

MA2014-8

**MARINE ACCIDENT
INVESTIGATION REPORT**

August 29, 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 YUSHO SEVEN

IMO Number: 9258569

Gross Tonnage: 2,972 tons

Accident Type: Fatality of a stevedore

Date and Time: Around 15:45, July 17, 2011 (local time, UTC+9 hours)

Location: Port Island North Wharf External Trade Berth R, Kobe District,
Hanshin Port
Around 215°, 800 m from the Kobe No. 3 Breakwater East
Lighthouse, located in Kobe City
(approximately 34°40.5'N 135°13.1'E)

August 7, 2014

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 >

At around 15:45 on July 17, 2011, while the cargo ship YUSHO SEVEN was loading pipes and other cargo at the Port Island North Wharf External Trade Berth R, Kobe District, Hanshin Port, pipes stacked on the starboard side of the lower deck of No. 1 cargo hold collapsed and a worker, who was on the pipes, fell to the deck with the pipes and was killed.

< Probable Causes >

It is probable that the accident occurred because while YUSHO SEVEN was loading pipes and other cargo at the Port Island North Wharf External Trade Berth R in Kobe District, Hanshin Port, a bundle of two wrapped pipes and other wrapped pipes stacked from the fifth to the seventh tier near the sidewall started sliding athwartships, and a lasher, who was on the wrapped pipes on the sixth tier, fell to the lower deck with the wrapped pipes, which fell on top of him.

It is probable that the bundle of two wrapped pipes and other wrapped pipes stacked from the fifth to the seventh tier near the sidewall started sliding athwartships due to the

following facts: (i) two stevedores inserted a turnbuckle between the starboard sidewall and the bundle of two wrapped pipes stacked on the seventh tier near the sidewall, and moved the turnbuckle to create a clearance gap, (ii) YUSHO SEVEN listed to the port side at an angle of about 2.8° when YUSHO SEVEN hoisted coils from the cargo ship moored alongside the port side of YUSHO SEVEN using the aft crane, (iii) the height was not adjusted from the fifth tier and only three lines of dunnage were laid out to the fore, middle, and aft because each tier consisted of wrapped pipes and was almost even, (iv) the pipes were not lashed down because they were due to be lashed after all the pipes had been stacked on the starboard side, (v) no wedges were inserted.

It is probable that two stevedores tried to create a clearance gap between the sidewall and the bundle of two wrapped pipes stacked on the seventh tier near the sidewall using a turnbuckle because No. 1 cargo hold supervisor, who heard from the leader of the lashing operation that the wire lashing rope could not be pulled out since the height of the dunnage that was put against the sidewall was so short that the bundle of pipes came into contact with the sidewall when the bundle was pushed in using the fork of a forklift truck, thought that creating a clearance gap would allow the wire lashing rope to be pulled out, and instructed two stevedores to try to move the bundle of pipes.

1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

At around 15:45 on July 17, 2011, while the cargo ship YUSHO SEVEN was loading pipes and other cargo at the Port Island North Wharf External Trade Berth R, Kobe District, Hanshin Port, pipes stacked on the starboard side of the lower deck of No. 1 cargo hold collapsed and a worker, who was on the pipes, fell to the deck with the pipes and was killed.

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 July 17, 2011.

1.2.2 Collection of Evidence

July 19, August 8, 11, 23, 31, September 20, 2011, and January 10, 2014: Collection of written replies to the questionnaires

July 21 and August 8, 2011: On-site investigation and interviews

July 22, 23, August 3, 24, 26, 2011, September 26, 2012, and August 2, 2013: Interviews

1.2.3 Comments from the Parties Relevant to the Cause

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

1.2.4 Comments from the Flag State

Comments on the draft report were invited from the Flag State of the cargo ship YUSHO SEVEN.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

According to the statements of the master (hereinafter, "Master A") of YUSHO SEVEN (hereinafter, "Vessel A"), the master (hereinafter, "Master B") of a cargo ship moored alongside the port side of Vessel A (hereinafter, "Vessel B"), six stevedores from the Kobe branch of Sankyu Inc. (hereinafter, "Company C") and a subcontractor of Company C (hereinafter, "Company D"), and one lasher from Miyake Shokai Co., Ltd. (a contractor of Company C, hereinafter, "Company E"), and according to the reply to the questionnaire by Company C, the events leading to the accident were as follows.

2.1.1 Situation While Loading the Cargo

The cargo handling operation for Vessel A at the Port Island North Wharf External

Trade Berth R in Kobe District, Hanshin Port (hereinafter, “the Berth”) was contracted to Company C, which made an order to lash down the cargo loaded onto Vessel A to Company E.

Vessel A left Nagoya Port in Aichi Prefecture at around 14:20 on July 16, 2011, with Master A and 14 crew members on board, loaded with 530.5 tons of steel plate and other cargo. At around 13:54 on July 17, she berthed with her starboard side alongside the Berth in Kobe District, Hanshin Port.

After the loading operation at the Berth in Kobe District, Hanshin Port, Vessel A was scheduled to call at Keelung Port and Kaohsiung Port in Taiwan, in that order.

All the stevedores from Company C had a meeting at the office of Company C at around 13:00 to prepare for the cargo handling operation on Vessel A.

The foreman^{*1} explained and ordered the following to the stevedores using the stowage plan and cargo list.

- (1) Vessel A will list to one side due to loading operations in the other cargo holds. Therefore, stevedores must keep out of the starboard and port sides of the cargo and must wait fore and aft.
- (2) Stevedores must keep out of the direction in which the forklift trucks are moving.
- (3) The pipes will be stacked to a height of about 3 m.
- (4) Three hundred and ninety seven tons of pipes that are to be discharged first at Keelung Port (hereinafter, “Keelung Cargo”) will be loaded on the middle of the lower deck, and 167 tons of pipes that are to be later discharged at Kaohsiung Port (hereinafter, “Kaohsiung Cargo”) will be loaded on both sides of the lower deck. The forklift driver has a lot to do; however, the loading operation must be done in a careful manner.

After the meeting, the stevedores from Company C moved to the Berth in Kobe District, Hanshin Port. At around 13:45, the foreman explained the order of the loading operation to the leader of the lashing operation (hereinafter, “Lasher E₁”), while the chief of the stevedoring operations (hereinafter, “Operations Chief”) explained the height that the pipes would reach to Lasher E₁. The foreman, who was asked the scheduled finish time by Lasher E₁, answered that it would be around 02:00 on July 18.

At around 14:00, prior to the loading operation, the foreman had a meeting with the chief officer of Vessel A (hereinafter, “Chief Officer A”) and confirmed that eye plates for the wire lashing rope to run through should be welded to the walls of the cargo hold.

Crew members of Vessel A opened the hatch covers^{*2} of No. 1 and No. 2 cargo holds on the upper and tween deck.

At around 14:20, the Operations Chief explained the safety points described in the work instruction to all workers engaged in the loading operation for Vessel A.

The outline of the cargo handling plan for Vessel A was as follows:

- (1) A barge is moored alongside the port side of Vessel A, and Vessel B is moored

^{*1} “The foreman” is the supervisor of loading operations who discusses the time of arrival/departure and operations schedule with the shipping company or agent and shipper, and the cargo work procedure, safety operations, etc. with the chief officer.

^{*2} “Hatch cover” is a cover made of steel that covers the opening used to load/unload cargo into/out of the hold.

alongside the port side of the barge.

- (2) Machines packed in wooden crates are loaded from the barge and pipes from the quay into No. 1 cargo hold. The pipes make up the Keelung Cargo and Kaohsiung Cargo.
- (3) Coils from Vessel B and other steel products from the quay are loaded into No.2 cargo hold.
- (4) Both loading operations into No. 1 and No. 2 cargo holds are carried out using the two cranes on board Vessel A.

The foreman and Operations Chief supervised the entire cargo handling operations for Vessel A. The eight workers who were engaged in cargo handling operations for No. 1 cargo hold consisted of the No. 1 cargo hold supervisor, the operator of the forward crane (hereinafter, “Operator C”), the forklift driver (hereinafter, “Driver C”), two stevedores who were engaged in general cargo handling operations (hereinafter, “Stevedore C” and “Stevedore D”), Lasher E₁, and two lashers who were engaged in lashing down the cargo (hereinafter, “Lasher E₂” and “Lasher E₃”).

2.1.2 Situation Leading to this Accident

At around 14:30, Vessel A started loading cargo into No. 1 and No. 2 cargo holds. One of the six cargoes of machines, which were loaded from the barge moored alongside the port side, could not be stowed in No.1 cargo hold and was temporarily placed on the quay. The foreman decided to load the cargo onto the tween deck.

Operations Chief confirmed that several dozen small-diameter pipes bundled together (hereinafter, “Bundled Pipe”) and two stainless pipes wrapped in synthetic resin sheet and a stainless pipe wrapped in synthetic resin sheet (hereinafter, “Wrapped Pipe”) were placed on the quay.

There were two kinds of Wrapped Pipes: one was 6.0 m in length, about 27 cm in diameter, and about 366 kg in weight and the other was 6.0 m in length, about 33 cm in diameter, and about 448 kg in weight.

