

MA2011-10

**MARINE ACCIDENT
INVESTIGATION REPORT**

October 28, 2011

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.

Norihiro Goto
Chairman,
Japan Transport Safety Board

Note:

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

MARINE ACCIDENT INVESTIGATION REPORT

Vessel type and name: Vehicles Carrier PYXIS

IMO number: 8514083

Gross tonnage: 43,425 tons

Accident type: Fire

Date and time: About 0948 hrs (JST), October 14, 2008

Location: East Offing of Kinkazan, Ishinomaki City, Miyagi Prefecture, Japan
Around 089° true, 340 nautical miles from Kinkazan Lighthouse
(Approximate 38° 24.5' N 148° 49.2'E)

October 6, 2011

Adopted by the Japan Transport Safety Board

Chairman Norihiro Goto

Member Tetsuo Yokoyama

Member Kuniaki Shoji

Member Toshiyuki Ishikawa

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1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

On a vehicles carrier PYXIS, boarded by a master and a chief engineer with 19 crew members and an observer, and loaded with 3,900 cars, while navigating on in the high seas in the east offing of Kinkazan, Ishinomaki City, Miyagi Prefecture, Japan, a fire broke out on the car decks¹ at about 0948 hrs on October 14, 2008.

Although the fire was extinguished by Carbon Dioxide (CO₂) gas released onto the car decks from a fire-extinguishing system, consequently a chief engineer died.

The ship sustained fire damage on 4 layers of car decks where structural frame materials were deformed, and about 2,800 of the cars sustained fire damage or were stained with soot and dust.

1.2 Outline of the Accident Investigation

1.2.1 Set up of the Investigation

Because the accident occurred in the high seas on a ship registered in the Republic of Panama, the Japan Transport Safety Board (JTSB), according to the International Maritime Organization (IMO) Casualty Investigation Code², has no obligations to investigate. However, for the reason that the chief engineer of Japanese nationality died, the JTSB, as the substantially interested state, investigated the accident.

On October 15, 2008, the JTSB designated an investigator-in-charge and three investigators to investigate this accident. In addition, the JTSB designated an expert adviser as follows:

For the investigations on car fires;

Tetsuo Taniguchi, Coordinator, National Traffic Safety and Environment Laboratory (designated on January 28, 2009)

1.2.2 Collection of Evidence

October 16 and 27, 2008, July 11, 2009, and June 29, 2010: On-site Investigations and interviews

October 17 and 22, November 4, 5, 7, 10, 12, 13, 18, 19, 21, 25, and 26, December 5, 9, and 24, 2008, January 13, 19, and 23, February 9, 10, and 13, March 16, 19, and 26, May 25, June 2 and 9, July 25 and August 15, 2009: Interviews

October 20, 2008, April 14 and 15, May 12, 2009, April 29, and June 28 and 30, 2010: On-site investigations

October 20 and 21, November 7, 13, 17, 25 and 26, December 1, 3, 8, 9, 15 and 18, 2008, January 19, February 27, March 3, 19 and 26, April 24, May 11 and 25, June 9, July 25, and August 5 and 9, 2009: Collection of the written replies to the questionnaires.

1.2.3 Interim Report

On December 18, 2009, the JTSB submitted an interim report to the Minister of Land, Infrastructure, Transport and Tourism based on the facts found up to that date and made it available to the public.

1.2.4 Comments of Parties Relevant to the Causes

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

1.2.5 Comments from Flag State

Comments on the draft report were invited from the Flag State.

¹ A “car deck” refers to a deck where cars are stored as cargo. The vehicles carrier PYXIS had 13 car decks consecutively stacked from the lowest layer.

² “Casualty Investigation Code” refers to the Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident adopted by the resolution MSC.255(84), IMO.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

2.1.1 Events Leading to the Accident according to the records in Voyage Data Recorder

According to the records in the Voyage Data Recorder³ (hereinafter referred to as the “VDR”) of PXYIS (hereinafter referred to as the “Ship”), the events leading to the accident are as follows:

(1) Voices and others

The voices or sounds recorded in the VDR on October 14, 2008 are as follows, where all the time stamps were in JST(Japan Standard Time, UTC+9), and the words were in English, Tagalog and Japanese (hereinafter, words in English, Tagalog or Japanese are denoted by “E,” “T” or “J” respectively);

Time	Voices or Sounds
09:48:37	Fire alarm notifying activation of the smoke sampling type fire detection system ⁴
09:49:44	“Carry a transceiver” (E) (The master)
09:49:46	“Roger.” (E) (The third officer) Sounds of footsteps running out of the wheel house
09:52:40	“Fire in cargo-hold No. 3” (hereinafter, a cargo-hold numbered by “x” is denoted as “HLD x”) (E) (The third officer on transceiver)
09:52:45	“Already on fire?” (E) (The master)
09:52:46	“Yes, Sir.” (E) (The third officer on transceiver)
09:53:19	Sounds of footsteps running in, then “Smoke. Smoke, Sir.” (E) (The third officer)
09:53:27	General alarm ⁵ (Bell sounds)
09:54:09	“Car deck No.11 (hereinafter, a car-deck numbered by “x” is denoted as “DK x”), HLD 3, Fire” (T) (The third officer, on the direct telephone line to the engine control room)
09:54:18	“Fire, Fire, Fire, DK 11, HLD 3. Fire. Not an exercise.” (E) (The third officer on PA)
09:55:58	“Something smells” (T) (An unidentified voice)
09:56:57	“Smoke from the cargo hold” (E) (on transceiver)
09:57:16	“All crews to fire station ⁶ immediately, to fire station immediately.” (E) (The third officer on PA)
09:57:33	General alarm (Five long blasts of about five seconds each)
09:59:55	Call buzzer of direct telephone from the engine control room. “Which switch to be off? Breaker? Roger.” (T) (The third officer)
10:00:39	“Shut down the electric circuits in the compartment on fire.” (T) (The chief officer)
10:04:52	“First Engineer, Releasing CO ₂ .” (E) (The third officer on PA)
10:05:50	“All crews, immediately go to the muster station ⁷ for roll call. CO ₂ will be released” (E) (The third officer on PA, twice)
10:06:13	“All crews, immediately go to the muster station for roll call. First Engineer,

³ A “Voyage Data Recorder” refers to an apparatus that records navigation data such as the position, course, speed, and radar information, as well as voices from VHF radio-telephone communications and conversations on the bridge in a recoverable capsule.

⁴ “A smoke sampling type fire detection system” refers to a smoke sample extraction detection system that has sensors which detect smoke by using diffracted light from small particles of smoke collected through air accumulators installed on the ceiling of each compartment.

⁵ “General Alarm” refers to the emergency alarm directed to every person on board and requesting every person to pay attention. (Life Saving Appliance Code, Article 82 and the Ship Fire-extinguishing System Code, Article 51, 52, etc.) In order to inform every person of the emergency level, the alarm is, in the case of manual operation, to be blasted in combinations of long and short blasts. The general alarm is designed to automatically ring when 2 minutes of uninterrupted pushing of the acknowledge button have passed after an alarm sounded by the fire alarm system.

⁶ “Fire Station” refers to a post in a ship assigned to a crew member in the firefighting station, or under the firefighting arrangement. Note that the positions where, in the accommodation compartment, fire alarm display panels or CO₂ fire extinguishers are installed have the same name.

⁷ “Muster Station” refers to the place in a ship to go to in an emergency for roll-call and other matters.

	Release CO ₂ , Sir.” (E) (The third officer on PA)
10:06:25	Five long blasts of buzzer on PA
10:06:45	“All crews, go to the muster station.” (E) (The master on PA, twice)
10:07:30	“Hello, this is PYXIS, fires in the cargo hold, DK 11, HLD 3. CO ₂ will soon be released. Uncontrollable.” (J) (The master on maritime telephone with the Ship Management Company)
10:08:00	“The Chief Engineer is missing.” (T) (Unidentified voice)
10:08:21	“Chief Engineer, leave the engine room, immediately go to the muster station.” (E) (The third officer on PA)
10:08:36	“All in the muster station?” (E) (The master)
10:08:40	“Except for the Chief Engineer, Sir.” (E) (The third officer)
10:08:55 to 10:09:07	“Chief Engineer, leave the engine room, immediately go to the muster station.” (E) (The third officer on PA, six times consecutively)
10:10:02	“Chief Engineer, immediately to the muster station. CO ₂ will be released.” (E) (The third officer on PA, consecutively)
10:10:34	“Captain, I will go to see.” (T) (Unidentified voice)
10:11:14	“Still missing?” (T) (Unidentified voice)
10:14:51	“Which zones* on fire?” (E) (The master on transceiver) (* for zone, see Page 13)
10:14:56 to 10:15:08	“Zone D on fire, Sir.” (E) “Zone F and Zone D on fire.” (E) “DK 9, DK 8, DK 6 and DK 11.” (E) (The second officer or the third officer on transceiver)
10:15:12	Fire alarms in the accommodation space.
10:15:21	“Chief Engineer, go to the muster station.” (E) (The third officer on PA)
10:17:42	“(Inaudible) Chief Engineer (inaudible)” (T), “Where is he?” (T), “I called, but he has not shown-up.” (T) (unidentified voice)
10:20:11	“Smoke is coming.” (Unidentified voice)
10:30:31 to 10:33:00	“(Inaudible) I will propose to return. There is little CO ₂ left. Fire extinguishment has not been confirmed. (Inaudible) no injuries. No distress signals yet.” (J) (The master on maritime telephone)
10:37:19	“We will return to Japan.” (E) (The master)
10:37:37	“Course 242 ⁰⁰ ” (E) (Unidentified voice)
10:38:00	Call tone of INMARSAT telephone. “Still smoke. I heard the alarm of sensor 54 on DK 11, HLD 3, went down and found it full of smoke there. No flames. I thought the fire would spread to the entire ship, so I shut the doors and released CO ₂ . The alarm rang in other zones too, so I released CO ₂ there. Likely not able to continue voyage. I will propose to return. (J) (The master)
10:51:46	“Chief Officer, when was the CO ₂ released?” (E) (The master on transceiver)
10:51:49	“1010 hrs, Sir.” (E) (The third officer)
11:07:15	“Probably, still on fire (inaudible). Will release more CO ₂ .” (E) (The master on transceiver)
11:09:18	Call tone of maritime telephone, “Captain is releasing CO ₂ again (inaudible). Situation is yet to be confirmed. Still smoke. Captain is busy, so he will call back.” (E) (The third officer)
11:12:13	“Deck surface is very hot now, possibly due to sunshine. There must be explosions, if the fire had spread there. (Inaudible) impossible to open to enter. (Inaudible) a lot of smoke (inaudible). I propose to exhaust them all. If no damages to the engine, we will be able to return to Japan while cooling the ship.” (J) (The master on maritime telephone)

(2) The Ship Position

According to the GPS⁸ records on the VDR, it was as follows:

⁸ “GPS” is the abbreviation for Global Positioning System, which enables a ship equipped with the system to know its exact position by receiving signals from multiple satellites to calculate the distance to each satellite.

The ship position at the time of the fire alarm of the fire detection system:
38°24.5' N, 148°49.2' E

2.1.2 Records of alarms on Alarm Printer

According to the records of the engine alarms printed on the alarm printer⁹ installed in the engine control room on October 14, it is as follows:

09h59m30s: Alarm of insulation degradation in AC 220 V power line.

10h14m25s: Alarm of abnormality in CO₂ gas pressure.

2.1.3 Statements from Crew Members

According to the statements from the master, the chief officer, the second officer, the third officer, the first engineer, the boatswain, the able bodied seaman (hereinafter referred to as "A/B A") who had served bridge watchkeeping from 0000 to 0400 hrs ship's time, and the able bodied seaman (hereinafter referred to as "A/B B") who had served bridge watchkeeping from 0400 to 0800 hrs, the events leading to the accidents are as follows:

(1) Events from the departure to the sounding of the fire alarm

The Ship, a vehicles carrier serving on a line between Japan and North America, left Mikawa Port, Tahara City, Aichi Prefecture, Japan, loaded with 3,900 cars, at about 1840 hrs on October 12, 2008, heading to Portland Port, Oregon, in the northwest of the U.S.A.

The bridge watchkeeping arrangement on the voyage was 3 shifts of 4 hrs by a unit of two people—an officer and an able bodied seaman—and the able bodied seaman after finishing the duty was to patrol the car decks.

In the Ship, from about 0800 to about 1645 hrs on October 13, the day after the departure, the deck department members executed inspection of the lashing status of cars through DK 13 to DK 8.

In addition, from about 0300 hrs October 14 (0400 hrs ship's time), A/B A patrolled car decks, and from about 0700 hrs (0800 hrs ship's time) A/B B patrolled there. Neither of the A/Bs found any problems.

On October 14, at about 0700 hrs, the deck department members restarted inspection of the lashing status of cars in cargo on DK 7 and down to the lower decks, and the engine department members started maintenance work including overhaul of the auxiliary exhaust valves of the main engine.

On October 14, at about 0948 hrs, while navigating on the east offing of Kinkazan in the high seas, the Ship had a warning on the control panel installed in the bridge of the cargo hold smoke sampling type fire detection system, where the red indicator 54, for Zone F, DK 11, port side came on and an alarm followed.

The time and date of the occurrence of the accident was about 0948 hrs, October 14, 2008, and the location was in the high seas, around 089° true 340 nautical miles (M) from Kinkazan Lighthouse.

(See Figure 1: Map of Accident Location, Figure 2: General Arrangement Plan, Figure 3: Layout of Smoke Accumulators and CO₂ Release Nozzles of Smoke Sampling Type Fire Detection System on DK 11, Photo 1: Bird's-eye View of the Ship (after the accident))

(2) Events from the sounding of the fire alarm to the emergency call

The third officer on the bridge watchkeeping immediately reported the occurrence of the fire alarm to the master. The master rushed into the wheel house, confirmed the location of the fire on the fire detection system and instructed the third officer to identify the site of the fire.

The third officer rode on the elevator in the middle of the starboard side of the boat deck, went down to Deck No. 10, opened the fire door at the entrance of DK 10, saw a bright yellow light and reported to the master with transceiver.

The master instructed the third officer to come back to the wheel house and, on the way to

⁹ An "alarm printer" refers to an apparatus that, when an alarm is made, prints the time, location and description of the alarm.

DK 11, with the chief officer heard the fire alarm, picked up a portable chemical fire extinguisher installed on Deck No. 13 with the ladder in the starboard bow. He then opened the fire door of DK 11, HLD 3 to rush to the location of the smoke accumulator that had detected smoke, gave up on using the portable chemical fire extinguisher for initial firefighting and decided to go back to the wheel house because of the irritating odor and growing density of the smoke.

The master, on the way back to the wheel house, thought of using the fixed CO₂ fire extinguisher system, instructed the chief officer to close the dampers.¹⁰ At the same time, he instructed with transceiver the third officer in the wheel house to sound the general alarm and make a PA announcement of the fire breakout in order to notify the deck department crew members inspecting the lashing status of the cars on the car decks and the engine department crew members working on maintenance in the engine room.

The third officer, upon the instruction from the master, sounded the general alarm at about 0953 hrs, and repeatedly made announcements on the PA of "Fire, Fire, Fire, Fire on DK 11."

A/B A and A/B B, upon the PA announcement of the fire breakout, went down the stairs in the engine room to DK 6 to inform the deck department crew members of the fire, and after that, went to the muster station on the boat deck.

On the other hand, in the engine room, the chief engineer, the first engineer and other members, upon the general alarm, went to the engine control room and confirmed by a call to the wheel house that the location of the fire breakout was DK 11, HLD 3. After that, at about 0959 hrs, the first engineer, upon the alarm of insulation degradation of the AC 220 V Power line, suspected that the electric cables for lighting in the car decks were being melted by the heat of the fire and instructed with telephone the third officer in the wheel house to shut off the breaker for the line in question.

The third officer, after having shut down the breaker for the lighting power line on the car deck, while repeating the PA announcement, was instructed by the chief officer who had received the instruction from the master to announce that all crew should go to the muster station and be ready for the release of CO₂ at about 1004 hrs, and repeated the announcement. The chief engineer and the first engineer, who had stayed in the engine control room because that the room becomes the muster station in the case of fire, heard the PA announcement that all crew should go to the boat deck, which was the muster station for abandoning ship, and be ready for the release of CO₂ at about 1006 hrs.

The first engineer proposed the chief engineer to go up to the boat deck together. However, the first engineer went up by himself onto the boat deck and went near the life boats, because the chief engineer told the first engineer that he would stay in the engine room and be the last man to go up to the boat deck.

The master, at about 1008 hrs, inquired with the third officer whether all were in the muster station, then found out that the chief engineer was not in the muster station, and was reported by the third officer that the chief engineer had told the first engineer to go first because he would be the last to go.

(3) Firefighting with the fixed CO₂ fire extinguisher

The master, in the fixed CO₂ fire extinguisher system room (hereinafter referred to as the "CO₂ Room") at the stern end of the accommodation space, received from the boatswain the report of the confirmation that all the dampers were closed, and at about 1010 hrs, with an expectation that the chief engineer was in the engine control room away from Zone F, into which CO₂ was to be released, started the release of CO₂ into Zone F, where the smoke sampling type fire detection system had detected smoke. After that time, the master, at about 1014 hrs, upon receiving the report that the smoke sampling type fire detection system had sounded alarms for zones E and D, thought that the fire had spread to those zones, and released CO₂ into zones E and D. The master, at about 1025 hrs, after having released about 60 % of about 35 tons in total of the CO₂ in zones F, E and D, closed the release valve.

The master, in order to cool the car deck, instructed to discharge water onto the boat deck, around the position corresponding to the ceiling of DK 13, and released CO₂ again at about 1107 hrs into zones D, E and F because the master was not confident that the fire had been extinguished. At

¹⁰ A "Damper" refers to an apparatus installed inside the air duct of the blower and others. to control the air flow.

about 1116 hrs, all the CO₂ had been exhausted.

(See Figure 2: General Arrangement Plan and Figure 3: Layout of Smoke Accumulators and CO₂ Release Nozzles of Smoke Sampling Type Fire Detection System on DK 11)

(4) Confirmation of fire extinguishing

At about 1040 hrs, the Ship made a full turn in order to return to Japan, and at about 0700 hrs, October 15, met a Japan Coast Guard patrol boat that had come to rescue it by the request from the ship management company (Kagoshima Senpaku Kaisha, Ltd., hereinafter referred to as "Company A"). At about 0758 hrs, the Ship accepted six members of the Japan Coast Guard special rescue team (hereinafter referred to as the "SRT members") on board to investigate the situation of the fires and the search and rescue of the chief engineer.

The SRT members measured the temperature on the side walls of the car decks, requested the master to ventilate all the car decks, entered the inside of the car decks with the master, and then, at about 1020 hrs, confirmed that the fire in all the car decks had been extinguished.

As a result, the Ship, at about 0730 hrs, October 16, berthed at Quay No. 3, Ariake Wharf, Mikawa Port, Aichi Prefecture, Japan.

2.1.4 Search and Rescue of Chief Engineer

According to the statements from the master, after the first release of CO₂, he instructed the crew members to search after the chief engineer through the places other than the cargo holds, such as the engine room, the engine control room and emergency escape routes. However, he was not found.

According to the written replies to the questionnaires of the SRT members, the SRT members, after having confirmed that the fire was extinguished, started to search for the chief engineer, and about 1045 hrs, found his body near the car ladder on the starboard quarter end of DK 7, trapped between a car and the bulkhead of the engine room. He was dead.

2.2 Death, Missing and Injuries to Persons

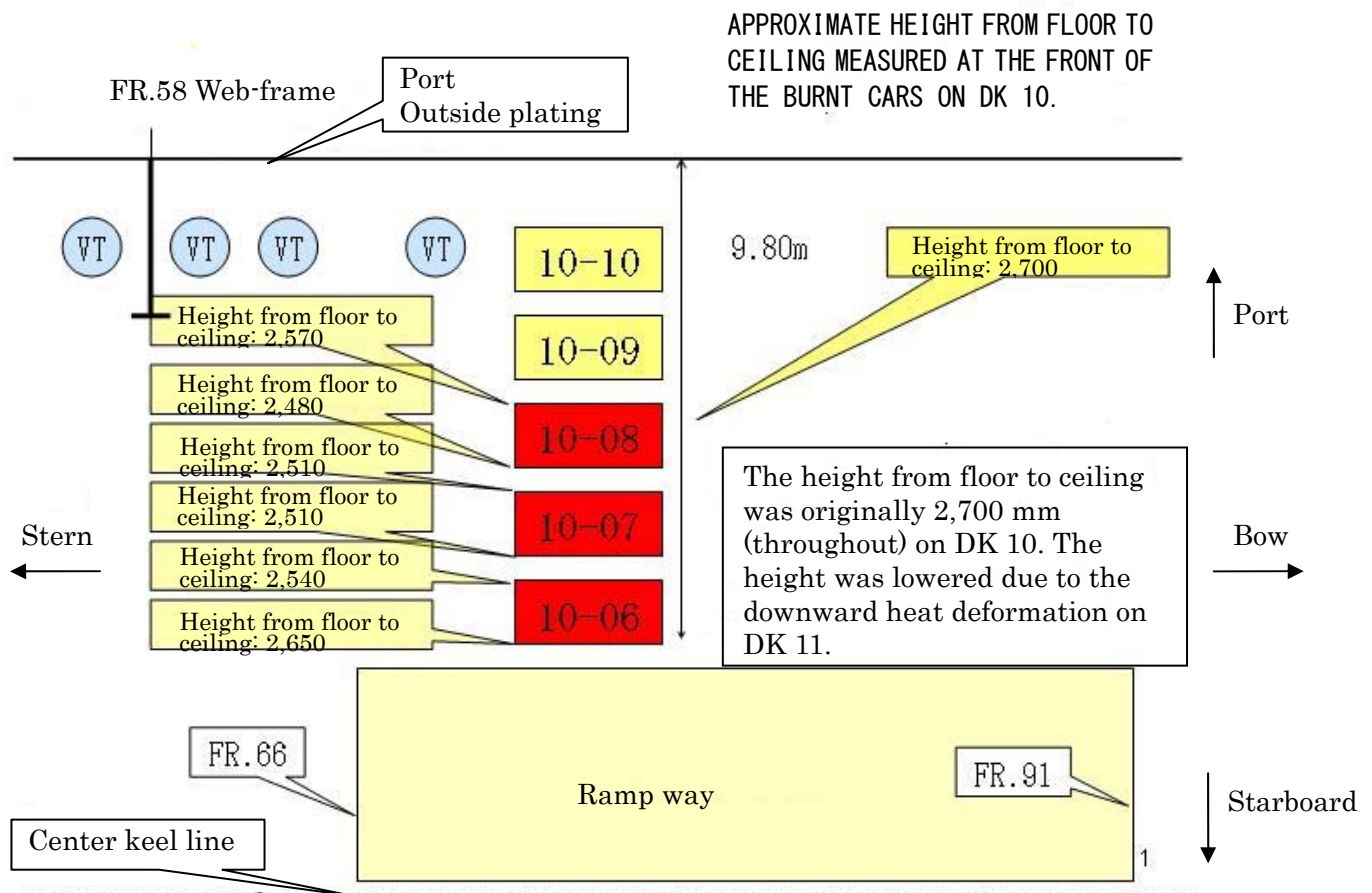
According to the judicial autopsy record of the chief engineer, is considered probable that the cause of death was suffocation due to carbon dioxide intoxication, and that the elapsed time from the death to the beginning of the autopsy (about 1500 hrs October 16, 2008) was 2 to 3 days.

