



Marine Safety Investigation Report

on Bulk Carrier *ENVY*

– Fatality of stevedores –

Accident Date : 2021.03.18.

Publication Date : 2022.12.28.



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.

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Summary of Accident

1. Summary of Accident

- 1.1 After the bulk carrier *ENVY* unloaded her cargo (zinc concentrates, etc.), which had been loaded in Australia, at several Chinese ports and at Onsan, Korea, the vessel entered Donghae Port, Korea, which was the last place of unloading, at around 19:05 on March 18, 2021, to discharge the zinc concentrates that remained in the No. 2 cargo hold.
- 1.2 After the completion of berthing, the Chief Officer (C/O) of the bulk carrier surveyed her drafts with the cargo surveyor and filled out the ship/shore safety checklist with the shore foreman. After completing the checklist, at the request of the foreman, the hatch cover of the No. 2 cargo hold began to be opened at around 20:07, and the hatch cover was completely opened at around 20:12.
- 1.3 The No. 2 cargo hold had been kept closed since the cargo had been loaded in Australia. About two hours before entering Donghae Port, the C/O had measured the atmosphere composition and it was confirmed that the oxygen concentration within the cargo hold was 12.1%.
- 1.4 At around 20:30, the ship's crane was used to move an excavator onshore in the direction of the cargo hold for the purpose of placing the excavator inside the cargo hold. While doing so, the stevedoring team chief, who was looking down into the cargo hold from above, noticed that one stevedore had fallen on top of the cargo of zinc concentrates within the cargo hold.
- 1.5 To rescue the stevedore, an employee of the stevedoring company put on a self-contained breathing apparatus (SCBA) and went inside the cargo hold. While carrying out rescue activities inside, the rescuer also fell down inside the cargo hold.
- 1.6 At around 20:40, a rescue team from a local fire station boarded the ship to carry out rescue activities, but the two people who had fallen inside the cargo hold had already died due to the lack of oxygen inside the hold.

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Factual Information

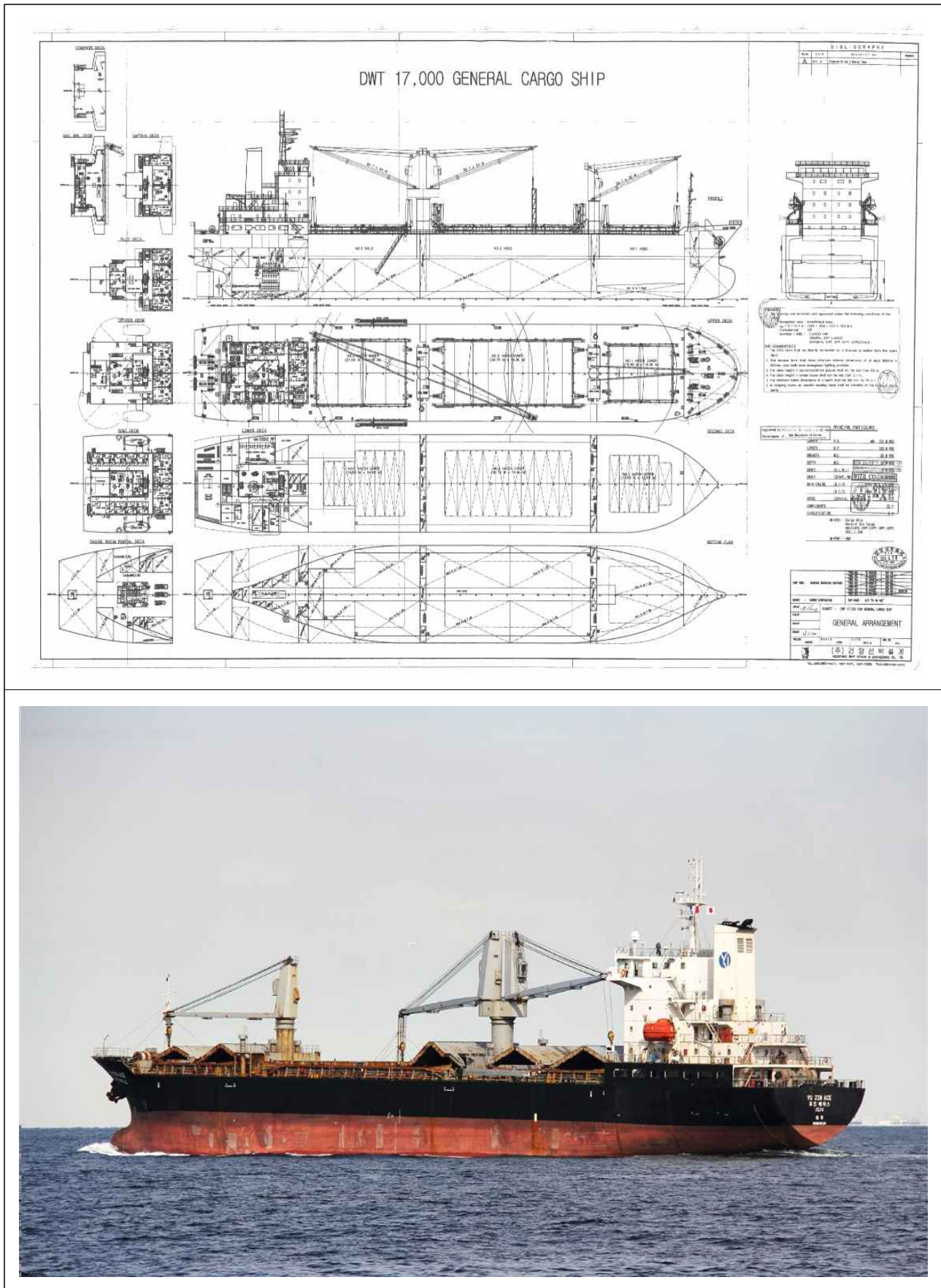
2. Factual Information

2.1 Ship Particulars

2.1.1 Principal particulars of *ENY*

Ship Name	<i>ENY</i>
Flag State	Republic of the Marshall Islands
Port of Registry	Majuro
IMO No.	9382695
Ship Type	Bulk Carrier
Owner	Carmel Shipping Ltd.
Safety Management Company(ISM)	FCN Management Inc.
Ship Builder	Iwagi Josen Co., Ltd, Japan
Date of Keel Laying/Launch	December 6, 2004 / April 24, 2006
Classification Society	Nippon Kaiji Kyokai (Class NK)
Gross Tonnage (t)	29,988
Length / Overall Length (m)	183.06 / 189.94
Beam (m)	32.26
Depth (m)	17.30
Main Engine	Diesel engine (MITSUI-MA B&W5L50MC)
Max. Output	9,480kW × 127RPM
Propeller	1 (solid screw-type propeller)
Rudder	1

2.1.2 *ENY* is a bulk carrier that was launched at Iwagi Josen in Japan on April 24, 2006, with a gross tonnage of 29,988 tons, length of 183.06 meters, width of 32.26 meters, and depth of 17.30 meters.



