Marine Safety Investigation Unit

Transport Malta

SAFETY INVESTIGATION REPORT

201903/018 REPORT NO.: 05/2020 March 2020

MV *LEOPOLD LD*
Failure of auxiliary engines and the emergency generator leading to total loss of power in position 06° 08.58' N 014° 40.65' W 14 March 2019

SUMMARY

MV *Leopold LD* was en route from the port of Saldanha Bay, South Africa, to Hamburg, Germany, laden with a cargo of iron ore.

On 14 March 2019, the only running auxiliary engine of the vessel tripped and the emergency generator automatically cut in. Attempts by the crew to restart the tripped auxiliary engine and to start the other auxiliary engines failed and on the next day, the emergency generator also stopped, resulting in a total loss of power.

The vessel was towed to Freetown, Sierra Leone. One auxiliary engine and the emergency generator had sustained extensive damages, due to this occurrence

It was also found that the fuel compensation damping tank was empty and that the drain valves of the diesel oil service tanks were blanked.

Considering the safety actions taken by the Company, the MSIU has issued no recommendations.

MV *Leopold LD*

FACTUAL INFORMATION

Vessel

MV *Leopold LD* was a 93,801 gt bulk carrier, built in China in 2014, and owned by Caroline 29 SAS. The vessel was taken under the management of Anglo-Eastern Ship Management Ltd., Hong Kong, on 19 January 2019.

The vessel had a length overall of 292.0 m, a moulded breadth of 45.0 m, a moulded depth of 24.8 m, and a summer draft of 18.4 m. At the time of the accident, the vessel was drawing a mean draught of 14.7 m.

Propulsive power was provided by a 6-cylinder, two-stroke, slow speed, single-acting, direct drive MAN B&W 6S70ME-C8.2 marine diesel engine, built in 2013 by Dalian Marine Diesel Co. Ltd., China. The engine produced 15,530 kW of power at 86 rpm, and drove a single fixed pitch propeller, which enabled *Leopold LD* to reach an estimated speed of 15 knots.

Electrical Installations

The main source of electrical power on board *Leopold LD* were three Yanmar 6EY22ALW auxiliary diesel engines (Figure 1), each capable of bearing the full electrical load of the vessel, under normal operational conditions. The rated output power of each of these auxiliary engines was 970 kW.

Figure 1: Auxiliary engines on board *Leopold LD*

The emergency source of electrical power was a Sisu 645 DSBIG diesel generator, which had a rated output power of 170 kW (Figure 2).

Figure 2: Emergency generator of *Leopold LD*

The emergency generator supplied power through the emergency switchboard. With reference to the operation of the auxiliary engines (A/Es), the emergency switchboard only provided power to the vessel's diesel oil pump and to the lubricating oil pump of A/E no. 3.

The last on load test of the emergency generator was carried out during the vessel's annual surveys on 30 January 2019 and the running hours of this generator, prior to its complete failure, were recorded to have been about 53 hours.

Crew

The Minimum Safe Manning Certificate of the vessel stipulated a crew of 16. At the time of the accident, the complement of the vessel was in excess of these requirements. The crew members were all nationals of the Philippines.

The chief engineer had served for a total of 12 years in this rank with STCW III/2 qualifications, 2.4 years as a chief engineer with this Company. He had joined *Leopold LD* on 30 August 2018, at the port of Tianjin, China. Prior to the accident, he

had sailed on board *Leopold LD* from 06 March 2014 to 07 November 2014, while the vessel was under the management of a different company.

The second engineer had a total of 13.1 years of seagoing experience. He had served for 3.1 years in the rank of a second engineer with STCW III/2 qualifications, 1.2 years of which with this Company. He had joined *Leopold LD* on 24 November 2018, at the port of Singapore.

The third engineer had a total of 11.1 years of seagoing experience, of which 5.6 years were served in the rank of a third engineer with STCW III/1 qualifications. He had joined *Leopold LD* on 18 August 2018 at the port of Singapore and this was his first contract as a third engineer with the Company.

The fourth engineer had a total of 2.1 years of seagoing experience, six months of which were served in the rank of a fourth engineer with STCW III/1 qualifications. He had joined *Leopold LD* with the third engineer and this was his first contract as a fourth engineer with the Company.

Environment

The weather in the area was reported to be clear and the sea was calm.

Pre-accident events

On 20 February, A/E no. 1 tripped from the main switchboard due to a low lubricating oil pressure shut down. On board investigation revealed excessive wear in the components of the lubricating oil pump of A/E no. 1, which led to the pump's failure and, eventually, to A/E no. 1 shut down and tripping.

