Report on the investigation of the

parting of a mooring line on board

Dublin Viking

alongside at Berth 52 in the Port of Dublin, Ireland

resulting in one fatality

7 August 2007

Marine Casualty Investigation Board
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Dublin 2
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Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

The MAIB has conducted this investigation taking the lead role pursuant to the IMO Code for the Investigation of Marine Casualties and Incidents (Resolution A.849(20)). MAIB wishes to acknowledge that the Marine Casualty Investigation Board of Ireland has registered its interest as a substantially interested state, and thanks it for its cooperation and support.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

2/O	-	Second Officer
AB	-	Able Seaman
COSWP	-	Code of Safe Working Practices for Merchant Seamen
DNV	-	Det Norske Veritas
DOC	-	Document of Compliance
DPA	-	Designated Person Ashore
HMPE	-	High Modulus Polyethylene
IMO	-	International Maritime Organization
ISM	-	International Safety Management system
ISO	-	International Standards Organisation
kN	-	kilonewtons
kW	-	kilowatt
MBL	-	Minimum Breaking Load
MCA	-	Maritime and Coastguard Agency
MEG	-	Mooring Equipment Guidelines
MGN	-	Marine Guidance Note
MMM	-	Meridian Marine Management
MSC	-	Maritime Safety Committee
MSM	-	Marine and Safety Manager
OCIMF	-	Oil Companies International Marine Forum
OS	-	Ordinary Seaman
PPE	-	Personal Protective Equipment
PUWER	-	Provision and Use of Work Equipment Regulation
RINA	-	Registro Italiano Navale Classification Society
Ro-Pax	-	Roll on Roll off and Passenger

SOLAS	-	International Convention for the Safety of Life at Sea
STCW	-	International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers
UV	-	Ultra Violet
VDR	-	Voyage Data Recorder

All times used in this report are UTC + 1 unless otherwise stated

SYNOPSIS

On 7 August 2007, the ro-ro passenger ferry *Dublin Viking* was preparing to leave her usual berth for a scheduled sailing from Dublin. Wind and tidal conditions were benign, but in the process of letting go the stern line, the operator of the stern line winch heaved in the line instead of paying out slack. The stern line parted with a loud crack and snapped back, striking the second officer's legs. Both his legs were broken and the left leg was almost severed. The recoil of the line also dislocated a shore worker's shoulder and elbow.

The vessel's first-aid team and off duty master quickly arrived to treat the second officer. His injuries were severe and it was difficult to control the bleeding. The second officer was evacuated to hospital, where his left leg had to be amputated. He remained in a critical condition and died 6 days later.

The second officer, in charge of the after mooring deck, was obliged to stand in 'snap-back' zones near the fairleads, so that he could relay orders to line handlers ashore and deck crew. Analysis of the mooring line after the accident showed that it had deteriorated, its breaking load having reduced from 60 to 35 tonnes, largely due to exposure to Ultraviolet (UV) radiation from sunlight. Although the vessel's mooring ropes were required to be inspected, the onboard procedures were informal and no records were kept.

The winch operator was attempting to control two winches at the same time, one heaving up the stern ramp and the other veering the stern line. The operator had controlled the winches before, and knew that the controls of the mooring winch operated in the opposite sense; however he was distracted and pushed the stern winch control away from him when intending to veer the rope. This caused the winch to heave in. Tests showed that the electric mooring winch was capable of pulling a far greater load than its stated output for a very short period when it first started to turn. This was sufficient to part the mooring line.

Following the accident, the vessel's management company has implemented a number of measures designed to prevent a re-occurrence, and the winch manufacturer has undertaken to mark all new mooring winches with their maximum, as well as nominal, rated loads and also to provide more detailed technical information in its manuals.

Recommendations have been made regarding: the technical information supplied with winches; the need to consider the implications of any shore supplied moorings on the mooring structure as a whole; and the dissemination of a "flyer" that the MAIB has published, drawing attention to the lessons learned from this accident.

Dublin Viking

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *DUBLIN VIKING* AND ACCIDENT

Vessel details

Registered owner	:	Belfast Freight Ferries Ltd
Manager(s)	:	Meridian Marine Management Ltd
Port of registry	:	Belfast
IMO No.	:	9136022
Flag	:	United Kingdom
Type	:	Ro-ro passenger ferry
Built	:	1997, Cantieri Navale Visentini, Italy
Classification society	:	Det Norske Veritas
Construction	:	Steel
Length overall	:	186.0 m
Gross tonnage	:	21856.0
Engine power and/or type	:	15600kW Wartsila diesel, driving twin controllable pitch propellers
Service speed	:	21 knots

Accident details

Time and date	:	2214 on 7 August 2007
Location of accident	:	Aft mooring deck while the vessel was alongside at Berth 52 in the Port of Dublin, Ireland
Persons on board	:	44 crew, 101 passengers
Injuries/fatalities	:	Second officer fatally injured, 1 shore worker suffered dislocated elbow and shoulder
Damage	:	Stern mooring line parted

1.2 NARRATIVE

1.2.1 Background

The ro-ro passenger ferry *Dublin Viking* sailed from Liverpool at about 1030 on Tuesday 7 August 2007 on a scheduled passage to Dublin. On arrival at 1700, the cargo and passengers were disembarked, and loading of the freight began at 1839. Main engines were prepared for the intended departure at 2200, ready for the 7 hour overnight passage back to Liverpool.

1.2.2 Trading operations

Dublin Viking shared a regular trading pattern with a sister vessel, *Liverpool Viking*, sailing between the 12 Quays jetty at Birkenhead and Berth 52 in the Port of Dublin. Sailings departed Liverpool and Dublin at 1000 and 2200 each day and the schedules incorporated layover time in Liverpool and Dublin on Sundays and Mondays to allow maintenance and crew training. Each vessel berthed in both Liverpool and Dublin every day from Tuesday to Saturday. On Sunday and Monday, each vessel berthed in one port only. Considering berthing and unberthing as separate mooring operations, each vessel undertook 24 such operations each week. The route was operated by Norfolk Line and the vessels were owned by a subsidiary company, Belfast Freight Ferries Ltd.

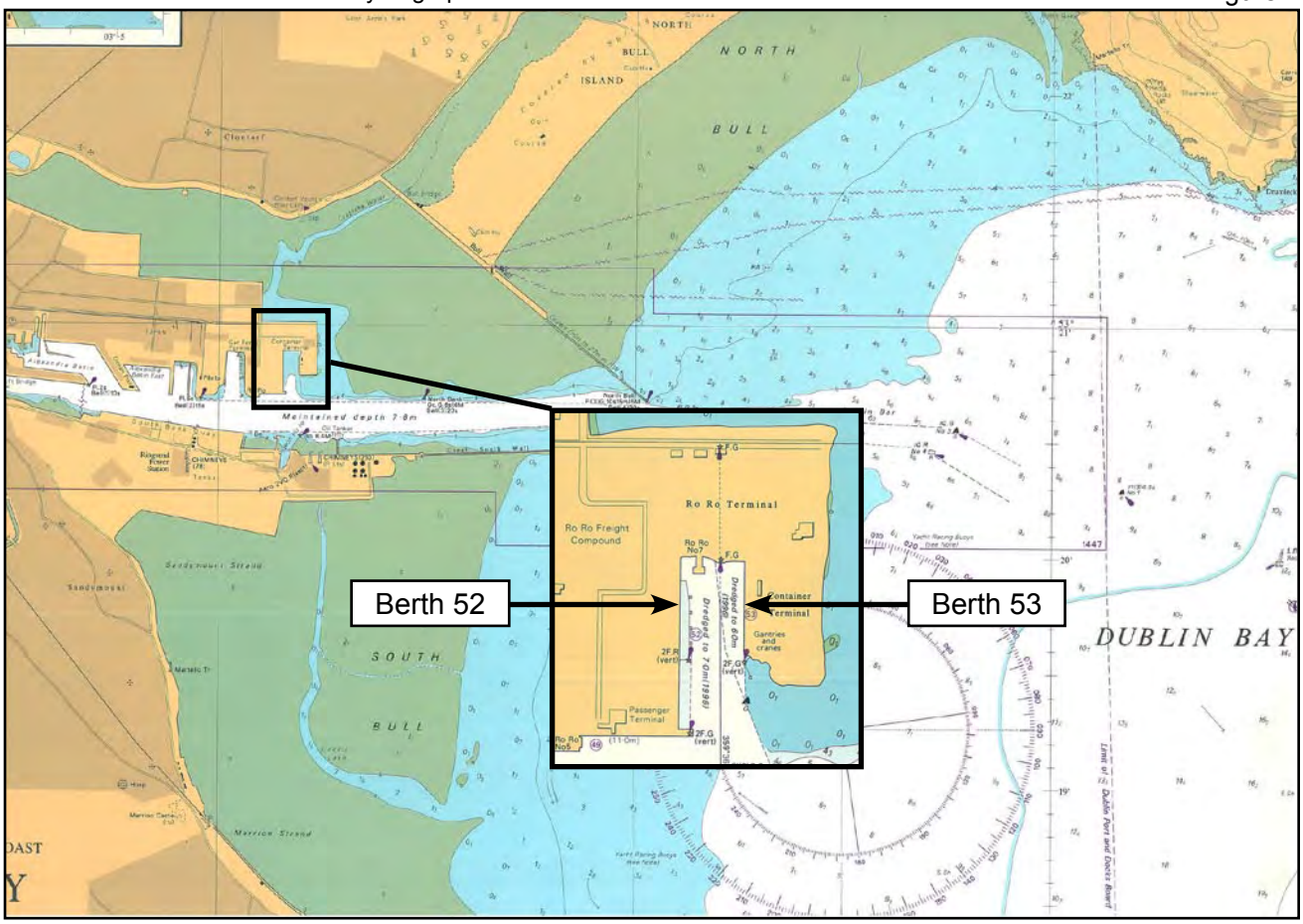
Dublin Viking had two masters to divide the duties in order to comply with requirements for hours of work and rest. In addition to traditional deck duties, deck ratings on board *Dublin Viking* were employed to assist with arranging trestles to support unaccompanied lorry trailers and lashing all vehicles for the passage. Typically, they worked 2 x 6 hour shifts, from 0400 to 1000 and 1600 to 2200, berthing, then assisting with cargo operations, and finally unberthing. The majority of their rest periods were taken while the vessel was on passage.

1.2.3 Arrival and cargo operations in the Port of Dublin

The more senior of the two masters was in command of the vessel during the arrival into Dublin and was assisted on the bridge by the chief officer. The vessel entered the port as normal, turning and coming astern to enter the basin where Berths 52 and 53 are situated **(Figure 1)**. Berth 52 was arranged to allow *Dublin Viking* to secure starboard side to dolphins positioned some way off the edge of the berth to give the necessary depth of water. The vessel's stern ramp could then be lowered onto a pontoon which connected to the shore to provide access for vehicles and pedestrians.

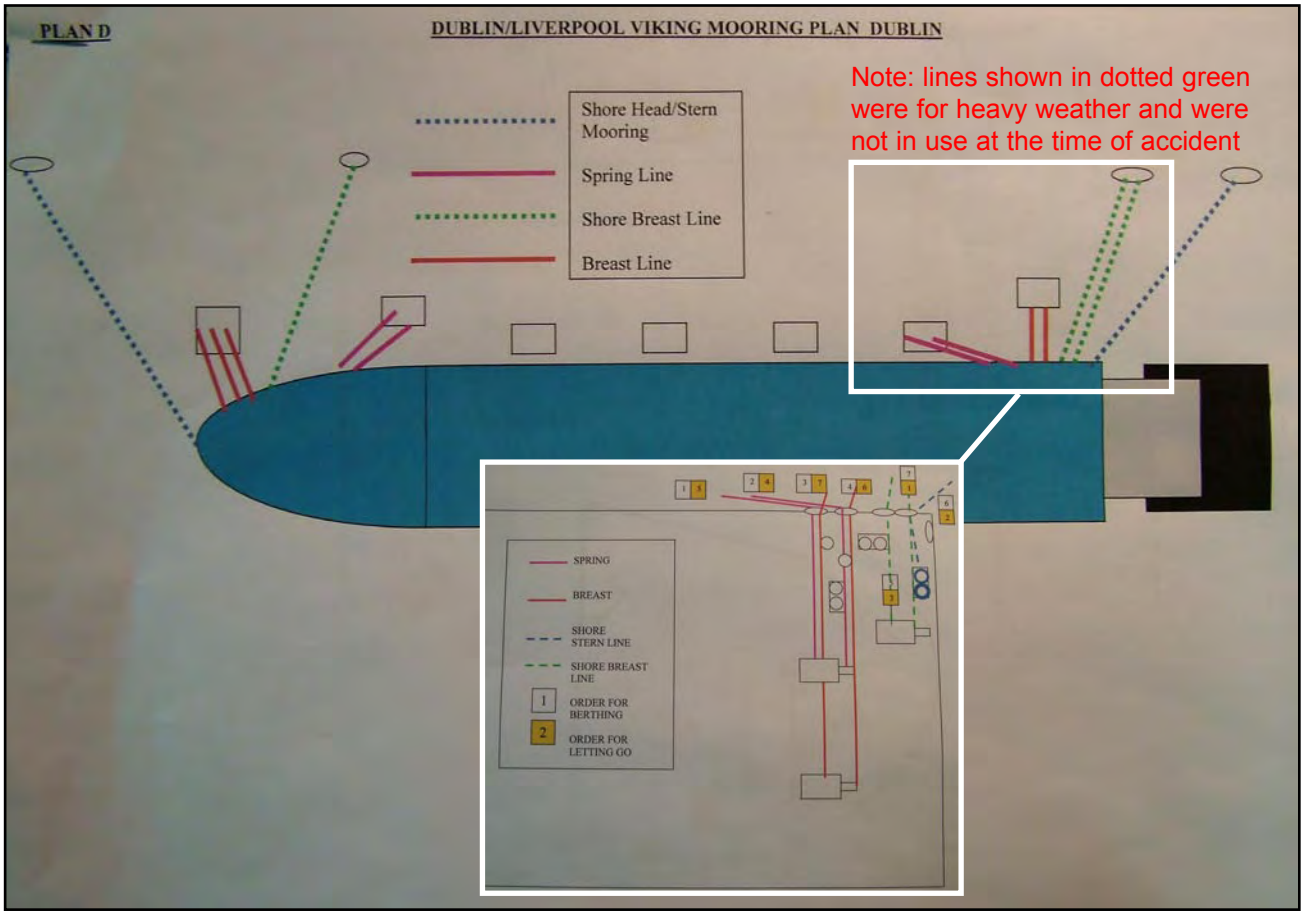
Weather conditions were good, with no deterioration forecast, and mooring lines were attached in the configuration that had been developed on board for normal operations **(Figure 2)**. The first lines were ashore soon after 1700, and it was reported that the stern was approximately 1.5m out of position, preventing the stern ramp from aligning with the loading pontoon. The stern was heaved into position using the after mooring lines, with some slack being given on the forward lines. The combined effect caused the ship to move astern and this was countered using ahead thrust from the port engine. The vessel was secured in position and main engines were shut down at 1718.