<Figure 1> General arrangement and view of the *ENY*

2.2 Shipowner and Operation

- 2.2.1 The owner of *ENY* is Carmel Shipping Ltd., and safety management is handled by FCN Management Inc.
- 2.2.2 As a tramp bulk carrier, this vessel sails to Southeast Asia, North America, and the Middle East to transport zinc concentrates, coal, wheat, iron ore, and other cargoes.

2.3 Ship Surveys carried out for the ship

- 2.3.1 *ENY* passed the renewal survey on May 14, 2016, and she had statutory certificates, including the Cargo Ship Safety Construction Certificates, required by the SOLAS Convention, that were valid until June 9, 2021. The most-recent survey conducted before the accident was an annual survey conducted on September 3, 2020, by Class NK.

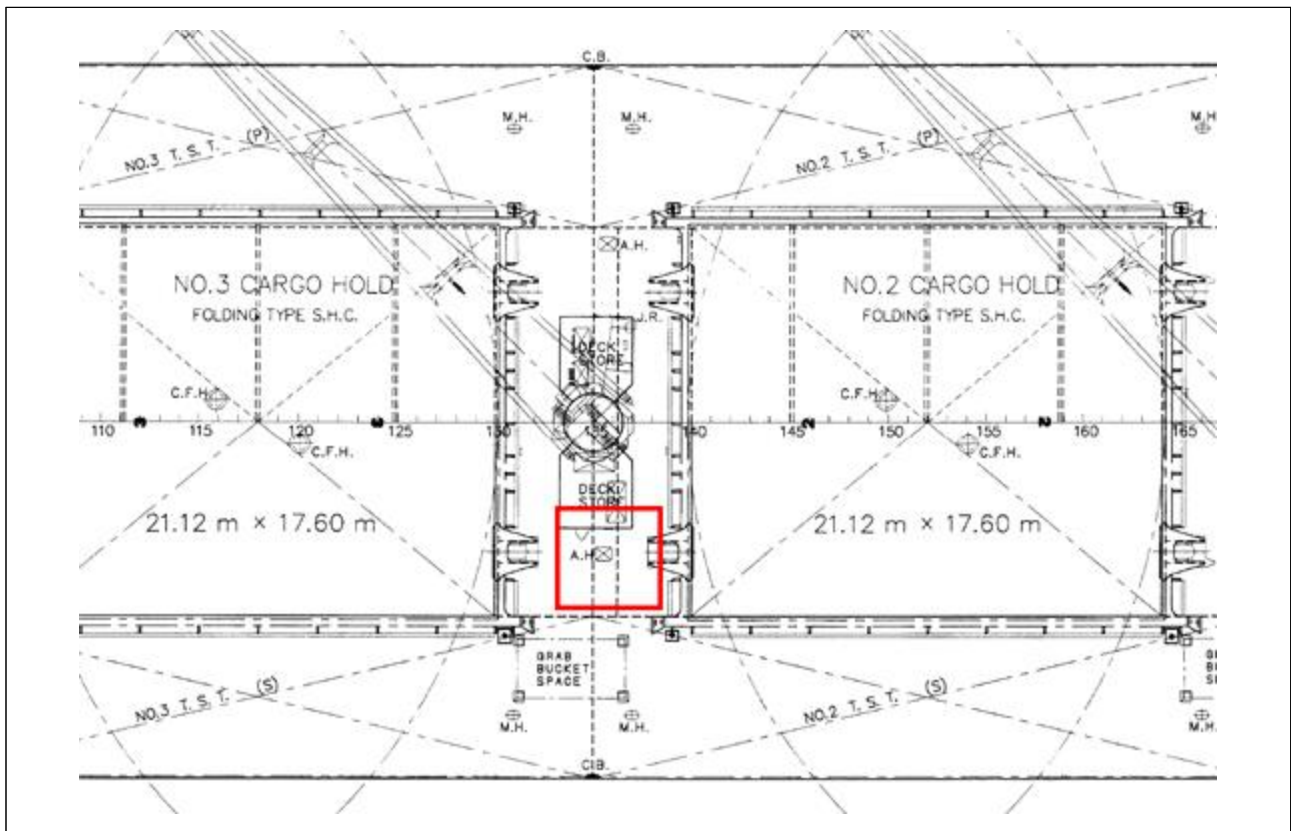
2.4 Crew Members

- 2.4.1 At the time of the accident, there were 21 crew onboard. Eleven of them (all of the officers and some staff members), including the captain and C/O, were Ukrainian, and 10 were Indonesian.
- 2.4.2 The captain has been in his role for about six years. He has experience on similar ships, but first boarded the ship concerned in August 2020. This was his first ship after joining the ship's ISM Company. It was his first time serving as captain on a ship carrying zinc concentrates.
- 2.4.3 The C/O had about seven years of experience as C/O. He had served on *ENY* before, but it was his first time loading a cargo of zinc concentrates. He boarded *ENY* on March 30, 2020.

2.5 Ship Structures

- 2.5.1 *ENY* has a stern bridge arrangement, with five cargo holds at a size of 21.12 meters

by 17.60 meters each, located at the front of the engine room area, which is arranged below the upper deck. Each cargo hold has a hatch cover and access hatches. The access hatch to the No. 2 cargo hold, where the accident occurred, is located at the cross deck between the No. 2 and No. 3 cargo holds.



<Figure 2> Location of access hatch (A.H) to No. 2 cargo hold

2.5.2 At the cross decks between the No. 1 and No. 2 cargo holds, No. 2 and No. 3 cargo holds, No. 3 and No. 4 cargo holds, and No. 4 and No. 5 cargo holds, there are jib cranes installed in each one for loading and unloading.

2.6 Cargoes

2.6.1 At the time the cargo was loaded, the descriptions of the cargo were provided in the cargo declaration received from the consignor. According to the declaration, the cargoes being loaded were "Mineral Concentrate/MIM Zinc Concentrate."

2.6.2 These cargoes, commonly called "zinc concentrates," fall under "Mineral

Concentrates,(BCSN¹⁾ : Mineral Concentrates)’ in accordance with the International Maritime Organization (IMO)’s International Maritime Solid Bulk Cargoes (IMSBC) Code.

- 2.6.3 Mineral concentrates are minerals in powder form made by enriching the valuable components through the removal of waste materials. Related characteristics are described in detail in the Appendix of the IMSBC Code.

General Information	
Shipper	Transport document number
Consignee	Carrier
Name/means of transport M.V "ENY".	Instructions or other matters
Port/place of departure	The specification data has been established from the stockpile in the shore storage shed. The moisture content will be monitored during loading and a declaration of the actual average moisture content of the full cargo will be provided for the Master after completion of loading. This material may liquefy if shipped at moisture content in excess of its transportable moisture limit (TML). These cargoes are non-combustible or have low fire risks.
Port/place of destination BUKPYUNG PORT, KOREA	
Cargo Information	
General description of the cargo (For solid bulk cargo – type of material/particle size) Mineral concentrate are refined ores in which the valuable component have been enriched by eliminating the bulk of waste material. Please refer to page 266 of the 2018 edition of the IMSBC code for further details on the safe handling of the cargo.	
Gross mass (kg/tonnes) General cargo: Cargo unit(s): Bulk cargo: 10,700 tonnes	Relevant special properties of the cargo (eg highly soluble in water. For solid bulk cargo, see Section 4 of the IMSBC Code)
Solid Bulk Cargo Information	
BCSN Mineral Concentrate / MIM Zinc Concentrate	
Specification of bulk cargo (if applicable) Stowage factor: 0.600 m3/t Angle of repose: 41.0 Degrees Trimming procedures: If potential hazard - chemical properties*: *eg: Class, UN number or MHB	Group of the cargo <input type="checkbox"/> Group A and B* <input checked="" type="checkbox"/> Group A* <input type="checkbox"/> Group B <input type="checkbox"/> Group C * For cargoes which may liquefy (Group A and Group A and B cargoes)

<Figure 3> Cargo information on the cargo declaration

1) Bulk Cargo Shipping Name(BCSN) : Name of shipment of solid cargo. If a solid cargo is shipped by sea, the cargo shall be identified as BCSN in the shipping document

Hazard

The above materials may liquefy if shipped at a moisture content in excess of their transportable moisture limit (TML). See sections 7 and 8 of this Code.

