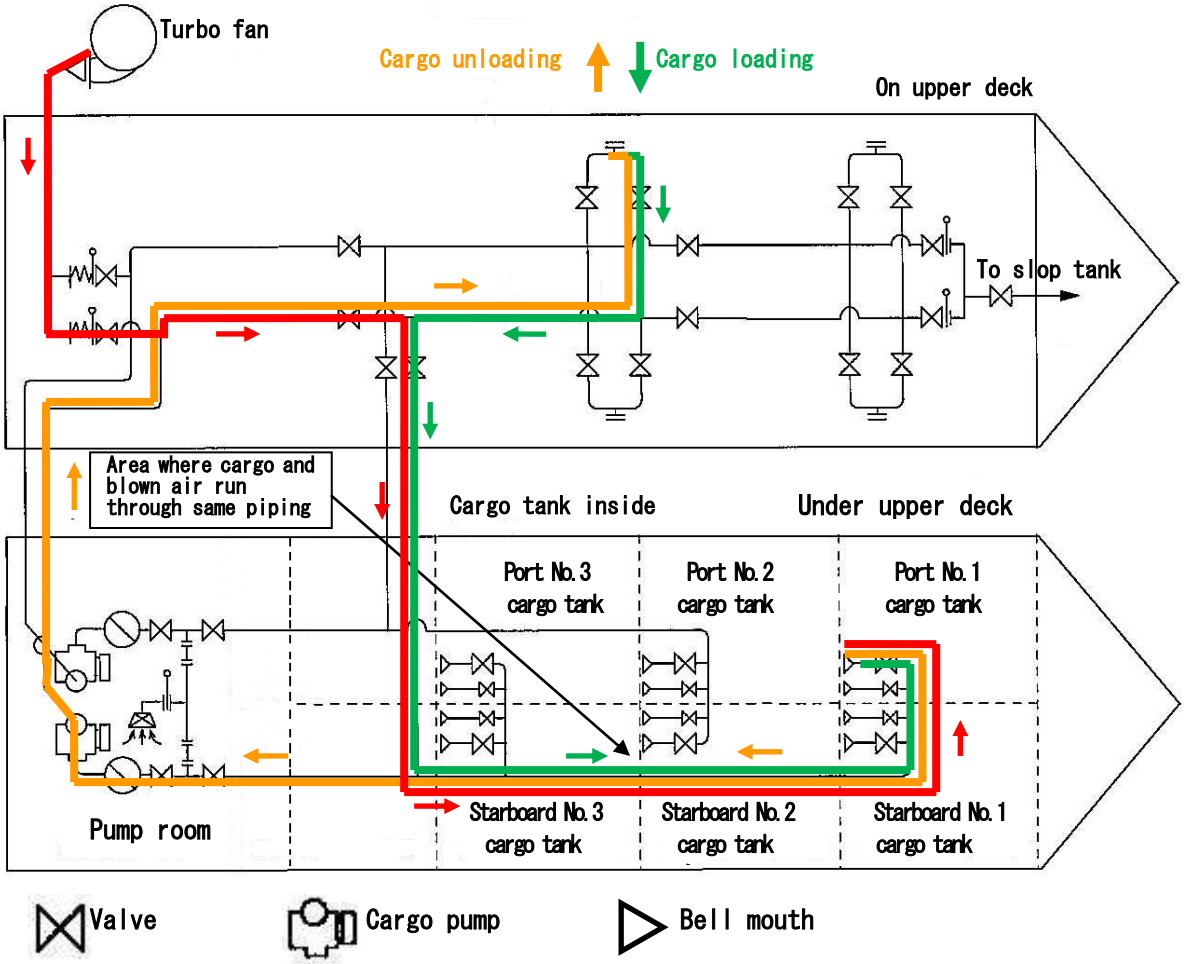
For the ventilation of the cargo tanks of the Ship, a fixed electric turbo fan was installed in the cargo pump room. After cargo unloading, the tanks were washed with fresh water, the used wash water was transferred to the slop tank, and the turbo fan was operated to ventilate the 6 cargo tanks to dry and render gas-free the inside of them. Usually, air was blown into the 6 tanks simultaneously, but owing to the turbo fan location, the force of the airflow was strongest to the tank nearest to the fan. To the port No.1 cargo tank, being farthest from the fan, the force of the air was weakest.

(6) Cargo Pump

According to the P&A manual, the cargo pumps were operated as follows:

The Ship was equipped with two gear cargo pumps driven by the main engine and two motor-driven centrifugal cargo pumps in the pump room. The centrifugal cargo pumps were used exclusively for latex, and the gear cargo pump were for cargoes other than latex. For the chloroform and methylene chloride loaded on the Ship, the gear cargo pumps were used. The cargo pumps also served as stripping pumps.

*15 "Procedure & Arrangement manual" is a manual prepared for marine contamination prevention by the owner of a chemical tanker for the operation of the tanker and approved by the District Transport Bureau Director. It prescribes the ship's equipment (tanks, pumps, tank washer, air blow washer, etc.) and arrangement, and procedures for unloading, stripping, cargo tank washing, post-washing remainder discharging, slop treating, etc. Conformance to the prescriptions including the procedures stated in the manual can satisfy all the requirements related to the legal regulations for harmful liquids. It is also called as "P&A manual".



(Fig. 2.5-3　Cargo Loading, Unloading and Pneumatic Line System Diagram)

(7) Provision for Dangerous Goods Handling Manual

The Ship was provided with the Safety Guidelines for Coastal Tankers*16 and Dangerous Goods Handling Manual*17 (operation manual) pursuant to Article 5-8 of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (hereinafter referred to as "DG Regulations") (Ordinance No. 30 of Ministry of Transport, 1957) based on the Ship Safety Act (Act No. 11 of 1933).

At the time of this accident, the hull, engine and instruments, pumps, turbo fan and other cargo handling equipment of the Ship had been in satisfactory operating conditions.

---

*16 " Safety Guidelines for Coastal Tankers" are compiled to raise crew's awareness of coastal oil tanker, chemical tanker and LPG tanker safety, to ensure their safe operations on board them, and to prevent accident. The guidelines consist of the dangerous goods handling manual, tank cleaning procedures, manual of prevention of pollution by oil, and manual of prevention of pollution by noxious liquid substances. ("Coastal Tanker Safety Guidelines" (sheaf binding), Japan Coastal Tanker Association, Seizando-Shoten Publishing Co., March 2006)

*17 "Dangerous Goods Handling Manual" is a manual provided by a ship owner, in which the properties and handling procedures of dangerous goods, including their handling in the event of an accident, and other cautions are stated in detail to prevent danger occurrence during transportation of dangerous goods. Also called an operation manual.

2.5.4　Oxygen and Gas Concentration Detectors

According to the statements of the master, the chief engineer and a representative of the oxygen and gas concentration detector manufacture, and to the operation manual of the detectors, the information about the detectors was as follows:

(1) Oxygen and Gas Concentration Detectors

The Ship was equipped with a portable detector and a pocketable detector for the measurement of oxygen and other gas concentration.　The portable detector was for simultaneously measuring the lower explosion limit of combustible gas and oxygen concentration, while the pocketable detector was for simultaneously measuring the lower explosion limit of hydrogen sulfide, carbon monoxide and combustible gases, and oxygen concentration.　They both had functions to indicate the measurements down to the first decimal place on their display and to audibly alarm if the measurement exceeds a set level. Although the both detectors were unable to measure incombustible gases, the crew of the Ship mistakenly thought that the detectors were able to measure the concentration of all gases including incombustible gases.

The oxygen and gas concentration detector manuals contained the statements requiring the users to check their specifications prior to the use of them and to apply them properly to applicable gases.

(Photo 2.5-6　Portable Detector)

(Photo 2.5-7　Pocketable Detector)

(2) Toxic Gas Detection

The Ship was furnished with "a toxic gas detector and detector tubes" (hereinafter referred to as "gas detector") but the crew of the Ship had never used them.　It was required in the operation manual and in Attached Table 8-3 pursuant to Section 10, Article 2 of the Notification*[18] providing standards for the transportation of dangerous goods by vessels (Ministry of Transport Notification No. 549, 1979), that the chemicals to which toxic gas detection is required include chloroform, and that a toxic gas detector must be used for chloroform gas detection.　Furnishing respirators and eye protectors for escaping in emergencies was also required, and the Ship was furnished with them.

*[18] "The Notification providing standards for the transportation of dangerous goods by vessels" denotes the Notification in 2b of Para. 1, Article 2 of DG Regulations.

(Photo 2.5-8　Gas Detector and Detector Tube)

2.5.5　Implementation of Onboard Safety and Health Committee

According to the statement of the master, and to the minutes of "onboard safety and health committee" and onboard training record, the implementation of education and training about safety and health was as follows:

The person who had worked as the master of the Ship till December 2011 (hereinafter "the ex-master") and the master had implemented the safety and health education and training pursuant to Article 11 of Occupational Safety and Health Rules for Seafarers (Ordinance No. 53 of the Ministry of Transport, 1964) for about one hour once every month.　On November 2, 2011, the ex-master instructed the crew to measure oxygen and other gas concentration before entering the cargo tanks and the pump room.　On January 20, 2012, the master gave cargo tank cleaning procedure instructions to the crew for confirmation.　The safety general manager and the operation manager approved the instructions.

2.5.6　Alcohol Check on the Day of the Accident

According to the statements of the safety general manager, the assistant operation manager, the president of Company B and the master, the Ship had made no alcohol check on the day of this accident but had planned to perform it after a meeting to which all the crewmembers had been expected to attend prior to berthing alongside the quay for cargo loading soon after the decision of a next destination.

2.6　Weather and Sea Conditions

2.6.1　Observed Weather Conditions

(1) Weather, Wind Direction, Wind Velocity and Temperature

The observed weather conditions at the Sakai Regional Weather Station situated at approximately 9.9 km east of the location at which this accident took place was as follows.

12:10　Weather: cloudy; wind direction: south-east; wind velocity: 2.1 m/s; temperature: 8.8ºC

12:20　Weather: cloudy; wind direction: west south-west; wind velocity: 2.0 m/s; temperature: 8.9ºC

12:30　Weather: cloudy; wind direction: west; wind velocity: 2.1 m/s; temperature: 8.8ºC

(2) Humidity

The humidity observed at the Osaka District Meteorological Observatory situated at approximately 17.0 km north-east of the location at which this accident took place was as follows.

Time and date	Humidity
Feb. 6, 20:00	87 %
21:00	88 %
22:00	90 %
23:00	92 %
24:00	92 %
Feb. 7, 01:00	94 %
02:00	94 %
03:00	95 %
04:00	95 %
05:00	95 %
06:00	92 %
07:00	94 %
08:00	93 %
09:00	91 %

2.6.2 Observation by Crew

According to the statements of the master, the chief officer and the chief engineer, it rained from the evening of February 6 till the morning of February 7. At the time when this accident occurred, it appeared the weather was changing from cloudy to fine, the wind direction was west, the relative wind velocity was about 10 m/s, and small whitecaps were seen on the sea.

2.7 Vessel Operation Management

2.7.1 Coastal Shipping Business Act

(1) Coastal Shipping Operator

Company A ran a coastal shipping business*19 specified in Section 2, Article 2 of the Coastal Shipping Business Act, was a coastal shipping operator pursuant to Article 7 of the said Act, and was required per Article 8-2 thereof to bear in mind that securing transportation safety is most important and to always strive for improving transportation safety.

