



SAFETY INVESTIGATION REPORT

202201/011

REPORT NO.: 01/2023

January 2023

The Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011 prescribe that the sole objective of marine safety investigations carried out in accordance with the regulations, including analysis, conclusions, and recommendations, which either result from them or are part of the process thereof, shall be the prevention of future marine accidents and incidents through the ascertainment of causes, contributing factors and circumstances.

Moreover, it is not the purpose of marine safety investigations carried out in accordance with these regulations to apportion blame or determine civil and criminal liabilities.

NOTE

This report is not written with litigation in mind and pursuant to Regulation 13(7) of the Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011, shall be inadmissible in any judicial proceedings whose purpose or one of whose purposes is to attribute or apportion liability or blame, unless, under prescribed conditions, a Court determines otherwise.

The report may therefore be misleading if used for purposes other than the promulgation of safety lessons.

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MV NEPTUNE THELISIS

**Leaking thermal oil
leading to an engine-room fire while underway
in position 31° 16.8' N 029° 48.6' E
17 January 2022**

SUMMARY

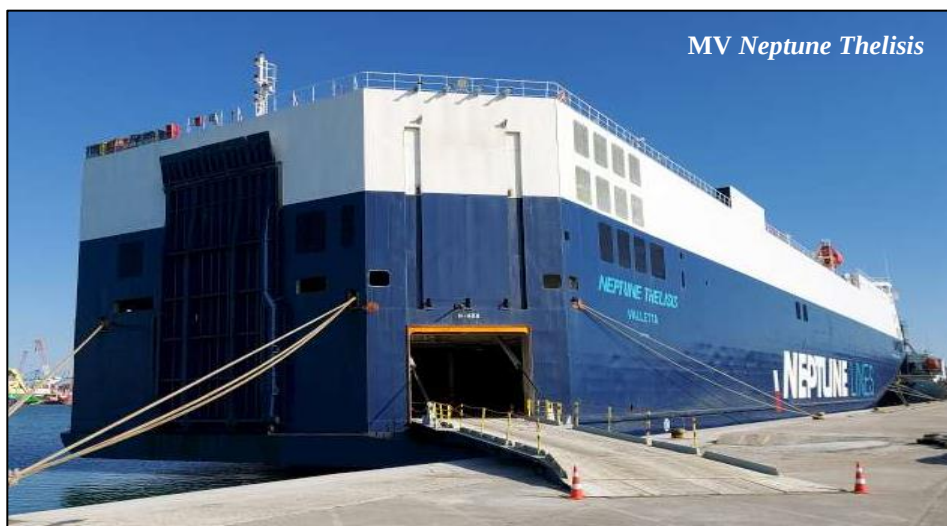
Shortly after 1651 (UTC+1) on 17 January 2022, a fire was discovered by the engine-room crew members on board the Maltese registered motor vessel *Neptune Thelisis*. At the time, the vessel was approaching Alexandria pilot station.

The crew members gathered at the designated muster station and commenced fire-fighting operations. The fire was controlled and extinguished after the fixed fire-fighting

installation was activated.

The safety investigation established that the immediate cause of the fire was the failure of a pipe on the thermal oil system. Leaking thermal oil came in contact with a hot surface on the boiler's economiser.

The MSIU has issued one recommendation to the Company designed to raise awareness on the importance of proper welding techniques.



FACTUAL INFORMATION

Vessel

Neptune Thelisis (**Figure 1**) was a 27,788 *gt* ro-ro / car carrier, owned by Thelisis Shipping Ltd., and managed by Neptune Lines Shipping & Managing Enterprises S.A. of Greece (Company). The vessel was built by Fincantieri Cantieri Navali Italiani S.p.A., Italy in 2006 and was classed by Det Norske Veritas (DNV).

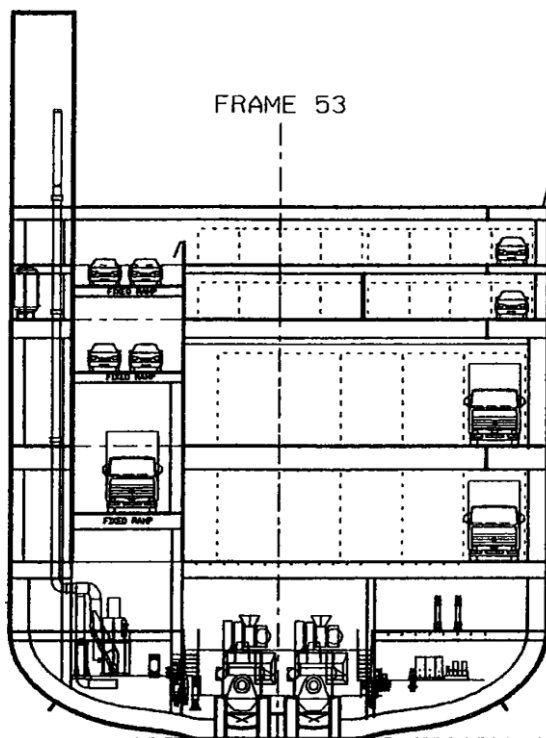


Figure 1: MV *Neptune Thelisis*
GA plan section at Frame 53

Neptune Thelisis was fitted with 10 decks, had a length overall of 164.4 m, a moulded breadth of 26.2 m, and a moulded depth of 8.6 m to the main deck. It had a summer draught of 6.2 m, corresponding to a summer deadweight of 5,668 metric tonnes. The vessel was fitted with 8,632 m of lanes for cars and 1,783 m of lanes for trailers. In total, the vessel had 18,350 m² of cargo spaces.

