

MA2014-1

**MARINE ACCIDENT
INVESTIGATION REPORT**

January 31, 2014



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: Cargo ship GUANG DA

IMO number: 8859029

Gross tonnage: 2,460 tons

Accident type: Fatality during mooring operation

Date and time: At around 07:08 on January 11, 2012 (local time, UTC+9 hours)

Location: Katsunan District, Chiba Port, Chiba Prefecture 095° true bearing, approximately 2.6 nautical miles from the Chiba Port Katsunan Ichikawa lighthouse
(approximately 35°39.8'N 139°59.2'E)

December 19, 2013

Adopted by the Japan Transport Safety Board

Chairman Norihiro Goto

Member Tetsuo Yokoyama

Member Kuniaki Shoji

Member Toshiyuki Ishikawa

Member Mina Nemoto

SYNOPSIS

Summary of the Accident

While the cargo ship GUANG DA, with the master and 11 other crew members on board, was berthing at the south berth of the Keiyo Food Industrial Complex in Katsunan District, Chiba Port, Chiba Prefecture, at around 07:08(Japan Standard Time, UTC+9) on January 11, 2012, a stand roller on the forecastle deck came off the deck. Subsequently, the stand roller or the associated mooring line hit an ordinary seaman who was on the deck at that time. The seaman died.

Probable Causes

It is probable that in this accident, while the GUANG DA was berthing at the south berth of the Keiyo Food Industrial Complex in Chiba Port, the master put the engine astern in an attempt to bring the stern closer to the berth and that when the first headline, which had been secured onto the berth, became taut, the stand roller in the center of the forecastle deck, on which the line had been engaged, came off the deck, causing either the stand roller or the headline to hit the ordinary seaman.

It is probable that the stand roller in the center of the forecastle deck came off the deck because the weld between the doubling plate and the deck developed brittle fracture, causing the weld to break at or below the breaking strength of the first headline.

It is somewhat likely that improper ship management by HK LIWEIDA SHIPPING MANAGEMENT LIMITED, not having the stand roller in the center of the forecastle deck surveyed and approved by ISTHMUS BUREAU OF SHIPPING, contributed to the occurrence of the accident.

1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

While the cargo ship GUANG DA, with the master and 11 other crew members on board, was berthing at the south berth of the Keiyo Food Industrial Complex in Katsunan District, Chiba Port, Chiba Prefecture, at around 07:08(Japan Standard Time, UTC+9) on January 11, 2012, a stand roller on the forecastle deck came off the deck. Subsequently, the stand roller or the associated mooring line hit an ordinary seaman who was on the deck at that time. The seaman died.

1.2 Outline of the Accident Investigation

1.2.1 Setup of the Investigation

The Japan Transport Safety Board appointed an investigator-in-charge and two other marine accident investigators to investigate this accident on January 12, 2012.

1.2.2 Collection of Evidence

January 12, 13 and 20, and February 1, 2012 : On-site investigation and interviews

January 27, and February 8 and 28, 2012 : Interviews

February 3, 6, 7, 20 and 24, April 17, July 13, August 25, September 4, 18 and 22, November 5 and 22, and December 14, 2012 : Collection of written replies to questionnaires

1.2.3 Cooperation in the Investigation

Cooperation from the National Maritime Research Institute was gained to analyze the strength and weld rupture of the stand roller.

1.2.4 Comments from Parties Relevant to the Cause

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

1.2.5 Comments from the Flag State and the Substantially Interested State

Comments on the draft report were invited from the flag State and another substantially interested State of the GUANG DA.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

2.1.1 Navigation History of the Vessel According to the Records of the Automatic Identification System

According to the records of the Automatic Identification System (AIS)*¹ (hereafter referred to as “the AIS Records”) received by the Tokyo Wan Vessel Traffic Service Center, operation of the GUANG DA (hereafter referred to as “the Vessel”) between 05:20:47 and 07:27:40 of January 11, 2012, was as follows.

The course over the ground represents the true bearing (hereafter the same). The heading was not recorded.

| Time (hour:min:sec) | Vessel position | | Speed over the ground (knot (kn)) | Course over the ground (°) |
|------------------------|----------------------------|----------------------------|---|----------------------------------|
| | North latitude (-°-′-″) | East longitude (-°-′-″) | | |
| 05:20:47 | 35-35-01.8 | 139-59-30.2 | 0.1 | 021.5 |
| 05:26:47 | 35-35-01.3 | 139-59-31.2 | 0.5 | 185.4 |
| 05:27:40 | 35-35-00.9 | 139-59-31.3 | 0.6 | 180.2 |
| (Skipped) | | | | |
| 06:48:42 | 35-39-46.4 | 139-59-15.7 | 1.0 | 354.3 |
| 06:49:42 | 35-39-46.9 | 139-59-15.6 | 0.8 | 339.5 |
| 06:50:42 | 35-39-47.6 | 139-59-15.1 | 0.6 | 336.8 |
| 06:51:42 | 35-39-47.8 | 139-59-15.1 | 0.6 | 275.2 |
| 06:52:42 | 35-39-47.6 | 139-59-14.5 | 0.6 | 231.8 |
| 06:53:42 | 35-39-47.3 | 139-59-14.1 | 0.4 | 217.2 |
| 06:54:42 | 35-39-47.0 | 139-59-14.1 | 0.2 | 181.7 |
| 06:55:42 | 35-39-47.0 | 139-59-14.1 | 0.1 | 146.5 |
| 06:56:42 | 35-39-47.0 | 139-59-14.1 | 0.1 | 066.4 |
| 06:57:42 | 35-39-47.2 | 139-59-14.2 | 0.2 | 042.4 |
| 06:58:42 | 35-39-47.4 | 139-59-14.4 | 0.2 | 046.4 |
| 06:59:42 | 35-39-47.4 | 139-59-14.7 | 0.2 | 069.6 |
| 07:00:42 | 35-39-47.9 | 139-59-14.8 | 0.4 | 010.5 |
| 07:01:42 | 35-39-47.8 | 139-59-14.7 | 1.0 | 218.1 |
| 07:02:42 | 35-39-46.9 | 139-59-14.1 | 0.7 | 195.8 |
| 07:03:42 | 35-39-46.6 | 139-59-14.1 | 0.7 | 261.4 |
| 07:04:42 | 35-39-47.6 | 139-59-13.8 | 0.9 | 009.8 |
| 07:05:31 | 35-39-48.1 | 139-59-13.7 | 0.8 | 296.9 |
| 07:05:42 | 35-39-48.2 | 139-59-13.5 | 1.0 | 274.6 |
| 07:06:02 | 35-39-48.2 | 139-59-13.1 | 0.8 | 264.2 |
| 07:06:22 | 35-39-48.1 | 139-59-12.7 | 0.8 | 258.3 |

*¹ The “Automatic Identification System (AIS)” is a system that enables a ship to automatically exchange its information such as call sign, type, name, position, course, speed, destination and condition as well as safety-related information, with other ships or with shore facilities to assist navigation.

| | | | | |
|-----------|------------|-------------|-----|-------|
| 07:06:41 | 35-39-48.0 | 139-59-12.4 | 0.8 | 255.0 |
| 07:07:02 | 35-39-47.9 | 139-59-12.2 | 1.0 | 251.8 |
| 07:07:21 | 35-39-47.8 | 139-59-11.8 | 0.8 | 242.8 |
| 07:07:41 | 35-39-47.9 | 139-59-11.8 | 0.8 | 322.7 |
| 07:08:02 | 35-39-48.2 | 139-59-12.0 | 1.2 | 034.8 |
| 07:08:21 | 35-39-48.5 | 139-59-12.3 | 1.2 | 046.2 |
| 07:08:41 | 35-39-48.6 | 139-59-12.8 | 1.1 | 051.9 |
| 07:09:02 | 35-39-48.8 | 139-59-13.1 | 0.9 | 057.2 |
| 07:09:41 | 35-39-49.3 | 139-59-13.7 | 0.6 | 059.8 |
| 07:10:41 | 35-39-49.1 | 139-59-14.4 | 0.2 | 070.0 |
| 07:11:41 | 35-39-49.4 | 139-59-13.8 | 0.6 | 274.3 |
| (Skipped) | | | | |
| 07:27:40 | 35-39-49.9 | 139-59-12.4 | 0.1 | 097.4 |

(See Figure 2.1-1, Figure 2.1-2 and Figure 1)

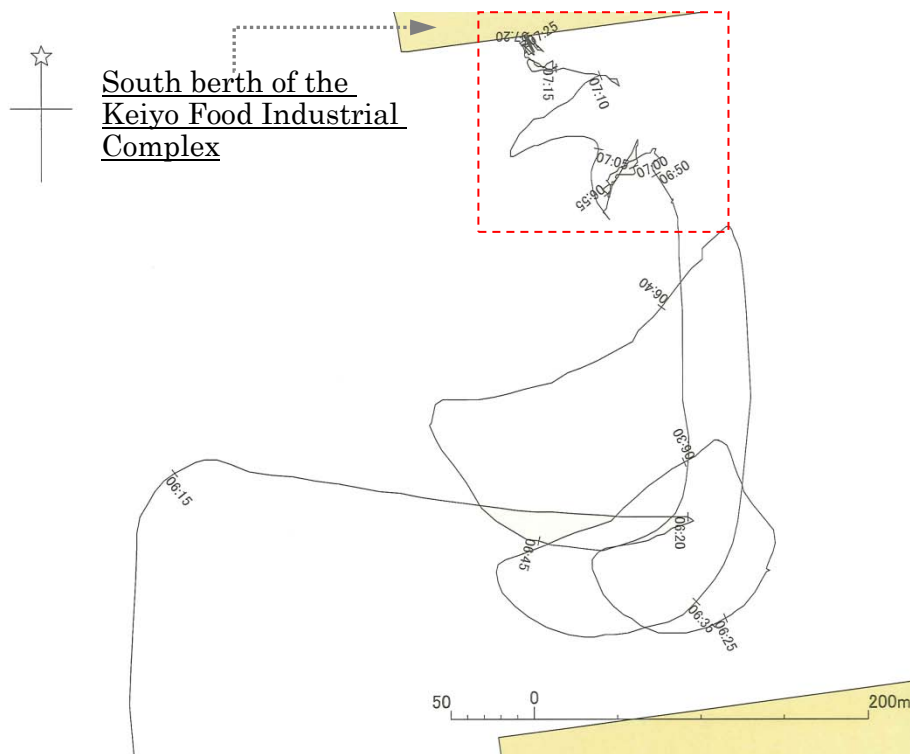


Figure 2.1-1 Vessel track shown by the AIS Records (near the berth) (1)

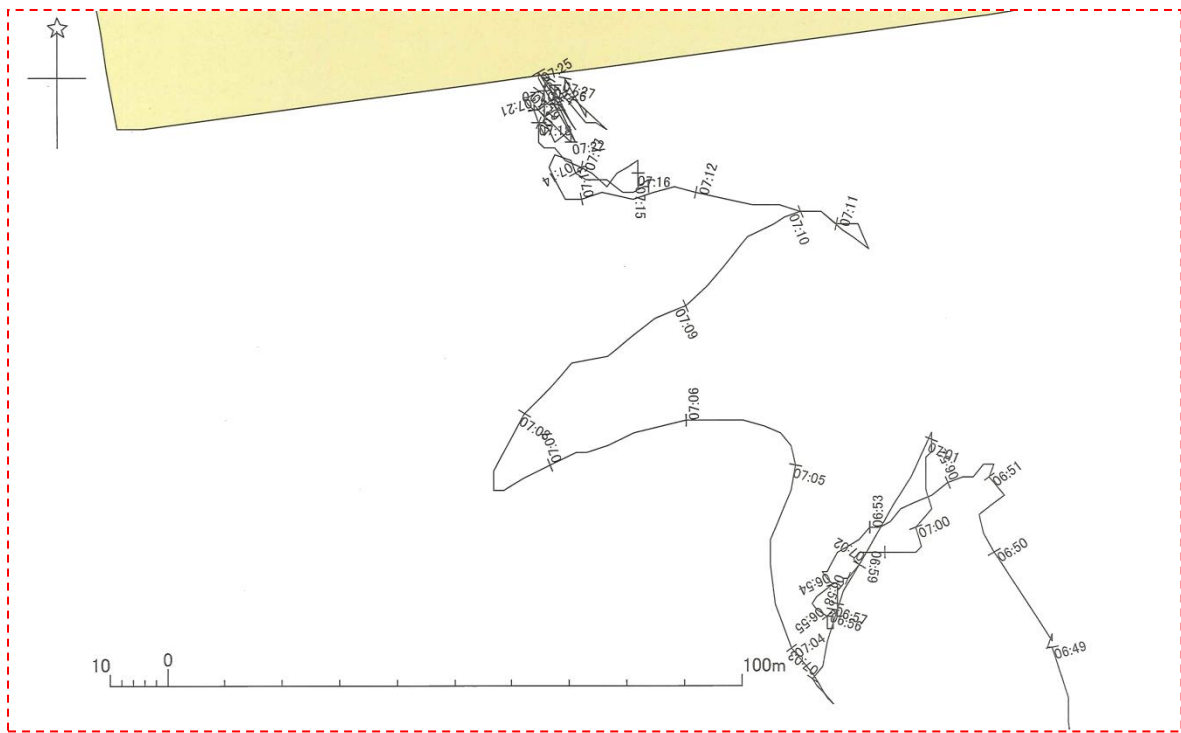


Figure 2.1-2 Vessel track shown by the AIS Records (near the berth) (2)

2.1.2 Images of the Berthing of the Vessel

According to images of the south berth of the Keiyo Food Industrial Complex, Katsunan District, Chiba Port (hereafter referred to as “the Berth”), taken by a fixed camera operated by a weather information company*2, the berthing operation of the Vessel was as follows.

