～ Case Studies and Accident Analysis ～

JTSB Digests

JTSB (Japan Transport Safety Board)

(Issued in December, 2012)

Digest of Marine Accident Analyses

For prevention of "Fatal and Injury Accidents Related to On-Board Works"

1. Introduction

In recent years, we have seen many fatal and injury accidents to crew and shore workers carrying out such works as repairing, stevedoring and cleaning on vessels, in connection with the structure, equipment or operation of vessels. The main factors contributing to the occurrence of these accidents include properties of cargo on board, existence of enclosed space and hazardous zones and failure of such equipment as cargo lifting appliances.

In particular, with regard to those works on vessels at anchor or at berth with a risk of explosion or other accidents to persons, it is necessary to take preventive measures taking into consideration the current safety issues in the industries concerned and the nature of the vessel as a working environment. These accidents occurred in relation to factors unique to the vessel operation on cargo ships or dangerous goods carriers, such as cargo lifting appliances, hazardous substances in tanks and oxygen level in cargo holds, and what are behind these accidents include the situation that shore workers may possibly have started working without full knowledge of the particularly dangerous working environment on vessel and are not well trained for avoiding risks associated with the work.

In view of these ongoing situations, we present some case studies of serious accidents investigated by the Board and various statistical data aiming at a digest featuring fatal and injury accidents related to on-board works for prevention of similar accidents.

We hope that this digest will be on various occasions such as safety seminars held by the parties concerned, and will be able to contribute to the improvement of safety at sea.

※ The definition in this digest of "Fatal and injury accidents related to on-board works":
Accidents which occurred while working on a vessel, involving death or injury of a person in relation to the structure, equipment and operation of the vessel, excluding, accidents which occurred to fishing vessels during their operation.

2. Statistics

※Some of the accidents referred to in this digest are under investigation, and the figures may change.

Breakdown by the type of accident and work

The number of fatal and injury accidents related to on-board works (accidents which occurred while working on vessels) which occurred during the period of 2008 to June 2012, and which the Board conducted investigations for and made the investigation reports of public was 95 (95 vessels).

By the accident type, the number of fatal accidents was 38 (40.0% of the total), while the number of injury accidents was 57 (60.0%). (See Figure 1)

By the type of works when the accidents occurred, the number of accidents during mooring and anchoring was 31 (32.6%), stevedoring 23 (24.2%), working inside tanks and holds 13 (13.7%) and engine rooms 5 (5.3%), showing that work categories of mooring, anchoring, stevedoring and working inside tanks and holds accounted for almost 70% of the total. (See Figure 2)

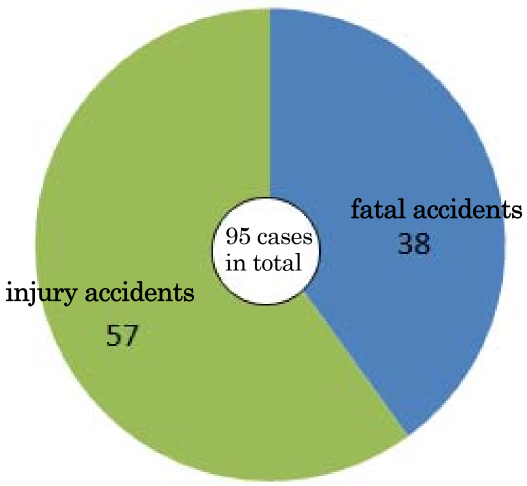


Figure 1: By the type of accidents

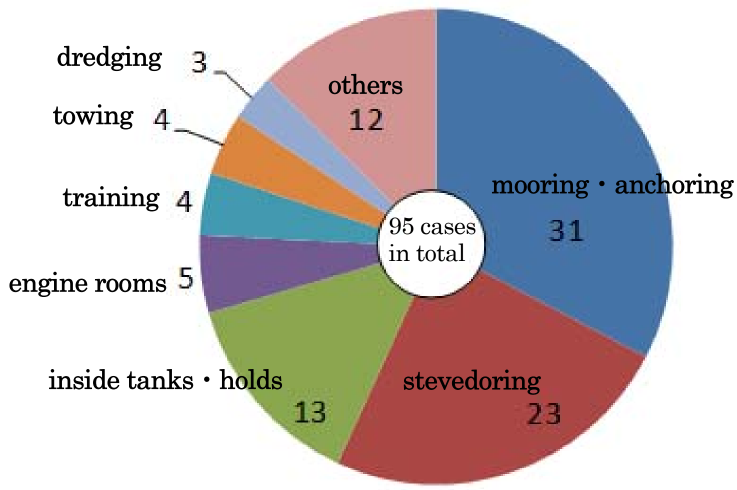


Figure 2: By the type of works

* Fatal accidents include accidents involving both the dead and injured

Breakdown of fatalities and the injured

The number of fatalities and the injured involved in 95 accidents was 116. The breakdown is, fatalities 41 (35.3%), the seriously injured 43 (37.1%) and the slightly injured 32 (27.6%). (See Figure 3)

By the occupational category, the number of crew was 84 (72.4%), while workers 30 (25.9%) and others 2 (1.7%), indicating that the number of accidents involving deaths and injuries of crew members was quite large. (See Figure 4)

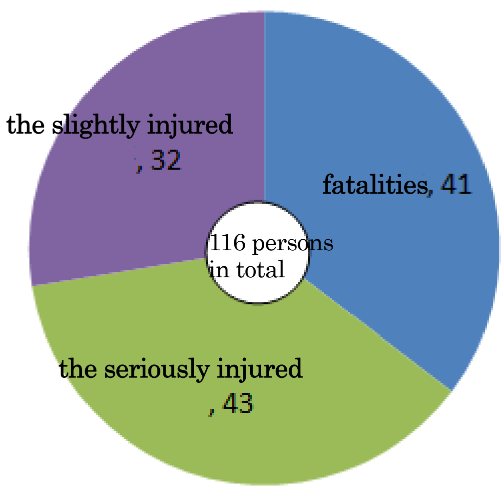


Figure 3: The number of fatalities and the injured

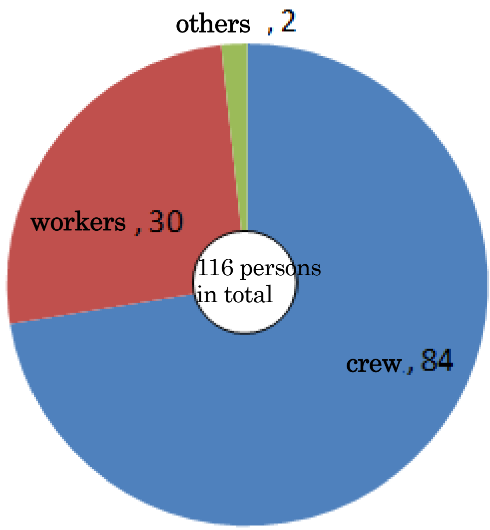


Figure 4: By the occupational category

By the type and tonnage of vessels

By the type of vessels, the number of cargo ships was 43 (45.3%), the largest among all, followed by passenger ships 13 (13.7%), oil tankers 12 (12.6%), barges 7 (7.4%) and tugboats 5 (5.3%). Cargo ships and oil tankers which are very likely to handle hazardous materials accounted for almost 60 % of the total. (See Figure 5)

By the tonnage, the number of vessels in the range of 100 to 200 tons was 18 (18.9%), 200 to 500 tons 17 (17.9%), 500 to 1,600 tons 14 (14.7%) and 1,600 to 3,000 tons 9 (9.5%), showing that vessels with a tonnage of 100 to 1,600 accounted for about 50% of the total. (See Figure 6)

