FINAL REPORT

FATALITY AND INJURY OF SHORE WORKERS DURING UNMOORING OPERATION INVOLVING BAHAMAS REGISTERED VESSEL PACIFIC ENLIGHTEN ON 17 APRIL 2017

MIB/MAI/CAS.017

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

29 January 2019

The Transport Safety Investigation Bureau

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SYNOPSIS

On 17 April 2017 at about 1530H, two shipyard workers involved in an unmooring operation in Keppel Shipyard (Benoi), were injured as a result of being struck by the opened bight from a mooring line tail rope used for the mooring of a liquefied natural gas (LNG) tanker. One of them was fatally injured.

The TSIB classified the occurrence as a very serious marine casualty and launched an investigation.

The investigation revealed that the tail rope of the mooring line had been seized using a seizing twine to make a smaller eye (bight) for the purpose of securing onto smaller bollards ashore. As the ship's crew slackened two of the three mooring lines (on the same bollard), the seizing twine of the mooring line that had likely taken load, parted, while the tail of the mooring line was intact. As a result, the opened up bight of the tail of the mooring line struck two workers who were preparing to release the slackened mooring lines from the bollard.

The investigation also revealed that the tail rope in use at the time was a "used" tail rope which had been removed after an 18-month service but was temporarily restored for the berthing duration. It was also noted in the investigation that although inspection of seizing twines, where used, was not a part of a typical tail rope inspection regime, it would have been desirable that when appraising the condition of the tail rope, the condition of the seizing twine was also taken into account.

The investigation further determined that a formal and structured training process to ensure a thorough understanding of the risks involved in a high risk operation, such as the mooring and unmooring of a ship, was desirable and that there were gaps in mooring related training required for marine terminal operations and those in the shipyards.

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DETAILS OF VESSEL

Name	PACIFIC ENLIGHTEN
IMO Number	9351971
Flag registry	Bahamas
Ship type	Tanker - LNG Carrier
Year Built	2009
Company / Operator	NYK LNG Ship Management Ltd
Crew list	30 persons [11 Officers / 19 Ratings] [1]
Gross tonnage	122361
Length overall	288.00m
Breadth	49.0m
Freeboard	20 m to 22m
Actual Draught	5.5m (Fwd) / 5.9m (Aft)

[1] All officers and ratings held valid statutory certificates for their position under the STCW Convention. There were 3 Chief Officers on the vessel. One of them was supervising the forward mooring station.

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1 FACTUAL INFORMATION

All times used in this report are Singapore Local Time. (UTC +8.0 H)

1.1 Sequence of events

1.1.1 Bahamas registered vessel, Pacific Enlighten (PE), was berthed portside alongside at the Quay 2-Extension of the Keppel Shipyard (Benoi) from 7 to 17 April 2017 after having undergone repairs at the dry dock in the shipyard. PE's forward and aft mooring arrangement was a 2-3-3 configuration[2]. (see **Figure 1 and 2**). Prior to this day, she had also berthed at the same quay on 27 March 2017.

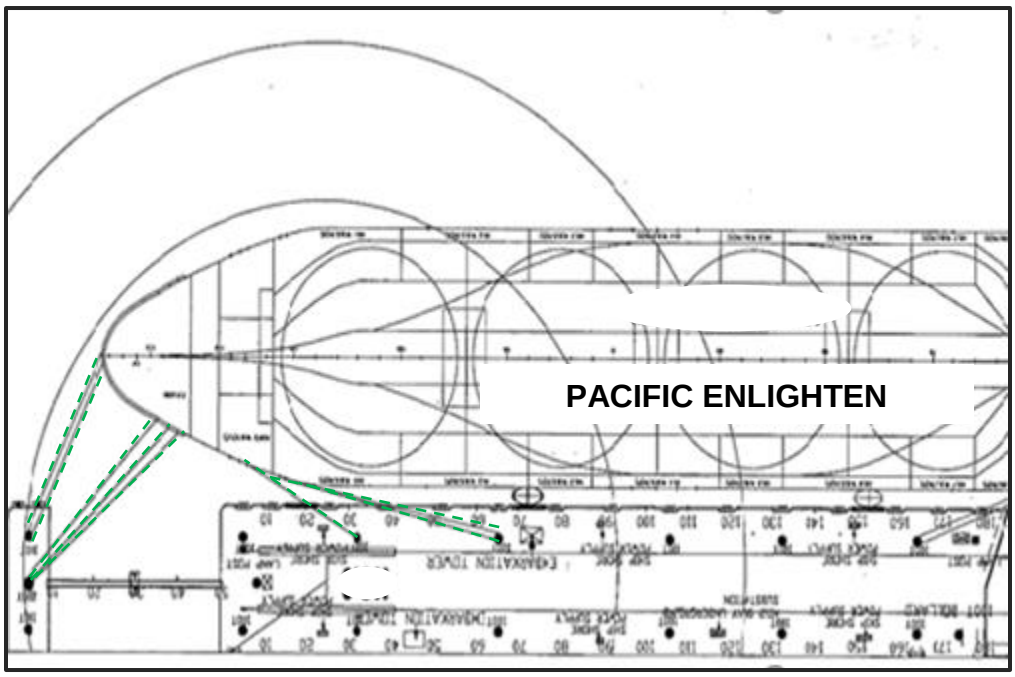

Figure 1 - The forward mooring arrangement of 2-3-3 indicated by green lines
(*Source*: Keppel Shipyard)

1.1.2 PE was scheduled to depart the Quay 2-Extension on 17 April 2017. A PSA Marine Pilot boarded at about 1500H. Four tugs were used to unberth[3] PE, with two of them keeping PE in position by pushing the starboard parallel body-length. The forward mooring station was under the charge of a Chief Officer

[2] Refers to (from PE's perspective) – two headlines, three breast lines and three spring lines for both forward and aft, with mooring tails on each. Keppel Shipyard refers to this configuration as two **breast lines, three headlines** and three spring lines. The report will hereafter refer to this forward mooring arrangement from PE's perspective.

[3] Unberth- Leaving (unmooring from) the berth

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with four crew assisting him, comprising the Bosun and three Able Seafarers Deck (ASD). The Bridge was manned by the Pilot and the Master who was being assisted by an ASD on manual steering of PE. Main engines were on standby and tested as a part of a routine check.

1.1.3 At about 1521H, under the Pilot's advice, the headlines and stern lines of PE were slackened by the ship's crew. By about 1525H, these four mooring lines had been released from the bollards by the shore workers.

