FINAL MARINE SAFETY INVESTIGATION REPORT ON A SERIOUS MARINE CASUALTY

VESSEL NAME / IMO NO	: M/T TORC / 9544683
FLAG OF THE VESSEL	: Malta
CALL SIGN	: 9HA2351
LOCATION OF CASUALTY	: Port Of Bandırma Çelebi / Balıkesir
DATE AND TIME OF MARINE CASUALTY	: 28/08/2022 / 17:00 (LT) (GMT +3)
DEAD / INJURED	: - / 2
DAMAGE DEGREE	: The burner, which had become unusable, was replaced, and the thermal oil boiler was repaired and put into operation upon class approval.
ENVIRONMENT POLLUTION	: None

Board Decision No: 15 / D-07 / 2023 *Date: 17 / 07 /2023*

The sole objective of this investigation is to make recommendations for the avoidance of similar casualties and incidents within the framework of the Transport Safety Investigation Center regulation. This report is neither the product of a judicial or administrative investigation nor intended to attribute blame or liability.

LEGAL BASIS

This marine casualty has been investigated by the provisions of the "Directive of Investigation of Marine Casualties and Incidents" published and enacted in the Official Journal dated 27/11/2019 and numbered 30961.

Resolution MSC.255(84) [Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code)] of the Maritime Safety Committee of the International Maritime Organization (IMO), Resolution A.1075(28) Guidelines to Assist Investigators in the Implementation of the Casualty Investigation Code, as well as Directive 2009/18/EC of the European Parliament and of the Council Establishing Fundamental Principles Governing the Investigation of Accidents in the Maritime Transport Sector, have also been taken into account for the procedures and principles of the investigation.

LIST OF CONTENTS

LIST OF IMAGES

LIST OF LINE DIAGRAMS

LIST OF FIGURES

ABBREVIATIONS

MGO	: Marine Gas Oil
FO	: Fuel Oil
Thermal Oil Boiler	: Hot Oil Boiler
ULSFO	: Ultra-low Sulphur Marine Oil
VLSFO	: Very-low Sulphur Oil
SECA	: Sulphur Emission Control Area

DEFINITIONS

Lower Explosion Limit: The lowest possible concentration of a gas or vapor in the air which will burn or explode if ignited

Upper Explosion Limit: The highest possible concentration of a gas or vapor in the air which will burn or explode if ignited

Risk: The possibility of loss, injury or other detrimental consequences resulting from the hazard

Risk Assessment: The studies required to be carried out to identify the hazards that may exist in the workplace or that may come from outside, analyze and grade the factors that turn such hazards into risks, and the risks resulting from the hazards, and determine the control measures

Prevention: All of the measures planned and taken to eliminate or mitigate the risks associated with occupational health and safety at all stages of the work carried out in the workplace

Acceptable level of risk: The level of risk that poses no risk of loss or injury, in accordance with legal obligations and the prevention policy of the workplace

SUMMARY

Image 1 Location of the Accident, Port of Bandırma Çelebi

Note: All times used in the report are local time (GMT +3)

The Malta-flagged chemical tanker M/T TORC uses ULSFO (MGO) fuel as it navigates in the SECA region. Since the vessel would navigate on Mediterranean and Black Sea voyages, service was called for the failure of the Thermal Oil boiler to fire fuel in VLSFO. On 28 August 2022, Malta-flagged chemical tanker M/T TORC was waiting for the discharge operation of sunflower oil at berth no. 5 of the Port of Bandırma Çelebi.

The Service Technician and his assistant, who was called, arrived on board on 28 August 2022 to repair the said failure. Following the assembly of a nozzle of 250 kg/h in port side boiler No. 2 in the Boiler Room of the Engine Room, an explosion took place at around 17:00 during the firing process of the boiler, and the Service Technician was seriously injured and the Second Engineer of the Ship sustained minor injuries.

Recommendations have been directed to the Ship Operator, Boiler Maintenance and Repair Provider, and Chambers of Shipping (IMEAK DTO and Mersin DTO) based on the outcome of the casualty investigation.