(See Photo 2.1-1)

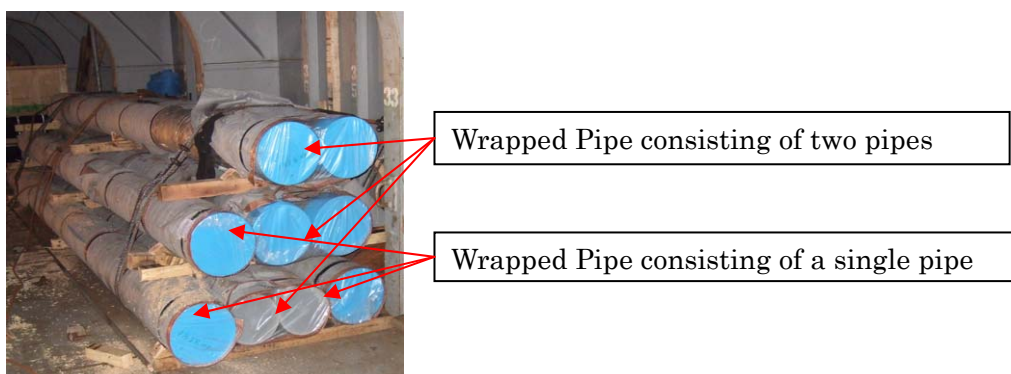


Photo 2.1-1 Wrapped Pipes

Operations Chief stacked heavy Bundled Pipes on both sides of the lower deck in No. 1 cargo hold and then stacked Wrapped Pipes on them.

Operations Chief hoisted Bundled Pipes using the forward crane, moved them into No. 1 cargo hold, and then distributed and stacked them on both sides using the forklift truck.

After the barge moved away from the port side, Vessel B moored alongside the port side of Vessel A and 16 coils were hoisted one by one using the aft crane of Vessel A, loaded and stowed in No. 2 cargo hold.

(See Figure 2.1-1)

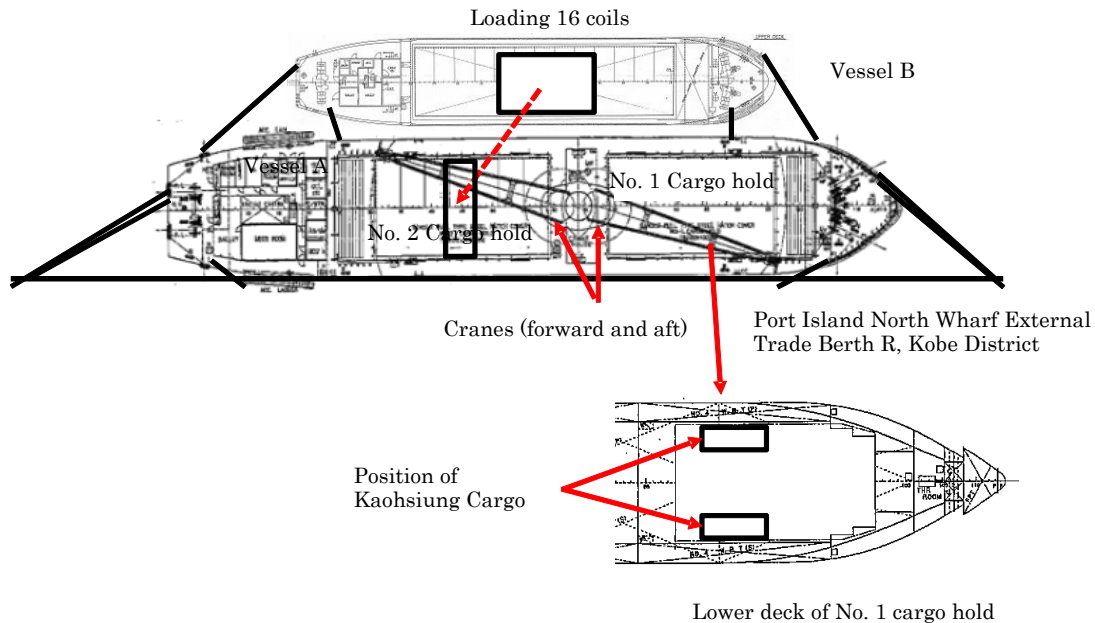


Figure 2.1-1 Loading Cargo into the Cargo Hold

When the coils were hoisted, Master B noticed that Vessel A listed to port.

No. 1 cargo hold supervisor had stevedores put three-inch (about 9 cm) square timbers with a length of about 3 m that functioned as a cushion (hereinafter, “dunnage^{*3}”) fore and aft of the starboard and port sidewalls in each cargo hold, adjusting them to the height of the stacked pipes. The thickness of dunnage provided a clearance gap between the stacked pipes and the sidewall, where wire lashing rope that ran through the eye plates welded to the sidewalls could be pulled out.

Dunnage was laid out in three rows on the lower deck where pipes were stacked to support the load of each pipe at both ends and in the center.

No. 1 cargo hold supervisor planned to lash down the Kaohsiung Cargo after it had been stacked. Usually, he had wedges inserted right after the forklift truck stacked a single pipe to stop it tumbling down, but when pipes were in groups of two or Bundled Pipes, he waited until all the pipes had been stacked before inserting the wedges, or inserted the wedges while the pipes were being lashed because they could not tumble down. The wedges were made by the lashers.

^{*3} “Dunnage” refers to various kinds of laying materials used in holds to protect different types of stacked cargoes from damage from contacting the hold surfaces, shifting, mechanical shock caused by motion at sea, and moisture.

No. 1 cargo hold supervisor had sometimes secured the stacked pipes by middle-lashing*4 when the pipes were unstable.

Stevedores planned to insert wedges after the Kaohsiung Cargo had been stacked on both sides and they did not insert wedges on all tiers due to the fact that there was a mixture of pairs of Bundled Pipes and Wrapped Pipes that could not tumble down although there were still some Wrapped Pipes consisting of single pipes. (See Photo 2.1-2, Photo 2.1-3)

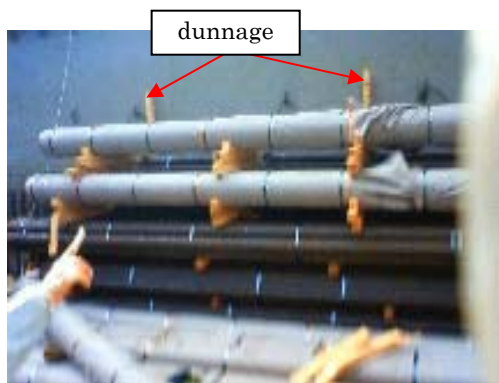


Photo 2.1-2 Laying of dunnage 1



Photo 2.1-3 Laying of dunnage 2

Lasher E1 passed wire rope to lash the stacked pipes through the eye plates welded to the sidewalls. He planned to climb up onto the pipes and pull out the wire rope to lash down the pipes after they had been stacked to several tiers.

(See Photo 2.1-4, Photo 2.1-5)



Photo 2.1-4 Wire Rope for Lashing down Pipes

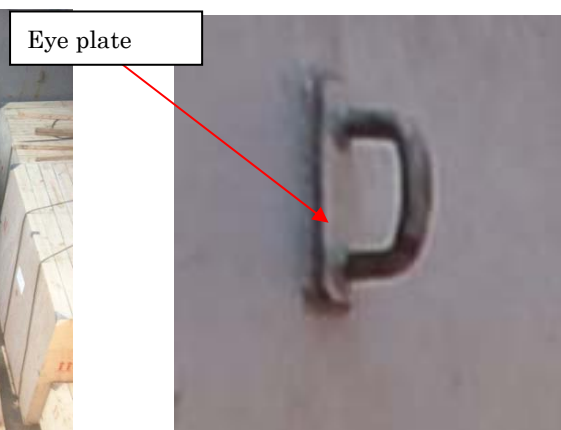


Photo 2.1-5 Eye Plate

Every time pipes were stacked on another tier, Stevedore C climbed up onto the pipes and inserted two or three pieces of dunnage on the small-diameter pipes to minimize the difference in the level of the top faces of the stacked pipes with different diameters.

No. 1 cargo hold supervisor moved fore and aft to visually ensure that each tier was even in height. He had inserted wedges every time a single pipe was stacked, but because the pipes were in bundles, he decided to insert wedges when the pipes were

*4 "Middle-lashing" refers to lashing stacked cargo with wire rope halfway through the stowing work.

lashed down as usual.

When the pipes on the port side had been stacked to six tiers, three lashers pulled out the wire rope that hung through the eye plates on the port sidewall, tied all the pipes together at three locations, and tightened the wire rope using turnbuckles.

(See Photo 2.1-6)



Photo 2.1-6 Turnbuckles of the Same Type

Then, in accordance with instructions from No. 1 cargo hold supervisor, Lasher E₂ hewed square timbers to make wedges to the fore of No. 1 cargo hold.

(See Photo 2.1-7)



Wedge

(Hewn timber with one pointed end and one thick end)

Photo 2.1-7 Wedge

Stevedore C stacked Bundled Pipes near the starboard sidewall from the first tier up to the first half of the fourth tier, and stacked Wrapped Pipes on the second half of the fourth tier. Because the height of the fourth tier consisting of both Bundled Pipes and Wrapped Pipes was not even, he adjusted the height by putting dunnage on the Wrapped Pipes. However, because only Wrapped Pipes were stacked on the fifth tier, which was therefore almost even, he did not adjust the height and laid out three lines of dunnage to the fore, middle, and aft.

Driver C pushed one Wrapped Pipe consisting of two pipes that was stacked near the sidewall on the seventh tier (hereinafter, “the Pipe”) toward the starboard sidewall of No. 1 cargo hold using the fork of the forklift truck, and then stacked and pushed in another Wrapped Pipe consisting of two pipes.

Operations Chief informed No. 1 cargo hold supervisor that the Pipe was touching the starboard sidewall.

Lasher E₁, who heard from No. 1 cargo hold supervisor that the Pipe was touching the starboard sidewall, climbed onto the Pipe to confirm the fact and saw that there

was no clearance. He told No. 1 cargo hold supervisor that the wire rope threaded through the eye plates could not be pulled through in that situation. No. 1 cargo hold supervisor thought they should create a clearance gap to pull out the wire lashing rope.

