



Marine Safety Investigation Report

on Chemical Tanker *Onsan Chemi*

- Fatality of a crew -

Date of Accident: 23 November 2020

Date of Publication: 10 November 2021



Korea Maritime Safety Tribunal
Marine Safety Investigation Team

Note

This marine safety investigation report aims to identify the causes of the marine accidents and prevent similar marine accidents or incidents in the future under Article 18.3 of the Act on the Investigation of and Inquiry into Marine Accidents. It is therefore advised that this report not be used for assigning blame or determining liability.

The names of the relevant acts and agencies described in this report were quoted at the time of its writing.

Contents

1. Synopsis	2
2. Factual Information	5
2.1 Ship information	5
2.2 Ownership and operation of <i>Onsan Chemi</i>	7
2.3 Ship surveys and safety management	8
2.4 Crew composition and watchkeeping system	8
2.5 Ship structures	11
2.6 Cargo tank where the accident occurred	11
2.7 Cargo tank cleaning procedures of chemical tankers	13
2.8 Gas freeing and drying cargo tanks of <i>Onsan Chemi</i>	14
2.9 Weather conditions	14
2.10 Damage	15
3. Development of Accident	18
3.1 Voyage before accident	18
3.2 Accident	19
3.3 Rescue operations	21
4. Analysis	25
4.1 Cause of the C/O's death	25
4.2 Confined space entry procedures	26
4.3 Checking the safety of air inside the cargo tank	27

4.4 Preparation for and response to dangerous situations	28
4.5 Supervision of the master on safety management	29
5. Conclusions	32
6. Lessons Learned	34
6.1 Strictly observing confined space entry procedures	34
6.2 Strengthening supervision on the safety of onboard operations	34
6.3 Securing the safety of rescuers	35
6.4 Insuiling safety habits by observing work safety procedures	35

section

1

Synopsis

1. Synopsis

- 1.1 All the cargo in cargo tank(CT) No.4 on the chemical tanker *Onsan Chemi* was discharged at Ulsan Port in Korea on 6 November 2020, and the tank cleaning work was finished the next day. Traces of water remaining inside the tank after the cleaning were removed, and the vessel set sail with the tank empty until the time of the accident.
- 1.2 After departing from Ulsan Port in Korea, *Onsan Chemi* carried phosphoric acid, butanediol, ethylene dichloride, and other chemical products in the cargo tanks other than CT No. 4 (P) to ports in China and Taiwan between 11 and 20 November 2020. On 21 November, the tanker departed from Mailiao Port in Taiwan for Manila Port in the Philippines to change crew.
- 1.3 While underway, the tanker's chief officer (C/O) checked the cleanliness of the empty tanks prior to loading cargo at the next destination port (Bangkok in Thailand). At that time, he discovered dampness and residue remaining inside CT No. 4 (P) and decided to remove them.
- 1.4 At around 08:30 (hereinafter the "Korea Time") on 23 November, the C/O briefed the bosun and two ordinary seamen (OS), referred to here as OS A and OS B, on the overall mopping task and the procedures for wiping away any remaining dampness and residue inside the tank. Thus, under the C/O's instructions, OS A and B began mopping at around 09:00, without having conducted gas freeing or checking oxygen and gas levels beforehand. They started their work without carrying a portable detector or wearing personal protective equipment (PPE).
- 1.5 While mopping, OS A felt drowsy and dizzy and came out of the tank to breathe in fresh air at around 10:00. After two to three minutes, he was about to go back to work when he noticed OS B lying on the floor at the bottom of the tank.
- 1.6 OS A informed the bosun, who was also working nearby at CT No. 10, of the situation, and the bosun reported it to the C/O. Later, the bosun and OS A went to the stern to get a self-contained breathing apparatus (SCBA).

- 1.7 At that time, the C/O went to CT No. 4 (P), the scene of the accident, and entered the tank alone without the PPE or any observers. He tried to rescue the collapsed OS B, and while doing so, he himself collapsed onto the tank floor.
- 1.8 The bosun who went to the stern to get the SCBA notified the situation to the third officer (3/O) B, who was keeping navigational watch on the bridge. At around 10:30 on the same day, 3/O B reported the accident to the master and announced an emergency call to crew ordered by the master.
- 1.9 Under the master's direction, 3/O A, the bosun, and one able seaman (AB) B put on SCBAs and entered CT No. 4 (P) to rescue the collapsed crewmembers. There, they put SCBA face-pieces of the SCBAs on the collapsed seamen. OS B seemed to recover consciousness, but the C/O did not. The master pulled the C/O onto the upper deck outside CT No. 4 (P) and tried first-aid treatment. However, the C/O did not recover.
- 1.10 At around 12:20 on the same day, the master asked the Philippine Coast Guard (PCG) for assistance. At around 15:20, a doctor came aboard and confirmed that the C/O had died.

