



Transporta nelaiemes gadījumu un incidentu izmeklēšanas birojs

Transport Accident and Incident Investigation Bureau of the Republic of Latvia

Brīvības iela 58, Rīga, LV-1011, Latvia, phone +371 67288140, mob. phone +371 26520082, fax +371 67283339,
e-mail taiib@taiib.gov.lv, www.taiib.gov.lv

MARINE SAFETY INVESTIGATION REPORT Nr.3-2017

Safety investigation into the fire on board the Latvian registered oil tanker ZIRCON on May 25, 2017



Transport Accident and Incident Investigation Bureau
58 Brīvības street, Riga, LV-1011, Latvia
Phone: 67686271,67686272
Fax: +371 67283339
www. taiib@taiib.gov.lv

FOREWORD

The purpose of this investigation is to improve maritime safety and to prevent pollution from ships, and similar marine casualties and incidents in the future.

This report shall in no case create a presumption of liability or blame and has not been written, in terms of content and style, with the intention of it being used in legal proceedings.

The findings of the safety investigation are not binding on any party and the conclusions reached and recommendations made shall in no case create a presumption of liability (criminal and/or civil) or blame. It should be therefore noted that the content of this safety investigation report does not constitute legal advice in any way and should not be construed as such.

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1.SUMMARY

At 1043 LT on May 25, 2017, a fire broke out in the engine room of the oil products tanker ZIRCON. At the time the vessel was on passage from Riga port to Skagen, Denmark abt. 15 NM off the Riga breakwaters, out of pilotage area having full sea speed. The ship was loaded with the cargo of 7268 tons of Gas Oil and Fuel Oil.

The navigational officer of the watch at 1043LT noticed the activation of the engine-room fire alarm and immediately phoned the engine control room to alert the engineering officer of the watch. The engineers took immediate action and confirmed that main engine was on fire.

Due to the intensity of the fire and the dense smoke, attempts to extinguish the fire with portable fire extinguishers could prove futile. Consequently, the engine-room had to be abandoned and prepared for CO2 release.

The fire was eventually brought under control and extinguished after the activation of the fixed CO2 installation at 1048LT. No evacuation of the crew was needed. There were no injuries, fatalities or pollution of the environment because of this accident. The vessel was towed to Riga shipyard to effect repairs.

The Transport Accident and Incident Investigation Bureau (TAIIB) determines that the probable cause of fire on board the ZIRCON was the spray of fuel oil on a hot surface and igniting, following the fracture of the securing bolt on the low pressure fuel supply pipes flange, located on the main engine.