Figure 1



Berth 52 in the Port of Dublin

Figure 2



Arrangement of mooring lines

1.2.4 Departure from Berth 52

In Dublin,137 trailer units and 101 passengers were loaded. Five lorries were loaded, just prior to departure, including two car transporters which, due to their height, had to be loaded onto the ramp leading to the upper vehicle deck. Cargo documents were brought on board at 2205, and loading was completed at 2209. Deck crew went immediately from the vehicle decks to their mooring stations to prepare for unberthing.

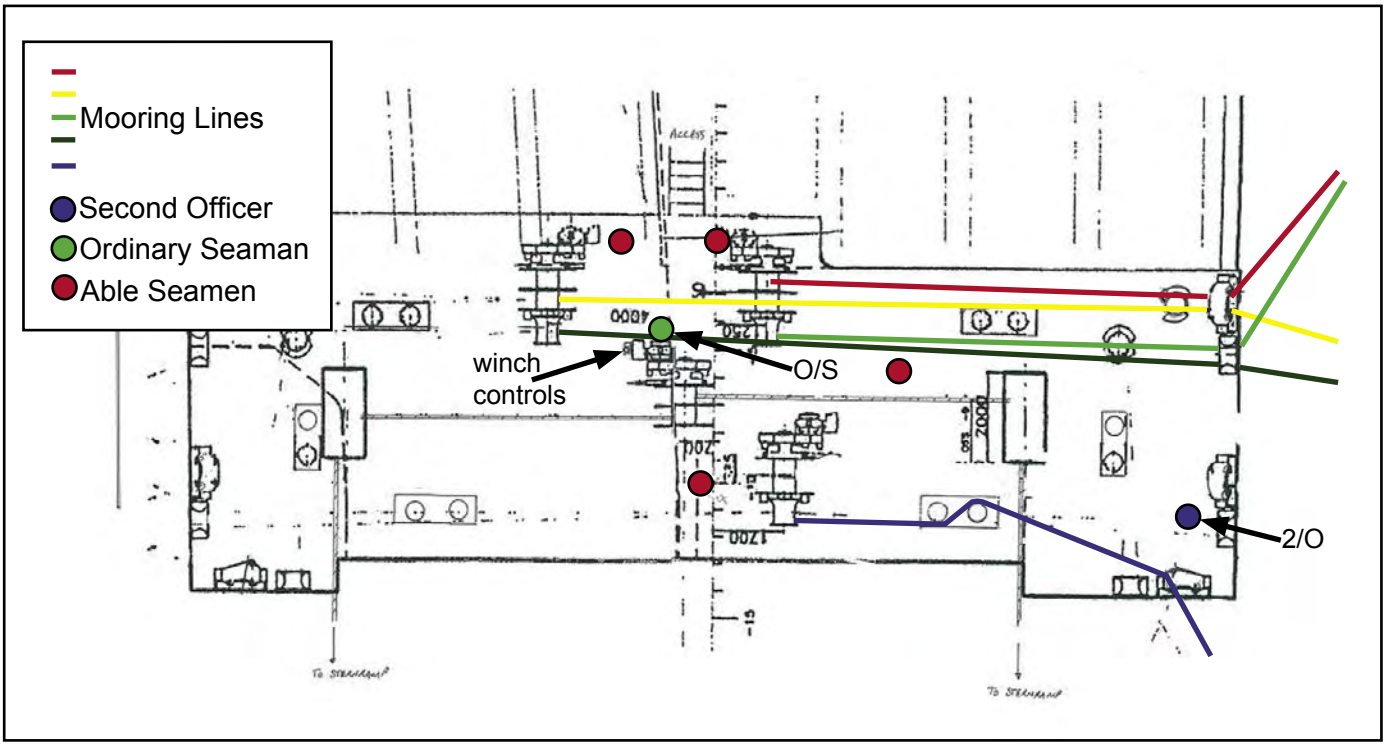
One ordinary seaman (OS) and four able seamen (ABs) were assigned to the aft mooring deck. The first to arrive was the OS who, following accepted practice, started the ramp and mooring winches and heaved in the slack on both the stern ramp wires and after breast lines. He was joined by the ABs, who took up positions to operate the other mooring winches and to tend the lines **(Figure 3)**. Tasks were allotted either by personal preference or habit, and the OS remained at the controls for the stern ramp. The controls for the stern line winch were close by, and it was normal practice for one person to operate both sets of controls **(Figure 4)**.

The 2/O was the last person to arrive because he had been helping the chief officer supervise the cargo loading and had then shut down the ballast anti-heeling system in preparation for going to sea. The 2/O left the cargo office on the main vehicle deck and climbed up to the after mooring deck, where he took up position on the starboard side so that he could pass instructions to shore line handlers and crew on deck. The chief officer received instructions from the bridge to close the stern ramp once he was ready and, at 2212, using portable radio, he asked a member of the after mooring party to close the stern ramp. This order was passed on to the O/S, who operated the ramp winch to heave in the two steel wire ropes and close the stern ramp. The chief officer was standing on the stern ramp to check that all shore personnel were clear when he realised that he had forgotten to record the aft draught with the last five additional vehicles on board. The chief officer ordered the 2/O, who had now arrived at the after mooring deck, to lower the stern ramp again to allow him access to the jetty in order to read the vessel's draught marks. This order was relayed to the O/S, who operated the stern ramp winch. By 2213 the chief officer was back on board and the stern ramp was raised again.

At 2214, the duty master, who was on the bridge, ordered the 2/O to let go the aft stern line, by which time the ramp was approximately a quarter raised. The 2/O gave hand signals indicating the OS to pay out the stern line to give sufficient slack for the line to be lowered to the pontoon to allow shore workers to disconnect the ship's line from a permanent shore line which was secured to bollards on the quay **(Figure 5)**. The OS was still operating the ramp winch, pulling the control lever towards him to heave in the ramp wire. He pushed the stern winch control lever away from him, intending to pay out the stern line, but the tension on the line increased. Two ABs standing nearby shouted warnings and the OS stopped the stern line winch.

The stern line had been turned up on the warping drum during berthing earlier in the day, with either five or six turns to secure the vessel alongside. The OS asked one of the ABs to remove some turns and surge the line under its own weight to provide the necessary slack; the AB declined, and told the OS to continue veering the warping drum end. The OS was still operating the stern ramp winch by pulling the lever towards him,

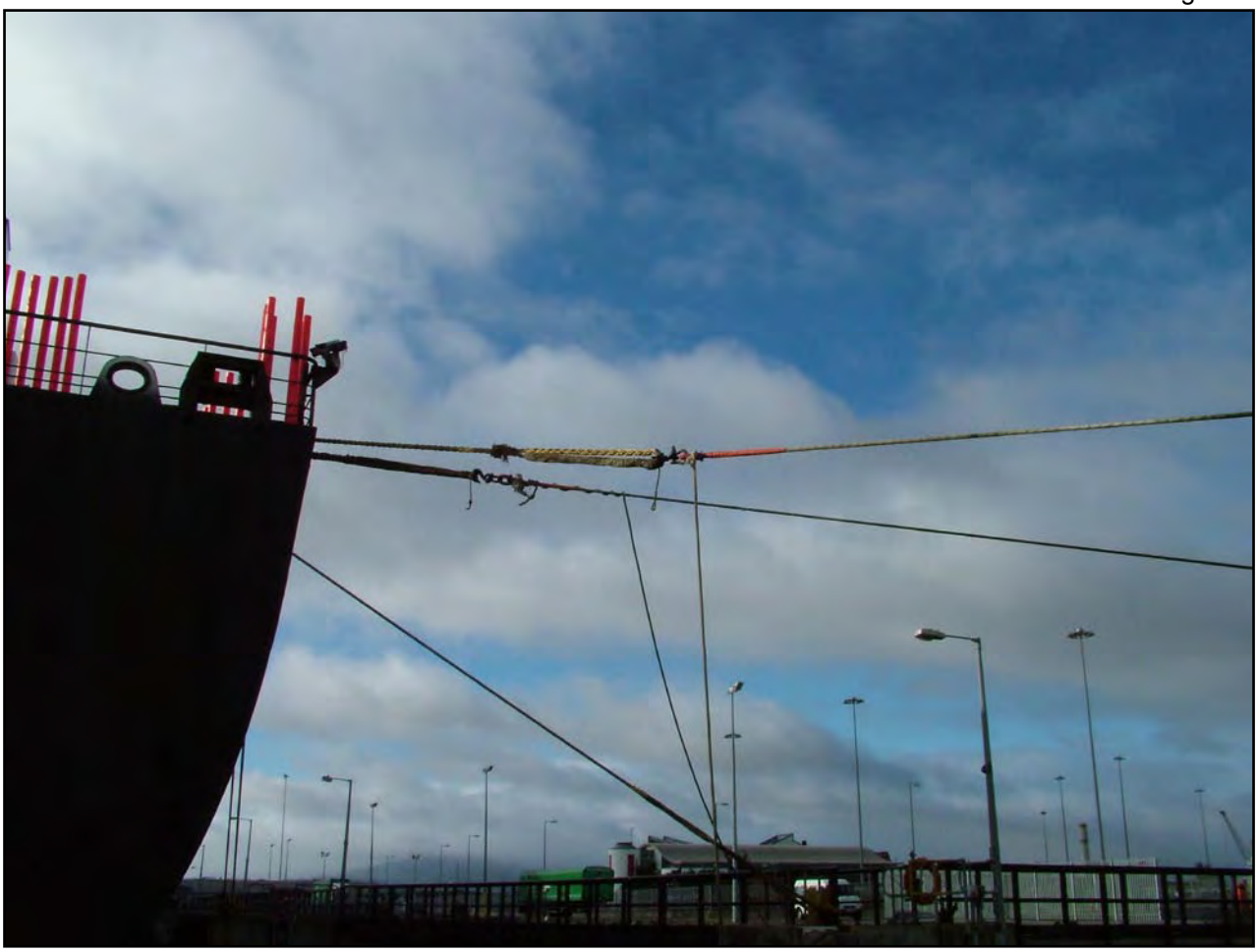
Figure 3



Position of crew on the after mooring deck

Figure 4

Stern line and stern ramp winch controls



Shore supplied stern line

and pushed the lever of the mooring winch away from him, intending to pay out the stern line. The winch turned in the opposite way from the intended direction, applying more tension to the stern line. The two ABs standing nearby heard the line start to make cracking noises, and fell to the deck to protect themselves. The 2/O was some distance away from the stern line when it parted, making a loud cracking noise. The OS saw the 2/O fall to the deck, stopped the mooring winch and went to assist him.

The chief officer was near the cargo office on the main vehicle deck and heard a loud noise. He used his portable radio to ask the 2/O what had happened, but received no response, so climbed up the partially raised stern ramp to see for himself. He could see that someone had been injured on the mooring deck, and contacted the bridge to report an accident and request medical assistance. He could also see one of the shore line handlers nursing an apparently injured arm, and saw the shore superintendent pointing to the remains of the parted stern line floating in the water. The chief officer shouted to the shore workers to call an ambulance, and went back into the vehicle deck to go up through the engine room uptake spaces to the aft mooring deck.