These cargoes will decompose burlap or canvas cloth covering bilge wells. Continuous carriage of these cargoes may have detrimental structural effects over a long period of time.

These cargoes are non-combustible or have low fire risks.

Precautions

Bilge wells shall be clean, dry and covered as appropriate, to prevent ingress of the cargo. The bilge system of a cargo space to which this cargo is to be loaded shall be tested to ensure it is working.

Ventilation

The cargo spaces carrying this cargo shall not be ventilated during voyage.

<Figure 4> Hazards of mineral concentrates under the IMSBC Code

- 2.6.4 In the cargo declaration and IMSBC Code, there are mentions of the possibility of the liquefaction of mineral concentrates, decomposability of burlap or canvas, and prohibition of ventilation during transportation, but there is no specific guidance or information on the possibility of oxygen absorption.

2.7 Safety Equipment

- 2.7.1 *ENVY* was equipped with an oxygen/gas detector to measure the oxygen and gas concentration before entering enclosed areas. The last calibration date of the equipment was February 18, 2021.
- 2.7.2 There were cargo hold air vents installed on the side of the cargo hold's hatch cover, but there was no mechanical ventilation device for forced ventilation.



<Figure 5> Gas detector on *ENVY*



<Figure 6> Cargo hold air vent.

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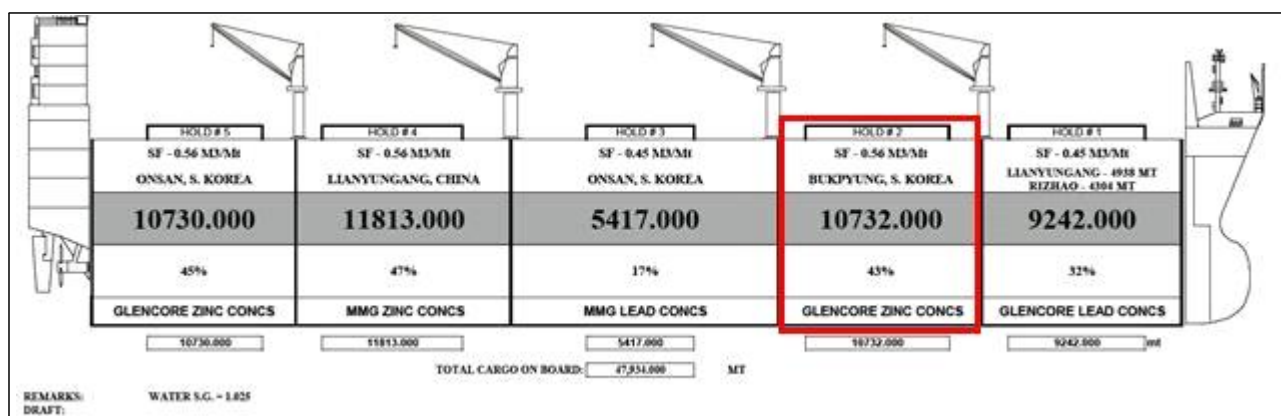
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Development of Accident

3. Details of Accident

3.1 Berthing of vessel

3.1.1 The *ENVY* loaded about 48,000 tons of cargoes, including zinc and lead concentrates, and departed from Townsville, located in the northeast of Australia, on February 15, 2021. Excluding the cargo in the No. 2 cargo hold, most of the cargoes were unloaded at the Lianyungang and Rizhao ports in China and Onsan Port in Korea, after which the vessel departed from Onsan Port on March 15, 2021. The cargo in the No. 2 cargo hold (10,732 tons of zinc concentrates) was going to be unloaded at the next port, Donghae Port²⁾.



<Figure 7> Details of cargo loading by cargo hold

3.1.2 On March 18, 2021, about two hours before entering Donghae Port where the cargo was to be unloaded, the C/O checked the oxygen concentration through the No. 2 cargo hold's gas sampling point. The oxygen concentration was measured at 12.1%.

2) In the related documents, Donghae Port is indicated with its former name of "BUKPYUNG."

No. C/H'S QUANTITY		CH 1 9242 mt	CH2 10732 mt	CH3 5417 mt	CH4 11813 mt	CH5 10730 mt	Checked/Verified by (NAME/RANK/SIGNATURE)
18.03.21 GAS SAMPLE POINT	CH-4 (METHANE) LEL, %	EMPTY	0	EMPTY	EMPTY	EMPTY	Kudner / CO [Signature]
	O2 (OXYGEN) VOL%	EMPTY	12.1	EMPTY	EMPTY	EMPTY	
	CARBON MON. CO, PPM	EMPTY	4	EMPTY	EMPTY	EMPTY	
	VENTILATION	EMPTY	CLOSED	EMPTY	EMPTY	EMPTY	

<Figure 8> Record of confirmation of concentrations of oxygen and other gases in the cargo hold before entering port

3.1.3 At around 19:05 on March 18, 2021, *ENY* completed berthing at Donghae Port.

3.2 Occurrence of accident

3.2.1 After surveying the ship's drafts with the cargo surveyor, which they started at around 19:25, the C/O entered the ship's office at around 19:50 to calculate the cargo volume. At around 20:00, the shore foreman came into the office and discussed the unloading procedures with the C/O. The "ship/shore safety checklist," which was managed and used by the ship, was filled out at that time.

SHIP / SHORE SAFETY CHECK LIST for loading or unloading dry bulk cargo carriers			
Date	2024.03.18		
Port	BUKPYUNG	Terminal / Quay	PIER 23
Available depth of water in berth	9.80 M	Minimum air draught	N/A
Ship's name	ENY		
Arrival draught (read / calculated)	FWD-6.39 M AFT-6.39M	Air draught	12.88 M
Calculated departure draught	FWD-4.45M AFT-6.30M	Air draught	14.29 M
<p>The master and terminal manager, or their representatives, should complete the checklist jointly. Advice on points to be considered is given in the accompanying guidelines. The safety of operations requires that all questions should be answered affirmatively and the boxes ticked. If this is not possible, the reason should be given, and agreement reached upon precautions to be taken between ship and terminal. If a question is considered to be not applicable write "N/A", explaining why if appropriate.</p>			
12.	Has the shipper provided the master with the properties of the cargo in accordance with the requirements of chapter VI of SOLAS?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
13.	Is the atmosphere safe in holds and enclosed spaces to which access may be required, have fumigated cargoes been identified, and has the need for monitoring of atmosphere been agreed by ship and terminal?	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

<Figure 9> Ship/shore safety checklist for loading or unloading work that was used on the day of the accident

3.2.2 At around 20:07 on the same day, some of the crew, at the foreman's request, started to open the cargo hatch cover. At around 20:12, the hatch cover of the No. 2 cargo hold was completely opened. Next, preparations were made to enable the ship's crane to be used. After the hatch cover of the cargo hold was opened, the stevedore on shore went up to the hatch coaming of the cargo hold on the upper deck to check the loading status of the cargo inside the cargo hold.