- (1) From around 06:37 to 06:40, the Vessel approached the Berth and then went astern away from the Berth. (See Figure 2.1-3.)

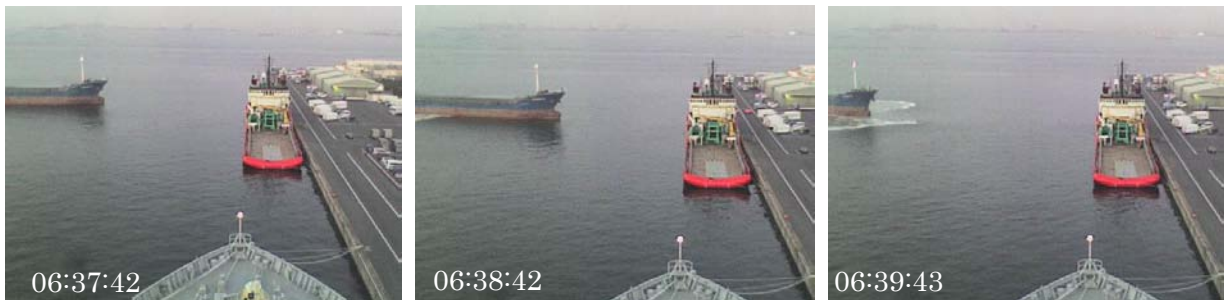


Figure 2.1-3 Images of the Berth (between 06:37:42 and 06:39:43)

*2 The “fixed camera operated by a weather information company” is a camera installed at the upper wheelhouse of the weather observation ship SHIRASE moored at Katsunan District (east of the berth at which the Vessel berthed), Chiba Port. Images are taken once every minute.

(2) From around 06:48 to 06:52, the Vessel approached the Berth again and, after the first mooring line was sent out to the Berth, went astern away from the Berth. (See Figure 2.1-4.)

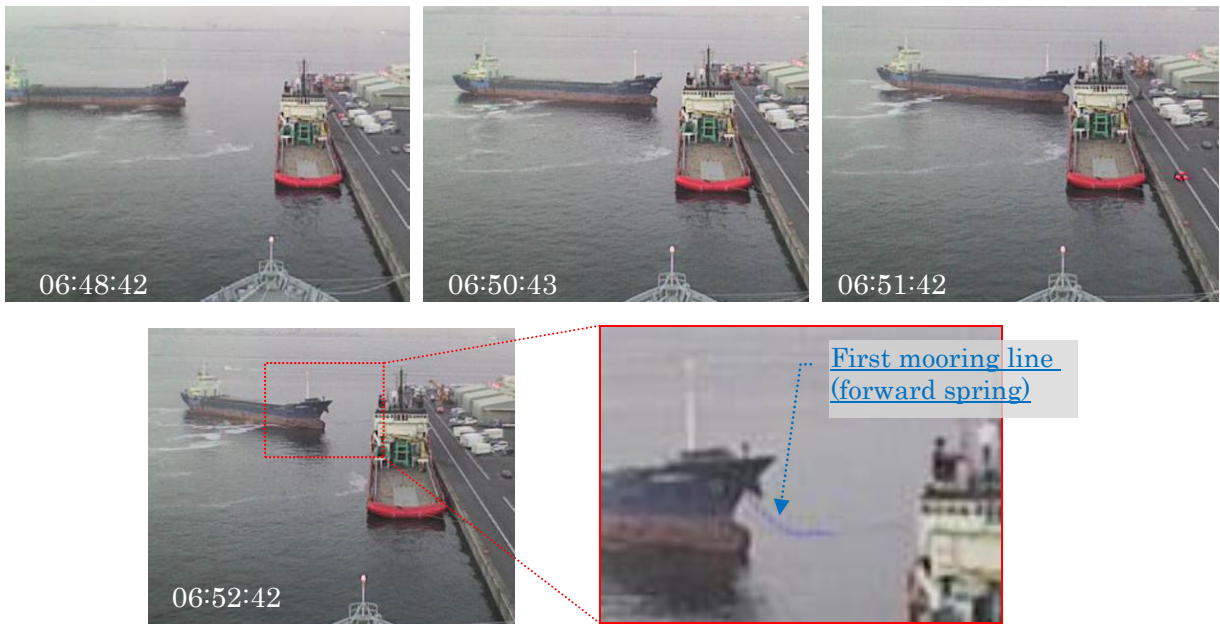


Figure 2.1-4 Images of the Berth (between 06:48:42 and 06:52:42)

(3) From around 06:53 to 06:59, the Vessel kept a distance of 30 meters to 40 meters from the Berth. At around 07:00, the Vessel approached the Berth and the second mooring line was sent out. Then, the Vessel went astern away from the Berth. (See Figure 2.1-5.)

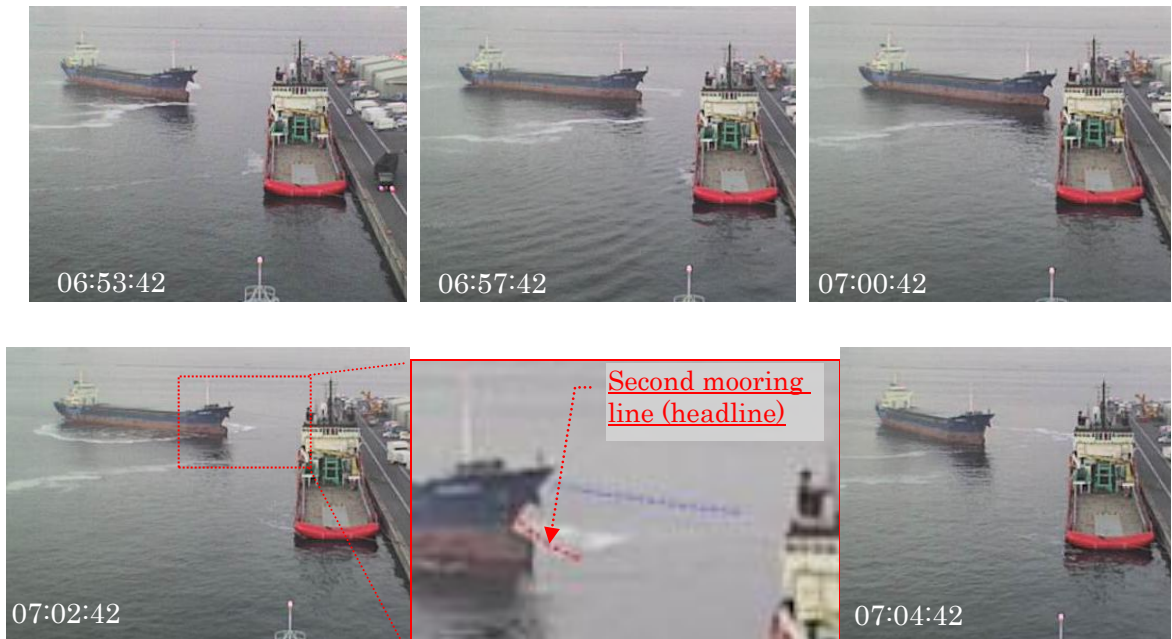


Figure 2.1-5 Images of the Berth (between 06:53:42 and 07:04:42)

(4) At around 07:05, whitecaps occurred around the stern of the Vessel. At 07:07:42, the mooring line sent out from the starboard bow to the Berth became taut. At 07:08:42, the stern of the Vessel came nearer the Berth. (See Figure 2.1-6.)



Figure 2.1-6 Images of the Berth (between 07:05:42 and 07:09:42)

(5) At around 07:27, the Vessel berthed port side alongside at the Berth. (See Figure 2.1-7.)

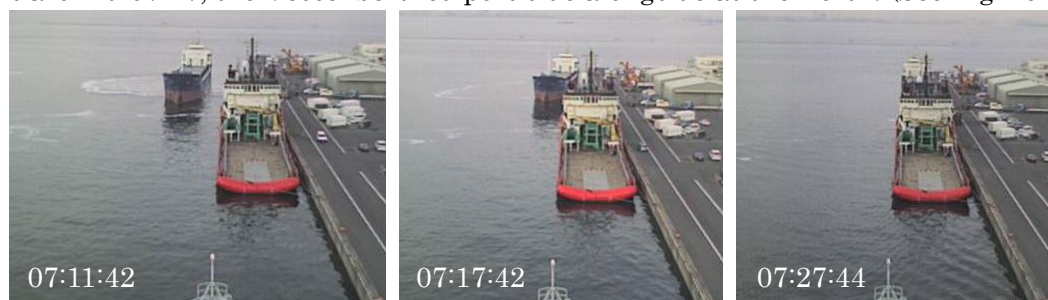


Figure 2.1-7 Images of the Berth (between 07:11:42 and 07:27:44)

2.1.3 Events Leading to the Accident According to the Statements of Crewmembers and others

Events leading to the accident were as follows according to the statements of the Vessel's master (hereafter referred to as "the Master"), a second officer (hereafter referred to as "2/O"), the boatswain, an able seaman on watch duty when the accident occurred (hereafter referred to as "AB A") and the representative of the shipping agent.

(1) Crewmembers

The Vessel, boarded by the Master, an ordinary seaman (hereafter referred to as "OS A") and ten other crew members (nationality : 9 Chinese, 2 Burmese and 1 Indonesian) and left Yingkou Port, China, on December 30, 2011, and berthed at Tokyo District, Keihin Port, on January 6, 2012, to unload approximately 3,150 tons of coke. On January 10, the Vessel left Keihin Port for Chiba Port to load approximately 2,520 tons of scrap. The Vessel anchored off Chiba Port to stand by.

On the following day, January 11, the Master had the crew on standby for entering port. At around from 05:00 to 05:20, 2/O, the boatswain, another able seaman (hereafter referred to as "AB B") and OS A were assigned to the forward station while the Master and AB A

stationed themselves in the wheelhouse to maneuver the Vessel. At around 05:30, the Vessel heaved up anchor and began proceeding to the Berth.

On the forecastle deck, a mooring line was veered out on the deck, and then the hawser drum^{*3} was set on standby with the clutch engaged and the brake released.

The Vessel proceeded Funabashi Fairway and approached the Berth. However, as it was dark, the Vessel went past the intended berthing spot. The Vessel then went ahead and astern repeatedly until it reached near the Berth. However, the Vessel came too close to a work ship moored east of the Vessel's berthing spot (hereafter referred to as "the Moored Ship"). The Vessel then went astern away from the Berth.

The Vessel attempted again to approach the Berth nearly perpendicularly to send out a mooring line. Again, the Vessel came close to the Moored Ship ahead and the engine was put astern. At that time, the crew assigned at the forward station sent out the forward spring^{*4} (hereafter referred to as "the Forward Spring") to the Berth, the first mooring line to be sent out by the forecastle deck crew. Then, the next line, called the first headline^{*5} (hereafter referred to as "the Line") did not reach the Berth easily, forcing the crew to make several attempts unsuccessfully.

The Master ordered AB A to assist in the operation at the forward station, and to return to the wheelhouse after confirming that the Line was secured onto a bitt^{*6}.

On the forecastle deck, 2/O, the boatswain and AB A were near the bow while AB B and OS A were around a stand roller^{*7} at the center of the deck (hereafter referred to as "the Stand Roller"). After the Line was secured onto the bitt, AB B engaged the Line onto the Stand Roller.

The boatswain ordered those at the forward to retreat to the stern side of the forecastle deck: the boatswain and AB B moved to the stern side of the hawser drum, AB A returned to the wheelhouse and OS A moved to the starboard stern side of the forecastle deck. (See Figure 2.1-8 and Figure 2.1-9.)

*3 A "hawser drum" is a rotating drum used to heave up or veer out a mooring line wound around it.

*4 A "forward spring" is a mooring line stretched astern from the bow.

*5 A "headline" is a mooring line stretched ahead from the bow.

*6 A "bitt" is a short iron post typically installed on a berth to secure mooring lines.

*7 A "stand roller" is a roller with a stand installed on a deck to change the direction of a mooring line.