By 2215, the chief officer had arrived on the aft mooring deck, where he found the 2/O lying on the deck, slumped against a bulwark on the starboard side. One of the 2/O's legs was bent back underneath his body and the other was lying on his chest at a very unnatural angle. He was bleeding profusely from his left thigh and knee area. The OS, who was trying to comfort the 2/O, and the ABs were in a state of shock. The OS attempted to report the accident to the bridge using the 2/O's radio, but his voice was garbled and personnel on the bridge could only determine that the 2/O had been injured. The duty master reported the accident to the Dublin Port Authorities by radio and asked them to call an ambulance. Anticipating that shore access would be needed, he ordered the stern ramp to be lowered.

The chief officer noticed that once the ramp had been lowered again after the stern line had parted, it was approximately 1.2m (4 feet) further forward than before. The weight of the stern ramp on the pontoon was known to have a significant anchoring effect and was capable, in benign conditions, of maintaining the ship's position while mooring lines were being secured.

1.2.5 Medical response

Although deck ratings had received elementary first-aid training, the policy on board *Dublin Viking* was for the principal first-aid response to come from the 'Mike Team'. This consisted of four crew members from the catering department, three of whom were qualified in accordance with the requirements of STCW A-VI/4-1[1] for those designated to provide medical first-aid. The team leader was the head chef, who was qualified in accordance with the requirements of STCW A-VI/4-2 for those designated to take charge of medical care on board ship.

The chief officer's report of the accident to the bridge was relayed to the purser, who was in the vessel's passenger reception area on deck 5 with the head chef. The head chef went to the ship's hospital, which was close to reception, and began to gather first-aid equipment while the other team members mustered. Shortly afterwards, the 'Mike Team' members went to the after mooring deck, carrying first-aid dressings and therapeutic oxygen.

[1] International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers

Members of the ‘Mike Team’ arrived at the aft mooring deck at 2220. They were shocked by the extent of the 2/O’s injuries, and quickly realised that even the largest of the dressings they had brought were insufficient for the wounds. The 2/O was semi conscious, and although a substantial pool of blood had formed on the deck there were no obvious signs of arterial bleeding. The head chef decided that the priority was to give the 2/O oxygen, and applied a mask to his face. The 2/O became more alert and began to struggle. The rate of bleeding increased and while attempting to calm and restrain the 2/O, the head chef requested towels, blankets and morphine.

The off duty master had been resting, but became aware that an accident had occurred and came to the bridge to offer assistance. The chief officer had given the duty master on the bridge a brief summary of the 2/O’s condition via radio, and he requested that morphine be sent to the aft mooring deck. Concerned that the medical situation was serious, the off duty master decided to go to the aft mooring deck, with the duty master remaining in command on the bridge.

The off duty master arrived at the aft mooring deck at about 2221, joining the chief engineer who had also just arrived. He quickly realised that the scale and extent of the injuries had shocked both the deck crew and members of the ‘Mike Team’. The 2/O was still bleeding from his left leg, and the off duty master attempted to find the source in order to stem the flow. Unable to reduce the flow sufficiently through direct pressure, he applied a tourniquet to what remained of the 2/O’s upper thigh and asked for assistance to move the rest of the left leg to a more natural position. The chief engineer and the safety officer, who had been stationed on the bridge, comforted the 2/O and assisted the off duty master.

At 2223 the duty master contacted Dublin Port Authorities by radio requesting confirmation that an ambulance was on its way. They confirmed that the ambulance was expected to arrive within 2 minutes and, shortly afterwards, at 2226, the ambulance was seen approaching the vessel. Morphine had arrived at the after mooring deck, but was not administered because the ambulance was seen close by. The ambulance crew were met at the stern ramp by the chief officer and escorted up to the after mooring deck, where they arrived at 2232.

The ambulance crew took charge of treating the casualty. The 2/O was put onto a stretcher, his legs bandaged, and he was made ready for transport to a local hospital. The chief officer had realised that the two car transporters that had been the last vehicles to be loaded were obstructing the evacuation route and he began to make arrangements with the hotel services staff to summon the drivers. The drivers of the two vehicles were requested to return to their vehicles at 2236 and the driver of a third vehicle was requested to return to his vehicle at 2239. By 2241 two of them were with their vehicles, but their exit was blocked by the third vehicle, whose driver had yet to return. The local Fire and Rescue Services were now on board, and they assisted the ambulance crew move the stretcher, which was carried forward across the starboard side of the upper vehicle deck and passed across to the port side under a trailer towards the ramp back down to the stern. Further announcements were made for the third driver, who arrived to move his vehicle soon afterwards. At 2249 the senior master reported to the bridge that the ambulance had left the ship with the casualty.

The 2/O’s left leg was subsequently amputated in hospital and he remained in a critical condition. He died as a result of his injuries on 13 August.

1.2.6 Crew

The off duty master was British, and was an experienced master on the route, having served on *Dublin Viking* for several years. His most recent Medical Care course had been completed in September 2004, and he had gained experience of treating casualties from other medical emergencies during his career. The duty master was Italian and had served periodically on board the vessel as second and chief officer since 2000. He was promoted to master in 2002.

The 2/O was Polish, and began working at sea in 2003 as a deck rating on board general cargo and bulk carriers. He was a deck cadet at sea from April to August in 2004, and qualified as an officer in charge of a navigational watch at the Maritime Academy in Gdynia in May 2005. Returning to sea on a bulk carrier as an AB in July 2005, he was promoted to third officer on the same vessel in October 2005. In July 2006, he joined *Dublin Viking* as third officer for a 2-month contract, and later transferred to *Liverpool Viking* for a 1-month contract. He then returned to *Dublin Viking* for two more contracts and was recommended for promotion to second officer. Appraisal reports recorded that he was considered to be a very capable officer, and he was promoted as a special measure to encourage him to stay with the company. He rejoined *Dublin Viking* on 8 July 2007 on his first contract as second officer.

There were four ABs working on the after mooring deck, all of whom were mature, experienced deck ratings. The AB who was standing by the stern mooring line had also previously worked as a bosun and an officer of the watch.

The OS was the youngest member of the aft mooring party. He had attended maritime school in Poland and had gained an STCW certificate for a Rating Forming Part of a Navigational Watch in January 2006. He began working at sea in 2003 as a deck apprentice on board ferries in Scandinavia and Northern Germany. After a brief period as a cadet on board a bulk carrier in 2006, he worked as an OS on board a general cargo vessel until January 2007. He joined *Dublin Viking* in April 2007 and had worked a total of three months over two contracts.

The vessel's management company maintained a policy of familiarisation and safety training in accordance with the requirements of SOLAS, ISM and STCW Conventions[2]. This included training on board and instruction on how to operate the mooring equipment. The OS had completed this training during his first week on the vessel. The 2/O had completed familiarisation training and had also worked as an understudy to other second officers on the aft mooring deck while he was working on board as a third officer.

All the senior officers had served on board the vessel for a number of years and had been retained by the current managers from the various different crewing agencies and management companies that had previously supported the vessel. Meridian Marine Management had subcontracted the administration and recruitment of Polish officers and ratings to a manning agency.

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[2] International Maritime Organization, Conventions on the Safety of Life at Sea, International Safety Management and Standards of Training, Certification and Watchkeeping for Seafarers

1.2.7 Commercial background

Dublin Viking was built under the original name, *Mersey Viking*, and was renamed in September 2005 as part of a restructuring of the Irish Sea fleet. The vessel was ordered from the Italian Cantieri Navale Visentini yard in 1995 and entered service in early 1997, under Italian registry and RINA[3] classification. Although the vessel was intended for service on the Irish Sea routes, it was originally owned and managed by Visentini Francesco Trasporti Fluvio Maritimi in Bari, part of the same group as the building yard. *Mersey Viking* was operated by Norse Irish Ferries until the business was acquired by Norse Merchant Ferries in 1999. The parent company CENARGO purchased the vessel in 2001 but entered into administration in 2003, and Irish Sea operations were restructured to form the Norse Merchant Group. *Mersey Viking* was flagged in to the UK Register in July 2004 and the Norse Merchant Group, including the vessel's registered owners, Belfast Freight Ferries, was acquired by Norfolk Line Shipping BV, part of the AP Moller-Maersk Group in 2006.

1.2.8 Vessel management

At the time of the accident, *Dublin Viking* had had four different ship managers since it entered service. Visentini Francesco Trasporti Fluvio Maritimi managed the vessel until March 2001, when management was awarded to V Ships UK. A year later in 2002, Bluewater Marine Management took over, until June 2004 when the contract was transferred to Meridian Marine Management Ltd (MMM).

MMM provided all ship management functions for *Dublin Viking* and were the International Safety Management (ISM) Code registered 'company' on behalf of the vessel's owners.

MMM operated a structured management system split into four levels of increasing detail describing company policies, procedures, personal responsibilities and authority. The system had been audited in accordance with the requirements of the ISM Code and MMM had been awarded Documents of Compliance (DOC) from several Flag State Administrations, including the UK's Maritime and Coastguard Agency (MCA) for ferry operations.

The Safety, Health, Environmental and Quality Manual described the high level functions of the system. Beneath this level were generic operating procedures common to all vessels managed by MMM followed by specific instructions for similar types of vessel (e.g. ro-ro ferries). Finally, fleet circulars, vessel memoranda and work instructions were produced for individual vessels and activities as required.

MMM appointed a ship manager for the day to day support of the vessel and a marine and safety manager (MSM) to oversee operations and conduct audits and inspections. The MSM reported to the company's risk, safety and security manager, who was also the Designated Person Ashore (DPA) for *Dublin Viking*.

One of the three second officers on board *Dublin Viking* was appointed the vessel's operational safety officer. Following concerns from MMM risk, safety and security managers about an adverse trend of accidents and incidents during the first half of 2006, chief engineers were appointed as occupational safety officers. This measure was intended to give support to the operational safety officer and demonstrate commitment to improving safety at a senior management level.

[3] Registro Italiano Navale Classification Society

Risk assessments, using MMM's proforma, had been completed for making fast and letting go of tugs. These were dated 16 July 2006 and included the '*undesired event*' of a line or wire parting. The likelihood was listed as '*unlikely'* which, by the company's definitions, applied to '*events which were probable but infrequent, or events which were infrequent but probable'* [sic]. The risk had been assessed as *'medium'*, which was defined as an event having major or severe consequences which, in terms of injuries, were those requiring third party medical assistance or causing permanent disability and/ or death. Existing controls to prevent the undesired event were described as being:

- Planned maintenance system
- Training
- Use of appropriate Personal Protective Equipment
- Guards and rails
- Qualified personnel
- Good communications.

MMM considered incidents and lost time due to injuries to be Key Performance Indicators in measurement of their business performance. These increased in the second half of 2006 and some of the early months in 2007, and were noted as a cause for concern. A number of management actions were instigated to reverse this trend, including a more proactive approach to safety inspections and the appointment of chief engineers on board as occupational health and safety officers. A video, to be shown to all staff, was also commissioned which featured the company's managing director reinforcing safety policies and encouraging crew to focus on improving safety.

1.2.9 Mooring arrangements

Four hydraulic winches were ordered for the vessel in 1994, prior to the start of building. Two were combined anchor and mooring winches for the forecastle deck and the remaining two were mooring winches for the after deck. Part way through the building process in 1996, two additional electric winches were ordered, one forward and one aft. These electric winches were simpler to install than hydraulic units and gave additional line handling capacity. The after mooring deck had limited area and the electric winch was offset to starboard in order to clear the stern ramp winch. Both the electric winches had the capability to operate in an automatic, self tensioning mode. This mode was not used, and the after winch load meter was reported to be defective.

The trading pattern of *Dublin Viking* required it to make a substantial number of mooring operations, with the management company estimating the total number of berthing and unberthing operations each year to be approximately 1250. The tidal range in Liverpool, and to a lesser extent in Dublin, required that lines were tended throughout the period alongside; a task which deck crew were required to fit in with their cargo work duties.

Although the vessel had originally been fitted with steel wire ropes, these had all been replaced with man-made fibre ropes prior to the accident. The usual mooring arrangements were to deploy two springs, two breast and one stern line at the after end of the vessel. Additional breast and stern lines could be deployed if required in poor conditions.

Figure 6

Stern line electric mooring winch

One officer and five deck ratings were needed to work the after mooring deck for berthing and unberthing operations. Deck ratings were needed to operate each of the two hydraulic winches used to secure the breast and spring lines. Two ratings assisted working the lines on warping drum ends and coiling the free ends. The fifth rating was required to operate both the electrically driven stern ramp and stern line winches, whose controls were located next to one another. There were no remote controls for any of the winches.