section

2

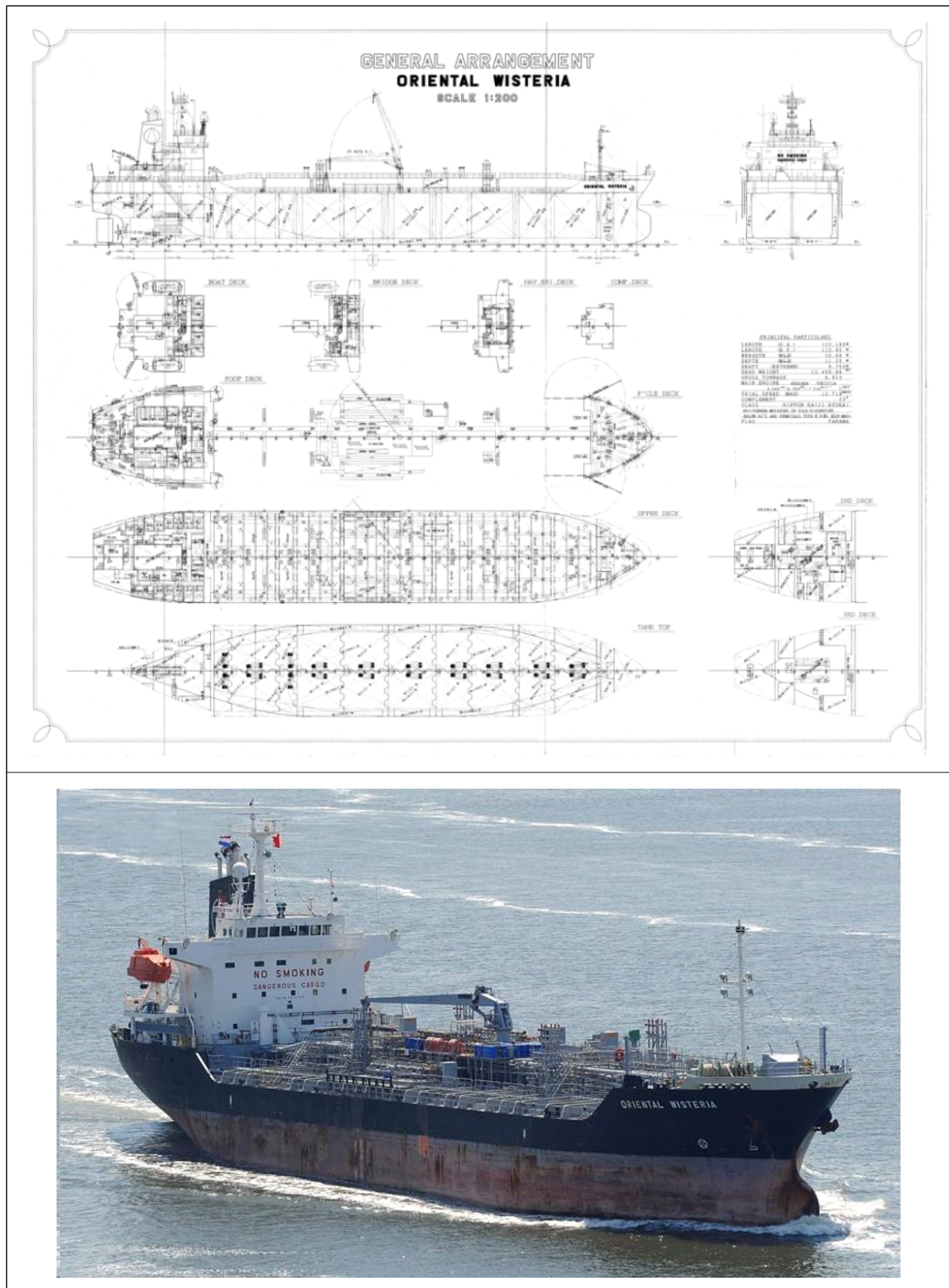
Factual Information

2. Factual Information

2.1 Ship information

2.1.1 Particulars of *Onsan Chemi*

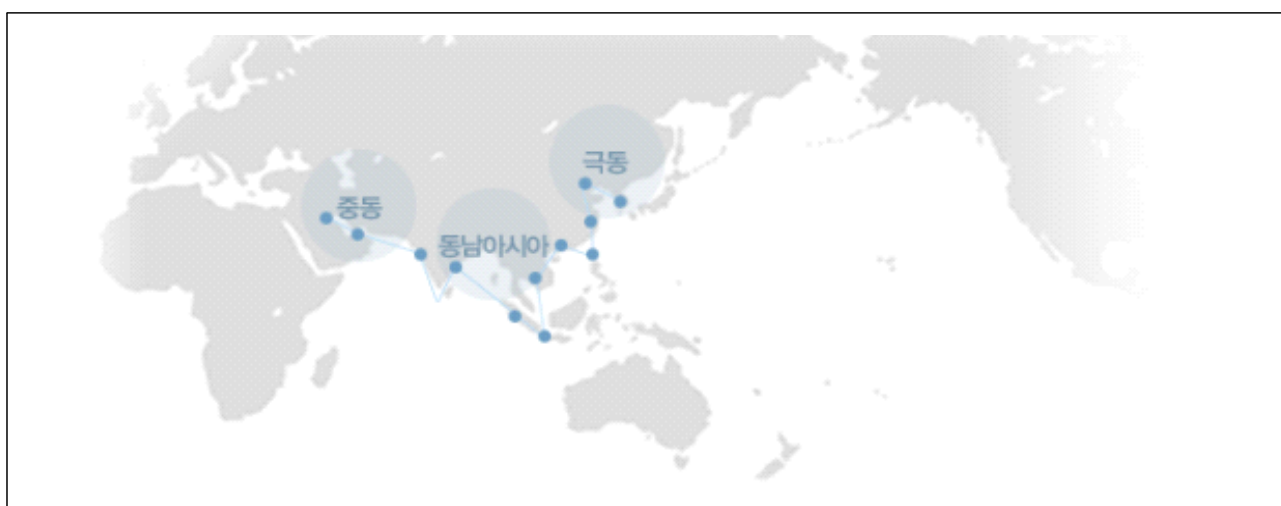
Ship Name	<i>ONSAN CHEMI</i>
Flag State	Republic of Korea (ROK)
Port of Registry	Jeju
IMO No.	9244386
Ship Type	Tanker (Oil & Chemical)
Owner	Sunwoo Tanker Co., Ltd.
Safety Management Agency	Eastern Tanker Co., Ltd.
Max. No. of Crew (Pers.)	23
Builder	Fukuoka Shipbuilding Co., Ltd.
Date of Keel Laid	10 Feb. 2001
Date of Launch	25 Apr. 2001
Date of Delivery	1 Aug. 2001
Classification Society	Korean Register of Shipping (KR)
Gross Tonnage (t)	6,823
Length Overall (m)	123.18
Beam (m)	20.00
Depth (m)	11.20
Deadweight Tonnage (t)	12,498.86
Type of Main Engine	Diesel
Max. Output	3,640kW × 210RPM
Propeller	1(Solid screw-type propeller)
Rudder	1
Thruster	480kW × 1 unit



[Figure 1] General arrangement and photo of *Onsan Chemi* (Ex. *Oriental Wisteria*)

2.2 Ownership and operation of *Onsan Chemi*

- 2.2.1 *Onsan Chemi* is a chemical tanker with 6,823 in gross tonnage, an overall length of 123.18 meters, a beam of 20.00 meters, and a depth of 11.20 meters, transporting oil and liquid chemical products in bulk. She was launched at the shipyard of Fukuoka Shipbuilding Co., Ltd. in Japan on 25 April 2001.
- 2.2.2 After her launch, the tanker was initially operated under the Panamanian flag and then registered in the Republic of Korea on 21 February 2012. On 27 July 2017, she was sold to Sunwoo Tanker Co., Ltd. (Sunwoo Tanker) and she was renamed *Onsan Chemi*¹⁾ on 10 October 2017. The shipowner, Sunwoo Tanker, had operated her for about three years and four months before the accident occurred.
- 2.2.3 Sunwoo Tanker runs the following fleet for transporting oil and chemical cargoes: three chemical tankers ranging between 6,000 and 7,000 tons, including *Onsan Chemi*; and five chemical tankers in the 5,000-to-6,000-ton range.
- 2.2.4 These tankers carry liquid chemical products in bulk, such as benzene, toluene, ammonia, and caustic soda, and their shipping routes are mainly in the Far East, including China, Japan, and Korea; as well as to Southeast Asian nations such as Singapore, Malaysia, and Indonesia.



[Figure 2] Shipping routes of Sunwoo Tanker's fleet

1) The tanker was previously named *Oriental Wisteria*.

2.3 Ship surveys and safety management

- 2.3.1 *Onsan Chemi* was classed by KR in February 2012. At the time of the accident, she was holding ship survey certificates²⁾ valid until 31 July 2021.
- 2.3.2 The tanker had undergone a total of six occasional surveys by KR from 2016 to 2020, all of which were associated with machines in the engine room, such as generators, and nothing to do with cargo tank defects or cleanliness.
- 2.3.3 Sunwoo Tanker signed a contract with Eastern Tanker Co., Ltd. on 13 May 2019 and entrusted it with safety management, to include crew management, technical administration, ship surveys, and safety management systems (SMS) under the Maritime Safety Act of Korea as well as the International Safety Management (ISM) Code.
- 2.3.4 *Onsan Chemi* had received five port state control (PSC) inspections at ports in the Philippines, China, and Vietnam between 2017 and 2018. These inspections identified deficiencies in lifesaving gear, malfunctioning dampers in the deck store, and absence of the international shore connection (ISC). Meanwhile, five additional PSC inspections had been conducted in Thailand and Indonesia between 2019 and 2020, with no deficiencies identified.

