MARINE SAFETY INVESTIGATION REPORT

Safety investigation into the engine-room fire on board the Maltese registered chemical tanker

USICHEM

about 40 nautical miles off Rhodes Island

on 19 April 2017

201704/023

MARINE SAFETY INVESTIGATION REPORT NO. 09/2018

FINAL

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International Convention on the Safety of Life at Sea, 1974, as amended

ISM Managers – MT Usichem

Master and crew members MT Usichem

MSC.1/Circ.1321 - Guidelines for measures to prevent fires in engine-rooms and cargo pump-rooms (11 June 2009)

MSIU Safety Investigation Reports 06/2014, 16/2016, 07/2017, 22/2017
# GLOSSARY OF TERMS AND ABBREVIATIONS

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<tr>
<td>BS</td>
<td>British Standard</td>
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<tr>
<td>CPP</td>
<td>Controllable pitch propeller</td>
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<td>cSt</td>
<td>Centistokes</td>
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<td>ECR</td>
<td>Engine control room</td>
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<td>FO</td>
<td>Fuel oil</td>
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<tr>
<td>HV</td>
<td>Vickers Pyramid Number</td>
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<tr>
<td>IFO</td>
<td>Intermediate fuel oil</td>
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<tr>
<td>Kgs</td>
<td>Kilograms</td>
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<tr>
<td>LA</td>
<td>Local application</td>
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<tr>
<td>LT</td>
<td>Local time</td>
</tr>
<tr>
<td>Lts</td>
<td>Litres</td>
</tr>
<tr>
<td>MDO / MGO</td>
<td>Marine diesel / gas oil</td>
</tr>
<tr>
<td>m</td>
<td>Metres</td>
</tr>
<tr>
<td>mt</td>
<td>Metric tonnes</td>
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<tr>
<td>PMS</td>
<td>Planned Management Schedule</td>
</tr>
<tr>
<td>QCVs</td>
<td>Quick closing valves</td>
</tr>
<tr>
<td>RPM</td>
<td>Revolutions per minute</td>
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<tr>
<td>SE</td>
<td>Southeast</td>
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<td>SOLAS</td>
<td>International Convention on the Safety of Life at Sea, 1974, as amended</td>
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<td>UMS</td>
<td>Unattended Machinery Space</td>
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SUMMARY

On 19 April 2017, a fire broke out in the engine-room of the Maltese registered chemical tanker Usichem. At the time, the vessel was sailing in a laden condition, about 40 nautical miles off Rhodes Island, on a voyage from Taman, Russia to the port of Sudan, Sudan.

The first crew member to notice the fire on the main engine was the vessel’s electrician and promptly alerted other crew members, although no alarm was activated. The main engine was stopped by the chief engineer, who tried to extinguish the fire with a portable CO₂ fire extinguisher. Eventually, the fire alarm automatically activated at 1030 (LT).

Eventually, the flames and heavy smoke overwhelmed the crew members and the fire was deemed uncontrollable. Consequently, the engine-room was evacuated at 1035 and all crew members mustered on the poop deck. At around 1110, the fire was extinguished using the vessel’s fixed CO₂ system. The vessel was towed to Istanbul, Tuzla to affect permanent repairs.

The immediate cause of the fire was identified to be a spray of fuel oil and diesel oil (IFO / MDO) mixture on the hot turbo charger housing.

As a result of the safety investigation, the Marine Safety Investigation Unit made one recommendation to the Company, aimed at addressing machinery status in cases of power failure and machinery shut down.
1 FACTUAL INFORMATION

1.1 Vessel, Voyage and Marine Casualty Particulars

Name | USICHEM
Flag | Malta
Classification Society | Registro Italiano Navale (RINA)
IMO Number | 9344344
Type | Chemical/Oil Tanker
Registered Owner | USI Shipping Ltd.
Managers | Densa Tanker Isletmeciligi Ltd.
Construction | Steel
Length overall | 119.10 m
Registered Length | 111.90 m
Gross Tonnage | 4,798
Minimum Safe Manning | 11
Authorised Cargo | Liquid in bulk - Class II chemical products