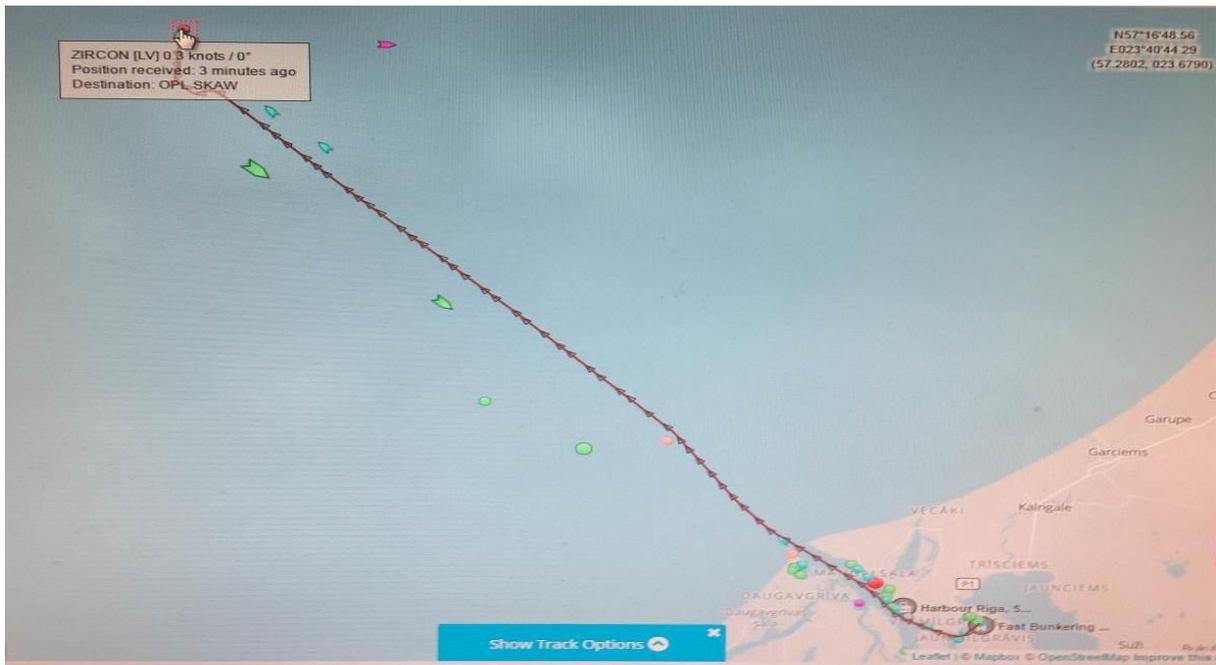


Fig.1 Ships track before the accident

This investigation is based on collected evidence, recorded information from the vessel's VDR audio files, fire detection system, crew interviews following the accident. All times are UTC+3 (Universal Time Coordinated).

2.FACTUAL INFORMATION

Name	ZIRCON
Flag	LATVIA
Call sign	YLOX
Port of Registry	Riga
Classification Society	Registro Italiano Navale (RINA)
IMO Number	9010929
Year of build	1993
Type	Oil Products Tanker type A
Registered Owner	NT Bunkering AS
Manager	Welton Enterprises
Construction	Steel
Length overall	124,86m
DWT	8000
Gross Tonnage	5045
Minimum Safe Manning	12
Manning	17 Crew
Port of Departure	Riga
Port of Arrival	Skagen roadsted
Type of Voyage	International
Cargo Information	FO and GO in cargo tanks

Engine Power	4080kW
Number of Engines	1
Propulsion Type	Controllable Pitch Propeller
Date and Time	May 25,2017/ 0743 UTC
Type of Marine Casualty	Serious Marine Casualty
Location of Incident	57° 15.9N, 023° 42.6E
Place on Board	Engine-room
Injuries/Fatalities	N/A
Damage/Environmental Impact	Cables, panels in engine room
Ship Operation	On passage
Voyage Segment	Mid-water
External & Internal Environment	Wind: Light air, Calm sea

2.1 Vessel

Tanker ZIRCON is Latvian registered double hull oil product tanker. She was built by NUOVI CANTIERI APUANIA S.p.A, Marina di Carrara, Italy. Keel was laid in 1989 and she was delivered in 1993, classed by Registro Italiano Navale (RINA) in 1993. The vessel is owned by NT BUNKERING AS, managed by WELTON ENTERPRISES OU since August 05, 2016. At the time of the accident she was dully certified according to Statutory and Class rules. The management company and the ship complied with the International Safe Management Code (ISM Code) for the Safe Operation of Ships and for Pollution Prevention and held a valid DOC and SMS certificates.

A marine engine has to be maintained in conformity with the various international rules and regulations as per the ISM code. The advice of the manufacturer, as well that of the class and the Administration has to be followed. Thus, all marine engines have a maintenance schedule, which is normally integrated into the preventive planned maintenance program of the company. It is kept on a dedicated computer with specialized software. This allows a superintendent engineer to monitor the ship from the shore office and instruct the chief engineer accordingly. To make sure that the marine engine runs smoothly, engineer officers carry on the daily routine maintenance.

2.2 Welton Fleet Maintenance (Asset Management Operating System).

The company's procedures in chapter Maintenance, of its safety management system (SMS) provides comprehensive guidance to the engine-room staff. The chief engineer is responsible for the maintenance of all mechanical, electrical, safety, environmental and control equipment on board the vessel, ensuring that the vessel is maintained in a safe and efficient manner and that appropriate entries into AMOS are made on all undertaken maintenance jobs.

Last major ME maintenance repairs on ZIRCON was done at REMONTOWA ship repairyard in Poland on March 01, 2016. After the overhaul, ME running-in was carried out by Quality Control Department in presence of representatives from Class, Owners and Workshop. Results were positive.

2.3 Engine room and machinery

The engine rooms on ships are hot, noisy, and potentially dangerous. The presence of flammable fuel, high voltage (HV) electrical equipment and internal combustion engines (ICE) means that a serious fire hazard exists in the engine room, which is monitored continuously by the ship's engineering staff and various monitoring systems located in (ECR) engine control room (Figure 7).

Engine room on tanker ZIRCON is separated from cargo tank area by A-class watertight bulkhead, ballast tanks and ballast pump room.

