MA2025-4

MARINE ACCIDENT
INVESTIGATION REPORT

April 24, 2025

JTSB Japan Transport Safety Board

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

RINOIE Kenichi
Chairperson
Japan Transport Safety Board

Note:

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

《Reference》

The terms used to describe the results of the analysis in "3. ANALYSIS" of this report are as follows.

i) In case of being able to determine, the term "certain" or "certainly" is used.

ii) In case of being unable to determine but being almost certain, the term "highly probable" or "most likely" is used.

iii) In case of higher possibility, the term "probable" or "more likely" is used.

iv) In a case that there is a possibility, the term "likely" or "possible" is used.

MARINE ACCIDENT INVESTIGATION REPORT

Vessel Type and Name: Bulk Carrier EVER FELICITY
IMO Number: 9379856
Gross Tonnage: 9,589 tons

Accident Type: Injury and Fatality of Stevedores
Date and Time: May 20, 2024, at around 07:35
Location: North Wharf, Hibarino, Ishinomaki Port, Ishinomaki City, Miyagi Prefecture;
Approximately 960 meters from the Hibarino Leading Light in Ishinomaki Port, at true bearing 346.7°
(Approximate Position: Latitude 38°24.4′N, Longitude 141°16.9′E)

March 19, 2025
Adopted by the Japan Transport Safety Board
Chairperson: TAKEDA Nobuo
Member: ITO Hiroyasu
Member: UENO Michio
Member: SODA Hisako
Member: OKAMOTO Makiko

SYNOPSIS

<Summary>

While the bulk carrier EVER FELICITY (hereinafter referred to as "the Vessel") was engaged in cargo handling operations berthed at the North Wharf of Hibarino in Ishinomaki Port, Ishinomaki City, Miyagi Prefecture, at around 07:35 on May 20, 2024, two stevedores lost consciousness and collapsed inside a cargo hold. Both of Stevedores were transported to a hospital; one was later pronounced dead, and the other sustained injuries.

<Probable Causes>

This accident is more likely to have occurred during the loading of palm kernel shells (hereinafter referred to as "PKS") at the North Wharf of Hibarino in Ishinomaki Port. Two stevedores entered No.1 CH without a prior working environment measurement. As a result, they inhaled air with an oxygen concentration lower and a carbon dioxide concentration higher than those of standard atmospheric conditions, lost consciousness, and collapsed onto the PKS.

The failure to conduct a working environment measurement in No.1 CH prior to entry is more likely to have resulted from the fact that the Sempoku Branch of Nippon Express Co., Ltd. did not prepare a safe work procedure manual—including a risk assessment covering the working environment inside the cargo hold—nor did it implement the legally mandated safety management measures for stevedores engaged in cargo hold operations.

The absence of a safe work procedure manual for the PKS loading operation is more likely to have resulted from the following factors:

(1) The Sempoku Branch of Nippon Express Co., Ltd. representative judged that, due to the vessel entered the port in a light (empty) condition and there was no perceived hazard inside the cargo hold, the work could be conducted simply by reversing the unloading procedure. Accordingly, he determined that the loading operation did not constitute work involving the adoption of new work methods or procedures as stipulate under the Nippon Express Occupational Safety and Health Management System.

(2) Within the Sempoku Branch of Nippon Express Co., Ltd., did not conduct to direct instructions or comments were issued indicating that a new risk assessment work procedure manual should be prepared, in response to the judgment made by the representative as described in (1) above. It is probable that the implement of the loading operation could be safely conducted using conventional methods according to experience and procedures related to the loading of bulk cargo, and subsequently the stevedores were instructed to perform the operation in accordance with the planning sheet.

(3) The representative and stevedores at the Sempoku Branch of Nippon Express Co., Ltd. failed to recognize that the working environment might change as the loading of PKS progressed within cargo hold, and they were not aware that the operation fell under the requirements of the Industrial Safety and Health Act (Act No. 57 of 1972), the Ordinance for Enforcement of the Industrial Safety and Health Act (Cabinet Order No. 318 of 1972), and the Ordinance on Prevention of Oxygen Deficiency, etc. (Ministry of Labour Ordinance No. 42 of 1972), which mandate the measurement of the working environment in such situations.

1 PROCESS AND PROGRESS OF THE MARINE ACCIDENT INVESTIGATION

1.1 Summary of the Accident

The bulk carrier EVER FELICITY was engaged in cargo handling operations berthed at the North Wharf of Hibarino in Ishinomaki Port, Ishinomaki City, Miyagi Prefecture, when, at around 07:35 on May 20, 2024, two stevedores lost consciousness and collapsed inside a cargo hold. Both stevedores were transported to a hospital, where one was later pronounced dead and the other was injured.

1.2 Outline of the Accident Investigation

1.2.1 Setup of the Investigation

The Japan Transport Safety Board appointed an investigator-in-charge and two other investigators to investigate this accident on May 23, 2024.

1.2.2 Collection of Evidence

May 23 and December 27, 2024: Interviews and Collection of Questionnaires

May 24–25 and July 25–26, 2024: On-site inspections, interviews, and Collection of Questionnaires

May 30; June 4, 5, 13, 14, and 21; July 3, 20, 22, and 23; August 2, 21, and 28; October 2, 18, and 23; and November 12 and 13, 2024: Collection of Questionnaires

1.2.3 Support for the Investigation

Factual information regarding the fermentation process of palm kernel shells (PKS) was provided by the Japan Society for Bioscience, Biotechnology, and Agrochemistry and the Japan Woody Bioenergy Association.

1.2.4 Opinions of Parties Relevant to the Cause

Comments were obtained from parties involved in the cause of the accident.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

The sequence of events leading up to the occurrence of the accident, as well as the subsequent rescue operations, were determined according to on-site investigations; statements from the master (hereinafter referred to as “the Master”) of the EVER FELICITY (hereinafter referred to as “the Vessel”); two navigation officers (hereinafter referred to as “N. Officer A” and “N. Officer B”); a representative of Nippon Express Co., Ltd. (hereinafter referred to as “Company A”), and its Sempoku Branch (hereinafter “A1 B. Office”), which was contracted to carry out cargo handling operations for the Vessel; the injured stevedore (hereinafter “Stevedore B”) who entered No.1 CH (hereinafter referred to as “No.1 CH”) along with another stevedore (hereinafter “Stevedore A”); the rescue personnel who recovered

Stevedores A and B; and according to the reply to questionnaires by A1 B. Office and the hospital to which Stevedores A and B were transported.

2.1.1 Vessel Operation and Events Leading to the Accident

The Vessel, manned with the master and 17 other personnel (5 from the People's Republic of China, 4 from the Republic of Indonesia, 6 from the Republic of the Union of Myanmar, and 2 from the Socialist Republic of Vietnam), berthed starboard side at the North Wharf of Hibarino in Ishinomaki Port, Ishinomaki City, Miyagi Prefecture (hereinafter referred to as "the Wharf"), at around 07:00 on May 15, 2024, with its bow facing west, for the purpose of loading Palm Kernel Shells (hereinafter referred to as "PKS") *1.

At the time of berthing, the Vessel was in a light (empty) condition, and under the cargo handling contract, it was scheduled to load 10,000 MT*2 of PKS—stored in open piles at the Wharf—into No.1 CH and No.2CH. The loading of the PKS (i.e., the operation of loading cargo onto a vessel or similar platform, hereinafter referred to as "the Loading Operation") was carried out from May 15, the day of berthing, through May 18, except on May 17 when the operation was suspended due to bad weather. On the evening of May 18, the hatch covers were closed, and no work was conducted on May 19, the day before the accident, as it was a designated non-working day. (See Table 1, Figure 1, and Figure 2.)

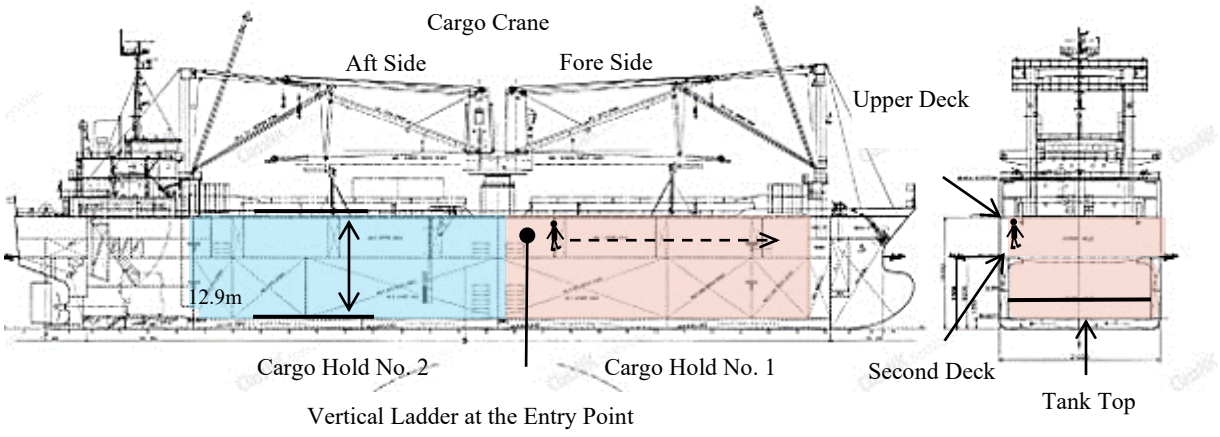
Table 1 – Progress of the Loading Operation (May 15–19)

Date	No.1 CH Accumulated Load (MT)	No.2CH Accumulated Load (MT)	Weather / Relative Humidity Hatch Cover Status
May 15	1,104	1,182	Clear, later cloudy / 81% Open during operation only
May 16	2,430	2,490	Cloudy with occasional rain / 86%

*1 PKS (Palm Kernel Shell) refers to the dried shells remaining after oil has been extracted from the fruit of the oil palm. It is a fibrous material, with a particle size of approximately 5 to 20 mm.

*2 MT (Metric Ton)" is a unit of mass defined according to kilograms (kg). One metric ton is defined as equal to 1,000 kilograms (1 megagram or 1 Mg).

			Open during operation only
May 17 Operation suspended due to bad weather	2,430	2,490	Cloudy with occasional rain / 61% Closed all day
May 18	3,576	3,390	Clear / 66% Open during operation only
May 19 (Holiday)	3,576	3,390	Clear / 74% Closed all day



Note: The second deck inside the cargo hold is walkable.

Figure 2 – Overview of Vessel Structure

At around 07:05 on May 20, in accordance with prior instructions from A1 B. Office, N. Officer B—who was on deck duty watch during the cargo operations—together with the boatswain and ordinary seaman, opened the hatch cover of No.2 CH, which had been closed. They then opened the hatch cover of No.1 CH in preparation for the Loading Operation.

The entrance to No.1 CH, located at the center of the port side of the upper deck (hereinafter referred to as “the Entry Point”), was positioned at the aft-most section of No.1 CH. At the area beneath this Entry Point, Palm Kernel Shells (hereinafter referred to as “the PKS”) had been loaded to approximately halfway between the upper deck and the second deck—approximately 10.3 meters above the tank top deck, about 3.2 meters below the Entry Point hatch opening, and approximately 2.6 meters below the upper deck. In addition, from approximately the midsection of No.1 CH toward the fore end, the Subject PKS had been loaded to a height at where the stage of the second deck remained visible—about 7.7 meters above the tank top. (See Figure 3.)

