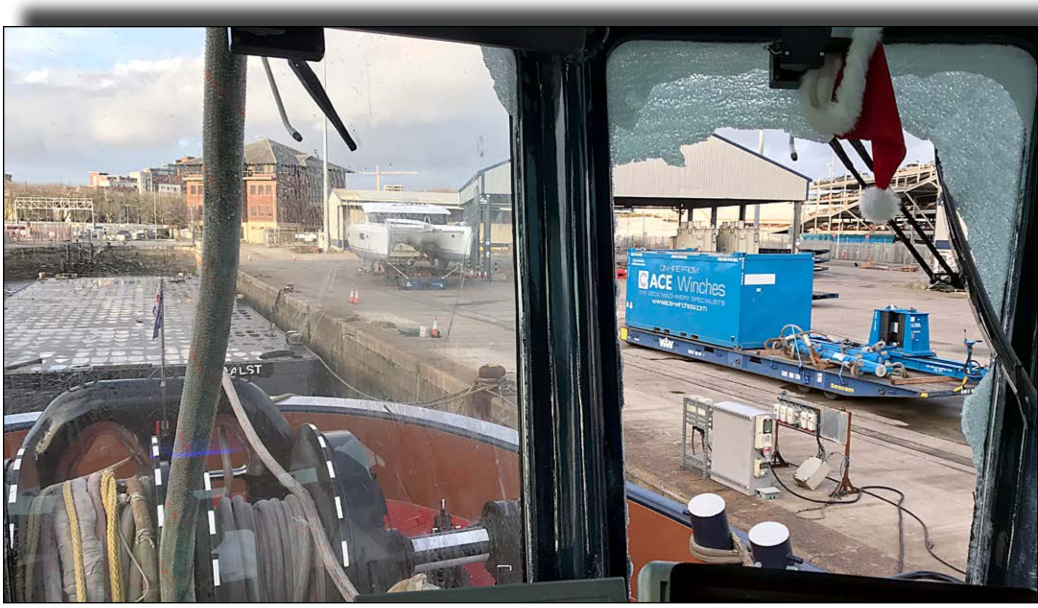
ACCIDENT REPORT

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

Report on the investigation of the failure of a towline pennant and injury to the crew on board the tug *Svitzer Mercurius* in Southampton, England on 22 December 2019



SERIOUS MARINE CASUALTY | REPORT NO 15/2022 | DECEMBER 2022

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

Front cover image courtesy of Svitzer (UK)

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	-	able seaman
ASD	-	Azimuth Stern Drive
ATD	-	Azimuth Tractor Drive
BS	-	British Standard
BV	-	Bureau Veritas
COSWP	-	Code of Safe Working Practices for Merchant Seafarers
Damen	-	Damen Shipyards Group
DNV	-	Det Norske Veritas
g	-	gram
gt	-	gross tonnage
HMS	-	Harmonised Management System
IACS	-	International Association of Classification Societies
Iskes	-	Iskes Towage and Salvage
ISM Code	-	International Safety Management Code
ISO	-	International Organization for Standardization
kg	-	kilogram
kts	-	knots
kN	-	kilonewton
kPa	-	kilopascal – a unit of pressure. 101.3kPa = one atmosphere
kW	-	kilowatt
kg/m	-	kilograms per metre
LR	-	Lloyd’s Register
LMP	-	Line Management Plan
m	-	metre
MBL	-	minimum breaking load
MCA	-	Maritime and Coastguard Agency
MEG4	-	Mooring Equipment Guidelines Fourth Edition
mm	-	millimetre
MGN	-	Marine Guidance Note
M+F	-	Merchant ships and fishing vessels
m/min	-	metres per minute

N/mm^2	-	newtons per square mm
OCIMF	-	Oil Companies International Marine Forum
PMS	-	planned maintenance system
rpm	-	revolutions per minute
SCT	-	Southampton Container Terminal
SMS	-	Safety management system
STCW	-	The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978
Svitzer	-	Svitzer Euromed B.V.
SWL	-	safe working load
t	-	tonne
TTI	-	Tension Technology International
UR	-	Unified Requirement
UTC	-	Universal time coordinated
WLL	-	working load limit

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

Image courtesy of Sergejs Nik (www.vesselfinder.com)

Svitzer Mercurius

SYNOPSIS

At 1231 on 22 December 2019, the starboard forward towline pennant on board the tug *Svitzer Mercurius* parted and snapped back while the vessel was acting as stern tug to the ultra-large container ship *CMA CGM Marco Polo* as it berthed in Southampton. The towline and pennant recoiled back toward the tug, breaking one of its forward wheelhouse windows and damaging several others. Five of the seven-man crew, who were standing in the wheelhouse, were sprayed with glass fragments from the broken toughened glass window and suffered multiple minor lacerations. Fortunately, they were all wearing either glasses or sunglasses and no eye injuries occurred.

Svitzer Mercurius had recently changed ownership and had joined Svitzer's Southampton operations from the Netherlands. It continued to operate with its Dutch crew, who were contracted to provide familiarisation training to Svitzer crews over a 3-month handover period. Svitzer tug masters provided local port knowledge.

The towline pennant was found to have failed at approximately 52% of its original minimum breaking load. Close examination of the pennant indicated that it had previously sustained high shock loads and cyclic load damage to its load-bearing core. Due to its jacketed construction, the core was difficult to examine. Svitzer representatives visited the vessel several times before the tug started work in Southampton, and an independent survey of the tug and its equipment had been carried out. Neither identified existing wear and damage to the pennant nor its unsuitability for further work.

The wheelhouse windows met specific international standards as part of classification society requirements for 'green seas' loading. The standards did not require resistance to solid body impact such as a recoiling towline. However, in 2018, the tug manufacturer Damen Shipyards Group had introduced an impact-resistant window glass on its new tugs as standard equipment, having recognised the snapback hazard and potential for serious crew injuries.

The tug's classification society, Det Norske Veritas, has been recommended to take the findings of this investigation to the International Association of Classification Societies to develop a unified requirement to minimise, in the event of impact from a recoiling towline, the risk of injury from broken window glass to personnel within tug wheelhouses. A recommendation has also been made to the tug operator, Svitzer Marine Limited, to review the risk to wheelhouse crews across its fleet posed by towline snapback and, where it is assessed to be high, evaluate the viability of introducing laminated glass for wheelhouse windows.

SECTION 1 – FACTUAL INFORMATION

1.1 PARTICULARS OF *SVITZER MERCURIUS* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Svitzer Mercurius*
Flag	UK
Classification society	Det Norske Veritas
IMO number	9695523
Type	Tug (Class IX)
Registered owner	Svitzer Euromed B.V.
Manager(s)	Svitzer (Middlesbrough)
Construction	Steel
Year of build	2014
Length overall	32.7m
Registered length	32.7m
Gross tonnage	447
Minimum safe manning	3
Authorised cargo	Not applicable

VOYAGE PARTICULARS	
Port of departure	Southampton
Port of arrival	Southampton
Type of voyage	Internal waters
Cargo information	Not applicable
Manning	7

MARINE CASUALTY INFORMATION	
Date and time	22 December 2019 at 1231
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Southampton
Place on board	Foredeck; wheelhouse
Injuries/fatalities	Minor injuries to 5 crew
Damage/environmental impact	Failure of pennant line; 3 wheelhouse windows damaged and 1 shattered
Ship operation	Towing
Voyage segment	Arrival
External & internal environment	Calm, Force 4 breeze, good visibility, sunny
Persons on board	7

1.2 BACKGROUND

Svitzer Mercurius was an Azimuth Stern Drive (ASD) tug. Previously named *Mercurius* **(Figure 1)**, the tug had been owned and operated by the Dutch tug operator Iskes Towage and Salvage (Iskes) since build in 2014. In 2019, it was purchased by Svitzer Euromed B.V. (Svitzer) to fulfil a new contract commitment that was scheduled to begin on 1 January 2020.

On 16 December 2019, *Svitzer Mercurius* arrived in Southampton, England from IJmuiden, Netherlands. During its initial 3-month handover period, the tug was to be operated by an Iskes crew, supplemented by Svitzer crew to provide knowledge of the port and help ensure Svitzer's safety management procedures were followed. At the same time, the Iskes crew were tasked to provide familiarisation training for Svitzer's tug crew members.

On 20 December 2019, Svitzer tasked *Svitzer Mercurius* with its first job, assisting the departure of a car carrier from Southampton. On that occasion, a towline was attached but not put under load.

1.3 NARRATIVE

On 22 December 2019, *Svitzer Mercurius*, along with the tugs *Svitzer Ferriby* and *Svitzer Eston*, was tasked to assist the ultra-large[1] container ship *CMA CGM Marco Polo* up Southampton Water and on to its berth at Southampton Container Terminal (SCT); *Svitzer Mercurius* was allocated the role of stern tug.

At about 1100, the master, chief officer and chief engineer from the tug *Svitzer Alma*, who had been appointed to the new tug for the day, boarded *Svitzer Mercurius* at Ocean Dock, berth 45. At about 1115, *Svitzer Mercurius*'s Dutch master unberthed the tug and handed over the helm to *Svitzer Alma*'s master. Under the Dutch master's supervision, *Svitzer Alma*'s master began manoeuvring evolutions to gain an appreciation of the tug's capabilities. This included mooring it alongside on both port and starboard sides. Once complete, *Svitzer Mercurius* headed down Southampton Water to rendezvous with the inbound container ship.

As *Svitzer Mercurius* proceeded down Southampton Water, its master gave *Svitzer Alma*'s master permission to drive the tug during the towing operation. The Dutch master was aware of the local master's experience and had seen him handle the tug.

At 1146, *Svitzer Mercurius* met *CMA CGM Marco Polo* off Netley shore and was manoeuvred into position to assume its role as stern tug and pass its starboard forward towline across to the container ship's aft mooring deck. Once in position, the tug's deck crew connected a heaving line received from the container ship to the starboard towline's messenger line[2]. Up to 40m of towline was then run out from the starboard drum of the tug's forward towing winch **(Figure 2)**. The eye of the towline pennant[3] was pulled up through the container ship's centreline Panama lead and placed over a set of bitts immediately inboard. With its towline slack and its winch brake applied at 100% holding capacity, *Svitzer Mercurius* held station astern of *CMA CGM Marco Polo* as the container ship proceeded towards SCT Berth 5.

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1 Ultra-large container ship means a container ship with a carrying capacity, length, beam, or draught equal to or greater than 14,501 twenty-foot equivalent unit, 366m, 49m and 15.2m respectively.

2 A messenger line is a light rope that has sufficient strength to heave the tug's towing assembly on the assisted vessel's mooring deck.

3 A towline pennant is a short length of wire rope or synthetic line used to prevent damage to the main towline, where it is made fast on the assisted vessel's stern.

Image courtesy of ISKES Towage & Salvage

Figure 1: *Mercurius*

Image courtesy of Auke De Haan

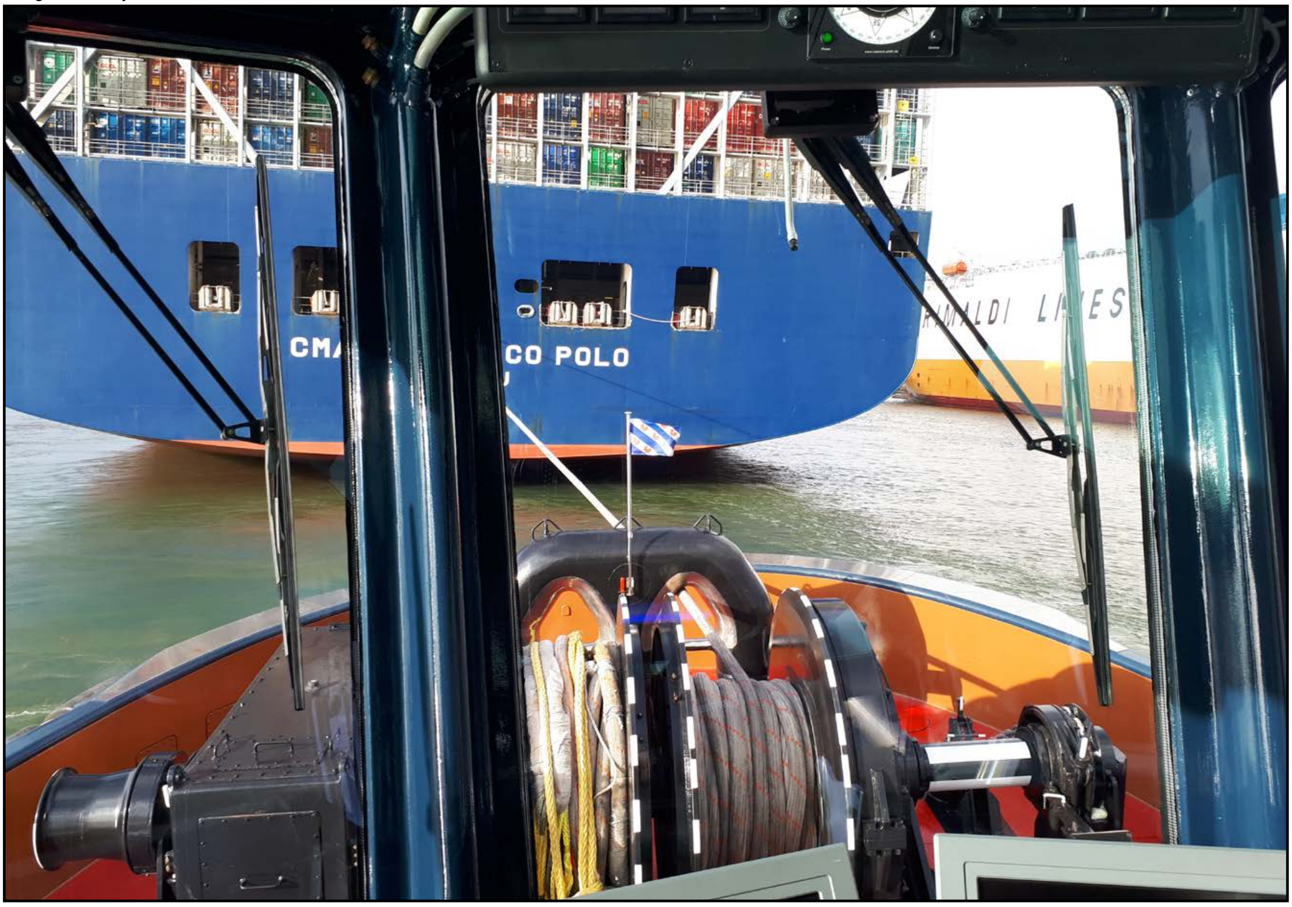


Figure 2: *Svitzer Mercurius*' starboard towline connected to *CMA CGM Marco Polo* prior to failure

At about 1225, *CMA CGM Marco Polo* entered the turning basin adjacent to its berth at a speed over the ground of 3.7 knots (kts); *Svitzer Eston* was at the container ship's bow and *Svitzer Ferriby* was on its port quarter **(Figure 3)**. As the ship began to turn to port, the pilot requested *Svitzer Mercurius* to provide 50% astern thrust to slow the ship. Shortly afterwards, the pilot requested that *Svitzer Mercurius* increase the stern thrust to 100%. As the load on the towline increased, the tug's winch brake slipped and a few metres of the towline were released. With full astern power being maintained, the line quickly became taut and the winch brake slipped a second time, with another several metres of towline being released.

