Report on the investigation of

the uncontrolled descent of an

accommodation ladder from the container ship

Ever Elite

San Francisco Bay

10 September 2009

resulting in one fatality

Marine Accident Investigation Branch
Mountbatten House
Grosvenor Square
Southampton
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Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

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

NOTE

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

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CONTENTS

Figures, Tables and Annexes

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	-	Able bodied seaman
ABS	-	American Bureau of Shipping
BS	-	British Standard
C	-	Celsius
CoSWP	-	Code of Safe Working Practices for Merchant Seamen
EMU	-	Evergreen Marine UK Ltd.
EN	-	European Norm
GPS	-	Global Positioning System
HSE	-	Health and Safety Executive
ILO	-	International Labour Organisation
IMO	-	International Maritime Organization
ISM	-	International Safety Management
ISO	-	International Organization for Standardization
kg	-	kilogram
Knots	-	Nautical miles per hour
kW	-	kilowatt
LOLER	-	Merchant Shipping and Fishing Vessels (Lifting Operations and Lifting Equipment)(LOLER) Regulations 2006
LT	-	Lloyd Triestino
m	-	metre
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
mm	-	millimetre
MSC	-	Maritime Safety Committee
MSN	-	Merchant Shipping Notice

N	-	Newtons
Nakano	-	Nakano Seisakusho Co. Ltd.
NOAA	-	National Oceanic and Atmospheric Administration
PFD	-	Personal flotation device
P & I	-	Protection and Indemnity
PMS	-	Planned maintenance system
PPE	-	Personal Protective Equipment
PUWER	-	Merchant Shipping and Fishing Vessels (Provision and Use of Work Equipment)(PUWER) Regulations 2006
SMS	-	Safety management system
SOLAS	-	International Convention for the Safety of Life at Sea
USCG	-	United States Coast Guard
VDR	-	Voyage Data Recorder

Times: All times used in this report are local (UTC-7) unless otherwise stated

Ever Elite

SYNOPSIS

On 10 September 2009, an able seaman from the UK registered container ship *Ever Elite* drowned in San Francisco Bay after the lower section of the accommodation ladder he was standing on broke free and fell into the water. The vessel was approaching the container terminal in Oakland, California when the accident occurred and the seaman's body was soon spotted by an accompanying tug and recovered onto a pilot launch.

The accommodation ladder was set free when the hoist winch gearbox failed; the gearbox had been incorrectly re-assembled by the ship's crew following maintenance. Factors leading to this error included: the lack of technical information held; an ineffective management system of onboard maintenance; and the low-level maintenance and testing requirements adopted for the hoist winch because it had not been considered to be lifting gear as defined in national regulation.

Rigging the ladder when underway was unnecessarily hazardous, and a safe system of work had not been developed. The seaman fell into the water and drowned because he was not wearing a fall arrest device and a lifejacket, which should have been required for working over the side. Other, unrelated, safety shortfalls were identified during the investigation.

From 1 January 2010 international regulation obliges the construction of hoist winches fitted to accommodation ladder systems to meet the requirements of an ISO standard, and for the maintenance of accommodation ladder systems to be in accordance with prescribed guidelines. This is a significant step forward, but the application of this regulation would not necessarily have prevented the accident on board *Ever Elite.*

A recommendation has been made to the British Standards Institution aimed at improving the international standard applicable to the hoist winches fitted to accommodation ladder systems by taking into account current technology, best practice, and the full scope of accommodation ladder operations. Recommendations have also been made to the Maritime and Coastguard Agency which are intended to highlight the weaknesses in the international standard and to make the guidelines on maintenance and testing of accommodation ladder systems more effective. A further recommendation aims to ensure that accommodation ladder hoist systems carried on board UK registered vessels are tested and maintained in accordance with national regulation. A recommendation made to Evergreen Marine UK is aimed at strengthening its safety culture and improving the maintenance management systems on board its vessels.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *EVER ELITE* AND ACCIDENT

Vessel details

Registered owner	:	Aries Line Shipping S.A.
Manager	:	Evergreen Marine UK Ltd.
Port of registry	:	London
Flag	:	UK
Type	:	Container
Built	:	2002 in Japan by Mitsubishi Heavy Industries Ltd.
IMO number		9241281
Classification society	:	American Bureau of Shipping (ABS)
Construction	:	Steel
Length overall	:	230m
Gross tonnage	:	76,067
Engine power and type	:	48,600kW / Mitsubishi Sulzer 12RTA84C-UG
Service speed	:	24.5 knots
Other relevant info	:	2 x slide-out type telescopic accommodation ladder systems manufactured by Nakano Seisakusho Co. Ltd.

Accident details

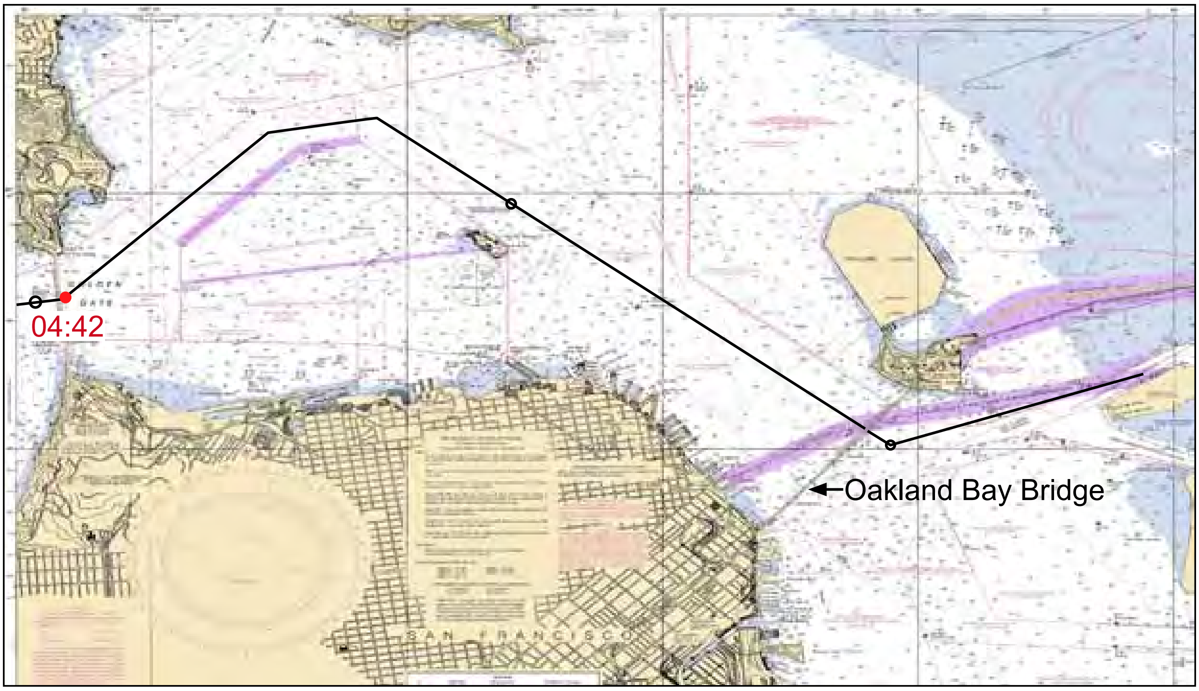
Time and date	:	0505 on 10 September 2009
Location of incident	:	37º 48.3N 122º 22.7W, 0.25 nautical miles north of the Bay Bridge, San Francisco Bay
Persons on board	:	19
Injuries/fatalities	:	1 fatality
Damage	:	Material damage to the port accommodation ladder.

1.2 NARRATIVE

At 0406 on 10 September 2009, the container ship *Ever Elite* embarked a harbour pilot and a trainee pilot for passage in to the container terminal at Oakland, California. At 0442 the vessel passed under the Golden Gate Bridge **(Figure 1)**. About 13 minutes later, the crew were called to their stations in preparation for entering harbour.

Chart courtesy of NOAA®

Figure 1

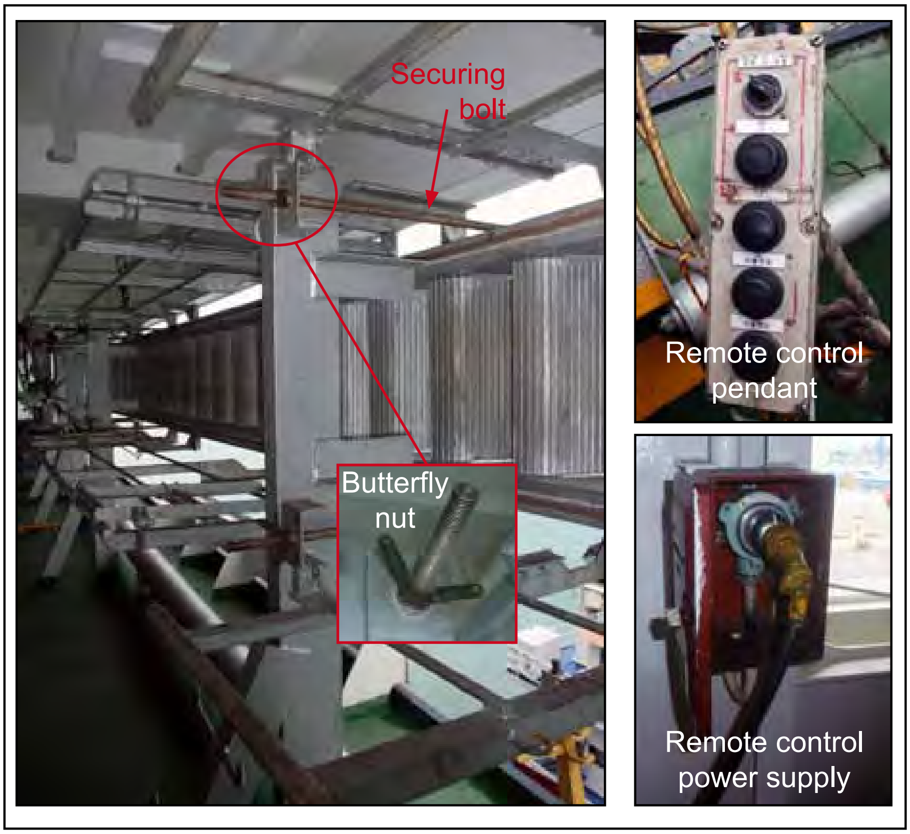


San Francisco Bay

Two off-watch able seamen made their way to the upper deck to prepare the port accommodation ladder prior to mustering at their mooring stations. Able Seaman (AB) Chin-Fu Huang arrived first and began to release the bolts securing the ladder system in its stowage **(Figure 2)**. The second AB (AB2) switched on the power supply to the accommodation ladder winches and collected two working life vests. He put the two life vests on the deck and then connected the wandering lead for the winch remote control pendant.

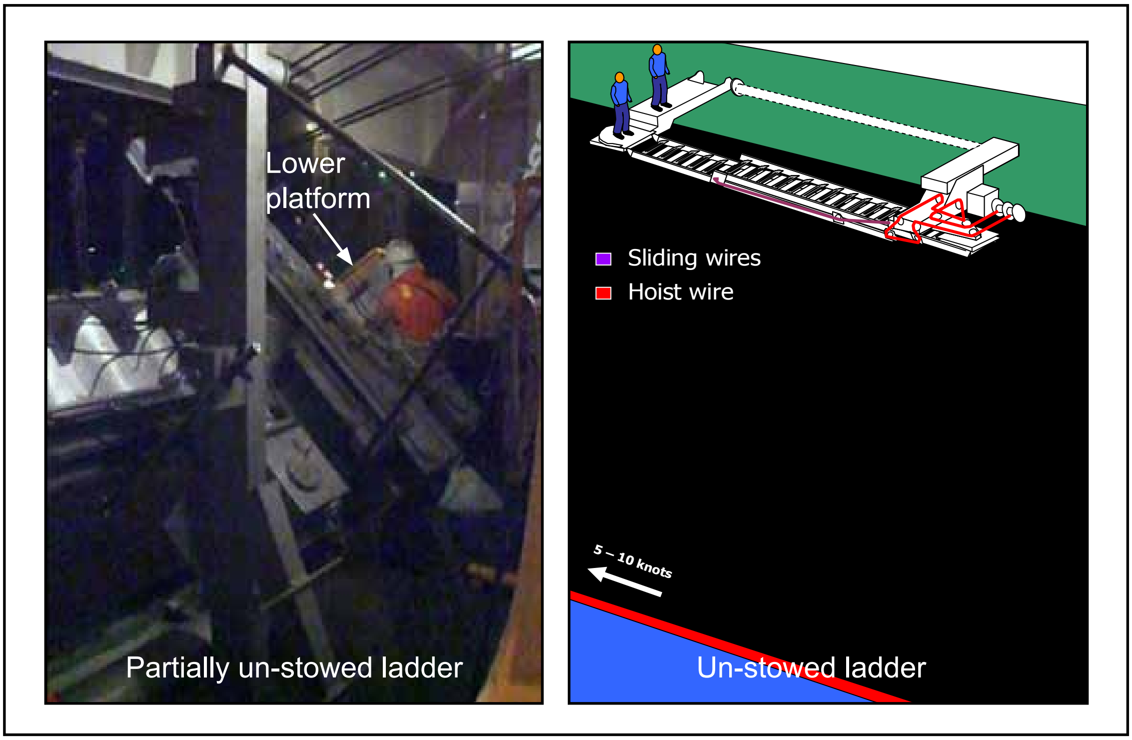
When all of the securing bolts had been released, AB2 partially un-stowed the ladder system using the remote control. AB Huang then unfolded the ladder's lower platform and inserted its two portable handrail stanchions **(Figure 3)**. The telescopic ladder system was then fully un-stowed until it was outboard and horizontal.

Figure 2



Accommodation ladder stowage securing arrangements and controls

Figure 3



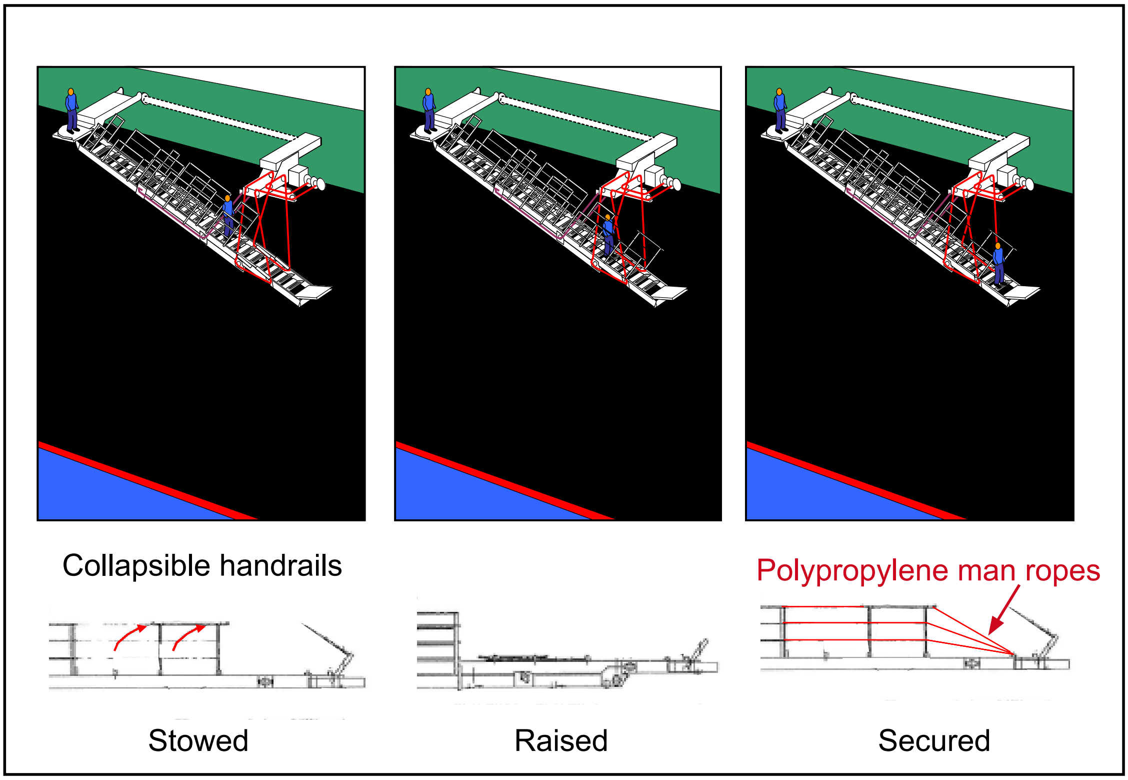
Un-stowing operation

AB2 tested that the hoist winch was functioning by lowering the accommodation ladder approximately 1m and then slightly raising it. He then lowered it approximately 3m to allow his crewmate to walk under the davit frame **(Figure 4)**. AB Huang stepped on to the upper platform and proceeded to the lower end where he rigged a section of collapsible handrails **(Figure 5)**. He then went to the lower platform to make the rails secure while AB2 secured the safety ropes around the upper platform.