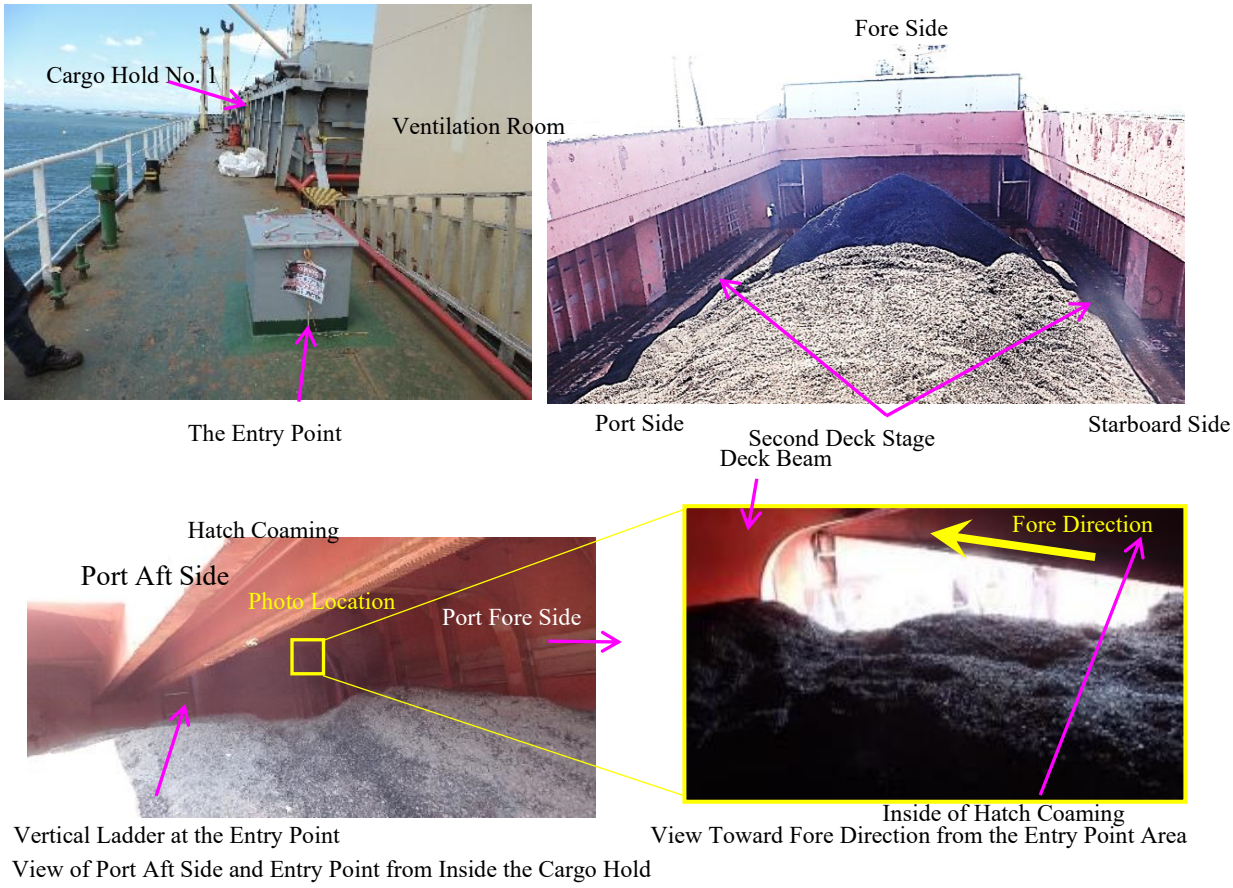


Figure 3 – Condition Inside No.1 CH and at the Entry Point

At around 07:15, nine stevedores from A1 B. Office (hereinafter referred to as "the Stevedores"), including Stevedore A and Stevedore B, who were responsible for the Loading Operation, held a pre-operation meeting at the Wharf. Led by the work supervisor, they verbally confirmed the procedure for the Loading Operation and conducted hazard prediction activities and other safety checks. However, during the meeting, there was no discussion regarding the working environment measurement*3 inside the cargo hold. It should be noted that the Loading Operation was primarily carried out by the Stevedores of A1 B. Office, while the Vessel's crew was only responsible for operating the hatch covers and performing other tasks as necessary.

At around 07:20, the Stevedores moved to their assigned positions. Stevedore A began setting up a protective net to prevent the scattering of the Subject PKS, while Stevedore B began attaching a lifting fixture*4 to the cargo handling crane (hereinafter simply

*3 "Working environment measurement" refers to the development of a measurement plan, sampling, and analysis (including interpretation) of the air and other environmental conditions, conducted in accordance with relevant parameters, for the purpose of understanding the actual conditions of the working environment.

*4 "Lifting fixture" refers to a load adjustment device used in construction or worksite cranes. It is installed between the crane hook and the load to stabilize the load or adjust its position during lifting operations.

referred to as “the Crane”) in preparation for bringing a piece of heavy machinery, commonly referred to as a “backhoe,” *5 into the cargo hold.

At around 07:30, Stevedores A and B moved from the Wharf to the upper deck of the Vessel. Stevedore A intended to enter No.1 CH via the Entry Point to detach the lifting fixture from the backhoe, while Stevedore B, as the operator of the backhoe, also proceeded to enter the hold via the vertical ladder at the Entry Point.

Stevedore B found it difficult to enter from the Entry Point, as the Subject PKS was visibly piled directly beneath the hatch, making access appear obstructed. He attempted to find an alternative entry point, however, unable to locate one, began descending the vertical ladder at the Entry Point. Stevedore A followed behind him.

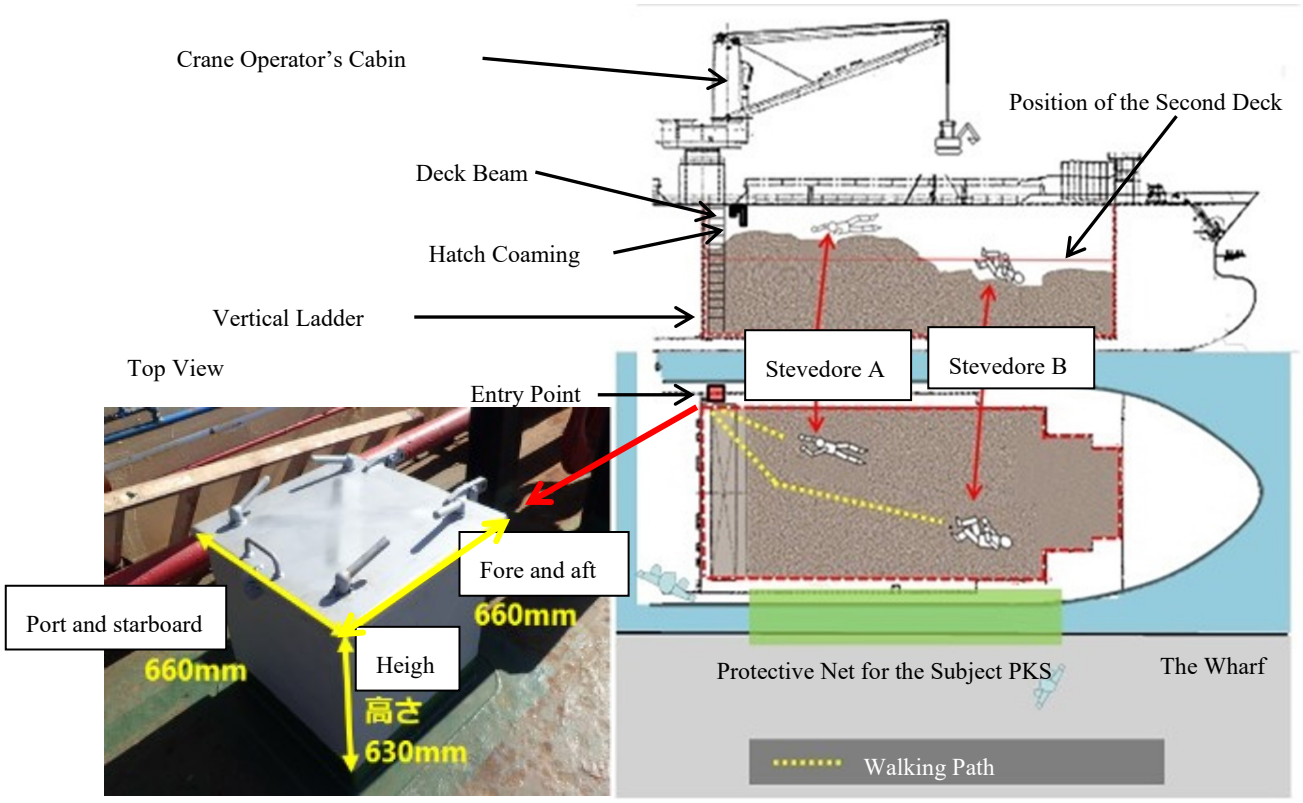
Upon stepping onto the surface of the Subject PKS, Stevedore B sensed something unusual. After seeing Stevedore A begin to descend into the hold behind him, Stevedore B, apparently unconsciously, turned toward the brighter area ahead and proceeded in the fore direction of No.1 CH, crouching beneath a deck beam and the hatch coaming—running across the top of the hold in the port-starboard direction—located above his head (approximately 0.6 meters and 1 meter below the upper deck, respectively). He then began to feel his consciousness fading and subsequently lost all memory of what happened next.

The stevedore operating the fore-side crane (hereinafter referred to as “the Crane Operator”) took his position in the operator’s seat and, at around 07:35, attempted to contact Stevedore A via radio. When there was no response from Stevedore A, he sensed something was wrong. Acting on his own judgment, he rotated the Crane to look into No.1 CH, where he discovered that Stevedore A had collapsed on the port aft side and Stevedore B on the starboard fore side, both lying on top of the Subject PKS.

(See Figure 4.)

At around 07:40, the Crane Operator shouted to the Stevedores on the Wharf to alert them to the occurrence of the accident. The work supervisor immediately reported the occurrence and situation of the accident via mobile phone to both A1 B. Office and the person in charge of overseeing the management of the Loading Operation at A1 B. Office.

*5 “Backhoe” is a type of hydraulic excavator, classified as self-propelled heavy machinery, with a shovel (bucket) mounted in a direction facing the operator.



Note: The walking paths of Stevedore A and Stevedore B are according to information collected by A1 B. Office.

Figure 4 – Injury Locations of the Stevedores Inside No.1 CH

2.1.2 Progress of Rescue Operations Following the Accident

Upon receiving the report of the accident, A1 B. Office made an emergency call (119) at around 07:42.

An ordinary seaman, having been informed of the accident by the Stevedores, reported the accident to N. Officer B at around 07:45. After being notified by the ordinary seaman, N. Officer B reported the accident to N. Officer A—the Vessel's cargo handling supervisor—and to the Master. He also brought two sets of self-contained breathing apparatus to the center of the upper deck.

The Master, having been informed by the Stevedores that ambulances would be arriving shortly, instructed the crew to stop rescue preparations and remain on standby inside the Vessel.

In response to the 119-emergency call, the Fire Command Center dispatched two ambulances and other emergency vehicles. At around 07:50, the ambulances, a rescue truck, and other vehicles arrived at the Wharf. A team of 15 rescue personnel began assessing the situation and preparing for rescue operations. Additionally, officers from the police station and the Coast Guard station, both of which had been contacted by the

Fire Command Center, arrived at the Wharf at around 08:10.

The rescue personnel, police officers, and Coast Guard officers (hereinafter collectively referred to as "the Rescuers") looked into No.1 CH from the upper deck and confirmed that Stevedore A had collapsed on the Subject PKS on the port aft side, and Stevedore B had collapsed on the Subject PKS on the starboard fore side. They called out to both individuals. However, there was no response from either Stevedore A or Stevedore B.

The Rescuers conducted an oxygen concentration measurement inside No.1 CH and confirmed that the oxygen level was lower than that of normal atmospheric conditions. Subsequently, two of the Rescuers donned self-contained breathing apparatus and began the rescue operation.

At around 08:20, the Rescuers observed that Stevedore B regained consciousness in response to their calls and stood up. He walked on his own toward the Entry Point, reaching an area near the center of the port side, but appeared to be in a dazed state. Just before reaching the Entry Point, he sat down, holding both of his legs. Subsequently, Stevedore B was assisted by a Rescuer wearing a self-contained breathing apparatus and climbed the vertical ladder at the Entry Point to exit onto the upper deck, where another Rescuer provided additional support.

Stevedore A was found to be unconscious, with no breathing or pulse, as confirmed by the Rescuers. He was secured in a basket stretcher—a transport device that encloses and immobilizes the body—and lifted to the upper deck using the fore-side Crane. He was then lowered onto the deck by the Rescuers.

Stevedore A and Stevedore B were each transported by ambulance to a hospital in Ishinomaki City. During transport, Stevedore A's condition remained unchanged, while Stevedore B's breathing and pulse both returned to normal levels. Upon arrival, both individuals received medical treatment.

Stevedore B recovered and was discharged from the hospital later that day. Stevedore A remained hospitalized but was pronounced dead by a physician at 08:06 a.m. on the following day, May 21.

After the accident, the A1 B. Office representative obtained additional information from Stevedore B and other Stevedores, indicating that Stevedore A had collapsed on the Subject PKS on the port aft side of No.1 CH, and that Stevedore B had collapsed on the starboard fore side of the same hold. Based on this information, the representative judged that Stevedore A had entered the hold through the Entry Point and moved toward the port aft side, while Stevedore B had entered through the same Entry Point and moved toward the starboard fore side, and that each had collapsed on the Subject PKS in those respective areas.

2.2 Information on Injury and Fatality

According to the postmortem certificate, medical certificate, and the reply to the questionnaires by the attending physician, the details were as follows.

(1) Stevedore A

The cause of death for Stevedore A was post-resuscitation encephalopathy*6, with suspected carbon dioxide poisoning as a contributing factor. However, the possibility of poisoning due to oxygen deficiency or other toxic gases could not be ruled out.

(2) Stevedore B

Stevedore B's injuries were suspected to be due to carbon dioxide poisoning and aspiration pneumonia. However, the possibility of poisoning due to oxygen deficiency or other toxic gases could not be ruled out.