At about 1231, after the winch had slipped a second time, the towline pennant parted close to *CMA CGM Marco Polo*'s deck **(Figure 4)** and snapped back towards the tug. Part of the line struck and shattered the starboard forward wheelhouse window. It also struck the centre forward window, causing its inner pane to fracture **(Figure 5)**. The remaining line landed on the wheelhouse deck and roof **(Figure 6)**.

Five crew who were stood in the wheelhouse (*Svitzer Mercurius*'s master, mate and chief engineer, and the *Svitzer Alma*'s master and mate) **(Figure 7)** were struck by flying glass fragments **(Figure 8)** and suffered multiple minor facial, arm and upper body lacerations. All of the crew were wearing some form of eyewear, which prevented any eye injuries. The rest of the wheelhouse was peppered with glass fragments **(Figure 9)** and two of the inner panes of the aft-facing windows were also cracked but did not break **(Figure 10)**. *Svitzer Mercurius*'s mate took control of the tug while the Dutch master went below to clean blood from his face. When the tug's master returned to the wheelhouse, he took back control.

The pilot on board *CMA CGM Marco Polo* contacted *Svitzer Mercurius* and asked if everything was okay. He was informed that the pennant had failed and that *Svitzer Mercurius* could swap places with *Svitzer Eston*. By 1240, *Svitzer Mercurius* had been repositioned on the container ship's port bow and *Svitzer Eston* was at the stern. About 20 minutes later, *CMA CGM Marco Polo* was berthed alongside and *Svitzer Mercurius* was released.

When *Svitzer Mercurius* arrived back at its berth, all five injured crew were taken to Southampton General Hospital to have embedded fragments of glass removed from their faces and arms.

1.4 ENVIRONMENTAL CONDITIONS

The wind at Netley was south-westerly force 4, visibility was good and the conditions were sunny. The conditions at the SCT were similar, with the tidal stream ebbing to the south-east at 0.2kts and low water at 1300.

Image courtesy of [Associated British Ports](#) (Southampton)

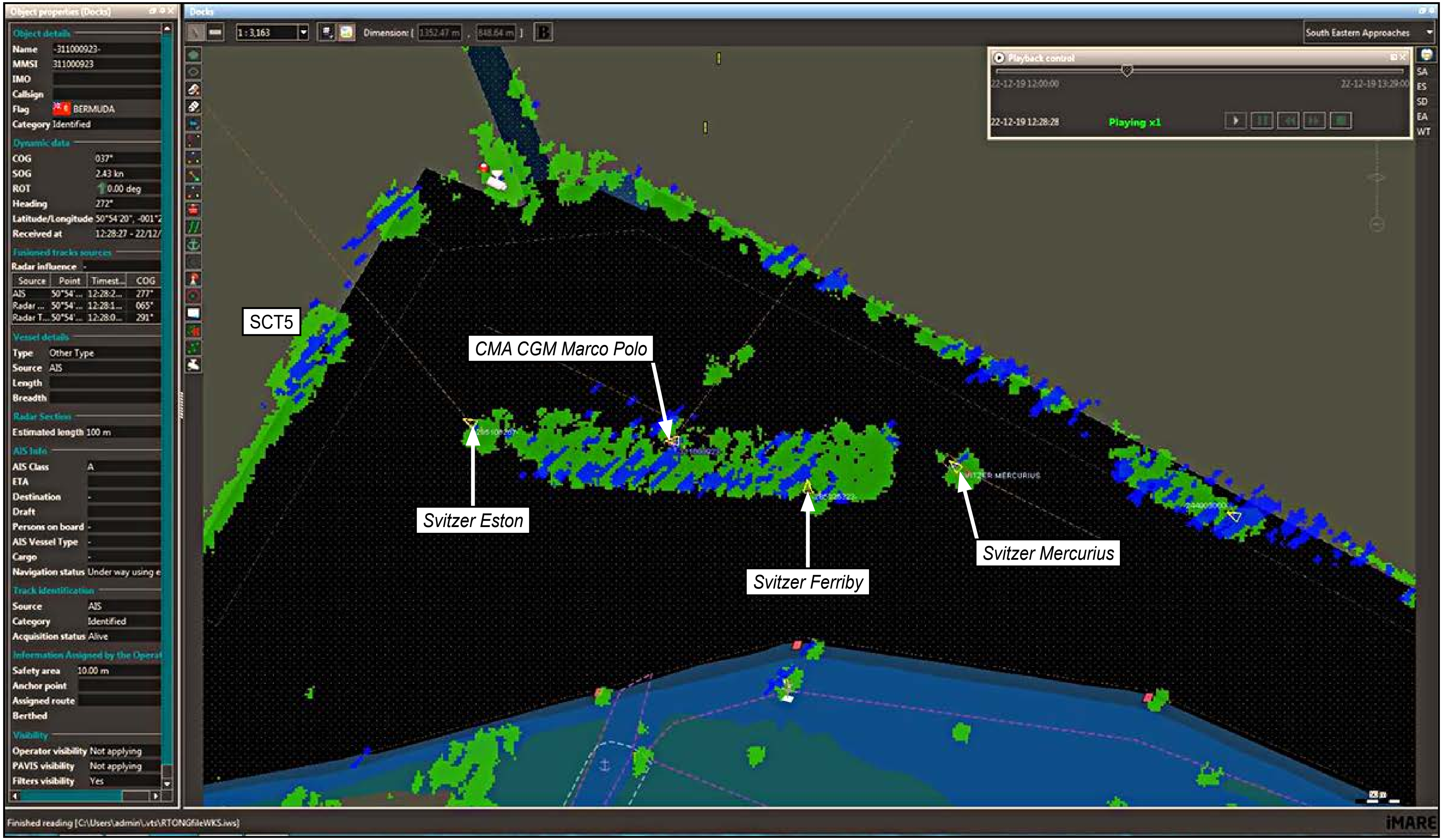


Figure 3: Svitzer tugs assisting *CMA CGM Marco Polo* in Southampton turning basin

Figure 4: Parted starboard towline pennant

Image courtesy of Svitzer (UK)

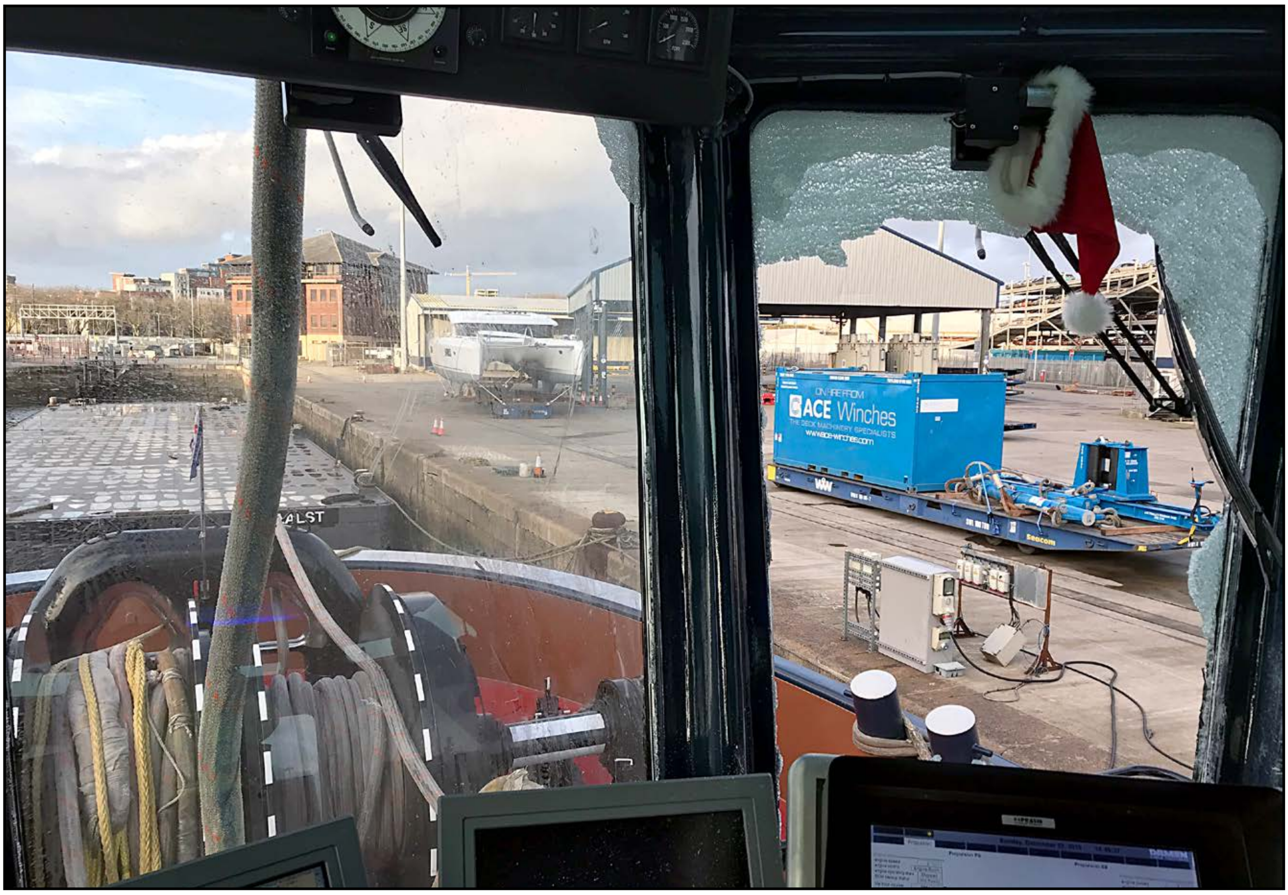


Figure 5: Broken starboard forward wheelhouse window

Image courtesy of Svitzer (UK)

Figure 6: Starboard towline and pennant on wheelhouse deck and roof

Image courtesy of Svitzer (UK)