SECTION 1 - FACTUAL INFORMATION

1.1 Information on the Vessel M/T TORC

Flag	Malta
Classification Society	Rina
Type	Oil/Chemical Tanker
Port of Registry	Valletta
Call Sign	9HA2351
Place and Year of Building	Selah Shipyard / Tuzla / Istanbul / 2010
Gross Tonnage	2391
Deadweight Tonnage	13214
Length Overall	135,6 meters
Breadth	20,6 meters
Main Engine and Its Power	MAN 9L32/40 - 4,439 kW

Image 2 M/T TORC

1.2 Information on the M/T TORC Navigation

Previous Port	Reni / Ukraine
Port of Arrival	Bandırma / Balıkesir
Number of Crew	15
Minimum Safe Manning	13
Type of Navigation	International

1.3 Information on Casualty

Date & Time of Casualty	28/08/2022 - 17:00 UTC
Casualty Type (IMO)	Serious Marine Casualty
Type of Casualty	Occupational Casualty (Explosion of Boiler)
Location of Casualty	Port of Bandırma Çelebi Berth No. 5/ Balıkesir / Türkiye
Dead/Injured/Missing	-/2/-
Damage	The burner has been renewed, the boiler has been repaired, the damaged boiler equipment has been renewed, and the boiler has been approved and put into operation on 23/03/2023.
Pollution	None

1.4 Information on Environmental Conditions

Wind	Calm
Sea Condition	Calm
Visibility	Good
Weather Condition	Clear

1.5 Specifications of Thermal Oil Boiler

Manufacture Year	2009
Heating Capacity	2300 kW
Oil Capacity	1285 lt
Heating Surface	91.2 m^2
Operating Pressure	10 Bar
Test Pressure	15 Bar
Operating Temperature	280°C

Image 3 Boiler No.1 Currently Operating Onboard

1.6 Hot Oil Properties

Texatherm® 32 thermal transfer oil, which meets the hot circulation requirements up to 316^{0}C, is used as hot oil in the boiler.

Typical Characteristics	
ISO Viscosity Grade	**32**
MPID	
Density at 15°C, kg/l	0.86
Density at 100°C, kg/l	0.80
Density at 200°C, kg/l	0.73
Density at 300°C, kg/l	0.67
Pour point, °C	-15
Flash point COC, °C	220
Oxidation (ASTM D943), hrs to TAN = 2.0 mg KOH/g	3500
Rust test, synthetic seawater	PASS
Kinematic viscosity at 0°C, mm^2/s	313.0
Kinematic viscosity at 40°C, mm^2/s	32.0
Kinematic viscosity at 100°C, mm^2/s	5.5
Viscosity Index	106
Copper corrosion, 3h at 100°C	1a
Water by Karl Fischer, mg/kg	<50
TAN, mg/KOH/g	0.08
Air release ag 50°C, min.	2.3
Foam Seq II, after blowing, ml	0
Foam Seq II, after 10 minutes, ml	0

Table 1 Thermal Transfer Oil Properties

1.7 Vessel M/T TORC and Service Personnel

The Malta-flagged M/T TORC must be manned with 13 crew according to the Minimum Safe Manning Certificate issued under the International Convention for the Safety of Life at Sea (SOLAS 74) Rule V/14. There were 15 crew onboard, including the master, on the day of the accident and the tanker was manned with a sufficient number of qualified seafarers according to the Minimum Safe Manning Certificate.

The following provides information about the key crew members involved in the casualty.

1.7.1 Master

The Master is a citizen of the Philippines. He was 49 years old at the time of the accident. He holds the Certificate of Competency as Oceangoing Master in accordance with Rule II/2 of the Standards of Training, Certification, and Watchkeeping of Seafarers (STCW) Code issued by the

Philippine Maritime Administration. He is experienced for 12.5 years as a Master and served at sea for 21 years in tankers and 22 years in all types of vessels.

1.7.2 Chief Officer

The Chief Officer is a Turkish citizen. He was 32 years old at the time of the accident. He holds the Certificate of Oceangoing Chief Officer Competence in accordance with Rule II/2 of the Standards of Training, Certification, and Watchkeeping of Seafarers (STCW) Code issued by the Turkish Maritime Administration. He is experienced for 4 years as a Chief Officer and served at sea for 7.5 years in tankers. The Chief Officer also acts as a safety officer on board.

1.7.3 Chief Engineer

The Chief Engineer is a citizen of the Philippines. He was 48 years old at the time of the accident. He holds the Certificate of Chief Engineer Competence in accordance with Rule III/2 of the Standards of Training, Certification, and Watchkeeping of Seafarers (STCW) Code issued by the Philippine Maritime Administration. He has been working as Chief Engineer on the M/T TORC tanker for 3 months. He served approximately 16.5 years in the tankers and approximately 19.5 years in all vessel types.