According to the reply to the questionnaire by the hospital, the symptoms of oxygen deficiency and carbon dioxide poisoning are difficult to distinguish by appearance alone and must be assessed through blood gas analysis. However, unless the blood sample is taken immediately after the inhalation of the gas, it is not possible to distinguish the cause from the phenomenon in which carbon dioxide levels rise due to cardiopulmonary arrest.

2.3 Information on Damage to the Vessel

There was no damage to the hull of the Vessel resulting from the accident.

2.4 Information on Crew Members and Related Personnel

(1) Age, Certificates of Competency, etc.

i) Master – 54 years old

Nationality: People's Republic of China

Endorsement attesting the recognition of certificate under STCW regulation I/10: Management class (Navigation, Master) (issued by the Republic of Panama)

Date of Issue: May 17, 2023

(Valid until December 1, 2027)

ii) Stevedore A – 57 years old

iii) Stevedore B – 53 years old

iv) A1 B. Office Representative – 48 years old

(2) Work History, Health Condition, etc.

i) Stevedore A

Joined Company A in April 2004 and had since been engaged in port cargo handling operations. On the day of the accident, the record of the hazard prediction activity conducted by A1 B. Office prior to the start of operations (hereinafter referred to as the "Hazard Prediction Sheet") indicated "Good" in the section for health status.

Stevedore A was engaged in the Loading Operation on the third day of cargo handling, May 18, and on the fourth day, May 20 (the day of the accident).

ii) Stevedore B

Joined Company A in November 2010 and had since been engaged in port cargo handling operations. On the day of the accident, the health section of the Hazard Prediction Sheet indicated that his health condition was good. He had also completed the training course for Supervisors of Skill Training Course for Operations Supervisors of Dangerous Work in Oxygen-Deficient Air or Involving Hydrogen

*6 Post-resuscitation encephalopathy refers to brain damage that occurs following the resuscitation of cardiopulmonary arrest.

Sulfide*7.

Stevedore B had prior experience in unloading operations involving PKS (i.e., operations for unloading cargo from vessels, etc.), beginning around December 2022. He was engaged in the Loading Operation on May 15 (the first day of cargo handling), May 18 (the third day), and May 20 (the fourth day and the day of the accident).

iii) A1 B. Office Representative

Joined the company in April 1999 and, after being assigned to A1 B. Office in 2014, had been engaged in port cargo handling operations. Since 2023, he has served as the person responsible for overseeing those operations. In the Loading Operation, he acted as the person in charge of management and prepared the work plan. On the day of the accident, his health condition was good.

2.5 Information on the Vessel

2.5.1 Principal Particulars

IMO Number: 9379856
Port of Registry: Panama (Republic of Panama)
Shipowner: SINOWEALTH SHIPPING CO., LIMITED
Ship Management Company: EVERTEMPO MARINE CO., LTD
Gross Tonnage: 9,589 tons
Class: Nippon Kaiji Kyokai General Incorporated Foundation (NK)
L x B × D: 119.99 m × 21.20 m × 14.30 m
Hull Material: Steel
Engine: One diesel engine
Output: 3,900 kW
Propulsion: One 4-blade fixed pitch propeller
Launch Date: October 24, 2006
Type of Vessel: Bulk Carrier
Capacity of persons on board: 22 persons
(See Photo 1)

Photo 1: The Vessel

*7 "A Supervisor of Work Involving the Risk of Oxygen Deficiency or Hydrogen Sulfide" is a person designated under Article 14 of the Industrial Safety and Health Act (Act No. 57 of 1972) to supervise operations in environments where there is a risk of workers being exposed to oxygen-deficient or hydrogen sulfide gas conditions.

2.5.2 Information on Draft

According to the on-site investigation of the Vessel and the reply to the questionnaires by A1 B. Office, the draft upon entering Ishinomaki Port was approximately 2.40 meters at the fore and approximately 4.80 meters at the aft. At the time of the accident, the draft was approximately 7.42 meters at the bow and 8.00 meters at the stern.

2.5.3 Information on Ship Equipment, etc.

According to the on-site investigation, the statements of the Master and Officer A, the reply to the questionnaires by A1 B. Office, and the Vessel's general arrangement plan, the following was determined:

The Vessel is a bulk carrier with an aft bridge and double-deck configuration.

The dimensions of No.1 CH were approximately 41.5 meters in the fore-and-aft direction, approximately 19.0 meters in the port-starboard direction, and approximately 14.8 meters in height from the tank top to the upper edge of the coaming.

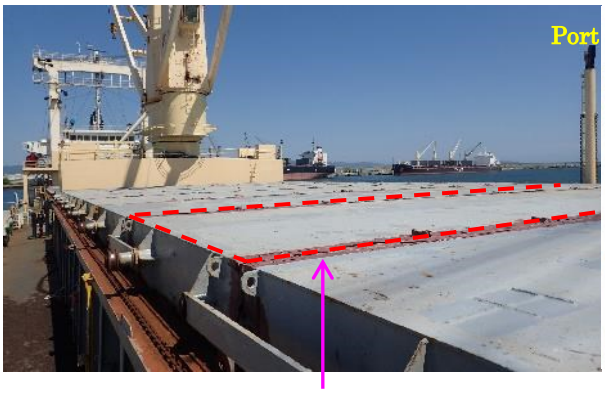
The cargo hold hatch cover was of the Single Pull Type*8, and when opened, the hatch cover of No.1 CH was stowed toward the fore side.

In No.1 CH, a total of three mechanical ventilators were installed for the purpose of forced ventilation and humidity control—one unit for exhaust located at the fore side, and two units for both supply and exhaust located in the machinery room at the center of the upper deck. Air supply and exhaust inlets were installed in the ventilation boxes located below each mechanical ventilator.

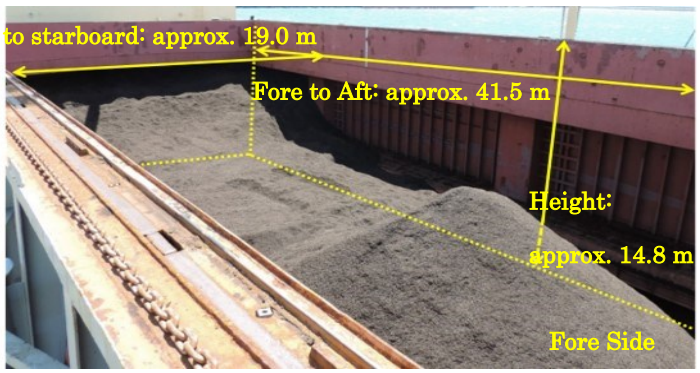
These mechanical ventilators were not in operation during the Loading Operation in question, and on the day of the accident, the inside of the Cargo Hold was naturally ventilated.

At the time of the accident, the Vessel had no abnormalities in its hull, machinery, hatch covers, or other cargo-handling equipment and related systems.

(See Figure 5.)



The hatch cover is divided into multiple sections.



Note: Arrows indicate the dimensions inside the cargo hold.

Cargo Hold No. 1

*8 The "Single Pull Type hatch cover" refers to a structure in which the hatch cover is divided into several panels, each connected by chains, and retracted toward the fore or aft by means of a hydraulic motor.

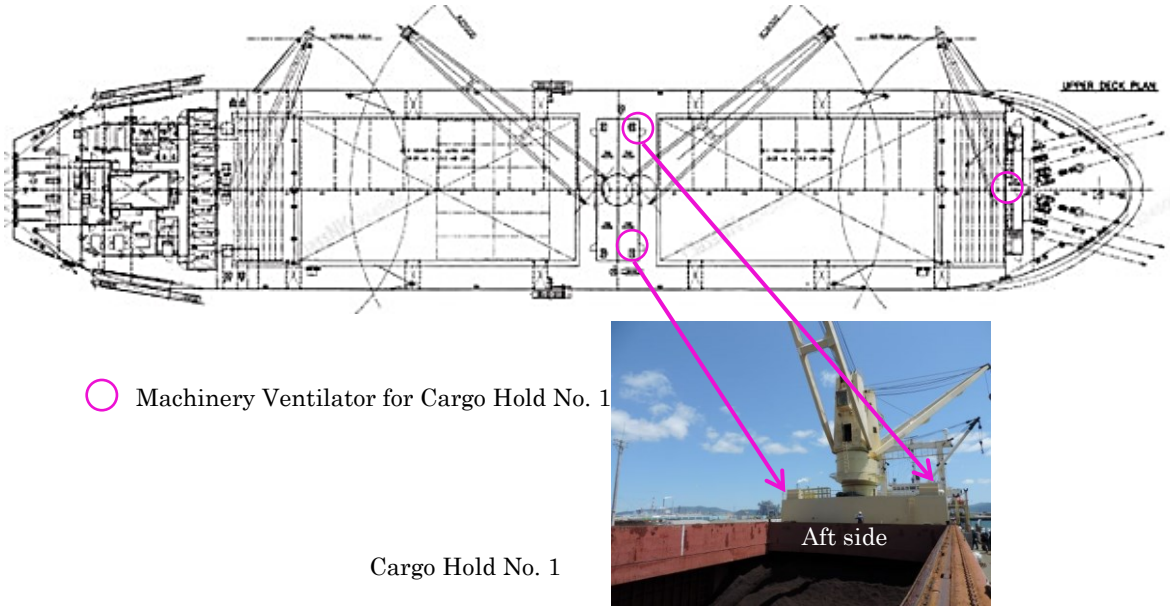


Figure 5 - Hull Structure and Equipment

2.6 Information on Work Environment Measurement in the Cargo Hold

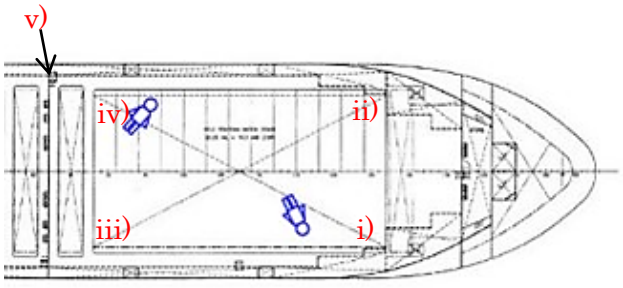
According to the on-site investigation and the reply to the questionnaire by A1 B. Office and the rescue party, the facts are as follows:

2.6.1 Work Environment Measurement

(1)Measurement Results by the Rescue Party

At around 08:15, prior to entering No.1 CH to carry out rescue operations, the rescuers measured the oxygen concentration directly above the PKS at five locations inside the hold: the four corners of the hatch opening and the area near the Entry Point. The measurement results were as follows (Note: The oxygen concentration in standard atmosphere is approximately 21%.):

Location in Cargo Hold	Oxygen Concentration (%)
i) Starboard Fore Side	17.6
ii) Port Fore Side	17.9
iii) Starboard Aft Side	19.9
iv) Port Aft Side	20.6
v) Entry Point	19.1



(2) Measurement Results by A1 B. Office and Others

At around 13:30 on May 22, following the occurrence of the accident, A1 B. Office and others measured the oxygen concentration directly above the Subject PKS through the

Entry Point of No.1 CH, for the purpose of observing changes in internal oxygen concentration corresponding to the open/closed state of the hatch cover. The results were as follows: The oxygen concentration increased over time after the hatch cover was opened.

Measurement Condition	Oxygen Concentration (%)
Hatch cover fully closed	Approx. 14.0
Hatch cover partially open (after approx. 4 min)	Approx. 17.0
Same as above (after approx. 6 min)	Approx. 19.5
Same as above (after approx. 7 min)	Approx. 20.1
Weather: Clear Temperature: 18.0 °C Relative Humidity: 59% Wind Direction (average): South-southeast Average Wind Speed: 5.6 m/s Loading condition of the Subject PKS in No.1 CH: Same as that on May 19 shown in Table 1	

(3) Measurement Results by the JTSB Marine Accident Investigator

i) At around 11:00 on May 25, the Investigators for the purpose of measuring the oxygen concentration through the Entry Point of No.1 CH, with the hatch cover having remained closed for approximately one day. The results were as follows:

Measurement Condition	Oxygen Concentration (%)
Area around the slightly opened hatch at the Entry Point	19.9
Approx. 0.2 m below the hatch (near the Entry Point)	17.5-18.7
Inside No.1 CH (approx. 3.2 m below the hatch, directly above the Subject PKS)	15.9
Weather: Clear Temperature: 18.5 °C Relative Humidity: 44% Wind Direction (average): West-northwest Average Wind Speed: 10.1 m/s Loading condition of the Subject PKS in No.1 CH: Same as that on May 19 shown in Table 1.	

After the measurement, the hatch cover of No.1 CH was opened, and a large amount of condensation was found on its underside.

The port aft side of No.1 CH, where Stevedore A collapsed, had a relatively high accumulation of the Subject PKS. This area was located in a corner near the hold's inner wall and was enclosed above by the overhanging hatch coaming from the upper deck, resulting in poor ventilation even when the hatch cover was open. During the investigation conducted on May 25, steam was observed rising from the surface of the Subject PKS.