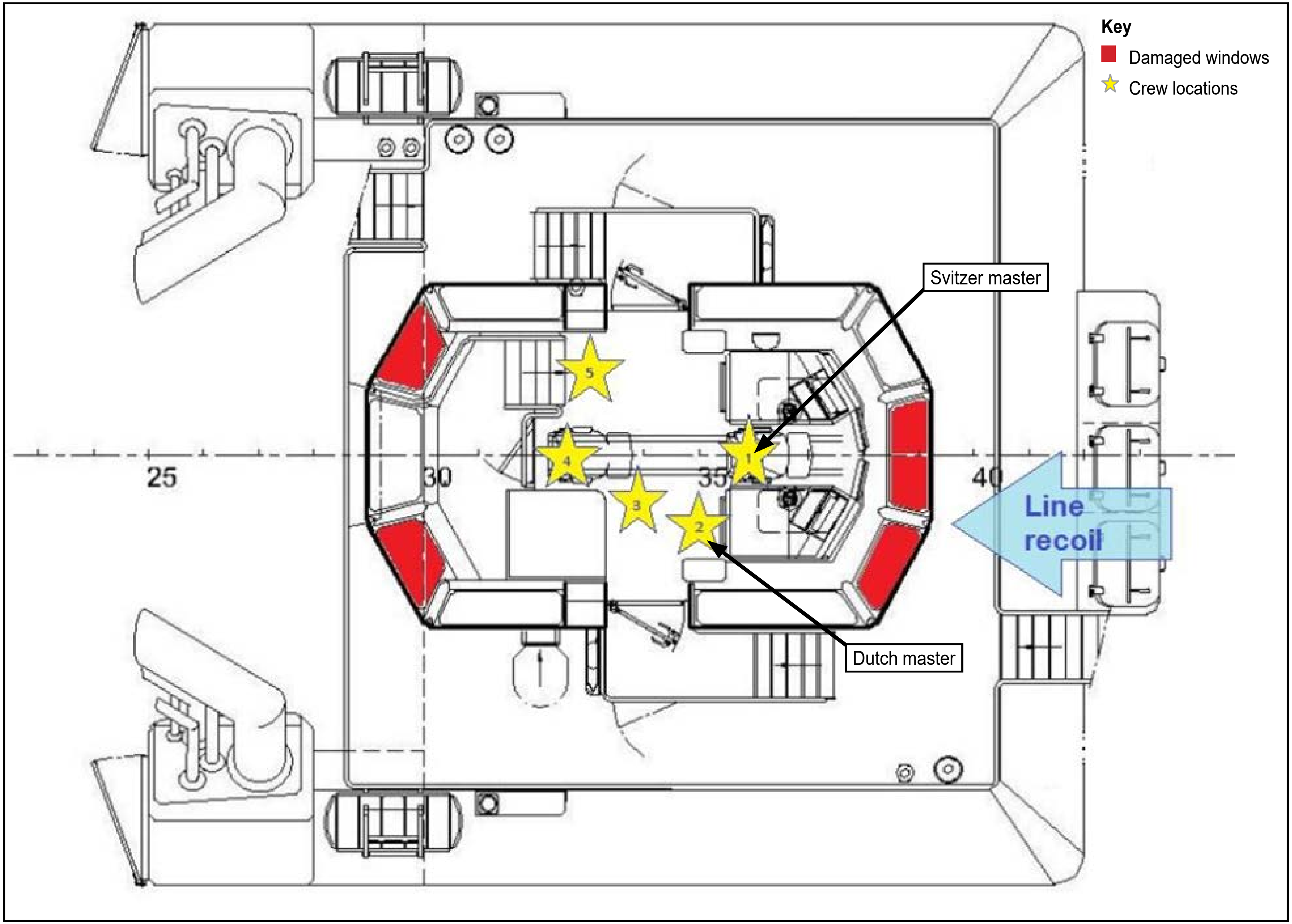


Figure 7: Positions of crew in wheelhouse when struck by flying glass

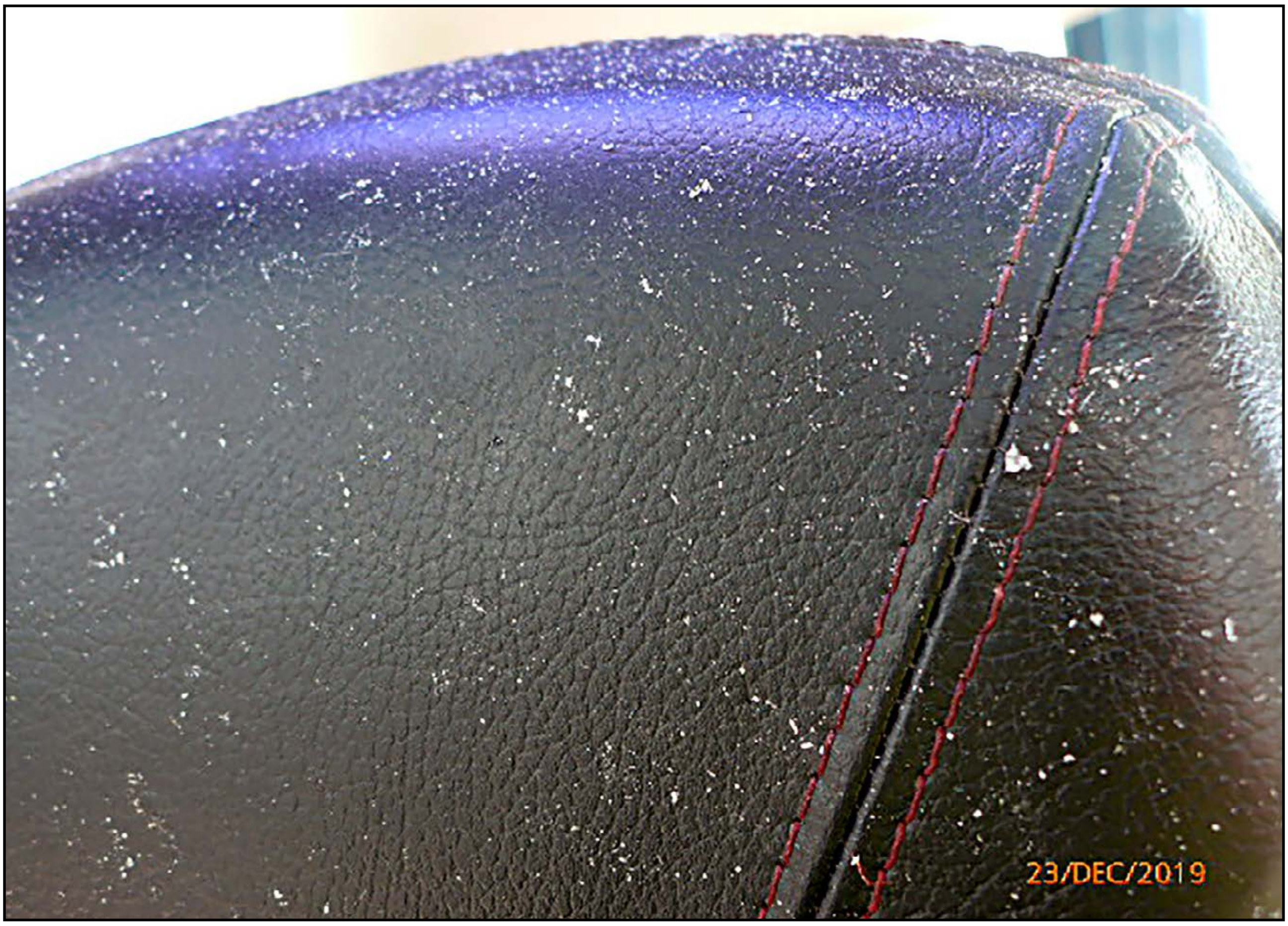


Figure 8: Glass particles embedded in wheelhouse chair

Figure 9: Starboard wheelhouse window glass fragment

Figure 10: Cracked aft-facing wheelhouse windows

1.5 SVITZER CREW

1.5.1 *Svitzer Mercurius*

Svitzer Mercurius had a crew of four Dutch nationals that comprised the master, mate, chief engineer and an able seaman (AB). They were agency crew engaged by the Dutch tug operator Iskes and had previous experience of the tug.

The master had been employed by Iskes for 10 years and had served as a tug master on board a variety of the company's tugs for nine of them, working predominantly in Rotterdam. He had experience in twin screw, Voith, Azimuth Tractor Drive (ATD) and ASD propulsion systems, including several years as master on board *Mercurius*. He held an STCW II/3 Master less than 500gt certificate of competency.

1.5.2 *Svitzer Alma*

The three *Svitzer Alma* crew on board *Svitzer Mercurius* at the time of the accident were British nationals. *Svitzer Alma*'s master had worked on board tugs since 1973 and became a tug master in 2000. He held an STCW II/3 Master less than 500gt certificate of competency and had experience of a wide range of propulsion types, including Voith, ATD and ASD. He had also received annual familiarisation training on each tug in Svitzer's Southampton fleet.

1.6 *SVITZER MERCURIUS*

1.6.1 Overview

Svitzer Mercurius was designed as a deep-sea escort, port and terminal tug and was built in 2014 for Iskes in the Netherlands by Damen Shipyards Group (Damen). Iskes had provided harbour towage services in the Netherlands since 1928 and provided similar services to other ports worldwide. Damen operated globally in a wide range of marine markets, and its tugs were often described by their length/beam dimensions in metres; *Mercurius* was a 3212 tug, which denoted 32m length and 12m beam.

Mercurius was registered in the Netherlands and operated in the port of IJmuiden, where it was used for both direct and indirect[4] towing operations. It was built to Bureau Veritas (BV) classification society rules and, on delivery in July 2014, transferred to Lloyd's Register (LR). On 16 August 2019, Det Norske Veritas (DNV)[5] took over classification society responsibilities for the tug.

On 13 December 2019, the renamed *Svitzer Mercurius* was registered under the UK flag. On 15 August 2020, its classification was transferred back to LR.

1.6.2 Propulsion drive and towing winch

Svitzer Mercurius's ASD propulsion system comprised two Rolls-Royce thrusters, each with 2.8m fixed pitch azimuth propellers, giving a 360° arc of movement. The thrusters were driven by two Caterpillar 3516C diesel engines that provided a total power of 5,050kW. The propulsion system provided a maximum speed of 14.1kts ahead and 14kts astern. The tug's bollard pull was 82.5t ahead and 76.1t astern.

The tug's towing winch was manufactured by DMT Marine Equipment and installed by Damen at build. It was a two-speed hydraulically driven winch and had a split double drum arrangement. The drums were designed for storing up to 150m of 80mm towline. The winch **(Figure 11)** had the following operating characteristics:

- 38t pull at 12m/min at the second layer;
- a rendering[6] capacity of 100t at 100m/min; and
- a 200t brake hold capacity (second layer).

The winch operation manual stated that the winch's hydraulically operated band brake friction linings had to be checked for wear every 15 cycles or twice a year. Grease lubrication of the winch's moving parts was required before and after winch operation, or once a week if the winch was not used. The manual warned that the band brake's holding capacity would be reduced if grease or oily fluids came into contact with the brake surfaces.

[4] Indirect towing is a way of enlarging the exerted force when turning and/or decelerating the tow. This mode applies only to the trailing tug (stern tug). The tug is made fast to the vessel by a towline and is dragged by the assisted vessel. The tug uses its thrust to maintain a sheered position relative to the tow's heading, while the towing force is generated by the drag forces acting on the tug's hull and transmitted via the towline. The drag forces on the tug can be substantially higher than the bollard pull when the speed through the water is greater than 6kts.

[5] At the time of the accident DNV was known as *Det Norske Veritas-Germanischer Lloyd*.

[6] The force required to turn the winch in the opposite direction when set to heave with the driving force applied.

Figure 11: Forward towing winch

The winch control system used a line length and force measurement system to measure the spooled line and to track the forces under towing conditions. It also recorded alarms but these were deleted when the system power was reset. Consequently, no alarm history was available after the accident.

1.6.3 Towline assembly

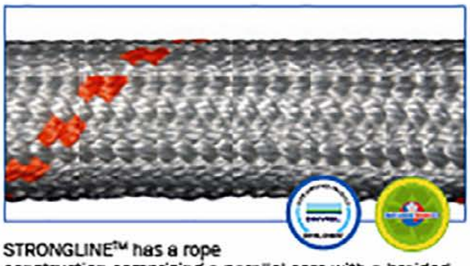
Svitzer Mercurius's port and starboard towline assemblies individually comprised a 100m long mainline, 20m long pennant and a soft link, each manufactured by Lankhorst Ropes. The mainlines and pennants were 88mm diameter STRONGLINE™ synthetic fibre ropes with eye splices at either end. The pennant was joined to the main towline by a 24mm diameter Lanko®nect soft link synthetic fibre rope connection.

The 88mm STRONGLINE™ ropes had a three-strand polyester parallel load-bearing core and a polyester braided jacket that provided abrasion protection **(Figure 12)**. They had a mass per unit length of 4.93kg/m and a minimum breaking load (MBL) of 229.5t (2250kN). After bedding in, they had an elongation of about 4.5% at 50% MBL. The Lanko®nect soft link was rigged to provide a theoretical breaking force of 184t.

Image courtesy of Lankhorst Ropes

SYNTHETIC ROPES

STRONGLINE™

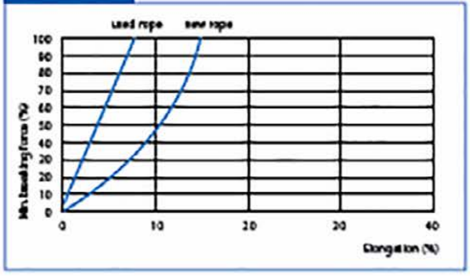


STRONGLINE™ has a rope construction comprising a parallel core with a braided protective cover. The parallel core produces a far higher strength rope than might be expected for a rope of this diameter and material. The protective cover ensures a long service life due to its excellent resistance against abrasion. Regular maintenance can significantly lengthen the rope service life. The main applications of STRONGLINE™ are towing and mooring.

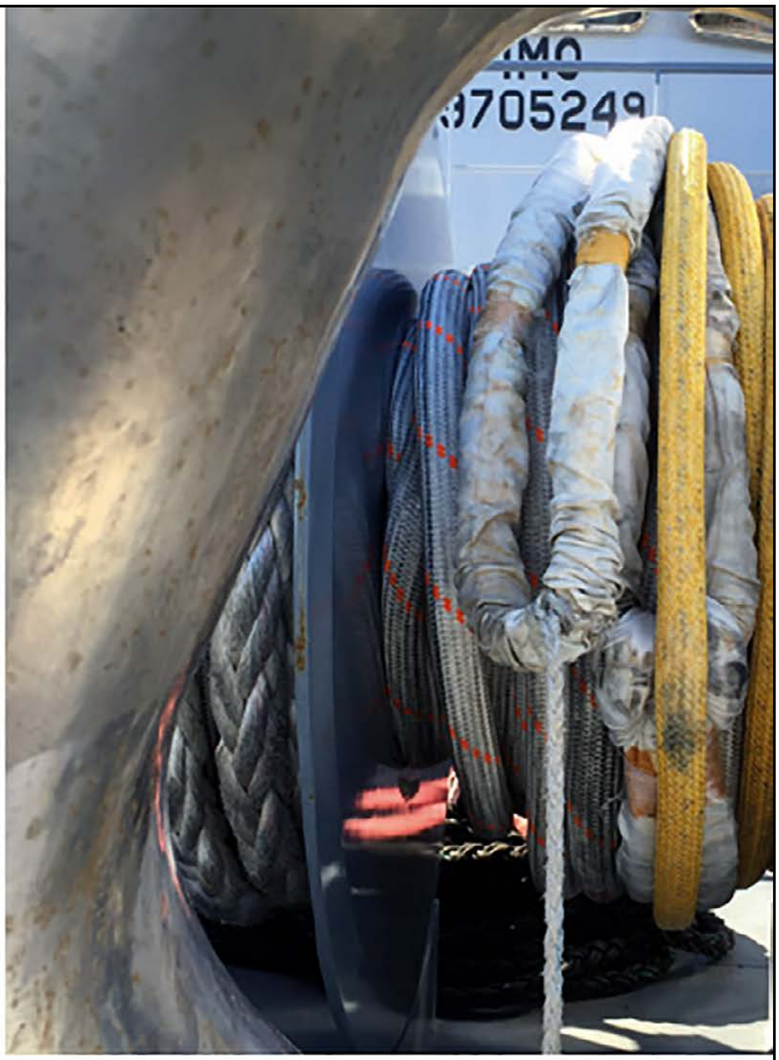
When STRONGLINE™ is installed on a towing winch, twists in the rope during installation can reduce the service life of the rope once put to work. To prevent twisting, it is crucial to use a turning table for unwinding from a coil. To facilitate the installation and avoiding induced twisting, a longitudinal marking has been added to the STRONGLINE™ during manufacture. Please make sure the longitudinal marking line is always on the same position while winding up the STRONGLINE™ on your towing winch.