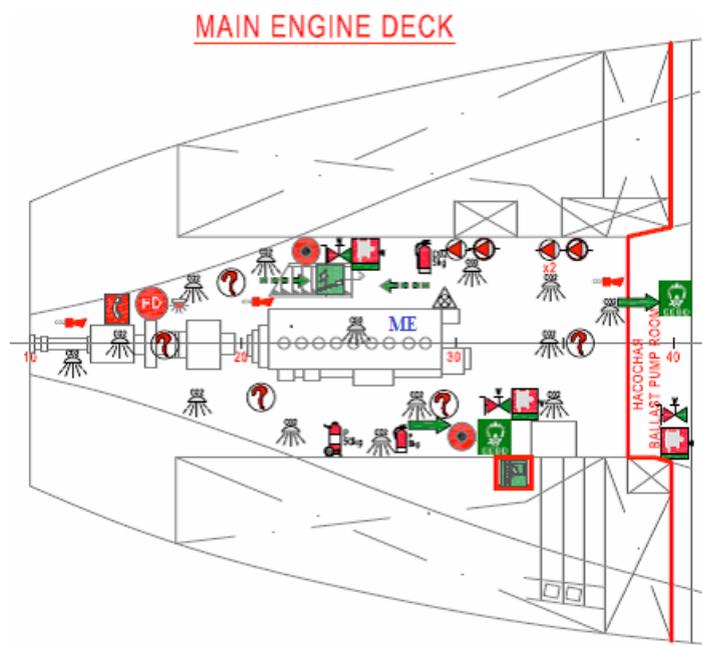


Fig.2 ME Deck layout showing fire zones

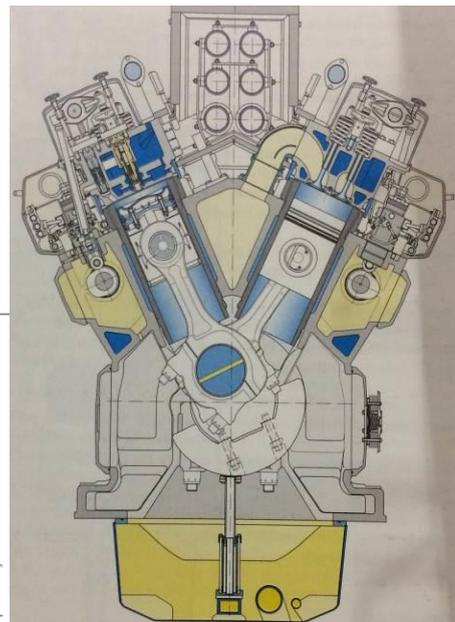


Fig.3 Type of main engine

Tanker ZIRCON is powered by Wartsila, VASA 12V32, 12 cylinder four-stroke medium speed V-type diesel engine (ME). Propulsion shaft via reduction box connects the prime-mover with left handed controllable pitch propeller. ME is placed on Main Engine Deck.

The fuel oil supply tanks are equipped with QCV (quick closing valves) (Figure 4), operated from a room next to CO2 station on 3rd tier deck. In

accordance with the relevant SOLAS regulations, when activated, these valves cuts off fuel oil supply to prime-mover, auxiliary engines and boilers.



Fig.4 Operating levers for Fuel System Quick Closing Valves (QCV)