2.4 Crew composition and watchkeeping system

- 2.4.1 *Onsan Chemi* can accommodate up to 23 persons onboard under the ship survey certificate and a minimum of 13 persons under the safe manning certificate.
- 2.4.2 When the accident occurred, 20 crewmembers were on board: three Koreans, including the master, the chief engineer (C/E), and the chief officer (C/O); one first assistant engineer (1/AE) from Indonesia; and the other officers and crew, including the second officer (2/O), from the Philippines.
- 2.4.3 *Onsan Chemi*'s master had worked in his position for about six years. Since he was an officer, he had always been onboard chemical tankers. *Onsan Chemi* was the first vessel of Sunwoo Tanker to

2) Cargo Ship Safety Construction Certificate (SC), Cargo Ship Safety Equipment Certificate (SE), Cargo Ship Safety Radio Certificate(SR), etc.

which he had been assigned, and the accident occurred about five months after his assignment. He was 63 years old at the time of the accident.

- 2.4.4 The C/O had about 19 years³⁾ sailing experience in his position, mostly aboard chemical tankers. *Onsan Chemi* was the first Sunwoo Tanker vessel he was onboard, and the accident occurred about nine months after his boarding began. He was then 55 years at the time of the accident.
- 2.4.5 The officers' watch system on *Onsan Chemi* was as follows: the 2/O kept watch from 04:00 to 08:00 and from 16:00 to 20:00; 3/O A from 00:00 to 04:00 and from 12:00 to 16:00; and 3/O B from 08:00 to 12:00 and from 20:00 to 24:00. Each officer was assigned to watchkeeping duties with one helmsman.
- 2.4.6 The C/O manages and supervises deck maintenance and cargo management duties while the vessel is at sea. The C/O works in the daytime from 08:00 to 17:00 on weekdays, except when the ship arrives at or departs from ports. The cargo tanks are generally also cleaned during the daytime.

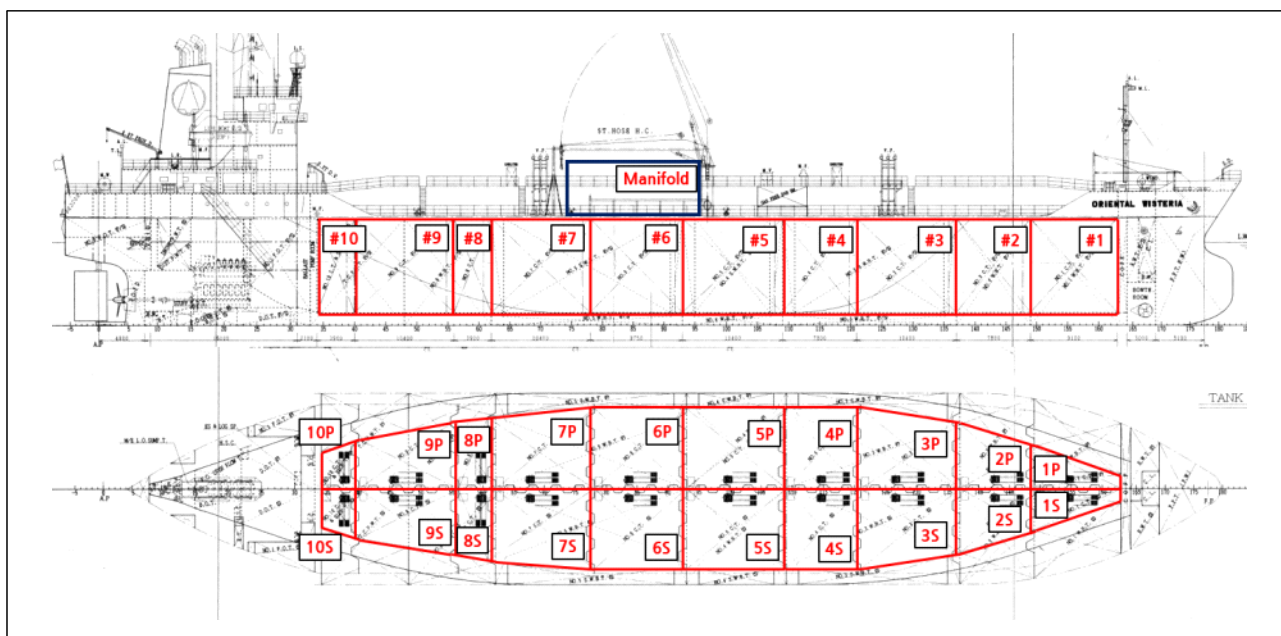
3) He had worked on about 27 ships as a C/O since 2002.

[Table 1] Crew composition of *Onsan Chemi* by rank

Dept.	Rank		No. of Crew (Nationality)	Min. No. of Manning
Deck	Officer	Master	1 (Repulic of Korea)	1
		Chief Officer	1 (Repulic of Korea)	1
		2nd Officer	1 (Philippines)	1
		3rd Officer	2 (Philippines)	1
	Rating	Bosun	1 (Philippines)	3
		Able Seaman	2 (Philippines)	
		Ordinary Seaman	2 (Philippines)	
		Chief Steward	1 (Philippines)	1
		Cook	1 (Philippines)	
Engine	Officer	Chief Engineer	1 (ROK)	1
		1st Assistant Engineer	1 (Indonesia)	1
		2nd Assistant Engineer	1 (Philippines)	1
		3rd Assistant Engineer	1 (Philippines)	1
	Rating	No.1 Oiler	1 (Philippines)	1
		Oiler	3 (Philippines)	
		Total	20	13

2.5 Ship structure

2.5.1 *Onsan Chemi* bridge is in the vicinity of her stern, and her cargo tanks are located from the bridge to the bow. She has ten cargo tanks each on the port and starboard sides, numbered from one to ten from the bow to the stern.



[Figure 3] Structure and cargo tank layout of *Onsan Chemi*

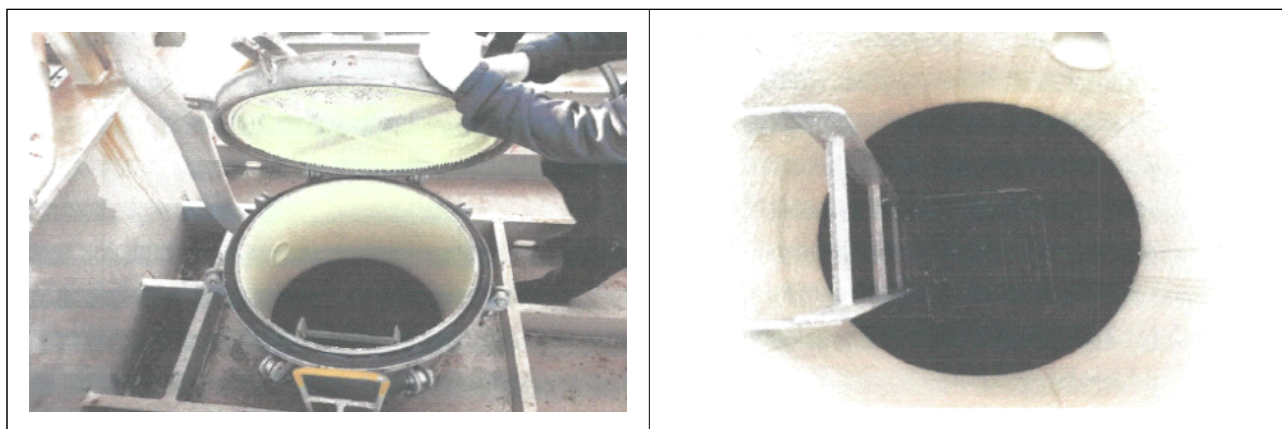
2.5.2 As mentioned above, the bridge is at the stern. The crew quarters, mess hall, and office/cargo control room are on the boat deck and poop deck below the bridge. Below the poop deck is the machinery space.