2.3 Damage to Vessel

According to on-site investigations and the written replies to the questionnaires of Company A, the damage was as follows:

(1) DK 10

A strip of paint on the surface, about 10 m wide and about 21 m long, from the port outside plating of HLD 3 to the Center keel line was burnt away, and the structural materials in beam frame No. 70, supporting DK 11, were melted down to about 220 mm at most due to heat.



(2) DK 11

DK 11 suffered severe damage in the form of a wider strip of paint being burnt away than that on DK 10, and had several dents about 50 cm in diameter and 10 cm deep on the car deck floor.

(3) DK 12

A part of the floor was deformed and covered with soot, and the surface paint on the ceiling was burnt away.

(4) DK 13

A part of the floor was deformed and covered with soot, and a part of the ceiling was also covered with soot.

(5) Fluorescent lights on ceilings

On DK 10 to DK 13, the plastic covers of some of the fluorescent lights on the ceilings melted, and the fluorescent bulbs were broken or some of the lights were down on the floor due to coming off the mounting equipment.

(6) DK 1 to DK 9

No damages of material deformation or paint loss due to burning were found.

(See Photo 2: Fire Damage Situation of DK 10 Ceiling, Photo 3: Fire Damage Situation of Fluorescent Lights)

2.4 Damage to Cars

According to the written replies the questionnaires of the automobile manufacturer (hereinafter referred to as "Company B"), the cars in the car decks received damage as follows:

(1) Burnt damage

Of the cars stored on DK 10 to DK 12, 111 cars sustained outside damage, such as burns on

body surfaces, wheels or tires; inside damage, such as burns in the compartments or the engines; or cracks in glass parts, such as the wind shield. Of the 111cars, 74cars were unable to run.

The most severely damaged ones were those around the ramp way of DK 10.

(2) Contamination by Soot

Almost all the cars in cargo on DK 6 to DK 13, except for the damaged 111cars described in (1), were covered with soot.

Accordingly, almost all the damaged cars mentioned in (1) and (2) were dismantled as scrap.

2.5 Crew Information

(1) Gender, Age, and Certificate of Competence

The master Male, 63 years old

Nationality: Japan

First Grade Maritime Officer (Navigation)(issued by Japan)

Date of Issue: March 9, 1992

Date of Revalidation: April 21, 2006

Date of Expiry: March 8, 2012

Endorsement attesting the issue of a certificate:

Captain (issued by the Republic of Panama)

Date of Issue: June 5, 2006

(Valid until May 25, 2011)

The chief engineer Male, 65 years old

Nationality: Japan

First Grade Maritime Officer (Engineering)(issued by Japan)

Date of Issue: May 17, 1974

Date of Revaluation: July 28, 2008

Date of Expiry: March 5, 2014

Endorsement attesting the issue of a certificate:

Chief Engineer (issued by the Republic of Panama)

Date of Issue: May 20, 2003

(Valid until May 5, 2009)

The chief officer Male, 48 years old

Nationality: The Republic of the Philippines

Endorsement attesting the issue of a certificate:

Chief Officer (issued by the Republic of Panama)

Date of Issue: November 18, 2005

(Valid until July 20, 2009)

The first engineer Male, 34 years old

Nationality: The Republic of the Philippines

Endorsement attesting the issue of a certificate:

First Engineer (issued by the Republic of Panama)

Date of Issue: June 12, 2007

(Valid until July 13, 2009)

(2) Significant Experience in Service Aboard

The master

According to the statements from the master and the questionnaire of Company A, it is as follows:

The master, after having obtained a certificate for marine officer, joined a shipping company when he was 26 years old and boarded cargo ships, vehicles carriers or other ships as an officer. When he was 45 years old, he began to serve as a ship master. The master had boarding experience on more than nine ships as an officer or a master on vehicles carriers, and at around 40

years old began to board multi nationality manned ships.

The chief engineer

According to the written replies to the questionnaire of company A, it is as follows:

The chief engineer, after having graduated from a high school, joined a shipping company, obtained a certificate for the First Grade Maritime Officer (Engineering) when he was 31 years old, and boarded reefers, chemical tankers, container ships or other ships as an engineer or a chief engineer. After having retired, he registered at a temporary seaman service company, boarded a variety of ships and, in August 2008, boarded the Ship as a chief engineer. He had boarding experience on more than five vehicles carriers, and at around 50 years old. The chief engineer began to board multi nationality manned ships.

The chief officer

According to the written replies to the questionnaire of Company A, the chief officer boarded a cargo ship as a third officer when he was 36 years old, and was promoted to a first officer at 45 years of age. He had eight years of experience on board vehicles carriers of 10 ships.

The first engineer

According to the written replies to the questionnaire of Company A, the first engineer, after having obtained a certificate of maritime officer(engineering), boarded a cargo ship as a third engineer when he was 25 years old, and was promoted to first engineer at 32 years of age. He had about three years of boarding experience on four vehicles carriers.

(3) Health conditions

According to the written replies to the questionnaires of Company A, neither the master, the chief engineer, the chief officer, nor the first engineer had any chronic diseases, and their health conditions were good.

2.6 Vessel Information

2.6.1 Particulars of Vessel

IMO number:	8514083
Port of registry:	Panama (Republic of Panama)
Owner:	Feng-Li Maritime Corporation (Republic of Panama)
Time-charter company:	Toyofuji Shipping Co., Ltd. (hereinafter referred to as "Company C")
Management company:	Company A
Gross tonnage:	43,425 tons
L × B × D:	199.00 m × 32.20 m × 20.12 m
Hull Material:	Steel
Engine:	One diesel
Output:	11,069 kW (Maximum continuous)
Propulsion:	One fixed-pitch propeller
Date of Launch:	February, 1986
Navigation sea area:	Ocean (International voyage)
Usage:	Vehicles carrier
Classification society:	Nippon Kaiji Kyokai (Class NK)
Number of crew:	21 (Two Japanese, 19 Filipinos)
Number of others:	One observer (Japanese)

2.6.2 Loading Condition

According to the statements from the master, the Ship was loaded with 3,900 cars, and the draught at departure was about 7.40 m at the bow and about 8.40 m at the stern.

2.6.3 Structure of Hull

The Ship was a multideck type vehicles carrier which consisted of box-shaped structures spanning from the bow to the stern. The whole hull under the upper deck, except for the engine

room and others on the stern end, was used for cargo holds which had 13 car decks.

The hull was equipped with two tilting car ladders opened-closed by hydraulic powered winches and wire-ropes, of which one was on the starboard casing wall around the midship and the other was on the stern end of the casing wall. Cars run on the ladders tilted in such a way that the ends of the ladders touch the surface of the berth, enter DK 6 or DK 7 of HLD 2, or DK 6 or DK 7 of HLD 3, through ramp ways between each car deck, and stop at the storing positions on the car decks.

On the weather deck, there were a container deck in front of a superstructure and a superstructure with a boat deck. The accommodation space, including the cargo office, the dining room and the fire station, and the CO₂ room equipped with firefighting equipment were on the bow end of the boat deck. The wheel house and the radio room were above the accommodation space and the CO₂ room. The ventilators for the cargo holds were on both sides of the container deck and both sides of the boat deck.

(See Figure 2: General Arrangement Plan, Photo 1: Bird's-eye View of the Ship (after the accident))

2.6.4 Structure of Car decks

(1) The cargo holds were located and named HLD 1 to HLD 4 from bow to stern respectively. Also, the cargo holds consisted of 13 layers of car decks named DK 1 to DK 13 from the bottom to top respectively. Each of DK 1 to DK 9 had HLD 1 to HLD 4, and each of DK 10 to DK 13 had HLD 3 to HLD 4.

(2) Each of DK 1 to DK 5 was walled at the bow and stern ends by partitions equipped with fire doors and bulkheads, and separated into three cargo hold compartments. The floor of DK 6 on the upper deck was the ceiling of DK 5.

(3) Each of DK 6 to DK 9 was a through deck from bow to stern. The bow mooring deck and the stern mooring deck were placed at the bow end and the stern end of DK 9 respectively.

The car ladders, used for car loading, were interchangeably attached to DK 6 or DK 7. On the car deck, near the stern-end car ladder, was a vertical ladder with 7 steps connecting DK 6 and DK 7. The hatch on DK 7 was about 60 cm wide and long.

The distance from the hatch on DK 7 to the spot where the body of the chief engineer was found was about 4.4 m.

(4) Each of DK 10 to DK 13 was about 100 m long and about 32.2 m wide. The height was about 2.700 m for DK 10, about 2.635 m for DK 11, about 2.035 m for DK 12 and about 2.150 m for DK 13. Each of them was used as HLD 3 or HLD 4.

(5) A ramp ways spanning from HLD 2 to HLD 3 were installed to connect decks from DK 1 to DK 9, and ramp ways installed within HLD 3 for DK 10 to DK 13. Those ramp ways were used to make a traffic passage connecting the upper car deck and the lower car deck.

(6) On the floor of each car deck except for DK 1, DK 6, DK 9 and DK 10, there were a number of holes of about 58 mm in diameter for latching lashing devices called clasps.¹¹ On DK 1, DK 6, DK 9 and DK 10, eyes for clasps were installed because those decks were gastight.

(See Figure 2: General Arrangement Plan, Figure 4: Details around DK 6 Car Ladder, Photo 5: Vertical Ladder Connecting DK 6 and DK 7, Photo 15: Clasps.)

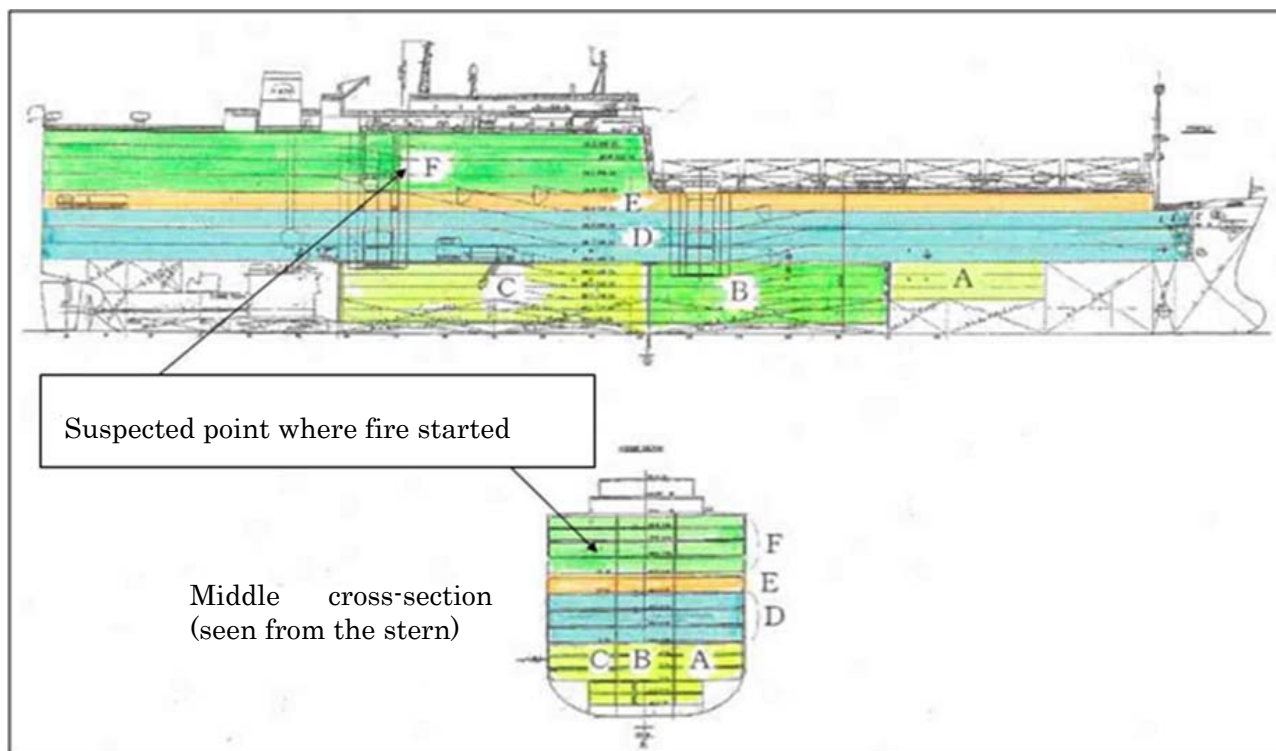
2.6.5 Description of Fire Protection Structure of Car Decks

(1) Fire retarding divisions

The fire retarding divisions were combined with car decks and cargo holds, and were divided into 6 zones and named as shown in the table below;

¹¹ A "clasp" refers to belt-shaped lashing equipment used to tie cars to the hull.

Zone	Compartments
A	DK 3 to DK 5 in HLD 1
B	DK 1 to DK 5 in HLD 2
C	DK 1 to DK 5 in HLD 3
D	DK 6 to DK 8
E	DK 9
F	DK 10 to DK 13 in HLDs 3 and 4



(2) Partitions of fire retarding divisions

A watertight partition was installed between Zone B and Zone C. In addition, the doors listed below worked to provide protection from smoke and flames.

{1} Bulkhead doors

In each of DK 3 to DK 5, between Zone A and Zone B, a sliding bulkhead door driven by a pneumatic winch and wire ropes was installed.

(See Photo 6: Sliding Bulkhead door.)

{2} Tilting gastight doors

The ramp ways penetrating the fireproof compartments of the car decks were equipped with tilting gastight doors which rise or fall to close or open, driven by a hydraulic piston and wire ropes. Those doors were usually closed during a voyage.

Zone	Installment Position	Number of Doors
Zone B to Zone D	Ramp way DK 5 to DK 6	1
Zone C to Zone D	Ramp way DK 5 to DK 6	1
Zone D to Zone E	Ramp way DK 8 to DK 9	1
Zone E to Zone F	Ramp way DK 9 to DK 10	1
Zone D to Zone F	Ramp way DK 8 to DK 10	1

(See Photo 7: Tilting Gastight Door)

{3} Fire Doors to and from staircases to car decks

The starboard door and the port door on the bow end of the boat deck, the doors from the starboard quarter staircase to car decks and the doors to car decks through the engine room from

the elevator exits on deck No. 6 and deck No. 10 were fireproof to enable prevention of smoke and flames from flowing into and out of the staircases, the engine room and car decks. Therefore, such structures in combination were able to block each zone in the fireproof compartments from the outer air through the closing of the bulkhead doors, the tilting gastight doors, the fire doors and the ventilation holes, which will be described in 2.6.6.

The Ship passed the ship inspection on fire protection construction in April 2008 and received a Cargo Ship Safety Construction Certificate.
(See Photo 8: Fire Door from Staircase to Car deck)

2.6.6 Ventilators for Cargo hold Ventilation

Ventilators for removing the exhaust gas produced during car loading/unloading and vaporized gasoline coming out of car gas tanks were installed on the boat deck and the container deck. On the boat deck and the container deck, ventilation holes were installed, and on the car deck, exhaust holes and intake holes were installed.

Thirty five ventilators in total were installed: 8 modules on the starboard side of the boat deck, 12 modules on the port side of the boat deck, two modules on the starboard stern of the boat deck, seven modules on the starboard side of the container deck and six modules on the port side of the container deck. Each of those modules had an explosion-proof bidirectional axial flow type electric blower with an output of 15 to 18.5 kW (hereinafter referred to as the “blower”), which was able to be turned on or off in the power distribution panel room or in the cargo office. Also, three natural ventilation trunks without a blower were installed on the starboard side of the container deck, and two were installed on the port side of the container deck.

The ventilation holes in the zone of fire retarding positions were connected to the exhaust holes and intake holes in the same zone by the steel ventilation trunks embedded in the hull, and the ventilation holes were able to be shut by closing the up-down or tilting dampers installed on the boat deck or container deck, so as to separate the corresponding zone from the outside air.
(See Photo 9: Ventilator (Damper and Ventilation Holes))

2.6.7 Electric Equipment in Cargo Hold

The cargo holds were equipped with AC 220 V, 40 W drip-proof fluorescent lights installed all along the ceiling and explosion-proof fluorescent lights installed on the ceiling almost all along the fore and aft line and around the side bulkhead.

According to the statements from the person in charge from Company A, the AC 220 V line was used only for the fluorescent lights in cargo holds, and the power lines and electric equipment, such as fluorescent lights, had no reconstructions or additions since the entering service and were kept in original condition.

Warning air horns and DC 24 V solenoid valves, to be blown for one minute prior to the release of CO₂, were installed on the car decks in the cargo holds. However, DK 10 did not have such a warning air horn or solenoid valve installed. The controller of those solenoid valves was embedded in the release control panel installed in the CO₂ room at the stern end of the accommodation space, so as to unlock the interlock to blow the air horn, upon the completion of the necessary procedures, including opening the release valves.

2.6.8 Escape Routes from Engine Control Room

(1) Engine control room

According to the general arrangement plan and the layout plan of the engine room, the engine control room, placed at the port side, stern end of DK 4, was about 6.0 m long along the fore and aft line, about 8.0 m wide in the abeam direction, about 2.6 m high, and was equipped with the main engine control system, the warning system, the instruments, the main electric distribution panel, the data-logger, and others.

In addition, the room was equipped with one Emergency Escape Breathing Device (hereinafter referred to as “EEBD”) and four transceivers always charged at the stern end.

(2) Escape routes

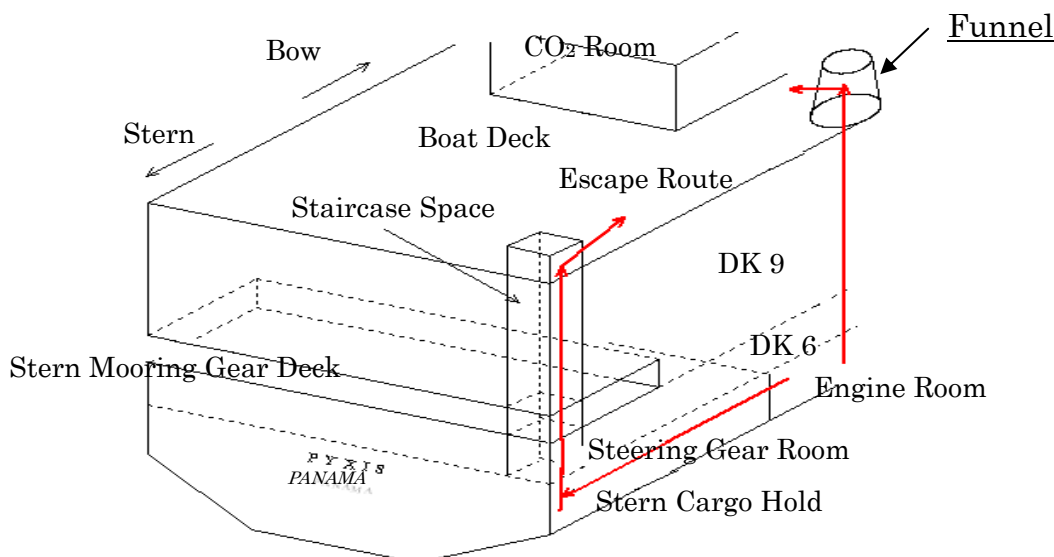
{1} Escape route through the steering gear room

The escape route through the steering gear room was predetermined as follows: to go in the

stern direction from the engine control room, pass through the storage hold at the stern to DK 6, go through the steering gear room placed at the stern end of DK 6, go up the stairs installed at the starboard stern, and reach the starboard quarter of the boat deck. By taking this route it was possible to bypass the cargo hold. The route was the prescribed escape route in an emergency, and guide signs were posted along it. By taking this route it was possible to enter or exit any car deck, because the route was accessible from any of the stairs on DK 6 to DK 13.

{2} Escape routes through the stairs in the engine room

As for the escape routes using staircases, two routes were available as follows: the first is to go up the stairs installed in the engine room along the exhaust pipes, go up through the funnel, and reach the middle of the starboard side on the boat deck; and the second is to go up the stairs installed vertically along the elevator to DK 13, and go up to the boat deck. Along those two routes, there were doors to enter or exit from the car decks on DK 6 and DK 10, where the elevator stops. However, on DK 7, there was no door to the elevator.



(Escape Routes through Staircases in Steering Gear Room or Engine Room)

{3} Escape route through the port bunker station

An escape route was available through the port bunker station¹² as follows: to go up the stairs and the vertical ladder installed on the port side outside the engine control room, reach the port bunker station, and open a watertight door to enter DK 6. However, as described in 2.10.4 below, at the time of the accident, the watertight door could not be opened from the bunker station because it had been locked inside DK 6.