MADE OF 100% POLYESTER

ELONGATION:



SPECIFIC GRAVITY	1,38
UV-RESISTANCE	excellent
ABRASION RESISTANCE	excellent
CHEMICAL RESISTANCE	good
MELTING POINT	approx. 265°C
CONSTRUCTION	parallel cores with jacket
TCLL VALUE	70%
COLOUR	white
MARKER YARN	orange
WATER ABSORPTION	< 1%
ELONGATION USED ROPE	4,5%
A3 SPLICE	
ENHANCED EYE PROTECTION	



article number	nominal diameter mm	nominal diameter inch	weight kg/100m	weight lb/100ft	minimum breaking force kN	minimum breaking force t (metric)	minimum breaking force lbs
081.056	56	2 1/4	227	152	1.106	112,7	248.550
081.060	60	2 3/8	256	172	1.256	128,1	282.260
081.064	64	2 5/8	284	190	1.411	143,8	317.093
081.068	68	2 11/16	307	206	1.578	160,9	354.622
081.072	72	2 13/16	367	248	1.744	177,8	391.927
081.076	76	3	390	261	1.922	195,9	431.929
081.080	80	3 3/16	417	280	2.100	214,1	471.931
081.088	88	3 7/16	493	330	2.500	254,9	561.823
081.092	92	3 5/8	528	354	2.722	277,5	611.712
081.096	96	3 3/4	560	375	2.922	297,9	656.658
081.100	100	3 15/16	630	423	3.167	322,9	711.717
081.104	104	4 1/8	662	444	3.433	350,1	771.495
081.112	112	4 7/16	778	522	4.058	413,8	911.501

Other diameters on request
Common diameters of Strongline mainline are available from stock in several standard lengths.
Diameter, weight and MBF (as well as other mechanical and physical properties) are determined according ISO 2307:2010. The MBF refers to the breaking strength in the rope / wire itself, without splices or any other form of termination that can be formed with or without the use of accessories / fittings.

A3 splice

In case of the unique A3 splice, the splice and the eye have been fully integrated. The A3 splice handling advantages include:

- No doubling of the rope in the splice area, therefore no doubling of the splice weight
- No stiffness due to the splicing, the rope maintains its natural flexibility
- Neater spooling on the storage drum of the winch if the line has an eye at both ends
- It yields 100% splice efficiency

Figure 12: STRONGLINE™ rope

1.6.4 Wheelhouse windows

Svitzer Mercurius had six forward, six side and six aft-facing tinted double-glazed wheelhouse windows **(Figure 13)**. The window panels were constructed of toughened safety glass fitted within steel frames. The larger tapered lower windows were designed to provide unobstructed views fore and aft, while the smaller sky windows allowed an optimal view of the assisted vessel.

The outer and inner panes of the lower window panels were 15mm and 6mm thick respectively and had a 15mm argon-filled gap between them. The outer and inner panes of the forward and side-facing sky window panels were 16mm and 6mm thick respectively; the 16mm panes were of laminated construction and comprised glass panes with a thickness of 10mm and 6mm. The glass panes used to construct all the windows were thermally hardened and had a minimum tensile strength of 180N/mm².

Base drawing courtesy of Damen Shipyards (Gorinchem)

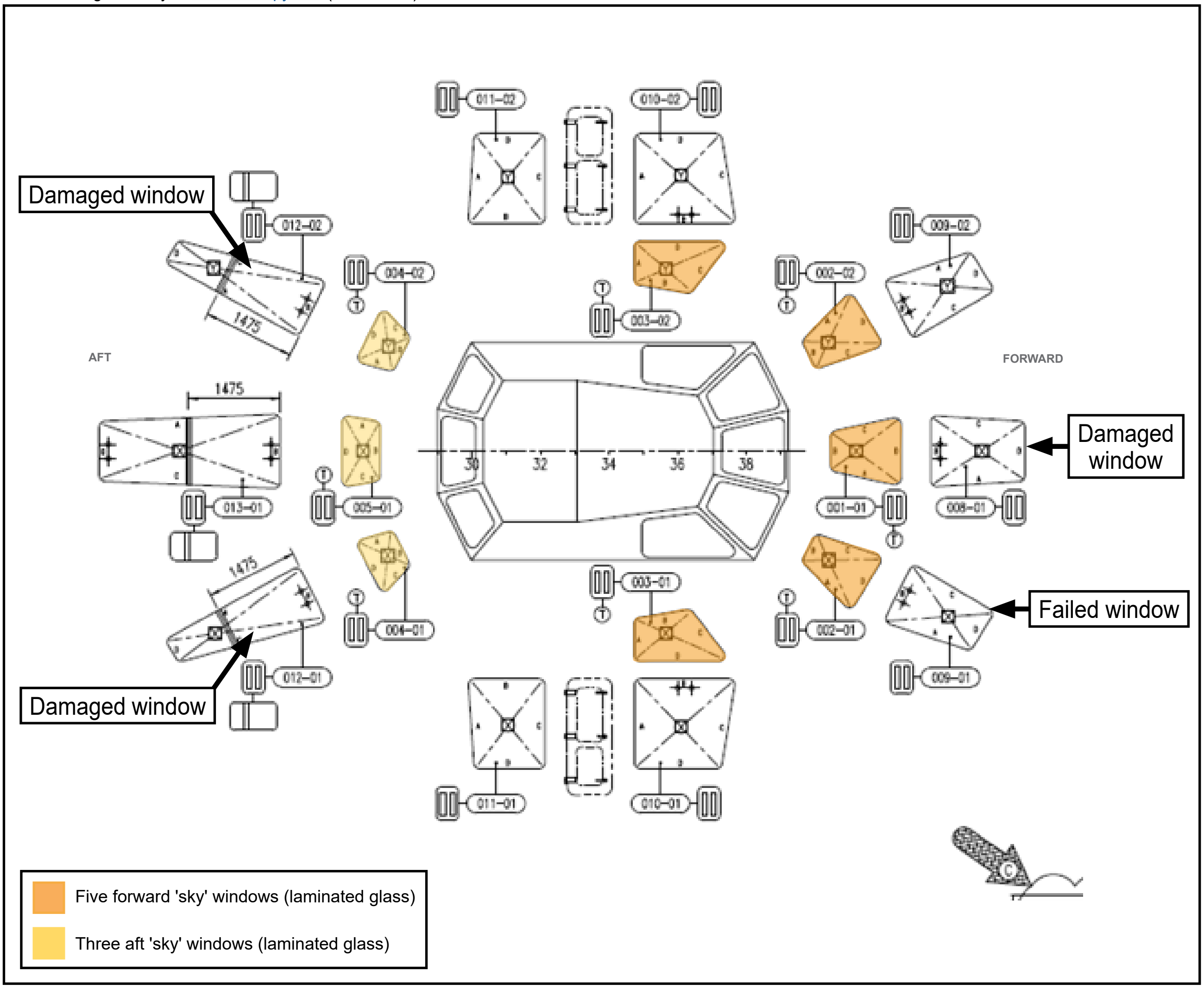


Figure 13: Wheelhouse windows configuration

1.7 SVITZER

1.7.1 Southampton tugs

Svitzer operated six tugs, including *Svitzer Mercurius*, in the port of Southampton, two of which were smaller Damen 2212 tugs (22m length and 12m beam). The tugs' bollard pulls ranged from 53t to 82.5t, with three in the 60t to 70t range. Three of the tugs had ASD propulsion systems, two had ATD and one had a Voith tractor arrangement.

All six tugs were class IX ships and were surveyed under *The Merchant Shipping (Survey and Certification) Regulations 2015*. Svitzer's safety management system (SMS) was contained within its overarching Harmonised Management System (HMS), which the crew on board could access electronically. The SMS was common to all the tugs in the fleet.

1.7.2 Pre-purchase inspection

As part of the pre-purchase arrangements, an independent marine consultancy was requested to perform a technical survey of *Mercurius*, which took place on 16 September 2019. The report concluded that the vessel appeared well maintained and the hull was in good condition. Regarding its towlines, the report stated, *Harbour wire: 2 x 150mtr 88mm Dynema* [sic]

1.7.3 Introduction of new tugs into the Svitzer fleet

Procedures for the introduction of new tugs into the Svitzer fleet were contained in its HMS and included:

- *Transfer of Vessels*;
- *Implementing Health Safety Security Environment and Quality in New Operations*; and
- *Technical Inspection*.

The *Transfer of Vessels* procedure required the acquisition and mobilisation process for a new tug to be managed and documented. This included the need for a technical inspection report.

The *Implementing Health Safety Security Environment and Quality in New Operations* procedure detailed the processes and responsibilities for all new towage operations on Svitzer managed vessels. It stated that:

> *The Harmonised Management System applies to all SVITZER towage operations. New operations have specific hazards such as: new employees, lack of experience, unsuitable equipment, and lack of clear operating procedures.*

The *Technical Inspection* procedure was designed to determine the material state and seaworthiness of a tug prior to transfer/sailing to its destination. It stated that:

> *A thorough survey/inspection and a Risk Assessment must be carried out … prior to any Repositioning/Transfer of Vessels by qualified, experienced personnel.* [sic]

The HMS contained a technical inspection form **(Annex A)** to assist this process. The inspection form included a section on towing gear, but this had not been completed.

1.7.4 Introduction of *Svitzer Mercurius* into the Svitzer fleet

In October 2019, preparations for *Svitzer Mercurius*'s change of ownership began. In November 2019, simulator trials and a new escort towline were ordered. During November and December 2019, members of Svitzer's operational and technical management teams and tug crew, including *Svitzer Alma*'s master, visited *Mercurius* several times in the Netherlands. Svitzer staff were familiar with *Mercurius*, having previously worked with Iskes under towage agreements.

The tug's transfer from the Netherlands to Southampton involved various managerial staff, who had to work around a couple of vacant posts that had arisen. Commercial sensitivities precluded the wider dissemination across the company of the decision to purchase *Mercurius* and when the transfer would occur.

As part of the transfer, and to enable *Svitzer Mercurius* to immediately participate in Southampton harbour towage operations, Iskes was contracted to provide a full-time crew for a minimum of 90 days. No clear timeframes had been set; however, the plan was to bring the tug into service using the Dutch crew who, once familiar with operating the vessel in Southampton, would begin training Svitzer's local masters and crew. This also allowed time for Svitzer to select the tug's crew and have everyone in place by the end of January 2020.

Due to the short timeframe between the decision to purchase the vessel and the commitment to use the tug in Southampton by the beginning of January 2020, Svitzer management decided to progressively transfer the vessel to the Svitzer HMS after it entered operation. Information about the tug transfer process and induction training of the Dutch and Svitzer crews was exchanged via email. The Dutch crew had no access to the Svitzer email account before the accident and were not kept informed of the process.

1.7.5 Application of the International Safety Management Code

Svitzer voluntarily undertook to comply with the requirements set out in the International Safety Management Code (ISM Code) and its compliance was verified by the Maritime and Coastguard Agency (MCA). Paragraph 1.2.2.2 of the ISM Code stated that:

> *Safety management objectives of the Company should… establish appropriate safeguards...*[sic]

The International Association of Classification Societies (IACS)[7] referred to risk assessment within the context of the ISM Code:

It is important to recognize that the company is responsible for identifying the risks associated with its particular ships, operations and trade. It is no longer sufficient to rely on compliance with generic statutory and class requirements, and with general industry guidance. These should now be seen as a starting point for ensuring the safe operation of the ship. [sic]

Svitzer's risk assessments identified a towline failure as a hazard, and recognised that crew could be struck and severely injured or killed by a recoiling rope. Consequently, the HMS's *Towlines – Mooring lines – Details and Hazards* procedure referred to the risk of injury and required that:

…all crew must keep clear of recoil areas when ropes are under load and the dangers of recoil must be considered during job safety analysis and toolbox meetings.

The risk assessments did not include the likelihood and potential consequences associated with a recoiling towline striking a wheelhouse window. Svitzer's accident and incident records, which dated back to 2014, contained no reports of recoiling ropes breaking or striking wheelhouse windows.

During its brief operational phase in Southampton, up to and including the incident, *Svitzer Mercurius* was being operated under its previous owner's safety management system and it had not been certified by the MCA as compliant with the ISM Code.