Port of Departure | Taman, Russia
Port of Arrival | Port Sudan, Sudan
Type of Voyage | International
Cargo Information | Sunflower oil (5,930 mt)
Manning | 17

Date and Time | 19 April 2017 at 10:30
Type of Marine Casualty | Serious Marine Casualty
Place on Board | Engine-room
Injuries/Fatalities | Minor, first degree burns of chief engineer
Damage/Environmental Impact | None
Ship Operation | Normal Service – On passage
Voyage Segment | Transit
External & Internal Environment | Daylight and clear sky. Northeasterly sea and Northeasterly, force 3 wind.
Persons on Board | 17
1.2 Description of Vessel

*Usicchem* (Figure 1) is a 4,798 gt, double hull chemical/oil tanker, owned by USI Shipping Ltd. and managed by Densa Tanker Isletmeciligi Ltd. The vessel was built by Selah Shipyard, Turkey in 2005, and is classed with RINA.

The vessel has seven decks, a length overall of 119.10 m, a moulded breadth of 16.9 m and a moulded depth of 8.4 m.

![MT Usicchem](image)

**Figure 1: MT Usicchem**

Propulsive power is provided by an 8-cylinder, four stroke, Caterpillar 8M32C, medium speed turbocharged diesel engine, producing 3,840 kW at 600 rpm. This drives a single controllable pitch propeller (CPP) through a reduction gearbox, to give a service speed of about 14.0 knots.

The engine-room (Figures 2a, 2b and 2c) is on three levels, namely the lower platform, where the main engine, shaft generator and the pumps are fitted, the intermediate platform where the auxiliary engines, steering gear, fuel oil, lubricating oil and fresh water tanks are located and the main deck platform where the engine control room is situated. The auxiliary boilers and the engine-room’s workshop are also located at the main deck platform.
Figure 2a: Engine-room lower platform

Figure 2b: Engine-room intermediate platform

Figure 2c: Engine-room main deck platform
1.3 Main Engine Fuel Oil System

The main engine fitted on board Usichem (Figure 3) was reportedly renewed and therefore not the one originally fitted when the vessel was built. As for all main engines of this size, this main engine operates on intermediate fuel oil (IFO) while the vessel is on sea passage and marine diesel / gas oil (MDO / MGO) during manoeuvring and continuous operation at low rpm.

At sea, the main engine uses IFO at 180 cSt, which is heated to a temperature of between 155 °C and 120 °C.

![Figure 3: Usichem’s main engine side and front elevations](image)

The main engine exhaust manifold is fitted on the port side (flywheel end) and is completely insulated in lagging. The fuel oil (FO) piping system is fitted on the starboard side. The fuel supply lines are connected with the main engine’s main fuel supply piping at the free end and distributed along the main engine’s length. The FO supply system is enclosed behind eight cover plates, one for each cylinder unit. These cover plates are meant to prevent any leakage of FO from coming in contact with the main engine hot parts and to contain any leakages.

The IFO supply cycle for the main engine is of a typical design (Figure 4). From the IFO bunker tank, the preheated fuel is pumped into the settling tanks (HT5 / HT6), where water and impurities are separated from the fuel and drained off. From the settling tanks, the fuel is pumped through a pre-heater (HH3) and into the separators (HS1 / HS2) to purify the fuel.
Before injected in the main engine, the FO is pumped from the separators into the daily IFO service tank (HT1) and to a mixing tank (HT2) using the low pressure fuel pumps (HP1 / HP2). The FO is then pumped through a final pre-heater (HH1 / HH2) using the circulating pumps (HP3 / HP4). Prior to the injectors, the fuel is passed through a final, fine fuel filter/strainer (HF1).

The FO supply line is connected to the return line by means of a connecting pipe, which is fitted in close proximity to unit no. 1 fuel injection pump (at the flywheel
end. The connecting pipe consists of two machined ends which are joined by a small length of pipe, brazed in the respective Banjo body ends.