The starboard fore side of No.1 CH, where Stevedore B collapsed, was relatively

open compared to other areas of the hold. The Subject PKS was not loaded as high as in the aft side, and no steam was observed rising from its surface.
(See Figure 6.)

Figure 6 – Condition Inside No.1 CH (May 25)

ii) On the morning of July 26, in order to measure changes in oxygen and carbon dioxide concentrations inside the hold before and after opening the hatch cover, an environmental measurement was conducted on a bulk carrier similar to the vessel (hereinafter referred to as "the Similar Bulk Carrier"), which was also loaded with PKS. The measurement was taken near the second deck, approximately 6.5 meters below the hatch cover, directly beneath the entry point located on the starboard fore side of No.1 CH. The results were as follows. The measurement was conducted at the entry point located on the starboard fore side of the Similar Bulk Carrier.

Hatch Cover Status	Closed	Open	
Time of Measurement	06:15	07:06	07:16
Oxygen Concentration (%)	16.5	20.9	20.9
H_2S Concentration (%)	0	0	0
CO Concentration (ppm)	2	0	0
CO_2 Concentration (%)	Approx. 8.0	0.882	0.050

Time of Hatch Cover Opening: 06:40
Measurement Environment
Weather on the Previous Day: Rain (Total Precipitation: 31.0 mm)
Weather on the Day of Measurement: Cloudy
(Total Precipitation: 15.0 mm)
Air Temperature: 23.4 °C　Relative Humidity: 97%
Wind: Direction (average): East-northeast　Average Wind Speed: 2.1 m/s
Temperature Inside the Hold: 26.0 °C
The loading condition of the PKS in the hold was as follows: Out of the planned 4,540MT to be loaded into No.1 CH, approximately 1,080 MT had been loaded at the time.

When the hatch cover of the hold was closed, the oxygen concentration inside the hold was approximately 17%, and the carbon dioxide concentration was approximately 8%. However, when the hatch cover was opened, natural ventilation caused the oxygen concentration to rise to the level of standard atmospheric conditions, while the carbon dioxide concentration decreased.

The Subject PKS loaded on the Wharf had been stored in an open pile. Due to rainfall on the previous day, the PKS had become damp, and steam was observed rising from its surface as a result of internal heat generation.

2.6.2 Information on Oxygen Deficiency and Carbon Dioxide Poisoning

(1) The Ministry of Health, Labour and Welfare provides the following information*9 on the prevention of oxygen deficiency. (See Figure 7.)

i) Air is composed of approximately 78% nitrogen and about 21% oxygen, which sustains the lives of humans and other organisms. A condition in which the oxygen concentration in the air falls below 18% is referred to as oxygen deficiency.

ii) Inhaling air with a low oxygen concentration even once can be fatal and is extremely dangerous.

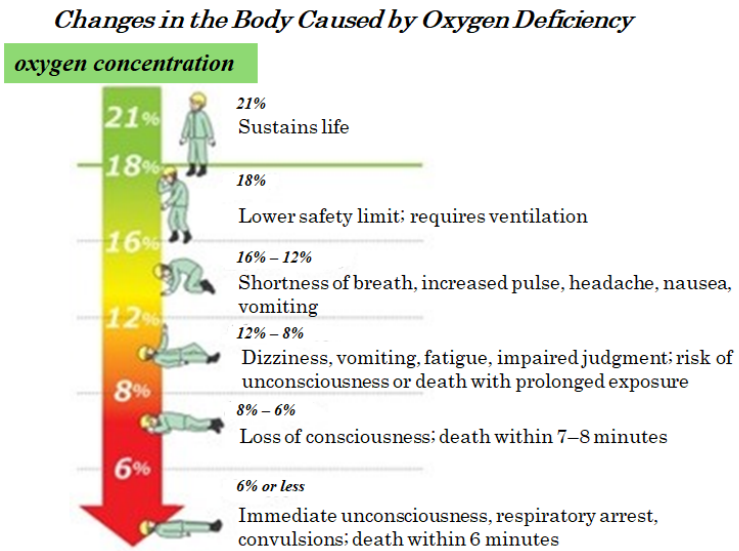


Figure 7 – Physical Effects of Oxygen Deficiency

*9 https://www.mhlw.go.jp/content/11200000/000628946.pdf (Ministry of Health, Labour and Welfare) (Japanese)
https://www.mhlw.go.jp/content/11200000/000629017.pdf (English)

(2) The Consumer Affairs Agency provides the following information*10 on carbon dioxide poisoning. *10 (See Table 2.)

Table 2 – Effects of Carbon Dioxide Concentration on the Human Body

Concentration (%)	*Symptoms / Effects*
0.5%	*Permissible exposure concentration for 8 hours per day, 40 hours per week*
3.0%	*Short-term exposure limit: shortness of breath, headache, dizziness, nausea*
4.0%	*Escape limit concentration (concentration at which one can escape within 30 minutes without irreversible health effects or being unable to escape)*
5.0%	*Dizziness, headache, confusion, shortness of breath*
8-10%	*Severe headache, sweating, blurred vision, trembling; loss of consciousness within 5–10 minutes*
30%	*Near-instant loss of consciousness*

*10 https://www.caa.go.jp/policies/policy/consumer_safety/caution/caution_071/assets/consumer_safety_cms205_230921_01.pdf (Consumer Affairs Agency)

2.7 Meteorological Information

The meteorological data observed on the day of the accident at the Ishinomaki Special Regional Meteorological Observatory, located approximately 2.6 km northeast of the accident site, are shown in Table 3.

Table 3 – Meteorological Observations (May 20)

Time	Weather	Precipitation (mm)	Wind Direction (Avg.)	Wind Speed (m/s)		Temperature (°C)	Relative Humidity (%)
				Avg.	Max.		
7:00	Rain	0.0 mm	East-northeast	0.8	1.2	16.9	88
7:10		0.5 mm	Northeast	1.0	1.6	17.2	89
7:20		0.0 mm	East-northeast	2.0	2.9	17.2	90
7:30		0.0 mm	Northeast	1.5	2.5	17.2	88
7:40		0.0 mm	Northeast	1.7	2.4	17.6	88
7:50		0.0 mm	Northeast	0.9	2.3	17.8	84
8:00	Cloudy	0.0 mm	Southwest	1.1	2.5	18.0	77
[Reference] Precipitation Scale "–": No measurable precipitation associated with the phenomenon. "0.0 mm": Precipitation occurred, but less than 0.5 mm. "0.5 mm": Equivalent to light drizzle							

The meteorological data observed at the Ishinomaki Special Regional Meteorological Observatory from before the vessel entered port until the day of the accident are shown in Table 4.

According to the statement of the representative from A1 B. Office and the reply to the questionnaires by A1 B. Office, light rain continued at the accident site from before the start of the Loading Operation on the day of the accident, followed by cloudy weather in the afternoon.

Table 4 – Meteorological Observations (May 13–20)

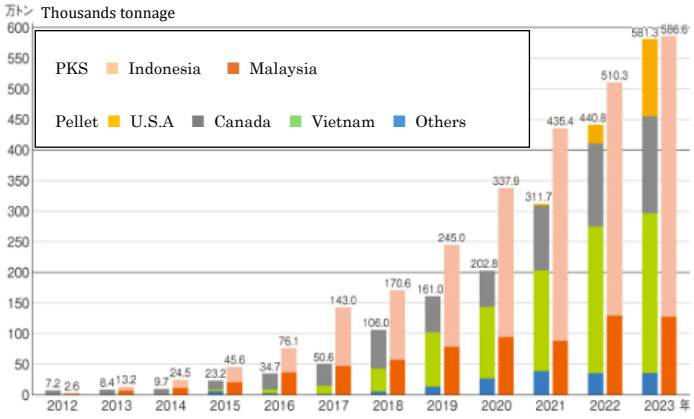
Date	Weather	Total Precipitation (mm)	Relative Humidity (Avg. %)	Average Wind Speed (m/s)	Remarks
May 13	Rain	55.5	92	5.6	
May 14	Cloudy, later Clear	—	73	3.4	
May 15 Arrival Date	Clear, later Cloudy	—	81	3.7	Cargo Handling – Day 1
May 16	Cloudy with occasional rain	1.0	86	4.4	Cargo Handling – Day 2
May 17	Cloudy with	0.0	61	5.4	Due to forecasted bad

	occasional rain				weather, The Loading Operation was suspended.
May 18	Clear	—	66	3.2	Cargo Handling – Day 3
May 19	Cloudy, later Clear	0.0	74	3.5	Holiday
May 20 Date of the Accident	Rain, later cloudy	10.0	89	2.4	Cargo Handling – Day 4

2.8 Information on PKS and Related Matters

2.8.1 Utilization of Biomass Fuel

According to a publication*11, PKS (palm kernel shells) has recently attracted attention as a fuel for biomass power generation. In Japan, it is considered essential to secure stable sources of supply to support the operation of existing biomass power plants and the construction of new facilities in the future. As shown in Figure 8, the volume of imported biomass fuel has increased over the 12-year period from 2012 to 2023. In terms of PKS imports by country, the Republic of Indonesia and Malaysia account for the vast majority.



Source: Biomass White Paper 2024 Edition

Figure 8 – Trends in Imports of PKS and Wood Pellets*12

2.8.2 Current Handling Practices for the Transportation of PKS

According to the International Convention for the Safety of Life at Sea (SOLAS

*11 Biomass White Paper 2024, Biomass Industrial Society Network (a specified nonprofit corporation) https://www.npobin.net/hakusho/2024/topix_02.html

*12 "Wood pellets" refer to a type of woody biomass fuel made by pulverizing dried wood and compressing it under pressure into cylindrical shapes with a diameter of 6–8 mm and a length of 5–40 mm. These are used as boiler fuel in biomass power plants.

Convention) and the International Maritime Solid Bulk Cargoes Code*13 (hereinafter referred to as the "IMSBC Code"), the required transport conditions for PKS are as follows:

Although PKS is a type of cargo subject to the IMSBC Code under Chapter VI ("Carriage of Cargoes") of the SOLAS Convention, it is not included in the cargo list*14 of the IMSBC Code. The IMSBC Code provides procedures for the carriage of cargoes not listed therein, and for PKS, the method of loading and other requirements are determined in accordance with those procedures. The website*15 of the Maritime Bureau provides the following information regarding the loading method and related requirements for PKS.

Properties and Transport Conditions of Cargo Not Listed in the IMSBC Code (Partial Excerpt)

1. Tentative Bulk Cargo Shipping Name

Palm Kernel Shells (PKS)

2. Description of Cargo

- *This cargo consists of fragments of palm kernel shells of plant origin and is dark brown to black in color.*
- *It is insoluble in water and contains 15–24% moisture.*

3. Characteristics

3.1 Group: Group C

3.2–3.6: Omitted

4. Hazard

- *This cargo may pose a risk of oxygen deficiency.*
- *This cargo is non-combustible or has low fire risk.*

5. Transport Conditions

5.1–5.2: Omitted

5.3 Weather-related Requirements : No specific requirements.

5.4: Omitted

5.5 Precautions

- *Measures must be taken to prevent bilge well blockage.*
- *When entering the cargo hold, the hatch cover should be opened, and sufficient ventilation should be ensured.*

5.6 Ventilation Requirements :

- *No specific requirements.*

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*13 The International Maritime Solid Bulk Cargoes Code refers to the regulations established under Chapter VI of the SOLAS Convention, which have been internationally enforced since January 1, 2011. As a result, only substances listed in the IMSBC Code or those approved by the competent authority of the country of loading (i.e., provisionally assessed cargoes) may be carried in bulk by ship for maritime transport.

*14 In the Cargo List, the IMSBC Code classifies cargoes for maritime transport into the following categories according to their physical properties and characteristics:

- Group A: Cargoes that may liquefy or undergo dynamic separation if shipped with a moisture content in excess of the transportable moisture limit.
- Group B: Cargoes that possess a chemical hazard such as fire or self-heating.
- Group C: Cargoes that are not classified as Group A or Group B.

*15 https://www.mlit.go.jp/maritime/content/001583316.pdf

5.7–5.9: Omitted

2.8.3 Properties and Issues Related to PKS

(1) According to documents submitted jointly by a P&I Club*16 and several member states to the Sub-Committee on Carriage of Cargoes and Containers (CCC) of the International Maritime Organization (IMO), namely CCC 3/5/16 and CCC 3/INF.21—which were proposals to include PKS as a new cargo in the International Maritime Solid Bulk Cargoes Code (IMSBC Code)—the following issues regarding PKS have been identified.

i) PKS is prone to oxidation. As a result, oxygen in the surrounding atmosphere is consumed, while carbon monoxide and carbon dioxide concentrations increase. When the overall moisture content exceeds 11%, fermentation may occur, and in some cases, the methane concentration may exceed flammable levels.

ii) It has been reported that, in some cases, within 48 hours after the hatch cover of a cargo hold containing PKS is closed, the concentration of carbon monoxide may reach 990 ppm, and the oxygen concentration may fall below 1%.

iii) PKS must be kept as dry as possible and should not be handled during rainfall. In adjacent spaces, there is a heightened risk of oxygen depletion and carbon monoxide generation.