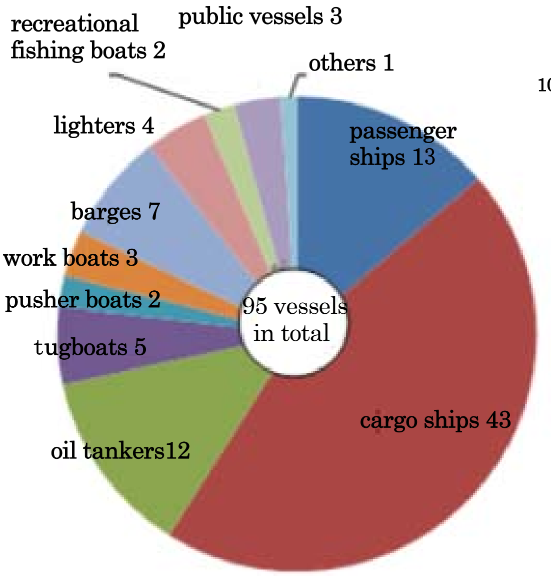


Figure 5: By the type of vessels

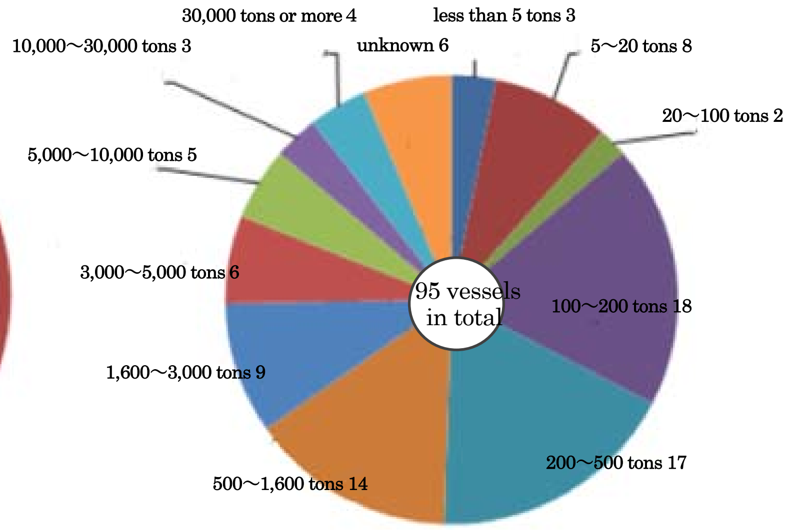


Figure 6: By the tonnage of vessels

By the registry of vessels

By the registry of vessels, the number of vessels registered in Japan was 79 (83.2%), Panama 6 (6.3%) and Hong Kong 4 (4.2%). (See Figure 7)

By the type of deaths and injuries

By the type of deaths and injuries, the number of contacts and heavy blows was 26 (27.4%), fall and man overboard 24 (25.3%), crush 23 (24.2%), caught in machinery 7 (7.4%), and anoxia and toxic gas inhalation 6 (6.3%), indicating that accidents caused by physical factors accounted for the great majority. (See Figure 8)

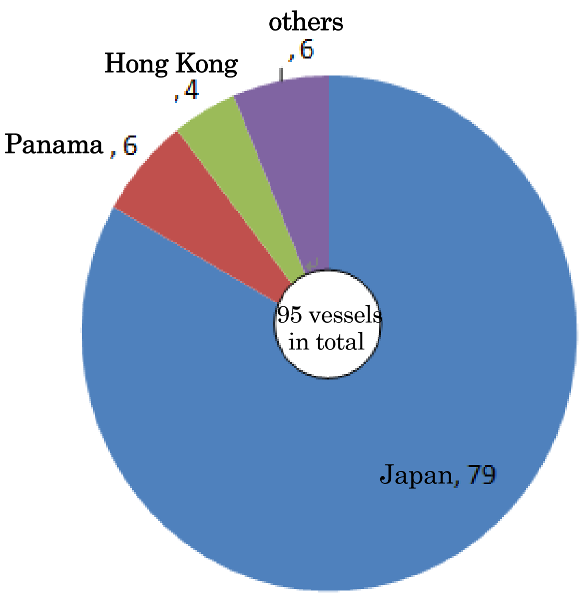


Figure 7: By the registry of vessels

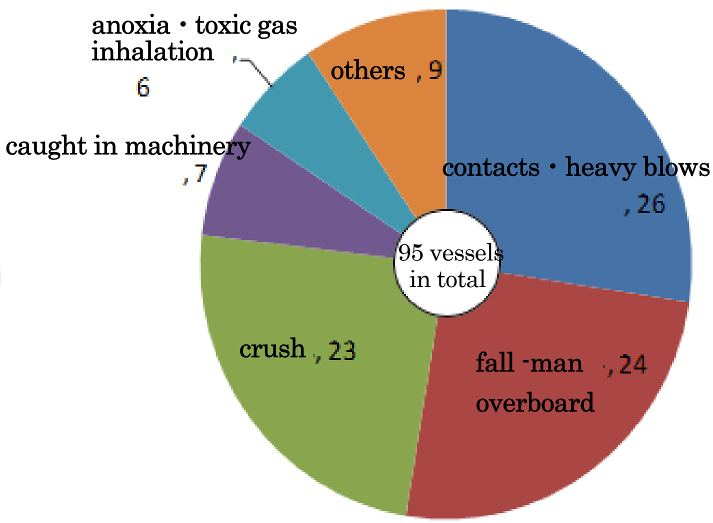


Figure 8: By the type of deaths and injures

The breakdown of work categories (By the type of deaths and injuries)

By comparing the figures for mooring and anchoring, stevedoring, and working in tanks and holds which accounted for almost 70% of all the accidents when classified by work categories, it becomes clear that the type of deaths and injuries which accounted for the most in each work category was contacts and heavy blows with 35.5% (11 cases) in the case of mooring and anchoring, fall and man overboard with 39.1% (9 cases) for stevedoring and anoxia and toxic gas inhalation with 46.1%(6 cases) for working in tanks and holds.

Also, accidents caused by crushed accounted for 25.8% (8 cases) in the case of mooring and anchoring, and 34.8% (8 cases) in the case of stevedoring, either of which showing a high occurrence ratio. (See Figure 9)

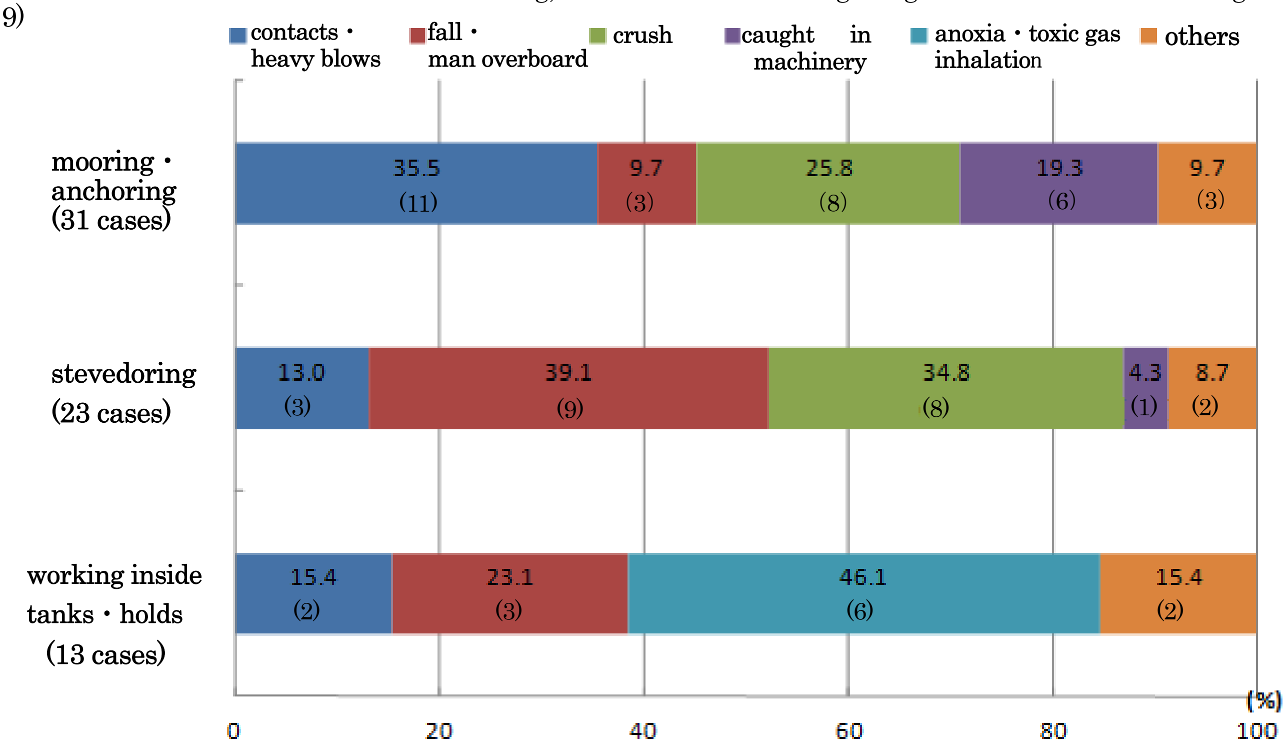


Figure 9: The breakdown of work categories (By the type of deaths and injuries)

The breakdown of work categories (By the number of fatalities and the injured)

The work category showing the largest number of fatalities and the injured was stevedoring with 35 in number, while mooring and anchoring with 31, and working in tanks and holds with 17.