1.4 Machinery Spaces Fire Fighting Arrangements

The fixed CO$_2$ system\(^1\) covers the following areas:

- engine control room;
- auxiliary boiler room;
- machinery spaces workshop;
- machinery spaces at the main deck level;
- machinery spaces and the separator room at the intermediate deck; and
- machinery spaces at the double bottom level.

In the event of an uncontrollable fire in the engine-room, the CO$_2$ can be manually released, either from the manual controls fitted in the CO$_2$ room, or by operating the respective controls, located in the changing room.

In addition to the high-pressure CO$_2$ system, a fixed water-based LA, (which could be activated either automatically from the engine control room (ECR), or manually from the changing room) is installed in the following areas:

- incinerator room;
- steering gear room;
- separator room;
- machinery spaces; and
- auxiliary boiler room.

\(^1\) The system comprises a central bank of high pressure CO$_2$ bottles.
The engine-room spaces are supplied with the following extinguishers:

- one 6 kgs CO₂ extinguisher;
- six 6 kgs dry powder portable extinguishers;
- two 50 lts foam extinguishers;
- two 50 kgs dry powder extinguishers; and
- one portable foam applicator and hoses.

All fire fighting equipment had been serviced and reported to be in a fully functional condition.

1.5 Crew

The Minimum Safe Manning Certificate issued by the flag State Administration stipulated a crew of 11 persons. At the time of the accident, the vessel was manned in excess of the minimum safe manning requirements.

The majority of the officers were Turkish nationals, except for the third officer, who was Romanian. Ratings were Indian, Georgian and Romanian nationals. The working language on board was English.

The chief engineer had joined Usichem in January 2017. He was 42 years old and had over 26 years of seagoing experience, five years of which as chief engineer. He was employed by the Company with a 9-month contract and was in possession of all the required certificates for his rank.

The second engineer was 33 years old and had 14 years of seagoing experience. He was employed by the Company for a three month period and he also had all the required certificates to serve on board in this rank.
1.6 Environment

The prevailing weather in the area of the accident was fair. The wind was Northeasterly force 3, while the sea was moderate with Northeasterly waves. Visibility was good. The conditions in the engine-room were normal and all the machinery was running within the designed parameters.

1.7 Narrative

Usichem had loaded 5,930 mt of sunflower oil at Port Taman, Russia, bound for Port Sudan, Sudan. The cargo operation had been completed on 14 April 2017.

The voyage was uneventful until the early hours of 19 April. At the time, the vessel was transiting the Southeast Aegean Sea, when the engineering officer of the watch (OOW) noticed a low level alarm in the cooling water header tank. Following a closer inspection and in consultation with the chief engineer and the master, it was decided that the repairs had to be carried out at sea. The repairs, which were necessary due to a water leak on unit no. 5\(^3\), were scheduled to be carried out later during that morning, following the notification and confirmation from the Company, since the main engine had to be stopped.

The preparation for the repairs were commenced as planned. The main engine bunker supply was changed over to MDO at about 0936 and until the system was completely flushed with MDO, the necessary tools were prepared. At this stage, the chief engineer thought of taking the opportunity and while one team disassembled the unit, a separate team replaced the injectors on all the units. The full change over to MDO normally takes about one hour, and therefore this would have allowed enough time for the crew members to make the required preparations for the task.

At 0945, in preparation for the task and after the system was changed over to MDO, the main engine FO high pressure pump covers were removed and placed on the upper platform starboard side. It was reported that when the fuel injection pumps ‘covers were removed, no leakages were visible.

\(^2\) Unless otherwise stated all times are local (UTC +3).

\(^3\) The water leak was observed to originate from between the cylinder head and the cylinder liner.
At around 1030, the electrician, who was moving the control cable of the engine-room’s overhead gantry crane, heard a loud noise coming from the direction of the main engine’s flywheel end. Turning around, he noticed a flame between cylinder heads nos. 1 and 2. He rushed to the ECR, shouting “Fire, Fire,” grabbed a dry-powder portable fire-extinguisher and tried to put out the fire. His efforts, however, were unsuccessful since the fire was spreading out fast. At about this time, *i.e.* 1031, the fire alarm activated automatically.