(2) According to the reply to the questionnaires by the cooperation of microbiological research organizations*17, it is considered that the condition of the Subject PKS may have changed as follows when exposed to a moisture-rich environment:

i) When the PKS was stored in an open pile outdoors, rainfall may have caused the moisture content to rise above the minimum water activity*18 level required for fungal growth, thereby accelerating fermentation.

ii) During fungal activity, if readily biodegradable organic matter*19 remained in the palm kernel shells, aerobic fungi*20 may have metabolized*21 the organic matter on the surface of the Subject PKS, leading to oxygen consumption and carbon dioxide generation. Inside the piled PKS, anaerobic fungi*22 may have produced carbon dioxide through the same metabolic process. In an enclosed space such as a cargo hold, the continued drop in oxygen concentration may allow anaerobic fungal activity to persist, potentially resulting in the generation of organic acids—such as lactic acid, butyric acid, and acetic acid—depending on the type of attached microorganisms. If methanogenic bacteria

*16 P&I Club (Protection and Indemnity Club) is a mutual insurance association established for the purpose of providing shipowners with protection against liability and expenses arising from maritime incidents that are not covered by hull insurance, marine cargo insurance, or seafarer insurance.

*17 Organizations include the Japan Society for Bioscience, Biotechnology, and Agrochemistry (JSBBA), the Japan Woody Bioenergy Association, and other related institutions.

*18 Water activity refers to the proportion of free water in a substance that can be utilized by microorganisms for growth.

*19 Readily biodegradable organic matter refers to organic substances that are easily decomposed by microbial activity.

*20 Aerobic fungi are microorganisms that decompose organic matter through aerobic respiration.

*21 Metabolization (Assimilation) refers to the ability of fungi or microorganisms to utilize a substance as a nutrient source and grow.

*22 Anaerobic fungi are fungi that do not require oxygen for growth.

further break down the material, methane gas is more likely to be generated as well.

iii) In an enclosed space such as a cargo hold, the fermentation and related changes may have progressed under conditions similar to silage fermentation*23 used for preserving livestock feed.

(3) According to information provided by the company importing the PKS, records of the environment inside the cargo holds of vessels loaded with PKS showed that the oxygen concentration inside the cargo holds varied between 7.4% and 20.8%.

2.9 Information Related to Safety Management

2.9.1 Overview of A1 B. Office's Business Operations

According to statements by the A1 B. Office representative, the reply to the questionnaires by A1 B. Office, and the website of Company A, the operational overview of A1 B. Office was as follows:

A1 B. Office, as a division of Company A—a comprehensive logistics company—conducted operations at Ishinomaki Port involving import/export customs clearance, port work, cargo handling, vessel loading arrangements, communication with overseas partners, and domestic and international marine transportation services.

In March 2020, A1 B. Office entered into a contract with a power plant located in Ishinomaki City (hereinafter simply referred to as "the Power Plant") for the import operations of PKS and wood pellets. Subsequently, in October 2022, A1 B. Office began unloading operations for biomass fuel at the Wharf.

In February 2024, A1 B. Office received a temporary cargo handling request from the Power Plant for the export of approximately 20,000 metric tons of non-certified PKS*24, which would no longer be permitted for use in Japan. A contract was subsequently concluded for the Loading Operation. This PKS had been imported from overseas in 2023 and had since been left in open-air storage without any protective covering such as sheeting, both on the premises of the Power Plant and at the Wharf. The Loading Operation was the first such operation conducted under this new contract.

2.9.2 Safety Management of Company A and Its Branches

The statements of the A1 B. Office representative, the representative of the Sendai Branch of Company A (hereinafter referred to as "Branch A2"), and a representative of Company A, as well as the reply to the questionnaires by Branch A2 was as follows:

(1) Company A

The Ministry of Health, Labour and Welfare has established the Guidelines on Occupational Safety and Health Management Systems (Notification No. 53 of 1999, Ministry of Labour) pursuant to Article 24-2 of the Ordinance on Industrial Safety and Health (Ordinance No. 32 of 1972, Ministry of Labour). These guidelines promote the

*23 Silage fermentation is a preservation method in which grass or feed is packed into a silo and stored long-term by lowering oxygen levels and promoting lactic acid fermentation, thereby inhibiting spoilage organisms and protein-degrading activity.

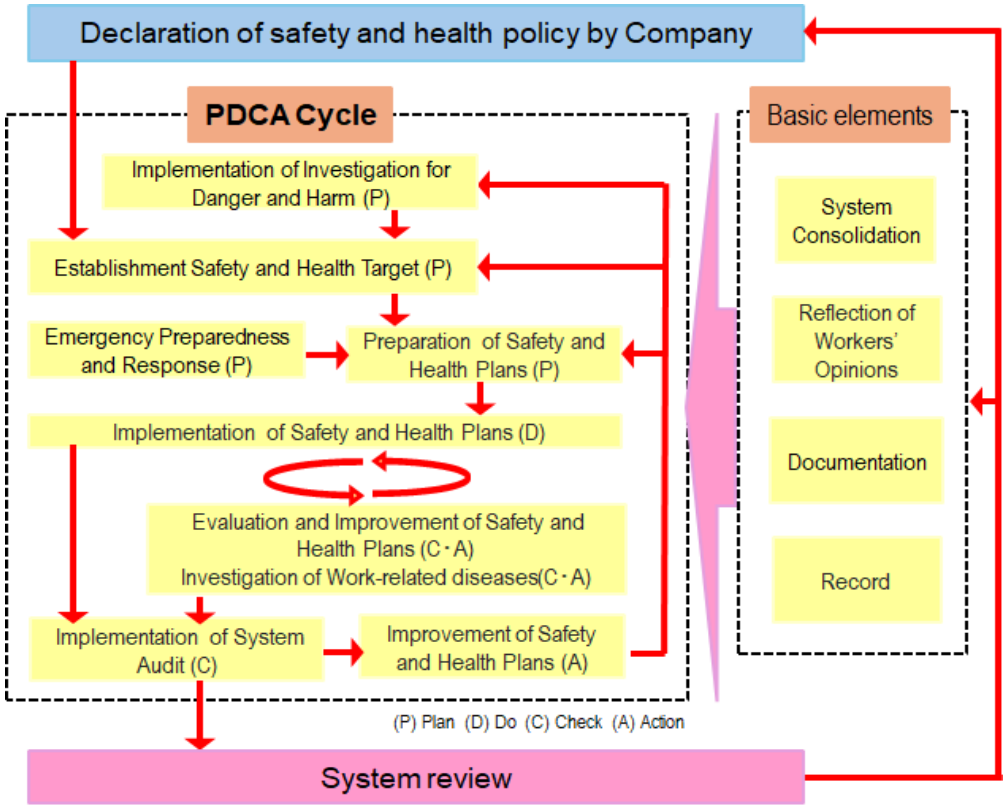
*24 "Non-certified PKS" refers to PKS that does not meet the sustainability criteria set forth in the "Guidelines for Reviewing Business Plans (Biomass)" established by the Agency for Natural Resources and Energy of the Ministry of Economy, Trade and Industry (METI).

development of a safety and health management structure incorporating an Occupational Safety and Health Management System*25 by employers.

Company A, in accordance with the aforementioned guidelines issued by the Ministry of Health, Labour and Welfare, introduced its own "Company A's Occupational Safety and Health Management System for Enhancing Workplace Safety and Health Standards" (hereinafter referred to as the "A-OSHMS") in 2010.

Company A, under its A-OSHMS, declared its safety and health policy, documented its business activities, established the procedures for the PDCA cycle, and disseminated the system to all of its branches, offices, and related facilities. Through this system, it engaged in efforts to improve the working environment and enhance quality.

(See Figure 9)



Source: Ministry of Health, Labour and Welfare / Japan Industrial Safety and Health

Figure 9 – Model of Occupational Safety and Health Management System

Under this A-OSHMS, when adopting or changing work methods or procedures, the system requires the implementation of a risk assessment*26 necessary for carrying out

*25 An Occupational Safety and Health Management System" is a safety and health management framework by which an employer, with the cooperation of workers, independently and continuously improves safety and health in the workplace by implementing a cycle of "Plan, Do, Check, and Act (PDCA)." Its objectives are to prevent occupational accidents, promote the health of workers, create a comfortable working environment, and enhance the overall level of safety and health in the workplace.

*26 "Risk assessment" refers to a method for identifying and evaluating potential hazards or harmful factors

"investigations into potential hazards and harmful factors and actions according to the results," in accordance with Article 28-2 of the Industrial Safety and Health Act.

With regard to Company A's cargo handling operations aboard vessels, the department responsible for port transport oversees accident prevention, supervision, and training related to domestic port transport operations. Additionally, the department responsible for safety, quality, and operational promotion manages safety control measures—including the A-OSHMS—as well as labor accident prevention and training related to skill-based operations. Each department is also responsible for coordinating with regional branches and other offices throughout Japan.

(2) Branch A2

Branch A2 is the regional headquarters of Company A's Hokkaido–Tohoku block, which includes Ishinomaki Port, and has A1 B. Office under its jurisdiction.

Branch A2 is responsible for managing and supervising various operations conducted by the branches under its jurisdiction, including cargo handling operations aboard vessels.

(3) A1 B. Office

i) With respect to unloading operations involving PKS, A1 B. Office carried out the work in accordance with the A-OSHMS by preparing a Safe Work Procedure Manual that included the work process and its details, the results of the risk assessment related to the process, and accident prevention measures (corresponding to the "Safety and Health Plan" shown in Figure 9; hereinafter referred to as the "RA Work Procedure Manual").

The RA Work Procedure Manual outlined the steps of the operation in chronological order, from preparation to completion, and included operational check items for each step. It also identified potentially hazardous or harmful elements, estimated the level of risk using numerical values, and provided a format for reassessing the risk after implementing countermeasures. The implementation of these risk countermeasures was mandatory for the stevedores assigned to the relevant work procedures.

For unloading operations involving PKS, the RA Work Procedure Manual explicitly stated that a working environment measurement inside the cargo hold was required, and that oxygen and carbon monoxide concentrations were to be measured. In the risk estimation for oxygen deficiency and similar hazards, although the frequency was assessed as "rare," the severity was evaluated as "fatal." Accordingly, the checklist for working environment measurement included the standard:
"Oxygen concentration must be 21% or higher, and carbon monoxide concentration must be 50 ppm or lower." In the section on risk countermeasures, it was clearly stated:
"If the values do not meet the standard, do not enter the cargo hold."

In past oxygen concentration measurements conducted during PKS unloading operations, alarms (with a threshold setting of approximately 18%) were rarely triggered. For this reason, the A1 B. Office representative and others considered the risk of oxygen deficiency and similar hazards during cargo hold operations to be low.

ii) The A1 B. Office representative, based on the following circumstances, judged that

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in the workplace and taking appropriate measures to eliminate or reduce such risks according to the evaluation results.

the Loading Operation did not fall under "work involving the adoption or modification of work methods or procedures" as defined in the A-OSHMS. Accordingly, it was considered unnecessary to conduct a risk assessment or perform a working environment measurement inside the cargo hold. As a result, an RA Work Procedure Manual was not prepared.

(a) Unlike in unloading operations, the Vessel entered the port in a light (empty) condition, and due to no cargo was present in the cargo hold at the start of the Loading Operation, it was regarded as posing no hazard.

(b) The Loading Operation was considered to be a temporary handling task. In the past, cargo handling of PKS onto vessels had been conducted using only shore-based cranes without requiring stevedores to enter the cargo hold or performing any working environment measurements. It was therefore assumed that the Subject PKS could be loaded in the same handling procedure—simply by reversing the procedure used for unloading.

iii) In carrying out the Loading Operation, the A1 B. Office representative explained the work details to another staff member and instructed the creation of a document referred to as the "Work Planning Sheet" (hereinafter referred to as "the Planning Sheet"), which included only the arrangement of stevedores and vehicles, and the description of the operations for each vessel involved in cargo handling, but did not contain any risk assessment items.

The Planning Sheet included information on personnel assignments, working hours, work locations, work content, cargo handling vehicle deployment, and the names of the assigned drivers. However, it did not describe the work procedures or detailed tasks in chronological order, nor did it contain any reference to the implementation of working environment measurements inside the cargo hold.