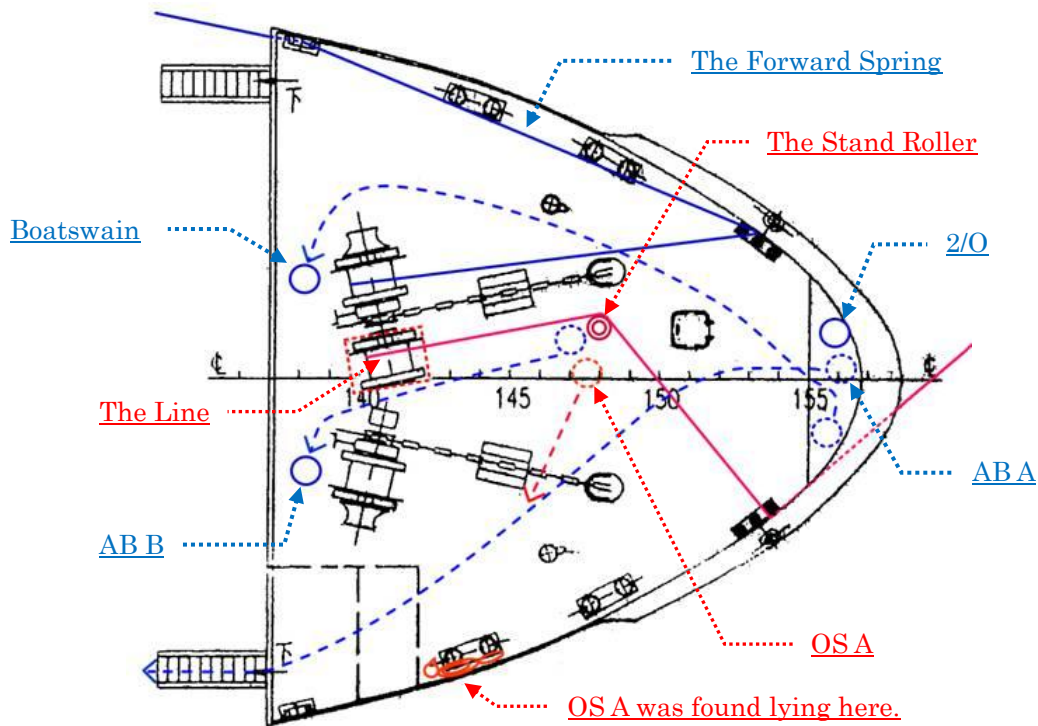


Figure 2.1-8 Crew positions at the forward station when the accident occurred

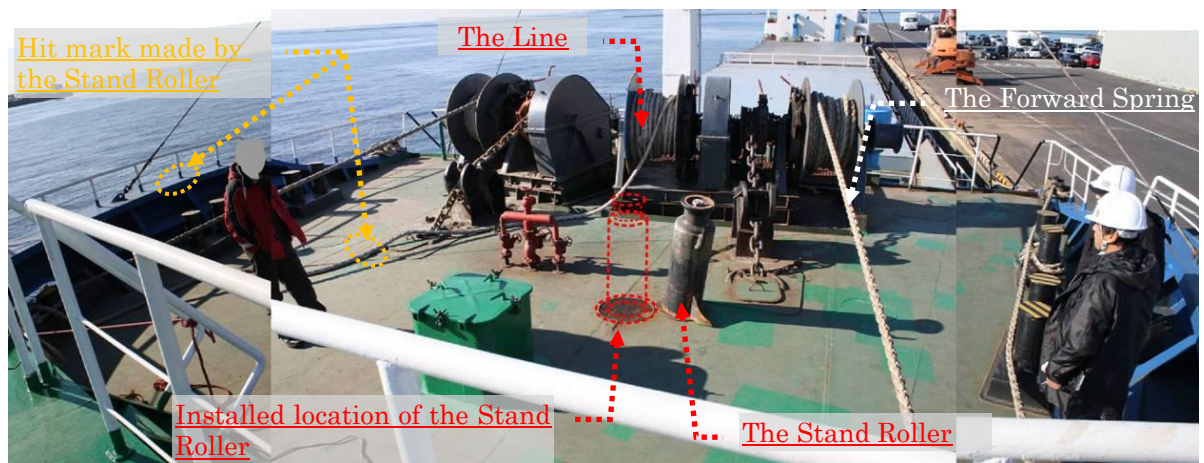


Figure 2.1-9 The forecastle deck

The Master put the engine dead slow astern for about five seconds with the rudder put amidships in an attempt to bring the stern, which was farther away from the Berth, closer to the Berth using the engine, without notifying those at the forward and at the aft station of the maneuver as he thought that would not be necessary because it would last only briefly. This brought the stern of the Vessel closer to the Berth while swinging the bow to the right and farther away from the Berth.

When AB A passed under the Line, he felt that the Line had suddenly become taut. Continuing his trip down the forecastle deck to the wheelhouse, he heard a loud noise that sounded like something had snapped. As he heard nothing after that, he continued the trip and returned to the wheelhouse.

When the Vessel's bow was swung to the right and farther away from the Berth, the Master saw the Line become taut, and saw the Stand Roller come off the deck, fly at about one

to two meters above the deck, land on the starboard forecastle deck, and immediately bounce off the deck, and then fall off the starboard and into the sea.

The crew assigned at the forward station found OS A lying along the starboard bulwark plating on the forecastle deck.

The Master received a report from 2/O requesting an ambulance as OS A had been injured. He called the shipping Agent and the general agent in Japan while continuing with conning the berthing operation until the Vessel berthed.

After the accident, the Stand Roller was retrieved from the sea by the Japan Coast Guard.

(2) Representative of the shipping Agent

At the time of the accident, the representative of the shipping Agent was on standby on the Berth with the manager of the Berth, having erected a flag at the spot on the Berth where the bridge of the Vessel would be aligned when berthed and having had mooring gang stationed near the bitt onto which the Forward Spring, the first mooring line, would be secured.

The representative of the shipping Agent, who had notified the Vessel crew the previous day of the berthing site and that it would be “berth head-in on her port side,” thought that the Vessel crew had misunderstood the instruction as “berth head-out on her starboard side” when he saw the Vessel approaching the Berth at right angles.

With the Vessel positioned almost perpendicularly to the Berth, after sending out the Forward Spring, the Vessel crew attempted a couple of times in vain to send out the Line only to see the heaving line*⁸ fail to reach the Berth each time.

With the Line secured on a bitt on the Berth, when the engine was put astern briefly and the stern was swung to the port side toward the Berth, the representative of the shipping Agent saw the Line become taut and heard a high-pitched metallic sound.

The Vessel berthed at the Berth from 15 to 20 minutes after the metallic sound.

The date and time of occurrence of the accident was at around 07:08 on January 11, 2012, and the location was around 095° (true bearing, hereafter the same), approximately 2.6 nautical miles from the Chiba Port Katsunan Ichikawa lighthouse.

2.1.4 Emergency Services for OS A

According to the statements of the Master and the representative of the shipping Agent, and the written reply to the questionnaire from the City of Funabashi Fire Department, emergency services for OS A were as follows.

(1) The Master and the representative of the shipping Agent

After the Vessel berthed at the Berth, the representative of the shipping Agent joined the Master, who had descended from the wheelhouse, and went to the forecastle deck to check the condition of OS A. At 07:39, they made an emergency ambulance call (Dial 119).

OS A was found lying along the starboard bulwark plating on the forecastle deck, with his head on the stern side and facing the port side. He was breathing with his eyes open. He was not bleeding. He looked pale and did not respond to any calls.

Subsequently, OS A's complexion was backed in his face and was moved from the deck, which was cold, onto a coat spread over a wooden board to wait for the arrival of ambulance

*⁸ A “heaving line” is a long, thin rope tied to the eye of a mooring rope, to be tossed overboard to shore workers for the purpose of sending out the mooring line.

crew. After ambulance crew arrived, he was carried on a stretcher to an ambulance. While he was being lowered from the Vessel, he lost color again.

(2) Emergency Services Organization

At 07:39, the City of Funabashi Fire Department received the emergency ambulance call, and then dispatched a team of emergency services, who arrived at the accident site at 07:54.

The injured crew member (OS A) was lying in the supine position^{*9} on the deck near the bow. He was breathing, but was unconscious and groaning, with froth seen at the mouth. On his way to an ambulance on a cloth stretcher, he started mandibular respiration^{*10} on the accommodation ladder and fell into a state of cardiopulmonary arrest.

The emergency services requested the dispatch of a special emergency services (physician response vehicle) while performing cardiopulmonary resuscitation on OS A in the ambulance, including airway maintenance, artificial respiration, oxygen inhalation and intravenous catheterization.

The special emergency services arrived at the accident site at 08:25. At 08:27, an automatic external heart massage device was used on OS A while at the same time other treatments were administered such as tracheal intubation and injection of medicine.

Following the doctor's advice, the emergency services continued cardiopulmonary resuscitation. At 08:50, they left the site with OS A, the doctor and the special emergency services. At 09:08, OS A was admitted to a medical institution.

2.2 Injuries to Persons

The doctor who had attended to OS A at the medical institution provided the following information.

OS A was already in a state of cardiopulmonary arrest when he was brought in. At 09:10, he was confirmed dead.

OS A was showing symptoms of subcutaneous emphysema^{*11} in the upper part of the body. Computed tomography scan revealed bilateral traumatic hemopneumothorax^{*12} and pneumoderma in the chest and pelvic fracture. OS A died from hemorrhagic shock from bilateral traumatic hemopneumothorax and pelvic fracture.

2.3 Damage to Vessel

(1) The Stand Roller had been welded to the deck along the circumference of the doubling plate and the bracket: the weld between the doubling plate and the deck (hereafter referred to as "the Doubling Plate Circumference Weld") and the weld between the bracket and the deck (hereafter referred to as "the Bracket Weld") were found to have broken. No crack, bend or other damage was found on the Stand Roller or the doubling plate while the bracket was slightly bent at the edge. No bulge or dent was found on the deck where the Stand Roller had been welded.

There were scratch marks on the starboard forecastle deck and the top of the starboard

^{*9} A person in "the supine position" means he/she is lying on his/her back.

^{*10} "Mandibular respiration" is irregular breathing accompanied by vertical motion of the lower jaw, which is a typical sign of transition to death.

^{*11} "Subcutaneous emphysema" is a soft and elastic tumor that results when air is trapped under the skin typically after the skin is hit hard.

^{*12} "Hemopneumothorax" is a state of both pneumothorax and hemothorax existing together at the same time. Pneumothorax is a state of gas trapped in the pleural cavity while hemothorax is a state of blood trapped in the cavity.

bulwark plating.

According to the statement of the Master, those scratch marks were made by the Stand Roller during the accident. (See Figure 2.1-9 and Figure 2.6-1.)

(2) According to the statements of the Master, 2/O and the representative of the shipping Agent, the broken welds of the Stand Roller were shiny with no rust immediately after the accident.

2.4 Crew Information

(1) Gender, Age, and Certificate of Competence

The Master: male, 38 years old

Nationality: People's Republic of China

Documentary proof of application for an endorsement under STCW regulation I/10: master (issued by the Republic of Panama)

Date of issue: November 22, 2011 (valid until February 21, 2012)

OS A: male, 58 years old

Nationality: People's Republic of China

(2) Major Seagoing Experience

1) The Master

According to the statement of the Master, he has the following major seagoing experience.

At the age of 20, he began boarding ships as a crewmember. After graduating from a maritime institute, he first boarded a ship as a third officer. He has been boarding ships as the master for five years, including on ships as large as 5,000 tons.

He has been serving as the master of the Vessel on a 6-month contract since September 26, 2011. He had made a port call at Funabashi (Katsunan District, Chiba Port) several times in the past as the master, but never before on the Vessel.

He was in good health at the time of the accident.

2) OS A

According to the statements of the Master, the boatswain and AB A, OS A had the following major seagoing experience.

OS A also served as a mess man. He had seagoing experience spanning 20 or 30 years, during the entire period of which he was involved in stewardship. On the Vessel, he used to be assigned at the forward station when entering and leaving ports.

At the time of the accident, OS A was wearing separate top and bottom work clothes, a helmet, gloves and other things. After the accident, the helmet was found on the upper deck. He had appeared to be in good health on the day of the accident.

2.5 Vessel Information

2.5.1 Particulars of Vessel

IMO number: 8859029

Port of registry: Panama, the Republic of Panama

Owner: HK LIWEIDA SHIPPING MANAGEMENT LIMITED (hereafter referred to as "Company A") (The Hong Kong Special Administrative Region of the People's Republic of China)

Management company: Company A

Classification society: ISTHMUS BUREAU OF SHIPPING (hereafter referred to as "the

Classification Society^{*13}) (The Republic of Panama)

Gross tonnage: 2,460
L×B×D: 89.85 m × 12.80 m × 7.30 m
Hull material: steel
Engine: one diesel engine
Output: 1,471 kW
Propulsion: one 3-blade fixed pitch propeller
Date of launch: July 1991

2.5.2 Vessel Structure and Conversion

(1) Vessel structure

The general arrangement plans of the Vessel shows that it is an aft-bridge bulk carrier engaged on international voyages, with two cargo holds: from the bow, the No. 1 hold and the No. 2 hold. Above the upper deck at the stern are three decks: the navigation bridge deck, the captain's deck and the boat deck. A forecastle deck is provided above the upper deck at the bow. (See Figure 2.5-1.)

