ACCIDENT REPORT

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

Report on the investigation of the fatality of a rescue boat crewman on board

Tombarra

at Berth 3, Royal Portbury Docks,

7 February 2011

Part A - The failure of the fall wire

VERY SERIOUS MARINE CASUALTY REPORT NO 19A/2012 July 2012

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

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

NOTE

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

Front cover image courtesy of Martin Edmondson

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	-	Able seaman
BSI	-	British Standards Institute
CCTV	-	Closed Circuit Television
DAD	-	Design Appraisal Document
DNV	-	Det Norske Veritas
EN	-	EuroNorm
ERA	-	ERA Technology Limited
EU	-	European Union
FRB	-	Fast rescue boat
FRC	-	Fast rescue craft
GA	-	General Arrangement (drawing)
Hz	-	hertz
IACS	-	International Association of Classification Societies
ICS	-	International Chamber of Shipping
IEC	-	International Electrotechnical Committee
ILAMA	-	International Life-saving Appliance Manufacturers Association
IMO	-	International Maritime Organization
IP	-	Ingress Protection
ISO	-	International Standards Organisation
kg	-	kilogram
kgf	-	kilogram-force
kN	-	kilonewton
kNm	-	kilonewton-metre
KPR	-	KPR Engineering (M&E) Ltd
kt	-	knot
kW	-	kilowatt
LR	-	Lloyd’s Register
LRQA	-	Lloyd’s Register Quality Assurance
LSA	-	Life Saving Appliance

mA	-	milliampere
MBL	-	Minimum Breaking Load
MCA	-	Maritime and Coastguard Agency
MED	-	Marine Equipment Directive
mm	-	millimetre
MSC	-	Maritime Safety Committee
Nm	-	newton-metre
OIC	-	Officer in Charge
PAN	-	Product Awareness Notice
PPE	-	Personal Protective Equipment
rpm	-	Revolutions per minute
SMS	-	Safety Management System
SOLAS	-	International Convention for the Safety of Life at Sea
SWL	-	Safe Working Load
SWM	-	Safe Working Moment
USH	-	Umoe Schat-Harding AS
UTC	-	Universal Time, Co-ordinated
VHF	-	very high frequency
WLCCL	-	Wilhelmsen Lines Car Carriers Ltd

Times: All times in this report are UTC

Tombarra

SYNOPSIS

At 1549 on 7 February 2011, the rescue boat on board the UK registered car carrier, *Tombarra*, plummeted approximately 29m from its davit into the water below, killing one of the rescue boat's four crew. The accident occurred when the boat's fall wire parted as the boat was being recovered to its stowage during a monthly drill. *Tombarra was* alongside Royal Portbury Dock, Bristol.

The rescue boat's fall wire failed because an electronic proximity switch, which was intended to stop power to the winch motor as the rescue boat davit neared its stowed position, did not operate. As a result, the rescue boat was hoisted fully home into its davit and the fall wire became overstressed by the davit winch, which was fitted with a 15/20kW electric motor.

The investigation has identified a number of factors that contributed to the accident, including:

- The proximity switch that failed to operate was not fitted in accordance with its manufacturer's instructions, and was not suitable to be used as a 'final stop' device in man-lifting equipment.
- The functionality of the proximity switch was not tested immediately before the rescue boat's recovery.
- Although the davit system manufacturer intended that the winch motor be stopped by its operator before the proximity switch was activated, the manufacturer's guidance was misleading.
- The winch motor was able to easily and rapidly overstress the fall wire.

Although the International Maritime Organization recommends that all davit system designs are checked to ensure the compatibility of component parts, the Life Saving Appliance (LSA) Code accepts that overstressing of components could occur, but requires that this is prevented by the use of safety devices. However, the Code does not specify any standard to which such safety devices must conform or the number of safety devices that must be fitted to davit systems.

Recommendations have been made in this section of the report to the Maritime and Coastguard Agency and the International Life-saving Appliance Manufacturers Association aimed at improving the safe operation of davit systems through improved design and construction. Recommendations have also been made to the davit system manufacturer to take action to ensure that both its currently supplied SA1.5/1.75 davits with W50RS winch/15/20kW electric motor combinations, and its future davit systems are safe to operate.

During the investigation, it was found that the rescue boat was significantly overweight. This did not contribute substantially to the failure of the fall wire on this occasion, but the increase in the weight of the boat while in service is a cause for concern. The MAIB's investigation into the causes and circumstances is covered in **Part B** of this report.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *TOMBARRA* AND ACCIDENT

SHIP PARTICULARS

Vessel's name	*Tombarra*
Flag	UK
Classification society	Det Norsk Veritas
IMO number	9319753
Type	Vehicles carrier
Registered owner	Assetfinance December (R) Ltd
Manager	Wilhelmsen Lines Car Carriers Ltd
Construction	Steel
Length overall	199.90m
Registered length	192.12m
Gross tonnage	61321
Built	2006
Authorised cargo	Vehicles

VOYAGE PARTICULARS

Port of departure	Koper, Slovenia
Port of arrival	Royal Portbury Docks, Bristol
Type of voyage	International
Manning	23

MARINE CASUALTY INFORMATION

Date and time	7 February 2011, 1549
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	Royal Portbury Docks, Bristol
Place on board	Rescue boat

Injuries/fatalities	One fatality. Three crew suffered from hypothermia
Damage/environmental impact	Rescue boat fall wire failure, structural damage to the rescue boat
Ship operation	Cargo discharge alongside
Voyage segment	In port
External & internal environment	External air temperature: 7.6ºC Average wind speed: 13.9kts Water temperature 5ºC
Persons on board	23 (four on board the rescue boat)

1.2 NARRATIVE

1.2.1 The fall wire failure

Mv *Tombarra*, a vehicles carrier operated by Wilhelmsen Lines Car Carriers Ltd (WLCCL), arrived at berth 3, Royal Portbury Docks, Bristol at 1012 on 7 February 2011 **(Figure 1)**. The discharge of her vehicle cargo then commenced.

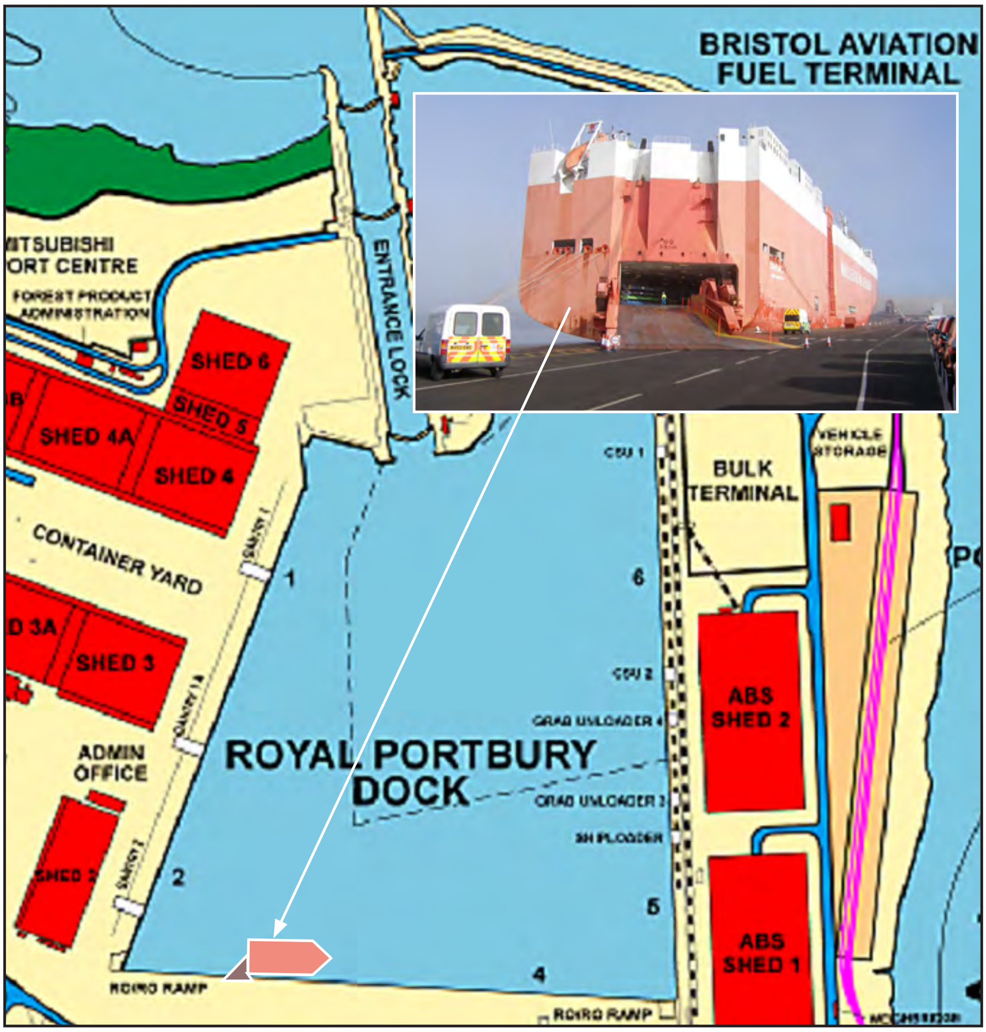

Figure 1: Royal Portbury Docks

At 1505, the chief officer was given permission from the Bristol Port Company, the port authority, to launch the vessel's rescue boat as part of a monthly drill. About 10 minutes later, the chief officer, bosun, an able seaman (AB), the electrician, and the rescue boat's crew assembled at the rescue boat stowage. The boat stowage was located about 29m above water level on the upper deck midway along the port side **(Figure 2)**. The junior third officer also went to the boat stowage to take photographs during the drill. The boat's crew comprised the second officer, fourth engineer, an AB, and an engineer cadet. Their personal protective equipment included lifejackets, full body safety harnesses with lanyards, and hard hats.

The deck team and the boat's crew unlashed the rescue boat from its davit. The boat crew then climbed into the rescue boat and connected their safety harness lanyards to the hand-hold on the fall wire hook. At 1531, the bosun began to lower the rescue boat under gravity by raising the winch brake handle **(Figure 3)**.