2.6 Cargo tank where the accident occurred

2.6.1 CT No. 4 (P) is where the accident occurred; the tank has a volume of about 675m³ and a length of about 7.8 meters. The inside of the tank is made of molybdenum (Mo)-containing low-carbon stainless steel (SUS-316L), which has strong corrosion and acid resistance as well as excellent strength to store high-temperature cargoes.

2.6.2 This cargo tank is installed with one access hatch, which is fitted with a ladder so that persons can

climb down into the tank.



[Figure 4] Hatch of CT No. 4 (P)

- 2.6.3 This cargo tank is equipped with a mechanical ventilation system that provides fresh air to the tank and ventilates it with a gas-freeing fan, located inside the gas-freeing fan room on the upper deck of CT Nos. 4 and 5.
- 2.6.4 The gas-freeing fan operation is started with a battery pack⁴⁾, a type of hydraulic power unit located in the bosun store at the bow, and turned on using a control lever on the upper deck of CT No. 4.
- 2.6.5 *Onsan Chemi* transported a cargo of unconverted oil (UCO) in CT No. 4 (P) at Bangkok Port and discharged all of it at Ulsan Port during voyage No. 16⁵⁾, leaving the tank empty until the time of the accident. After departing from Gunsan Port in Korea, the last port of voyage No. 16, the vessel completed the cleaning operations of CT No. 4 (P), including mopping.
- 2.6.6 The UCO is a residual oil that was not converted into other petroleum products during the crude oil refining process. It is used as a feedstock for lubricating oil. According to the material safety data sheet (MSDS) of *Onsan Chemi*, the UCO cargo has a flash point of 120°C or above⁶⁾. Although the crewmembers are required to be careful not to directly expose it to flame, the cargo poses no high risk during handling and storage.

4) The on/off switch of the battery pack is located in the cargo control room(CCR)

5) One voyage refers to one shipping cycle from loading and discharging cargoes.

6) Under the ship survey certificates, *Onsan Chemi* is allowed to transport oil with a flash point of 60°C or under, or above 60°C and chemical products listed in the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bunks (IBC).

- 2.6.7 In accordance with the MSDS, gas generated from the UCO cargo may cause minor itching of the nose and the throat, headache, sleepiness, and nausea. If a person inhales such gas, he/she should get out of the place where the gas has collected, inhale clean air, and receive first-aid treatment, such as cardiopulmonary resuscitation (CPR), if he/she has difficulties in breathing.

2.7 Cargo tank cleaning procedures of chemical tankers

- 2.7.1 A chemical tanker carrying liquid chemical products such as benzene and caustic soda is suitable for transporting loads of various products in small quantities, as her cargo tanks are divided into multiple compartments. The vessel loads and discharges cargoes by connecting manifolds linked to the pipelines of the cargo tanks and the pipelines on shore.
- 2.7.2 The different cargoes are loaded alternately into the tanks, so the cargo to be loaded at the next port must not be contaminated by the residue of the previously loaded/discharged cargo. Thus, once the discharging is complete, the empty cargo tanks undergo a cleaning operation to remove any residue inside.
- 2.7.3 The cleaning operation varies depending on the composition and properties of the cargo that had just been loaded into any given tank. However, the operation is generally conducted according to the following procedures: (i) pre-cleaning, (ii) chemical washing, (iii) main wash with seawater, (iv) rinse with fresh water, (v) steaming, (vi) gas freeing, (vii) drying, and (viii) mopping.
- 2.7.4 The pre-cleaning uses sea or fresh water to remove residue left inside the cargo tank immediately after the cargo has been discharged. The chemical washing cleans the cargo tank by using chemical agents after the tank's pre-cleaning has been completed.
- 2.7.5 The main wash with seawater, rinse with fresh water, and steaming are performed to remove remaining chemicals and dispose of salt and odor after the chemical washing. The gas-freeing operation ventilates the tank to remove gases generated from cargo or chemicals. The drying process removes moisture inside the tank after the washing procedures have been completed.
- 2.7.6 The mopping is the final step of the cleaning operation. This requires crewmembers to go directly into the tank and wipe away any remaining traces of water with mops after the tank has become

mostly dry.

- 2.7.7 Once the above cleaning procedures have been completed, the cargo tank hatches and manholes must be shut to prevent impurities or seawater to flow inside. The cargo tanks also must be subjected to forced ventilation so that moisture does not re-form with changing temperatures.

2.8 Gas freeing and drying cargo tanks of *Onsan Chemi*

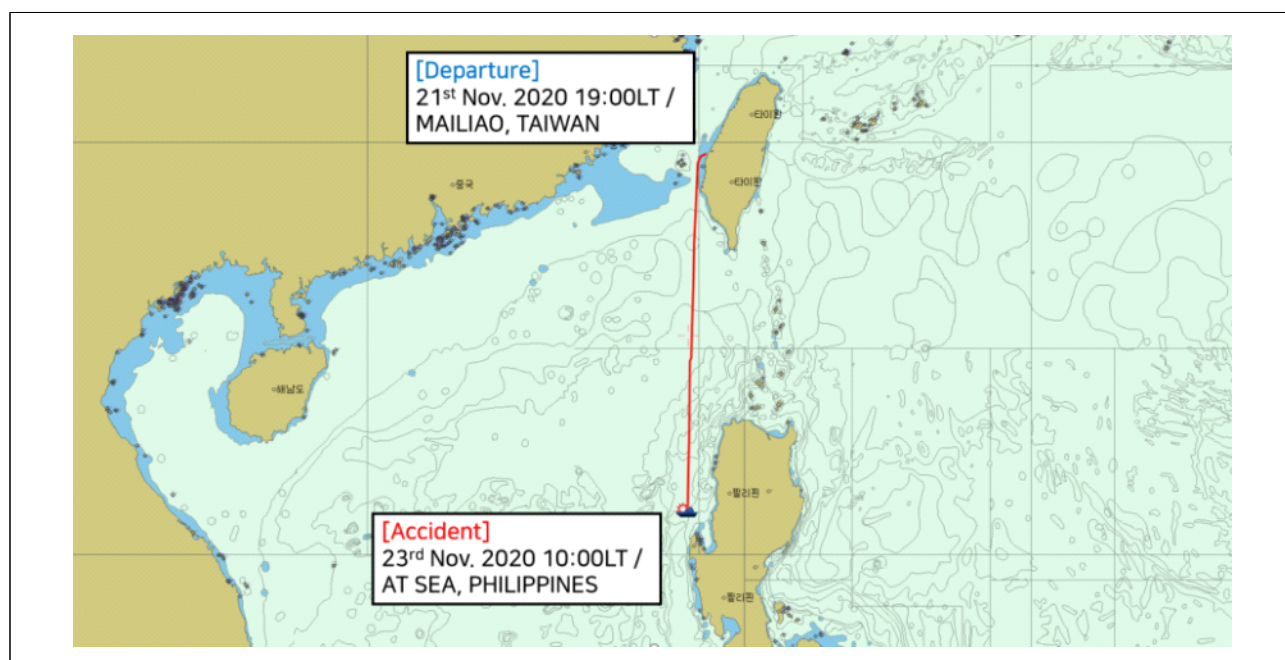
- 2.8.1 The tank cleaning procedures of *Onsan Chemi*, including gas freeing and drying, were prescribed in Chapter 9 (Tank Washing and Cleaning) of the Cargo Management Procedures, established and operated by the tanker's shipping company.
- 2.8.2 To wash a cargo tank, usually a washing machine, called a portable Butterworth machine, is hung onto the tank's manhole. This machine cleans the tank with hot seawater, rinses it with fresh water, and dries it out with a gas-freeing fan.
- 2.8.3 The gas-freeing and drying operations on *Onsan Chemi* entail operating a gas-freeing fan and blowing fresh air from outside into the cargo tank through a blast pipe connected to the tank ceiling so that the air inside is circulated.
- 2.8.4 When the gas-freeing and drying processes are completed on the vessel, the person responsible for tank washing (C/O) measures the condition of the air at three levels-the top, middle, and bottom-of the cleaned tanks. If the responsible person confirms that the air inside contains sufficient oxygen and no flammable or toxic gases, crewmembers enter the tanks and start mopping.