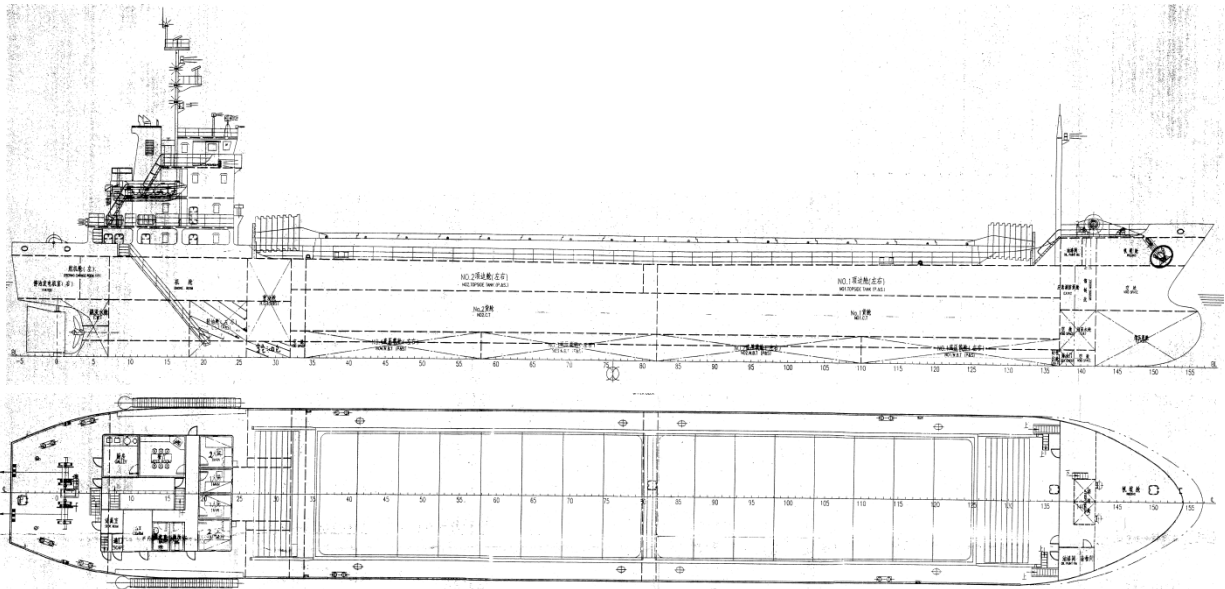


Figure 2.5-1 Side view and upper deck top view of the Vessel

(2) Conversion

- 1) The written reply to the questionnaire from the Ministry of Land, Infrastructure, Transport and Tourism provided the following information.
 - a. The Vessel was originally a domestic vessel (hereafter referred to as “the Pre-Conversion Vessel”) built at a shipyard in Japan (hereafter referred to as “the Shipyard”) and registered in Japan, with a gross tonnage of 495 tons, measuring 63.62 m (L) × 12.80 m (B) × 6.20 m (D).
 - b. The Pre-Conversion Vessel was an aft-bridge carrier of stone, sand and gravel, with one hold in the center. Above the upper deck at the stern were two decks: the navigation bridge deck and the boat deck.

^{*13} A “classification society” is a third-party organization that inspects and certifies hulls, engines and equipment according to international regulations or its own criteria.

- c. The Pre-Conversion Vessel was sold to a company based in the Hong Kong Special Administrative Region of People's Republic of China in May 2008.
- 2) According to the written reply to the questionnaire from Company A, the Vessel underwent conversion from April to October 2008 at a shipyard in Fuan, Fujian Province, China, which included extension of the hull in the middle.

2.5.3 Mooring Equipment on the Forecastle Deck

(1) There were two electrohydraulic broadside windlasses^{*14} on the stern side of the deck. The port windlass was equipped with a hawser drum and a warping end^{*15} on the port side and another hawser drum (hereafter referred to as "the Hawser Drum") on the centerline side. The starboard windlass was equipped with a hawser drum and a warping end on the starboard side.

The hawser drums were driven independently of each other using a disengaging-clutch and were equipped with a manual brake. Mooring lines were released from the top of the drums at a height of about 1.5 meters above the deck.

(2) A fairleads^{*16} were provided at the openings of the bulwark platings on both port and starboard sides of the bow and was also provided on both port and starboard sides on the stern side of the deck. Two pairs of bollards^{*17} were provided, one along the port bulwark platings and the other along the starboard bulwark platings. There were remains of the weld of the Stand Roller about one meter port side from the centerline of the deck.

There also were weld remains at two other spots that looked similar in shape to those of the Stand Roller: one around the center of the port deck and the other around the center of the starboard deck.

(3) The general arrangement plans of the Vessel shows mooring equipment around the center of both the port and starboard sides but no such equipment near the weld remains of the Stand Roller. The general arrangement plans does not show the Hawser Drum, either. The Stand Roller and the Hawser Drum are shown in Figure 2.1-8 and Figure 2.5-2.

(See Figure 2.1-8, Figure 2.1-9 and Figure 2.5-2.)

*14 A "windlass" is deck-equipment generally installed on the bow deck, and is used for anchoring, unanchoring and heaving mooring ropes.

*15 A "warping end" is a rotatable drum in a windlass that winds up ropes using friction.

*16 A "fairlead" is a guide such as a roller used to guide ropes, including mooring ropes, toward an intended direction without damaging the rope.

*17 A "bollard" is a post installed on the deck used for securing mooring ropes. Generally, a pair of two posts is called a "bollard," whereas a single post is called a "bitt."

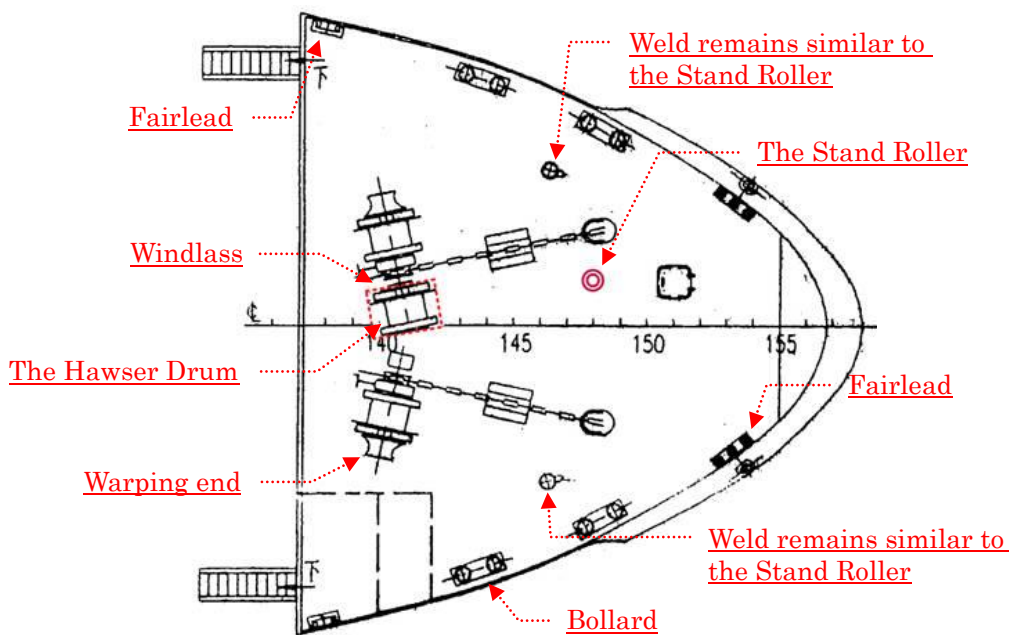


Figure 2.5-2 The Mooring Equipment on the Forecastle Deck

2.5.4 Mooring Line

- (1) The Line was not broken.
- (2) According to the written reply to the questionnaire from the Classification Society, the equipment number^{*18} of the Vessel was 551.751.

According to MSC/Circ. 1175^{*19} issued by the International Maritime Organization, the minimum breaking strength for mooring lines on vessels with an equipment number exceeding 550 but not exceeding 600 is 132 kN.

- (3) According to the written reply to the questionnaire from Company A, the Line was an eight-strand polypropylene filament rope with a diameter of 52 mm, a length of 220 m and a breaking strength of 167 kN.

2.5.5 Other

- (1) In the middle of the wheelhouse stood a console. On the console, the steering wheel and the autopilot were arranged in the center; the radar, the GPS plotter, the AIS equipment and other things. were arranged on the port side; and the engine telegraph, the main engine remote control system, the navigation light control panel and other thing. were arranged on the starboard side.

According to the written reply to the questionnaire from Company A, the main engine revolution table was as follows.

| Speed display | Revolutions per minute (rpm) | Speed (kn) | Speed display | Revolutions per minute (rpm) | Speed (kn) |
|-----------------|------------------------------|------------|------------------|------------------------------|------------|
| Dead slow ahead | 195 | 4.0 | Dead slow astern | 195 | 3.0 |

^{*18} An “equipment number” is a figure calculated based on the vessel’s length, width and depth, the size of the superstructure and other specifications to determine the size, quantity and strength of the anchor, the anchor chain, mooring line, etc. that are to be equipped on the vessel.

^{*19} “MSC/Circ. 1175” refers to the “GUIDANCE ON SHIPBOARD TOWING AND MOORING EQUIPMENT.”

| | | | | | |
|------------|-----|------|-------------|-----|-----|
| Slow ahead | 215 | 6.0 | Slow astern | 215 | 4.0 |
| Half ahead | 235 | 8.0 | Half astern | 235 | 5.5 |
| Full ahead | 255 | 10.0 | Full astern | 255 | 8.0 |

- (2) The GPS receiving antenna was located on the port bow side in the upper part of the wheelhouse.
- (3) With the fairlead at the opening of the port bulwark plating on the stern side of the deck, one of the three rollers was missing.
- (4) According to the statement of the Master, the Vessel was in ballast when it entered Chiba Port, with the draught of about 1.5 meters bow and about 3.1 meters stern. The propeller's direction of rotation was clockwise.

2.5.6 Inspection Under the Port State Control

According to the written reply to the questionnaire from the Ministry of Land, Infrastructure, Transport and Tourism, the Vessel was inspected and controlled by port state control officers of the maritime administration after the accident. The action led to an order for compliance with technical standards in the fire-extinguishing system and rectification orders for 12 deficiencies including in the Stand Roller, the mooring equipment, the statutory certificate, the weather-tight condition and the ISM code.

2.6 Installation of the Stand Roller

2.6.1 The Stand Roller

(1) Dimensions and figure of the Stand Roller

- 1) The Stand Roller consists of a cylindrical stand and the roller fitted on the top of the stand. The stand was installed on the doubling plate that had been welded on the deck, and had a bracket. The doubling plate was a disc.
- 2) The safe working load*²⁰ (SWL) has not been displayed on the Stand Roller. The roller was not fixed ; therefore, was able to be rotated by hand.
- 3) Some of the measurements of the Stand Roller are as follows.
 - a. Various measurements: shown in Figure 2.6-1
 - b. Thickness of the doubling plate: about 10 mm
 - c. Thickness of the bracket: about 12.5 mm
 - d. Inclination of the stand: about 13° towards the bracket

*²⁰ A "safe working load" (SWL) corresponds to 80% or less of the design load of a mooring device. Vessels of 500 tons or more that started to be constructed on or after January 1, 2007, and are engaged on international voyages must have it indicated on the device with a weld bead or by other similar means.



Figure 2.6-1 The Stand Roller

(2) Weld remains of the doubling plate and the bracket

The weld remains of the doubling plate were almost continuous while missing in some parts, forming a circle of inverted “V” protrusions. The weld remains of the bracket were left on the bow direction. The width of the weld remains was measured, and was as shown in Figure 2.6-2. The highest point of the weld remains was about 6 mm high.

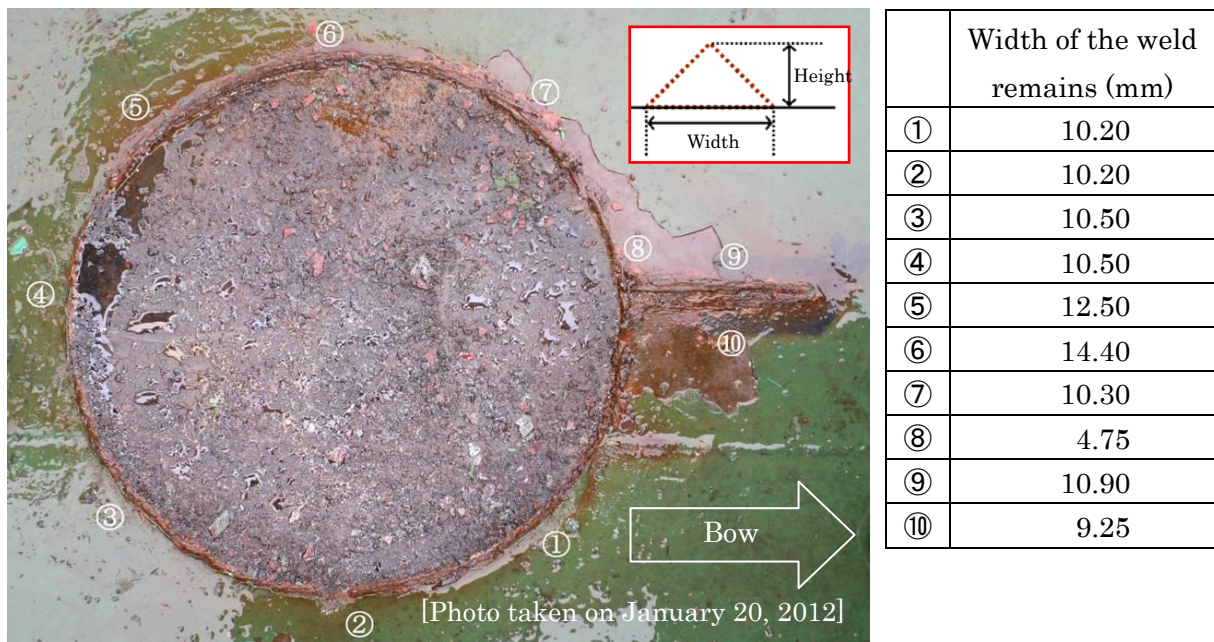


Figure 2.6-2 Measurements of the weld remains

(3) Installation of the Stand Roller

- 1) According to the statement of the Master, the Stand Roller was already there when he boarded the Vessel. He had never received reports of problems with the Stand Roller from other crewmembers, neither had he thought anything was wrong with the Stand Roller. However, he was not comfortable with the fact that the location of the Stand Roller was different from that shown in the general arrangement plan.
- 2) The written reply to the questionnaire from Company A provided the following information.
 - a. In 2011, Company A had one of the two stand rollers located around the centers of the port and starboard sides of the forecabin deck moved to a new location (the location of the Stand Roller) near the centerline of the deck.
 - b. Company A had no information about the reason for the relocation or by whom and how it was carried out, as the person in charge of the Vessel's maintenance at the time of the relocation had left the company and no documents about the relocation work remained. Incidentally, Company A had not been commissioning minor pieces of work to shipyards or repair companies to retrench expenses.