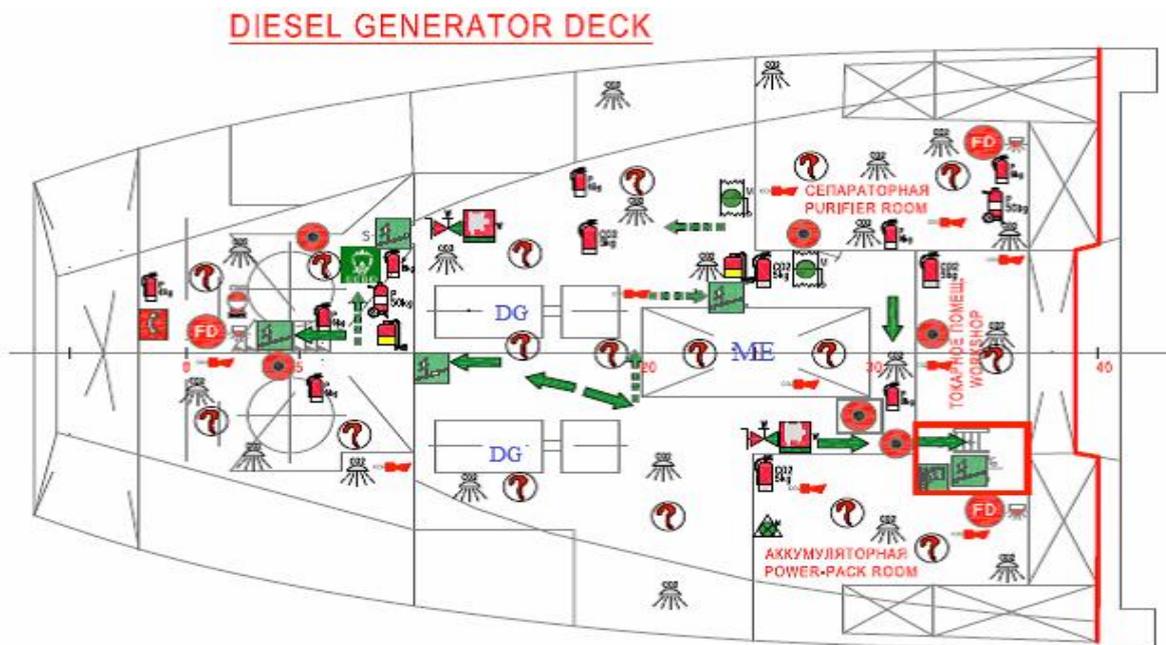


Fig.5 DG Deck layout showing fire zones

Two DG (diesel generators) are placed on Diesel Generators deck (Figure 5), above the ME deck on port and starboard side. This deck has large opening over the main engine so that it forms a platform around the top of ME. Casings extending upwards to the funnel provide space for the exhausts from the ME and DGs.

Emergency DG room is located on the starboard side of 3rd tier Deck. This space contains marine gas oil supply storage tank, emergency switchboard and emergency generator, and it starts automatically when blackout occurs.

2.4 Fuel system

Fuel is transferred from storage tanks using a booster pump to settling tanks. These are narrow vertical tanks where fuel is allowed to stand for a period of time to allow water, sediment, and heavy particles to settle to the bottom of the tank and are then removed. The fuel is then transferred from the settling tank via a separator feed pump to a separator. The separator operates as a centrifuge, removing any remaining water, sediments or heavy particles, and the fuel is then discharged into a service tank for use in the engines. A cascade system causes fuel to revert back to the settling tank if the service tank reaches a high level, for example, if the engines were slowed or stopped and fuel demand was reduced.

In general, the vessel may operate on different grades of fuel oil. A cold start of the main engine would be accomplished using Marine Gas Oil (MGO). When suitably heated Heavy Fuel Oil (HFO) is available the engine is switched over. HFO has a higher calorific value and is more economical, however it requires heating to be at the correct viscosity at the engine fuel injectors. HFO is carried in two grades, high and low sulphur, to comply with environmental restrictions on engine emissions in certain marine areas.

On tanker ZIRCON ME and DGs are designed for continuous heavy fuel duty. They can be started and stopped on heavy fuel, provided that the fuel is preheated to operating temperature 60-70C (subject to velocity) with a maximum velocity of 55 cSt/100C.

2.5 Exhaust outlets

The exhaust outlets from each cylinder lead to an exhaust manifold on top of the prime-mover, between the two cylinder banks. Insulated metal box protects exhaust manifold from contact with flammable materials. The normal temperature of the exhaust gas headers is about 400°C. The ignition temperature of the preheated fuel oil used in the engine is about 220°C.

2.6 Fire control

Tanker ZIRCON is fitted with fire detection system. This system monitors the vessel to detect smoke throughout. Detectors are mounted in critical areas of the vessel. The ER (engine room) is fitted with smoke detectors. Manual call points are also located throughout the ship.

The fire detection systems control panel on the bridge (Figure 6) is manned continuously. From this position, it is possible for crewmembers to identify on the screen the location of any activated alarm. A repeater device to detect alarm is located in the ECR.



Fig.6 Fire detection alarm panel on the bridge



Fig.7 Engine Control Room

The ship's engine room machinery and systems are all controlled from the Engine control room on Main Deck. This space contains the remote operating controls for the engine room machinery, data recorders, event and alarm logs, emergency shutdowns for the engines.

ZIRCON has a Carbon Dioxide (CO₂) fixed firefighting system (Figure 8) that can be used to extinguish fires in Engine Room, Purifiers Room and Power Packs Room . The CO₂ system is housed on 3rd tier deck, and contains 28 x 60 liter cylinders in two banks.



Fig.8 General view of CO₂ station

2.7 Alcohol Tests

At about 1730 on May 25, the Coast Guard boarded the ship and performed alcohol tests on all the crewmembers. All the alcohol tests were negative.

3.NARRATIVE

3.1 Events Leading up to the Fire

On Thursday, May 25, 2017, at 0815 tanker ZIRCON had completed its loading, on board pre departure procedures and check lists and at 0825 pilot boarded the ship. Zircon departed Riga, loaded with 7276 MT of Fuel Oil and Gas Oil. She was bound for Skagen. At 0845 she was off the berth and at 1000 pilot disembarked, the master ordered the engines to Full Away (full sea speed). Power supply was from shaft generator.