In addition, following Lasher E₁, Stevedore C and Stevedore D climbed onto the Pipe and confirmed that the dunnage that was placed against the sidewall was lower than the position of the Pipe so that the Pipe was touching the sidewall instead of the dunnage. Stevedore C learned that the Pipe was touching the sidewall at this point in time.

In accordance with the instruction from No. 1 cargo hold supervisor to try to move the Pipe, Stevedore C and Stevedore D inserted a turnbuckle between the sidewall and the Pipe, and moved it right and left, but they could not move the Pipe. Stevedore C had never used a turnbuckle to move pipes before.

(See Figure 2.1-2)

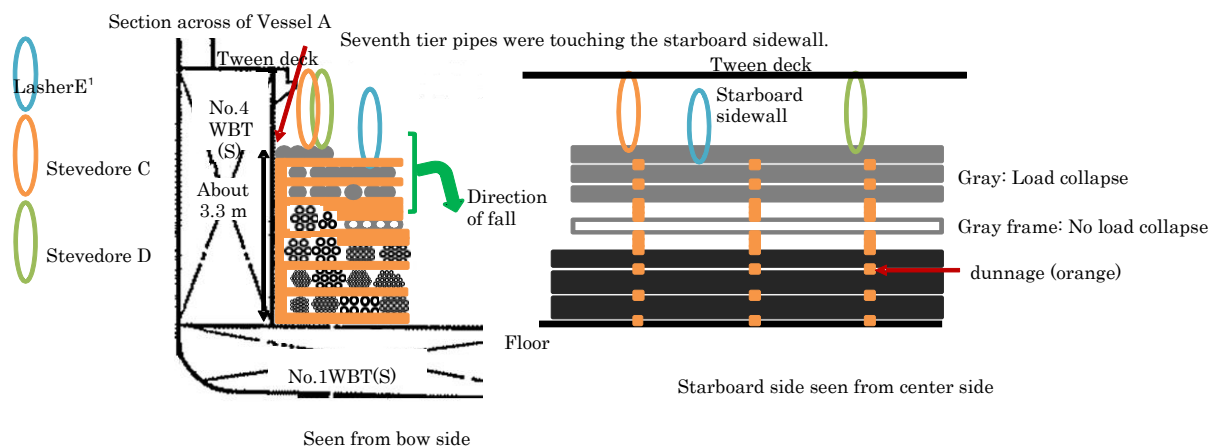


Figure 2.1-2 Positions of Lasher and Stevedores

No. 1 cargo hold supervisor, who was instructed to change the fork on the forklift truck from a short fork (1.22 m) to a long one (2.22 m) to move pipes by the Operations Chief, told Driver C to park the forklift truck in front of No. 1 cargo hold with the fork pointing toward the bow side, and started replacing the fork for a long one together with Driver C.

After moving the turnbuckle from side to side many times on the aft end, Stevedore C and Stevedore D managed to create a clearance gap to pull out the wire rope. They did the same on the fore end and created a clearance gap about 10 cm wide on the fore end to pull out the wire rope. Stevedore C was told by Lasher E₁ that the wire rope could be pulled out.

(See Figure 2.1-3)

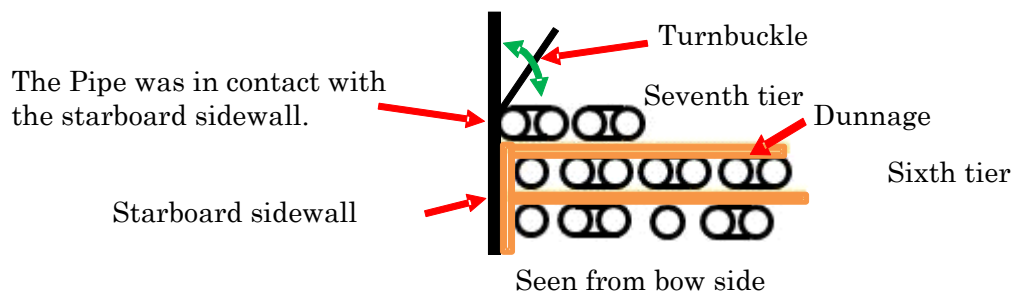


Figure 2.1-3 Use of the Turnbuckle

Lasher E₁ was on the Wrapped Pipes on the sixth tier, on the port side, a little to the fore, and Stevedore C and Stevedore D were on the Pipe near the starboard sidewall, to the fore and aft respectively. The Operations Chief, who saw the operation from the upper deck, noticed that the Wrapped Pipes on the sixth tier and the Pipe were sliding athwartships, and shouted, "Watch out!"

Stevedore C heard the Operations Chief's shout and at the same time felt something shift under his feet. Noticing that the Pipe was moving, he turned around to starboard and crawled to the tween deck on his hands and elbows.

Stevedore D noticed that the Pipe was moving, responded to the Operations Chief's shout, and jumped onto a wooden box stowed at the aft side.

At around 15:45, Lasher E₁ started walking from fore to aft on the port side of the Wrapped Pipes on the sixth tier, stopped in the middle of the pipes and turned around to starboard, but could not step over the Pipe and fell down onto the lower deck with the Wrapped Pipes, which fell on top of him.

(See Photo 2.1-8)

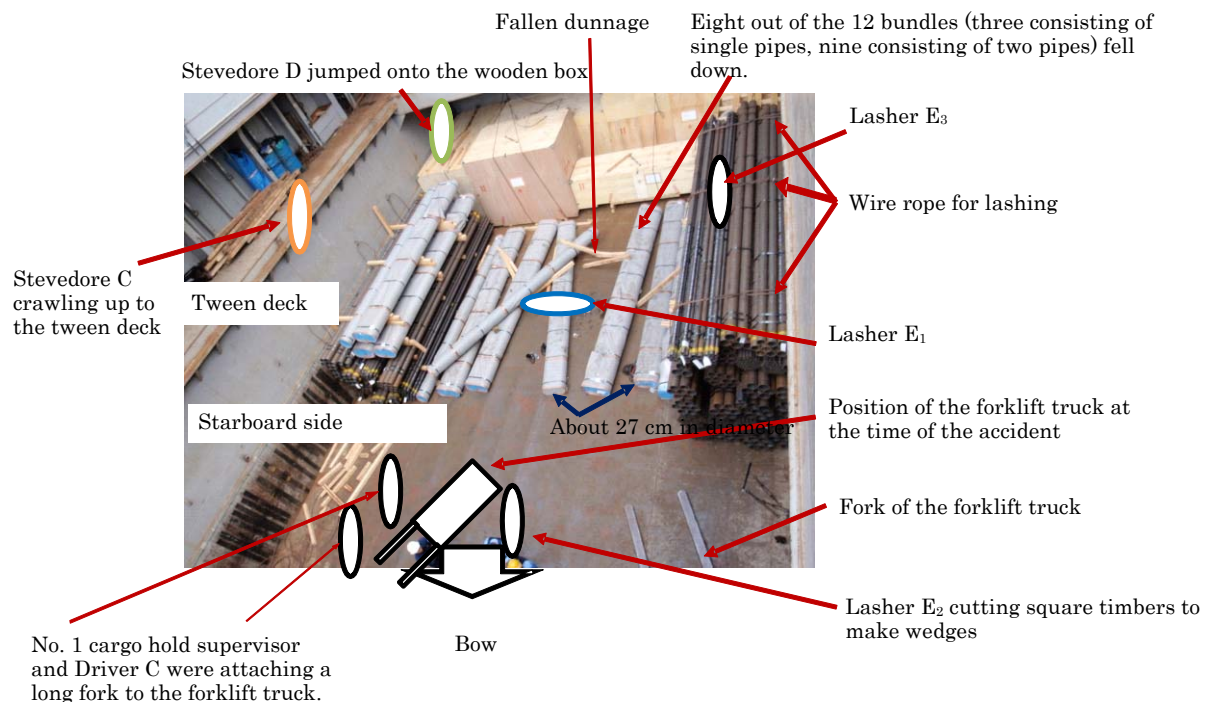


Photo 2.1-8 Situation on the Lower Deck of No. 1 Cargo Hold after the Cargo Collapsed

When the 11th coil was hoisted, Master B saw that Vessel A was listing to the same degree to the port side as when Vessel A hoisted the 10th coil, and heard loud clangs coming from Vessel A.

2.1.3 Rescue

The foreman heard the Operations Chief's shout when he was walking on the upper deck passageway on the port side of No. 1 cargo hold. He saw Lasher E₁ fall, rushed into No. 1 cargo hold, and used his own mobile phone to call an ambulance.

The foreman told the stevedores to remove the Wrapped Pipes consisting of single pipes that had fallen onto Lasher E₁ by hand, and told Driver C to lift off the Wrapped Pipes consisting of two pipes that had fallen onto the legs of Lasher E₁ using the forklift truck.

Lasher E₁ was given emergency treatment by the rescue team and doctor who had just arrived, and was taken to hospital. However, he was pronounced dead at around 17:06.

This accident occurred at around 15:45 on July 17, 2011, at the Berth in Kobe District, Hanshin Port (in No. 1 cargo hold of Vessel A moored at the Berth).