In the category of working in tanks and holds, the number of fatalities accounted for as high as 82.3% (14 persons) of the total number of fatalities and the injures, which suggests the work involves a high risk of a severe accident. (See Figure 10)

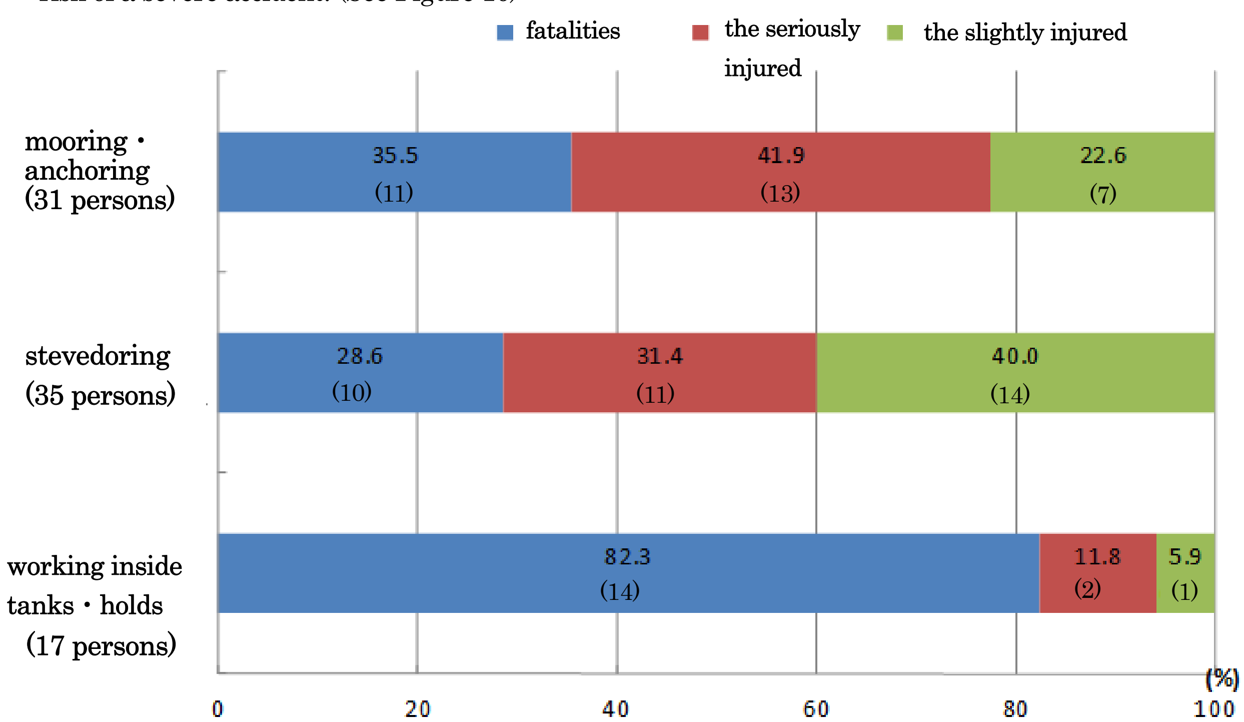


Figure10: The breakdown of work categories (By the type of deaths and injuries)

Examples of accident cases which were investigated by regional offices of the Board by type of accident and work are as follows.

Mooring・Anchoring

Contacts・Heavy Blows

・ While anchoring with spuds cast into the sea, a vessel listed to starboard, and it attempted to lift the spud on the starboard side. However, the lifting was unsuccessful with the hydraulic system only, and instead, a crane was put into operation to lift the spud from the sea, which was prohibited by the operational procedures. In the meantime an end of the wire hooked on the crane came off the crane, and the wire contacted an ordinary seaman on the left side of the head. He died of brain contusion and traumatic intracerebral bleeding.

(*) a "spud": an iron post to be stuck in the bottom of the sea for the purpose of stabilizing the vessel, which will also be used to move the vessel up and down with its gear wheel engaged with the gear wheel of the hydraulic appliance.

Caught in machinery

・While leaving shore, when an ordinary seaman was engaged in the operation of a winch to wind a mooring rope, and the rotation speed of the drum became fast because of his erroneous remote controlling. Then, he tried to stop the drum by trampling the rope, when his right foot came into an eye of the rope, and he was pulled by the rope and caught in the drum. He had his rib, pelvis and thigh bone fractured.

Stevedoring

Fall-Man overboard

・During stevedoring, an officer was about to start cleaning the floor of the cargo hold ,descending a rope ladder. As he had not inspected the rope ladder, when he weighed his whole body on a step of the rope ladder with both of his feet, these ropes which had decreased in strength were cut off both ends of the step, making him fall on the floor of the hold. He suffered an open fracture-dislocation of the left foot joint

Crush

・During stevedoring, the chief officer, positioned between the port side of a container and a guard pipe, completed a guiding operation for the container, when he got his chest pinched between the port side of the container loaded on the port side of his vessel and the guard pipe. He was crushed to death.

Working in tanks・holds

Anoxia・Toxic gas inhalation

・During discharging of tert-butyl alcohol, which is a liquid chemical substance, the chief officer entered the hold with a gas mask where the oxygen level became low because of the nitrogen gas which was injected as an inert gas, and he came to inhale the air with low oxygen concentration. In view of the fact that, upon noticing a drain plug was not installed inside the tank, the chief officer was in a hurry for the installation in the tank, and it is considered somewhat likely that the chief officer entered the tank because he forgot that nitrogen gas had been injected into the tank. The chief officer died from suffocation resulting from anoxia.

Fall-Man overboard

・ While engaged in decompressing a cargo tank, an ordinary seaman entered a hazard area and stood in front of the gas outlet, and he was blown off by the pressure of the gas being emitted and fell into the sea. It is considered somewhat likely that insufficient notification of the measures for keeping out of hazard areas contributed to his entering the hazard area and standing in front of the gas outlet. The ordinary seaman died from drowning.

From among the published accident investigation reports, let us introduce a few examples of serious fatal and injury accidents related to on-board works, which occurred in Japan.

Serious Accident : Case 1

During discharge of copper sulfide concentrate, oxygen-deficient air was inhaled, leading to anoxia

Outline: While the cargo ship was berthed at the wharf of Port of Saganoseki for discharging a cargo load of copper sulfide concentrate at about 08:30, June 13, 2009, one of the workers fell while descending a ladder inside No. 3 cargo hold on his way to undertaking the job of stevedoring. Two of the three other workers who went to rescue him also collapsed in the cargo hold. All of the three workers were rescued from No. 3 cargo hold, but later they were confirmed dead.

【Operation Team Members】 (7 workers as below)

① Foreman (*1)(victim, cargo work supervisor)
② Heavy vehicle driver in cargo hold No. 3 (victim, "Driver B")
③ On-shore crane senior operator (victim, "Operator C")
④ Ship crane operator ("Operator D")
⑤ Heavy vehicle driver in cargo hold No. 1 ("Driver E")
⑥ Operator of on-shore crane ("Operator F")
⑦ Heavy vehicle's slinging worker, etc.

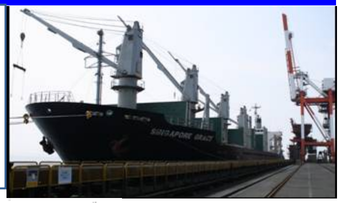
*1 : "The Foreman" is a person who discusses the time of arrival/departure and operation schedule with the shipping company, agent and shipper, and cargo work procedure, safety operations, etc. with chief officer, as well as supervising cargo work.

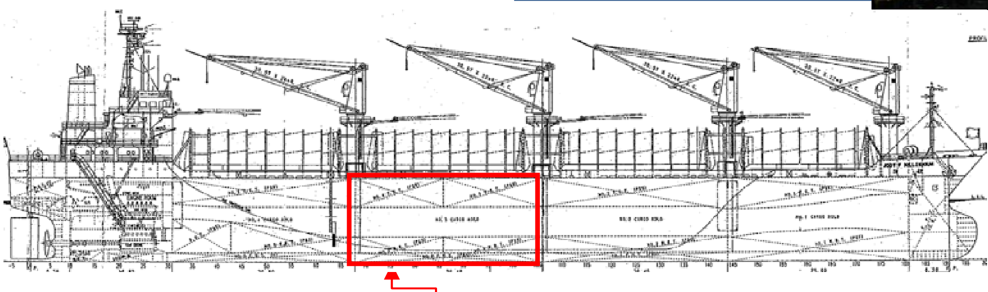
The Ship (Cargo Ship)

Gross ton: 15,071 tons

L × B × D: 159.94m × 26.00m × 13.50m

Port of registry: Hong Kong





cargo hold No. 3
Above: general arrangement"(excerpt)
Left: approach to cargo hold
Right: rescue operation

Events Leading to the Accident

The ship carrying copper concentrate at Port Moresby Harbour (Independent State of Papua New Guinea) sailed to port of Saganoseki.