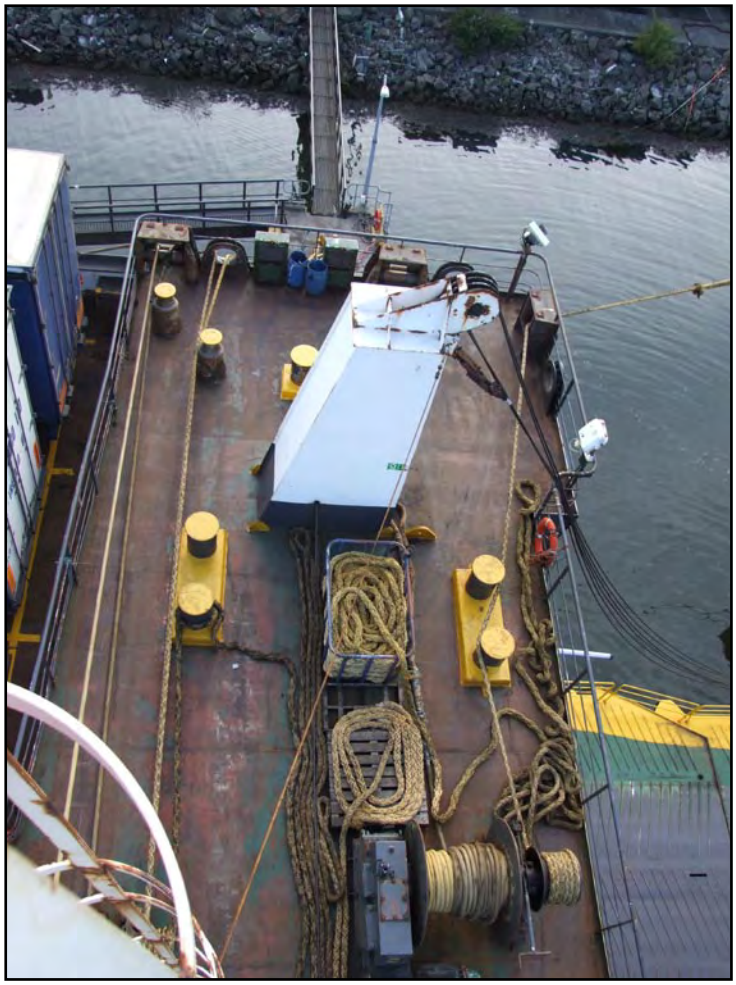
Each of the three mooring winches was fitted with rope storage barrels and warping drum ends **(Figure 6)** and were suitable for either steel wire or man made fibre ropes. The storage barrels were undivided[4] and could be declutched from the main shaft and secured using external band brakes. The warping drums were permanently attached to their respective winch shafts.

The vessel's aft mooring deck extended across the whole beam of *Dublin Viking*, above the upper vehicle deck on the starboard side, and over the ramp leading from the stern ramp up to the upper vehicle deck on the port side. In order to gain the necessary height clearance above the ramp, the after mooring deck was relatively short, giving a wide but narrow working deck area. A variety of bitts and old men[5] had been fitted, designed to offer a selection of leads to panama and roller fairleads, to suit the requirements of different berths. The layout was further complicated by the

[4] Rope storage barrels may be either undivided or divided into two portions. The latter configuration separates the drum into two parts, one for rope storage and the other for tensioning the line. This minimises the risk of a line under tension digging into other rope already wound onto the drum and becoming snagged.

[5] Roller lead placed on a pedestal mounting

Figure 7



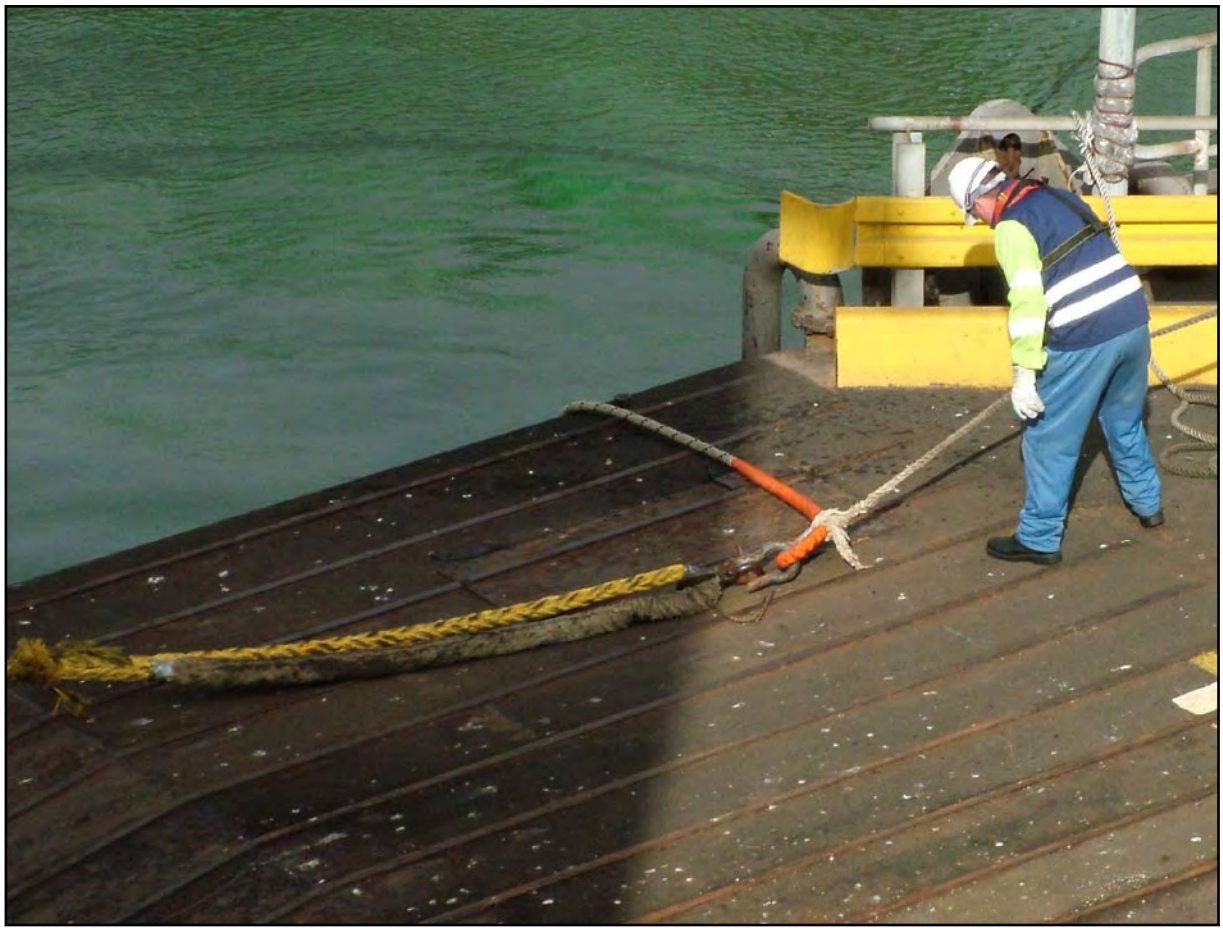
Starboard side of aft mooring deck

substantial towers needed to guide the stern ramp cables to the winch gear for raising and lowering the ramp. Builder's drawings of the deck that were held on board the vessel were extremely limited and suggested that additional sets of bitts had been fitted at a later date. The consensus from the longest serving members of the crew was that four sets of bitts had been added soon after the vessel entered service **(Figure 7)**.

The hydraulic winches for the spring and breast lines each had a line permanently fitted to their rope storage barrel, and once the vessel was alongside, these were secured with their band brakes applied. The rope storage barrels were then declutched and the second spring and breast lines were turned up on the warping drum ends using as many turns as would fit onto the drum. Once the vessel was secured, the rope storage barrels were put back into gear. The single stern line was also left turned up on the warping drum end of the stern line winch. The line that was permanently fitted on the rope storage barrel was used as an additional breast line when required. Although crew and the management company recognised that leaving lines turned up on warping drum ends was not considered best practice, it was accepted in order to minimise the manual handling needed to tend mooring lines during cargo operations. MMM stipulated that where lines were left turned up on warping drum ends, the free end should be backed up on bitts. Observations of mooring practice after the accident showed that backing up occurred infrequently and was not in the recommended figure of eight style.

A single composite stern line was used, made up of several shore supplied components terminating at a hook, which was connected to an eye in the ship supplied line **(Figure 8)**. Measurements of the ship's line with no tension applied varied between 62 and 70mm in diameter, and it was of 12 stranded multiplait construction and blue in colour. The connection to the shore supplied hook was approximately 9m outboard from the ship's stern, and the line then came inboard through a universal roller fairlead at the starboard quarter. This fairlead was on the transom, rather than the ship's side, and the line then led to a set of bitts and onto the warping drum end **(Figure 7)**. The bitts were positioned with the intention that they could be used to back up a line coming from the winch in the opposite direction, but in this instance had the effect of

Figure 8

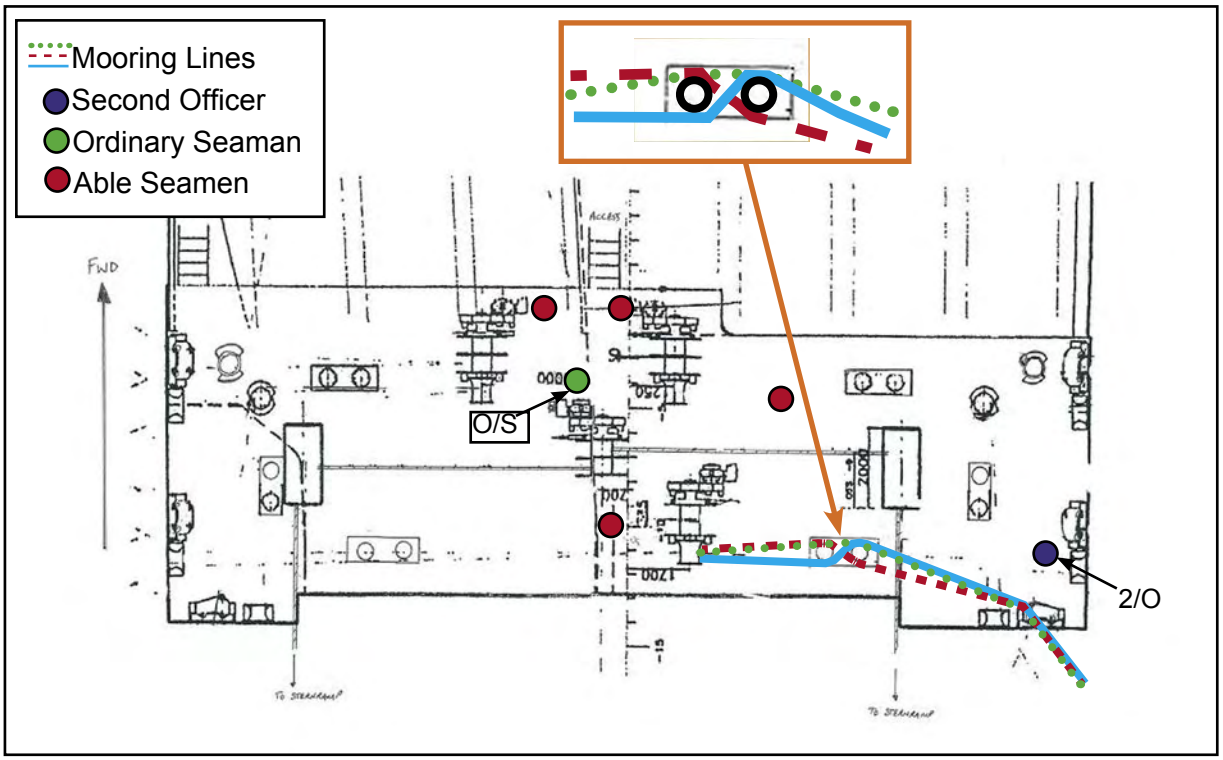


Connection between ship and shore supplied stern lines

straightening the lead from the transom fairlead to the winch. It was possible to lead the stern line around the bitts in three different configurations, each considered to be correct by different witnesses **(Figure 9)**. The position of the bitts dictated that the stern line had to be turned up from the bottom of the warping drum so that it did not ride over the bitts. Inspection of the mooring winch rope storage barrel and band brake arrangement indicated that this was the correct orientation to place the band brake deck connection under tension as the strain came onto the stern line **(Figure 10)**.

All the mooring equipment showed evidence of wear and polishing on areas in regular use. Rust and scale had developed in other areas such as the reverse side of bitts **(Figure 11)** where a single yarn from the parted rope was seen to have caught. The lower and inboard rollers on the universal fairlead being used for the stern line were both free to turn, but several other rollers in less frequent use had seized. Ship's staff had recorded these defects in the vessel's maintenance management system in October 2005, and also during an internal audit conducted by MMM in July 2006, but repair work had been deferred from a maintenance period in November 2005. Vessel managers had instructed crew to either free the rollers themselves, or use the seized universal rollers as a panama fairlead. The order for replacement parts was cancelled in January 2007. Grooves and rough edges resulting from the time spent working with steel wire ropes had been filled and smoothed.