It should be noted that Company A recognized that, regardless of whether the operation involved unloading or loading, working environment measurements—including oxygen concentration measurement—were to be reliably conducted when work was performed inside a cargo hold.

iv) At A1 B. Office, no instructions or comments were given that a new RA Work Procedure Manual should be prepared in response to the judgment made by the A1 B. Office representative described in paragraph ii) above. Accordingly, in carrying out the Loading Operation, A1 B. Office considered that the work could be safely performed using conventional methods, according to general experience and established procedures related to bulk cargo*[27] loading. The Stevedores were instructed to carry out the operation in accordance with the Planning Sheet.

v) At A1 B. Office, a meeting known as a "Workplace General Meeting" was established to share information related to safety and health, quality, and logistics costs. This meeting was attended by managerial staff, including section managers and office directors. However, because no RA Work Procedure Manual had been prepared or presented for the Loading Operation, the matter was not discussed at the meeting.

*27 "Bulk cargo" refers to cargo such as iron ore, coal, grain, timber, wood chips, and other granular or powdered materials that are loaded directly into a cargo hold without individual packaging.

Furthermore, because the Loading Operation was not deemed to constitute "work involving the adoption or modification of work methods or procedures," no report was made to Branch A2, which supervises and oversees A1 B. Office.

vi) The A1 B. Office representative was aware, based on the past fire accident at a biomass power plant that occurred at another workplace, that wood pellets could generate heat, release steam from their surface, and produce methane gas. However, the representative was unaware that PKS could consume oxygen or generate carbon dioxide as a result of fermentation or oxidation when moisture was present. The Stevedores likewise had the same level of understanding regarding the properties of PKS.

2.9.3 Legal Provisions Related to Work Inside Cargo Holds

When stevedores perform tasks inside a cargo hold, the applicable laws and regulations include the Industrial Safety and Health Act, the Ordinance for Enforcement of the Industrial Safety and Health Act (Cabinet Order No. 318 of 1972), and the Ordinance on Prevention of Oxygen Deficiency, etc. (Ordinance of the Ministry of Labour No. 42 of 1972), among others (hereinafter referred to as "the Relevant Laws and Regulations"). These laws stipulate, among other things, the obligation to conduct working environment measurements inside cargo holds, as described below.

(1) Industrial Safety and Health Act

(Assessments to Be Carried Out by Employers)

Article 28-2

An employer, pursuant to Order of the Ministry of Health, Labour and Welfare, must endeavor to assess the potential for danger or harm arising from constructions, equipment, raw materials, gases, vapor, dust, or other such factors, as well as from work activities and other duties (text omitted), and, based on the results of such assessments, to take not only the measures required under this Act or any order based on this Act, but also any other necessary measures to prevent danger to workers or impairment of their health.

(Omitted thereafter)

(Work Environment Monitoring)

Article 65 (1)

An employer, pursuant to Order of the Ministry of Health, Labour and Welfare, must conduct the necessary work environment monitoring for indoor and other workspaces in which hazardous operations take place that are specified by Cabinet Order, and keep records of the results.

(2) Order for Enforcement of the Industrial Safety and Health Act

(Workshops Which Should Conduct Working Environment Assessments)

Article 21

The workshops prescribed by the Cabinet Order set forth in paragraph (1) of Article 65 of the Act are as follows:

(Items 1 to 8 omitted)

9. workshops where work is carried out in places with an oxygen deficiency hazard, as listed in Appended Table 6;

(Items 10 omitted)

Appended Table 6 Places With an Oxygen Deficiency Hazard (related to Articles 6 and 21)

(Items 1 to 4 omitted)

5. inside of a storage facility such as a tank, hold or hopper, containing coal, lignite, sulfide ore steel, scrapped iron, lumber, chips, volatile oil, fish oil and other oxygen absorbing substances or materials

(Items 6 to 55 omitted)

(3) Ordinance on Prevention of Anoxia

(Working Environment Measurement, etc.)

Article 3

Employers shall, with respect to workplaces listed in Item 9 of Article 21 of the Order for Enforcement of the Industrial Safety and Health Act, measure the concentration of oxygen in the air at the relevant workplace before commencing operations on each workday (and in the case of workplaces involving Class II oxygen-deficient hazardous work, both oxygen and hydrogen sulfide concentrations shall be measured).

2. When an employer has conducted the measurement set forth in the preceding paragraph, the employer shall, on each occasion, record the following matters and retain the records for a period of three years.

1. Date and time of measurement

2. Method of measurement

3. Location of measurement

4. Conditions of measurement

5. Measurement results

6. Name of the person who conducted the measurement

7. A summary of the measures taken to prevent oxygen deficiency or similar hazards, if such measures were implemented according to the measurement results.

According to the statement of the A1 B. Office representative, he was not aware that the Relevant Laws and Regulations included provisions requiring working environment measurements to be conducted inside cargo holds. He also did not recognize the need to conduct such measurements in accordance with the A-OSHMS for the purpose of identifying potential hazards when carrying out work inside cargo holds. Furthermore, even as the loading of the Subject PKS progressed, he did not consider the possibility that the working environment might change, and therefore did not recognize that the Loading Operation fell under the scope of the Relevant Laws and Regulations.

2.9.4 Implementation of the Loading Operation and Related Work

According to the on-site investigation, the statements of the A1 B. Office representative and Stevedore B, and the reply to the questionnaires by the A1 B. Office representative, the facts are as follows:

(1) Overview of the Operation

At the time of the accident, the Subject PKS was being transported by vehicle from a designated storage area at the power plant to the Wharf in accordance with the Plan Sheet, and was being loaded into the cargo hold of the Vessel using the Vessel's crane.

(2) Implementation Status of the PKS Unloading Operations and the Loading Operation

i) PKS Unloading Operations

When conducting PKS unloading operations, A1 B. Office carried out working environment measurements inside the cargo hold in accordance with the risk assessment in the RA Work Procedure Manual. Before the start of work, oxygen concentration measurements inside the cargo hold were conducted and confirmed. During the pre-operation meeting, the results of the oxygen concentration measurement were reviewed, and, as part of the evaluation and countermeasures against the anticipated hazards listed in the Hazard Prediction Sheet, precautions for heavy lifting operations were also confirmed.

ii) The Loading Operation

Because the Planning Sheet did not indicate any working environment measurement inside the cargo hold, A1 B. Office did not carry out oxygen concentration measurement. The Hazard Prediction Sheet only included general cautions such as during heavy lifting or fall prevention.

In addition, the A1 B. Office representative, the work supervisor, and the Stevedores did not consider the possibility that the working environment inside the cargo hold could change as the Loading Operation progressed, and therefore did not raise the need for working environment measurements during routine inspections or improvement activities.

At the time of the accident, Stevedore B did not believe that oxygen deficiency—a condition typically associated with enclosed spaces such as tanks, as taught in the Supervisor of Work Involving the Risk of Oxygen Deficiency or Hydrogen Sulfide training—could also occur during work inside a cargo hold with the hatch covers open, such as in the Loading Operation. Therefore, he perceived no inconsistency in the fact that no oxygen concentration measurement was conducted prior to the work inside the cargo hold, nor that no warnings regarding oxygen deficiency were included in the Hazard Prediction Activity.

2.9.5 Safety Management of the Vessel

The Vessel had established a Safety Management System (hereinafter referred to as the "SMS") *28 in accordance with the International Safety Management (ISM) Code to ensure the safe operation of the ship, and maintained a manual for implementing the SMS (hereinafter referred to as the "SMS Manual").

The SMS Manual states the following regarding cargo handling operations:

"The Chief Officer and crew shall monitor the safety of the vessel, equipment, cargo, and

*28 A Safety Management System (SMS) is a structured and documented safety management framework mandated by the International Safety Management (ISM) Code. It is designed to enable the personnel of a ship management company to effectively implement the company's policies on the safe operation of ships and environmental protection.

crew during loading and unloading operations." However, the safety management of stevedores who are not crew members falls outside the scope of the SMS. Therefore, the SMS did not assign responsibility for conducting working environment measurements inside the cargo hold or managing the safety of the stevedores during the Loading Operation.

According to the statements of the Master and N. Officer A, only the loading plan was handed over to the Vessel by A1 B. Office. During the Loading Operation, the crew operated the hatch covers in accordance with instructions from the work supervisor and others, and performed tasks such as monitoring the vessel's heel and trim, and checking for any damage to the hull. However, they were not directly involved in the Loading Operation.

2.10 Information on Accidents Involving Oxygen Deficiency in CHs and Similar Locations

According to marine accident investigation reports published by the Japan Transport Safety Board between 2008 and 2024, there were 31 cases of accidents caused by oxygen deficiency and harmful gases occurring onboard vessels.

Of these 31 cases, there were two in which, similar to the present case, crew members entered a cargo hold containing plant-based cargo such as grain, in a condition where oxygen had been depleted by them, without conducting a working environment measurement, and subsequently suffered oxygen deficiency that resulted in fatality and serious injury.
(See Appendix Table 1 – Accident Cases of Oxygen Deficiency in Cargo Holds Loaded with Grain)

3 ANALYSIS

3.1 Situation of the Accident Occurrence

3.1.1 Events Leading to the Accident

Considering Section 2.1.1, it is probable that:

(1) The Vessel, at around 07:00 on May 15, berthed at the Wharf in a light (empty) condition in the holds and commenced the Loading Operation.

(2) The Vessel had loaded 3,576 metric tons of the PKS into No.1 CH and 3,390 metric tons into No. 2 CH by May 18. The hatch covers were then closed at around 17:00 on the same day. And then, the hatch covers remained closed all day on May 19 due to it being a scheduled day off for the stevedores,

(3) N. Officer B and other crew member, at around 07:05 on May 20, opened the hatch covers in accordance with the first of No.2 CH, and then of No.1 CH.

(4) The Stevedores, at around 07:15, before commencing the Loading Operation, held a meeting that included hazard prediction activities, however, there was no discussion regarding working environment measurements inside the CHs, and such measurements were not conducted.

(5) Stevedore A and Stevedore B, at around 07:30, moved to the upper deck of the

Vessel and entered No.1 CH through the Entry Point. After Stevedore A proceeded to the aft port side of the CH and Stevedore B to the starboard fore side, both collapsed onto the surface of the PKS.

The crane operator of the fore-side crane, at around 07:35, discovered that Stevedore A and Stevedore B had collapsed onto the PKS inside No.1 CH.

3.1.2 Date, Time, and Location of the Accident

Considering Section 2.1, it is probable that:

(1) Stevedore A and Stevedore B entered No.1 CH at around 07:30 and subsequently moved around inside. In addition, since the crane operator discovered that both Stevedore A and Stevedore B had collapsed inside No.1 CH at around 07:35 the date and time of the accident are considered to have been around 07:35 on May 20, 2024.

(2) The location of the accident was inside No.1 CH of the Vessel while berthed at the North Wharf of Hibarino, Ishinomaki Port, approximately 960 meters from the Hibarino Leading Light in Ishinomaki Port, at a true bearing of 346.7°.

3.1.3 Injuries and Fatalities

Based on Sections 2.1, 2.2, 2.6, 2.8.2, and 2.8.3, the following is considered to have occurred:

(1) Stevedore A

The cause of death for Stevedore A was post-resuscitation encephalopathy. Considering the possibility that the CH may have contained a higher-than-normal concentration of carbon dioxide originating from the PKS, it is also possible that the contributing factor was the onset of carbon dioxide poisoning. It was confirmed that, following the accident, the oxygen concentration inside No.1 CH was lower than that of normal atmospheric conditions. Therefore, it is also possible that Stevedore A may have suffered from oxygen deficiency. However, because no Blood Gas Analysis was conducted immediately after the accident, it was not possible to determine whether the cause was carbon dioxide poisoning or oxygen deficiency.

(2) Stevedore B

Considering the possibility that a higher-than-normal concentration of carbon dioxide originating from the PKS, may have been present inside the CH, it is possible that Stevedore B may have suffered from carbon dioxide poisoning and aspiration pneumonia. As with Stevedore A, it is also possible that Stevedore B may have suffered from oxygen deficiency. However, it was not possible to determine whether the cause was carbon dioxide poisoning or oxygen deficiency.

3.1.4 Damage Assessment

Considering Section 2.3, it was determined that the Vessel sustained no damage as a result of the accident.

3.2 Analysis of Accident Factors

3.2.1 Status of Stevedores

Based on Section 2.4, the following is considered:

It is probable that Stevedore A have had approximately 20 years of experience in port cargo handling operations, and Stevedore B approximately 14 years. Stevedore B is certain to have held the qualification of Supervisor completed Skill Training Course for Operations Supervisors of Dangerous Work in Oxygen-Deficient Air or Involving Hydrogen Sulfide.

It is certain that the A1 B. Office representative had approximately nine years of experience in port cargo handling operations and served as the person responsible for management, including the planning of the Loading Operation.

It is probable that Stevedore A, Stevedore B, and the A1 B. Office representative were all in good health on the day of the accident.

3.2.2 Status of Onboard Equipment

Based on Sections 2.3, 2.5.3, and 2.8.2, it was determined that, at the time of the accident, there were no abnormalities and no malfunction in the Vessel's hull, machinery, hatch covers, cargo handling equipment, or other systems.