1.7.4 Second Engineer

The Second Engineer is a Turkish citizen. He was 49 years old at the time of the accident. He holds the Certificate of Competency as Second Engineer in accordance with Rule III/2 of the Standards of Training, Certification, and Watchkeeping of Seafarers (STCW) Code issued by the Philippine Maritime Administration. After 12 years of service as Chief Engineer in the Naval Forces Command and retired, he worked as Second Engineer in private companies since 2015. He has been working as Second Engineer on the M/T TORC tanker for 5 months.

1.7.5 Boiler Maintenance Technician, The Casualty

The casualty, who was a boiler maintenance technician at the time of the accident, was 45 years old and graduated from the technical high school electrical department. After working as an electrical officer on vessels for 8 years and then in shipyards for 2 years, he has been engaged only in boiler maintenance work since 2004. He is the Turkish representative of well-known boiler brands in the sector. The boiler maintenance technician is a well-known and recognized name in the sector for maintenance, repair, and service of boilers.

1.8 The Chemical Tanker, M/T TORC

The chemical tanker named M/T TORC was built in Tuzla/Istanbul/Turkey in 2010. The vessel is equipped with one main engine with a power of 4,439 KW. There are three generators with 592 kW of power on board. The ship's overall length is 135.6 meters, its breadth is 20.6 meters, its depth is 11 meters, its gross tonnage is 8,391 and its net tonnage is 4,171.

1.9 Works Carried out for Boilers Onboard M/T TORC in 2020

The service report shows that the casualty maintenance technician worked to switch the existing boilers from LSMGO to VLSFO on different days during February and March 2020, but it appears that no regular operation regime was achieved and no solution could be provided. During such maintenance, he installed a nozzle of 250 kg/h on the boiler, put it into operation, and observed its operation but identified no failure.

SECTION 2 - NARRATIVE

The sequence and time of the incident that leads to the marine casualty under investigation and the location of people mostly depend on eyewitness statements and interviews.

2.1 Sequence of Events

Boilers are manufactured with advanced boiler technology and are complicated structures classified as hazardous in terms of occupational safety where electrical, electronic, mechanical, and hydraulic systems operate together.

The chemical tanker M/T TORC normally navigates in the Baltic Sea. The Baltic Sea serves as a Sulphur emission control area (SECA) according to MARPOL Annex-6. The Sulphur limit in fuels in Sulphur emission control areas is 0.1%. Except for SECA, the Sulphur limit of fuels to be used in vessels has been lowered to 0.5% as of 2020 globally. (Figure 1) Since the ship normally navigates in the SECA region, it is not allowed to fuel with VLSFO and uses MGO.

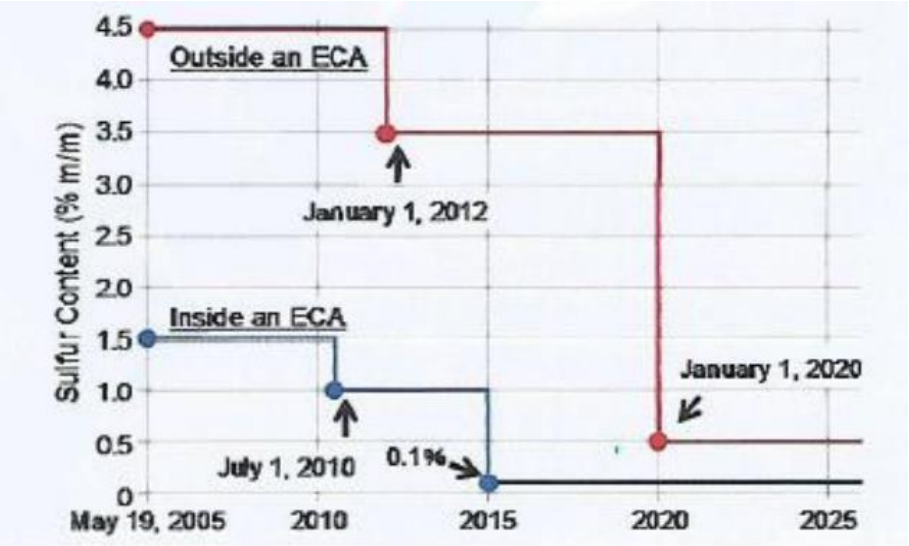


Figure 1 Effective Date of Sulphur Ratio Regulations

The M/T TORC ship began to sail in the Black Sea due to the arrangements for the grain corridor, and the Operator switched to using VLSFO due to the lack of a restriction on the fuel utilized in that region and the benefit of a cost advantage.

