SAFETY INVESTIGATION REPORT

201306/022

REPORT NO.: 17/2014

June 2014

**MV Zenith**

Fire in the engine-room
in position 45° 11.7’N 012° 41.9’E
25 June 2013

**SUMMARY**

On 25 June 2013, at 0335, the fire alarm sounded in the engine-room of the Maltese registered passenger ship *Zenith*. Upon investigation, a fire was noticed on the starboard father main engine.

The seat of the fire was between the turbocharger and cylinder head no. 1. Immediate actions were taken by the crew members to contain the fire and ensure the safety of all persons on board.

The safety investigation identified that the immediate cause of the fire was the fracture of a low carbon steel pipe on a fuel damping cylinder assembly on the starboard father main engine.

This fracture led to the release of gas oil, at a pressure of about 6 bars, which sprayed on an exposed high temperature area of the main engine exhaust gas manifold.

The MSIU has issued one recommendation to the Company intended to enhance the vessel’s maintenance regime vis-à-vis all the critical equipment installed in the machinery spaces.
FACTUAL INFORMATION

Vessel
Zenith is a Maltese registered passenger ship, owned by Pullmantur Cruises Zenith Ltd. and managed by Pullmantur Cruises Ship Management Ltd. of Spain. The vessel was built by Jos L Meyer GmbH & Co. in Papenburg, Germany in 1993 and is classed by Germanischer Lloyd.

Zenith has 13 decks and a length overall of 208.0 m, a moulded breadth of 29.0 m and a moulded depth of 24.10 m. The vessel has a gross tonnage of 47413, a summer draught of 7.7 m and a summer deadweight of 54008.

Propulsive power is provided by four medium speed diesel main engines, arranged in a father and son configuration, driving two CP propellers at 130 rpm, through flexible couplings and a single reduction tandem gearbox. The vessel’s service speed is about 21 knots.

Engine-room configuration
The propulsion installation on Zenith consists of four main engines, a father and son arrangement on the port and starboard sides in compartment no. 10 at deck level no. 0. The auxiliary diesel generator sets are housed aft of this compartment, in compartment no. 11. The main air compressors are fitted in compartment no. 9, forward of the main engines (Figure 1).

Figure 1: Machinery spaces
Weather
The wind was Northeasterly, force 1, and the sea state was calm from the Northwest. Air temperature was recorded at 18°C and the sea temperature was 23°C.

Narrative
On the night of 24 June 2013, Zenith was on a Mediterranean cruise and had left Ravenna, Italy heading to Venice, Italy. Her ETA in Venice was 0530 (UTC+1) on 25 June. The vessel had 1672 passengers and 600 crew members on board.

For the departure from Ravenna, all four main engines were started and used during the manoeuvres. However, after full away on passage was announced, the port and starboard son main engines were stopped. During the sea passage, two generators were left running to cater for the ship’s propulsion and hotel services.

On 25 June 2013 at 0335, the fire alarm sounded in the engine-room. At the time, the duty engine-room personnel were preparing for the end of their watch and the hand-over to the following watch. The 0000-0400 watch arrangement consisted of the second engineer, the third engineer and two motormen. The second engineer was filling the engine-room logbook and the third engineer, with the motormen, were making the final checks around the machinery spaces.

CCTV cameras indicated that a fire had started on the starboard father main engine, on the entablature around no. 1 cylinder head, exhaust manifold, and the turbocharger (Figures 2 and 3). Video footage available revealed that within minutes, the fire spread around the aft end of the main engine, rising up to the exhaust trunking, the underside of deck no. 1 and the area above deck no. 1, over the starboard father main engine.

On seeing this, the starboard main engine was remotely shut down, the pitch on the port main engine reduced and the ventilation fans and booster pumps stopped.

In the meantime, the general alarm was raised and passengers were led to their mustering stations. An urgency signal (PAN PAN) was transmitted to all the traffic in the area. The Office of the Harbour Master of Venice was also contacted. Noting the favourable weather conditions, traffic situation, water depth, and the vessel’s
reduction in speed, the master dropped the starboard anchor.

Immediate action was taken by the engineering officers of the watch and the watch ratings who were assisted by the fire parties sent to the engine-room. Despite the release of the water hi-fog fixed system and the fire parties’ attempts to suppress the flames with portable fire extinguishers and fire hoses, the fire intensified and spread above and around the main engine.