<Figure 10> Appearance of the cargo being loaded into the cargo hold at the time of the accident

3.2.3 To prevent the cargo from falling into the sea during the unloading process, the crewmen installed a net between the shore and the ship's side. At the time, the foreman and stevedoring team chief discussed the unloading and decided to bring an excavator into the cargo hold.

3.2.4 At around 20:30, the ship's crane started to lift up the excavator from the shore.³⁾ Since the excavator was going to be placed inside the No. 2 cargo hold, the stevedoring team chief went onto the cargo hold's hatch coaming on the upper deck to look down inside the cargo hold. While doing so, he noticed that Stevedore A had fallen on top of the cargo (zinc concentrates). The excavator that was hanging from the crane at the time was then placed back down on the dock.

3.3 Rescue efforts

3) The stevedore on shore boarded the ship to operate the ship's crane.

- 3.3.1 After finding that a person had fallen inside the cargo hold, the stevedoring team chief informed the shore foreman of such fact and also reported the accident to a local fire station. The foreman also notified his superior (C)⁴⁾, who was on shore at the time, of the incident.
- 3.3.2 The foreman tried to enter the cargo hold to attempt a rescue while only wearing a dust mask. Half way down the ladder into the cargo hold, he started to feel dizzy and came back up to the deck.
- 3.3.3 Upon returning to the deck, the foreman screamed at the gangway duty crewman by the gangway ladder to give him an “oxygen mask,” and the crewman brought a respirator and self-contained breathing apparatus (SCBA) from the ship’s hospital. The foreman put on the SCBA and took the hospital respirator and went back down into the cargo hold. In hopes of getting the fallen stevedore to regain consciousness, he kept shouting at him. While doing so, he went back up to the deck thinking that “there’s nothing I can do by myself.
- 3.3.4 The foreman’s superior (C) was on shore when he was notified of the accident by the foreman. As soon as he was notified, he boarded the vessel, donned the SCBA and went down into the cargo hold,⁵⁾ where he conducted emergency first aid on Stevedore A. While C doing so, Stevedore B also went down into the cargo hold. This was when C, who was performing first aid, fell down on top of the cargo inside the cargo hold. Stevedore B fell down when he returned to the deck.
- 3.3.5 Meanwhile, at around 20:40, the local fire station rescue team on shore came up the gangway ladder and began rescue operations for Stevedore A. After being notified of the accident by the officer on duty, the captain went out to the deck and helped the local fire station rescue team with their rescue activities.

3.4 Casualties

4) One of the people who died from this accident.

5) The foreman who was shouting passed the foreman’s superior (C) and Stevedore B on the ladder as he was coming up out of the cargo hold.

3.4.1 This accident caused two fatalities and one injured person. The fatalities were Stevedore A, who went into the cargo hold first, and the foreman's superior (C), who had gone inside to rescue Stevedore A, and the injury was sustained by Stevedore B, who had gone inside the cargo hold to attempt to rescue Stevedore A.

section

4

Analysis

4. Analysis

4.1 Cause of Death

- 4.1.1 Until the ship entered Donghae Port, the No. 2 cargo hold, where zinc concentrates were loaded, had not been opened for more than one month since the vessel departed from Australia on February 15, 2021.⁶⁾ Since zinc concentrates are a cargo that carries the possibility of liquefaction, there was no ventilation of the cargo hold during the voyage. About two hours before entering Donghae Port, the C/O confirmed that the oxygen concentration in the No. 2 cargo hold was 12.1%, using the gas sampling tube.
- 4.1.2 After entering Donghae Port, the No. 2 cargo hold was completely opened at around 20:12. At around 20:30, the ship crane was used to start bringing over an excavator from the shore. Based on the testimonies given by the captain, C/O, and stevedore, it is assumed that Stevedore A fell into the cargo hold through the hatch (cargo hold hatch) of the cargo hold while the excavator was being moved to the cargo hold.
- 4.1.3 Since only a short time of about 30 minutes had passed after the cargo hold had been opened and there was only natural ventilation, the atmosphere inside the cargo hold had not yet undergone complete exchange with the air outside, so it is assumed that the atmosphere inside the cargo hold would have had a low concentration of oxygen.⁷⁾
- 4.1.4 Also, since it was stated that “the possibility of suffocation due to lack of oxygen should be considered,” according to the autopsy result of the fatalities,⁸⁾ it can be assumed that the direct cause of death was suffocation due to lack of oxygen.

6) According to the IMSBC Code, since there is the possibility of liquefaction if the moisture content of the mineral concentrates is high, it is prohibited to ventilate the cargo hold loaded with such cargoes during the voyage.

7) However, since the oxygen concentration inside the cargo hold was not measured separately before entering the cargo hold, the exact oxygen concentration inside the cargo hold at the time of the accident cannot be known.

8) Conducted by the National Forensic Service.

4.2 Cargo characteristics

- 4.2.1 Enclosed spaces on ships are prone to developing low oxygen concentrations due to the oxidation of the hull. The oxygen concentration in a cargo hold loaded with a cargo that can easily oxidize can decline particularly quickly.
- 4.2.2 At the time of the accident, the *ENY* was carrying zinc concentrates (BCSN⁹⁾: Mineral Concentrate). To identify whether this cargo contributed to the low-oxygen environment in the cargo hold, the characteristics of the cargo were analyzed, including oxygen absorption.
- 4.2.3 First, the cargo information document that was provided by the consignor when the cargo was loaded in Australia¹⁰⁾ was reviewed. In general, the cargo is called “zinc concentrates,” but the official name of the cargo (BCSN) written on the cargo declaration was “mineral concentrates.” The document provides information on the characteristics of the cargo, including stowage factor, angle of repose, and liquefaction possibility, among others. However, there was no explicit precaution about the fact that the cargo could absorb oxygen.
- 4.2.4 Next, the cargo information of the IMSBC Code was reviewed. This is because the characteristics of the loaded cargo and handling precautions for safe transportation are stated in it. Regarding the mineral concentrates of the bulk carrier *ENY*, it is included in the IMSBC Code, but it is not explicitly mentioned that this cargo can absorb oxygen. However, in terms of the use of information on metal concentrates, it is stated that the information on metal sulfide concentrates should be used as a reference and that such information mentions oxygen absorption as one characteristic of metal sulfide concentrates.

9) Bulk Cargo Shipping Name (BCSN): Each solid bulk cargo in the Code has been assigned a BCSN, which is the official and proper shipping name of the cargo. All sea transport documentation must identify a solid bulk cargo by its BCSN.