Due to the damages/wear of the gear assembly, the shaft, the cover assembly and the bushes, the managers placed an order for a new lubricating oil pump. As maintenance on A/E no. 2 was planned, the crew members removed the lubricating oil pump from A/E no. 2 and installed it on A/E no. 1, thereby restoring operation of A/E no. 1. Thereafter, A/E no. 2 was overhauled and was flushed with low sulphur marine gas oil (LSMGO).

During the morning of 14 March, A/E no. 1, which was on load and running on heavy fuel oil (HFO), was taken off load and A/E no. 3, was put on load, also on HFO. Thereafter, the crew members removed the lubricating oil pump from A/E no. 1 and had planned to install it back on A/E no. 2, in order to carry out routine checks and tests on A/E no. 2[1].

In the meantime, routine inspections of the emergency generator were carried out every week, the last being carried out on 09 March 2019. During these inspections, the following were checked:

- the levels of lubricating oil, fuel oil and coolant;
- the condition of the batteries;
- the external condition of the generator, for signs of leaks and/or damages; and

the testing of its primary and secondary means of starting.

Narrative[2]

On 14 March, at 1527, while the vessel was proceeding through the South Atlantic Ocean, with only A/E no. 3 running, a 'main engine lubricating oil low pressure' alarm was activated in the engine-room. This triggered a 'main engine slowdown' alarm and consequently, two units of the auxiliary blowers for the main engine and two units of the hydraulic power supply started automatically. This sudden additional load resulted in a preferential trip, followed by a

[1] At the time of the occurrence, this pump was neither installed on A/E no. 1, nor on A/E no. 2.

[2] Unless specified otherwise, all times are Local (LT) (UTC + 2) until 15 March 2019. From 16 March 2019, LT = UTC).

high frequency on the bus bar of the main switchboard. As two air conditioning units were also in operation, A/E no. 3 could not cope with the additional load and tripped, with the emergency generator automatically coming on load. Since the engine-room was manned at this time, A/E no.
1 was not kept on a 'stand-by' mode.

The crew members tried to restart A/E 3, but they noticed that, although the engine was turning with air, there were no signs of combustion in any of its cylinders. The crew members then re-installed the lubricating oil pump onto A/E 1 and, by providing power supply to the lubricating oil priming pump from the emergency switchboard, tried to start A/E 1; however, the results were the same as for A/E 3.

At 1900, the crew members recalibrated the fuel injection valves of A/E 1 and found the results for cylinder nos. 2 and 5 to be unsatisfactory; so they replaced the nozzles for these cylinders, and resumed their efforts to restart A/E 1 and A/E 3.

Several efforts to restart the A/Es drained the main and the auxiliary air reservoirs by 2330. Attempts to top up the auxiliary air reservoir, using the emergency air compressor, were unsuccessful.

On 15 March, at 0215, the crew members replaced the low pressure and high pressure valves of the emergency air compressor; yet, they could still not fill the auxiliary air reservoir. A close inspection revealed a partially open drain valve on the auxiliary air reservoir. The drain valve was then closed and at 0300, the auxiliary air reservoir was topped up to the required starting air pressure.

At 0310, after running for a period of 12 hours, two fan belts on the emergency generator broke. These were replaced by new ones; however, 30 minutes later, the radiator of the emergency generator started to leak and consequently, the generator had to be stopped. The only source of power available to the vessel, thereafter, was the emergency batteries.

At 0600, the lubricating oil pump from A/E 1 was removed, and installed on A/E 2. In order to supply power to the lubricating oil priming pump from the emergency switchboard, the emergency generator was re-started. As the radiator was leaking, one crew member was posted in the emergency generator room to monitor the temperature of the generator and to top-up the radiator with water, as required. At 0800, A/E 2 was successfully started and supplied power to the main switchboard, however, after 10 minutes, smoke and abnormal sounds emanated from A/E 2.

At 0923, the vessel suffered a total loss of power. All through this time, the vessel had been drifting in open sea.

Post-power failure events

On 16 March, the vessel's clocks were retarded by two hours to bring them in line with the local time of Sierra Leone. On the same day, the crew managed to partially arrest the leak on the radiator of the emergency generator and at 0900, the emergency generator was started once again. However, 15 minutes later, the crew noticed that the lubricating oil temperature had risen to 91°C, and a 'crankcase pressure high alarm' was triggered. The emergency generator was immediately stopped.