Figure 4

Accommodation ladder preparation

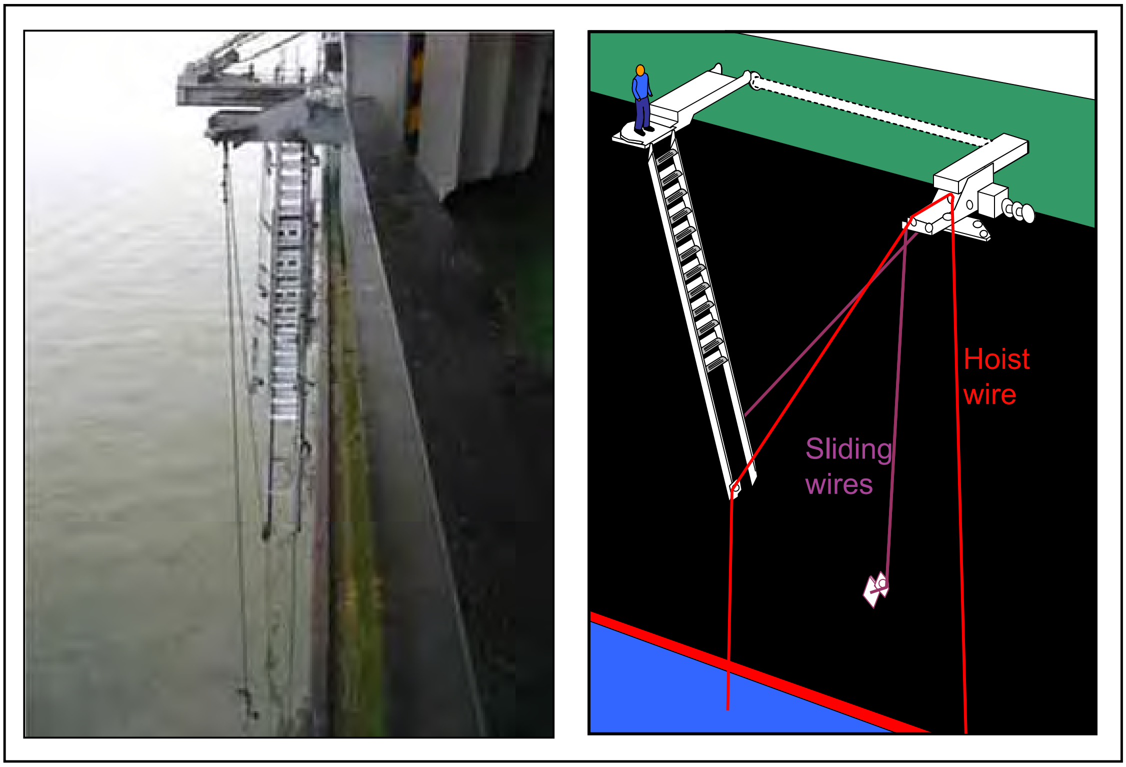
Figure 5



Collapsible handrail rigging

At approximately 0505, AB2 heard a loud bang followed by a whirring sound as the ladder fell rapidly towards the sea. The lower ladder broke away and entered the water, taking AB Huang with it. The upper section of the ladder was left hanging vertically down from its upper platform hinges and the hoist wire was dangling from the davit **(Figure 6)**.

Figure 6



Damaged ladder

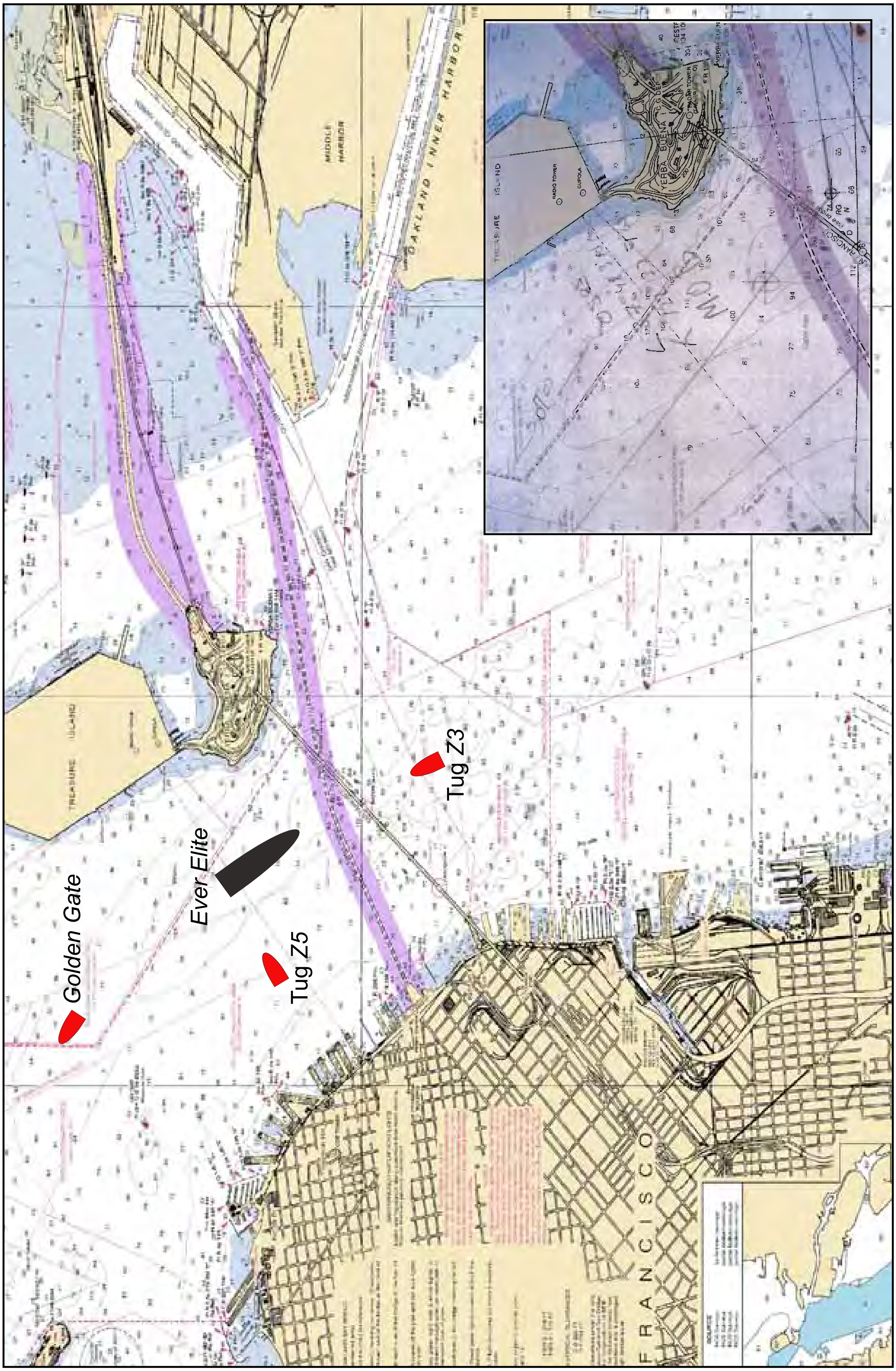
AB2 alerted the bridge by hand-held radio and grabbed a lifebuoy from the accommodation ladder stowage position. He couldn't see his crewmate over the side so he ran to the aft station to look for him over the stern. AB2 and the crew at the aft station saw a tug close by, but there was no sign of AB Huang. The lifebuoy was not thrown into the water.

The ship was a quarter of a mile from the Oakland Bay Bridge. Her engine was set at half ahead and she was making between 5 and 6 knots through the water. The trainee pilot had the con and had committed the vessel to pass under the bridge. Two tugs were standing by: *Z5* was positioned north of the bridge ready to take a line and *Z3* was stationed to the south **(Figure 7)**.

The pilot instructed the trainee pilot to continue conning the ship and released *Z5* to help look for AB Huang. He also instructed the vessel traffic service to record the ship's position and requested the pilot boat *Golden Gate* be made available to assist. The deck cadet marked the position of the man overboard on the ship's paper chart **(Figure 7)**.

Chart courtesy of NOAA®

Figure 7



Position of vessel at 05:05 when the man overboard alarm was raised

AB Huang was spotted about half a metre below the surface by the crew of *Z5* between 10 and 15 minutes after entering the water. He was recovered on board the pilot boat *Golden Gate* but there were no signs of life. AB Huang was transferred to a United States Coast Guard (USCG) lifeboat and taken ashore. *Ever Elite* berthed starboard side-to at the container terminal at Oakland at about 0630. No action was taken to save the information recorded on the vessel's voyage data recorder (VDR).

1.3 ENVIRONMENTAL CONDITIONS

It was dark, the visibility was good, the sea state was calm and the wind was north-westerly force 1. The sea temperature was 16.5ºC and the tidal stream was negligible.

1.4 OWNERSHIP AND OPERATION

The container ship *Ever Elite*, previously named *Hatsu Elite*, had been UK-registered since build in 2002. She was one of 11 container ships managed by Evergreen Marine UK Ltd. (EMU), and was trading on a trans-Pacific service between Kaohsiung, Taipei, Hong Kong and Yantian in the Far East, and Los Angeles, Oakland and Tacoma on the west coast of the USA. Her base port was Kaohsiung and she was manned by a mix of Taiwanese and Filipino officers and crew; one UK deck cadet was also on board.

EMU is based in London and markets its container services under the brand name 'Evergreen Line', together with Evergreen Marine Corp (Taiwan) Ltd., Evergreen Marine (Hong Kong) Ltd., Italia Marittima S.p.A and Evergreen Marine (Singapore) Pte Ltd. EMU is responsible for the safety management of its ships but technical management and manning are primarily controlled by Evergreen Corps in Taiwan.

1.5 THE RIGGING CREW

AB Huang was 41 years old, Taiwanese, and had been employed by Evergreen for 10 years. He had been on board *Ever Elite* for 5 months and had been the bridge lookout from midnight to 0400 prior to the vessel's arrival in San Francisco Bay. His swimming ability is unknown.

AB2 was 29 years old, Filipino, and had been employed by Evergreen for 9 years. He had been on board *Ever Elite* for 9 months and was the bridge lookout during the 8 to 12 watches at sea.

Both ABs had prepared and deployed the ship's accommodation ladders on many occasions during their time on board.

1.6 CAUSE OF DEATH

The Office of the Chief Medical Examiner for the City and County of San Francisco determined the cause of death to be '*drowning with blunt force injuries*'. AB Huang had suffered blunt force injuries to his head, neck, chest, back, abdomen and legs, resulting in a broken right femur, fractured ribs, multiple bruising and abrasions. These injuries were not considered to be fatal.

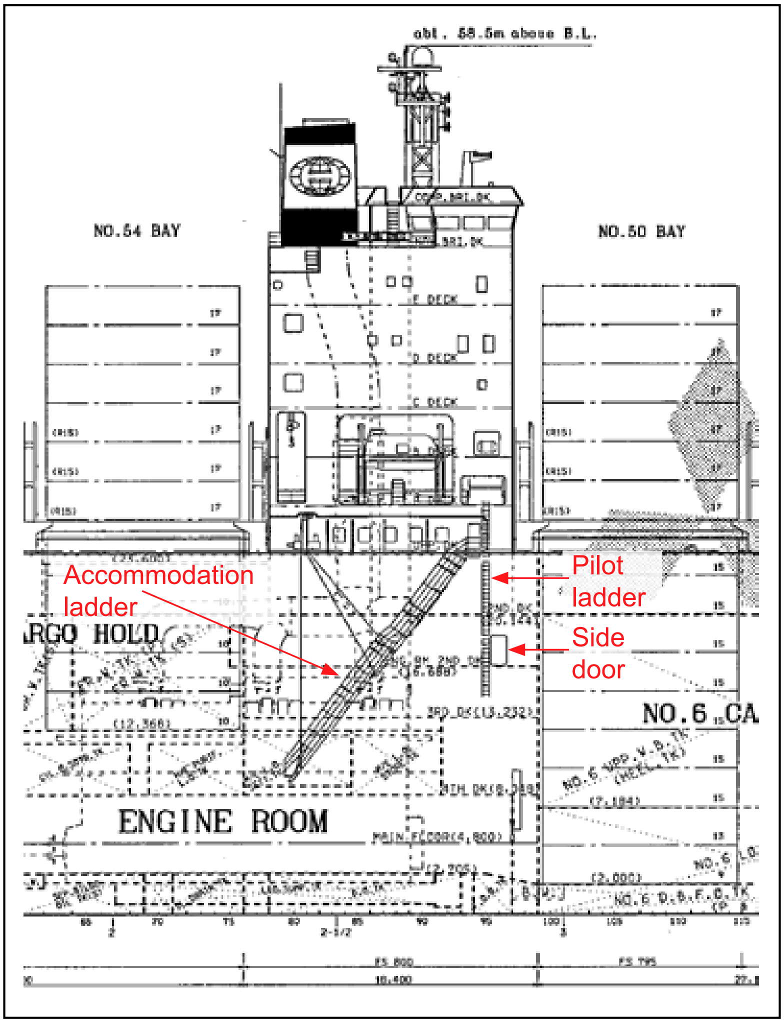
1.7 ACCOMMODATION LADDER SYSTEM

1.7.1 General description

The telescopic accommodation ladder system on board *Ever Elite* was designed and manufactured by Nakano Seisakusho Co. Ltd. (Nakano). It was one of several types manufactured by Nakano. The majority of these were single flight ladders, but it had also built and supplied approximately 300 telescopic systems. The telescopic-type system fitted on board *Ever Elite* had been modified to allow its hoisting davit to slide-out along a steel rail so that the lower platform could be positioned over the quay prior to being lowered. The system was developed and supplied to 28 container ships built by Mitsubishi Heavy Industries Ltd. in Kobe, Japan. Twenty ships were built for Evergreen and the remainder for Lloyd Triestino (LT).

The telescopic ladder, its davit and its winches were built as a single modular unit which was stowed on its side on the upper deck between frames 78 and 95 **(Figure 8)**. The unit was made of steel and weighed 5,450kg; it was designed to enable the ladder to be un-stowed, lowered to the quay, raised and re-stowed without the need for crew members to step onto the ladder while it was suspended from its hoisting gear.

Figure 8



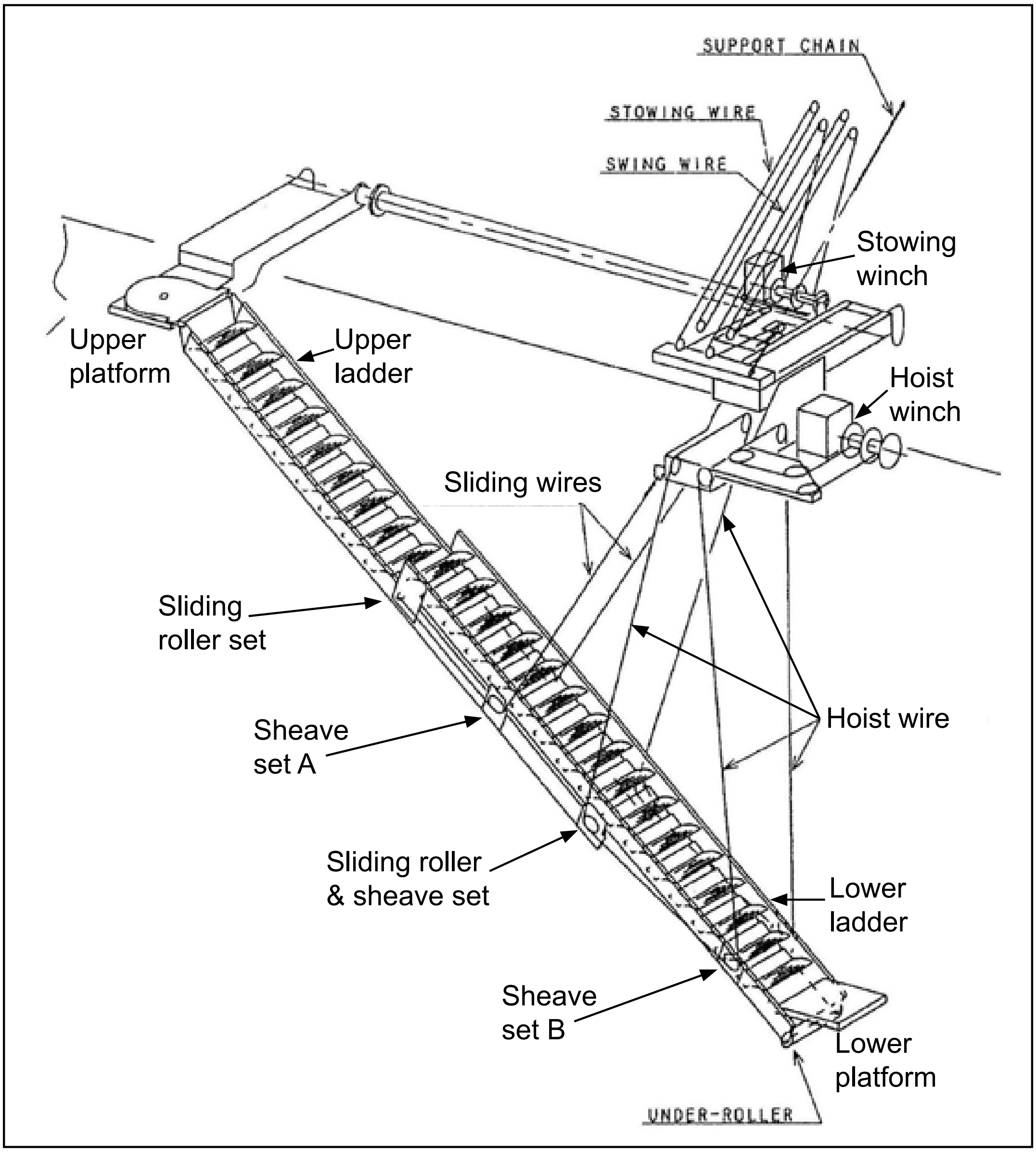
Location of the accommodation ladder, pilot ladder and side door

1.7.2 Telescopic ladder

The telescopic ladder weighed 2,848kg, had 51 steps and extended to 18.55m. The upper ladder was 10m long and was connected to the upper platform's turntable. The lower ladder, which was 11.1m long, lay on top of the upper ladder. It had a roller fitted at the bottom which supported the weight of the telescopic system when it rested on a quay. Access to the lower ladder from the quay was via an adjustable lower platform.