Propulsive power was provided by two, 6-cylinder Wärtsilä 6L46A, medium speed

diesel engine, each producing 6,300 kW at 600 rpm. These drove a single controllable pitch propeller, enabling *Neptune Thelisis* to reach an estimated speed of 20 knots. The vessel was also fitted with a shaft generator and a bow thruster.

Crew

Neptune Thelisis' Minimum Safe Manning Certificate stipulated a crew of 15. At the time of the accident, the vessel was manned by 21 crew members. All the deck and engine-room crew members were Ukrainian nationals.

The master was 43 years old. He started his seafaring career in 1999 and had been serving as a master for six years. He had been working for the Company also for six years and had obtained his STCW¹ II/2 qualifications for a master in 2016, issued by the Ukrainian authorities. The master took command of *Neptune Thelisis* on 18 December 2021 in the port of Chornomosk, Ukraine.

The chief engineer was 53 years old and had started his seafaring career in 1990. He had been serving as a chief engineer for five years and had been working for the Company also for five years. He had obtained his STCW III/2 qualifications for a chief engineer in 2014, issued by the Ukrainian authorities. The chief engineer joined *Neptune Thelisis* on 13 November 2021.

Neither the master nor the chief engineer had designated watches in port and at sea.

The third engineer was the officer of the watch in the engine-room when the fire broke out. He was 36 years old and had started his seagoing career in 2008. He had been serving as a third engineer for three years but had been working for the Company for five

¹ IMO. (2010). The Manila amendments to the annex to the International convention on standards of training, certification and watchkeeping for seafarers (STCW), 1978. London: Author.

years. He had obtained his STCW III/1 qualifications in 2017, issued by the Ukrainian authorities. The third engineer signed on *Neptune Thelisis* on 20 December 2021.

The oiler who was assisting in the engine-room when the engine-room fire broke, was 29 years old and had been at sea since 2016. He had been serving as an oiler with the Company for six months. At sea, he used to keep the 04:00 – 08:00 and 16:00 – 20:00 watches. The oiler joined the vessel on 03 August 2021.

Environment

At the time of the accident, the weather was reported to be clear, with slight sea and a North Northwesterly gentle breeze. Visibility was recorded to be 12 nautical miles. The air and sea temperatures were recorded at 12 °C and 10 °C, respectively.

***Neptune Thelisis'* thermal oil system**

Thermal oil systems are a common installation on board ships, fitted to heat auxiliary systems. The one fitted on *Neptune Thelisis* (**Figure 2**) was designed to heat the fuel oil and related system, although the thermal oil schematic drawing showed a domestic freshwater heater which had a thermal oil coil inside.

The system had an oil-fired boiler, but also an exhaust heat recovery system, comprising of two economisers to heat the thermal oil. Main lines were also fitted with expansion joints and stop valves, which could be operated locally and remotely. The thermal oil system was not a closed system and was fitted with several goose necks and globe valves at high levels.

Dump coolers were fitted to reduce the temperature of the thermal oil, when the thermal oil demand was reduced and hence, excess heat was generated. The control system prevented the thermal oil temperature

from exceeding the set limit above which, excessive deterioration rate of the thermal oil would be experienced.

An expansion tank was also fitted high in the system, to accommodate for volume fluctuations, which the thermal oil would experience because of changes in the operating temperatures. The expansion tank was fitted with an overflow pipe system, leading to the drain tank. Copper and copper alloys were not used in the thermal oil system, which is a common practice, given the catalytic effect which could increase the aging of the thermal oil, unless specific additives are added to the oil.

The thermal oil system comprised of two main tanks. Double bottom tank (DB) no. 1 port was the system's storage tank, while DB no. 2 port served as the drain tank. A filling and drain pump could either drain DB no. 2 port or top up the system's header tank, either from DB no. 1 port or DB no. 2 port.

To circulate the oil, the system had five circulating pumps; two fitted to the oil-fired boiler and three pumps supplying the exhaust gas economisers². All the pumps' suction sides were connected to a main suction line from the system's expansion tank, and the return from the heating coils. This enabled hot thermal oil to be directed from the economisers to the oil-fired boiler for further heating but also directly to the oil-fired boiler say, when the vessel's main engine is not running and there is limited / no exhaust gas passing through the economiser.

Thermal oil heating coils were fitted in the HFO storage tanks, settling tanks, day / service tanks, overflow tanks, sludge tank, and the bilge leak and clean fuel oil tanks.

The purifier room was also supplied with thermal oil, along with tracing lines fitted to all fuel oil lines.

² The exhaust gas economisers were fitted with a fixed fire-extinguishing system.