At 1043 the OOW (Officer of the Watch) on the bridge noticed the activation of ER fire alarm, pos.9 and 10 on panel (Figure 6).

3.2 Manning

At the time of the fire, third officer (OOW-0800-1200) manned the bridge, second engineer (OOW-0800-1200) manned the engine room. Chief Engineer was also present in the ER.

All the crewmembers on board were found duly qualified under the provisions of STCW.

3.3 Emergency Response

Within seconds before activation of ER fire alarm, the CE in the ECR noticed activation of Fuel pressure drop sensor alarm. The second engineer was in purifier room at that time. Entering ER, he found that fire was raging over main engine. The smoke and heat were very intense. He reported to Chief engineer. Soon after the chief engineer along with the second engineer, activated the QCV (Figure 4) to cut off Fuel Oil supply, stopped the circulation pump and closed the engine-room ventilation dampers in quick succession.

The OOW on the bridge by that time, having confirmation on fire from engine room, immediately contacted the Master. At 1045, the Master from the bridge wing noticed the smoke coming out from ER ventilation outlets. The Master sounded vessel's general alarm and radioed vessels in the area, alerted all the crew members and those, tasked with fire-fighting operations to proceed to MS (Muster station). He activated emergency stop of the ME from the bridge and ordered engine staff to evacuate and prepare the ER for CO2 release. The Master radioed vessels in the area.

The Chief Engineer dispatched teams to verify that the engine room had been secured before releasing the CO2.

Activation of ME emergency stop button on the bridge caused black out (power supply was from shaft generator). Emergency DG was automatically engaged, enabling basic bridge navigation equipment and the vessel's emergency lighting to function. However, primary electrical power, propulsion, and steering capability were lost.

At 1053, the crew's roll call was completed first and following the permission of the Master, the CO2 flooding system was activated. One bank of CO2 (14 cylinders) was released into the ER.

By that time emergency DG was already running and emergency fire pump was employed to cool down engine room boundary (surrounding bulkheads). The Master ordered the crew to remain on deck outside superstructure.

ZIRCON continued to drift (not under command) in the position about 15NM NW off the Riga port anchorage.

3.4 External Response

At 1053 as the fire was under control, the master reported to Coast Guard on VHF (very high frequency) about accident and requested assistance. The Coast Guard dispatched helicopter. The rescue helicopter arrived on scene at 1145. Coast Guard patrol vessel was riding nearby. At 1450 tugboat delivered shore side fire-fighters team, with proper firefighting equipment to consult, assist and to provide guidance, if needed. The crew continued cooling down and checking temperature of the bulkheads.

From 1832 till 1920 shore side fire-fighters team three times entered the ER to assess the extent of fire, hot spots and overall situation. At 1920 the fire was extinguished and commander of the shore side fire-fighters team suggested starting ventilation of the ER.

The fire was taken under control in a relatively very short period because of the adequate and rapid response of the Master who stopped the prime mover, engine-room team who cut off the fuel oil supply, shut down the ventilation and released CO2 into ER.

3.5 Towage

The next day, on May 26 at 0205 pilot boarded the ship and with the assistance of two tug boats tanker ZIRCON was taken inside the Riga port shipyard area. She was safely moored alongside at 0540.

3.6 Post-fire Survey and Damage

Following the fire, representatives from the TAIIB, attended the vessel to investigate the accident. Despite of an early response by the crew to control the fire and extinguish it, the vessel suffered extensive damage.

ER space from forward end of the prime-mover to funnel shows traces of extensive heat end fire. Heat and smoke reached up the engine-room casing and resulted in damage to monitoring components of the prime mover, electrical installations, cables, control panels, automation, switch cabinets, ventilation canals, piping systems, rubber components.



Fig.9 ceiling of engine room



Fig.10 Pumps control board



Fig.11 Ceiling DG deck



Fig.12 ME control box

Heat and smoke damage to electrical components and associated cabling of the fire detection system, general lighting. Cables supporting other equipment and systems that transited through the diesel engine-room suffered from extensive heat. An electrical sub-station located above the area of the diesel engine-room sustained damage to its deck plating, cabling, light fixtures, transformers and breaker cabinets.



Fig.13 ME Deck Port side forward end, arrow shows where the fire started

4.ANALYSIS

4.1 Aim

The purpose of the analysis 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.

The information in this section is based on recorded information from the vessel's VDR audio files, fire detection system, crew interviews following the accident. All times are UTC+3 (Universal Time Coordinated).

