ACCIDENT REPORT

Report on the investigation of

the collapse of a mezzanine deck on board

the roll-on roll-off passenger ferry

St Helen

Fishbourne Ferry Terminal, Isle of Wight

on 18 July 2014

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

SERIOUS MARINE CASUALTY REPORT NO 1/2016 FEBRUARY 2016

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 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 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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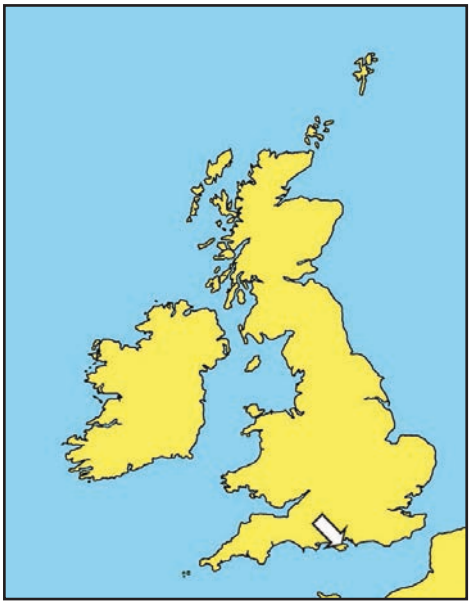
GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ACOP	-	Approved Code of Practice
°C	-	Degrees Celsius
CoSWP	-	Code of Safe Working Practices for Merchant Seamen
DOC	-	Document of Compliance
DP	-	Designated person
HGV	-	Heavy goods vehicle
HSE	-	Health and Safety Executive
IACS	-	International Association of Classification Societies
ISM Code	-	International Safety Management Code
ISO	-	International Organization for Standardization
kN	-	kilo Newton
kts	-	knots (nautical miles per hour)
LOLER	-	Merchant Shipping and Fishing Vessels (Lifting Operations and Lifting Equipment) Regulations 2006
m	-	metre
MacGregor	-	MacGregor-Navire Ltd
MCA	-	Maritime and Coastguard Agency
MEIF	-	Macquarie European Investment Fund Shipping Ltd
MGN	-	Marine Guidance Note
mm	-	millimetre
NCR	-	Non-conformance report
PUWER	-	Merchant Shipping and Fishing Vessels (Provision and Use of Work Equipment) Regulations 2006
ro-ro	-	Roll-on roll-off
RSA	-	Royal & Sun Alliance Engineering Inspection & Consultancy
SMC	-	Safety Management Certificate
SMS	-	Safety Management System

SOLAS	-	International Convention for the Safety of Life at Sea 1974, as amended
STCW	-	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (STCW Convention)
SWL	-	Safe working load
TTH	-	The Test House (Cambridge) Ltd
UTC	-	Co-ordinated Universal Time
VHF	-	Very high frequency

TIMES: all times used in this report are UTC+1 unless otherwise stated

SYNOPSIS



At 2221 on 18 July 2014, the starboard forward mezzanine deck on board the UK registered roll-on roll-off passenger ferry *St Helen* partially collapsed, causing injuries to a crewman and several passengers. *St Helen* was berthed at the Fishbourne ferry terminal, Isle of Wight, and the mezzanine deck was being lowered in preparation for the disembarkation of the cars parked on it. The injured crewman, who was rendered unconscious from a head injury, and three passengers, who had suffered a variety of minor injuries while seated in their cars, were taken to hospital. None of the injured remained in hospital overnight.

The mezzanine deck collapsed when its inboard steel wire ramping rope suddenly parted. This caused the forward inboard corner of the suspended deck to drop from a height of about 2m and hit the main deck below. The force of the impact caused the failure of one of the mezzanine deck's main structural beams. Post-accident analysis of the failed wire rope found that it had suffered a significant amount of mechanical wear. The mechanical wear, which had primarily been attributed to internal and external abrasion caused by a lack of lubrication, had severely diminished the strength of the rope.

The investigation found weaknesses in the way that Wightlink had managed the day-to-day maintenance of its vessels and, in particular, their mezzanine decks. This was despite the mezzanine decks being subject to regular inspections and mandatory 6-monthly thorough examinations by a Royal & Sun Alliance Engineering Inspection & Consultancy surveyor.

Wightlink was aware of many of the safety issues and contributing factors highlighted in this investigation report. Of note: the absence of a formal mezzanine deck greasing routine had been subject to an internal safety management system non-conformity for over 2 years; the failure to address the non-conformity was highlighted by the Maritime and Coastguard Agency 9 months prior to the accident; and the failure to lubricate the steel wire lifting ropes was identified during 6-monthly examinations. Given this knowledge, and the potential consequences of a rope parting, Wightlink demonstrated little or no appetite to allocate the resources necessary to resolve this long-standing issue. This apparent lack of impetus was probably influenced by an over reliance on its 4-yearly wire rope replacement program and the Royal & Sun Alliance Engineering Inspection & Consultancy and the Maritime and Coastguard Agency's reluctance to escalate the issue.

On 7 August 2014, the Chief Inspector of Marine Accidents wrote to Wightlink and issued a recommendation to immediately instigate a mezzanine deck steel wire lifting rope maintenance programme, and seek independent assurance that the mezzanine decks on its vessels were of sound condition. Wightlink accepted the recommendation and has taken action to improve the material condition of its mezzanine decks and maintain them in accordance with accepted best practice.

This report makes recommendations to Wightlink, British Engineering Services Ltd and the Maritime and Coastguard Agency designed to improve the overall management of maintenance across the Wightlink fleet and improving the levels of assurance provided by the statutory thorough examination of lifting equipment.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *ST HELEN* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*St Helen*
Flag	UK
Classification society	N/A
IMO number/fishing numbers	8120569
Type	Ro-ro passenger ferry
Registered owner	MEIF Shipping Ltd (Until 16/2/2015)
Manager(s)	Wightlink Limited
Construction	Steel welded
Year of build	1983 Cochrane Shipbuilders Ltd, Leith
Length overall	76.97m
Gross tonnage	2983
Minimum safe manning	8
Authorised cargo	Passengers, private and commercial vehicles
VOYAGE PARTICULARS	
Port of departure	Portsmouth
Port of arrival	Fishbourne, Isle of Wight
Type of voyage	Internal waters
Cargo information	181 passengers, 64 private and 5 commercial vehicles
Manning	11
MARINE CASUALTY INFORMATION	
Date and time	18 July 2014, 2221
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Fishbourne ferry terminal
Place on board	Starboard forward mezzanine deck
Injuries/fatalities	1 crew member and several passengers injured
Damage/environmental impact	Failure of a mezzanine deck steel wire lifting rope and structural longitudinal beam
Ship operation	In service
Voyage segment	Alongside
External & internal environment	External: Dry, 18°C, light airs, calm sea
Persons on board	192

St Helen

1.2 NARRATIVE

At 2130 on 18 July 2014, the roll-on roll-off (ro-ro) passenger ferry *St Helen* sailed from the Wightlink ferry terminal at Gunwharf Quays, Portsmouth, bound for Fishbourne on the Isle of Wight **(Figure 1)**. *St Helen* was carrying 181 passengers, 64 cars and 5 heavy goods vehicles (HGV), and it was the vessel's last crossing of the day. The cars were parked on the port and starboard main decks and the starboard mezzanine decks. The port mezzanine decks were not in use and had been raised to their stowed positions **(Figure 2)** to enable the high-sided HGVs to park on the port main deck.

At 2216 *St Helen* was manoeuvred onto its berth at the Fishbourne ferry terminal and its bow ramp was lowered onto the quay. Once the vessel was secure, the second mate and the deck crew started to disembark the vehicles parked on the starboard side of the main deck. When the starboard main deck was clear, the crew began to disembark the vehicles parked on the port side of the main deck.

As the vehicles disembarked, the second mate went to the forward mezzanine deck control station **(Figure 3)**, which was located on the forward facing bulkhead between the port and starboard vehicle decks. A crewman positioned himself on the forward outboard side of the starboard forward mezzanine deck, in the second mate's line of sight, and confirmed that it was clear to lower the deck. The second mate checked that the starboard main deck was clear and, at about 2221, he began to lower the starboard forward mezzanine deck to its ramped position.

As the forward end of the mezzanine deck descended, a loud bang was heard and the deck's forward inboard corner fell about 2m to the main deck below **(Figure 4)**. The forward edge of the mezzanine deck came to rest at an angle of approximately 30° to the horizontal, with its outboard corner remaining in its suspended position. The mezzanine deck crewman was thrown to the deck by the force of the impact and struck his head.

The second mate immediately contacted the master on the bridge via VHF radio and advised him of the incident. Another member of the deck crew climbed on to the mezzanine deck to assess the situation. The injured crewman was found slumped face-down at the outer edge of the mezzanine deck; he was unconscious and bleeding from a cut close to his left temple. Several of the passengers seated in their cars had suffered whiplash and other impact-related injuries; others were suffering from shock. The chief officer went to the main deck and requested paramedic assistance and rapidly disembarked the remaining vehicles from the port main deck.

Some of the passengers went to the aid of the unconscious crewman; one of them identified herself as a medical professional and requested the ship's medical bag. As other crew members arrived on the scene, the uninjured passengers were instructed to leave their cars and make their way to the vessel's passenger lounge **(Figure 5)**. This process was hastened when a crewman hurried the passengers by warning them that the outboard side of the deck might also collapse.

The unconscious crewman was carried off the mezzanine deck and laid on the main deck, where his condition was closely monitored. By 2230, the police, fire service and ambulance service paramedics had arrived on board and the injured crewman had regained consciousness. An ambulance took the injured crewman and one of the injured passengers to a local hospital for treatment.

Reproduced from Admiralty Chart BA 2045-0 by permission of the Controller of HMSO and the UK Hydrographic Office.

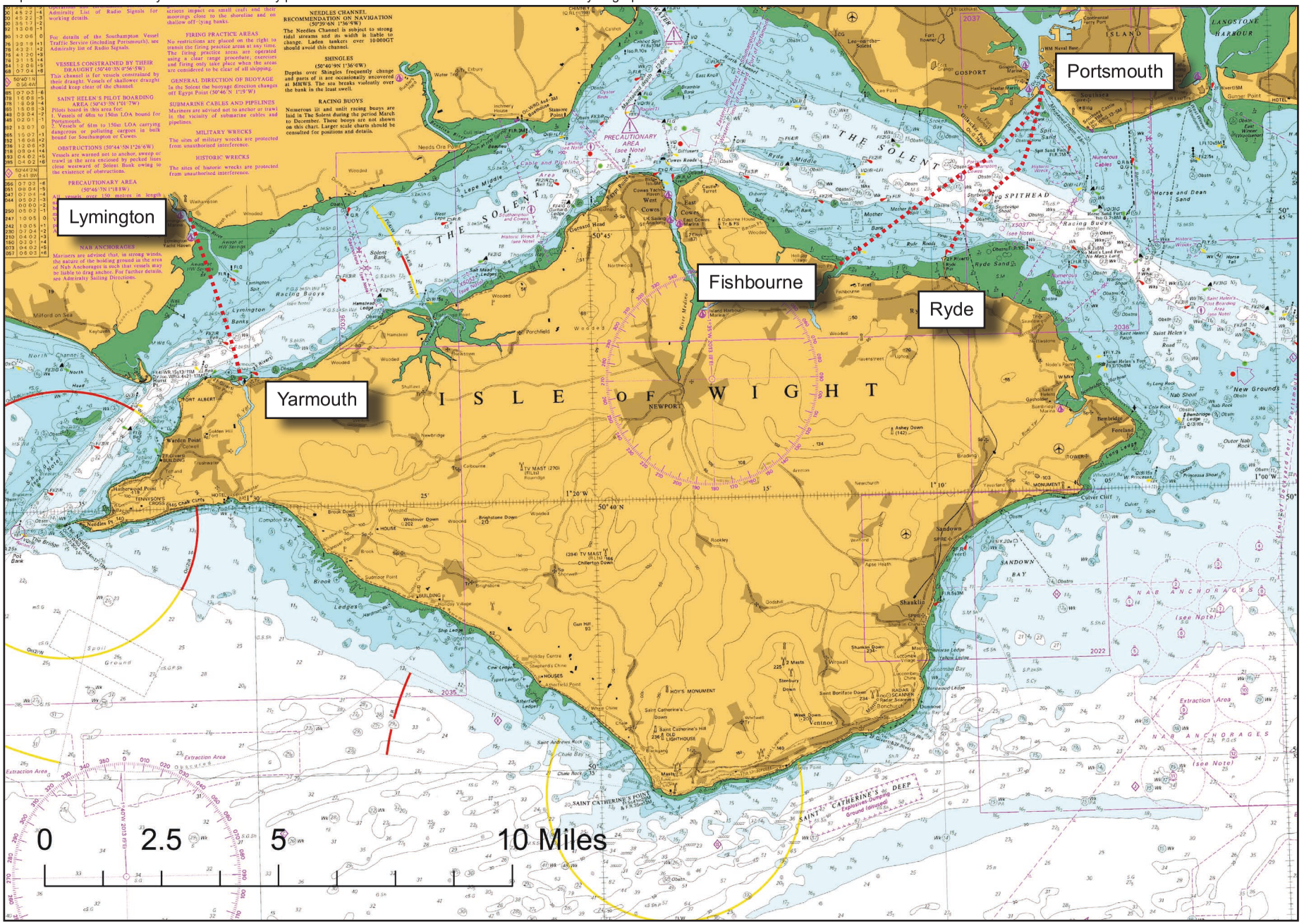


Figure 1: Wightlink ferry routes between the Isle of Wight and the mainland

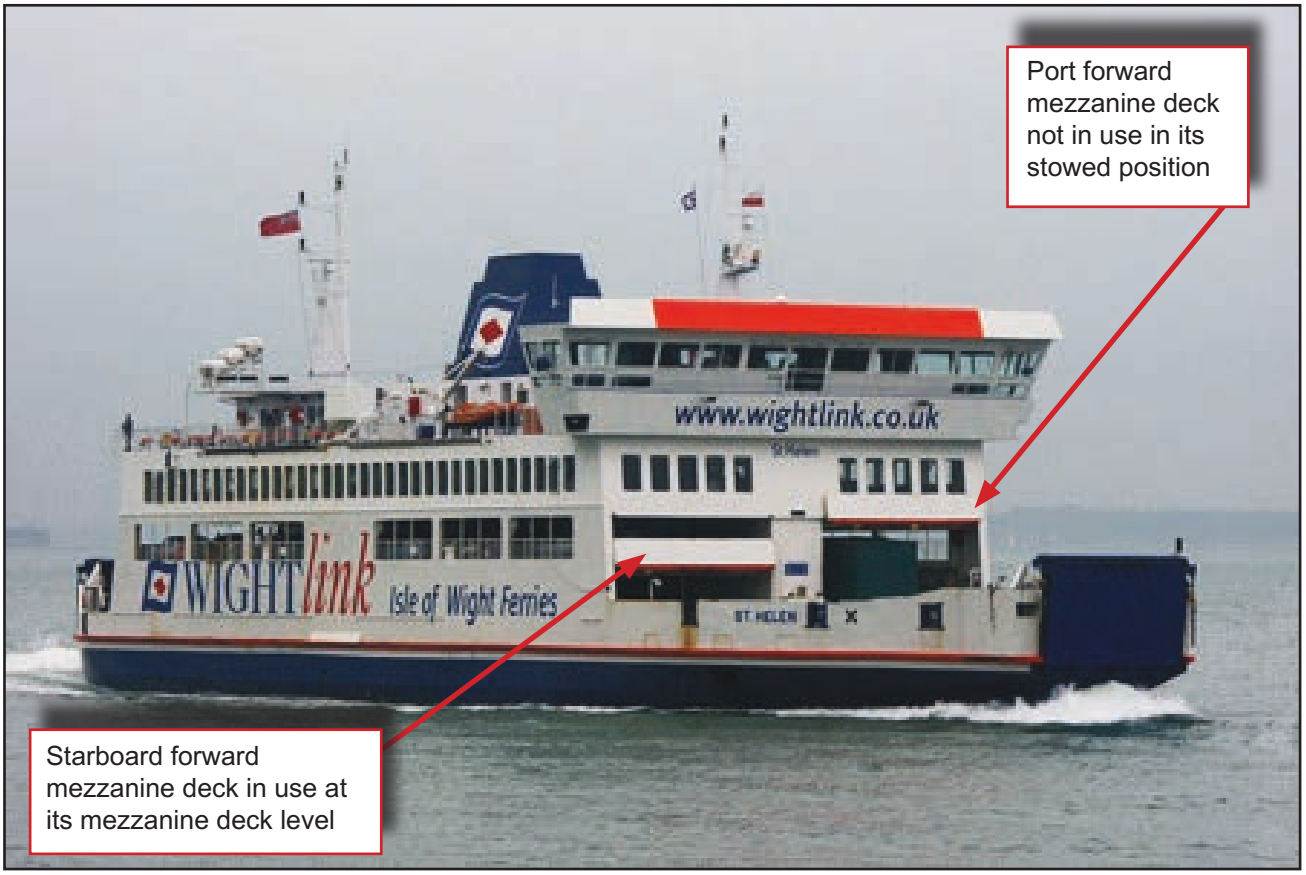


Figure 2: *St Helen* on passage in the Solent with its starboard mezzanine decks in use and its port mezzanine decks in their stowed position