2.6.2 Regulations on Mooring Equipment

The MSC/Circ. 1175 and the IACS*²¹ unified requirement (UR A2) stipulate the required strength for shipboard fittings used for mooring operations and their supporting hull structures. Under the requirement, vessels of 500 tons or more that were constructed on or after January 1, 2007, and are engaged on international voyages must have a design load of whichever is greater among the two values listed below for shipboard fittings used for mooring operations and their supporting hull structures.

*²¹ The "IACS" (International Association of Classification Societies) is an international organization having major classification societies as its members. It formulates the Unified Requirement (UR) for member societies and Unified Interpretation (UI) for application to international treaties.

- (1) 1.25 times the intended maximum working load
- (2) 1.25 times the breaking Strength of the mooring line determined by the ship's equipment number

In addition, the design load for shipboard fittings used for mooring operations and their supporting hull structures must take into account the resultant force of the design load (1.25 times the breaking Strength of the mooring line determined by the ship's equipment number) acting in the tensile direction of the mooring line.

2.6.3 Survey and Approval by the Classification Society

The written reply to the questionnaire from the Classification Society and the cargo ship safety construction certificate of the Vessel provided the following information.

- (1) In 2009, the Vessel was surveyed for the conversion and approved by the Classification Society. The Vessel met the IACS unified requirement for mooring equipment and, after the major conversion, the requirements had been applied to the Vessel as constructed on June 1, 2008.
- (2) The stand rollers on the forecastle deck that had been approved by the Classification Society (hereafter referred to as "the Approved Stand Rollers") were located around the centers of the port and starboard sides of the deck. They both had a design load of 202 kN and an SWL of 162 kN. They both were fitted with a circular doubling plate and a bracket extending to the bow.
- (3) The Approved Stand Rollers had a bracket extending to the bow because these rollers were intended largely for guiding forward springs through the fairleads on the stern port and starboard sides of the forecastle deck to the shore. Their design load of 202 kN was intended to counter the force acting in the stern direction.
- (4) One of the Approved Stand Rollers had been relocated by Company A to become the Stand Roller without any knowledge or approval by the Classification Society.

2.6.4 General Installation Method of a Stand Roller and Remarks on the Installation of the Stand Roller

- (1) The following information was provided by staff in charge of outfitting at a domestic shipyard and staff in charge of construction and maintenance at a domestic ship management company.

1) General installation method of a stand roller

Installation of a stand roller is normally accompanied by one or more of the following reinforcement works.

a. Reinforcement of the deck

The deck is reinforced by carlings, i.e. by installing girder reinforcements under the deck, inserting steel plates in the deck, or installing a doubling plate on the deck.

A doubling plate typically has a hole in the center. Its inner and outer peripheries are welded onto the deck, after which a stand roller is welded from above onto the plate.

b. Brackets

At least four brackets should be installed in the directions of forward, rearward, left and right. The length of the contact portion of the cylindrical stand and bracket should be sufficiently long ; more over, a doubling plate should be provided between the bracket and the deck to counter the concentration of stress.

c. Shape of the stand roller

The height of the stand roller should be minimized by veering out the mooring line from the bottom of the hawser drum or by installing the stand roller as close to the fairlead as possible.

If the height of the stand roller cannot be sufficiently reduced, the stand should be shaped not like a cylinder but like a cone to maximize the area of contact with the deck to disperse load.

2) Remarks on the installation of the Stand Roller

- a. The height of the bracket welded on the bow side of the Stand Roller appears too short relative to the height of the roller.
- b. With the doubling plate being 10 mm thick, the weld leg length^{*22} should be 6 to 7 mm. However, the weld remains of the doubling plate suggest that the weld leg length was too short and that the throat thickness^{*23} of the fillet weld^{*24} was not sufficient.
- c. If a piece of mooring equipment that has been properly installed is subjected to load exceeding its strength, typically, the weld between the equipment and the deck will not break, but instead the deck will be lifted or bent while the weld remains intact.
- d. The Stand Roller may not have been properly evaluated for strength or installed by skilled workers. It may have been installed by the crewmembers of the Vessel while anchored or on voyages without being brought into dock.

(2) The following information was provided by the representative of the Shipyard.

- 1) Doubling plates would be welded after making a hole in their center or slots in them. Brackets would be provided in four directions around the stand roller as it is subjected to substantial lateral load. (See Figure 2.6-3.)

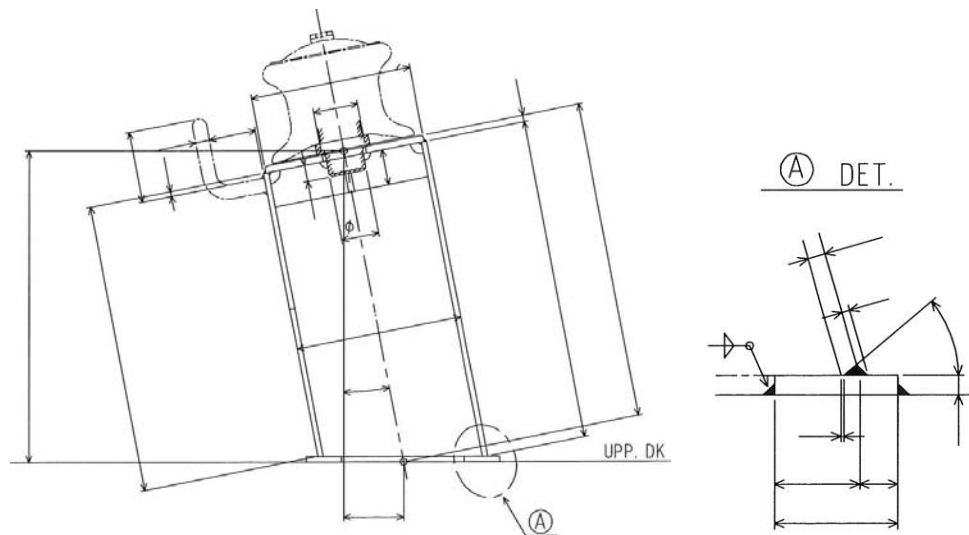


Figure 2.6-3 Example of stand roller installation

^{*22} The “weld leg length” is the distance between the point where the two fillet-welded base metals meet and the toe of the fillet weld (the point where the face of the weld and the base metal meet).

^{*23} The “throat thickness” is the shortest distance between the point where the two fillet-welded base metals meet and the face of the weld.

^{*24} The “fillet weld” is made on two base metals arranged almost perpendicular to each other, such as a lap joint, T joint and corner joint, and has a triangular cross section.

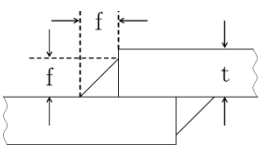
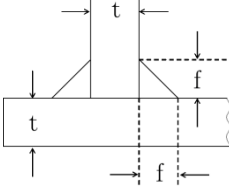
2) The Stand Roller may be a reutilization of one of the original stand rollers from the Pre-Conversion Vessel as it resembles the original rollers in shape, including the arm. The original stand rollers were made using rollers made by contractors and pipes for the stand that were purchased and had the appropriate outer diameter and thickness for the roller.

2.6.5 Weld leg length

(1) According to some reference^{*25}, it is as follows.

This report presents leg length standards based on the thickness of outfitting metals on the assumption that practically sufficient strength can be ensured without calculation based on certain appropriate leg length standards.

Shown below is a table (excerpt) of leg lengths based on base metal thickness. Leg length f_0 should be 7 mm when the base metal thickness is 10 mm for outfits including stand rollers and other anchoring and mooring equipment that are subjected to great external force during use.

| | | | | |
|-------------------------------------|---|-------|---|--|
| Types and dimensions of fillet weld |  | |  | |
| | Lap joint | | T joint | |
| Base metal thickness t | Leg length f (continuous weld) [Unit: mm] | | | |
| | f_0 | f_1 | f_2 | |
| 8 | 6 | 5 | 4 | |
| 9 | 7 | 6 | | |
| 10 | 8 | | 5 | |
| 11 | | | | |
| 12 | | | | |

f_0 : Applicable to outfits subjected to substantial external force during use

f_1 : Applicable to general outfits and their weld assemblies that are not subjected to external force during use but require consideration against such as external force and vibration caused by ocean waves

f_2 : Applicable to outfits barely subjected to external force

(2) According to another reference^{*26}, it is as follows.

Outfitting

2.2 Fillet weld leg length (continuous welding)

While weld leg lengths for members requiring strength should follow design criteria, the following table can serve as a general guide.

| | | | | | | |
|--|------------------------|---|---|-----|-----|----|
| Base metal thickness t (mm) | 5 or less | 6 | 7 | 8 | 9 | 10 |
| Installation of fairlead, bollard or stand | Leg length (f) 4 mm | 5 | 5 | 5.5 | 6.5 | 7 |

^{*25} Outfitting Welding Guidelines (Leg Length Standards), Issues 611 and 618 of the Bulletin of the Society of Naval Architects of Japan, 1980

^{*26} Correspondence Course Text on Shipbuilding – Outfitting, (Currently) The Cooperative Association of Japan Shipbuilders, 2000

As indicated above, the leg length for base metals 10 mm in thickness should be 7 mm for fairleads, bollards and other mooring equipment and stands.

2.7 Safety Management

2.7.1 Document of Compliance

The document of compliance issued to Company A by the Classification Society and the safety management certificate issued to the Vessel by the Society show that Company A has a safety management system in place and complies with the requirements of the International Safety Management (ISM) Code for “other cargo ships.”

2.7.2 Safety Management Manual

The safety regulation for ship berthing and unberthing in the safety management manual of Company A covers command and communication, which can be summarized as follows:

- (1) The operation of mooring line shall be carried out according to the orders of the master.
- (2) The chief officer shall be in charge of the command and safety supervision of the forward station, and the second officer shall be in charge of the command and safety supervision of the stern station.
- (3) Tune up the frequency of transceivers before operation, and keep in touch among fore, stern and bridge free in order to operate in cooperation.
- (4) The crewmembers involved these operations shall stand in the correct positions but not inboard of mooring line stretch direction or above the line.

2.7.3 Language Onboard

According to the statement of the Master, Chinese was used among the Chinese crewmembers while English was used among the chief officer (hereafter referred to as “C/O”), the chief engineer, both of whom were Burmese, and the second engineer (hereafter referred to as “2/E”), an Indonesian. Most of the crewmembers on board were able to speak the minimum level of English required to work on the Vessel.

2.7.4 Berthing Operation

(1) Station assignment

According to the statement of the Master, the station assignment was as follows.

- 1) The Master and AB A were stationed at the wheelhouse, 2/O, the boatswain, AB B and OS A were stationed at the forward station, C/O, the chief engineer, 2/E and a motorman were stationed at the aft station, and a third engineer and another motorman were stationed at the engine room.
- 2) Normally, a chief officer is stationed at the forward station to take command there. The practice on the Vessel, however, had been, even before the Master came on board, that Chinese crewmembers were stationed at the forward station while those of other nationalities were stationed at the aft station to help overcome language problems.

(2) Roles of those stationed at the forward station

According to the statements of the Master and the boatswain, the roles were as follows:

- 1) 2/O took command at the forward station while other crewmembers, who had not been given specific assignments, operated at their own discretion. The hawser drums were operated by the boatswain and AB B under the Master’s directions.

2) Communication among the crewmembers was maintained by the Master at the wheelhouse, 2/O at the forward station and C/O at the aft station with transceivers among them.

(3) Mooring plan

1) According to the statements of the Master and the boatswain, the mooring plan was as follows.