1.8 LANKHORST ROPES

Lankhorst Ropes provided specific guidance on rope selection, the types of ropes and materials suitable for tug towline assemblies, and their through-life service. The guidance for STRONGLINE™ ropes included:

Lankhorst's high strength STRONGLINE™ rope offers high abrasion resistance and easy handling through its parallel core and braided protective cover [jacket] *design. As well as ensuring long service life the cover also provides protection to crew from snap back. STRONGLINE™'s highly visible orange markings also help to indicate twisting which may shorten the service life of the rope.* [sic]

The guidance for tugs also included several suggested configurations for an 80t bollard pull. This included: an 80mm diameter, 100m long STRONGLINE™ main line connected to either a 38mm (double) or 48mm (single) diameter 20m long Lanko®Force Dyneema® pennant, with the elongation of the STRONGLINE™ providing shock absorption. There was no suggested option for a towline assembly that used a STRONGLINE™ for both the main line and the pennant.

A further Lankhorst publication, *Tug & Towing*, provided similar information for tug operators and included a residual strength test diagram that indicated the strength degradation of a used tow rope and the point at which it should be discarded; approximately 50-60% of the MBL **(Figure 14)**. No specific guidance was provided on pennant inspection and replacement.

[7] IACS Recommendation No.127, June 2012, A Guide to Risk Assessment in Ship Operations.

Image courtesy of Lankhorst Ropes, Tug & Towing brochure

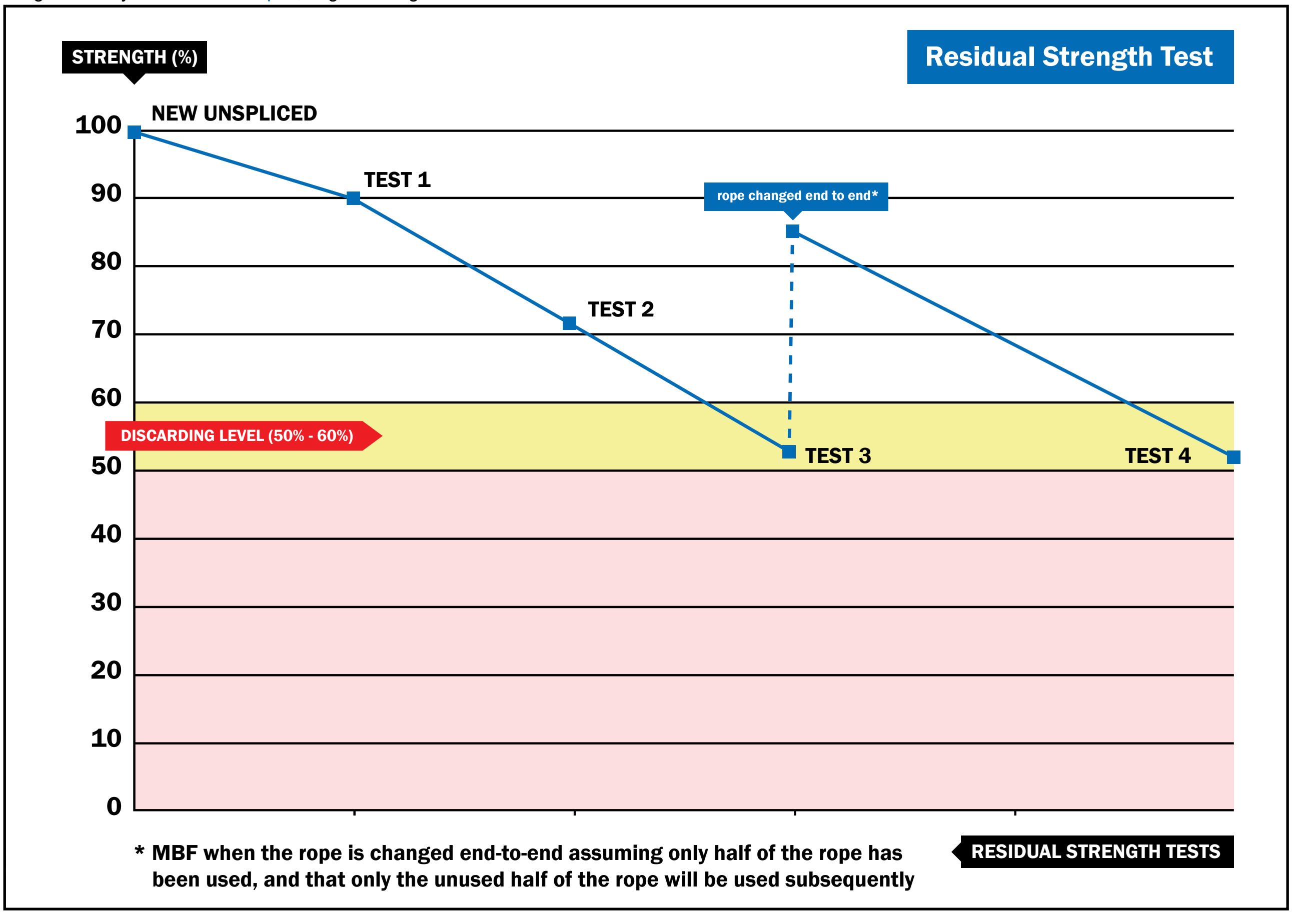


Figure 14: Lankhorst Ropes Residual Strength Test diagram

1.9 TOWLINE MANAGEMENT

1.9.1 Best practice guidance

In its *Mooring Equipment Guidelines Fourth Edition* (MEG4), the Oil Companies International Marine Forum (OCIMF)[8] explained that a comprehensive line management plan was essential to ensure mooring ropes were fit for purpose. This was enabled through holding appropriate information on the rope's material and construction, its testing methods and results, operational limitations, maintenance and inspection and suitable discard criteria. Many of these principles were equally applicable to towlines.

Lankhorst Ropes' *Mooring Rope Manual* highlighted key MEG4 elements for its customers, including rope characteristics, selection, line performance factors, and inspection and discard criteria. It also contained examples of rope inspection reports and a line management plan.

In the snapback section of its mooring rope manual, Lankhorst Ropes reminded its customers to be aware of the risks of snapback and warned that:

> *All persons in the path of the rope or in the wider snap-back danger zone are at risk of serious injury or death. They won't react in time to avoid the impact of snap-back…*[sic]

8 The OCIMF is a voluntary organisation of oil companies having an interest in the shipment and terminalling of crude oil and oil products and utilises the accumulated knowledge of its broad-based industry members.

Concerning rope overload, it advised:

The Working Load Limit (WLL) is the maximum load that a mooring line should be subjected to in operational service. If the maximum load exceeds the WLL, for synthetic ropes this is 50% of the rope ship design MBL, we refer to this as an overload. Overloading a rope can cause significant loss of strength and reduce service life. It can be difficult to determine if there's been an overload. Next to visual inspection, checking the log book (history of the rope) will help.

And, for repairing a damaged jacket, it stated:

When the rope jacket is damaged, we recommend inspection of the inner strength member. If the inner strength member is damaged, then it may be necessary to downgrade the rope. The cause of the damage should be determined and, if possible, removed. Depending on the extent of the damage, either a small repair or an extensive repair is recommended.

Iskes did not have a towline management plan and made decisions based purely on visual inspections. The main towlines were typically turned end-for-end every two and a half years. The starboard towline was supplied to *Mercurius* on 23 May 2019 and installed on 17 August 2019. Throughout its life with Iskes in the Netherlands, the towline was used for 540 towage jobs.

1.9.2 Pennant history, inspection and repair

Svitzer Mercurius's failed pennant had been delivered to Iskes on 22 February 2018 and was attached to the starboard towline assembly on 25 March 2019. On 21 September 2019, following a suspected overload damage, the pennant was turned end-for-end.

Throughout its use by Iskes in the Netherlands, the pennant was used for 769 jobs, commensurate with the work the tug was designed for, and with varying loads and durations, including escort, port, and terminal operations in conjunction with a variety of vessel types.

The pennants were visually inspected before every job and monthly in accordance with the tug's planned maintenance system (PMS). The inspections could be carried out by the master, mate or AB; most were completed by the master. Any damage found on the jacket was repaired by seizing[9] it **(Figure 15)**. Damage to the core was not easily identified but, when found, the pennant was discarded and replaced with a spare kept on board and from ashore. The last recorded inspection on the starboard pennant was on 15 November 2019; the associated remark column in the PMS stated, *done*. There were no indications that either the main towlines or pennants had undergone residual strength testing to help determine when they should be discarded. Before the sale of *Mercurius*, no damage to the core of the starboard pennant had been recorded.

During his visit to *Mercurius* in the Netherlands *Svitzer Alma*'s master inspected the towline assemblies to determine their lengths and type. No faults or damage to the towlines and pennants were recorded. Neither the Iskes nor Svitzer master had undertaken any rope manufacturer's towline inspection or maintenance training.

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[9] Using twine to bind ropes together or repair rope damage.

Figure 15: Towline pennant seizing repair

1.9.3 Svitzer towline and pennant policies

Svitzer's towline strength policy for harbour duties required the MBL to be at least twice the tug's maximum achievable towline force[10] or design bollard pull. There was no stipulation for the type of towing gear used as this was specific to the operation involved and type of tug used. STRONGLINE™ was used in the Svitzer fleet but not as a pennant. Pennants were generally selected according to whether the product:

- could be readily and easily replaced if damaged
- was light and manageable on deck
- provided a degree of bend, chafe and twist protection.

Svitzer also had policies on the inspection and replacement of main towlines and pennants on board its tugs. These included its HMS procedure 06-002, *Inspection of Towing Equipment*. The purpose of the procedure was to provide towing equipment inspection and maintenance guidance to ensure operational readiness. It stated that the master was both accountable and responsible for ensuring that towing equipment was inspected and in good condition.

[10] A tug undertaking an indirect towage can generate up to twice its rated bollard pull.

Svitzer's HMS procedure 06-005, T*owlines - Mooring Lines - Details and Hazards*, dated 9 September 2019, explained that:

> *Towing pennants are relatively short lengths of wire rope or synthetic line… The primary purpose of the pennant is to avoid damage to the main towline… In the event of such damage, the pennant can be readily replaced.*
>
> *During towing operations dynamic conditions may result in loads that exceed the strength of the towline and cause it to part. It is recommended that the sacrificial tail (pennant or grommet) or soft joining shackles has a lower design MBL than the main line.*

And,

> *Each port or operation should develop and maintain standard rope configuration guidelines regarding types, construction, size, weight, elasticity and SWL/WLL for all major lines in use such as: Grommet/Pennant, Stretchers, Main towlines and mooring lines.* [sic]

For Southampton, the standard towline assembly used on board Svitzer tugs was:

- Main towline: STRONGLINE™ 130m long, 80mm diameter, MBL 193t
- Towline pennant: Saturn-12 (Dyneema® jacket) 20m long, 52mm diameter, MBL 207t, manufactured by Samson Rope Technologies.

On discard criteria, procedure 06-005 stated that:

> *Synthetic towlines should be monitored for number of jobs and use, with trends used to determine replacement policy appropriate to the port/operation with the line being end-for-ended roughly half life, where appropriate. When synthetic lines part, they should be sent ashore for load testing, if failure occurs at less than 70% of rated WLL, then discard criteria should be reviewed.*

Svitzer applied a 'master's discretion' or 'local operations' policy for towline replacement and discard, which was dependent on inspection results. However, the overarching requirement for Southampton operations was that main towlines be end-for-ended after 1000 jobs and replaced after 2000 jobs. Pennants were to be replaced after 1000 jobs and not end-for-ended. In addition, the tug PMS included weekly and monthly visual inspections. For snapback, the procedures included tug foredeck danger zone illustrations **(Figure 16)**.

1.10 POST-ACCIDENT INSPECTIONS AND TESTING

1.10.1 Towline pennant

Both sections of the failed pennant were recovered and inspected after the accident. The section connected to the mainline was about 15m long and the other section, which had been connected to the container ship, was about 5m long. The failure occurred 1.1m outboard of *CMA CGM Marco Polo*'s aft mooring deck centreline Panama fairlead.

Image courtesy of Svitzer (UK)

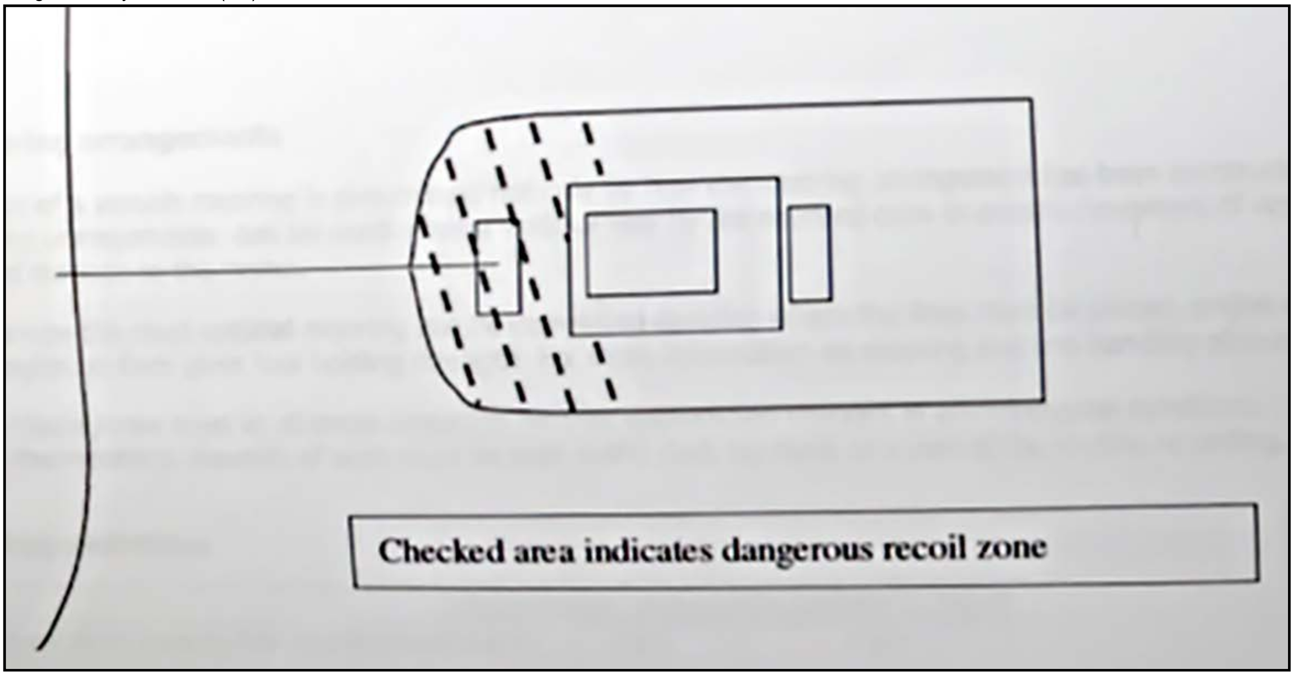

Figure 16: Svitzer tug towline snapback zone illustration

Svitzer contracted Tension Technology International (TTI) to examine the failed pennant and carry out residual strength testing. TTI's examination and testing process included:

- visual inspection of the rope jacket
- removal of sections of the rope jacket to expose the load-bearing core
- examination of the load-bearing yarns at the point of failure and at other sections along the pennant length
- yarn residual strength testing
- full load break testing of the respliced pennant.