4.2 Findings

Probable cause of the fire on board the tanker ZIRCON was the failure of low-pressure fuel oil pipe flange joint, resulting in oil spraying onto the engine's exhaust manifold and igniting. The safety investigation found that:

- one M8 screw was missing from its place on flange;
- another M8 screw fractured, loosening the joint completely;
- hot surface of the exhaust gas manifold ignited the fuel oil mist;
- both screws were found under the cover of high-pressure fuel oil pump cyl.A6



Fig.14 Arrow shows the gap in insulation of manifold cover, illuminated from inside.

From the theory and mechanics of screws, it is known, that vibration, heating and cooling causes screw loosening.

The threads on the screw act like a wedge or inclined plane, which translates force from the in-plane, rotation direction (torque) into an out-of-plane force along the axis of the screw. That is, when rotate the screw clockwise, it applies an inward force to the screw by wedging its threads against those of the screw hole.

Once the head of the screw runs into an obstruction, turning it further begins to store potential energy in the elastic deformation of the metal, like compressing a spring. Clearly there is a constant force trying to push the screw back out. The same applies when the screw head simply compresses the surface it's screwed into (here flange).

The reason the screw doesn't pop out immediately due to this outward force is because the friction of the threads is proportional to the axial force which pushes the metal of the screw threads into the metal of the hole threads. As the outer surface deforms, the elastic force applied to the screw increases, which increases the friction of the threads

Over time, the threads can deform inelastically, reducing the amount of normal force available to create friction between the screw and the hole. As a result, it becomes easier for vibrations to rotate the screw. Since the surface are trying the push the screw out, it will preferentially move outward rather than inward due to vibrations.

Once the screw comes out enough that surface are no longer deformed elastically, there is no longer an asymmetry to the inward and outward vibrations. This is why screws will often loosen over time to a point and then stop. However, external vibrations or tensions can often cause screws to continue coming out after the screw is loose.

Loose screws could lead to inadequate clamping force in the joint. Joint slip (here between two flanges) then occurs which leads the screw being subjected to bending loads and subsequently failing by fatigue and fracturing.

On ZIRCON, as the first screw (Fig.16, arrow 2) become loose, the joint slip on flanges (side sliding relative flange to flange) and bending loads started effecting second screw (Fig.16, arrow 1) leading to fracture.

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.

When engineers carry out daily routine engine-room rounds, which include walking through machinery compartments, examining ME, DGs, etc., no one spotted that the lower screw was missing on the flange joint. Another Fuel supply pipe hid the missing screw on flange.

After the remaining screw fractured under the banding loads, the flanges separated slightly, thus causing fuel, at a pressure of up to 7 bar, to spray through the gap in the seal. The fuel mist would have found a number of hotspots near the failed flange, such as the exhaust manifold and ignited. The continuing supply of fuel from the failed flange would then have fed the fire until the Chief engineer stopped the fuel oil booster pump and activated FCV.

The Wartsila Finland Oy technical bulletins 3217T011Gb and 3217T044GB(01) provided advice including the replacement of two bolt flanges with four bolt flanges and other modifications aimed at dampening pressure pulses and vibrations in the fuel supply system. The recommended modifications had not been carried on and were not known to the owners.

Fluids under pressure tend to atomize, that is, become fine mist, when pushed through a small opening or leak in a pressurized system. Because the Fuel Oil leak was in the form of atomized spray, it created a fuel-air mixture that ignited when exposed to the near 400C hot exhaust manifold (Fig.15 and 16) through a little gap (Fig.14) in insulated containment.

It was apparent from the physical evidence that Fuel Oil spray from a supply pipes flange exposed to a hot surface of the exhaust gas manifold would have been enough to ignite the Fuel Oil mist.



Fig.15 Exhaust manifold on the top of the engine



Fig.16.Exhaust from cylinder A6, ignition of Fuel Oil

After the prime mover and pumps were stopped and QCV activated, fuel oil would have continued to escape for a while because of the remaining pressure in pipeline.

The hot exhaust manifold was the fire's ignition source and spray (leak) was the fire's fuel source. In turn, the missing and fractured screws loosening the joint caused Fuel Oil spray under pressure.



Fig.17: arrow 1-fractured screw, arrow 2-missing screw, arrow 3-gap in manifolds insulation box.



Fig.18 Screw hole on flange.