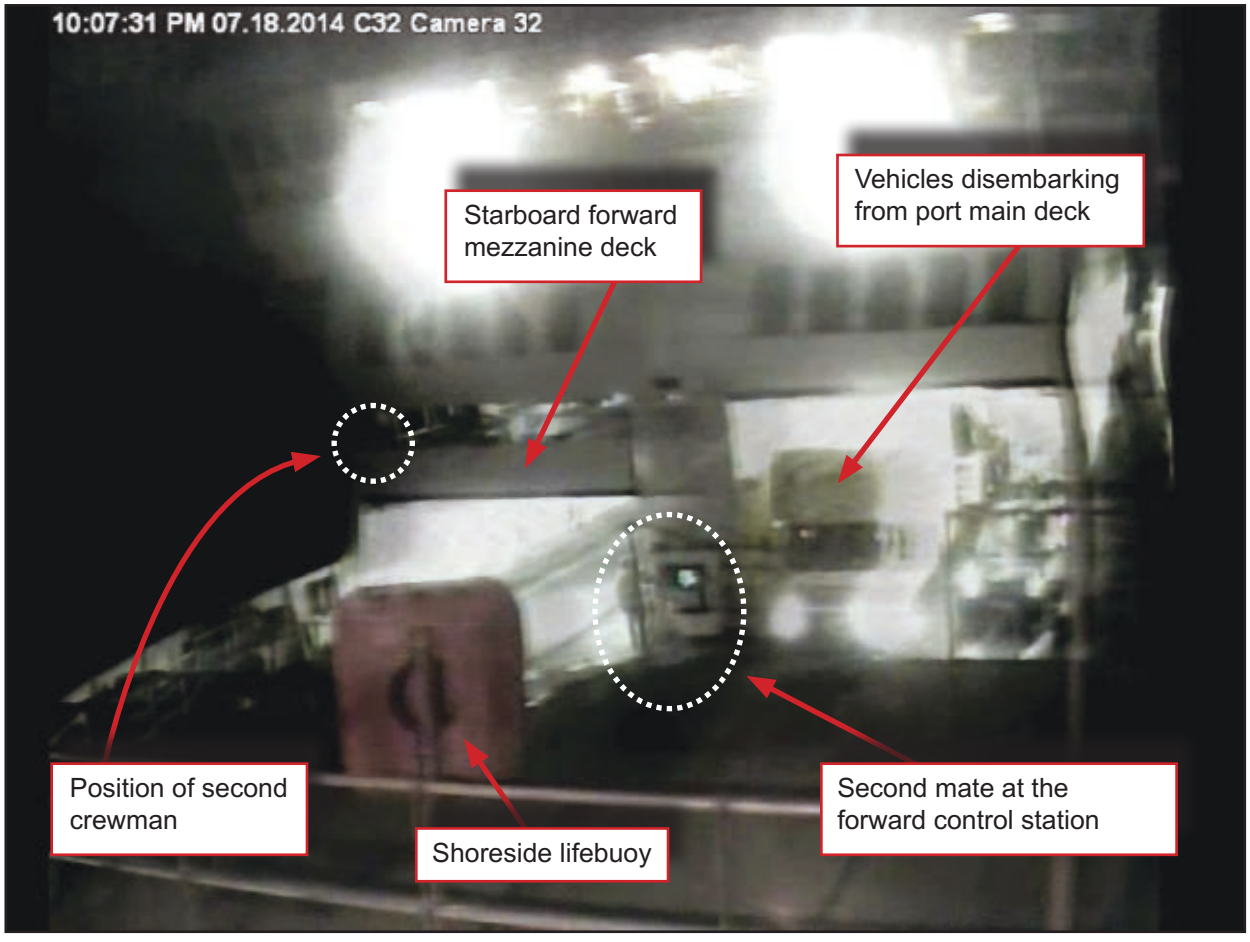


Figure 3: Second mate at the forward mezzanine deck control station while vehicles are being driven off the port main deck

Figure 4: Closed-circuit television footage of the mezzanine deck collapse

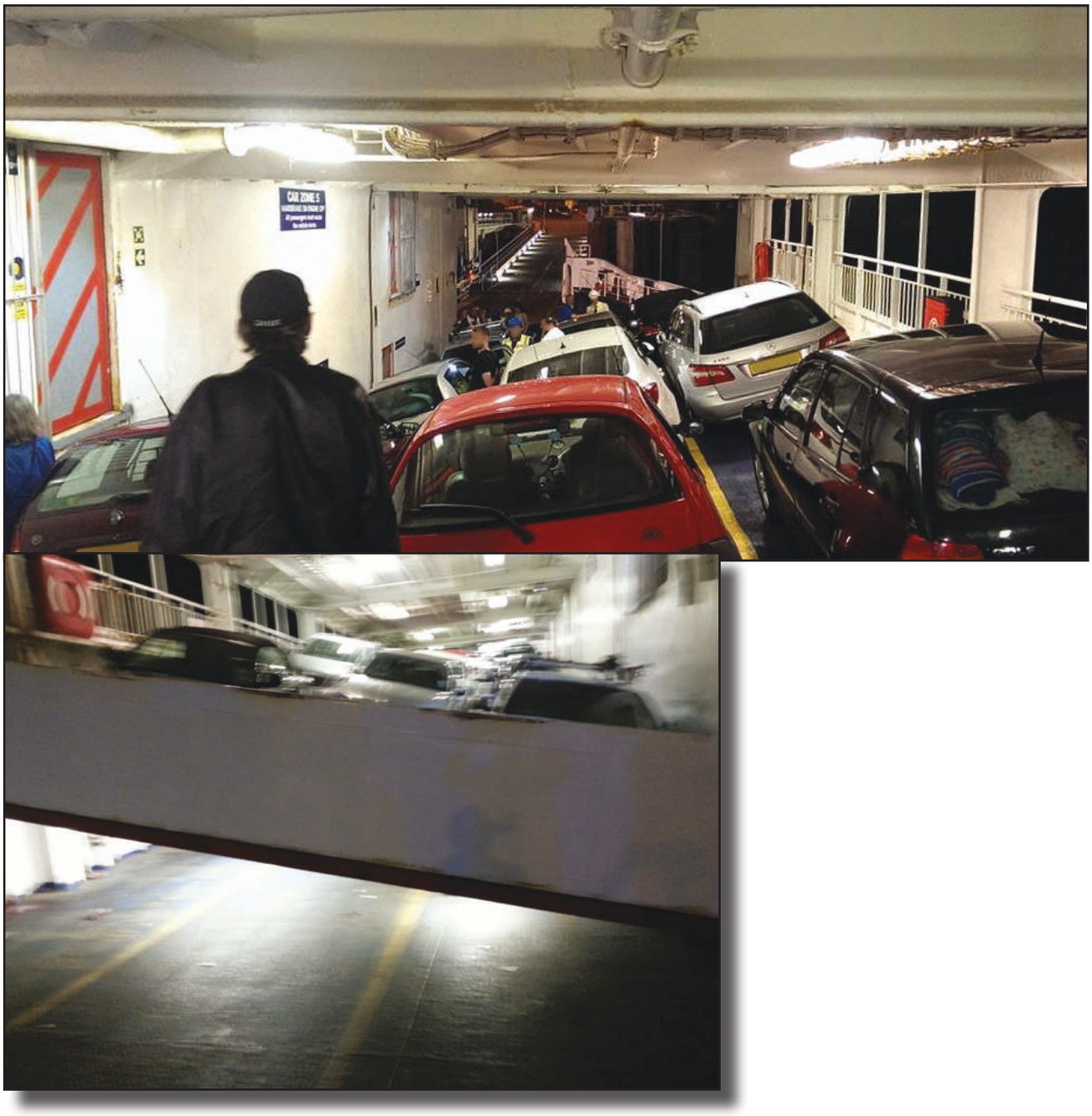


Figure 5: Evacuation of the passengers from the mezzanine deck to the passenger lounge

When the forward mezzanine deck was clear of passengers, the crew lowered its forward outboard corner to the main deck **(Figure 6)**. Once the forward edge of the deck was level on the main deck, the crew were unable to drive the vehicles off the mezzanine deck because they could not lower its end flap. The crew then lowered the starboard aft mezzanine deck and, with the assistance of the police, the passenger vehicles were reversed onto the main deck.

After all the passengers and vehicles had been disembarked, *St Helen* was taken out of service and returned to Portsmouth. During the evening, two other passengers made their own way to hospital. The injured crewman and passengers were all released from hospital later that evening.

Figure 6: Outboard side of mezzanine deck lowered to main deck level

1.3 ENVIRONMENTAL CONDITIONS

The accident occurred on a dry summer evening. The sea was calm with light airs and the ambient air temperature was about 18°C. Sunset had occurred at 2054 but *St Helen*'s vehicle decks and bow ramp were illuminated well by the ship's lighting and ferry terminal floodlights.

1.4 *ST HELEN*

St Helen was a double-ended ro-ro passenger ferry. It had an overall length of 76.97m and was certified to carry up to 772 passengers and 142 cars. It entered service on the Solent in 1983 and was operated by Wightlink Ltd (Wightlink). Wightlink and *St Helen* were owned by Macquarie European Investment Fund Shipping Ltd (MEIF).

St Helen was propelled by three Voith Schneider propulsion units and had a maximum speed of 12.5kts. The main vehicle deck ran the full length of the vessel and was fitted with hydraulically-operated bow and stern ramps. Vehicles were driven onto the vessel at one end of the main vehicle deck and driven off at the other. *St Helen* had four independent hydraulically-operated hoistable ramp-type car decks, which were referred to as the mezzanine decks **(Figure 2)**. The vehicle decks were of open construction and were exposed to the prevailing environmental conditions.

1.5 WIGHTLINK LIMITED

Wightlink operated nine vessels on three scheduled routes between the Isle of Wight and the south coast of England **(Figure 1)**. It operated conventional ro-ro passenger ferries on its Fishbourne to Portsmouth and Yarmouth to Lymington routes, and high-speed passenger craft on its Ryde to Portsmouth route. Annually, Wightlink carried almost 5 million passengers and completed about 48,000 crossings.

St Helen, the oldest vessel in the fleet, was one of four vessels operated on the Fishbourne to Portsmouth route; the others were *St Cecilia*, *St Faith* and *St Clare*. The crossing took about 45 minutes and the service ran 7 days a week.

St Helen, St Faith and *St Cecilia* all entered service on the Solent in the 1980s. *St Clare* entered service in 2002. It was the largest vessel in Wightlink's fleet and subsequently became the permanent night operating vessel. *St Helen*, along with the other *Saint* Class vessels was secured alongside a layby berth at Wightlink's Portsmouth ferry terminal when not in operation overnight. Although *St Helen* was used year-round, it had lower usage levels than the other ships in the fleet because its lower mezzanine deck heights made it inaccessible for higher vehicles. Consequently, *St Helen* was often the last of the *Saint* Class vessels to be brought into service.

1.6 THE MACQUARIE EUROPEAN INFRASTRUCTURE FUND SHIPPING LTD

Commercial ferry services between the Isle of Wight and the mainland have been operating for more than 150 years. During the 1970s, ownership of the ferries operating between Fishbourne and Portsmouth passed from the British Railways Board to Sealink UK Limited. In November 1991, following several further changes of ownership, the ferry service was rebranded under the trading name Wightlink. In June 1995, Wightlink was the subject of a management buy-in supported by a private equity fund. In 2005, the company was purchased by MEIF but continued to operate as Wightlink.

MEIF was an Australian wholesale investment fund that was established in 2004 to invest in infrastructure and related businesses located within European countries that were members of the Organisation for Economic Co-operation and Development. MEIF's primary investors were pension funds.

During MEIF's ownership, Wightlink had purchased three new conventional ro-ro ferries for its Yarmouth to Lymington route, and two high speed passenger catamarans. In recent years *St Helen* had become increasingly difficult and expensive[1] to maintain and its replacement with a newer vessel had been mooted. However, investment was deferred while the Isle of Wight Council Cross Solent Services Scrutiny Task and Finish Group[2] was conducting an investigation.

On 24 November 2014, Wightlink announced its decision to remove *St Helen* from service in 2015. *St Helen* was later sold to the Italian ferry operator Delcomar, which also operated Wightlink's former vessel *St Catherine*. On 16 February 2015, MEIF announced that Wightlink had been sold to the infrastructure investment firm Balfour Beatty Infrastructure Partners LLP.

[1] At the time of the accident, *St Helen* was operating with the second highest budget in the Wightlink fleet.

[2] As the local transport authority, the Council undertook an investigation into the impact of reduced ferry services on the Island's economy following Wightlink's strategic decision to reduce the frequency of its crossings in 2012.

1.7 MANNING

1.7.1 *St Helen*'s crew

St Helen had a crew of 11 comprising the master, chief officer, second mate, chief engineer, engineer officer and three ratings, two passenger services staff and one cabin attendant.

The master was British and held an STCW II/2 Master Unlimited Certificate of Competency. He began his career at sea in 1970, joined Wightlink in 1990 and was promoted to master in 1992. From 1995 - 2001 he held the position of company senior master. One of his objectives was the standardisation of working practices across the fleet. From 2001, he reverted to his role as master.

The second mate was British, joined Wightlink in 1996 and became a permanent deck officer in 2000.

The injured mezzanine deck crewman was also British. He had a commercial yachting background and was working for Wightlink as a seasonal employee. His duties included assisting with passenger embarkation and disembarkation, conducting deck patrols and acting as helmsman.

1.7.2 Fleet manning arrangements

A mandated minimum number of qualified crew was required to operate each passenger vessel. The number of passengers carried on a particular crossing could be increased if additional qualified crew were on board. Wightlink used a modal manning system which was designed to meet mandated minimum manning requirements, peak passenger demand and safe evacuation. The system utilised an early, middle and late shift rota system to crew its vessels. Crew shortages caused by unforeseen high passenger demand, leave commitments or illness were managed through overtime.

The crew members were not allocated to a particular vessel and moved around the fleet on a regular basis, typically serving four concurrent days on the same vessel. The working patterns of the ship's deck officers, engineer officers and ratings differed to some degree. Until 1995, a senior master had been appointed to each vessel. Subsequently, to improve standardisation and efficiency of working practices two company senior master roles were introduced followed by a fleet commodore. In addition, survey chief engineers[3] were appointed to individual vessels. Changes to the vessel's safety equipment and manning arrangements had also led to crew reductions in both the deck and engineering departments, including the transfer of some engineering staff to shore-based maintenance duties. With the introduction of *St Clare*, and the overnight layup of the *Saint* Class vessels, further rostering changes meant that only the standby layup vessel had night engineers on board. The night engineers typically carried out engine room maintenance work while maintaining the vessel's state of readiness.

[3] The survey chief engineers were responsible for ensuring that maintenance of the ships' engine rooms, machinery spaces, deck machinery and auxiliary equipment was carried out in a standardised manner.

1.8 THE MEZZANINE DECKS

1.8.1 General construction and design

St Helen's mezzanine decks were manufactured by MacGregor-Navire Ltd[4] (MacGregor). The decks had three car lanes and were designed to carry an equally distributed load of vehicles, each with a maximum weight of 1.5t. As a guide, the mezzanine decks could carry the following number of cars:

- 1 deck in use (*quarter deck*) 12 cars
- 2 decks in use on one side (*half deck*) 27 cars
- 3 decks in use (*three quarter deck*) 39 cars
- All 4 decks in use (*double deck*) 54 cars.

The mezzanine decks were fabricated from high tensile steel and each had a safe working load (SWL) of 20.25t. The forward mezzanine decks were 21.1m long and 6.885m wide; the aft decks were 19.9m long and 6.885m wide. The mezzanine deck's top plates were welded onto a fabricated framework of longitudinal and transverse deck beams.