TTI identified two main areas of damage to the pennant's load-bearing core; one at the failure point and one at about 5m from the tug end of the pennant. The damage included strand fusion under the rope's tight jacket. It was assumed that the pennant had been end-for-ended after damage to the jacket was sustained.

The TTI report explained that tight jackets can cause the inner core structure to be restricted from movement during tensile loading, which in the event of sudden tensile load reduction after shock loading can cause uneven loading in the strands and yarns. Short wavelength kinks (also known as Z-kinks) associated with axial compression fatigue[11] were found in the yarns **(Figure 17)**. Polyester is known to have excellent resistance to this type of fatigue; however, in extreme cases, axial compression fatigue can cause yarns to fail in a similar manner to being cut by a knife.

[11] Axial compression fatigue is characterised by sharp cooperative kinking of yarns. Repeated flexing of the line leads to flex fatigue breakage of fibres.

Image courtesy of TTI

Figure 17: Failed towline pennant yarn kinks

TTI pointed out that, in terms of pennant versus main line strength, LR guidance[12] for a tug bollard pull of 83t gave a minimum design load factor of 2.15. This meant that the MBL should be 178.45t during the towline service lifetime. Given the towline's MBL of 229.5t, this equated to 78% residual strength for the pennant. DNV guidance used a similar safety factor for the MBLs of towlines and connections. During testing, the respliced pennant broke at a load of 119t (1167kN).

TTI's report stated:

> *Given that these minimum factors should be at the end of the rope's service life and that the towline is the primary tool of a tug, a robust rope management system encompassing inspection, maintenance, loading history and retirement, and residual strength testing should (if not already in place) be implemented.* [sic]

The TTI report concluded that:

- *The inspection and testing of the pennant has indicated that the rope had suffered significant strength loss through both mechanical damage to the rope and through probable high tensile/shock loads.*

- *The load during the failure is likely to have been at most equivalent to the load achieved during the respliced pennant test of 1167kN (119 tonnes) representing 51.8% residual strength.*

[12] Guidance Note for the Classification, Safe Design, Construction and Operation of Tugs. Published by Lloyd's Register, August 2018.

- *Given the limited usage of the pennant in Southampton it is likely that it had suffered significant damage during previous towage operations and that the line has subsequently failed due to this historic damage.*

- *This type of damage is difficult to detect and may well have not been picked up by the crew in routine inspection.*

The report recommended that:

- *If not already in place, a line management plan (LMP) should be implemented to manage the maintenance, inspection and retirement of the pennant and indeed all towlines used during their service life. While primarily designed to manage ships' mooring lines, OCIMF's Mooring Equipment Guidelines (MEG4) gives advice on what should be included in this type of plan.*

- *Consideration should be given to carrying out further residual strength testing and condition monitoring to build up retirement criteria.*

- *Further training of crews on rope maintenance and inspection should be considered.*

1.10.2 Towing winch

Inspections of the towing winch conducted after the accident found no faults in its hydraulic systems and established that the band brake friction linings were within the manufacturer's recommended thickness limits. The brake pretensioner was within its specified limits.

Visual inspection of the starboard drum band brake arrangement identified scoring and debris on the surface of the drum's stainless steel brake rim **(Figure 18)**. On examination, Svitzer and the winch manufacturer suggested that the debris was either a combination of brake dust and water or brake dust and/or grease. No contamination was found on the surface of the port drum's band brake rim.

1.11 WHEELHOUSE WINDOW STANDARDS

1.11.1 Flag state guidance

The MCA outlined the survey standards for hull construction, machinery, electrical and control systems, to which vessels were expected to be built and maintained, in its Marine Guidance Note (MGN) 322 (M+F) *Ship Survey Standards*. The MGN was published in July 2006 and required wheelhouse and deckhouse windows to be toughened safety glass.

Figure 18: Starboard forward winch brake contamination

1.11.2 International Association of Classification Societies and rules for ship windows

IACS Unified Requirements (UR) were the minimum class requirements shared among all IACS member societies. Each member society remained free to set more stringent requirements. The existence of a UR did not oblige a member society to issue respective rules if it chose not to have rules for the type of ship or marine structure concerned.

UR S requirements related to the strength of ships and UR S3, Rev.1 *Strength of End Bulkheads of Superstructures and Deckhouses* explained that:

> *These requirements define minimum scantlings based upon local lateral loads and it may be required that they be increased in individual cases.*

Ship builders generally comply with classification society requirements when they design and build a vessel. Glass fittings on board a vessel can conform to a variety of standards, which are developed through a range of tests to determine strength capabilities. The requirements are commonly based on withstanding water pressure. Toughened safety glass is the commonly accepted type used for bridge/wheelhouse/deckhouse windows, with reference to the appropriate international standards.

Laminated safety glass provides extra strength and can withstand solid body impact and remain in one piece after breakage occurs. Structural safety glass, such as that used for stairwells and balustrades on large yachts and passenger vessels, must be laminated.

1.11.3 Ship window glass standards

The standard for a ship's ordinary rectangular windows was toughened safety glass, which met the requirements of:

- BS ISO 614:2012 Ships and marine technology – *Toughened safety glass panes for rectangular windows and side scuttles -- Punch method of non-destructive strength testing*;
- BS ISO 21005:2018 Ships and marine technology – *Thermally toughened safety glass panes for windows and side scuttles*; and
- BS ISO 3903:2012 Ships and marine technology – *Ships' ordinary rectangular windows*.

These windows could be either heavy-type rectangular windows (Type E[13]) or light-type rectangular windows (Type F[14]).

BS ISO 614:2012 provided a method for quality assurance through non-destructive testing to verify the required glass surface tension. BS ISO 21005:2018 specified that the material used in the windows should be thermally toughened safety glass and tested in accordance with BS ISO 614:2012. BS ISO 3903:2012 detailed the classification, dimensions, materials, fastening, tests, marking and designation of ships' rectangular windows.

Damen's arrangement of windows and portholes for its 3212 tug referenced BS ISO 21005:2004, which was a previous version of BS ISO 21005:2018 and specified thermally hardened glass with a minimum flexural strength of 180N/mm², as per BS ISO 3903:2012 for Type E windows.

Mercurius was built to BV Class rules, which included the wheelhouse windows. Although the change of Class to DNV, via LR, did not assume a transfer of applicable Class rules, DNV's type approval document CP-0094 *Side scuttles and windows* also referred to the same international standards.

On tug wheelhouse windows, DNV *Rules for Classification*, July 2019 edition, section 5.2.2 *Side scuttles and windows*, stated that:

> *For windows in a wheelhouse in the second tier, Type E windows as per ISO 3903 are required when direct access to spaces below is provided. Glass thicknesses for intermediate sizes, not covered by ISO 3903, shall be determined using ISO 21005.*

DNV *Rules for Classification* also included references to laminated glass as an alternative standard for specific uses in opening and closing devices and glass balustrades.

[13] Subjected to a mechanical strength test of 75kPa.

[14] Subjected to a mechanical strength test of 35kPa.

1.11.4 Damen safety glass

Non-laminated toughened safety glass was designed to shatter into small fragments on breaking; a feature intended to minimise injury severity. In 2016, following increased reports of wheelhouse glass failures attributed to recoiling towline impact and the potential for crew injuries, specifically for those on its ASD tugs with forward towing winches, Damen decided to research safety glass options that exceeded the standards set by Class. Following its research and in-house testing programme, Damen decided to develop its own high-impact resistance glazing that met recognised security glass standards and incorporated a polyvinyl butyral[15] laminate[16] **(Figure 19)**. The term security is applied to safety glass that can withstand a variety of deliberate manual, ballistic or blast attacks. This is usually a combination of toughened and laminated glass panes.

Image courtesy of Damen Shipyards Gorinchem (https://www.damen.com/en)

Figure 19: Damen safety glass

[15] Polyvinyl butyral is a resin mostly used for applications that require strong binding, optical clarity, adhesion to many surfaces, toughness and flexibility. Its major application is in laminated vehicle windscreens.

[16] There are different types of polyvinyl butyral laminate (also known as foil) providing different levels of shear deformation.

The British Standards Institute's BS EN 356:2000: *Glass in building–Security glazing–Testing and classification of resistance against manual attack* included a hard body drop test and an axe test. The drop test involved dropping a 4.11kg steel sphere (100mm diameter) several times from different heights to ascertain glass impact resistance. The resultant classification levels were:

- P1A: 3 times from 1.5m
- P2A: 3 times from 3m
- P3A: 3 times from 6m (the standard met by Damen safety glass*)*
- P4A: 3 times from 9m
- P5A: 9 times from 9m

Damen recognised that the amount of energy that can be released when a towline snaps back was hard to determine due to the numerous variables involved, including the type of rope, direction of forces, vessel dynamics, and bollard pull. The use of a recognised standard provided Damen with a level of known impact protection with, crucially, the polyvinyl butyral providing protection from flying glass to the crew inside the wheelhouse.

Damen's safety glass meets both the BS ISO 614:2012 and EN 356:2000 P3A standards. Since 2018, with the exception of wheelhouse door windows, Damen has fitted its safety glass to the wheelhouses of all its new build tugs.

1.11.5 Laminated glass and safety window film

The use of laminated glass should consider the following:

- The glass is bonded to the frame (to prevent the whole glass pane detaching on impact), the same way that vehicle windscreens were attached, and the frame strengthened for the same impact load.
- The inner insulating pane should be laminated or omitted.
- The effect of the additional weight of the glass on the vessel's stability.

Car windscreens are chemically strengthened and laminated. Chemically toughened glass has a much higher residual load-bearing capacity due to its breaking behaviour, and resists the development of multiple cracks that can affect visibility.

At the time of the accident, laminated glass safety window films were available that could be applied retrospectively to window glass to hold the glass together if a window shattered. However, these products provided varying degrees of protection, from simple safety glass resistance up to blast resistance, and no glass film standard existed for marine use.

1.12 THE CODE OF SAFE WORKING PRACTICES FOR MERCHANT SEAFARERS

The MCA's Code of Safe Working Practices for Merchant Seafarers (COSWP) provided guidance for seafarers and vessel operators to meet statutory safety obligations and apply best practice. Section 26, *Anchoring, mooring and towing operations* explained the specific risks and dangers associated with towing operations and the importance of identifying and applying appropriate safety control measures based on vessel and task-specific risk assessment. It emphasised the importance of considering the consequences of failure of any equipment, with particular attention to potential risk of snapback. To reduce the likelihood of failure, COSWP stated that:

> *Equipment used for towing should be adequately maintained and inspected before use because during towing operations, excessive loads may be applied to ropes, wires, fairleads, bitts and connections. If there are suspicions over the quality of the towline, it should be rejected and an alternative line used.*

To reduce the consequence of any failure, it advised that:

> *Once the tow is connected, seafarers should keep clear of the operational area. If anyone is required to remain in this area or to attend to towing gear during the towing operation, they should take extreme care to keep clear of bights of wire or rope and the snap-back zone at all times.* [sic]

COSWP made no reference to the risk to tug boat crew in the event of a wheelhouse window being struck by a recoiling towline.

1.13 SIMILAR INCIDENTS

1.13.1 Svitzer towline failures

Between 2017 and 2019, Svitzer recorded 87 towline failures on board its European tug fleet. During this period, its tugs had completed approximately 160,000 jobs; this equated to a failure about once every 2000 jobs (0.05% failure rate). Within Svitzer's Europe area of operations, 23 STRONGLINE™ rope failures occurred. On average, its STRONGLINE™ ropes failed after 777 tow jobs.

1.13.2 *SD Shark* – parted towline and snapback

On 12 February 2018, in Southampton, *SD Shark* suffered substantial damage forward of its superstructure when its towline parted and snapped back inboard. The towing winch had rendered, causing the towline to snatch while applying full weight to the stern of a container vessel. There were no injuries.

1.13.3 *Smit Elbe* – parted towline and snapback

On 14 January 2016, *Smit Elbe*'s towline parted while assisting a ship in the port of Rotterdam. The line snapped back and broke the tug's wheelhouse side windows, injuring the master and a pilot who was on the deck.