1.1.4 Under the Pilot's advice, with two tugs pushing, at about 1527H, the Chief Officer prepared to slacken the three forward breast lines to facilitate their removal from another shore bollard (Centre bollard 200T). The outer and middle breast lines were slackened by the Chief Officer using the winch remote controller, while the inner breast line had not been slackened. While PE's crew were in the process of slackening this line, the Chief Officer briefly observed that the shore workers approached the bollard near the two slackened lines.

1.1.5 Soon, the Chief Officer heard a loud cracking sound (of a rope) and saw that the inner breast line which was under tension, jerked briefly. He noticed that the seizing twine (which held the bight of the rope tail together) of the inner breast line had parted, causing the bight of the tail to spring open wider. He also noted two shore workers lying beside the bollard. The three breast lines and their tails were still intact.

1.1.6 The Chief Officer informed the Master through walkie-talkie who called for the unmooring operations to be suspended by informing the Pilot. The Pilot was also informed at the same time by the shore supervisor to suspend the operations. The injured workers were conveyed to the hospital for medical attention using the shipyard's emergency response service[4]. At about 1630H, with the concurrence of the shipyard, the Pilot advised the Master for the unmooring operation to resume, and PE departed the quay at about 1650H for the anchorage within Singapore port limits.

1.1.7 At the time of the occurrence, the Chief Officer was positioned at the port bow of the forecastle operating the winch using the remote controller. From this location, he was able to sight the quay and had walkie-talkie communication with the Bosun at the starboard winch. (see **Figure 3**). The Chief Officer had

[4] Keppel Shipyard has a registered ambulance in each of their yards.

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an in-rank experience of about one year and had been on board PE since 14 Oct 2016. The Bosun had been working with the company for more than 20 years.

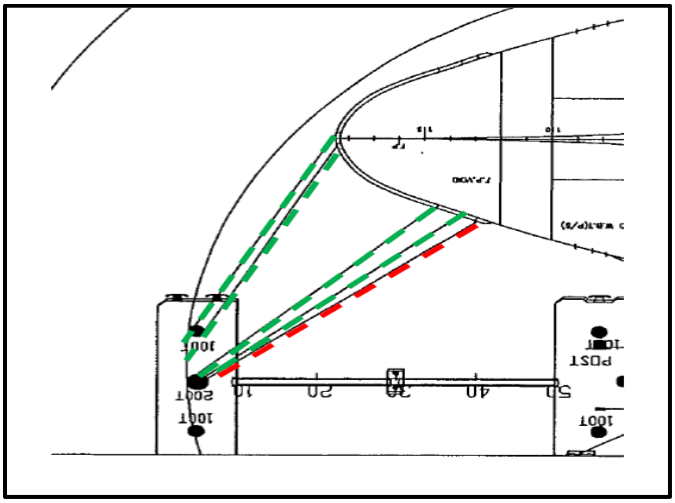

Figure 2 - The forward mooring arrangement with the affected inner breast line in red
(*Source:* Keppel Shipyard)

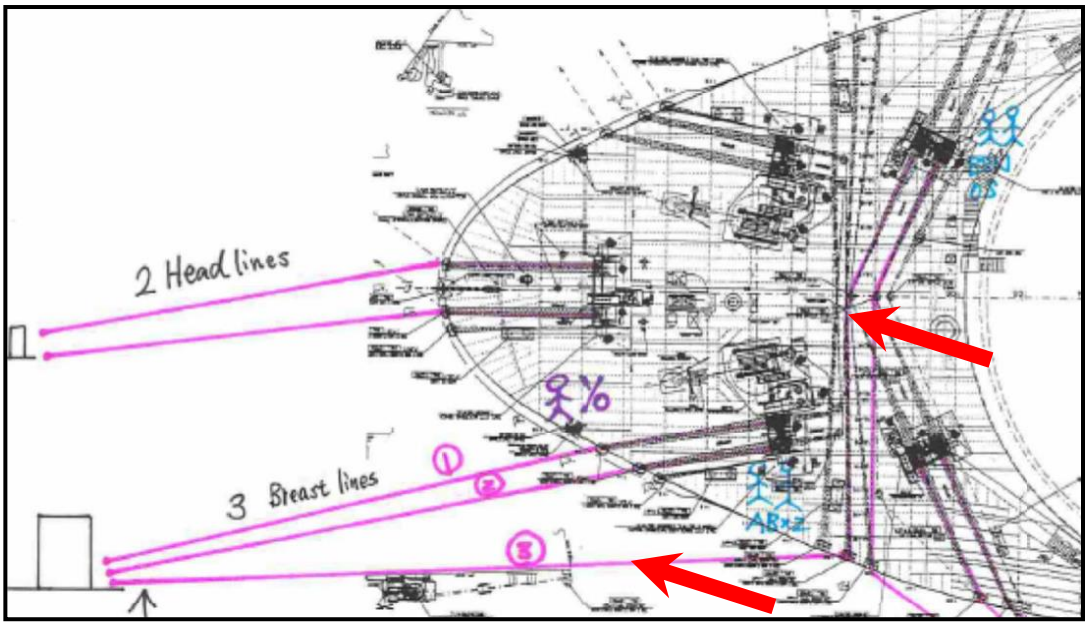

Figure 3 - The forward mooring arrangement and the manning at the forward station relative to the winch and capstans at the forecastle. The red arrows point to the affected breast line
(*Source:* Bahamas Maritime Authority)

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1.2 Narrative from shipyard workers[5]

1.2.1 On the same day, at about 1255H, a safety briefing which focused on task allocation regarding PE's unberthing operation was attended by about 11 shipyard workers from the shipwright department[6]. All those who attended the briefing were involved in the unberthing operation of PE.

1.2.2 The unberthing operation was managed by two teams. A team led by a supervisor and five persons for the aft lines and a second team led by another supervisor with five persons for the forward lines. This second team comprised of a Supervisor, four general workers (GW) and an Assistant Manager (AM) at the extended mooring dolphin (i.e. the eastern end of the quay) (see **Figure 4**). The supervisors and the AM held walkie-talkies to communicate with the Pilot. The AM was not a part of the safety briefing.