2.6.9 Smoke Sampling Type Fire Detection System

The Ship was equipped with a smoke sampling type fire detection system, which detects fires in car decks and sounds alarms.

(1) Construction and Operating Principle

The smoke sampling type fire detection system consists of smoke accumulators, smoke

¹² “Bunker Station” refers to the working space for the loading of fuel by connecting the fuel in-take pipe on the hull to the fuel hose extended from outside the ship.

conduction pipes, a smoke detection control panel, exhaust-fan units and a remote display panel. The smoke accumulators and a part of the conduction pipes were installed in the cargo holds, the control panel was installed in the wheel house, the exhaust-fan unit was installed on the compass deck on the bridge, and the remote display panel was installed in the fire station.

According to the operation manual of the system, the smoke detection control panel draws the air in the cargo holds with fan, measures, continuously and electrically, incident light scattered from smoke caused by fire, and sounds alarms and displays the location of the smoke in the case where the measurement exceeds the predefined value.

(2) Locations of Smoke accumulators

A total of 122 smoke accumulators were located in fire retarding divisions, called zones and consisting of several car decks, in such a way that the car decks, except for DK 2, DK 4, DK 7, DK 10 and DK 12, were equipped with one smoke accumulator for every two decks, which were installed on the deck floor of the upper car decks of the pairs.

(3) Time from intake of smoke to sounding of alarm

{1} Regulations of Classification Society Nippon Kaiji Kyokai

According to the regulations in the Rules and Guidance for the Survey and Construction of Steel Ships by Classification Society Nippon Kaiji Kyokai (hereinafter referred to as “NK”), the time from the intake of smoke until the alarm is sounded should be less than 3 minutes, and, for a system cyclically measuring different compartments in a predefined period, the cycle time, in which the measurements in all the compartments are completed, should not exceed 120 seconds.

{2} Results of Efficiency Test

According to the results of an efficiency test conducted in April 2008 of the smoke sampling type fire detection system installed in the Ship, which is a continuous measurement type that continuously measures without switching the target compartment of measurement, the average time from the intake of smoke until the sounding of the alarm was about 57 seconds.

(See Figure 5: Simplified Diagram of Construction of Smoke Sampling Type Fire Detection System, Photo 10: Smoke Detector Control Panel)

2.6.10 Fixed CO₂ Fire Extinguisher System

On the Ship, the CO₂ room was on the stern end of the accommodation space, and was equipped with a fixed CO₂ fire extinguisher system which releases CO₂ out of a CO₂ storage tank into the car decks and others when fire breaks out, in the case when a fire occurs in a car deck or the engine room.

(1) Construction of the fixed CO₂ fire extinguisher system

The fixed CO₂ fire extinguisher system, which was a low-pressure CO₂ fire extinguisher system, consisted of a storage tank containing about 35 tons of CO₂, a release control panel and a cooling system for cooling the inside of the tank to keep the inside pressure at around 2.1 MPa. The extinguisher system was able to release CO₂ into the cargo decks of each zone and the engine room.

(2) Release of CO₂ into Individual Zones

CO₂ was able to be selectively released into individual zones by operating, in the CO₂ room, the master valve, the release valve and the cargo hold selection valve of the CO₂ storage tank. CO₂ is released from the discharge nozzles mounted on the cargo hold ceilings of the selected zone to extinguish fires through the choking effect and cooling effect.

(See Figure 6: Block Diagram and Construction Map of Fixed CO₂ Fire Extinguisher System, Photo 11: Fixed CO₂ Fire Extinguisher System)

2.6.11 Communication Equipment on Car Decks

The car decks were equipped with non-powered transceiver antennas.

According to the statements from the boatswain, on the car decks, the transceivers were available for communications with the wheel house. However, there was no equipment for alarms, except for the CO₂ release alarm, or PA equipment.

(See Photo 12: Transceiver Antenna installed in Cargo Hold)

2.6.12 EEBD

(1) NK Regulations

The NK Rules and Guidance for the Survey and Construction of Steel Ships stipulate the following:

All ships should be equipped with EEBDs in such a way that EEBDs are installed at easily noticeable locations and can be used and accessed promptly in whatever type of fire situation. An EEBD—a supplier of air or oxygen—should be used only in a situation of escape from a compartment in danger. An EEBD should not be used for firefighting or entering oxygen deficient spaces or tanks. An EEBD is required to supply air or oxygen continuously for at least 10 minutes. The numbers and locations of EEBD installation should be clearly shown on fire control plans.

(2) EEBDs on the Ship

The operation manual of the EEBDs installed in the Ship states the following:

The EEBD was the type that supplies compressed air, and consisted of a hood, a 2.3 liter container of highly-compressed air, a pressure regulator, an exhaust valve, a tube, a neck band and a waist belt. Decompressed air was supplied through the tube into the head-covering hood, and the air in the hood was mixed with exhaled breath and exhausted through the exhaust valve.

The effective period of the EEBD was about 10 minutes.

(See Photo 13: EEBD (Engine Control Room))

(3) Number of EEBDs

According to the fire control plan, ten EEBDs were installed in total, and two of them were in the accommodation space, six in the engine room and two for back-up. One EEBD was installed for use in the engine control room at the port bow end.

(4) Inspection of EEBDs

According to the written replies to the questionnaires of Company A, the EEBDs installed in the Ship received a visual inspection by crew members every week, in accordance with the management and maintenance schedule of fire protection equipment, where the compression pressures and other matters were checked. In addition, the EEBDs received an annual visual inspection by NK.

2.7 The Ship's Operation

2.7.1 Status of the Ship's Operation

According to the statements from the person in charge of ship operation in Company C, the Ship served on the North America West Coast Line or North America East Coast Line carrying new cars made by Company B. The time required for one voyage was about one month on the North America West Coast Line, and about two months on the North America East Coast Line.

2.7.2 Charter Contract

According to the statements from the persons in charge in Company A and Company C, Company D, an overseas affiliate in the Republic of Panama established by Company C owned the Ship and had a bareboat charter contract with Overseas Affiliate Company E, established by Company A in the Republic of Panama. At the same time, Overseas Affiliate Company E had a time charter contract with Company C and a ship management contract with Company A.

2.7.3 Relevant Companies

(1) Company A

According to the statements from the person in charge in Company A, Company A had been engaged in managing 17 ocean-going ships and leasing 8 coastal ships, all of which were vehicles carriers.

(2) Company B

According to the articles of incorporation, Company B had been mainly engaged in

manufacturing, selling, leasing and repairing automobiles and industrial vehicles.

(3) Company C

According to the statements from the person in charge in Company C, Company B, a logistics company and car transport company established Company C by co-funding in 1964, and had been engaged in the marine transportation of the cars which mainly Company B manufactured.

2.7.4 Crew employment information

According to the letters of agreement on temporary seaman's service, Overseas Affiliate Company E, under a temporary seaman's service contract with a seaman's temporary service company located in Minato Ward, Tokyo, Japan, had accepted the master, and under a temporary seaman's service contract with a seaman's temporary service company located in Yanai City, Yamaguchi Prefecture, Japan, had accepted the chief engineer.

In addition, according to the AGENCY AGREEMENT FOR EMPLOYMENT OF FILIPINO CREW, Company A, under an agency contract with the seaman's temporary service company located in Panama City, the Republic of Panama, accepted the crew members who were nationals of the Republic of the Philippines.

2.7.5 Combination-crew ship

According to the statements from the person in charge in Company A, the Ship was built in 1986 as a ship registered in Japan, was converted in 1996 to a combination-crew ship registered in the Republic of Panama, and at the time of the accident, only the master and the chief engineer had Japanese nationality.

2.8 Safety Management Arrangement

2.8.1 Safety Management Arrangement of Company A

According to the statements from the person in charge in Company A, Company A had obtained DOC (Document of Compliance) and SMC (Safety Management Certificate), had prepared the Safety Management Manual, and had guided the master to execute ship operations in accordance with the manual, all in order to comply with the ISM Code (International Safety Management Code).

In addition, the person responsible for the management of the ISM Code visited the Ship when it called in Japan, hearing from the master and the chief engineer about the safety requirements and proposals to be discussed in the monthly safety meeting in Company A, where problems of ships, safety goals and specific activities were discussed, and requested the Ship to submit the minutes of the ship safety environment compliance committee, the in-ship orientation records and the in-ship emergency exercise reports.

Company A had prepared, regarding safety management manuals, the pre-boarding preparation procedures, the in-ship orientation procedures and emergency handling procedures. In addition, Company A prepared "operating table for CO₂ Fire Extinguisher System and Smoke Sampling Type Fire Detection System" and posted the table in the CO₂ room.

2.8.2 Pre-boarding Orientation

(1) Orientation for crew of Japanese nationality

According to the pre-boarding orientation records, it was as follows:

Company A gave an approximately one-day-long orientation that included explanations of the company structure and points of contact, and descriptions on the ISM Code and the latest rules and regulations. At the orientation, Company A confirmed the health condition, seagoing experience and competence certificates of the crew, and then concluded temporary service contracts. However, Company A gave no explanations on the CO₂ release procedure.

(2) Orientation for crew of nationality of the Republic of the Philippines

According to the statements from the master and the guide book for the pre-boarding orientation, it was as follows:

Company A, after holding an approximately 5-day-long orientation in Manila City, the Republic of the Philippines and confirming competency through tests, concluded the temporary

service contracts with the crew members

The guide book of this orientation included: the basic concept of the ISM Code; explanations on safety signs, preparations in cargo holds before entering ports, safety confirmation during loading/unloading, and the wearing of safety equipment; rules and guidelines of stowage of cars; rules and guidelines for car inspection during a voyage; dos/don'ts during unloading; and examples of accidents on a ramp way.

2.8.3 Muster Lists and Instructions in Emergency

On the Ship, there were muster lists prepared for the life-boat station (abandon ship and rescue station), the fire-protection station, the water-protection station, oil pollution prevention station, the emergency steering station, the anti-terrorist station, the anti-piracy station and others. Those lists listed the names of the station members, the station's missions, the equipment to be carried and descriptions of work.

In the muster list for the fire-protection station, such items as the following are prescribed:

(1) Group Structure

{1} COMMAND GROUP IN BRIDGE

The group was headed by the master, and consists of three members including the master. The mission was to conduct overall command of the Ship from the bridge.

{2} FIRE FIGHTING GROUP

The group was headed by the chief officer, and consists of 11 members. The mission was to fight fires and open/close the dampers on the ventilation holes in the ventilators or the fire doors.

{3} ENGINE CONTROL GROUP

The group was headed by the chief engineer, and consists of five members. The mission was to control the engine and operate fire-pumps in the engine room, and to open/close the dampers on the ventilation holes in the engine room ventilators.

{4} MEDICAL RESCUE GROUP

The group was headed by the chief steward, and consists of two members. The mission was to save lives.

(2) Description regarding the Chief Engineer

POSITION: ENGINE CONTROL GROUP

DUTIES: ENGINE DEPT. COMMAND

EQUIPMENT TO BE CARRIED: TRANSCEIVER

(3) Duties of the chief officer

CHIEF OFFICER AND CHIEF ENGINEER ARE RESPONSIBLE FOR MAINTENANCE OF THE FOLLOWING AS SAFETY OFFICER

CHIEF OFFICER – FIRE EXTINGUISHER, FIRE HYDRANT, FIRE LINE, HOSES, AND VENTILATION DAMPERS, EQUIPPED OR KEPT IN ANY PLACE OR THE SHIP EXCEPT THE E/R, CAR HOLD FIRE ALARM DETECTORS, CO₂ EXTINGUISHING SYSTEM, FIRE DOORS, ALL FIREMAN'S OUTFIT, INTERNATIONAL SHORE CONNECTION

(4) Actions to be taken during a fire

IMPORTANT:

1) ALL CREW MUST BE VIGILANT WHEN ON DUTY, IF FIRE IS DETECTED RAISE THE ALARM AND THEN FIGHT THE FIRE AFTER HELP ARRIVES.

2) CONTACT OFFICER ON DUTY RAPIDLY WHEN FIRE IS FOUND OR SUSPECTED, CREW AROUND FIRE TAKE FIRST FIRE FIGHTING UNTIL CHANGE TO FIRE FIGHTING GROUP, INITIAL FIRE FIGHTING MOST IMPORTANT.

3) WHEN RECEIVED THE REPORT, OFFICER ON DUTY CONTACT WITH CAPTAIN AND OTHER CHIEFS, ORDER FIRE FIGHTING STATION.

4) ENGINEER ON DUTY BREAK DOWN ELECTRIC SOURCE CONNECTED TO FIRE LOCATION.

5) OFFICER ON DUTY OPERATION CO₂ FIRE EXTINGUISHING SYSTEM ONLY BY CAPTAIN'S COMMAND.

2.8.4 Exercises

(1) Records of exercises

According to the written replies to the questionnaires of Company A, the Ship had had exercises since April 2008, as shown in the table below.

Date	Stations and other trainings
April 30, 2008	Abandon ship station, Fire-protection station, Water-protection station, Oil pollution prevention station, Main engine emergency-stop training and Blackout training
May 11	Abandon ship station, Rescue station, Fire-protection station, Water-protection station, Oil pollution prevention station, Emergency-steering station, Bunker-training and station-communication training
June 28	Abandon ship station, Fire-protection station, Water-protection station and Oil pollution prevention station
July 26	Abandon ship station, Rescue station, Fire-protection station, Water-protection station, Oil pollution prevention station, Main engine emergency-stop training and Blackout training
August 30	Abandon ship station, Rescue station, Fire-protection station, Water-protection station, Oil pollution prevention station, Emergency-steering station, Bunker training and Station-communication training
September 27	Abandon ship station, Fire-protection station, Water-protection station and Oil pollution prevention station

(2) Outline of firefighting training

According to the written replies to the questionnaires of Company A, the outline of an actual firefighting training session carried out on the Ship is as follows:

Scenario: May 11, 2008, fire broke out in the galley

1425H = Assumed that fire was discovered at Galley's hot plate, C/CK applied initial fighting using Portable CO₂ extinguisher and M/Man shouting "FIRE AT THE GALLEY" repeatedly & run to the Bridge to inform OOD. Immediately call the Master, report the situation, the Master order to OOD to raise the alarm followed by announcement. Mustered crew to their respective station. C/O confirmed that there is fire at the Galley, closed all ventilation, fire doors & shut off electrical power, laid down fire hoses & order to E/R start Emergency fire pump, then extinguished the fire Back-up group applied bounde(a)ry cooling. C/O notice that fire cannot (be) controlled, immediately report to the Bridge. Master order to back-off and prepare for abandon(ing) ship.

Note: Inside "()" was added by the writer of this draft when correcting any apparent errors in the original.

In addition, firefighting training on other scenarios, such as a fire in the auxiliary generator room or a fire in the engine room was carried out. However, there were no exercise records of the search and rescue of missing persons or firefighting using the fixed CO₂ fire extinguisher system.

(3) Orientation for EEBD application

According to the written replies to the questionnaires of Company A, an orientation for EEBD application was given as one of the topics of the in-ship general guidance held on September 8, 2008, about one month before the accident, and all crew members participated. At this time, dos and don'ts regarding EEBD were explained to crew members, such as that it is equipment for escaping from a compartment filled with smoke, that it should not be used for firefighting, and that the maximum period for breathing was about 10 minutes.

(4) Practice of abandon-ship station exercise

According to the written replies to the questionnaires of Company A, an abandon-ship station exercise was held approximately once a month.

(5) Orientation for CO₂ release

According to the statements from the chief officer, no exercise or training on CO₂ release had been held for all crew members; guidance in the CO₂ room on how to release CO₂ was only given to the newly-on-board crew members.

2.8.5 Assembly Position in Emergency

(1) According to the muster list, it was pre-determined that, under the rescue-boat station (abandon-ship station), the muster station for all the crew members was near the starboard or port side boat position on the boat deck. However, under other stations, the assembly position were pre-determined on group basis.

(2) According to the statements from the chief officer, the second officer and the boatswain, at the occurrence of the accident, upon hearing the PA announcement by the third officer stating, "All crew members to the muster station for roll call," the chief officer, the second officer and the boatswain showed up near the starboard side rescue boat.

2.8.6 Training and Muster List stipulated in the SOLAS Convention

The SOLAS Convention¹³ Training Manual stipulates the following:

(1) Training

The training manual requests a ship master to provide crew members with training on taking actions in emergency situations, in such a way that the training shall be provided cyclically within a predefined period according to the type of training. The training shall include instructions on how to use life saving equipment, fire extinguishing appliances and ship-launch-type life rafts, as well as exercises on the firefighting operations assigned to the individual crew members. In addition, the training manual requests that training shall be carried out based on as precisely simulated actual scenarios as possible.

(2) Muster List

The training manual requests a ship master to prepare a muster list prescribing the duties of crew members in an emergency, to post the table in appropriate places in the ship, and to carry out training according to the table. Furthermore, the training manual requests that such list shall, depending on the types of stations, clearly identify the positions assigned to individual crew members, duties, equipment to be carried, work descriptions and signals.

(3) Firefighting training

The training manual requests that training shall be carry out in such a way that, the preparations for the duties prescribed in the muster list, and inspections of fire-fighter accouterments, rescue accouterments and communication equipment should be carried out. It also requests that operation tests for fire pumps as well as inspections and operation tests for fire doors, fire-protection dampers, and intake/outlet ducts of ventilation systems should be carried out.

2.9 Cargo Management

2.9.1 Car Stowage

(1) Stowage

According to the statements from the persons in charge of Company B and Company C, cars were carried and placed in the following way:

A driver dedicated to loading work gets into one of the cars line-upped in the birth yard, drives it up the car ladder into the cargo hold, and stops at the predefined position to wait for a

¹³ "The SOLAS Convention" is the abbreviation for "The International Convention for the Safety of Life at Sea," which was concluded in 1974.

ground workman. The ground workman guided the driver to adjust the position in such a way that the door-to-door distance between cars was about 10 cm, the bumper-to-bumper distance was about 30 cm, and the distance between a car and the wall, which was used for walking space, was about 60 cm. The ground workman then used clasps to clamp the car to the car deck.
(See Photo 14: Car Stowage)

(2) Car situation after loading

According to the written replies to the questionnaires from Company B, it is as follows:

After having placed a car in the required position, the driver switched off the ignition key, turns-off all the lights, and left the car unlocked with the key left inside. Windows were all closed, and battery was connected.

Note that the responsibility of the Ship was to confirm the number of the cars in cargo and inspected them for damage. The Ship had no obligations or responsibility for loading and placement.

2.9.2 Patrol and Inspection of Lashing during Voyage

According to the statements from the master, in order to protect the cars from damage caused by the rolling and pitching of the Ship due to bad weather, the lashings were inspected and confirmed over a period of two days following the departure from Mikawa Port.

In addition, according to the statements from the chief officer and A/B B, after finishing the watchkeeping, A/Bs regularly conducted fire-protection patrols on the car decks for over an hour every 4 hours. However, the selection of the patrol route and area was up to A/Bs.

2.9.3 Operation of Ventilation System and Fluorescent Lights in Cargo Hold

According to the statements from the master and the chief officer, after having passed Irako Channel Route after the departure from Mikawa Port, the Ship regularly stopped the operation of all the ventilation systems and closed the dampers. However in some cases, where the crew members feel unwell due to the smell of tires or paint during the lashing inspection work after departure, natural ventilation was adopted, where dampers were kept open and the fans were off. In addition, in some cases during a patrol of car decks, the dampers of 1 to 3 ventilators, specified by the chief officer, were open.

During a voyage, all the fluorescent lights in the cargo hold were always on, for the inspection of the cars.

2.9.4 Smoking

According to the statements from the master, the Ship specified the private space, the smoking room, the salon, the cargo office and the wheel house as smoking-permitted areas. The other areas, such as the engine room and the car decks, were smoking-prohibited areas. Also, taking cigarettes out of the private space was prohibited. In addition, carrying goods or materials other than the tools needed for lashing inspection work into the car decks was prohibited.

2.10 Situations in Cargo Holds after Departure from Mikawa Port

2.10.1 Ventilation system

(1) From the departure to the fire breakout

According to the statements from the boatswain, it was as follows:

On the night of October 12, after having passed Irako Channel Route, for the preparation of the clamp inspection work scheduled for the next day, October 13, all the dampers, except for 10 ventilation hole dampers of the ventilators installed on the boat deck for the ventilation of Zone F, were closed. After the inspection work in October 13, opening 10 dampers were also closed. In the early morning of October 14, all the ventilation hole dampers installed on the container deck were opened for the preparation of the lashing inspection work in the car decks below DK 7, and then the inspection was started.

(2) After the fire breakout

According to the statements from the second officer, he heard the general alarm, then went to the boat deck, began to prepare fire hoses, noticed smoke coming out of the ventilation holes of

the ventilators and shut the dampers.

On the other hand, according to the statements from the chief officer, the master abandoned the initial firefighting, went to the boat deck, noticed smoke coming out of the ventilation holes of the ventilators and ordered a crew member of the deck department to shut the damper.

2.10.2 Opening/Closing of Fire Doors on the Car Decks

According to the statements from the master, the master noticed the fire on the car decks, headed to DK 11 using the stairs on the starboard bow, and noticed that the fire doors on DK 12 and DK 13 were left open, so he shut those doors.

On the other hand, according to the statements from a person in charge in Company A, the person heard from a SRT member that, when the SRT member got on board and went down the stairs on the starboard bow, the fire door in the entrance to DK 10 was open, and the fire doors on the entrances to the other car decks were all closed.

2.10.3 Lighting Equipment in Car Decks

According to the statements from A/B B, the fluorescent lights in the car decks were always on during a voyage.

2.10.4 Door separating DK 6 from Port Bunker Station

According to the statements from a person in charge in Company A, although a steel, watertight door separating DK 6 from the port bunker station was installed, during the voyage of the accident the door was, as usual, locked from inside DK 6 and not able to be opened from the bunker station due to security reasons.

2.11 Car Stowage

According the stowage plan, the number of cars stored in the cargo holds and the car decks was as shown in the table below. Each car was loaded in the final manufacturing stage with between 3 and 15 liters of gasoline for runs during loading/unloading.