(2) Instructions by the Minister of Land, Infrastructure, Transport and Tourism

(Instructions for Transportation Safety Securement)

Article 25 If the Minister of Land, Infrastructure, Transport and Tourism recognizes a fact that a coastal shipping operator or a person who filed a notice under Section 2 of Article 3 is disturbing transportation safety by the operator's or the person's business, the Minister may order the operator or the person to take necessary

*19 The "coastal shipping business" is a business of coastal shipping or a business of leasing vessels for coastal shipping.

measures for improving the transportation facilities, for compliance with the safety management manuals, and/or for securing transportation safety by other means, within a period specified by the Minister.

2 If the Minister determines it necessary for supporting the sound development of the coastal shipping operations, the Minister may advise any coastal shipping operator or any person who filed a notice under Section 2 of Article 3 to improve and/or rationalize the operator's or the person's operation and management, ship's construction, and/or the shipping business.

2.7.2 Safety Management Manuals

Company A had prepared a safety management manual pursuant to Article 9 of the Coastal Shipping Business Act, which established particulars to be abode by coastal shipping operators and designated a safety general manager, an operation manager, and an assistant shipping manager. It prescribed the implementation of safety educations as follows:

Safety Management Manual

(Safety Education)

Article 48 To the assistant operation manager, ship-owner etc.[20]*, crew, safety management personnel, and internal auditor, the safety general manager and the operation manager shall periodically give education specifically and in a manner easy to thoroughly understand about the safety management manual (including operation manual and accident treatment manual but limited to those related to ship operation), the Seaman Law, and other relevant laws and acts including the Act on Preventing Collision at Sea, as well as about anything considered necessary for securing the safety of shipping, and make those things well known to them.*

2 The ship-owner etc. shall educate the crew pursuant to Paragraph 1 above.

3 The operation manager and the ship-owner etc. shall study and research navigation course condition, marine accidents, and incidents (dangerous events that entailed no accident or other damage) and make the crew thoroughly understand them as needed, or through the education above.

2.7.3 Onboard Safety and Health Promotion Plan and Visit to Tanker

According to the statements of the safety general manager, the operation manager and the master and to the log of visits to the tanker, the related activities were as follows:

(1) Shipping Safety and health Meeting

Company A held a shipping safety and health meeting three times a year with the attendance of ship-owners, at which Company A heard comments of the ship-owners for its safety and health planning. For 2011, Company A had prepared a promotion plan with emphasis placed on the elimination of (1) cargo handling and other work-related accidents, (2) accidents at berthing/unberthing alongside a quay, (3) collision and grounding accidents, (4) marine pollution accidents, and (5) mixed contamination*[21] accidents.

---

*[20] "Ship-owner etc." is a term covering a ship owner, a ship manager, and a ship charterer.

*[21] "Mixed contamination" means the mix of the remainder of a previously unloaded liquid cargo with a newly loaded liquid cargo of a different type.

(2) Visits to Tanker

1) Implementation of Visits to the Tanker

a) For a chemical tanker, usually the cargo handling work is very busy and Company A scarcely has time to talk with crewmembers leisurely except at the time in dock. At occasions when a chemical tanker entered into the terminal in its property, Company A visited the tanker as far as possible, posted written cautions in places easy to see and gave oral instructions to the crewmembers.

b) Prior to the occurrence of this accident, Company A visited the Ship when she came into dock on August 20, 2011, and when arrived in Kawasaki and Chiba Ports on November 24 and 25, respectively. Company A had an internal audit annually.

2) Activities at Visits to Tanker

a) When the Ship Docked on August 20

The operation manager showed the crew examples of accidents, gave them instructions for safe berthing alongside a quay, the establishment of a double check system for human error minimization, the promotion of onboard communications, the strict practice of daily health care, and the awareness of dangerous cargo onboard, checked safety by a safety evaluation check list, and held a hearing.

b) When Visited on November 24

The office Manager of Company A distributed leaflets to the crewmembers, performed a regular inspection and checked per all check items, including the inspection for carrying MSDS*22 during cargo handling work, the implementation of education and training, the management of safety fittings and tools, the education and training, the management of safety fittings and tools, the operating condition of gas detectors and oxygen concentration detectors, and the measurement of oxygen and remaining gas concentrations.

c) When Visited on November 25

The assistant operation manager carried out a regular inspection always required when visiting a chemical tanker, gave warning for navigation or anchoring in waters near the Nakanose route in the Tokyo Bay after giving leaflet describing about the latest finding of a dud under the route, and directed repainting over rusted portions on the aft of the upper deck.

2.7.4 Treatment of Oxygen and Gas Concentration Detectors

According to the statements of the safety general manager, the operation manager, and the assistant operation manager, and to the summary manual of the portable detector and the oxygen concentration and remaining gas concentration measurement record table (hereinafter referred to as "measurement table") prepared by Company A, related information about oxygen and gas concentration detectors was as follows:

(1) Lending Portable Detector to Ships Operated by Company A

Some two years before the occurrence of this accident, Company A checked the oxygen and gas concentration detectors provided in the ships operated by Company A and found that

*22 "MSDS" (Material Safety Data Sheet) is a sheet in which information including the physical and chemical properties, the danger and harmfulness, and cautions for handling, of a chemical material or product containing such a material (which is subject to reporting) is stated. It is prepared by the assigner or supplier of a material, subject to reporting, to the assignee or the recipient. It is also called “product safety data sheet”.

the detector types were varied and that they were not always used properly. Company A then decided to purchase portable detectors and lend them to the ships.

The assistant operation manager visited to the Ship, instructed the usage and cautions to the master and the chief officer while operating a portable detector according to its summary manual prepared by Company A, and requested the master and the chief officer to give other crewmembers what they have learned.

(2) Usage of Portable Detector

1) Summary Manual

Company A prepared a summary manual of the portable detector and distributed its copies to ships under its operation, describing that the detector can measure the lower explosion limit concentration of oxygen and other combustible gases, that whenever the detector indicates a measured lower explosion limit concentration value, there exists a combustible gas, and that, as for an incombustible or nonflammable liquid cargo, the detector cannot measure its gas concentration but, whenever it indicates a measured oxygen concentration value lower than its usual level, entry into the cargo tanks and the pump room must be strictly prohibited, seeing that the presence of any such cargo gas can lower the oxygen concentration.

2) Action in the Event of Incombustible or Nonflammable Cargo Gas Detection

To the crew of tankers operated by Company A to carry incombustible or nonflammable cargo, Company A had given instructions to carry out a gas-free operation in the event of gas detection by 1) above.

(3) Measurement Record

1) Company A had prepared a measurement record form and furnished its tankers with this form. This record form had spaces to be filled with information, including a space for the time of measurement, a space for the duration of ventilating, a space for the check of the presence of tools for entry into tanks in emergencies, to be marked with a circle "○" if confirmed present, and a space for the check of oxygen concentration 21% and other remaining gas concentration 0%, to be marked with a circle "○" if the oxygen concentration is 21% and other gas concentration is 0%, or marked with an "X" if the oxygen concentration/other gas concentration is not 21%/0%.

2) The measurement record of the Ship (from December 29, 2011 through February 6, 2012) shows all its spaces for the check of the presence of tools for entry into tanks in emergencies and for the check of oxygen concentration 21% and other remaining gas concentration 0% marked with "○", none with "X". Ever since the introduction of the measurement record table into the Ship in March 2010, lower oxygen concentration had never been checked.

2.7.5 Gas Detectors

According to the statements of the safety general manager and the assistant operation manager, the gas detector was treated as follows:

For incombustible or nonflammable cargos, Company A had not instructed the crew to carry out gas concentration measurement using the gas detector because the use of the detector had required the replacement of its detector tube each time for a different cargo and had therefore been bothersome, and had instructed them to determine gas concentration according to 2.7.4 (2)

1).

2.7.6 Precautions for Entry into Cargo Tanks and Pump Room

According to the cautions provided by Company A for entry into the cargo tanks and the pump room, the rules were as follows:

(1) Responsible Persons

The chief officer shall be assigned responsible for entry into cargo tanks, and the chief engineer for entry into the pump room.

(2) Safety Check in Cargo Tanks and Pump Room

1) *Non-presence of remaining liquid and remaining odor shall be confirmed.*
2) *Oxygen and other remaining gas concentration shall be measured before and during operation appropriately, and the measurements shall be kept on record. The oxygen concentration shall be 21%, and other remaining gas concentration shall be 0%. If dangerous atmosphere should be noted, entry into the tanks and the room shall be prohibited.*

(3) Safety Preparations prior to Entry into Cargo Tanks and Pump Room

1) *Prepare an additional air-supply mask or an aspirator with cylinder, and a waist rope, ready for use.*
2) *Before entering the cargo tanks or the pump room, forced ventilation shall be carried out in the cargo tanks for at least one hour.*
3) *A watchman shall be posted at the outside of the manhole hatch and at the entrance of the pump room.*
4) *If the safety of the inside of the cargo tanks and the pump room has been confirmed but the ventilation of the tanks and the room has been insufficient (less than one hour) due to a fan failure or by other reason, anybody entering the tank or the room shall wear an air-supply mask or an aspirator with cylinder and a rope tied to the waist of the body.*
5) *The work shall be carried out by more than one person under the direction of the responsible person. Actions without an attendant and on his/her own judgment shall be strictly prohibited.*

(4) Oxygen Deficiency

No gas mask is effective for oxygen deficiency.

2.7.7 Accidents in 2010 and 2011 of Tankers Operated by Company A

According to the statements of the safety general manager, the operation manager and the assistant operation manager, and to the marine accident investigation reports, the accidents in 2010 and 2011 of tankers operated by Company A were as follows:

The accidents occurred in 2010 and 2011 of the tankers operated by Company A (hereinafter referred to as "the past accidents") denote the fatal accident of the crewmember of the chemical tanker KYOKUHO MARU NO.2 that occurred in the Kawasaki Section of the Keihin Port on March 10, 2010 (hereinafter referred to as "the accident 2010"), and the injury accident of the crewmember of the chemical tanker HOTOKU MARU that occurred in the Chiba Section of the

Chiba Port on July 7, 2011 (hereinafter referred to as "the accident 2011").

(1) Accident 2010

1) Outline

When engaged in the unloading work, the chief officer noticed the absence of the drain plug of the cargo tank piping and, without measuring oxygen and other gas concentration, without arranging safety rigging, and under the watch of the chief engineer from the deck, rushed into the cargo tank and died of oxygen deficiency.

2) Post-accident Actions by Company A

a) Company A established precautionary practices for entry into the cargo tanks and a procedure for checking the drain plug fitting.

b) In its activities of marine safety and health promotion plan and of its visits to its tankers, Company A newly included the prevention of oxygen deficiency and gas poisoning in the onboard education.

c) When the tanker was docked, Company A visited the tanker and gave onboard education to the crew.

In order to have the intent of a) through c) well known to the crew, and also to educate the crew on oxygen deficiency and organic solvents, Company A visited the tanker and gave the crew onboard education.

(2) Accident 2011

1) Outline

After completion of the chloroform unloading, the engine rating noticed seawater flooding out of the ballast tank air venting pipe and, without measuring oxygen and other gas concentration, and intending to close the seawater intake valve, entered in the ballast pump room, inhaled chloroform gas, and fell into a coma.

2) Post-accident Actions by Company A

a) The review of the cleaning procedures for HOTOKU MARU, sure and streamlined implementation of the cleaning works under the command of the master, and the establishment of personal positions where responsibility and authority lie.

b) The implementation of product education and overall work reeducation to the engine rating.

c) The implementation of meeting before starting onboard work, at which questions and answers, and points repetition, should be performed to ensure thorough practice.

d) The ballast pump room should be regarded as a dangerous area same as the cargo tanks and the pump room and, whenever a crewmember is going to enter there, at least two crewmembers should measure oxygen and remaining gas concentrations there beforehand.

e) The education of future newcomer seafarers for products and all kinds of work related to shipping cargoes.