At 1505, a tug, arranged by the Company arrived at the vessel's location. She was made fast to the forward part of the vessel and towing operations commenced towards Freetown, Sierra Leone.

On 19 March, the towing line was shifted from forward to aft because too much of a sheer[3] was being experienced by

[3] In towing operations, the movement of the tow off to either one or to both sides of the towing vessel is known as sheering. Excessive sheering may

Leopold LD and towing operations resumed. On 20 March, at 0755, another tug was engaged in the towing operations and was made fast to the forward part of the vessel. At 1640, the vessel anchored off Freetown, and the two tugs were cast off.

During the evening of 21 March, a portable generator was transferred from one of the tugs to *Leopold LD*, following which, representatives from the Company, shore service technicians and a surveyor from the vessel's Classification Society boarded the vessel. At 2215, the portable generator was connected and power restored on board *Leopold LD*.

Investigation by the Company and the technicians revealed that the compensation fuel damping tank, which should have been pressurized, was empty.

The fuel oil supply and booster module were switched over to MDO, with power supply for the MDO pump taken from the emergency switchboard, and the valves of the auxiliary fuel oil system were lined up in order to flush the system with LSMGO. The technicians then tried to start A/E no 1 and A/E no. 3 after flushing these two engines with LSMGO. Attempts were, however, unsuccessful. Thereafter, the fuel pumps and fuel valves of both A/Es were overhauled by the service technicians, but they still were unable to start the A/Es.

Further investigation revealed that the drain line on the service tank for LSMGO was blanked. Once the blank was removed, the presence of water was observed. It was then decided to clean the marine diesel oil (MDO) service tank, and to transfer LSMGO from the storage tank into this tank. While the MDO service tank was being cleaned, it was noticed that the drain line on this tank was also blanked.

After cleaning the MDO service tank, LSMGO was transferred from the storage tank into the MDO service tank and on 24 March 2019, at 1024, *Leopold LD*'s power was successfully restored using A/E no. 3.

On 25 March, a service technician from the main engine manufacturers boarded the vessel to carry out checks on the main engine, which had been stopped for about six days on heavy fuel oil. After checks were completed, the fuel valves of all cylinders and the fuel booster unit of cylinder no. 1 were overhauled, and the system was flushed with LSMGO.

On 27 March, following a successful sea trial, *Leopold LD* departed Freetown and resumed her voyage to Hamburg.

Damages to the auxiliary engines and the emergency generator

Preliminary investigation on A/E no. 2 by the crew revealed that the piston assembly, liner, connecting rod, crankshaft counterweight and the engine block were damaged. Further investigation by the service technicians revealed that A/E no. 2 had sustained severe damages (Figure 3) due to which, amongst other components, the complete engine block, the crankshaft with counterweight and bolts, piston rings, big end bearings, the main bearing and thrust bearings would have to be renewed.

cause excessive chaffing and additional strain on the towing line, as well as a reduction in towing speed.

Figure 3: Damaged components on A/E no. 2

Investigation of the emergency generator by the service technicians revealed that the piston assembly, the connecting rod assembly, the liners, the big end bearings, the main bearing, the thrust bearings of all cylinders of the generator were severely damaged and would require renewal. In addition, it was also found that the cylinder block would have to be renewed. Figures 4 and 5 show the extent of damages sustained by the emergency generator.

Figure 4: Damaged piston and connecting rod of the emergency generator

Figure 5: Damaged cylinder liner

Compensation damping tank

The fuel oil service system was fitted with a compensation damping tank (Figure 6). The purpose of a compensation damping tank is to damp off pressure peaks and quick load alterations within the fuel oil system.

Figure 6: Compensation damping tank

The tank (Figure 7) had a nominal capacity of approximately 19 litres with a maximum working pressure of 1.6 MPa[4].

As per the manufacturers' instructions, this tank had to be kept pressurized with an air cushion charge. In addition to the damping of pressure, the manufacturers' instructions also stated that if this tank was properly operated and kept correctly charged, the fuel oil pressure in the supply lines would be sufficient, for a few minutes, to start the auxiliary engines without having to put the fuel oil supply and booster pump in service; *i.e.* even during a black-out, sufficient pressure would be maintained in the fuel supply lines to the engines.

[4] MPa (Megapascal) is a unit of pressure. 1 MPa = 10 bar.