1.13.4 *Bülk* – parted towline and snapback

In September 2012, *Bülk*'s towline parted while the tug was assisting a ship in the Holtenau lock, on the Kiel Canal. When the line broke it snapped back and smashed the wheelhouse window. The tug's master suffered a serious arm injury and was taken to hospital for treatment.

1.13.5 Road vehicle windscreen impact

In October 2020, a car was parked on a quay in a UK port as the driver waited for a container vessel to berth. One of the vessel's mooring lines parted during the berthing operation and snapped back along the quay. The mooring line hit the parked car's windscreen while the driver was sat in the car **(Figure 20)**. The windscreen, which was laminated glass, held together, resulting in the driver sustaining no injuries.

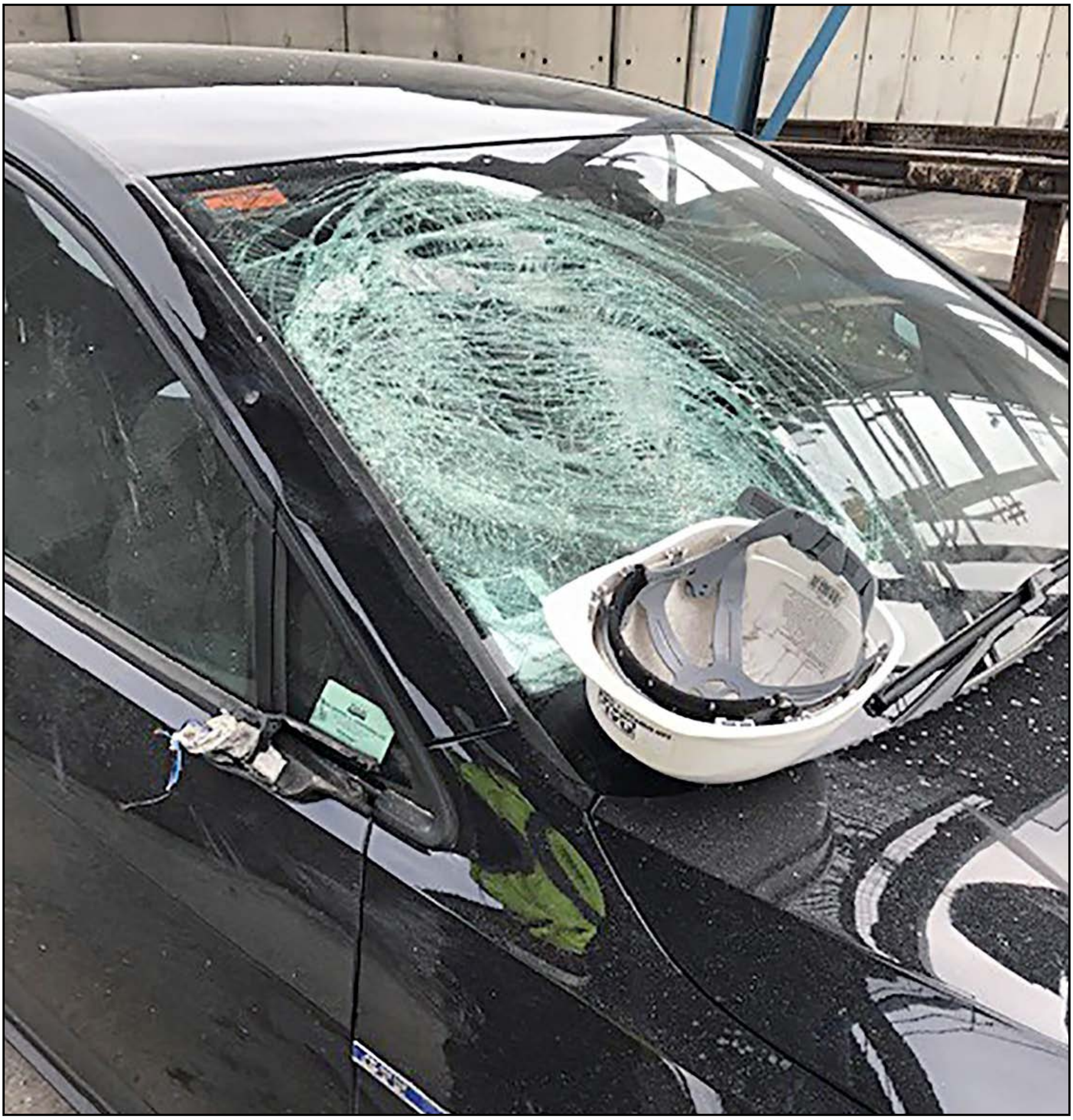

Figure 20: Vehicle laminated windscreen damage

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 OVERVIEW

Svitzer Mercurius was assisting the berthing of the ultra-large container ship *CMA CGM Marco Polo* when its towline pennant parted and snapped back towards its deck. Five tug crew members were struck by fragments of glass and suffered multiple laceration injuries when the recoiling towline hit and shattered one of the tug's wheelhouse windows.

In this section of the report the cause of the towline pennant failure and the underlying factors that contributed to it will be analysed. The reasons why the wheelhouse window shattered and the crew were struck by glass fragments will also be discussed.

2.3 SLIPPAGE OF THE TOWING WINCH BAND BRAKE AND TOWLINE PENNANT FAILURE

Svitzer Mercurius was acting as the stern tug and applying full astern thrust when its towline pennant parted. The hydraulic band brake holding the tug's towline winch drum, which was set to its full 200t holding capacity, slipped twice immediately prior to the pennant failure. On each occasion, the brake quickly regained its grip and the towline assembly snapped tight as the tug driver continued to apply full astern thrust. The specified MBL (229.5t) of the towline pennant was three times greater than *Svitzer Mercurius*'s maximum astern bollard pull (76t).

As *Svitzer Mercurius* was engaged in a direct towage operation, and its astern thrust was increased gradually at the request of the assisted vessel's pilot, the winch drum must have slipped at a load well below its design holding capacity. After the accident, the winch hydraulic system was found to be functioning correctly, the brake friction linings were within the manufacturer's recommended thickness and the brake pretensioner was within its specified limits. However, visual inspection of the winch drum brake surfaces identified scoring and the presence of debris on the starboard drum's brake rim. The debris, which was thought to be a combination of brake dust and water or grease, would have acted as a lubricant and reduced the holding capacity of the brake.

Examinations of the pennant identified damage in several locations along its length that could only have been caused before the tug's arrival in Southampton. TTI's report concluded that the load at failure was likely to have been equal to or less than the load recorded (119t) during its destructive tensile load test, which was about 52% of its original MBL.

It is possible that the pennant simply failed at a load equal to the tug's maximum bollard pull. However, it is much more likely that it parted when the towing assembly was exposed to higher levels of shock loading following the brake slippage incidents. The strength of the entire towing assembly, including the recovered sections of pennant might have been reduced due to exposure to the shock loading, and therefore the tensile strength of the pennant could have been a little higher than 119t before its failure. Regardless, it was clear that the poor condition of the towline pennant and the debris on the towing winch band brake were the two primary factors that contributed to this accident.

2.4 TOWLINE MANAGEMENT

The starboard towline pennant was installed on the tug's starboard winch on 25 March 2019 and was turned end-for-end on 21 September 2019. It had been used to carry out a reported 769 jobs before arrival in Southampton, which was less than the 1000 job replacement policy given as a rough guide by Svitzer for its Saturn-12 (Dyneema®) pennants. However, Saturn-12 rope uses HMPE[17]/Dyneema® material that has a higher fatigue resistance and better cut and abrasion resistance compared to STRONGLINE™.

The pennant had suffered mechanical damage to its outer jacket that would have been visually apparent and had been repaired. TTI's examination and test report identified two main areas of damage to the rope's load-bearing core that would not have been visually apparent and would have been difficult for the tug's crew to detect. The types of damage found included core strand fusion and axial compression fatigue, both of which were attributed to previous high and/or shock loading exposure.

Although no towline load history information was available for *Mercurius*, both direct and indirect towage were known to have taken place during the vessel's time in the Netherlands, potentially with loads of around 160t (twice the bollard pull). These loads exceeded the rope manufacturer's guidance and Svitzer's policy regarding a WLL of 50% of the MBL (115t) and therefore should have been recorded as overload events. Given the extent of the repairs carried out to the pennant and the knowledge that it had been exposed to shock loading, a robust LMP might have allowed Iskes to identify that the rope had reached the end of its safe operating limits, and led to a decision to discard it rather than end-for-end it.

2.5 INSPECTION, TESTING AND DISCARD CRITERIA

Svitzer had a towline assembly management system in place that included guidance on towing assembly inspections, testing and discard criteria. However, *Svitzer Mercurius* was being crewed by Dutch agency staff that had worked on the tug under its previous owners in the Netherlands. Although its towline assemblies had been inspected by Svitzer representatives before the tug arrived in the UK, Svitzer's management team in Southampton had little or no understanding of their history or condition.

While under the control of Iskes the crew conducted towline condition assessments and carried out repairs as necessary, primarily to the outer jacket as damage to the load-bearing core was difficult to identify under the tightly bound jacket. The range of repairs, which included fixing external mechanical damage and some excessive tension/shock loading, indicated that the starboard pennant had been worked hard. The external damage appeared to be the reason the pennant was end-for-ended in September 2019.

[17] High modulus polyethylene.

Without a detailed manufacturer's inspection or a load test, it would have been impossible to determine the extent of the damage to the load-bearing core and consequent reduction in strength. Given its short length, the 20m pennant, which acted as the wear element in the towline assembly, should have been replaced as it would have been impractical to load test a section of it. Furthermore, compared with a long mooring line, which may have a considerable portion of unused length remaining on the winch drum, end-for-ending a short pennant probably was of little value and could have provided a false sense of security.

Pennants are a sacrificial element of the towing arrangement; they should be frequently replaced, certainly after damage or high load occurrences, because they cannot always be suitably examined or load tested. This accident has highlighted the potential consequences of sudden failure under load, demonstrating the risk to crew safety of not having a robust policy for replacing pennants.

2.6 INDUCTION OF VESSEL AND CREW

2.6.1 Pre-purchase inspections

Svitzer had planned to bring *Svitzer Mercurius* into operation by 1 January 2020. To achieve this, Svitzer's management team arranged for several pre-purchase and delivery inspections to be carried out by its operational staff as well as a pre-purchase survey by an independent marine consultant. No deficiencies or concerns relating to the tug's towline assemblies or winch brakes were raised during this process.

The independent pre-purchase survey report contained incorrect information about the tug's towline assemblies and made no comment about their condition. The towing gear section of Svitzer's internal vessel inspection report form **(Annex A)** made no observations about the towline assemblies. This lack of detailed technical oversight was significant given the pennant's condition and that the towline assembly differed from Svitzer's standard arrangement and was not listed as a recognised arrangement by the rope manufacturer.

Mercurius was seen as a working tug that had performed successfully under its previous ownership. Svitzer had a working knowledge of the tug and the Iskes towing arrangement was therefore assumed to be suitable for similar operations in Southampton. This view failed to consider the way the Dutch crew operated the vessel, their towline inspection and maintenance processes, or the pennant's actual condition. There was a clear assumption that, because the vessel was well maintained, this would also extend to its towing equipment.

Reportedly, *Mercurius*'s starboard pennant had been used in 769 tow jobs before the tug started work in Southampton and Svitzer's post-accident data review identified that the STRONGLINE™ ropes used on its European fleet had an average life expectancy of 777 tow jobs, based on 54 recorded towline and pennant failures over 3 years. This reinforces the conclusion that the pennant was operating at the end of its useful life and should have been renewed as soon as the vessel arrived in Southampton.

A thorough documented inspection process for *Mercurius*'s induction into the Svitzer fleet could have identified and rectified the suitability of the towline arrangement and condition. It was apparent that the required comprehensive inspection process was curtailed, in part, due to the commercial imperative of bringing the vessel to Southampton.

2.6.2 Winch condition

Following the accident, the winch hydraulic system was found to be functioning correctly, the brake friction linings were within the manufacturer's recommended thickness and the brake pretensioner was within its specified limits. However, visual inspection of the starboard winch brake identified scoring and a form of lubricant on the brake surface that was either a combination of brake dust and water, or grease; this would have reduced its frictional force and lowered its holding capacity. The fact that the winch was observed to slip twice when the brake was set to 100% (200t brake hold capacity), with a considerably reduced pennant strength, clearly indicates that the brake was not performing to its full capacity. Consequently, in slipping and then gripping, it allowed the line to surge and cause high shock loads. These peak loads were sufficiently high to breach the remaining strength of the pennant, predicted as 52% MBL.

Regular maintenance was undertaken while operating as *Mercurius*; however, it is unclear what inspection and maintenance the winches received once *Svitzer Mercurius* arrived in Southampton. Although the winch operations manual specified regular greasing of the winches, it also highlighted the need to ensure the braking surfaces were not contaminated by oils and greases. The winch had not been effectively maintained in this instance, including washing it down after the voyage from IJmuiden, which led to the winch brake slipping at almost half its intended holding capacity.

2.6.3 Familiarisation and application of the safety management system

Svitzer did not closely follow the applicable HMS requirements for introducing a new vessel into its fleet. Indeed, email trails indicated a more ad hoc process, with general bullet point lists of things to do and little reference to the HMS.

It was unfortunate that vacancies within the Svitzer management team involved in the vessel transfer meant that responsibility for the process of receiving the new tug was vague. As a result, potential gaps in the transfer's oversight were neither identified nor resolved and further exposed the problem of not maintaining a formal documented, procedure-driven, action plan whereby missing inspections, instructions, training, and equipment upgrades, etc., could be readily identified and dealt with.