Company A reported the above corrective measures of a) through e) to the Kinki District Transport Bureau and instructed them to all the crew of the tankers including this ship under its operation.

2.7.8 Evaluation of Transport Safety Management, and Instructions on Safety Securement

According to the statements of the assistant operation manager and a Safety Management and Seafarers Labor Inspector of the Marine Safety Environment Department, Kinki District Transport Bureau, on August 7, 2007, the Kinki District Transport Bureau executed a transport safety management evaluation*23 of Company A, appreciated the Company A's effort for maintaining communication with on-site crew, and expressed expectations for further improvement in the maintenance and enhancement of the Company A's safety management system in future as follows.

1) The continuation of more explicit leadership and commitment by the top management.
2) The establishment of an education and training system necessary for the maintenance and improvement of the safety management system.
3) The implementation of internal audit related to the safety management system, and the establishment of a process of reviewing the system following the audit.

2.7.9 Ship Operator, Owner and Charterer

According to the statement of the assistant operation manager, the relation between the Ship operator, owner and charterer was as follows:

Company C was the owner of the ship and chartered it to Company B.

Company B chartered the ship from Company C, maintained it, arranged crew manning, and executed labor management of the crew.

Company A managed shipping schedules for cargoes consigned from shippers, and provided safety operation instructions to ships under its operation and to Company B.

2.8 Information of Cargoes

2.8.1 Chloroform

(1) Properties

According to the product safety data sheet, the international chemical safety card*24, and the P&A manual, the properties of chloroform are as follows:

1) Chloroform is an incombustible toxic liquid, and a noxious liquid substance of Type Y*25 defined in Attached Table 1 of Article 1-2 of the Law Enforcement Ordinance for prevention of marine pollution and marine accidents (Cabinet Order No. 201).
2) Chloroform vapor is 4.1 times heavier than air and is liable to stay on low surfaces. It can anesthetize the human body. When a person has taken in an alcoholic beverage, he/she may be disabled to fully sense the presence of the vapor even if it is in excess of the tolerable concentration limit – a property to which careful caution should be paid.
3) Chloroform has sweet smell and its threshold value*26 is 200 ~ 300 ppm*27. Chloroform can be taken into human body through mouth and skin and by inhalation, and its acute

*23 The “transport safety management evaluation" is based on a governmental system, according to which the government can evaluate the establishment and its continuous improvement of the total safety management system of a shipping operation business covering all its corporate actions, including that of top management through middle office to line sections. As a result, the government can give suggestions to improve the safety consideration, if necessary.

*24 An "international chemical safety card" (ICSC) is a card in which important information concerning the effects of chemicals on health and safety are collectively summarized.

*25 "Type Y" is one of the following three types of noxious liquid substances classified according to their danger to marine resources and human health as: Type X (Major hazard), Y (Hazard), and Z (Minor hazard).

*26 "Threshold value" is the minimum value of stimulation needed for exciting the sensation of a living body.

*27 200 ~ 300 ppm = 0.02 ~ 0.03 vol%. 1,000 ppm = 0.1 vol%

symptoms include coughing, giddiness, lethargy*28, headache and nausea. It can affect the central nervous system, cardiovascular system, digestive tracts, liver, and kidneys, to cause the loss of consciousness and the cessation of breathing to eventual death.

200 to 300 ppm: the smell-sensible lowest level
400 ppm: endurable for 30 minutes without complaint
1,000 ppm: 7-minute exposure causes giddiness, headache and nausea, and leaves a sense of exhaustion and headache several hours later
1,500 ppm: giddiness in several minutes
4,000 ppm: nausea and faint
15,000 ppm: anesthetic and dangerous

(2) Unloading Work in the Past

According to the statement of the chief officer, the crew were engaged in unloading chloroform from the Ship on 19th through 21st February 2011 at the Kobayashi Terminal and, after finishing the unloading, cleaned the inside of the cargo tanks as usual, performed stripping and the ventilation for about 13 hours and cleaned out them, completely removing water remainder there. There was no trouble.

2.8.2 Other Cargoes

The cargo record book*29 of the Ship shows that the Ship carried various liquid cargoes including combustible and toxic liquids, in addition to chloroform and that, in about 7 months since July 2011 till the occurrence of this accident, it carried a total of 28 kinds of noxious liquid substances.

2.9 Safety and Emergency Response on Chemical Tankers

The Coastal Tanker Safety Guidelines describes as follows:

(1) Awareness of Safety

It should be borne in mind that in most cases the cargo of a chemical tanker has various potential dangers, including the danger of fire and explosion, the danger of poisoning, the danger due to corrosion, the danger due to chemical reactions, the danger due to high or low temperatures, the danger due to high pressure, the danger of suffocation (oxygen deficiency), and the hazard to sea and air pollution. The cargo may differ from time to time but one cargo usually has more than one danger. Whatever a cargo may be, having sufficient preliminary study and previous knowledge of it is necessary.

1) Toxic Material

First of all, fully recognize the characteristics of the toxicity of the cargo by the use of its information and data, and properly handle it without unreasonable fear.

When entering into an enclosed area (a cargo tank from which a toxic liquid cargo has been unloaded, a pump room when a toxic liquid is being loaded or when washing there is not made yet, or a vacant space around a cargo tank loaded with a toxic liquid), always follow instructions of the responsible person.

---

*28 "Lethargy" is a state in which an individual soon falls asleep if left undisturbed, is dull against stimulations, and does not wake up easily.

*29 "Cargo record book" is a record book for noxious liquid substances in which cargo loading, cargo tank inside washing, wash water discharge, and other information are recorded.

When carrying out tank washing and rendering gas-free after cargo unloading, work under the direction of the responsible person because the danger of personal accident (gas poisoning by toxic gas) is high.

2) Multiple Dangers

Assume that a cargo of a chemical tanker mostly has multiple dangers. Assume that a toxic material is also corrosive, and that a reactive material or a material in need of low or high temperatures is also harmful. Most of organic compounds produce a combustible (flammable) gas.

For cultivating comprehensive assessment and for wearing proper protectors against multiple dangers, provide onboard education and training. Practice working under the instruction, direction or supervision, avoiding acting on the worker's own judgment even for a short work.

(2) Basic Practices

1) Gas Detection

Onboard gas detection is indispensable for security. Even when rendering gas-free has been performed and there is no gas smell, practice safety check using a gas detector. In addition to flammable gas detection, a chemical tanker requires gas concentration measurement. In this connection, learn that the type and the usage of a detector tube vary from gas to gas applicable. Master, therefore, the proper use and usage of detector tubes.

Oxygen concentration measurement is indispensable for work in a chemical tanker. In addition to gas detection, also always measure oxygen concentration not only when entering an enclosed space to which no body usually has access but when entering a cargo tank.

2) Danger of Enclosed Areas

Before entering a cargo tank, ensure that the responsible person has confirmed a gas-free state and the safety there by flammable gas, toxic gas and oxygen concentration measurements, and wear proper protectors. For this entering, the use of a safety rope and the presence of a watchman are required. Even for a several-minute work, or even for rescuing a poisoned and fainted crewmember, never enter there impulsively without the necessary prearrangements.

3) Traffic to Enclosed Areas

When approaching to an enclosed area, make sure of the following.

(1) Have instructions of the responsible person. (2) Ensure that safety has been confirmed by the measurement of flammable/toxic gas and oxygen concentrations. (3) Have an attendant stationed at or near the entrance to it. (4) Ensure that a proper ventilator is operating. (5) Ensure that a hoist, rescuing rope, and a stretcher are ready for use. (6) Provide rescuing protectors near the entrance. (7) Always form a team of two persons each for entering and for attending, respectively, between whom the work to be done, the working procedure and signaling should be mutually understood. (8) For respirators, lifelines, lights, tools and other safety provisions, follow the instructions of the responsible person. (9) In the event of a leak or other anomaly, stop working at once and have instructions of the responsible person. (10) As long as a person is in an enclosed area, continue keep draft (ventilation) gas concentration measurement.

(3) Rescue in Enclosed Area

Cautions in the event of an accident in an enclosed area are as follows.

1) There should be no impulsive actions. (Calm judgment is important to avoid involvement of even the rescuer in the accident.)

2) Report should be given immediately to the person in charge or to the bridge by an alarm or other means. (The finder should not act on his own judgment.)

3) Support should be waited for (until a necessary number of rescuers gather).

4) No one should enter into the area without wearing a respirator and other protectors.

5) No rescuer should enter into the area unless an attendant for the rescuer is posted at the entrance.

6) Rescuing actions should be carried out promptly but carefully and with composure.

2.10 Medical Information

2.10.1 Amount of Alcoholic Liquor Taken in, Alcohol Concentration in Blood, and General Symptom of Inebriety

According to the literature*30; concerning the phases of inebriety and the amounts of alcoholic liquor taken in, generally, the blood alcohol level of 1.00 to 1.50 mg/mℓ is regarded as the early phase of inebriety, after drinking three caps (540 mℓ) of sake, in which the drinker may swing loosely, if tries to stand up.

2.10.2 Symptom due to Drinking

According to the statement of Assistant Director of National Hospital Organization Kurihama Alcoholism Center*31, a symptom due to drinking is as follows:

The blood alcohol level of 1.12 mg/mℓ suggests an early phase of inebriety, that is, a not strong inebriation. The blood alcohol level and inebriety is proportional but greatly varies from drinker to drinker. The same level does not cause the same symptom. For a habitual drinker, the early phase will not maintain his soberness but may merely cause him somewhat talkative.

2.10.3 Effect of Ethanol Intake upon the Sense of Smell

According to the literature*32:

16 adult subjects (8 male and 8 female) were examined for the effect of ethanol*33 intake. They all showed higher threshold values under the ethanol condition than those under the non-ethanol condition, denoting a noticeable effect in ethanol detection threshold value.

2.10.4 Causes of Death due to External Causes

According to the literature*34, causes of death due to external causes are explained as follows:

There are cases where morphological impairment (e.g., cerebral contusion) directly leads to the cause of death, where impairment (e.g., thermal injury), expressing an external cause acting

---

*30 The literature: "Alcohol and Health" published by Taiheisha (issued by Health and Medicine of Alcohol Association in April 2005).

*31 On April 1, 2012, "the Center" was renamed National Hospital Organization Kurihama Medical and Addiction Center.

*32 The literature: Suketu J. Patel ; Andrew D. Bollhoefer ; Richard L. Doty.Influences of ethanol ingestion on olfactory function in humans.Psychopharmacology.2004, vol.171, 429-434.

*33 "Ethanol" is a liquid having a characteristic smell, is a kind of alcohol, and is the main constituent of sake.

*34 The literature: “Essentials of Forensic Medicine” (2011 Revision) by lecturer Toru Oshima, Forensic & Sociological Environmental Science, Medical Section in Medical/Pharmacological/Health Research, Kanazawa University.

on a living body, directly leads to the cause of death, where a functional loss (e.g., suffocation) leads to the cause of death, and where a symptom caused by damage (e.g., traumatic shock) directly leads to the cause of death.