Figure 9



Possible line configurations around bitts (light blue is the most likely)

Figure 10

Orientation of band brake on mooring winch

Figure 11

Snagged yarn from parted rope on mooring bitts

1.2.10 Development of mooring practice

The Marine and Safety Manager (MSM) responsible for the vessel had noted in a Safety and Quality Assurance audit in January 2007 that crew were leaving mooring lines turned up on warping drum ends. He considered that this was contrary to the principles of good seamanship, and included it as a supplementary note in his occupational health and safety inspection report of the after mooring deck. The issue was discussed between crew, senior officers and the management company and the consensus reached was that, although it was recognised that the practice was undesirable, it was acceptable if lines were backed up on bitts. This decision was recognised as a balance between the risk and effort involved in stoppering off a mooring line and transferring it to bitts, against leaving it turned up on the warping drum and backed up.

Over subsequent months it became common practice for winch barrels to be left in gear, with their band brakes on and with lines turned up on drum ends, either loosely backed up or not backed up at all **(Figure 12)**. The band brake was applied to the rope storage barrel, and the barrel was left clutched into the main shaft, transferring the braking effect to the warping drum end.

The paint coating on the aft mooring deck had deteriorated and been worn away in several places, exposing the deck material. Corrosion products and other debris had accumulated on the deck. This was in contrast to the forward mooring deck, which was

Figure 12

Example of methods used to secure mooring lines

well presented and marked with yellow areas indicating potential rope snap-back zones. The lack of snap-back zone markings on the aft mooring deck was identified in an MMM internal inspection, ISM and safety report dated August 2006. This subject had been raised at each of the subsequent monthly safety meetings thereafter, with poor weather being stated as the reason why the markings had not yet been painted.

An analysis of mooring loads had been commissioned for *Dublin Viking* by the vessel's previous managers in 2001. This was conducted by specialist consultants in preparation for a change from a berth in Liverpool to the newly opened 12 Quays facility across the River Mersey in Birkenhead. The analysis calculated environmental loadings on the vessel from wind and tidal effects and gave guidance on the maximum limiting conditions for safe mooring.

The report was found on board after the accident and is significant because it referred to polypropylene lines of similar construction and dimensions to the stern line. The report also referred to the tension developed by the electric mooring winches being 360kN, stating that this gave an unsafe mooring arrangement and advising that it be reduced to 12 tonnes (120kN). Despite discussing the analysis and report with the author and previous managers, it cannot be determined how the value of 360kN was reached.

1.2.11 Monitoring of mooring lines

Generic procedures applicable to all vessels managed by MMM required the officer in charge of each mooring station on board *Dublin Viking* to verify that mooring lines were in a satisfactory condition before berthing or unberthing. In addition, the bosun checked mooring lines during the weekly layover periods, or if any defects were brought to his attention by the crew. Due to the frequency of mooring operations, those lines that were in use remained on the upper deck, either on winch storage barrels, coiled into baskets or onto wooden pallets on the deck. The stern line was stored on pallets at the after most part of the mooring deck **(Figure 13)**.

Figure 13

Parted stern line in normal storage position

The mooring decks were included in formal Occupational Health and Safety Inspections conducted by the operational safety officer and the occupational health and safety officer. Inspections were arranged so that each area of the ship was inspected every 3

months, with the last inspection of the aft mooring deck taking place on 28 June 2007, 6 weeks before the accident. The inspection was conducted against a generic checklist suitable for all areas of the ship, under the following headings:

- Safe Movement
- Environment
- Working Conditions
- Remarks and Other Items

The findings were recorded and a copy of the report is reproduced at **Annex A**. Key findings have been extracted as follows:

3.	**Working Conditions**		**Yes**	**No**
	n)	Are necessary safe operating instructions clearly displayed?	X	
	t)	Is there any evidence of defective plant or equipment?		X
	u)	Is the level of supervision adequate, particularly for inexperienced crew?	X	
	v)	What practical occupational safety improvements could be made?	NONE	
4.	**Other Items**		**Yes**	**No**
	w)	Are all statutory and Company procedures being followed	X	
	x)	Is the Safety advice in publications, such as the “Code of Safe Working Practices” for Merchant Seamen, M-Notices being followed where possible?	X	

[sic] Table 1-1 Extracts from the Occupational Health and Safety Inspection Report 28 June 2007

1.2.12 Mooring line replacement

There were no procedures to identify lines uniquely, record the date when they were first put into service, or when they were last inspected. The bosun who was on board at the time of the accident had his own system of putting new ropes at one end of the store and rotating the stock. Although this was reported to have been described during verbal handovers between incoming and outgoing bosuns, there were no formal arrangements to maintain a consistent system.

When a mooring line was considered to be worn, it was either ‘end for ended’ to put an unworn part into service, or a similar line was taken from the store to replace it. Lines were not marked with serial numbers or other unique identification, and it was not possible to refer back to an individual delivery note or warranty certificate, and be certain that it was the correct one. Crew members stated that they were unable to estimate a typical service life for a mooring line due to a substantial variation in working life resulting from differing weather conditions, such as wind loading on the vessel and moorings.

New mooring lines were either stored in the forecastle store or at the forward part of deck 4. The forecastle store was adjacent to the paint store and also contained the hydraulic machinery for the anchor windlasses. Examination of the forecastle store after the accident showed that oil from a leak in the hydraulic machinery had become spread across the deck and the air smelt strongly of fumes from the paint locker and work nearby. Mooring lines were stored in a variety of configurations, some on wooden racking off the deck and others directly on the deck. It was not readily apparent which were the next lines due to be used in service. Lines intended for use on the after mooring deck were stored on pallets, under the covered forward part of the upper vehicle deck, for ease of access. Although these lines would have been exposed to a certain amount of vehicle exhaust fumes, the area was positively ventilated.

Requests for the purchase of new lines originated on board the vessel, either from the bosun or chief officer who prepared a request in the computerised purchasing system. The originator used his own specification for the line that was needed. Examination of purchase orders shows several different technical specifications, reference to different trade names or manufacturers, with no consistent format. Normal practice was for a worn out line to be replaced with one that was considered to be similar, and line selection was a matter of professional judgment at the time of ordering. MMM purchasing officers requested quotations against the specifications provided by ship's crew, which were then interpreted by the different manufacturers and suppliers involved. Once quotations were returned, the vessel's ship manager approved the order and the purchase contract was awarded as appropriate. Warranty certificates for a minimum breaking load were only specifically requested on purchase orders for 6 out of a total of the 25 lines purchased during the period from March 2005 to September 2007. No certificates were specifically requested for mooring lines purchased after the accident.

New mooring lines were delivered directly to the vessel and stored on board. Delivery notes were given to the crew, and a receipt of stores entered into the computer system for payment to be authorised. Certificates, where received, referred to a sample from the batch of rope being examined for conformity with the manufacturer's specification and tested to prove a representative minimum breaking load. A single warranty certificate could function as the certificate for multiple ropes, depending on the size of the order.

The stern line that parted during this accident was thought to have been brought into service in January 2007, and 'end for ended' in April 2007, due to the poor condition of the soft eye. It was still considered to be in a satisfactory condition, but there were no formal records of inspection. It was not possible to match this mooring line to any of the rope certificates held on board, with any confidence. One certificate was found for a mooring line with similar 12 stranded construction, made from polyolefin and supplied in April 2004, but subsequent tests on the parted line found that it had been made from polypropylene. A purchase order dated 30 March 2005 was also found for 6 polypropylene lines, but the construction was 8 strand rather than the 12 strands of the parted line.

1.2.13 Development of mooring arrangements in the Port of Dublin

Berths 52 and 53 were operated by Norfolk Line, which leased the area from the Dublin Port Company. Norfolk Line terminal staff were responsible for providing any mooring lines that remained permanently attached to the shore and for providing shore line handlers.

The shore part of the stern line had been provided many years previously in response to concerns from vessels that they were unable to adequately secure the stern in position. The distance from the stern of a ship berthed in position and the appropriate bollard to provide a stern lead was approximately 60m, so a shore line was provided to simplify line handling **(Figure 5)**.

The arrangement had evolved, and it was estimated that the current shore line had been fitted about 2 years before the accident. A certificate of warranty for the line was dated 28 November 2003 and identified it as being a Marlow Steelite HMPE[6] fibre rope with a braided cover. The rope was fitted with a thimble eye at each end, and at the shore end was connected to a bollard via three short lengths of chain doubled up and shackled together **(Figure 14)**. The other end was shackled to a hook, which was then used to attach to the soft eye of the ship's stern line. A messenger was also attached to the shackle and led down to the pontoon so that line handlers could recover the line as the ship veered its stern line, and unhook the connection **(Figure 15)**.

The shore line was manufactured to have similar properties to a steel wire rope, but was much lighter and floated. It was relatively inelastic, with only about 2% elongation at its minimum breaking strength of 73.6 tonnes.

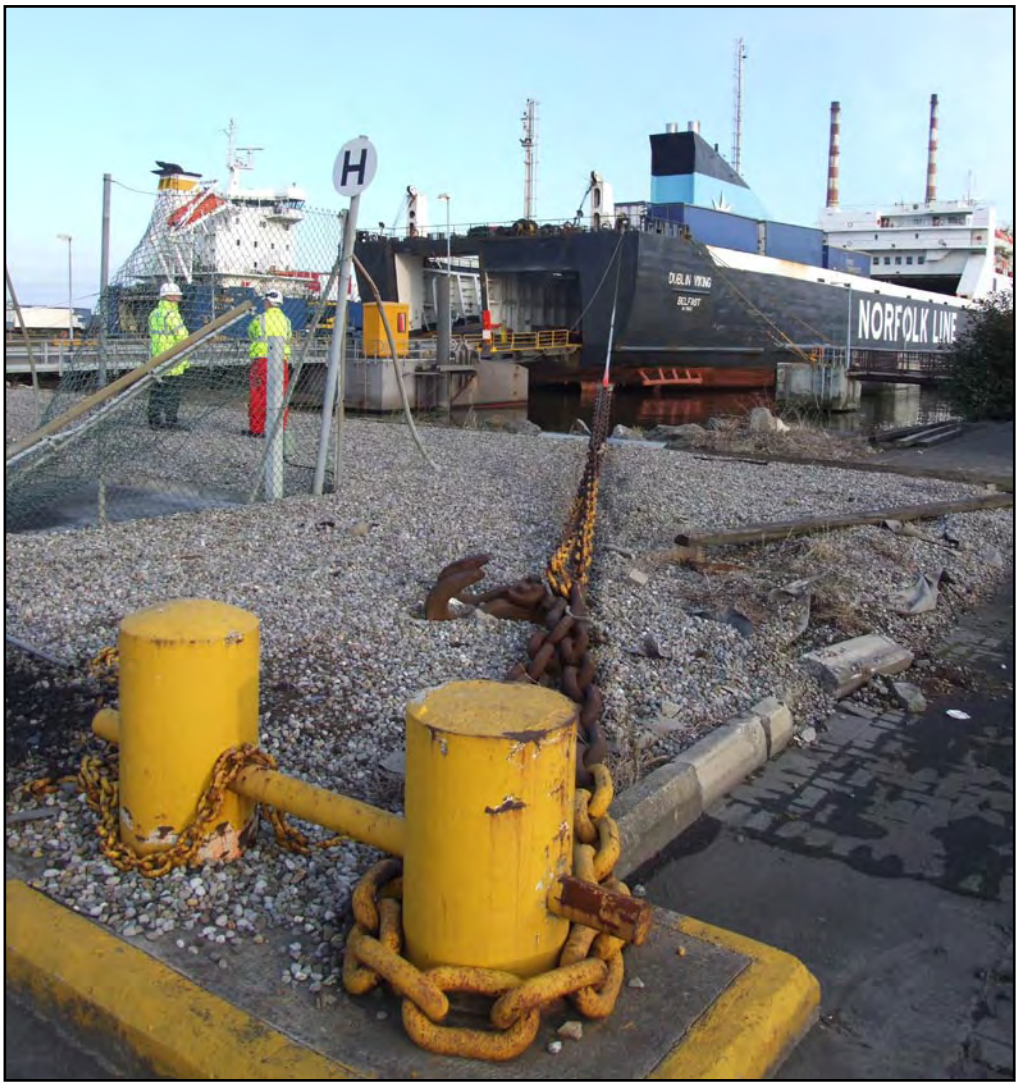
1.2.14 Design and operation of mooring winches

All the electric and hydraulic mooring winches were supplied by the same manufacturer (Hatlapa), and were built to comply with the requirements of 'ISO 3730, Second Edition 1998, Shipbuilding – Mooring Winches'. This document, "*specifies the characteristics of automatic and non automatic mooring winches with electric, hydraulic or steam drive, which fulfil the functions of manoeuvring, holding and storing mooring ropes on a single drum*" [sic]. The standard also applies to winches fitted with warping drum ends.

ISO 3730 defines the terms used to describe winch capability, design criteria and the relationships between the nominal drum load, minimum breaking strength of the rope, rendering and brake loads. Winches are designed around the nominal drum load, which is defined as "*the maximum rope tension, kilonewtons (kN), measured at the drum exit when the winch is hoisting or hauling in the nominal speed with the rope wound on the drum in a single layer"* [sic]. It is common practice for winches to be referred to and specified in design or purchase instructions by their nominal size, which is a direct reference to their nominal load.

