Marine Safety Investigation Unit

Transport Malta

SAFETY INVESTIGATION REPORT

201605/016 REPORT NO.: 10/2017 May 2017

MV *Delfini*
Burn injuries to two persons at Sliema Ferries, Sliema 20 May 2016

SUMMARY

Two motor mechanics, from the Company's workshop were sent on board MV *Delfini* to investigate an engine problem reported by the vessel's skipper and engine driver. Work was necessary on the port main engine to identify and eliminate the exhaust white smoke, which was being emitted by the engine under load conditions.

The mechanics dismantled the port main engine turbocharger and exhaust manifold as they suspected that the problem was caused by faulty injector(s) on either one or more of the units.

To troubleshoot the faulty fuel injector valve(s), the engine was started on idle speed with these parts removed.

In the process, one of the two mechanics suffered severe burns to his face, hands and chest, while his colleague sustained a superficial injury to his forehead, caused by the explosion and fire that escaped from the engine exhaust ports.

The MSIU has issued two recommendations to the Company, designed to ensure that a shipboard planned maintenance regime is safely implemented.

MV *Delfini*

FACTUAL INFORMATION

Vessel

MV *Delfini* is a 160.56 gross tonnage, steel passenger vessel with an overall length of 25.97 m, main beam of 7.41 m and depth of 2.51 m. The vessel is registered under the Maltese flag. *Delfini* berths stern-to at Sliema Ferries in Sliema (Figure 1).

Delfini is a twin screw vessel, propelled by two 1996 Cummins MT855-M 14L six-cylinder, turbocharged, internal combustion diesel engines, developing a total of 448 kW of shaft power at 1900 rpm.

The vessel is licensed to operate within three nautical miles from land and not more than three nautical miles from a place of refuge in favourable weather. In calm weather and up to Beaufort Scale Force 4, *Delfini* is authorised to carry 256 passengers.

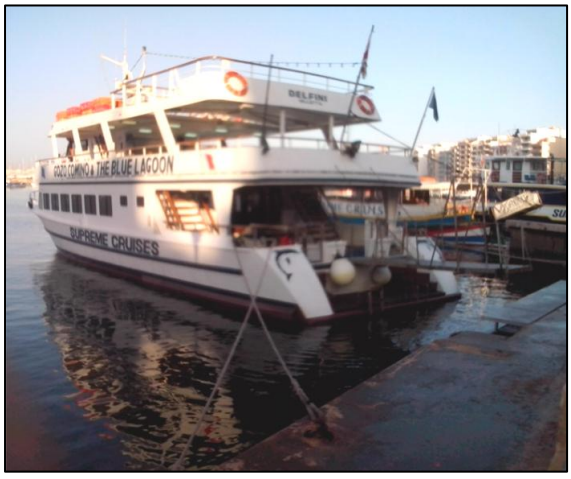

Figure 1: *Delfini* moored stern-to

Manning levels

The minimum manning level of the vessel is four crew members and includes one skipper and three general purpose hands (GPH). One of the three GPHs is required to hold an Engine Driver Grade 3 Certificate. Any person serving as a skipper has to be a holder of a Boatskipper Grade 1 Certificate of Competency. The Minimum Safe Manning Document was issued by the Ports and Yachting Directorate of the Authority for Transport in Malta in accordance with the relevant local commercial vessels regulations.

The minimum qualifications and level of competency for persons serving on commercial vessels operating within ports, internal and territorial waters of Malta is provided in the Training and Certification Guidance Document issued by the Ports and Yachting Directorate. The operational skills and knowledge required for obtaining a Certificate of Competency to serve on commercial vessels are different from those prescribed in the STCW requirements[1].

The engine driver was the only person in charge of the engine-room and machinery spaces upkeep. He carried out basic routine maintenance, including oil changes, disposable fuel and lubrication oil filter changes, and drive belts adjustment / replacement. Shore assistance (from the Company) had to be requested if any other preventive or repair maintenance was required; more so if no spare parts were available on board.