10) According to Regulation 2, Chapter VI of the International Convention for the Safety of Life at Sea (1974 SOLAS Convention), it is stated that “The shipper shall provide the master or his representative with appropriate information on the cargo sufficiently in advance of loading to enable the precautions which may be necessary for proper stowage and safe carriage of the cargo to be put into effect”.

Mineral concentrates*(see Bulk Cargo Shipping Names below)*

CEMENT COPPER	LEAD ORE RESIDUE	PYRITIC CINDERS
COPPER CONCENTRATE	LEAD SILVER	SILVER LEAD
IRON CONCENTRATE	CONCENTRATE	CONCENTRATE
IRON CONCENTRATE	MANGANESE	SLIG (iron ore)
(pellet feed)	CONCENTRATE	ZINC AND LEAD
IRON CONCENTRATE	NEFELENE SYENITE	CALCINES (mixed)
(sinter feed)	(mineral)	ZINC AND LEAD
LEAD AND ZINC CALCINES	NICKEL CONCENTRATE	MIDDLEINGS
(mixed)	PENTAHYDRATE CRUDE	<u>ZINC CONCENTRATE</u>
LEAD AND ZINC MIDDLEINGS	PYRITES	ZINC SINTER
LEAD CONCENTRATE	PYRITIC ASHES (iron)	ZINC SLUDGE

See also the entries for metal sulphide concentrates.

Description

Mineral concentrates are refined ores in which valuable components have been enriched by eliminating the bulk of waste materials.

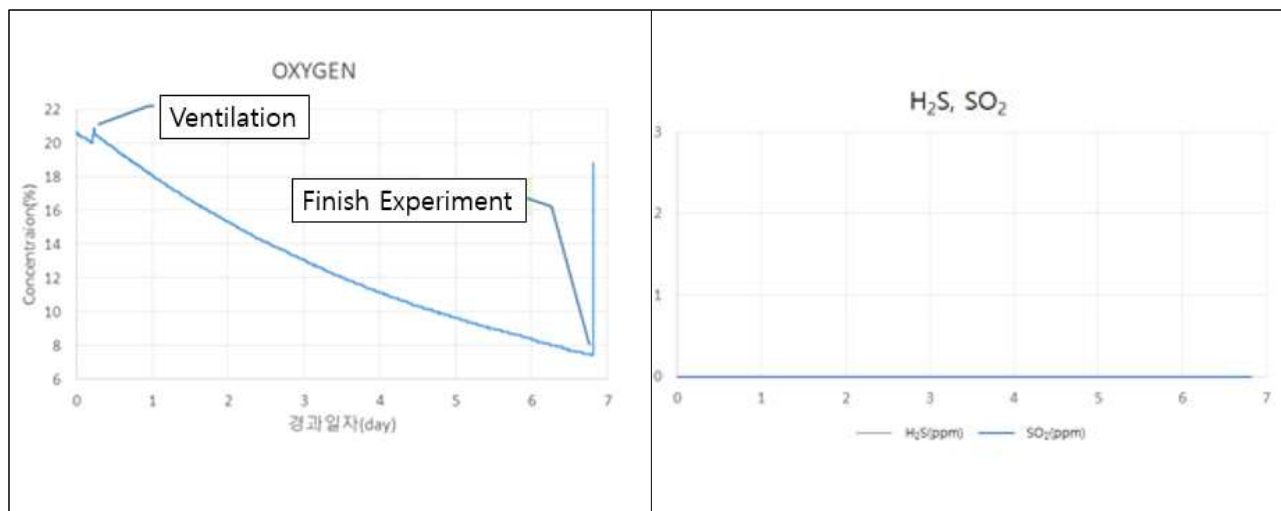
<Figure 11> Bulk cargo shipping names related to mineral concentrates under the IMSBC Code

4.2.5 It could not be confirmed through the cargo declaration whether there was a risk of oxygen absorption. According to the IMSBC Code, it could not be confirmed whether the cargo (mineral concentrates) concerned had the capability to absorb oxygen. Therefore, to clearly confirm whether the zinc concentrates loaded at the time of the accident reduced the concentration of oxygen in the air, a zinc concentrate sample was collected from the cargo hold and placed in an airtight test container and the oxygen concentration measured.¹¹⁾

4.2.6 The results showed that the oxygen concentration in the test container decreased steadily. The oxygen concentration declined from 20.5% at the beginning of the test¹²⁾ to 7.4% after about 6.5 days.




11) Conducted at the Occupational Safety and Health Research Institute (OSHRI).

12) The concentrations of hydrogen sulfide (H₂S), sulfur dioxide (SO₂), volatile organic compounds (VOC), and carbon monoxide (CO) were also measured, but no significant decreases were observed.



<Figure 12> Test results of zinc concentrates loaded on the ship

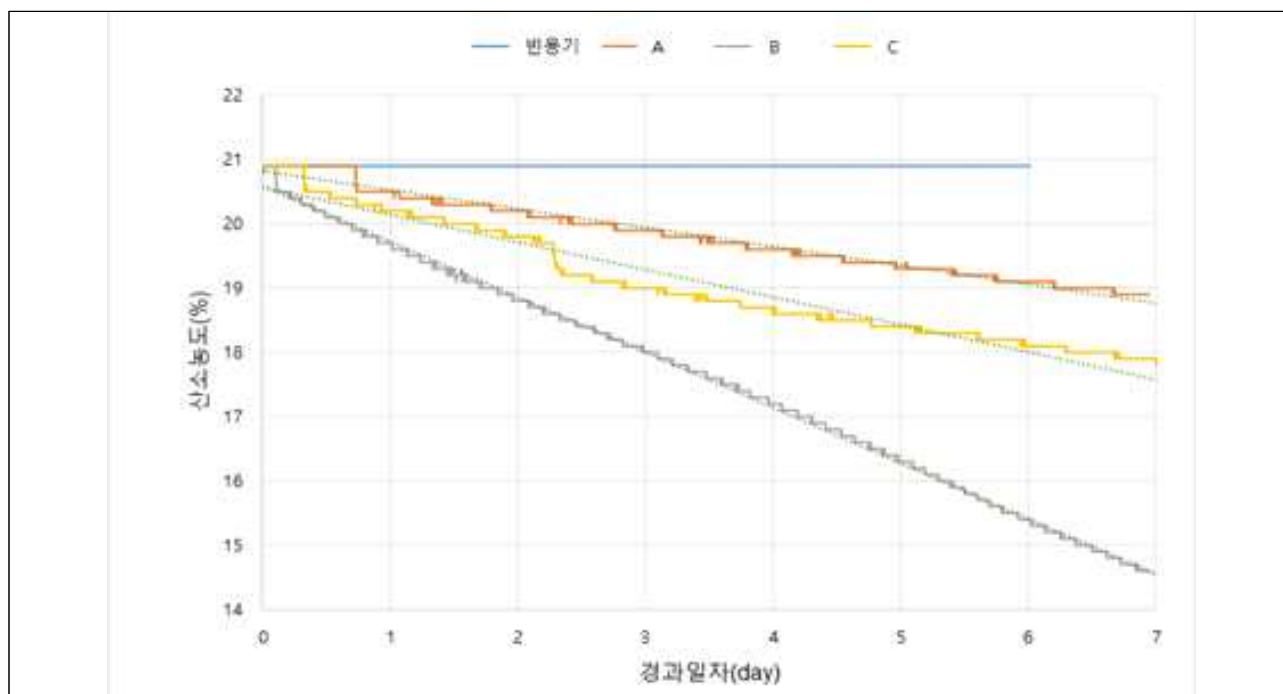
4.2.7 Also, to find out whether the characteristic of reducing oxygen concentration is common among zinc concentrate cargoes or if it is a special property of the particular zinc concentrates that were loaded on the ship at the time of the accident, samples of zinc concentrates that had been loaded on three different vessels¹³⁾ were collected and placed in test containers and the oxygen concentration observed for about seven days.