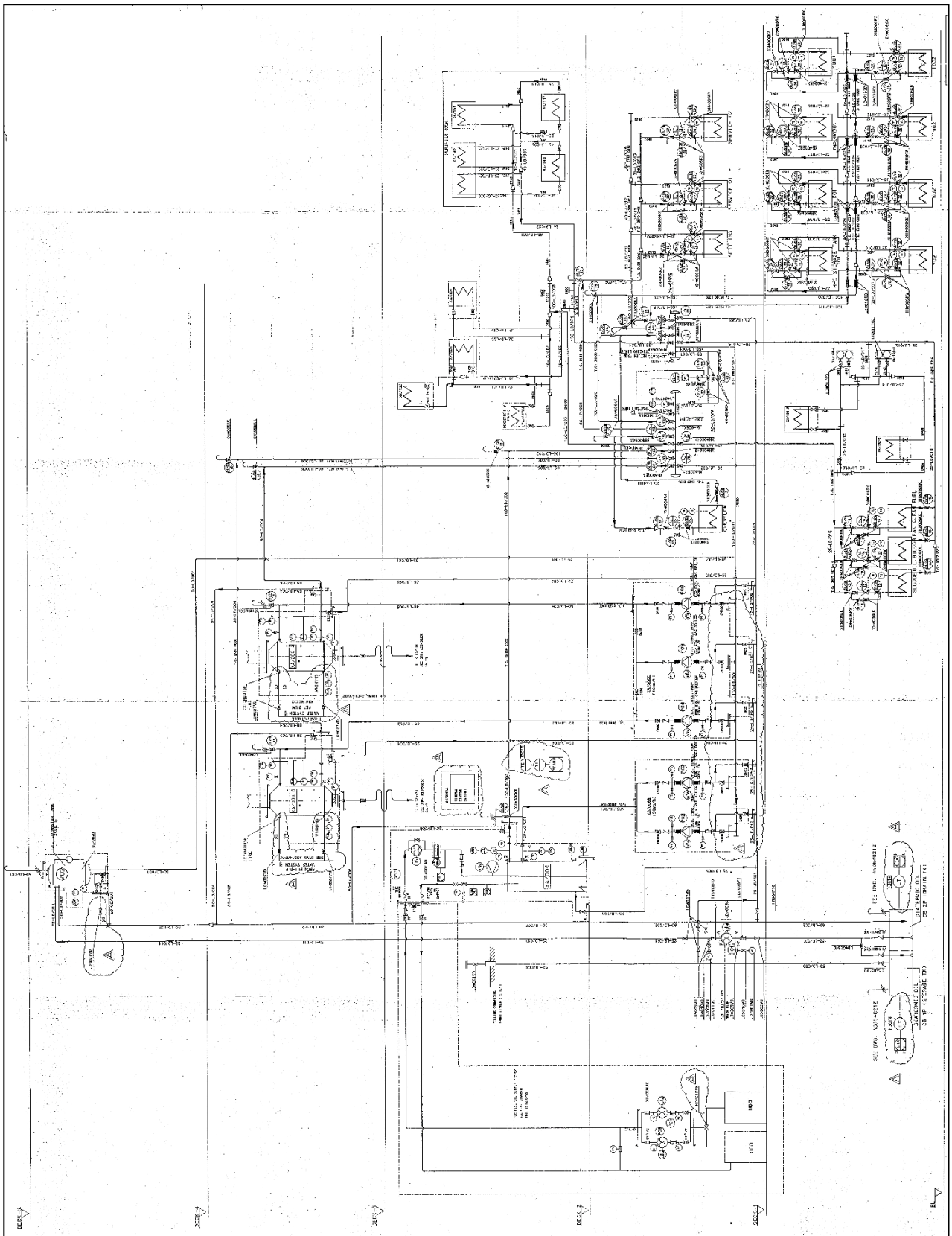


Figure 2: Thermal oil schematic plan

DB no. 1 port could be filled / topped up through a connection flange on the port side bunker station, on deck.

Narrative³

At about 2145 on 16 January 2022, *Neptune Thelisis* departed from the port of Ashdod, Israel, carrying 166 vehicle units. The vessel's next port of call was Alexandria, Egypt. The international voyage was short, and the vessel was expected to reach Alexandria pilot station by late afternoon of the following day.

The voyage had been uneventful and at 1600 on 17 January, the engine-room was given a 30-minute arrival notice by the master, who was on the bridge. A helmsman was also stationed on the bridge. The estimated time of arrival at the pilot station was 1630; however, the port authorities advised the vessel that the pilot would be delayed by about one hour.

At 1645, thermal oil economiser no.1 alarm activated, followed by a fire alarm in the machinery space at about 1651. The third engineer and one of the oilers, who were on stand-by in the engine-room, proceeded to the area to investigate further. Walking closer to the economiser, they observed an open fire in the area.

Both crew members returned to the engine control room and informed the bridge of the fire. The master sounded the fire alarm and requested for the emergency pump to be started. By this time, dense smoke was already being observed on the upper deck, escaping through the ventilation grids on the funnel.

At 1653, the master requested the shutdown of the starboard main engine. In the meantime, both the third engineer and the oiler donned an emergency escape breathing

device (EEBD) and started to fight the fire, using fire hoses, a foam applicator and portable fire extinguishers. All ventilation fans were stopped, and dampers closed.

At 1656, all crew members gathered at the designated muster station⁴. Having ascertained that none of the crew members were injured, the Company's DPA was notified of the situation. Although no more than 15 minutes had passed since the first alarm had triggered, signs of paint scorching on the port side shell plating in way of deck nos. 3 and 5, directly below the funnel structure were already visible.

With the fire-fighting operation in progress, the emergency generator was switched on at about 1700. Boundary cooling of the funnel casing was also initiated from deck no. 7 and the upper weather deck (no. 9), using the vessel's main and emergency fire pumps (**Figure 3**).