The master ordered all fire parties to evacuate the compartment. The area was sealed and isolated by shutting down electrical equipment and the settling and service quick closing valves. At 0355, after verifying that all crew members were accounted for, the chief engineer was ordered by the master to release the FM-200.1

The fire was successfully extinguished although small secondary fires re-ignited and were controlled by the fire parties watching decks nos. 0, 1, and 2 within the main engine-room space (Figure 4). By 0523, the assessment party confirmed that the fire in the engine-room was extinguished. 50 FM-200 cylinders were used during the fire fighting operation.

Post-fire events and damage assessments

Although the duration of the fire was short, the damage sustained was extensive. Machinery in the proximity of the fire, pipe work, cables, insulation and distribution switchboards at deck levels nos. 0 and 1 were damaged.

Arcing was observed on the bow thruster no. 2 circuit breaker on the main switchboard. Low insulation resistance was also measured on the generators and feeder cables. Consequently, at 0508, the chief engineer informed the master that he had to shut down the main generators to eliminate a fire hazard on the main switchboard.

The generators were shut down remotely by pressing their emergency stop buttons. The emergency generator started automatically and lights were restored on board.

As part of the assessment, the chief engineer decided to split the main busbars in two sections. The starboard side of the main switchboard was isolated, permitting the chief engineer to start the port side main generator and feed the port side part of the main switchboard.

![Figure 4: Zenith’s 13 decks](image)

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1 FM-200 extinguishes fire through a combination of chemical and physical mechanisms. The system is waterless and the extinguishing agent is stored as a liquid in pressurised cylinders. When discharged, liquid flows through the piping into the protected area and vaporises. The extinguishing agent is a hydrofluorocarbon (HFC).

2 During the final stages of the fire fighting operation, the lighting was noted to dim several times. A circuit breaker on the main switchboard located in compartment no. 10 on deck no. 3 had been damaged and the breaker contacts were ‘making and breaking,’ causing smoke and arcing.
The engineering officers also discovered that the prime mover of the port generator could not be started by compressed air. As a result of the fire, the compressed air in the main air receivers was lost. Moreover, the main air compressors could not be started due to damage to the air compressor control system. Taking emergency measures and by improvising, the chief engineer succeeded in raising the air pressure in the receivers to 17 bars, but still was unable to start the port generator.

At the same time, the emergency generator which was still running, started to overheat due to lack of cooling water and had to be stopped at 1025. At this stage, the vessel had no power. After the blackout, the chief engineer again attempted to raise the air pressure, using the small emergency air compressor, in the hope to start and run the port generator and restore the main power supply on board. His efforts, however, were futile.

**Towage to Venice and Trieste**

On deck, the crew members were also very much engaged in mitigating the situation. Shore fire-fighters had arrived on board at 0639. Various announcements in different languages were made on the PA System to keep the passengers informed of developments. By 0645, all passengers had been accounted for. Tug assistance was available at around 0739. Passengers were kept on open decks nos. 8 and 11 due to the blackout and smoke inside the accommodation.

Since the vessel had no power, the starboard side anchor chain could not be heaved up. The anchor chain had to be burnt and was released in the sea at 1645, permitting the vessel to be towed to Porto Marghera. The chain was connected to a marker before being released, where it was retrieved later and fitted back on board.

**Zenith** was at anchor about 17 nautical miles off the coast of Venice. She was towed by four tugboats to Porto Marghera and arrived safely alongside at 0052 on 26 June 2013. Passengers’ disembarkation commenced at 0116.

Following the necessary surveys over the following hours, the flag State Administration authorised the towage of the vessel to a shipyard in Trieste in order to carry out the necessary permanent repairs.

**Fuel damping unit**

The fuel damping unit consisted of two steel pipes and a damping cylinder. The inlet pipe to the damping cylinder had one end of the pipe connected to the fuel manifold branch socket on the main engine. The other end was tightened to the damping cylinder. The damping cylinder was fastened to the backside of the charge air cooler by a single bracket. The (fractured) outlet pipe connected the damping cylinder to the fuel oil pressure gauge on the main engine instrumentation panel. A T-connection was used to assemble the pipe to the damping cylinder. One side of the T-connection had been blanked off (Figure 5).