The ladder was raised and lowered by the hoist winch using a 14mm diameter, 85m long, steel wire rope with a breaking load of 9,150kg. The hoist wire was rove continuously from the hoist winch through the sliding roller and sheave sets on the upper ladder and the sheave sets on the lower ladder **(Figure 9)**. Both ends of the wire were clamped to the split winch drum.

Figure 9

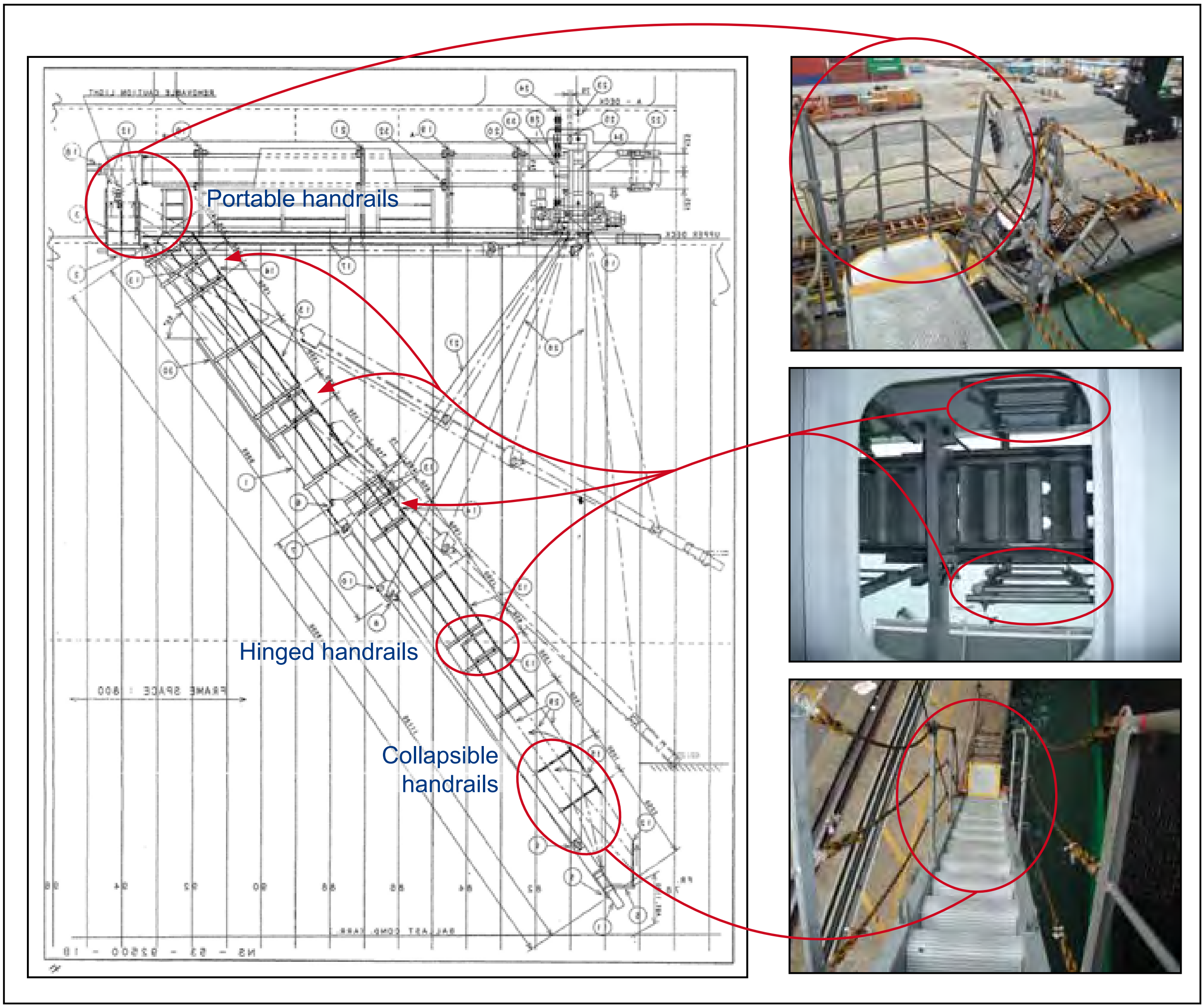


Nakano slide-out telescopic ladder system

Two 16mm diameter, 9m long, sliding wires rigged between the davit frame, and the sheave sets and sliding roller sets on the upper and lower ladders respectively, maintained tension in the hoist wire by ensuring the lower ladder extended and retracted smoothly as it was deployed and recovered.

A combination of fixed and hinged handrails was fitted to the upper ladder and the top 6.2m of the lower ladder **(Figure 10)**. A set of collapsible handrails was fitted to the bottom 4.9m of the lower ladder. Portable stanchions with polypropylene man ropes were fitted around the upper and lower platforms. The use of hinged, collapsible and portable handrails enabled the ladder to be stowed on its side on the upper deck.

Figure 10



Ladder handrails

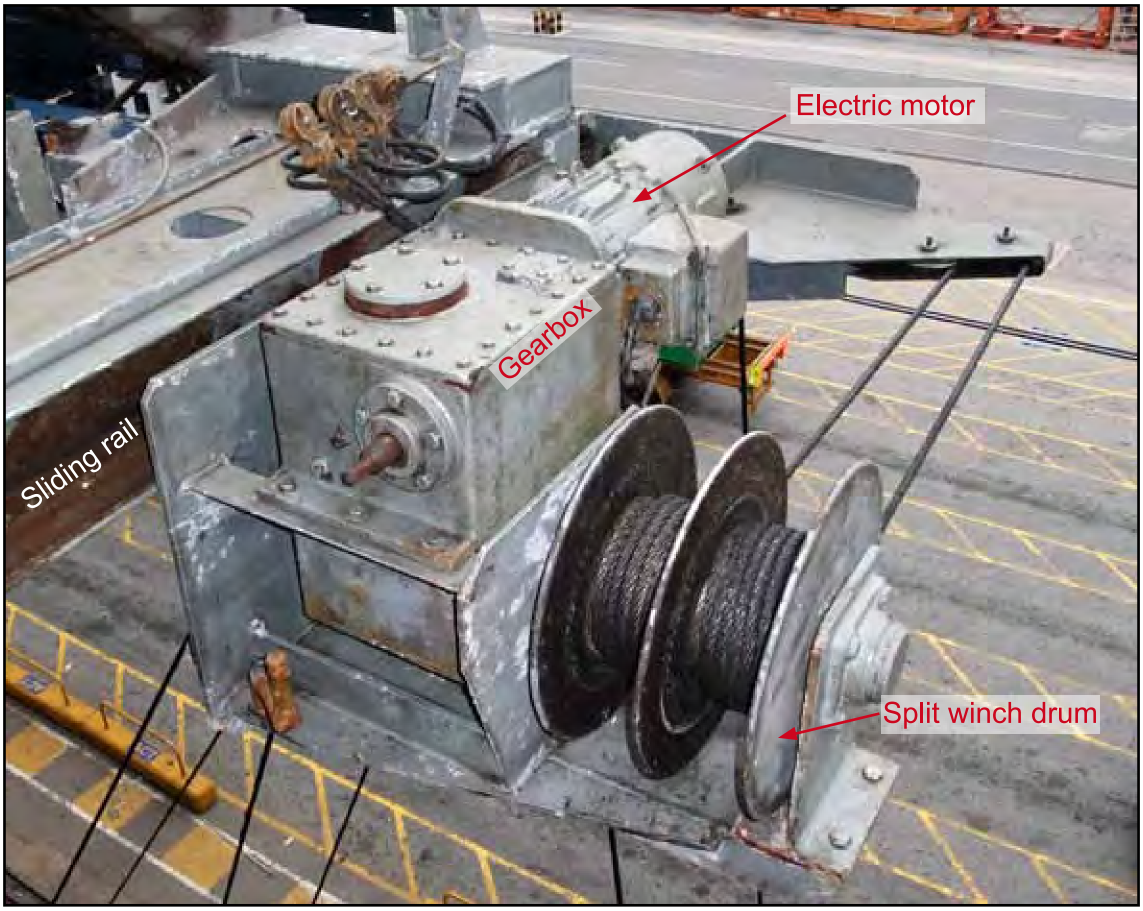
The ladder system was transferred to and from its stowage and horizontal operating positions using the stowing winch. This winch was also used to slide the hoisting davit along its rail.

Nakano considered that its telescopic ladder met the design and construction requirements set out in ISO 5488:1979*, Shipbuilding – accommodation ladders.*

1.7.3 Hoist winch

The hoist winch had a maximum drum load rating of approximately 970kg. Its split drum was driven by a 3.7kW electric motor via a two chamber reduction gearbox **(Figure 11)**.

Figure 11



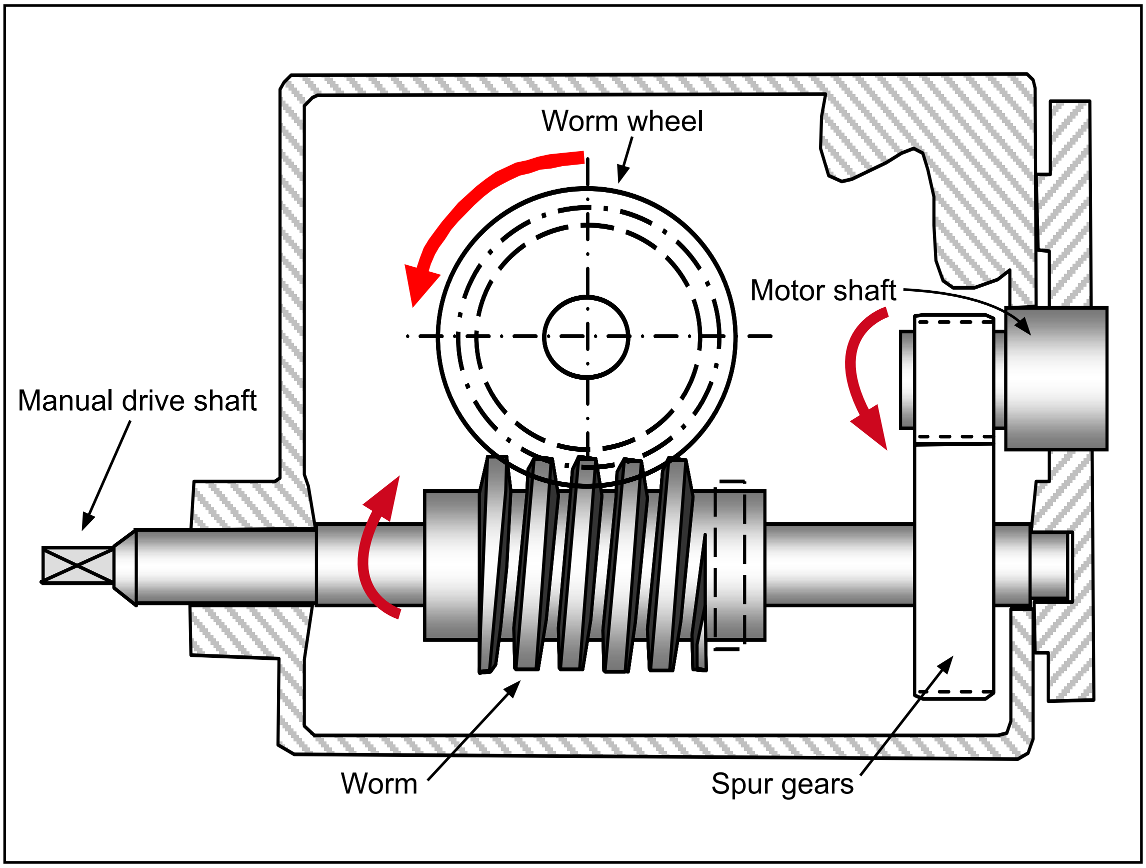
Hoist winch

The motor was coupled to the upper chamber of the gearbox and drove a horizontal worm gear shaft via a set of spur gears **(Figure 12)**. The worm meshed with a gear wheel to drive a vertical bevel gear shaft. This vertical shaft passed through the intermediate bearing housing into the lower chamber of the gearbox **(Figure 13)**. Here, its spiral bevel gear teeth meshed with those on the external casing of the differential gear unit. The differential gear unit, supported horizontally between two bearing housings, drove the split winch drum.

An electromagnetic brake was fitted to the non-drive end of the electric motor and a secondary braking system was provided by the self-locking characteristics of the worm and wheel gear arrangement in the upper chamber of the gearbox. The approximate holding capacity of the winch was 3,750kg.

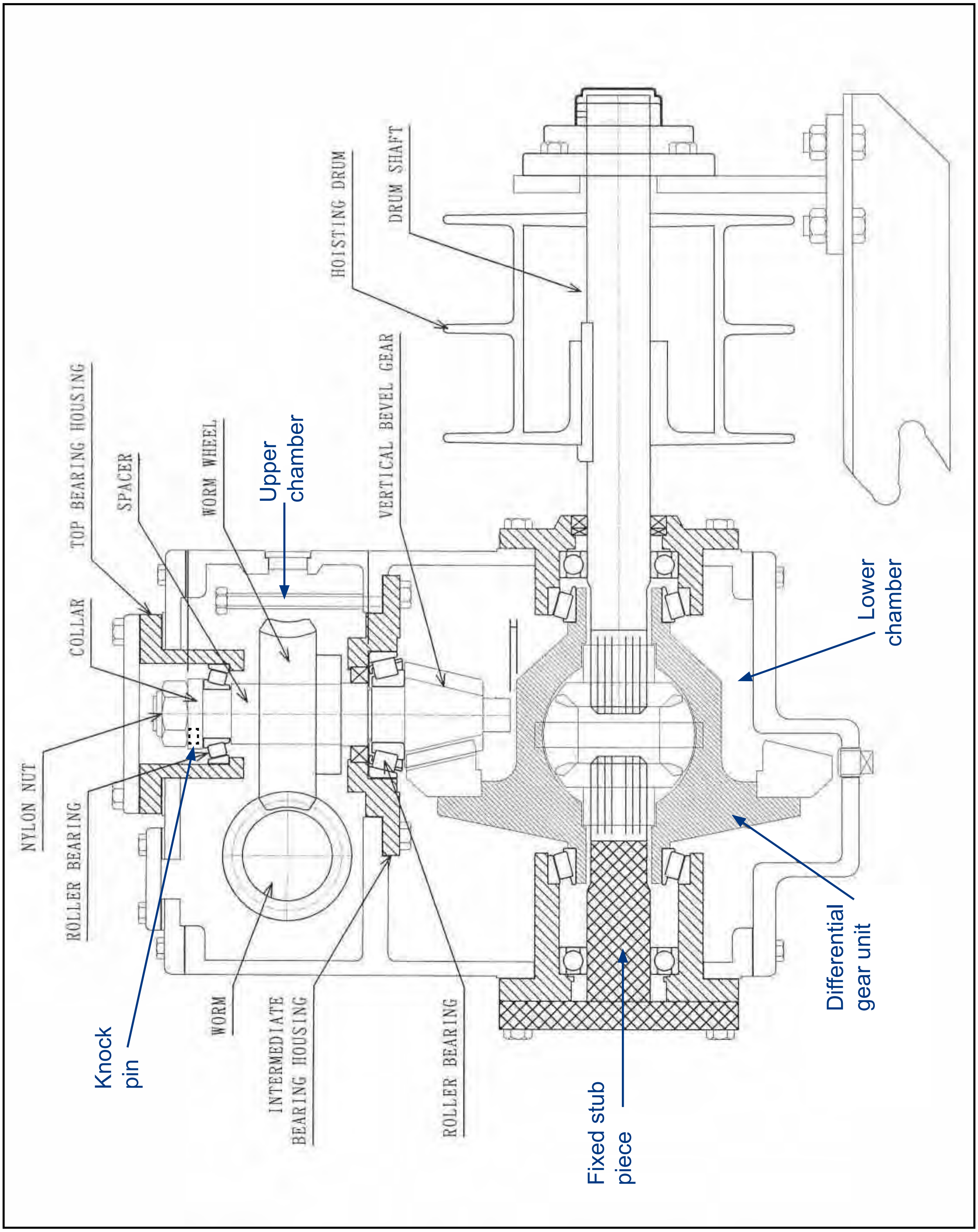
The winch was a modified version developed by Nakano in the 1960s that was designed to both hoist and stow. In the original design, the differential gear unit drove two winch drums independently without the need to use a clutching arrangement. The hoist winch fitted to the slide-out type telescopic ladder system was modified to drive a single drum. As only one output from the differential gear unit was required, a fixed stub piece was fitted to the redundant side of the unit.