Since the boilers of the Chemical Tanker M/T TORC failed to fire and operate properly in VLSFO, a service was called from the Boiler Maintenance-Repair Provider on 24/08/2022, as this is work that requires expertise due to technological reasons. The Boiler Maintenance Technician and his assistant, who arrived on board at noon on 28 August 2022 from the Boiler Maintenance Provider, repaired the firing failure of port side boiler No: 2 in the Boiler Room in

the Engine Room and replaced the solenoid valve No: 4 which was brought from the ship's store. (Line Diagram 3) He did the necessary cleaning, measured the flue gas (Image 4), set the air/fuel ratio, returned the black smoke emitted out of the flue to normal, ignited the boiler many times with the existing 200 kg/h nozzle, operated it for a while, and observed that it was normal.

Image 4 Flue Gas Meter

Upon the request from the vessel for tank washing requirements, a nozzle of 250 kg/h brought from the ship's store was installed on the boiler to increase the boiler's capacity by 25%.

Subsequently, there was an explosion during the firing process of the boiler. At the explosion, the cover and the burner of port side boiler No. 2 were ejected from their places; the burner became unusable, and the Service Technician was seriously injured, while the Second Engineer, who was nearby, sustained minor injuries. The Service Technician who was seriously injured and the Second Engineer who sustained minor injuries were transferred to the hospital.

The Second Engineer, who sustained minor injuries, recovered shortly after the accident, and the Service Technician, who suffered spinal cord paralysis resulting from serious injuries, continues to undergo physiotherapy treatment.

2.2 Works Carried Out on the Boiler No. 2 and Classification Society Approval

Renewal and replacement parts of the boiler damaged after the accident:

- ✓ Burner, complete
- ✓ Inlet/outlet fuel hoses for burner
- ✓ Several damaged electrical cables
- ✓ Differential pressure and flow meter for thermal oil
- ✓ Fuel shut-off valve mechanism
- ✓ Limit switch for the fuel shut-off valve
- ✓ Pressure switch on the fuel inlet line
- ✓ Safety thermostats for thermal oil temperature and pressure gauge (2 pcs.)
- ✓ Thermal oil temperature meter (PT100 type)
- ✓ Manhole cover bolts (size M16, 12.9 pull)
- ✓ Insulating elements at the joints of the fuel and oil circuits

After parts were updated and replaced, the classification society in Bozcaada performed all functional tests, safety equipment, internal controls, and inspections on 23/03/2023 and upon satisfactory results, it was approved to be put into operation.