2.9 Weather conditions

- 2.9.1 Prior to this accident, *Onsan Chemi* departed from Mailiao Port in Taiwan for Manila Port in the Philippines. The vessel was sailing off the coast of the Philippines when the accident occurred.
- 2.9.2 The weather conditions were recorded in the logbook as in [Table 2], and the wind and waves were mostly in fair condition.

[Table 2] Weather conditions

Date and Time (LT)	Wind and Wave						Weather	
	Wind Direction	Wind Scale	Wind Speed (m/s)	Wave Direction	Wave Scale	Wave Height (m)	Atmosphere	Temp.
2020.11.22. 04:00	N	2	1.6 ~ 3.3	S	3	1	Overcast	23
2020.11.22. 08:00	SE	3	3.4 ~ 5.4	NW	3	1	Overcast	25
2020.11.22. 12:00	NE	3	3.4 ~ 5.4	SW	3	1	Blue sky	29
2020.11.22. 16:00	NE	4	5.5 ~ 7.9	SW	4	1.5	Cloudy	31
2020.11.22. 20:00	NE	3	3.4 ~ 5.4	SW	4	1.5	Overcast	26
2020.11.22. 24:00	NE	4	5.5 ~ 7.9	SW	4	1.5	Overcast	25
2020.11.23. 04:00	NE	4	5.5 ~ 7.9	SW	4	1.5	Overcast	26
2020.11.23. 08:00	NE	3	3.4 ~ 5.4	SW	4	1.5	Overcast	26
2020.11.23. 12:00	NE	3	3.4 ~ 5.4	SW	3	1	Blue sky	30

[Figure 5] Track of *Onsan Chemi* and the accident location

2.10 Damage

- 2.10.1 The C/O and OS B both lost consciousness and collapsed on the tank floor during the accident. OS B regained consciousness, but the C/O failed to recover and ended up dead despite first-aid treatment.

section

3

Development of Accident

3. Development of Accident

3.1 Voyage before accident

- 3.1.1 *Onsan Chemi*, as a chemical tanker transporting oil and liquid chemical products in bulk, loaded phenol, ethylene chloride and other such cargo at ports in Thailand and Taiwan and discharged them at ports in Korea, China, Vietnam, and other countries.
- 3.1.2 The tanker loaded about 6,061 tons of UCO in CT Nos. 2, 4, 5, 7, and 9 (P/S) at Bangkok Port in Thailand on 25 October 2020 during voyage No. 16. On 26 October, about 3,996 tons of phenol were loaded into CT Nos. 3, 6, and 10 (P/S) at Map Ta Phut Port in Thailand.
- 3.1.3 The tanker completed voyage No. 16 by shipping all of the loaded cargoes to Korea: the UCO cargo, among those, was completely discharged at Ulsan Port on 6 November 2020; and all of phenol was discharged at Gunsan Port on 10 November 2020, completing voyage No. 16.

AFTER Loading Stowage Plan (Delete as applicable)													
Ship's Name : <u>ONSAN CHEMI</u>													
Rotation:													
Voyage No. : <u>20016</u>													
Date : <u>26. OCT. 2020</u>													
TC TK													
10P	265.268	9P	861.621	8P	338.579	7P	904.366	6P	846.977	5P	903.559	4P	676.580
PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO
251.999	823.480	251.999	823.480	251.999	823.480	251.999	823.480	251.999	823.480	251.999	823.480	251.999	823.480
263.415	651.373	263.415	651.373	263.415	651.373	263.415	651.373	263.415	651.373	263.415	651.373	263.415	651.373
95.00%	95.57%	95.00%	95.57%	95.00%	95.57%	95.00%	95.57%	95.00%	95.57%	95.00%	95.57%	95.00%	95.57%
L	MAPTAPHUT	L	BANGKOK	L	BANGKOK	L	MAPTAPHUT	L	BANGKOK	L	BANGKOK	L	MAPTAPHUT
D	KUSAN	D	ULSAN	D	ULSAN	D	KUSAN	D	ULSAN	D	ULSAN	D	KUSAN
PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO	PHENOL	UCO
252.531	833.830	252.531	833.830	252.531	833.830	252.531	833.830	252.531	833.830	252.531	833.830	252.531	833.830
263.971	658.927	263.971	658.927	263.971	658.927	263.971	658.927	263.971	658.927	263.971	658.927	263.971	658.927
95.31%	95.75%	95.31%	95.75%	95.31%	95.75%	95.31%	95.75%	95.31%	95.75%	95.31%	95.75%	95.31%	95.75%

[Figure 6] Stowage plan of *Onsan Chemi* (Voyage No. 16)

- 3.1.4 *Onsan Chemi* crew cleaned CT Nos. 2, 4, 5, 7, and 9 (P/S), where the UCO cargo had been loaded on 7 November 2020, before embarking on voyage No. 17. At that time, the crewmembers washed the tanks with hot seawater for about 10 minutes with a portable washing machine and then