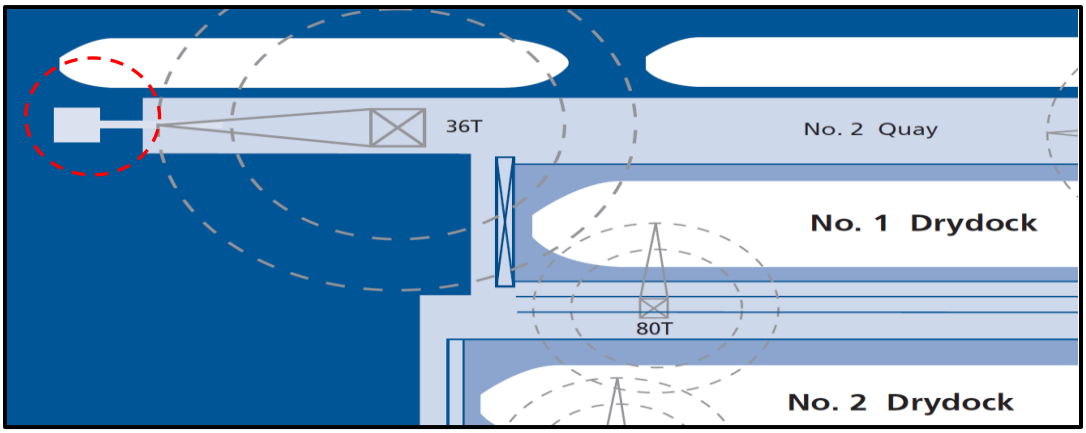

Figure 4 - The red circle is known as the extension (mooring dolphin) of Quay 2 of the shipyard (*Source:* Keppel Shipyard)

1.2.3 At the forward mooring dolphin, the head lines were released from the 100T bollard by the supervisor and a GW(A). After that, the supervisor and GW(A) moved to the centre 200T bollard to standby for the removal of the breast lines. When two of the three breast lines had been slackened by the PE's crew, with the inner breast line still taut, in preparation to release them from the centre bollard, the supervisor instructed another GW [referred to as GW(B)], who was

[5] The group of mooring workers at the extended mooring dolphin who witnessed the incident

[6] The shipwright department handles all mooring and docking operations, including maintenance of mooring ropes, wires and gangways. Typically, they comprise workers who have been performing mooring related tasks, amongst others.

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near the centre bollard with the AM, to throw a coil of the messenger line[7] below the breast lines to facilitate their removal.

1.2.4 GW(B) moved closer to the bollard and bent down to throw the coil of messenger line under the breast lines for the supervisor to pick up. At about this time, the AM had also moved closer to the breast lines, when the seizing twine on the inner breast line (which was still taut) parted (see **Figure 5**).

Figure 5 - The fragments of the seizing twine
(*Source*: Ministry of Manpower)

1.2.5 The bight of the inner breast line sprung open and hit the AM and GW(B). GW(B) fell onto the ground on his back and AM moved backward and leaned against a coiled mooring rope which was on the mooring dolphin (see inset in **Figure 6**). The supervisor informed the Pilot to suspend the operations and called for medical assistance from the shipyard's in-house medical services. At about 1550H the in-house ambulance conveyed the AM and GW(B) to the hospital.

1.2.6 The AM succumbed to his injuries at the hospital while the GW(B) was given three days of medical leave after receiving outpatient treatment.

1.2.7 The GWs had been working in their respective roles for between 2.5 to 4 years. The supervisor had been with the shipyard for about 40 years and the AM had been in his role for about four years.

[7] A messenger line was intended to be tied to the breast lines' bight individually and thereafter connected to a mooring boat so as to remove the bight of the rope from the bollard.

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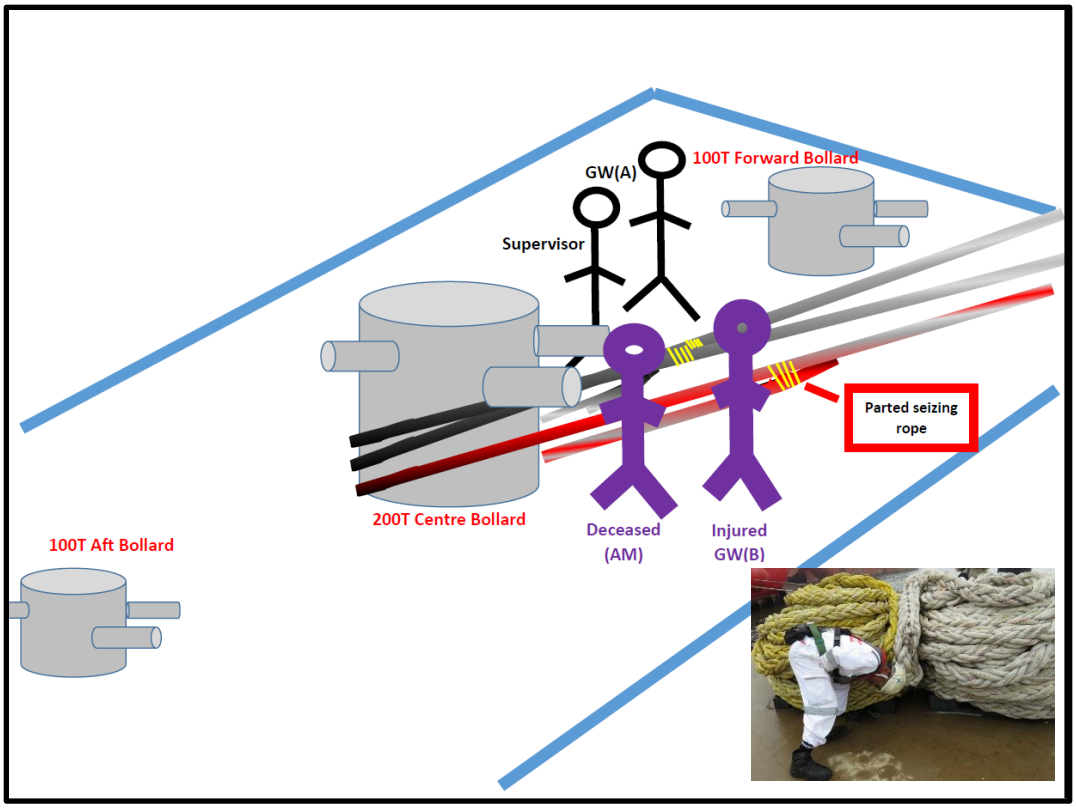

Figure 6 - Approximate position of mooring crew nearest to the bollard with three breast lines. The red-coloured line shows the affected (inner) breast line – For illustration only

1.3 Shipwright Department – training and certification

1.3.1 The department had in-house safe work procedures for berthing and unberthing operations and carried out internal training for implementing them. These procedures provided for knowledge and skills, including safety precautions such as wearing personal protective equipment, and for them to be imparted through on-the-job-training (OJT). The OJT was typically done for new workers by senior supervisors of the department and covered areas such as ship-to-shore interface involving the handling of mooring ropes, including wires.