[6] High Modulus Polyethylene

Figure 14



Shore supplied stern line connection to bollard ashore

Figure 15

Connecting hook and messenger on shore supplied stern line

The electric winches fitted to *Dublin Viking* had a nominal drum load of 125kN and were therefore a size 12 in accordance with ISO 3730. The standard requires each size of winch to be operated with a rope of an appropriate minimum breaking load (MBL). The rope for a size 12 winch must have an MBL of at least 426kN, which includes a margin for some rope deterioration in service and greater peak loads from the winch machinery. The nominal drum load was marked on the manufacturer's plate attached to the winch, but there were no indications on the machine or in the manufacturer's manual of the corresponding rope MBL that was required.

The standard requires all mooring winches to have a brake, capable of maintaining the nominal winch load. The brake holding load must not exceed 33% of the MBL of the rope being used on the winch. However, electric winches must also be fitted with an automatic braking system to stop the winch when either the operating controls are in the 'off' position or when the main supply power is off. This automatic brake must be capable of holding at least 1.5 times the nominal drum load. The practice of applying the brake to the rope storage barrel and leaving this clutched into the main shaft combined the braking effect of the band brake with that of the automatic brake.

The band brake fitted to the rope storage barrel was not required to be tested under Flag State or Classification Society regulations and, due to the variation in the amount of braking tension that could be used, it can not be determined how much braking force was being applied prior to the accident. However, in accordance with the standard, it should have been greater than 310kN. The braking force developed by the automatic electric brake fitted to the winch motor was required to be more than 187.5kN and was shown by calculation to be approximately 220kN. This gave an approximate braking effect of 530kN on the warping drum end.

It is manufacturers' convention to design warping drum ends to suit the nominal winch loads. They are not intended to withstand the maximum tension loads that the design rope could theoretically impart.

ISO 3730 requires that winches should stall and then render if the tension in the rope rises above half the appropriate rope MBL while the winch is heaving in under power at its nominal speed. The electric winches on *Dublin Viking* were driven by 3 phase asynchronous motors, with a control system giving three different speeds in each direction. The speeds were controlled by changing the electro magnetic properties of the motor windings (number of pole pairs) and so the torque produced by the motor varied in relation to its speed. It is a characteristic of this type of motor that the torque produced is greatest shortly after the motor has been started and reduces to its nominal, rated value for each speed, only after the motor has accelerated to the nominal speed. There are no requirements in ISO 3730 to restrict the maximum starting torque, it being accepted that this lies within the safety margin provided by the rope MBL specification. The motor produced its maximum torque at the second speed setting, but the control system always started the motor at the slowest speed regardless of the selected input, before shifting to the desired setting.

A convention for mooring winch controls is established in ISO 3730, stating that where levers are used to control the direction of operation, the lever should be pulled towards the operator to haul in the mooring line. This presumes a single mode of operation for the winch or that a line is always turned up on a warping drum in the same direction. The designed direction of rotation is determined by the orientation of the band brake fitted to the rope storage barrel. This is connected to a strong point on the deck, which must be placed under tension as the load on the line increases **(Figure 10)**. This has the effect of clamping the parts of the band brake together, improving the braking effect. Inspection of the electric stern mooring line winch on the after deck determined that the mooring lines on both the storage barrel and warping drum end were in the correct orientation to load the band brake correctly.

1.2.15 Winch maintenance

The manufacturer's manual was held on board, and maintenance for the electric winches was incorporated in MMM's planned maintenance system with quarterly and annual checks. Brake linings, operation of couplings, and checks for the security of the mountings were included in the quarterly checks, with the inspection of the gear train, shafts and bearings conducted annually. There was no requirement to check the internal motor disc brake, operation of the auto tension mode or correct operating direction of the controls.

1.2.16 Examination of VDR and port records

The vessel's Voyage Data Recorder (VDR) was downloaded and replayed. This confirmed witness reports that there were no engine orders or unrequested movements around the time of the accident.

Radar recordings and records from the Port of Dublin showed that other vessels passed the mouth of the basin containing berths 52 and 53 at 2142, 2154 and 2235. All these vessels were travelling within the port's speed limits.

1.2.17 Post-accident equipment testing

After the accident, it was not immediately apparent why the stern line had parted, even though it was clear that the winch had been operated in the wrong direction. The label on the winch stated its output was 125kN. Estimates of the line's minimum breaking load, based on its size and construction, suggested that it should be in the order of 600kN (approximately 60 tonnes). Tests were therefore arranged to measure the actual breaking load of the stern line and the maximum tension that the winch was capable of developing.

Three 4.5m samples were taken from the damaged line and soft eyes spliced into each end. The samples were taken from different parts of the stern line as follows:

- No. 1 – from the unused section of the stern line
- No. 2 – from the used section of the stern line
- No. 3 – from the shortest, broken part of the stern line, incorporating the original eye at one end.

The samples were loaded into a 150 tonne digital horizontal tensile test machine that had been appropriately calibrated in tonnes, for conducting such tests. The results of the each test were as follows:

Sample No.	Area of stern line	Onset of failure (tonne)	Ultimate failure (tonne)	Failure point
1.	Unused section	34	49.97	500mm inboard of splice
2.	Used section	n/a	37.6	600mm inboard of splice
3.	Nearest broken part	28	35.6	In existing eye, at point of splice entry

Sections of the parted mooring line, and a second sample taken from a similar but unused rope, were submitted to a laboratory for chemical analysis. The laboratory confirmed that the material was polypropylene and used advanced techniques to determine the 'Oxygen Induction Time'. This is proportional to the chemical degradation of the material during processing and long term service. All the samples showed very poor performance, indicating a combination of:

- Poor stabilisation of the material during manufacture to prevent degradation by ultraviolet (UV) radiation from sunlight.
- Leaching of the chemicals used to protect the rope material during service.
- Effect of UV radiation and chemical ageing (oxidative degradation) during service.

A second technique was used to determine the level of products of the oxidation ageing process. The results of these tests showed significant deterioration of the material at the surface and immediate sub-surface of the rope and, to a lesser extent, deterioration all the way to the core of the rope.

Finally, the material was tested to indicate the presence of contaminants that might have affected the strength of the rope. Some traces of contamination from oil, water and products of corrosion were found on samples taken from the heavily soiled surface of the rope.

The analysis concluded that both rope samples contained insufficient stabiliser to protect the polypropylene material from the effects of chemical ageing and UV radiation. This had caused the rope to be more susceptible to these effects and had led to a reduction in the rope's strength over time.

The winch was inspected by a manufacturer's service technician and found to be generally in working order, with two exceptions: the wiring connection to the strain gauge in the auto tensioning system was reversed, and the springs to automatically return the control lever to the neutral position had corroded and failed.

Tests to determine the winch's maximum pull were conducted by a specialist contractor. A load cell was connected to a line secured to a set of bitts and the other part connected to a line which was turned up on the warping drum end. The tests found that the winch was capable of developing a load of 27 tonne at its slowest setting, and a load of 37.8 tonne at its second setting. The load produced at the fastest speed was not measured, however study of the motor's published torque / speed characteristics showed that this would be the lowest of the three.

1.2.18 Similar accidents

Two other ro-pax vessels managed by MMM have experienced parted mooring lines, one in February and the other in March 2006. The first incident occurred when a vessel was making fast, and a winch was used on its fastest speed to heave in a line, causing the tension to increase rapidly and part the line. It struck a deck rating, causing bruising to his leg. The second incident also occurred while another vessel was making fast and a stern line was secured prematurely, before the vessel was in position. Tension increased on the line, causing it to part and strike an AB on his right arm, knocking him to the deck.

Two other incidents involving mooring lines have occurred on board *Dublin Viking*. The first in 2002, when a shore worker mistakenly removed a line, causing additional tension to come onto a spring line. This parted, injuring a deck rating and another worker ashore. In November 2005, the vessel broke away from the berth at 12 Quays in Birkenhead, while under main engine power, parting 6 mooring lines forward and 7 lines aft. The accident was found to be caused by the propeller pitch controls in the engine room not having been reset; the ship surged forward when engine control was passed from the bridge back down to the engine control room. No one was injured, either by the lines parting or when the stern ramp came away from the link span.

MMM investigated all the accidents and, in the case of the incident which occurred while the vessel was under main engine power, produced a detailed report and made a number of recommendations from the lessons that had been learnt. Recommendations from the more minor incidents were implemented locally.

1.2.19 Standards, regulations and guidance for mooring practices

The Maritime Safety Committee (MSC) of the International Maritime Organization (IMO) developed guidance for the application of SOLAS[7] regulations for the arrangements, equipment and fittings for towing and mooring operations. The IMO published MSC Circular 1175 in 2005 which became effective in January 2007 for new vessels. Although this does not apply retrospectively to *Dublin Viking*, the Circular contains pertinent guidance on methods to calculate safe working loads and, particularly, the minimum breaking strengths of mooring lines.

Mooring equipment is not included as a specific part of normal inspections or surveys conducted by the Maritime and Coastguard Agency (MCA) for passenger ships. The area is included under the general requirements of the ISM Code, for equipment to be suitable for use and any risks to be assessed appropriately.

The MCA publishes additional guidance on the safe installation and operation of mooring equipment in the Code of Safe Working Practices for Merchant Seamen (COSWP), which is expanded in Marine Guidance Note (MGN) 308. These documents emphasise the need to consider the overall mooring system rather than just the individual components. Regular inspection and maintenance routines are recommended for ropes and mooring equipment to help identify potential failures at an early stage. Other guidance includes the following statements:

- *'Personnel who are essential to the operation, should as far as reasonably practicable be able to stand in a protected position.*
- *Very short lengths of line should be avoided where possible, as such lines will take a greater proportion of the total load*
- *In most circumstances up to three turns are sufficient to undertake a successful operation, and an excessive number of turns should be avoided.'* [sic]

[7] International Convention on the Safety of Life at Sea

Both the COSWP and MGN 308 recommend that the danger areas presented by rope snap-back zones are identified and avoided by all personnel.

Det Norske Veritas (DNV) does not require mooring lines to be subject to classification, but offer guidance and additional notation if required. *Dublin Viking* did not have any additional notation for mooring equipment. DNV guidance includes methods to calculate the appropriate size of mooring lines, based on the same methods as those used in MSC Circular 1175. Guidance also includes notes on the performance characteristics of mooring winches, specifying similar requirements to those in ISO 3730.

The Oil Companies International Marine Forum (OCIMF) has published Mooring Equipment Guidelines (MEG) since 1992, based on the knowledge and experience of its member companies. This book, which was on board *Dublin Viking* has, for many years, been the most detailed source of technical guidance on mooring processes and has many applications for all types of vessels.

The second edition of the OCIMF MEG produced in 1997 includes design specifications for mooring winches, in general agreement with the requirements of ISO 3730. The MEG goes further, however, in describing test procedures for winch brakes, and recommends that brakes have the ability for their holding power to be reduced from 80 down to 60% of the mooring line's minimum breaking load. Guidance is included on best practice for the handling, maintenance and inspection of synthetic ropes and description of the factors that cause lines to deteriorate. A third edition of the MEG, expected to be published in 2008, expands this section to include practical guidance, more suitable for day to day use on ships.

The Nautical Institute is also expected to publish a mooring guide in 2008 which is intended to give a broader analysis of the subject for all sectors of the industry.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 STERN MOORING LINE

The condition of the stern mooring line had deteriorated and, as a result, its minimum breaking load had been reduced to approximately 50% of its original strength. At the time of failure, there were no significant external influences from wind, tide or passing vessels, and there were no engine movements. The line had been under tension while the vessel was alongside, and was secured in such a way that the winch was prevented from rendering. When preparing to let go, the additional tension inadvertently applied by the mooring winch exceeded the line's MBL and caused it to part.

2.2.1 Condition of the line

The nature of *Dublin Viking*'s trade placed extremely high demands on the mooring lines, which were not only worn during the high proportion of the time that was spent alongside, but also by frequent handling in making fast and letting go. Due to the design and relative position of the aft mooring deck, it was considered impractical for the ropes to be stored undercover, so they were continuously exposed to UV radiation from sunlight and, to a lesser extent, exhaust fumes from the vessel and cargo vehicles. The aft mooring deck was in heavy use, and paint coatings had been worn away, allowing rust and other debris to accumulate. The frequency of mooring operations and the routine that developed around them invited complacency, and led to general acceptance of poor practices such as leaving multiple turns of rope on the warping drum end with the rope barrel in gear, and sporadic backing up of the free end.

The lead chosen for the polypropylene stern line involved two changes of direction through a universal roller fairlead, then around or through a set of bitts before being turned up on the winch drum end. The mooring line changed direction either three or four times, each of which caused additional localised wear and loading. This also increased the number and size of potential snap-back zones if the rope parted. Examination of the parted line showed some areas where yarns had been fused together by heat generated in localised overloading, probably at the points where the line passed round bitts or fairleads. Although working areas of bitts and fairleads were worn smooth, scaling and corrosion were evident close by and a yarn from the parted line was found snagged in rust scaling on one of the bitts. All these factors contributed to the deterioration of the mooring lines.