(See Figure 2.1-4)

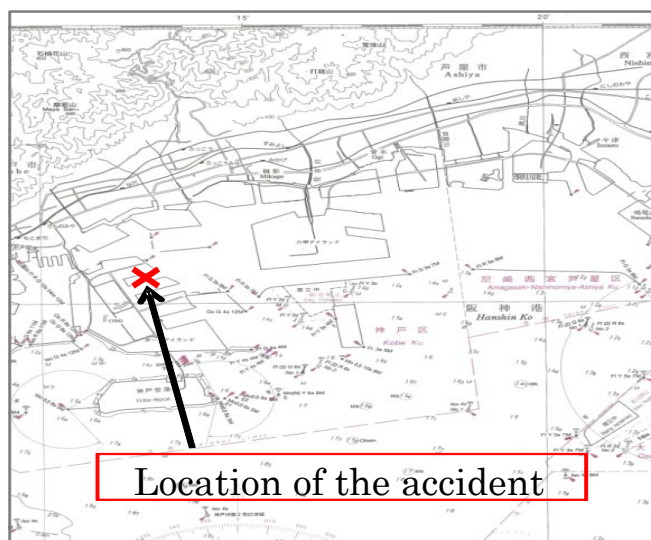


Figure 2.1-4 Location of the accident

2.2 Fatality

According to the death certificate, the cause of death of Lasher E₁ was as follows:

He died from blood loss resulting from ruptures to the main artery, pulmonary artery and vein, and right ventricle, etc., caused by chest bruising and compression.

2.3 Damage to Vessel

There was no damage to Vessel A.

2.4 Stevedores

According to the statement of the safety officer of Company E, the foreman, Stevedore C, and Stevedore D, etc., the details were as follows.

(1) Primary Personal History in Company

[1] Lasher E₁ (fatality), male, 57 years old

He joined Company E in around 1989, and was engaged in cargo work. He had about 22 years of stevedoring experience and was in good health.

[2] Foreman, male, 25 years old

He joined Company C in around October 2009, and was engaged in cargo work as a foreman about three times a week. He had about two years of experience as a foreman.

[3] Operations Chief, male, 42 years old

He joined Company C in around 1988, and was engaged in cargo work. After gaining experience as the supervisor of the cargo hold, forklift driver, crane operator, etc., he had been in the position of Operations Chief for about 10 years. He had about 23 years of stevedoring experience and took the stevedoring skills training course for Operations Chiefs.

[4] No. 1 cargo hold supervisor, male, 31 years old

He joined Company C in around 2004, and was engaged in cargo work. He had about seven years' experience of stevedoring. He had often been responsible for cargo holds recently.

[5] Stevedore C, male, 28 years old

He joined Company C in around 2008, and was engaged in cargo work in holds. He had about two and a half years' experience of stevedoring.

[6] Stevedore D, male, 22 years old

He joined Company D in around 2008, and was engaged in cargo work in cargo holds and coastal areas. He had about two and a half years' experience of stevedoring.

2.5 Crew Information

(1) Gender, Age, and Certificate of Competence

Master A: Male, 65 years old

Nationality: Republic of the Philippines

Certificate of Competency as Master (issued by Republic of Panama)

Date of Issue: March 1, 2011

(valid until November 24, 2015)

(2) Major Seagoing Experience

Master A worked on ocean going cargo ships from around 1969 as an apprentice officer. After becoming a master in 1976, he has worked on cargo ships or container ships as a master for about 35 years.

2.6 Vessel Information

2.6.1 Particulars of Vessels

IMO Number: 9258569

Port of Registry: Republic of Panama

Owner: PINE FOREST NAVIGATION S.A. (Republic of Panama)

Classification Society: Nippon Kaiji Kyokai (NK)

Gross Tonnage: 2,972 tons

L x B x D: 83.90 m x 14.80 m x 9.00 m

Hull Material: Steel

Engine: Diesel engine x 1

Output: 1,912 kW

Propulsion: Fixed pitch propeller x 1

Date Keel Laid: July 9, 2001

Number of Persons on Board: 15 (all Filipinos)

(See Figure 2.6-1, Photo 2.6-1)

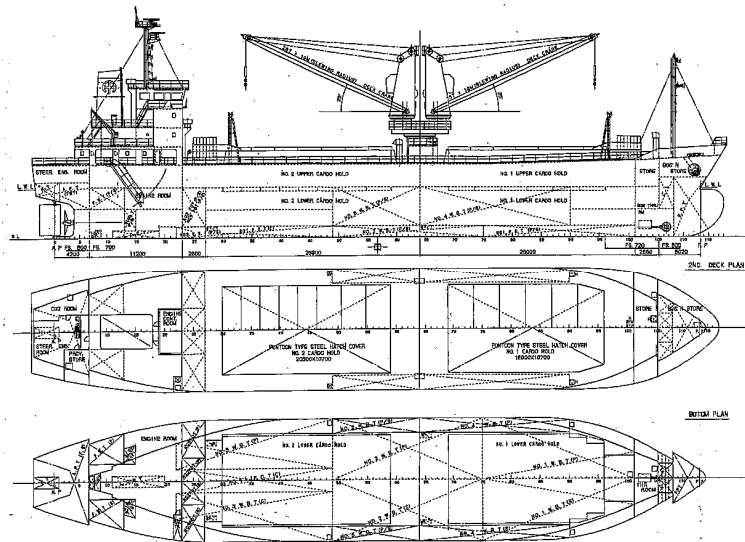


Figure 2.6-1 General Arrangement (excerpt)



Photo 2.6-1 Vessel A

2.6.2 Other Relevant Information on Vessel A

Cargo-loading particulars of Vessel A are as follows.

Upper deck hatch openings	No. 1 Cargo hold	18.9 m x 10.2 m
	No. 2 Cargo hold	19.6 m x 10.2 m
Tween deck hatch openings	No. 1 Cargo hold	18.9 m x 10.7 m
	No. 2 Cargo hold	20.3 m x 10.7 m
Depth of hold, etc.	Lower deck to top of tween deck	4.80 m
	Lower deck to top of upper deck	7.65 m

2.6.3 Cargo Loading Conditions for Vessel A

According to the stowage plan, bill of lading, and the statement of Chief Officer A and the foreman, the details were as follows.

(1) Weight of Cargo

[1] Nagoya Port

Vessel A was loaded:

Place	Weight
Lower deck of No. 1 cargo hold	100.0 tons
Lower deck of No. 2 cargo hold	430.5 tons

[2] Hanshin Port

At the time of the accident, Vessel A, which had been loaded with 95.6 tons of steel pipes and other cargo on the lower deck in No. 1 cargo hold and 241.1 tons of steel coils and others on the lower deck in No. 2 cargo hold, loaded about 18.2 tons of steel coils with a width of about 1.9 m from the cargo hold of Vessel B using the aft crane.

(2) Ballast Water

[1] When moored at the Berth in Kobe District, Hanshin Port, the seawater volume in each ballast tank was as follows.

Tank on Board	Weight	
Forepeak Tank	approx. 79 tons	(fully loaded)
No. 1 Ballast Tank (both port and starboard sides)	approx. 260 tons	(fully loaded)
No. 2 Ballast Tank (both port and starboard sides)	approx. 320 tons	(fully loaded)
No. 4 Ballast Tank (both port and starboard sides)	approx. 310 tons	(fully loaded)
No. 5 Ballast Tank (both port and starboard sides)	approx. 180 tons	(fully loaded)

[2] After mooring at the Berth in Kobe District, Hanshin Port, Vessel A discharged about 15 tons of seawater from No. 2 ballast tank (both port and starboard sides) from the start of the cargo handling operation to the time of the accident.

(3) Freshwater

When moored at the Berth in Kobe District, Hanshin Port, Vessel A carried about 27 tons of freshwater in the freshwater tank (both port and starboard sides) and about 67 tons of freshwater in the afterpeak tank.

(4) Fuel Oil

When moored at the Berth in Kobe District, Hanshin Port, fuel oil volume in each fuel tank and the lubrication oil sump tank were as follows.

Tank on Board	Weight
No. 1 Fuel Tank	approx. 2.9 tons
No. 2 Fuel Tank	approx. 45.0 tons
No. 3 Fuel Tank	approx. 26.5 tons
Lubrication Oil Sump Tank	approx. 1.0 tons

(Total weight: approx. 75.4 tons)

(5) Weight under Light Conditions and Constants

According to the loading manual, the weight under light conditions and constants^{*5} are as follows.

Weight under light conditions: 1,486.1 tons
 Constants: 35.3 tons

(6) Displacement and GM

According to the stability calculations, the displacement and GM^{*6} were as follows.

Displacement (W): 3,726.63 tons
 GM: 1.36 m

(7) Draft while moored at the Berth in Kobe District, Hanshin Port

Bow Draft: 3.34 m, Aft Draft: 4.90 m

2.6.4 Information on Cargo on Vessel A

According to the bill of lading, the wrapped pipes were as shown in the table below.

	Bundle	Weight	Bulk	Length
[1]	2 bundles (4 pipes)	1.464 tons	1.969 m ³	6.0 m
[2]	10 bundles (17 pipes)	7.611 tons	10.424 m ³	6.0 m

[1] was two bundles of Wrapped Pipe consisting of two pipes. Seven bundles out of ten bundles of [2] were Wrapped Pipes consisting of sets of two pipes, and three bundles were Wrapped Pipes consisting of single pipes. The diameter of [1] was about 27 cm, and the diameter of [2] was about 33 cm.

The cargo that collapsed consisted of eight bundles of pipes, or 14 pipes: two bundles of [1] (Wrapped Pipes consisting of two pipes), four bundles of [2] (Wrapped Pipes consisting of two pipes), and two bundles of [2] (Wrapped Pipes consisting of single pipes). Two bundles of Wrapped Pipes consisting of two pipes were in the middle of the fifth tier, four bundles of Wrapped Pipes (three consisting of two pipes and one

^{*5} “Constants” is the difference between the weight under light conditions when the ship was built and the current weight under light conditions, or the total weight of water remaining in the tanks, various facilities added after completion, and others.