The decks were raised and lowered by a hoisting arrangement that comprised a direct double-acting hydraulic 'pulling' cylinder (main ram), a sliding carrier assembly and four galvanised anti-twist steel wire lifting ropes **(Figure 7)**. The main ram and sliding carrier assembly were mounted within the mezzanine deck structure underneath the top plates. The mezzanine decks had three operational positions **(Figure 8)**. These were:

- The *stowed* position
- The *working* or *mezzanine* position, and
- The *ramped* position.

Placing the empty mezzanine decks in the stowed position provided the head room needed on the main vehicle deck to accommodate HGVs. To be used as a car deck, the mezzanine decks had to be lowered to their working position. To allow vehicles to drive on and off the mezzanine decks, they had to be lowered to the ramped position.

Each mezzanine deck had two fixed hinge pins and six hydraulically-operated retractable locking bolts. The hinge pins were designed to support the inner end of the mezzanine deck during ramping operations; the locking bolts were designed to transfer the weight of the decks and the vehicles parked on them from the lifting ropes to the ship's superstructure. When the decks were in their horizontal stowed and working positions, the extended hydraulic locking bolts sat on their bulkhead mounted support housings **(Figure 9)**. When the decks were lowered from the stowed position to the working position their hinge pins slid down a set of vertical guide rails to their hinge cups.

[4] When *St Helen* was built MacGregor-Navire Ltd was trading as MacGregor (GBR) Ltd.

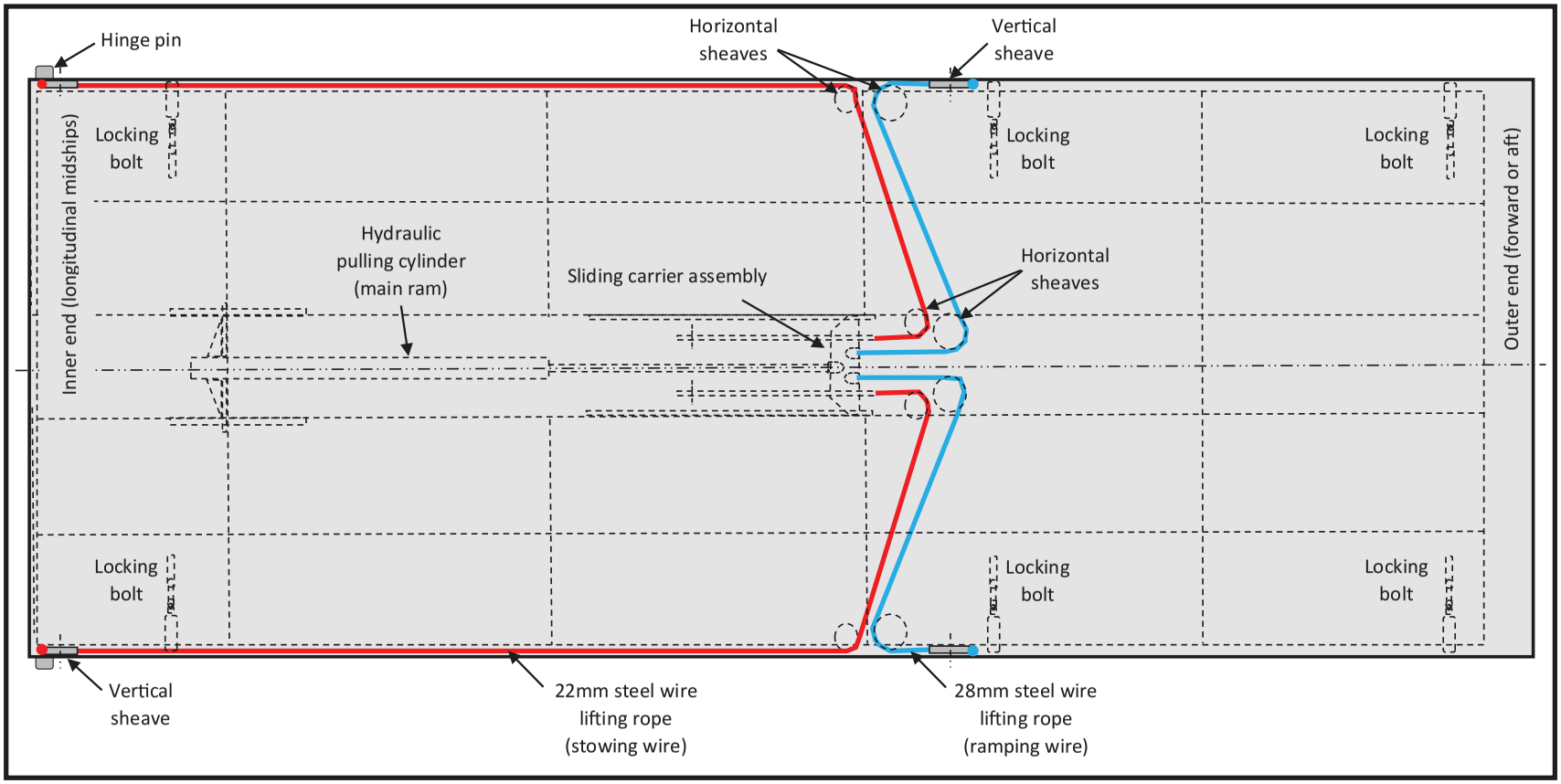


Figure 7: Mezzanine deck raising and lowering arrangements

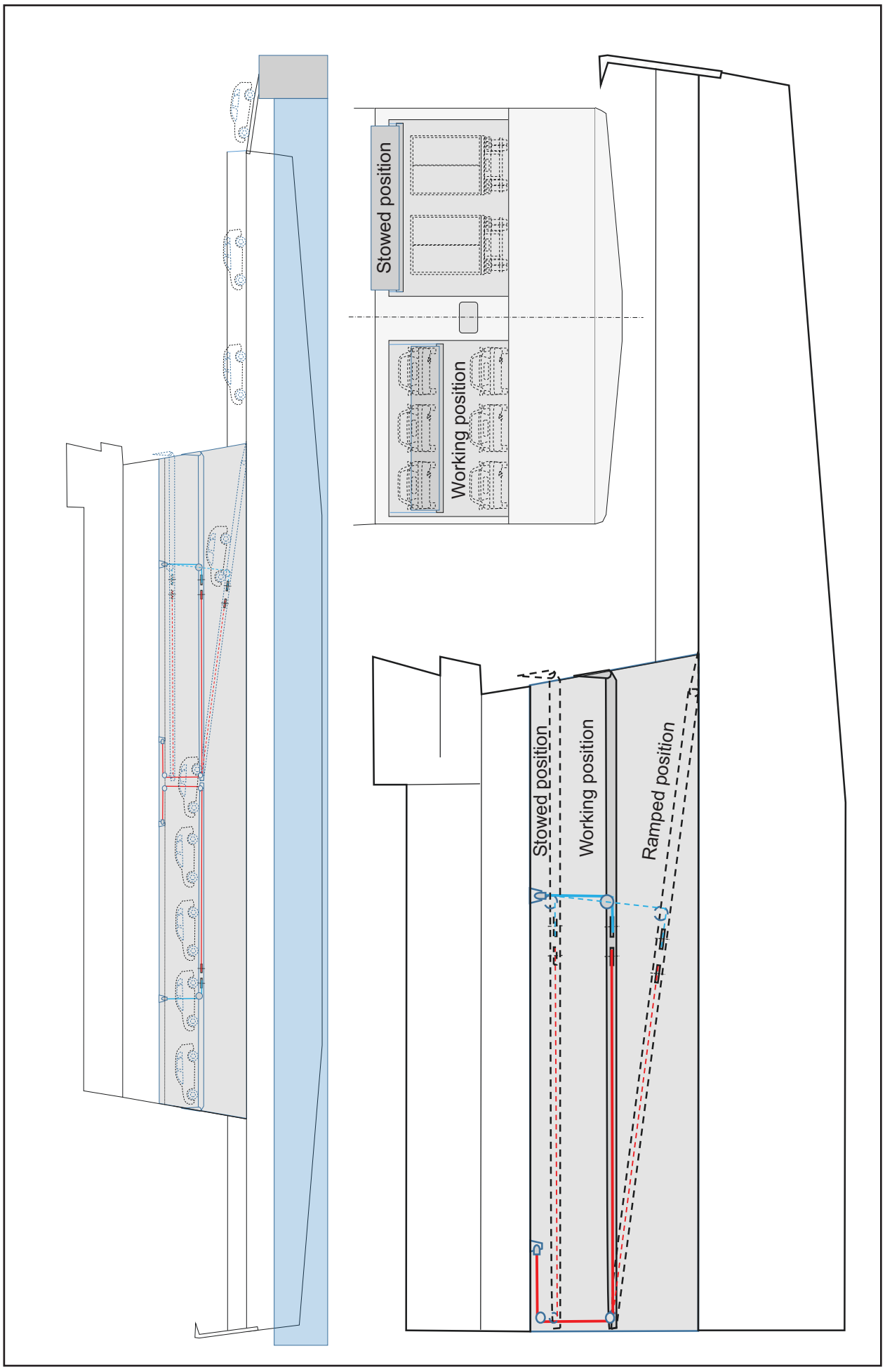


Figure 8: Mezzanine deck positions

Figure 9: Mezzanine deck retractable locking bolts

To lower a mezzanine deck to the ramped position the deck had to be raised slightly to take the weight off the locking bolts and allow them to be retracted. As the outer end of the deck was lowered the inner end pivoted in the hinge cups at the mezzanine deck level.

The outer ends of the decks were fitted with hydraulically-operated end flaps that ran the full width of the deck. The end flaps provided mini-ramps for the smooth transfer of cars between the main deck and the ramped mezzanine deck. When not in use, the end flaps were folded up at right-angles to the deck to form a 1m high safety barrier.

The passengers remained sitting in their vehicles when the mezzanine decks were being raised to their working positions. Once the decks were resting on their locking bolts, the passengers were guided from their vehicles to the passenger lounge. The passengers returned to their vehicles when the ferry arrived at its destination and remained seated as the decks were lowered to the ramped position.

Eleven vehicles were parked on the starboard forward mezzanine deck when it collapsed. Prior to the second mate's attempt to lower the deck, his crewman checked the locking bolts and reported that they had fully retracted.

1.8.2 Mezzanine deck steel wire lifting ropes

The four steel wire lifting ropes on each mezzanine deck comprised two 28mm diameter *ramping* ropes, and two 22mm diameter *stowing* ropes. The ramping and stowing ropes had a minimum breaking load of 675 kilo Newtons (kN) and 399kN respectively. With a safety factor of 5:1, they provided an SWL of 135kN and 79.8kN respectively. The larger ramping ropes supported the outer end of the deck when it was being raised and lowered between the stowed, working and ramped positions. The stowing ropes supported the inner end of the deck when it was being raised and lowered between the stowed and working positions. When the deck was in its fully ramped position, some tension on the ramping ropes was retained to help support the midsection of the deck.

The lifting ropes were anchored at one end to the ship's superstructure at deckhead level. The other end of each rope was rove through a series of sheaves located at the edges and underneath the mezzanine decks, and connected to the sliding carrier assembly. The sliding carrier assembly was moved by the main ram. To raise the mezzanine deck, the main ram pulled in on the sliding carrier assembly; this caused the deck sheaves to roll up the anchored lifting ropes **(Figure 10)**. To lower the deck, the hydraulic pressure in the system was released and the weight of the deck forced the sheaves to roll down the lifting ropes. The mezzanine decks on the newer *Saint* Class vessels operated in a similar way, but they had a double lifting rope arrangement that provided 100% redundancy should one rope fail.

When *St Helen*'s mezzanine decks were in the horizontal working position the exposed upper ends of the lifting ropes introduced the risk of passenger clothing coming into contact with the ropes and being soiled by grease. To avoid this, hinged wooden guards **(Figure 11)** had been provided. The guards were clipped onto the ropes when the deck was in the working position and lowered whenever the deck was being moved. *St Clare* had a similar issue, and protection was provided using an elasticated guard arrangement. The lifting ropes on board *St Cecilia* and *St Faith* were recessed into the bulkheads and no guards were required.

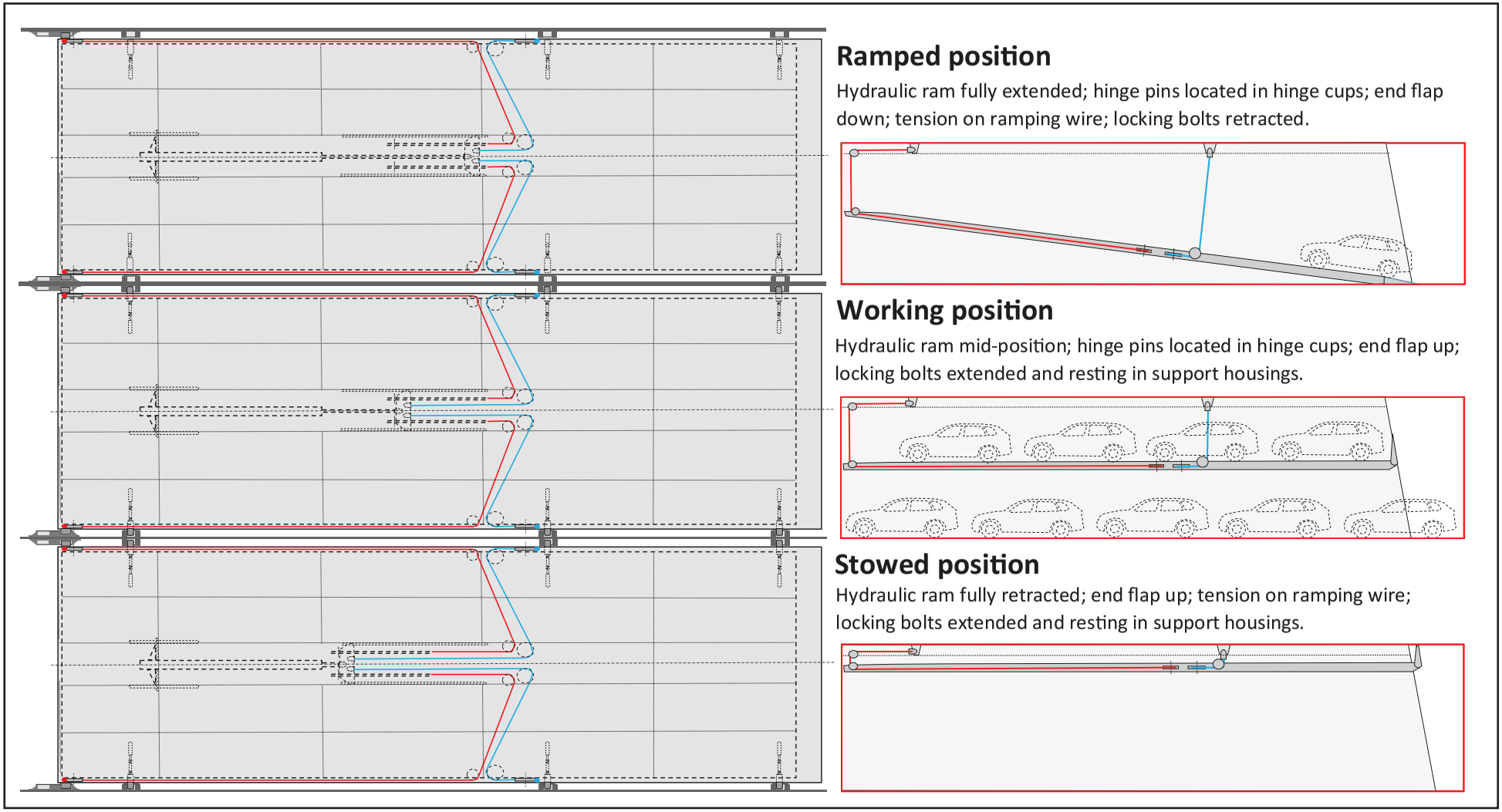


Figure 10: Operation of the mezzanine deck hydraulic pulling cylinder and sliding carrier assembly

Hinged wooden lifting rope grease guard on board *St Helen*

Elasticated lifting rope grease guard on board *St Claire*

Figure 11: Lifting rope grease guards

1.8.3 Mezzanine deck controls

St Helen had two mezzanine deck control stations: one located on the central bulkhead at the forward end of the main vehicle deck **(Figure 12)** and the other on the central bulkhead at the aft end. The forward controls operated the port and starboard forward decks, and the aft controls operated the port and starboard aft decks. The mezzanine deck control stations contained a start/stop button for the hydraulic power pack, and the operating levers for the hydraulic control valves.