Suffocation, mentioned as a typical example of the functional loss leading to the cause of death, is a state of the functional loss of a living body owing to oxygen deficiency induced by obstruction to oxygen intake and carbon dioxide discharge which are indispensable to individual life. It is classified into external suffocation*35 and internal suffocation*36. Internal suffocation originates from anemia (owing to quantitative or qualitative anomaly of hemoglobin), circulatory malfunction (owing to oxygen supply shortage due to blood stream anomaly (e.g., heart failure)), or a histotoxic condition (in which brought-in oxygen cannot be used on account of the malfunction of cells themselves). Typical histotoxic examples include chloroform poisoning, hydrocyanic poisoning, and urine poisoning.

2.11 Cases of Crewmember Death Accidents Owing to Oxygen Deficiency and Gas Poisoning

According to the marine accident investigation reports of the Japan Transport Safety Board (JTSB) and the written judgment of the former Marine Accident Inquiry Agency, 17 death accidents owing to oxygen deficiency and gas poisoning have occurred on chemical tankers since 1989 (or since 2008 as to JTSB). The causes of them were as follows.

(1) No oxygen or gas concentration measurement was performed. (14 cases)

(2) Pump shaft seal maintenance, wearing of respirator, and stationing an attendant were not performed. (1 case)

(3) Mixed slop tank wash water caused chemical reactions. (1 case)

(4) Gas generated in the cargo hold leaked into the crew cabins because the cargo hold ventilation duct had been removed. In addition, the shipper, when entrusting the cargo, did not identify it as a dangerous cargo to the operation manager, and the operation manager did not check the cargo for its danger.

(See Attached Table 1 Accidents Related to Oxygen Deficiency or Gas Poisoning)

2.12 Other Necessary Information

According to the statement of the chief officer, the time required for the usual work was as follows:

Concerning the usual work on such chemical tankers as the Ship of less than 500 tons, the time required for fitting the cargo piping drain plug was 1 minute 30 seconds to 2 minutes 00 seconds, for closing the seawater intake valve in the ballast pump room was similarly 1 minute 30 seconds to 2 minutes 00 seconds, and for completely removing wash water remaining in the suction wells in the cargo tanks was 15 to 20 minutes (3 to 5 minutes per crewmember as this work is carried out in shifts of some crewmembers), respectively. Each of the work was finished in a short time.

---

*35 "External suffocation" means the functional impairment of external respiration (the process covering from inhalation till the gas exchange with blood in pulmonary alveoli.).

*36 "Internal suffocation" means the impairment of internal respiration (gas exchange between blood and tissues).

3 ANALYSIS

3.1 Situations of the Accident Occurrence

3.1.1 Course of the Events

From 2.1, it is probable that the course of the events was as follows.

(1) Operations on Days before the Accident

1) The Ship, with the master, the second officer and other three crewmembers onboard, and with approximately 150 tons of chloroform loaded in the No.1 and No.3 cargo tanks, and approximately 150 tons of methylene chloride in the No.2 cargo tanks, left the Section 1 of Tokuyama-kudamatsu Port at around 16:10 on February 4. The Ship had its cargo unloaded at the Kobayashi Terminal and left the terminal at around 14:05 on February 6, after that, had the inside of the cargo tanks cleaned, and arrived at the Komatsu Wharf at around 16:55.

2) The master confirmed that the Ship had no scheduled duty yet until a notice was given from Company A on the following day of February 7, and had the inside of the No.1 through No.3 cargo tanks dried by the operation of the turbofans seeing that the chloroform wash water in the cargo tanks had been cleaned out. At the same time, the master kept ventilating the tanks for about 13 hours till the following day to render them gas-free.

(2) Situations between Departure from Komatsu Wharf and Occurrence of the Accident

1) At around 12:00 February 7, the master stationed himself in the bridge, the chief and the second officers on the bow, the chief engineer and the engine rating on the stern, respectively, and at around 12:10, the Ship left the Komatsu Wharf for the Umemachi Terminal.

2) The chief and the second officers arranged between them to check the inside of the cargo tanks on the starboard by the chief officer, and on the port side by the second officer. At around 12:25, the chief officer came near the starboard No.1 cargo tank, and he told the second officer, who were near the port No.1 cargo tank, to open the cargo tank manhole hatch cover.

3) When the second officer was opening the hatch cover, the chief officer perceived chloroform smell, and told the second officer not to enter in the cargo tank. Starting at around 12:26, he measured oxygen concentration in the starboard No.1 and the No.2 cargo tanks in this sequence, using a portable detector.

4) At around 12:29, the chief engineer looked into the port No.1 cargo tank through its manhole hatch whose cover had been opened, found the second officer collapsed as if leaning against the bulkhead near the suction well, and reported the finding to the chief officer and the master.

(3) Rescue Operation

1) On receipt of the chief engineer's report, the master dropped the anchor at about 34° 34' N and 135° 23' E, directed the chief engineer to stay in the bridge, came to the port No.1 cargo tank, stepped down into the cargo tank four times, trying to carry up the second officer, but smelt gas each time and vainly came out of the tank.

2) The master reported this accident to Company A and, at around 12:47, dialed 118 for rescue.

In the meantime, air was blown into the port No.1 cargo tank to render the tank inside dry and gas free.

3) The Sakai Station dispatched the patrol boat SHIGIKAZE to meet the Ship at around 13:43 for rescuing the second officer and, SHIGIKAZE carried the second officer out of the port No.1 cargo tank at around 13:55, and transferred the second officer to the fire and rescue service. The second officer was carried to the hospital but was confirmed dead there.

3.1.2 Date and Location of the Accident Occurrence

From 2.1, it is probable that the accident occurred at a time between 12:26 and 12:29 of February 7, 2012 at a location near 204°, 2,600 meters from the south light house at the south breakwater at Yamato River, Sakai-senboku.

3.1.3 State of the Fatality

Based on 2.1.2, 2.1.3, 2.2, 2.10.4 and 3.1.1 (3) 3), it is probable that the cause of death was as follows.

The second officer collapsed as he was removing chloroform remainder in the suction well of the port No.1 cargo tank. He was carried out of it by the Japan Coast Guard, transferred to the fire and rescue service and then to a hospital, where he was given resuscitation treatment but confirmed dead at around 15:43.

Chloroform gas inhalation and subsequent breathing disability resulting in oxygen deficiency was determined by examination to have been the cause of the death, because chloroform was detected in the body of the second officer.

3.2 Causal Factors of the Accident

3.2.1 The Crew and the Ship

(1) Crew

The master, the chief officer, the second officer and the chief engineer had a legal and valid certificate of competence, respectively.

(2) The Ship

According to 2.1.1, 2.1.2 and 2.5.3:

1) On the day before this accident, the chloroform wash water in the port No.1 cargo tank had been transferred to the slop tank of the Ship, and the chief engineer had confirmed thereafter no presence of the wash water remainder in the suction well. On the day of the accident, gas smelt in the cargo tank and the wash water remained in the suction well. It is somewhat likely, therefore, that wash water that had remained in the piping was forced out into the cargo tank when air was blown through the piping.

2) It is probable that the hull, engine, machines including pumps and turbo fans, and other cargo handling equipment of the Ship were not in out of order.

3.2.2 Weather and Sea Condition

From 2.6, it is probable that the weather and the sea condition at the time of this accident were cloudy, with the atmospheric temperature of approximately 8.8°C, and the wind velocity of approximately 2.1 m/s in a westward direction. The humidity at between 20:00 February 6 and 09:00 February 7 was high, 87 to 95%.

3.2.3 Analysis of Effect of Drinking Alcoholic Liquor

Reasoning by 2.1.2, 2.2, 2.4 (2) 3), 2.4 (4), 2.8.1 (1), and 2.10.1 through 2.10.3:

(1) Whether Sober or Not

On the day of the accident, the second officer carried out work, including the preparation for Ship's anchoring in the Umemachi Terminal, and looked just as usual, but the examination of his corpse indicated a blood alcohol level of 1.12 mg/mℓ. It is probable therefore that he worked in the early stage of inebriation.

(2) Recognition of Chloroform

Seeing that the second officer was found collapsed in the port No.1 cargo tank, wearing an organic solvent mask and gloves, it is probable that he had recognized the toxicity of chloroform, although he had had a disposition to rely on his empirical sense when cleaning the cargo tank inside.

(3) Effect of Liquor on the Sense of Smell

From (1) above, it is probable that the second officer was working in the early stage of inebriation. By the fact that, if the sense of smell should be affected by a taken-in alcoholic liquor, the chloroform gas smell is not perceived even when it exceeds the 200 to 300 ppm level which is the lowest limit the sense of smell can perceive, and also by the fact that the drinking affects the sense of smell to show a high threshold value, it is somewhat likely that the sense of smell of the second officer was in a dull state to perceive the chloroform gas smell.

Thus, it is somewhat likely that the second officer had been in a dull state to perceive chloroform gas smell, though he had recognized the toxicity of chloroform, when he entered the port No.1 cargo tank.

3.2.4 Analysis of Action without an Attendant

Based on 2.1.2 and 3.1.3, it is probable that the second officer nodded in consent as he was warned by the chief officer against entering the port No.1 cargo tank, but, noticing chloroform wash water remainder in the suction well, he dared to enter in the cargo tank on his own judgment to remove the remaining wash water, against the warning of the chief officer, while the chief officer was away toward the accommodation space to fetch the both detectors.

3.2.5 Analysis of Cautions for Entering the Cargo Tanks

Based on 2.1, 2.5.3 (2), (3), 2.7.6 and 3.2.1 (2) 1), it is probable that the procedure for entering the cargo tanks was as follows:

For checking the port No. 1 tank inside condition on the Ship at the time of this accident, it was necessary to check chloroform wash water through the peep hole in the manhole hatch cover to see if there was any remainder or not; and if it remained, it was necessary to remove the remainder by stripping, to ventilate the tank to dry it and render it gas-free, and to measure oxygen and other gas concentration.

Company A had provided precautions for checking residual liquid and residual smell in the cargo tanks for entry there, but had provided no tank cleaning procedure in cases of wash water

remaining there. In the event of wash water remaining in the cargo tanks, therefore, the above-mentioned actions were not taken on the Ship.

3.2.6 Analysis of Measurement of Oxygen and Other Gas Concentration

According to 2.1.2, 2.4 (4), 2.5.4, 2.7.3 through 2.7.6, 2.8.1 (1), 2.9 (2) and 3.2.3, the measurement of oxygen and other gas concentration were carried out as follows:

(1) Measurement of Oxygen and Other Gas Concentration by Second Officer

1) It is certain that, when the second officer was entering the port No.1 cargo tank, the chief officer was away to the accommodation space to fetch the both detectors, and that this meant that the second officer had no detector and did not measure oxygen and other gas concentration.

2) It is probable that, for entry in the cargo tanks, Company A had provided instructions that work in the tanks must be done by at least two crewmembers under the direction of the responsible person, strictly prohibiting working without an attendant or on the crewmember's own judgment, and had provided education and training for the Ship's crew in the ship visiting activities and by prepared materials, and that 1) above, however, shows that the cautions to the crew of the Ship for measurement of oxygen and other gas concentration when entering the cargo tanks had not been thoroughly observed.

(2) Instruction for Measurement of Oxygen and Other Gas Concentration by Company A

1) In the Notification of Requirements for Carrying Dangerous Goods by Vessels, chloroform is specified as a toxic incombustible liquid whose gas concentration must be determined by a gas detector or the like.

2) It is probable that Company A had explained the master and the chief officer that the concentration of incombustible and nonflammable gases was undeterminable by a portable detector, but had not sufficiently explained the same to the crew of the Ship to their due understanding of it, seeing that they had thought that it could measure oxygen concentration and could measure the concentration of all gases including incombustible gases.