Fig.19 Fractured screw and missing one

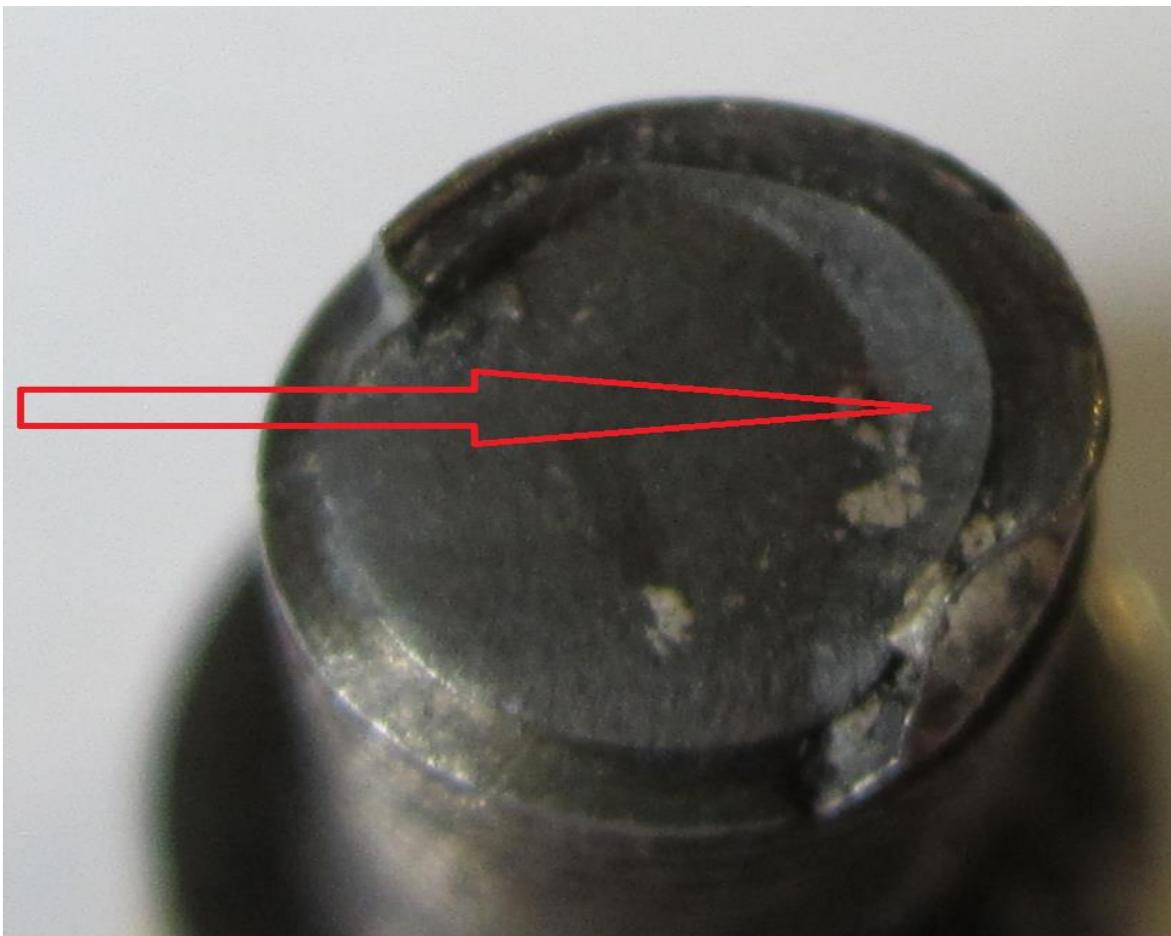


Fig.20 Area where fatigue developed under banding loads.

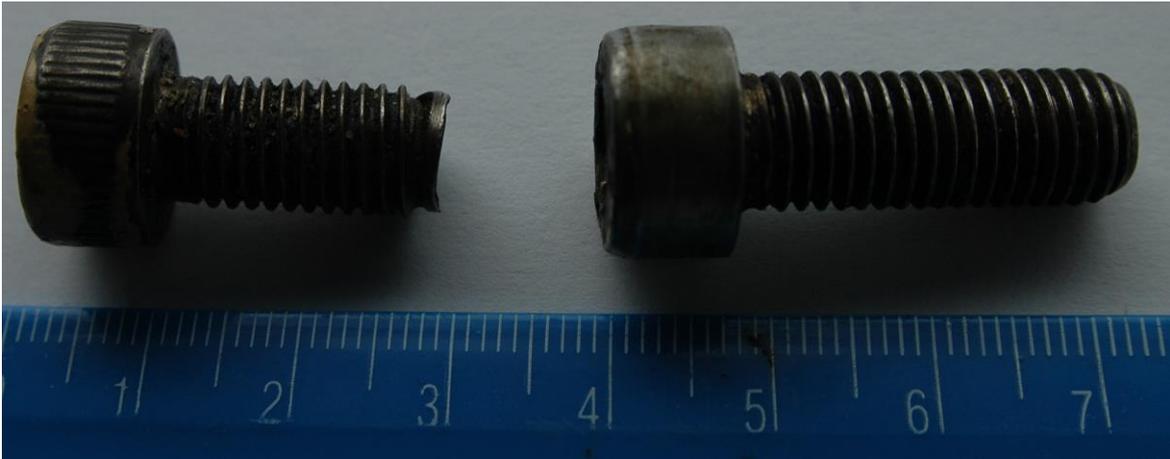


Fig.21 Size of screws (M8).