Each deck had three control valves, which were labelled X, Y and Z. Control valve X engaged and disengaged the locking bolts, and control valves Y and Z operated the main ram to raise and lower the decks. Illustrated operating instructions were provided at the control stations.

The hydraulic system worked to a maximum pressure of 250 bar and incorporated load control valves to lock the hydraulic cylinders in the event of a hydraulic hose failure. The system was also fitted with hydraulic 'anti-crush' valves designed to prevent the decks being raised to the stowed position with cars still on them. The electrical system incorporated deck position sensors and limit switches to prevent inadvertent operation and potential damage if the decks were operated with the locking bolts engaged. In addition, override buttons had been installed for use in situations when the deck position sensors had not indicated the correct position of the bolts.

Only trained officers were permitted to operate the mezzanine decks. The training provided was a combination of practical demonstration and theoretical instruction, and was supported by the company's document *Guidelines for the safe operation of mezzanine decks*. The guidelines provided an overview of the system operation and highlighted the differences between the four *Saint* Class vessels. Once trained, the officers were issued a *licence to operate*, and their competency was subject to periodic review. The second mate had completed the training and had many years' experience of taking charge of the vehicle deck crew and operating the mezzanine decks.

1.9 POST-ACCIDENT INSPECTIONS, TESTS AND TRIALS

1.9.1 Initial observations

The morning after the accident, an MAIB inspector, two Maritime and Coastguard Agency (MCA) surveyors and Wightlink staff inspected the collapsed mezzanine deck. It was immediately apparent that the deck's inboard steel wire ramping rope had parted. It was also apparent that the main inboard longitudinal deck beam had fractured and failed **(Figure 13)**.

The inboard ramping rope was found to have parted 2.45m from the deckhead. The failure point coincided with the location of the deck's inboard steel wire sheaves **(Figure 14)**. The longitudinal deck beam fracture was approximately 18.5m from the mezzanine deck's inner (hinged) edge, just aft of the stowing rope's horizontal sheave.

A non-intrusive visual inspection of the other mezzanine decks and their lifting ropes was undertaken and the operation of the starboard aft deck was demonstrated by the ship's crew. Externally, the steel wire ropes were found to be dry and devoid of

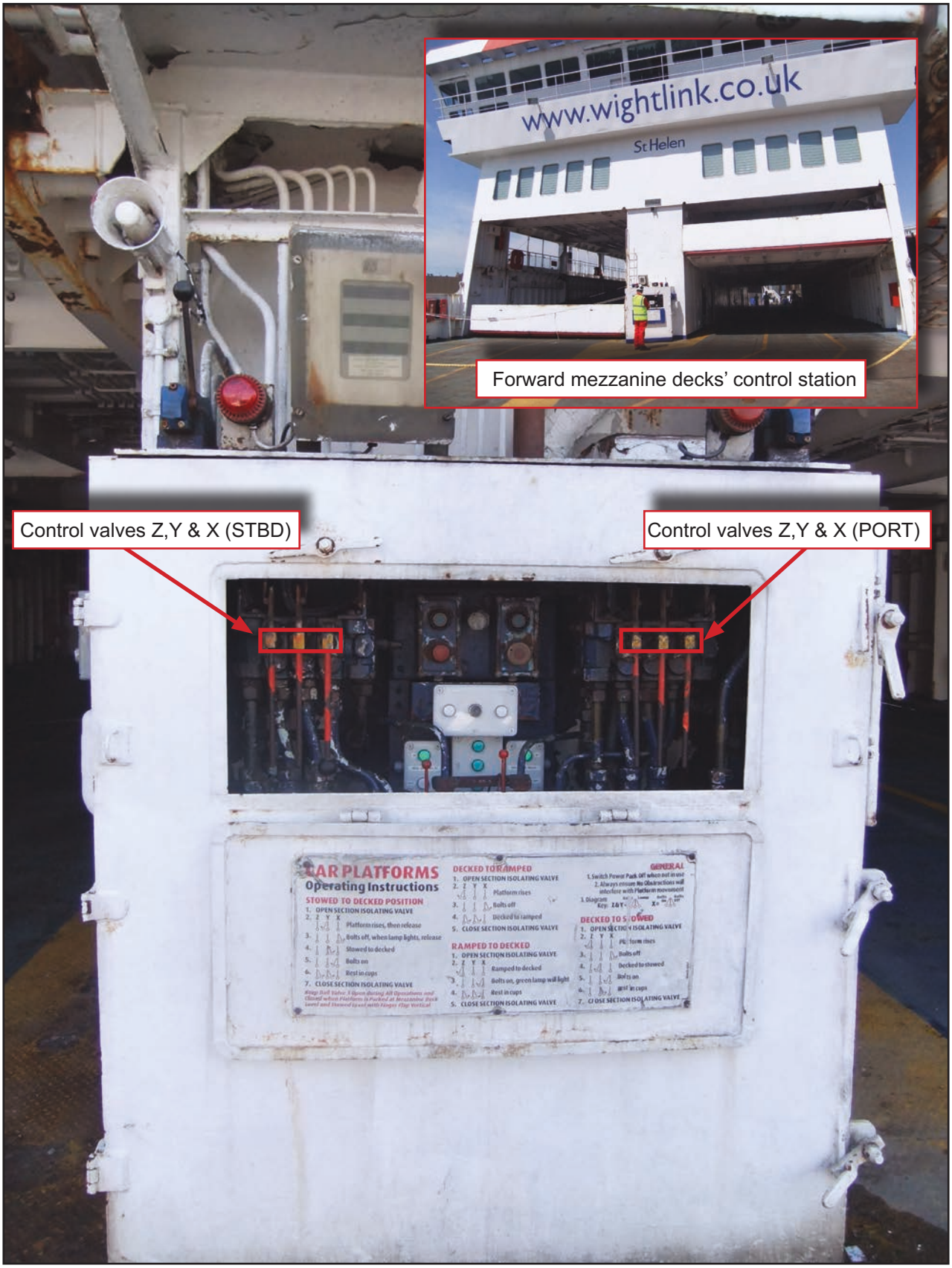


Figure 12: Mezzanine deck control station

Figure 13: Parted inboard ramping rope and fractured deck beam

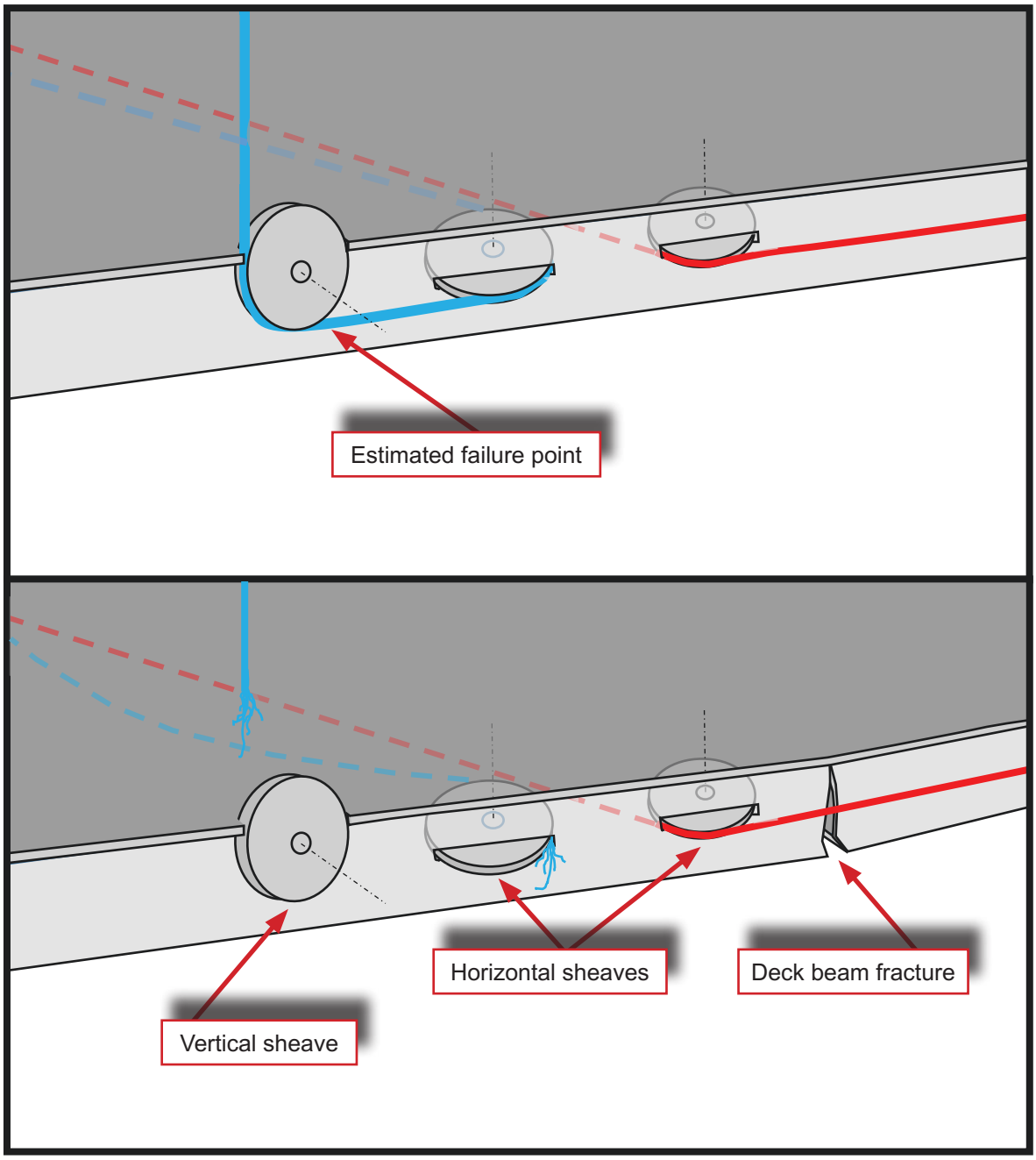


Figure 14: Locations of the ramping rope failure point and the deck beam fracture

grease; some showed signs of corrosion and wire strand damage **(Figure 15)**. The deck beam fracture appeared to have started at its bottom plate and propagated up to the deck's top plate through a vertical weld seam. The quality of the weld appeared to be poor.

Steps were taken to preserve evidence and sections of steel wire rope and the deck structure were identified for removal and testing. Wightlink arranged for the identified sections to be cut from the vessel and forwarded to The Test House (Cambridge) Ltd (TTH) for laboratory analysis.

The certificate of test and examination for the failed 28mm steel wire ramping rope fitted to the starboard forward mezzanine deck is at **Annex A**.

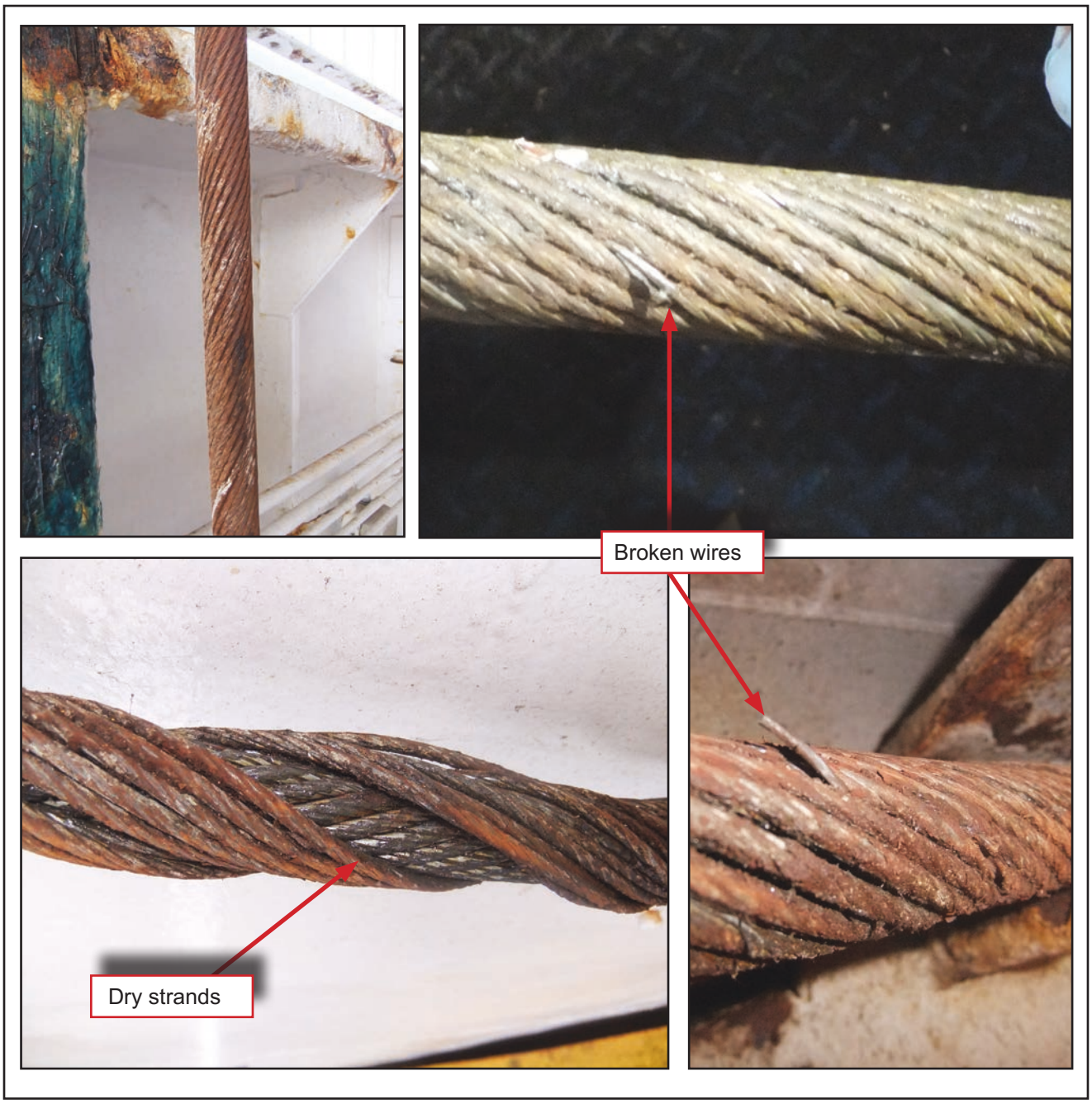


Figure 15: Condition of *St Helen*'s mezzanine deck steel wire lifting ropes

1.9.2 Laboratory analysis conducted by The Test House (Cambridge) Ltd

TTH was tasked to conduct a detailed inspection of the failed rope and its associated mezzanine deck sheaves. It was also tasked to conduct a break load test on the starboard forward mezzanine deck's outboard ramping rope, and a detailed examination of the longitudinal beam fracture.

TTH found that the outer strands of both inboard and outboard steel wire ropes were dry and had suffered mechanical wear **(Figure 16)**. TTH also identified that there was little penetration of lubrication to the internal strands of the ropes.