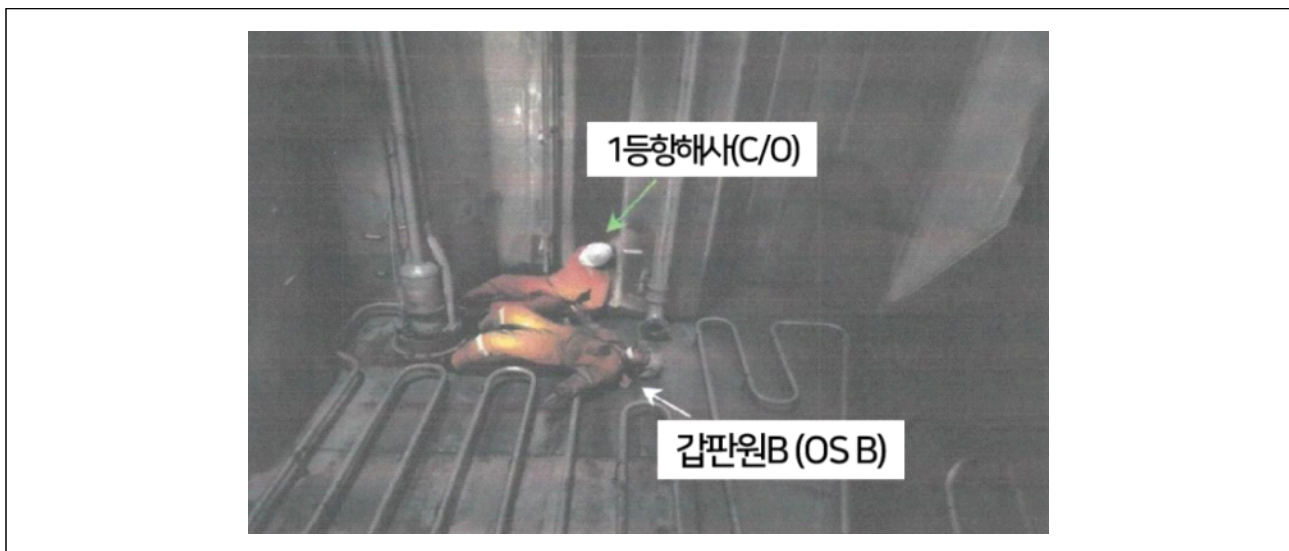
- 3.2.2 At around 08:30 on 23 November, the C/O briefed the bosun, OS A, and OS B at the ship's office on the mopping operation and the procedures to be conducted on that day.
- 3.2.3 However, no other safety instructions or risk factor warnings were given in relation to the operation. The plan of mopping cargo tanks was not reported to the master and a permit for entry into a confined space⁷⁾ was not documented, either.
- 3.2.4 Meanwhile, after having breakfast, the C/E asked the C/O whether it would be possible to clean the cooling systems of the battery pack (for a gas-freeing fan)⁸⁾ in the bosun store at the bow, and the C/O replied he could wash them.
- 3.2.5 The C/O ordered the deck ratings to start their mopping, without checking the oxygen and gas levels inside the cargo tank first. Therefore, the bosun suggested gas freeing to the C/O, but he said it would not be necessary⁹⁾.
- 3.2.6 At around 09:00 on the same day, OS A and B went inside CT No. 4 (P) to do the mopping without wearing any PPE and with no observer posted. At that time, the C/O and the bosun were removing cargo sediment inside the stripping pipe of CT No. 10 (P).
- 3.2.7 Both OS A and B were mopping the tank while wiping away residue remaining inside with a rust stain remover (RSR).
- 3.2.8 At that time in the bosun store at the bow, the C/E, 1/AE, 2/AE, 3/AE, and the oiler had taken off the cover of the battery pack in the store and were cleaning its cooling systems with brushes.
- 3.2.9 While mopping, OS A felt sleepiness and dizziness and left the cargo tank to get some fresh air at around 10:00. About two to three minutes later, OS A he was preparing to go back to work when he spotted OS B lying face up on the floor.

7) In Paragraph 4.3 of Chapter 4 (All Hazardous Operations) of the Safety Management Manual PR-13 (Safety Management) of *Onsan Chemi*, a confined space is defined as an area, including cargo tanks, where an opening for entry and exit is limited; the air inside is not naturally ventilated; and operators are not allowed to constantly stay.

8) *Onsan Chemi* is installed with a battery pack to operate hydraulic pumps and motors. The cleaning operation is to remove impurities from the cooling systems to prevent the hydraulic motors from overheating. In general, the operation is conducted every three months and takes about four hours. During the operation, the hydraulic machines on the deck, such as windlasses, winches, cranes, and gas-freeing fans, cannot be used.

9) The statement given by the bosun

- 3.2.10 OS A immediately reported what he had seen to the bosun, who was engaged in operations near CT No. 10 (P), and the bosun reported it to the C/O, who was in the vicinity.
- 3.2.11 After reporting, the bosun and OS A went to the stern to get SCBAs. The bosun ordered OS A to move the SCBAs to the area near CT No. 4 (P) and reported the accident to 3/O B, who was on navigational watch on the bridge.
- 3.2.12 The C/O, having been informed of the accident by OS A, went to CT No. 4 (P) while the bosun and OS A went to the stern. The C/O then went into the tank alone to rescue OS B, and while attempting to do so, he collapsed on the floor as well.
- 3.2.13 After OS A returned to CT No. 4 (P) with SCBAs, he discovered the C/O had collapsed inside the tank.
- 3.2.14 Meanwhile, 3/O B had been alerted by the bosun and called the master, who was in the captain's room, reporting the accident to him at around 10:30. The master came onto the bridge and ordered the crew to be gathered. Then, he moved to where the accident had occurred to take charge of the crew at the scene.



[Figure 8] Reenactment of the situation where the C/O and OS B collapsed
(Source: Korea Coast Guard Station Busan)

3.3 Rescue operations

- 3.3.1 On 23 November 2020, OS A discovered the C/O had fallen inside the tank and reported this accident to the crew of the engine department, including the C/E, who were cleaning the battery pack's cooling systems at the bosun store at around 10:30¹⁰⁾.
- 3.3.2 The master, 3/O A, and the bosun arrived at the scene with two more SCBAs. The master ordered other crewmembers at the scene to bring stretchers, harnesses, and automated external defibrillator (AED) as well as set cranes to pull the C/O and OS B out of the cargo tank.
- 3.3.3 The master directed his crewmembers to turn on the gas-freeing fan to ventilate the air inside CT No. 4 (P), and ordered 3/O A, the bosun, and AB B to don SCBAs and enter the tank to rescue the collapsed crewmembers.
- 3.3.4 The three crewmembers assigned to rescue operations by the master approached CT No. 4 (P). Other crewmembers standing by on the deck tied the SCBAs with rope and lowered them onto the tank floor so that the rescuers could put them on the collapsed crewmembers.
- 3.3.5 Those who entered the accident tank put the SCBA face-pieces on OS B and the C/O and supplied them with air. OS B recovered consciousness inside the tank during the rescue operations while the C/O remained unconscious.
- 3.3.6 The master ordered his men to use the crane to take OS B and the C/O out of the tank. OS B, who recovered consciousness, climbed up the ladder and out of the cargo tank on his own. However, the C/O remained unconscious, and the crewmembers connected his body with the harness and pulled him onto the upper deck.
- 3.3.7 The unconscious C/O received CPR, and AED was used as well. Yet white foam remained in his mouth.
- 3.3.8 Despite the first-aid, the C/O did not regain consciousness. Thus, the master went onto the bridge and called the 119 Marine Rescue Center by satellite telephone and asked about emergency medical treatment. However, the center answered that it would be difficult to practice additional medical treatment on board under the circumstances of the vessel¹¹⁾.

10) After being informed, the C/E and the engine department crews reassembled the battery pack's cooling systems.