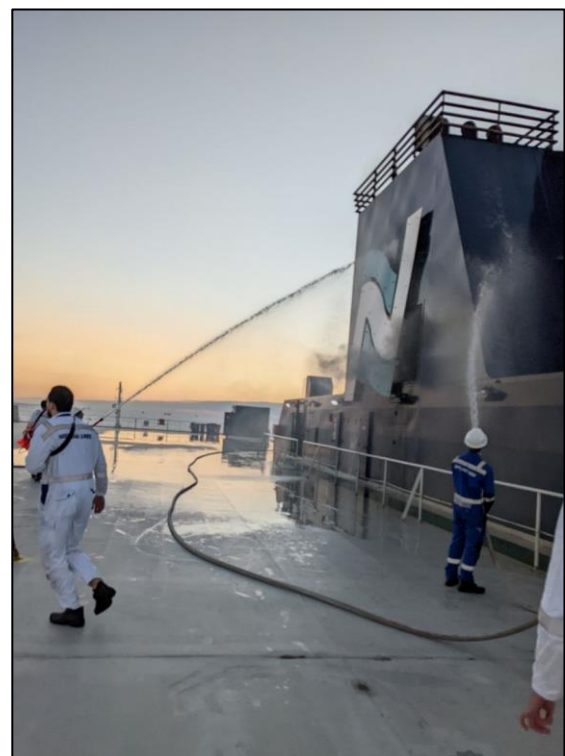


Figure 3: Boundary cooling of the funnel casing from the upper weather deck

³ Unless otherwise specified, all times refer to the vessel's time (UTC+1).

⁴ The second engineer was also in the engine-room, assisting in the fire-fighting efforts.

By 1703, the density of the smoke inside the engine-room, related staircases and the economisers' areas had increased significantly. To this effect, the master and the chief engineer requested the crew members to isolate the spaces and then report to the muster stations. Subsequently, all engine-room access doors were closed.

At 1705, the master requested that the port main engine is shut down and the fixed fire-fighting installation to be activated. Quick closing valves were also closed remotely from deck no. 3. At 1721, the chief engineer and the second engineer activated the fixed fire-fighting installation and released CO₂ in the main engine-room area. About 40% of the total system volume was released.

Five minutes after the release, dense smoke was still escaping through the funnel ventilation grids, prompting the chief engineer to release the remaining CO₂ bottles, bar the ones serving the emergency generator room. This second release appeared to have had the desired effect, since about four minutes later, the density of smoke from the ventilation grids subsided significantly and eventually stopped. In total, 54 CO₂ bottles had been activated and emptied.

Boundary cooling was nonetheless maintained, and fire and patrolling teams were assigned to monitor the area. However, entry into the engine-room remained prohibited due to the released CO₂ gas.

At 1848, the starboard anchor was dropped in position 31° 15.84' N 029° 48.302' E and Alexandria Port Control was informed of the situation on board.

Post-accident events

On the morning of 18 January, two tugs were made fast forward and aft, using a total of four mooring lines. Two pilots also boarded the vessel. At 1115, the starboard anchor and the full length of the anchor chain were let

free into the sea and the towing operation initiated. *Neptune Thelisis* was all fast alongside at 1410.

Following a thorough risk assessment, an entry permit into the engine-room was granted at 0800 on 19 January. By 1100, power had been restored.

Reported damages

Damage surveys were carried out by a DNV surveyor, between 20 January and 23 January. The surveys revealed the following:

- several areas of the insulation on the aft thermal oil heater casing, inlet and outlet piping and associated valves was damaged;
- cabling and several sensors on the automation system for the aft thermal oil heater and exhaust gas economiser were damaged;
- smoke damage and damages to lighting equipment in several areas; and
- loss of starboard anchor and the full length of the anchor chain.

Failure point

During their inspection on 19 January, crew members observed a crack in way of an air vent, fitted on the inlet thermal oil piping (**Figure 4**). The crack on the weld seam was also confirmed by the attending class surveyor.

Figure 5 shows part of the main schematic drawing, indicating the failure point, in relation to the system.