3) It is probable that Company A had been aware of the necessity of using a gas detector or so for the measurement of incombustible and nonflammable gas concentration, but in view of the bother of replacing detector tubes for different cargoes, had not instructed the crew for the use of a gas detector and, instead, guided them to determine the presence of incombustible and nonflammable gases by the decrease in oxygen concentration, and that Company A probably had not instructed the crew in accordance with the Notification of Requirements for Carrying Dangerous Goods by Vessels, and the Safety Guidelines for Coastal Tankers.

(3) Danger of Judging Chloroform Gas Presence by Decrease in Oxygen Concentration

1) A portable detector is designed for measuring the lowest explosion concentration limit of oxygen and other combustible gases, and a pocketable detector is for measuring the lowest explosion limit of hydrogen sulfide, carbon dioxide and combustible gases and the concentration of oxygen. They are unable to measure the concentration of other gases, and their specifications should be made sure of for their proper use.

2) It is probable that Company A had instructed the crew of the Ship to determine the presence

of a incombustible or nonflammable gas by the decrease in oxygen concentration, and that the instruction of Company A was incorrect because, if the presence of any gas other than oxygen were to be determined by the decrease in oxygen concentration, a decrease in oxygen concentration by 0.1 vol% displayed on the both detectors corresponds to the chloroform concentration of 1,000 ppm, exposure to which for 7 minutes could cause giddiness, headache and nausea, could leave headache and a feeling of exhaustion even after several hours later, and thus could dangerously affect human body.

3.2.7 Analysis of Accidents of Ships Operated by Company A

According to 2.4 (4), 2.5.3 (1), (2), 2.7.6, 2.7.7, 2.9, 2.12, 3.2.4 and 3.2.6 (1) 1), accidents of ships operated by Company A had occurred as follows:

(1) Situations up to this Accident and Past Accidents

It is probable that the causal factors that led to the accidents of the crewmembers were as follows.

1) No implementation of measurement of oxygen and other gas concentration at the entry into the cargo tank or the ballast pump room.
2) Entry into the cargo tank on the crewmember's own judgment.

(2) Measurement of Oxygen and Other Gas Concentration

It is somewhat likely that the victims of this and the past accidents had not measured oxygen and other gas concentration at the entry into the cargo tank or the ballast pump room, assuming that the lack of the measurement would cause no problem.

(3) Action without an Attendant

It is probable that the victims of this and the past accidents had had previous experience of entering the cargo tanks or the ballast pump room for the purpose of fitting the drain plug, closing the seawater intake valve, and performing the removal of wash water, and that they had so entered the cargo tanks or the ballast pump room reckoning that any of the said work was accomplishable by themselves in a short time even if they smelt gas there because the distances from the upper deck to the cargo tank and the pump room were short.

Thus, it is probable that, although Company A had made a practice of visiting the ship with the accident of 2010 as motivation and implemented crew education and training for the ships operated by the company for accident recurrence prevention, measurement of oxygen and other gas concentration for entry into the cargo tanks and the ballast pump room had not been practiced and the crewmembers entered there by themselves on their own judgment had been made on the Ship, and that the lessons from the past accidents and the recurrence preventive measures had not been fully made use of, eventually to see this Accident.

3.2.8 Past Accidents of Crewmember Death or Injury by Oxygen Deficiency and Gas Poisoning

17 accidents of crewmember death or injury owing to oxygen deficiency or gas poisoning on chemical tankers have occurred since 1989, 14 of which featured non-implementation of oxygen and other gas concentration measurement, as stated in 2.11.

3.2.9 Possibility of Secondary Accident and Rescuing in Enclosed Area

According to 2.1.3, 2.9 (3), 3.1.1 (3) 1) and 3.1.3, there was a possibility of a secondary accident as follows:

It is probable that the master entered the port No.1 cargo tank 4 times to rescue the second officer but each time he returned out of there in about 30 seconds as he smelt gas and felt its danger, and that chloroform gas was actually present in the cargo tank and there was the potential danger of the secondary accident.

It is probable that, for rescuing a person in an enclosed area, it is necessary to educate that the finder of the person should not take actions impulsively or on his/her own judgment but should immediately report the finding to the bridge and wait until necessary rescuing personnel arrive, that entering into an enclosed area in harmful atmosphere and rescuing a person there is not easy, and that the inhalation of chloroform gas in the cargo tank will cause breathing disability and oxygen deficiency to disable safe return; that is, it was necessary to establish measures to respond to accidents or other emergencies through education and training.

3.2.10 Analysis of This Accident

According to 2.1.2, 3.1.1, 3.2.1 (2) 1), and 3.2.3 through 3.2.6 (1), this accident occurred as follows:

(1) It is probable that the Ship, with the master, the second officer and other 3 crewmembers onboard, and loaded with chloroform and methylene chloride, was unloaded at the Kobayashi Terminal at around 14:05 February 6, left the terminal, had then its cargo tank inside washed with fresh water, had the used wash water transferred to the slop tank, and arrived at the Komatsu Wharf at around 16:55.

(2) It is probable that the master operated the turbo fan to dry the inside of the No.1 to No.3 cargo tanks and continued the turbo fan operation till the morning of February 7 for 13 hours to render there gas-free.

(3) It is probable that the chief and the second officers arranged between them the charge for checking the cargo tank inside condition, assigning the chief officer to the cargo tanks on the starboard side and the second officer to those on the port side, that the chief officer directed the second officer to open the port No.1 cargo tank hatch cover at around 12:25, felt the smell of chloroform when the second officer was opening the hatch cover, warned the second officer not to enter the cargo tank, went to the accommodation space to fetch the both detectors, and at around 12:26 measured oxygen concentration in the starboard No.1 cargo tank and then the starboard No.2 cargo tank using the detectors.

(4) It is somewhat likely that, seeing that the inside of the port No.1 cargo tank smelt gas and that the chloroform wash water remained in the suction well, the wash water which had remained in the piping was forced back into the cargo tank by the airflow.

(5) It is certain that the second officer did not measure the oxygen and other gas concentration because the chief officer was away to the accommodation space to fetch the both detectors.

(6) It is probable that the second officer entered the port No.1 cargo tank on his own judgment to remove the chloroform wash water that had remained in the suction well of the cargo

tank.

(7) It is somewhat likely that the second officer had known the toxicity of chloroform but his sense of smell had been blunted by preceding liquor drinking as he entered the port No.1 cargo tank.

(8) It is probable that Company A, although it had provided cautions for the necessity of checking remaining liquid and remaining smell for entry into the cargo tanks, had manifested no tank cleaning procedure to be followed in the event of wash water found in the cargo tank, and that consequently the removal of remaining wash water by stripping, subsequent drying, rendering gas-free, and measurement of oxygen and other gas concentration, which were required in the event of the presence of used wash water remaining in the cargo tank, were not performed.

(9) It is probable that Company A had provided cautions, education and training for the crew of the Ship by means of visits to her and others for entry into the cargo tanks, but the caution instructions for measurement of oxygen and other gas concentration, the posting of attendant, and the prohibition of work without an attendant at entry into the cargo tanks had not been fully observed on the Ship, seeing that the second officer entered into the port No.1 cargo tank by himself without carrying out measurement of oxygen and other gas concentration.

(10) It is probable that at around 12:29 the chief engineer noticed the port No.1 cargo tank manhole hatch cover being open, looked into the cargo tank, found the second officer collapsed as if leaning against the bulkhead near the suction well, and reported the finding to the chief officer and the master.

(11) It is probable that the master entered the port No.1 cargo tank four times to rescue the second officer, but each time smelt gas, felt its danger, could not rescue him, and ventilated the tank, and that later the second officer was carried out of the tanks by the Coast Guard, transferred to the fire and rescue service, sent to the hospital, but was confirmed dead there.

(12) It is probable that the second officer entered the port No.1 cargo tank, where the wash water had remained with a smell of gas, and inhaled the chloroform gas and died there because Company A had not made the crew well accustomed to taking careful actions when entering the cargo tank, including measurement of oxygen and other gas concentration, and also because Company A had not manifestly established tank cleaning procedures in case of wash water found remaining in the cargo tank.

(See Attached Fig. 2　Causal Factors of this Accident (Summary))

3.3 Analysis of Measures to Minimize Damage

According to 2.1.2, 2.1.3, 2.7.2, 2.7.3, 2.9 (1) and 3.2.4 through 3.2.6, the necessary measures to minimize damage are as follows:

It is certain that when the second officer was entering the port No.1 cargo tank he did not measure oxygen and other gas measurement because the chief officer had then been away to the accommodation space to fetch the both detectors.

It is highly probable that, if the second officer had removed by stripping the chloroform wash water remaining in the suction well of the port No.1 cargo tank, had the inside of the cargo tank rendered gas-free by ventilating the tank and had secured safety by measuring oxygen and other gas concentration with the gas detector as he decided to enter the cargo tank, he would not have entered the cargo tank where the chloroform gas remained and could have evaded the accident.

Considering that Company A had not manifested tank cleaning procedures for treating used wash water if remained in the cargo tanks, it is probable that the used wash water remaining in the cargo tank of the Ship was not treated by the afore-mentioned procedures.

It is probable that Company A had had poor knowledge of the gas concentration detectors as seen from the Company A's incorrect instructions to the crew of the Ship of determining the presence of incombustible and nonflammable gases by decrease in oxygen concentration, and that the instructions of Company A to the crew about the usage of the portable detector had been understood not properly but differently by the crew.

Thus, it is considered necessary for Company A to acquire the knowledge of gas detectors suited for cargoes; to establish tank cleaning procedures which include the check for the presence of wash water in the cargo tank by looking through the peep hole in its manhole hatch cover when entering the cargo tank, and the removal of wash water, if found remaining there, by stripping and ventilating the cargo tank to dry and render the tank gas-free, and to make the crew observe the procedures; to make the crew fully understand the necessity of the measurement of oxygen and other gas concentrations; to make them confirm proper usage of the detectors with sure knowledge of their specifications; and to provide the crew with instructions for measuring incombustible and nonflammable gas concentrations by using a gas detector, not only by preparing documents and by orally informing them at visits to the Ship, but also by instructing them with periodic demonstrations of a proper measurement to ensure their implementation, as well as to check to see how the crew have comprehended them.

4 CONCLUSIONS

4.1 Findings

4.1.1 Situations of the Accident

(1) Courses of the events

1) It is probable that the Ship finished unloading at the Kobayashi Terminal at around 14:05 February 6, then left the terminal, washed the cargo tank inside, arrived at the Komatsu Wharf at around 16:55, and operated the turbo fan to dry and render gas-free the inside of all the cargo tanks No.1 to No.3 for about 13 hours until the morning of February 7. (3.1.1 (1))*37

*37 The number parenthesized at each end of the paragraphs in this subsection shows the main subsection number under which related description is contained in "3. Analysis", "5. Safety Actions" and "6. Recommendations".