Vessel	Name of ship	Ship A	Ship B	Ship C
	Gross tonnage	24,842	17,027	9,611
Cargo	Classification	A	B	C
	BCSN on cargo declaration	METAL SULPHIDE CONCENTRATES (ZINC CONCENTRATE)	METAL SULPHIDE CONCENTRATES (ZINC CONCENTRATE)	ZINC CONCENTRATES
	Port of loading	Oceania	Oceania	South America
	Photo			

[Table 1] Zinc concentrate samples collected from three different ships

13) The names (BCSN) of the zinc concentrates sampled from the three ships were not all the same on the cargo declaration.

4.2.8 The results showed a tendency for the oxygen concentration to decrease in all cases, with some differences by cargo. After about seven days, the oxygen concentration of the zinc concentrates for A¹⁴⁾ decreased from 20.9% to 18.9%; for B,¹⁵⁾ decreased from 20.9% to 14.6%; and for C,¹⁶⁾ decreased from 20.9% to 17.9%.¹⁷⁾



<Figure 13> Test results of zinc concentrate samples collected from three different ships

4.2.9 Looking at these test results, the cargo loaded on the *ENVY* at the time of the accident is judged to have been a cargo with the capability to absorb oxygen. However, this information was not specified in the cargo declaration, and such information was also not provided to the vessel in the appropriate way.

4.2.10 Meanwhile, the cargo that is generally called “zinc concentrates” is classified in various ways in the IMSBC Code, including as metal sulfide concentrates and mineral concentrates. Regarding oxygen absorption, it was reviewed how they are

14) BCSN: METAL SULPHIDE CONCENTRATES (ZINC CONCENTRATE) on the cargo declaration.

15) BCSN: METAL SULPHIDE CONCENTRATES on the cargo declaration.

16) BCSN: ZINC CONCENTRATES on the cargo declaration.

17) The decrease in oxygen concentration caused by the zinc concentrates on the ship involved in this accident was more sudden than the decreases caused by the zinc concentrate samples collected from other ships. However, given the difference in test conditions, including the sample size, it is difficult to make a direct comparison.

specified in the IMSBC Code.

4.2.11 In the former, it is stated in the IMSBC Code that “some sulfide concentrates are liable to oxidation and may have a tendency to self-heat, with associated oxygen depletion” and “entry into the cargo space of this cargo shall not be permitted until the space has been ventilated and the air tested for concentration of oxygen.” On the other hand, in the latter case (mineral concentrates), which was the same type of cargo loaded on the *ENVY*, no clear precaution is stated regarding oxygen absorption. In terms of utilizing the information on mineral concentrates, since it is stated that the information on mineral sulfide concentrates should be referred to, it is possible to identify the risk of oxygen absorption by mineral sulfides only after confirming the information on mineral sulfide concentrates.

Hazard

This cargo may liquefy if shipped at a moisture content in excess of its transportable moisture limit (TML). See sections 7 and 8 of this Code.

Some sulphide concentrates are liable to oxidation and may have a tendency to self-heat, with associated oxygen depletion and emission of toxic fumes. Moisture in the cargo will form sulphurous acid which is corrosive to steel. Some metal sulphide concentrates may have acute and long-term health effects.

Precautions

Entry into the cargo space for this cargo shall not be permitted until the space has been ventilated and the atmosphere tested for concentration of oxygen. Appropriate precautions shall be taken to protect machinery and accommodation spaces from the dust of this cargo. Bilge wells shall be clean, dry and covered as appropriate, to prevent ingress of the cargo.

<Figure 14> Characteristics of metal sulfide concentrates (precautions for entry, etc.) stated in the IMSBC Code

4.2.12 Both cargoes (metal sulfide concentrates and mineral concentrates) were loaded on *ENVY* in Australia.¹⁸⁾ The comparison of the oxygen absorption shown on various documents is shown below.

¹⁸⁾ Mineral sulfide concentrates (unloaded at Lianyungang Port) were loaded in the No. 4 cargo hold, and mineral concentrates (unloaded at Donghae Port) were loaded in the No. 2 and No. 5 cargo holds.

Port of discharge	Name of cargo		Tendency to absorb oxygen			
	STOWAGE PLAN	Shipping order (BCSN)	Shipping order	MSDS ¹⁹⁾	IMSBC (based on BCSN)	Test results
Lianyungang Port	MMG ZINC CONCENTRATES	METAL SULFIDE CONCENTRATES	Oxygen absorption	Oxygen absorption	Oxygen absorption	-
Donghae Port	GLENCORE CONCENTRATES	Mineral Concentrate /MIM Zinc Concentrate	Not mentioned	Not available ²⁰⁾	Not mentioned ²¹⁾	Oxygen absorption

[Table 2] Comparison of zinc concentrates unloaded at Lianyungang Port and Donghae Port

4.2.13 Looking at the test results, it can be seen that the cargo loaded on the *ENVY* had the capability to absorb oxygen. However, there was no specific mention of such oxygen absorption tendency in the cargo declaration for the IMSBC Code.²²⁾ Considering that there are a variety of zinc concentrates with varying characteristics, it is assumed that it would have been difficult for the crew of the vessel to know the oxygen absorption characteristics of the loaded cargo.

4.3 Ship/shore consultation and information sharing before the loading/unloading process

4.3.1 In the Chapter 7 “Shipboard Operation” of the company’s shipboard safety management manual, it is required that the ship and shore information be exchanged before the loading/unloading process and the ship/shore safety checklist for loading or unloading dry bulk cargo carriers be filled out. Therefore, the C/O and the shore foreman discussed and filled out the safety checklist before opening the cargo hold (No. 2).