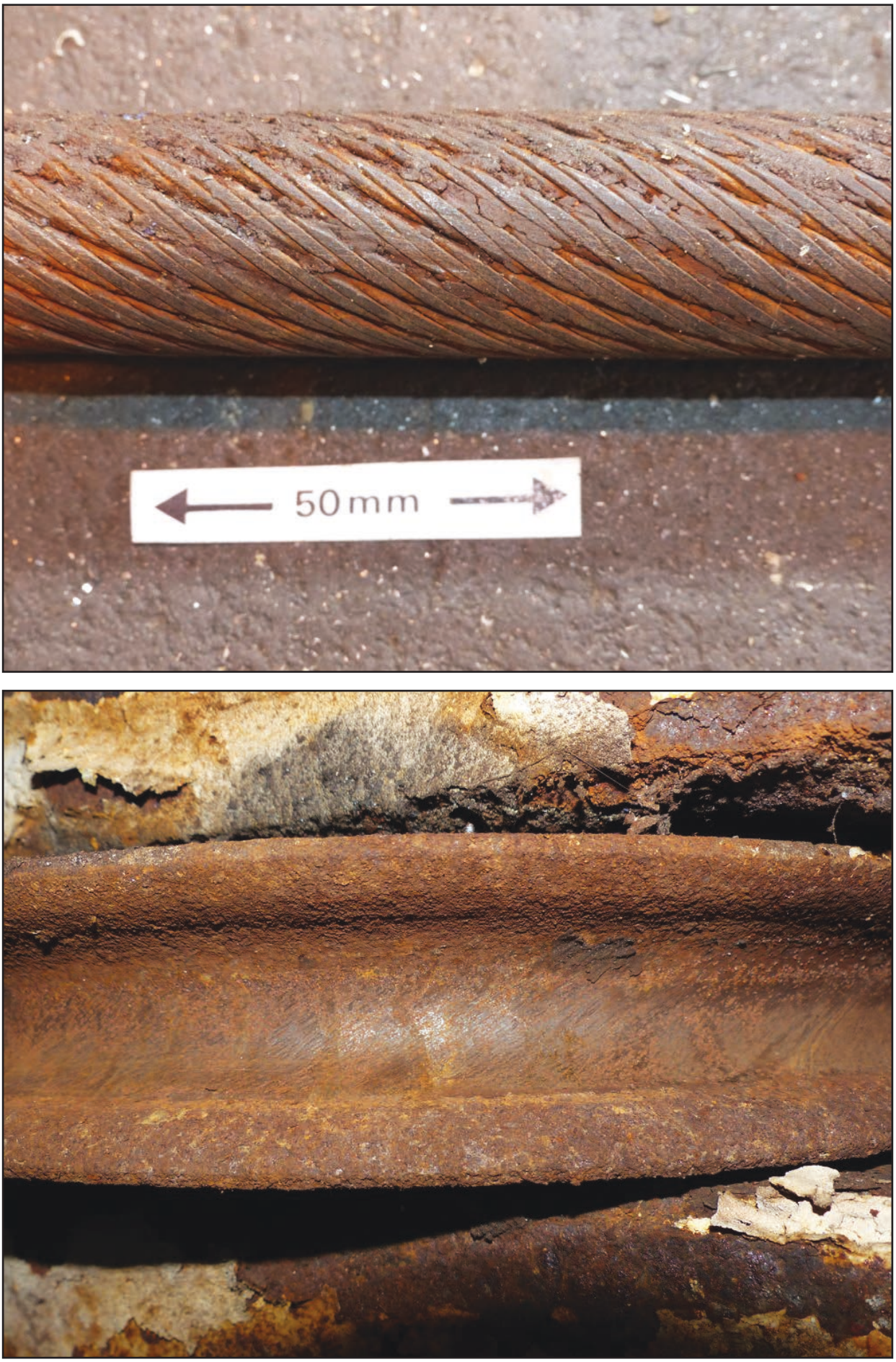


Figure 16: Photographs from the TTH report

TTH attributed the external wear to abrasion of the crown wires in the outer strands of the rope resulting from rubbing contact, under pressure with the grooves of the sheaves. The internal wear was caused by friction between the rope's individual wire strands. Referring to the failed rope, the report stated:

> *Our detailed examination concludes that the dominant factor at the break site appeared to be overload due to excessive mechanical wear which in turn resulted from lack of service lubrication. Corrosion and fatigue are secondary contributing factors which are also attributed to the lack of lubrication.*

The report also identified that the wire rope sheave grooves had suffered wear **(Figure 16)**. The ramping wire's vertical sheave was deformed, and off centred wear was found on its horizontal sheave, which was indicative of an incorrect fleet angle[5]. Both sheaves showed material wastage through corrosion and the absence of lubrication.

TTH identified a number of factors that had contributed to the parting of the inboard ramping rope. These included the apparent failure to:

- Maintain a suitably protective level of service lubricant on the rope.
- Maintain a suitably protective level of service lubricant on the sheaves.
- Monitor the ropes' condition through regular effective inspections.
- Monitor the groove wear of the sheaves and their fleet angles.

The deck beam examination found that the fracture had propagated through the beam plate and vertical welded seam in a ductile manner. This suggested that the beam failure was consequential damage arising from a change in loading after the rope failure.

The report stated that:

> *The fractured deck beam weld was grossly riddled with worm holes and porosity, lack of fusion and slag inclusions. The weld was covered up with layers of paint during its service …The flaws resulted in the load bearing capacity of the weld being severely diminished.*

The report also stated that the flaws in the weld should have been identified by visual inspection at the fabrication stage. A copy of TTH's report, and selected photographs, are at **Annex B**.

1.9.3 Equipment manufacturer's inspections

At Wightlink's request, the original equipment manufacturer, MacGregor, conducted detailed inspections of all the mezzanine decks, and other MacGregor equipment fitted on board its conventional ferries.

[5] The angle between the centreline through the sheave and the centreline of the rope leading to the sheave is called the fleet angle.

MacGregor's inspections identified a range of issues that supported the findings in the TTH report. In particular, the manufacturer's reports highlighted that the lifting ropes had not been protected against corrosion, several lifting ropes were found to be damaged, and many of the rope sheaves were corroded and had visible imprints of the steel wires in their grooves. The MacGregor inspections also found examples of:

- Incorrect adjustment of lifting ropes.
- Slack wire rope adjusting mechanisms.
- Ropes fouling the edges of the deck beam lightning holes.
- Hydraulic pipe corrosion.
- Hydraulic oil leaks from various components.

The inspections of the MacGregor bow and stern doors found:

- A lack of lubrication on the door assemblies.
- Wear on bow and stern door locking mechanisms.
- Inoperative warning sirens.
- Damaged guide rails.

A copy of *St Helen*'s inspection report is at **Annex C**.

1.10 SAFETY MANAGEMENT

1.10.1 Wightlink's safety management system

St Helen was a domestic passenger ferry, and Wightlink's operations were limited to UK internal waters. Despite this, Wightlink voluntarily undertook to comply with the requirements set out in the International Safety Management (ISM) Code[6].

Wightlink's safety management system (SMS) was predominantly paper-based and its key processes and procedures were set out in its SMS manual. The SMS manual was supported by the company's risk assessments and several individual guidance and instructions manuals. The company's Designated Person[7] (DP) was responsible for the maintenance and development of the SMS. The upkeep of some guidance and instruction manuals had been delegated to senior masters and other senior staff.

The SMS manual was last reviewed in November 2013 and the risk assessment for operating the mezzanine decks **(Annex D)** was last reviewed on 24 May 2010. The failure of a lifting rope was not identified as a hazard.

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[6] The International Safety Management (ISM) Code provides an international standard for the safe management and operation of ships and for pollution prevention. Under Chapter IX of SOLAS, management for the Safe Operation of Ships requires the mandatory application of the ISM Code on ships engaged on international voyages.

[7] The DP is the link between ship and shore senior management.

1.10.2 Maintenance management system

The company's maintenance management system comprised planned maintenance schedules, inspection routines and procedures for rectifying in-service defects. The system was primarily paper-based, but did include some electronic planned maintenance sheets for the main propulsion systems and some of the auxiliary equipment in the engine room.

Machinery breakdowns and equipment defects were recorded by the ship's crew in the vessel's defect report books. The defects were either rectified by the ship's crew, or repair requests were submitted for shore-based assistance. The repair requests were processed by the route superintendent; basic defects were allocated to the company's shore-based technicians; and, more complex defects were contracted out to specialist companies.

The defect repair tasks allocated to Wightlink's shore-based technicians were usually delivered verbally by the route superintendent. Once the technicians had completed the repairs they were expected to record their work in the ship's engine room logbooks.

1.11 MEZZANINE DECK MAINTENANCE

1.11.1 Planned maintenance schedules and inspection routines

In accordance with the Company operations manual, the chief officer on board each ship was responsible for the safe operation of the mezzanine decks and for ensuring that they had been maintained in accordance with the equipment manufacturer's instructions. Wightlink's planned maintenance system included daily, monthly, 6-monthly and 4-yearly mezzanine deck maintenance and inspection routines.

Daily and monthly inspections were conducted by the ship's crew and recorded in various logbooks and checklists. The 6-monthly inspections were conducted by an external surveyor and the 4-yearly overhauls were typically carried out during annual refit periods by dock workers and shore contractors.

1.11.2 Daily crew inspections

After an overnight or longer layover period, a member of the deck crew inspected the mezzanine decks prior to loading vehicles for the first crossing of the day. This included a visual inspection of the lifting ropes. The inspections were recorded on a daily inspection log sheet. Additionally, any faults or other problems that were identified during the crossings were recorded within the vessel's *bridge day book*.

At the end of every shift the master completed an *operational status* form listing the status[8] of all critical and important equipment. The mezzanine decks were classified as 'Important' equipment. The last status report recorded on the day of the collapse gave the starboard forward mezzanine deck an operational status of 'A'.

[8] The operational status equipment was categorised as: A – *Operational*, B – *Defect*, and C – *Non-operational*.

1.11.3 Monthly maintenance schedules and inspection routines

The deck officers were required to carry out a monthly visual inspection and operational function test of each mezzanine deck and their control boxes. The monthly inspection checklist did not require the lubrication status of the lifting ropes to be recorded.

During the months preceding the accident, the operational status of *St Helen*'s mezzanine decks was consistently recorded as 'A'. A monthly inspection of the starboard forward mezzanine deck was conducted on 7 July 2014, 11 days before it collapsed **(Annex E)**.

In addition to the daily and monthly visual inspections and function tests, the crew were required to complete a monthly deck equipment greasing routine. The mezzanine deck lifting ropes were not included on the greasing routine checklist.

1.11.4 Six-monthly thorough examinations

Wightlink had contracted the Royal & Sun Alliance Engineering Inspection & Consultancy (RSA) to conduct 6-monthly thorough examinations of all its vessels' lifting equipment. The list of equipment examined included the mezzanine decks. On 1 May 2014, 2½ months before the starboard forward deck collapsed, an RSA surveyor carried out a 6-monthly thorough examination of the mezzanine decks on board *St Helen*.

The results of RSA's examinations are discussed at **1.14.3**.

1.11.5 Four-yearly overhauls

The mezzanine decks on board Wightlink's *Saint* Class vessels were subject to a 4-yearly maintenance cycle. The company's aim was to carry out one major mezzanine deck overhaul during each annual refit period. The 4-yearly overhaul included the replacement of the steel wire lifting ropes and the repair or replacement of the wire rope sheaves.

St Helen's starboard forward mezzanine deck was last overhauled and its lifting ropes replaced in March 2010 **(Table 2)**.

Table 2: *St Helen*'s mezzanine deck 4-yearly overhaul and scheduled steel wire lifting rope replacement history January 2003 to 18 July 2014

Port Forward	Port Aft	Starboard Forward	Starboard Aft
June 2014	March 2012	March 2010	November 2012
January 2010	January 2008	January 2007	January 2009
February 2006	January 2004	January 2003	February 2005

When *St Helen* had its 2014 annual refit (22 - 30 April), the 4-yearly overhauls of its forward mezzanine decks were overdue. Because of time constraints, the overhauls were postponed. The port forward deck was subsequently overhauled in June 2014;

the starboard forward deck was deferred until September 2014. At the time of the accident, the starboard forward mezzanine deck's lifting ropes had been in service for 4 years and 3 months[9].

1.11.6 Defect repairs

St Helen's bridge day book showed a range of problems that were encountered and had to be addressed on a regular basis. These included locking bolts not retracting, slack ropes, slow moving decks and oil leaks. Examples of near misses and structural damage caused by vehicle impacts were also recorded.

In November 2012, a damaged lifting rope on the port forward mezzanine deck rope was renewed. Other examples of mezzanine deck damage that required contractor assistance include:

> *13 March 2013: Stbd aft mezz deck – crack approx. 250mm long on stbd side approx. 10m fwd of flap. Visible from both sides.* [sic]
>
> *19 July 2013 - Please arrange for repair of port aft mezz deck frame as sheared and bent by impact by high lorry. Allow for 1.5m x 0.5m x 10mm of steel.* [sic]

1.12 WIRE ROPE MAINTENANCE

1.12.1 Manufacturer's requirements

MacGregor's list of recommended inspection and maintenance routines included:

- Wire ropes to be inspected according to stipulations issued by classification societies, national bodies and ISO 4309-1981(E)[10].
- Wire ropes and wire rope sheaves to be lubricated with recommended grease at recommended intervals.
- Wire rope sheaves to be aligned carefully after replacing or repairing.
- Rope installation and lubrication to be checked by a competent person, preferably a member of MacGregor staff.

MacGregor's maintenance instructions recommended a 4-weekly lubrication routine for its mezzanine deck lifting ropes and lifting rope sheaves. It also advised that local practical/operational aspects would determine the extent of lubrication required to obtain the maximum working life of the equipment.

MacGregor did not give a maximum working life for the steel wire lifting ropes but did provide guidance on when they should be discarded. The discard criteria included:

- *Thread breakage according to authorities and ISO 4309-1981(E).*

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[9] Note: Table 2 shows that the port forward deck overhaul had taken place 5 months after the planned 4-yearly maintenance cycle

[10] ISO 4309:1981(E) had been subject to several revisions; at the time of the incident, the extant version of the international standard was ISO 4309:2010 – Cranes – Wire ropes – Care and maintenance, inspection and discard.

- *The wire rope is badly flattened.*
- *There is a kink at the wire rope.*
- *Inner damage of the wire rope i.e. rust, broken steel or fibre cord. (Often indicated by deformated or thinner parts of the wire rope.)*
- *Suspected that the inner parts of the wire rope are damaged due to strong friction between strands.*
- *Broken threads close to end fittings.*

The instructions also recommended that operators should contact their service department for advice if they had any doubts over the condition of wire ropes.

The TTH report **(Annex B)** emphasised that had the inboard ramping rope been managed in accordance with the best practice specified in ISO 4309:2010, its condition should have been recognised earlier and the rope discarded before it parted.

1.12.2 Wightlink wire rope dressing routine

A company-produced document entitled 'Mezzanine deck – guidance notes', dated 11/5/88, provided operational information and drawings of the *Saint* Class vessels' mezzanine decks for maintenance purposes. Under the section heading 'Care of rope' it stated:

> *The Heart of the rope is to give flexibility and to provide a means of lubricating the wire. This is achieved by oiling with fish oil or other suitable oil, in our case Ensis oil is used.*

Under the heading 'Maintenance of mezz decks and prows', the guidance notes stated:

> *Grease sheaves, check wires for dryness and rusting.*

The work had typically been carried out during vessel layup by the vessels' deck crew, and included the lubrication and adjustment of the mezzanine decks' lifting ropes and sheaves **(Figure 17)**. Despite this guidance it was evident that Wightlink had experienced difficulties implementing a robust greasing and lubrication routine for its mezzanine decks and their steel wire lifting ropes over a prolonged period of time. Over greasing of the exposed lifting wires, in the late 1980's and early 1990's, had resulted in the soiling of passenger clothing and cars but this problem was largely mitigated by the fitting of the rope guards.

In the mid-1990's, changes to ship scheduling, because of mezzanine deck height clearances, and crew rostering, reduced the opportunities for the deck crews to carry out lifting rope lubrication on *St Catherine* and *St Helen*. Responsibility for rope maintenance was then transferred to the engineering department. After the subsequent transfer of some of the engineering department staff to a shore-based maintenance team, lubrication of the ropes decreased further.