Figure 2: Rescue boat location

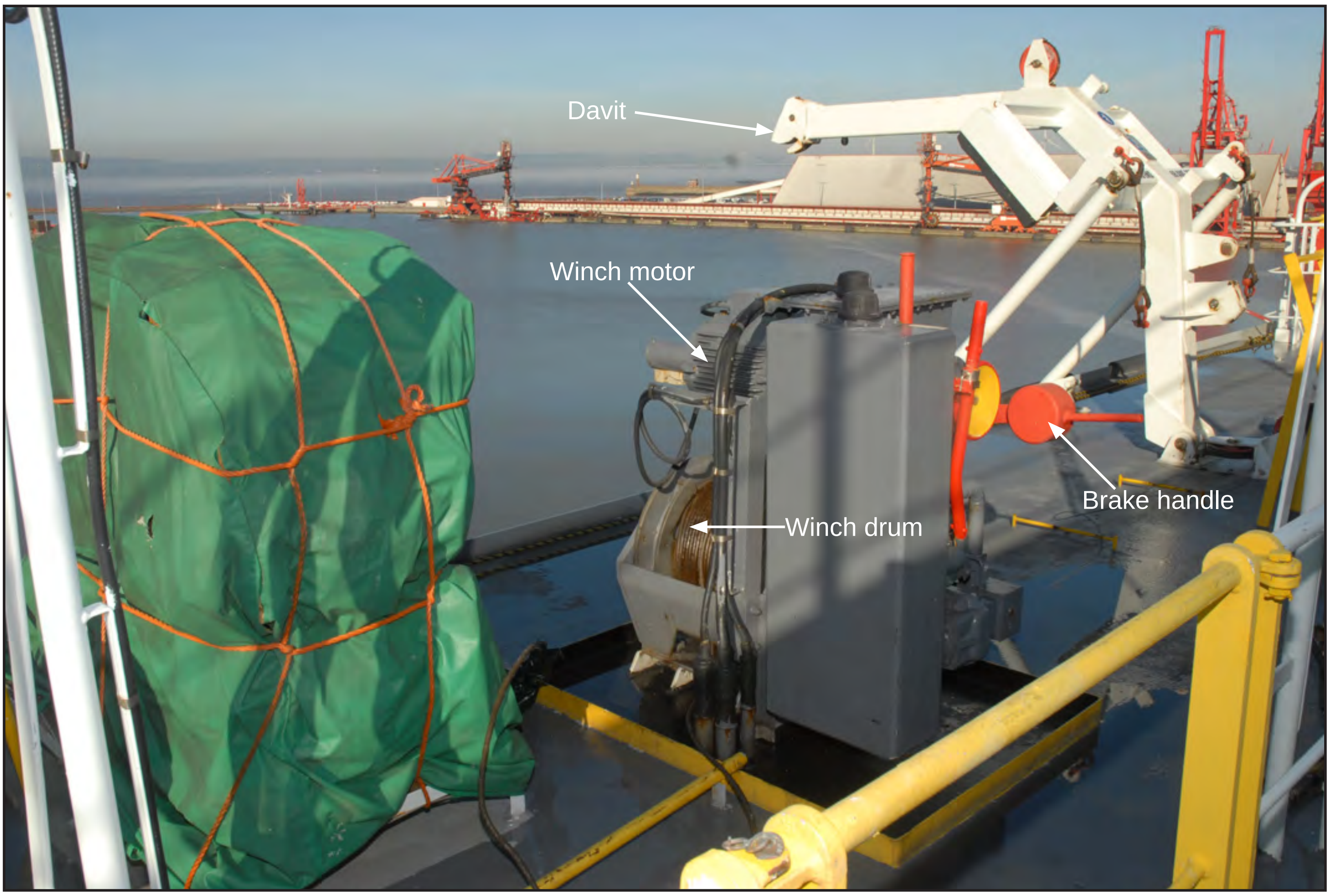

Figure 3: Davit winch arrangement

At 1533, the rescue boat entered the water and its outboard engine was started. The crew unclipped their harness lanyards, released the fall wire hook and let go the forward painter. The second officer was at the helm and drove the boat around the dock. The cadet was also allowed to drive the boat for a short period.

At about 1540, the second officer brought the rescue boat to the side of the vessel where the boat crew re-connected the painter and fall wire hook, re-attached their harness lanyards to the hand-hold on the hook, and stopped the boat's engine. The bosun, who was standing at the winch control box forward of the rescue boat davit **(Figure 4)**, then pressed the high speed button and lifted the boat until it reached the upper deck level. Hoisting was then stopped while the fourth engineer raised the outboard engine. The boat's AB unclipped his harness in preparation to disembark **(Figure 5)**, but was quickly told by the chief officer that the boat crew were not to disembark until the rescue boat was in its stowed position.

Figure 4: Winch control box

The hoisting of the rescue boat was recommenced, this time with the bosun keeping the low speed button depressed to bring the davit arm and rescue boat towards their fully stowed positions. The chief officer and the deck AB steadied the boat and the chief officer also checked that the guide pins on the fall wire hook were correctly housed in the davit head horns.

Figure 5: Rescue boat recovery

At about 1549, the rescue boat came hard against the davit fenders. Almost immediately, a bang was heard, the fall wire parted and the rescue boat and its davit swung out. The boat then rolled to port before plummeting bow-first into the water **(Figure 6)**.

1.2.2 Rescue and recovery

The rescue boat surfaced upside down. Three of its crew also surfaced alongside the upturned hull with their lifejackets inflated **(Figure 7)**. The deck crew immediately threw life rings towards the men. At 1555, the chief officer informed the master and then the port authority of the accident, using his hand-held very high frequency (VHF) radio. The port authority immediately tasked its workboat *Gordano* and the port police to assist. *Gordano* was at berth 5 and quickly headed towards *Tombarra,* stopping between berths 3 and 4 en route to collect two port policemen. The port authority also made a request for an ambulance to attend.

By this time, the boat's AB had swum from the upturned rescue boat to the side of the ship. *Tombarra*'s crew managed to help the AB on to the gangway and into the vessel's accommodation.

When *Gordano* arrived on scene, the rescue boat had drifted toward the flare of *Tombarra*'s bow. Two of the rescue boat's crew were together on one side of the hull, and were still attached to the rescue boat by their safety harness lanyards. The lanyards were cut and the two boat crew were pulled on board the workboat.

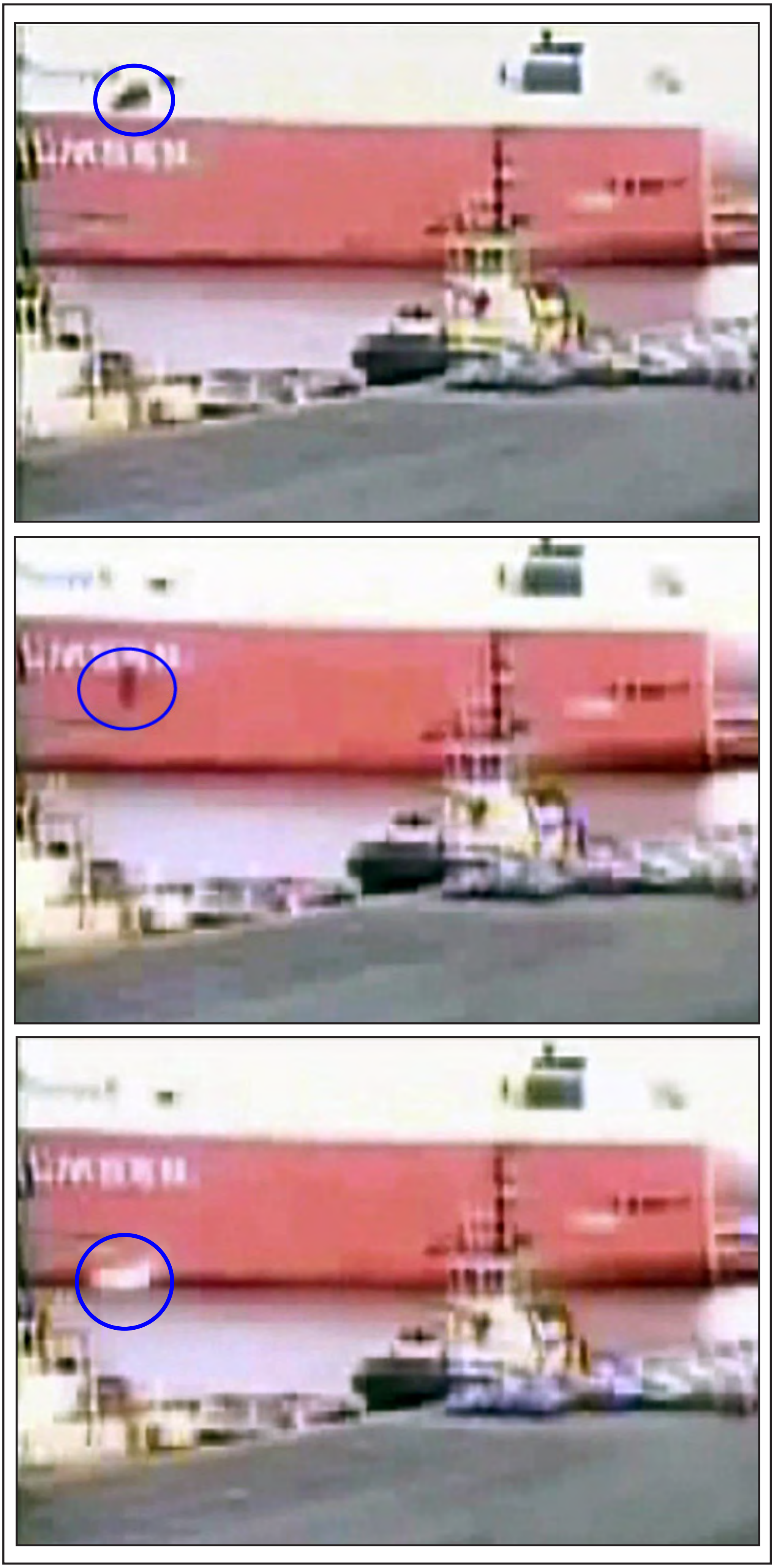

Figure 6: CCTV footage of fall

Figure 7: Rescue boat capsized

In the meantime, *Gordano* was alerted by *Tombarra*'s crew that one of the boat's crew was trapped under the upturned hull. The workboat's crane was connected to the rescue boat's bow cleat and the bow was raised clear of the water **(Figure 8)**. *Tombarra*'s fourth engineer, Gerardo Tonogbanua was then seen by the rescuers. His 275N lifejacket was inflated, he was face-down in the water and his harness lanyard was still attached to the fall wire hook.

Figure 8: Recovery of fourth engineer

The rescuers cut Gerardo's harness lanyard and then moved him onto a second workboat where two paramedics immediately began cardio pulmonary resuscitation. Gerardo and the three other boat crew were then transferred to waiting ambulances and taken to Bristol Royal Infirmary, where Gerardo was pronounced deceased. Post-mortem examination identified that Gerardo died as a result of a mediastinal haemorrhage due to a tear of the thoracic aorta. The boat's other crew suffered minor injuries and were hypothermic.

1.3 *TOMBARRA*

Mv *Tombarra* was built by Mitsubishi Heavy Industries, Nagasaki, Japan in 2006 and was owned by Assetfinance December (R) Ltd. The vessel was one of 10 Torrens class vessels constructed from 2003 onwards, and was capable of carrying about 6350 cars. *Tombarra* primarily plied between Asia and northern Europe, including the Baltic Sea, and was manned by Filipino officers and crew, comprising the master, nine officers, two officer cadets and 11 ratings.

The deceased, Gerardo Tonogbanua was 23 years old and he had been employed by WLCCL since September 2006. In addition to his engineering qualifications, he had completed training courses on the use of survival craft and rescue boats, in the Philippines, in 2009.

1.4 DAVIT AND WINCH SYSTEM

1.4.1 Main components

*Tombarr*a's rescue boat was lowered and hoisted on a single fall wire, by an Umoe Schat-Harding AS (USH) SA1.5 davit and a W50RS winch powered by a two-speed electric motor. An electronic proximity switch was fitted to the davit frame (davit proximity switch) which was intended to stop the winch motor before the davit arm reached its fully stowed position. USH supplied the system to *Tombarra* and to the other Torrens class vessels during build.