SECTION 3 - ANALYSIS

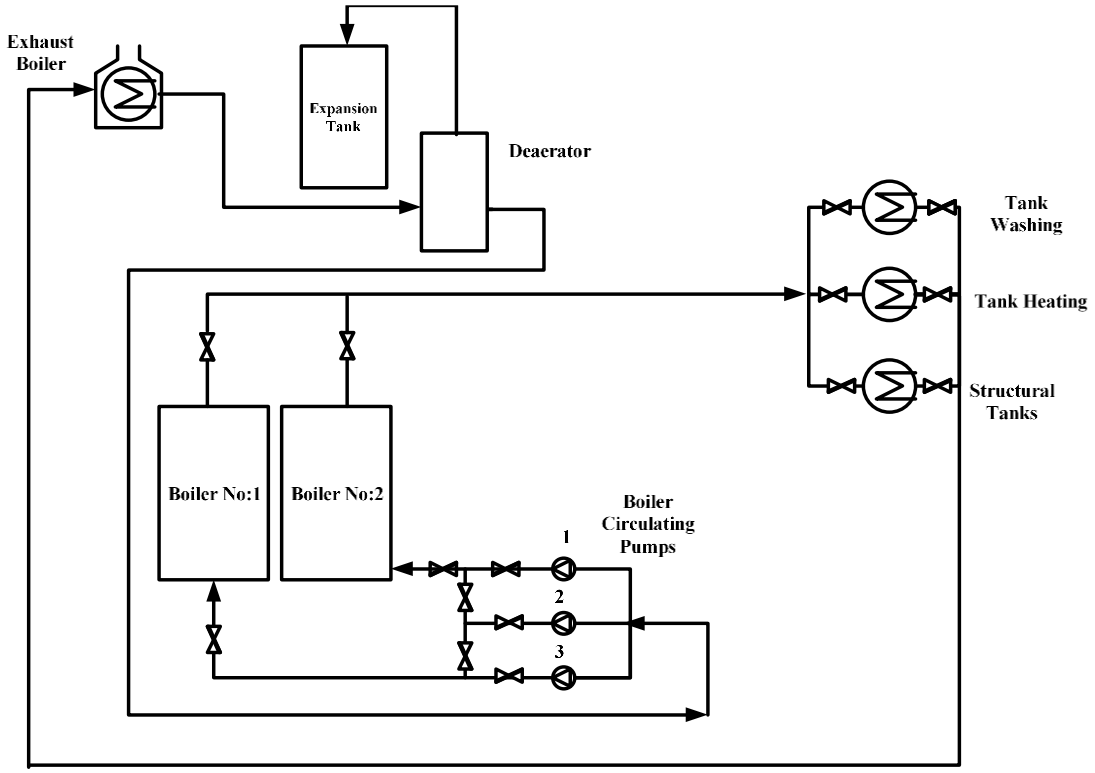
When analyzing the marine casualty under investigation, the sequence and analysis of events aimed to identify the safety factors that led to the occurrence of the casualty to draw valuable conclusions to guide safety recommendations.

Service was called from a well-known provider in the sector for the operation of the boiler by switching it from ULSFO fuel, which is suitable for 0.1094 Sulphur in the ECA zone for a long time, to VLSFO fuel, which is suitable for 0,506 Sulphur out of the ECA, since it requires expertise for technological reasons.

As stated in the narrative, the service provider replaced the solenoid valve No. 4 of the boiler (Line Diagram 3), adjusted and maintained the boiler, operated the boiler for a while with the existing nozzle of 200 kg/h on the boiler, and observed that the operation was normal. Subsequently, upon the request of the vessel to increase the boiler capacity, a nozzle of 250 kg/h brought from the ship's store was installed on the boiler. An explosion took place during the firing of the boiler. The explosion ejected the cover with a diameter of approximately 2 m and weighing 1500 kg, which was fixed to the body with 8 M16 bolts and nuts, and the burner of the boiler from their places. The boiler explosion resulted in serious injuries to the Service Technician who was on the cover and minor injuries to the Second Engineer who was nearby, and a fire broke out. The ship's crew responded to the fire effectively and extinguished it in a short time before it grew. A request was made by contacting the Turkey Representative of the burner and boiler manufacturer to identify the root causes and contributory factors of the burner and parts damaged by the explosion of the port side boiler by analyzing them at the factory level, but they neither adopted a positive approach nor provided any assistance and support.