At the time of the accident, six persons were on board *Delfini* including the skipper, two GPHs, the engine driver and two shore-based maintenance personnel. At the time of the accident, the engine driver and the two shore-based maintenance personnel were in the engine-room.

Environment

The wind was North Northwest, force 6, and the sea state was calm inside the sheltered area. Weather was reported clear with an air temperature of 19 °C.

[1] A Certificate of Competency (for a seafarer employed on a vessel with a Commercial Vessel Certificate) issued by the Authority under the Commercial Vessel Regulations, is a qualification limited to service on commercial vessels operating in Maltese ports, inland and territorial waters as defined in the Authority for Transport in Malta Act.

Narrative

Due to the bad weather forecast announced earlier during the week, the day cruise around the Maltese islands for Friday 20 May 2016 had to be cancelled in advance. The Company had informed the skipper that a maintenance programme would instead be scheduled, since the vessel was to remain berthed throughout the entire day.

Several days earlier, the skipper and the engine driver had informed their Technical Manager that the port main engine had a combustion problem and white exhaust smoke was being emitted. It was also noticed that when the load on the engine was increased, the white smoke would become denser. Taking advantage of the trip cancellation, the Technical Manager decided to deploy two shore-based mechanics from the Company's Servicing Department to look into the problem.

On the day, the two mechanics arrived early on board and were ready to start their work by 0700. They had been advised by their Technical Manager that the main issue might be defective fuel injectors. The Technical Manager had previously encountered this problem on Cummins engines and according to him, white smoke was the result of faulty fuel injector(s). The mechanics brought with them four reconditioned fuel injectors, which had been previously dispatched to an approved Cummins servicing station abroad for inspection, testing and calibration.

Before commencing the work, the engine driver started one of the two Cummins 4-cylinder diesel generators to provide electrical power on board[2].

Information provided to the MSIU indicated that the mechanics had been instructed to dismantle the exhaust manifold, turbocharger, and associated ancillary equipment (Figure 3), momentarily start the offending engine on idle speed, and try to identify the problematic unit(s) by observing the exhaust coming from each individual cylinder head exhaust port. It appeared that this procedure was commonly used by the Company to identify faulty fuel injectors.

The engine driver was not continuously in attendance to assist the mechanics while they were working on the main engine since he had other tasks to attend. However, he provided the necessary support when requested. By 0830, the exhaust manifold had been dismantled and the exhaust ports were exposed.

After a short break, the mechanics, together with the skipper and engine driver, went down to the engine-room to discuss the way forward. Since the starting arrangement did not allow for the diesel engine to be started locally, the skipper had to start the main engine from the bridge. It was agreed that the engine driver was to stay on the air intake side forward, ready to stop the engine manually as soon as it picks up and before reaching idling speed.

Accessibility around the engine-room was very restricted (Figure 4) and it was therefore necessary for the two mechanics to stay very close to the port main engine during the starting operation.

Figure 3: Dismantled exhaust manifold, turbocharger and exposed exhaust ports

[2] The vessel is completely shut down for the night after returning from the day cruise.

Figure 4: Restricted accessibility around the port main engine

It was also agreed that one of the mechanics had to position himself on the starboard side, aft of the engine, while the younger mechanic had to stand adjacent to the exhaust cylinder head exhaust ports and at the same time use his mobile phone to record the starting of the engine. Both mechanics were to observe the smoke from the cylinder head (exposed) exhaust ports, hoping to identify the faulty fuel injector(s) on the basis of the exhaust emitted through the exhaust ports. They also hoped that the recording on the mobile phone would assist them in their diagnosis.

By 0900, all the preparations were concluded and the skipper went on the bridge to start the port main engine. Upon starting, flames immediately escaped from a number of exhaust ports, injuring the younger mechanic who was in the way to record the procedure as it had been previously agreed.

On seeing this, the engine driver stopped the engine by manually tripping the fuel pump shut off valve. The smoke from the exhaust ports triggered the smoke detector and activated the engine-room fire alarm.