1.4.2 Davit and fall wire

The SA1.5 davit had a Safe Working Load (SWL) of 14.715kN (1500kgf)[1] and used both stored mechanical power and gravity for launching. The davit comprised a deck-hinged 'A' frame **(Figure 3)** which supported the boat from its fall wire. Two spring-loaded hydraulic guide rods, connected to the lower arms of the 'A' frame, enabled the rescue boat to be launched with the vessel listing up to 20º. A locking pin held the davit structure and davit arm together in the stowed position.

The fall wire was 55m long and made from a single galvanized 12mm diameter anti-twist steel wire rope. The wire test certificate, dated 7 October 2005, indicated that the wire had a Minimum Breaking Load (MBL) of 141kN (14380kgf) and an actual breaking load of 145kN. The wire's SWL was 23.5kN, calculated by dividing the 141kN MBL by a factor of safety of 6. The fall wire was reeved through six sheaves attached to the davit.

[1] 1kgf = 9.807N

1.4.3 Winch

The W50RS winch was one of 41 types within the 'W' range of davit winches made by USH. The '50' designation referred to the 51kN nominal wire pull[2]. The 'RS' designation referred to ***R***escue boat, ***S***ingle wire drum. The winch's technical specification is at **Annex A**. The operation and maintenance manual provided to *Tombarra* by USH included:

> *The winch type used with this davit is denoted as W 50RS providing a maximum hoisting capacities of 1.5 or 1.75 tons.* [sic]

The winch was sited aft of the davit and comprised: a drum and integrated gearbox, a lowering brake system, a secondary gearbox, a stopping/holding brake, a two-speed electric motor and a hydraulic brake release system **(Figure 3)**. A proximity switch was installed on the winch adjacent to the manual winch handle to prevent the motor from operating and causing injury to the crew once the winch handle was fitted.

The electric motor was operated by high and low speed buttons located in a control box at the deck edge forward of the davit to allow the operator to monitor the hoisting operation. An emergency stop button was also sited in the control box **(Figure 4)**.

The electric motor fitted to the W50RS winch was a Lönne 15/20kW output, two-speed type 7BA 160 L1 motor, operating at 60Hz. The motor's test certificate is at **Annex B**.

The winch was assembled at the USH factory in Slany, Czech Republic according to a specification provided by the USH head office in Norway. The winch was tested on 27 March 2006 using a static load test of 166.2kN and a dynamic load test of 119.5kN. A 22mm diameter wire was used during the tests; the 12mm diameter wire was fitted before the system was delivered on board *Tombarra*.

1.4.4 Davit proximity switch

The electronic proximity limit switches installed on the davit and winch on board *Tombarra* were type XS7-C40FP260 and were manufactured by Telemecanique, a subsidiary of Schneider Electric Ltd.

The davit proximity switch was intended to stop the winch motor as the boat and davit arm neared the stowed position during hoisting. The switch operated by detecting the metal davit as it approached using an electronic integrated circuit sealed in a potting compound; a two-wire alternating current supplied a normally open (NO) or normally closed (NC) programmable device. The sensing range was 0-12mm from the head. The unit had an ingress protection rating of (IP) 67 (conforming to International Electrotechnical Committee (IEC) 60529). The switch was not designed or categorised as a safety device, and Schneider Electric Ltd did not consider that it was suitable for use as a 'final stop' device in a high risk operating system.

[2] The nominal wire (or rope) pull, or load, is how winch capability is referred to in common practice and refers to the maximum rope tension when the winch is hoisting at the nominal speed (in the case of rescue boats this was a minimum of 18m/min).

The davit proximity switch was mounted on the forward part of the fixed davit structure adjacent to the sheaves. It was orientated so that the sensing head faced outboard and angled downward at approximately 20º to the horizontal **(Figure 9)**. The sensor head could be rotated in order to align it with the actuating object. The switch manufacturer's instructions stated that the switch should be mounted either horizontally or vertically.

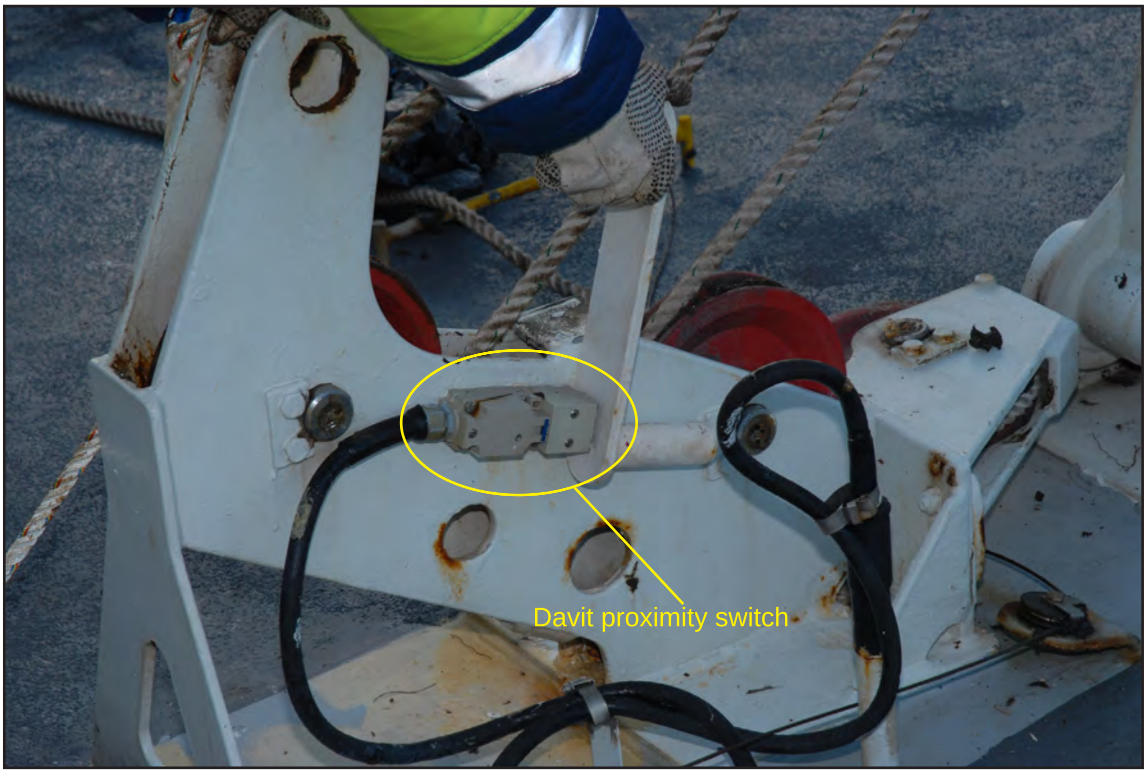

Figure 9: Proximity switch testing in situ

USH guidance on the maintenance of the limit switches included:

- *These are to be checked for secure mounting and that no damage has been done to the glands or cables.*

The guidance advised that the limit switches be checked during each lifeboat drill to ensure that they were functioning correctly, and that the mountings and cables were checked every 6 months. The guidance also included:

Recommended spare parts for an operational period of two years

Item	Qty	Part name
2	1	Limit switch end hoisting

1.4.5 Operation

With the vessel in a normal, upright condition, the lowering/hoisting height of the davit head above the sea surface was 29.62m increasing to 36.4m when the vessel was heeled 20º to starboard. To deploy the rescue boat, the locking pin was removed from the davit and the lashings and winch brake were released. The guide rods then extended and swung the davit arm and boat to the ship's side. The boat was then lowered under gravity to the sea by raising the brake lever to provide a controlled descent. The boat was recovered using the electrically-powered winch to hoist the boat and davit arm to just before the stowed position, at which stage the manual winding handle was fitted and the boat manually winched until fully home. The USH manual stated:

> *The davit arm will stop approximately 100mm from the stowed position because of the limit switch which will stop the winch motor. To complete stowage, the hand crank on winch has to be connected and operated.*

USH expected that winch operators would normally, as a matter of routine, stop the winch motor before the proximity switch was activated.

1.5 POST-ACCIDENT EXAMINATIONS

1.5.1 Fall wire

The fall wire was measured and found to have failed approximately 5.54m from the hook. With the boat and davit in the stowed position, the failure point coincided with the last sheave on the davit **(Figure 10)**.

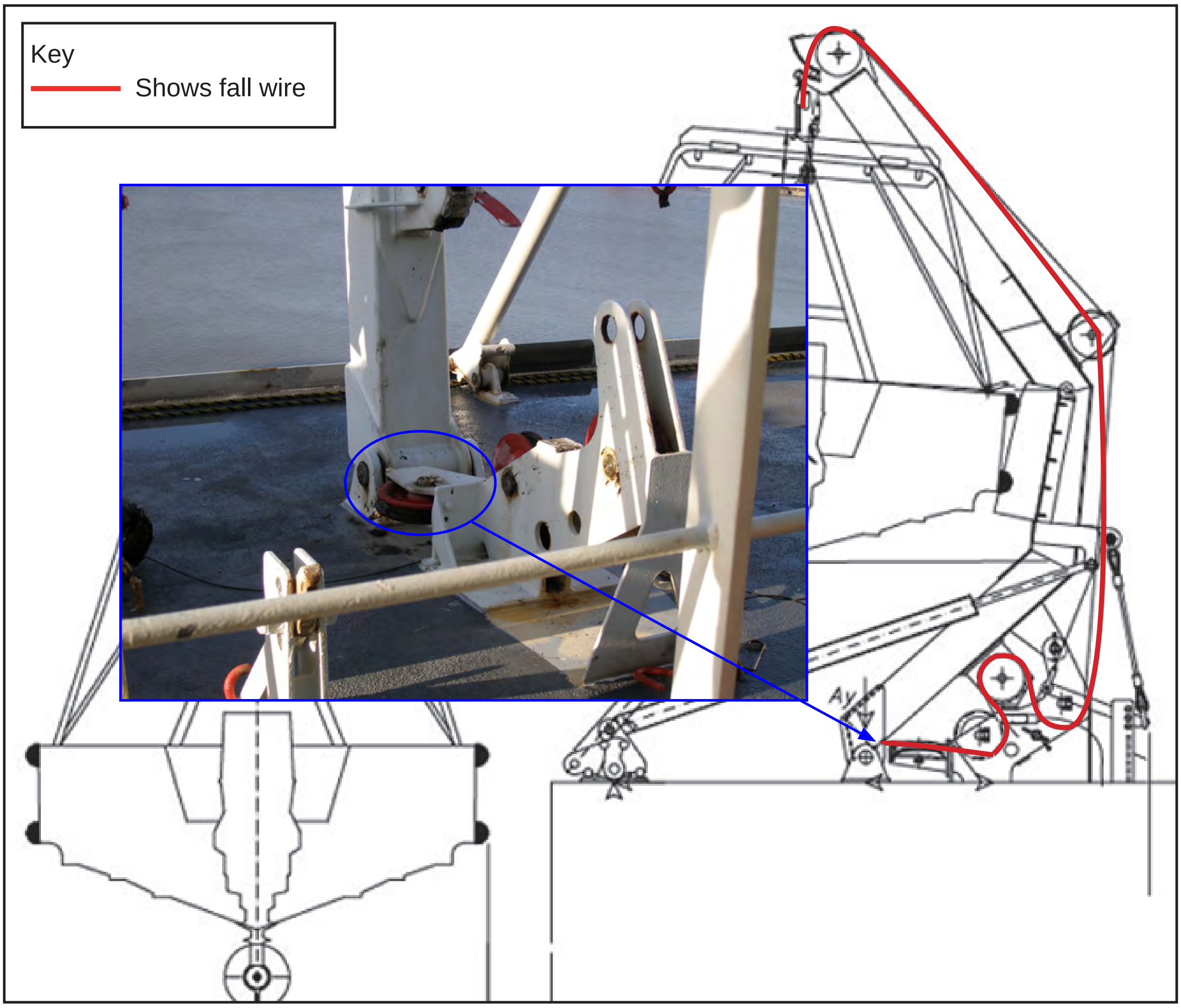

Figure 10: Position of fall wire failure

The 5.54m section of wire, together with a 10m section of wire taken from the drum side of the failure point, and a further 10m section of wire from the drum end of the fall wire were removed from the vessel and sent to The Test House (Cambridge) Ltd, for analysis. The test report **(Annex C)** included:

> *In conclusion, our laboratory based failure analysis and material characterisation failed to identify any material or metallurgical issues or defects that could have pre-disposed the rope to failure. In the apparent absence of defects and/or metallurgical anomalies in the rope, the accident investigators are advised to look elsewhere for the cause of failure, and in particular the source of a tensile overload that must have been in excess of 133kN.*

1.5.2 Davit proximity switch

On 8 February 2011, an electrician from KPR Engineering (M&E) Ltd (KPR) inspected the davit electrical system. In situ tests indicated that the davit proximity switch did not stop power to the davit winch when a metal object was placed in close proximity to the sensor head. The switch was opened and inspected, and the electrical control box for the davit was also inspected and tested. The electrician also identified that a 2amp fuse had been used in the proximity switch control circuit instead of a 0.4amp fuse as stipulated in the switch manufacturer's instructions. The electrician's report **(Annex D)** concluded that, although a fuse of a higher rating had been used, there was no evidence to suggest that a short circuit had occurred.

The davit proximity switch was removed and sent to ERA Technology Ltd (ERA) for assessment. ERA's test reports **(Annexes E** and **F)** concluded that although there was evidence of water ingress in to the electrical connection of the switch, this was not the direct cause of the failure. The cause of failure was due to a partial short circuit on the internal printed circuit board. The report **(Annex F)** concluded:

> *The first report showed that the proximity sensor unit was inadequate for the application, at the very least because the sensor head rubber seal had degraded significantly over its life, and whether through that seal or through the cable gland seal, water had ingressed into the unit.*
>
> *It logically stands that if, as seems apparent, the operating procedure on the ship (either as formally written or as practically operated) permitted the sole stop function to rely on this proximity switch, then both the switch was inadequate for the purpose and the operating procedure was deficient, because there was no fail-safe function or back-up cut-out in the system. This is unacceptable in a safety critical function.*

1.5.3 Rescue boat

The Watercraft Hellas S.A. WHFRB6.50 (fast)[3] rescue boat (FRB) supplied to *Tombarra* was fitted with a 67kW outboard two-stroke petrol engine. The recorded weight of the boat and its equipment when new was 980kg.

[3] The WHFRB6.50 was designed as a fast rescue boat for use on board passenger vessels. *Tombarra* was a cargo vessel, which required a rescue boat to be fitted. A key difference between a fast rescue boat and a rescue boat is that a fast rescue boat should be capable of a speed of not less than 8 knots with a full complement of persons and equipment, and 20 knots with a crew of three persons. A rescue boat need only be capable of a speed of 6 knots.

Following the accident on 7 February 2011, the boat was removed from the water and weighed 1550kg. When the drain plug in the transom was opened, a strong flow of water came out of the hull.

The cause of the rescue boat's increase in weight since build is addressed in **Part B** of this report.

1.5.4 Tests on board *Toscana*

In May 2011, during tests of the rescue boat davit on board *Toscana*, *Tombarra*'s sister vessel, the SA1.5 davit arm was brought to the stowed position by the W50RS winch using both the low and high speed buttons. The tests found that the electronic proximity switch, of the same type as fitted to *Tombarra,* stopped the davit when hoisted at slow speed but not at high speed, causing the davit arm to come up hard against the davit.

KPR was instructed to determine the cause of the apparent fault. KPR's tests concluded that the proximity switch, although working correctly, was unable to respond quickly enough to stop the winch motor in sufficient time when operated at high speed. A summary of findings included:

- *Confusion was caused by operators not being aware of the necessity to release the high speed button prior to the rescue boat reaching the top of the ship* [sic]

The report recommended:

> *Given that the fall wire has proven to break if too much force/load is applied by the winch/boat and its contents, it is preferable that the fall wire and winch combination are resized so as to prevent the fall wire from breaking.*
>
> *As continuously driving the davit into its home position would lead to stretching and weakening the fall wire, the proximity sensor design could be improved to ensure that the davit isn't driven continuously against the fully home position.*

1.6 DAVIT AND WINCH DEVELOPMENT AND APPROVAL

1.6.1 Umoe Schat-Harding AS

USH has factories in Rosendal, Seimsfoss and Olve in Norway, Slany in the Czech Republic, and Qingdao in China. The company's quality management system was first approved by Lloyd's Register Quality Assurance (LRQA) to ISO standard 9001: 2000 on 1 January 2001.

1.6.2 Davit

USH has manufactured SA1.5 davits since 1996 and has supplied 443 of the davits to vessels. The SA1.5 was one of a range of pivoted single arm davits designed to launch and recover rescue boats. Other davits in the range included the SA1.2 (SWL 1200kg), SA1.75 (SWL 1750kg), and the SA 3.5 (SWL 3500kg). Since 1993, all of the SA series davits have incorporated a single davit proximity switch. The diameter of the fall wire used on the SA1.5 davit was limited to 12mm by the size of the boat hoisting hook arrangement. In comparison, the SA1.75 davit utilised a 14mm wire, and the SA3.5 davit utilised wires between 18mm and 20mm diameter.

The SA1.5 davit was designed and built in accordance with Chapter III of International Convention on the Safety of Life at Sea (SOLAS) 1974 (with 1983 amendments), the Life Saving Appliances (LSA) Code, and was tested in accordance with International Maritime Organization (IMO) Resolution (MSC) 81(70), Parts 1 and 2.

The davit was initially type approved[4] and issued with a Declaration of Conformity under the European Union (EU) Marine Equipment Directive 96/98/EC (MED)[5], modules B and D by Lloyd's Register (LR) on 30 October 1999. As part of LR's assessment, USH provided calculations detailing the factor of safety for each part of the davit under static conditions.

The LR Design Appraisal Document (DAD), dated 31 October 2001 detailed the approval documentation, test reports and the conditions of compliance. The conditions included:

> *3. This davit is to be supplied with an approved winch of type 'FME 3.3 SA' or 'FME 3.3 SALD' manufactured by Umoe Schat Harding certified for a safe working moment (SWM) at the winch of 3.3 kNm.*

Accordingly, the first of the SA1.5 davits were installed with a USH FME 3.3 winch fitted with a 6.5kW electric motor. The FME winch had a drum torque of 3.3kNm, and a drum capacity of 19m when fitted with a 12mm fall wire. However, the wire capacity of the FME 3.3 winch drum prevented its use on vessels where the davit head was relatively high. Consequently, USH started to fit W50RS winches, which had a greater wire capacity, with the SA1.5 davits on vessels with high freeboards such as car carriers, including the Torrens class.

The use of the W50RS, in conjunction with the SA1.5 davit, was submitted by USH to LR. LR approved the proposed amendment and revised the davit's DAD on 4 December 2003 to include:

> *In cases where a vessel's freeboard exceeds the wire capacity of these winches, approved winch type W50RS (SWM 11.7kNM) may be supplied.*

LR also amended the W50RS winch DAD to reflect the use of the W50RS with the SA1.5 davit. The size of the fall wire to be used with this combination was not included in either the assessment nor the amendment.

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4 "Type approved" means that equipment has been certified to meet certain minimum regulatory, technical and safety requirements of a State. Type approval enables the product to display a mark, eg CE (Conformité Europeenne) within the European Union. Type approval generally requires: a technical evaluation, including prototype tests to establish that a design complies with specific codes or specifications; the witnessing of a product's manufacture (type test); and an assessment of a manufacturer's ability to consistently manufacture a product in accordance with approved specifications.

5 The EU Directive 96/98/EC on marine equipment, as amended, came into force on 1 January 1999 and became mandatory for all equipment from 1 January 2001. The Directive, commonly referred to as the Marine Equipment Directive (MED), applies to all ships with safety certification issued by or on behalf of European Union (EU) member States. Notified bodies are responsible for assessing the conformity of marine equipment with the provisions of the MED. Different conformity assessment modules may apply; module B = type-examination and module D = production quality assurance.

1.6.3 Winch

On 12 January 2000, LR issued type approval and MED certification for the W50 winch range. The type approval certificates state:

This certificate is not valid for equipment, the design or manufacture of which has been varied or modified from the specimen tested. The manufacturer should notify Lloyd's Register of any modifications or changes to the equipment in order to obtain a valid certificate.

The system details for the W50RS winch included in LR's DAD for the W50 range, dated 8 October 2002, are shown in **Table 1**.

Maximum Rope Load at Winch, **Kg**	5200
Rope diameter, **mm**	18
Number of ropes/Drums at Winch	2
Hoisting Speed of Boat, **metres/min**	20
Lowering Speed of Boat, **metres/min**	90
Electric Motor Type	7BA 160 L21
Motor Particulars: Voltage, **V** Speed, **rpm**	440 1750
Output, **kW**	15

Table 1: W50RS system details

In January 2003, USH revised the outline drawing of the winch (N65431) to include a 6.5/11kW electric motor (Lönne 7BA132M21) as an option. USH considered that the 15/20kW motor was potentially too powerful and the drawing was further revised on 7 May 2004, removing the use of the 15/20kW motor as an option when fitted in conjunction with a SA1.5 davit. This change in specification was relayed to LR in December 2004.

On 12 January 2005, LR re-issued its type approval and MED certification for the W50RS winch. The conditions of certification on the associated DAD took into account the use of the smaller motor, and was revised to include:

Drum safe working moment (SWM) *11.7kNm*

Required input power (el. Motor) for lifeboat/rescue boat recovery *17.0kW*

(Required input power (el.Motor) specific to davits SA1.5/SA1.75) *11.0kW* [sic]

On 27 April 2009, drawing N65431 was further amended to reflect that the standard fall wire diameters for the SA3.5 and the SA1.5 davits were 18/20mm and 12/14mm respectively. The W50RS DAD was not amended to reflect this change in wire dimension.