In the meantime, the chief engineer, who was outside the ECR, heard the electrician’s shouting. He also turned round towards the main engine and noticed a fire propagating from between units nos. 1 and 2. He quickly proceeded to the ECR and shut down the main engine. The fire alarm was also activated at about 1031. The shutting down of the main engine resulted in an automatic blackout since at the time, the switchboard was powered by the shaft generator.

After shutting down the main engine, the chief engineer left the ECR and attempted to extinguish the fire with a portable CO₂ extinguisher. About one minute after the blackout, auxiliary engine no. 2 started automatically. Power was restored, including to the IFO booster pump. The restarting of the booster pump fed more fuel to the fire.

Other crew members present in the machinery spaces attempted to put out the fire with portable CO₂ and dry powder extinguishers. However, due to the smoke and rapid rate of fire dispersion, the efforts to extinguish it were futile, eventually forcing them to evacuate the engine-room.

The fire alarm had also activated on the bridge. The master requested the third mate to proceed to the engine-room and verify the fire alarm. He also sounded the general alarm at around 1034.

Once the machinery space had been evacuated, the chief engineer closed the ventilation system to the engine-room and tripped the quick closing valves (QCVs). The master called the chief engineer to confirm that no crew members were in the machinery space and to have an update on the severity of the fire and the situation inside the engine-room. The chief engineer informed the master that the fire could not
be contained and extinguished by local portable fire extinguishers. The master requested that the QCVs are closed⁴ (Figure 5).

Upon the master’s orders, the crew members mustered on the poop deck for a head count. At around 1038, it was confirmed that all crew members were accounted for. The second mate returned to the bridge and following confirmation from the master, he transmitted a distress at around 1042, which was received by the local (Greek) distress station, Olympia Radio at around 1045. The master also informed the Company by telephone at about 1048. After the engine-room was sealed, the ventilation closed, and a head count confirmed the safety of all crew members, the master authorised the chief engineer to release the fixed CO₂ system⁵.

![Figure 5: One of the QCVs in the closed position](image)

At around 1400, the fire team started taking temperature measurements of the engine-room bulkheads at regular time intervals, using a laser thermometer and wearing protective thermal suits and breathing apparatus. Late at night on the following day, a safety meeting was held with the fire patrol, the salvage master and the ship’s master. The salvage team entered the engine-room to lock the propeller shaft, following which, the compartment was sealed again until she arrived alongside.

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⁴ At this time, the chief engineer had already tripped the QCVs.
⁵ The fixed CO₂ was released at about 1056.
Eventually, the vessel was towed from the area to Istanbul, Tuzla repairs zone. The towing was initiated on 20 April at 1600 and was successfully completed five days later at 0850.

1.8 Damages and Injuries as a Result of the Fire

No injuries were reported except for the chief engineer who, being in close proximity of the fire, suffered minor burns to his face and ears.

Although the engine-room in general sustained smoke damage in various areas (Figure 6), the fire damage was very evident within the proximity of the fire seat (Figure 7). A survey of the engine-room revealed damages to the:

- main engine;
- main engine governor;
- main engine and engine-room cables (Figure 8);
- main engine turbo charger (Figure 9);
- transformers nos. 1 and 2 (Figure 10);
- several smoke and flame detectors (Figure 11); and
- several light fittings (Figure 12).

Figure 6: Smoke damage was evident within the engine-room spaces
Figure 7: Fire damage on the main engine, close to where the fire seat was located

Figure 8: Damaged cables inside the engine-room
Figure 9: Damages to the main engine turbo charger

Figure 10: Damaged transformers located in the engine-room
Figure 11: One of the damaged smoke detectors

Figure 12: Damaged light fittings
During *Usichem*’s stay in the shipyard, extensive repairs were carried out, including:

- repairs to the damages listed above;
- renewal of the main engine and crank pin bearings;
- main engine fuel pumps’ barrels and plungers; and
- all pistons’ rings.
2 ANALYSES

2.1 Purpose

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

2.2 Immediate cause of the fire

Physical evidence from the fire seat suggested that the immediate cause of the fire was pressurised IFO / MDO spray, which escaped from a crack in the low pressure fuel return line (Figure 13).