Figure 12



Gearbox upper chamber

Figure 13

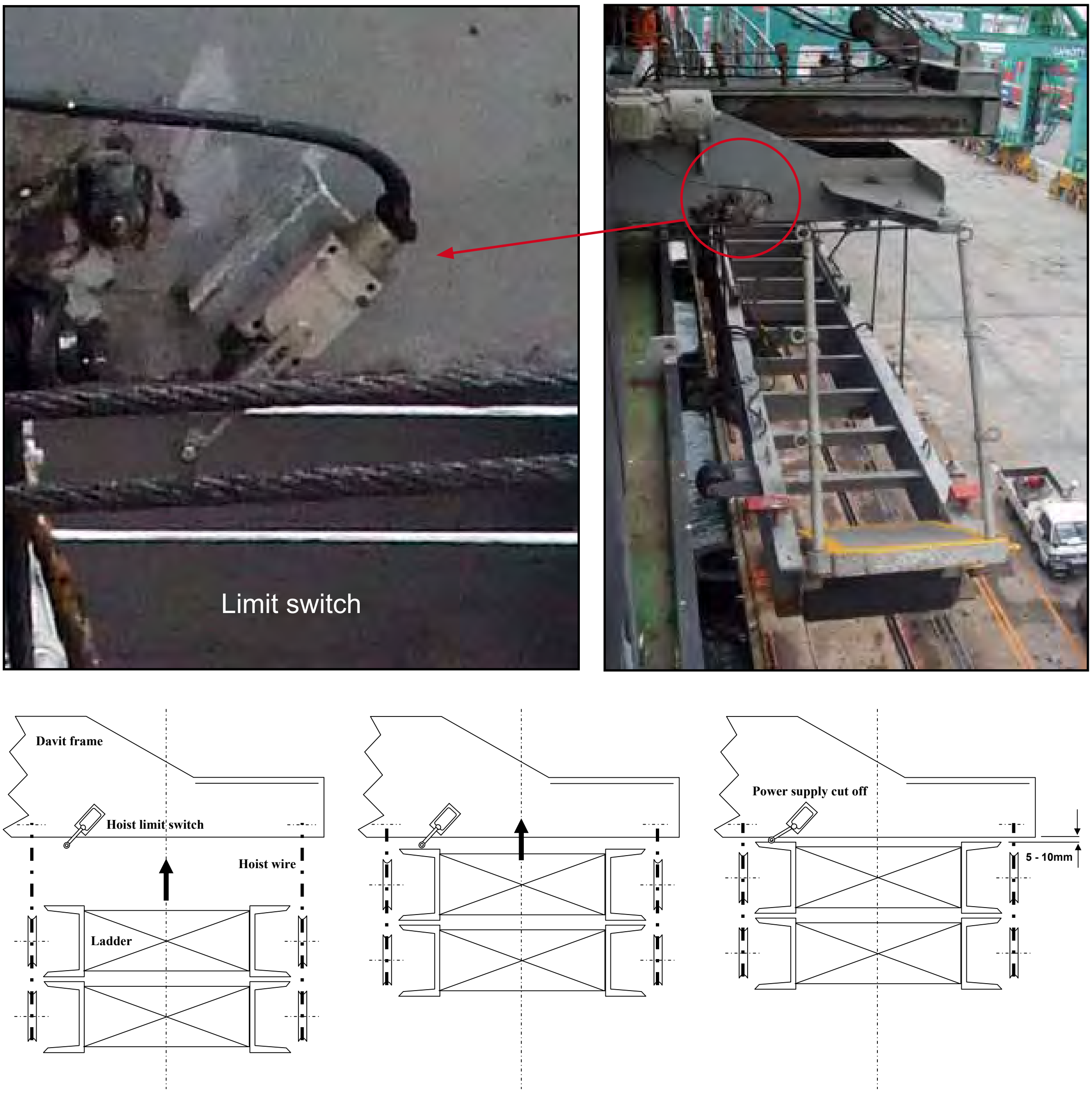


Exploded view of hoist winch gearbox

1.7.4 Hoist winch limit switch

A limit switch was fitted to the underside of the davit frame to cut off the power supply to the hoist winch motor once the telescopic ladder reached its upper position **(Figure 14)**. The limit switch was intended to provide a 5 to 10mm gap between the ladder and the underside of the davit frame. An overload current cut-off relay was also fitted in the electrical control circuit to protect the winch gearbox in case the limit switch failed or was incorrectly adjusted.

Figure 14



Hoist winch limit switch

1.7.5 Onboard guidance

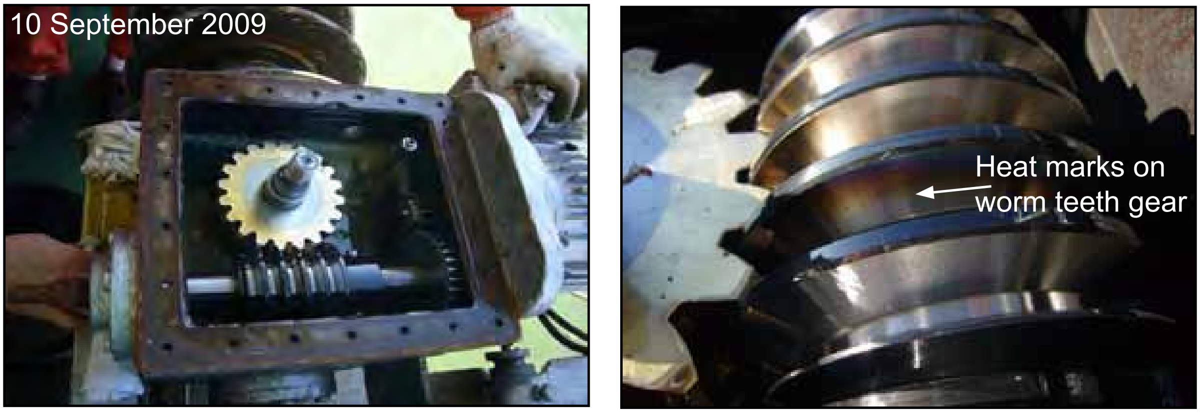
A system manual, written by Nakano was held on board. This included system diagrams, parts lists, maintenance tasks and maintenance instructions. It did not contain any information or instructions relating to the maintenance of the hoist winch gearbox and diagrams of the gearbox were inaccurate and lacked detail.

1.8 POST-ACCIDENT SURVEYS AND INVESTIGATIONS

1.8.1 Ship's investigation

On the day of the accident, the hoist wire was recovered from the davit by the ship's crew and the upper chamber of the gearbox was inspected by the chief engineer in the presence of two Protection & Indemnity (P&I) club surveyors. The self-locking worm and wheel gear arrangement was found to be intact but evidence of heat damage was found on the steel worm **(Figure 15)**.

Figure 15



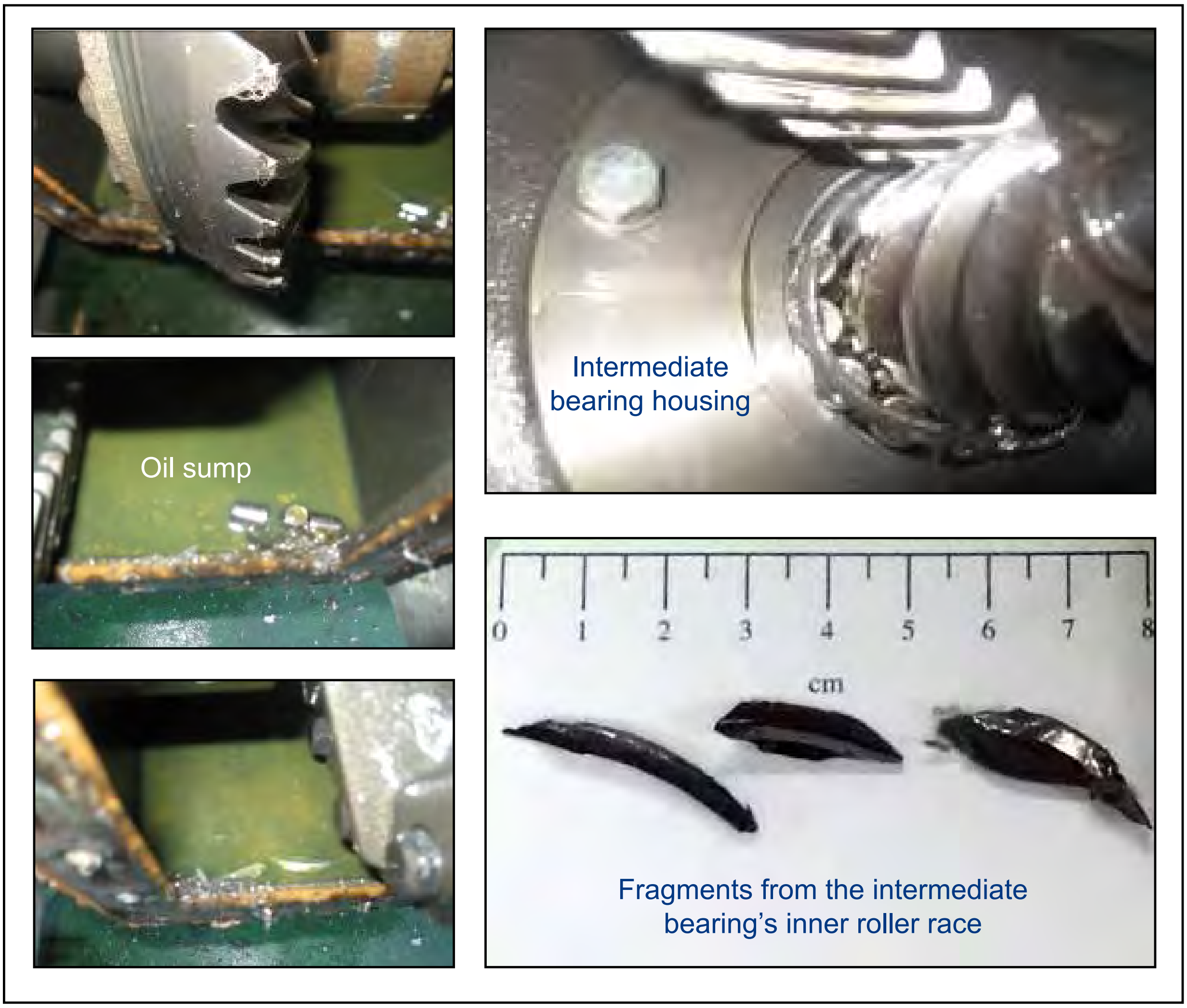
Top bearing housing and upper chamber cover removed by ship's crew for inspection

Initial inspection of the gearbox upper chamber

The initial cause of the accident was reported to be a failure of the hoist wire, but when the wire was measured after the ship had left San Francisco on 11 September 2009, it was still 85m in length. The chief engineer resumed his technical investigation and opened the lower chamber of the gearbox. Several taper rollers and steel fragments were found lying in the sump **(Figure 16)**. The chief engineer concluded that the spiral bevel gear teeth in the lower chamber had disengaged.

On 14 September 2009, the gearbox was taken to the engine room for overhaul. When the gearbox was stripped down, damage to the intermediate bearing and the spiral bevel gear teeth was exposed. The chief engineer then inspected the starboard accommodation ladder hoist winch gearbox. He found damage to the outer edges of the differential gear unit's spiral bevel gear teeth. As a precaution, he replaced the unit.

Figure 16



Debris and damage found when the lower chamber of the gearbox was opened up and inspected

1.8.2 MAIB observations

MAIB inspectors attended the vessel in Hong Kong on 27 September 2009. By this time, the hoist winch and its gearbox had been stripped down and partially overhauled, but the damaged components removed from the gearbox were made available for inspection **(Figure 17)**. Observations included:

- Polishing or wear marks were evident on the upper edge of the faces of the worm wheel gear teeth and the underside of worm wheel body.
- Two score marks, one of which appeared to be recent, were found on the lower spacer of the vertical bevel gear shaft.
- The spiral bevel gear teeth on both the vertical bevel gear shaft and the differential gear unit were damaged.
- Rubbing marks were found on the top land of the spiral bevel gear teeth on the differential gear unit.
- A rubbing mark on the outer circumference of the differential gear unit body, directly below the vertical bevel gear shaft, was found in line with a deeper localised gouge mark.

- Distinct circumferential wear marks were evident on the faces of the intermediate bearing's tapered rollers.
- The knock pin fitted to the vertical bevel gear shaft was burred.

While observing the recovery of the starboard accommodation ladder, it was noted that contact was taking place between the ladder and the underside of the davit frame.

Figure 17

Polishing or wear marks on worm wheel base

Score marks on the vertical bevel gear shaft's lower spacer

Damaged vertical spiral bevel gear teeth

Damaged gear teeth on differential unit

Rubbing marks found on top land of gear teeth

Rubbing mark and localised gouge mark

Circumferential wear marks on intermediate bearing tapered rollers

Burred knock pin fitted to vertical bevel gear shaft

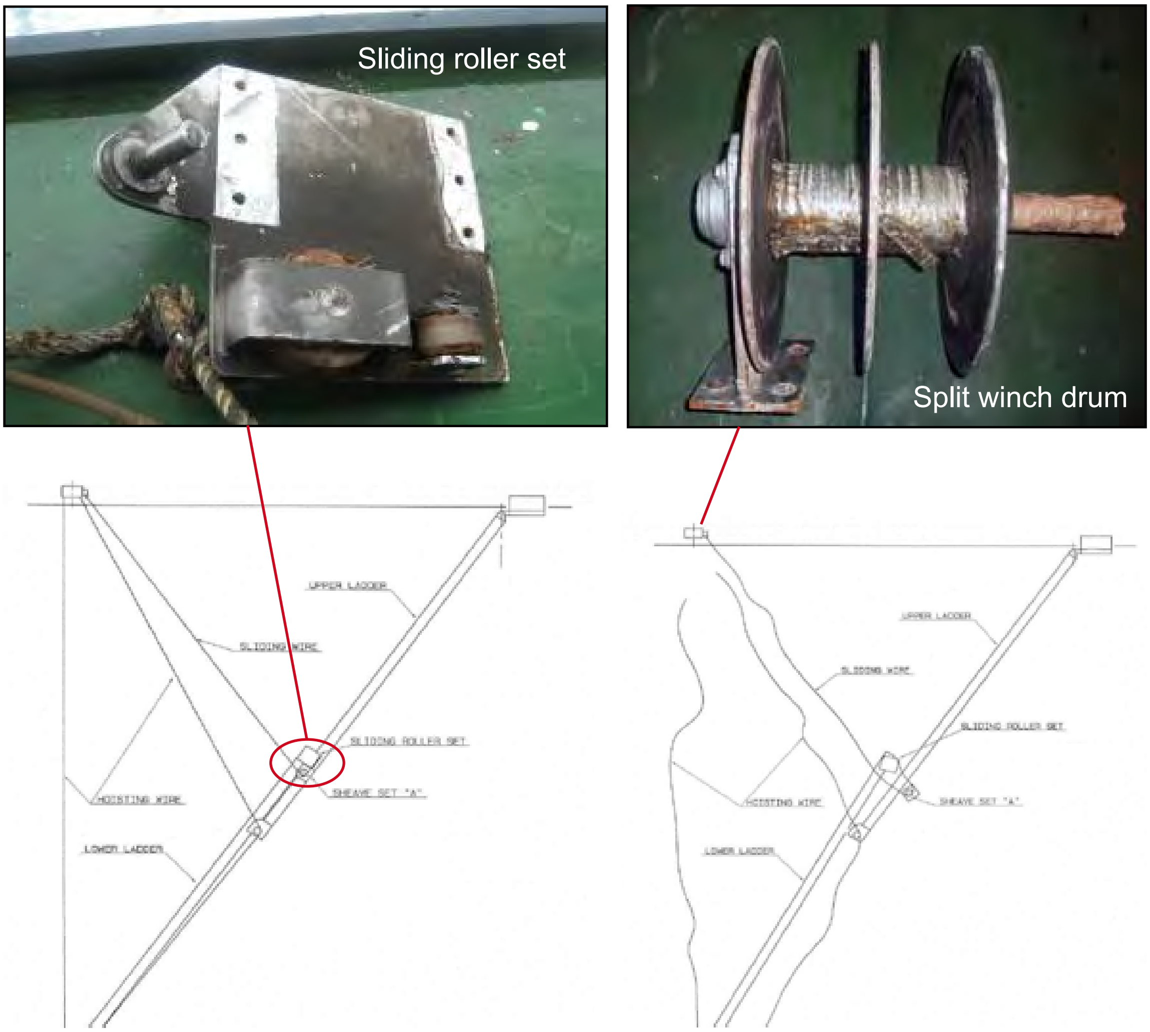
MAIB observations during inspection of damaged gearbox components

1.8.3 Manufacturer's investigation

Three Nakano representatives attended the vessel at Taipei Port in Taiwan on 28 October 2009 to repair the port accommodation ladder system and identify the potential causes of the accident. Nakano's investigation report **(Annex A)** concluded the potential cause of the accident was the failure of the intermediate bearing and, as a result, the *'bevel gear unit holding the hoist drum was set free'*.

Once this had occurred, the sliding wires accelerated the lower ladder outwards until the base plates of its sliding roller sets impacted with those of the upper ladder sheave blocks **(Figure 18)**. The force of the impact caused the 16mm base plate securing bolts to shear, releasing the lower ladder from the upper ladder. The ends of the hoist wire were torn from the drum and the lower ladder was lost overboard.

Figure 18



Detachment of lower ladder

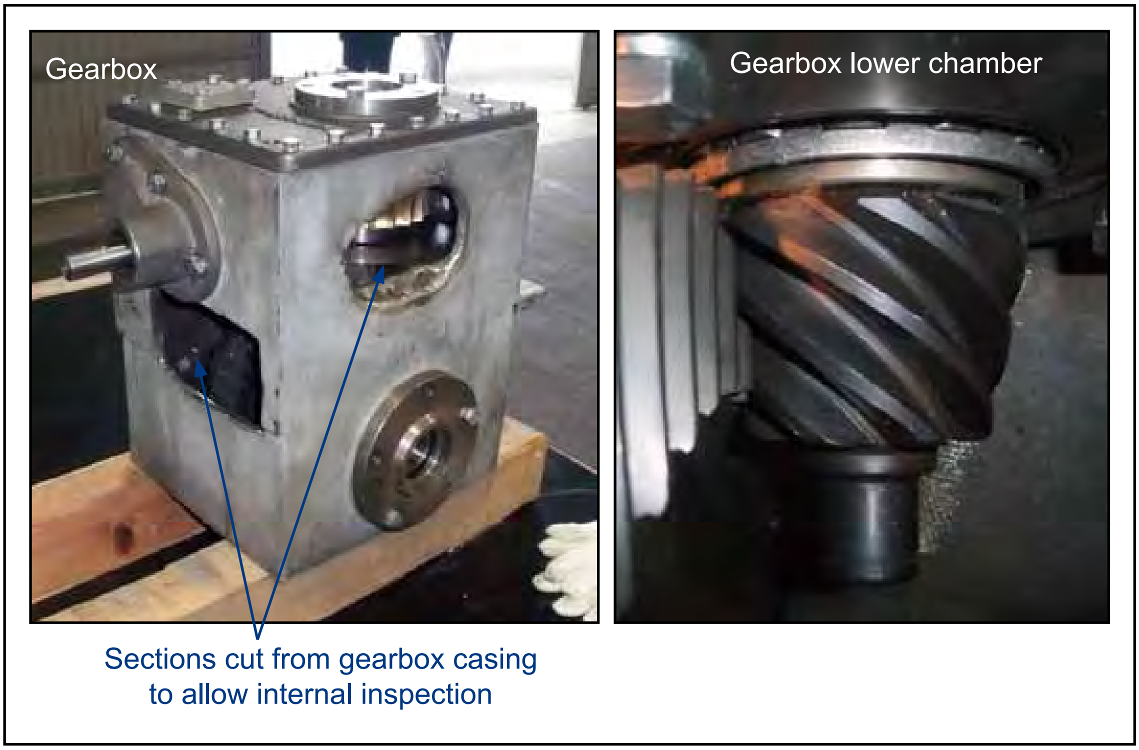
Nakano found evidence indicating that, prior to the failure, the vertical bevel gear shaft had dropped or was positioned at least 3mm lower than designed. It concluded that the failure of the intermediate bearing was probably the result of contact between its inner roller race and the teeth of the differential gear unit. The report identified two possible reasons why the shaft might have assumed this position: foreign body intrusion or the use of unauthorised parts.