1.6.4 The Torrens Class

The General Arrangement (GA) drawing for the SA1.5/WHFRB6.50 and W50RS combination to be fitted on the Torrens Class vessels **(Annex G)** supplied by USH to LR was dated 29 September 2004. The winch motor specified on the GA was the 7BA132M21. The diameter of the fall wire specified was 12mm with a 149.4kN MBL. LR did not amend the W50RS winch DAD to reflect these changes. On 5 January 2009, USH revised the MBL of the wire shown on the GA to 162kN but did not inform LR.

'As fitted' drawings supplied to the Torrens class vessels incorporated options within statutory requirements either requested by the vessels' owner, or necessary to meet the specific requirements of the vessel. The 'as-fitted' drawing **(Annex H)** for the Torrens class vessels specifies the winch motor as the 160L 21, and the fall wire diameter as 12mm with an MBL of 141kN.

1.6.5 Davit and winch combination

The SA1.5 davit and the W50RS winch were approved by separate sections within LR. In common with other classification societies, LR's organisation for the approval of these apparatus reflected the equipment-specific structure of the classification society rules against which the equipment was assessed. LR did not assess the compatibility of the davit/winch/motor/fall wire combinations.

Between 2000 and 2005, USH supplied sixteen SA1.5/1.75 davits - W50RS (15/20kW motor) winch combinations to vessels. A further thirty-three SA1.5/1.75 – W50RS (15/20kW motor) combinations were supplied from 2005, including four in 2010.

1.7 MOTOR / WINCH LOAD CAPABILITY

1.7.1 Comparison of motor torque

The speed torque curves for the 7BA160L21 (15/20kW) and the 7BA132M21 (6.5/11kW) motors are shown in **Figure 11**. The performance of the two motors when operating at low speed (high torque) is shown in **Table 2**.

Motor type	Mn (Nm)	Mstart (Nm)	Mmin (Nm)	Mkipp (Nm)
7BA160L21	82	201	164	255
7BA132M21	35.5	93	83	113

Table 2: Winch motor comparison at low speed (high torque)

Key for Table 2 and Figure 11:

Mn: Rated load (normal duty)

Mstart: Starting torque

Mmin: Lowest torque in the torque curve during the acceleration to rated speed

Mkipp: The maximum overload state the motor can achieve before it stalls.

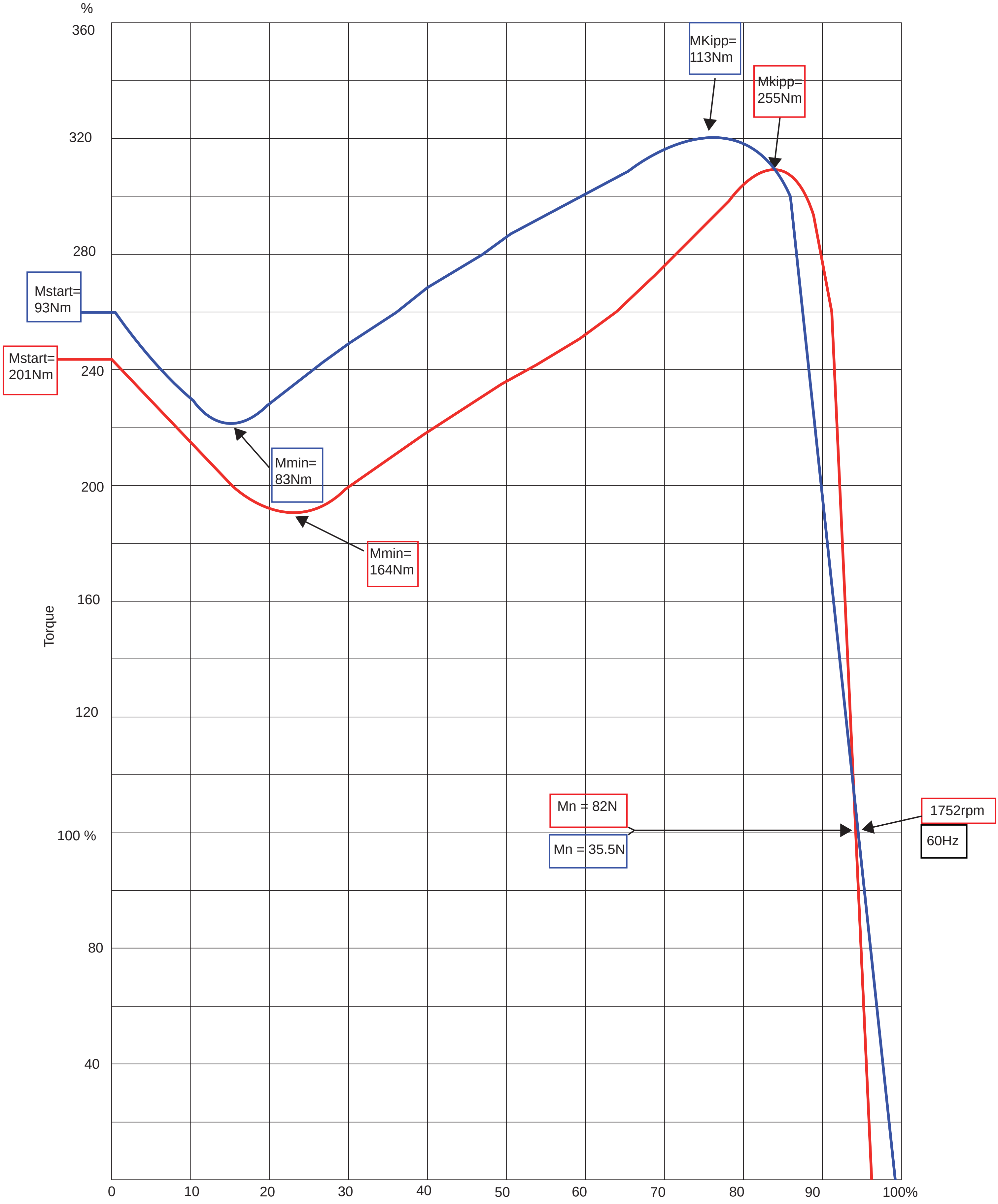

Figure 11: Motor type 7BA 160L 21 and Motor Type 7BA 132M21 speed/torque curves

1.7.2 Comparison of winch capability

At the request of MAIB, LR calculated the maximum winch pulls at low speed (high torque) for both electric motors with a 12mm wire rope. The calculated maximum pull and the pull at the motor stall torque[6] condition are shown in **Table 3** columns (a) and (b).

On 4 October 2011, practical winch load tests were conducted at USH's Slany factory to establish the W50RS winch capability with the 6.5/11kW and the 15/20kW motors operating at low speed (high torque). The results are shown in **Table 3** column (c).

Electric Motor	LR Calculations		USH Tests
	Maximum pull (a)	Stall condition (b)	Maximum load achieved (c)
7BA132M21 (6.5/11kW)	100kN	83kN	110.8kN
7BA160L21 (15/20kW)	227kN	179kN	210.6kN

Table 3: Results of winch load calculations and tests

The USH test report is at **Annex I**.

1.8 ONBOARD DAVIT OPERATION AND MAINTENANCE

Rescue boat drills had been conducted on board *Tombarra* each month, usually when the vessel was in port. During the drills, it was usual practice for the crew to raise the boat and davit arm using the winch control buttons until the davit proximity switch operated and cut power to the winch motor. Onboard instructions provided by the ship's manager, for the operation of the rescue boat davit, included:

- *Operation of limit switches and similar devices must be checked/confirmed before recovery.*
- *Check the safety cut out/limit switch arrangements for the motor for ease of movement and proper operation.*

Onboard procedures also required the crew to embark into and disembark from the rescue boat when the rescue boat was in its stowed position. This procedure, which was at variance with the guidance provided in the USH manual, had been introduced due to a gap of approximately 600mm between the side of the boat and the side of the vessel when the boat was at the deck level. Risk assessment had also identified the need for the boat crew to wear full body harnesses and lanyards **(Figure 5)** during the launch and recovery due to the risk of falling from the boat.

[6] The motor stall torque is the amount of torque produced with voltage applied with the motor shaft not rotating, or locked. Also referred to as locked-rotor torque.

The rescue boat was last used during a monthly drill on 8 January 2011. On that occasion, the boat was recovered to its stowage without incident. The davit system had been checked weekly by the ship's crew and was last visually inspected on 5 February 2011. The davit system was last serviced by USH on 21 September 2010 in China under a fleet service agreement with WLCCL.

Following the accident on board *Tombarra*, investigations by WLCCL identified that the testing of davit proximity switches on board its vessels was a critical safety barrier that needed to be reinforced among its crews prior to recovering the rescue boat. The investigations also identified that the winch was routinely operated during the recovery of the rescue boat until the davit proximity switch cut power to the winch motor.

1.9 RESCUE BOAT REQUIREMENTS

1.9.1 Carriage

The Safety of Life at Sea Convention (SOLAS) requires all ro-ro passenger vessels to carry a fast rescue boat and for cargo vessels to carry a rescue boat. The requirement was introduced in 1995 following the *Estonia* disaster[7] and was effective for existing vessels from July 2000.

1.9.2 Launching and embarkation

SOLAS Chapter III, Regulation 17 rescue boat embarkation, launching and recovery arrangements requires:

> *1 The rescue boat embarkation and launching arrangements shall be such that the rescue boat can be boarded and launched in the shortest possible time.*
>
> *3 Launching arrangements shall comply with the requirements of regulation 16. However, all rescue boats shall be capable of being launched, where necessary utilizing painters, with the ship making headway at speeds up to 5 knots in calm water.*
>
> *4 Recovery time of the rescue boat shall be not more than 5 min in moderate sea conditions when loaded with its full complement of persons and equipment…*

SOLAS Chapter III, Regulation 24 recommends a maximum davit head height of 15m height for survival craft[8] on passenger vessels.

The International Maritime Organization (IMO) Resolution Maritime Safety Committee (MSC) 81(70) requires that a fast rescue boat launching appliance is tested in a Beaufort force 6 wind[9] in conjunction with a significant wave height[10] of at least 3m. The height of the davit head above water for this test is not specified.

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7 *Estonia,* an Estonian-registered ro-ro passenger ferry, foundered in the Baltic on 28 September 1994 with the loss of 852 of her 989 passengers and crew.

8 In accordance with SOLAS, survival craft are 'craft capable of sustaining the lives of persons in distress from the time of abandoning the ship'. Fast rescue boats and rescue boats are not included as survival craft in the LSA Code.