^{*6} “GM (metacentric height)” is the distance between the metacenter (M), which is the intersection of the ship centerline and the line of action of the buoyant force running through the center of buoyancy when the ship lists to one side, and the center of gravity of the ship (G).

consisting of a single pipe) were on the sixth tier, and two bundles of Wrapped pipes consisting of two pipes were on the seventh tier. The total weight was about 1.790 tons. (See Photo 2.6-2)

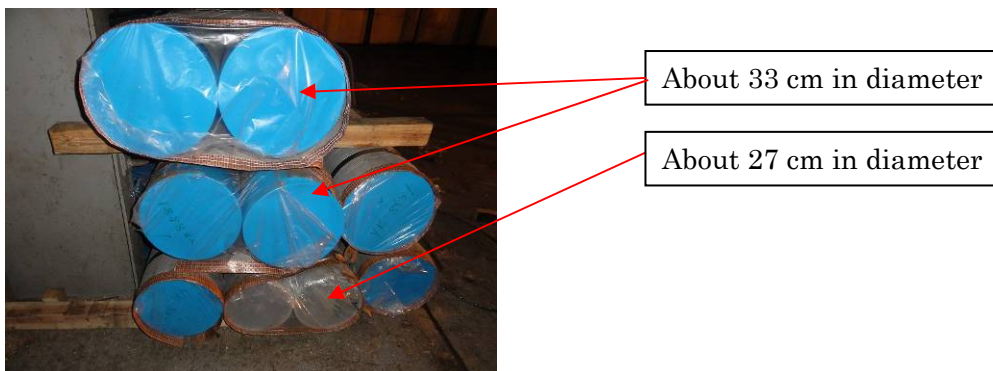


Photo 2.6-2 Wrapped Pipes

(1) Bundled Pipes under the Wrapped Pipes that Collapsed

According to the bill of lading, the Bundled Pipes under the Wrapped Pipes that collapsed were as shown in the table below.

Bundled Pipe	Weight	Bulk
48 bundles	70.283 tons	49.052 m ³

(2) Cargo stacked in No. 2 Cargo Hold

According to the bill of lading, the cargo stowed in No. 2 cargo hold from Vessel B was as shown in the table below.

Steel Coil	Weight	Bulk
16 bundles	290.560 tons	74.383 m ³

The coils, which were stowed in four fore-and-aft columns and in four abeam rows at the center of the cargo hold (openings 30 m x 7.5 m) of Vessel B moored on the starboard side of Vessel A, with a fender with a width of about 0.4 m placed between the vessels, were loaded onto Vessel A, starting from the four coils at the bow end, and then from the four coils to the aft. The accident occurred when hoisting the third coil on the starboard side using the crane on Vessel A. Subsequently, the hoisted coil was put back onto Vessel B. Therefore, six coils were left on Vessel B.

When the coils were hoisted, Vessel B had adjusted the length of her mooring lines to bring her just beside the arm of Vessel A's aft crane.

2.6.5 Cargo Handling Equipment on Vessel A

(1) Structure

Vessel A is an aft-bridge type cargo vessel engaged in international voyages, with No. 1 and No. 2 cargo holds from the bow end under the upper deck and two cranes fore and aft of the deck between No. 1 and No. 2 cargo holds.

(2) Cranes

According to the operating manual for the cranes, the cranes that Vessel A was equipped with were revolving jib-type hydraulic cranes. The safe working load,

turning radius, and turning angle of both forward and aft cranes were 25 tons, 4 to 19 m, and 200° respectively.

The maximum design hull inclination angle with cargo was 5°.

There was no trouble with or breakdown of the hull, engine or instruments at the time of the accident.

(See Photo 2.6-3)

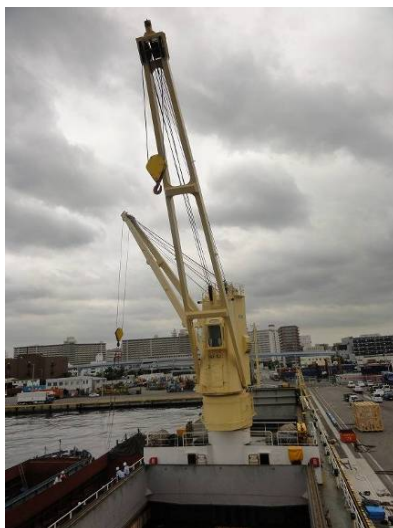


Photo 2.6-3 Vessel A Cranes (The aft crane is facing the front.)

2.7 Weather and Sea Conditions

The recorded data and figures on the weather from Kobe Local Meteorological Observatory, which is located about 2.5 km north-northwest of the site of the accident, were as follows.

At 1540 hours:

Weather: fair, wind direction: east-southeast, average wind speed: 1.7 m/s, maximum instantaneous wind speed: 2.5 m/s

At 1550 hours:

Weather: cloudy, wind direction: east, average wind speed: 3.7 m/s, maximum instantaneous wind speed: 5.8 m/s

The recorded data and figures on the sea conditions observation by a Doppler-type wave directional meter^{*7} installed by the Ports and Harbors Bureau of the Ministry of Land, Infrastructure, Transport and Tourism about 6.2 km east-southeast of the site of the accident, were as follows.

At 1540 hours:

Significant waves, height: 0.27 m, cycle: 3.7 s, direction: south-southwest

2.8 Motions of Vessel A at the Time of the Accident

According to the statements of the foreman, the Operations Chief, No. 1 cargo hold

^{*7} A “Doppler-type wave directional meter” is an ocean wave meter that takes advantage of the Doppler effect of ultrasonic waves in seawater to observe the three-dimensional movement of water particles. The function is added to an ultrasonic wave height meter, which is designed to measure wave height and period, to calculate wave direction based on the movement of water particles.

supervisor, Lasher E₂, and Lasher E₃, the situation was as follows.

At the time of the accident, Vessel A listed to port and rolled as she hoisted coils from Vessel B moored alongside the port side of Vessel A into No. 2 cargo hold. However, the rolling was mild and normal.

In addition, since there were no large vessels leaving or arriving at nearby berths, Vessel A was berthed without loosening her mooring lines.

2.9 Conditions of the Cargo Handling Operations

2.9.1 Request for work

The safety instruction in the request for work prepared by Company C stipulated the following:

- (1) Operations shall be done in accordance with the contracted operation standards.*
- (2) Every day, the person in charge of operations shall take the station assignment sheet to the foreman, assign workers to each hatch in accordance with the instructions from the foreman, and report the assignment of persons in charge of hatches to the foreman, all operations chiefs, and all cargo hold supervisors.*
- (3) All lashers shall attend a meeting held by the foreman before operations. After that, all the lashers for each cargo hold shall attend a toolbox meeting held by the operation chief and cargo hold supervisor to receive operating and safety instructions.*

2.9.2 Work Instruction from Company C

The safety points in the work instruction on the day of the accident stipulated the following:

- (1) When long cargo is being loaded, lower the cargo down through the center of the hatch to avoid catching the coaming.*
- (2) When cargo is being hoisted up from the quay, keep out of the area where crushing hazards are present.*
- (3) When handling steel products, watch your hands and watch your step.*
- (4) Keep away from the area under hoisted loads.*
- (5) Since operations are being conducted by two teams, pay attention to the rolling of the ship.*

2.9.3 Service Agreement

Company C entered into a service agreement with Company E. The commissioned operations were as follows:

- (1) Port transportation service (Lashing and unlashings of cargo)
- (2) Packing operations

2.9.4 Safety and Health Management Code of Company C

Although the safety and health management code of Company C required a safety and health supervisor to establish standards for operations and to compile them into operational guidelines in accordance with the Industrial Safety and Health Act, and

rules and guidelines pursuant to this Act, side stowage*⁸ of long cargo (pipes, bars, etc.) was not included in the operational guidelines.

2.9.5 Safety Operation Procedure

The onboard carpentry operations (lashing) in the safety operation procedure prepared by Company E stipulated the following:

(1) Preparation for operations

[1] Wear the correct protective clothing including a safety helmet and shoes.

[2] Assignment of the person responsible

Assign a person in charge of each site who calls workers' attention to operation procedures and safety points.

[3] Tool checks

[4] Meeting prior to operation

(2) Operation on board ship

[1] Prevention of falling accidents

[2] Prevention of chain saw accidents

[3] Cooperative or mixed operation

When operations are conducted at the same site where other onboard/shore stevedore teams are in operation, comply with the general safety standards and work in concert with each other.

Keep away from the area under a load being hoisted.

When forklift trucks are working during operations, let operation chiefs and drivers know workers' whereabouts.

[4] Practice finger pointing and calling out.

2.9.6 Training for Safety Operations

The foreman and No. 1 cargo hold supervisor had received risk assessment training for hazard prevention.

Operations Chief explained examples of actual accidents to stevedores about once a month.

2.10 Port Transportation Service

According to the statement of the safety officer from Company C and the safety officer from Company E, Company C and Company E were members of the Japan Port Transport Industry Safety & Health Association.

3 ANALYSIS

3.1 Analysis of the Course of Events

3.1.1 Conditions of Vessel A prior to Cargo Handling Operations

According to 2.1.1, it is probable that the details were as follows.

*⁸ "Side stowage" is where cargoes are stowed against the sidewalls of the cargo hold.