2) It is probable that the Ship departed from the Komatsu Wharf for the Umemachi Terminal at around 12:10. (3.1.1 (2))

3) It is probable that when the chief officer approached to the Starboard No.1 cargo tank of the Ship to check the inside condition of the cargo tanks at around 12:25, he directed the second officer, who had been near the port No.1 cargo tank, to open the manhole hatch cover of the cargo tank. (3.1.1 (2))

4) It is probable that when the second officer was opening the manhole hatch cover of the port No.1 cargo tank, the chief officer smelt chloroform, told the second officer not to enter the cargo tank, and started measuring at around 12:26 oxygen concentration in the starboard No.1 cargo tank and the starboard No.2 cargo tank in this order, using a portable detector. (3.1.1 (2))

5) It is probable that at around 12:29, the chief engineer found the second officer collapsed as if leaning against the bulkhead near the suction well and reported the finding to the chief officer and the master. (3.1.1 (2))

6) It is probable that the master attempted to rescue the second officer, could not rescue him as he felt danger of the gas smell, and ventilated the port No.1 cargo tank to render the tank inside gas-free, and that the second officer was later carried out of the cargo tank by Coast Guard, was transferred to the fire and rescue service, and was then carried to the hospital, where he was confirmed dead. (3.1.1 (3))

(2) Chloroform Wash Water in Port No.1 Cargo Tank

Considering that there was a smell of gas in the port No.1 cargo tank and that the chloroform wash water remained in the suction well, it is somewhat likely that the chloroform wash water that had remained in the piping was forced back into the cargo tank by the airflow. (3.2.1 (2))

(3) Effect of Drinking

It is somewhat likely that while the second officer had been aware of the toxicity of chloroform, his sense of smell had been blunted by drinking alcohol to properly perceive the chloroform gas. (3.2.3)

(4) Action without an Attendant

Considering that the second officer entered the port No.1 cargo tank, against the prohibiting warning of the chief officer, while the chief officer was away to the accommodation space to fetch the both detectors, it is probable that the second officer entered the tank on his own judgment. (3.2.4)

(5) Cautions for Entry in Cargo Tank

Considering that Company A had not manifestly provided tank cleaning procedures in the event of wash water remaining in the cargo tank, it is probable that the procedure of wash water stripping in the cargo tank and subsequent drying, rendering gas-free, and oxygen and other gas concentration measurement had not been carried out on the Ship. (3.2.5, 5, 6)

(6) Oxygen and Other Gas Concentration Measurement

It is certain that when entering the port No.1 cargo tank, the second officer did not measure oxygen and other gas concentrations because the chief officer was away to the accommodation space to fetch the both detectors which were not on the spot. (3.2.6 (1), 5, 6)

Considering that, although Company A had provided cautions to the crew of the Ship for entry into the cargo tanks by means of visits to the Ship, education and training, the second officer entered the port No.1 cargo tank by himself without carrying out measurement of oxygen and other gas concentration, it is probable that the cautions for entry into the cargo tank, including measurement of oxygen and other gas concentration, posting attendants, the prohibition of work without an attendant, had not been fully observed in the Ship. (3.2.10 (9), 5, 6)

(7) Causal Factors to this Accident

It is probable that the second officer entered the port No.1 cargo tank, where the wash water had remained with a smell of gas, and inhaled the chloroform gas and died when checking the inside of the tanks while the Ship was heading north to the Umemachi Terminal, because Company A had not made the crew well accustomed to taking careful actions when entering the cargo tank, including measuremnt of oxygen and other gas concentration, and also because the company had not manifestly established tank cleaning procedures in case of wash water found remaining in the cargo tank. (3.1.1 (2), 3.1.3, 3.2.10 (8), (9), (12), 5, 6)

4.1.2 Analysis of Measures to Minimize Damage

Considering that the chief officer was away to the accommodation space to fetch the both detectors when the second officer was entering the port No.1 cargo tank, it is certain that the second officer did not measure oxygen and other gas concentration.

It is highly probable that this accident could have been avoided if the second officer had removed the chloroform wash water by stripping, had ventilated the port No.1 cargo tank of the Ship to dry and render the inside of the cargo tank gas-free, had measured oxygen concentration and other gas concentration using the gas detector, etc., and then had determined the safety or danger of entering the cargo tank.

Considering that Company A had not manifested tank cleaning procedures for treating used wash water if remained in the cargo tanks, it is probable that the used wash water remaining in the cargo tank of the Ship was not treated by the afore-mentioned procedures.

Considering that Company A had given incorrect explanation to the crew of the Ship about the determinability of incombustible and nonflammable gases and that there had been different understanding of the usage of the portable detector between Company A and the crew of the Ship, it is probable that Company A lacked proper knowledge of the gas concentration measurement and that crew of the Ship had not properly understood the usage of the portable detector.

Thus, it is considered necessary for Company A to establish tank cleaning procedures which include the check for the presence of wash water in the cargo tank by looking through the peep hole in its manhole hatch cover when entering the cargo tank, and the removal of wash water, if found remaining there, by stripping and ventilating the cargo tank to dry and render the tank gas-free, and to make the crew observe the procedures; to make the crew fully understand the necessity of the measurement of oxygen and other gas concentrations; to make them confirm proper usage of the detectors with sure knowledge of their specifications; and to provide the crew with instructions for measuring incombustible and nonflammable gas concentrations by using a

gas detector, not only by preparing documents and by orally informing them at visits to the Ship, but also by instructing them with periodic demonstrations of a proper measurement to ensure their implementation, as well as to check to see how the crew have comprehended them. (3.3)

4.2 Probable Causes

It is probable that this accident occurred as the second officer entered the port No.1 cargo tank, where the wash water had remained with a smell of gas, and inhaled the chloroform gas when checking the inside of the tanks while the Ship was heading north to the Umemachi Terminal, because Company A had not made the crew well accustomed to taking careful actions when entering the cargo tank, including measurement of oxygen and other gas concentration, and also because the company had not manifestly established tank cleaning procedures in case of wash water found remaining in the cargo tank.

4.3 Other Safety Issues Identified

It is probable that the master entered into the port No.1 cargo tank to rescue the second officer, which might have led to the secondary accident because chloroform gas was present in the atmosphere in the tank, but returned from the tank feeling the danger of the gas smell and avoided incurring the secondary accident.

As the Ship handles dangerous cargoes, it is somewhat likely that the Ship can avoid the secondary accident of the crew in the event of such a case as this as long as appropriate education and training of the crew are maintained.

It is probable that information and the procedures of actions and measures to be taken for and in emergencies including rescuing a crew from danger in enclosed areas should have been previously established through education and training, requiring that taking actions impulsively or on the crewmember's own judgment should not be avoided, and that immediate reporting should be made to the bridge and the arrival of necessary rescuers should be awaited, and informing that it is not easy to rescue anyone stricken by harmful atmosphere in an enclosed area, and that the inhalation of chloroform gas in the cargo tank disables respiration, results in oxygen deficiency, and jeopardizes safe return.

5 SAFETY ACTIONS

It is probable that this accident occurred as the second officer entered the port No.1 cargo tank, where the wash water had remained with a smell of gas, and inhaled the chloroform gas when checking the inside of the tanks while the Ship was heading north to the Umemachi Terminal, because Company A had not made the crew well accustomed to taking careful actions when entering the cargo tank, including measurement of oxygen and other gas concentration, and also because the company had not manifestly established tank cleaning procedures in case of wash water found remaining in the cargo tank.

It is probable that Company A had given the crew the incorrect instruction of determining the presence of incombustible and nonflammable gas by a decrease in oxygen concentration, and that there had been a difference in the understanding of the usage of the portable detector between Company A and the Ship's crew.

It is probable that the accidents of the crewmembers in the present and the past cases were caused by the non-implementation of oxygen and other gas concentration measurement for entry into an enclosed area, by the entry of the crewmembers on their own judgment, and by the work done by themselves in view of a short distance to the work site and of a short time to finish the work.

It is considered, therefore, that the Company A should establish tank cleaning procedures, and should make the crew observe to check for the presence of wash water in the cargo tank when entering there, to remove wash water, if found remaining there, by stripping and ventilating the cargo tank to dry and render the tank gas-free, to measure oxygen and other gas concentrations, and not to enter there on their own judgment; and also should make the crew confirm proper usage of the detectors with sure knowledge of their specifications, and should provide them with instructions for measuring incombustible and nonflammable gas concentrations by using a gas detector, not only by preparing documents and by orally informing them at visits to the Ship, but also by instructing them with periodic demonstrations of a proper measurement to ensure their implementation, as well as to check to see how the crew have comprehended them.

It is probable, on the other hand, that the master, on the scene of the accident, entered the port No.1 cargo tank to rescue the second officer in danger of the secondary accident, but went out of the tank feeling danger by the smell of gas and avoided the secondary accident.

It is considered that Company A should provide the crew with education and training for accidents and other emergencies based on the instructions for prohibiting taking actions impulsively or on their own judgment, etc. when rescuing in an enclosed area.

5.1 Accident Preventive Measures Taken after this Accident

5.1.1 Measures Taken by Ministry of Land, Infrastructure, Transport and Tourism

In view of the fact that Company A have had crewmember accidents in the three consecutive years of 2010, 2011 and 2012 (this accident), the Kinki District Transport Bureau gave Company A cautions and instructions on March 30, 2012, in regard to the safe navigation and safe operations of vessels, to review the company's conformance to the Safety Management Manual and other related Acts including the Seaman Law, to take accident recurrence preventive measures, and to promptly take actions to thoroughly strengthen the safety management system, and required Company A to report to the Bureau on improvement measures for recurrence prevention and securer shipping.

5.1.2 Measures Taken by Company A

Company A convened the ship owners and the shipping representatives of the ships under its operation to an emergent security meeting, discussed the plan drafted by its Accident Countermeasure Task Force, decided the following matters, and, on February 18 through April 4, visited the ships under its operation, informed the decided matters, and conducted safety education and security training.

(1) Implementation of On-Board Education

Referring to the past accidents as examples, Company A reviewed its rule and the background of the establishment of its rule, the necessity of onboard communications and the establishment of a double-check system, the necessity of cautions for entry into the cargo tanks and the pump room, the necessity of alcohol check, and the accident preventive

measures in the document prepared by Company A.

(2) Tying Manhole Hatches Fast with a Black-and-Yellow Rope

For cargo tanks whose inside safety has not checked yet, the manhole hatches of all of them should be kept tied with a black-and-white rope.

(3) Checking the P&A Manual for Ventilating and Washing Procedures

Even when cargo tanks can be cleaned up merely by ventilating, the shipping operation manager or his representative should definitely direct its cleaning to be carried out by washing with water on the day of unloading completion.

(4) Review of Ship Cleaning Procedures

The ship cleaning procedures should be reviewed, and affirmed procedures should be distributed for education to the ships under its operation.

In response to the requirement of the Bureau for reporting of improvement per 5.1.1 above, Company A submitted to the Bureau a report describing an outline of the accident, the actions and measures taken after the accident, crew accident recurrence preventive measures, and future countermeasures related to the crew accident prevention planned by Company A.

5.2 Measures Needed for Prevention of Future Accidents

It is considered necessary for Company A to practice the following actions, to strive for securing shipping operations, to educate the crew through means including periodic demonstrations of proper gas measurements, and to make sure how these measures are comprehended by the crew.

(1) Implementation of Oxygen and Other Gas Concentration Measurement for Entry into Enclosed Areas

The direction to the crew for thorough practice of oxygen and other gas concentration measurement for entry into enclosed areas, and periodic visits to the ship to ensure that oxygen and other gas concentration measurement is properly implemented.

(2) Oxygen and Other Gas Concentration Measurement Recording

The direction to the master for practicing the recording of oxygen and other gas concentration measurement performance, and, if a gas detector is used for gas concentration measurement, the recording of the quantities of the detector tubes, purchased, consumed and remaining. In addition, periodic visits to the ship, and the review of the performance record and the detector-related record to ensure that oxygen and other gas concentration measurement has been properly practiced.

(3) Establishment and Posting of Tank Cleaning Procedures

The preparation in a summary style easily understandable by the crew, of the tank cleaning procedures, including checking for the presence of used wash water, stripping of used wash water if remaining, and drying and rendering gas-free, as specified in the Safety Guidelines for Coastal Tanker and the P&A manual, and the posting of the procedures at

places easy to see.