While the ship was berthed at the wharf of port of Saganoseki, and Driver B entered cargo hold No. 3 and was descending toward the bottom, he inhaled oxygen-deficient air (*4), developed anoxia and died.

The Foreman, Operator C and Operator F entered cargo hold No. 3 in order to rescue Driver B. The foreman inhaled oxygen-deficient air, developed anoxia and died.

To next page

Causal Factors of the Accident

During the voyage, the copper concentrate loaded in cargo hold No.3 oxidized, and the oxygen in the airtight hold was consumed. The atmosphere (*2) in cargo hold No. 3 became oxygen-deficient, and at the same time, odorous hazardous gases, which were heavier than air, were generated by the floatation reagents (*3) adhering to the copper concentrate and accumulated in the cargo hold.

For details, refer to "Causal Factors of the Accident Occurred" (The primary accident) (next page)

For details, refer to "Causal Factors of the Accident Occurred" (The secondary accident) (next page)

*2: "Atmosphere" is defined as the conditions of a particular gas or mixed gas.

*3: "Floatation" is one ore dressing method that processes copper ore with a low percentage content to obtain copper concentrates. Specifically, powdered crude ore is suspended in water, an oil or flotation reagent stirred in and the copper concentrates float and attach to surface where they are collected. Oils and reagents used in this process are called "Floatation reagents."

*4: "Oxygen deficiency" is the reduction of O_2 concentration in air, and can cause anoxia if inhaled. Anoxia causes dizziness, loss of consciousness and even death.

From previous page

Upon entering cargo hold No.3 after the Foreman and Operator C, Operator F felt choked. Operator F returned to the upper deck with Operator C as Operator C signaled him to go back.

As Operators C and F entered cargo hold No. 3 once again in order to rescue the Driver B and the Foreman, Operator C inhaled oxygen-deficient air, developed anoxia and died. When Operator F came back to near the entrance hatch, he was pulled up to the upper deck by the crew of the ship and was rescued.

At that time, although Operator F thought of deterring the Foreman and Operator C, he thought he also had to join the rescue, felt impatient and responsible and lost his sense of composure.

"Standard for Measuring O_2 Concentration (on-board works)" by the stevedoring company

- ✓ The operations chief of oxygen deficient danger measures the O_2 concentration, after the mooring of a vessel and opening the hatches and before the workers board.
- ✓ The operations chief of stevedoring should not allow workers into the cargo hold unless O_2 concentration is 18% or more, after the chief received the report.

For details, refer to "Causal Factors of the Accident Occurred" (The tertiary accident) (this page)

Causal Factors of the Accident Occurred (The primary accident: Driver B)

The following factors are considered to have contributed to the occurrence of the accident.

- Driver B entered cargo hold No. 3, which was oxygen-deficient, inhaled oxygen-deficient air and developed anoxia.
- Causal factors leading to Driver B entering oxygen-deficient cargo hold No.3
  - ・the access permit notice board was posted at the entrance hatch of cargo hold No.3
  - ・another operator had started driving a heavy vehicle in cargo hold No.1
- Casual factors leading to oxygen-deficiency in cargo hold No.3
  - ・the copper concentrate loaded in cargo hold No. 3 had oxidized during transportation from Port Moresby Harbour to port of Saganoseki, and the oxygen in airtight cargo hold No.3 had been consumed, creating an oxygen-deficient environment
- Other factors
  - ・the Foreman was not aware of the oxygen-deficient atmosphere in cargo hold No.3
  - ・it became customary to measure O_2 concentrations without following the prescribed method
  - ・the smelter (Company A) and the stevedoring company (Company B), unaware that the cargo operation supervisors including the Foreman had not practiced the O_2 concentration measurement method as regulated, did not instruct them to follow the regulated measurement method

access permit notice

gas mask and canister

Causal Factors of the Accident Occurred (The secondary accident: the Foreman)

The following factors are considered to have contributed to the occurrence of the accident.

- The Foreman, informed that Driver B had collapsed, was unaware of the oxygen-deficient atmosphere in cargo hold No.3 and entered the hold to rescue Driver B together with Operator C and Operator F, and as a result, the Foreman inhaled oxygen-deficient air and developed anoxia.
- It is likely that the Foreman was not aware of oxygen-deficient atmosphere in cargo hold No. 3 as he felt impatient and responsible to rescue Driver B, and lost his sense of composure.
- There were workers who had a misunderstanding that oxygen-deficient conditions in cargo holds were removed by natural ventilation as time passed after opening the hatch covers. (Odorous gases, heavier than air, generated by the floatation reagents accumulated at the lower layer of the hold, and were not replaced by air).
- Since the fatal accident from anoxia in a hold four years ago, measurements for detecting oxygen-deficient atmosphere had not been done by the time when this case occurred, and there had been no accidents causing injury or death.
- No appropriate instruction or training had been given to the workers by the stevedoring company in dealing with cases of a fatal accident in a cargo hold loaded with copper concentrate.

Causal Factors of the Accident Occurred (The tertiary accident: Operator C)

The following factors are considered to have contributed to the occurrence of the accident.

- Operator C entered cargo hold No.3 wearing a gas mask, together with Operator F, to rescue the Foreman and Driver B, and as a result, he inhaled oxygen-deficient air and developed anoxia.
- He thought he could cope with the condition of oxygen-deficient atmosphere with a gas mask only.
- He felt impatient and responsible, and lost his sense of composure.
- As he had already developed anoxia when he went to rescue at the time of the primary accident, he could not make appropriate decisions.
- Appropriate education and training on coping behavior in case of fatal accidents in a cargo hold loaded with copper concentrate had not been provided to the personnel by the stevedoring company.

Proposals (Recommendations・Safety Recommendations・Opinions)

In view of the results of this accident investigation, the Japan Transport Safety Board recommended Companies A and B to implement the following measures, pursuant to paragraph (1) of Article 27 of the Act for Establishment of the Japan Transport Safety Board.

Recommendations to Company A

(1) To train all employees who have the possibility of being engaged in cargo operation to understand the properties and risks of copper sulfide concentrate.
(2) To train all employees, who have the possibility of being engaged in cargo operation, with the handling of O_2 meters in order to measure O_2 concentrations safely and surely as necessary.
(3) To request the MSDS (*5) of floatation reagents from shippers.
(4) To inform all employees who have the possibility of being engaged in cargo operation that depending on the floatation reagent adhering to copper sulfide concentrate, it may generate toxic gas, and since the generated toxic gas is heavier than air, it stagnates in cargo hold, hence, there is a danger of not being replaced by air.
(5) To make the risks of oxygen-deficient conditions and anoxia known to all personnel who have the possibility of being engaged in cargo operation and to familiarize them with appropriate coping behavior in case of fatal accidents occurring in cargo holds loading copper sulfide concentrate.

Recommendations to Company B

(1) To train all employees who have the possibility of being engaged in cargo operation to understand the properties and risks of copper sulfide concentrate.
(2) To train all employees, who have the possibility of being engaged in cargo operation, with the handling of O_2 meters in order to measure O_2 concentrations as necessary.
(3) To make the risks of oxygen-deficient conditions and anoxia known to all employees who have the possibility of being engaged in cargo operation and to familiarize them with appropriate coping behavior in case of fatal accidents occurring in cargo holds loading copper sulfide concentrate.

In view of the results of this accident investigation, the Board recommended Companies C, shipper of copper sulfide concentrate, to implement the following measures (safety recommendations).

Safety Recommendations to Company C

In case of the possibility of the existence of floatation reagents adhering to copper sulfide concentrate, it is recommended to Company C as the shipper to submit information (MSDS, etc.) on floatation reagents in addition to information of copper sulfide concentrate (MSDS, etc.) to ships and consignees in order to make the properties and the risks of copper sulfide concentrate and floatation reagents known to ships and consignees.

In view of the results of this accident investigation, the Board expressed its opinions as follows to the Minister of Land, Infrastructure, Transport and Tourism, pursuant to Article 28 of the Act for Establishment of the Japan Transport Safety Board in order to prevent the recurrence of similar casualties.

Opinions to the Minister of Land, Infrastructure, Transport and Tourism

The Board requests the Minister to widely disseminate through the International Maritime Organization (IMO) such information regarding the risks of the use of floatation reagents as that depending upon the properties of the floatation reagent adhering to copper sulfide concentrate, it may generate toxic gas, and that since the generated toxic gas is heavier than air, it stagnates in cargo hold, hence, there is a danger of not being replaced by air.