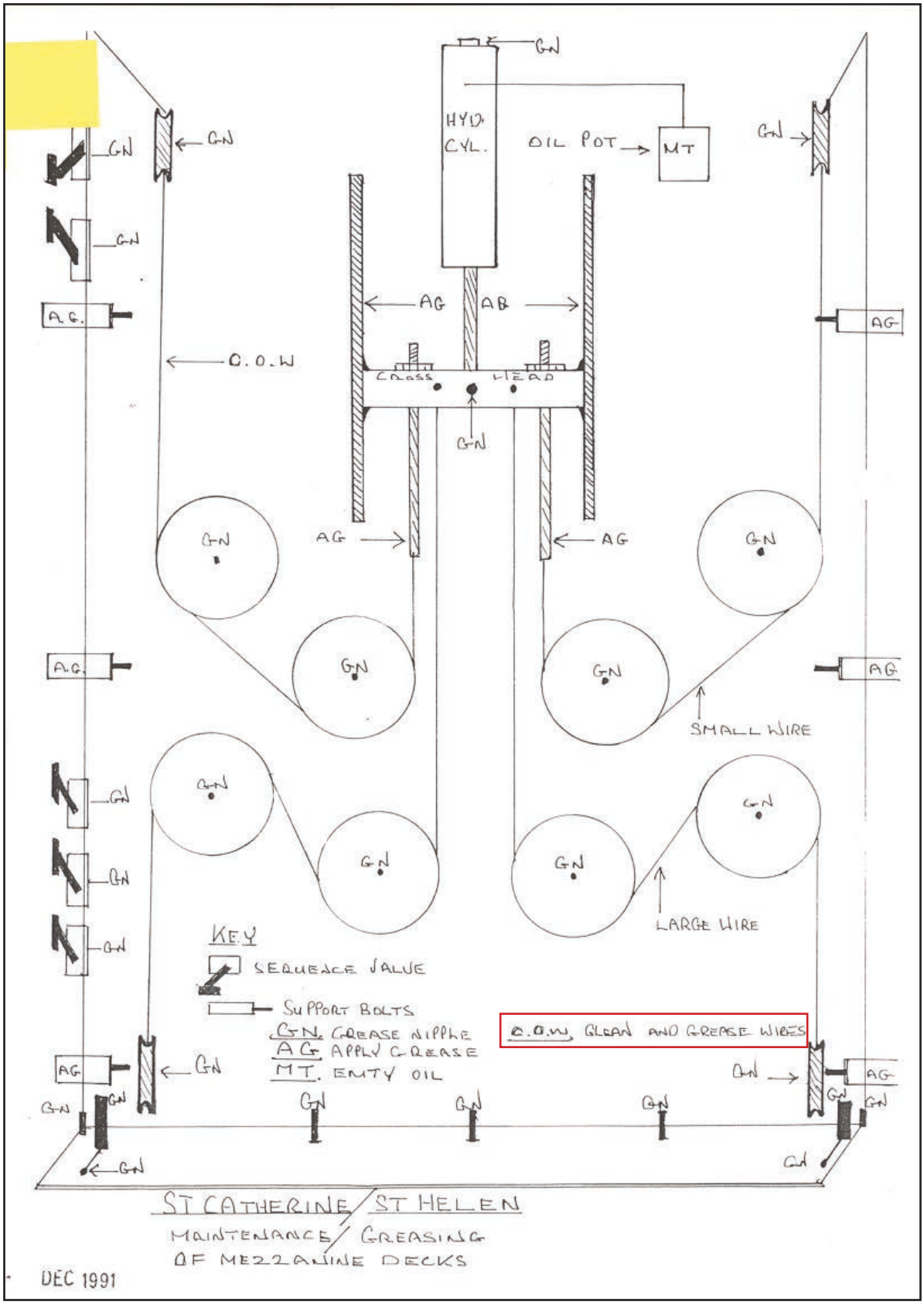

Figure 17: Mezzanine deck maintenance plan used in 1991

Post 2002, after the introduction of *St Clare,* and further changes to ship scheduling and crew rostering arrangements, wire rope lubrication became less frequent as the older *Saint* Class vessels were commonly laid up overnight, without deck crew on board, and there was little opportunity to conduct in service maintenance. This problem persisted throughout the following decade, and the weaknesses in the mezzanine deck maintenance routines and the lack of a formal wire rope dressing routine were periodically highlighted as a safety risk by Wightlink's masters on several occasions.

Wightlink had no record of *St Helen*'s mezzanine deck lifting ropes being oiled or greased during the 4-year maintenance cycle prior to the collapse of the mezzanine deck. However, it is understood that the shore-based fleet technicians lubricated the ropes during May 2014. The oil used, Exxon Mobil MOBILARMA LT, was a general purpose rust preventative and was not suitable for use as a wire rope lubricant.

1.13 REGULATORY REQUIREMENTS

1.13.1 Maintenance and inspection of ships' work equipment

The UK requirements for the maintenance and inspection of work equipment are set out in the Merchant Shipping and Fishing Vessels (Provision and Use of Work Equipment) Regulations 2006 (PUWER). Additional requirements for ships' lifting equipment[11] are provided in the Merchant Shipping and Fishing Vessels (Lifting Operations and Lifting Equipment) Regulations 2006 (LOLER).

PUWER and LOLER place the onus on the employer to ensure that work equipment, including lifting equipment, is appropriate for its intended purpose and is safe to use. MCA's interpretation of the PUWER and LOLER regulations was provided in its Marine Guidance Note (MGN) 331 (M+F), and 332 (M+F) respectively.

PUWER requires all work equipment to be subject to regular preventative maintenance, repairs, inspections, examinations and tests. This work must be properly planned, appropriately supervised and carried out in accordance with the manufacturer's instructions by trained competent persons. Records of maintenance, inspections and tests are also required to be kept.

Section 4.4 of MGN 331 stated:

> *The condition of all ropes and chains should be checked regularly for wear, damage and corrosion and replaced as necessary*.

St Helen's mezzanine decks were classed as lifting equipment used for lifting persons. The additional requirements for lifting equipment set out in LOLER, include periodic thorough examinations and inspections. Regulation 12 states, inter alia:

> *the employer shall ensure that where lifting equipment or an accessory for lifting is exposed to conditions causing deterioration which is liable to result in dangerous situations, it is*
>
> *(a) thoroughly examined*

[11] Lifting equipment means work equipment used for lifting or lowering loads and includes its attachments used for anchoring, fixing or supporting it.

(i) in the case of lifting equipment for lifting persons or an accessory for lifting, at least every 6 months;…

(b) if appropriate, inspected by a competent person at suitable intervals,… to ensure that health and safety conditions are maintained and that any deterioration can be detected and remedied in good time.

MGN 332 provided definitions of 'thorough examination' and 'inspection' as follows:

Thorough Examination means a detailed visual examination by a 'competent person', supplemented if necessary by other suitable means or measures in order to arrive at a reliable conclusion as to the safety of the lifting equipment or accessory for lifting examined. Additionally it is recommended, following any overload test or dismantling of gear that a function test with a nominal load is also carried out before any lifting equipment is put into service.

Inspection means a visual inspection by a 'competent person' to establish that no defects or deterioration is present in the equipment and that it remains safe to use.

Under the regulations, the person making a thorough examination had to notify the employer, or person responsible for the lifting equipment, of any deficiency that, in his opinion, was or could become a danger to persons. The equipment examiner was also required to submit a report of his findings to the employer as soon as practicable. If, in the examiner's opinion, a deficiency posed an existing or imminent risk of serious personal injury, he was required to send a copy of the report to the relevant enforcing authority.

Where an employer has been notified of a deficiency that is liable to result in a dangerous situation, they must ensure that it is remedied in good time. In the case of a deficiency that poses an existing or imminent risk of serious personal injury, the lifting equipment must be taken out of service until the deficiency is rectified.

Both LOLER and PUWER place an onus on employers to liaise with equipment manufacturers and consider the appropriate codes of practice and standards when determining the tests to be conducted. An employer must also determine who is a competent person to operate, maintain, examine and test work equipment.

1.13.2 Code of Safe Working Practices for Merchant Seamen

The CoSWP requires ship owners to identify all lifting appliances and associated loose gear and list them in a lifting gear register. All tests and thorough examinations are also to be certified by a nominated competent person using a prescribed format. Any defects or deficiencies identified must be recorded and any that could become a danger to persons must be reported to the employer.

Section 7.2.3 of CoSWP stated:

The decision on what maintenance work is required rests with the employer/ competent person however the following should normally form part of a maintenance routine:-

(a) greasing of bearings etc. should be thorough and frequent as bearings and other moving parts that are dry will impose additional loads that can lead to failure;

(b) the condition of all ropes and chains should be checked regularly for wear, damage and corrosion and replaced as necessary.

Section 20.9.8 of CoSWP stated:

When using steel wire ropes it is important that they are properly installed, maintained and lubricated as appropriate to their use. Manufacturer's guidelines and recommendations for use should be followed.

Chapter 21 of CoSWP details the measures intended to protect people from the risks associated from the provision and use of lifting equipment.

Section 21.12.18 stated:

Wire ropes should be regularly inspected and treated with suitable lubricants. These should be thoroughly applied so as to prevent internal corrosion as well as corrosion on the outside. The ropes should never be allowed to dry out.

1.13.3 Approved Codes of Practice and Health and Safety Executive guidance for lifting equipment

The Merchant Shipping PUWER and LOLER regulations are similar to the UK's land regulations[12] for work and lifting equipment. The land regulations are supported by Approved Codes of Practice (ACOPs)[13] and guidance material provided by the UK government's Health and Safety Executive (HSE). The HSE publication INDG422 - *Thorough Examination of lifting Equipment*, stated:

….lifting equipment may also need to be inspected at suitable intervals between thorough examinations. This is usually where your risk assessment has identified a significant risk from the use of the equipment.

The HSE advises employers not to wait for the results of a thorough examination before carrying out maintenance on their lifting equipment. The guide also explains that:

If the competent person discovers a defect that involves an existing or imminent risk of serious personal injury, then they must tell you immediately and send a copy of the report to the relevant enforcing authority[14] *(HSE or the local authority), even if the defects are remedied immediately. A competent person who fails to report a defect, simply because it has been remedied on the spot, is disguising a potentially dangerous situation*.

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[12] The *Provision and Use of Work Equipment Regulations 1998 (PUWER)*; and the *Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)*.

[13] ACOP L22: *Safe use of work equipment - Provision and Use of Work Equipment Regulations 1998*; and, ACOP L113: *Safe use of lifting equipment - Lifting Operations and Lifting Equipment Regulations 1998*.

[14] In the case of UK registered ships, the MCA is the enforcing authority.

1.14 LIFTING EQUIPMENT THOROUGH EXAMINATIONS

1.14.1 Royal & Sun Alliance Engineering Inspection & Consultancy

RSA offered a range of machinery and equipment commissioning, approval and inspection services that were intended to assist its customers to meet their regulatory requirements. The provision of a competent person[15] to carry out the mandated periodic thorough examinations of lifting equipment was one of the services offered.

Since April 2000, the 6-monthly thorough examinations of Wightlink's mezzanine decks had been conducted by RSA surveyors. Between November 2009 and July 2014, the same surveyor had conducted all the examinations. The surveyor had a marine engineering background and had been employed by RSA since October 1998. In addition to his marine engineering qualifications and experience, he had completed a range of specialist lifting equipment and wire rope examination training courses.

RSA's surveyors were provided with *risk assessments*, *risk analysis documents, method statements and inspection procedures* for a generic group of lifting equipment. The risk analysis document set out the basic scope of the examination based on the risk of individual component failure. In respect of the risk rating, RSA provided the following guidance:

> *Assessment of all components included in the Risk Analysis' must be undertaken at each examination, however, components in the higher risk rating groups may require a relatively more intrusive inspection regime or more frequent supplementary examinations or tests.*

As RSA primarily assessed shore-based machinery, it did not have an inspection procedure for hoistable ramp-type car decks. The inspection procedure that RSA considered most appropriate for the mezzanine decks was its *Vehicle Lift – Four Post screw lift or rope type* **(Annex F)**. In respect of the thorough examination of vehicle lifts, RSA's risk analysis document assessed the consequences of a failed lifting rope to be catastrophic, and the scope of the examination included:

- Visual examination to assess integrity, security and condition of components.
- Check ropes for broken wires, reduction in diameter, corrosion.
- Check sheaves for correct operation, wear, scoring, bearing/bush wear.

The RSA surveyors were also provided with an aide-mémoire for wire rope rejection or discard criteria. The aide-mémoire reflected the rejection criteria contained within ISO 4309 and RSA surveyors were also provided with a copy of the ISO standard itself as part of the guidance documents supplied for their reference when undertaking examinations.

[15] RSA defined a competent person as: *a person who has the appropriate practical and theoretical knowledge and actual experience of the plant they are examining to enable them to detect defects or weaknesses and to assess their importance in relation to the safety and continued use of the plant.* This definition was similar to that provided by the HSE in its PUWER and LOLER ACOPs.

1.14.2 Wightlink ro-ro vessel mezzanine decks

The thorough examination of Wightlink's ro-ro vessels' mezzanine decks was usually carried out while the vessels were in operation, and often while vehicles were parked on them. Typically, the RSA surveyor would examine the mezzanine decks on board two vessels during one 6-hour visit.

The structures and components inspected during a thorough examination of *St Helen*'s mezzanine decks included: the longitudinal and transverse deck beams; the lifting guides; the fixed ends of the hydraulic rams; and the full length of the wire ropes, including the end sockets and pins. Once the inspections were complete the surveyor's examination reports were sent to Wightlink and copies were held on board each ship.

RSA's examination reports were set out generally in accordance with the requirements of the land-based LOLER regulations. Dangerous defects were recorded in Section 6 of RSA's reports, and other defects were recorded in Section 7. The examiner's general observations[16] were recorded in Section 8 of the reports.

The dangerous defects listed in Section 6 of the reports were required to be given a time period by which a specified remedy should be carried out. Items identified in Sections 7 and 8 were not given a time period for repair as this was the responsibility of Wightlink as part of its maintenance regime.

Prior to and during his visits, the RSA surveyor had access to his previous examination reports. In Section 8 of his previous reports, he had regularly instructed the ships' crews to *clean and dress* the mezzanine deck lifting ropes. The surveyor did not deem the corrosion on the lifting wire ropes as meeting the rejection, or discard, criteria as set out in the relevant ISO standard (paragraph 1.15).

1.14.3 RSA examination report data

The report of the examination of *St Helen*'s starboard forward mezzanine deck carried out on 1 May 2014 **(Annex G)**, included:

Section 6:

None

Section 7:

The platform longitudinals and transverse deep beams have isolated areas of wastage and a general breakdown of preservation coatings. All affected areas particularly around the diverting sheave and hinge pin and support boxes should be cleaned back to bright metal and suitable preservation coatings applied

Section 8 stated:

Suspension ropes[17] remain serviceable, they should be cleaned and dressed[18].

[16] An observation is a statement of fact.

[17] The RSA surveyor referred to the mezzanine deck lifting ropes as *suspension* ropes.

[18] The expectation was that the ropes should be cleaned of contaminants (i.e. rust) with a wire brush, and lubricated with a protective coating, in accordance with the manufacturer's guidance

Between March 2007 and July 2014, RSA carried out 45 thorough examinations of *St Helen*'s mezzanine decks. Analysis of those reports revealed the following statistics:

Section 6 - *Dangerous defects*:

- No dangerous defects were identified.

Section 7 - *Other defects and remedies*:

- 58% (26) of the reports highlighted examples of mechanical wear.
- 100% (45) noted failures of the preservation coatings.

Section 8 - *Observations*:

- 82% (37) of the reports stated that *Suspension ropes should be cleaned and dressed*.

Analysis of the reports for *St Helen*'s other lifting equipment found that defects or corrosion had been identified on 90% of the reports for bow and stern doors, and the passenger lifts.

On 28 July 2014 (10 days after the accident), RSA conducted thorough examinations of the mezzanine decks on board *St Faith* and *St Cecilia.* Failures of preservation coatings were identified on all of the eight decks (four per vessel), and examples of mechanical wear were found on six of the decks. Observations were made about the condition of the steel wire lifting ropes on seven of the eight decks.

1.14.4 Thorough examination quality assurance

RSA was accredited by the Accreditation Services (UKAS) as a Type A inspection body and as such was subject to annual audit by UKAS. Its quality management system included a number of procedures to monitor the examination work and reports produced by its surveyors. The checks included:

- A periodic technical audit of the surveyors' work during an examination of lifting equipment.
- An assessment day in which the surveyor was accompanied by a line manager during a customer site visit.
- A review of representative samples of reports produced over a period of between 6 months and 2 years.

In addition, RSA benchmarked its surveyors' reports against nationwide statistics and reviewed their operating licences at 4-yearly intervals.

On some occasions where it was identified that its clients had not carried out the actions recommended by its surveyors, RSA had sent letters highlighting the issues of concern. No such letters had been sent to Wightlink.

1.15 INDUSTRY GUIDANCE

The international standard for care and maintenance, inspection and discard of steel wire ropes used for cranes and hoists is set out by the International Organization for Standardization (ISO) in standard ISO 4309:2010[19].

With regard to maintenance, the ISO standard states, inter alia:

> *Maintenance of the rope shall be carried out relative to the type of crane, its frequency of use, the environmental conditions and the type of rope.*
>
> *During the life of the rope, and before it shows any signs of dryness or corrosion, particularly over those lengths which travel through sheaves and enter and exit the drum and those sections which are coincident with a compensating sheave, the rope shall be dressed from time to time, as determined by a competent person. In some cases, it may be necessary to clean the rope before applying the dressing in order for it to be effective.*
>
> *The rope dressing shall be compatible with the original lubricant applied by the rope manufacturer and shall have penetrating characteristics. …*
>
> *A shorter rope life is likely to result from a lack of maintenance, particularly if the crane or hoist is used in a corrosive environment or, for whatever reason, no rope dressing can be applied. In such cases, the period between inspections shall be reduced accordingly.*

With regard to corrosion, the standard states:

> *Corrosion occurs particularly in marine and in industrial polluted atmospheres and not only reduces the strength of the rope by reducing its metallic cross sectional area, but also accelerates fatigue by causing an irregular surface from which stress cracking can propagate. Severe corrosion can also cause decreased elasticity of the rope.*

Table 6, within the standard, provides the discard criteria for corrosion and intermediate severity ratings. For external corrosion, wires with a surface which was rough to the touch had a severity rating of 'High – 60%', and a wire which was heavily pitted had a severity rating of 'Discard – 100%'.