(4) Actions in Emergencies

Continuous implementation of education and training for emergencies, including accidents, according to the cautions, with emphasis placed on avoiding taking actions impulsively or on the crewmember's own judgment in emergencies.

6 RECOMMENDATIONS

6.1 Recommendations to the Minister of Land, Infrastructure, Transport and Tourism

It is probable that this accident occurred as the second officer entered the port No.1 cargo tank where the wash water had remained and chloroform gas odor had been in its atmosphere, and inhaled the gas while the chemical tanker was heading north to the Umemachi Terminal, because AST Inc. had not made the crew well accustomed to taking careful actions when entering the cargo tank to check its condition, including measurement of oxygen and other gas concentration, and because AST Inc. had not manifestly established the tank cleaning procedures including the treatment of wash water remaining after tank cleaning.

Since 1989, there have been 17 accidents caused by oxygen deficiency or gas poisoning, in 14 cases of which no oxygen and other gas concentration measurement had been made when entering into the enclosed spaces.

For the purpose of preventing the recurrence of similar accidents, the Board recommends the Minister of Land, Infrastructure, Transport and Tourism based on the result of this accident investigation, pursuant to Paragraph 1, Articles 26 of the Act for Establishment of the Japan Transport Safety Board, as follows:

The Minister should give directions to coastal chemical tanker operators to ensure that they take the following measures:

(1) give their tanker crew instructions in the measurement of oxygen and other gas concentration when entering in enclosed spaces so as to make sure they implement it, and regularly visit their tankers to check that the measurement of oxygen and other gas concentration is carried out without fail;

(2) instruct their masters to keep record of the measurement of oxygen and other gas concentration and, if a gas detector is used in the gas measurement, also keep record of the number of detector tubes purchased, used, and remaining, and regularly visit their tankers to check the record of gas concentration measurement and the detector tubes to ensure that the measurement and the recording are carried out without fail;

(3) develop, in a simple form easy for their crew to understand, specific tank cleaning procedures, including check of wash water remains, removal of the remainder by stripping, and drying and gas-freeing operation as stated in the coastal tanker safety guidelines and P&A manual, and post them at places easy to see on work site; and

(4) being aware of the importance of avoiding taking actions impulsively or on the crewmember's own judgment in an emergency, provide education and training to their crew regularly in responding to accidents and other emergencies.

In addition, the Minister should, when inspecting tankers, give their crew necessary instructions concerning 1) through 4) above and check their detector tube record to see if the measurement of oxygen and other gas concentration is properly performed, and make sure, by auditing the operators, that they have been active in the effort of assuring transportation safety and improving shipping operations.

6.2 Recommendations to AST Inc.

It is probable that this accident occurred as the second officer entered the port No.1 cargo tank where the wash water had remained and chloroform gas odor had been in its atmosphere, and inhaled the gas while the chemical tanker was heading north to the Umemachi Terminal, because AST Inc. had not made the crew well accustomed to taking careful actions when entering the cargo tank to check its condition, including measurement of oxygen and other gas concentration, and because AST Inc. had not manifestly established tank cleaning procedures including the treatment of wash water remaining after tank cleaning.

AST Inc. had had two similar accidents on the tankers they operated. After each of such accidents, AST Inc. gave education and training to its crew to make sure they practice oxygen and other gas concentration measurement, but the crewmember did not practice it properly as instructed and trained, to result in this accident.

For the purpose of preventing the recurrence of similar accidents, the Board recommends AST Inc. based on the result of this accident investigation, pursuant to Paragraph 1, Article 27 of the Act for Establishment of the Japan Transport Safety Board, as follows:

AST Inc. should take the following measures for the prevention of similar accidents:

(1) give their tanker crew instructions in the measurement of oxygen and other gas concentration when entering in enclosed spaces so as to make sure they implement it, and regularly visit their tankers to check that the measurement of oxygen and other gas concentration is carried out without fail;

(2) instruct their masters to keep record of the measurement of oxygen and other gas concentration and, if a gas detector is used in the gas measurement, also keep record of the number of detector tubes purchased, used, and remaining, and regularly visit their tankers to check the record of gas concentration measurement and the detector tubes to ensure that the measurement and the recording are carried out without fail;

(3) develop, in a simple form easy for their crew to understand, specific tank cleaning procedures, including check of wash water remains, removal of the remainder by stripping, and drying and gas-freeing operation as stated in the coastal tanker safety guidelines and P&A manual, and post them at places easy to see on work site; and

(4) being aware of the importance of avoiding taking actions impulsively or on the crewmember's own judgment in an emergency, provide education and training to their crew regularly in responding to accidents and other emergencies.

Fig. 1　Location of the Accident

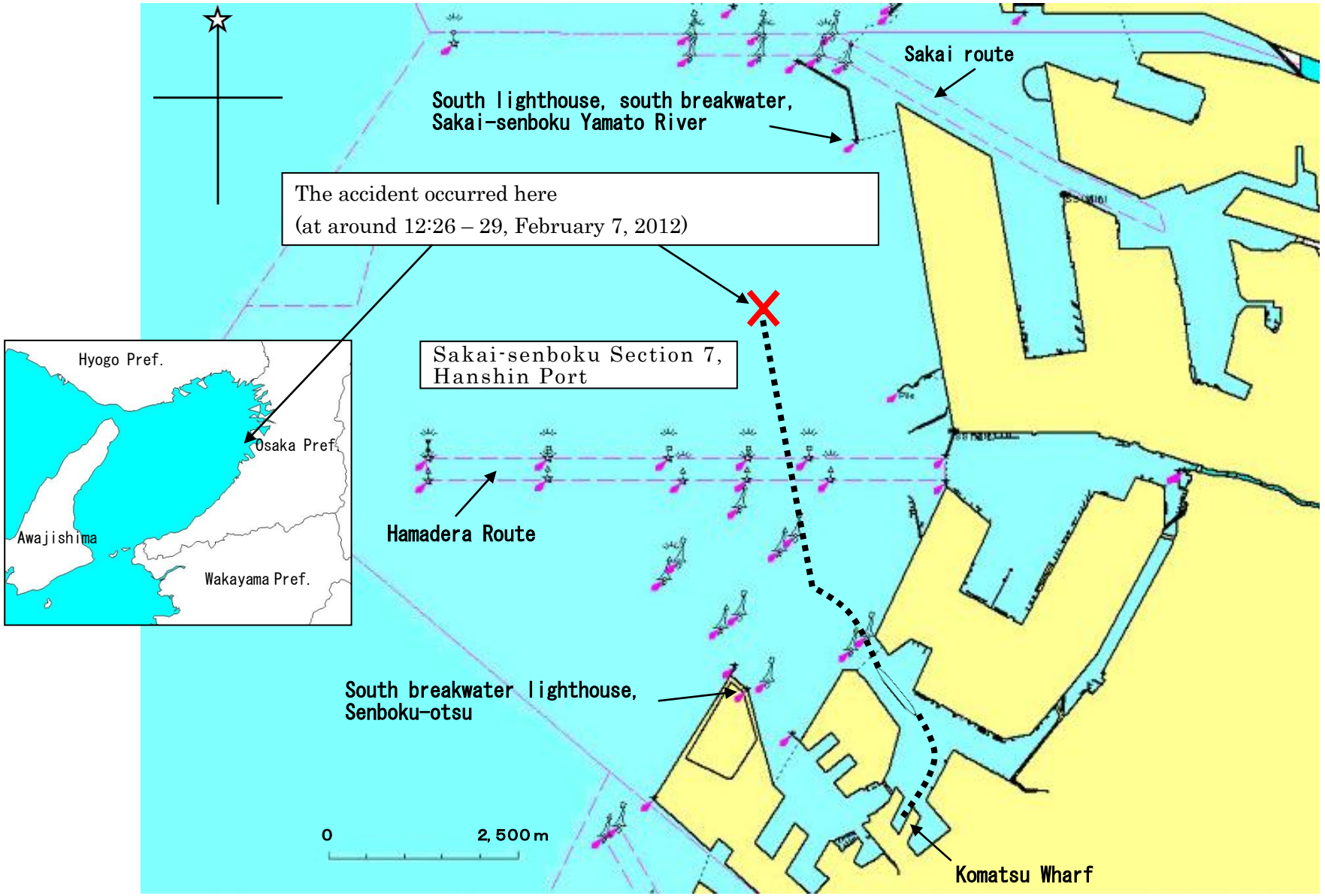


Fig. 2　Causal Factors of this Accident (Summary)

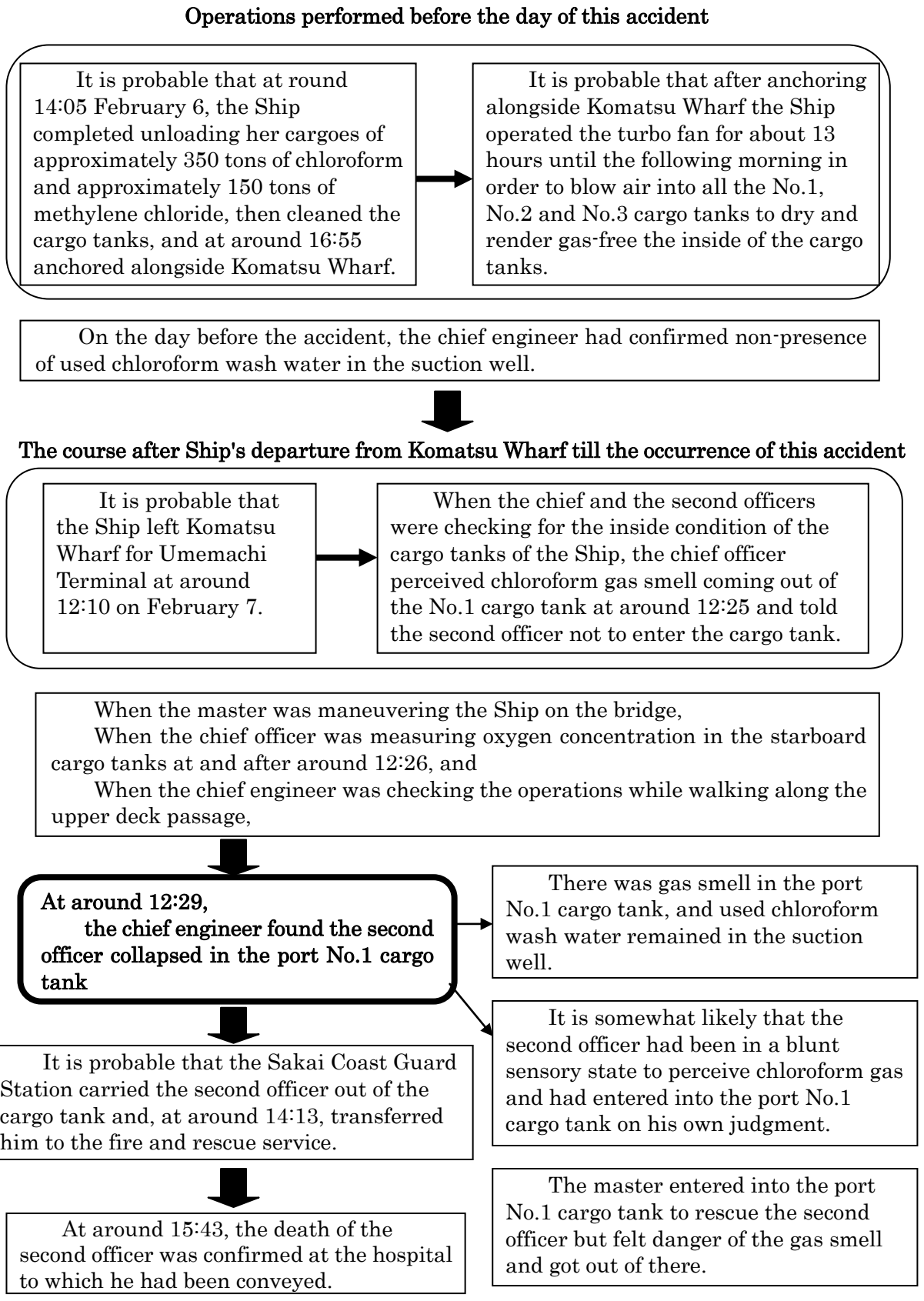


Table 1 Accidents Related to Oxygen Deficiency or Gas Poisoning on Chemical Tankers