The report also emphasised the need for the winch to be thoroughly examined by a *'third person'* following any intrusive maintenance.

1.8.4 Reconstruction

At the request of the MAIB, Nakano made a new gearbox available for inspection **(Figure 19)** at its factory near Imabari, Japan, on 17 December 2009. The manufacturer recreated the circumstances that would have led to the failure mode described in its report, and several potential reasons for the displacement of the vertical bevel gear shaft were explored. It was noted during the reconstruction that the outer tips of the spiral bevel gear teeth on the differential gear unit made contact with the inner race of the intermediate bearing. This caused the vertical shaft to move up and down during winch operation.

Figure 19



Failure mode reconstruction

1.9 MAINTENANCE MANAGEMENT

1.9.1 Planned maintenance

The routine maintenance schedules for the accommodation ladder systems were held on *Ever Elite*'s computerised planned maintenance system (PMS). The system generated job sheets which listed the tasks required to be carried out during the next month. The job sheets detailed the name of the equipment and a description of the maintenance to be conducted. They also listed the task expiry dates, schedule frequencies and the designated persons in charge. The designated person in charge was responsible for ensuring the maintenance was carried out, and the date of its completion was entered on the database. It was also possible to record on the database remarks relating to a particular task, but this function was not used.

The chief officer was the designated person in charge for the planned maintenance of the accommodation ladders and their winches. However, in practice, he only oversaw the non-intrusive maintenance such as greasing routines, operational inspections, function tests, wire condition monitoring and wire renewal. The more technical requirements such as the internal inspection of winch gearboxes, gearbox oil renewal, motor brake inspections and defect repairs were carried out by engineering department personnel.

The maintenance schedules for the vessel's two accommodation ladder systems on the PMS database are listed at **Table 1**. A summary of the maintenance tasks documented in Nakano's ladder system manual are listed in **Table 2**. The task required by the manufacturer to '*check gearbox bearings for wear and noise'* had been input to the vessel's PMS as '*function check and inspect brake gear wheel'*.

Maintenance task	**Task frequency (months)**
Checking, wire greasing	3
Accommodation & pilot ladder limit switch general checking	3
Wire rope inspection, greasing & check gearbox oil level	6
Function check & inspect brake gear wheel	12
Renew wire rope	24

Table 1 - Routine tasks generated by the ship's computerised planned maintenance system for the accommodation ladder and hoist winch

Maintenance task	Task frequency (months)
Grease wire rope	1
Grease sheaves	1
Grease upper platform turntable centre pin	1
Check winch gearbox lubrication oil level	1
Check condition of winch gearbox lubrication oil	1
Grease winch bearings and rotary parts	3
Check gearbox bearings for wear and noise	12
Renew gearbox oil	12
Renew wire rope	12

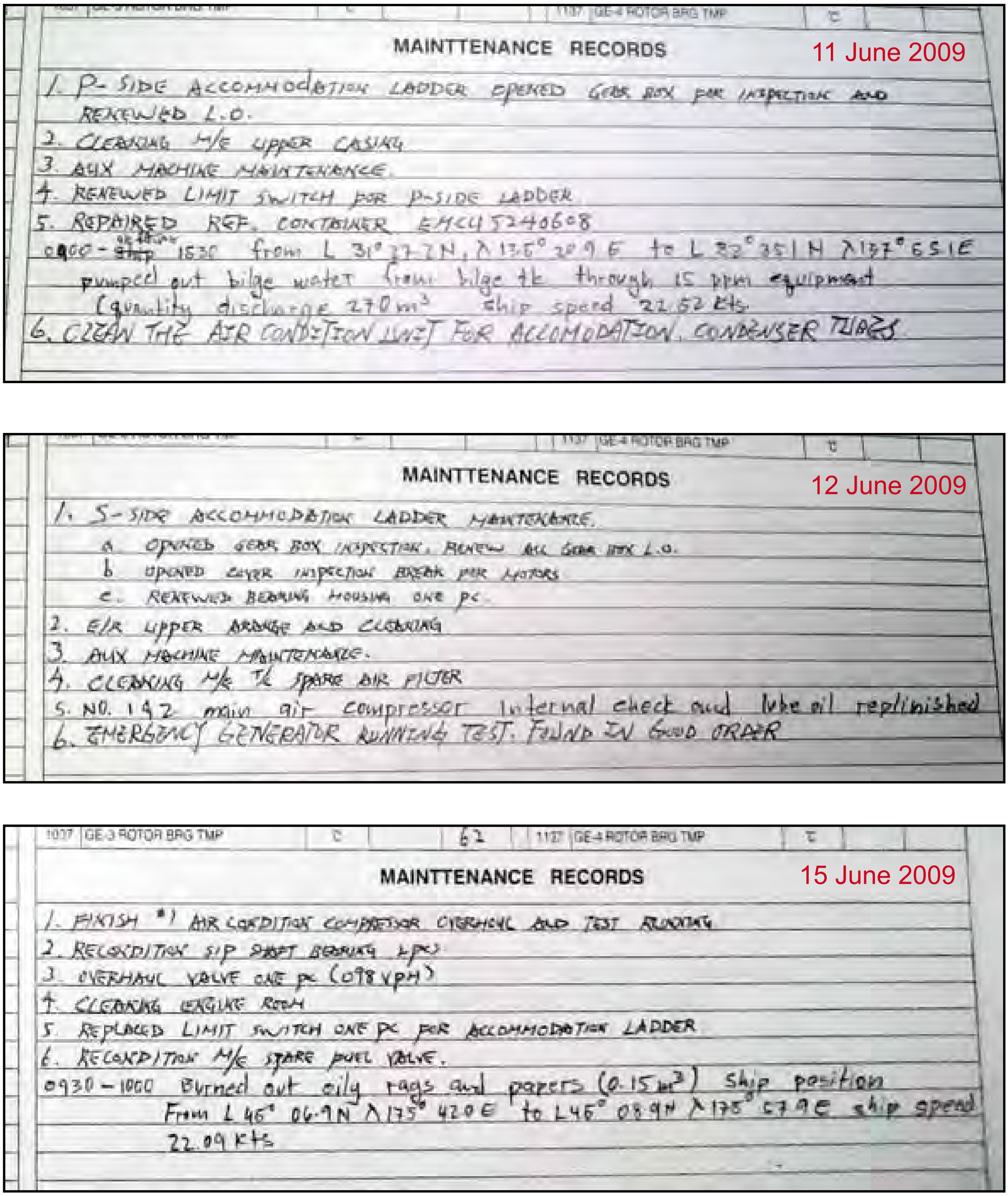
Table 2 - Routine maintenance tasks listed in the manufacturer's equipment manual

According to the PMS database, at the time of the accident all the routine maintenance schedules were in date, having been completed on or shortly before the stipulated due dates. However, onboard investigation identified that two of the tasks listed were not carried out as recorded. First, the accommodation ladder wires were renewed on 18 April 2008, not on 24 January 2009 as recorded in the PMS. Second, although the PMS shows that a 12 monthly requirement to *'function check and inspect brake gear wheel'* was carried out on 4 September 2009, this task was not undertaken.

1.9.2 Unplanned maintenance

Unplanned or defect maintenance carried out by the ship's engineers was recorded in the engine room logbook; it was not noted on the PMS database. A review of the engine room logbooks identified that unscheduled maintenance was last carried out on the port accommodation ladder hoist winch and limit switches on 11 June 2009 **(Figure 20)**. A permit to work outboard issued on that day indicates the maintenance took 8 hours and was carried out by the second engineer, a third engineer, a fitter and a general purpose crewman. The reason for this unscheduled maintenance was not recorded and remains unknown. The condition of the equipment was also not recorded and the parts replaced, other than a limit switch, were not listed.

Figure 20



Engine room logbook maintenance entries

Similar work was carried out on the starboard system the following day, but on that occasion a work permit was not raised. The logbook entry noted that a bearing housing had been replaced, but it did not state which one. On 15 June 2009 an accommodation ladder limit switch was replaced, but the logbook entry did not state which one or which system.

The computerised system did not allow routine tasks such as gearbox oil renewal or gearbox inspections, undertaken ahead of schedule as part of defect repair, to be taken into account when automatically calculating and scheduling future maintenance requirements.

1.10 RISK ASSESSMENT

The initial assessment of the preparation and deployment of the accommodation ladders was conducted on 16 August 2007 and considered three hazards:

- *crew engaged in rigging or recovering accommodation ladder fall into the sea*
- *wire broken*
- *mishandling operation*

The control measures in place at the time of the assessment included:

- *wearing of lifejacket & helmet is required*
- *inspect wire periodically*
- *instruct crew on safe operation procedure* [sic]

These controls were not considered sufficient to reduce the residual risk to below *substantial* and therefore, a detailed risk assessment was conducted. This assessment prescribed the following additional controls:

- *duty officer supervise on scene*
- *close communication with the bridge while crew inspection* [sic]
- *check lifejacket in good condition & Lifebuoy with self-igniting light, buoyant safe line ready for use* [sic]
- *familiarise the procedure for inspect* [sic]
- *familiarise the safe procedure of operation* [sic]

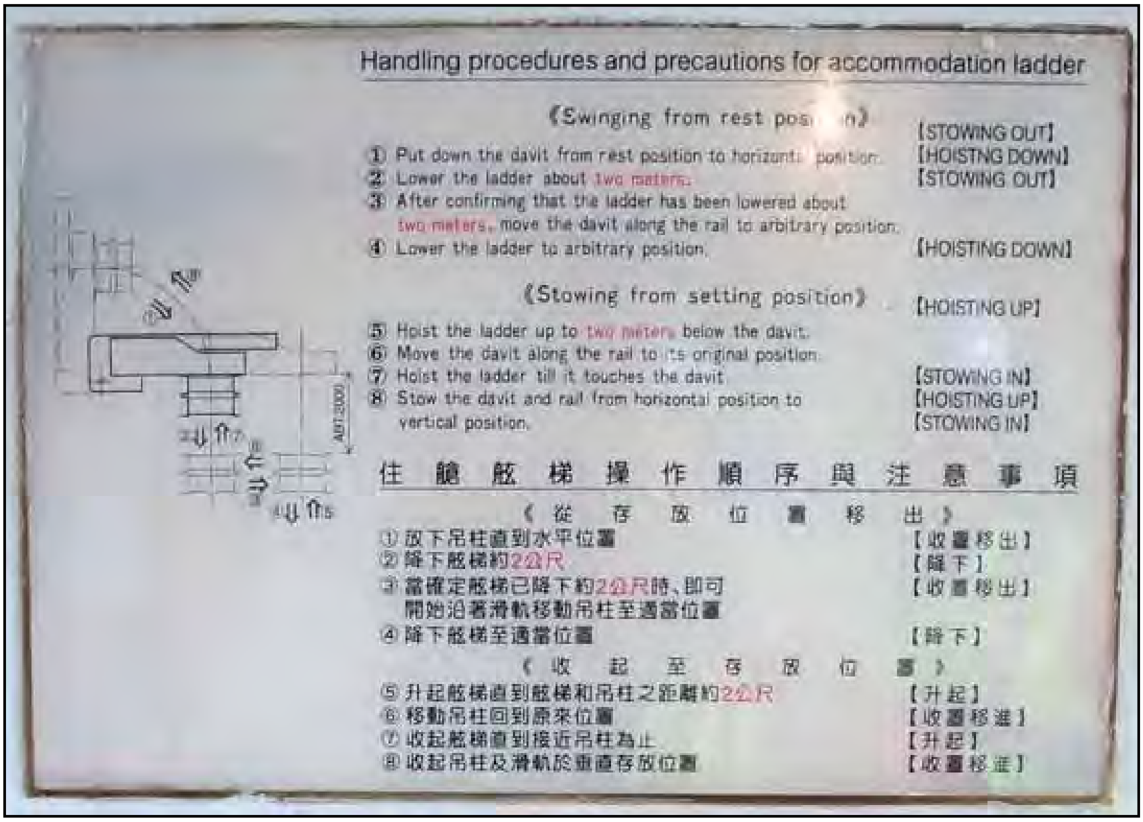
The risk assessment did not consider the hazards associated with working outboard or at height.

1.11 ONBOARD PRACTICE AND EQUIPMENT

1.11.1 Operating procedure

The handling procedure and the precautions to be taken detailed in the maker's manual were posted on the upper deck next to the accommodation ladders **(Figure 21)**. The procedure explained how to operate the winches but it did not describe how to deploy, rig and recover the equipment.

Figure 21



Accommodation ladder procedure posted on the upper deck

It was normal practice on board *Ever Elite* for two off watch ABs to prepare the accommodation ladders without supervision before making their way to their stations for entering harbour. This required at least one of the ABs to work over the ship's side while the vessel was underway.

Although the vessel's telescopic accommodation ladder was not designed to be used to transfer pilots, it was common practice on board *Ever Elite*, and other Evergreen vessels, to disembark pilots using the accommodation ladders after departing from Kaohsiung. This practice also required the crew to access the ladder while it was suspended from its hoist wire.

1.11.2 Work permits

The vessel's permit to work *outboard or aloft* required the person in charge of the task to check that the crew carrying out the work used a safety harness or safety belt connected to a fixed point on the ship's structure. However, a work permit was never raised when the accommodation ladders were required to be rigged or unrigged.

1.11.3 Personal protective equipment (PPE)

The life vests provided for use while working over the ship's side on board *Ever Elite,* and other EMU vessels, were manufactured in China and had 7.5kg (74N) of buoyancy **(Figure 22)**. They were not fitted with lights or whistles.

Figure 22

Working life vests and safety belts provided on board *Ever Elite*

To protect its crews against the risk of falling from height, EMU had provided its vessels with safety belts with rope lanyards, but it was not normal practice for the crew on board *Ever Elite* to wear these when preparing the accommodation ladders. There were no dedicated anchorage points, rails or lines in the vicinity of the ladders to which the lanyards could be secured.

1.12 EMERGENCY RESPONSE

1.12.1 Manoverboard procedure

EMU's *guidance for shipboard emergency response actions* listed the following immediate actions to take in response to a person falling overboard:

- *Plotted the position as soon as possible by GPS so that an urgency signal can then be transmitted to warning other vessels in the area and given assistance as required* [sic].
- *Extra lookouts should be posted*.
- *During night time, and/or when the exact time or location can not be assured, the manoeuvring method known as the 'Williamson Turn' is recommended to be executed in response to the man overboard alarm* [sic].
- *The rescue boat's crew should be mustered and boats should be prepared for launching as soon as the man overboard alarm is sounded….*[sic].

A copy of the International Chamber of Shipping's Bridge Procedures Guide, which includes a checklist of the actions to be taken following a man overboard **(Annex B)**, was also kept on the bridge. Onboard records indicated that the only manoverboard drill conducted in 2009 occurred on 17 July. However, none of the crew interviewed who were on board at the time recalled this drill taking place.

1.12.2 Lifebuoys

Ever Elite had 14 lifebuoys. These included two quick release lifebuoys with self-activating light and smoke signals which were sited on each bridge wing **(Figure 23)**. The UK's Merchant Shipping (Means of Access) Regulations 1988 require a lifebuoy with a self-activating light and a separate safety line attached to a quoit or some similar device to be provided ready for use at the point of access on board the ship. The lifebuoy picked up by AB2 was located adjacent to the port accommodation ladder stowage position; it was attached to a buoyant safety line and was not fitted with a self-activating light.

Figure 23

Port bridge wing quick release lifebuoy with self-activating light and smoke float

Lifebuoy with buoyant line attached located next to the port accommodation ladder

Lifebuoys provided on board *Ever Elite*

1.13 DESIGN AND CONSTRUCTION STANDARDS

1.13.1 Accommodation ladders

SOLAS regulation II-I/3-9[1] requires all ships constructed on or after 1 January 2010 to be provided with means of embarkation and disembarkation for use in port and in port related operations which have been constructed and installed in accordance with the guidance given in MSC circular 1331[2]. For accommodation ladders, the guidance requires compliance with applicable international standards such as ISO 5488:1979*, Shipbuilding – accommodation ladders*.

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[1] SOLAS chapter II-I, regulation 3-9 - Means of embarkation on and disembarkation from ships.

[2] MSC.1/Circ.1331 – Guidelines for construction, installation, maintenance and inspection/survey of means of embarkation and disembarkation.