Svitzer and Iskes had an agreement that a Southampton Svitzer master would initially accompany the Dutch crew and provide knowledge that would enable the vessel's immediate operation. Once both masters were comfortable with the working arrangement, they would begin building competence to enable a successful handover. However, until the Svitzer crews were able to train the Dutch on the Svitzer HMS, the vessel would inevitably operate under the Iskes SMS, which the Dutch crew were familiar with, even though this was in direct conflict with the new operation's HMS requirements. The Iskes SMS required new joiners to complete a familiarisation form, although there is no record of one and neither was the similar HMS form started for the Dutch crew. This was exacerbated because *Svitzer Mercurius* was not connected to the Svitzer email account; therefore, key planning information necessary for the vessel transfer and operation, and the respective Dutch/Svitzer crew training, was not sufficiently communicated to those on board. Consequently, the lack of a clearly understood action plan for the crew meant neither SMS was followed and the transfer was insufficiently formalised.

Svitzer's towing equipment guidance (HMS 06-002) stated that the master was both accountable and responsible for ensuring that the towing equipment was inspected and in good condition. Although *Svitzer Alma*'s master was on board *Svitzer Mercurius* on 22 December 2019, the Dutch master remained in command during the familiarisation period. As Svitzer crew were intended to train the Dutch in the use of the HMS, the condition of the starboard winch brake and the starboard pennant indicated that this aspect of training had not occurred.

The expectation that the Dutch crew would become conversant across the range of HMS procedures and guidance in such a short period of time after *Svitzer Mercurius* arrived in Southampton was optimistic. The lack of clear direction as to the practical integration of the Dutch crew, and the vessel's operation and maintenance, opened up the possibility of divergence from what Svitzer management expected or assumed would happen. *Svitzer Mercurius*'s master was well aware of *Svitzer Alma*'s master's experience and local knowledge and, without clear instructions from ashore, it was perhaps understandable that he allowed him to take the helm. However, given acting as stern tug to *CMA CGM Marco Polo* was the first job with the towline and pennant under load in Southampton, if *Svitzer Mercurius*'s master had remained at the helm it would have maximised the opportunity to react to unexpected events.

2.7 SNAPBACK

Snapback is a well-known hazard to personnel when towlines and mooring lines part and ultimately led to the crew's injuries after the wheelhouse windows failed on impact with the recoiling towline.

The STRONGLINE™ polyester rope towline had elongation properties of around 4.5% at 50% MBL when broken in. For the 40m of towline payed out when *Svitzer Mercurius* was connected to the stern of *CMA CGM Marco Polo*, and with about 80t bollard pull (giving approximately 35% of line MBL and 2.5% elongation), this could equate to about 1m line elongation. This elongation provided the stored energy basis for snapback when the line was suddenly released after a failure. Snapback speed can be anything up to 380 miles per hour and those in the vicinity have little forewarning to react. Despite line failure under load and snapback causing many crew fatalities and injuries, the risk is often poorly recognised on board.

Svitzer Mercurius's pennant and towline were effectively acting as a stretcher, absorbing the dynamic loading but storing it as energy, using the STRONGLINE™ rope's elongation properties. However, the manufacturer did not highlight a STRONGLINE™ towline/pennant combination as an option and a STRONGLINE™ pennant was not part of Svitzer Southampton's standard arrangement. Although the rope manufacturer's guidance stated that the rope jacket provided protection against snapback, this was probably on the proviso that the jacket was in good condition without multiple repairs.

It is apparent that insufficient consideration was given to the lines fitted to *Mercurius* when it changed ownership, including the arrangement as a whole, whether the individual components were suitable for the intended purpose and their fitness for continued use.

2.8 WHEELHOUSE WINDOW FAILURE

2.8.1 Overview

The double-glazed wheelhouse window struck by the recoiling towline was constructed using toughened safety glass. Svitzer had no records of similar wheelhouse window failures; however, the tug builder Damen had been and was concerned about the risk that wheelhouse window failure posed to tugboat crews. Following a programme of in-house research and impact testing, Damen developed its own wheelhouse safety glass, which combined the strength of toughened glass and the additional protections provided by lamination.

Svitzer Mercurius's forward and side-facing sky windows were similar in design to Damen's safety glass, in that the outer pane of the double-glazed panels was laminated. The sky windows were designed to provide the tug master with the optimal view of the assisted vessels' mooring decks and therefore Damen might have assessed they were most susceptible to recoiling towlines. Equally, the sky windows might have been laminated to meet structural safety glass requirements as it might have been considered foreseeable that crew or maintenance contractors might stand on them.

It was fortunate that all the crew in the wheelhouse were wearing either glasses or sunglasses when the window glass shattered. Future similar incidents could easily result in more serious life-threatening or life-changing injuries. It is therefore apparent that the minimum requirements set out for tugs in the wheelhouse strength and design standards need to be reviewed and increased in accordance with the risk, as set out in this report.

2.8.2 Tug wheelhouse window Class standard

At the time of the accident, the main standard commonly required by classification societies and applied to shipboard glass windows was withstanding a hydrostatic pressure head, equating to a 'green seas' loading from waves. The standard intended to provide equivalence to the surrounding wheelhouse structure during expected operational conditions. To determine whether windows met the requirements, tests included applying gradually increasing pressure to the glass surface to emulate increasing water pressure. In the UK, the MCA's MGN 322 (M+F) reinforced this standard.

However, the tests applied for ship wheelhouse window glass standards were not intended to replicate impact loads from solid objects, including high-speed, heavy or point loads. Although toughened safety glass is perceived as safe when broken, due to its ability to shatter into small fragments, when subjected to a high energy impact the resultant fragments can themselves present a significant hazard. The fragments from *Svitzer Mercurius*'s shattered forward window not only injured the crew but also caused minor damage to the entire wheelhouse and cracked two aft-facing windows. This demonstrated the potential for harm following such a heavy impact load. Subsequently, the potential for severe injuries, particularly loss of eyesight, was very apparent.

IACS URS3 requirements reflect a vessel's actual operating conditions, including local lateral loads such as wind and waves, which toughened glass is normally capable of resisting. In general, classification societies view a towline failure as a component failure, due to either maintenance or operational factors, and therefore outside their design rules. However, a failed towline under load, and its associated snapback, is a foreseeable high risk event for a tug. Although the towline recoil is difficult to predict, the possibility of its impact with a wheelhouse window exists. While tug crews can minimise the risk of towline failure, it is impossible to completely eliminate the hazard given aspects that are outside their control; for example, what the towline is secured to and the condition of Panama eyes and fairleads.

The safety benefits of using laminated glass are evident from the ship's mooring line failure impacting a laminated car windscreen **(Figure 20)**. Given the close proximity of tug wheelhouses to the towing winches, and the realistic possibility of towline failures while under high loads, sudden high-speed impact on the wheelhouse windows was predictable. Had *Svitzer Mercurius*'s wheelhouse windows been fitted with laminated glass, it is unlikely the crew would have been injured by flying glass fragments.

It is apparent that there was a lack of a suitable glass standard for tug wheelhouse windows that provided a measurable level of crew safety against the hazard of a recoiling towline. To ensure crew safety inside the wheelhouse, it is important that the glass requirements reflect the operating conditions a tug is likely to experience during its service.

2.8.3 Risk assessment

As tug bollard pull capabilities increased to manage the ever-increasing size of vessels needing tug services, so did the forces on towlines. This occurred without full consideration of the associated risks to crews when lines suddenly fail. Tug crews can be directly in the line of recoil when a towline parts under tension, particularly with forward winch towing arrangements. Although the risk of a towline failure and its subsequent snapback was recognised and understood, Svitzer had not assessed the likelihood and consequence of a recoiling line striking the wheelhouse windows; probably because Svitzer had not recorded such an incident since 2014.

COSWP focused on risk assessment to assist companies in meeting their regulatory requirements. Similar to Svitzer, it referred to mooring deck and winch deck snapback zones, which crew should avoid when lines are under tension. However, it seemed there was an assumption that the recoil from mooring lines or towlines would remain within the boundaries of a mooring/winch deck; this is not the case and it is difficult to predict the recoil direction or distance, particularly where the rope is bent around a deck fitting. A risk assessment needs to consider what range a recoiling line could achieve, beyond just the mooring deck.

Svitzer's towline data showed that failure events were not uncommon across its fleet, although the failure rate was statistically low given the number of tow jobs. Nevertheless, towline failures can occur for a variety of reasons, some of which are outside the control of the tug crews. Svitzer's crews appeared not to have previously suffered injuries after such an event; however, other tug crews were not so fortunate as detailed in the similar accidents section of this report.

In deciding to use laminated glass in their tug wheelhouse window design, Damen had recognised the dangers tug crews face when a towline parts. Furthermore, in using a recognised security glass standard, the additional strength the extra level of safety provided to the crew was measurable. As an alternative to replacing toughened glass with laminated high strength window glass, simpler measures to mitigate against the risk of wheelhouse windows shattering may be appropriate. These measures may include fitting a type approved internal window film to prevent toughened glass fragments becoming projectiles, or some form of external protection to prevent impact with windows.

Whatever mitigation method is considered appropriate, it is clear that tug crews working in wheelhouses, where the possibility of towline failure snapback into wheelhouse windows is foreseeable, are at risk if the windows are not resilient to impact. As per the ISM Code, companies should establish safeguards against all identified risks.

SECTION 3 – CONCLUSIONS

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

1. Not enough consideration was given to the towlines and pennants fitted to *Mercurius* when it changed ownership, including whether the individual components were suitable for the intended purpose and their fitness for continued use. The result was that *Svitzer Mercurius* started operating in Southampton with a starboard winch towline pennant that was no longer fit for purpose due to its reduced residual strength from the shock loading and wear sustained under its previous ownership. [2.3, 2.4, 2.7]

2. Without a detailed inspection by the manufacturer, or a load test, it would have been impossible to determine the extent of the damage to the load-bearing core of the pennant and the consequent reduction in strength. As pennants are not always able to be suitably examined and/or load tested, they should be replaced frequently and certainly after damage or high loads have occurred. [2.5].

3. *Svitzer Mercurius*'s wheelhouse toughened glass windows were unable to withstand the high energy impact load of a towline snapping back and shattered, showering the wheelhouse in glass fragments. More severe injuries to the crew in the wheelhouse were only prevented because they were wearing glasses or sunglasses. [2.8.1]

4. It is apparent that there is a lack of a suitable glass standard for tug wheelhouse windows that provides a measurable level of crew safety against the hazard of a recoiling towline. [2.8.2]

5. Although the risk of a towline failure and its subsequent snapback was recognised and understood, the likelihood and consequence of a recoiling line striking the wheelhouse windows had not been assessed. [2.8.3]

6. The thorough documented inspection process, in accordance with Svitzer's procedures, for the *Mercurius*'s induction into the Svitzer fleet did not occur. As a result, the suitability of the towline arrangement, and condition of the winch brake and pennant, were not identified. [2.6.1]

7. The starboard winch brake was contaminated because it had not been effectively maintained after arrival in Southampton, leading to the winch brake slipping at almost half its intended holding capacity and causing a high shock load on the towline and pennant. [2.6.2]

8. Without a clear formal induction process for new crew, and given acting as stern tug to *CMA CGM Marco Polo* was the first job with the towline and pennant under load in Southampton, if *Svitzer Mercurius*'s master had remained at the helm it would have maximised the opportunity to react to unexpected events. [2.6.3]

3.2 OTHER SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT

1. The tests applied for wheelhouse window glass standards are not intended to replicate impact loads from solid objects, including-high speed, heavy or point loads. [2.8.2]

SECTION 4 – ACTION TAKEN

4.1 ACTIONS TAKEN BY OTHER ORGANISATIONS

Svitzer Marine Limited has:

- Commissioned a detailed examination of the failed pennant to fully understand the failure mode.
- Undertaken a comprehensive internal investigation of the incident, with nine actions taken forward, including:
    - review of the HMS 06-005 Towlines procedure
    - review of change management processes for new vessels
    - towline retirement and discard criteria
    - issuing a winch inspections fleet notice
    - adding manufacturers' rope management guidance to the PMS
    - global review of similar winch incidents to develop a trend analysis
    - review and revision of the pre-towage checklist
    - review and revision of the master's training and familiarisation processes.
- Introduced a database for tow gear equipment to provide towing arrangement data across its global tug fleet.

The **Maritime and Coastguard Agency** has:

- Raised the need for a bridge window glass standard for tugs at the Recognised Organisations British Certification Committee meeting.
- Considered, for inclusion in the revision of the Code of Safe Working Practices for Merchant Seafarers, the need to consider the risk of toughened glass shattering in the event of an impact from a parted line when risk assessing on board operations.

In June 2021, the **British Tugowners Association** published its towline *Rope Selection, Procurement and Usage* guidance document. The document was drafted with support and guidance from rope manufacturers and tug operators, including Lankhorst Ropes and Svitzer. The guidance provided information on tug characteristics, operational and environmental considerations, rope strength, rope certification and installation, methods of connection, rope safety (including snapback), factors affecting rope usage (including elongation), rope maintenance and testing, inspection and retirement. It provided similar guidance to the MEG4 and Lankhorst Ropes publications.

SECTION 5 – RECOMMENDATIONS

Det Norske Veritas is recommended to:

2022/137 Take the findings of this investigation to IACS, with respect to the failure of the wheelhouse window glazing, and propose the development of a unified requirement to minimise the risk of injury to personnel within the tug wheelhouse from broken window glazing and/or broken skylight glazing, in the event of impact from a recoiling towline.

Svitzer Marine Limited is recommended to:

2022/138 Undertake a fleetwide risk assessment to determine the level of risk associated with towline failure and snapback and the potential for impact by a line recoiling into wheelhouse windows, and, where appropriate, employ appropriate laminated glass or other defences to mitigate against the risk of flying glass injuring its tug crews.

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

Marine Accident Report