4.3 Laboratory analysis

The fractured screw was sent to Riga Technical University Department of Material Processing Technology for expertise. Examination of the fractured screw revealed that the failure was caused by fatigue. Fatigue occurs when a material is subjected to repeated cyclic stresses, the magnitude of which is below the strength of the material.

As from laboratory analysis, the cause of the fracture of the screw is of a variety of operating loads: engine vibrations, fuel pressure change and maintenance errors. The output of the lower screw from the flange developed banding loads in remaining one. Screw breaking occurred in the second, third full wind, in the screwed part of the housing, where higher load concentration exist. Fractured screw has fatigue, fracture nature. Screw materials are fine-grained.

The safety investigation was unable to determine the screws loosening mechanism with absolute certainty.

4.4 General

ZIRKON sustained about \$1.1 million in damage.

5. CONCLUSIONS

1. This fracture of screw led to the release of fuel oil, at a pressure of about 7 bars, and sprayed over an exposed high temperature area.
2. Laboratory examinations of the fractured screw revealed that the failure was caused by fatigue.

The TAIIB determines that the probable cause of the fire on board the tanker ZIRCON was the failure of low-pressure fuel oil pipe flange joint, resulting in oil spraying onto the engine's exhaust manifold and igniting.

Contributing to the survivability of the vessel, and to the absence of injury or loss of life, was the early response by the crew to control the fire and extinguish it.

Contributing to the extent of the damage was the delay (5 minutes) in attempts at the beginning to extinguish fire by portable fire extinguishers located in the ER, communications, stop of fuel booster pump, activating QCV and cutting off ER ventilation.

Maintenance tasks are more arduous than operations, with the need to access components, which may be restricted or hidden from sight. In this particular case, the maintenance efficiency (missing screw, gap in the insulation) had a dramatic effect on safety of the vessel.

It is important that owners or technical managers, when acquiring second-hand vessels, should ensure that they are in receipt of the most up to date technical bulletins from manufacturers.

6. RECOMENDATIONS

In view of the conclusions,
WELTON ENTERPRISES is recommended to carry out the following with a view of improving safety in its fleet:

2017-1 Identify maintenance tasks of critical equipment on board Company ships, which could be overseen and / or not carried out effectively and implement the necessary corrective actions, taking also into consideration the IMOs MSC.1/Circ.1321 „Guidelines for measures to prevent fires in engine rooms and cargo pump rooms.“ as well as previously issued recommendations from Wartsila Finland Oy.

2017-2 Review the training of its staff in firefighting with special reference to fires in engine room and adequate and fast action with QCV and ER ventilation system during an emergency.

2017-3 Consider installation of CCTV cameras in the ER.

7.SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION

Following the accident, the Company carried out an internal investigation and took the following safety actions to prevent reoccurrence:

- Post-fire repairs had been completed to full RINA satisfaction.
- ME pipework had been fully replaced with original maker's spare parts. Additional covers and barriers had been installed around pipework flanges.
- Additional safety inspection had been arranged on board of all fleet vessels, aiming specifically on fire safety in ER.
- Fleet-wide training of engine room crew on first actions on discovery of fires has been arranged. Results of such training had been verified by the Company representative with each engine room crewmember on each Company ship individually.
- Frequent checks of ME fuel pipework had been added into ship PMS.
- CCTV had been installed around ER, providing additional control to the ECR.
- Company has established new position in the Office – QA/Vetting Manager, in order to review SMS, and gradually improve overall safety culture within the fleet.
- Revision of Company drills requirements, especially in respect of firefighting drills, to ensure that they are thorough, effective and cover various scenarios; relevant drills will include suitable CO2 system checks.
- Introduced new measures to improve the safety culture in the company and on board managed vessels.
- Established close contacts with fleet ships' MEs & AEs manufacturers, in order to receive periodical updates of manufacturers technical bulletins.
- FIREKILL automatic extinguishing system (fire suppressors) are being installed in ER on board of Company ships (in progress).