![Figure 13: Crack in the low pressure fuel return line](image)

It was estimated that the fuel oil leak was under a pressure of between 5 bars and 6 bars, and a temperature of approximately 90 °C. The mixture auto-ignited as soon as it came in contact with an exposed patch on the hot turbo charger housing, whose operating temperature was well above the auto-ignition temperature of the leaking mixture. The proximity of the failed low pressure fuel return pipe to the turbo charger housing was a determinant factor of the ignition and development of the fire. The spread of the fire was accelerated when the booster pump started automatically after power was restored, leading to more IFO / MDO mixture to spray out of the cracked Banjo assembly.
2.3 Development and Spreading of the Fire

2.3.1 Metallurgical examination of the fractured Banjo fitting
The onsite investigation revealed a fractured pipe segment with Banjo fittings. The pipe segment connected the low pressure FO return coming from the fuel injection pump lines to unit no. 1 (Figure 14).

Figure 14: Location of the fractured pipe segment on the main engine

The complete Banjo / pipe fitting were removed and sent for a metallurgical examination to an independent laboratory, specialising in material failure analysis.

The Banjo assembly consisted of two machined ends, joined by a small length of pipe, which was brazed to the respective Banjo body ends. Chemical analysis results for Banjo couplings on each side, indicated that Banjo bodies had been manufactured from a low carbon, manganese steel with high levels of sulphur and lead. This was consistent with a free machining grade of steel, equivalent to BS 970-1991 grade 220M07. The analysis consisted of a microstructure observation. The hardness tests confirmed a hardness of both Banjo couplings of the order of 132 HV and 140 HV.
Both Banjo connection bolts showed some head damage mainly due to the use of either an incorrect spanner / socket size or excessive force when tightening. The four copper washers used in the Banjo fittings were of different materials and of variable dimensions and exhibited hardness of above 100 HV. The examination concluded that their condition and irregularities were not the decisive factor for the component’s failure.

The metallurgic examination revealed no evidence of defective conditions or pre-existing damages or cracking that would have cracked the Banjo pipe surface. No obvious evidence of localised deformation in way of the crack was found, although a permanent deformation in the order of 3° was measured on the assembly (Figure 15).

![Figure 15: View of the low pressure fuel return pipe fitting, showing permanent deformation and crack through the full wall thickness](image)

The fractured surface was then cleaned and studied by means of stereomicroscope and scanning electron microscopes. The study revealed that the fracture surface was rough and irregular, with no obvious discernible feature, such as prior corrosion or progressive (fatigue) cracking. The study also revealed that the Banjo joint was subjected to a micro-void coalescence fractures at the stress concentration zone imparted by these two factors. On the basis of these factors, it was deduced that the fracture in the Banjo body had occurred instantaneously due to overload. It was also
concluded that the fitting was permanently deformed, suggesting that it had been subjected to a high bending load, which exceeded its strength.

### 2.3.2 Banjo fitting cause of failure analysis

Investigation of previous engine-room fires (including MSIU safety investigations)\(^6\) suggested that fuel system failure is mostly due to incorrect fitting, worn out components, over-tightening or unsuitable components. The major contributing factors to structural failure of the fuel system components are:

- Frequent partial dismantling and reassembly of the system for maintenance purposes;
- High frequency, short duration pressure pulses generated by the fuel injection pump which are then transmitted through the fuel supply system; and
- Vibrations created by the engine and surrounding machinery.

*Usichem* had undergone a main engine overhaul in Tuzla shipyards before the accident and after being laid up for a number of years\(^7\). The main engine fuel oil system was partially dismantled and overhauled during the repairs. In December 2016, the fuel injection pumps and fuel injectors had been disassembled, overhauled and boxed up again. The main engine had 2,310 running hours. At the time of the accident, the main engine had 2,433 running hours. This suggested that the accident happened about 123 running hours later. To that effect, although the fuel injection pumps would have generated substantial pressure pulses and vibrations in the piping installation, this could not realistically be considered as the cause of the Banjo fittings failure. This was also reflected in the metallurgical analysis carried out in the laboratory.