(Note: A to F in the red-frame at table below designates the fire protection zone.)

DK	HLD 4	HLD 3	HLD 2	HLD 1	ramp way
DK 13	133	134			6
DK 12	140	120			
DK 11	130	130			14
DK 10	124	120			
DK 9	88	123	100	109	6
DK 8	115	133	99	111	6
DK 7	138	136	109	102	
DK 6	97	131	109	72	12
DK 5		143	103	43	
DK 4		146	97	39	
DK 3		127	87	31	
DK 2		70	51		
DK 1		71	39		6

2.12 Electric Cabling in Cars

According to the written replies to the questionnaires of Company B, the cables used in the engine hood of the car placed at the port side on DK 10 (car 10-07), which was the most severely burnt, had copper cores coated with vinyl chloride, polypropylene or polyethylene, in compliance with ISO6722 by the International Organization for Standardization¹⁴ and JASO-608 and JASO-D611 by the Japanese Automotive Standards Organization.¹⁵ The total length of the cables was about 30.1 m and the total weight was about 16.7 kg.

The dark current¹⁶ in storage-state, where the engine was not running, was about 4.79 mA and ran from the battery to computers or displays.

2.13 Occurrence of Fire

2.13.1 Time of Fire Alarm, Fire Breakout Location, and Confirmation of Fire

(1) According to the voice records in the VDR, the activation time of the smoke sampling type fire detection system installed in the wheel house was at about 09:48:37, October 14, 2008.

(2) According to the statements from the third officer, and according to the general arrangement plan and the fire control plan, the smoke accumulator that detected smoke was Intake-No.54. It was installed at the port side of DK 11 and consists of two smoke pipe ends, installed at about 7.1 m from the port outside plating and about 24.8 m and 42.6 m, respectively, from the bow bulkhead to the stern, with two suction openings, combined into one smoke pipe running to the smoke sampling type fire detection system in the wheel house.

(3) According to the statements from the third officer and the voice records in the VDR, the third officer, upon the instruction from the master, went down to DK 10 by elevator, opened the fire door of DK 10 and checked the fire.

2.13.2 Initial Firefighting

According to the statements from the master, it is as follows:

The master, upon receiving the report from the third officer of the fire breakout, decided to confirm the situation of the fire himself and control the fire in the initial stage. The master, in spite of knowing that a fire had broken out in a car, thought that at most one car was on fire and was controllable with a portable chemical extinguisher if it had not spread to other cars. The master, on the way to DK 11, picked up a portable chemical extinguisher installed at the staircase landing of DK 13 and reached smoke accumulators No.54, which was sounding the fire alarm. At that point he discovered no flames but encountered a severe irritating odor, and in addition knew that the smoke was increasing. The master abandoned the initial firefighting with portable chemical extinguisher and returned to the wheel house.

2.13.3 Emergency Call and Confirmation of Crew Member Attendance

According to the voice records in the VDR, it was as follows:

The third officer, at about 09:53:27, sounded the general alarm, and at about 09:54:09, on the phone from the engine control room, informed that "Fire broke out on DK 11, HLD 3." Moreover, the third officer, at about 09:54:18, announced via the PA that "Fire, fire, fire, fire broke out on DK 11, HLD 3, this is not an exercise," and at about 09:57:16, announced via the PA, "All crews, go to the fire station, immediately."

After that, at about 1007 hrs, the chief officer made a muster of the crew members. At about 10:08:00, a voice saying, "Chief Engineer is missing," was recorded.

2.13.4 Action Taken by the Chief Engineer in response to the Emergency Call

According to the statements from the first engineer, it was as follows:

The first engineer, when he and the chief engineer went to the engine control room, which

¹⁴ "International Organization for Standardization (ISO)" is an organization that designs international standards in the industrial area.

¹⁵ "Japanese Automotive Standard Organization (JASO)" is a standard for automotive parts set out by the Society of Automotive Engineers of Japan, Inc.

¹⁶ "Dark current" refers to the electric current always flowing even when the engine is stopped or the keys are not in the ignition. The dark current is consumed to maintain the functionality of the remote controller or the security device, or preserve the contents of computer memory.

was the position of their fire station, heard the PA announcement, “Evacuate. All crew, go to the muster station on the boat deck. CO₂ will be released.” The chief engineer also heard the PA announcement. The first engineer proposed to go up to the boat deck together, but the chief engineer refused, and told the first engineer to go up first.

2.13.5 Use of Fixed CO₂ Fire Extinguisher System

(1) Time of release of CO₂

According to the voices recorded in the VDR, it was as follows:

The third officer, at about 10:04:52, made a PA announcement informing that CO₂ would be released, and at about 10:05:50, made the same PA announcement again.

On the other hand, the master, at about 10:07:30, via marine telephone, reported that CO₂ would be released soon.

After that, the third officer was asked by the master to confirm the time of CO₂ release, and answered that it had been 1010 hrs.

(2) Release operation on the fixed CO₂ fire extinguisher system

According to the statements from the chief officer, he opened the cargo hold selection valve for Zone F, the first engineer opened the master valve of the CO₂ storage tank, the third engineer watched the pressure of the tank, and then the master opened the release valve.

(3) CO₂ release from the CO₂ storage tank

According to the statements from the master, it was as follows:

The master, three to five minutes after the release of CO₂ into Zone F, received a report that fires broke out in Zone E and Zone D, and then released CO₂ into Zone E and Zone D. Those initial releases were completed at about 1025 hrs. The master, not confident that the fire was extinguished, at about 1107 hrs made the second release into the same zones as the initial release. At about 1116 hrs, the volume of CO₂ left in the tank reached zero.

2.13.6 Fire Extinguishment

According to the written replies to the questionnaire of the Japan Coast Guard, it was as follows:

Six members of SRT, at about 0758 hrs, October 15, 2008, boarded the Ship with a helicopter from helicopter carrying the patrol boat. After the boarding, the SRT members measured the temperature and gas density at the fire doors of each of the car decks, and then at about 0934 hrs, equipped with air breathing apparatuses, entered the car decks, made temperature and gas-density measurements of the cars that had received the most severe damage, and confirmed that the fire was extinguished at about 1020 hrs.

2.14 Discovery of Chief Engineer

According to the written replies to the questionnaire of the Japan Coast Guard, the SRT members confirmed that the fire had been extinguished and then began a search and rescue operation for the chief engineer. At about 1045 hrs, October 15, 2008, they discovered the chief engineer’s body, trapped in a space between the side wall of the engine room and car at about 4.4 m to stern of the hatch of the car deck near the car ladder in the starboard quarter end of DK 7. Air of the EEBD used by the chief engineer was confirmed empty, and flash light and transceiver was not found near his body.

According to the statements from the master and the first engineer, the transceiver to be carried by chief engineer was left in engine control room; it was found in the engine control room. (See Figure 7: Map of Location of Discovery of the Bay of Chief Engineer (DK 7), Figure 8: Detailed Map of Location of Discovery of Chief Engineer (around the DK 7 car ladder))

2.15 Possibility of Fire Breakout Caused by the Ship Equipment

2.15.1 Electric Equipment Installed in the Cargo Hold

On DK 10 and DK 12, one fluorescent light in each deck had fallen due to the mounting gear being burnt up. The installation location of those fallen lights was not above the most severely

burnt cars; moreover, about 11 minutes had passed between the fire breakout and sounding of the insulation degradation alarm on the AC 220 V line.

No alarm-air horns or solenoid valves of such horns had been installed on the ceiling of DK 10 above the most severely burnt cars. Besides, about 20 minutes had passed since the confirmation of the fire breakout before the air-horn blew.

In addition, circuits in the non-powered antennas for transceivers were open in each car deck, and free from heat or flames caused by an electric circuit shorting.

According to the table of measurements of insulation resistance executed on April 15, 2008, no irregularities were found in the measurements of insulation resistance of the lighting power lines in the car decks.

2.15.2 Other Equipment Installed in the Cargo Holds

According to the statement from the master, smoking spaces were specified and limited, and the crew members were well informed of them. The cargo hold was a prohibited-smoking space. Moreover, taking cigarettes out of the accommodation space was prohibited.

Furthermore, no goods or materials other than the tools necessary for lashing inspections were allowed to be taken into the cargo decks.

2.16 Possibility of Fire Breakout Caused by Cars

According to the results from the site inspections, the results from the inspections by the expert adviser for the possibility of fire breaking out in cars, and the questionnaires of Company B, it was as follows:

(See APPENDIX “Investigations on the Possibility of Fire Breakout in Cars”)

2.16.1 Inspections of Burnt Cars in Cargo Deck

(1) DK 10

{1} Distribution of burnt cars

Of the cars loaded on the port side of the ramp way and facing the stern direction in frames 66 to 91, 14 cars received severe burnt damage.

{2} Burnt damage situation

Car 10-06, car 10-07 and car 10-08 received very severe damage, but the most severely damaged car was car 10-07. This car was burnt inside the engine bay, and all the paint on both sides of the body was burnt away. Also, signs that fire had spread to the fuel intake of the fuel tank and to the rear trunk were found.

Cars next car 10-07, such as car 10-06 on the starboard side, car 10-08 on the port side, car 10-02 on the bow side and car 10-12 on the stern side, received severe damage on their bodies, and tires and aluminum wheels nearest car 10-07, and received damage partially on their bodies on the opposite side of car 10-07.

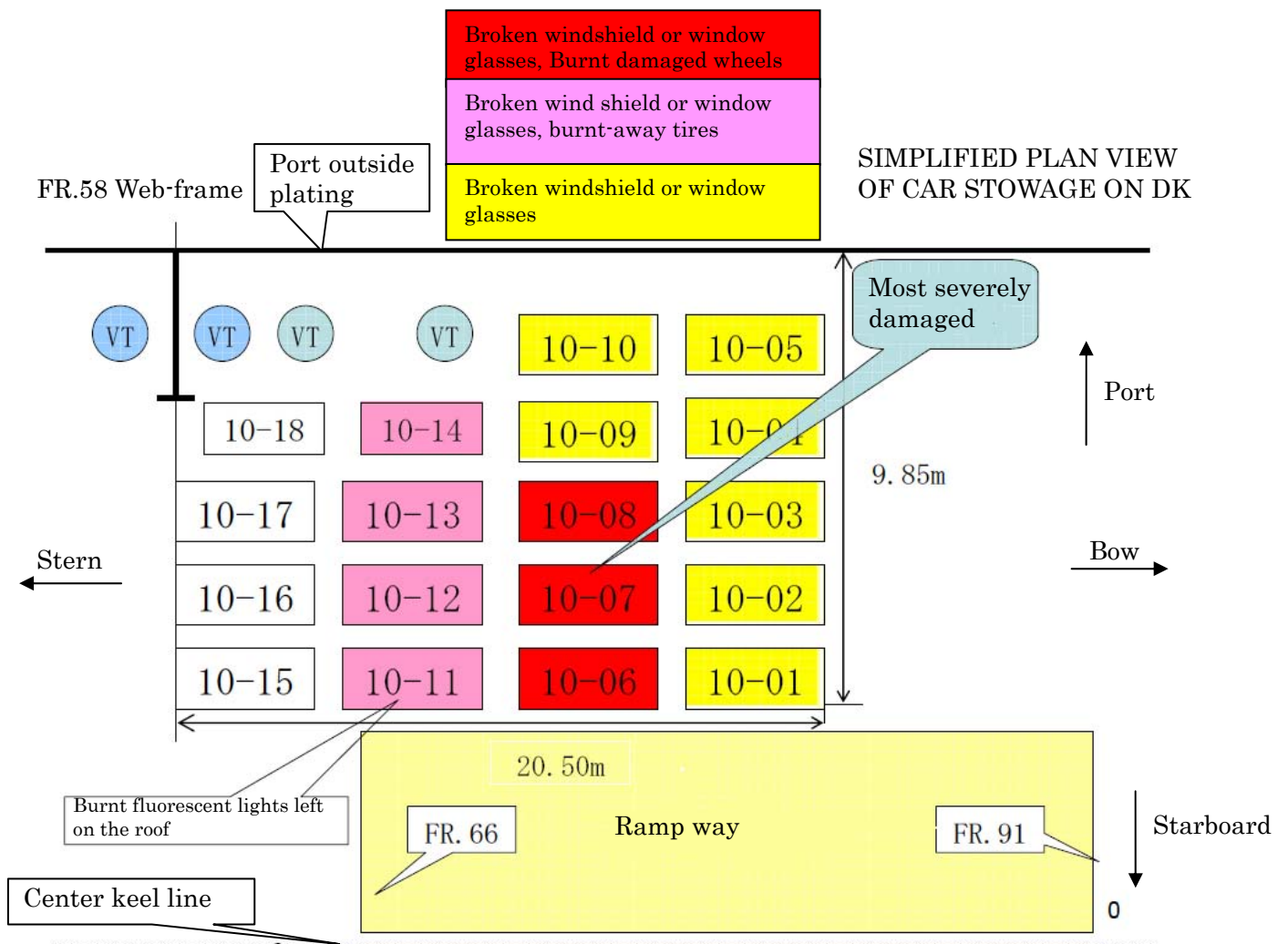
{3} Investigations based on functions

(a) As for electric circuit systems, in the three most severely damaged of the 14 cars, no fuses were found to have melted, while in the other 11 cars, the fuses were found to have melted and were identified later as the results of secondary short circuit¹⁷ of the electric cables or between the cables and the body due to cable coating being melted or burnt away.

(b) As for fuel systems, although the fuel tanks of the three most severely damaged cars were found to have received burnt damage, no burnt damage was found inside of those tanks, and some of fuel was vaporized, some remained. As for the other 11 cars, in 2 cars, similar situations were found.

(See Photo 4: Fire Damage Situations of Cars on DK 10)

¹⁷ “Secondary short circuit” refers to short circuit caused by the cable coating being melted or burnt away due to the heat of a fire, not a short circuit that caused a fire.



(Intentionally left blank for editorial convenience)

(2) DK 11

{1} Distribution of burnt cars

Of the cars loaded facing the stern direction on the port side of the ramp way on DK 11, the 15 cars that were placed approximately directly above the burnt car on DK 10 received severe damage.

{2} Burnt damage situation

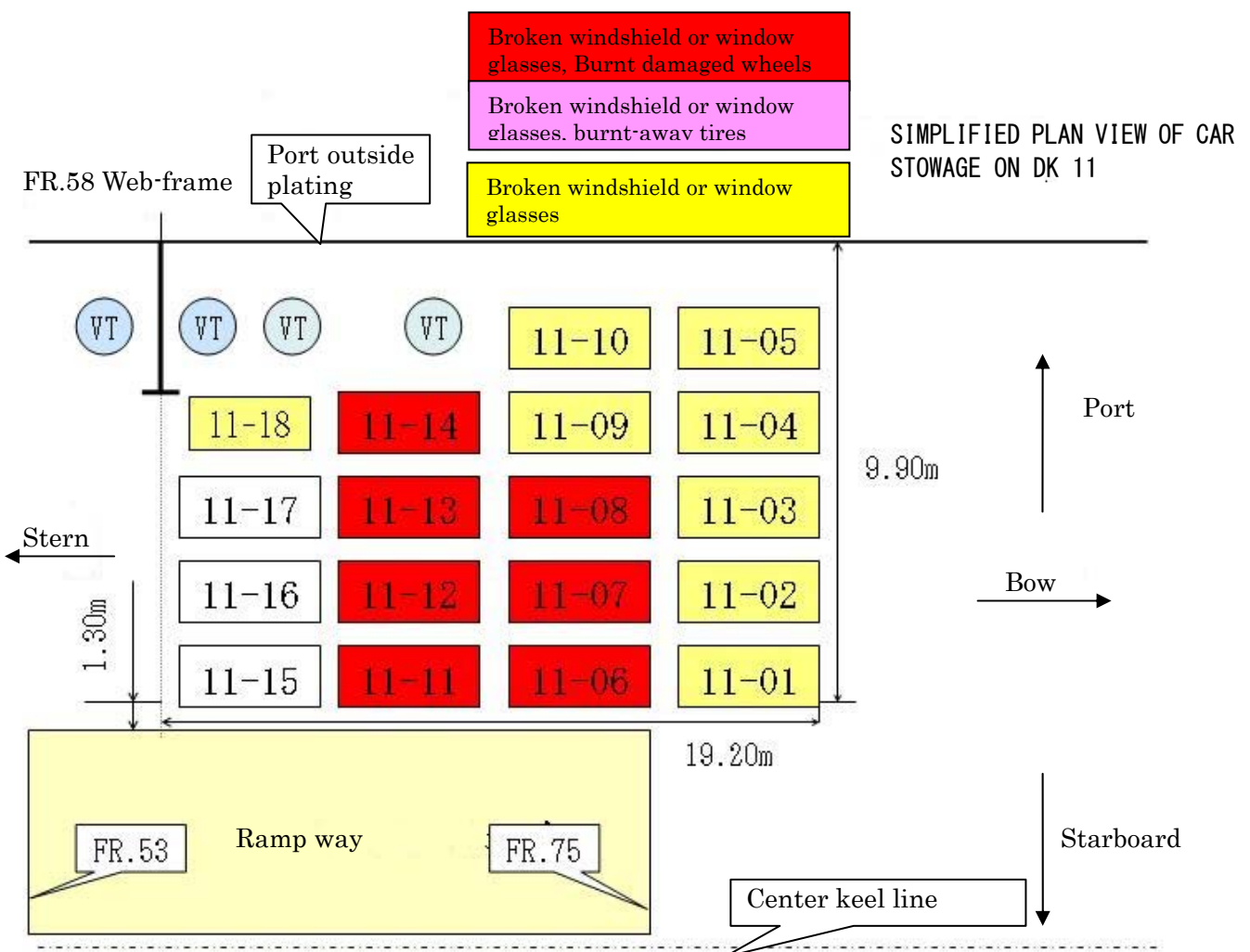
The damage appeared to be caused by the heat coming from the lower layer through the holes for lashing clasps in the deck floor. The situation of the melting or burning away was less severe than the burnt cars on DK 10 but severer than the burnt cars on DK 12.

As for the engine hoods, in the three cars placed almost directly above the most severely damaged car on DK 10, although all the flammable parts were burnt away, no severe damage was found except for melted plastic or covered with soot.

{3} Investigations based on functions

(a) As for electric circuit systems, in nine of the 15 severely damaged cars, fuses were found to have melted and were identified as being caused by the secondary short circuit of the cables or between the cables and the body, because cable coating was melted or burnt away. In 4 out of the other 6 cars, it was not confirmed that fuses had melted because the fuse boxes were burnt away.

(b) As for fuel systems, melt damage was found on the fuel tanks of 9 of the 15 cars. However, the parts around the fuel tanks were not burnt away, and vaporized fuel remained in the tanks.



(3) DK 12

{1} Distribution of burnt cars

Of the cars placed facing the stern direction on the port side of the ramp way on DK 12, the 14 of the same type, which were placed almost directly above the burnt cars on DK 11, received the most severe damage.

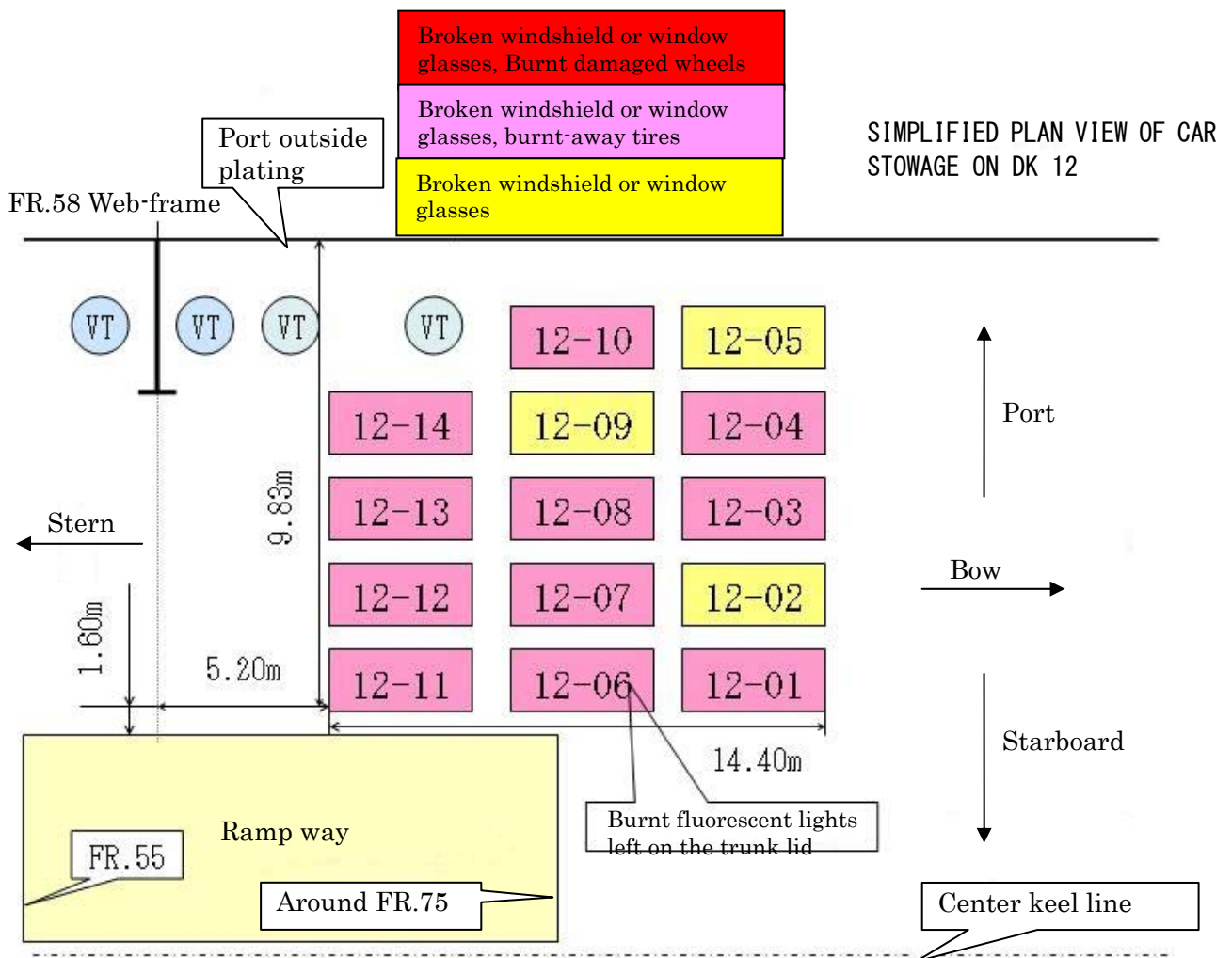
{2} Burnt Damage situation

Like the burnt cars on DK 11, the cars on DK 12 appeared to be burnt at first on the bottom by the heat coming through the openings on the deck.