1.3.2 At the time of the occurrence, a Risk Assessment form for vessel movement, dated 26 Feb 2016 (and valid till 25 Feb 2019), identified hazards associated with receiving ship's mooring ropes or wires at the wharf side, if they were to break. Mitigating measures included proper coordination between shore and

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ship crew and to ensure no one was to stand close to a mooring line under tension (load). The investigation team was not able to sight any evidence to show that the AM, GW(B) and the supervisor had been a part of this Risk Assessment or aware of its contents[8]. Training records for the AM, GW(B) and supervisor for mooring related operations were also not available for sighting.

1.4 Ship-to-shore interface – berthing/unberthing operations

1.4.1 Under the Ministry of Manpower (MOM) regulations, employees engaged in shipyards were required to obtain the relevant training and certification, in accordance to their appointment(s) and job scope, as elaborated in the Workplace Safety and Health Manual[9] for Marine Industries (WSH Manual) (see **Figure 7**).

1.4.2 Under MOM's regulations there was also a list of Approved Code of Practices[10] (ACoP), which comprised of (i) Codes of Practice developed by WSH Council and (ii) Singapore Standards developed by Enterprise Singapore[11], for various types of activities and was regularly updated[12]. Some examples of ACoP were Codes of Practice for Confined Spaces/Welding, cutting, diving at work to name a few, many of which included activities in shipyards. There was no ACoP for mooring/unmooring operations.

[8] The shipyard did not mandate any requirements to keep a record of their risk assessment briefings undertaken before the commencements of mooring/unmooring operations

[9] Issued by Workplace Safety and Health Council in 2009 and Ministry of Manpower in collaboration with the Association of Singapore marine Industries as a guidance for stakeholders to take reference from when developing their safety management systems. This manual states - Operations at a quay-side or dock-side are subject to the risk of injury from contact with mooring lines and winch equipment. It also states that for berthing, there should be procedures for handling the vessel on arrival, including mooring, gangways and towers, connection of services, means of communications etc.

[10] Section 40(B) of the WSH Act 2011 – Approved Code of Practice, was intended to be used as a yardstick to assess whether reasonable practical measures have been taken in regards to the upkeep of safety and health standards at the workplace – *Source MOM*

[11] A government agency championing enterprise development, which worked with companies to build capabilities. It was also the national standards and accreditation body.

[12] The latest ACoP was published in the Government Gazette No. 3135 on 23 November 2018.

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Appointment	Course(s)
Fire Watchman	Fire Watchman Course
Lifting Supervisor	Safety Instruction Course for Lifting Supervisors
Marine Metal Scaffold Erector	Marine Metal Scaffolding Erector Course or Certificate of Competency Marine Metal Scaffolding Certificate
WSH Officer	Specialist Diploma in WSH
Safety Assessor (Hot Work)	Shipyard Safety Assessors (Hot Work Certification) Course
Safety Supervisor	Shipyard Safety Assistants Course
Supervisor	Shipyard Supervisor Safety Course
Marine Tradesman	Shipyard Safety Instruction Course (SSIC) – General Trade
Welder, Burner, Gouger, Pipe Worker, Steelworker	Shipyard Safety Instruction Course (SSIC) – General Trade and SSIC - Hot Work Trade
Ship Repair Manager	Shipyard Safety Instruction Course (SSIC) for Ship Repair Managers
Painter	Shipyard Safety Instruction Course (SSIC) – General Trade and SSIC - Painter Trade
Tower Crane Operator	Tower Crane Operator
Mobile Crane Operator	Mobile Crane Operator
Metal Scaffold Supervisor	Marine Metal Scaffolding for Supervisors Course
Noise Monitoring Officer	Noise Monitoring Course
Noise Control Officer	Noise Control Course
Rigger	Marine Rigger Course
Signalman	Marine Signalman Course

Figure 7 **-** The courses and certification for employees engaged in shipyards, according to the appointment(s) and job scope of Workplace Safety and Health (WSH) manual for Marine Industries
(*Source*: – WSH Council of Ministry of Manpower and Association of Singapore Marine Industries)

1.4.3 This WSH Manual also stated that operational controls[13] and related safe work procedures should be developed (by the stakeholders) for activities which included ship movements, for handling the vessel, its moorings and means of communication.

1.4.4 In 2011, a ship-to-shore interface sub-committee for logistics & transport in the WSH council established a Workplace Safety and Health Competency Framework (WSH Framework) which included moor, tend mooring and unmoor ships. This framework aimed to provide training and assessment guidance to ensure that operators and supervisors carry out ship/shore interface operations in a safe and competent manner.

[13] To eliminate or control the identified risks

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1.4.5 The WSH Framework comprised of a Competency Map[14], Competency Standards and Curriculum, Training and Assessment Guides (CTAG)[15]. The competency standard was provided for the explicit use and guidance of training providers as information resource for development and assessment. The WSH Framework was targeting at marine terminals, specifically, for the oil, chemical and gas industry.

1.4.6 In 2016, the International Maritime Organisation (IMO) had revised its circular[16] stipulating guidelines on minimum training and education of mooring personnel. The objective of these guidelines was to provide Member Governments, port authorities and the port industry with guidance on minimum levels of training and education of mooring personnel[17], unless covered by other regulations, so as to ensure that there was an adequate level of competency in ports.

1.4.7 This circular stated that training should cover procedures for securing, adjusting and releasing of lines as well as awareness of hazards when working with wires and ropes under tension, including snapback zones and appropriate safe working practices (see relevant extract in **Annex A**).

1.5 Autopsy[18] of Assistant Manager

1.5.1 The injuries cited in the autopsy report included:

- Bruises on the right outer thigh on both the lateral and medial aspects
- Bruises on both the right forearm and upper-arm towards the lower back
- Trace of serous fluid in the lungs to groin cavities
- Accumulation of blood in the right kidney
- Dislocation of the 2nd and 3rd lumbar vertebrae

1.5.2 The cause of death was determined to be a cardio respiratory failure.

[14] This document served as a national guide for marine terminal progression as well as guideline for qualification and competency required by the industry.
[15] The competency standards and CTAG's laid out competencies required for four common work activities, one of which was Moor, tend mooring and unmoor ship.
[16] FAL.6/circ.11. Rev.11
[17] Defined within this circular as personnel tasked to assist in the activity of mooring and unmooring of ships, either ashore or from mooring boats, carried out within the framework of port marine services.
[18] Provided by Forensic Medicine Division – Health & Science Authority (Singapore)

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1.6 Additional information about tail ropes

1.6.1 According to the Chief Officer, when PE was berthed on 27 March 2017 one or two breast lines were not hung (*sic*) directly on the shore bollard and a chain was connected between the tail rope and the bollard. This was confirmed by the shipyard, as another vessel was sharing the bollard with PE and was double-banked on PE's starboard side. During the stay from 7 – 17 April 2017, the tail ropes were directly connected to the bollard.