The Banjo bolts used to tighten the fittings showed no wear and tear on the threads which is usually the case with over tightening. Moreover, the copper washers were not deformed, which is a typical indication of excessive tightening.

\(^6\) *Vide* MSIU safety investigation reports 22/2017; 07/2017; 16/2016 and 06/2014.

\(^7\) The vessel had not been operational for about five years until April 2017.
On the basis of the above factors, the MSIU believes that the immediate cause of the Banjo assembly was the permanent distortion, which subjected the entire system to the excessive bending load mentioned in sub-section 2.3.1.

2.3.3 Maintenance while underway and acceptance of risk

The fire on board the ship originated in the engine-room, from a crack in the fuel system, producing a mist of IFO / MDO and coming in contact with the high surface temperature of the turbocharger housing.

On the morning of 19 April, the main engine was stopped for troubleshooting and repairs following the detection of water leakage from cylinder no. 5. As already indicated elsewhere, the main engine fuel supply was changed over from IFO to MDO, in preparation for the reduction in rpm and stopping. Moreover, the chief engineer also considered taking advantage of this time to carry out an inspection and testing of the fuel oil injector valves. This decision was motivated following an earlier observation of variations in the exhaust gas temperature on all the main engine units while the vessel was underway. (Other troubleshooting had included the replacement of the no. 1 unit high pressure fuel oil pump in Istanbul during the loaded voyage).

Given that the main engine and the fuel oil system had only 123 running hours since the last overhaul, the overhaul of the fuel oil injector valves was not a scheduled operation required by the PMS; rather, it was the concern on the discrepancy in the exhaust gas temperatures on all units. In order to carry out this task, the crew members had to remove all the shielding guards, which cover the fuel lines (Figure 16).

While dismantling the shielding guards, the main engine was still running. *Per se*, this was the removal of a protective physical barrier system, whose scope was to provide a physical shield and prevent (or reduce the probability) any leakages from fuel oil supply lines to come in contact with hot parts of the main engine\(^8\). Moreover, the exposed fuel line system had been left unattended following the shields’ removal.

\(^8\) The IMO Safety of Life at Sea (SOLAS) Convention, 1974 provides the key regulatory framework for fire safety on board vessels. Regulation II-2/4.2.2.5.3 addresses the required measures to reduce the probability of oil leaks igniting in engine-rooms. SOLAS determines that “…oil fuel lines shall be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakage
It was evident that the new hazards and related risks were accepted by the involved crew members. The safety investigation analysed a number of factors which could have influenced this approach. As much as the removal of the shields was carried out by the crew members themselves, it was possible that the potential hazards of leaking fuel coming in contact with hot parts were not necessarily appreciated.

The MSIU, however, considered another important factor which potentially could have influenced the acceptance of risk. Two main factors, relevant to group risk attitudes were researched and were considered as having potential relevance to this case. These factors are discussed in more detail below.

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onto hot surfaces, into machinery air intakes, or other sources of ignition.” The SOLAS requirement for fuel oil lines shield protection applies to both, high and low-pressure fuel oil piping installations. It has been documented that engine-room fires have originated also from low pressure pipes, usually as a result of leakages from joints spraying onto hot engine parts / the exhaust manifold. Low pressure pipes on the return side of fuel injector pumps may have high pressure pulses, capable of spraying oil over a considerable distance.

MSC.1/Circ. 1321 provides further guidelines for specific measures to prevent fires in vessels’ engine-rooms. Guidance on the design and installation of low pressure piping to this end, is provided. The effects of high frequency, short duration pressure pulses generated by the action of the fuel injection pumps and which are transmitted back into the fuel oil supply and spill rails are analysed in the document. Moreover, the application of spray shields for joints of low pressure flammable oil piping systems is emphasized in the Circular.
2.3.3.1 The ‘Moses’ effect
This phenomenon happens when a group (in this case the crew members in the engine-room) follows the risk attitude adopted by the leader (in this case the chief engineer) even if, perhaps, this attitude does not necessarily reflect the individual preference towards risk attitude. Then, leaders can adopt different power styles to achieve this.