- (1) The team in No. 1 cargo hold consisted of eight workers: No. 1 cargo hold supervisor, Operator C, Driver C, Stevedore C, Stevedore D, Lasher E₁, Lasher E₂, and Lasher E₃.
- (2) Stevedores were told that the Kaohsiung Cargo would be loaded onto both sides of the lower deck, that the Keelung Cargo would be loaded onto the middle of the lower deck, and that the pipes would be stacked to a height of about 3 m, and were given safety instructions by the foreman explaining that, because Vessel A would list due to other loading operations, stevedores must keep out of the starboard and port sides and wait fore and aft, and that stevedores must keep out of the direction in which the forklift trucks are moving.
- (3) Lasher E₁ was given an explanation of the order of the loading operations by the foreman, and the height that the pipes would reach by the Operations Chief.
- (4) The Operations Chief explained the safety points described in the work instruction to all workers engaged in the loading operations on Vessel A.
- (5) On Vessel A, the foreman had a meeting with Chief Officer A and confirmed that eye plates for the wire lashing rope to run through should be welded to the walls of the cargo hold, and crew members opened the hatch covers of No. 1 and No. 2 cargo holds on the upper and tween decks.

3.1.2 Course of Events

According to 2.1.2, it is probable that the details were as follows.

- (1) On July 17, 2011, while loading pipes and other cargo at the Berth in Kobe District, Hanshin Port, Vessel A stacked Bundled Pipes for the Kaohsiung Cargo on the starboard and port sides of No. 1 cargo hold, and then stacked Wrapped Pipes on top of the Bundled Pipes.
- (2) Master B, who had moored Vessel B that had loaded 16 coils alongside the port side of Vessel A, saw the forward crane of Vessel A hoisting the coils one by one to stow them into No. 2 cargo hold and noticed that Vessel A was listing to port when the coils were being hoisted.
- (3) No. 1 cargo hold supervisor created a clearance gap using dunnage with a length of about 3 m so that the pipes were not touching the sidewalls and so that the wire lashing rope that ran through the eye plates welded to the sidewalls could be pulled out through the clearance gap.
- (4) Stevedore C placed dunnage onto the pipes stacked on the starboard side to minimize the difference in level, but he did not adjust the height from the fifth tier or insert wedges.
- (5) When Driver C pushed the Pipe stacked on top of the Wrapped Pipes on the sixth tier on the starboard side toward the sidewall using the fork of the forklift truck, the Pipe came into contact with the sidewall and the wire lashing rope could not be pulled out.
- (6) In accordance with the instructions from No. 1 cargo hold supervisor, Stevedore C and Stevedore D climbed onto the Pipe, inserted a turnbuckle between the sidewall and the Pipe, and moved it from side to side. Stevedore C and Stevedore

D managed to create a clearance gap to pull out the wire rope, and Lasher E₁ told Stevedore C that the wire lashing rope could be pulled out.

- (7) When Lasher E₁ was on top of the Wrapped Pipes on the sixth tier on the fore port side, the Operations Chief noticed that the Wrapped Pipes on the sixth tier and the Pipe had started to slide athwartships.
- (8) At around 15:45, Lasher E₁ fell down onto the lower deck along with the Wrapped Pipes, which fell onto his body, killing him.

Stevedore C and Stevedore D, who were also standing on the Pipe, escaped the accident.

3.1.3 The Fatality and the Rescue

According to 2.1.2 and 2.1.3, the details were as follows.

- (1) It is probable that when Lasher E₁ was on top of the Wrapped Pipes on the sixth tier to the fore on the port side and Stevedore C and Stevedore D were on top of the seventh tier near the starboard sidewall to the fore and aft respectively, the Operations Chief noticed that the Wrapped Pipes on the sixth tier and the Pipe had started to slide athwartships and shouted to them to watch out.
- (2) It is probable that Lasher E₁ started walking from fore to aft along the Wrapped Pipes on the sixth tier on the port side, stopped in the middle of the pipes and turned around to starboard, but as the Pipe started sliding athwartships he could not step over the Pipe and fell down onto the lower deck with the Wrapped Pipes, which fell on top of him.
- (3) It is probable that the foreman, who saw Lasher E₁ falling, called for an ambulance using his own mobile phone, told the stevedores to lift off the Wrapped Pipe consisting of a single pipe that had fallen onto Lasher E₁ by hand, and told Driver C to lift off the Wrapped Pipe consisting of two pipes that had fallen onto the legs of Lasher E₁ using the forklift truck.
- (4) Lasher E₁ was given emergency treatment by the rescue team and doctor who had just arrived, and was taken to hospital. However, he was pronounced dead at around 17:06.

It is probable that Stevedore C, who heard the Operations Chief shout and at the same time felt something moving under his feet, noticed that the Pipe was moving, turned around to starboard, and crawled onto the tween deck on his hands and elbows.

It is probable that Stevedore D noticed that the Pipe was moving, heard the Operations Chief shout to watch out, and jumped onto the wooden box stacked aft.

3.1.4 Time, Date and Location of the Accident

According to 2.1, it is probable that the time and date of the accident was around 15:45 on July 17, 2011, and the location was the Berth in Kobe District, Hanshin Port (in No. 1 cargo hold of Vessel A moored at the Berth).

3.2 Causal Factors of the Accident

3.2.1 The Situation with the Cargo Handling Operation

According to 2.1, it is probable that the situation involving loading the Pipe into No.1 cargo hold was as follows.

- (1) The No. 1 cargo hold supervisor put two pieces of dunnage with a length of about 3 m against both fore and aft of the sidewall so that the pipes were not touching the sidewall, and created a clearance gap so that after the pipes had been stacked to several tiers, Lasher E₁, who climbed onto the stacked pipes, could pull out the wire lashing rope, which ran through the eye plates welded to the sidewalls, through the gap and lash down the pipes.
- (2) Stevedore C stacked the Bundled Pipes near the starboard sidewall from the first tier to the first half of the fourth tier, and stacked Wrapped Pipes on the second half of the fourth tier. He adjusted the height by laying out dunnage until the fourth tier was stacked because the diameters of the Bundled Pipes and Wrapped Pipes were different. However, from the fifth tier, he did not adjust the height and just laid out three lines of dunnage to the fore, middle, and aft because only Wrapped Pipes were being stacked and each tier was almost even. In addition, no wedges were inserted as described in 3.2.2 below.
- (3) When Driver C pushed the Pipe on the Wrapped Pipes on the sixth tier to the starboard side toward the sidewall using the fork of the forklift truck, the Pipe came into contact with the sidewall and the wire lashing rope could not be pulled through because the height of the dunnage that was placed against the sidewall did not reach up to the position where the Pipe was touching the sidewall.

3.2.2 Situation Regarding Inserting Wedges

According to 2.1, it is probable that the situation regarding inserting wedges was as follows.

- (1) Usually, No. 1 cargo hold supervisor inserts wedges just after the forklift truck has stacked each single pipe to stop it tumbling down, but when pipes were Bundled Pipes or in groups of two, they did not insert the wedges until after all the pipes had been stacked or while the pipes were being lashed down because the pipes could not tumble down.
- (2) Stevedores planned to insert wedges after the Kaohsiung Cargo had been stacked on both sides and they did not insert wedges on all tiers due to the fact that there was a mixture of pairs of Bundled Pipes and Wrapped Pipes that could not tumble down although there were still some Wrapped Pipes consisting of single pipes.

3.2.3 Situation Regarding Lashing down the Pipes

According to 2.1.2, it is probable that the situation regarding lashing down the pipes on the starboard side was as follows.

- (1) On Vessel A, dunnage placed against the sidewalls provided a clearance gap between the stacked pipes and the sidewall, allowing the wire lashing rope running through the eye plates welded to the sidewalls to be pulled out.

- (2) On Vessel A, as described in 3.2.1 (3), the height of the dunnage that was placed against the starboard sidewall came to below the position at which the Pipe was in contact with the sidewall, and so the wire lashing rope could not be pulled through. In addition, the pipes were to be lashed after all the pipes had been stacked on the starboard side. For this reason, the pipes had not been lashed down yet.

3.2.4 Situation Regarding Movement of the Pipe

According to 2.1.2, it is probable that the situation regarding movement of the Pipe stacked on the starboard side was as follows.

- (1) No. 1 cargo hold supervisor, who heard from Lasher E₁ that the wire lashing rope could not be pulled out because there was no clearance gap between the Pipe and the sidewall, thought that creating a clearance gap would allow the wire lashing rope to be pulled out and instructed Stevedore C and Stevedore D to try to move the Pipe. Stevedore C and Stevedore D climbed onto the Pipe, inserted a turnbuckle between the sidewall and the Pipe, and moved the turnbuckle from side to side.
- (2) The Operations Chief instructed the No. 1 cargo hold supervisor to change the fork on the forklift truck to a long fork to move the Pipe.
- (3) After moving the turnbuckle inserted between the sidewall and the Pipe from side to side many times to the aft of the Pipe, Stevedore C and Stevedore D managed to create a clearance gap through which they could pull out the wire lashing rope. They did the same to the fore and created a clearance gap about 10 cm wide there. Lasher E₁ told Stevedore C that the wire lashing rope could be pulled through.

3.2.5 Rolling of Vessel A

According to 2.1.2 and 2.8, it is probable that at the time of the accident, Vessel A listed to port and rolled as she hoisted coils from Vessel B moored alongside the port side of Vessel A using the aft crane. However, the degree of roll was not unusual.