The Vessel would berth head-in on her port side while mooring lines would be slackened as follows, as would normally be done at other ports as well: a forward spring, the Line and the second headline would be slackened from the forecastle deck, and then an aft spring and two stern lines would be slackened from the quarter deck.

The Line was slackened from the Hawser Drum, around the Stand Roller, and then through a fairlead at the starboard bow to the Berth.

2) The Line had to be guided around the Stand Roller because it would have interfered with the drum flange if it had been slackened from the Hawser Drum directly to either of the fairleads on the port and starboard sides of the bow.

2.8 Weather and Sea Conditions

2.8.1 Weather and Tide Data

(1) Weather observations

Observations around the time of the accident by the Funabashi Regional Meteorological Observation Station located about 7.2 km northeast of the site of the accident were as follows:

At 07:00 – wind direction: NW, wind velocity: 1.2 m/s, temperature: 1.9°C

At 07:10 – wind direction: NNW, wind velocity: 1.3 m/s, temperature: 2.2°C

At 07:20 – wind direction: NNW, wind velocity: 1.6 m/s, temperature: 2.4°C

(2) Tide

According to tide tables published by the Japan Coast Guard, it was high tide in Funabashi at the time of the accident and the rise of the tide was about 1.8 meters.

(3) Time of sunrise

According to lunisolar rise/set time calculations provided on the website of the Hydrographic and Oceanographic Department of the Japan Coast Guard, the time of sunrise around the site of the accident on the day of the accident was 06:50.

2.8.2 Observations by Crewmembers and others

(1) According to the statement of the Master, it was cloudy with a N to NNE wind of force 3.

The sea was very calm, with the weather and sea conditions not affecting vessel maneuvering in any way.

(2) According to the statement from the representative of the shipping Agent, wind was negligible apparently measuring less than 5 m/s. The sea appeared calm with no significant waves.

2.9 Calculations of the Strength and Weld Rupture of the Stand Roller

With cooperation from the National Marine Research Institute, the following calculations were made on the strength and weld rupture of the Stand Roller.

2.9.1 Conditions for Calculations

(1) Calculations were based on the shapes and dimensions measured on the Stand Roller, the

doubling plate and the bracket during the on-site investigation.

- (2) It was assumed that the stand portion of the Stand Roller was made of STPG410^{*27} Schedule 40 steel to Japanese Industrial Standard (JIS) G3454 (outer diameter 318.5 mm, thickness 10.3 mm) and that the doubling plate was made of SS400^{*28} steel to JIS G3101.
- (3) Based on the descriptions in 2.6.5, it was assumed that the leg length for the Doubling Plate Circumference Weld and that for the weld between the bottom of the stand and the doubling plate (hereafter referred to as “the Stand Bottom Weld”) had been 6 mm, 7 mm and 8 mm, with 7 mm being the standard, and that the leg length for the Bracket Weld had been 7 mm, 8 mm and 9 mm, with 8 mm being the standard, on the assumption that the cross section of the fillet weld had been shaped in a right-angled isosceles triangle.

2.9.2 Calculation of Breaking Strength in Assumed Ductile Fracture Mode

Assuming that the Stand Roller broke in a mode of ductile fracture^{*29}, strength calculations were made using the beam theory, which is normally used for standard outfits.

Given that a mooring line was tensioned at about 120° at the Stand Roller, it was assumed based on the equilibrium condition of forces that the horizontal force and the tensile force of the mooring line that acted on the roller were equal to each other. In addition, it was assumed that the horizontal force was acting at about 110° relative to the bow.

The following formula was used to express the conditions for weld rupture.

$$\sigma_{eq} = (\sigma^2 + 3\tau^2)^{1/2} \geq \sigma_B$$

where σ_{eq} = equivalent stress, σ = bending stress, τ = shearing stress and σ_B = tensile strength. (See Figure 2.9-1.)

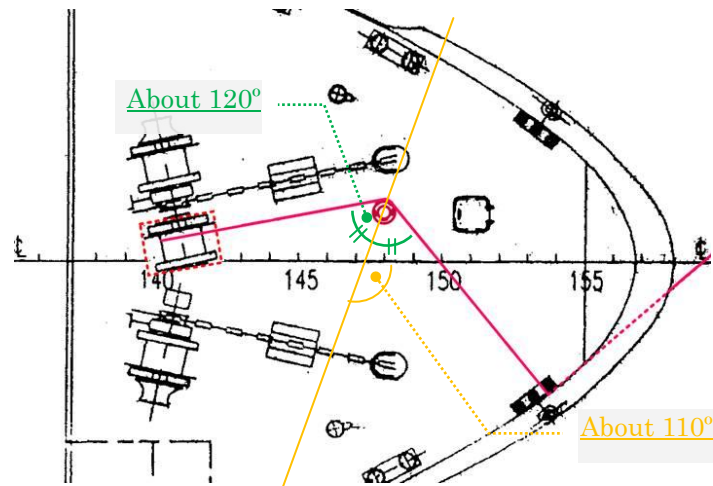


Figure 2.9-1 Direction of the horizontal force acting on the roller relative to the bow

- (1) Calculation of breaking strength without the bracket installed

1) The Stand Bottom Weld

Assuming that the Doubling Plate Circumference Weld would not break, the fillet weld on the stand bottom was estimated to break with a tensile force of 185 kN or more on the

^{*27} “STPG410” is a type of carbon steel tubes for pressure service of 410 N/mm² or more.

^{*28} “SS400” is a type of rolled steels for general structure of 400 to 510 N/mm² or more.

^{*29} “Ductile fracture” is caused when tensile force is applied and is accompanied by plastic deformation such as elongation and contraction.

mooring line if the weld leg length was 7 mm, as shown in Table 2.9-1.

Table 2.9-1 Breaking Strength on the Stand Bottom Weld (without the bracket)

| Tensile strength [N/mm ²] | Weld leg length [mm] | Tensile force of mooring line at rupture [kN] | Stress at rupture [N/mm ²] | |
|---------------------------------------|----------------------|---|--|-----------------|
| | | | Bending stress | Shearing stress |
| 410 | 8 | 212 | 405 | 37 |
| | 7 | 185 | 405 | 37 |
| | 6 | 158 | 405 | 37 |

2) The Doubling Plate Circumference Weld

Assuming that the Stand Bottom Weld would not break, the fillet weld on the doubling plate circumference was estimated to break with a tensile force of 393 to 501 kN on the mooring line if the weld leg length was 7 mm, as shown in Table 2.9-2.

Table 2.9-2 Breaking Strength on the Doubling Plate Circumference Weld (without the bracket)

| Tensile strength [N/mm ²] | Weld leg length [mm] | Tensile force of mooring line at rupture [kN] | Stress at rupture [N/mm ²] | |
|---------------------------------------|----------------------|---|--|-----------------|
| | | | Bending stress | Shearing stress |
| 400 to 510 | 8 | 450 to 574 | 390 to 497 | 53 to 67 |
| | 7 | 393 to 501 | 390 to 497 | 53 to 67 |
| | 6 | 337 to 429 | 390 to 497 | 53 to 67 |

3) The results in 1) and 2) above suggest that the fillet weld on the stand bottom is more likely to break at a lower load than the fillet weld on the doubling plate circumference, i.e. the Stand Bottom Weld is more likely to break before the Doubling Plate Circumference Weld.

(2) Calculation of breaking strength with the bracket installed

1) Table 2.9-3 shows a scenario in which a bracket is installed in the bow direction and the fillet weld on the doubling plate circumference breaks first. φ denotes the angle measured anticlockwise from the point facing the bow at which the maximum stress occurred. The maximum stress was observed at an angle of 77.9° – 80.0°, indicating that the bracket installed in the direction of the bow did not effectively counter the bending moment.

Table 2.9-3 Breaking Strength on the Doubling Plate Circumference Weld (with the bracket)

| Tensile strength [N/mm ²] | Leg length of the Doubling Plate Circumference Weld [mm] | Leg length of the Bracket Weld [mm] | Angle ϕ of max. stress [deg] | Tensile force of mooring line at rupture [kN] | Stress at rupture [N/mm ²] | |
|---------------------------------------|--|-------------------------------------|-----------------------------------|---|--|-----------------|
| | | | | | Bending stress | Shearing stress |
| 400 | 8 | 9 | 78.9 | 502 | 392 | 46 |
| | | 8 | 78.4 | 499 | 392 | 47 |
| | | 7 | 77.9 | 496 | 391 | 48 |
| | 7 | 9 | 79.4 | 441 | 392 | 45 |
| | | 8 | 78.9 | 439 | 392 | 46 |
| | | 7 | 78.4 | 436 | 392 | 47 |
| | 6 | 9 | 80.0 | 380 | 393 | 44 |
| | | 8 | 79.5 | 378 | 392 | 45 |
| | | 7 | 79.0 | 376 | 392 | 46 |

2) Based on the data in Table 2.9-3, the tensile force of a mooring line at which the fillet weld on the doubling plate circumference would break first among all the welds is calculated as 439 kN assuming that the leg length of the Doubling Plate Circumference Weld and that of the Bracket Weld are the standard values. Figure 2.9-2 shows the corresponding stress changes when such breakage occurs on the Doubling Plate Circumference Weld.

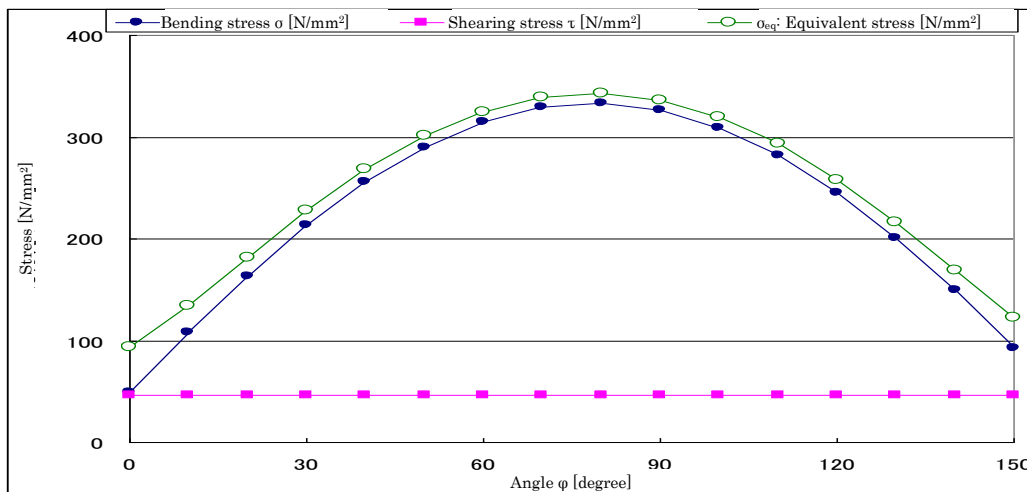


Figure 2.9-2 Stress Changes on the Doubling Plate Circumference Weld

(3) Possibilities of rupture at places other than the Doubling Plate Circumference Weld

Places other than the Doubling Plate Circumference Weld were assessed for strength against possible rupture. For this assessment, Cross Section N₁ – N₂ (which includes the weld at the upper end of the bracket) and Cross Section N₃ – N₄, both shown in Figure 2.9-3, were chosen. For the assumption described in (2) 2) above to be valid, it must be verified that those cross sections will not break with the tensile force of a mooring line indicated in (2) 2).

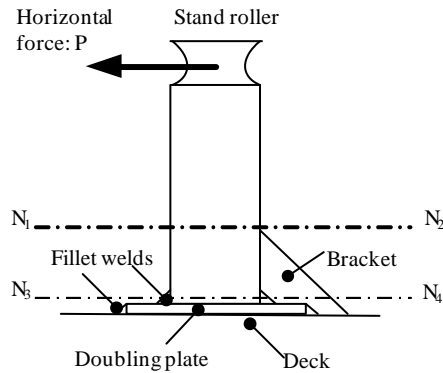


Figure 2.9-3 Places other than the Doubling Plate Circumference Weld that can possibly break

The stresses on Cross Section $N_1 - N_2$ and Cross Section $N_3 - N_4$ were calculated as follows:

- 1) Assuming that Cross Section $N_3 - N_4$ would not break, the equivalent stress on Cross Section $N_1 - N_2$ would reach the maximum value of about 611 N/mm^2 with a tensile force of 439 kN on the mooring line, which exceeds the tensile strength 410 N/mm^2 of the stand. This indicates that Cross Section $N_1 - N_2$ would break before the Doubling Plate Circumference Weld.
 - 2) Assuming that Cross Section $N_1 - N_2$ would not break, the equivalent stress on Cross Section $N_3 - N_4$ (leg length 7 mm on the Stand Bottom Weld) would reach the maximum value of about 823 N/mm^2 with a tensile force of 439 kN on the mooring line. This indicates that Cross Section $N_3 - N_4$ would break before the tensile force of a mooring line reaches 439 kN .
- (4) Consideration from the calculation results
- 1) The results described in (3) above are basically the same as the descriptions in (1) above. Both show that the weakest point differs between those scenarios and the accident in which the stand and the doubling plate broke in a single welded unit from the deck.
 - 2) The discrepancy between those scenarios and the accident in the mode of rupture suggests that the Stand Roller did not break in a mode of ductile fracture of the fillet weld as assumed in the calculations. This is also supported by the fact that the doubling plate and the deck showed few signs of permanent (plastic) deformation.