	Mo./d./yr.	Time	Location	Vessel Name/Accident Type	Summary	Toll
1	9/12/1989	06:30	Hibikinada	Oil tanker KOEI MARU NO.5, Fatality and injury of crewmembers	The chief officer entered an oxygen-deficient cargo oil tank with staying oil gas, and collapsed. To rescue the chief officer, the master and the chief engineer also entered there without checking oxygen concentration, and also collapsed when rescuing.	1 died 3 injured
2	5/21/1992	10:25	Kawasaki Section, Keihin Port	Cargo ship SURUGA MARU, Fatality and injury of crewmembers	When a crewmember of the cargo ship, fully loaded with coal, was going to ventilate an area liable to oxygen deficiency, he entered there without measuring oxygen concentration and without connecting air hose and nozzle. The third officer died of the lack of O_2, and the 2nd engineer suffered serious consciousness disturbance.	1 died 1 injured
3	10/25/1994	11:00	Udono Port, Mie Prefecture	Cargo ship HOSEI MARU, Fatality of crewmember	The boatswain, when preparing for unloading the chips of a raw material for paper making, entered the deck store, adjacent to a cargo hold, where O_2 had been deficient due to the respiration of the chips, and died of the lack of O_2. The cargo ship was equipped with no O_2 concentration detector.	1 died
4	4/5/1996	01:00	Wakamatsu Section, Kanmon Port	Cargo ship KUMI MARU NO.8, Fatality and injury of crewmembers	This cargo ship originally had had a construction to discharge gases, generated in the cargo hold, to the outside through the cargo hold ventilation duct, but the duct had been removed and the flanged joint had been left open. As a result, the generated gases leaked into the crew cabins, and poisoned the chief engineer to death, and the chief officer and a deck hand to a hospital for medical treatment. The consigner, when consigning the cargo, had not informed of the gas danger, and the cargo ship manager had not checked the danger of the cargo.	1 died 2 injured
5	4/3/1999	15:00	Arakawa, Tokyo	Oil tanker FUJIMIYA MARU NO.5, Fatality of crewmember	When the 2nd engineer of the tanker was collecting the oil remainder on the tank bottom in the gas freeing work after unloading of the gasoline, he entered the cargo tank without measuring the gas concentration in the cargo tank and died of O_2-deficient suffocation. The Ship Management Department of the shipping company had instructed the master to measure gas concentration in the cargo tank for entry there as gas freeing procedure, but after that, had not checked its implementation.	1 died
6	1/24/2001	19:00	Chiba Port	Chemical tanker NEW KATSURAGI, Fatality and injury of crewmembers	Chloroform leaked out of the pump shaft seal of this tanker and diffused over the pump room floor at the bow, while the tanker continued its operation without ventilation of the room. Without wearing a respirator and without posting an attendant, the master	2 died 1 injured

					and the chief officer entered the room and died, and the chief radio officer did same and suffered injury. The master had not arranged for pump shaft seal repair. The chief officer had not prepared for entry into an enclosed area, i.e., for wearing a respirator and for posting an attendant. The ship owner had neither checked change of pump shaft seal specification nor corrected bow pump room ventilator failure, and had not instructed the preparation of a respirator and the posting of an attendant for entry in the pump room.	
7	5/30/2001	08:20	Yokosuka Port	Chemical tanker KAGAWA MARU, Fatality of crewmember	After cleaning of the cargo tank inside following the unloading of the benzene from the tanker, the chief steward entered the oil cargo tank to dispose of remaining wash water without checking the air in the tank using a toxic gas detector, inhaled dense benzene fume and died. The master had not directed the chief officer to check the oil cargo tank inside using a toxic gas detector, and the chief officer had not checked the oil cargo tank inside using the gas detector. The operation manager had not fully educated the crew for the safety cautions required in the operation manual.	1 died
8	12/27/2001	08:13	Niigata Port, Niigata Prefecture	Chemical tanker SHORI MARU, Fatality of crewmember	While the tanker was under liquid asphalt unloading operation, ventilation, oxygen and other gas concentration measurement, and posting an attendant were not made for entry into the hold which was an enclosed area. The chief officer entered the enclosed area alone and died of monoxide poisoning. The master had neither educated the crew for the importance of ventilation nor made them aware of that. The crew had been complacent about the danger of the lack of the inspection work because the work had been routinely carried out. The ship owner had established safety measures for ventilation, gas detection and attendant posting, had often visited the ship, and educated the crew in this respect.	1 died
9	6/12/2003	21:30	East China Sea	Waste cargo ship MINAKATA, Injury of crewmembers	When cleaning the inside of the cargo tank after the dumping of the waste liquid, the junior chief officer entered the unventilated cargo tank and lost consciousness due to hydrogen sulfide generated from the waste liquid. The master, the chief officer and the chief engineer entered the cargo tank to rescue him and also fell in gas poisoning. They were hospitalized and given treatment for 1 week to 1 month. Previous gas poisoning prevention by ventilation and oxygen and other gas concentration measurement had not been sufficiently performed.	4 injured

					For the cargo tank cleaning, the master had not directed the crewmembers to perform ventilation, the chief officer had not proposed it to the master, and the junior chief officer had not followed the caution for not entering the cargo tank beyond allowable limits.	
10	4/8/2005	15:07	Okayama Port, Okayama Prefecture	Chemical tanker KOWA MARU, Fatality and injury of crewmembers	After unloading the sodium hydrogen sulfide, crewmembers entered the cargo tank, not free of hydrogen sulfide gas, inhaled hydrogen sulfide gas, and other crewmembers also entered there for rescuing, with no gas mask, resulted in death of the master and the chief engineer, and gas poisoning of the chief officer and the boatswain. The operation manager had neither explained the master and the crew about the danger of hydrogen sulfide gas, nor had required them to observe the tank cleaning procedure for measuring oxygen and other gas concentration, checking for gas-free, and then entering there. The coastal shipping company had not fully provided the crew with safety education.	2 died 2 injured
11	5/22/2006	12:07	North of Tokyo Bay	Chemical tanker SHUHO MARU, Fatality and injury of crewmembers	In the course of benzene gas-free for loading preparation, the crew entered into the cargo tank which had not been completely rendered benzene gas-free, inhaled dense benzene fume, and resulted in the death of the master, chief engineer, and the engine rating owing to acute benzene poisoning, and the injury of the chief officer. The marine cargo shipping company had not executed crew safety-related education to make them fully understand the operation manual, and had not equipped the tanker with a gas detector suited for benzene. The operation manager had not fully instructed the crew to observe the safety management standard of gas-free and others,	3 died 1 injured
12	4/23/2007	06:25	Nishiyama Section, Kanmon Port	Cargo ship CHIYO MARU NO.25, Fatality of crewmembers	The master and the chief engineer entered into the bow store where oxygen was deficient due to the decomposition and fermentation of the loaded waste chips, without previous ventilation, and died of the lack of oxygen. The coastal shipping company had neither confirmed the practice of safety measures by the crew and nor had equipped the ship with an oxygen concentration detector and respirators.	2 died
13	6/13/2009	08:30	Saganoseki Port, Oita City, Oita Prefecture	Cargo ship SINGAPORE GRACE, Fatality of workers	In the course of unloading the refined copper sulfate ore from the No.3 cargo hold, an unloading worker entered the cargo hold, where oxygen had been deficient, and suffered hypoxia. Another worker entered there to rescue him, and also collapsed suffering hypoxia. The cargo-related refinery had not advised the implementation of oxygen concentration measurement according to a prescribed	3 died

					procedure.	
14	8/27/2009	08:00 ~ 20	Mizushima route to the east off the No.6 breakwater lighthouse, Honjima Port, Marugame City, Kagawa Prefecture	Oil tanker HOEI MARU NO.8, Fatality of crewmember	In the pump room where gasoline gas concentration had been at a high level, the master was alone in preparation working to render there gas-free, inhaled the gas, lost consciousness and was poisoned by the gas to death. The strainer cover O-ring had been damaged to allow gasoline leak during the cargo unloading, and the master had not operated the exhaust fan, and had turned off the gas detector power switch.	1 died
15	3/10/2010	13:55	Kawasaki Section, Keihin Port	Chemical tanker KYOKUHO MARU NO.2, Fatality of crewmember	The chief officer, without measuring oxygen concentration in the cargo tank wherein nitrogen gas had been supplied along with the cargo unloading operation, and oxygen concentration had subsequently been reduced, entered the cargo tank, inhaled the air short of oxygen, and died. The chief officer noticed the drain plug not attached in the cargo tank, and hastened to attach it, forgetting that nitrogen gas had been supplied into the cargo tank.	1 died
16	6/28/2011	11:27	North route, Nagoya Port, Aichi Prefecture	Chemical tanker NISSHO MARU, Fatality and injury of crewmembers	Following the completion of sodium hydrogen sulfide cargo unloading, the cargo tank inside cleaning had been finished, the sodium hydrogen sulfide wash water had been transferred to the slop tank containing acrylic acid wash water, and the sodium hydrogen sulfide wash water and the acrylic acid wash water had produced hydrogen sulfide gas by chemical reaction. The crew who were cleaning the tank inside inhaled the hydrogen sulfide gas that gushed from the manhole hatch, and the chief engineer inhaled the gas that spouted from the exhaust pipe of the tank and that gushed from the manhole hatch. Consequently, the chief officer and the second engineer died, and the junior chief officer and the chief engineer were injured. Company A had not recognized the danger of mixing the wash waters, had not stated the cargo tank wash water transferring procedure in its working procedures, and had not educated the crew concerning the danger of cargo tank wash waters that could chemically react when mixed and concerning the usage of the slop tank. Consequently, the crew had had no knowledge of the dangerous material generation by chemical reaction of wash waters when mixed, and nor had had recognition of the dangerous goods handling manual.	2 died 2 injured
17	7/7/2011	16:35 ~ 40	Near the entrance of the Sodegaura channel, Chiba Section, Chiba	Chemical tanker HOTOKU MARU, Injury of crewmember	In the process of filling the ballast tanks, the engine rating entered the ballast pump room to close the seawater intake valve of the ballast pump at the bottom of the pump room, inhaled the	1 injured

			Port, Chiba Prefecture		chloroform gas which had stayed at the bottom, and went into a coma. The ventilation between the cargo piping and the suction port of the blower in the ballast pump room had been in a free state because the screen and the sluice valve to partition between the cargo piping and the blast piping in the cargo tank had been opened and, therefore, the chloroform gas, heavier than the air in the cargo piping, was drew up by the blower which had been operated in the pump room, and flowed through the blast piping and the suction port of the blower into the pump room. The operator had assumed no possibility of harmful gas presence in the ballast pump room because cargo pump had not been installed there, and had given no direction to the tanker for harmful gas detection.	