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**Figure 5: Fuel damping unit**
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.

Immediate cause of the fire
An inspection of the area in close proximity of the fire seat revealed that the fire was caused by the fracture of a low carbon steel pipe on the starboard father main engine’s damping cylinder. The damping cylinder formed part of the low pressure fuel line supply to the fuel gauge on the main engine instrumentation panel.

The fuel pipe had fractured from the outlet connection of the damping cylinder close to the union nut that formed part of a T-connection (Figures 6a and 6b). This fracture led to the release of gas oil, at a pressure of about 6 bars, which sprayed to an area between the cylinder head of unit no. 1 and the turbocharger casing. The gas oil came in contact with the exposed hot surface of the unshielded part of the exhaust manifold and ignited (Figures 7a and 7b).
Destructive and non-destructive analysis
Metallurgical examinations of the fractured pipe, which was sent for analysis, revealed that the failure was caused by fatigue. Fatigue is a phenomenon, which occurs when a material is subjected to repeated cyclic stresses, the magnitude of which is below the strength of the material and generally insufficient to lead to permanent deformation or yield of the material.

The laboratory analysis revealed that the region of the fracture surface (Figure 8 - white arrow) was generally flatter and smoother and was therefore a probable fracture origin.

The complementary fracture surface to Figure 8 (and the probable region of failure origin) is indicated by the white arrow in Figure 9. The yellow arrows indicate part of the surface of the pipe between the fracture surface and the olive, which suggests evidence of rubbing contact with another object. This was almost certainly the bore of the union nut.

In fact, photomicrographs of the micro-section mentioned referred to above (Figure 10) concluded that the material structure showed no significant deformation to the grain structure of the (low carbon steel) material.

Figure 8: Probable origin of fracture (white arrow)

Figure 9: Evidence of rubbing contact

Figure 10: Montage of photomicrographs of the micro-section (the white arrows indicate direction of fracture development of the fatigue mechanism)
If a material is subjected to loading and unloading cycles, which exceed a threshold limit for that material, incipient fatigue cracks start to develop. The cracks will increase in length with further loading until eventually a fatigue crack reaches a critical size that is sufficient to allow the material to fracture in response to a single cyclic load even though the same material had withstood millions of the same reversal loads previously.

The laboratory analysis concluded that the initiation of the fatigue fracture probably occurred relatively close to the time of the fire (i.e. weeks or months rather than years). It is possible that the damping cylinder support had either become loose when refitting the tank after a recent maintenance work or the bracket had progressively loosened with time. It was also possible that a long term loosening of the damping cylinder promoted localised contact between the T-connection and the union as the pipe displayed evidence of rubbing at the probable point of origin of the fracture.

### Technical instructions

A Circular Letter issued in February 2001 by the engine manufacture warned against the potential fire risk on L 40/45 engines due to pressure gauge pipe leakages. The manufacturer had recommended installing “a valve which closes automatically in the case of flow” between the ball cock on the fuel manifold and the pressure gauge pipe. This valve would shut automatically and prevent the flow of fuel under pressure to be sprayed at a pressure on the main engine, should a fracture on the pipe leading to the manometer occur.

Although fitted (Figure 5), such an arrangement did not work on the starboard father main engine. Upon failure of the pipe, gas oil was sprayed at a pressure on the hot exhaust manifold and ignited since the temperature of the exhaust manifold was above the auto ignition temperature of the gas oil.

### Maintenance management

Components are expected to function reliably. Equally, maintenance regimes are expected to anticipate risks caused by either the technology/equipment itself or on board practices.

It has to be appreciated that the maintenance regime on board a ship (especially a passenger ship) may be extremely complex, even because maintenance is a combination of manual labour and knowledge-intensive work. Even more, temperatures, pressures, flow of liquids, mechanical and electrical power, the design of the equipment, and how these interact with each other, will all culminate in extremely complex maintenance actions.

In view of the abovementioned complexities, it is not an uncommon situation where there are no specific management procedures pertaining to each and every single component fitted in the machinery spaces. This does not mean to say that the SMS Manual did not have in place general procedures requiring the inspection of the machinery spaces. In fact, the Company does have a robust preventive maintenance system for the entire machinery spaces.