2.9.3 Calculation of Breaking Strength in Assumed Brittle Fracture (Low Stress Fracture) Mode

Assuming that the Stand Roller broke in a mode of brittle fracture^{*30}, in which the root of the fillet weld cracked and the cracks spread across the throat, the conditions for that to lead to fracture can be expressed as follows:

$$\text{Stress intensity factor}^{*31} \geq \text{Fracture toughness value}^{*32} \text{ [N/mm}^{1.5}\text{]}$$

(1) Calculation of stress intensity factor

- 1) Stress intensity factors were calculated with reference to the handbook^{*33}, substituting an

^{*30} In "brittle fracture," a solid material cracks under load with little deformation and, as the cracks spread, eventually breaks.

^{*31} "Stress intensity factor" is a value used to represent the intensity of stress distribution gradient (stress state) near the tip of a crack. It is normally used as a reference to predict the occurrence of brittle fracture.

^{*32} "Fracture toughness value" is an index that represents the strength of a material containing a cutout.

^{*33} "Handbook" refers to "Hiroshi Tada: The Stress Analysis of Cracks Handbook 2nd edition, Paris Productions Inc. St. Louis, Missouri, 1985."

existing model regarding the fillet weld roots as cracks as outlined in Figure 2.9-4. Where the weld leg length of the stand bottom and that of the doubling plate circumference are 7 mm and the tensile force on a mooring line is 167 kN (which is the breaking strength of the Line), the calculation results of stress intensity factor for the fillet weld root are shown in Table 2.9-4.

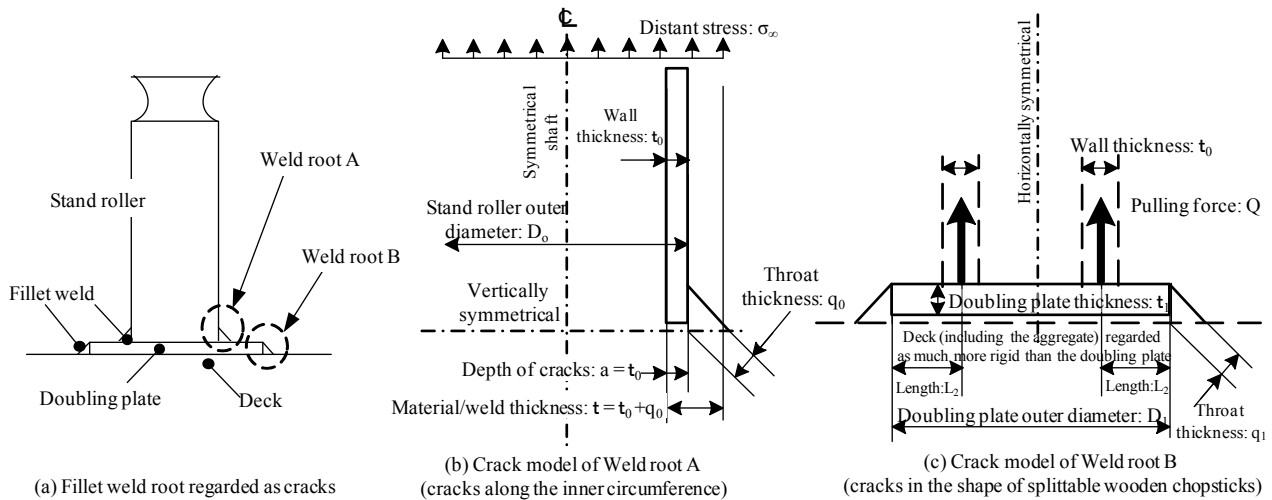


Figure 2.9-4 Crack models of fillet weld roots

Table 2.9-4 Stress intensity factors

| | Stress intensity factor [N/mm ^{1.5}] |
|---------------------------------------|--|
| The Stand Bottom Weld | 1,318 |
| The Doubling Plate Circumference Weld | 3,817 |

2) The results show that, with the same tensile force of 167 kN on a mooring line, the fillet weld root of the doubling plate circumference has a greater stress intensity factor than that of the stand bottom. This suggests that the fillet weld root of the doubling plate circumference can develop rapid fracture, which matches the actual fracture observed in the accident.

(2) Calculation of fracture toughness value

1) Fracture toughness values are calculated using empirical formulas based on correlation with Charpy impact values^{*34}. The Charpy impact values used for the calculation were taken from reports published by (Currently) the Japan Ship Technology Research Association. In addition, the master curve concept of Charpy transition characteristics was used.

The relationship between the temperature of the fillet weld and the Charpy impact values is shown as a solid line in Figure 2.9-5. The vertical axis represents Charpy impact values while the horizontal axis represents temperature. The origin of the horizontal axis was set at 15°C.

*34 The “Charpy impact value” provides a measure of a material’s toughness; it is the energy required to break a notched test piece using a hammer impact divided by its cross-sectional area. The higher this value, the tougher the material.

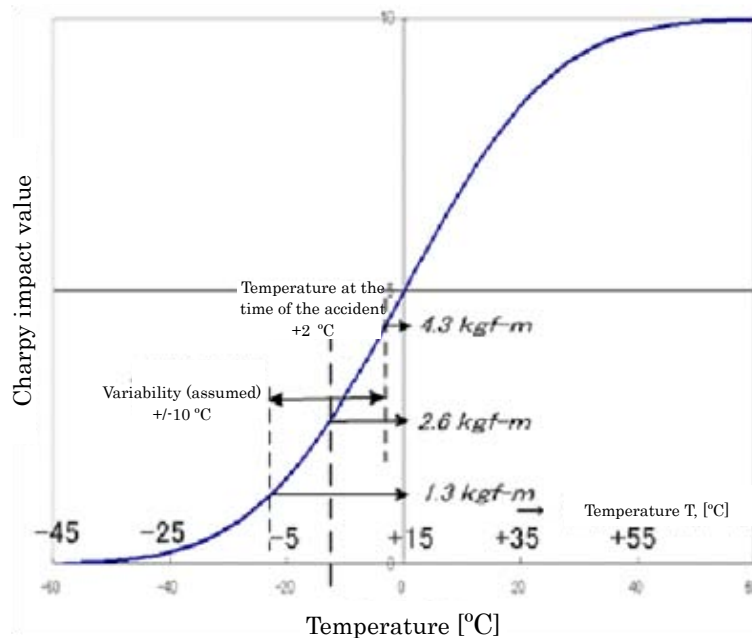


Figure 2.9-5 Relationship between the temperature of the fillet weld and Charpy impact value

2) As shown in Figure 2.9-5, the Charpy impact value was estimated at 25.5 N·m (2.6 kgf·m) at the temperature (about 2°C) at which the accident occurred. With an assumed variability of +/-10°C factored in, the Charpy impact value was then estimated at 12.7 to 42.1 N·m (1.3 to 4.3 kgf·m).

Fracture toughness values can be estimated based on those Charpy impact values. Then, with reference to stress intensity factors described in (1) 1), the tensile force of a mooring line at which brittle fracture occurs can be calculated. The calculated values are shown in Table 2.9-5. Based on the results, it is estimated that the Stand Roller broke at a tensile force of about 106 kN on the Line.

Table 2.9-5 Fracture toughness values and tensile forces of mooring line at which the Doubling Plate Circumference Weld suffers brittle fracture

| Charpy impact value [N·m] | Fracture toughness value [N/mm ^{1.5}] | Tensile force of a mooring line [kN] |
|--|---|--------------------------------------|
| At 2°C | 25.5 | 106 |
| Highest temperature in the variability range | 42.1 | 155 |
| Lowest temperature in the variability range | 12.7 | 63 |

2.9.4 Summary

It is highly likely that the Stand Roller broke in a mode of brittle fracture (low stress fracture) originating from the root of the fillet weld on the doubling plate circumference. Possible causes include lack of fillet weld length and incorrect fillet welding conditions (incorrect welding material, incorrect current/voltage, etc.). The temperature (about 2°C) at the time of the accident is thought to also have contributed to the occurrence of the fracture.

In addition, if the bracket had been designed and installed properly, the stress on the fillet weld would have been less.

3 ANALYSIS

3.1 Situation of the Accident Occurrence

3.1.1 Course of Events

According to 2.1, 2.2 and 2.3 (1), the timeline of the accident occurrence is as follows.

- (1) It is probable that on January 11, with 2/O, the boatswain, AB B and OS A stationed at the forward station while the Master and AB A were stationed in the wheelhouse to maneuver the ship, at around 05:27 the Vessel heaved up anchors and began sailing for the Berth and that at around 06:15, the Vessel reached near the Berth.
- (2) It is probable that the vessel approached the Berth almost perpendicularly to send out a mooring line, that at around 06:52 the engine was put astern as the Vessel came close to the Moored Ship ahead, and that at that time the Forward Spring was sent out to the Berth.
- (3) It is probable that, to help send out the Line to the Berth AB A came down from the wheelhouse to the forecastle deck while the engine was put ahead to bring the Vessel closer to the Berth and that at around 07:01, with the Line sent out to the Berth, the engine was put astern to bring the Vessel away from the Berth.
- (4) It is probable that after the Line was secured onto the bitt on the Berth, AB B engaged the Line onto the Stand Roller, those at the bow except 2/O (the boatswain and AB B) retreated to the stern side of the forecastle deck, AB A went to the wheelhouse and OS A moved to the starboard stern side of the forecastle deck.
- (5) It is probable that at around 07:05 the Master put the engine dead slow astern for about five seconds in an attempt to bring the stern, which was away from the Berth, closer to the Berth. It is highly probable that at around 07:05:31 to 07:05:42, the course over the ground (COG) of the Vessel was about 275° to 297° while its speed over the ground (SOG) was 0.8 to 1.0 kn.
- (6) It is highly probable that between around 07:06 to 07:07 the Vessel sailed astern with COG about 252° to 264° and SOG about 0.8 to 1.0 kn and that, after the Line became taut at around 07:07:42, the Vessel sailed ahead with COG about 035° to 057° and SOG about 0.9 to 1.2 kn between about 07:08 to 07:09 to bring the stern closer to the Berth.
- (7) It is probable that the Stand Roller came off the deck, flew at about one to two meters above the deck, landed on the starboard forecastle deck, immediately bounced and hit the starboard bulwark plating, and fell into the sea.
- (8) It is probable that the crew stationed at the forward station found OS A lying along the starboard bulwark plating on the forecastle deck.
- (9) It is probable that OS A was transported to a medical institution by emergency services and at around 09:10 was confirmed dead.

3.1.2 Date, Time and Location of the Accident Occurrence

- (1) According to 2.1.2 (4) and 3.1.1, the Line became taut at 07:07:42 and that the Vessel's stern came closer to the Berth at 07:08:42; therefore, it is probable that the accident took place at around 07:08 on January 11, 2012.
- (2) According to 2.1 and 3.1.1, it is probable that the accident took place at 095° and approximately 2.6 nautical miles from the Chiba Port Katsunan Ichikawa lighthouse.

3.1.3 Situation around the Time of the Occurrence of the Accident

(1) Position of the Vessel

According to 2.1.1, 2.1.2, 2.5.1, 2.5.5 and 3.1.1, it is probable that the Position of the Vessel were as follows.

- 1) After the Line was sent out to the Berth and with the bow about 30 to 40 meters away from the Berth and facing northeast, the engine was put dead slow astern for about five seconds.
- 2) After sailing astern about 40 to 50 meters west-southwest, the Vessel sailed ahead about 70 meters northeast while turning to starboard, which brought the bow further away from the Berth and the stern closer to the Berth.

(2) The Line

According to 2.1.3, 2.5.3, 2.5.4 and 2.7.4 (3), the situation was as follows.

- 1) It is probable that the Line had been slackened from the Hawser Drum and over the forecandle deck with the clutch of the drum engaged and its brake released.
- 2) It is probable that the Line was slackened from the Hawser Drum, around the Stand Roller, and then through a fairlead at the starboard bow to the Berth where it was secured onto a bitt.
- 3) The Line did not break when the accident occurred.

(3) OS A

According to 2.1.3 and 3.1.1, it is probable that the situation was as follows.

- 1) After the Line was engaged onto the Stand Roller, OS A moved from near the Stand Roller to the starboard stern side of the forecandle deck and that no one saw him when the accident occurred.
- 2) After the accident, OS A was found lying along the starboard bulwark plating on the forecandle deck, and that when the Stand Roller came off the deck, he was near the starboard bulwark plating or between the imaginary line drawn from the Hawser Drum to the starboard bow fairlead and the Line.

3.1.4 Damage

According to 2.3, it is probable that the situation was as follows.

- (1) The Doubling Plate Circumference Weld and the Bracket Weld of the Stand Roller were broken. Part of the tip of the bracket underwent plastic deformation while the Stand Roller and the doubling plate underwent no plastic deformation.
- (2) No bulge, dent or other plastic deformation was found on the deck where the Stand Roller had been welded.