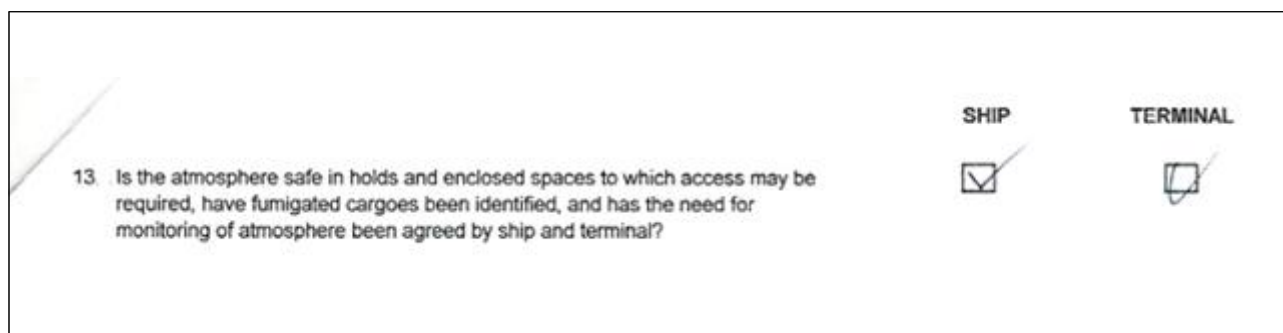
19) Material Safety Data Sheet (MSDS)

20) Requested the related MSDS from the company, but has not received it.

21) The phrase “see also the entries for metal sulfide concentrates” is stated.

22) If the information on metal sulphide concentrates had been referred to, it would have been known that the cargo could absorb oxygen.

4.3.2 On the safety checklist, the C/O and shore foreman are required to check with each other whether the atmosphere in a cargo hold or any enclosed area is safe to enter or whether observation of the atmosphere, including in the cargo hold, is needed. To indicate that the atmosphere in the cargo hold was safe, the C/O and the shore foreman each marked that item on the checklist with a checkmark.



13. Is the atmosphere safe in holds and enclosed spaces to which access may be required, have fumigated cargoes been identified, and has the need for monitoring of atmosphere been agreed by ship and terminal?

SHIP ☒

TERMINAL ☒

<Figure 15> Ship/shore checklist regarding the atmosphere inside the cargo hold

4.3.3 During the investigation, the shore foreman testified that he had filled out the checklist with the C/O. Regarding the information on the MSDS of the cargo and the cargo's oxygen absorption property, he also stated that he had not received such information from the vessel. Based on this, it can be determined that there was insufficient exchange of ship/shore safety information.

4.3.4 The foreman had a lot of experience with unloading zinc concentrates in the same method, but there had not been any accidents related to oxygen depletion. Also, since no information on oxygen concentration had been provided by the ship, he stated that he was unaware of the oxygen absorption property of the ship's cargo. Considering that the foreman did not know about such property, it is assumed that the stevedore (the deceased) who received orders from the foreman also did not know about the oxygen absorbing property of the cargo.

4.3.5 Meanwhile, the foreman stated that he had been given the cargo information from the MSDS received from the consignor.²³⁾ However, according to the investigation result, the MSDS was not about zinc concentrates but zinc metal,²⁴⁾ and there was

23) The shore did not receive the MSDS from the ship.

24) Compared to how the zinc content of zinc metal is more than 99.9% on the MSDS, it was found that the zinc

no mention of oxygen absorption.

4.4 Procedures for entry into enclosed spaces

- 4.4.1 In the Chapter 8 “Emergency preparedness” of the company’s shipboard safety management manual and its appendix of the health and safety manual, the procedures for entry into enclosed spaces are stated.
- 4.4.2 According to the manual, since enclosed spaces such as a cargo hold can create the conditions for deadly accidents such as suffocation, it is specified to “never assume that the conditions are safe.” Also, when entering enclosed spaces, in order to confirm the procedures to be completed before entry, it states that a checklist for entering the enclosed spaces should be filled out.

8.17 SAFE ENTRY AND RESCUE FROM CONFINED SPACES

ENTRY INTO DANGEROUS SPACES

Every year a number of merchant seamen lose their lives through enclosed space incidents. The responsibility has been placed on the Master, or person in charge on board, who have not taken necessary precautions in order to avoid such accidents. A summary of the main points should be considered and measures to be taken for avoiding accidents.

- a. Entrances to unattended dangerous spaces to be kept closed or secured.
- b. The Master must ensure safe entry procedures are followed.
- c. The principles and guidance contained in the Code of Safe Working Practices (Chapter 10).
- d. An offence will have been incurred by any person entering an enclosed space not following the procedures or without authority.
- e. Drills to be carried out for rescue from enclosed spaces at periods not exceeding two months.
- f. Oxygen meters and other appropriate testing devices are carried on vessels where entry into dangerous spaces may be required.

<Figure 16> Regulation on entry into enclosed spaces (manual on emergency situations)

concentrates loaded on the ship contained 49.7% zinc.

2.4 ENTERING ENCLOSED OR CONFINED DANGEROUS SPACES

2.4.1 GENERAL

Unsafe atmosphere may be present or arise subsequently in any enclosed or confined space including tanks, holds, void spaces, double bottoms, duct keels, pump rooms, cofferdams, chain lockers, CO₂ rooms, sewage tanks, pressure vessels, battery lockers, inter barrier spaces, etc. Entering any confined space is hazardous and can result in rapid death from harmful gases and/or lack of oxygen. **NEVER ASSUME A TANK OR HOLD IS SAFE.** It is the Master's responsibility to identify hazardous spaces and to establish procedures for safe entry.

Any tank, cargo hold or space which has contained a liquid or which has been sealed must be assumed to have a dangerous atmosphere and consequently be unsafe for entry without the protection of breathing apparatus. Unprotected entry should not be attempted until a competent person has made an assessment and taken the appropriate measures to ensure the space is safe for man entry. Any open tank which has NOT been «gas freed» should be secured against entry and a NO ENTRY notice hung on the hatch opening. The Master or Chief Mate MUST ensure that it is safe to enter an enclosed space by:

- a) Identifying potential hazards.
- b) Ensuring the space is prepared for entry and has been thoroughly ventilated by natural or mechanical means.
- c) Testing the atmosphere of the space at different levels for oxygen deficiency and harmful vapour (where suitable instruments are available).
- d) Ensure procedures are instituted before and after entry. If any doubt as to adequacy of ventilation or testing ensure breathing apparatus is worn by all persons entering the space.

In all cases and prior to entry, the ENTRY PERMIT CHECKLIST must be completed.

<Figure 17> Procedures for entering enclosed spaces according to the health and safety manual (ventilation, etc.)

4.4.3 3 The manual states the danger of oxygen depletion in detail. Due to oxidation, oxygen depletion can occur in enclosed spaces on a ship. It also clearly states that certain cargoes have properties that cause oxygen absorption, which introduces risks related to a lack of oxygen.

2.4.3 OXYGEN DEFICIENCY

If an empty or other confined space has been closed for some time, the oxygen content may have been reduced by the rusting process. Lack of oxygen may occur in boilers and pressure vessels where oxygen absorbing chemicals have been used to prevent rusting. Certain cargoes absorb oxygen, thus creating the danger of oxygen reduction in the holds. Some of these cargoes are: concentrates; vegetable products and grains; certain types of wood cargoes; steel / iron products; coal; sulphur; etc. If CO₂ steam or other fire extinguishing chemical has been discharged into a space, the oxygen contents of that space will be depleted.

2.4.4 EFFECTS OF OXYGEN DEFICIENCY

Normal air contains approximately 21% of oxygen by volume. Atmospheres containing 16% or less of oxygen may cause serious injury or death to people breathing them, depending on the actual concentration, length of exposure, and physical activity of the exposed persons. It has to be emphasised that symptoms indicating an oxygen deficiency in the atmosphere do not provide sufficient warning and most persons would fail to recognise the danger until they are too weak to be able to escape without help.