For internal corrosion, obvious visible signs, including corrosion debris exuding from the valleys between the strands gave a severity rating of 'Discard – 100%'.

Section 5.3 'Periodic inspection' includes:

> *5.3.3 Extent of inspection*
>
> *Each rope shall be inspected along its entire length.*
>
> *Particular care, however, shall be taken at the following critical areas and locations:*
>
> *c) any section that travels through one or more sheaves;*

[19] ISO 4309:2010 – Cranes – Wire ropes – Care and maintenance, inspection and discard.

f) in case of cranes performing a repetitive operation, any part of the rope that lies over a sheave while the crane is in a loaded condition;

j) any section that is subjected to abrasion by external features.

Section 6 'Discard criteria' provides the range of criteria that can lead to the wire rope being discarded. These include: visible broken wires, decrease in rope diameter, fracture of strands, corrosion, deformation and damage.

Section 6.5 'Corrosion' includes:

When assessing the extent of corrosion, it is important to recognize the difference between corrosion of the wires and any corrosion on the rope surface that is associated with the oxidation process of foreign particles.

Section 6.6 'Deformation and damage' includes:

6.6.1 General

Visible distortion of the rope from its normal shape is classified as deformation. It usually results in an uneven stress distribution in the rope in the area of the deformation, often found to be localized.

6.6.3 Basket deformation

Ropes with a basket or lantern deformation (…) shall be immediately discarded or, provided the remaining length of rope is in a serviceable condition, have the affected section removed.

1.16 THE INTERNATIONAL SAFETY MANAGEMENT CODE

1.16.1 Overview

The ISM Code places responsibilities for safety and environmental protection on the ship operators as well as those on board their ships. Documents of Compliance (DOCs) and Safety Management Certificates (SMCs) are issued to companies and ships respectively after it has been verified that they comply with the ISM Code. DOCs and SMCs are valid for 5 years, subject to periodic verification audits during that period.

Section 1.2 of the ISM Code sets out safety management objectives and states that the company should, inter alia:

- *provide for safe practices in ship operation and a safe working environment;*
- *assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards; and*
- *continuously improve safety management skills of personnel ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection.*

Section 10 of the ISM Code sets out the maintenance management requirements for the ship and its equipment. It requires ship owners and operators to establish procedures to ensure that the ship is maintained in conformity with the provisions of any relevant rules and regulations and with any additional requirements it might set. In meeting these requirements, the company should ensure that:

- *inspections are held at appropriate intervals;*
- *any non-conformity[20] is reported, with its possible cause, if known;*
- *appropriate corrective action is taken; and*
- *records of these activities are maintained.*

Owners and operators should identify equipment and technical systems, the sudden operational failure of which may result in hazardous situations. The SMS should provide for specific measures aimed at promoting the reliability of such equipment or systems.

1.16.2 Internal audits

Wightlink managed a programme of internal audits to verify that its safety and environmental protection practices complied with the company SMS. The audits were conducted by trained personnel at intervals of not more than 12 months, with the possibility of further audits as necessary.

At the time of the accident, Wightlink had several outstanding internally generated non-conformance reports (NCRs). Two of these related to non-conformities identified in early 2011, and four referred to the need to develop suitable databases.

1.16.3 Mezzanine deck maintenance non-conformance report

On 5 June 2012, *St Helen*'s master raised an NCR relating to the maintenance of the mezzanine decks on board *Saint Faith*. The NCR stated:

> *Maintenance of mezzanine decks OPM 12.5.3 Neither ER nor deck maintenance systems include requirement for greasing mezzanine decks. ER online system indicates for example that stbd aft mezzanine deck has not been greased since 2/06/11 (one year). Long term oversight that applies to all P~F car ferries.*

The corrective action suggested by the master on the NCR stated:

> *Implement robust greasing programme that is recordable and auditable. Possibly also applies to Saint Clare. Note that OPM 7.6.1 states C/O responsible for maintenance of mezz decks and SMS appendix B.4 states it is C/Eng responsibility.*

[20] A non-conformity means an observed situation where objective evidence indicates the non-fulfilment of a specified requirement of the ISM Code. A non-conformity should normally be closed out within 3 months of the date of the audit.

The maintenance shortfall applied to all the *Saint* Class vessels but the proposed corrective action was not implemented and the NCR expired on 5 September 2012. A new NCR was issued to replace it, which also time expired, as did the subsequent ones that replaced it. At the time of the mezzanine deck collapse the recommended corrective action had not been taken and the NCR was still extant.

1.16.4 Fleet management meetings

Wightlink's senior management team held fleet management meetings at 6-monthly intervals. During the fleet management meeting held on 16 October 2012, the mezzanine deck greasing routine NCR was raised as an agenda item by the company's DP. According to the minutes of the meeting, the DP explained that:

> *There is no time to do greasing whilst a St Class vessel is on the run, and it needs to be done properly [suggested possible use of fleet technicians]. The programme would need to be documented on a practical form, and be fully auditable.*

On 22 October 2013, the fleet management meeting minutes included the following update from the DP:

> *A Mezz Deck Greasing Programme is required for the St Class vessels. This will be carried out by the Fleet Technicians, but I will need to produce a formal procedure.* ***Work in progress.***

A similar update was provided at the meeting held on 23 April 2014.

1.16.5 MCA inspections and audits

Wightlink's last DOC certificate was renewed by the MCA on 15 October 2010, and *St Helen*'s SMC was renewed on 28 February 2012. Annual verification audits had subsequently been undertaken by the MCA.

A review of recent audit reports identified the following:

26/10/12: Wightlink DOC audit observation:

> *The numerous spreadsheets and checklists in use to control maintenance inhibit full and effective oversight & management of maintenance*

27/02/12: *St Helen* SMC audit minor non-conformity:

> *Some requests for repairs (eg to main structural superstructure due to corrosion) remain outstanding since 2009/10*

18/10/13: Wightlink DOC audit observation:

> *Mezzanine deck greasing NC is ongoing from June 2012.*

In addition to verifying compliance with the ISM Code, the MCA conducted the hull and machinery surveys for *St Helen*, *St Faith* and *St Cecilia*; Wightlink's other vessels were surveyed separately by a Classification Society. As such, structural

repairs and other work, which could affect *St Helen*'s certification, were expected to be reported to the MCA. This was to enable the regulator to decide whether or not its involvement was necessary to ensure that appropriate repairs were undertaken.

1.16.6 DOC removal

In August 2005, the DOC and SMCs for operating Wightlink's four high-speed craft were removed by the MCA due to failings in the SMS. These included a failure to report two engine room fires. The certificates were reinstated a short while later, after appropriate reporting procedures were introduced.

1.17 PREVIOUS MEZZANINE DECK INCIDENTS

1.17.1 *St Helen*

On 16 May 2012, a daily mezzanine deck inspection on board *St Helen* identified that the port forward deck's outboard ramping rope had suffered chafing and fraying damage, with several strands broken **(Figure 18)**. The repair request raised by the crew stated that the rope needed to be replaced.

The lifting rope was subsequently inspected by the company's route superintendent, who concluded that the damage had probably occurred when the rope was installed in 2010. The superintendent decided to keep the rope in service and instructed the crew to monitor its condition closely. Subsequent inspections on 23 May 2012, 17 July 2012 and 17 October 2012 found no further apparent deterioration.

On 7 November 2012, the RSA surveyor attended the vessel and immediately condemned the damaged rope. During the same visit the RSA surveyor condemned a lifting rope on *St Helen*'s starboard aft mezzanine deck. New ropes were fitted the following week.

1.17.2 Other *Saint* Class vessels

During the investigation, it was suggested that there might have been other lifting rope failures leading to the collapse of mezzanine decks on the *Saint* class vessels, however no concrete evidence could be found of these. In addition to ongoing operational problems, a range of incidents involving the mezzanine decks on the *Saint* Class vessels has occurred over a period of time. These include:

During the operation of one of *St Faith*'s mezzanine decks, its deck flap moved inboard from its vertical position. This was not noticed by the crew member operating the controls, and the deck subsequently snagged and twisted on the ship's superstructure. The warped deck had to be taken off the vessel for repair. Wightlink's investigation concluded that the operator was inexperienced and his lack of competence had contributed to the failure. The incident resulted in changes to both the company's training procedures and the competency requirements for the mezzanine deck operators.

Several incidents on board *St Cecilia* were also identified during the investigation. Of note:

A hydraulic fault resulted in the latch arm on one of the mezzanine decks not properly retracting, causing the deck to twist.

- A relatively new outboard lifting rope began to strand and unravel. Before it failed, the deck was taken out of service and the rope was replaced.

1.17.3 MAIB database

The most recent similar incident recorded on MAIB's database occurred on 5 December 2014. A ro-ro vessel, which had been converted to an accommodation vessel operating in the offshore sector, suffered a mezzanine deck collapse.

The senior officer had failed to disengage the locking bolts fully after raising the deck from the stowed position. The lifting ropes became slack, and when the pins were disengaged the deck fell to the main deck. Structural failure occurred to the hydraulic ram mounting points and minor damage occurred to the superstructure.

Figure 18: Photograph taken of a damaged mezzanine deck lifting rope by crew on board *St Helen* following an inspection carried out on 23 May 2012

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 COLLAPSE OF THE MEZZANINE DECK

St Helen's starboard forward mezzanine deck collapsed as it was being lowered to its ramped position during the disembarkation of passenger and freight vehicles at the Fishbourne ferry terminal. The forward inboard corner of the mezzanine deck fell from a height of about 2m and struck the main deck below. A crewman who was standing on the forward outboard side of the mezzanine deck, and several passengers who were seated in their cars, suffered minor impact and (in some cases) whiplash related injuries.

At the time of the collapse, the weight of the loaded mezzanine deck was being supported at its forward end by two 28mm diameter steel wire ramping ropes. On initial visual inspection it was evident that the mezzanine deck's inboard ramping rope had parted. The ramping rope was a single point of failure and, therefore, once it had parted there was nothing to prevent the inboard side of the deck collapsing.

2.3 FAILURE OF THE STEEL WIRE RAMPING ROPE

The steel wire ramping rope parted under tension at a point where it was passing over or between its inboard horizontal and vertical sheaves. The laboratory examination of the parted rope found that it had suffered both internal and external mechanical wear. Similar wear was found in the outboard ramping rope. The internal wear was caused by friction between individual wire strands within the rope; the external wear was caused by rubbing contact, under pressure, between the outer strands of the rope in the sheave grooves.

The fact that the rope failed under tensile load does not mean that it failed because it or the deck's SWL had been exceeded. At the time of failure, the deck was carrying 11 cars, their seated passengers and a crewman. As the deck was designed to accommodate up to 13½ cars, each weighing 1.5t, it is extremely unlikely that the deck was overloaded or the rope's SWL had been exceeded.

TTH's laboratory report identified that the internal abrasion wear had caused a reduction in the cross-section of the rope's individual wire strands. As the diameter of the wire strands diminished, and individual strands failed, the ramping rope was no longer able to support the load, and it parted.

Steel wire ropes are particularly susceptible to abrasion wear when they are subjected to bending. As the lifting ropes were fixed at both ends, each sheave rotated over the same respective section of wire rope each time the deck was raised or lowered. Given these localised repetitive compressive bending stresses, the location of failure, at a sheave, was not particularly surprising.

2.4 FAILURE OF THE LONGITUDINAL DECK BEAM

The fractured longitudinal deck beam was the only other significant damage to the mezzanine deck that was visually evident after the collapse. The structural beam was located on the inboard side of the deck and failed at a mid-length position close to the lifting wire ropes' inboard sheaves **(Figures 13 and 14)**.

The failure appeared to have occurred at a previous fracture point, which had been weld repaired to a poor standard. The quality of the weld repair had effectively left the mezzanine deck in a weakened condition. One of the initial objectives of the investigation was to determine if the deck beam failure had been causal to the rope parting or a consequence of the collapse.

The beam's horizontal bottom plate had suffered a ductile fracture that had propagated up through the welded repair in the beam's vertical plate towards the deck's top plate. A simple assessment of the component forces **(Figure 19)** acting on the structural beam in the area of the failure indicated that its bottom plate would probably have been in compression when the deck was suspended by its ramping ropes. Therefore, as highlighted in TTH's report, the fracture must have been consequential damage arising from a rapid change in loading after the rope failure and the deck's subsequent impact with the main deck.

2.5 MATERIAL CONDITION OF THE MEZZANINE DECKS

2.5.1 General

The post-accident inspections and the surveys conducted by the equipment manufacturer identified a substantial number of mezzanine deck defects on board *St Helen* and the other *Saint* Class vessels. Several common factors were identified; of note:

- Many of the steel wire lifting ropes were dry and had suffered from corrosion.
- Some of the lifting ropes had not been properly adjusted and were rubbing on the steel edges of the deck beams.
- Many of the sheaves had worn; some to the extent that they had assumed incorrect fleet angles.
- The decks' preservation coatings had not been maintained and there was evidence of extensive corrosion.

The *Saint* Class vessels' vehicle decks are not enclosed and the mezzanine decks and their lifting ropes are exposed to the wind and sea. As a result, the deck's preservation coatings and lifting wires are under constant corrosive attack from salt water and the damp salt laden atmosphere. This would explain why observations relating to the breakdown of deck preservation coatings were repeatedly made in RSA's 6-monthly examination reports. However, the deterioration of the decks' lifting ropes and their sheaves had occurred over a prolonged period of time and could easily have been avoided by the simple application of grease.

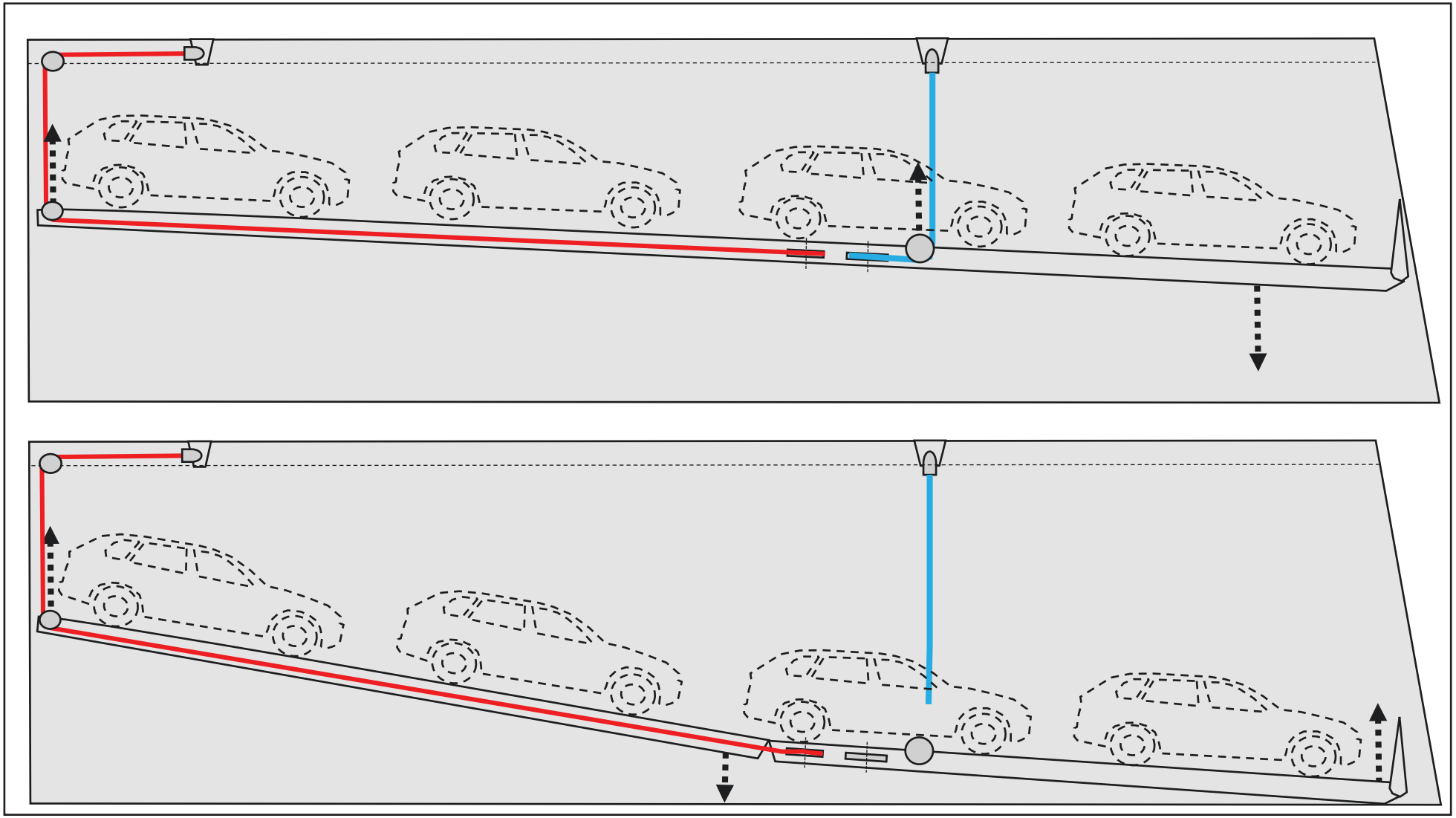

Figure 19: Change in the forces acting on the mezzanine deck's longitudinal beams after the wire rope parted

The condition of the lifting rope sheaves would have increased the stresses acting on the wire ropes and accelerated their deterioration. The sheaves' worn bearings and incorrect fleet angles would have affected the adjustment of the ropes and increased the likelihood of rubbing contact between the ropes and the decks' steel edges.