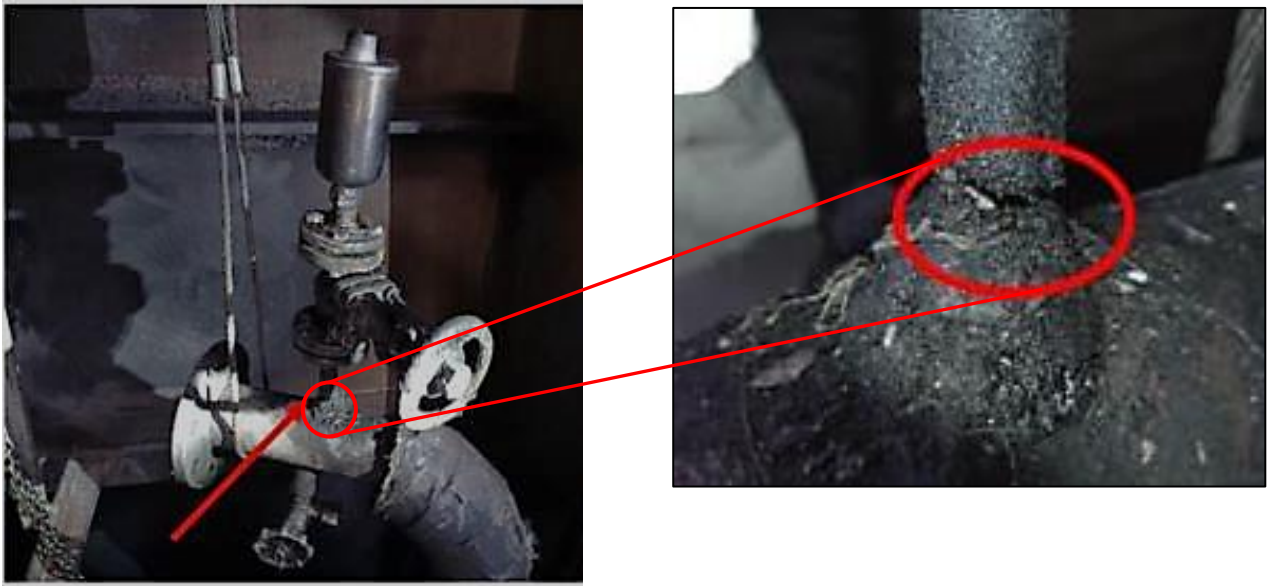


Figure 4: Crack at the weld seam

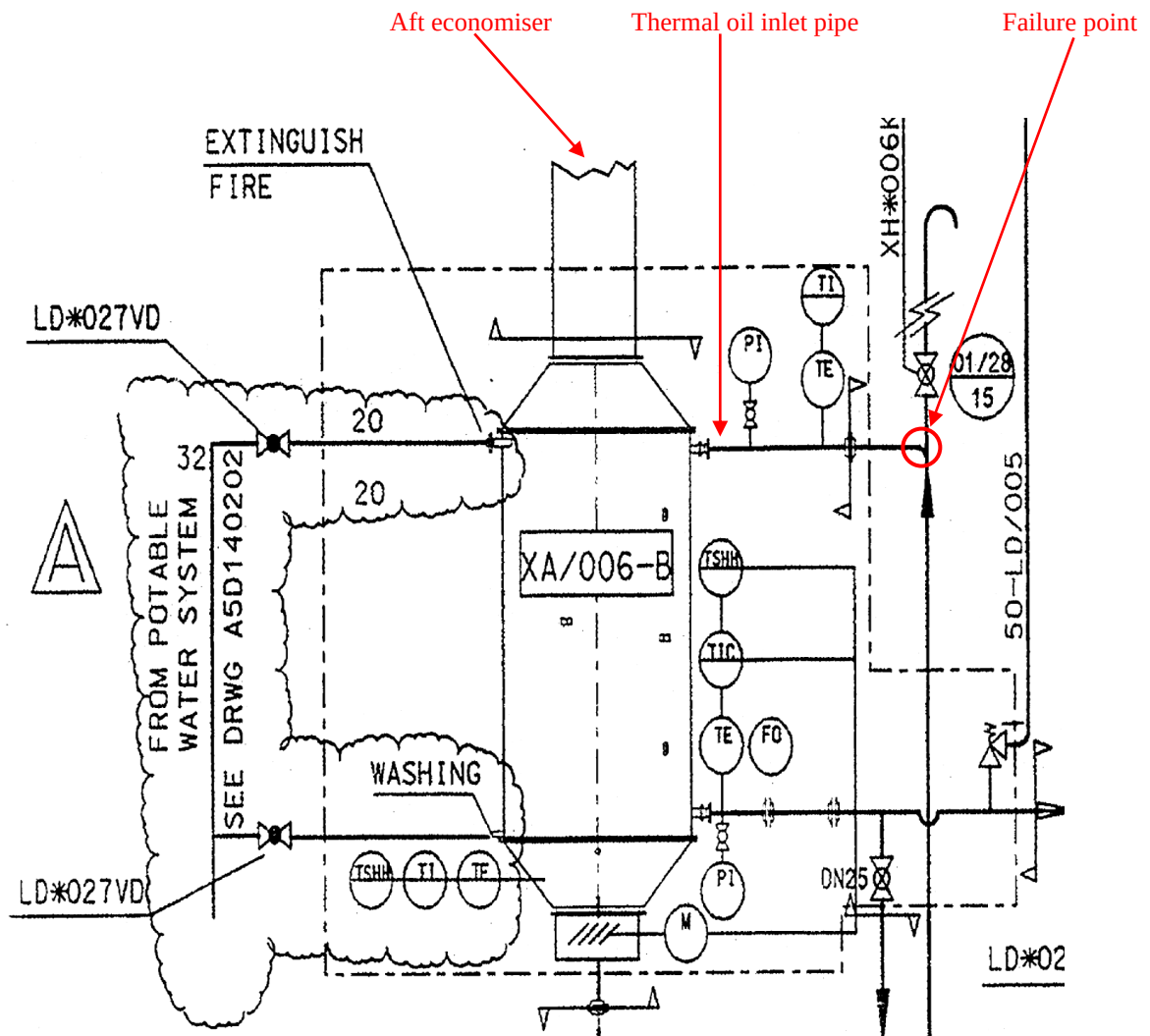


Figure 5: Part of the schematic drawing, showing the failure point

System restoration

Cleaning operations of the machinery spaces with chemicals and high-pressure water machines were commenced on 19 January, with the assistance of a shore contractor. Empty CO₂ bottles were also landed ashore for recharging. Cargo operations commenced on 20 January.

Damaged insulation was removed. Empty CO₂ bottles, EEBD and breathing apparatus (BA) sets were all landed ashore for testing and refilling. Crew members helped in the removal of the generated debris around the fire area. The inlet thermal oil piping was also removed, drained and re-secured.

A new vent pipe was manufactured by a DNV approved welding shop and fitted in place, followed by the necessary non-destructive testing (NDTs) and pressure testing. The thickness of different areas of the system was measured to ascertain that it was still within the approved criteria. Additional supports were also manufactured and installed to minimise vibration as much as possible.

Class conditions were imposed until a new starboard anchor and chain were installed. Moreover, pending receipt and installation of all parts on the automation system, the economiser and thermal oil heater had to be operated in the manual mode.

Investigated engine-room fires involving thermal oil systems

The fire on board *Neptune Thelisis* is but one of a series of fires involving thermal oil on several ships and reported to the IMO. Listed below are four similar occurrences:

- MT *Samus Swan*⁵: On 11 September 2021, while the vessel was *en route*, the second and third engineers were tasked to clear a clogged thermal oil line in the

purifier room. During this process, pressurized thermal oil sprayed out of the thermal oil line. A fire broke out, which quickly spread to the vicinity of the purifier room. The third engineer managed to escape the engine-room, suffering serious burn injuries. The second engineer, however, remained trapped and did not survive the accident. The vessel was later towed to a repair yard for permanent repairs.