The UK's Merchant Shipping (Means of Access) Regulations 1988 require every ship of 120m or more registered length to carry an accommodation ladder which complies with the requirements set out in the Code of Safe Working Practices for Merchant Seamen (CoSWP). Chapter 18, Annex 18.1 of the CoSWP states *'accommodation ladders must comply with the specifications set out in Standard BS MA 89:1980 or be of an equivalent standard'*. BS MA 89:1980 is identical to ISO 5488:1979.

The ISO standard specifies the requirements and method of test for single and multi-flight accommodation ladders utilising both revolving[3] and fixed platforms[4]. Revolving-platform type ladders *'maybe supported by steel wire ropes or chains from the lower suspension point or by rollers fixed to the bottom of the ladder'*, and the fixed-platform type is to be *'supported by steel wire ropes or chains'*.

1.13.2 Accommodation ladder winches

MSC Circular 1331 states:

> *the construction and test of accommodation ladder winches should be in accordance with applicable international standards such as ISO 7364:1983 Shipbuilding and marine structures – deck machinery – accommodation ladder winches*.

This standard specifies the requirements and characteristics for lightly powered and unpowered ships' accommodation ladder winches. The requirements for the winch brake (*holding device*) are:

- *The winch shall be provided with a device capable of holding the drum at 1.5 holding load*[5]*.*
- *For powered winches, such device shall automatically operate when the drive is being shut off or if power fails.*
- *A self-locking wormgear (or equivalent) may be considered a holding device if agreed between the purchaser and the manufacturer*.

The standard also sets out the design requirements for the winch drum(s), steel wire rope(s), bearing lubrication, emergency stop and electrical equipment.

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3 Revolving-platform type – The ladder, of single-flight or multi-flight construction, is hinged from an upper revolving platform and is capable of being varied in direction and inclination between the ship and the lower access level.

4 Fixed-platform type – The ladder is hinged from a fixed anchorage, and is capable of being varied in inclination between the ship and the lower access level.

5 Holding load = 3 x drum load, where the drum load is the maximum rope tension in the rope or ropes at the drum exit either when the winch is hoisting an unloaded accommodation ladder at the nominal speed, with the rope or ropes wound on the drum in a single layer, or when the winch is placing the accommodation ladder in its stowage position.

The ladder winches on board *Ever Elite* did not meet all of the design and construction requirements set out in the ISO 7364. Notably, the winch drum and hoist wire dimensions and specification differed from those stipulated, and no protection from a revolving manual crank handle was provided.

A number of manufacturers of accommodation ladder hoist winches offer safety features in excess of those in the standard. These include: secondary braking systems, automatic or manually operated winch drum brakes, preventer (or hanging off) wires, limit switches and load limiters. Some of these optional extras are commonly fitted to hoist winches used on lifting equipment ashore and are a regulatory requirement for winches used to raise and lower people.

1.13.3 Pilot transfer arrangements

Where the distance from the waterline to the point of access on board a vessel exceeds 9m, a means of access other than a vertical ladder must be provided to embark and disembark pilots. In circumstances where accommodation ladders are used in combination with pilot ladders the additional requirements set out in SOLAS Chapter V Regulation 23 – *Pilot transfer arrangements* must be met.

Ever Elite was fitted with a side access door and fixed pilot ladder system on both her port and starboard sides at frame 95 **(Figure 8)**. When rigged, the pilot ladder rested on the ship's hull just aft of the side access doors located on the 2nd deck. The distance from the waterline to the side access door was less than 9m.

1.14 MAINTENANCE AND TEST REQUIREMENTS

1.14.1 International

From 1 January 2010 all ships must meet the maintenance requirements introduced by SOLAS chapter II-I, regulation 3-9, which states:

> *For all ships the means of embarkation and disembarkation shall be inspected and maintained in suitable condition for their intended purpose, taking into account any restrictions related to safe loading. All wires used to support the means of embarkation and disembarkation shall be maintained as specified in regulation III/20.4*[6]*.*

The regulation requires accommodation ladder systems to be inspected, surveyed, tested and maintained in accordance with the guidance in MSC Circular 1331. This requires all inspections, maintenance work and repairs to be carried out at appropriate intervals, in accordance with manufacturers' instructions, and recorded in order to provide an accurate history for each piece of equipment. It also requires accommodation ladders and their winches to be thoroughly examined during the annual surveys required by SOLAS I/7[7] and I/8[8] and to be tested during the 5-yearly renewal surveys.

[6] SOLAS chapter III - Life-saving appliances, regulation 20 – Operational, readiness maintenance and inspections, 4 – Maintenance of falls.

[7] SOLAS I/7 – Surveys of passenger ships.

[8] SOLAS I/8 – Surveys of life-saving appliances and other equipment of cargo ships.

Tests are to be in accordance with ISO 7364:1983, which states:

> *The winch shall be tested as part of the complete accommodation ladder unit. The minimum extent of the test shall be as follows:*
>
> *a) twice hoisting the accommodation ladder up to its full height and lowering it.*
>
> *b) holding a static load for the complete accommodation ladder unit loaded as specified in ISO 5488 paragraph 6.1.3[9].*

The guidance in MSC Circular 1331 also states:

> *The lifting equipment should be inspected, tested and maintained paying careful attention to the condition of the hoist wire. The wires used to support the means of access should be renewed when necessary…*

All tests and thorough examinations are to be carried out to the satisfaction of the administration.

1.14.2 UK requirements

Provision and Use of Work Equipment Regulations (PUWER)

Accommodation ladder systems are considered to be work equipment[10] as defined in the UK's Merchant Shipping and Fishing Vessels (Provision and Use of Work Equipment)(PUWER) Regulations 2006. Guidance on the interpretation of these regulations is provided by the Maritime and Coastguard Agency (MCA) in MGN 331 (M+F) and in Chapter 7 of the CoSWP. The regulations require employers to ensure regular preventative maintenance, repairs, inspections, examinations and tests are 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 to be kept.

Lifting Operations and Lifting Equipment Regulations (LOLER)

The UK's Merchant Shipping and Fishing Vessels (Lifting Operations and Lifting Equipment)(LOLER) Regulations 2006 revoked the Merchant Shipping (Hatches and Lifting Plant) Regulations 1988, which included:

> *"Lifting appliance" means any ship's stationary or mobile appliance (and every part thereof including attachments used for anchoring, fixing or supporting that appliance but not including vehicle coupling arrangements) which is used on a ship for the purposes of suspending, raising or lowering loads or moving them from one position to another whilst suspended and includes ship's lift trucks and similar vehicles; it does not include –*
>
> *(a) pipes, or gangways; or*
>
> *(b) screw, belt, bucket or other conveyors;*

---

[9] ISO 5488 paragraph 6.1.3 – Design loading: The ladders shall be designed to support a uniform load equivalent to 735N on every step when the ladder is in the horizontal position.

[10] "Work equipment" means any machinery, appliance, apparatus, tool or installation for use at work.

used for the continuous movement of cargo or people but does include the lifting appliances used to suspend, raise, lower or move any of these items"

LOLER requires additional controls for lifting equipment[11]. Guidance on the interpretation of these regulations is detailed in MGN 332 (M+F) and in Chapter 21 of the CoSWP. In addition to regular preventative maintenance and periodic inspections the employer shall ensure that lifting equipment is:

- tested:
  - after initial installation
  - after any repair or modification that is likely to alter the safe working load or affect the strength or stability of the equipment
  - at intervals not exceeding 5 years.
- thoroughly examined:
  - after installation
  - at least annually (6 monthly for equipment used for lifting people)
  - following any test.

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 which could become a danger to persons must be reported to the employer. *Ever Elite* did not hold a lifting gear register.

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. Holding a specific certificate of competency does not automatically mean a person is competent to carry out work on all types of equipment found on board ship.

The MCA does not consider accommodation ladder hoist systems to be lifting equipment, and therefore does not require them to meet the requirements of LOLER. EMU also did not consider the accommodation ladder winches to be lifting equipment. However, the MAIB is aware that some shipping companies do consider accommodation ladder winches, hoist wires and associated accessories to be lifting equipment, and maintain and test them accordingly.

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

1.15 PPE REQUIREMENTS

The Merchant Shipping and Fishing Vessels (Personal Protective Equipment) Regulations 1999, require employers to ensure suitable PPE is provided on board UK ships for use when risks cannot be avoided or reduced to an acceptable level. Merchant Shipping Notice (MSN) 1731 (M+F)[12] provides guidance on these regulations to employers of crew, masters, safety officers and safety representatives. It also lists the appropriate European Norm (EN) and British standards (BS) for the PPE most commonly provided on board ships. The working life vests and safety belts provided on board *Ever Elite* did not comply with the EN or BS standards listed.

1.16 AUDIT AND INSPECTION

1.16.1 Pre-accident

The last external International Safety Management (ISM) audit on board *Ever Elite* was carried out by the MCA in Kaohsiung on 8 and 9 January 2008. It was conducted in parallel with the ship's ISO 9001:2000, ISO 14001:2004 and ILO 178 external audits. Three observations against the ISM Code were made, one of which noted that the plans for emergencies were not complete as they did not include a requirement to save VDR evidence. No non-conformities were identified.

The last internal health, safety, quality and environmental audit was conducted by EMU in Kaohsiung on 3 October 2008. This audit was also undertaken to verify compliance of the management system to the ISM Code, ISO 9001:2000, ISO 14001:2004 and the ILO 178 convention. No non-conformities were raised and no observations were made.

1.16.2 Post-accident

On arrival at the container terminal at Oakland two teams of USCG officials boarded *Ever Elite*. One of the teams conducted a *serious marine accident* investigation and the other team conducted a port state control inspection. The observations made during the port state control inspection led the Captain of the Port of San Francisco to question the crew's implementation of the requirements set out in the ISM Code. As a result, he recommended that the MCA arrange an additional ISM audit prior to the ship departing San Francisco. The MCA informed the USCG that it would not be able to attend the ship prior to its scheduled departure time. It also advised that it did not usually delegate ISM audits to recognised organisations, and requested the vessel be allowed to depart San Francisco on the understanding that an audit would be conducted within 1 month.

[12] MSN 1731 (M+F) – The Merchant Shipping and Fishing Vessels (Personal Protective Equipment) Regulations 1999.

The additional audit was conducted on behalf of the MCA, by an American Bureau of Shipping (ABS) surveyor in Taipei, on 24 September 2009. The scope of the audit was to verify if there was a breakdown in the ship's SMS that might have contributed to the accident. The auditor's findings included:

- Onboard training and emergency drills were carried out in accordance with documented procedures.
- The search for the man overboard was carried out in accordance with the documented procedures.
- Maintenance was carried out in accordance with the ship's computerised planned maintenance schedules.

No non-conformities or observations were raised.

1.17 SIMILAR ACCIDENTS

1.17.1 Nakano slide-out type telescopic ladder system

In September 2004, the port accommodation ladder on board the container vessel *Ever Uranus* fell to the quay when the ship was in China. The ladder's hoist winch had recently been repaired by shore contractors in Tokyo and, despite crew concerns about the gearbox making an unusual noise, it had been returned to service.

Nakano's investigation of the failure found that the gearbox had been assembled incorrectly, causing the spiral bevel gear teeth within the lower chamber to disengage. Evergreen was recommended to either employ Nakano service engineers to carry out all future gearbox repairs, or replace defective gearboxes with factory assembled spares.

On 7 December 2004, following the incident in September 2004 and other similar gearbox failures, Nakano advised Mitsubishi Heavy Industries to modify the ladder systems on the 28 vessels fitted **(Annex C)**. Nakano had identified that the telescopic ladders had been hitting the underside of the davit frame, causing the hoist winch gearboxes to be overloaded. The modifications enabled the limit switches to be adjusted to give a clearance of between 5 and 10mm between the ladder and the davit frame. Procedures for testing the limit switch, checking the gearbox for abnormal noise and inspecting the gears and bearing housings were also provided.

On 9 August 2007, following further similar failures on board *LT Unica* and *LT Universo*, Nakano wrote to both Evergreen and LT explaining the reasons for the relatively high failure rate. The letter emphasised the importance of setting the limit switches correctly and ensuring they were fully operational. To reduce the likelihood of further catastrophic failures, Nakano also provided an overload current cut-off relay and more resilient bearing housings for all ships fitted with the slide-out telescopic ladder system. Nakano provided detailed installation instructions **(Annex D)** and requested that ships' crews be tasked to fit the new components.

The overload current cut-off relays had been fitted on board *Ever Elite* prior to the accident, but the replacement bearing housings had not. The more detailed gearbox strip down and assembly procedure issued with the new parts was not available on board the vessel, and her crew were unaware of the previous hoist winch failures.

1.17.2 MAIB incident reports

The MAIB marine incident database includes eight fatal accidents which occurred during the rigging of accommodation ladders. In all cases, safety harnesses were not used. In the seven cases where the casualty entered the water, lifejackets were not worn.

Six accommodation ladder hoist failures have been reported to the MAIB in the last five years, two of which resulted in the loss of life. In one of these cases, which occurred in early 2006, an AB was thrown overboard and died. The accommodation ladder hoist wire parted while the AB was rigging the handrails on board a cargo ship as it entered a UK port. He was not wearing a safety harness or lifejacket and was not being supervised while working over the ship's side. A tug had been standing by at the time of the accident and the AB's body was recovered within 10 minutes of entering the water. The hoist wire was found to be in very poor condition.

1.17.3 Similar accidents reported to other accident investigation bodies

On 12 June 2006 a crewman drowned after falling overboard from the accommodation ladder of the oil tanker *Formosa Thirteen* as it departed Wellington Harbour in New Zealand. The accommodation ladder had been rigged in combination with the pilot ladder in preparation to disembark the pilot. The conditions were too rough for the pilot to leave the vessel, and the crew were instructed to secure the accommodation ladder. One crewman descended the ladder without a lifejacket or safety harness and was washed over the side by rough seas. The investigation report produced by Maritime New Zealand[13] found that the ship had not been provided with approved working lifejackets, permits for working outboard were not used and, despite the procedures set out in the ship's ISM manual, the work was not supervised by an officer.

On 26 January 2006 the boatswain on board the German registered container vessel *Heinrich S* died after falling from the accommodation ladder. He was rigging its handrails without a safety harness and fell backwards, striking the quay before entering the water. An investigation by Germany's Federal Bureau of Maritime Casualty Investigation[14] found that the manufacturer's instructions were not comprehensive and that the ship owner had not provided anchorage points to allow crew to clip their fall prevention equipment to the ship's structure. The investigation report noted that such safety devices did not form part of the accommodation ladder system but are usually provided by shipyards at the request of owners.

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[13] Maritime New Zealand – Class B Accident Report Man Overboard *Formosa Thirteen*.

[14] Federal Bureau of Maritime Casualty Investigation Report 28/06 – Fatal occupational accident on board MV *"Heinrich S"* in the port of Kopa on 25 January 2006.

On 26 November 2004 two crewmen fell from an accommodation ladder into the water when the ladder was hit by a launch. The crew were disembarking from MV *Chenan* while the vessel was anchored at Ko Si Chang in Thailand. Neither crewman was wearing a lifejacket and one drowned.

1.17.4 Newcastle, Australia

Many of the accommodation ladders fitted to the bulk carriers using the Australian port of Newcastle are unable to reach the quay and have to be used while suspended. Following a spate of hoist wire failures, including one which resulted in three crewmen entering the water, the port authority recommended all visiting ships using suspended ladders to rig preventer wires. As a result, Nakano developed an adjustable preventer, or sub-wire, arrangement for its single flight accommodation ladder systems for use on vessels operating in Australian waters **(Annex E)**.

1.17.5 Offshore industry

In 2005, following the uncontrolled lowering of a crane boom on an offshore platform, the UK's Health and Safety Executive (HSE) issued a safety notice[15] informing the offshore industry of the incident and outlining the actions required to be taken. The braking system on the crane's main and boom hoist winches had been located on the power (drive motor) side of the gearbox. This resulted in several single points of failure within the hoisting system. The HSE found:

> *'Many offshore cranes, particularly older cranes, may have hoisting and braking systems that contain 'single line components'; the failure of one such component will result in the failure of the system. This failure will almost always result in the uncontrolled lowering of the boom and/or the load'.*

The HSE recommended duty holders to review the design of their cranes and employ methods such as *failure modes effects analysis* to identify any potential single line components and take appropriate actions to mitigate them.

[15] HSE Safety Notice 2/2005 – 'Single line components' in the hoisting and braking systems of offshore cranes.