9 Beaufort force 6 equates to 24kts or 12.3m/s mean wind speed.

10 Significant wave height (SWH) is traditionally defined as the mean wave height of the highest third of the waves (crest to trough)

Annex 3 of Chapter 6 of the Life Saving Appliances (LSA) Code details launching and embarkation requirements for rescue boats, and includes:

- *6.1.1.6 Structural members and all blocks, falls, padeyes, links, fastenings and all other fittings used in connection with launching equipment shall be designed with a factor of safety on the basis of the maximum working load assigned and the ultimate strengths of the materials used for construction. A minimum factor of safety of 4.5 shall be applied to all structural members, and a minimum factor of safety of 6 shall be applied to falls, suspension chains, links and blocks.*

- *6.1.2.7 Where davit arms are recovered by power, safety devices shall be fitted which will automatically cut off the power before the davit arms reach the stops in order to prevent overstressing the falls or davits, unless the motor is designed to prevent such overstressing.*

1.9.3 Measures to prevent accidents

Published on 17 June 2003, the IMO/MSC circular 1094 *Application of SOLAS Regulation III/26 concerning fast rescue boat systems on ro-ro passenger ships,* highlighted the concerns in using fast rescue boats. Item 2 of the circular states:

> *2 The Committee has been informed of many accidents and near-misses as a result of trials and drills involving the launching and recovery of fast rescue boats that have been fitted to date onboard ro-ro passenger ships. Concerns have also been expressed that some masters of these ships and the crews involved in the launching and operation of fast rescue boats do not have confidence in this equipment, especially regarding its use in emergency conditions when the weather and sea state may be unfavourable.*

The circular provides a list of salient points that contribute to the successful operation of rescue boats. These include:

> *5.1 all parts of the stowage, launch and recovery system are proven to be compatible well before installation, preferably at the design stage, and are supplied and supported by a single source;*
>
> *5.2 the fast rescue boat is installed as near the mid-length of the ship as possible, the height of the lifting davit head is minimised,…*

The circular also advises:

> *6 Member Governments and other parties involved in the design, installation, testing, approval, survey and operation of FRB systems are urged to take note of the information in paragraph 5 above and to pay particular attention to the location and integration of the system components when installing such systems…*
>
> *7 The Committee, at its seventy-seventh session (27 May to 6 June 2003), agreed that work on this issue should continue. Until the study is completed, however, and any revised measures are agreed by the Organization, it is*

recommended that due caution is exercised when installing, testing, launching and operating fast rescue boats, particularly where high launch heights are involved.

The IMO Maritime Safety Committee (MSC) Circular.1206/Revision.1 *Measures to prevent accidents with lifeboats* was published on 11 June 2009 in response to the unacceptably high number of accidents involving lifeboats in which crew were being injured, sometimes fatally, while participating in lifeboat drills and/or inspections.

Although recommendatory, it applies a range of principles for the safe operation, training, and maintenance of lifeboats, which could also apply to the periodic servicing and maintenance of liferafts, rescue boats, fast rescue boats and their launching appliances and on-load release gear. The circular categorises the main causes of accidents associated with lifeboats, and includes:

2.3.9 all tests required for the design and approval of life-saving appliances are conducted rigorously,…, in order to identify and rectify any design faults at an early stage;

In addition, Annex 1, *Guidelines for periodic servicing and maintenance of lifeboats, launching appliances and on-load release gear* states:

2.8 The following items should be examined for satisfactory condition and operation:

.4 functioning of limit switches;

Annex 2, *Guidelines on safety during abandon ship drills using lifeboats* includes:

1.5.4 The lowering of a boat with its full complement of persons is an example of an element of a drill that may, depending on the circumstances, involve an unnecessary risk. Such drills should only be carried out if special precautions are observed.

2.3.2 When performing drills with persons on board a lifeboat, it is recommended that the boat first be lowered and recovered without persons on board to ascertain that the arrangement functions correctly. The boat should then be lowered into the water with only the number of persons on board necessary to operate the boat.

1.10 SIMILAR ACCIDENTS

On 7 August 2007, the passenger ferry *Dublin Viking* was preparing to sail from her berth. In the process of letting go, the operator of the stern line winch inadvertently heaved in the line instead of paying out the slack. The line parted and snapped back, striking the legs of the officer in charge (OIC). Both of the officer’s legs were broken. A shore worker was also injured. The OIC was evacuated to hospital, where he remained in a critical condition until he died 6 days later.

The MAIB investigation[11] found that the electric mooring winch used for the stern line had a stated nominal load of 12.7 tonnes. However, tests showed that the winch was capable of pulling up to 37 tonnes for a short period on first starting. There were no indications, either on the winch markings or in the manufacturer's manual, that the starting load was so much greater than the running load, nor was there any reference to the MBL of the rope to be used on the winch.

On 4 February 2011, Safety Flash (11-07) **(Annex J)** was issued by the Marine Safety Forum which highlighted the near total failure of a fall wire being used to launch a fast rescue boat. As the boat was lifted and swung out, a loud bang was heard and the boat's coxswain saw that the fall wire was unstranding about 1m from the hook. The boat was immediately returned to its stowed position. Subsequent inspection found the docking head limit switch had failed, allowing the docking head to be raised further than designed. As a result, the hydraulic winch had started to overload the wire.

On 5 June 2011, a fast rescue boat fall wire parted **(Figure 12)** during a drill on board a ro-ro passenger ferry when alongside. The boat fell about 15m to the water below and was materially damaged. Fortunately, it was usual practice to first lower the boat to the water and recover it without crew on board.

Subsequent inspection identified several contributory factors, including:

- The original electronic proximity switch had been replaced by a mechanical limit switch which was in poor condition, was not working properly, and did not comply with the davit manufacturer's specifications**.** Further inspection of the switch found significant signs of corrosion and, although originally IP67 rated, the general appearance indicated that it had not been maintained for some time, including the actuating arm not being firmly connected to the switch head **(Figure 13)**.

- The fall wire, specified in the davit/winch manufacturer's drawings as 14mm with a MBL of 151kN (15400kgf), had been replaced in July 2009 with a 12mm wire with an actual breaking load of 107kN (10910kgf). Subsequent tensile load tests of the failed wire using a 6.5kW motor, produced failure loads of 82.38kN (8400kgf) and 83.06kN (8469kgf) respectively.

[11] Report on the investigation of the parting of a mooring line on board *Dublin Viking* alongside at Berth 52 in the Port of Dublin, Ireland, resulting in one fatality 7 August 2007. Report 7/2008

Figure 12: Failed fall wire

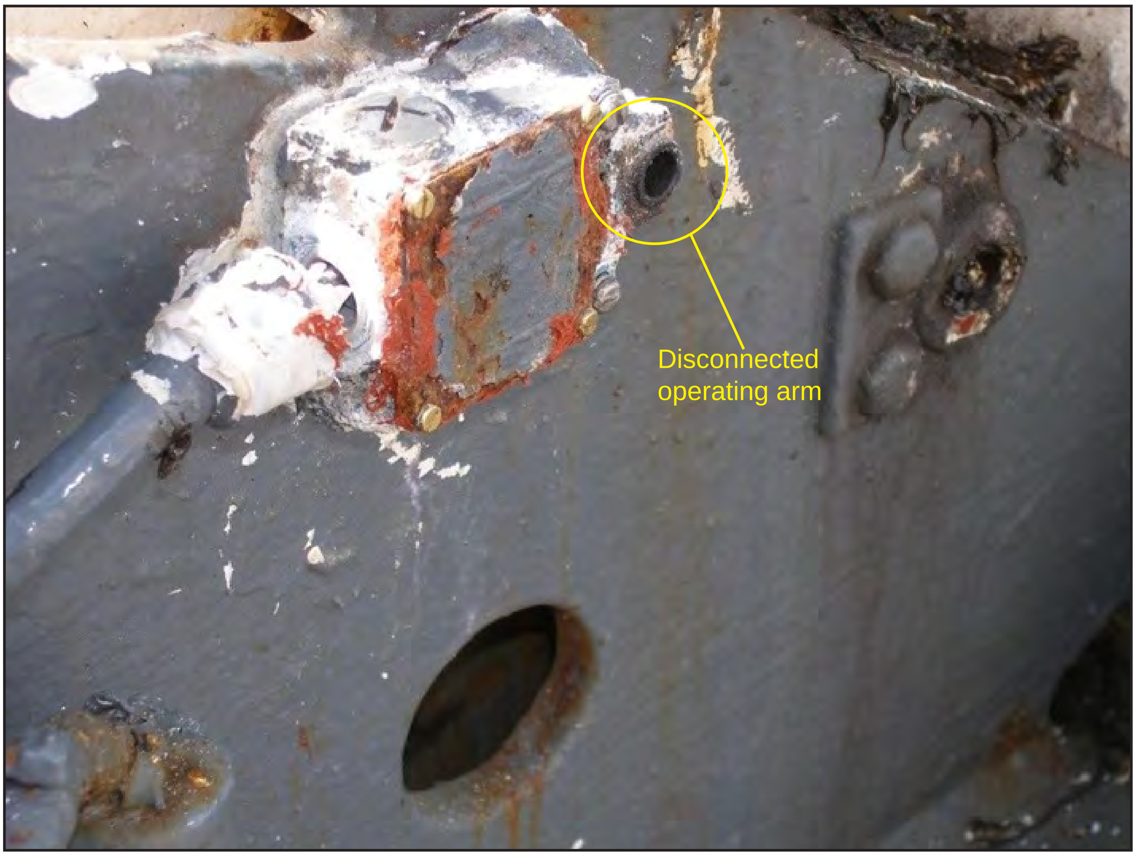

Figure 13: Broken limit switch

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 FAILURE MECHANISM

It is evident, from the test report at **Annex C**, that the fall wire was in good condition and was fit for purpose. The failure of the wire was caused by a rapid single tensile load in excess of 133kN. Although the weight of the rescue boat and its crew (approximately 1550kg (boat) plus 300kg (4 persons)), exceeded the davit's SWL of 1500kg, it was much less than the breaking load required to part the fall wire.

Tombarra's rescue boat was hoisted towards its stowed position at slow speed with the expectation that the davit proximity switch would stop the winch motor before the davit arm made contact with the davit structure. However, it is evident from the circumstances of the accident, and the post-accident inspections and tests **(Annexes D, E** and **F)**, that the davit proximity switch did not function as designed or intended. Consequently, the winch motor continued to operate while the control button was depressed.

As the davit arm came hard up against the fixed davit structure, the winch motor would have drawn more electrical current and the winch's pull would have increased rapidly in order to overcome the resistance encountered. Given the maximum pull of the W50RS winch when fitted with a 15/20kW motor was between 210kN and 227.5kN **(Paragraph 1.7** and **Annex I)**, it was more than capable of exceeding the 133kN force needed to break the wire. The wire's failure in proximity to the final sheave on the davit **(Figure 10)** was not significant, as its strength would have been marginally reduced where it bent round the sheave.

2.3 DAVIT PROXIMITY SWITCH

It is likely that the davit proximity switch did not function as intended due to the gradual ingress of moisture into the unit **(Annexes E** and **F)** leading to the eventual absorption of the moisture by the epoxy resin potting compound which probably caused a short circuit on the printed circuit board. This failure mode is consistent with long-term exposure to moisture and extreme temperature fluctuations. Although the switch enclosure met the IP67 standard when new, the moisture resistance of the switch was possibly compromised by several factors. These factors included the physical deterioration of the cover seal and/or cable gland with age, the extreme changes in atmospheric conditions and temperatures experienced during the ship's voyages from the tropics to the Baltic, and the use of pressure washers or similar to clean the adjacent deck areas. The likelihood of moisture ingress was certainly increased by the orientation of the switch on the davit **(Figure 9)**, which was contrary to the switch manufacturer's guidance, and would have increased the possibility of moisture ingress due to capillary action through the cable gland.

However, it is also possible that the short circuit in the printed circuit board was caused by the fitting of a 2 amp, rather than a 0.4 amp fuse. The short circuit within the printed circuit board, which would not have been identifiable without specialist examination, could have been caused by transient power surges that were not prevented by the 2 amp fuse.