11) The statement given by the master

- 3.3.9 At around 12:20, the master contacted the PCG via the Philippines' VHF to ask for medical assistance, and the PCG said to the master that the vessel should wait in the vicinity of Siraqui Island of Lingayen Gulf of the Philippines. Therefore, the master sailed for the location at a full speed.
- 3.3.10 At around 12:32, the master called the designated person (DP) of Eastern Tanker by satellite telephone and reported the accident to him, and the DP contacted the local ship agency to ask for medical assistance. The DP checked the C/O's condition while communicating with the master on the line.
- 3.3.11 At around 13:25, the PCG called the master via radio communication, saying that they could not provide a helicopter, but they could send a doctor and rescue teams via ship.
- 3.3.12 At around 13:30, *Onsan Chemi* arrived at the appointed location to meet with the PCG. However, there was a delay in arranging a doctor and getting permission to come aboard due to COVID-19.
- 3.3.13 The ship of the PCG arrived at the scene at around 15:00, and a doctor was on board *Onsan Chemi* by around 15:20. At around 15:30, the doctor confirmed that the C/O had died.

section

4

Analysis

4. Analysis

4.1 Cause of the C/O's death

- 4.1.1 On 23 November 2020, the C/O entered CT No. 4 (P) to rescue OS B, who had fallen on the floor while mopping. The C/O also lost consciousness and collapsed.
- 4.1.2 After being rescued by the other crewmembers, OS B regained consciousness. However, the C/O ended up dying even though he received CPR and other first-aid from the crew onboard.
- 4.1.3 CT No. 4 (P), where the accident occurred, had last been cleaned on 7 November 2020 and had remained empty for about fifteen days during the voyage. Before mopping on the date of the accident, the crew did not gas-free the tank. Moreover, oxygen and gas levels inside were unknown, as they had not been measured at the time of the accident.
- 4.1.4 According to the MSDS, UCO is not a high-risk cargo. Moreover, the tank where the UCO cargo had been carried had undergone the cleaning operation after the cargo had been discharged. However, even if the tank was cleaned, a small portion of less-visible residue could have remained and generated some gas.
- 4.1.5 *Onsan Chemi's* cargo tanks have an enclosed structure. Therefore, once gas is generated and not intentionally removed, it stays inside the tanks. Also, the tanks are not ventilated, so the possibility remains that the oxygen level inside could have dropped during the voyage for many reasons.
- 4.1.6 The National Forensic Service (NFS) of Korea also assumed that the C/O's death was caused by asphyxiation from oxygen deficiency and/or by gas poisoning (volatile organic compounds, VOCs).
- 4.1.7 Given this conclusion, the C/O is presumed to have died from gas poisoning and/or oxygen deficiency, because he entered a cargo tank where hazardous gas was generated from residue and oxygen was insufficient.

4.2 Confined space entry procedures

- 4.2.1 Chapter 4 (All Hazardous Operations) of the Safety Management System (SMS) Procedures of *Onsan Chemi* defines "confined space" as "an area where an opening for entry and exit is limited; the air inside is not naturally ventilated; and operators are not allowed to constantly stay." Examples of confined space are cargo tanks, double bottoms, fuel oil tanks, ballast tanks, and pump rooms. According to the SMS Procedures, CT No. 4 (P), where the accident occurred, also corresponds to the confined space definition.
- 4.2.2 The SMS Procedures detail the procedures which persons must comply with when entering a confined space. For the safety of operators, the following steps must be verified: ventilate the operation site; measure oxygen and gas concentrations; install lighting inside the operation site; and check whether those who enter the confined space carry a portable detector. It is also necessary to have SCBAs, oxygen resuscitators, lifelines and rescue safety belts on standby as well as to post an observer at the entrance of the confined space, just in case.
- 4.2.3 The operation manager (C/O) is supposed to note whether such procedures are being well followed when he issues the "confined space entry permit" prior to the operation. The permit must ultimately be approved by the master, and only then, operators are allowed to work in the confined space.
- 4.2.4 In this case, however, the confined space entry permit was not submitted for the mopping operation even though the operators had to enter a cargo tank designated as a confined space for mopping. It was also proven by the master's statement as he stated that no entry permit had been issued for the mopping operation.
- 4.2.5 Also, the last confined space entry permit approved by the master was dated at 28 October 2020¹²⁾. Since then, no entry permits had been written until the date of the accident (23 November 2020) were identified during the investigation.

12) The master stated that he had approved the confined space entry permit three to four times after 28 October 2020. However, he could not submit supporting documents.

4.3 Checking the safety of air inside the cargo tank

- 4.3.1 A cargo tank, as a confined space, is not ventilated, causing oxygen levels to be insufficient or toxic or flammable gases to remain inside. Therefore, it is always necessary to prepare against the risk of asphyxiation from oxygen deficiency, gas poisoning, or explosion when working inside the tank.
- 4.3.2 For such reasons, the crew must check the condition of the air inside by using an oxygen meter and a gas detector¹³⁾ before entering the confined space. If the air inside is not safe¹⁴⁾, it needs to be ventilated with fresh air. The space has to be constantly ventilated during the operation, and persons engaged in the operation are required to carry a portable detector to constantly check oxygen, hydrocarbon, and hydrogen sulfide concentration levels.
- 4.3.3 In this case, however, crewmembers stated that the C/O had not checked the oxygen and gas levels before entering in CT No. 4 (P) on the day of the accident, and that the air inside the tank had not been ventilated (gas-freed) as well.
- 4.3.4 In the morning on the day of the accident, the C/E asked the C/O whether he could clean the battery pack's cooling systems on the bosun store, and the C/O answered the C/E could start cleaning. However, the battery pack is a device for turning on the ship's hydraulics, and when it is off, a gas-freeing fan cannot be operated. Given that, the C/O had no intention of ventilating the air inside the tank before the operation.
- 4.3.5 The bosun stated that he had suggested gas freeing of the operation site, CT No. 4 (P), but that the C/O had not agreed, saying the measure was unnecessary.
- 4.3.6 Also, the ordinary seamen (OS) who participated in the operation were put into work without carrying portable detectors even though the air inside the tank was not identified as safe. Thus, the OS were unable to check the danger posed by the air inside. The C/O also entered the tank without a portable detector when attempting to rescue OS B.

13) There were a total of five detectors on board *Onsan Chemi*: three portable detectors for operators; and two movable detectors.

14) According to the SMS Procedures, a person may enter a confined space only when the air inside satisfies the oxygen concentration level of 21% ($\pm 0.5\%$); the lower explosive limit of hydrocarbon at 1%; hydrogen sulfide of less than 2ppm; and carbon monoxide of less than 25ppm.

- 4.3.7 Several crewmembers stated there had been cases where the C/O had not checked oxygen and gas concentrations before entering cargo tanks. They added that sometimes he had not accepted their suggestion when they had asked him to take safety measures before entering cargo tanks¹⁵).
- 4.3.8 Meanwhile, the master stated that the crew would have understood that "UCO cargo is safe¹⁶." He added that he himself had believed that the collapsed crewmember had been knocked out by the toxicity of the cleaning agent, since UCO cargo is not toxic. Since the C/O died, he left no statement to explain why he had entered the confined space without taking safety measures. Until, the C/O could very well have regarded UCO as a low-risk cargo based on its properties alone, while ignoring the danger of the confined space, and would not have taken additional safety measures.
- 4.3.9 The C/O was not aware he is obligated to ventilate the cargo tank when working inside such a confined space, and thereby, he did not take the required safety measures, such as checking oxygen and gas concentrations, ventilating the space, and carrying a portable detector.