- MV *Pride of Hull*⁶: On 20 October 2020, the ro-ro passenger ferry was outbound in the Humber Estuary, UK, when a fire was detected in the vicinity of the thermal oil circulation pumps. The vessel's Hi-Fog fire suppression system activated automatically but did not operate as anticipated and could not control the fire, which was eventually extinguished using the vessel's fixed CO₂ system. The vessel returned to port, under its own power, the next day. No one was injured and there were limited damages reported to the vessel.
- MV *Kelly*⁷: On 06 September 2019, the vessel was *en route* from Rotterdam, The Netherlands, to Kaliningrad, Russia. A fire in the separator room triggered the fire alarm. The fire was eventually brought under control and extinguished, but one crew member was fatally injured and two other sustained severe burns. The immediate cause of the accident was identified to be impurities in the thermal oil.
- MV *Java Sea*⁸: On 24 May 2005, a fire started on board the Singapore registered general cargo vessel *Java Sea*, which was alongside at Cairns, Australia. The safety investigation hypothesised that a leakage of hot pressurised thermal fluid (mineral oil), possibly in the form of a spray, ignited when it came into contact

⁵ The safety investigation by the MSIU into this occurrence is active at the time of writing of this safety investigation report.

⁶ [Bahamas Maritime Authority Investigation Report.](#)

⁷ [BSU Investigation Report 338/19](#)

⁸ [ATSB Investigation No. 215.](#)

with an un-lagged section of the oil-fired thermal fluid heater exhaust piping. The fire was fuelled by the contents of the thermal fluid expansion tank, the main engine cylinder oil service tank, and the stern tube lubricating oil tank.

ANALYSIS

Aim

The purpose of a marine safety investigation is to determine the circumstances and safety factors of the accident as a basis for making recommendations, and to prevent further marine casualties or incidents from occurring in the future.

Metallurgical analysis

A section of the air vent pipe (**Figure 4**), was shipped to the MSIU for analysis in a metallurgical laboratory. The pipe section had a pipe nominal diameter of 21.3 mm, while the wall thickness was measured at 2.5 mm.

Section preparation

In preparation for standard metallographic tests, the pipe was cleaned using ethanol and a soft brush to allow inspection and photography. The sample's wider end was then ground and polished to a mirror finish following which, microscopical imaging was carried out using an Optiphot-100 optical microscope and a Nikon SMZ-2T stereomicroscope equipped with a Leica DFC 290HD fast-acquisition digital camera.

Finally, the sample was sectioned along its principal axis. The section was mounted in cold setting resin and once again this section was ground and polished. The section was also etched in Nital (2% Nitric acid) to allow for microstructural evaluation. Microhardness tests were carried out on the same sample using a Mitutoyo MVK-H2 microhardness testing machine equipped

with a Vickers indenter at loads of 500 gf and for a dwell time of 10 seconds⁹.

Tests' findings

Examination of the pipe clearly showed a relatively large amount of weld material. Cracking was very apparent around the transition between the weld and the pipe material (also known as toe cracking). Furthermore, the polished cross section of the sample showed very large internal pores/blow holes inside the weld material build up (**Figure 6**).

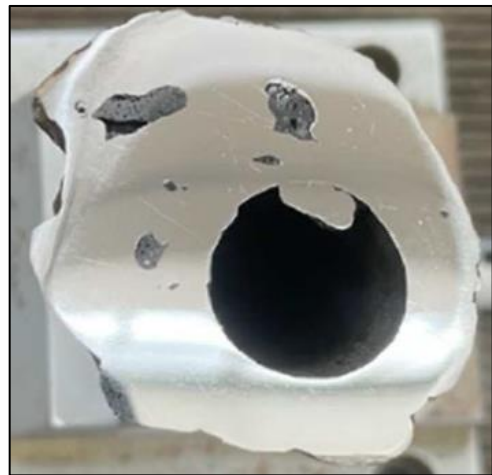


Figure 6: Polished transverse section

The section also showed weld undercutting with extensive cracking across the entire pipe wall thickness, visible in **Figure 7**. It appeared that the crack propagated from the undercut to the inner tube with the front on one side of the pipe reaching full depth while still progressing at the opposite end.

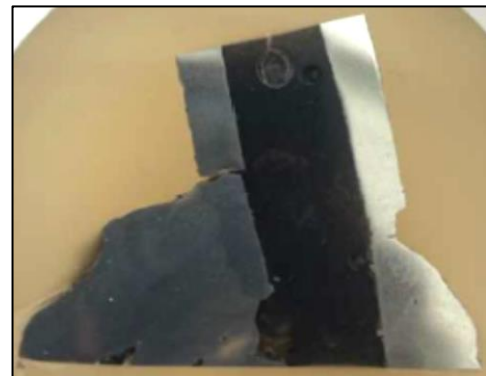


Figure 7: Polished longitudinal transverse section

⁹ 1 gf = 9.81 N.

Figure 8 shows higher magnification images of the longitudinal section of the pipe, following etching in Nital. Comparison of the resultant microstructures across the near-weld region and pipe metal further away from the weld, showed significant differences, indicative of recrystallisation and grain growth. This was also correlated to Vickers microhardness measurements (HV200) at the region corresponding to the

heat affect zone, which showed a hardness reduction of approximately 15% to 135.9HV200. However, it should be stated that these metallurgical and resultant mechanical property changes are considered within the norm.