1.6.2 The Chief Officer also added that prior to the accident, he had not given specific instructions to the shore workers in releasing the breast lines from the shore bollard and was still in the midst of preparing all three breast lines to be slackened simultaneously. The shore supervisor, however, claimed that hand signals for removal of the ropes were given by the ship.

1.6.2 The 11m tail rope of the inner breast line, connected by a tonsberg[19] shackle to a flexible steel wire rope, was an 8-strand, 90mm diameter, fibre-reinforced polypropylene-polyester composite rope with a certificated breaking load of 1750KN. The bight of the tail rope had been tied up into five smaller parts, each with a seizing twine[20], the first one being about 2.5m (see circled below) from the crown of the tail. And the second seizing was at about 2.1m (see **Figure 8**).

[19] Similar widely used shackles includes Mandal and Boss (Mooring Equipment Guidelines - MEG – OCIMF)
[20] "Seizing" is commonly used in place of a knot or a splice to bind ropes of the same material. In this case, the tail had been seized to make smaller hooks for use at LNG berths and ease of handling by reducing the size of the bight of the mooring rope so as to reduce accidental unloop from the bollard especially in ports where the bollard is small. The twine was wound around 13-14 turns. According to the company, this was the case for all the tails used on other mooring lines.

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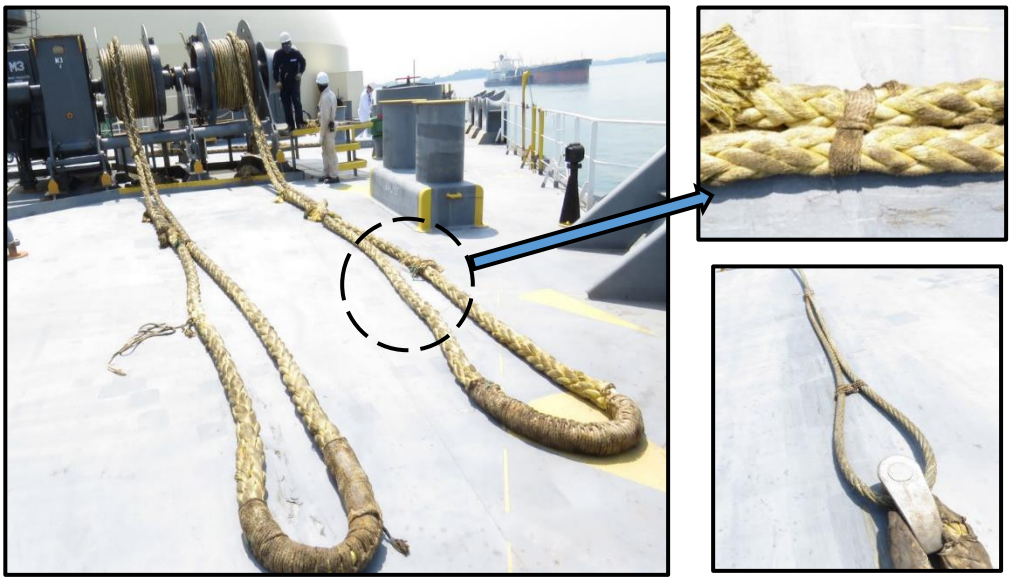

Figure 8 - An example of the original seizing on the tail end about 2.5m from the bight (top right) prior to it parting. Bottom right image shows tail's connection to the mooring wire via a tonsberg shackle
(*Source*: Ministry of Manpower)

1.6.3 The company had a Tail Rope Control Standard 2008/012 which required ropes to be inspected every quarter. Ropes of inspection Level 2 and below were to be discarded or considered for reversal. The tail rope on which the twine parted had been in use for about 18 months. It was last inspected on 8 Dec 2016, replaced on 5 Feb 2017 in accordance with the company's procedures. This particular tail rope, together with the others, was restored on 7 Apr 2017 for the berthing after dry dock. The relevant results of the last inspection on 8 Dec 2016 were documented as follows –

Visual check, degradation	Level 3
Eye splice	Good

1.6.4 The Tail Rope Control Standard 2008/012 was replaced with Tail Rope Management guidelines on 15 Dec 2016, in accordance with the company's Safety Management System. The revised guidelines provided for among other things, appraisal criteria for inspection (see **Figure 9**). Photographic evidence of any such inspection was also to be documented and ropes deemed to be below Level 2 were to be replaced according to the revised guidelines. The new Tail Rope Management guidelines was in-force at the time of the incident.

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This tail rope guideline did not include inspection of the seizing twine that bound the rope's eye into smaller eyes.

3	 About 10 pieces of the outer layer Yarns are cut.	 Whole dis-coloration, and fusion due to frictional heat is partially seen.
2	 About 1/4-1/2 of the strand yarns are cut.	 Discoloration and fusion due to frictional heat are seen considerably

Figure 9 – Appraisal Criteria for tail rope inspection as per new guidelines (*Source*: NYK LNG Ship Management Ltd)

1.6.5 According to the company, the tail ropes (with the twine[21]) on-board PE were renewed on 5 Feb 2017, about a month prior to PE entering the dock for repairs. To prevent damage to the newly changed tail ropes during the stay at the berth, the company requested the shipyard to accept mooring wires without tail ropes for berthing at Quay 2- Extension. However, as no conclusion was reached, the company then instructed PE to restore the used mooring tail ropes for the duration of the berthing at Quay 2-Extension. The tail rope that was involved at the time of the accident is shown in **Figure 10**.