SECTION 2 - ANALYSIS

2.1 AIM

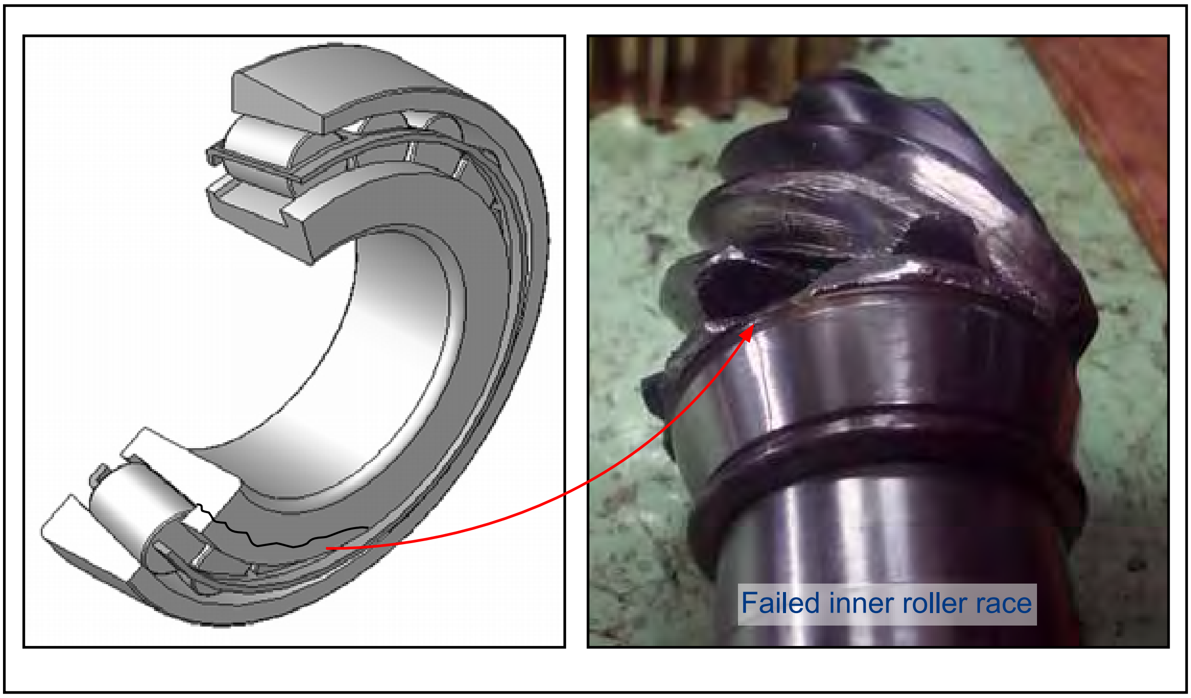
The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 FAILURE MODE

There is little doubt that the port accommodation ladder was set free when the inner roller race of the intermediate taper roller bearing in the hoist winch gearbox failed **(Figure 24)**. This displaced the vertical bevel gear shaft and allowed the spiral bevel gear teeth in the lower chamber to disengage **(Figure 25)**. The failure of the inner roller race is likely to have been caused by repeated high frequency impacts with the outer tips of the teeth on the differential gear unit combined with the downward force generated by the wedging effect on the tapered rollers.

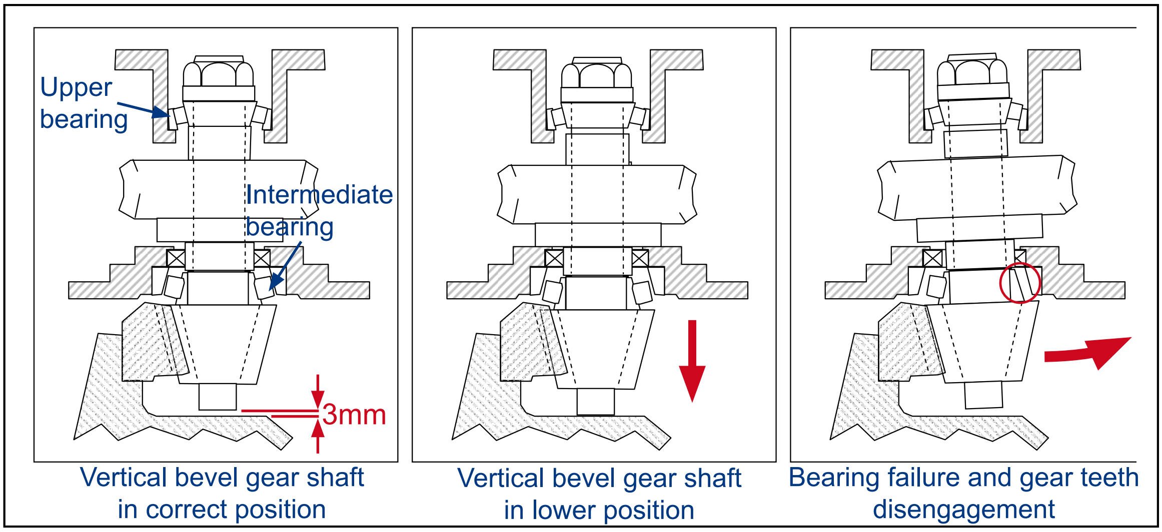
The marks found on the top land of the spiral gear teeth of the differential gear unit and the damaged teeth of the vertical bevel gear shaft, resulted from contact between the two components as the winch drum rotated rapidly when the ladder fell **(Figure 26)**. This is consistent with the whirring sound heard by AB2 directly after the initial loud bang.

Figure 24



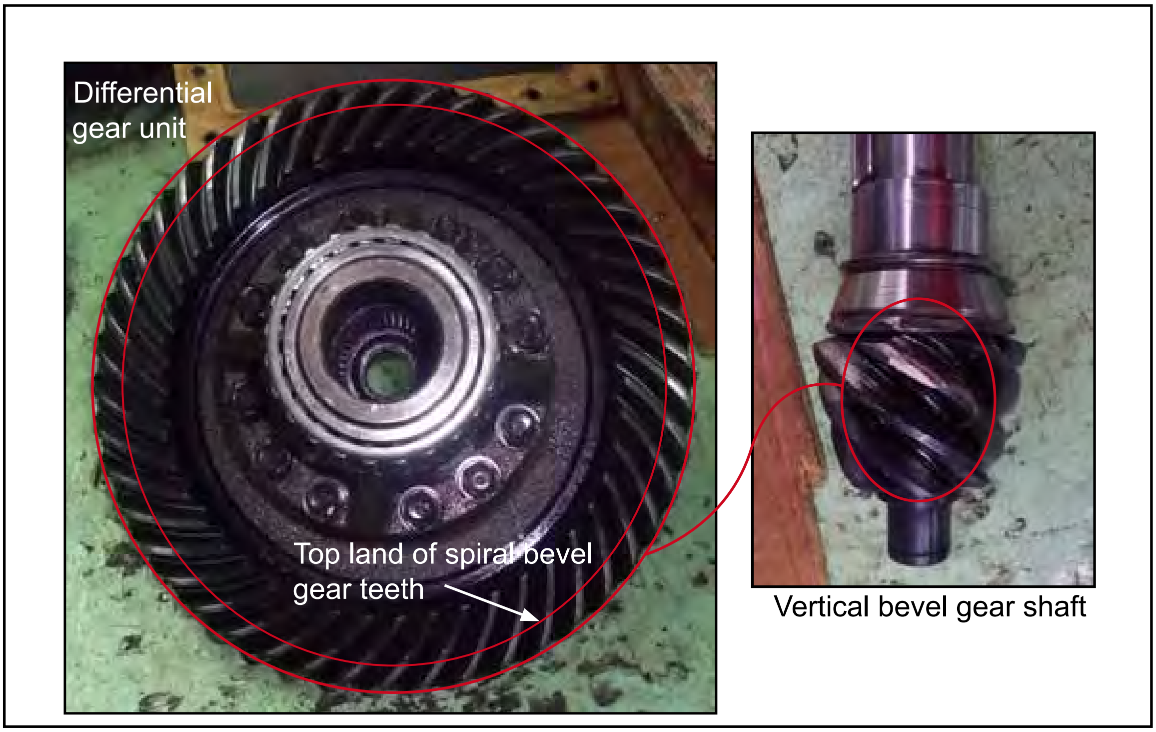
Intermediate bearing failure

Figure 25



Spiral bevel gear teeth disengagement

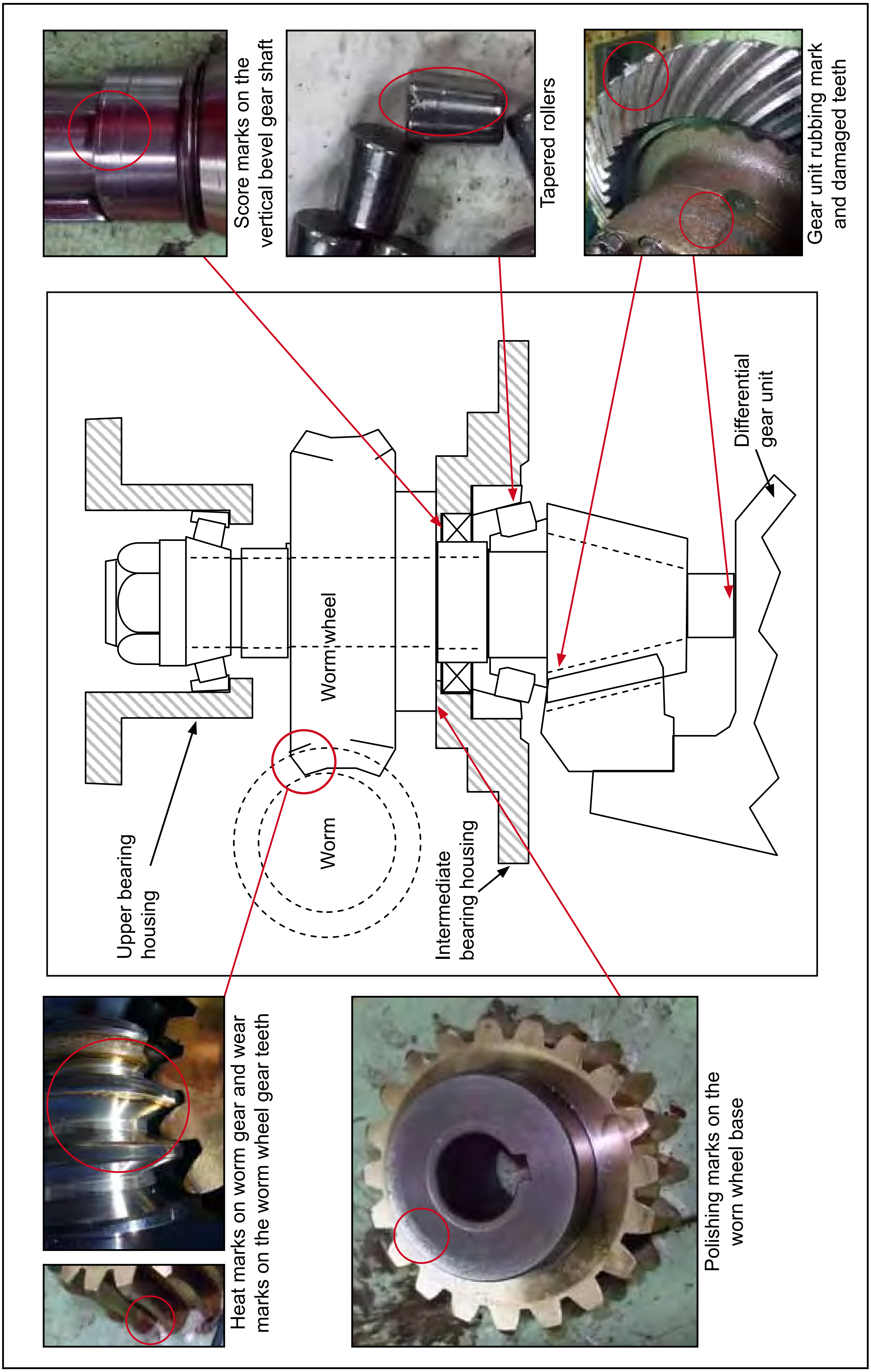
Figure 26



Marks found on the top land of the differential gear unit's spiral bevel gear teeth

Other damage to the gearbox components noted in **paragraph 1.8** and shown at **Figure 27** indicates that the vertical bevel gear shaft had dropped by at least 3mm prior to the ladder being set free. In particular:

- The heat marks on the worm in the upper chamber would have resulted from contact with the upper edges of teeth on the worm wheel.
- The polishing marks on the underside of the worm wheel body indicate it had been rubbing against the top of the intermediate bearing housing.



Evidence to support the lower position of the vertical bevel gear shaft

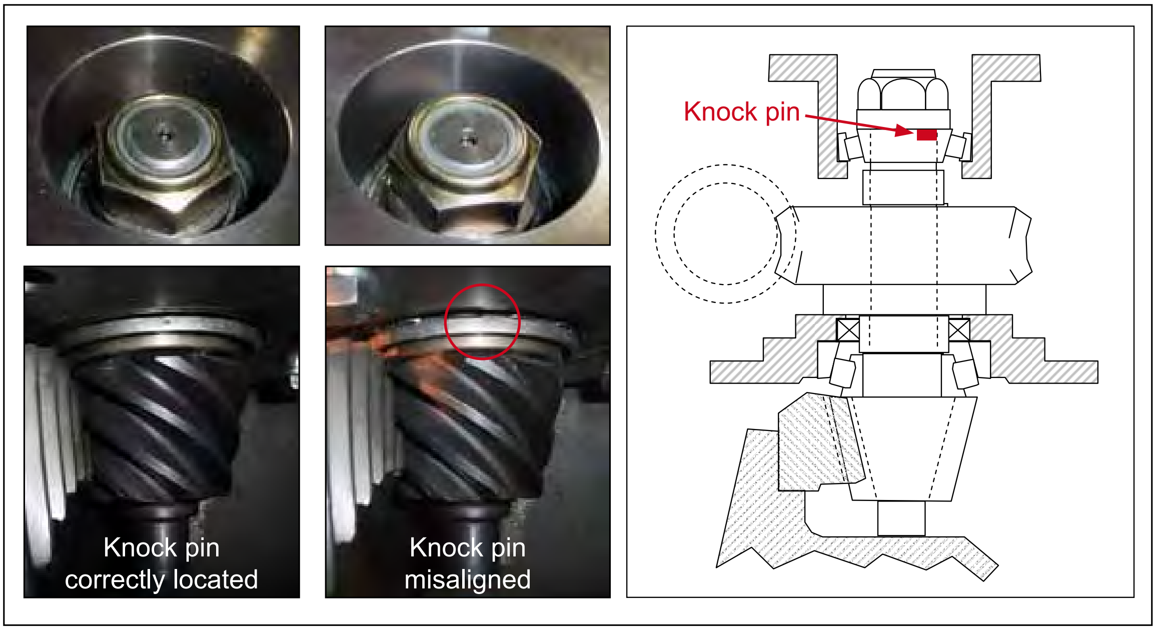
- The score marks on the vertical bevel gear shaft appear to have been caused by the shaft rubbing against its oil seal. As the upper mark was more recent than the lower score mark, it is highly likely that the shaft had been turning in the lower of two positions at the time of the failure.

- The marks on the tapered rollers show that the inner roller race had dropped sufficiently to contact and damage the outer tips of the gear teeth of the differential gear unit.

- The marks on the body of the differential gear unit indicate it had been in contact with the vertical gear shaft.

The rotational, polishing and heating nature of much of the damage highlighted also indicates the shaft had been out of position for some time prior to the accident. Furthermore, the burring on the knock pin indicates that the shaft was lower than designed due to the misalignment of, or interference between, the shaft's lock nut collar and the pin **(Figure 28)**. This is most likely to have occurred through the incorrect re-assembly of the gearbox following maintenance, and would have been extremely difficult to identify by external visual inspection.

Figure 28



Vertical bevel gear shaft knock pin misalignment

2.3 WINCH MAINTENANCE

2.3.1 Onboard Maintenance Management

The previous incidents involving slide-out type telescopic accommodation ladder systems described in **paragraph 1.16.1** indicate that the hoist winch fitted on board *Ever Elite* was susceptible to gearbox damage from the repeated impacts between the ladder and davit frame. Although Nakano had issued guidance to try and rectify this problem in 2004 and 2007 **(Annexes C and D)**, the unscheduled overhauls of the port and starboard hoist winch gearboxes and limit switches 3 months before the accident, and the impact marks on the port davit frame, strongly indicate that the problems with the gearboxes had not been resolved on board *Ever Elite*.

However, it was not possible to accurately determine the scope or detail of either the scheduled or unscheduled maintenance carried out to the accommodation ladder systems from onboard records because:

- the task completion dates recorded on the ship's computerised PMS database were inaccurate
- maintenance and inspection reports were not produced
- the reasons for conducting repair or defect maintenance were not recorded
- replaced components were not listed
- the remarks function on the PMS database was not used.

The PMS did not automatically take into account maintenance tasks that were completed ahead of schedule when calculating the date a task was next due. Therefore, it is feasible that when tasks previously undertaken during defect rectification were prompted by the PMS, they were recorded as being done on the date generated by the PMS, instead of the date they were actually completed. This possibly explains why the 12 monthly task to '*function check and inspect brake gear wheel'* was incorrectly recorded as being completed 6 days before the accident when it had been carried out during the unscheduled overhaul in June 2009.

2.3.2 Schedules and tasks

In comparing **Tables 1 and 2** it is evident that the maintenance schedules and requirements included on the ship's PMS were not as stringent as those recommended by Nakano. Several tasks recommended by the manufacturer had been omitted, and a number were required at less frequent intervals. Furthermore, the task descriptors in the PMS were unclear and differed from those in the manufacturer's manual. For example, the 12 month PMS task to *'function check and inspect brake gear wheel'* was intended to reflect Nakano's 12 monthly *'check winch gearbox bearings for wear and noise'.* However, there is no evidence to suggest these differences contributed to the failure on this occasion.

2.3.3 Guidance

It is apparent that Nakano recognised that intrusive maintenance of its gearboxes was a relatively complex task. It made a recommendation to Evergreen in 2004 either to employ Nakano service engineers to carry out gearbox repairs or to replace defective gearboxes with factory assembled spares **(Annex C)**. However, the subsequent supply of more detailed installation instructions and assembly diagrams **(Annex D)** also indicates that, by 2007 the manufacturer considered the work required to fit the more resilient bearing housings was within the capabilities of ships' crews.

Deciding whether or not a person is competent to maintain a piece of equipment is the responsibility of vessels' owners and masters, but all maintenance requires clear and accurate instructions and guidance. In this case, the Nakano manual did not provide anywhere near sufficient information to enable the gearboxes to be overhauled safely, and the more detailed guidance provided in 2007 was not available on board *Ever Elite*.

Given the complex nature of the gearbox, the lack of detailed manufacturer's guidance significantly increased the risk of error during re-assembly. However, this does not appear to have been considered by the ship's staff before maintenance of the gearbox was commenced. Despite the remedial measures already taken by Nakano, the possibility of similar errors occurring on the remaining 27 vessels fitted with the same winch cannot be significantly reduced until all of the vessels concerned have been provided with appropriate technical information.