3.1.5 Fatality

According to 2.1.4, 2.2, 3.1.1 and 3.1.3, the situation was as follows.

- (1) It is probable that OS A was found lying along the starboard bulwark plating on the forecandle deck, with his head on the stern side and facing the port side, and that he fell into a state of cardiopulmonary arrest while being carried on a stretcher to an ambulance. OS A died from hemorrhagic shock from bilateral traumatic hemopneumothorax and pelvic fracture.
- (2) It is probable that the Stand Roller came off the deck, causing either the roller or the Line to hit OS A.

3.2 Causal Factors of the Accident

3.2.1 Crewmembers

According to 2.4, the situation was as follows.

- (1) The Master had a valid documentary proof of application for an endorsement under STCW regulation I/10. It is probable that the Master had been boarding ships as the master for five years and that he had made a port call at Katsunan District, Chiba Port, several times in the past.
- (2) It is probable that OS A had primarily worked as a mess man in his seagoing career and that on the Vessel he also served as a mess man and used to be stationed at the forward station when entering and leaving ports. It is somewhat likely that OS A was in good health at the time of the accident.

3.2.2 The Vessel

According to 2.3 (1), 2.5.2, 2.5.4 to 2.5.6, 2.6.1 and 2.6.3, the situation was as follows.

- (1) It is probable that the Vessel was built in Japan in 1991; that it went through conversion from April to October 2008, which included the extension of the hull in the middle, the extension of the quarter deck and the addition of the forecastle deck; and that the Vessel was surveyed for the conversion and approved by the Classification Society in 2009.
- (2) It is probable that the Vessel had had the defects of such as its fire-extinguishing system, mooring equipment, weather-tight condition when the accident occurred.
- (3) The Stand Roller, on which no SWL was indicated, was installed on a disc shaped doubling plate and had a bracket extending in the bow direction. The doubling plate, about 10 mm in thickness, was welded onto the deck only along its circumference.
- (4) It is probable that the equipment number of the Vessel required mooring lines used on the Vessel to have the minimum breaking strength of 132 kN; therefore, the breaking strength of the Line was 167 kN.

3.2.3 Weather and Sea Conditions

According to 2.1.2 and 2.8, it is probable that at the time of the accident, it was cloudy with a N to NNE wind of force 3 and that the sea was calm. It is probable that the temperature was about 2°C.

3.2.4 Installation of the Stand Roller

(1) Requirements applicable to the Stand Roller

According to 2.6.2 and 2.6.3, it is probable that the requirements for the Stand Roller were as follows.

- 1) The Classification Society considered the Vessel built in 2008 and applied to its mooring equipment the relevant IACS unified requirement, which required the mooring equipment to have a design load of 1.25 times the intended maximum working load or 1.25 times the breaking strength of the mooring line determined by the ship's equipment number.
- 2) The Approved Stand Rollers were located around the centers of the port and starboard sides of the forecastle deck and had a design load of 202 kN and an SWL of 162 kN. They both were fitted with a circular doubling plate and a bracket extending to the bow. They both were intended largely for guiding forward springs and their design load of 202 kN was intended to counter the force acting in the stern direction.

(2) Installation of the Stand Roller

According to 2.6.1 (3) and 2.6.3 (4), the Stand Roller was installed as follows.

- 1) It is probable that Company A had one of the Approved Stand Rollers moved to a new location (the location of the Stand Roller) near the center of the forecastle deck in 2011. It is probable that Company A did not notify the Classification Society of the relocation and that the Stand Roller had not been surveyed and approved by the Classification Society.
 - 2) It could not be determined why, by whom and how Company A moved one of the Approved Stand Rollers to the new location.
 - 3) It is probable that Company A had not been commissioning minor pieces of work to shipyards or repair companies to retrench expenses.
- (3) According to 2.6.4 (1), and 3.2.4 (1) and (2), it is somewhat likely that the following occurred.
- 1) The Stand Roller was not surveyed or approved by the Classification Society; accordingly, it was not checked for sufficient strength, let alone designed and installed properly.
 - 2) The Stand Roller did not meet the requirements under the unified requirement applied by the Classification Society.

3.2.5 Effectiveness of the bracket

According to 2.9.2, 3.2.2 (3) and 3.2.4 (1), the situation was as follows.

- (1) It is somewhat likely that the Stand Roller was installed with a bracket extending in the direction of the bow, like the brackets on the Approved Stand Rollers, without consideration of the resultant force of load acting in the tensile direction of the mooring line.
- (2) It is probable that the bracket installed on the Stand Roller in the direction of the bow did not effectively counter the bending moment generated in the accident.

3.2.6 Strength and Rupture of the Stand Roller

- (1) According to 2.9.2 and 3.2.2 (4), it is probable that in an assumed ductile fracture mode, the comparison in breaking strength indicates that the Stand Bottom Weld would more likely break before the Doubling Plate Circumference Weld. It is probable that neither weld would break with the mooring line's tensile force of 167 kN which is the breaking strength of the Line.
- (2) According to 2.9.3 and 3.2.2 (4), it is probable that in an assumed brittle fracture mode, the Doubling Plate Circumference Weld had a greater stress intensity factor than the Stand Bottom Weld, indicating that the former would break before the latter. It is probable that the former would break with the mooring line's tensile force of 167 kN or less which is the breaking strength of the Line.
- (3) According to 2.6.4 (1), 3.1.3 (2) and 3.1.4, it is probable that the Line did not break when the accident occurred and that there was no plastic deformation where the Stand Roller, the doubling plate and the deck where the Stand Roller had been welded. It is probable that if a piece of mooring equipment that has been properly installed is subjected to load exceeding its strength, typically, the weld between the equipment and the deck will not break, but instead the deck will be lifted or bent while the weld remains intact.
- (4) According to 2.6.4, 2.9.4 and 3.2.5, the situation was as follows.
 - 1) It is somewhat likely that the Stand Roller was installed without consideration of the resultant force of load acting in the tensile direction of the mooring line. It is probable that the bracket did not effectively counter the bending moment generated in the accident.

- 2) It is probable that if the bracket had been installed properly, the stress on the Doubling Plate Circumference Weld would have been less.
- (5) According to 2.9.4, 3.2.4 (3) and 3.2.6 (1) to (4), the situation was as follows.
 - 1) It is probable that the Doubling Plate Circumference Weld of the Stand Roller developed brittle fracture, which allowed the weld to break at or below the breaking strength of the Line and caused the Stand Roller to break off from the deck.
 - 2) It is somewhat likely that the brittle fracture of the Doubling Plate Circumference Weld was caused by improper installation work such as incorrect weld leg lengths and fillet welding conditions. It is probable that the temperature at the time of the accident also contributed to the occurrence of the brittle fracture.

3.2.7 Safety Management by Company A

According to 2.5.6, 2.6.1 (3) 2), 3.2.4 (2) and 3.2.5 (1), the situation was as follows.

- (1) In the light of the following, it is probable that vessel management had not been properly conducted by Company A.
 - 1) It is probable that Company A did not notify the Classification Society of the relocation of one of the Approved Stand Rollers and that the relocated Stand Roller was not surveyed and approved by the Society.
 - 2) It is probable that Company A had no records of why, by whom and how the Stand Roller was relocated.
 - 3) It is somewhat likely that the Stand Roller was relocated without consideration of the resultant force of load acting in the tensile direction of the mooring line.
 - 4) It is probable that the Vessel had had the defects of such as its fire-extinguishing system, mooring equipment, statutory certificate, weather-tight condition, ISM code when the accident occurred.
- (2) It is somewhat likely that, had Company A had the Stand Roller surveyed and approved by the Classification Society for proper strength when it was relocated, the accident could have been prevented. It is therefore somewhat likely that improper ship management by Company A, not having the Stand Roller surveyed and approved by the Classification Society, contributed to the occurrence of the accident.

3.2.8 Communication between the Wheelhouse and the Crew Stationed at the Forward Station

According to 2.1.3, 2.7.2, 2.7.4, 3.1.1 and 3.1.3, the situation was as follows.

- (1) It is probable that when the Master put the engine dead slow astern after the Line was sent out to the Berth in an attempt to bring the stern, which was away from the Berth, closer to the Berth, he did so without notifying those at the forward as he thought the engine would be operated only briefly.
- (2) Considering that when the Master put the engine dead slow astern with the mooring line from the bow already secured onto the Berth, there was a possibility that the mooring line could become taut, leading to an unexpected result. It is therefore somewhat likely that had the Master notified those at the forward station of the maneuver, OS A might have been prompted to follow the boatswain and AB B as they moved towards the stern side of the forecastle deck, possibly preventing the accident.

3.2.9 Occurrence of the Accident

According to 3.1.1, 3.1.3 to 3.1.5, 3.2.2 and 3.2.4 to 3.2.7, the situation was as follows.

- (1) It is probable that, while the Vessel was berthing at the Berth in Chiba Port, the Line was sent out to the Berth after the Forward Spring, and that, with the Line secured onto a bitt on the Berth, AB B engaged the Line onto the Stand Roller on the forecastle deck, the boatswain and AB B except 2/O moved to the stern side of the deck, AB A left for the wheelhouse and OS A moved to the starboard stern side of the deck.
- (2) It is probable that while the Vessel was sailing astern at about 0.8 to 1.0 kn SOG as the Master put the engine dead slow astern for about five seconds in an attempt to bring the stern, which was away from the Berth, closer to the Berth, the Line became taut, causing the Stand Roller to come off from the deck.
- (3) It is probable that the Stand Roller came off the deck, causing either the Stand Roller or the Line to hit OS A, who later died from hemorrhagic shock from bilateral traumatic hemopneumothorax and pelvic fracture.
- (4) It is probable that the Doubling Plate Circumference Weld of the Stand Roller developed brittle fracture, which allowed the weld to break at or below the breaking strength of the Line and caused the Stand Roller to come off from the deck.
- (5) It is somewhat likely that the brittle fracture of the Doubling Plate Circumference Weld was caused by improper installation work such as incorrect weld leg lengths and fillet welding conditions.
- (6) It is somewhat likely that improper ship management by Company A, not having the Stand Roller surveyed and approved by the Classification Society, contributed to the occurrence of the accident.

4 CONCLUSIONS

4.1 Probable Causes

It is probable that in this accident, while the Vessel was berthing at the Berth in Chiba Port, the Master put the engine astern in an attempt to bring the stern closer to the Berth and that when the Line, which had been secured onto the Berth, became taut, the Stand Roller, on which the Line had been engaged, came off the deck, causing either the Stand Roller or the Line to hit OS A.

It is probable that the Stand Roller came off the deck because the Doubling Plate Circumference Weld developed brittle fracture, causing the weld to break at or below the breaking strength of the Line.

It is somewhat likely that improper ship management by Company A, not having the Stand Roller surveyed and approved by the Classification Society, contributed to the occurrence of the accident.

4.2 Other Safety Information

It is probable that when the Master put the engine dead slow astern after the Line was sent out to the Berth in an attempt to bring the stern, which was away from the Berth, closer to the Berth, he did so without notifying those at the forward as he thought the engine would be operated only briefly. However, considering that when the Master put the engine dead slow astern with the

mooring line from the bow already secured onto the Berth, there was a possibility that the mooring line could become taut, leading to an unexpected result. It is therefore somewhat likely that had the Master notified those at the forward of the maneuver, OS A might have been prompted to follow the boatswain and AB B as they moved towards the stern side of the forecastle deck, possibly preventing the accident.

5 SAFETY ACTIONS

It is probable that in this accident, while the Vessel was berthing at the Berth in Chiba Port, the Master put the engine astern in an attempt to bring the stern closer to the Berth and that when the Line, which had been secured onto the Berth, became taut, the Stand Roller, on which the Line had been engaged, came off the deck, causing either the Stand Roller or the Line to hit OS A.

It is probable that the Stand Roller came off the deck because the Doubling Plate Circumference Weld developed brittle fracture, causing the weld to break at or below the breaking strength of the Line.

It is somewhat likely that improper ship management by Company A, not having the Stand Roller surveyed and approved by the Classification Society, contributed to the occurrence of the accident.

It is probable that when the Master put the engine dead slow astern after the Line was sent out to the Berth in an attempt to bring the stern, which was away from the Berth, closer to the Berth, he did so without notifying those at the forward as he thought the engine would be operated only briefly. However, considering that when the Master put the engine dead slow astern with the mooring line from the bow already secured onto the Berth, there was a possibility that the mooring line could become taut, leading to an unexpected result. It is therefore somewhat likely that had the Master notified those at the forward of the maneuver, OS A might have been prompted to follow the boatswain and AB B as they moved towards the stern side of the forecastle deck, possibly preventing the accident.

It is therefore necessary for vessel owners, vessel management companies and those involved in vessel operations to take the following actions to prevent the recurrence of similar accidents.

- (1) When installing mooring or other equipment subjected to stress, the owner and the management company of the vessel must ensure that the equipment is designed, installed and reinforced properly in accordance with applicable regulatory requirements and must have the equipment surveyed by a classification society or other survey authorities.
- (2) When berthing the vessel, close communication must be maintained among those on board, especially between those maneuvering the vessel, including the engine, and those at the forward and at the stern to ensure coordinated actions.

Figure 1 Vessel Track Shown by the AIS Records