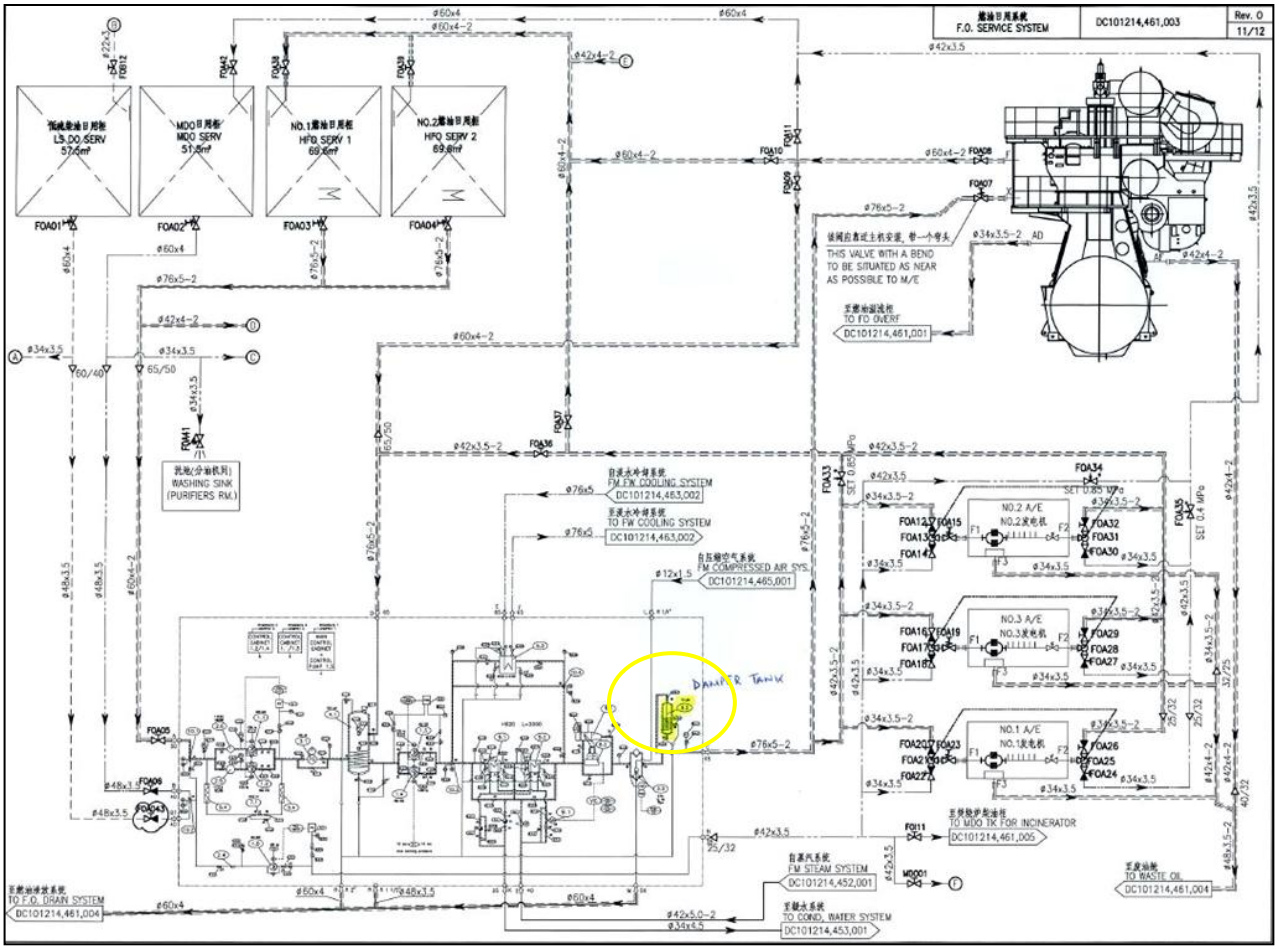

Figure 7: Fuel oil service system, showing the damper tank in yellow

The tank was fitted with a fuel inlet valve, a fuel outlet valve and an aerating valve, as shown in Figure 8.