*5: "MSDS" (Material Safety Data Sheet) is a document that contains information necessary for the safe handling of chemical substances or raw materials containing chemical substances

In order to Prevent Recurrence

In order to contribute to the prevention of recurrence of similar accidents, personnel who are engaged in the transport and the cargo operation of copper concentrate are requested to pay further attention to the followings:

(1) In order to know the atmosphere of enclosed space, it is necessary that the O_2 concentration and gases should be measured properly.
(2) It is necessary that personnel should understand the atmosphere of enclosed space. No personnel should enter enclosed space until the atmosphere becomes safe by forced draft, etc.
(3) It is necessary that personnel should keep in mind that it is not easy to enter the cargo hold and rescue quickly the injured, and that once anoxia developed, it is difficult to return from the cargo hold alive.

Also, the Board has requested the industry and organizations involved in the transport and the cargo operation of copper concentrate to familiarize the parties concerned with this report, and to remind them further of the risk which may arise in handling copper concentrate.

The investigation report of this case is published on the Board's website (issued on April 27, 2012)
http://www.mlit.go.jp/jtsb/eng-mar_report/singaporegrace.pdf

Serious Accident : Case 2

While in docking operation for a container ship, a mooring rope attached onto a bitt on the berth broke, and snapped back, hitting mooring workers, and took their lives

Outline: the container ship (the Ship) was docking at Port Island Container-Berth 18 at about 0736 hrs, May 20, 2009, when a mooring rope attached onto a bitt on the berth broke, snapped back and hit two workmen engaged in mooring work. Both of them died.

The Ship (container ship)
Gross tonnage: 15,095 tons
L×B×D : 168.13 m ×27.30 m × 13.50 m
Port of registry: Hong Kong
Crew : 20 crew members

Causal relations

Hull
- Container Liner. Regularly uses the same berth, moored in the same way.
- Specially designed for loading with as many containers as possible.

Mooring Line
- Had been used for less than a year.
- No criteria for discarding or replacing fiber ropes.
- No inspection or maintenance required clearly in the safety management manual
- Differently routed from the original routing at the construction.

Communication

Pilot A⇔ Master, Chief Officer: English
Master A ⇔ Crew: Chinese
Pilot A ⇔ Tug: Japanese

- No requests from Pilot A on the speed and the progress of docking, and no report from Master to Pilot

Docking Assignment
- Different from the regular assignment: Pilot A, Master A and Chief Officer on the deck, Second Officer at the bow and Third Officer on the stern

Ship handling while docking
- About 0.3 kn, forward headway at the time of running over the designated position.

Weather
- Wind force 3 (Maximum Instantaneous, 9.8 m/s), starboard quarter.

Mooring Operation
- Part-time workers, sufficiently skilled
- No sufficient safety education to specify the snap-back hazardous zone of a broken line and leave from the hazardous zone as promptly as possible
- More than one line latched onto a bitt
- Working close to the Line

- The Line had been repetitively used for a forward spring line.
- The Line had been repetitively used while touching the Bend Point
- Insufficient inspection of mooring ropes

- The Line was touching the Bend Point

- Against what the Pilot A intended, Master A gave a direction to heave the Line

- Pilot A and Master A shared no information on the situations of the headway and the mooring line.

- Second Officer gave a direction to heave the Line on the bow commanding post, from where the Bend Point are not visible.

- Stern line floating close to the propeller, the engine was unavailable.
- To reduce the headway by the Line, directed to heave
- The Ship was being blown off the Berth by the wind pressure.

- The second spring line was veered while the Ship was moving.
- Working inside the hazardous zone.
- No "sign of break"

Used the mooring rope with localized damage and losses

Possibility of break under a stress less than the specified breaking load

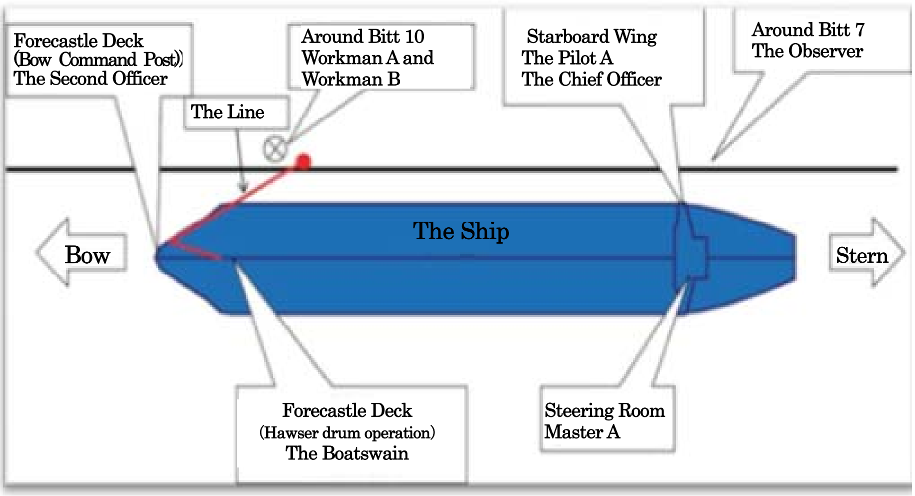
Additional tension on the Line touching the Bend Point
- impulsive tension caused by the winding moment in the hawser drum
- tension due to Wind Pressure
- tension due to the headway of about 0.3 kn

Break

Hit the workmen working inside the hazardous zone of snap back

Injury causing death

Positions of the workman and the crew when the Accident



weather at the time of the accident
average wind speed: 3.6～3.7m/s
max. instantaneous wind speed: 9.8m/s
wind direction: NE

the break of the mooring

A "spring line "is a mooring line taken backward from the bow, or taken forward from the stern.

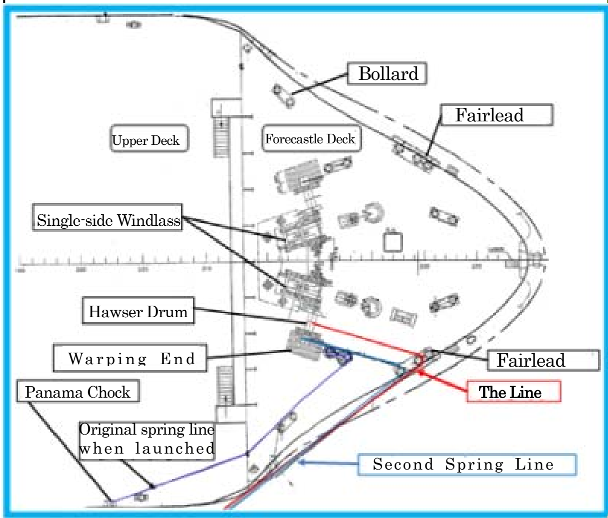
A "hawser drum" is a rotating drum that can wind up a rope about 200m in length, and is used for heaving or veering a mooring rope.

A "bollard" is a post installed on the deck used for latching mooring ropes. Generally, a pair of two posts is called a "bollard." On the other hand, a single post is called a "bitt."

Time of purchase and strength

It is considered probable that the Ship purchased a forward spring line (the Line) in June 2008 with a strength greater than the minimum breaking load specified in the IMO Guidance, and had used the Line since August 2008.

The route of a forward spring line



Route of Forward Spring Line

At the time of launching, a forward spring line was to run from the bollard on the forecastle deck to the panama chock on the upper deck, and to run to a bitt on a berth.

For adjusting the length of the forward spring line to the route as above, at least two workmen—an operator of the warping drum and a handler of the mooring line—are generally required.

A forward spring line is often veered out first for the purpose of decreasing the forward inertia in cases where there is no sufficient room in the forward direction. Therefore, the length of the line is required to be adjusted depending on the situations of displacement of the ship.

As regards the Ship,
- the berthing point was designated
- that four crew members beside the commanding officer were on the docking operation at the bow allocation
- a head line would be veered out to the quay following the forward spring line.

It is considered probable that the Line, wound on the hawser drum, was used as a forward spring line for operational efficiency.

The use of the Line

It is considered probable that the Line had been repeatedly used for the forward spring line, and therefore, it is considered probable that the Line's strength had degraded upon damage caused by repetitive touching the Bend Point, such as yarns sticking-out and breaks and fluff in the portion of 20m–34m from the end of the eye.

It is considered somewhat likely that the Ship continued using the Line although it sustained wear, because it had been used for less than a year.

The inspection of the Line

It is considered probable that the check list in the safety management manual developed by the ship management company (Company B) required no inspection or maintenance of mooring ropes.

It is considered somewhat likely that the Chief Officer and the Boatswain had not inspected the Line while referring to the "Inspection and Replacement of Fiber Ropes" described in the "The Mooring Equipment Guidelines, 2nd edition" published by OCIMF (the Oil Companies International Marine Forum), and its revised document as the 3rd edition, although had regularly conducted a visual inspection of the mooring ropes, including the Line.