{3} Investigations based on functions

(a) As for electric circuit systems, in 11 of the 14 severely damaged cars, fuses were found to have melted and were identified as being caused by the secondary short circuit of the cables or between the cable and the body, because cable coating was melted or burnt away.

(b) As for fuel systems, melt damage was found on the fuel tanks of seven of the 14 cars. However, the parts around the fuel tanks were not burnt away, and fuels in tanks were vaporized.



2.16.2 Investigations of Car 10-07, Car 10-08, and Car 10-06

According to the results from the investigations of car 10-07, car 10-08, and car 10-06, which received the most severe damage among the burnt cars on DK 10, it was as follows:

(1) Car 10-07

In the engine bay, severe damage was found, such as the burnt and deformed battery and burnt away aluminum parts. In addition, on the bottom of the battery and on the surface of the left

fender above the engine bay floor, several traces of cable adhesion were found. Moreover, the main ground wire connecting the engine with the body was found to have melted and been burnt away around the terminal on the body.

The fuel tank, although it received burnt spots on the upper side of surface, was not burnt inside, and the fuel remained. Some of the fuel pipes in the engine bay were burnt away. However, no fuel pipes were found to be disconnected.

As for the exhaust system, although soot depositions were found on the outer surface of the exhaust module containing a catalytic agent, no signs of over-heating were found inside, and no thermal history of extremely high temperatures, which would be caused by long and continuous running of the engine, was found.

(2) Car 10-08

In the engine bay, several traces of cable adhesion were found scattered high from the engine bay floor on the inner surface of the left fender, holes were found on the left fender, and the terminal of the main ground wire was found partly and slightly melted.

The situations of the fuel tank and the fuel pipes in the engine bay were similar to those of car 10-07, and fuel was found remaining in the fuel tank.

On the exhaust system, no signs of abnormally high temperatures were left.

(3) Car 10-06

In the engine bay, several signs of cable adhesion were found on the bottom of the inverter and scattered high from the engine bay floor on the inner surface of the left fender, and holes were found in the body under the inverter at the right end. However, the terminal of the main ground wire remained undamaged.

The situations of the fuel tank and the fuel pipes in the engine bay were similar to those of car 10-07, and fuel was found remaining in the fuel tank.

On the exhaust system, no traces of abnormally high temperatures were left. The situation of car 10-06 was similar to that of car 10-08.

2.16.3 Reproductive Experiment on Melt-down of Terminal of Ground Wire

Because the ground wire at the terminal on the body of car 10-07 was found to have melted, reproductive experiments were conducted in order to see whether the terminal of the main ground wire was melted if the wire had a dead earth.¹⁸ The experiment failed to reproduce a current flow larger than the current causing the electrode rod to melt, because the anode rod was melted inside the battery due to a large current, and consequently a melting of the main ground wire was not reproduced. In summary, the anode rod was melted before the main ground wire would melt.

On the other hand, in the case where a large current follows through the main ground wire, although a rise in the temperature of the terminal was found, the temperature did not reach the melting point.

(See Photo 16: Fire Damage Situations of Car 10-07 Engine Bay)

2.17 Generalization of Causes of Electric Fire

According to the "Inspection Manual of Cause of Fire (Explanations on Basics of Inspection for Cause of Fire)" published by the Institute for Fire Safety & Disaster Preparedness, published in March, 1999, the cause of electric fires were as follows:

1.6.2 Causes of Electric Fire

(1) Short Circuit

A short circuit occurs when a point in an electric circuit is connected to another point by a conductor with extremely low resistance. For example, when the coating of electric lamp wires or wires inside an outlet are damaged and the wire cores directly contact to form a circuit, so an electric current flows through the formed circuit with lower resistance. In this situation, which is also called a layer short circuit, a large electric current rushes into the contact point to cause sparks or melting of the contact point. Also,

¹⁸ "Dead earth" refers to a state where electric currents flow without load.

the Joule heat generated along the wires by such strong currents may cause fires in the following situations:

- (a) Flammable vapor or flecks of fibers exist around the point of the short circuit,*
- (b) In breakers, metal wires, or fuses with excessive current ratings make an excessive current flow and generate Joule heat.*

(The rest is omitted)

(2) Layer Short Circuit

(a) When coils in the motors, transformers or stabilizers in fluorescent lights suffer from insulation degradation due to small damage (pinholes), the aging of insulation coating or the deposition of moisture or dust, and, due to such insulation degradation, the core copper wires in different layers of the coil directly contact each other, a part of the coil separates from the rest of the coil to form a ring circuit, which causes a strong current to flow through because the load is extremely smaller via the ring circuit than that by the rest, resulting in local heating causing fire to break out. Such a phenomenon is called a layer short circuit.

(b) In the case of local heating due to a layer short circuit, chain reactions of insulation degradation due to the heat occur and leave easily identifiable traces around the contact spot.

When a layer short circuit occurs, motors fall into an overloaded state due to the decrease in output power, or, if the short occurs in the primary side of the transformer, both the primary side and secondary side of the transformer fall into an overloaded state, because the currents on both sides rise due to the rise in voltage in the secondary side.

((3) to (7) omitted)

(8) Leak

A leak, broadly defined, is a phenomenon where currents flow through paths they are not designed to flow through, and can include short circuits, grounding and discharge by electric leakage.

However, from the standpoint of fire investigations, a fire caused by electric leakage is narrowly defined as “a fire caused by the heating in a part of a building, facility or construction due to the current leaked out of the designed current paths flowing into there.

(The rest is omitted)

2.18 Weather and Sea Conditions

2.18.1 Weather

According to the surface analysis, Weather Map, at 9 a.m. on October 13, 2008, published by the Japan Meteorological Agency, a low-pressure system of about 1,010 hPa was passing through the south offing of the Kanto region in Japan, and at 9 a.m. on the next day, October 14, high-pressure systems of about 1,024 hPa overlay around the site of the accident.

2.18.2. Sea Condition

According to the Wave Analysis—Western North Pacific, at 9 a.m. on October 13, 2008, published by the Japan Meteorological Agency, the wave height in the offing of the Pacific Coast of Japan was less than about 2 m, and at 9 a.m. the next day, October 14, around the site of the accident, waves of about 1.5 m in height with a period of about 5 seconds, and a east-going swell of about 2.0 m in height with a period of about 6 seconds were observed.

2.18.3 Observation by Crew

According to the observation by crew members, it was as follows:

Time and Date	Wind Direction	Wind Force	Weather	Atmospheric Pressure (hPa)	Temperature (°C)
0000 hrs, October 13	NE	4	Fine	1,015	20.3
0600 hrs, October 13	ENE	4	Fine	1,016	21.5
1200 hrs, October 13	NE	4	Fine	1,015	20.5
1800 hrs, October 13	ENE	3	Cloudy	1,017	19.7
0000 hrs, October 14	ENE	3	Cloudy	1,019	19.1
0600 hrs, October 14	NE	3	Cloudy	1,022	18.2

3 ANALYSIS

3.1 Situation of the Accident Occurrence

3.1.1 The Course of the Events

According to 2.1, it is considered probable that the time line of the accident was as follows:

While the Ship, loaded with cars at Mikawa Port, was navigating toward North America in the offing of Kinkazan in the high seas, a fire broke out in a car stored in the port side of DK 10, activating the smoke sampling type fire detection system, which sounded the alarm in the wheel house. The master instructed all the crew members to go to the muster station, preannounced a release of CO₂, released the CO₂ and then extinguished the fire. Nevertheless, the chief engineer was found dead in the cargo hold.

3.1.2 Time, Date and Location of the Occurrence of the Accident

According to 2.1.1 and 2.1.3, it is considered probable that the time and date of the occurrence of the accident was about 0948 hrs October 14, 2008, and the location was around 089° true 340 M (38° 24.5' N, 148° 49.2' E) from the Kinkazan Lighthouse in the high seas.

3.1.3 Occurrence of the Accident

According to 2.1.3 and 2.13.2, it is considered probable that, during the voyage, in the Ship, a fire broke out in the engine bay of a car (car 10-07) stored on the port side of DK 10, and the fire spread to other cars stored on DK 10 to DK 12, and to the car decks above DK 10.

3.1.4 Injuries and Death of Person

According to 2.1.4, 2.2, 2.13.4 and 2.14, it is considered probable that the chief engineer, who had evacuated the engine control room alone and was found on DK 7 after the fire had been extinguished, died due to suffocation caused by CO₂ intoxication.

3.1.5 Damage to the Ship and others

According to 2.3 and 2.4, it is considered as follows:

(1) The Ship

On DK 10, structural materials of beam at frame no. 70, were melted by the heat down to about 220 mm maximum, while on DK 11 to DK 13, several dents were caused on the car decks, and the surface paint of DK 10 to DK 12 was burnt away. In addition, on DK 10 to DK 13, some fluorescent lights installed on the ceiling were broken due to the melting of plastic covers, or fell due to the loss of holding gear.

(2) Cars

Of the cars loaded on DK 10 to DK 12, 111 cars were burnt damaged, and all the cars loaded on DK 6 to DK 13 (not including the burnt damaged 111 cars) were covered with soot.

3.1.6 Weather and Sea Conditions

According to 2.18, it is considered probable that the weather at the occurrence of the accident was cloudy, the wind was NE, the wind force was three, and the waves were about 1.5 m high.

3.2 Causal Factors of the Accident

3.2.1 Crew

{1} Seaman's Certificate

According to 2.5, the master, the chief engineer, the chief officer, and the first engineer had legal and valid certificates of competence.

{2} Pre-boarding orientation

According to 2.8.2, it is considered probable that Company A accepted crew members after a pre-boarding orientation about 1-day long at Company A for crew members of Japanese nationality, and a pre-boarding orientation about 5-days long in Manila for crew members of the nationality of the Republic of the Philippines.

3.2.2 The Ship

(1) Fire proof compartments and ventilation system for car decks

According to 2.6.3 to 2.6.6, the following is considered probable:

The fire-proof compartment of the Ship consists of 6 zones—Zone A to Zone F—and each zone is composed of car decks and cargo holds. Fire doors were installed at the entrance to each car deck, a sliding bulkhead door was installed between Zone A and Zone B, and tilting gastight doors were installed on the ramp ways, which run through multiple zones from lower to upper.

In addition, on the boat deck and the container deck, ventilators were installed, and each ventilator was connected to the corresponding fireproof zone through a trunk embedded in the hull from the ventilation hole of the ventilator to the air-outlets and air-intake of the zone, and equipped with an open-close damper.

Such equipment was constructed so that each zone could be separated and shielded from outside air by closing the corresponding fire proof door, bulkhead door, gastight door and open-close damper.

(2) Electric equipment in the cargo hold

According to 2.6.7 and 2.15.1, the following is considered probable:

The AC 220 V lines were used only for the lighting in the cargo holds, 40 w fluorescent lights were installed on the ceiling of each car deck, and the electric equipment in the cargo holds such as power cables and fluorescent lights had not been altered or extended but were kept in the same condition as at the time of the maiden voyage.

No problems were found in the measurements of insulation resistance of the lighting system obtained about six months before the accident.

In addition, although DC 24 V solenoid valves for air horns for the alarm of CO₂ release were installed on the car decks, there were no such valves installed on DK 10.

(3) Escape route from the engine control room to the boat deck

According to 2.6.8, it is considered probable that there were 3 escape routes from the engine control room to the boat deck: through the steering gear room in the stern, through the staircase in the engine room, and through the port bunker station. However, it is considered probable that the route through the bunker station was not available because, at the time of the accident, the watertight door was locked from the DK 6 side, and was unable to be opened from the bunker station.

(4) Smoke sampling type fire detection system, fixed CO₂ fire extinguisher system and EEBD

According to 2.6.9, 2.6.10 and 2.6.12, it is considered probable that there were no problems with the smoke sampling type fire detection system and the fixed CO₂ fire extinguisher system installed on the Ship, and that the compression pressure in the compressed air container of the EEBD was normal.

(5) Information available on the car decks

According to 2.6.11, it is considered probable that, on the car decks of the Ship, communication by transceiver with the wheel house was available. However, neither fire alarms nor PA announcements were audible there.

3.2.3 Operation of the Ship

According to 2.7, it was as follows:

The Ship, under the operation of Company C, had carried new cars manufactured by Company B, and had been managed by Company A under the Ship management contract with the owner of the Ship.

3.2.4 Safety Management

According to 2.8.1, it is considered as follows:

Company A and the Ship had obtained DOC and SMC respectively. The Ship had been operated in compliance with the safety management manual, the person responsible for the ISM code had visited the Ship to talk with the crew about safety requirements and proposals, and discussed the problems or safety goals in the safety committee meeting of the company. In addition, Company A prepared “operating table for CO₂ fire extinguisher System and Smoke Sampling Type Fire Detection System” and posted the table at the scene.

3.2.5 Muster List and Emergency Exercise

According to 2.8.3 to 2.8.6 and 2.14, it was as follows:

(1) It is considered probable that the Ship had prepared the muster list, for such stations as the rescue boat (abandon ship) station and the fire station, including the names of persons in charge, duties, equipment to be carried and what to do, in compliance with the SOLAS Convention Training Manual, and carried out exercises approximately once per month.

(2) It is considered probable that the muster lists, for the assembly place in the rescue boat (abandon ship) station, specified the place near the rescue boats on the starboard or port side for all the crew members to go to, and for the other stations specified different assembly places for each group.

(3) It is considered probable that, although the SOLAS Convention Training Manual requires simulated exercises as close to actual situations as possible, there were no records of the exercises of the operation of the fixed CO₂ fire extinguisher system, which was considered to be done based on the simulation of the actual emergency.

(4) It is considered probable that, in an orientation held about one month before the accident, the use of EEBD were explained.

(5) It is considered probable that, although the muster list had listed a transceiver for the chief engineer to carry, the chief engineer failed to carry one.

3.3 Cargo

3.3.1 Car Stowage Situation

According to 2.9.1 and 2.11, the following is considered probable:

The Ship was loaded with cars carrying about 3 to 15 liters of gasoline and placed on the car decks according to the stowage plan in such a way that the bumper to bumper gap was about 30 cm, the door to door gap was about 10 cm, and the walk space from car to side wall was about 60 cm. The cars occupied the ramp ways, too. Those cars in storage were clamped with clasps.

In addition, in a car in storage, lights such as the headlights were turned off, the ignition key was removed and left in the car, and the doors were unlocked.

3.3.2 Problems on the Car Decks

According to 2.1.3 and 2.9.2, it is considered probable that the Ship, usually after the departure from Mikawa port, spent 2 days on the inspection to confirm whether the cars were clamped and had received no damage; hence, such inspections conducted on October 13 and 14, before the accident. In addition, on October 14, A/Bs patrolled, and no problems were found in the car decks.

3.4 Discovery of Fire and Fire Fighting

3.4.1 Discovery of Fire

According to 2.1, it is considered probable that the third officer, during the bridge watchkeeping, noticed that the smoke sampling type fire detection system had detected the smoke generated on DK 11 and had sounded the alarm in the wheel house, reported to the master, and then upon the instruction of the master, opened the fire door of DK 10 and confirmed the fire.

3.4.2 Initial Firefighting

According to 2.1.3, it is considered probable that the master, upon receiving the report of fire, entered DK 11 with a portable chemical extinguisher to conduct initial firefighting, headed to the smoke accumulator on the port side, from where the alarm was sounded, and then abandoned the initial firefighting because of the strong irritating odor and the increase of smoke.

3.4.3 Use of Fixed CO₂ Fire Extinguisher

According to 2.1.3, the following is considered probable:

The master, after having abandoned the initial firefighting with a portable fire extinguisher, thought of using the fixed CO₂ fire extinguisher system, instructed the chief officer to close the damper on the ventilation holes of the ventilator, and instructed the third officer to make a PA announcement for all the crew to go to the master station.

The master, although he was notified that only the chief engineer had not shown-up, thought that the chief engineer had stayed in the engine control room and released CO₂ into Zone F at about 1010 hrs, and after that, because the smoke sampling type fire detection systems sounded the alarm for Zone E and Zone D, released CO₂ into Zone E and Zone D.

The master halted the first release of CO₂ at about 1025 hrs, released CO₂ for the second time into Zone F, Zone E, and Zone D at about 1107 hrs, because he was not confident that the fire had been extinguished, and at about 1116 hrs, used all the CO₂ in storage.

3.4.4 Flow of Smoke into Zone E and Zone D

Although according to 2.1, 2.4, 2.6.5 and 2.10.2, the SRT member stated that the fire door of DK 10 had been open, it is considered probable that the fire doors to Zone E and Zone D were closed, and also it is considered probable that the tilting gastight door on the ramp way running through the car decks was closed. Therefore, it was could not be determined the process of the flow of smoke from a fire caused in Zone F into Zone E and Zone D.

3.4.5 Sound of Fire Alarm in Accommodation Space

According to 2.1.1 and 2.10.1 (2), it is considered probable that the smoke caused by the fire flowed out of the ventilation hole of the ventilator installed on the boat deck, the air conditioning system installed in the accommodation space inhaled the smoke from the air intake hole, and finally the fire alarm system installed in the accommodation space sounded the alarm.

3.4.6 Confirmation of Fire Extinguishment, and Death of Chief Engineer

According to 2.1.4, the following is considered probable:

The SRT members, upon the rescue request from Company A, boarded the Ship and confirmed fire extinguishment at about 1020 hrs October 15, 2008, and discovered the body of the chief engineer between the bulkhead of the engine room and a car in storage on DK 7 at about 1045 hrs. When discovered by the SRT members, the EEBD on the body of the chief engineer contained no air. In addition, no flash-lights and transceivers were found there.

3.5 Origin and Cause of Fire

3.5.1 Possibility that Fire Broke out in Electric Equipment in the Cargo Holds

According to 2.1.3, 2.6.7, 2.6.11, 2.10.3, 2.15 and 2.16.1, it is considered as follows:

As for the possibility that fire broke out in electric equipment in the cargo hold, problems on the AC 220 V line for lighting caused by the fluorescent lights which were always on can be suspected as the cause. However, the possibility that a fire broke out on the AC 220 V line was diminished, because the results of measurements of insulation resistance of lighting power lines

executed about six months before the accident showed no irregularities, the fluorescent light on DK 10 and the one on DK 12 that were found to have fallen due to the burnt away of the holding gear did not fall onto the most severely damaged cars, and the insulation degradation alarm on the AC 220 V line used only for lighting in the cargo holds was sounded about 11 minutes after the fire alarm.

On the other hand, the solenoid valve of the alarm air-horn for release of CO₂ was unable to be the cause of fire, because the solenoid valve was not installed on DK 10.

3.5.2 Possibility of Fire Break out due to Smoking

According to 2.9.4, it is considered probable that the possibility that fire broke out due to smoking was diminished because the smoking areas in the Ship were the accommodation area, the smoking room, the salon, the cargo office and the wheel house, smoking was prohibited in the other areas. In addition, the taking in of goods or materials other than the necessary tools for lashing inspections into the car decks was prohibited.

3.5.3 Possibility that Fire Broke out in Cars

(1) Identification of the car of origin of the fire

According to 2.1.3, 2.6.6 and 2.16, the following is considered probable:

Of the damaged cars, car 10-07 stored on DK 10 sustained the most severe damage, where the paint on both the side doors was burnt away. As for car 10-06 placed on the starboard side of car 10-07 and car 10-08 on the port side, the paint on the sides next to car 10-07 was completely burnt away, and the paint on the opposite sides was only partly lost. Moreover, the cars loaded on DK 11 and DK 12 were damaged by burning caused by the heat coming from below. Judging from these factors, car 10-07 was the origin of the fire. Furthermore, the fire started from car 10-07 and spread around, and the smoke caused by the fire flowed through the outlet or intake holes of the ventilator into DK 11 and activated the smoke sampling type fire detection system there.

(2) Origin of Fire in Car 10-07 and Possibility that Fire Broke Out in the Electric System

According to 2.16.1 (1), 2.16.2, 2.16.3 and 2.17, the results of the investigations of fire damage on cars and the situation of the spreading of fire, conducted separately on the fuel, exhaust and electric systems, were as follows:

{1} It is considered probable that the fire originated in the engine bay of car 10-07, because it was damaged the most severely and signs that the fire originated in the engine bay and spread into the compartment, the fuel intake of the fuel tank, and then the rear trunk were found.

{2} It is considered probable that the fuel system was not the origin, because the fuel remained in the fuel tank in spite of the burnt damage on the outer surface of the tank, and no fuel pipe connectors were found to be disconnected although all but a part of the fuel pipes was burnt away. It is considered probable that the exhaust system was not the origin, because there were no signs of excess heat caused by keeping the engine running for a long time, such as signs of overheating inside the exhaust pipe containing catalyst, except for soot deposition on the outer surface of the exhaust pipe. Therefore, it is considered impossible that the fuel system or the exhaust system was the origin.

{3} In the engine bay, melt-damage on the terminal of the main ground wire, cable adhesion and melt-damage on the battery were found. However, it is considered probable that, because similar cable adhesion and melt-damage on batteries were found in other cars, they were not the cause of the fire, and also the melt-damage on the terminal of the main ground wire was not the cause because of the reason stated below in {4}.