4.4 Preparation for and response to dangerous situations

- 4.4.1 In accordance with the Chapter 4 (All Hazardous Operations) of the SMS Procedures of *Onsan Chemi*, SCBAs and oxygen resuscitators must be on hand, and an additional observer, apart from operators, is to be posted at the entrance of the confined space. These measures are to monitor the safety of operators working inside and to be able to respond to dangerous situations with urgency.
- 4.4.2 At the time of the accident, however, neither SCBAs nor oxygen resuscitators were placed at the entrance of the confined space, CT No. 4 (P). Under such circumstances, the C/O attempted to go inside the tank to rescue OS B, who had lost consciousness and collapsed. In the process, the C/O himself also collapsed on the floor. At that time, no safety observer had been posted at the scene.
- 4.4.3 OS B was first found collapsed at two to three minutes past ten o'clock. The crewmembers, including the master, arrived at the scene with SCBAs at around 10:30. Given that the distance

15) The crewmembers stated that their company (crew management company) had ordered them to listen to the C/O and thus they had been worried that the company might cancel their contracts if they had refused such orders.

16) The crewmembers stated they had not prepared SCBAs since the cargo loaded in CT No. 4 (P) (loaded and discharged prior to the accident) had been nontoxic UCO.

between CT No. 10, where the C/O had originally been working, and CT No. 4 (P), where the accident occurred, is about 50 meters, the C/O is presumed to have entered the cargo tank between 10:10 and 10:20.

- 4.4.4 The area in the vicinity of CT No. 4 (P) was not prepared for responding to any dangerous situation. No SCBAs or oxygen resuscitators were placed there; no safety observers were posted there, and the C/O went inside the cargo tank without PPE on.
- 4.4.5 The SMS Procedures¹⁷⁾ of *Onsan Chemi* state that rescue operations may endanger a rescue team if the team rushes into a rescue operation within a confined space or proceeds without being fully prepared. Thus, rescue operations can be conducted only when the rescue team meets the requirements.
- 4.4.6 However, even the rescue operations after the C/O had collapsed were not conducted under the rescue process mandated in the SMS Procedures. The master also did not determine the risk of the rescue operation by measuring the gas concentration inside the cargo tank prior to entry.

4.5. Supervision of the master on safety management

- 4.5.1 As the overall supervisor of *Onsan Chemi's* safety management, the master is authorized and responsible for making the best decisions for the ship's safety and environmental protection at sea as well as for asking the company for support.
- 4.5.2 His authority and responsibilities include directing and supervising the ship's safe operations; managing the crew and the ship and conducting various surveys; maintaining order on board; supervising the safe transport and loading/discharging of cargo; educating and training the crew; and overseeing safety checks on board.
- 4.5.3 Tasks like setting out and managing stowage plans, transporting and managing cargo, and cleaning cargo tanks are basically the C/O's duties, but the master is responsible for constantly guiding and supervising the C/O so that the C/O can safely perform his duties.

¹⁷⁾ Paragraph 4.3.10 (Rescue from Cargo Tanks and Other Confined Spaces) of Chapter 4 (All Hazardous Operations) of the PR-13 (Safety Management) specifies procedures that crewmembers must follow when rescuing persons from confined spaces.

- 4.5.4 Moreover, a chemical tanker transports various liquid chemical products alternately in the same tanks, necessitating that her cargo tanks be cleaned after discharging each cargo. Therefore, the master can predict when the cargo tanks are cleaned and when the C/O receives the confined space entry permit.
- 4.5.5 The C/O of *Onsan Chemi* did not receive the master's approval on the confined space entry permits for cargo tank cleaning and mopping operations from 28 October to the date of the accident, 23 November 2020. Given the cargo operations conducted during the period, the master is presumed to have been aware that cargo tanks had been cleaned. Until, the master had not checked why the confined space entry permits were not written for cleaning operations.

section

5

Conclusions

5. Conclusions

- 5.1 A cargo tank on *Onsan Chemi* had long been shut, causing the oxygen level to drop and hazardous gases to accumulate inside from the cargo residue and cleaning agent. However, the tanker OS personnel were told to mop the tank without ascertaining the interior air quality in advance. One OS collapsed inside the tank from oxygen deficiency and/or gas poisoning.
- 5.2 The C/O went inside the tank to rescue the fallen OS without taking any safety measures, and so he also collapsed from oxygen deficiency and/or gas poisoning and he ended up dying.
- 5.3 The major causes of this accident are (1) the crew habitually did not strictly comply with the safety instructions required in the company's SMS Procedures and (2) the C/O lacked safety awareness and did not observe the confined space entry procedures, for he was convinced by his experience that such lack of following the rules had not led to accidents before.
- 5.4 The master did not check and supervise whether safety instructions were being well observed, even though operations had been conducted in confined spaces on the ship without approval for a long time. Therefore, the master could not correct the C/O's misconduct.
- 5.5 Also, the C/O rushed into the rescue without ensuring safety or taking safety measures in advance, which increased the risk of an accident.

section

6

Lessons Learned

6. Lessons Learned

6.1 Strictly observing confined space entry procedures

- 6.1.1 When entering confined spaces, including cargo tanks, an operation manager who supervises work in the confined space must issue a confined space entry permit, obtain approval from the master, and perform the work in strict accordance with the safety instructions under the SMS Procedures of the ship.
- 6.1.2 Operators working in a confined space risk the dangers of explosions from gases inside the tank, in addition to asphyxiation or poisoning by those gases. Therefore, they need to always ensure that the air quality inside is safe by ventilating the space before and during the operation and monitoring oxygen and gas concentrations.
- 6.1.3 The operators must always carry a portable detector and measure the oxygen and gas level periodically so they can be aware of potential danger and immediately act while working in a confined space.
- 6.1.4 Furthermore, SCBAs, oxygen resuscitators, and other such gear need to be placed at the entrance of the confined space, and a safety observer who can immediately call the responsible officer must always be posted.

6.2 Strengthening supervision on the safety of onboard operations

- 6.2.1 The master, as an overall commander of the safety management of the ship, has to constantly check and oversee whether the crew is strictly complying with the safety instructions when they are engaged in high-risk operations.
- 6.2.2 Also, the master should direct the operation manager to conduct danger prediction training or

safety meetings before conducting dangerous operations so that the crew can review operational risk and prevent accidents.

6.3 Securing the safety of rescuers

- 6.3.1 Rescuers may be put in danger if their rescue is conducted within a confined space without full preparations having been made. Therefore, ensuring the safety of the rescuers is essential before starting any rescue operations.

6.4 Insuiling safety habits by observing work safety procedures

- 6.4.1 Shipping companies must constantly provide training programs for crewmembers so that they do not let their experience, practices, and work efficiency concerns override the need to be safe in confined spaces. The shipping companies, too, need to maintain strict guidance and supervision through internal audits.
- 6.4.2 When the crew engaged in onboard operations make reasonable demands, such as asking their superiors to observe safety procedures, the shipping companies must ensure that their demands are not ignored or that the crew are not disadvantaged for making such demands.

Table

[Table 1] Crew composition of <i>Onsan Chemi</i> by rank	10
[Table 2] Weather conditions	15

Figure

[Figure 1] General arrangement and photo of <i>Onsan Chemi</i> (Ex. <i>Oriental Wisteria</i>)	6
[Figure 2] Shipping routes of Sunwoo Tanker's fleet	7
[Figure 3] Structures and cargo tank layout of <i>Onsan Chemi</i>	11
[Figure 4] Hatch of CT No. 4 (P)	12
[Figure 5] Track of <i>Onsan Chemi</i> and the accident location	15
[Figure 6] Stowage plan of <i>Onsan Chemi</i> (Voyage No. 16)	18
[Figure 7] Cargo loaded/discharged at the time of the accident (Voyage No. 17)	19
[Figure 8] Reenactment of the situation where the C/O and OS B collapsed (KCG Busan)	21



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