Refer to the information on the handling of mooring ropes (p.11)

Situations of the Mooring Workmen

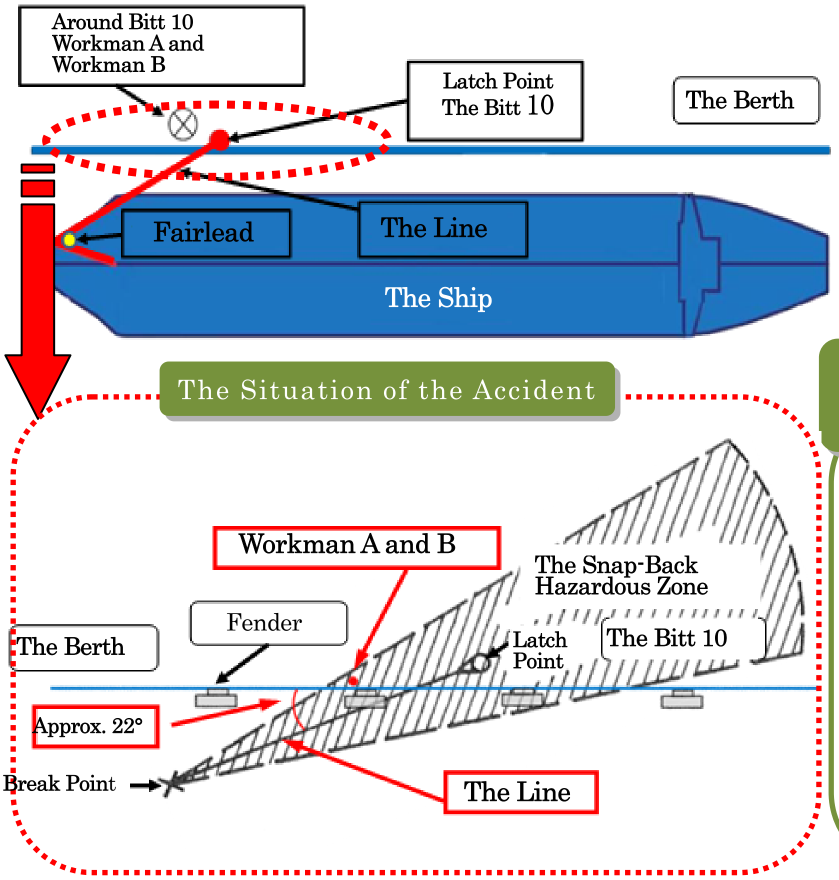
①It is considered probable that part-time workmen, Workman A and Workman B were winding-in the second spring line, standing about 10m from Bitt 10 toward Bitt 13, in order to prevent the Line from getting in under the fender.
②It is considered highly probable that the Line, upon breaking, hit the left side of Workman A's face, and the right side of Workman B's face and the his neck.

○It is considered probable that Company A had provided part-time workmen with safety management orientations at the time of hiring, had used seals to show the skills and the progress in learning, and had made squad leaders provide safety training at the job-sites by explaining actual accident situations and other matters, and that squad leaders had involved part-time workmen in site-work depending on their progress in gaining skills.
○It is considered probable that Company A had not provided mooring workmen with practical safety instructions, by giving information specifying extension of snap-back hazardous zone of a broken rope under tension, and by giving directions, in the case of working close to a rope put under tension, to complete the work as swiftly as possible and to move away from the snap-back hazardous zone as soon as possible.

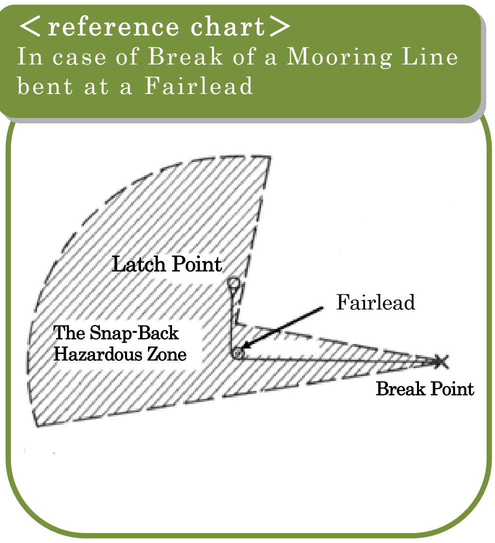
A "panama chock" is equipment for the leading rope, and is installed on the side of the deck.

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

The Situation of the Accident and the Snap-Back Hazardous Zone



snap-back: the sudden release of the static energy stored in the stretched synthetic line when it breaks



* The chart for the situation of the accident shows a snap-back hazardous zone when a break point is between a latch point and a fairlead.
In the case of the Ship, as in the reference chart, the mooring line was bent at the fairlead, although a snap-back hazardous zone will extend further if a break point is between a fairlead and a latch point.

Risk associated with mooring ropes

Handling of mooring lines has a higher potential accident risk than most of other shipboard activities.
The most serious danger is a snap-back.

○Synthetic lines normally break suddenly and without warning.
○Unlike wires, they do not give audible signals of imminent danger before completely parting; nor do they exhibit a few visible broken elements.

As a general rule, there is danger at any point in a conical zone of the synthetic lines enclosed by the circumference with an angle of 10° from the break point.

A broken line will snap back beyond the point at which it is secured, possibly to a distance almost as far as its own length.

● It is not possible to predict exactly where a snapback could happen .
● If the zone is suspected as potentially dangerous, keep away from any rope under tension.

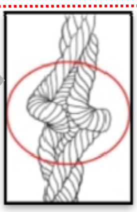
Countermeasures

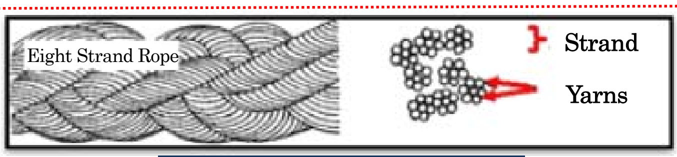
If you must work near a line under tension, do so quickly and leave the danger zone as soon as possible.

Handling of fiber ropes

Winch-mounted synthetic lines should be end-for-ended about every two years to distribute points of wear.

A "hockling" is a word referring to a deformation found only in twisted ropes





Structure of Fiber Rope

Inspection and replacement of fiber ropes

〇Synthetic lines should be checked for obvious signs of deterioration before each use and undergo a thorough inspection at least once each year.
〇Some signs of damage such as hockling, cuts, surface abrasion and fusion are readily visible. Others are not as evident. While it is not possible to prescribe definitive retirement criteria, the following sections discuss the types of damage and wear experienced by ropes and providing general guidelines.

Types of damage and wear and general guidelines for replacement

① Cuts
In general, any cut which penetrates through 25% of the area of one or more strands critically weakens the rope. The rope should be cut and spliced (*), or retired.

② External abrasion
External abrasion is evident as a general fuzzy appearance. If abrasion reduces the solid diameter by more than about 5%, then the rope should be retired.
When the abrasion on any one strand penetrates more than about 15% of the strand area, the rope should be cut and spliced.

③ Internal abrasion
Internal abrasion is caused by the strands and yarns rubbing against each other as the rope undergoes cyclic loading. If the abrasion has progressed to the extent that some yarns are worn through, the rope should be renewed.

"Splicing" is to join the ends of two ropes by interweaving their strands.

Inspection and Retirement of Mooring Ropes

Inspection of mooring ropes
If there is no actual fiber damage or distortion, there is no positive method by which the residual strength of used rope can be determined visually, but in synthetic fiber ropes, the amount of strength loss is directly related to the amount of broken fiber at the rope's cross-section.

Make sure of the conditions of abrasion, gloss, glaze, and discoloration as well as change of strand diameter and softness by means of a regular visual inspection.

Retirement of fiber mooring ropes
〇Factors such as load history, abrasion, bending radius and chemical attack need to be considered when assessing retirement criteria.
〇In the absence of other information, mooring ropes should be replaced when their residual strength has reached 75% of the original max breaking load.

For a conventional fiber mooring rope, 25% damage to a yarn at the rope's cross-section means 25% loss in the strength of the rope.

Proposals (Safety Recommendations)

The Board, based on the results of the accident investigation, recommended the operator and ship management company (Company B) to consider the following and take necessary actions, and Marine Department, The Government of Hong Kong to supervise the company mentioned above.

Recommendations to Company B and Marine Department, the Government of Hong Kong

The accident occurred when the mooring line with wear broke due to the additional tensions on the mooring line, which was touching the Bend Point, including the impulsive tension due to the winding moment in the hawser drum, the tension caused by the forward headway of the Ship and that caused by the wind pressure, and hit the two mooring workmen, causing them to die.

The safety management manual developed by Company B requires inspection of the mooring equipment while berthing to confirm that such equipment is in good condition. In the case of the accident, judging from the state of wear to the forward spring line, it is considered highly unlikely that the line was in a "good condition," as stated in the manual mentioned above.