{4} As for the investigations on the possibility that fire broke out in the main ground wire, it is considered probable that the results of the reproductive experiments showed that, in a case where electrodes were connected directly by a ground wire, the rods of electrodes might be melted-down inside the battery before the terminal of the main ground wire was melted due to a large current. Besides, in a case where a large current was applied to a ground wire, although the temperature of the terminal of the ground wire rises greatly, the temperature did not reach the melting point.

According to these factors, it is considered possible that the terminal of the ground wire was melt-damaged due to the secondary short circuit after the fire breakout, because, in a case where the terminal was already heated to a high temperature due to a fire which started from other parts, a large current caused by short circuit or other causes due to such fire could raise the temperature to the melting point.

{5} Possible process of fire breakout in a car

It is considered probable that a large current flowing through cables to cause a fire was well known as one of the causes of fire in the electric system. It is considered probable that, in the case of cars, circuit breakers were installed to shut down immediately upon encountering a large current, although the possibility of fire breaking out due to a short circuit still exists even in an usual transportation where the car was in a complete stop and the ignition key is removed, because some parts are live and applied with a voltage. It is considered probable that, even if such breakers were installed, a short circuit with a current too small to activate such breakers might occur. It is considered probable that, in such a situation, currents continue running and raise the temperature of the cable as time passes, melting the insulation coating, and starting a fire. It is considered possible, as for the cause of a short circuit in such a situation where the influence of humidity was unlikely because the car was stored in the cargo hold, that a short circuit due to the contact of cables or a leak from cables to the body was caused by defects occurring at the time of manufacture, damage on cables during running after manufacture or some other external factor. Therefore, it is considered probable that, although in the investigations after the accident on the burnt cars no evidence was found to identify the electric system as the origin of the fire, the possibility that fire broke out in the electric system of the car is undeniable.

{6} Summary

According to {1} to {5} above, it is considered probable that the fire started in the engine bay of car 10-07. However, because the damage situation in the engine bay was so severe and the melting of the terminal of main ground wire was unable to be reproduced in the reproductive experiments, it could not be determined the possibility of fire breaking out in the electric system in the engine bay.

3.5.4 Cause of Fire

According to 3.5.1 to 3.5.3, as for the fire breakout in the engine bay of car 10-07, it is less probable that the fire started in the electric equipment in the cargo hold or due to smoking there. On the other hand, it could not be determined the possibility of fire breaking out in the electric system of the car.

Therefore, the cause of the fire breaking out in the engine bay of car 10-07 remains unclear.

3.6 Damage Control

3.6.1 Prevention of Fire Spread

According to 2.1.3 and 2.13.2, the following is considered probable:

The master, upon the receipt of the report from the third officer of fire acknowledgement, entered DK 11 with a portable chemical extinguisher by himself in order to confirm the situation of the fire and execute initial firefighting, and headed to the position where the smoke accumulator was installed but abandoned the initial firefighting because of the strong irritating odor and the increase of smoke.

The master instructed to close the dampers of the ventilators, sealed the cargo hold and used the fixed CO₂ fire extinguisher system to fight the fire. That firefighting activity confined the fire damage to the cargo hold.

3.6.2 Control of Human Damage

(1) Delivery of the fire breakout information to the chief engineer and the crew members and announcement for the emergency roll-call

According to 2.1.3, 2.8.5, 2.13.3 and 2.13.4, it is considered probable that the third officer, upon the instruction from the master, sounded the general fire alarm, repeatedly made PA announcements about the fire breakout and informed the engine control room of the fire breakout

by answering the phone call from there; moreover, that the master and the third officer repeatedly announced on the PA that every crew member was to go to the master station for the preparation to the CO₂ release; therefore, all the crew members were well informed of the fire breakout and the emergency roll-call.

(2) Escape routes from the engine control room

According to 2.6.8, it is as follows:

It is considered probable that, although the usual escape route from the engine control room to the boat deck is to take the route running up the staircase installed in the starboard quarter or the route running up the staircase installed in the engine room, the chief engineer did not take either of the routes, judging from the fact that the chief engineer was found near the car ladder installed at the starboard stern end of DK 7.

On the other hand, according to 2.6.4 (2), it is considered possible that the chief engineer took the route climbing-up the staircase in the engine room to DK 6, climbing-up the nearest vertical ladder on the stern end of the car ladder to DK 7, and reached the point where he was found, judging from the distance of the vertical ladder to the point where he was found and from the reason that, by taking that route, he could avoid going through the narrow space in the cargo hold packed with cars very densely stored.

Company A should provide the crew with sufficient safety management by, for example, giving guidance to take, in the case of fire in the cargo hold, the escape routes designated by signs along the route to avoid the cargo hold.

(3) Roll-call

According to 2.1.1 and 2.1.3, it is considered probable that the master, before the release of CO₂, called the crew members for the roll in the muster station and confirmed the participants, knew of the absence of the chief engineer at the station, and received the report that the chief engineer had told the first engineer to go up to the boat deck first and that the chief engineer would be the last to leave.

(4) Release of CO₂

According to 2.1.3, 2.10.1 (2) and 3.6.2 (3), it is considered probable that the master, although he had not confirmed the presence of the chief engineer in the muster station, thought that the chief engineer was in the engine control room, away from the zone into which CO₂ would be released, because the master had received the report that the chief engineer had told the first engineer to go up first and that the chief engineer would be the last to leave, and then released CO₂ to extinguish the fire.

(5) Equipment carried by the chief engineer and the situation leading to death

According to 2.1.3, 2.2, 2.6.12, 2.13.4 and 2.13.5, it is considered probable that the chief engineer heard the PA announcement of the fire breakout on DK 11, in HLD 3; moreover, that the chief engineer knew of the release of CO₂ into Zone F by hearing the PA announcement of the CO₂ release too. However, it is considered possible that the chief engineer entered the cargo hold wearing an EEBD and was still in Zone D, DK 7, where the lighting had been lost, when CO₂ was released into zone D, that he was unable to move freely because he carried no flash light, that he had no means of communication because he carried no transceiver, that he failed to evacuate within the duration of the EEBD, and that he died due to suffocation caused by CO₂ intoxication.

It is considered possible that, if the chief engineer had carried a transceiver as prescribed in the muster list, he would have been able to communicate with people outside and be rescued.

(6) Orientations for emergency by Company A

According to 2.8.3 to 2.8.6, it is considered probable that, although Company A had instructed the Ship to prepare the muster list and carry out exercises in compliance with the Training Manual by the SOLAS Convention, judging from the fact that the chief engineer did not take a route with guide signs posted along the route and did not follow the instruction from the master to go to the muster station, and no records were left of the training for CO₂ release, which is one of the types of training based on a simulation of the actual emergency situation, the crew

members had not been sufficiently informed of the evacuate measures in the emergency situations or the importance of following the instructions from the master to evacuate.

3.7 Occurrence of Accident

3.7.1 Fire Broke Out

According to 2.16 and 3.5.2, it is considered probable that, while the Ship is navigating on the east offing on Kinkazan in the high seas, a fire broke out in the engine bay of a car loaded on the port side on DK 10, and spread to the cars stored on DK 10 to DK 12, and to the car decks above DK 10.

3.7.2 Cause of Fire

According to 3.5.4, regarding the fire breaking out in the engine bay of the car, it is less probable that the electric equipment in the cargo hold or smoking there caused the fire, while it could not be determined whether it was possible for the electric system in the car to cause the fire.

Therefore, the cause of the fire that started in the engine bay remains unidentified.

3.7.3 Events leading to Death of the Chief Engineer

According to 2.13.4 and 3.6.2, it is considered possible that the events leading to the death of the chief engineer are as follows:

The chief engineer, who had stayed in the engine control room alone, heard the PA announcement that all the crew members should go to the muster station, knew that CO₂ would be released, then evacuated from the engine control room wearing an EEBD but carried neither a flash light nor a transceiver, entered DK 7, where the lighting had been lost, and was unable to move freely in the dark. While the chief engineer was on DK 7 with no means of communication, CO₂ was released, and the chief engineer failed to evacuate within the duration of the EEBD and died due to suffocation caused by CO₂ intoxication.

The chief engineer did not use the route that had guide signs posted along the route and entered DK 7. It could not be determined the reason why the chief engineer died and no crew members witnessed how the chief engineer acted.

4 CONCLUSIONS

4.1 Findings

(1) Events Leading to Accident

It is considered probable that in the Ship, which was proceeding in the east offing of Kinkazan in the high seas, a fire broke out in the engine bay of a car stored in the port side of DK 10, CO₂ was released for firefighting because the fire spread to the cars stored on DK 10 to DK 12 and to the car decks above of DK 10, and although the fire was extinguished, the chief engineer was found dead on DK 7 due to suffocation caused by CO₂ intoxication.

(2) Analysis of Origin and Cause of Fire

{1} As for the possibility that the fire broke out in the electric equipment in the cargo hold, problems of the lighting AC 220 V power line caused by the fluorescent lights, which were always on in the cargo holds, could be suspected. However it is considered less probable that the fire broke out in the AC 220 V line, because: no irregularities were found in the measurements of the insulation resistance in the lighting lines, which were conducted about six months before the accident; the fluorescent lights that had fallen due to burnt damage were not found on the most severely burnt cars; and the insulation degradation alarm was sounded about 11 minutes after the fire alarm.

{2} As for the possibility that the fire broke out because of smoking, it is considered less probable that smoking was the cause of fire, because: smoking areas were limited and the cargo holds were non-smoking areas; taking cigarettes out of the accommodation space was prohibited; and moreover, taking goods or materials into car decks other than the tools necessary for inspection of lashing of cars was prohibited.

{3} As for the possibility that the fire broke out in a car, it is considered probable that the fire started in the engine bay of a car 10-07, because car 10-07 was the most severely burnt, and the damage situations of the cars around car 10-07 and on the upper decks suggested so.

It is considered probable that the fuel tank of car 10-07 sustained no damage inside and had fuel remaining inside, and the connectors of the fuel pipes remained plugged although almost all the pipes were burnt away. It is considered probable that no history of abnormally high temperatures was left inside the exhaust system, which would be caused when the engine was kept running for long hours. According to what is stated above, it is considered less probable that the fuel system or the exhaust system was the origin of the fire.

As for the electric system, it is considered probable that the melt damage on the terminal of the main ground wire, the cable adhesion and burnt away parts of the battery found in the engine bay were due to the secondary short circuit after the fire broke out, because similar cable adhesion and burnt-away parts of batteries were found in other cars, and the melt damage on the terminal of the main ground wire was unable to be reproduced by the reproductive experiments.

According to what is stated above, as for the cause of the fire in car 10-07, it could not be determined why the fire broke out in the electric system, because the inside of the engine bay was severely damaged and burnt away, and the melt damage on the terminal of the main ground wire was unable to be reproduced by the reproductive experiments.

{4} According to {1} to {3}, it is considered probable that the fire originated in the engine bay of a car 10-07. The cause of fire could not be determined.

(3) Firefighting

It is considered probable that the third officer on the bridge watchkeeping acknowledged the fire in the cargo hold by activating the smoke sampling type fire detection system. It is considered probable that the master, although he entered DK 11 with a portable chemical extinguisher for initial firefighting and headed to where the smoke accumulator was installed on the port side, which had sounded the alarm, abandoned the initial firefighting because of the strong irritating odor and the increase of smoke, and decided to fight the fire by using the fixed CO₂ fire extinguisher system. It is considered probable that the master released CO₂ into Zone F and then into Zone E and Zone D, after having instructed the chief officer to close the dampers in the ventilation holes of the ventilation system, instructed the third officer to announce the roll-call in the muster station to the crew members via the PA and confirmed the attendance on the roll. It is considered probable that the master released CO₂ twice and used all the CO₂ stored.

(4) Death of Chief Engineer and Mitigation Measures of Human Damage

It is considered probable that the chief engineer, who had stayed alone in the engine control room, knew that CO₂ would be released, wore an EEBD, evacuated from the engine control room without carrying a flash-light and transceiver, entered DK 7, where the lighting had been lost, was unable to move freely in the dark, had no means of communication, encountered the release of CO₂ and failed to evacuate within the duration of the EEBD.

It is considered probable that, after the fire had been extinguished, the body of the chief engineer was found dead on DK 7 due to suffocation caused by CO₂ intoxication.

It is considered probable that the crew members had not been well informed of how to evacuate in an emergency or of the importance of following the instructions from the master to evacuate, because the chief engineer did not use the escape routes with guide signs posted along route, he did not follow the instruction from the master to the crew members to roll-up to the muster station, and there were no records in the Ship of training on CO₂ release, which is the required training, simulating actual situations in an emergency.

(5) Cause of Occurrence of Accident

It is considered probable that in the Ship, proceeding in the east offing of Kinkazan in the high seas, a fire broke out in the engine bay of the car stored on the port side of DK 10 and spread to the cars nearby and the cars on the upper decks.

As for the cause of the fire in the engine bay, it is less probable that the electric equipment

in the cargo hold or smoking there was the cause of the fire, and it could not be determined whether it was possible for the electric system in the car to start the fire.

4.2 Probable Cause

It is considered probable that the accident occurred, while the Ship was navigating on the east offing of Kinkazan in high seas, because a fire broke out in the engine bay of a car stored on the port side of DK 10 and spread to the cars nearby and on the upper decks.

As for the cause of the fire breaking out in the engine bay of the car, it is less probable that the electric equipment in the cargo hold or smoking was the cause of the fire, and it could not be determined whether it was possible for the electric system in the car to start the fire.

5 REMARKS

It is considered probable that the accident occurred because a fire broke out in the engine bay of a car stored in the cargo hold by an unidentified cause and spread to other stored cars; CO₂ was released into Zone F, where the fire has started, as well as into Zone E and Zone D, where the fire detection system was activated; and the chief engineer died due to suffocation caused by CO₂ intoxication and was found in Zone D, DK 7.

As for the death of the chief engineer, it is considered probable that although the chief engineer had known of the release of CO₂ because the master repeatedly had made the announcement requesting to go to the muster station for the preparation of CO₂ release, the chief engineer entered DK 7 without carrying a transceiver, although he had been requested to carry one by the muster list.

It is desirable that Company A should inform crew members at an orientation about carrying, in an emergency, the equipment prescribed in the muster list and about the importance of following the instruction from the master to evacuate in an emergency; and as for CO₂ release, Company A should determine the procedures for safety confirmation of the place into which CO₂ will be released and instruct the ships under their management to conduct exercises simulating actual emergency situations.

Although the cause of fire in the engine bay of the car remains unidentified, the possibility that it was the electric equipment in the ship or the handling of fire such as smoking, or that the electric system of the car was involved cannot be completely denied. Therefore, it is desirable that Company A should motivate crew members to be more sensitive to fire protection, execute stricter controls on fire-handling, inspect electric equipment in cargo holds more strictly; and the automobile manufacturing company should give more consideration to fire protection starting from cars in transportation.

Figure 1: Map of Accident Location

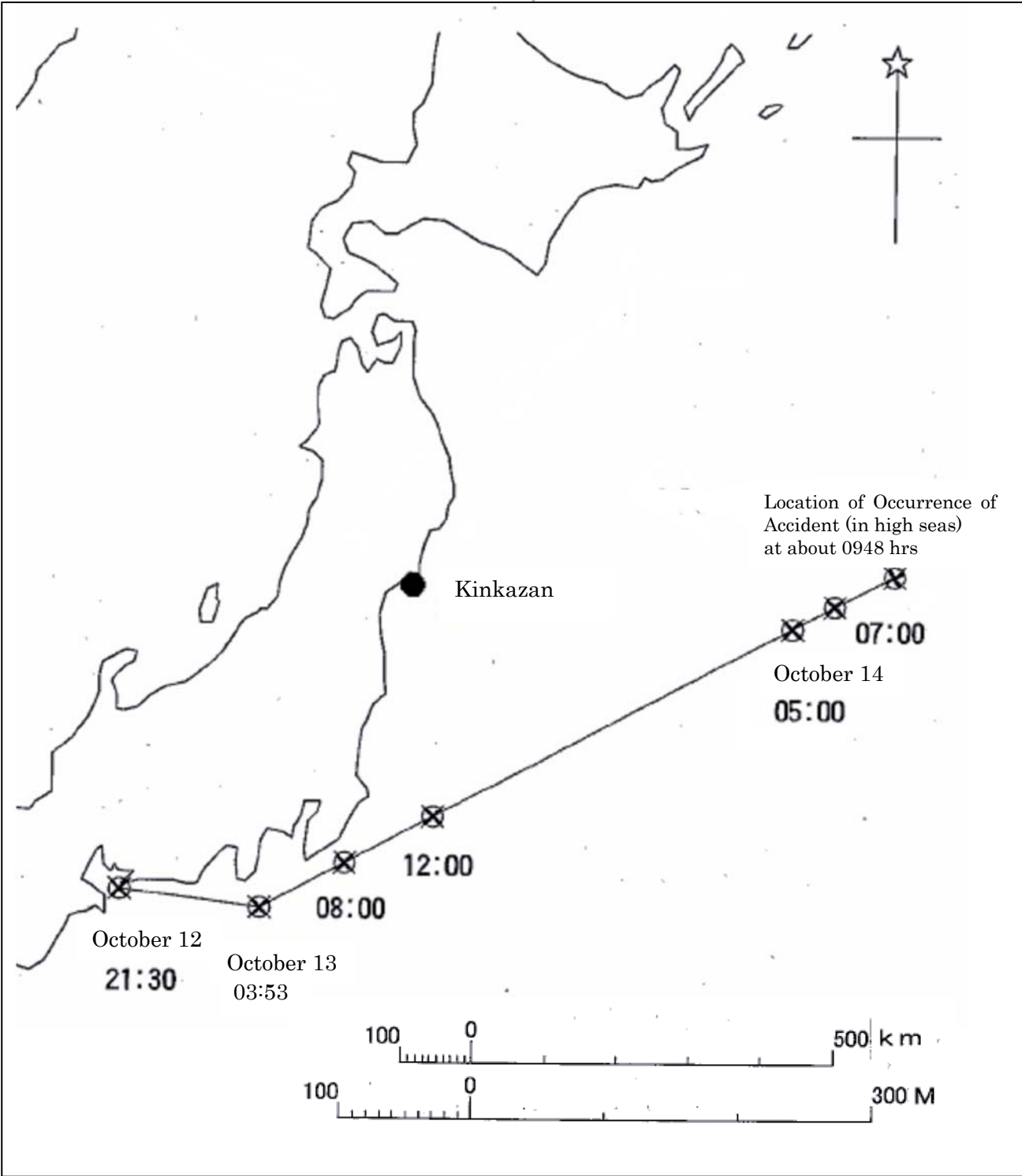


Figure 2: General Arrangement Plan

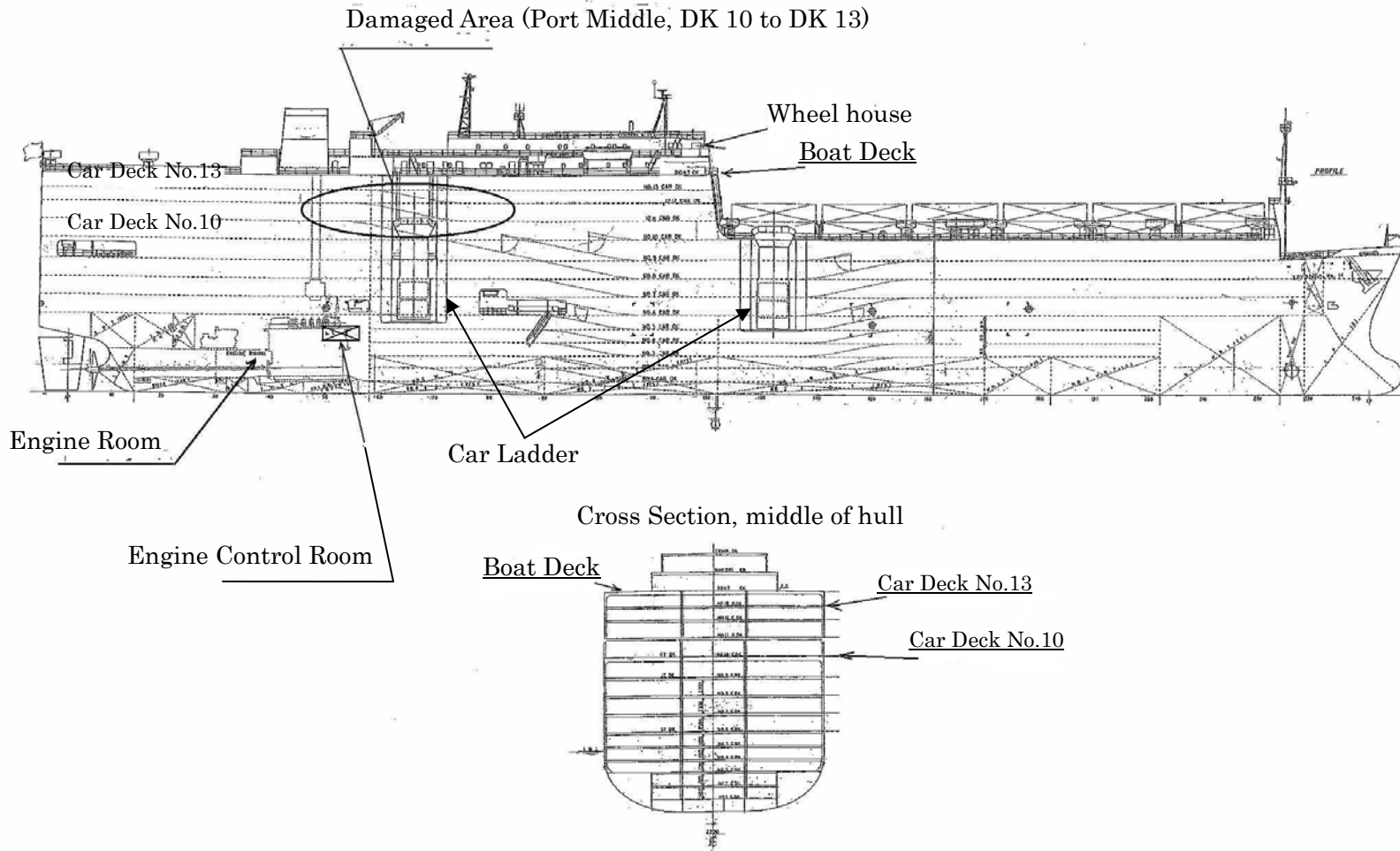


Figure 3: Layout of Smoke Accumulators and CO₂ Release Nozzles of Smoke Sampling Type Fire Detection System on DK 11