Routine examination of the mooring line was not based on any objective standards and, as differing environmental conditions are known to have such a variable effect on the service life of mooring lines, a typical working life could not be estimated. It was not possible to trace any of the lines to the warranty certificates with confidence, they were not included in the vessel's maintenance management system, and there were no other records of either when the line entered service or when it was inspected.

Although the company's generic procedures required mooring lines to be inspected by the officer in charge of the mooring station prior to the vessel berthing, this was not achieved in practice due to the number and frequency of berthing operations. This was mitigated by the weekly inspections conducted by the bosun during the layover periods, but with no way of identifying each rope, and no historical records or condition criteria to support his decision, it could only be subjective, and the risk of incorrectly assessing the rope's condition was increased. Equally, systems for replacing ropes and rotating the stock on board were informal and vulnerable to misunderstandings between different crew. Occupational Health and Safety Rounds could have identified that a rope was in poor condition, but were too infrequent to be considered a routine control measure.

Analysis of the stern line showed that it had deteriorated due to the effects of UV radiation and chemical ageing, which could have occurred both while the rope was stored on board and during service. Chemicals that should have protected against these effects had either lost their effectiveness, been leached away, or were not present in the first place. Rope specifications in the vessel's purchasing system did not include any requirement for UV resistance, and it would have been possible for a rope to have been supplied with little or no UV stabilisation without this limitation being detected. As neither a common specification nor trade product was used as a reference, supply of individual mooring lines was open to considerable interpretation by crew, purchasing officers, suppliers and ship managers.

2.2.2 Forces acting on the stern line

The stern line was a composite of steel chain, HMPE and polypropylene lines, and no consideration had been given to how the individual elements contributed to the system as a whole. Of all the components, the polypropylene line, provided by the vessel, was by far the most elastic. The relatively inelastic chain and HMPE line resulted in the majority of the elasticity being provided by a relatively short length of polypropylene line. This meant that any load on the stern line would cause the short length of polypropylene line to stretch the most and place that element under the greatest strain. The stretching cycle would have been repeated many times in service, contributing to increasing fatigue effects.

After the stern line had parted and the stern ramp was lowered, it was noted that the edge of the ramp was approximately 1.2m (4 feet) further forward than its position before the accident. At that stage, none of the other lines had been adjusted significantly, and with the stern ramp having been raised, it is most likely that the release of tension as the stern line parted allowed the vessel to move forward. A simplified calculation suggests that this movement is equivalent to the polypropylene stern line having been stretched by about 8%, which is a typical limit for this type of material.

The method used to secure the stern line prevented the opportunity for the winch to surge or render under excessive load. The band brake should have rendered at about 310kN and the motor surged under normal running conditions at 189kN. However, the rope storage barrel had been left in gear, with the band brake on, effectively combining the effects of the band brake (310kN) with the effect of the automatic motor disc brake (220kN) to generate a braking force approaching the rope's normal breaking load when new. While this holding load was not substantially different from the effect of securing

the line on bitts, the line was directly exposed to the winch's full starting load. The large number of turns on the warping drum prevented the stern line from surging, and it was quickly overloaded as there was no slack and relatively little elasticity in the system. Discussion with the winch manufacturer indicated that warping drum ends are, by convention, only designed to the nominal load of the winch, in this case 125kN, plus a safety factor. Warping drum ends are not intended to be used in place of mooring bitts and there was a risk that it could have failed.

The procedure of leaving the stern line turned up on the warping drum end had evolved through expediency and had been accepted and endorsed by management, albeit with the caveat of backing up the line on the bitts. It was acknowledged that this was not considered best seamanship practice, but the reasons for this best practice were not appreciated. None of those involved in developing the procedure on board had understood that it could overload the warping drum end or, if the barrel was left in gear, would significantly increase the braking effect preventing the possibility of the brake rendering.

2.2.3 Winch operation

The winch was only marked with its nominal load of 125kN, and it was assumed that this was also its maximum output. It was not possible to determine the maximum output from the manufacturer's manual and there were no requirements to test the winch.

The winch had been produced to comply with ISO 3730 for mooring equipment, whose methodology depends on the rope having the appropriate MBL to give the necessary margin of safety to allow for increased starting and stall loading. If the end user is not aware of the requirements of the standard and selects a different rope, or uses a rope in poor condition, there are no means to warn that the maximum winch output is far greater than the published, nominal load.

It is understandable that crew might consider that even a 70mm polypropylene line in a worn condition could withstand a 125kN load. Had they known that the winch could develop far higher loads, they might have rejected the line before the accident occurred.

Although the OS controlling the stern line winch was the least experienced of the deck ratings on duty, he had completed the appropriate training and operated the winches before. He had operated this particular winch at least twice, and knew that the controls operated in the wrong sense, i.e. pushing the lever away made the winch heave in. The winch was examined carefully and it was confirmed that lines on both the rope storage barrel and the warping drum end were turned up in the correct orientation for the band brake. In this configuration the controls should have worked in the correct sense. However, noting that the strain gauge also had its polarity reversed strongly suggests that the principal problem was that power supplies to the winch motor had been reversed at some stage, a single fault which would have caused both the controls and the strain gauge to be reversed.

It was common knowledge among the deck crew that the winch controls worked in the opposite direction, but this had not been identified in either the maintenance or any of the inspections or audits of the vessel.

It cannot be determined precisely why the OS operated the stern line winch in the wrong direction, but the following are considered to be factors that combined to distract him:

- Concurrent operation of two winches whose controls operated in opposite directions;
- Orders to raise, then lower, then raise the stern ramp immediately prior to the order to veer the stern line winch;
- Noise of the machinery ventilation fans and the stern ramp wires being wound onto the winch drum;
- The OS was at the end of his second 6 hour duty period that day.

It is likely that there was already considerable tension in the stern line caused by the positioning of the vessel when it first came alongside the berth. The first operation of the winch applied additional tension, probably close to the breaking strain. The second operation then added sufficient tension to part the line. The short lead of the polypropylene line meant that there was little margin for the line to stretch, and it is likely that the winch never accelerated sufficiently for the starting torque to drop back to the nominal output. Although the OS had asked one of the ABs to assist him slacken the stern line by removing turns and surging it around the warping drum end, this would have caused heat damage to the line, and the AB's decision not to surge the line was correct.

2.3 DECK EQUIPMENT AND LAYOUT

2.3.1 Design and layout

It is apparent from the time difference in placing the orders for the hydraulic and electric winches, during new building, that the electric winches were not part of the original design for the aft mooring deck. This design was further modified by the addition of four sets of bitts early in service. Original mooring equipment diagrams and specifications were not readily available, and *Dublin Viking*'s officers had developed their own mooring plans. The arrangements had evolved in practice and, other than the mooring analysis conducted in 2001, there had been no fundamental consideration of the loading on each element of the system.

The vessel's first managers were part of the same group as the builder's yard and, as a result, maintenance was done by the yard. A consequence of this was that the normal outfit of ship's drawings that may be expected to be provided, were retained by the yard and not passed onto *Dublin Viking.*

Construction of *Dublin Viking* pre-dates guidance such as MSC circular 1175 in calculating mooring loads, and the advice given in OCIMF's mooring equipment guide may not have been considered applicable as it is intended for oil tankers.

The arrangement of vehicle decks and ramps made the aft mooring deck extremely cramped. With five or six lines deployed, it required careful thought to move about the deck safely even with the vessel secured alongside; this situation was exacerbated when lines were being handled and was extremely hard if more than one line was being worked at a time.

The number and arrangement of mooring lines created several overlapping snap-back zones if any of the lines were to part. The 2/O was obliged to move in and out of these as he relayed orders to line handlers ashore and maintained visual contact with his own crew. The noise from the winches and machinery ventilation prevented verbal communication, and a system of hand signals had to be used to pass orders.

2.3.2 Mooring winches

Markings to indicate the direction of rotation of the stern line winch were ambiguous, difficult to see from the normal operating position and provided no indication that the winch operated in the opposite sense. There was no indication that crew understood the significance of the automatic disc brake in the electric motor of the stern line winch. Leaving the rope storage barrel with the band brake on and clutched into the main shaft increased the braking load on the warping drum end. This, and the practice of securing the stern line to the drum end without backing it up, gave the potential for overload of both the mooring line and the warping drum end.

2.4 INJURY AND MEDICAL RESPONSE

2.4.1 Injury to the second officer

The stern line parted with a tension in the order of 35 tonnes, the outboard end was free to accelerate through an arc of approximately 40^{o} before it struck the 2/O's legs. A loud crack was heard, and the impact was sufficient to break both legs and partially sever the left leg at the knee.

2.4.2 Medical response

The injuries were severe, and both the witnesses to the accident and those who came to assist were profoundly shocked. 'Mike team' members reported feeling overwhelmed by the scale of the 2/O's injuries, and it was clear to them that the dressings and bandages carried on board were inadequate for the task. The medical equipment met the appropriate regulatory requirements, and the head chef in charge of the team improvised, sensibly requesting towels and sheets to treat the wound.

The off duty master arrived on scene soon afterwards and was immediately concerned about the amount of blood that the 2/O had lost. The rate of bleeding increased after the 2/O had been given oxygen and become more alert, and the off duty master attempted to stem the flow by pressing on the wound. He felt that this was not having sufficient effect, and that the only remaining option was to use a tourniquet around the upper left thigh. This reduced the rate of blood loss.

An ambulance team was on scene quickly, and took charge of the treatment. Although some delay was caused by the need to call back drivers to move their vehicles, much of this time was also spent stabilising the 2/O and preparing him to be moved.

2.4.3 Medical training

Both the off duty master and the head chef were qualified in accordance with the requirements of the STCW Code for medical care. These qualifications are not intended to equip personnel with the skills necessary to deal with such serious medical trauma. The response from them and their assistants was commendable.

The potential for such a serious injury arises from many different hazards that exist on all vessels. It is worth considering, in the course of normal drills, how crew might react, and be able to treat very serious injuries to one of their ship mates.

2.4.4 Injury to shore worker

The shore worker had been holding onto the messenger, in preparation for recovering the stern line, when it parted. The weight of the shore component of the line suddenly came onto the messenger, causing dislocations in his right arm and shoulder. It was impractical, in the configuration of the lines, for there to be sufficient slack in the messenger to take up this sudden loading, and it is likely that the line parted too fast for the shore worker to be able to react and loosen his grip.

2.5 VESSEL MANAGEMENT

Ownership and management of *Dublin Viking* had changed several times in the 10 years that the vessel had been in service. Information had not been passed on effectively during the successive handovers, and useful information, such as the mooring assessment conducted in 2001, had been missed.

2.5.1 Management of mooring practice

Despite the importance of effective mooring to the vessel's successful trading, mooring practice had been allowed to evolve with little consideration being given to the effect on the mooring system as a whole. The late addition of the electric winches during the construction process exacerbated the already cramped deck area. Safe operation was very difficult, with the only practical solution being to work one line at a time. Co-location of stern ramp and stern line winch controls invited both to be operated by the same person, and it was inevitable that concurrent winch operation would be attempted.

The lack of builder's drawings or design specifications forced managers and crew to develop their own procedures without full knowledge of the capabilities or limitations of the equipment. They were unable to identify the hazards fully, and could not judge the implications of their decisions. Although the decision to allow lines to be left turned up on warping drum ends was consciously based on the balance of risk against using rope stoppers and transferring lines to bitts, it did not take account of the winch's design characteristics.

While the shore supplied stern line arrangement made berthing simpler than sending a ship's line out to the bollard, the significance of using different materials had not been appreciated. It was apparent that each part had evolved in isolation, and there was no record of the performance of the composite line being considered or assessed as a whole. Terminal operators were responsible for providing the chain and HMPE components, while MMM was responsible for the ship's lines. Both companies worked closely together in many other areas, but it appears that the implications of the stern mooring arrangements had not been considered.

2.5.2 Assessment and audit

A number of assessments and audits of the vessel were required by MMM procedures, all of which had been conducted. The practice of leaving lines turned up on warping drum ends, a number of seized roller fairleads, the worn condition of the aft mooring deck and lack of snap-back zone markings had all been identified by the marine and safety manager, but had not been rectified at the time of the accident.

Occupational Health and Safety Rounds of the aft mooring deck, conducted 6 weeks before the accident in June, had not found any deficiencies, recording that:

- The necessary operating instructions were displayed
- There was no evidence of defective equipment
- No practical occupational health and safety improvements could be made
- All statutory and company procedures were being followed
- The safety advice in publications such as the Code of Safe Working Practices for Merchant Seamen was being followed where possible.

Investigation after the accident found that the markings for the stern winch controls were not clear and certainly did not suggest that the directions were reversed. This defect was common knowledge among deck ratings, but had not been reported or detected by inspection and audits. Equally, the fact that the stern winch control lever did not spring back to the "off" position when not in use was not noted. Most significant, however, is the statement that no practical improvements could be made, and the acknowledgement that advice in the Code of Safe Working Practices was being followed. Actions taken after the accident indicate the opposite, and included several practical improvements.