It is probable that, at the time of the accident, no mechanical ventilators were in operation in No.1 CH, and that the hold was in a state of natural ventilation. In addition, it is certain that PKS, not being listed in the IMSBC Code, did not require forced ventilation using mechanical ventilators in the cargo hold, in accordance with its cargo characteristics and transport conditions.

3.2.3 Weather and Sea Conditions

Based on Sections 2.1 and 2.7, the following more likely occurred:

(1) At the time of the accident, the weather between 07:00 and 08:00 was rainy. The wind was from the northeast to east-northeast, with an average speed of 0.8 to 2.0 m/s and a peak gust of 2.9 m/s.

(2) In Ishinomaki City, rainfall had been observed from May 13 up to and including the day of the accident. It is probable that the PKS, which had been stored outdoors at the Wharf, was exposed to rain during this period.

3.2.4 Analysis of Environmental Changes Related to the PKS and No.1 CH

Based on Sections 2.1, 2.6, 2.7, 2.8, 2.10, 3.1.1, 3.1.3, 3.2.2, and 3.2.3, the following observations were made.

(1) It is highly probable that the PKS absorbed moisture from rainfall while being stored outdoors at the Wharf and was loaded into the cargo hold in that wet condition. In addition, it is most likely that the PKS was exposed to rain during the Loading Operation.

(2) The hatch cover of No.1 CH remained closed from around 17:00 on May 18 until the day of the accident, and the interior was more likely than not in a state of high humidity.

(3) Approximately one hour after the hatch cover of No.1 CH was opened following the accident, measurements revealed areas where the oxygen concentration was approximately 17%, lower than standard atmospheric levels. In the Vessel and the

Similar Bulk Carrier, it has been confirmed that when the hatch covers are closed, oxygen levels inside the CHs can drop to around 14.0 – 16.5%, while carbon dioxide levels can rise to approximately 8%, significantly above standard atmospheric levels.

(4) Steam was observed rising from the surface of the PKS in No.1 CH, as well as from the upper portion of the PKS stored in an open pile at the Wharf, due to internal heat generation.

(5) Based on the conditions described in (1) through (4), it is probable that No.1 CH had become a work environment in which the PKS, having absorbed moisture, underwent fermentation and oxidation, leading to the consumption of oxygen and the generation of heat and carbon dioxide. Consequently, the oxygen concentration in the air decreased, creating an environment that could have adversely affected the human (Stevedore's) body.

(6) Changes in oxygen and carbon dioxide concentrations inside the cargo hold due to natural ventilation were as shown in Table 5, when the hatch cover was changed from a closed to an open state.

Table 5 Changes in Oxygen and Carbon Dioxide Concentrations Due to Natural Ventilation

Measurement Date	Wind Direction (Avg.) / Average Wind Speed	Oxygen Concentration (%) (Carbon Dioxide Concentration (%))	
		Hatch Cover Closed	Hatch Cover Opened
May 22 No.1 CH of the Vessel	South-southeast / 5.6 m/s	Approx. 14.0 (CO_2: Not measured)	After approx. 7 minutes: approx. 20.1 (Same as left)
July 26 CH of a Similar Bulk Carrier	East-northeast / 2.1 m/s	16. 5 (CO_2: Approx. 8.0)	After approx. 26 minutes: 20.9 (CO_2: 0.882)

* The bow of the Vessel was oriented westward.

In the cargo hold shown in Table 5, the surrounding wind speeds were 2.1 m/s and 5.6 m/s on average, and it took approximately 7 to 26 minutes for the oxygen concentration inside the holds to reach a level comparable to standard atmospheric conditions through natural ventilation. On the other hand, at the time of the accident, the average wind speed around No.1 CH of the Vessel was approximately 2.0 m/s or lower (see Table 3). Therefore, it is highly probable that it would have taken longer for the oxygen concentration inside the hold to reach a level comparable to standard atmospheric conditions through natural ventilation than in the cases shown in Table 5. It is also probable that changes in carbon dioxide concentration inside the cargo hold can be regarded as equivalent to those in oxygen concentration.

Based on the above, it is probable that while safety can be ensured through natural ventilation when work is conducted by human in a cargo hold loaded with PKS, the time required for the internal environment of the cargo hold to reach a level comparable to standard atmospheric conditions may vary. Consequently, the implementation of working environment measurements is considered essential in the cargo hold.

(7) At the time of the accident, the aft port side of No.1 CH, where Stevedore A

collapsed, was located near the underside of the upper deck and the hold's side wall, resulting in poor ventilation. In contrast, the starboard fore side of the CH, where Stevedore B collapsed, was likely to have been more favorable to natural ventilation, as the PKS had not been loaded as heavily there as in the aft side.

It is probable that, in No.1 CH, differences may have existed in the degree of carbon dioxide accumulation and oxygen concentration levels, as more steam was observed rising from the PKS on the aft port side than from that on the starboard fore side, suggesting greater internal heat generation in that area.

(8) It is probable that such environmental differences within No.1 CH contributed to the consequence in which, although both Stevedore A and Stevedore B entered No.1 CH under similar conditions at the time of the accident, Stevedore A, who was on the aft port side, died, while Stevedore B, who was on the starboard fore side, regained consciousness after being rescued.

3.2.5 Analysis of Safety Management

Based on Sections 2.1.1, 2.4, 2.6, 2.8.2, 2.8.3, 2.9, 3.1.1, 3.2.1, and 3.2.4, the following is considered:

(1) A-OSHMS in the course of its business operations, and it is probable that the A1 B. Office representative and the Stevedores were familiar with the system.

Under the A-OSHMS, when entering into a new cargo handling contract and adopting or modifying work methods or procedures, a risk assessment related to the cargo handling operation must be conducted. It is highly probable that the Loading Operation fell under this requirement.

(2) It is probable that the A1 B. Office representative and the Stevedores did not have a sufficient understanding of the properties of PKS such as its potential to consume oxygen and generate carbon dioxide and of the risks and hazards associated with working inside the CH.

(3) It is probable that the A1 B. Office representative judged that, because the Vessel entered the port in a light condition and there was no perceived hazard inside the CH, the operation could be carried out simply by reversing the unloading procedure. Accordingly, the representative judged that the Loading Operation did not constitute work involving the adoption or modification of work methods or procedures as defined under the A-OSHMS.

(4) At A1 B. Office, in response to the judgment described in (3), no instructions or comments were issued indicating that a new RA Work Procedure Manual should be prepared. Therefore, in conducting the Loading Operation, the Loading Operation had been considered that it could be safely conducted using conventional methods based on prior experience and procedures related to the loading of bulk cargo. As a result, the Stevedores were instructed to proceed in accordance with the Planning Sheet.

(5) In light of (3) and (4), it is probable that, in conducing the Loading Operation, A1 B. Office did not prepare an RA Work Procedure Manual that included a risk assessment covering working environment measurements inside the CH, and did not implement safety management for work inside the CH in accordance with the Relevant Laws and

Regulations.

(6) It is probable that the A1 B. Office representative and the Stevedores did not recognize that the working environment could change as the loading of the PKS progressed within the CH and were not aware that the Relevant Laws and Regulations, which require working environment measurements to be conducted in the CH, were applicable.

(7) In light of (2) through (6), it is probable that, in conducting the Loading Operation, the Safety and Health Plan under the A-OSHMS was not prepared, and that the system and its PDCA cycle did not function, as neither the work supervisor nor the Stevedores pointed out the need for working environment measurements during routine inspections or improvement activities.

Although Company A recognized that working environment measurements, including oxygen concentration measurements, must be reliably conducted when performing work inside the CHs, this recognition had not been effectively communicated to the A1 B. Office representative or the Stevedores. As a result, it is probable that the possibility of oxygen deficiency or similar hazards during the Loading Operation was largely disregarded.

(8) Although Stevedore B had completed the Supervisor of Skill Training Course for Operations Supervisors of Dangerous Work in Oxygen-Deficient Air or Involving Hydrogen Sulfide and held the relevant qualification, it is probable that he regarded the working environment of the Loading Operation—i.e., inside a CH with the hatch covers open—as different from the enclosed spaces such as tanks discussed in the training.

As a result, he did not apply the knowledge gained through the training, and it is possible that his awareness of the risks associated with oxygen deficiency and similar hazards was insufficient.

3.2.6 Analysis of Accident Occurrence

Based on Sections 2.1, 2.2, 2.4, 2.5.3, 2.6, 2.8, 2.9, 3.1.1 through 3.1.3, 3.2.1, 3.2.3, 3.2.4, and 3.2.5, the following findings were made:

(1) It is highly probable that the PKS had absorbed moisture due to rainfall while it was stored in an open pile at the Wharf.

The Vessel berthed at the Wharf in a light condition and commenced the Loading Operation.

(2) In conducting the Loading Operation, it is more likely that an RA Work Procedure Manual was not prepared for the following reasons:

i) A1 B. Office representative judged that, because the Vessel entered the port in a light condition and there was no perceived hazard inside the CH, the Loading Operation could be conducted simply by reversing the unloading procedure. Therefore, the representative determined that the Loading Operation did not constitute applicable work involving the adoption of new methods or procedures as defined in the A-OSHMS.

ii) At A1 B. Office, in response to the judgment of the representative described in i) above, no instructions or comments were issued indicating that a new RA Work

Procedure Manual should be prepared. It was considered that the Loading Operation could be safely performed using conventional methods based on prior experience and procedures related to bulk cargo loading, and the Stevedores were instructed to carry out the operation in accordance with the Planning Sheet.

iii) A1 B. Office representative and the Stevedores failed to recognize the possibility of changes in the working environment as the loading of the PKS progressed within the CH, and were unaware that the Relevant Laws and Regulations requiring working environment measurements in the CH were applicable.

(3) The Vessel berthed at the Wharf in a light condition, and the Loading Operation for the PKS commenced. During that period, the cargo was exposed to rain, and later, the hatch covers of the CH were closed. It is probable that the PKS remained in a high-humidity state during the non-working day.

(4) It is probable that, as the loaded PKS underwent fermentation and oxidation, the oxygen concentration inside No.1 CH decreased and carbon dioxide was generated, resulting in a working environment that could adversely affect the human (Stevedore's) body.

(5) On the day of the accident, although the hatch covers of No.2 CH and then No.1 CH were opened in preparation for the Loading Operation, the average wind speed was 2.0 m/s or less. It is probable that this created conditions in which natural ventilation within the CH was limited, allowing the oxygen concentration to drop below standard atmospheric levels and the carbon dioxide concentration to rise.

(6) In conducting the Loading Operation, A1 B. Office did not prepare an RA Work Procedure Manual that included a risk assessment covering working environment measurements inside the CH, nor did it implement safety management for cargo hold operations in accordance with the Relevant Laws and Regulations.
As a result, no working environment measurement was conducted in No.1 CH in advance.

(7) It is probable that Stevedores A and B, who entered No.1 CH, inhaled air with an oxygen concentration lower and a carbon dioxide concentration higher than those of standard atmospheric conditions, lost consciousness, and collapsed onto the surface of the PKS.

4 PROBABLE CAUSES

The JTSB concludes that the probable cause of accident is more likely to have occurred because, during the Loading Operation at the Wharf, no working environment measurement was conducted in advance for No.1 CH. As the result that Stevedore A and Stevedore B, who entered the CH, inhaled air with an oxygen concentration lower and a carbon dioxide concentration higher than those of standard atmospheric conditions, lost consciousness, and subsequently, collapsed onto the surface of the PKS.

It is probable that the working environment measurement in No.1 CH did not conduct in advance, because A1 B. Office, in conducting the Loading Operation, did not prepare an RA

Work Procedure Manual that noticed a risk assessment covering working environment measurements inside the CH, nor did it implement safety management in accordance with the Relevant Laws and Regulations for work performed inside the CH.

It is probable that the RA Work Procedure Manual was not prepared during the implementation of the Loading Operation because of attributable to the following factors:

(1) A1 B. Office representative judged that, due to the Vessel entered the port in a light condition and there was no perceived hazard inside the CH, the work could be conducted simply by reversing the unloading procedure. In addition, A1 B. Office representative determined that the Loading Operation did not constitute work involving the adoption of new work methods or procedures as stipulated under the A-OSHMS.

(2) A1 B. Office did not conduct to direct instructions or comments were issued indicating that a new RA Work Procedure Manual should be prepared, in response to the judgment made by the representative as described in (1) above. It is probable that the implement of the Loading Operation could be safely conducted using conventional methods based on prior experience and procedures related to the loading of bulk cargo, subsequently, the Stevedores were instructed to perform the operation in accordance with the Planning Sheet.

(3) A1 B. Office representative and the Stevedores did not consider the possibility that the working environment might change as the loading of the PKS progressed within the CH, and then, were not aware that the Relevant Laws and Regulations, which require working environment measurements to be conducted in such cases were applicable.