Therefore, it is recommended to clearly state and require to pay attention to the route of mooring ropes and the bitts to moor the ropes onto in order to prevent mooring ropes from touching corners such as the Bend Point to the extent possible and obtain safe and effective mooring forces, and to place a person in charge to take command of operations in such a position from where the person can acquire the knowledge of the overall conditions of mooring ropes. At the same time, it is recommended to make all the ships under management comply with such requirements.

In order to Prevent Recurrence

In order to prevent recurrence of similar accidents, mooring rope manufacturers and line handling service providers are requested to be reminded of the following:

It is desirable that manufactures of mooring ropes establish guidelines to replace or discard their products by examining their appearance and provide users of the ropes with the guidelines.

It is desirable that line handling service providers provide their mooring workers with information on extension of the snap-back hazardous zones of ropes when broken under tension, and give them instructions such as to avoid working inside the zone unless necessary and to complete the work swiftly and leave from the snap-back hazardous zones as promptly as possible.

Also, the Board has requested the industry and organizations involved in manufacturing mooring ropes and providing line handling services to familiarize the parties concerned with this report and remind them further of the replacement and retirement guidelines for mooring ropes as well as the risk in carrying out such works.

The investigation report of this case is published on the Board's website (issued on April 22, 2011)
http://www.mlit.go.jp/jtsb/eng-mar_report/KuoChang.pdf
(This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.)

Serious Accident : Case 3

While hoisting cargo with a deck crane, the wire rope broke and the cargo fell into the hold of the barge

Outline: While the cargo ship (Vessel A), alongside with No.3 pier of Yamashita wharf in Section 1 of Yokohama Quarter, Keihin Port, on her starboard side, hoisting cargo using her No. 3 Crane from the hold of the barge (Vessel B), which was moored on Vessel A's portside, the hoisting wire rope of the deck Crane broke and the cargo fell into the hold of Vessel B at around 1005 hours on September 1, 2008.

Among barge crew and stevedores aboard Vessel B, five stevedores were thrown out by the impact. As a result, one stevedore was dead and three of them suffered bruises.

Events Leading to the Accident

Seven stevedores on board Vessel A and other stevedores hung four hoisting wire ropes (the Grommets) to the hook block of Crane No. 3 for hoisting a 320-ton load (the Main Hook Block). Then the jib (*1) was turned toward the portside direction, and the four Grommets were hooked to the four hoisting metal fittings of the Cargo that was in the hold of Vessel B, which was moored alongside Vessel A.

*1: A "jib" is an arm that extends outward from the Crane's driving gear.

After receiving a signal from the master, an ordinary seaman operated Crane No. 3 and stretched out the slacks of the hoisting wire rope (the Main Wire) and the four Grommets, and then started hoisting the Cargo by operating Crane No.3 at around 0940 hrs. At around 1000 hrs, the Cargo was lifted from the hold bottom of Vessel B. When the Cargo reached a level of approximately 7 to 8 meters above the hold bottom at around 1005 hrs, the Main Wire suddenly broke and the Cargo fell onto the hold bottom of Vessel B.

Causal Factors of the Accident

Analysis of the Break of the Wires

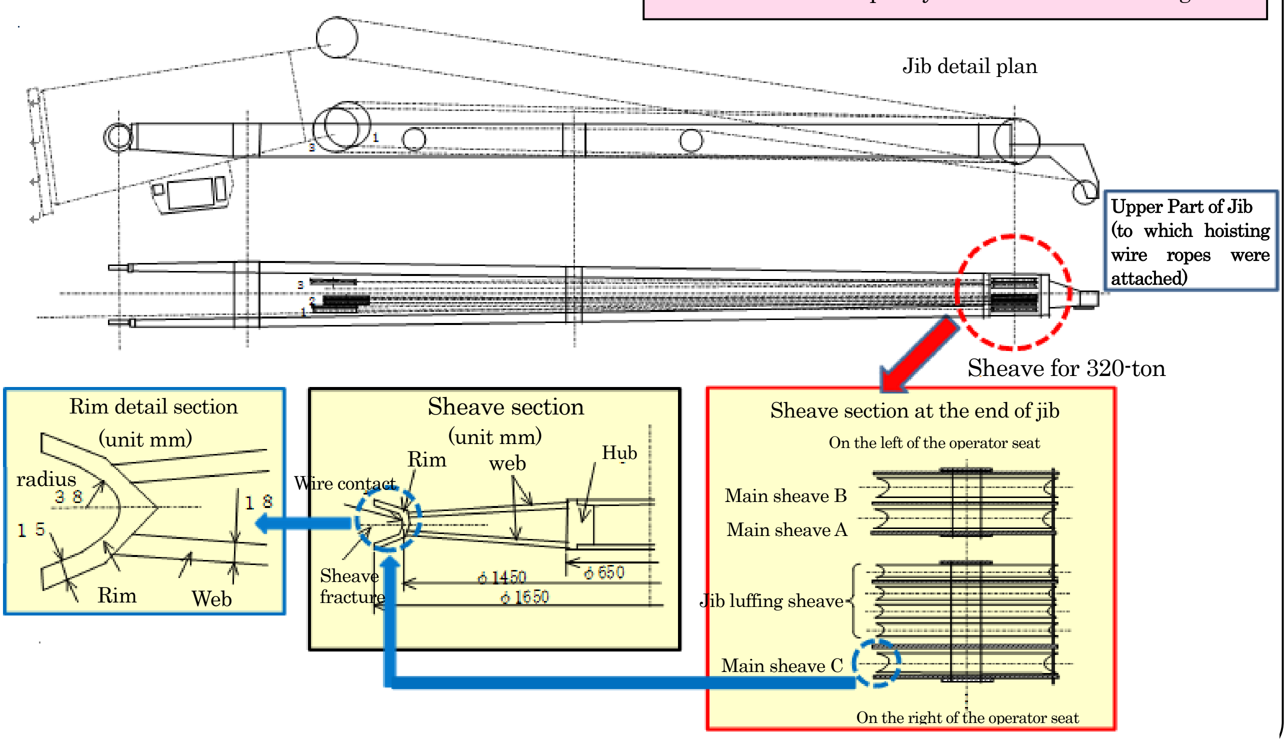
It is considered probable that tension on the Main Wire was sharply reduced due to the fracture of the entire circumference of the rim of the Main Sheave C (*2), and then the Main Wire dropped into the gap caused by the fracture and came to a stop on the hub, when a jolting overload larger than its break load was inflicted on the wire, leading to a break.

It is considered probable that: the rim of the Main Sheave C had small cracks in its backside portion of the wire guide surface and its surface was hardened due to the cold forming used in its manufacture, resulting in ductility reduction. In addition, residual stress was not completely removed from the rim. As a heavy cargo weighing approximately as much as the Safe Working Load was hoisted, conditions that allow brittle fracture were created inside the rim while Crane No.3 was in operation, thus finally resulting in the break.

It is considered probable that, through bending and shaping the material by cold forming and the elongation and narrowing down process during the rim production, the surface of the rim underwent substantial hardening, and caused significant ductility reduction.

* 2: A "sheave" is a pulley on which a wire is hanged.

Jib and Sheave



Three out of the eight persons, consisting of the seven stevedores of the cargo handling company and the towing manager who were working on board Vessel B, were able to safely move to a barge that was moored to the portside bow of Vessel B, but five stevedores fell into the water. Among the five stevedores who fell into the water, four were rescued by the vessel and barges that happened to be near the accident site, but one stevedore went missing.

In early evening of the day of the accident, the divers that were searching for the missing stevedore found him at the sea bottom, and he was confirmed dead. Among the four rescued persons, three were bruised.

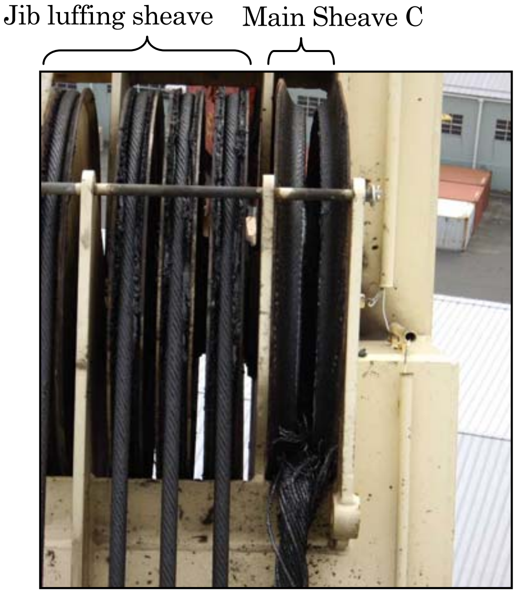
Vessel B sustained a fracture at the bottom of the hold because of the cargo, and sank.