The MSIU did not have enough evidence / information on the chief engineer’s approach towards his group but there the safety investigation considered two possible scenarios, which could have been of influence:

i.  *Referent power*, where the chief engineer would have been seen as a personality – almost a role model; and

ii.  *Legitimate power*, where the chief engineer would have been seen as a formal position within the group, which therefore gives him the rightful authority to make decisions and give directions.

2.3.3.2 The ‘risky’ shift
A risky shift occurs when the group’s attitude towards risk changes to a more risk-seeking one than it would be expected from individuals within the same group. Studies show that this may be due to lack of *individual* accountability given that the task in hand is being executed collectively rather than individually.

This can be also influenced by the group dynamics, in the sense that if the individual/s leaning towards the risk-seeking end of the spectrum is more vocal, or enjoys higher seniority and influence, other group members will follow.

2.3.4 Communication during the accident
As soon as the fire was noticed, the measures taken to inform the rest of the crew and deck officers was addressed differently from what was recorded as being practiced during shipboard fire drills. The first measure required that as soon as a fire is located, notification and co-ordination had to be set up on channel 72 with the bridge to inform the master. This procedure had not been followed, in all probability because of the overwhelming conditions in the engine-room at the time the fire was discovered. The overwhelming conditions were also manifested with the fact that the
fuel oil supply to the main engine was not isolated before the stand-by generator started automatically.

Fires caused by IFO/MDO are expected to generate thick, dense, black smoke, which would most likely impair visibility inside the engine-room, not to mention painful, watery eyes and difficulties to breath. It is believed that these conditions may have created a certain degree of confusion. For instance, although the chief engineer undertook local measures to mitigate the fire without success, other members of the crew tried to tackle the fire in a similar manner, also without success. Further to exposing themselves to more hazards, this may have led to further delays to contain the fire in a more effective manner.
THE FOLLOWING CONCLUSIONS AND RECOMMENDATIONS SHALL IN NO CASE CREATE A PRESUMPTION OF BLAME OR LIABILITY. NEITHER ARE THEY BINDING NOR LISTED IN ANY ORDER OF PRIORITY.
3 CONCLUSIONS

Findings and safety factors are not listed in any order of priority.

3.1 Immediate Safety Factor

.1 The immediate cause of the fire was the spray of IFO / MDO mixture, which escaped from a crack in the low pressure fuel return line, coming in contact with an exposed, hot section of the turbocharger casing.

3.2 Latent Conditions and other Safety Factors

.1 The proximity of the failed low pressure fuel return pipe to the turbocharger housing was a determinant factor of the ignition and development of the fire;

.2 The spread of the fire was accelerated when the booster pump started automatically after power was restored, leading to more IFO / MDO mixture to spray out from the cracked Banjo assembly.

.3 A permanent deformation in the order of 3° was measured on the assembly. This led the system to be subjected to a high bending load, which exceeded its strength.

.4 In order to carry out the maintenance task on the fuel oil injectors, the crew members had to remove all the shielding guards, which uncovered the fuel lines while the main engine was still running.

.5 The exposed fuel oil line system had been left unattended.

.6 The new hazards and related risks were accepted by the involved crew members.

.7 The potential hazards of leaking fuel coming in contact with hot parts were not necessarily appreciated.

.8 Acceptance of risk was mainly influenced either by the ‘Moses’ effect or the ‘risky’ shift.

.9 Communication was not effective during the course of the fire containment and mitigation.
The fuel oil supply to the main engine was not isolated before the stand-by generator started automatically.

4 RECOMMENDATIONS

In view of the conclusions reached and taking into consideration the safety actions taken during the course of the safety investigation,

Densa Tanker Isletmeciligi Ltd. is recommended to:

09/2018_RI Analyse the procedures related to power failure and shut down of machinery in the engine-room and the status of stand-by machinery as to how this could contribute to additional hazards.