[21] The twine was a 7mm diameter, kneaded polypropylene-polyethylene rope with a breaking strength of 5.5KN

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Figure 10 – Tail rope involved in at the time of the accident – Shown to indicate overall condition of the trope (*Source*: Ministry of Manpower)

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2 ANALYSIS

2.1 The seizing twine and tail rope

2.1.1 When the breast lines had been slackened (see Para 1.2.3), despite the tugs' push in keeping PE alongside, with one breast line (inner) still taut and three spring lines holding the vessel, there could be a possibility that the bow of PE may have, with the abatement of the initial fender compression, and an increase in the distance of the vessel's bow from the berth, caused further load on the inner breast line. It is likely that the seizing twine experienced additional strain from the load of the inner breast line and caused it to part, consequently opening the bight of the tail rope.

2.1.2 The first opening with the seizing twine was about 2.5m. When the seizing twine parted, a wider and longer 'new' bight would have formed (see **Figure 11**), causing a whiplash injury to both the AM and GW(B) who were standing close to the bollard

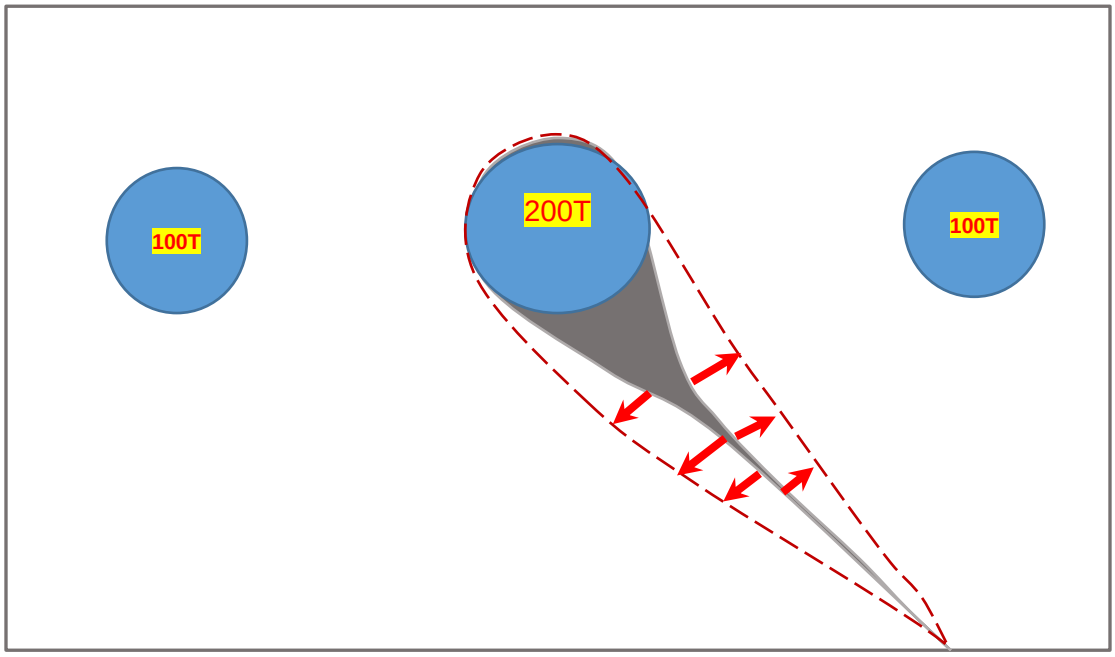

Figure 11 - Plan view of the dolphin showing the 200T bollard and the opening of bight at the tail-end when seizing twine parted (Not to scale)

2.1.3 The company's Tail Rope Management guidelines provided clear guidance on the appraisal criteria for an inspection of tail ropes and when they had to be

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discarded. This was in accordance with industry practice and guidance[22] for tail rope maintenance, replacement, inspections and record-keeping.

2.1.4 Industry practice for seizing twines varies on the type of ropes they are supposed to bind. Rope manufacturers generally follow the rules of ensuring that the twines are made of the same or similar materials as the main rope, as was in this case. The diameter of the twine typically is about 1/8 to 1/12 relative to the diameter of the mooring line to be bound. Seamanship techniques indicate that as a rule-of-thumb, the length of the twine should generally be about 3ft (about 0.91m) for every 1-inch diameter of the rope it is to bind. Although the diameter of the parted seizing twine (7mm) was about 0.5mm smaller than the general requisite, relative to the diameter (90mm) of the tail-rope, recognising that the tail rope had been in operation for 18 months without any known incident, the investigation team is of the view that the length[23] and material of the seizing twine was adequate and likely did not contribute to the occurrence.

2.1.5 Seizing twines are subjected to the same environmental conditions[24] as the rope they bind. Being relatively smaller in size, they are also likely to be more susceptible[25] to breakage. In this case the mooring rope and the twines had been used over a period of 18 months during which time, they collectively would have been subjected to twisting, expansion and compression.

2.1.6 However, there was no specific requirement (or industry practice) to inspect the seizing twine of the tail rope, where used. Typical inspection regimes for mooring lines/tail ropes were largely focused on the overall condition of the rope. It is likely that the possibility of the twine parting and causing the bight of the tail rope to open up was not anticipated by those involved when the tail rope was restored for temporary use, especially when the tail ropes had been stored for about two months where they could be subject to further deterioration.

2.1.7 Hence, it is desirable that when appraising the condition of the tail rope, the condition of the seizing twine is also taken into account.

[22] Mooring Equipment Guidelines recommends tail ropes to be replaced at least every 18 months with conditions of storage and other retirement factors to be taken into consideration.
[23] Calculated from the observed number of 13-14 turns, compensating for frapping and tying (dead) ends.
[24] Direct heat, moisture and friction
[25] Being a single strand rope, the propensity for breakage is higher than the tail rope.

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2.2 Coordination between shore and ship's crew

2.2.1 Pre-preparation for simultaneous lowering of mooring ropes, especially those connected to different winches, is a part of a routine operation on board a ship and requires coordination both amongst the ship's deck crew, as well as between the ship and shore personnel. Although PE's reference of a mooring arrangement was different from what the shipyard used (refer to Footnote 1), the investigation team learned that the Pilot and the shore supervisors knew which mooring ropes were being referred to.

2.2.2 When PE's deck crew were in the process of engaging the starboard winch for the inner breast line to be slackened, the Chief Officer had already slackened the outer and middle breast line using the winch remote controller. However, he had reportedly not given specific instructions to the shore crew to release these mooring lines. The forward team's supervisor however, dismissed this claim and asserted that hand signals for removal of the mooring lines were given by the ship's crew, specifically the Chief Officer.

2.2.3 This unverified and presumed communications between the ship and shore crew, with the two slackened mooring lines, might have indicated to the shore team that the mooring lines were ready for being released from the bollard. It must be noted however, that at this time one line had likely taken the load. It was thus inappropriate for the AM and GW(B) to move closer to this line under load to pass the messenger line for subsequent release of the ropes from the bollard.