Analysis of the Cause of the Death and Injuries

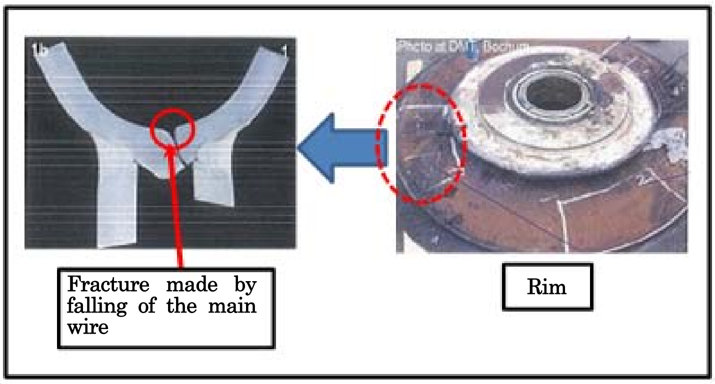
It is considered somewhat likely that one of the stevedores was hit either by a Main Hook Block or a Grommet that fell, and was killed.

It is considered probable that the other three stevedores suffered bruises by the impact sustained either when the Cargo fell into the hold of Vessel B or when they fell into the water.

Each of the four stevedores wore a helmet and safety shoes.



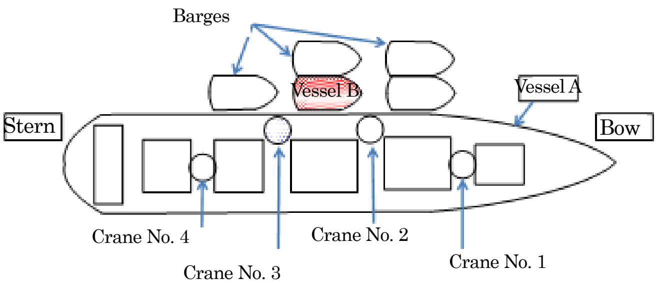
Sheaves at the end of Jib (Crane No. 3)



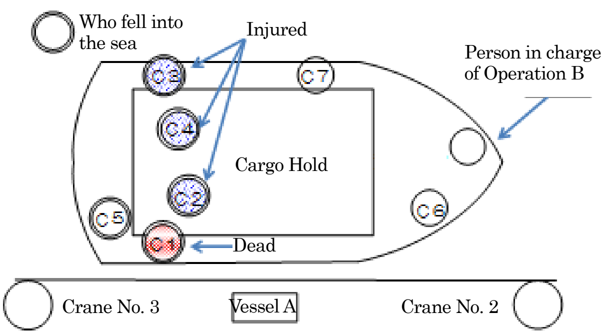
State of Rim Fracture

Vessel B Positioning

Vessel B Position



Positioning of Stevedores and Towing Manager on Vessel B



Information regarding Vessel A

Vessel A underwent a special survey on its four deck Cranes on August 13, 2008, at a dockyard in Shanghai, the People's Republic of China. This survey was carried out by the classification society (*3), Germanischer Lloyd (GL), wherein Crane No.2 and No.3 went through a load test of hoisting a 352-ton load that was 1.1 times as heavy as the Safe Working Load (*4) stipulated by GL rule. Both Cranes successfully passed this test.

*3: "Classification Society" is a nonprofit corporation that establishes standards for the construction of ships and onboard facilities. The organization inspects ships based on the standards and grants ship-class certificates.

*4: "Safe Working Load" is the maximum load a Crane can handle safely. The acronym S.W.L is often used. This value represents the capacity of the Crane in combination with maximum outreach (maximum turning radius that allows hoisting of the S.W.L)

Full View of Vessel A (after the accident)

Vessel B which Sustained a Fracture at the Bottom

Information regarding the Cargo

According to the cargo planning prepared by the Contract Company and the technical data sheet prepared by the Electrical Manufacturer for the cargo submitted by the ship management company of Vessel A, the Cargo was a steam turbine driven generator for a power plant made by the Electrical Manufacturer, with dimensions of approximately 11.4 m long, 5.5 m wide and 4.6 m high, and with the weight of 314 t.

The Cargo immediately before the accident

Proposals (Safety Recommendations)

The Board, based on the result of the accident investigation, recommended as follows to Crane manufacturers（safety recommendations）.

Recommendations to the Crane Manufacturers

It is considered somewhat likely that this accident was caused in the following sequence: While Crane No.3 of Vessel A was hoisting the Cargo, the rim of Main Sheave C at the extremity of the jib fractured, causing the Main Wire's precipitous drop into the gap caused by fracture. This caused a break in the Main Wire, and also, finally, the fall of the Cargo, Main Hook Block, and grommet onto Vessel B.

This accident occurred in spite of the fact that Crane No.3 had passed a load test three weeks earlier, and a later investigation revealed the occurrence of a brittle fracture on the fractured surface of Main Sheave C, and various sized cracks were observed on Main Sheave E's surface.

In the face of these findings, crane manufacturers should, when they produce a rim that requires strong bending and shaping processes as a part of a weld construction sheave, perform proper control of manufacturing processes, including the selection of materials.

The investigation report of this case is published on the Board's website (issued on June 27, 2011)
http://www.mlit.go.jp/jtsb/eng-mar_report/Rick_Shineimaru18.pdf

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

4. Summary

Based on our investigation reports on fatal and injury accidents related to on-board works including the three serious accident investigation cases mentioned in this digest, we summarized how these accidents occurred, and what the lessons which will help prevent recurrence are as follows.

How "Fatal and injury accidents related to on-board works" occurred

- By the type of accidents and by the type of works
  By the type of accidents, there were 38 cases of fatal accidents (40 % of the total), while works such as mooring and anchoring, stevedoring and working inside tanks and holds accounted for 70% of the total, by the type of works when the accidents occurred.
- The breakdown of fatalities and the injured
  The number of fatalities was 41 (35.3%), while the seriously injured and the slightly injured were 43(37.1%) and 32(27.6%), respectively. The breakdown of the fatalities and the injured by the occupational category was, crew 84 (72.4%), workers 30 (25.9%) and others 2 (1.7%).
- By the type and tonnage of vessels
  The number of cargo ships was 43 (45.3%), the largest among all, while, by the tonnage, vessels in the range of 100 to 1,600 tons accounted for about 50% of the total.
- By the type of deaths and injuries
  The number of contacts and heavy blows was 26 (27.4%), fall and man overboard 24(25.3%) and crush 23 (24.2%).

Accidents during mooring and anchoring

- By the type of deaths and injuries, contacts and heavy blows accounted for 35.5% (11 cases) while crush 25.5% (8 cases).

Accidents during stevedoring

- By the type of deaths and injuries, fall and man overboard accounted for 39.1% (9 cases) while crush 34.8% (8 cases).
- The number of fatalities and the injured in this category was 35, the largest among all.

Accidents during working inside tanks and holds

- By the type of deaths and injuries, anoxia and toxic gas inhalation accounted for 46.1% (6 cases).
- The number of fatalities accounted for 82.3% (14 persons).

Lessons from serious accident investigation cases

- During discharge of copper sulfide concentrate, anoxia was developed (Serious Accident Case 1)
  Lesson ① Before entering enclosed space, O_2 and gas concentration should be measured properly, and should carry out forced draft when the concentration is found dangerously high, and wait until it becomes within a safety level.
  Lesson ② Should get fully familiar with appropriate measures to deal with cases of a fatal accident which may occur in cargo holds loaded with copper sulfide concentrate.
  Lesson ③ Should understand the properties and risks of copper sulfide concentrate and floatation reagents adhering to it.
- A mooring rope was broken and snapped back, hitting mooring workers, and took their lives. (Serious Accident Case 2)
  Lesson ④ Should recognize the hazardous zone caused by the snap-back of broken ropes, and when it is necessary to work at a place near ropes put under tension, should complete the work swiftly and leave the zone as promptly as possible.
  Lesson ⑤ Should carry out a routine inspection of any degradation of fiber mooring ropes which are partially in touch with the bend point of a sheer strake, since it is hard to identify degradation

A word from Director for Analysis, Recommendation and Opinion

The accidents presented in this digest are not associated with vessel navigation, but mooring, stevedoring and working in tanks and holds.

These type of accident may not happen frequently compared to collision and capsizing of vessels, but they suggests that factors easily overlooked in normal situations can lead serious accidents.

Your comments are most welcome

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To prevent recurrence of similar accidents, it is important for the crew members and workers to understand the properties and risks pertaining to the loaded cargo, the facilities and instruments on the vessel. And I believe that this will accomplished only by taking appropriate initiatives in the industry, such as providing safety education and training regularly.