<Figure 18> Description of the risk of oxygen deficiency in the manual

- 4.4.4 4 However, the investigation showed that, at the time of the accident, there were no procedures implemented or restrictions on entry into the enclosed space, including filling out the checklist for entry into enclosed spaces. About the reason for doing so, the captain and C/O testified that no one on shore, including the foreman, informed the crewmen that anyone was entering the cargo hold.
- 4.4.5 At the foreman's request, the cargo hold's hatch cover was completely opened at around 20:12 on March 18, 2021, and the excavator on shore was lifted up. If the excavator had been lowered into the cargo hold, it is assumed that the stevedore (the deceased), would have opened the cargo hold's access hatch himself and gone inside the cargo hold to quickly separate the excavator from the crane.
- 4.4.6 The timing of the lowering of the excavator was not discussed in advance with the ship. Based on usual practice, the ship's crew would have expected that the excavator would be placed in the cargo hold after other cargo-related tasks had been completed.²⁵⁾ It is believed that the crewmen had not expected that the excavator would be deployed as soon as the cargo hold was opened. Therefore, it

25) According to the results of investigations conducted by other companies that unload zinc concentrates, the deployment of the excavator is done based on the judgment of the person responsible for the unloading work. In the case where the cargo hardens and it is difficult to unload with grab buckets, an excavator is deployed at the beginning of the unloading work.

was also not expected that the stevedore would go inside the cargo hold.

4.4.7 For these reasons, the atmosphere inside the cargo hold was not checked, and without any safety measures put in place in advance, including preparation of a stretcher or respirator for rescue efforts in the case of an accident such as suffocation, the stevedore entered the cargo hold.²⁶⁾

4.4.8 Meanwhile, “restricted area” signs were affixed to the cargo hold’s access hatches, but it seemed like there were no other measures in place to restrict anyone from entering, such as locking devices.²⁷⁾ The signs were not for safety but security purposes. Such signs are common on other ships, so even if the stevedore had seen it, it is assumed that he would not have perceived any danger.



<Figure 19> Appearance of the access hatch of the No. 2 cargo hold and the restricted area sign

4.4.9 The ship did not have any strict restrictions on entry to the restricted area, and the stevedore went inside the cargo hold by himself without any prior notification to the ship. As a result, the procedures for entry into an enclosed area were not followed.

26) The stevedore went inside the cargo hold without even carrying a personal oximeter.

27) According to the recommendations for entry into enclosed spaces aboard ships (IMO Res. A.1050(27)), since there could be a misunderstanding that the enclosed area concerned is safe to enter because the opening of the cargo hold has allowed for natural ventilation, it is stated that it is appropriate to place a person at the access hatch or close off the access hatch using physical methods such as ropes or chains with a warning.

In other words, if there had been sufficient restrictions on entry to the restricted area, it is believed that the stevedore entering the enclosed area alone without the crewmen's help or ship's permission could have been prevented.

2. 위험요인 및 안전대책			
선대	위험요인	안전대책	방 법
□	절삭	1. 밀폐공간에 산소농도 측정 후 작업실시 2. 밀폐공간 작업 장소 출입금지 게시 3. 밀폐공간 내 환기 및 공기호흡기 또는 송기마스크 사용 4. 비상사태 발생 시 응급처치방법 교육 실시	1. 최초 인력 투입 전 산소농도 측정 측정결과 18% ~ 23.5% ->작업진행 2. 인력 투입 시(2인 1조) 산소농도측정기 지급

<Figure 20> Confined Space Work Plan for Foreman (Stevedores)

section

5

Conclusions

5. Conclusions

- 5.1 The fatality that occurred during the unloading work was an accident where stevedores who entered a cargo hold (No. 2) loaded with zinc concentrates to carry out unloading work died from suffocation caused by a lack of oxygen inside the cargo hold.
- 5.2 The zinc concentrates that were going to be unloaded at the time of the accident are a cargo that is known to absorb oxygen, and when the ship entered the port, the oxygen level in the cargo hold was low. The accident occurred only 30 minutes after the cargo hold's hatch cover had been opened, with the stevedore entering the cargo hold, an enclosed space, after opening the cargo hold's access hatch by himself without the ship's permission.
- 5.3 The stevedore did not receive any information about the possible lack of oxygen in the cargo hold beforehand. It is believed that it was his experience of not perceiving any particular danger when unloading zinc concentrates in the past that led him to make the wrong judgment in this case and enter the cargo hold without any personal safety equipment, including an oximeter. Since the stevedore did not inform the ship that he was going to go inside the cargo hold alone, the safety procedures that must be complied with on the ship, including procedures on entry into enclosed spaces, were not followed.
- 5.4 At the time of the accident, it was indicated on the cargo hold's access hatch that the cargo hold was a restricted area, but there was no effective means provided to prevent entry at one's discretion, such as placing a crewman at the access hatch. As a result, a stevedore was able to enter the cargo hold unrestricted and without the ship's permission.

section

6

Recommendations

6. Recommendations

6.1 Restriction of entry into enclosed spaces and strengthening of entry procedures

- 6.1.1 The investigation showed that a stevedore on shore entered the cargo hold, which was an enclosed space, by himself without the ship's permission. It is believed that this kind of entry was possible because restrictions on enclosed areas on the ship had not been properly implemented and the people who boarded the ship to carry out the unloading work did not thoroughly understand the danger of entering an enclosed area.
- 6.1.2 The captain should have strictly prevented any entry so that non-crew members who came onto the ship were unable to enter an enclosed area by placing a person at the access hatch or setting up ropes, chains, or other equipment. Also, when a non-crew member boards the ship, it is necessary to sufficiently warn that person about the danger of entering enclosed areas, the procedures for entry, and other related matters.

6.2 Strengthening of ship/shore consultation when conducting unloading

- 6.2.1 Before beginning the unloading work, the C/O and foreman exchanged information related to unloading and filled out the ship/shore safety checklist about the work to be done. Regarding the information exchange/consultation and filling out of the checklist to ensure a safe and smooth unloading process, it seems that such safety measures were conducted as a mere formality in the case of this ship.
- 6.2.2 Therefore, to minimize any danger that may occur during unloading, the C/O and stevedoring company (foreman) should exchange information and consult with one another sufficiently before starting the unloading process, including the characteristics of the cargoes and procedures for entering enclosed areas.

6.3 Provision of clear information on any risks involved in handling the cargoes

- 6.3.1 From the cargo declaration, it could not be determined whether the loaded cargo had the property of absorbing oxygen. Also, in general, the cargo called “zinc concentrates” is indicated using various cargo names (BCSN) in the IMSBC Code, so it was difficult to clearly identify whether the particular zinc concentrates that were loaded had the property of absorbing oxygen or not.
- 6.3.2 Therefore, it is necessary for the consignor to clearly state or indicate on the cargo declaration any risks posed by the cargoes concerned to enable the crew, stevedores, and others to easily identify any risks involved in handling and be careful when handling them.



Ministry of Oceans and Fisheries

Korea Maritime Safety Tribunal