Finally, a closer inspection of the crack and its front showed no sign of corrosion damage or stress corrosion (**Figure 9**).

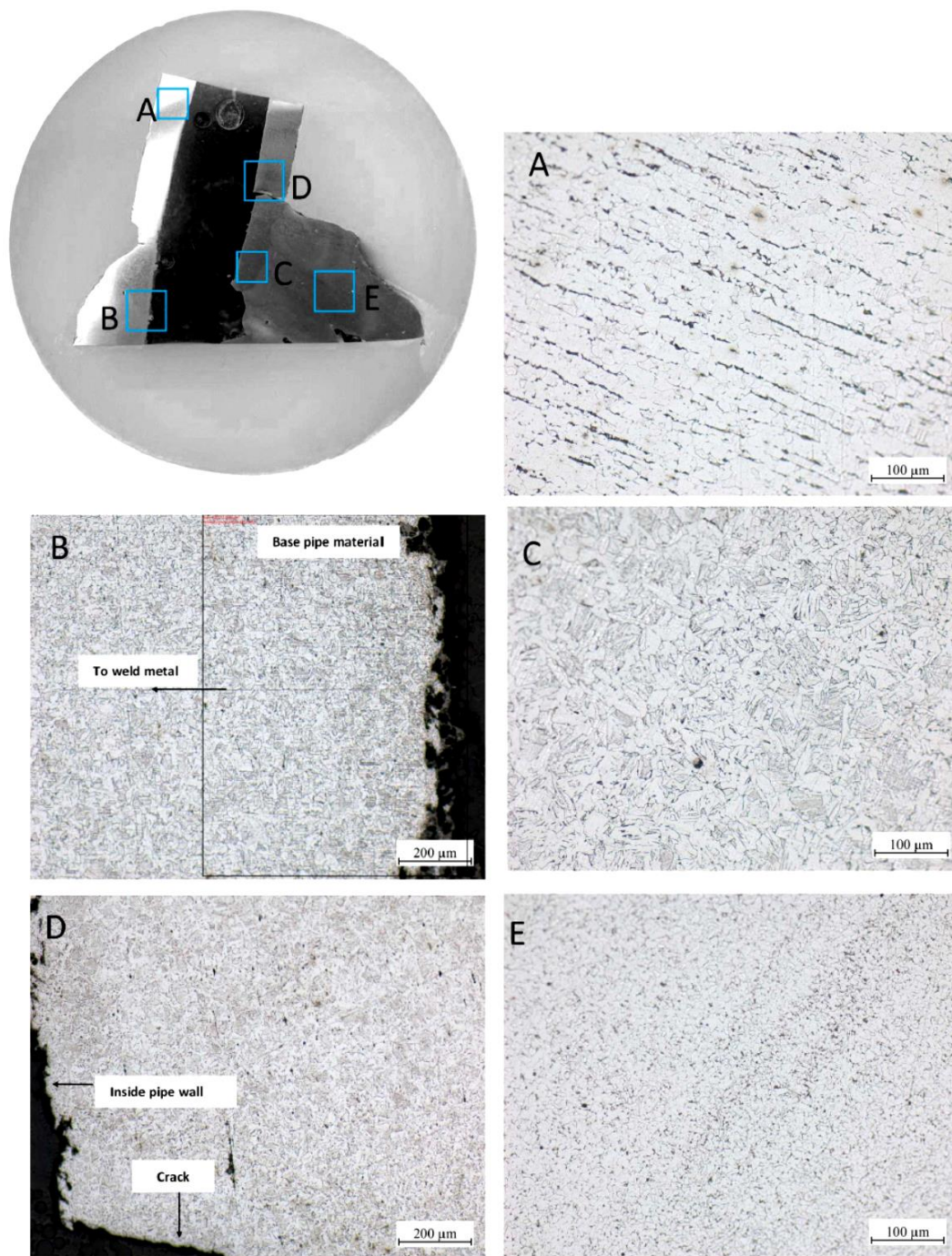


Figure 8: Optical micrographs of various sites across the pipe and weld material section

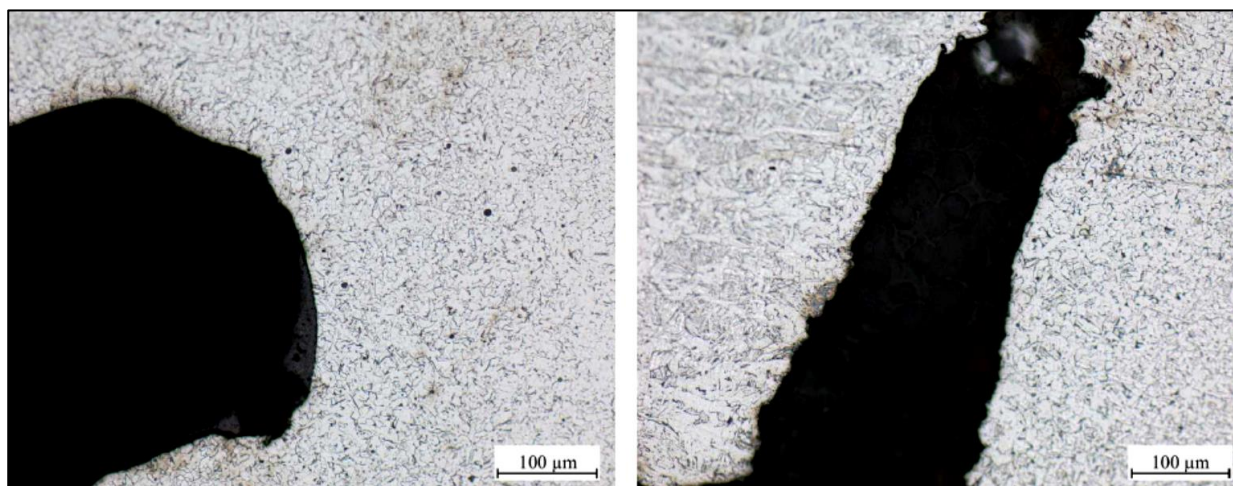


Figure 9: Optical micrographs of material around the crack fronts

Heat Source

The inlet thermal oil piping and the air vent were located outside the economiser area and not near the casing. However, the post-accident inspection revealed traces of leaked thermal oil, which had made contact with a hot surface on the economiser.