2.4 SAFETY DEVICES

2.4.1 Suitability

The *safety devices* commonly used on ships' davit systems are either electronic **(Figure 9)**, as on board *Tombarra*, or mechanical **(Figure 13)**. However, although the LSA Code requires that '*safety devices*' are fitted '*to prevent overstressing the falls or davits'*, the Code does not specify any standard or criteria these devices must meet, or the number of devices required. Consequently, the manufacturers of davit systems have a great deal of latitude when deciding on the type and number of safety devices to fit.

By comparison, the design of equipment used in land-based, man-lifting operations in the European Union, where equipment failure could result in a person falling from height, is guided by the European Machinery Directive[12], which, by addressing complete systems, rather than components, aims to reduce risk to as low as possible. Consequently, man-lifting equipment could expect to be fitted with a multi-channel, fail safe, safety system, preferably using different types of safety devices so as to avoid common-cause failures. The actions of a person operating the machinery, such as a winch operator, would not be included as a safety measure.

The use by USH of a single davit proximity switch as the *'safety device'* on board *Tombarra* and at least 442 other vessels, which met type approval and MED requirements, is of significant concern. The switch is not considered by its manufacturer to be suitable as a 'final stop' device in a high risk operating system. It does not fail safe or have a back-up in case of malfunction, its IP rating would not have remained valid indefinitely.

2.4.2 Use

The use of limit switches on ships' equipment is very common. A number are fitted to assist with equipment operation, while others are fitted to prevent equipment from being damaged. Importantly, although the limit switches fitted on davit systems are essential to prevent possible catastrophic failure, it is likely that many seafarers do not understand their significance, and so treat them in the same manner as limit switches on other, less safety-critical equipment.

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[12] The Machinery Directive 2006/42/EC (as amended) is intended to reduce the number of accidents involving machines by the use of inherently safe design and construction of machinery, and by proper installation and maintenance. The directive applies a range of principles to the design and construction of machinery, and the key legal requirement for placing new CE marked machinery in to the EU market is that it must meet essential health and safety requirements.

The guidance provided by USH in its davit system operations manual **(Paragraph 1.4.5)** did not make explicit the manufacturer's expectation that, under normal operating conditions, winch operators would stop the winch before the proximity switch was activated. In addition, no aids or marks were provided on the system to help winch operators judge when to cease power hoisting. Moreover, the crews were unlikely to use the manual winch handle sooner than necessary unless they were specifically warned of the dangers of relying on the proximity switch.

The only reference to the winch's capability available to *Tombarra*'s crew was its nominal rating. Like the mooring winch on board *Dublin Viking* **(Paragraph 1.10)**, there were no indications, either on the winch markings or in the manufacturer's manual, that the maximum winch pull that could be achieved was so much greater than the running load. Consequently, *Tombarra*'s crew was unaware of the possibility of the pull of the winch exceeding the MBL of the fall wire.

Furthermore, the switch's failure to prevent the davit arm driving into its home position when operated at high speed on board *Toscana* **(Paragraph 1.5.4)** was likely to have been due to the response time of the associated control circuit or mechanical inertia of the winch. In such circumstances, the continued reliance on the switch to stop the winch motor would have led to the stretching and weakening of the fall wire over time.

2.4.3 Maintenance and testing

The provision of comprehensive guidance on the purpose and use of *safety devices* by davit system manufacturers would undoubtedly assist seafarers, ship owners and managers to fully understand how davit systems should be operated. Nonetheless, there is an overriding obligation by davit system service engineers and ships' crews to ensure that all *safety devices* fitted to davit systems function as intended.

Tombarra's davit proximity switch had been maintained under a service agreement with USH. Although it could be interpreted that the USH manual required the davit proximity switch to be replaced every 2 years **(Paragraph 1.4.4)**, this was not clear, and was certainly not adhered to by USH's service engineers, who attended the vessel in 2010 and before.

Electronic proximity switches can fail in either the ON or OFF state, depending on the exact failure mechanisms. Both the failure mode of the switch and the time of occurrence, are random. On board *Tombarra*, the switch became inoperative some time between the rescue boat being hoisted on 8 January 2011 and moments before the fall wire parted 1 month later.

In view of the potential random nature of the switch's failure, the possibility that it malfunctioned due to a power surge in the output circuit when the switch was actuated by the davit arm moments before the fall wire parted, cannot be discounted. However, considering the condition of the switch's enclosure, the switch was just as likely to have failed during the 30 days prior to its deployment. Therefore, had the switch been tested immediately before the boat was recovered, it is probable that the inoperability of the proximity switch would have been highlighted in time to take remedial action. The failure to conduct this test, which was identified in MSC Circ.1206 and USH guidance, and required by onboard instructions, was a significant omission.

2.5 SYSTEM DEVELOPMENT AND APPROVAL

2.5.1 Winch and wire

Tombarra's davit system, which incorporated the SA1.5 davit, a W50RS winch fitted with a 15/20kW motor, and a 12mm fall wire, was a hybrid developed by USH for use on vessels with a high freeboard. USH had replaced the FME 3.3 with the W50RS winch due to its greater wire capacity. However, because the 18mm wire associated with the W50RS winch was incompatible with the boat lifting hook, USH continued to fit 12mm wire to SA1.5 davits supplied to high-sided vessels. As a result, the hybrid davit systems installed on board *Tombarra* and other high-sided vessels did not comply with the relevant type and MED approval documentation.

The W50RS winch was approved for use in conjunction with an 18mm fall wire (DAD dated 8 October 2002). However, in December 2003, LR approved the winch's use in conjunction with the SA1.5 for installations requiring a greater wire capacity, but it did not indicate the diameter of wire to be used. Furthermore, when the society reviewed the hybrid davit system GA drawing supplied by USH in September 2004, the size of wire specified on the drawing (12mm) did not comply with the approved wire size in the W50RS DAD (18mm), but this does not appear to have been identified. Consequently, all of the 49 W50RS winches supplied by USH in conjunction with the SA1.5 davit and a 12mm fall wire, which includes the winch fitted on board *Tombarra*, did not comply with the W50RS winch approval certification.

It is highly likely that USH's use of a 12mm fall wire with the W50RS winch when used in conjunction with the SA1.5 davit, was overlooked by LR because davit systems component parts were approved by a number of different sections within its organisation. It is clear from this investigation that, for the approval of systems where component compatibility and interoperability are essential, a more holistic approach is required.

2.5.2 Winch and motor

In December 2004, USH informed LR that the 6.5/11kW motor was to be used in conjunction with the W50RS winch when fitted to the SA1.5 and 1.75 davits, following which LR amended the DAD accordingly. However, USH then supplied a further 33 W50RS winches fitted with the 15/20kW motor for use with the hybrid davit systems. These winches therefore did not meet their conditions of certification with respect to the size of the motor fitted when used with the SA1.5 davit.

2.5.3 Quality assurance

Although USH has been accredited by LRQA as complying with ISO 9001: 2000, since 2001, its supply of davit systems that did not comply with the conditions of the applicable approval documentation over several years casts doubt on the effectiveness of the manufacturer's quality control processes and systems. Moreover, the use of a 12mm wire instead of an 18mm wire with the W50RS winch, without any apparent assessment of suitability, and the continued supply of the 15/20kW motor, once it had been identified to be too powerful, are of serious concern.

In view of the ability of the W50RS winch fitted with a 15/20kW motor to overstress a 12mm fall wire, it is imperative that action is taken on the 49 vessels fitted with this combination to ensure that similar accidents do not occur in the future.

2.6 SYSTEM DESIGN

IMO MSC/Circ.1094 includes a list of salient points that contribute to the safe operation of rescue boats, including (inter alia) that: *all parts of the stowage, launch and recovery system are proven to be compatible well before installation, preferably at the design stage*. The circular is directed at, among others, parties involved in the design, installation, testing and approval.

Importantly, however, in assessing component compatibility, the LSA Code requires that factors of safety only need to be applied to a support structure (the davit) with respect to the load **(Paragraph 1.9.2)**. Therefore, only the forces down the fall wire, namely the weight of a boat and its crew, are considered. No account is required to be taken of the potential maximum forces up the wire, namely the winch pull. Moreover, in stating that safety devices be fitted to prevent overstressing of the falls and davits, *unless the motor is designed to prevent such overstressing*, the Code infers that one component may have the ability to overstress another.

On board *Tombarra*, the maximum pull of the winch (210kN – 227.5kN) was over four times its nominal pull (51kN) and exceeded the actual breaking load of the fall wire (133kN) by at least 50%. However, this potential for the winch to overstress the wire was avoidable. A W50RS winch fitted with a 15/20kW motor would not have been able to overstress an 18mm fall wire (MBL 312kN), and a 12mm wire (MBL 141kN) would not have been overstressed by a 6.5/11kW motor (100kN maximum pull).

Consequently, in view of the circumstances of the accident on board *Tombarra*, along with other similar accidents **(Paragraph 1.10)** the need to ensure that component compatibility takes into account the loads up, as well as down, the fall wire is clear. Although safety devices might still be required in davit systems in which all components are compatible, they would only be necessary in order to prevent damage to equipment, not to prevent catastrophic failure.

2.7 RESCUE BOAT SAFETY

2.7.1 Disadvantage of a high davit head

In the light of the *Estonia* tragedy, the requirement for passenger vessels to carry fast rescue boats, and for cargo vessels to carry rescue boats, is a prudent safety measure. The boats provide a swift means of recovery for persons in the water, and are able to shepherd liferafts after a ship has been abandoned. However, there is no doubt that the boats' usefulness diminishes significantly the higher the position from which they are launched and recovered. There are several disadvantages of a high davit head:

- First, the higher the davit head, the greater is the pendulum effect that is likely to be encountered when a rescue boat is launched in a seaway. As a mother ship rolls, a rescue boat can crash against the ship's side, causing injury to persons and/or structural damage to the boat. Furthermore, although on board the Torrens class vessels a 20º heel to port reduces the distance of the davit head to the waterline to about 23.5m, the distance between the boat and the vessel's side at the waterline would be about 8m, making the boat extremely difficult to control.

- Second, in order to be able to safely launch and recover a rescue boat while making way, it is essential that a bow painter is rigged at a length and at an angle that will hold a rescue boat under the fall wire without the assistance of a rescue boat's engine. On board high-sided vessels, this is not easily achieved.

- Third, although a fall from, or of a rescue boat is dangerous, regardless of height, the further the fall, the more severe the consequences are likely to be. In this case, *Tombarra*'s rescue boat fell about 29m. Therefore, it was not surprising that Gerardo's fatal injuries were consistent with a sudden impact at speed. Indeed, it was extremely fortunate that the other three crew were not seriously injured, or worse.

- Finally, many seafarers do not feel comfortable when working at height, and as highlighted in IMO/MSC Circular 1094, it is clear that many masters of high-sided vessels are reluctant to deploy rescue boats during drills in anything but benign conditions. Consequently, there is a risk that the boats' crews will not be adequately prepared to respond safely in a real emergency.