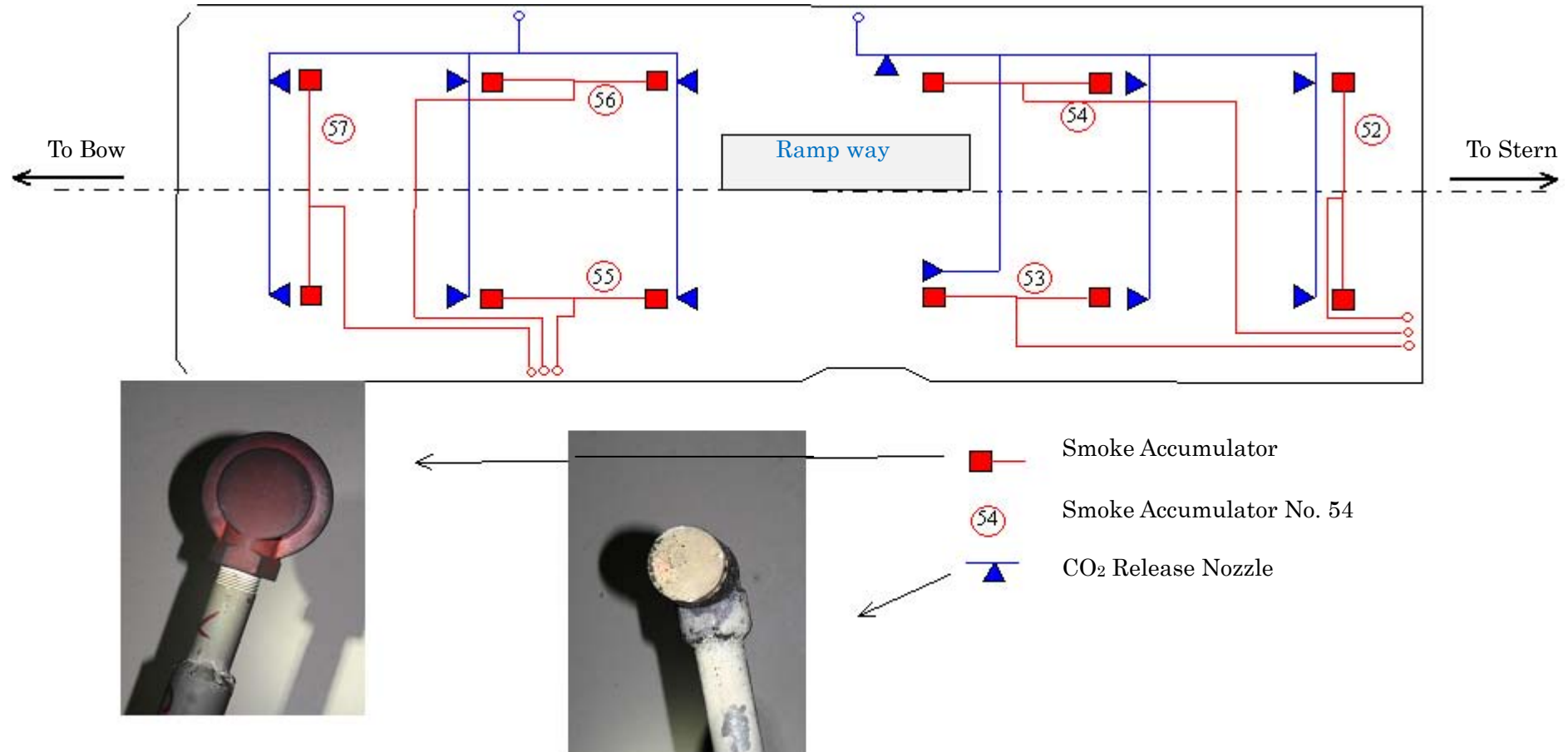


Figure 4: Details around DK 6 Car Ladder



Figure 5: Simplified Diagram of Construction of Smoke Sampling Type Fire Detection System

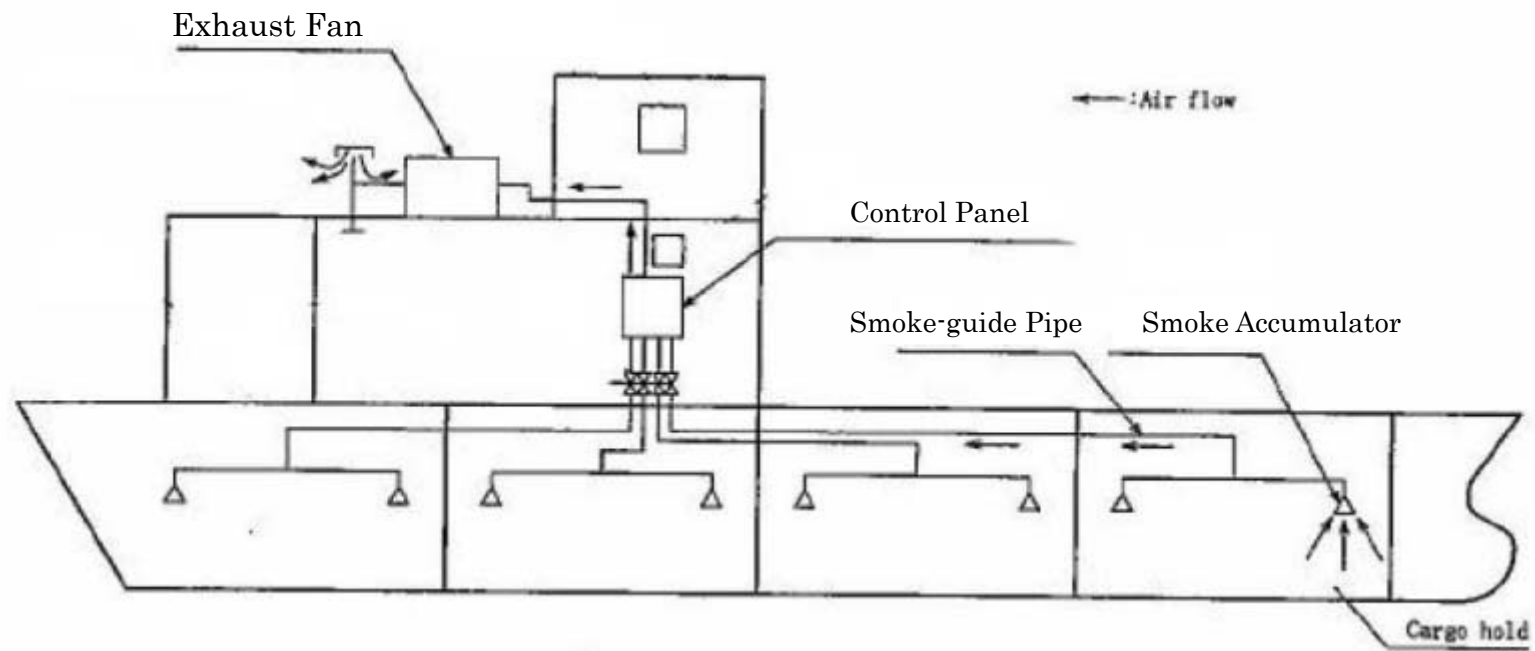


Figure 6: Block Diagram and Construction Map of Fixed CO₂ Fire Extinguisher System

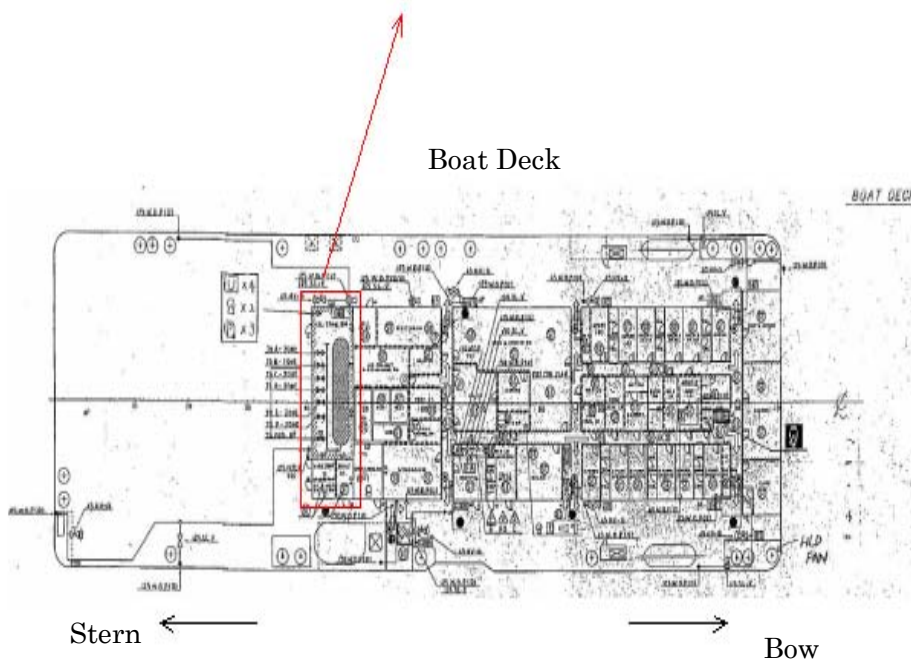
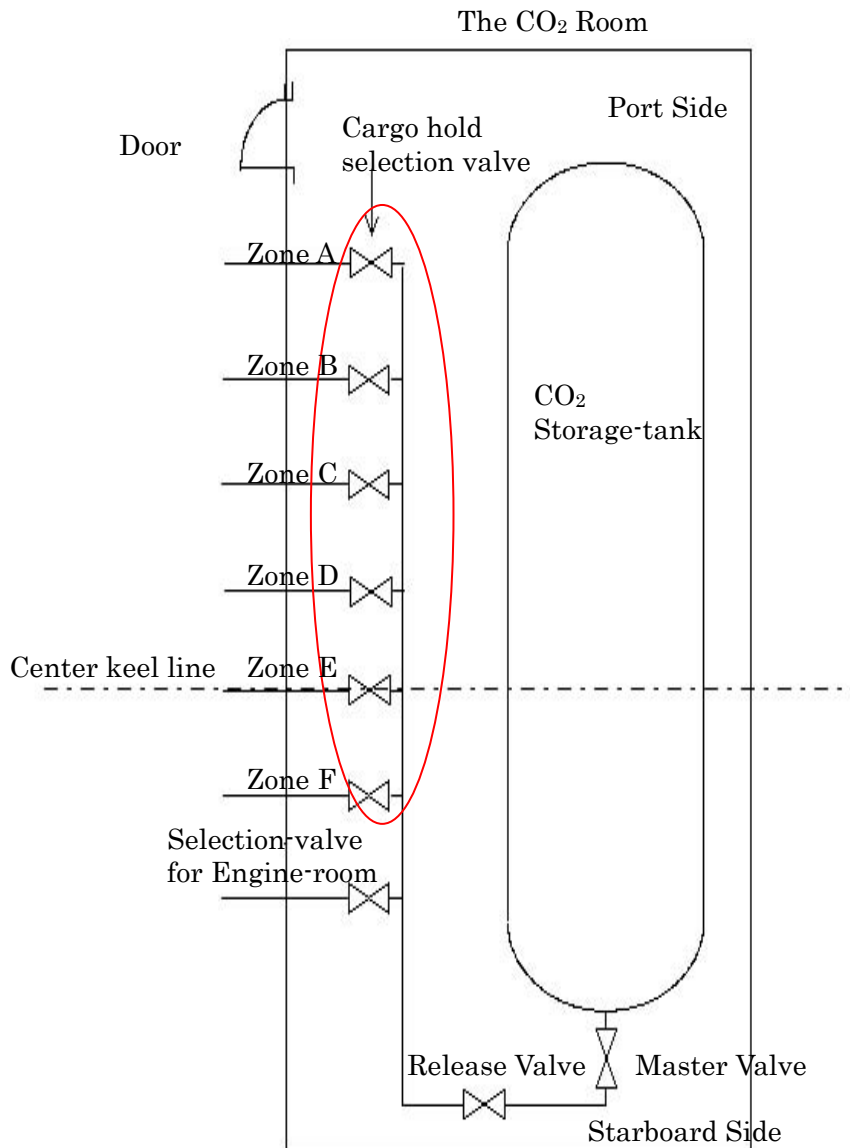


Figure 7: Map of Location of Discovery of the Bay of Chief Engineer (DK 7)

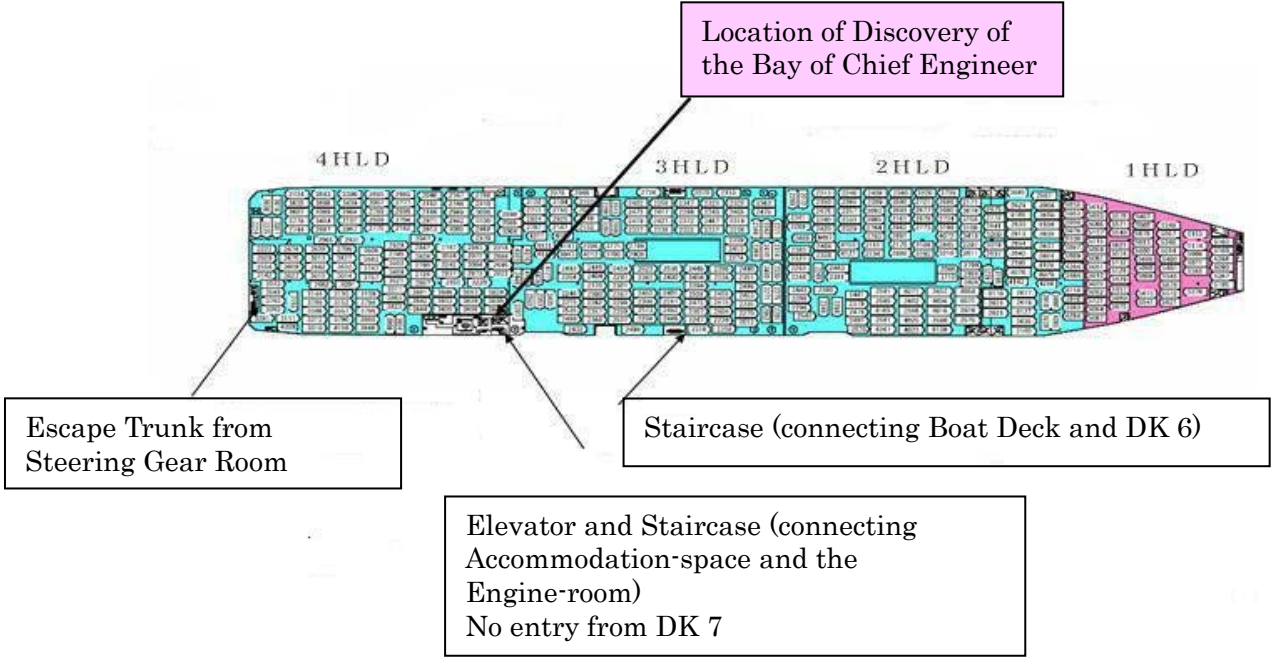


Figure 8: Detailed Map of Location of Discovery of the Bay of Chief Engineer
(near DK 7 Car Ladder)

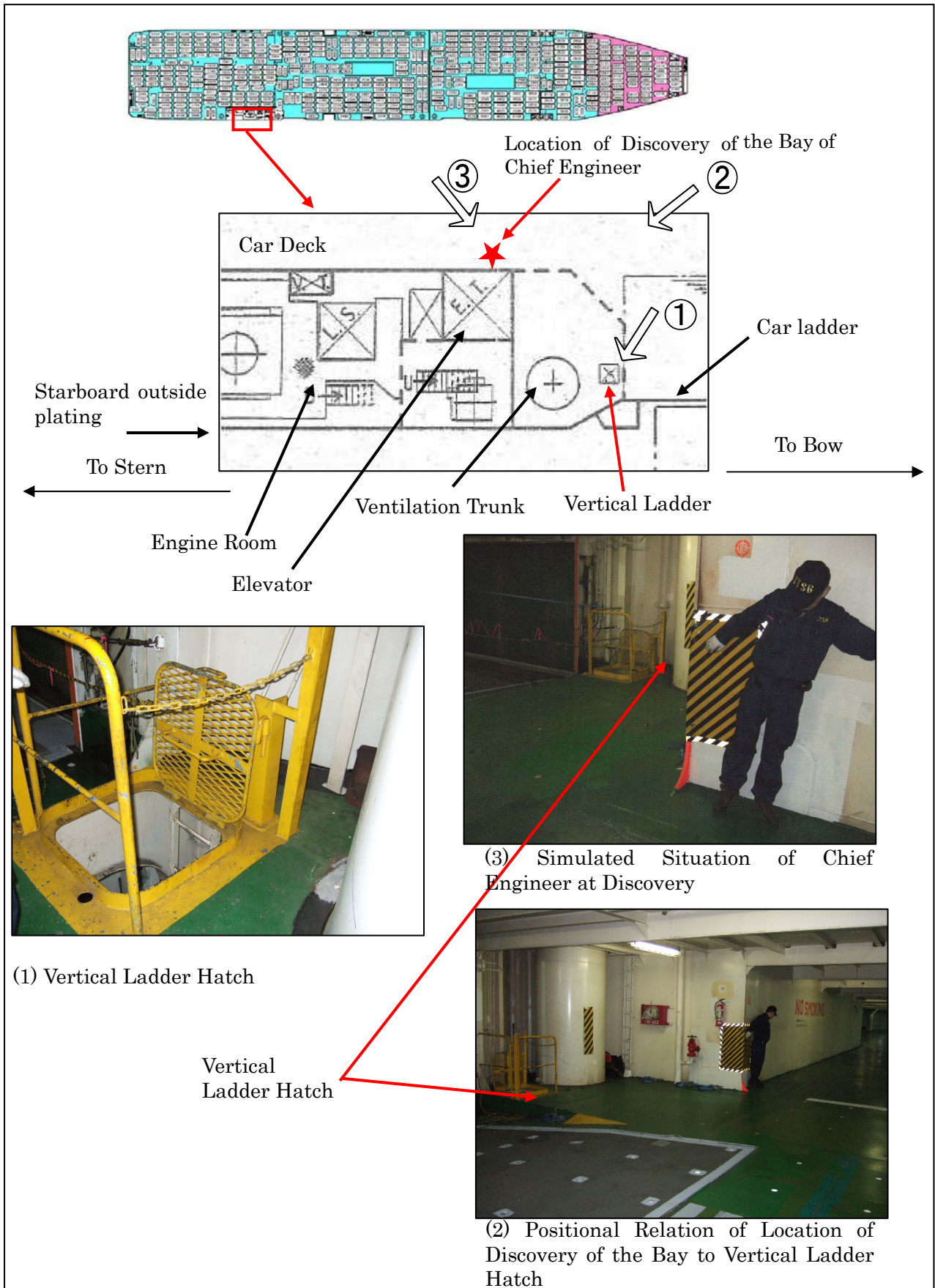
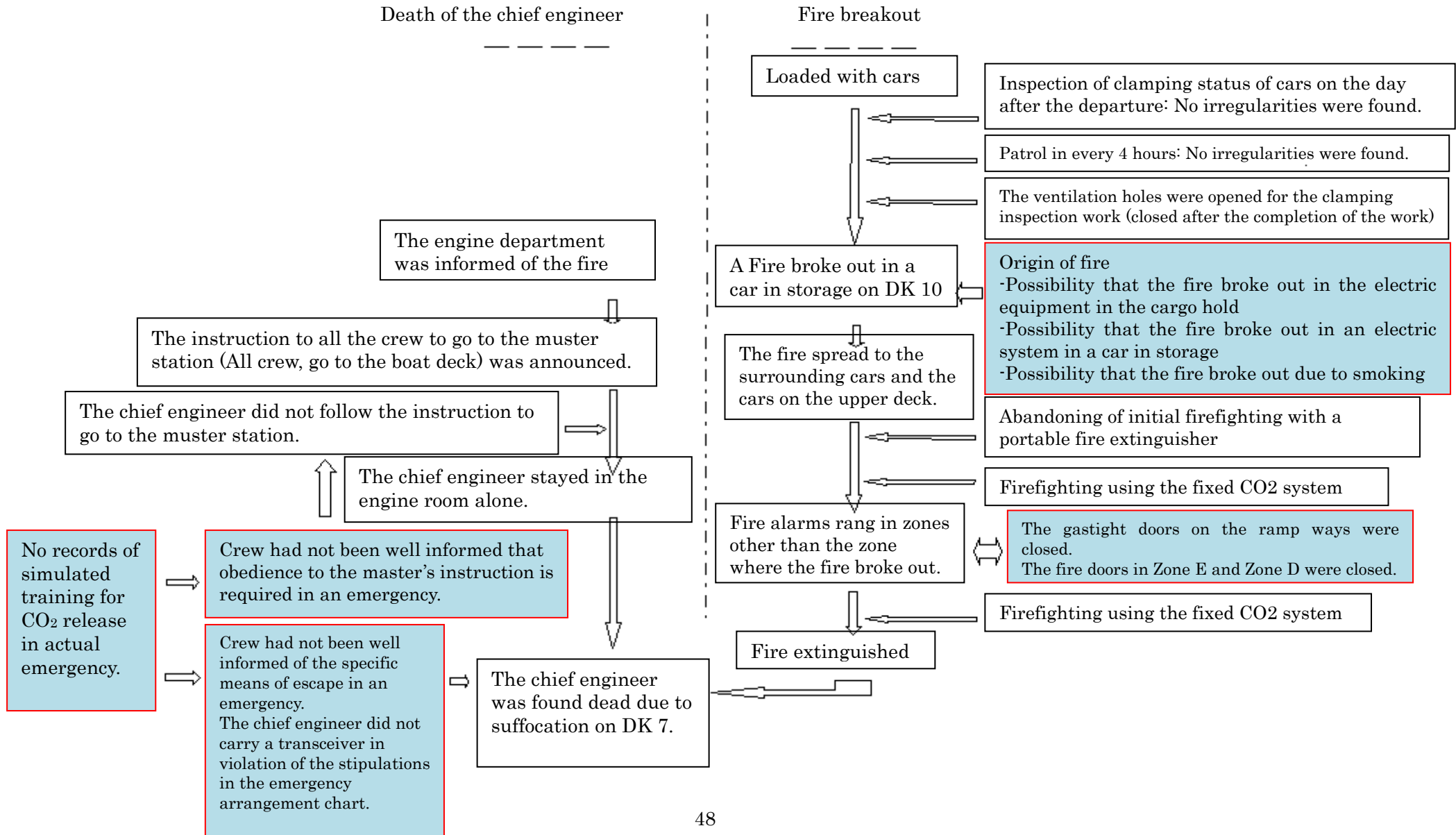


Figure 9: Cause and Effect Relation Diagram (Summary)



APPENDIX

Investigations on the Possibility of Fire Breakout in Cars

1. Possibility of Fire Breakout in Cars

In cars, there is a possibility or a risk of fire even during transit where the ignition switch is off, the engine is completely stopped, and the car is wholly cooled to near the ambient temperature.