Planned maintenance

Detection of the pipe failure prior to the accident would have been extremely difficult for the crew members, if not impossible. It would have been impractical to expect crew members to inspect every single pipe and weld – thousands of metres of them, some of which were either simply inaccessible or obscured behind other parts and equipment. This issue, in combination with the absence of cues that the pipe was about to fail, led to a situation where the failure was only visible through its effects, *i.e.*, leaking thermal oil.

The metallurgical results indicated the possibility of a previous repair job. The Company had no details / records of the repairs and therefore, there existed the possibility that the repair job may have not been a recent one. To this effect, the MSIU could not determine whether the repair job had been carried out by the crew members *in situ* (with all the access challenges which they would have to address) or in the engine-room workshop.

Also, it could not be determined whether the job was carried out by crew members or a shore repair team¹⁰. Nonetheless, from an engineering perspective, the repair job did not meet the industry's standards.

Use of EEBD during the fire-fighting operations

The use of EEBDs by the two crew members on duty in the engine-room was a way to gain valuable time and start fighting the fire immediately. This was the alternative to rushing out of the machinery spaces, get two sets of breathing apparatus (BA sets) from the storage locker and return to the engine-room to fight a (larger) fire. Moreover, the safety investigation also observed that the space in way of the economiser area was quite narrow to access by a person carrying a BA set. The need to access the narrow space led the two crew members to use the EEBDs.

Whilst for the safety investigation it was clear that this was a context-influenced decision, it must be highlighted that the EEBD's design purpose is for escaping rather than an aid to fight a fire. An EEBD is not a substitute to a BA set.

¹⁰ The vessel was last dry docked around June 2021.

CONCLUSIONS

1. Leaking thermal oil came in contact with a hot surface on the economiser
2. The examination of the sample showed an array of welding defects ranging from gross and excessive weld material build-up (necessarily generating large thermal stresses), distributed unevenly around the pipe circumference, and creating visible fillet distortion, to large undercutting at the pipe toe end of the fillet.
3. The cross section of the failed pipe also showed that the poor tie-in into the base metal caused a local reduction in the pipe wall, further weakening the vent tube.
4. The undercut served as a highly effective stress intensity site for crack initiation, with the pipe bending into the undercut region and allowing progression of the crack front into the inside of the tube.
5. Mechanical stress, either through vibration of the assembly, or by pressure variation inside the tube and / or residual thermal stresses, could have caused any number of these features, leading to premature failure.
6. Previous damage to the pipe may have been repaired, using inadequate welding techniques.
7. While specifically undercutting is a defect typically associated with improper welding parameters, the range and extent of defects present in this small section of weld may have been compounded on site, where access to proper surface preparation (before and in between runs) and positioning around the pipe was limited, as was the case for any subsequent weld inspection.

SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION¹¹

In relation to this occurrence, the Company has taken the following preventive measures:

- additional supports have been fitted in the new air vent pipe to minimise vibrations and possible cracks, to the satisfaction to the attending class surveyor;
- the Company's internal investigation report has been circulated to all vessels in the fleet.

RECOMMENDATIONS

Neptune Lines Shipping & Managing Enterprises S.A. is recommended to:

01/2023_R1 Communicate the findings of this safety investigation report to the fleet under its management, to highlight the issues related to poor welding techniques.

01/2023_R2 Highlight to the fleet under its management the different design concepts of a BA set and an EEBD.

¹¹ Safety actions and recommendations shall not create a presumption of blame and / or liability.

SHIP PARTICULARS

Vessel Name:	<i>Neptune Thelisis</i>
Flag:	Malta
Classification Society:	Det Norske Veritas
IMO Number:	9306718
Type:	Ro-ro / Car Carrier
Registered Owner:	Thelisis Shipping Ltd.
Managers:	Neptune Lines Shipping & Managing Enterprises S.A., Greece
Construction:	Steel
Length Overall:	164.40 m
Registered Length:	154.65 m
Gross Tonnage:	27,788
Minimum Safe Manning:	15
Authorised Cargo:	Ro-ro

VOYAGE PARTICULARS

Port of Departure:	Ashdod, Israel
Port of Arrival:	Alexandria, Egypt
Type of Voyage:	Short international
Cargo Information:	Ro-ro units
Manning:	21

MARINE OCCURRENCE INFORMATION

Date and Time:	17 January 2022 at 16:51 (LT)
Classification of Occurrence:	Serious Marine Casualty
Location of Occurrence:	31° 16.8' N 029° 48.6' E
Place on Board	Machinery space
Injuries / Fatalities:	None reported
Damage / Environmental Impact:	None reported
Ship Operation:	In passage
Voyage Segment:	Arrival
External & Internal Environment:	Clear, with slight sea and a North Northwesterly gentle breeze. Visibility was recorded to be 12 nautical miles. The air and sea temperatures were reported to be 12 °C and 10 °C, respectively.
Persons on board:	21