3.2.6 Angle of List of Vessel A

According to 2.6.1 and 2.6.4, the angle of list of Vessel A that was loading the coils from Vessel B can be calculated from the following formula:

$$\tan \theta = w \times l / ((W + w) \times GM)$$

where:

w: weight of a single coil 290.6 tons / 16 = 18.2 tons

l: distance from the center of Vessel A to coil being loaded (total of the following distances)

distance from the center of Vessel A to the port side: 14.8 m / 2 = 7.4 m

width of the fender between Vessel A and Vessel B: 0.4 m

distance from the starboard side of Vessel B to the cargo hold: (9.5 - 7.5) / 2 = 1.0 m

distance from the starboard side to the center of the nth coil where four coils

were placed in the 7.5 m width of the cargo hold of Vessel B:

first: 0.9 m, second: 2.8 m, third: 4.7 m, fourth: 6.6 m

W: 3,726.63 tons

GM: 1.36 m

The angle of list θ_1 , when the first coil was being hoisted from the starboard side of Vessel B, is as follows:

$$\tan \theta_1 = (18.2 \times (7.4 + 0.4 + 1.0 + 0.9)) / ((3,726.63 + 18.2) \times 1.36)$$

$$\theta_1 = 2.0^\circ$$

Similarly, the angles of list θ_n when the n^{th} coil was being hoisted from the starboard side of Vessel B are $\theta_3 = 2.8^\circ$ (at the time of the accident) and $\theta_4 = 3.1^\circ$.

Therefore, it is probable that the angle of list of Vessel A as it hoisted coils from Vessel B was about 2.0° to 3.1° to port, and that the angle of list at the time of the accident was about 2.8° .

3.2.7 Collapse of Pipes

According to 3.2.1, 3.2.2, 3.2.3, 3.2.4, and 3.2.6, the details were as follows.

It is probable that the Pipes and other Wrapped Pipes from the fifth to the seventh tier started sliding athwartships and fell down onto the lower deck due to the following facts: (i) Stevedore C and Stevedore D inserted a turnbuckle between the starboard sidewall and the Pipe and moved the turnbuckle from side to side to create a clearance gap, (ii) Vessel A listed to port at an angle of about 2.8° when Vessel A hoisted coils from Vessel B using the aft crane, (iii) the height was not adjusted from the fifth tier and only three pieces of dunnage were laid out to the fore, middle, and aft because each tier consisted of Wrapped Pipes and was almost even, (iv) the pipes were not lashed down because the pipes were to be lashed down after all the pipes had been stacked on the starboard side, (v) wedges were not inserted.

3.2.8 Weather and Sea Conditions

According to 2.7, it is probable that the weather was cloudy, with an easterly wind blowing at an average speed of 3.7 m/s and a maximum instantaneous speed of 5.8 m/s, and with significant waves of a height of about 0.27 m with a period of about 3.7 s coming in from the south-southwest.

3.2.9 Safety Management

According to 2.9.1, 2.9.2, 2.9.4, and 3.1.1(4), it is probable that the details were as follows.

- (1) Company C prepared a request for work and work instruction stipulating the safety instruction and safety points respectively.
- (2) Prior to the cargo handling operations on Vessel A, the Operations Chief explained the safety points described in the work instruction to all workers engaged in the loading operations on Vessel A.
- (3) Company C prepared operational guidelines to prevent occupational accidents during the work; however, the guidelines did not include side stowage.

3.2.10 Occurrence of the Accident

According to 3.1.2(7), 3.1.3(2), 3.2.1, 3.2.4(1), 3.2.4(3), and 3.2.7, the details were as follows.

- (1) It is probable that while Vessel A was loading pipes and other cargo at the Berth in Kobe District, Hanshin Port on July 17, No. 1 cargo hold supervisor put two pieces of dunnage with a length of about 3 m fore and aft of the sidewalls to create a clearance gap through which the wire rope for lashing down the pipes running through the eye plates welded to the sidewalls could be pulled out, and when pipes were stacked to several tiers, Lasher E₁ was to climb onto the pipes to pull out the wire rope through the clearance gap and lash down the pipes.
- (2) It is probable that Stevedore C stacked Bundled Pipes near the starboard sidewall from the first tier to the first half of the fourth tier, and stacked Wrapped Pipes on the second half of the fourth tier, adjusting the height by laying out dunnage until the fourth tier was stacked, because the diameters of the Bundled Pipes and Wrapped Pipes were different, but he did not adjust the height from the fifth tier on and just laid out dunnage to the fore, middle, and aft because only Wrapped Pipes were being stacked and each tier was almost even. In addition, it is probable that wedges were not inserted.
- (3) It is probable that when Driver C pushed the Pipe on the Wrapped Pipes on the sixth tier on the starboard side toward the sidewall using the fork of the forklift truck, the Pipe touched the sidewall and the wire lashing rope could not be pulled out because the dunnage that was placed against the sidewall was not high enough.
- (4) It is probable that the No. 1 cargo hold supervisor, who heard from Lasher E₁ that the wire lashing rope could not be pulled out because there was no clearance gap between the Pipe and the sidewall, thought that creating a clearance gap would allow the wire lashing rope to be pulled out, and instructed Stevedore C and Stevedore D to try to move the Pipe, and it is probable that Stevedore C and Stevedore D climbed onto the Pipe, inserted a turnbuckle between the sidewall and the Pipe, and moved the turnbuckle from side to side.
- (5) It is probable that when Stevedore C and Stevedore D inserted the turnbuckle between the sidewall and the Pipe and moved the turnbuckle from side to side, a clearance gap was created through which the wire lashing rope could be pulled out, and it is probable that Lasher E₁ told Stevedore C that the wire lashing rope could be pulled out.
- (6) It is probable that when Lasher E₁ was on the Wrapped Pipes of the sixth tier on the fore port side, the Operations Chief noticed that the Wrapped Pipes on the sixth tier and the Pipe started sliding athwartships.
- (7) It is probable that the Pipes and other Wrapped Pipes from the fifth to the seventh tier started sliding athwartships due to the following facts: (i) Stevedore C and Stevedore D inserted a turnbuckle between the starboard sidewall and the Pipe and moved the turnbuckle to create a clearance gap, (ii) Vessel A listed to

port at an angle of about 2.8° when Vessel A hoisted coils from Vessel B using the aft crane, (iii) the height was not adjusted from the fifth tier and only three pieces of dunnage were laid to the fore, middle, and aft because each tier consisted of Wrapped Pipes and was almost even, (iv) the pipes were not lashed because they were going to be lashed after all the pipes had been stacked on the starboard side, (v) wedges were not inserted.

- (8) It is probable that Lasher E₁ started walking from fore to aft on the port side of the Wrapped Pipes on the sixth tier, and stopped in the middle of the pipes and turned around to starboard, but when the Pipe started sliding athwartships he could not step over the Pipe and fell down to the lower deck with the Wrapped Pipes, which fell onto his body, killing him.

4 CONCLUSIONS

4.1 Findings

- (1) It is probable that while Vessel A was loading pipes and other cargoes at the Berth in Kobe District, Hanshin Port on July 17, No. 1 cargo hold supervisor put two pieces of dunnage with a length of about 3 m fore and aft of the sidewalls to create a clearance gap through which the wire rope for lashing down the pipes that ran through the eye plates welded to the sidewalls could be pulled out, and when pipes were stacked on several tiers, Lasher E₁ was to climb onto the pipes to pull out the wire rope through the clearance gap and lash down the pipes. (3.2.1 (1)) *⁹
- (2) It is probable that Stevedore C stacked Bundled Pipes near the starboard sidewall from the first tier to the first half of the fourth tier, and stacked Wrapped Pipes on the second half of the fourth tier, adjusting the height by laying out dunnage until the fourth tier was stacked because the diameters of the Bundled Pipes and Wrapped Pipes were different, but he did not adjust the height from the fifth tier and just laid out dunnage to the fore, middle, and aft because only Wrapped Pipes were stacked and each tier was almost even. In addition, it is probable that no wedges were inserted. (3.2.1 (2))
- (3) It is probable that when Driver C pushed the Pipe stacked on the Wrapped Pipes on the sixth tier on the starboard side toward the sidewall using the fork of the forklift truck, the Pipe touched the sidewall and the wire lashing rope could not be pulled out because the dunnage that was put against the sidewall was too low. (3.2.1 (3))
- (4) It is probable that No. 1 cargo hold supervisor, who heard from Lasher E₁ that the wire lashing rope could not be pulled out, thought that creating a clearance gap would allow the wire lashing rope to be pulled through and instructed Stevedore C and Stevedore D to try to move the Pipe, and it is probable that Stevedore C and Stevedore D climbed onto the Pipe, inserted a turnbuckle between the sidewall and the Pipe, and moved the turnbuckle from side to side. (3.2.4 (1))
- (5) It is probable that when Stevedore C and Stevedore D inserted a turnbuckle

*⁹ The numbers attached to the ends of sentences in this section refer to the items in chapter "3 ANALYSIS".

between the sidewall and the Pipe and moved the turnbuckle from side to side, a clearance gap through which to pull out the lashing wire rope was created, and it is probable that Lasher E₁ told Stevedore C that the wire lashing rope could be pulled out. (3.1.2 (6))

- (6) It is probable that when Lasher E₁ was standing on the Wrapped Pipes on the sixth tier on the fore port side, the Operations Chief noticed that the Wrapped Pipes on the sixth tier and the Pipe started sliding athwartships. (3.1.2 (7))
- (7) It is probable that the Pipes and other Wrapped Pipes from the fifth to the seventh tier started sliding athwartships due to the following facts: (i) Stevedore C and Stevedore D inserted a turnbuckle between the starboard sidewall and the Pipe and moved the turnbuckle to create a clearance gap, (ii) Vessel A listed to port at an angle of about 2.8° when Vessel A hoisted coils from Vessel B using the aft crane, (iii) the height was not adjusted from the fifth tier, and only three pieces of dunnage were laid to the fore, middle, and aft because each tier consisted of Wrapped Pipes and was almost even, (iv) the pipes were not lashed down because the pipes were going to be lashed after all the pipes had been stacked on the starboard side, (v) no wedges were inserted. (3.2.7)
- (8) It is probable that Lasher E₁ started walking from fore to aft on the port side of the Wrapped Pipes on the sixth tier, stopped in the middle of the pipes and turned around to starboard, but as the Pipe started sliding athwartships he could not step over the Pipe and fell down to the lower deck with the Wrapped Pipes, which fell on top of him. (3.1.3 (2))
- (9) Lasher E₁ was given emergency treatment by the rescue team and doctor that had just arrived and taken to hospital, but was pronounced dead. (3.1.3 (4))

4.2 Probable Causes

It is probable that the accident occurred while Vessel A was loading pipes and other cargo at the Berth in Kobe District, Hanshin Port. The Pipe and other Wrapped Pipes stacked on the fifth to seventh tier started sliding athwartships, and Lasher E₁, who was standing on the Wrapped Pipes on the sixth tier, fell down to the lower deck with the Wrapped Pipes, which fell on top of him.