Post-accident events

The fire alarm alerted the skipper, who left the bridge and proceeded to the bridge deck aft, from where he saw the engine driver running ashore (for assistance and to call an ambulance). The skipper hurriedly went to the main deck to investigate further what had happened.

By then, both mechanics had walked out of the engine-room unassisted. The skipper remained with the two injured persons until the ambulance arrived and took them to the hospital.

The skipper observed that the younger mechanic, who was not wearing a top, had his hands, abdominal area and face burnt, although at the time, his injuries were not considered to be very serious. He was not complaining of particular severe pain. His colleague had minor scald injuries on his forehead.

No structural or visible damages to the engine-room and / or equipment inside the compartment had been noticed and reported by the crew.

During the afternoon of the same day, a similar attempt on the port main engine was made in the presence of the Technical Manager. Fuel injectors on nos. 5 and 6 units were replaced. The port main engine was re-assembled and tested. It was confirmed that the white exhaust smoke problem had been resolved.

Delfini resumed its daily cruise itinerary on Sunday 22 May 2016. Both injured persons were eventually discharged from hospital after making a full recovery.

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.

Fuel injectors - performance and diagnosis

The Technical Manager had assumed that the white smoke released with the exhaust was the result of faulty fuel injector(s) on the port main engine. This assumption could be both professionally and technically correct (in, fact, the replacement of two fuel injectors solved the issue of white smoke).

As with regards to the accident, the MSIU was of the opinion that when the engine was stopped for the night, the faulty fuel injector/s may have leaked minute droplets of fuel onto the piston crown. When the engine was started the following morning (with the exhaust manifold and turbocharger removed), the (accumulated) fuel late ignition escaped through the exhaust ports producing an after-burning flame that injured the two shore-based maintenance personnel.

The fact that the engine driver reported a 'knock' during starting on previous occasions, when the engine was emitting white smoke, could also have been an indication of the same problem.

This detail was missed during the initial preparations for the overhaul and eventual start up of the main engine.

During the initial stages of the safety investigation, the MSIU identified a number of alternative methods which could have been employed to identify the offending faulty fuel injector(s). The easiest method, without dismantling the engine, was to replace a number of injectors at a time and test the engine to verify the exhaust gases.

Another method, which possibly required specialised equipment, was to isolate one cylinder at a time by shutting off the fuel to each fuel injector and again verify the condition of the exhaust gases.

Planned maintenance system

There was no preventive planned maintenance system for the engine-room machinery. Available evidence indicated that the manufacturer's recommended maintenance schedule for the port and starboard Cummins main engines was not followed. No records were kept of the running hours of the engine components to determine when such components had to be inspected, tested or overhauled. The maintenance policy on board was based on breakdown maintenance and / or when the machinery was judged to be operating outside its parameters.

Shore assistance and support

The Company operates a fleet of mini buses and coaches, a number of which are also fitted with Cummins engines. A team of mechanics are employed at the Company's servicing depot, *inter alia*, carrying out maintenance and repairs on motor vehicle engines. The same team members are also tasked to provide support to the Company's vessels, including *Delfini*.

The Company did not provide Cummins engine specific training courses to its mechanics. Experience was gained from their colleagues and practice along the years. Moreover, the operation and maintenance manual for the Cummins main engines was not available on board *Delfini* and the mechanics were unable to avail themselves of the engine maker's guidance.

Safe working practices

At the time of boarding, the two shore-based mechanics were wearing personal protective equipment. The safety investigation revealed

that while working in the engine-room, the younger mechanic had taken off his top. This reduced the protection which would have otherwise limited the extent of injuries when the port main engine was started (with the exhaust manifold removed).

No responsible person had been designated in charge of the maintenance work that was to be performed on the port main engine. Moreover, no risk assessment was carried out to identify any risks that could be encountered during the work on the port main engine.

Acceptance of risk

The practice of removing the exhaust manifold and turbocharger and start the engine is dangerous and not a recommended maintenance practice. Notwithstanding, the no alternative measures were adopted.