It was apparent that the material state of *St Helen*'s collapsed mezzanine deck had been allowed to deteriorate to a dangerous condition because it had not been maintained in accordance with the equipment manufacturer's instructions. Furthermore, the extent of the deterioration was not identified during the periodic inspections and 6-monthly examinations conducted by the ship's crew and the RSA surveyor.

2.5.2 Steel wire lifting ropes

It was evident that lubrication of the mezzanine deck steel wire lifting ropes on board Wightlink's vessels had fallen into abeyance over many years since the introduction of *St Clare* in 2002, and they had not been routinely dressed and lubricated. The outer strands of the collapsed deck's ramping ropes were dry and there was little penetration of lubrication to their inner strands.

Wightlink's management team was well aware of the maintenance shortcoming as it had been raised in communications from their masters on several occasions as a company SMS non-conformity 2 years earlier. The remedy was simple to implement but the non-conformity remained extant up until the rope failure. It was clearly apparent that there was no appetite within the company to implement a greasing routine as this would have required either manning the vessels during the night-time layup, or taking decks out of use while the vessels were in service.

To mitigate the risk of wire rope failure, Wightlink had a policy of discarding the lifting ropes after 4 years in service. However, the rope that parted had been in service for 4 years and 3 months. If the starboard forward mezzanine deck had been overhauled and its lifting ropes replaced as originally intended during *St Helen*'s refit in April 2014, the accident would not have happened. Nevertheless, the decision to delay the wire rope replacement should not mask the real issue. Steel wire ropes must always be properly maintained in accordance with best practice.

During production, steel wire ropes receive intensive lubrication to ensure ample protection against corrosion and to reduce the friction between the elements that make up the rope, as well as the friction between rope and sheaves or drums. However, this lubrication only lasts for a limited time and should be reapplied periodically as it is crucial to ensuring a rope's serviceability and minimum breaking load.

Unlike the newer *Saint* Class vessels, *St Helen*'s mezzanine decks had a single lifting rope arrangement. There was no redundancy or emergency back-up should a wire rope fail and each wire rope was effectively a single point of failure. Given that the mezzanine decks were lifting devices used to lift people, the maintenance regime for them, and in particular, their wire ropes, should have been of primary concern.

2.6 MAINTENANCE MANAGEMENT

St Helen, built in 1983, was the oldest vessel in the Wightlink fleet. The ageing ferry was becoming increasingly expensive to maintain but its retirement and Wightlink's vessel replacement plans had been deferred while the Isle of Wight Council's investigation into cross-Solent ferry crossings was being conducted. *St Helen* had the second largest operating budget in the fleet, but had experienced a catalogue of recurrent defects.

2.6.1 Record keeping

Wightlink's maintenance management system was primarily paper-based and comprised procedures for both planned maintenance and defect rectification. The vessels' engineers and deck crews, and Wightlink's shore-based technicians all had maintenance roles and responsibilities, and the route superintendents had overall responsibility for maintenance management on their vessels, and for co-ordinating activity between ships' crews and shore-based staff. Nonetheless, it was apparent that departmental roles and responsibilities were confused, and maintenance records, particularly those relating to defect rectification, were ad-hoc and incomplete. For example, no records could be found of either the earlier mezzanine deck beam failure on *St Helen*, nor of the weld repair carried out on the beam. Such a structural failure should have been reported to the MCA, and the repair subjected to a formal approval process. Further, the reported attempt to dress and lubricate *St Helen*'s mezzanine deck lifting ropes in April 2014 was carried out using a rust preventative instead of an approved lubricant, and the task was not recorded either on board or in the company's maintenance management system.

2.6.2 The impact of policy changes on the ownership of maintenance

Three of Wightlink's policy changes, taken over time, eventually interacted to detract from effective maintenance. These were: the rostering changes of the deck and engineering crews and transfer of maintenance to the shore-based team in the 1990's; and vessel scheduling, primarily the laying up of the older *Saint* Class vessels overnight following the introduction to service of the larger *St Clare* in 2002.

In the first instance, the manning arrangement meant that crews regularly moved between vessels, with the result that they no longer had ownership of the upkeep of a specific vessel. In the second, the shift of some maintenance responsibilities to the shore-based technicians resulted in a lack of clarity in some areas as to whether maintenance was a shore-based or crew responsibility, and within crews whether it was a deck or engineering responsibility. And finally, taking the older *Saint* Class out of service overnight and leaving them unmanned also reduced the time crews had available for maintenance.

2.6.3 Impact on rope maintenance

It was apparent that some of the changes above reduced opportunities to conduct deck maintenance and led to confusion as to who was responsible for some maintenance. As identified by the DP (Paragraph 1.16.4) there was no time to carry out lubrication maintenance while the *Saint* Class were operating, and therefore maintenance of the mezzanine decks suffered. Eventually, lack of rope lubrication became the norm, and heavy reliance was placed on the 6-monthly RSA examinations and the 4-yearly rope replacement policy.

2.6.4 International Association of Classification Societies (IACS[21]) Guidance

IACS has found that:

> *The management of shipboard maintenance is often regarded as an entirely technical matter, somehow unrelated to safety and pollution prevention, and the exclusive responsibility of the technical staff. As a result, shipboard maintenance is the least-developed and weakest element in many management systems.*

This certainly appeared to be the case with Wightlink's SMS. McGregor's post-accident inspection reports highlighted that the maintenance management shortcomings that contributed to the wire rope failure on board *St Helen* were not limited to the mezzanine decks and were evident fleet-wide.

2.7 SIX-MONTHLY THOROUGH EXAMINATIONS OF THE MEZZANINE DECKS

The mezzanine decks on board *St Helen* were classed as lifting equipment used for lifting persons. In accordance with the mandatory regulations set out in LOLER, they had to be subject to 6-monthly thorough examinations by a competent person. *St Helen*'s crew members conducted regular function tests and visual inspections of the mezzanine decks, but the task of conducting the thorough examinations had been delegated to RSA. RSA surveyors had conducted the 6-monthly thorough examinations of Wightlink's mezzanine decks for the past 14 years.

The RSA surveyor who had conducted the most recent examination of *St Helen*'s mezzanine decks (2½ months before the collapse) was well qualified. He had 5 years' experience with the vessel and its equipment, and had been an RSA surveyor for 16 years and was considered fully competent to conduct the 6-monthly thorough examinations. However, the number of defects found during the post-accident inspections, and the condition of the wire ropes in particular, is of serious concern and indicates a fundamental failing in the assurance process provided by RSA.

The root cause of the wire rope failure (lack of lubrication) was repeatedly identified and highlighted in the RSA surveyor's examination reports. Despite this, Wightlink took no steps to address the observations made in those examination reports. Of further concern, RSA did not rate the severity of the wire rope corrosion and took no steps to intervene; this was despite its generic inspection procedure and risk analysis documents identifying that the failure of a lifting rope presented a catastrophic risk.

Given the length of time the RSA surveyor had worked with Wightlink and its crew members, he should have gained a good understanding of the company's approach to its lifting rope maintenance. Having seen his inspection report observations being ignored repeatedly, he did not take the opportunity to escalate his concerns and raise a Section 6 *dangerous deficiency*. Had he done so, Wightlink would have been forced to take appropriate action to resolve its long-standing SMS non-conformity.

RSA had procedures in place to scrutinise and monitor its surveyors and their inspection reports. A review of the observations made in Section 8 of the Wightlink appointed surveyor's reports would have identified the repetitive nature of many

[21] IACs publication: The Guide to Managing Maintenance in Accordance with the Requirements of the ISM Code.

of the maintenance shortfalls discussed in this investigation report. Although the onus was on Wightlink to comply with the requirements set out in PUWER and LOLER, RSA had assumed the role of the company's competent person and had a responsibility to accurately reflect its findings. RSA also had a responsibility to report conditions liable to result in a dangerous situation, such as a damaged lifting rope, to the MCA. It did not do so, and therefore an opportunity for the regulator to intervene was lost.

2.8 INTERNAL AND EXTERNAL OVERSIGHT

General issues relating to maintenance management weaknesses were highlighted during Wightlink's internal SMS audits and the MCA's external ISM Code audits. Observations about the length of time taken to address internal NCRs were also recorded in internal and external audit reports.

The lack of a robust greasing programme for the mezzanine decks identified in an NCR in June 2012 was re-issued six times prior to the wire rope failure. The non-conformity could have been easily and quickly closed out with a written procedure for the fleet technicians to follow. However, the corrective action proposed at Wightlink's fleet management meetings was not implemented. This further highlights the conflict Wightlink had between maintaining the ropes in accordance with best practice and providing adequate resources and the necessary time to undertake the work.

The identification and rectification of SMS and maintenance management system weaknesses is crucial to ensuring the reliability of safety critical equipment. Effective audits provide a picture of the company's compliance, and the raising of NCRs can contribute to the continual improvement of safety and maintenance management performance. However, if the observations made and the corrective and preventative actions stipulated in NCRs are ignored, the process becomes a pointless form-filling exercise.

The MCA had recorded concerns about the conduct of maintenance during its recent DOC and SMC audits. These included: the multitude of maintenance documents and spreadsheets inhibiting effective management oversight, and structural repairs not being carried out. During a DOC audit on 18 October 2013 the MCA made an observation relating to the ongoing NCR for the lack of a robust greasing programme for the mezzanine decks. Given that the MCA audit occurred 16 months after the initial internal NCR was raised, and that the non-conformity had been re-issued four times by that stage, it would not have been unreasonable for the MCA to have registered the company's inaction as an ISM Code non-conformity. This would then have prompted Wightlink to take action to both respond to the non-conformity and to address the practical application of lubrication of the wire ropes.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. *St Helen*'s starboard forward mezzanine deck collapsed because one of its steel wire lifting ropes parted. [2.2]

2. The rope parted under normal working conditions. [2.3]

3. The parted rope had suffered excessive internal and external mechanical wear. This had caused a reduction in the cross-section of the rope's individual wire strands to a point where it could no longer support the weight of the loaded deck. [2.3]

4. *St Helen*'s mezzanine decks had not been maintained in accordance with the equipment manufacturer's instructions. This allowed the material condition of the collapsed deck to deteriorate to a dangerously unsafe condition. [2.5.1]

5. The material condition of the collapsed deck's wire rope sheaves increased the stresses acting on the lifting wires and contributed to the rope failure. [2.5.1]

6. Wightlink's mezzanine deck greasing routines had fallen into abeyance and their steel wire lifting ropes had not been routinely dressed and lubricated over many years. [2.5.2]

7. Wightlink's maintenance management system had weaknesses in key areas. In particular: maintenance roles and responsibilities were confused, record keeping was inconsistent and time was not allocated for the conduct of some essential maintenance. [2.6]

3.2 SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. One of the collapsed mezzanine deck's main structural beams failed on impact with the main deck. The beam failure occurred at the site of a previous fracture that had been repaired to a poor standard. [2.4]

2. The previous weld repair to the mezzanine deck's failed beam had not been subject to formal approval and had left the deck in a structurally weakened condition. [2.4]

3. Wightlink was aware that its mezzanine deck greasing routines had fallen into abeyance; the maintenance shortfall had been subject to an internal safety management system non-conformity for over 2 years. [2.5.2]

4. Following the introduction of *St Clare*, the lack of mezzanine deck lifting wire rope lubrication gradually became the norm, and lubrication was replaced by a heavy reliance on 6-monthly examinations and the 4-yearly rope replacement maintenance cycle. [2.6]

5. Wightlink's appointed lifting equipment surveyor repeatedly observed that the lifting wires for *Saint* Class mezzanine decks had not been dressed and lubricated. Given the previously identified potential catastrophic consequences of a lifting rope failure, the surveyor and/or his employers, Royal & Sun Alliance Engineering Inspection & Consultancy, should have elevated the recurrent report observations to a safety critical deficiency. [2.7]

6. As the mezzanine decks were raised and lowered with persons on them, the MCA should have been made aware of any structural failures. [2.7]

7. In respect of the requirement to introduce a mezzanine deck rope lubrication regime, Wightlink's processes for closing out non-conformities was ineffective. [2.8]

8. The MCA had made observations in its ISM Code audit reports about Wightlink's management of maintenance and the company's delay in addressing its mezzanine deck greasing routine non-conformity. The deck's lifting wires presented a single point of failure and, therefore, it would have been appropriate to raise an ISM Code non-conformity. [2.8]

SECTION 4 - ACTION TAKEN

4.1 MAIB

On 7 August 2014, the Chief Inspector of Marine Accidents wrote to Wightlink and:

- Recommended (MAIB recommendation 2014/136) that Wightlink implement, with immediate effect:
  - *a formal mezzanine deck wire dressing routine* on all its vessels with wire operated mezzanine decks, and
  - *seek independent assurance that the mezzanine decks and their hoisting/ support wires are of sound condition.*

4.2 ACTIONS TAKEN BY OTHER ORGANISATIONS

Wightlink has:

- Conducted immediate inspections on board all its vessels operating with MacGregor equipment to confirm the safe condition of the equipment, and replaced a number of wire ropes.
- Retired *St Helen* from service; prior to this its mezzanine decks had been permanently taken out of service.
- Written a formal monthly greasing schedule into an electronic planned maintenance system.
- Introduced a 30-month maximum wire rope replacement schedule.
- Developed a risk assessment to enable crew members to conduct mezzanine deck inspections while the decks are suspended only on the lifting wire ropes.
- Implemented a new centralised electronic Planned Maintenance System for all *Saint* Class vessels, and commenced roll out of the system across its other ships.
- Contracted the mezzanine deck manufacturers to carry out annual maintenance inspections.
- Contracted the mezzanine deck manufacturers to carry out annual maintenance inspections.

Royal & Sun Alliance Insurance Group Plc has:

Disposed of its engineering division, RSA Engineering Inspection & Consultancy, and no longer provides any engineering inspection services or inspections. All employees, contracts and intellectual property (except the trading name) have been acquired by the privately owned company British Engineering Services Ltd.

The Maritime and Coastguard Agency has:

Taken action in response to MAIB recommendation 2014/132 (*Celtic Carrier* investigation report) to improve its training and guidance provided to its surveyors on the raising and closing out of non-conformities.

SECTION 5 - RECOMMENDATIONS

2016/101 **Wightlink Ltd** is recommended to:

- Review and, as necessary, improve its safety management system to ensure the company:
  - Acts promptly in response to non-conformities affecting important and critical equipment on board its vessels.
  - Applies a proactive response to the management of observations and deficiencies identified during the thorough examination of its vessels' lifting equipment.
  - Notifies the relevant authority in the event of damage to a vessel that requires structural repair.

2016/102 **British Engineering Services Limited** is recommended to:

Ensure its policy on the scrutiny of its thorough examination reports:

- Identify the instances when its customers have repeatedly failed to address shortcomings identified during lifting equipment examinations, and
- Provide a mechanism for bringing shortcomings to the attention of its customers and, where appropriate, the relevant authorities.

2016/103 The **Maritime and Coastguard Agency** is recommended to ensure its audit inspections of Wightlink vessels provide specific focus on the effectiveness ofthe company's maintenance procedures.

Safety recommendations shall in no case create a presumption of blame or liability

Marine Accident Report

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