2.2.4 A desirable situation would have been for better coordination between the shore and ship to ensure that when mooring lines are under load shore crew do not approach such lines.

2.3 Risk assessments and training

2.3.1 Mooring lines under tension pose an inherent risk due to the possibility of a snapback and are also susceptible to parting, particularly when a ship is being unmoored and the load of the ship shifts to the remaining mooring lines holding the ship. Such risks exist regardless of the type of line use (a normal rope or a flexible steel wire). Although the Risk Assessment form by the shipwright department highlighted the dangers of working near mooring lines under

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tension, there was no evidence[26] to suggest that the persons in-charge of the mooring operation on this day, i.e. the supervisor, discussed the risk assessment during the safety briefing or implemented the mitigating measures for preventing the possibility of an injury resulted from a parting mooring line.

2.3.2 Dockside operations in this shipyard, mooring and/or other related ship-to-shore interface, and ensuring worker's competency were usually carried out by the immediate supervisor and/or the responsible person in the form of OJT schemes. This OJT training was devised based on their own criteria and skill requirements and imparted during the OJT.

2.3.3 OJT schemes typically work well when the job scope is consistent, but they have limitations, especially when definitive safety knowledge of hazardous activities and associated risks are to be imparted. There was no evidence to suggest that the persons responsible for the conduct of this OJT had undergone specific training related to mooring and unmooring operations. A formal and structured training process to ensure a thorough understanding of the risks involved in a high risk operation, such as the mooring and unmooring of a ship, is highly desirable.

2.4 Mooring related training for shipyards and other terminals

2.4.1 Although the WSH Manual required shipyards to establish procedures for ship movements, which included handling of moorings, there were no specific guidelines on what these procedures should cover. The WSH Manual made no reference to the competency standard in the WSH Framework developed by the logistics & transport sub-committee of the WSH Council for the oil, gas and chemical industry or to the IMO circular (Refer to Paragraphs 1.4.3 and 1.4.4).

2.4.2 The certificated courses required for employees engaged in shipyards do not specifically include knowledge and/or applied skills for handling mooring ropes and wires especially when involved in mooring/unmooring activities.

2.4.3 Considering the similarity in the risks involved when mooring and unmooring of ships in an oil, gas and chemical terminal and those at a shipyard or other

[26]The shipyard did not mandate the keeping of records on their risk assessment briefings undertaken before the commencements of mooring/unmooring operations. There was also no evidence to indicate that the OJT for the AM and supervisor had covered or that they had participated in the Risk Assessment concluded in 2016.

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terminals where mooring lines are used, it would be relevant and appropriate for such training and competency standards to be applied to shipyards and other terminals. In the adoption of such standards to ensure safety of its workers involved ship-to-shore interface, especially mooring and unmooring of a ship, a regulatory oversight would also be desirable.

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3 CONCLUSIONS

From the information gathered, the following findings, should not be read as apportioning blame or determining liability to any particular organisation or individual.

3.1 The occurrence was the result of a seizing twine, on a tail rope under load, parting during unmooring operations. This caused the bight of the tail rope to open up, which then caused a whiplash injury to two shore workers, who were standing close, in anticipation of releasing the tail ropes from the shore bollard.

3.2 In trying to preserve the new set of tail ropes which was only put to service one month prior to the occurrence, PE's crew used a previous set of tail ropes for this mooring. The used tail ropes although had been recorded to be in 'good' condition prior to being removed from service, they had been stored for two months which may have affected their previously known condition.

3.3 The company's inspection and appraisal criteria for mooring ropes (including tail ropes) was in line with the industry practice and guidelines. It did not specifically include the inspection of the seizing twine, which like the main tail ropes, are subjected to similar operational and environmental conditions. It is desirable that when appraising the condition of the tail rope, the condition of the seizing twine is also taken into account.

3.4 It must be recognised that a mooring lines under load have known to part and resulted in fatal injuries. A desirable situation would have been for better coordination between the shore and ship to ensure that whenever any of the mooring line is under load shore crew do not approach such lines.

3.5 There was no evidence to suggest that the Risk Assessment by the shipyard had been discussed during the safety briefing for the unmooring operations especially on matters relating to working close to mooring lines under tension.

3.6 The shipyard's training framework did not require that persons involved with mooring operations had to undergo structured training such as that contained in the competency standard for mooring and unmooring of ships.

3.7 Considering the similarity in the risks involved when mooring and unmooring of ships in an oil, gas and chemical terminal and those at a shipyard or other

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terminals where mooring lines are used, it would be relevant and appropriate for such training and competency standards to be applied to shipyards and other terminals. In the adoption of such standards to ensure safety of its workers involved ship-to-shore interface, especially mooring and unmooring of a ship, a regulatory oversight would also be desirable.

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4 SAFETY ACTIONS

During the course of the investigation and through discussions with the investigation team, the following safety actions were initiated.

4.1 The shipyard reviewed its risk assessment and formulated new procedures (safe work procedures) for mooring/unmooring operations. The bollards along the seafront of the shipyard were marked with a 1.5m all-round visual marking to restrict personnel from entering, when any vessel's mooring line on the bollard is taut.

4.2 The shipyard also implemented a procedure to ensure that its shore crew were allowed to enter the newly marked 1.5m all-round "danger zone" around a bollard for the release of bight only after confirming with the Pilot that the respective mooring lines have been slackened by the ship's crew.

4.3 The WSH Council circulated an accident alert in May 2017, providing information about the occurrence, and as a reminder to those involved in mooring operations to ensure that supervision of such operations are suitable and adequate, and that shore mooring workers have appropriate safety training with familiarity to hazards associated with mooring/unmooring operations. This alert made reference to, amongst others, IMO's circular FAL.6/circ.11/Rev.1.

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5 SAFETY RECOMMENDATIONS

A safety recommendation is for the purpose of preventive action and shall in no case create a presumption of blame or liability.