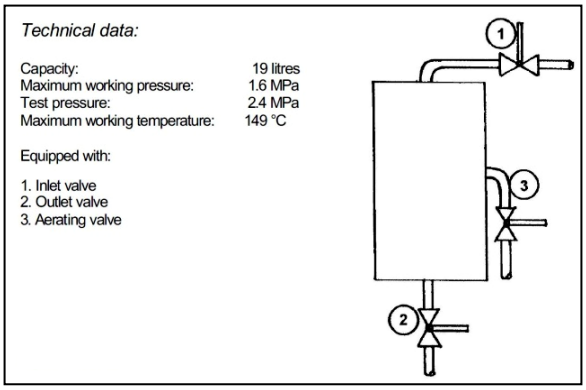

Figure 8: Side elevation of the compensation damping tank

In order to ensure perfect operation of the compensation damping tank, the manufacturers had recommended that the fuel should be drained out about every 14 days, so that the air cushion could be built up to 100% again[5]. It was not necessary for the engines to be stopped to carry out this procedure.

[5] This necessitated that the inlet valve is closed, and the outlet and the aerating valves are opened slowly. Once fuel stops flowing, both the outlet and the aerating valves had to be closed, followed by the gradual opening of the fuel inlet valve.

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.

Cause of main power supply failure

Regulation 41 of Chapter II-1 of SOLAS[6], as amended, requires a vessel, to which the Convention applies, to be provided with at least two generating sets to provide the vessel with a main source of electrical power. The capacity of each of these generating sets has to be sufficient to supply the vessel with services necessary to provide normal operational conditions of propulsion and safety, as well as minimum comfortable conditions of habitability.

As mentioned in the narrative section of this safety investigation report, A/E no. 3 tripped only after two auxiliary blowers and two hydraulic power supply units automatically started, which added load onto A/E no. 3. Until that moment, A/E no. 3 was stated to have been operating satisfactorily, supplying the vessel with the necessary services.

The safety investigation could not ascertain the cause of the lubricating oil low pressure alarm which triggered the main engine slowdown. Checks by the crew members on the pumps, motors, filters and pipelines did not reveal any abnormalities; and once A/E no. 3 and A/E no. 1 were put back into operation, the alarm did not activate again.

Operational availability of another A/E

Regulation 41 of SOLAS Chapter II-1 also requires that with any one generator out of operation, the remaining generators are capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition.

A Safety Construction renewal survey, which was completed on 30 January 2019, was satisfactorily carried out by the Classification Society on behalf of the ship's flag State Administration. A/E no. 2 was out of service due to the events that occurred on 20 February. The crew members had uninstalled the lubricating oil pump from A/E no. 1 and were yet to install it on A/E no. 2 as planned, when A/E no. 3 tripped.

The intention and action to put A/E no. 1 out of service, even if for a short period of time and knowing that A/E no. 2 was already out of service, suggested that the risks associated with these actions were accepted by the crew members. However, no record of the assessments of these risks was found on board.

Compensation damping tank not maintained charged

As mentioned in the narrative section of this report, the crew members noticed that A/E no. 1 and A/E no. 3 were turning on air, but there were no signs of combustion in any of the cylinders of the A/Es. This was due to insufficient fuel oil pressure in the lines. Had the compensation damping tank been kept charged in accordance with the manufacturers' instructions, sufficient HFO pressure would have been available for A/E no. 1 or A/E no. 3 to be restarted.

During the course of the safety investigation, it transpired that none of the engineer officers aware of the manufacturers' instructions (that the compensation damping tank had to be kept charged). Moreover, this procedure had not been incorporated into the vessel's planned maintenance system. The lack of awareness was evident through the actions of the crew members, whereby they recalibrated the fuel injection valves of

[6] The International Convention for the Safety of Life at Sea, 1974, as amended.

A/E no. 1 and replaced the valve nozzles of two of its cylinders, following which, there were of a number of unsuccessful attempts made to restart the A/Es.

Their attention was not drawn towards the compensation damping tank, until identified during the investigation by the Company and the service technicians. This suggested that the vessel's safety management system did not particularly specify the matter.

Line-up of the compressed air system

Once the main and auxiliary air reservoirs were completely drained, the crew members were unable to top up the auxiliary air reservoir. About three hours were lost until it was confirmed that the drain valve of the auxiliary air reservoir was partly open, causing a continuous air leak.

Considering the unfolding events on that day, the attention of the crew members would, in all probability, have been drawn towards failure of equipment rather than confirming the familiar, standard line-up of the systems and their respective physical status.

This probability could be drawn up from the fact that the crew members replaced the low pressure and high pressure valves on the emergency air compressor in an attempt to rectify the problem (which is quite laborious), before checking the physical status of the valves of the auxiliary air reservoir.

Complete failure of A/E no. 2

Within 10 minutes of starting A/E no. 2, it sustained damages which rendered it out of service. Investigation by the Company and the service technicians suggested a defect in the connecting rod bolt of cylinder no. 1.