It is because some portions of the car remain live and applied a voltage even while the ignition is off. These parts are called active parts, and if some insulation degradation or performance degradation in such parts occurs, it can cause short circuits leading to a fire that spreads to plastics, fuel or lubrication oil. Among such fires, the most common is the case where damage to electric cables leads to water invasion or between-cable contact causing a short circuit, and the current which flows through the short circuit generates heat and raises the temperature of the insulation coating or materials around the cable and starts a fire.

To prevent such fires, circuit breakers are installed on electric circuits in cars, so as to instantly shut the circuit when currents flow because of a short circuit. However, those breakers cannot work for a current less than the activation level of the breaker. If such a small current, not interrupted by breakers, continues to run, it makes the battery discharge continuously. In normal cases, such discharge causes some kind of problems in the car and is finally discovered. However, when the current is less than the breaker activation level but large enough to continuously heat the cables, as time passes the temperature will rise enough to cause insulation breakdown and will lead to a fire.

Such a case, where a fire breaks out without breaker activation, is well known to occur in electric cables used in usual electrical equipment or systems. In such a case, it takes a certain amount of time to lead to a fire. Such findings in usual electric appliances do not contradict with the fact that, in the case of the accident, more than 1.5 days had passed from when the sip was loaded with the cars until the fire broke out.

According to what is stated above, it is considered possible for a fire to break out in a car during transit, as it occurred in the case of the accident. However, the probability is never high, because such phenomenon occurs only when various conditions are satisfied simultaneously.

2. Possibility and Cause of Fire Breakout in Car for the Case

A fault tree analysis¹⁹ for the case of the accident is shown below. The investigations and the analysis from the standpoint of cars were conducted according to the FTA. As a result of the investigations and the analysis, the possibility that the fire broke out in the car in storage can not be denied.

What is considered to be undeniable among the possible causes of the fire is an electric short circuit, which occurred in a car, as described in 1. above. Such a short circuit, although the possibility is low, can lead to a large fire spreading consecutively to other objects, as seen in the case of the accident. As a cause of such short circuit, in such a situation as that in the case of the accident, where water invasion is less probable, it is suspected that a short circuit between cables or between a cable and a body occurred, and then the current leaking from a cable to the body flowed, due to breaks or damage in the cables caused by some unknown external factors.

As for such a cause, it is possible to suspect various factors, such as deficiency of materials or fabrications of parts in the electric system, damage in wires caused during the assembly process, breaks on the coating during the work of connecting connectors, and breaks in the electric system caused during the run after manufacturing. However, no similar troubles had been found in cars of the same model, and nothing suggesting a strong similarity to the examples of the events or causes described above was found in the investigations of the manufacturing process or of the residuals of the accident. Therefore, the cause of the fire breaking out in the car remains unidentified.

¹⁹ "FTA" is an abbreviation for Fault Tree Analysis, which shows the relations of events in the form of a fault tree, where the main event (top event) is placed on the root, then the events relevant to the top event are placed under it, and in such a way, relevant events are placed under the event in question.

FTA Diagram for Car Fire

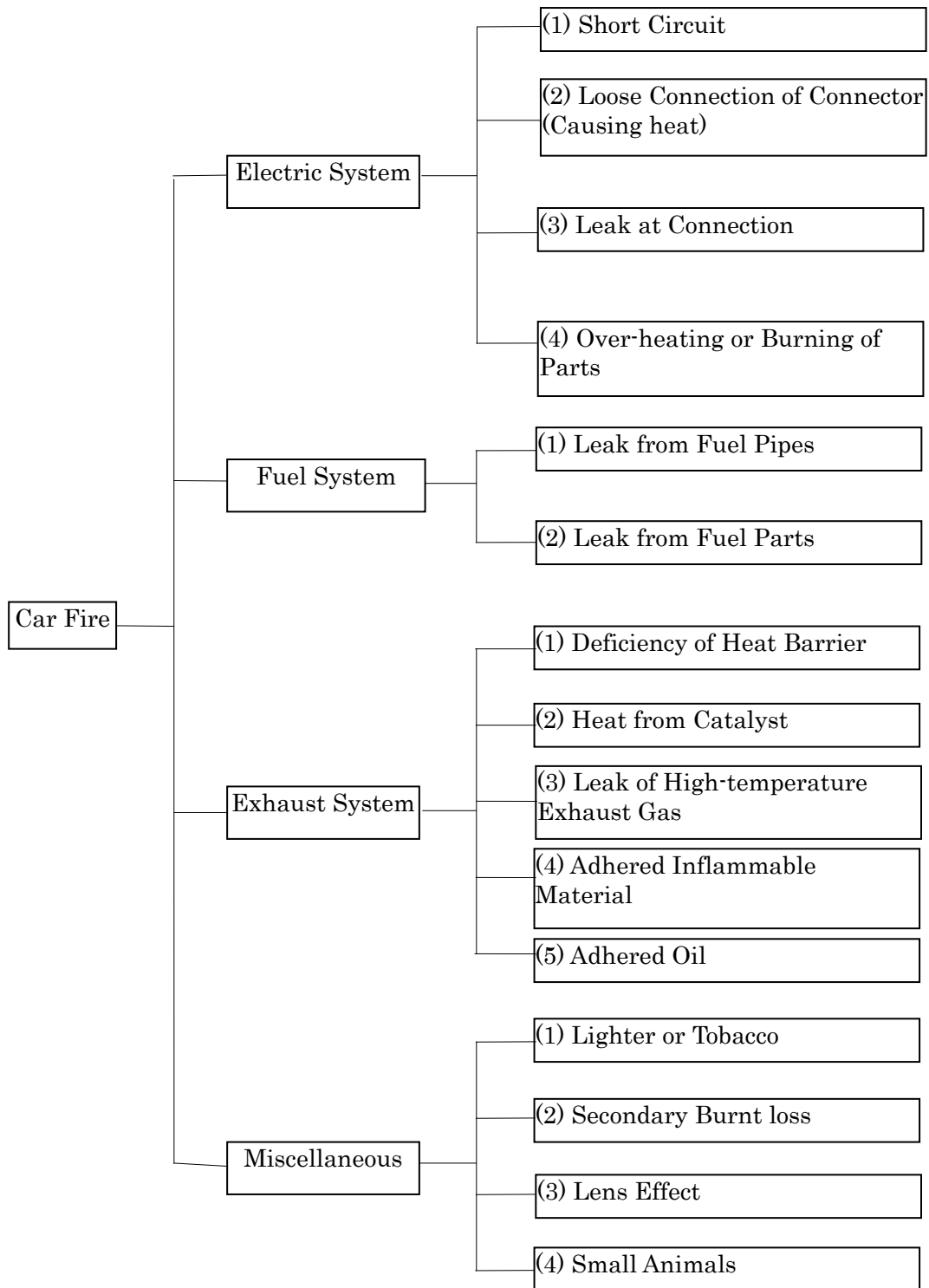


Photo 1: Bird's-eye View of the Ship (after the accident)



Paint was burnt away

Photo 2: Fire Damage Situation of DK 10 Ceiling



A fluorescent light was found to have fallen here

The light had been attached

Photo 3: Fire Damage Situation of Fluorescent Lights



Photo 4: Fire Damage Situations of Cars on DK 10





<p>Car 10-08</p>		<p>Front right</p> <p>Rear left</p>
<p>Car 10-07</p> <p>Front</p> 		<p>Right side</p> <p>Rear</p> <p>Left side</p>
<p>Car 10-06</p>		<p>Rear right</p> <p>Left side</p>

Photo 5: Vertical Ladder Connecting DK 6 and DK 7



Photo 6: Sliding Bulkhead Door



Photo 7: Tilting Gastight Door



Photo 8: Fire Door from Staircase to Car deck

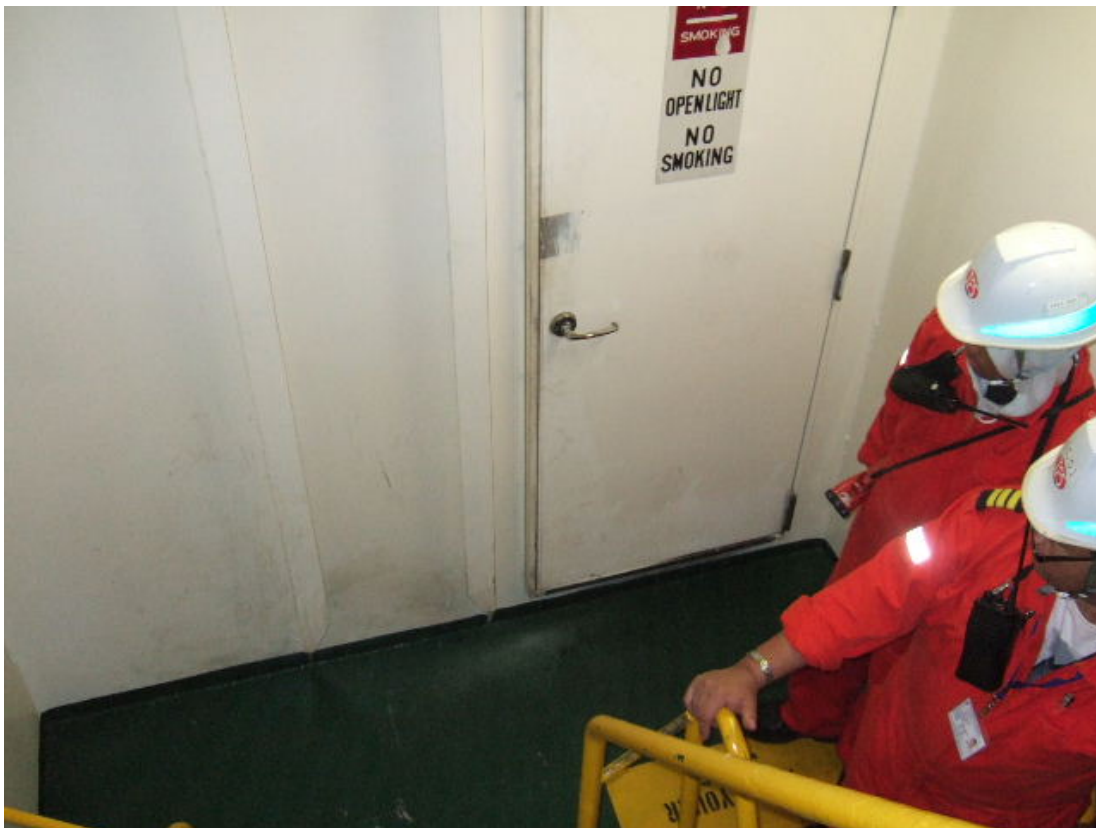


Photo 9: Ventilator (Dampers and Ventilation Holes)



Packing

Butterfly Nut

Photo 10: Smoke Detector Control Panel

Smoke Accumulator No. 54



Photo 11: Fixed CO₂ Fire Extinguisher System

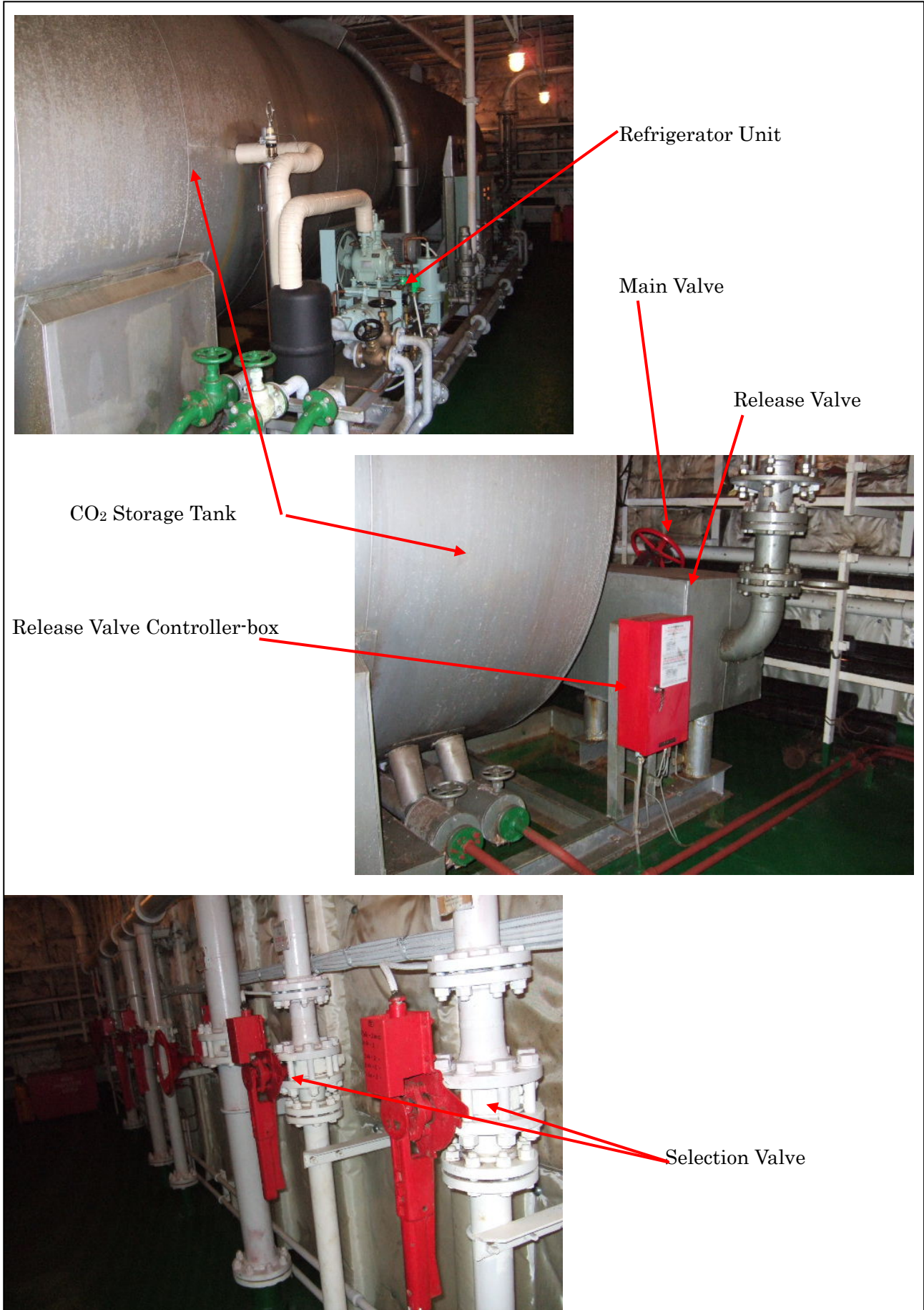


Photo 12: Transceiver Antenna installed in Cargo Hold

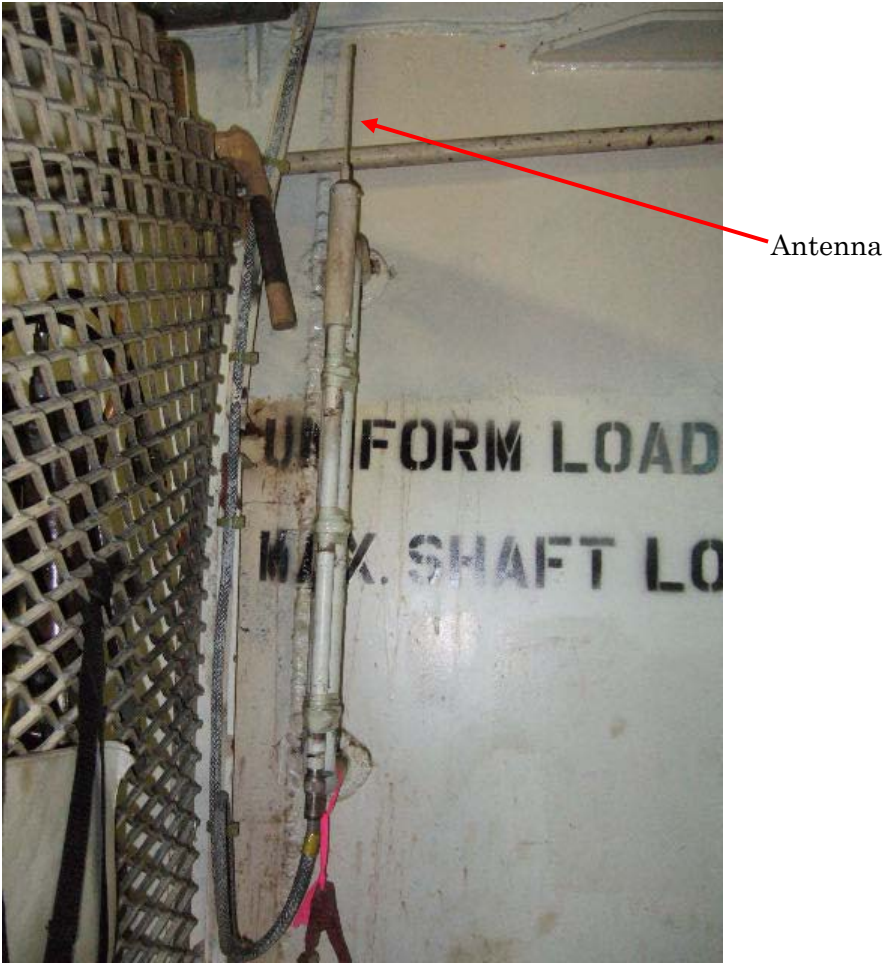


Photo 13: EEBD (Engine Control Room)



Photo 14: Car Stowage

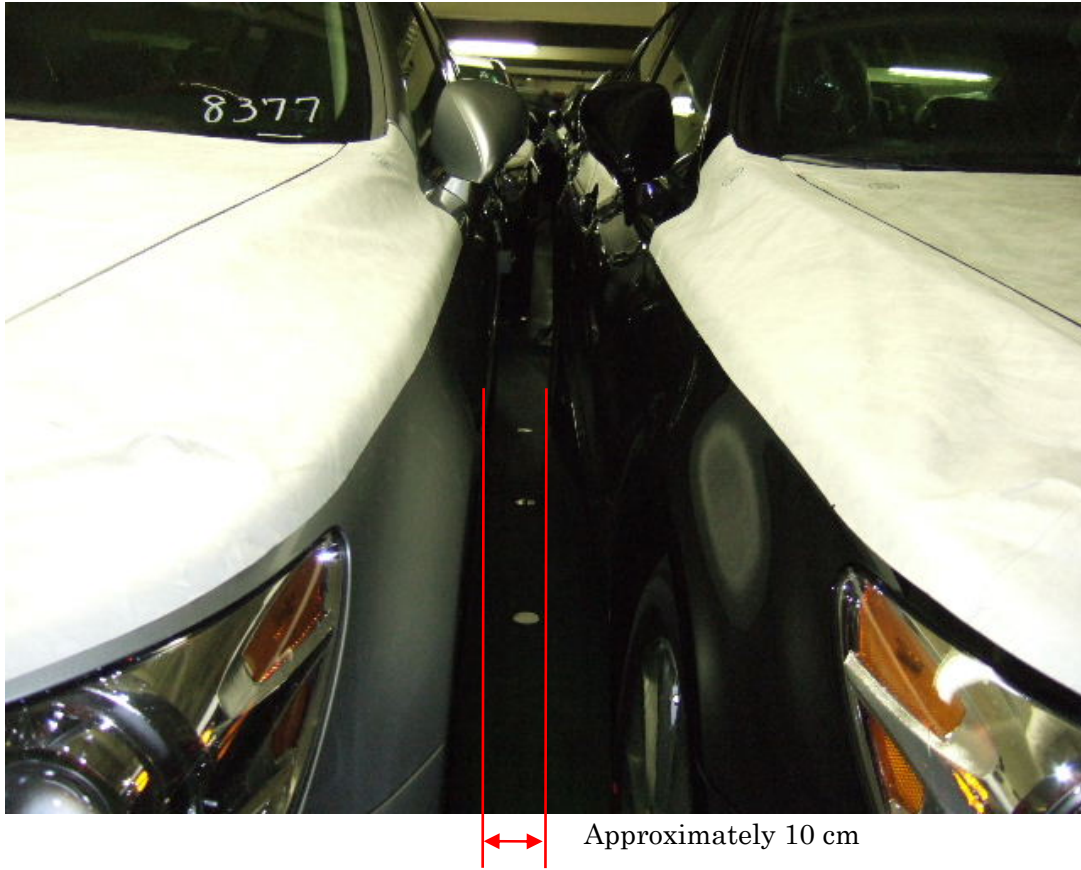


Photo 15: Clasps



Photo 16: Fire Damage Situations of Car 10-07 Engine Bay