5.1 For the shipyard

5.1.1 To enhance its existing training procedures by having structured training for its workers involved in mooring/unmooring activities to acquire the competency standards, e.g. as outlined in the WSH Framework established by the WSH Council. **[TSIB Recommendation-RM-2019-001]**

5.1.2 To ensure hazards identified in Risk Assessments are understood by all personnel involved with mooring/unmooring activities, prior to each operation. **[TSIB Recommendation-RM-2019-002]**

5.2 For the company

5.2.1 To consider taking the condition of the seizing twine into account when inspecting and appraising the condition of the tail rope and amend the Tail Rope Management guidelines accordingly. **[TSIB Recommendation-RM-2019-003]**

5.3 For the Workplace Safety and Health Council

5.3.1 To include shipyards and other terminals where ship-to-shore interface takes place, in the scope of competency standards for berthing/unberthing activities. **[TSIB Recommendation-RM-2019-004]**

5.3.2 To consider the need for an Approved Code of Practice to cover berthing/unberthing activities where mooring and unmooring takes place. **[TSIB Recommendation-RM-2019-005]**

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Annex A

ANNEX

GUIDELINES ON MINIMUM TRAINING AND EDUCATION FOR MOORING PERSONNEL

1 Definitions, objectives and application

1.1 *Mooring personnel* is defined as the personnel tasked to assist in the activity of mooring and unmooring ships, either ashore or from mooring boats, carried out within the framework of port marine services.

1.2 *Mooring boat* is defined as a boat handling mooring lines between the ship and ashore during mooring and unmooring operations and does not include harbour ship assist tugs.

1.3 The objective of these guidelines is to provide the Member Governments, port authorities and the port industry with guidance on recommended minimum levels of training and education for mooring personnel unless covered by other regulations, application of which should assure the shipping industry and the public at large that there is an adequate level of competence available in ports, which would ensure that ships could enter, stay and leave a port safely, securely and efficiently.

1.4 To ensure that port marine functions, which have an important bearing on maritime/port safety, security, environment protection and facilitation of maritime traffic, are carried out by competent personnel, the port industry should provide dedicated education and training. It is recognized that ports around the world have different practices in relation to the provision of mooring services.

1.5 The guidelines may be used, as a guide, by those seeking to develop programmes to upgrade the knowledge and level of education or training of new and existing mooring personnel.

1.6 The education and training may be conducted in a variety of ways depending on the local needs and the working schedules of the persons involved, for example as part of an organized on the job training programme, through a short duration training course or through a series of short duration training sessions spread over a period of time.

1.7 It is recognized that the extent and level of detail of the training and education to be provided would be dependent, inter alia, on the local conditions and needs, the educational background of the candidates and their previous work experience.

1.8 Those developing training guidance material pursuant to the present guidelines should bear in mind the provisions of the ILO Code of Practice on Safety and Health in Ports as well as relevant local regulations and guidance.

2 General principles for recommended standards of fitness, training and education for mooring personnel

2.1 These guidelines should not be construed as interfering with any national or local training or education requirements for mooring personnel.

2.2 Mooring personnel should be aware of risks to their health and safety and how these risks are controlled.

2.3 Mooring personnel should pass a medical examination and eyesight test and should be able to swim.

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3 **Standards for all mooring personnel**

3.1 Mooring personnel should have a knowledge, as appropriate, of:

Safety, communications and environmental protection

.1 the use and maintenance of appropriate safety appliances including personal protective equipment and personal flotation devices;

.2 relevant safe manual handling practice related to the moving of items either by lifting, lowering, carrying, pushing or pulling;

.3 procedures in preparation for mooring including briefing and muster location, and if required, wharf lighting set-up;

.4 basic maritime terminology, IMO Standard Marine Communication Phrases (SMCP), and how to communicate with all parties including hand signals, sound signals, and use of VHF radio;

.5 distress signals, recognition of these and measures to be taken when sighting them;

.6 lifebuoy and ladder locations and man overboard procedures;

.7 mooring systems, mooring line configuration and procedures for ship lines transfer;

.8 procedures for securing, adjusting and releasing lines;

.9 appropriate knots and splices;

.10 the hazards of working with wires and ropes under tension including awareness of snapback zone and appropriate safe working practices;

.11 fire prevention and basic first aid;

.12 local environment protection measures;

.13 the use of hydraulic and/or electric powered mooring equipment;

General geographical knowledge of the local working area

.14 fairways, channels and shoals, their buoyage and other navigational marks, tidal ranges, water level indicators, tidal streams and/or currents, etc.;

.15 ports and harbours, their berths, facilities, shipyards, etc.;

.16 bridges and locks and the signals for passage of these, where applicable;

.17 the origin of the water's course and the factors influencing and governing it, including the effects of tides, winds, embankments, shoals, dredging, etc. and any local weather or sea conditions;

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Shipping regulations

.18 shipping and port regulations in so far as they affect their work, harbour orders, police and customs requirements;

.19 reporting of incidents or accidents;

.20 working conditions during night time and inclement weather;

Characteristics of ships

.21 the different types of ships;

.22 the structure, composition and dimensions of seagoing ships, coastal ships and, where applicable, river crafts; and

Port security

.23 port security related issues, commensurate with their responsibilities and duties.

4 Additional standards for mooring personnel working on board mooring boats

4.1 These additional standards apply to mooring personnel working on board mooring boats. When mooring personnel are required to work on mooring boats and ashore, the additional standards of training, as set out in paragraph 4.2 below, should be applied.

4.2 Mooring personnel working on board mooring boats should have a knowledge, as appropriate, of:

Mooring boat handling

.1 the handling characteristics of the mooring boat and local conditions;

.2 the effects and hazards of the use of propellers, thrusters (bow, stern and azimuth) and rudders by a ship when manoeuvring in close proximity;

.3 the origin of suction and its effect on a ship's movements and subsequent manoeuvres;

.4 how different mooring lines behave in water and hazards of their use in close proximity to propellers;

.5 mooring and anchoring systems and the function and handling of winches, capstans, and windlasses and appropriate safe working practices;

.6 the direct and indirect actions of different types of propellers and the meaning of "pitch" and "slip" of propellers;

.7 the water movements caused by a ship making headway in a fairway of limited breadth and depth;

.8 the origin and effects of backwash eddies and turbulences in tidal streams and currents;

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.9 procedures for communication with the ship's master and crew, and pilot;

.10 emergency procedures including the use of bilge pumps on mooring boats;

.11 measures to be taken in cases of collision or stranding;

Shipping regulations

.12 the relevant rules of the Convention on the International Regulations for Preventing Collisions at Sea, 1972, as amended;

.13 the relevant buoyage systems;

.14 the preparation of reports following accidents and collisions;

.15 the documents appertaining to the launches/mooring boat where applicable;

Machinery

.16 the operation of diesel engines and other propelling and auxiliary machinery;

.17 the operation and maintenance of the mooring boats; and

.18 the electrical systems on board mooring boats.

-End of Report-

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