2.7.2 Vessel design

SOLAS III/24 recommends that the maximum height of a davit head used to launch and recover survival craft on passenger vessels is 15m. The IMO MSC/Circ. 1094 also recognises the disadvantages of high davit heads, and advises that for rescue boats fitted on board passenger vessels, *the height of the lifting davit head is minimised* **(Paragraph 1.9.3)**. However, no equivalent advice has been promulgated for the location of davit heads used with rescue boats or survival craft on board cargo vessels despite the disadvantages and dangers of operating both of these types of craft from height being similar.

The retrofitting of rescue boats to all vessels prior to 2000 was in some cases constrained by vessel design to site the craft on high weather decks. However, there are few practical reasons why the design of new high freeboard vessels cannot be modified in order to position the stowage of rescue boats and survival craft closer to the waterline **(Figure 14)**.

Although the positioning of rescue boats and survival craft on vessels with a high freeboard, such as car carriers, adversely affects their cargo capacity to some degree, the cost is relatively insignificant compared to the obvious safety benefits to be gained. However, as long as the height of a davit head is left to the discretion of ship owners, many are unlikely to fully heed the IMO's advice, particularly when this advice is only directed towards passenger vessels. It is only when a maximum height of a davit head is mandated for all vessel types that the disadvantages and dangers of operating rescue boats and survival craft from high-sided vessels will be significantly reduced.

Figure 14: Rescue boat located below the upper deck on a different series of car carrier also operated by Wilhelmsen

SECTION 3 - CONCLUSIONS

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

1. The fall wire was in good condition and its failure was caused by a rapid single tensile load in excess of 133kN. [2.2]

2. The davit proximity switch did not function as designed or intended due to a short circuit on its printed circuit board caused by either water ingress or a transient power surge. Consequently, the winch motor continued to operate. [2.3]

3. The maximum pull of the W50RS winch when fitted with a 15/20kW motor was between 210kN and 227.5kN, and it was more than capable of exceeding the 133kN force needed to break the 12mm wire. [2.2]

4. Although the davit proximity switch was not considered by its manufacturer to be suitable as a 'final stop' device in a high risk operating system, the LSA Code does not specify any standard or criteria these devices must meet, or the number of devices required. [2.4.1]

5. The guidance provided by the manufacturer on the operation of the winch was misleading and did not make clear its expectation that winch operators would stop the winch before the proximity switch was activated. [2.4.2]

6. The replacement interval of the davit proximity switch in the manual provided by USH was unclear. [2.4.3]

7. The 49 davit systems installed on board *Tombarra* and other high-sided vessels were hybrids, and did not comply with the relevant type and MED approval documentation. [2.5.1, 2.5.2]

8. The type and MED approval of winch and davit systems requires a holistic 'systems' approach. [2.5.1]

9. The use of a 12mm instead of an 18mm wire with the W50RS winch without any apparent assessment of suitability, and the continued supply of the 15/20kW motor, once it had been identified to be too powerful, are of serious concern. [2.5.3]

10. In view of the ability of the W50RS winch fitted with a 15/20kW motor to overstress a 12mm fall wire, it is imperative that action is taken on the 49 vessels fitted with this combination to ensure that a similar accident does not occur in the future. [2.5.3]

11. International guidance advises that only the forces down the fall wire, namely the weight of a boat and its crew, are considered when assessing system compatibility. No account is required to be taken of the potential maximum forces up the wire, namely the winch pull. [2.6]

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

1. The disadvantages and dangers of davit systems used to launch and recover survival craft increase with the height of the davit head. [2.7.1]

2. Many masters of high-sided vessels are reluctant to deploy rescue boats during drills in anything but benign conditions. [2.7.1]

3. The disadvantages and dangers associated with launching and recovering rescue boats and survival craft above 15m are the same on board cargo vessels as on board passengers. [2.7.2]

4. There are few practical reasons why the design of new high freeboard vessels cannot be modified in order to position the stowage of rescue boats and survival craft closer to the waterline. [2.7.2]

5. It is only when a maximum height of a davit head is mandated for all vessel types that the disadvantages and dangers of operating rescue boats and survival craft from high-sided vessels will be significantly reduced. [2.7.2]

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

1. The failure to test the davit proximity switch before the rescue boat was recovered, which was identified in MSC Circ.1206 Rev.1 and USH guidance, and required by onboard instructions, was a significant omission. [2.4.3]

2. It is likely that many seafarers do not understand the importance of limit switches fitted to davit systems and treat them in the same manner as limit switches on other, less safety-critical equipment. [2.4.2]

3. The only reference to the winch's capability available to *Tombarra*'s crew was its nominal rating. There were no indications, either on the winch markings or in the manufacturer's manual, to alert *Tombarra*'s crew that the maximum winch pull could easily exceed the MBL of the fall wire. [2.4.2]

SECTION 4 - ACTION TAKEN

4.1 MAIB

The MAIB has:

- Issued Safety Bulletin 2/2011 to the shipping industry **(Annex K)** which recommends that owners and operators of vessels equipped with boat davits should:
  - *In the case of vessels fitted with the USH SA1.5 and SA1.75 davits, follow the advice contained in the manufacturer's Product Advice Note (PAN), or urgently contact USH if a PAN has not been received.*
  - *Ensure that all devices (inductive or mechanical) fitted to boat davit systems to prevent overload, are tested on each occasion before a boat is hoisted, and that such devices are not relied upon during operation.*
  - *Follow manufacturers' recommendations regarding the maintenance and periodic testing, examination and replacement of safety devices, seeking clarification from manufacturers where ambiguity exists.*
  - *Verify the effectiveness of watertight seals on electrical equipment fitted to boat davit systems on weatherdecks*.
- Issued a Safety Flyer to the shipping industry highlighting the circumstances of this accident and several of the safety lessons to be learned **(Annex L)**.

The International Chamber of Shipping (ICS) and the International Life-saving Appliance Manufacturers Association (ILAMA) have undertaken to distribute the Safety Flyer to their members. ICS has also undertaken to distribute the flyer through the Asian Shipbuilding Experts Forum.

The International Association of Maritime Institutions has undertaken to distribute the flyer to its members.

4.2 MCA

The MCA has:

- Issued a temporary dispensation to WLCCL to suspend rescue boat launching drills while allowing simulation drills to take place to maintain crew familiarity with emergency and launching procedures.
- Issued an Operational Advice Notice recommending that during ship inspections and surveys its surveyors:
  - Check that the safe operation of all davit limit switches are included in onboard maintenance routines.
  - Establish that risk assessments for the launching and recovery of rescue craft have been conducted and recently reviewed.

4.3 WILHELMSEN LINES CAR CARRIERS LTD

WLCCL has:

- Instructed its masters to lower and raise their vessels' rescue boats without any persons on board during rescue boat drills.
- Circulated fleet internal safety bulletins highlighting the circumstances of this accident and providing instructions on the use, understanding, and maintenance of limit switches **(Annex M)**.
- Changed the design of its later vessels to site the rescue boat davit at a lower level in the ship side **(Figure 14)**.
- Engaged with USH to agree which changes need to be made to the davits and winches fitted on board its vessels.

4.4 UMOE SCHAT-HARDING AS

USH has:

- Issued a PAN advising owners of vessels fitted with SA1.5/1.75 davits to ensure that the davit proximity switch is working correctly before a rescue boat is hoisted to its stowed position **(Annex N)**.
- Reviewed its risk assessment of the winch and davit system fitted on board *Tombarra*. The review resulted in the davit system being upgraded to the specification of a SA1.75 by the fitting of a 14mm 195MBL wire and matching end link.
- Progressed the testing of a revised design of the electrical switch arrangements fitted to its davit systems.

4.5 LLOYD'S REGISTER

LR has:

- Issued a Marine Training Note to its surveyors highlighting the MAIB Safety Bulletin.
- Informed vessel owners of the circumstances of the accident through its Class News.
- Informed the classification societies of vessels fitted with the USH SA1.5 and SA1.75 davit systems fitted with the W50RS winch and a 15/20kW motor of the accident on board *Tombarra*.

LRQA has:

- Conducted an audit of USH between 24 May and 22 June 2011. The audit report was generally positive, but a number of areas for improvement were highlighted. These included:
    - Serious incidents involving equipment supplied by USH, which indicated that improvements to quality control procedures were required.
    - Lack of knowledge relating to the MED
    - Lack of communication between departments
    - Production drawing revisions not always updated on the computer system.

4.6 SCHNEIDER ELECTRIC LTD

Schneider Electric has:

- Raised the issues surrounding the failure of the davit proximity switch on board *Tombarra* at the SME/32 "Ships and marine technology" meeting at the British Standards Institute (BSI). It has also proposed an amendment to the International Standards Organisation (ISO) standard 15516 "*Launching appliances for davit-launched lifeboats*" to clarify the number, definition, and performance of "safety devices" referred to in the standard. The proposal is currently being considered by the BSI committee.

SECTION 5 - RECOMMENDATIONS

The **Maritime and Coastguard Agency** is recommended to:

2012/128 Submit to the IMO proposals for the LSA Code to:

- Reflect a requirement for a 'system approach' to davit and winch installations with the aim of eliminating the possibility of any component being over-stressed to the point of failure.

- Provide clarification on the fitting and use of 'safety devices' on davit and winch systems, using a goal-based approach to their application.

2012/129 Submit to the IMO a proposal to mandate a maximum height of the davit head used in conjunction with rescue boats and survival craft fitted on board both cargo and passenger ships, based upon:

- Recognition of the severe difficulties faced by the crews of high-sided vessels such as *Tombarra* when attempting to launch rescue boats in a seaway.

- The increased hazards to which the crews of rescue boats and survival craft are exposed when operating at height.

- The action taken by Wilhelmsen Lines Car Carriers Ltd to change the design of its future vessels to lower the height of the rescue boat davit head **(Figure 14)**;

- The maximum height of davit heads used in conjunction with survival craft already recommended for passenger vessels in SOLAS III/24; and,

- The guidance provided in MSC Circ 1094 regarding the height of davit heads used for fast rescue boats on board passenger ships.

The **International Life-saving Appliance Manufacturers Association** is recommended to advise all rescue boat and survival craft manufacturers to:

2012/130 Review their designs of davit and winch installations to ensure that the possibility of any component being over-stressed to the point of failure is eliminated by fully considering key factors, particularly the winch capability under stall conditions and single point failures.

2012/131 Ensure that the type, number and positioning of 'safety devices' used on winch and davit installations is critically assessed, taking into account:

- Manufacturers guidance

- The marine environment

- System design, and

- The consequences of malfunction.

Umoe Schat-Harding AS is recommended to:

2012/132 Work with the owners of vessels fitted with the SA1.5/1.75 davits/ W50RS winch/15/20kW electric motor combinations, to ensure that the fall wire or any part of the davit structure cannot be overloaded to the point of failure.

2012/133 Review and revise:

- The suitability and use of proximity switches as 'final stop' devices on man-lifting equipment such as davits.
- Its internal quality assurance systems to ensure that all equipment it supplies to vessels complies with the conditions of the equipment's certification.
- Its davit and winch operating manuals in order to make clear the need to cease hoisting before the davit arm reaches the davit proximity switch, and that the requirements for the replacement of components is unambiguous.

Marine Accident Investigation Branch
July 2012

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

Marine Accident Report

INVESTORS IN PEOPLE