2.3.4 Regulatory requirements

At the time of the accident there were no international maintenance, inspection or survey requirements specific to accommodation ladder systems. The systems were also not subject to classification society rules. Despite the potential consequences associated with a hoist winch or hoist wire failure, the intended level of maintenance management for the equipment was no more robust than that applicable to any other ancillary equipment.

The maintenance of the accommodation ladder systems on board *Ever Elite* did not achieve the standards for work equipment specified in PUWER. In addition, EMU did not treat accommodation ladders as lifting equipment as defined in LOLER. Consequently, the need for a more robust level of maintenance management, a full and accurate maintenance history, and for a nominated competent person to test and thoroughly examine the equipment after any maintenance was carried out that could affect the safe working load of the winch, was not met. Although there is no certainty that such measures would have prevented the accident on board *Ever Elite*, they might have reduced the possibility of the gearbox assembly error occurring and made its identification under a controlled test environment more likely.

As the hoist winch was used to raise, lower, position and suspend the port accommodation ladder, which weighed almost 2 tonnes and occasionally also supported the weight of persons when the ladder was not supported by the quay, it cannot safely or reasonably be excluded from the requirements of LOLER. The logic for this is reinforced by the approach taken by ship owners who already maintain accommodation ladder hoisting systems in accordance with LOLER.

The maintenance, test and examination procedures set out in MSC circular 1331 are very similar to those required by the LOLER regulations. Therefore, the introduction of regulation 3-9 in SOLAS chapter II-I should have relatively little impact on shipping companies already treating accommodation ladder hoist gear as lifting equipment. However, whereas PUWER and LOLER place the onus on employers to determine what constitutes a test, and who is competent to operate, maintain, examine and test the equipment, the SOLAS requirements are more prescriptive. Future annual thorough examinations and periodic tests must be carried out to the satisfaction of the administration. This should significantly improve the levels of maintenance carried out on accommodation ladder systems and so help to reduce the incidence of equipment failures. However, unlike LOLER, the IMO guidance does not require the testing of the hoist equipment following maintenance or repair which has the potential to adversely affect its safe working load.

2.4 WINCH DESIGN AND STANDARDS

The hoist winch on board *Ever Elite* did not comply with all of the design criteria detailed in ISO 7364:1983, but this was not required at the time of the accident and the areas of non-compliance did not contribute to its failure. Indeed, Nakano had recommended the annual renewal of the hoist wire to offset the system's shortfalls in respect to the standard, and its system included additional safety features such as a secondary braking system.

However, both the winch motor brake and the self-locking worm and wheel gear arrangements were positioned towards the power side of the gearbox. Similar to the failure of the crane boom in 2005 detailed in **paragraph 1.17.5**, this accident was caused by the failure of one of several single line components on the load side of the winch motor brake. It is disturbing that, although the recent introduction of ISO 7364:1983 as baseline for the design and construction of accommodation ladder hoist winches is a significant step forward, compliance with its requirements would not have eliminated these single points of failure. Therefore, it would not have prevented this accident.

ISO 7364:1983 is over 35 years old and does not consider some of the safety criteria included in modern offshore and land-based hoist winch standards and codes. Of note, secondary braking systems are not required, the location of the brake is not stipulated, and there is no requirement to identify or eliminate potential single points of failure.

There is also doubt whether the factors of safety in the ISO standard fully reflect the use of accommodation ladders suspended by their hoist wires when:

- the lower platform does not reach the quay
- used as the means of access at an anchorage
- local regulations require them to be used to embark and disembark pilots (e.g. at Suez and Kaohsiung)
- telescopic or folding systems can't be lowered until their collapsible handrails have been raised
- used in combination with pilot ladders.

Accidents resulting from accommodation ladders being used in this manner have already prompted preventative action by port authorities such as Newcastle, Australia.

To be effective, ISO 7364:1983 must be updated to reflect the technology available, and take into account the full scope of the use of accommodation ladder hoist systems and the reliance placed upon them.

2.5 RIGGING PROCEDURE

The accommodation ladder system was designed to be un-stowed and lowered to the quay without persons having to stand on it while the ladder was suspended by its hoist wire. Although the accommodation ladder was used to disembark the pilot in Kaohsiung when the vessel was underway, there was no reason why the ladder had to be rigged while the vessel was approaching Oakland. However, it had become usual practice to rig and un-rig the ladders when entering and leaving every port. Given the additional risks of standing on a ladder supported only by its hoist wire, and the possibility of falling into open sea, such practice was far more hazardous than when the vessel was alongside.

Furthermore, a safe system of work had not been developed to address the additional hazards inherent in this practice. In particular, the risk assessment did not consider the hazards of working outboard or at height. Therefore, a work permit was not required for this activity, the crew were not required to wear the fall restraint belts available, and no anchor points, rails or wires had been provided in the vicinity of the ladders to which safety belt lanyards could be secured. Several of the control measures identified by risk assessment were also not implemented: a detailed operational procedure had not been produced, lifejackets were not worn and the crew were not supervised by an officer.

Although AB Huang was extremely unfortunate to be standing on the ladder when the hoist gearbox failed, he fell into the water because he was not using fall arrest equipment, and probably drowned because he was not wearing a lifejacket.

2.6 PPE

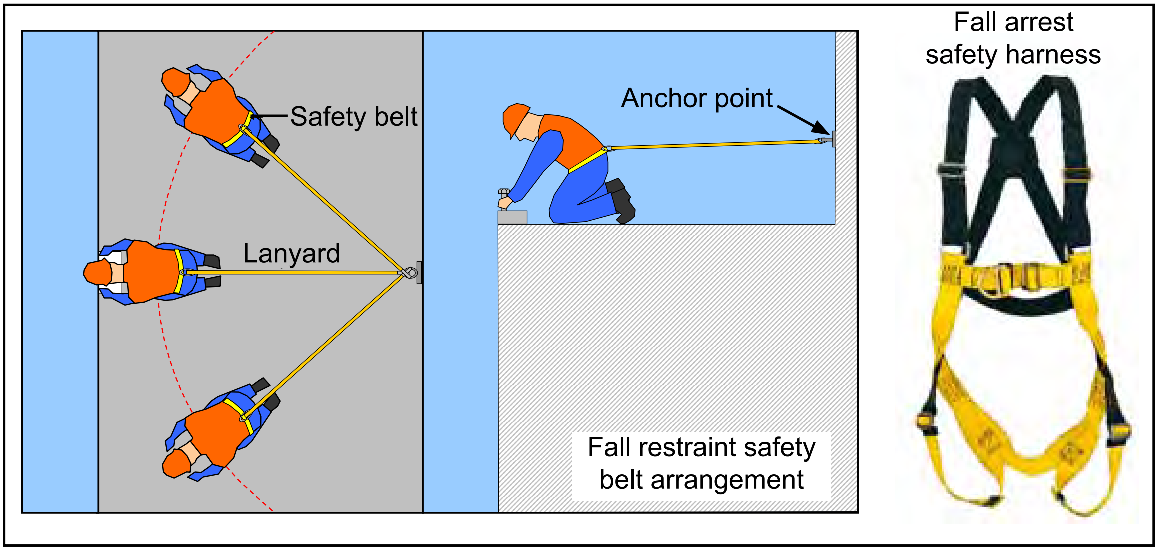
2.6.1 General

The safety belts and working life vests provided on board *Ever Elite* did not meet the UK's regulatory requirements and were not suitable for the activity being undertaken by AB Huang.

2.6.2 Fall arrest equipment

The safety belts provided on board *Ever Elite* were fall restraint, not fall arrest devices. These belts enable people to work up to the edge of a fall hazard, but prevent them from reaching the point from which they can fall **(Figure 29)**. In this case, where there was a possibility of AB Huang falling into the water from the accommodation ladder while rigging its handrails, the use of fall arrest equipment was appropriate.

Figure 29



Fall restraint and fall arrest PPE and associated equipment

Fall arrest body harnesses are designed to minimise the risk of injury to the wearer, suspend them in an upright position and maximise the chance of their safe recovery or rescue. The safety belts provided on board *Ever Elite* would not have achieved these aims and were likely to cause, rather than prevent injury.

2.6.3 Personal flotation devices (PFD)

PFDs are divided into the following two main classes[16]:

- those which provide face up in-water support to the user regardless of physical conditions (lifejackets); and
- those which require the user to make swimming and other postural movements to position the user with the face out of the water (buoyancy aids).

[16] BS EN ISO 12402 – Personal flotation devices.

There are four performance levels for PFDs:

- Level 275 (275N buoyancy) - for offshore use under extreme conditions. Designed to self-right the user and ensure he/she is floating in the correct position with the mouth and nose clear of the surface even when wearing clothing that might trap air.
- Level 150 (150N buoyancy) – intended for general application or for use with foul weather clothing. It will turn an unconscious person into a safe position.
- Level 100 (100N buoyancy) – intended for those who may have to wait for rescue, but are likely to do so in sheltered water. It should not be used in rough conditions.
- Level 50 (50N buoyancy) – intended for use by those who are competent swimmers and who are near to the bank or shore, or who have help and a means of rescue close to hand. They are of limited use in disturbed water, and cannot be expected to keep the user safe for a long period of time. They do not have sufficient buoyancy to protect people who are unable to help themselves as they require active participation by the user.

The acute injuries suffered by AB Huang during his fall were not considered to be fatal. However, they might have caused him to lose consciousness and would certainly have made it extremely difficult for him to stay afloat. Although this would have been easier if he had worn any PFD, the life vest available was only a 75N buoyancy aid, which would have been of marginal benefit.

The selection of the appropriate PFD is dependent on the task undertaken and the environment in which it is conducted. PFDs that do not require intervention, such as auto-inflate lifejackets, are suited to activities where persons are likely to enter the water unexpectedly. Self-activating lights, whistles and retro-reflective material fitted to PFDs assist in the detection of persons in the water. Given Mr Huang's injuries, had he worn a lifejacket with these features his chances of survival would have been increased significantly.

2.7 MANOVERBOARD PROCEDURE

When the alarm was raised, the vessel could not be manoeuvred due to navigational constraints. With the trainee pilot retaining the con, the actions of the harbour pilot to inform the shore authorities and co-ordinate the search by vessels in the vicinity were timely and effective. Consequently, the master was free to oversee the response of his bridge team and crew.

However, while the actions of the pilot and the assisting vessels led to the swift recovery of AB Huang, it is evident that some actions normally taken following a person falling overboard at sea were omitted. Neither of the lifebuoys with self-activating lights and smoke were released from the bridge wings, and the

GPS man overboard marker plot was not activated. The failure to release the lifebuoys was particularly significant. It denied the ships involved in the search a visible reference, and also potentially denied AB Huang the buoyancy he required to remain afloat.

Had the vessel conducted regular and realistic manoverboard drills, and also developed ship-specific checklists, the likelihood of such key actions being overlooked, would have been reduced significantly. Furthermore, the procedure for saving the information recorded on the VDR would have been well practised.

2.8 SAFETY CULTURE AND AUDITS

This investigation has highlighted a number of significant shortfalls in the safety management system and safety equipment on board *Ever Elite*. These strongly indicate the lack of development of a safety culture underpinning the vessel's operation and include:

- A safe system of work for rigging and un-rigging the accommodation ladders had not been developed.
- Control measures identified by risk assessment were not implemented.
- Maintenance records for the accommodation ladder systems were inaccurate and incomplete and therefore did not meet the requirements of PUWER.
- The life vests and safety belts provided did not meet the requirements of the UK administration, and the lifebuoy provided adjacent to the port accommodation ladder was not fitted with a light.
- Regular and effective manoverboard drills were not undertaken.
- The vessel did not hold a lifting gear register.

Although audits are by definition a sampling process, the significance and longevity of some of these shortcomings also casts doubt on the effectiveness of the internal and external ISM, ILO and ISO audits conducted on board during the previous 7 years.

It is particularly disturbing that none of the above was identified during the additional ISM audit conducted by ABS on behalf of the MCA following the death of Mr Huang. Although it is possible that the Taiwan-based auditor was not fully conversant with the UK's occupational health and safety regulatory requirements, many of the onboard deficiencies were within the scope of international regulation and the general principles of safety management.

SECTION 3 - CONCLUSIONS

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

1. Although the recent introduction of ISO 7364:1983 as a baseline for the design and construction of accommodation ladder hoist winches is a significant step forward, compliance with its requirements would not have prevented this accident. [2.4]

2. ISO 7364:1983 does not appear to reflect the technology currently available or take into account the full scope of the use of accommodation ladder hoist systems and the reliance placed upon them. Therefore, the need to review the standard is compelling. [2.4]

3. The risk assessment for the rigging and un-rigging of the accommodation ladders did not consider the hazards of working outboard or at height, and several of the control measures identified were not implemented. As a result, a safe system of work for this activity was not developed or followed. [2.5]

4. AB Huang fell into the water because he was not using fall arrest equipment, and probably drowned because he was not wearing a lifejacket. [2.5]

5. The actions of the pilot and the assisting vessels led to the swift recovery of AB Huang, but actions normally taken following a manoverboard at sea were omitted by the ship's crew. Had the vessel conducted regular and realistic manoverboard drills and developed ship-specific checklists, the likelihood of these actions and the need to save the information on the VDR being overlooked, would have been reduced significantly. [2.7]

6. The number of deficiencies identified concerning the safety management and planned maintenance systems, safety equipment, and emergency response casts doubt on the safety culture underpinning the vessel's operation. [2.7, 2.8]

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

7. It was not possible to accurately determine the scope or detail of either the scheduled or unscheduled maintenance carried out to the accommodation ladder systems because the information recorded on the ship's PMS was incomplete and inaccurate. [2.3.1]

8. The accommodation ladder hoist system was not considered to be lifting equipment, and therefore the additional maintenance and testing requirements of LOLER were not applied. These systems cannot safely or reasonably be excluded from the requirements of LOLER. [2.3.4]

9. Unlike LOLER, IMO guidance on the maintenance, testing and examination of accommodation ladder systems does not require the testing of the hoist equipment following maintenance or repair which has the potential to adversely affect the equipment's safe working load. [2.3.4]

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

10. The hoist winch gearbox failed due to its incorrect re-assembly following maintenance. [2.2]

11. The hoist winch was susceptible to gearbox damage from the repeated impacts between the ladder and davit frame. [2.3.1]

12. The possibility of assembly errors also occurring on the remaining 27 vessels fitted with the same winch cannot be significantly reduced until all of the vessels concerned have been provided with appropriate technical information. [2.3.3]

13. The safety belts and working life vests provided on board *Ever Elite* did not meet the UK's regulatory requirements and were not suitable for the activity being undertaken by AB Huang. [2.6]

14. The number of deficiencies identified concerning the safety management and planned maintenance systems, safety equipment, and emergency response casts doubt on the effectiveness of the auditing process [2.7]

SECTION 4 - ACTION TAKEN

Evergreen Marine UK Ltd. has:

- Informed its fleet about the circumstances of the accident on *Ever Elite* and instructed ships' staff to conduct urgent examinations of all accommodation ladder systems.

- Provided 150N inflatable working lifejackets for use on board its ships.

- Provided full body safety harnesses with safety lines.

- Rigged a fall prevention system for its accommodation ladders.

- Installed a securing wire to its accommodation ladders to mitigate the identified single points of failure.

Nakano Seisakusho Co. Ltd. has:

- Conducted a technical investigation and recommended to EMU:
  - The use of a preventer (sub-wire) arrangement on board its ships when accommodation ladders are to be used while suspended from their hoist gear.
  - All sheave and roller set base plates be welded to the ladder frames.
  - All winch gearbox maintenance be inspected and approved by a *third person*.

- Undertaken to inform all owners of ships fitted with its slide-out type telescopic ladder systems of the circumstances of this accident and issue the same recommendations made to EMU.

- Undertaken to produce a detailed winch maintenance manual which will be made available to all its customers.

The **American Bureau of Shipping** has:

- Investigated the conduct of the additional ISM audit carried out on board *Ever Elite* by its Taipei office and has taken action to help improve the effectiveness of similar audits in the future.

The **Maritime and Coastguard Agency** has:

- Conducted an additional Document of Compliance audit at the EMU head office following a further fatal accident on board one of its vessels later in 2009. The audit report highlighted the need for EMU to consider ways the safety culture on board its vessels could be improved.

The **MAIB** has:

- Commenced an investigation into the death of a chief engineer on board the container ship *Ever Excel* while conducting a routine inspection of an internal crew lift on 21 April 2010. This was the third occupational health and safety related fatality on board EMU's eleven UK registered vessels within an 8 month period.

SECTION 5 - RECOMMENDATIONS

The **British Standards Institution** is recommended to:

2010/113 Propose to the International Organization for Standardization that ISO 7364:1983 is updated to reflect current recognised best practice and available technology, and reflect the full scope of operation of accommodation ladder systems.

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

2010/114 Make IMO aware of the potential weaknesses in ISO 7364:1983 and to support initiatives for its review.

2010/115 Propose to IMO that MSC circular 1331 be revised to include the requirement for hoist winches to be tested following any maintenance, repair or modification work which might affect the safe working operation of the equipment.

2010/116 Take action to ensure that accommodation ladder hoisting systems on board UK registered vessels are maintained and records kept in accordance with the Lifting Operations and Lifting Equipment Regulations.

Evergreen Marine UK Ltd. is recommended to:

2010/117 Take urgent action to:

- Promote the development of a robust safety culture on board its vessels by ensuring that working practices are reviewed to verify compliance with UK occupational health and safety requirements, and that safe systems of work are put in place and followed for all work activities.

- Revise its onboard maintenance management procedures to ensure that the details of all maintenance are accurately recorded, computerised systems are used effectively, and that competent persons nominated to undertake maintenance tasks are provided with adequate guidance and instruction.

- Increase the effectiveness of manoverboard drills on board its vessels by ensuring they are realistic and conducted at sufficiently regular intervals.

July 2010
Marine Accident Investigation Branch

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