Complete failure of the emergency generator

Nearly after 12 hours of continuous running, two belts of its fan broke. The condition of the belts (Figure 9) revealed that it had sustained severe wear which, in the opinion of the safety investigation, could not have occurred during this period of twelve hours.

Figure 9: Broken belts of the emergency generator fan

In order to verify the condition of these belts, one would have to remove them from the assembly and flip them over. A visual inspection from above would be inadequate to verify its physical condition and the severity of the cracks. Although this generator was subjected to weekly checks and tests, the last one carried out was about five days before the occurrence; however, there was no available information to indicate that the condition of the belts was verified during the checks.

Bearing in mind that this generator had only run for about 53 hours, it was highly likely that checks on the condition of the belts were either missed or deemed unnecessary by the

crew members. Moreover, the procedures contained in the vessel's safety management system manual did not specify checks on the condition of the belts.

The damages to the running gear were attributed to the generator being operated with a leaking radiator, which would have compromised the cooling of the engine.

Inability to start A/E no. 1 and A/E no. 3 on LSMGO

The unmanned machinery space (UMS) checklist, contained in the vessel's SMS manual, required that all bunker fuel tanks were to be drained from water at the time of taking over engine-room watches at sea.

Upon *Leopold LD*'s arrival at Freetown, the drain lines of the MDO and the LSMGO service tanks were found blanked. On the removal of these blanks, water came out. Water was identified as the reason why A/E no. 1 and A/E no. 3 could not be started on LSMGO by the service technicians, even after flushing the system with LSMGO, as well as after overhauling the fuel pumps and fuel valves of these A/Es.

The safety investigation found no records of these blanks being installed, and the crew on board were unable to clarify this matter either and were unaware of the blanks. It would also appear that the crew members received no cues which would have alerted them to question the absence of water from the drains, whenever these were opened[7].

[7] It is expected that water is present in fuel oil tanks and it is also a normal practice that the tanks are drained at least twice every watch.

CONCLUSIONS

1. The failure to start the A/E following the black was attributed to an inadequately charged fuel oil compensation damping tank;
2. The crew members were neither familiar with, nor aware of the correct operation of the compensation damping tank;
3. The crew members accepted the risks involved with having two out of three generators out of service while only one was operating on full load;
4. Time was lost due to a missed, open drain valve in the compressed air system;
5. The condition of the Vee belts on the emergency generator was compromised with cracks in the material;
6. Water was present in the fuel lines of A/E no. 1 and A/E no. 3;
7. Water could not be drained from the fuel tanks because of blocked drains.

SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION[8]

During the course of the safety investigation, the Company has taken the following safety actions:

- The SMS has been amended and the maintenance schedule for the radiator fan belt has been reduced to six months from the 12 month interval. The second engineer (Senior Engineer) is now assigned to this critical job;
- A 14-day routine to drain the fuel and ensure build-up of 100% air cushion has been added in the vessel's PMS and included in the ship-specific familiarization checklist.

[8] **Safety actions shall not create a presumption of blame and / or liability.**

SHIP PARTICULARS

Vessel Name:	*Leopold LD*
Flag:	Malta
Classification Society:	Bureau Veritas
IMO Number / Official Number:	9617519
Type:	Bulk Carrier
Registered Owner:	Caroline 29 SAS
Managers:	Anglo-Eastern Ship Management Ltd.
Construction:	Steel
Length Overall:	292.0 m
Registered Length:	286.66 m
Gross Tonnage:	93,801
Minimum Safe Manning:	16
Authorised Cargo:	N/A

VOYAGE PARTICULARS

Port of Departure:	Saldanha Bay, South Africa
Port of Arrival:	Hamburg, Germany
Type of Voyage:	International
Cargo Information:	Iron Ore
Manning:	21

MARINE OCCURRENCE INFORMATION

Date and Time:	14 March 2019 – 1527 LT
Classification of Occurrence:	Serious Marine Casualty
Location of Occurrence:	06°08.58’ N 014°40.65’ W
Place on Board	Engine Room
Injuries / Fatalities:	None
Damage / Environmental Impact:	Material damages to one auxiliary engine and the emergency generator.
Ship Operation:	In passage
Voyage Segment:	In transit
External & Internal Environment:	Weather: Clear. Visibility: 10 miles. Wind: Beaufort Force 1. Sea State: Calm. Swell: 3 m.
Persons on board:	5