The risks associated with the actual actions taken by the two shore-based maintenance personnel were either accepted or not understood. The safety investigation is of the view that there were various reasons behind this.

As indicated elsewhere in this safety investigation report, the dismantling of the exhaust manifold to identify an offending fuel injector was not a one-off for the Company. The MSIU's understanding was that this practice had always worked and there was actually no reason why the procedure should have failed this time.

The Company's shore-based maintenance personnel had no idea which of the injector(s) was faulty, even because there was no planned maintenance to which they could refer in terms of running hours. Moreover, they only had four reconditioned fuel injectors and therefore they would have been unable to replace the entire set.

As much as it was a valid technical option, the shutting down of each cylinder was not deemed to be possible from a practical perspective, given that the necessary equipment / resources were either not available or not made available to the mechanics working on board.

The MSIU believes that the personnel involved were convinced that the removal of the exhaust manifold would have provided an immediate indication as to which of the six was the offending fuel injector(s). The decision to overhaul the exhaust manifold was therefore based on a rational decision and was seen and considered to be a reasonable option to solve the problem with the main engine.

CONCLUSIONS

1. When the engine was stopped for the night, the faulty fuel injector(s) may have leaked minute droplets of fuel onto the piston crown.
2. When the engine was started, the following morning (with the exhaust manifold and turbocharger removed), the fuel late ignition escaped through the exhaust ports, producing an afterburning flame that injured the mechanic.
3. There was no planned preventive maintenance system for the engine-room machinery.
4. The Company did not provide Cummins engine specific training courses to its mechanics.
5. The operation and maintenance manual for the Cummins main engines was not available on board *Delfini.*
6. While working in the engine-room, the younger mechanic had taken off his top, thereby compromising his protection.

7. No responsible person had been designated in charge of the maintenance work that was to be performed on the port main engine.
8. No risk assessment was carried out to identify any risks that could be encountered during the work on the port main engine.
9. The dismantling of the exhaust manifold to identify an offending fuel injector was not a new procedure to the Company.
10. The risks associated with the actual actions taken by the two shore-based maintenance personnel were either accepted or not understood.
11. The shutting down of each cylinder was not deemed to be possible from a practical perspective, given that the necessary equipment / resources were either not available or not made available to the shore-based maintenance personnel working on board.
12. The personnel involved were convinced that the removal of the exhaust manifold would have provided an immediate indication as to which was the offending fuel injector.
13. The decision to overhaul the exhaust manifold was therefore based on a rational decision and was seen as a reasonable option to solve the problem with the main engine.

RECOMMENDATIONS

Supreme Travel Ltd. is recommended to adopt and implement:

10/2017_R1 a planned maintenance regime on all Company operated vessels, in accordance with recommended maintenance schedules.

10/2017_R2 a health and safety policy to ensure that all Company employees implement relevant procedures.

SHIP PARTICULARS

Vessel Name:	*Delfini*
Flag:	Malta
Classification Society:	Not applicable
IMO Number:	Not applicable
Type:	Passenger ship
Registered Owner:	Supreme Travel Ltd.
Managers:	Supreme Travel Ltd.
Construction:	Steel
Length Overall:	25.97 m
Registered Length:	25.97 m
Gross Tonnage:	160.56
Minimum Safe Manning:	4
Authorised Cargo:	Not applicable

VOYAGE PARTICULARS

Port of Departure:	Sliema, Malta
Port of Arrival:	Sliema, Malta
Type of Voyage:	Coastal
Cargo Information:	Not applicable
Manning:	4

MARINE OCCURRENCE INFORMATION

Date and Time:	20 May 2016 at 0900
Classification of Occurrence:	Serious Marine Casualty
Location of Occurrence:	Sliema, Malta
Place on Board	Engine-room
Injuries / Fatalities:	Two injured, one seriously
Damage / Environmental Impact:	None
Ship Operation:	Moored
Voyage Segment:	Arrival
External & Internal Environment:	North Northwesterly winds, force 6, and calm sea. Clear weather with an air temperature of 19 °C
Persons on board:	6