Risk assessments for berthing procedures had been completed, and the following control measures had been identified:

- Planned maintenance system
- Training
- Use of appropriate Personal Protective Equipment (PPE)
- Guards and rails
- Qualified personnel
- Good communications

Consideration of the circumstances of the accident indicates several flaws: mooring lines were not part of the planned maintenance system, so this measure could not apply. There was no PPE capable of providing protection from the parted stern line, and there were no guards to prevent it from striking personnel. Although a system of hand signals was used for normal communications, there were no emergency signals and the noise in the area prevented the 2/O from hearing the stern line begin to crack and the warnings shouted by other crew. The only control measures in the risk assessment that could really be applied were the training and qualification of personnel; however the effectiveness of these measures might have been reduced due to the incorrect orientation of the stern winch controls.

2.5.3 Effectiveness of procedures

MMM procedures were clear, well documented and evident on board *Dublin Viking*. However, some aspects were impractical or ineffective. Instructions to the officer in charge of a mooring deck to inspect the condition of lines prior to berthing and unberthing were difficult to achieve in view of his other duties and a structured inspection regime based on the vessel's trade should have been put in place. Not all the deficiencies raised by the marine and safety manager had been rectified, and

crew inspections did not include the problems that were already known about on board. This implies that some procedures were not properly effective, and that there was minimal feedback from the crew on those procedures that were not working. Mooring operations seen during the investigation showed a number of poor practices which still persisted after the accident, despite the shock and loss that the crew clearly felt.

It was apparent that a gap existed between the good intentions of the management company and the practical realities of operating the vessel. Sustained education and supervision are needed to break existing poor habits and introduce safer working methods.

The lack of assessment of mooring arrangements, operating procedures, mooring line inspection routines, and acceptance of mooring system defects is in contrast to other aspects of the vessel's management, which had been well thought out and properly implemented. Although such observations are far easier with hindsight, the difference indicates that the topic had been overlooked or was considered to have a lower priority.

2.6 STANDARDS, REGULATIONS AND GUIDANCE

There were no mandatory requirements concerning the design or condition of the mooring equipment on board *Dublin Viking* other than the general requirements of the ISM Code and obligations under Health and Safety legislation.

Neither Flag State nor Classification Society inspections and surveys include the condition of mooring equipment as a specific item. The layout of the mooring deck and specification of equipment had not been formally assessed either during construction or while in service. This removed the additional third party oversight that is present in many other aspects of ship design and operation. Although the effect is unquantifiable, the lack of regulatory requirements for mooring equipment must contribute to forming an impression that such equipment is of a lower priority. Guidance from the MCA in both COSWP and MGN 308 is relevant and, had it been rigorously applied, could have prevented the accident.

Technical standards for mooring winches are aimed more at providing a consistent format of information for ship designers than as guidance for equipment users. The information contained in the ISO Standard, and its implication on the operating characteristics of mooring winches is significant, but was not readily available to managers or crew.

While a number of sources offer generic guidance on the inspection of ropes and the defects that cause deterioration in breaking load, this is typically abstract, and is not easy to translate into practice with confidence. An over-cautious approach will lead to higher usage of ropes, and it is inevitable that some financial constraint will apply. The converse approach, of using ropes until they part in service, is also unacceptable, so crew and managers need criteria that work in practice, without reference to a text book. The different materials in use, and the many variables on the effective service life of mooring lines make this even more difficult to achieve. Inspection methods used in the rope industry require the accumulation of many years' experience, and it is not realistic to expect crew to have these skills without specific guidance and training.

2.7 FATIGUE

The crew involved in this accident met the requirements for the hours of work and rest. The O/S operating the stern line winch knew that the orientation of the controls was reversed and he had operated the winch successfully on other occasions. The accident occurred late in the evening at the end of a second 6 hour duty period in a 24 hour cycle. The extent to which fatigue contributed to operating the winch in the wrong direction can not be determined, but its influence is likely.

2.8 SIMILAR ACCIDENTS

MMM had experience of at least three similar incidents where mooring lines parted during berthing operations. If the lessons from these incidents had been captured more effectively, they might have identified the shortcomings in systems used to monitor the condition of mooring lines and operation of the mooring winches.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT WHICH HAVE RESULTED IN RECOMMENDATIONS

1. There was no indication, either on the winch markings or in the manufacturer's manual, that the starting load could be much greater than the stated, nominal load. [2.2.3]

2. It was apparent that the shore and ship supplied parts of the stern line had evolved in isolation and the implications of each element on the performance of the whole system had not been considered. [2.5.1]

3.2 OTHER SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION ALSO LEADING TO RECOMMENDATIONS

1. The methodology of the relevant ISO Standard for mooring winches relies on rope of the correct minimum breaking load being used. This information was available only by referring to the ISO Standard. [2.2.3]

2. Markings to indicate the direction of rotation of the stern line winch were ambiguous, difficult to see from the normal operating position, and made no suggestion that the winch operated in the opposite sense. [2.3.2]

3.3 SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION WHICH HAVE NOT RESULTED IN RECOMMENDATIONS BUT HAVE BEEN ADDRESSED

1. The condition of the stern mooring line had deteriorated and, as a result, its minimum breaking load had been reduced to approximately 50% of its original strength. The additional tension inadvertently applied by the mooring winch exceeded the line's MBL and caused it to part. [2.2]

2. The frequency of mooring operations, and the routine that developed around them, invited complacency and led to a general acceptance of poor practices such as leaving multiple turns of rope on the warping drum end with the rope barrel in gear, and sporadic backing up of the free end. [2.2.1]

3. The lack of specification for mooring lines in the purchasing system left the selection and supply of replacement ropes open to interpretation and variation in what was procured. [2.2.1]

4. It was not possible to trace the stern mooring line to any of the warranty certificates held on board, and there were no objective means of recording when any of the mooring lines were put into service or inspected. [2.2.1]

5. Procedures on board for inspection and replacement of mooring lines were informal and vulnerable to misunderstandings between different crew. [2.2.1]

6. The following factors are considered to be significant in determining why the stern line mooring winch was operated in the wrong direction:

    - the winch operator was working two winches at the same time, whose controls operated in opposite directions;
    - the winch operator had been given orders to raise, then lower, then raise the stern ramp immediately prior to the order to veer the stern line winch;
    - the noise of the machinery ventilation fans and the stern ramp wires being wound onto the winch drum was distracting;
    - the winch operator was reaching the end of his second 6 hour duty period that day. [2.2.3]

7. The arrangement of vehicle decks and ramps made the aft mooring deck extremely cramped. This, combined with the number and arrangement of mooring lines created several overlapping snap-back zones if any of the lines were to part. The 2/O was obliged to move in and out of these because he relayed orders to line-handlers and maintained visual contact with his own crew. [2.3.1]

8. Personnel did not fully appreciate the capabilities and limitations of the mooring winch and, as a result, practices had evolved which could prevent the winch from rendering and overload the warping drum end. [2.3.2]

9. The lack of builder's drawings or design specifications forced managers and crew to develop their own procedures without full knowledge of the capabilities or limitations of the equipment. They were unable to identify the hazards fully, and could not judge the implications of their decisions. [2.5.1]

10. Management audit and review of Risk Assessments for mooring operations did not identify that several of the control measures listed could not be implemented in practice. [2.5.2]

11. Sustained education and supervision are needed to break existing poor habits and introduce safer working methods. [2.5.3]

SECTION 4 - ACTION TAKEN

Meridian Marine Management:

Undertook an investigation into the accident and, as a result, has implemented the following recommendations on *Dublin Viking,* her sister vessel *Liverpool Viking* and, where appropriate, on other vessels in its managed fleet:

- One-man simultaneous operation of stern ramp and mooring equipment ceased
- Master's Work Instruction completed to specify procedures for mooring operations
- Sprung return to 'off' position on controls for electric winches restored
- Moorings arranged so that only similarly constructed ropes are sent away through the same lead
- Covers provided for mooring ropes to improve protection while ropes are not in use
- Procedure for mooring rope inspections to be enhanced and documented, and made the responsibility of the chief officer
- Use of mooring ropes from storage to be controlled on a 'First in – First Out' basis
- A programme of rotating mooring ropes to reduce localised wear has been established
- Mooring lines to 'tagged' with unique identification labels that can be matched to appropriate warranty certificates
- All roller fairleads made free to rotate
- Mooring arrangement plans to be available on vessels, and to be prominently displayed
- Vessel / port specific moorings plans to be developed, when applicable
- Onboard familiarisation and training procedures to be ensured ship-specific, and enforced
- Members of all mooring parties to be made aware of 'snap-back' zones on board
- Mooring areas to be clearly signed as hazardous areas; 'snap-back' zones to be identified
- Terminal operators for ro-ro services to mark mooring 'snap-back zones on the quay
- The contents of the Code of Safe Working Practices Chapter 25 and Annex 25.1 to be reiterated to all members of the mooring parties
- Contents of COSWP chapter 25 to be reproduced in schematic form for ready reference
- Manufacturer's specifications regarding potential pulling power for all mooring winches to be marked on each winch

- The officer / petty officer in charge to give a tool box talk / pre-work briefing to the mooring party whenever the composition of the party changes or whenever there is a variation to the routine

- Inspections of mooring winches as per vessel's planned maintenance schedule to be adhered to, and any defects reported.

MMM also conducted a review of vessel mooring arrangements and an audit of mooring equipment to the guidance provided by the Health and Safety Executive for implementation of the Provision and Use of Work Equipment Regulation (PUWER). These reviews concluded that:

- The controls for the stern ramp and stern mooring winches should be moved apart to prevent them from being operated simultaneously

- The stern ramp should be fully closed before the stern line winch is operated

- Mooring winches should be checked to ensure the controls operate in the correct direction

- Each crew member should be given an allocated task to conduct at mooring stations

- An emergency signal introduced, consisting of one blast on a whistle at which point all winch operations must cease immediately. All members of the mooring party are to carry a whistle for this purpose

- Junior crew members to operate winches under supervision until they have had a formal appraisal by the chief officer and been considered competent

- Consider providing training aids such as appropriate training DVDs

- Additional lighting to be provided on the after mooring deck to improve working conditions during the hours of darkness

- Winches to be secured with the rope storage barrels disengaged from the warping drum shaft to prevent both motor and band brakes being applied to the warping drum end.

Specifications have been agreed for the purchase of new mooring lines, and all mooring lines on board have been 'tagged' with a unique identification mark to link them to the appropriate warranty certificate. Where this could not be achieved, lines have been replaced.

The review of vessel mooring arrangements determined that a straight lead could be used for the stern mooring line which would reduce the arc of the resultant snap-back zone should the line part. Proposals for the installation of additional rope storage barrels in place of the warping drum ends, and construction of raised, protected areas for the 2/O have been produced and passed to the vessel's owners for consideration.

Hatlapa has undertaken to:

Mark new winches with the maximum, as well as the nominal, loads. It also intends to include more information on the capabilities of winches in literature provided with new equipment.

The Oil Companies International Marine Forum (OCIMF) has:

Produced a third edition of the Mooring Equipment Guidelines, for publication in 2008. This edition includes more guidance on mooring equipment, and has an appendix describing practical methods of inspecting mooring lines.

The Nautical Institute is:

Producing a book entitled “The Mariner’s Guide to Mooring”, to be published during 2008.

The Marine Accident Investigation Branch has:

Issued a Safety Flyer **(Annex B)** which included the following safety issues:

- The risks in conducting mooring operations must be rigorously assessed and safe working practices developed.
- Operators should develop a *Rope Management System* to provide a formal inspection routine of all mooring lines
- Mooring arrangements should be assessed as a system, considering the suitability of each element and the compatibility of material properties, particularly ship and shore-supplied lines
- The full capabilities of mooring winches should be known and understood by all those involved in conducting and managing mooring operations
- Operators should consider, in the course of normal drills, how crew might react and be able to treat very serious injuries to one of their ship mates.

SECTION 5 - RECOMMENDATIONS

The Passenger Shipping Association is recommended to:

2008/119 Promulgate to ferry companies, through its Ferry Section, the need to consider mooring arrangements and operations with particular respect to the safety of personnel conducting those operations. Such consideration should include an assessment of the risks involved to personnel, and their mitigation.

2008/120 Distribute to ferry companies, through its Ferry Section, a copy of the MAIB's "flyer" regarding this accident to highlight to all concerned the extreme dangers that can exist during mooring operations.

The International Chamber of Shipping is recommended to:

2008/121 Highlight to its national ship owner associations the dangers that can exist during mooring operations by the distribution of the MAIB's "flyer" on this accident.

Winch Manufacturers (Hatlapa, Rolls Royce Marine, Maritime Pusnes AS, TTS – KOCKS, Brissonneau and Lotz Marine SA, Brohl and SEC) are recommended to:

2008/122M Review the information provided with mooring equipment to ensure that mooring winch markings and literature include, as a minimum: winch nominal loading, peak loading, and the Minimum Breaking Load (MBL) of ropes to be used on the winch.

The **United Kingdom Major Ports Group** and **British Ports Association** are recommended to:

2008/123M Pass on to their members, MAIB's advice on the need to consider any shore-supplied moorings in the context of the complete mooring arrangement, and ensure full compatibility with any ship's moorings to which they may be connected.

Marine Accident Investigation Branch
March 2008