The intrinsic safety of a piece of equipment may be related to its design and quality of material. However, its safety after it has been installed is mostly attributed to, *inter alia*, maintenance. Therefore, inadequate maintenance or inability to predict failures of equipment, which may occur throughout its lifespan, is correlated to lack of reliability. In fact, reliability is considered to be a key indicator of maintenance efficiency and efficacy.

Integrity management of equipment and (preventive) maintenance are related. Actually, integrity management is a process, which starts from the design to the discarding of the equipment after its lifespan would have expired; preventive maintenance is one important step within the integrity management process.
Therefore, lack of preventive maintenance has the potential to stall the maintenance regime adopted on board, endanger the ship and persons, and necessitate the switch from preventive maintenance to breakdown maintenance, which is not necessarily an optimal and/or possible situation.

CONCLUSIONS

1. The fire was caused by the fracture of a low carbon steel pipe on the fuel damping cylinder assembly on the starboard father main engine.

2. This fracture led to the release of gas oil, at a pressure of about 6 bars, and sprayed over an exposed high temperature area between the cylinder head of unit no. 1 and the turbocharger casing.

3. Metallurgical examinations of the fractured pipe revealed that the failure was caused by fatigue.

4. It is possible that the damping cylinder support had become loose either when the cylinder was refitted after a recent maintenance work or the bracket progressively loosened with time.

5. A self-closing valve, which was fitted between the ball cock on the fuel manifold and the pressure gauge pipe, did not shut automatically to prevent the flow of fuel under pressure.

6. The Company did not have specific management procedures pertaining to this component, although it does have a robust preventive maintenance system for the entire machinery spaces.

7. The crew’s fast response to control the fire and the frequent announcements on the vessel’s PA System in different languages to inform passengers of relevant developments helped prevent panic and injuries to the passengers.

SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION

Following the fire, the Company has taken the following safety actions on board its ships:

- Ships fitted with hi-fog fixed firefighting systems should ensure that the system is on auto mode at all times;
- Work has been initiated to install a system which would remotely indicate the status of the fuel oil and gas oil quick closing valves;
- The chief engineers’ standing orders require that only one starting air receiver remains open;
- All fuel oil shield protection on board Company ships will be inspected regularly to minimise the possibility of fuel oil leak coming in contact with hot surfaces on the main engine.

RECOMMENDATIONS

Pullmantur Cruises Ship Management Ltd. is recommended to:

17/2014_R1 carry out a risk assessment of the machinery spaces in order to identify critical equipment, with the scope of including such equipment in the vessel’s maintenance regime, taking also into consideration the IMO’s MSC.1/Circ.1321 ‘Guidelines for measures to prevent fires in engine rooms and cargo pump rooms.’

3 Safety actions and recommendations should not create a presumption of blame and/or liability.
SHIP PARTICULARS

Vessel Name: Zenith
Flag: Malta
Classification Society: Germanischer Lloyd
IMO Number: 8918136
Type: Passenger
Registered Owner: Pullmantur Cruises Zenith Ltd.
Managers: Pullmantur Cruises Ship Management Ltd.
Construction: Steel
Length Overall: 208.0 m
Registered Length: 181.64 m
Gross Tonnage: 47413
Minimum Safe Manning: 21
Authorised Cargo: NA

VOYAGE PARTICULARS

Port of Departure: Ravenna, Italy
Port of Arrival: Venice, Italy
Type of Voyage: Coastal
Cargo Information: NA
Manning: 600

MARINE OCCURRENCE INFORMATION

Date and Time: 25 June 2013 at 0335
Classification of Occurrence: Serious Marine Casualty
Location of Occurrence: 45° 11.7'N 012° 41.9'E
Place on Board: Engine-room
Injuries / Fatalities: None
Damage / Environmental Impact: Damage was reported to machinery in the proximity of the fire, pipe work, cables, insulation and distribution switchboards at deck levels 0 and 1.
Ship Operation: On Passage
Voyage Segment: Transit
External & Internal Environment: Northeasterly force 1 wind, and calm seas from the Northwest. Air temperature was recorded at 18°C and the sea temperature was 23°C.
Persons on board: 2272