5 SAFETY ACTIONS

5.1 Measures Considered Necessary to Prevent Recurrence

It is more likely that the accident occurred because, during the Loading Operation at the Wharf, no working environment measurement was conducted in advance for No.1 CH. As the result that Stevedore A and Stevedore B, who entered the CH, inhaled air with an oxygen concentration lower and a carbon dioxide concentration higher than those of standard atmospheric conditions, lost consciousness, and subsequently, collapsed onto the surface of the PKS.

It is probable that the working environment measurement in No.1 CH did not conduct in advance, because A1 B. Office, in conducting the Loading Operation, did not prepare an RA Work Procedure Manual that noticed a risk assessment covering working environment measurements inside the CH, nor did it implement safety management in accordance with the Relevant Laws and Regulations for work performed inside the CH.

Consequently, in order to prevent the recurrence of similar accidents, it is necessary to implement the following measures.

(1) Cargo Handling Companies that dispatch stevedores to the worksite should take the following measures to ensure the safe execution of cargo handling operations while confirming compliance with the Relevant Laws and Regulations:

i) When performing tasks inside a CH, the need for working environment measurements — as required by the Relevant Law — must be clearly recognized by stevedores. Instruct

and specify the necessary work procedures to stevedores to ensure that such measurements are always conducted prior to the commencement of operations for the purpose of safety assurance. Based on the measurement results, if conditions such as decreased oxygen concentration relative to standard atmospheric levels are identified, improve the working environment not only through natural ventilation but also by employing forced ventilation or other appropriate means.

Additionally, establish a safety management framework at the worksite that encourages stevedores to notify any doubts they may have regarding CH work procedures to a responsible supervisor without any hesitation.

ii) When adopting or modifying new work methods or procedures in cargo handling operations, review, and revise, as necessary, the operational systems related to the Occupational Safety and Health Management System (A-OSHMS) to ensure that risk assessments are reliably conducted.

iii) When handling new treatments of cargo such as PKS, collect information in advance regarding any potential hazards, and establish appropriate work procedures for cargo handling operations that take such risks into account.

(2) To implement the measures outlined in (1), Cargo Handling Companies should ensure the proper operation of the A-OSHMS by effectively utilizing workplace meetings and other opportunities attended by both management personnel and stevedores.

The departments responsible for supervising and managing the branches of the Cargo Handling Companies should ensure that the A-OSHMS is functioning effectively at each branch and should provide necessary guidance and supporting action.

5.2 Post-Accident Measures Implemented to Prevent Recurrence

5.2.1 Measures Taken by the Labour Standards Inspection Office

Following the accident, the Labour Standards Inspection Office pointed out to A1 B. Office that no RA Work Procedure Manual had been prepared for the Loading Operation. The Labour Standards Inspection Office provided guidance on reviewing the working environment measurement methods, including the measurement of carbon dioxide concentration and other factors.

5.2.2 Measures Taken by Company A and A1 B. Office

In response to the guidance issued by the Labour Standards Inspection Office after the accident, A1 B. Office prepared and submitted a corrective action report on May 27, 2024, which included the creation of an RA Work Procedure Manual for cargo loading operations involving PKS and similar cargoes. This report was accepted by the Labour Standards Inspection Office.

Other post-accident measures taken by Company A and A1 B. Office were as follows:

(1) Revision and Implementation of the Cargo Handling Safety Management Checklist

The Safety Management Department of Company A revised its Cargo Handling Safety Management Checklist, originally established in 2012, by clarifying the instructions and including provisions related to Regulations for Preventing Oxygen

Deficiency. The revised checklist and its application guidelines have been communicated to each department, business divisions, and branches, with the following operational procedures:

i) Upon the arrival of a vessel for cargo handling operations, inspections using the checklist shall be conducted at each worksite in principle, and records shall be retained for one year.

Any items requiring planned improvement shall be promptly addressed, and the corrective actions taken shall be added to the inspection record.

ii) At worksites where hazardous operations involving a risk of oxygen deficiency are conducted, compliance with Relevant Safety Regulations shall be confirmed.

iii) Safety officers and other responsible personnel at departments, business divisions, and branches shall verify the implementation status of items i) and ii) during safety inspections. Results shall also be shared with other branches conducting similar operations to promote organizational-wide awareness and the improvement of non-compliant items.

(2) Review of Working Environment Measurements for CH Operations

i) Measurement equipment for working environment is now kept on hand at all times. In addition to the previously conducted oxygen concentration measurements, A1 B. Office has added the measurement of carbon dioxide, carbon monoxide, and hydrogen sulfide concentrations.

ii) Forced ventilation using portable blowers has been adopted.

(3) Occupational Safety Training for A1 B. Office Employees

Employees involved in CH operations (both administrative and technical staff) have been required to complete the following training programs:

i) Skill Training Course for Operations Supervisors of Dangerous Work in Oxygen-Deficient Air or Involving Hydrogen Sulfide

ii) Occupational Accident Prevention Training and Workplace Safety Training conducted by the Japan Port Transportation Industrial Safety and Health Association

iii) Special education for the prevention of oxygen deficiency-related hazards, etc.

(4) Other Measures

i) Initial Response Manuals in the event of an accident or industrial accident have been re-communicated and retraining sessions have been conducted.

ii) Portable oxygen concentration meters and emergency-use portable oxygen spray devices have been introduced.

(5) Following the accident, Company A has implemented Safety Training for administrative and managerial staff involved in CH operations.

In addition, under the "2025 Safety and Health Management Policy" of the A-OSHMS, the following items are scheduled to be implemented as Special Promotion and Strengthening Measures for Safety:

i) Skill Training Course for Operations Supervisors of Dangerous Work in Oxygen-Deficient Air or Involving Hydrogen Sulfide

All departments involved in operations with a risk of oxygen deficiency shall actively ensure that both administrative and technical staff complete the certification training.

ii) Thorough reinforcement of confirmation and instruction during pre-operation meetings

Managers and work supervisors shall ensure that, prior to the commencement of operations, they confirm proper work procedures and provide clear working instructions to all relevant personnel.

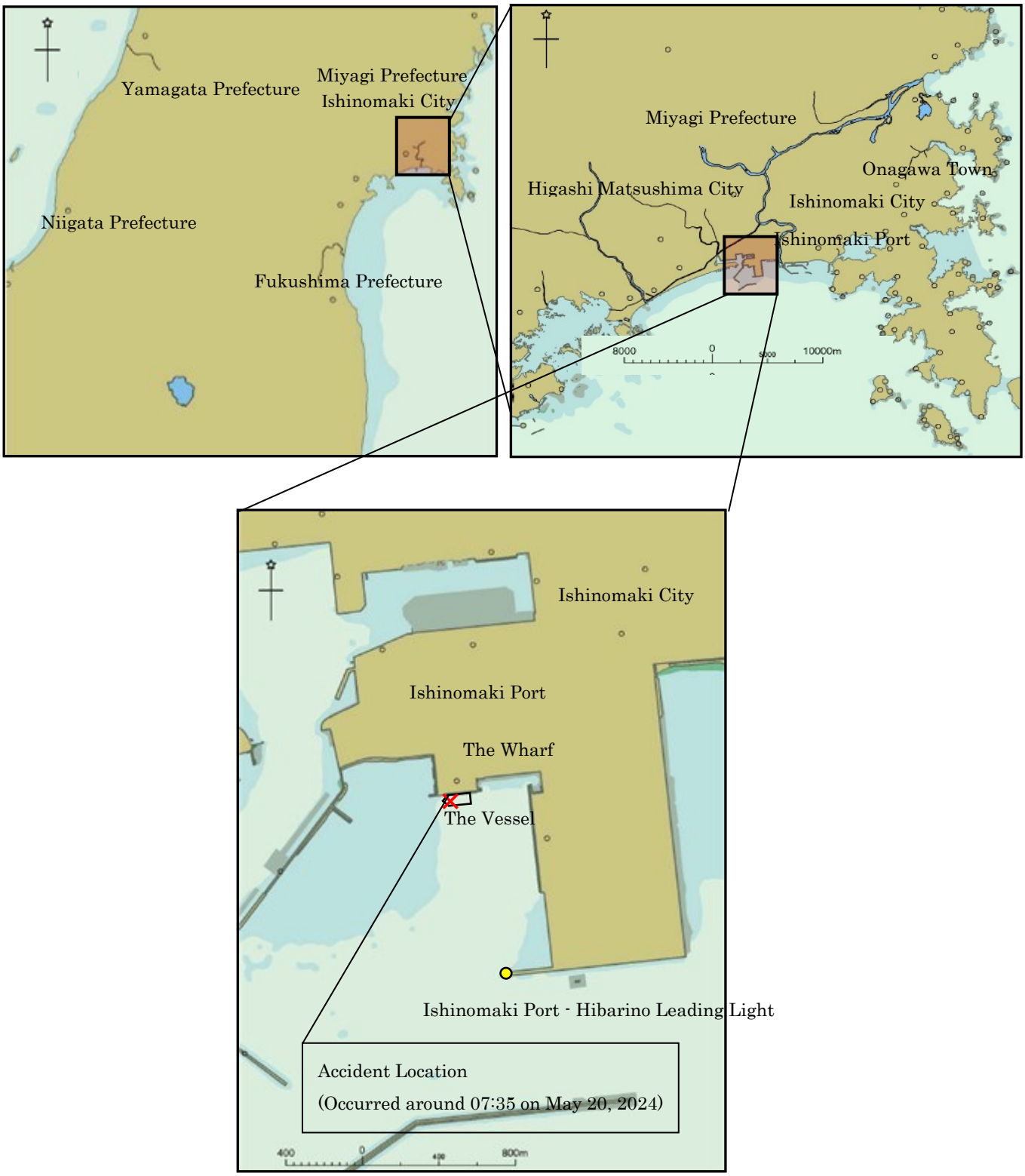
5.3 Additional Measures Required to Prevent Similar Accidents

To prevent accidents similar to the present case, Company A shall require its branches to systematically and continuously conduct training programs on oxygen deficiency-related risks, including certification training, case studies of past accidents, and near-miss incident awareness sessions. These efforts aim to enhance and maintain safety awareness at all levels, from supervisory and management personnel to frontline Stevedores.

Furthermore, it is recommended that not only branch-level personnel but also supervisory-level staff from Company A visit worksites to conduct safety inspections. Through direct observation of actual work practices, they should work to promote the development of safer working environments.

Based on the findings of this investigation, the Japan Transport Safety Board will request the cooperation of the Maritime Bureau and the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism; the Labour Standards Bureau of the Ministry of Health, Labour and Welfare; and the relevant port transport industry organizations such as the Japan Port Transportation Industrial Safety and Health Association.

ANNEX FIGURE 1- OVERVIEW MAP OF THE ACCIDENT LOCATION



Appendix Table 1 – Accident Cases of Oxygen Deficiency in Grain-Loaded Cargo Holds

No.	Date of Occurrence	Time of Occurrence	Location of Occurrence	Name of Accident	Accident Summary	Casualties
1	October 23, 2012	09:10 AM	Quay of Otaru Port, Otaru City, Hokkaido	Cargo Ship *HEILAN BROTHER* Crew Injury.	It is probable that this accident has occurred while the Vessel was moored at a quay in Otaru Port during preparations for unloading corn, when the Boatswain entered No.3 Cargo Hold in an attempt to unload spoiled corn. Ordinary Seaman B, who had donned a self-contained breathing apparatus (SCBA), and then entered the same hold in an attempt to rescue the collapsed Boatswain. When Ordinary Seaman removed his mask to let the Boatswain to use it, both individuals inhaled air with a reduced oxygen concentration and developed symptoms of oxygen deficiency. It is probable that the oxygen concentration in No. 3 Cargo Hold had decreased because the corn stored in the Cargo Hold consumed the oxygen in the sealed air during transportation from Gramercy Port in the United States to Otaru Port. It is also likely that the Boatswain entered No. 3 Cargo Hold, and that Ordinary Seaman B, who had donned a self-contained breathing apparatus (SCBA), entered the same Cargo Hold and removed his mask to rescue the collapsed Boatswain, due to not having accurate knowledge regarding the dangers of oxygen deficiency.	Injuries: 2 Crew Members (Boatswain and Ordinary Seaman)
2	October 19, 2015	08:50 AM	Grain Wharf of Kobe No.2 Ward, Hanshin Port	Cargo Ship *TRITON SWAN* Grain Inspector Fatality	It is probable that this accident has occurred when a grain inspector entered No. 3 Cargo Hold before the oxygen concentration had been confirmed, and consequently inhaled air in an oxygen-deficient environment. Although it could not be determined why the inspector entered No. 3 Cargo Hold prior to oxygen concentration confirmation due to the fatal	Fatality: Grain Inspector

					outcome, it is likely that the absence of established procedures by the Japan Grain Inspection Association for entering hazardous areas where oxygen deficiency may occur was the factor contributing to the accident. It is probable that the oxygen deficiency in No. 3 Cargo Hold resulted from the Hold having remained sealed for approximately one and a half months after corn was loaded.	