It is probable that the Pipes and other Wrapped Pipes stacked from the fifth to the seventh tier started sliding athwartships due to the following facts: (i) Stevedore C and Stevedore D inserted a turnbuckle between the starboard sidewall and the Pipe and moved the turnbuckle to create a clearance gap, (ii) Vessel A listed to port at an angle of about 2.8° when Vessel A hoisted coils from Vessel B using the aft crane, (iii) the height was not adjusted from the fifth tier and only three pieces of dunnage were laid down to the fore, middle, and aft because each tier consisted of Wrapped Pipes and was almost even, (iv) the pipes were not lashed down because the pipes were going to be lashed down after all the pipes had been stacked on the starboard side, (v) no wedges were inserted.

It is probable that Stevedore C and Stevedore D tried to create a clearance gap between the sidewall and the Pipe using a turnbuckle because the No. 1 cargo hold

supervisor, who heard from Lasher E₁ that the wire rope lashing could not be pulled out since the dunnage that was placed against the sidewall did not reach up to the point where the Pipe came into contact with the sidewall when the Pipe was pushed in using the fork of a forklift truck, thought that creating a clearance gap would allow the wire lashing rope to be pulled out and so instructed Stevedore C and Stevedore D to try to move the Pipe.

5 SAFETY ACTIONS

It is probable that the accident occurred while Vessel A was loading pipes and other cargoes at the Berth in Kobe District, Hanshin Port. The Pipe and other Wrapped Pipes stacked from the fifth to the seventh tier started sliding athwartships, and Lasher E₁, who was standing on the Wrapped Pipes on the sixth tier, fell down to the lower deck with the Wrapped Pipes, which fell on top of him.

It is probable that the Pipes and other Wrapped Pipes stacked from the fifth to the seventh tier started sliding athwartships due to the following facts: (i) Stevedore C and Stevedore D inserted a turnbuckle between the starboard sidewall and the Pipe and moved the turnbuckle to create a clearance gap, (ii) Vessel A listed to port at an angle of about 2.8° when Vessel A hoisted coils from Vessel B using the aft crane, (iii) the height was not adjusted from the fifth tier and only three pieces of dunnage were laid down to the fore, middle, and aft because each tier consisted of Wrapped Pipes and was almost even, (iv) the pipes were not lashed down because the pipes were going to be lashed after all the pipes had been stacked on the starboard side, (v) no wedges were inserted.

It is probable that Stevedore C and Stevedore D tried to create a clearance gap between the sidewall and the Pipe using a turnbuckle because the No. 1 cargo hold supervisor, who heard from Lasher E₁ that the wire lashing rope could not be pulled out since the dunnage that was placed against the sidewall did not reach up to the point where the Pipe came into contact with the sidewall when the Pipe was pushed in using the fork of a forklift truck, thought that creating a clearance gap would allow the wire lashing rope to be pulled out and so instructed Stevedore C and Stevedore D to try to move the Pipe.

It is therefore necessary for port transportation service providers to take the following measures to prevent the recurrence of similar accidents.

- (1) Preventing cargoes from collapsing
 - [1] Workers must insert wedges straight after each tier is stacked even when a mixture of bundled pipes and groups of two pipes are being stacked.
 - [2] Workers must adjust any level differences using dunnage when different diameter pipes are being stacked on a tier and level differences appear.
 - [3] Workers should use a forklift truck to move pipes when necessary.
- (2) Compliance with work procedures

Before stacking pipes, workers should check and lengthen dunnage to be placed against the sidewall if additional lengths of dunnage become necessary.

(3) Security of the work area

Workers shall not work or wait in areas where cargo is being moved.

5.1 Safety Actions Taken

After this accident, Company C held a post-accident review meeting on July 17 and set down the following safety actions.

- (1) Regardless of the packing type, wedges must be inserted on every tier for side stowage. (as of July 18)
- (2) Middle-lashing shall be conducted for side stowage before the height of the cargo reaches 2 m. (as of July 18)
- (3) When lashing is done on side stowage, all crane operations must be stopped before tying down the cargo temporarily. (as of July 18)
- (4) Contact operations with carpenters (lashers) shall be clarified. (as of July 31)
- (5) Operating guidelines for side stowage shall be prepared. (prepared on August 5)
- (6) Training shall be conducted based on operating guidelines for side stowage. (as of August 6)
- (7) Patrols should be conducted to confirm operation progress and to provide workers with necessary instructions. (as of July 18)
- (8) Onboard TBM^{*10} involving the foreman, operations chief and leader of carpenter shall be strengthened. (with written safety instructions) (as of July 31)

On August 5, Company C prepared operating guidelines for side stowage of long cargo (pipes, bars, etc.) (final revision on August 31), and since then all cargo handling operations have been conducted based on these guidelines.

Operation guideline for side stowage of long cargo (pipes, bars, etc.)

(1) Preparations for side stowage

[1] Put battens against bulkheads at the site of side stowage, lay out square timber, and prepare lengths of lashing wire.

[2] Prepare wedges at the time of use. (Some wedges shall be prepared beforehand.)

(See Photo 5-1, Photo 5-2)



Photo 5-1 Preparations for Side Stowage



Photo 5-2 Wedges (prepared)

^{*10} "TBM" stands for Tool Box Meeting where workers discuss the schedule and precautions for their work.

(2) Side stowage

[1] The forklift driver inserts the fork under unslung pipes in accordance with the guide.

[2] The forklift driver raises the fork to travel height and then tilt it backward to hold the cargo.

[3] Moving it back slightly, the cargo rests against the heel of the fork.

[4] The forklift driver drives the forklift truck to the site of the side stowage.

[5] The forklift driver stops short of the site in accordance with the guide.

[6] The forklift driver brings the fork down to the horizontal position, lowers the fork, and unloads the pipes at the site.

(See Photo 5-3, Photo 5-4)



Photo 5-3 Forklift Truck at a Temporary Stop



Photo 5-4 Stowing

[7] Stow pipes by repeating procedures from [1] to [6], making the lengths of the tiers equal.

[8] Workers in the cargo hold shall nail wedges to the square timbers firmly at the front of each tier to prevent tumbling or sliding. Nail the wedges down firmly, and then cut off any protruding part of the square timber.

(See Photo 5-5, Photo 5-6)

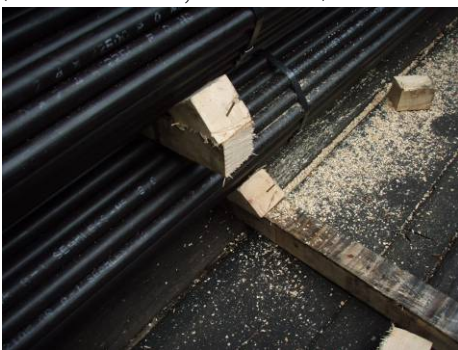


Photo 5-5 Nailing Down Wedges



Photo 5-6 Cutting off the Square Timber

[9] After stowing pipes on each tier and inserting wedges,

a. Level the top of the pipes.

b. Eliminate the gap between pipes.

After a and b using square timber, half-split lumber, or thin plates, lay out square timber for the next tier.

[10] Stack each tier by repeating procedures from [1] to [9]. When the height of the stack reaches 2 m, secure the pipes by middle-lashing.

Also secure the pipe by middle-lashing when the height exceeds the width of the stack.

[11] While middle-lashing is continuing, stop all crane operations until the possibility of collapse has been prevented (after temporary tying)

(See Photo 5-7)



Photo 5-7 Middle-lashing

5.2 Safety Actions Required

Company C needs to confirm the length of dunnage before stacking pipes, lengthen the dunnage when additional lengths are needed, keep the work area safe and keep stevedores out of the area where cargo is being moved; use a forklift truck to move pipes if necessary.

○ Why-Why Analysis

[Lasher E₁ fell.] → [The pipes in the sixth tier that Lasher E₁ was on started sliding athwartships.] → *1
→ *2
→ *3
→ *4
→ *5

- *1 [Stevedore C and Stevedore D inserted a turnbuckle between the starboard sidewall and the Pipe and moved the turnbuckle from side to side to create a clearance gap.] → *6
- *2 [Vessel A listed to port to an angle of about 2.8° when Vessel A hoisted steel coils from Vessel B using the crane.]
- *3 [The height was not adjusted from the fifth tier.] → [Three pieces of dunnage were laid to the fore, middle, and aft because each tier was almost even.]
- *4 [The pipes were not lashed.] → [The pipes were going to be lashed after all pipes were stacked on the starboard side.]
- *5 [No wedges were inserted.] → [Wedges were to be inserted after pipes were stacked on the starboard side.]
- *6 [Wire lashing rope that ran through eye plates welded to the sidewalls could not be pulled through.] → *7
- *7 [When the Pipe was pushed using the fork of a forklift truck, it came into contact with the sidewall.] → [The dunnage that was placed against the sidewall did not reach high enough.]