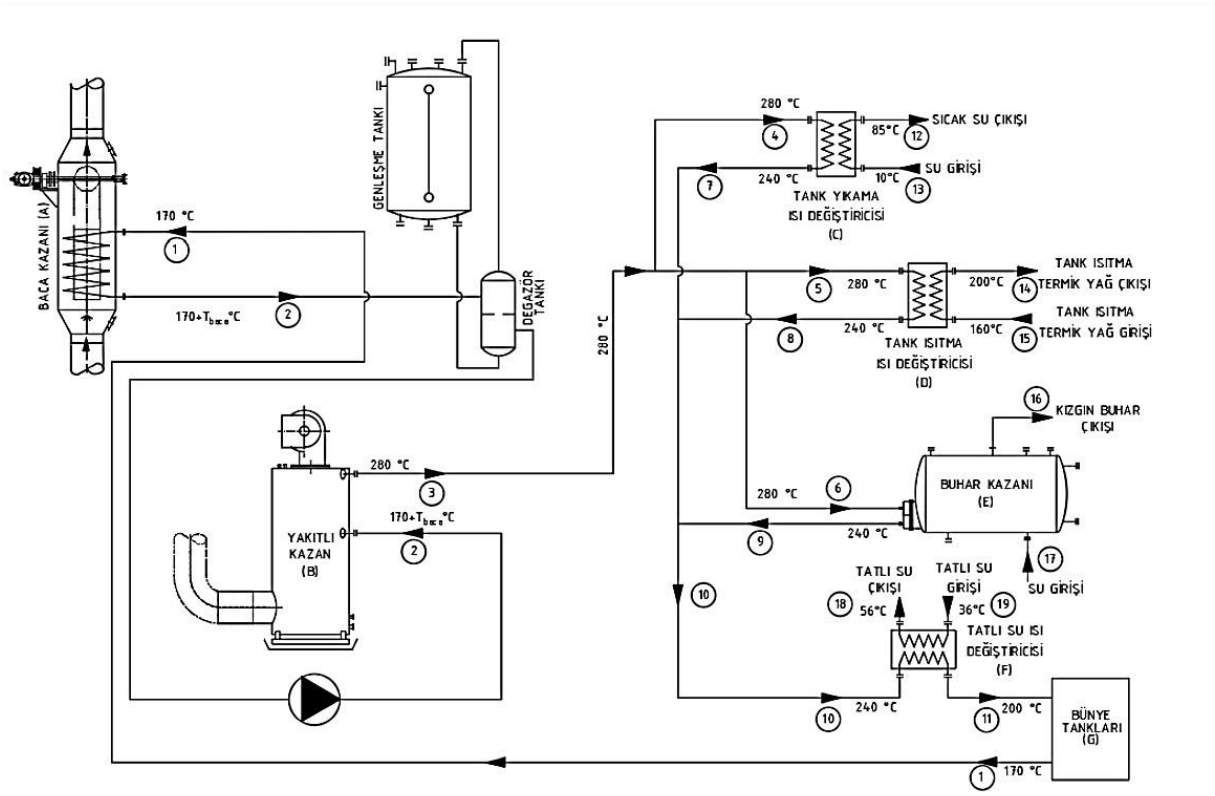
Based on the statements of those involved in the serious marine casualty investigated, possible judgements have been made.

3.1 Thermal Oil Boiler System



Line Diagram 1 Boiler Line Diagram of the M/T TORC (Concept)

Thermal oil boilers are preferred in vessels due to their high temperature at low pressures, no corrosion, freezing, calcification and more safety, energy efficiency and savings.



Line Diagram 2 Similar Thermal Oil Boiler Line Diagram

Line Diagram Components (Line Diagram 1):

- ✓ The Thermal Boiler (no. 1-2) heats the oil in the system.
- ✓ Exhaust Boiler: The boiler that is equipped to recover the waste heat from the exhaust gas of diesel engines and improve energy efficiency.
- ✓ Deaerator: Device for removing the gases in the oil
- ✓ Expansion Tank: This is used to maintain the pressure load in the system and replenish the missing oil.

Except for these line diagram elements, there are check valves, safety valves, on and off valves, press stats, and temperature and pressure gauges.

The oil heated to 280°C in the Thermal Oil Boiler reaches the exhaust gas boiler through the heat exchangers for tank washing and heating the product in the tanks and the structural tanks (fuel, oil tanks, etc.) and completes the line by pumping from the deaerator back to the boiler through the pump. There is approximately 40°C temperature difference (Δt= 40°C) between the inlet and outlet in the heat exchanger.

3.2 Risk Analysis Before the Maintenance/Repair of The Boiler

As it is known, the studies required to be carried out to identify hazards, analyze and rate the factors that cause these hazards to turn into risks and the risks resulting from the hazards and determine the control measures are defined as risk assessment.

The researches have revealed that 98% of accidents/incidents are related to human systems and can be prevented by measures to be taken as a result of appropriate risk management. It can be argued that risk management involves taking precautions and protecting life, property and environmental safety against possible hazards through the operation of a kind of early warning system, as well as hearing/seeing/feeling the footsteps of the accident/incident and taking precautions.

International Safety Management (ISM) Code, 1.2 Objectives, 1.2.2 The objectives of corporate safety management include Paragraph 1 which stipulates the provision of a safe work environment and safe practices in vessel operation; Paragraph 2 which stipulates the assessment of all identified risks to the vessel, crew and the marine environment and the establishment of appropriate measures.

As known, there must be a certain concentration of explosive material (flammable gas), oxygen (air), and an ignition source such as an arc, an open flame, or static electricity for an explosion to initiate. (Figure 2) This concentration must lie between the Lower Explosion Limit (LEL) and the Upper Explosion Limit (UEL). Explosions take place between these limits. In marine diesel oil, this concentration ranges between 1.3% and 6%.

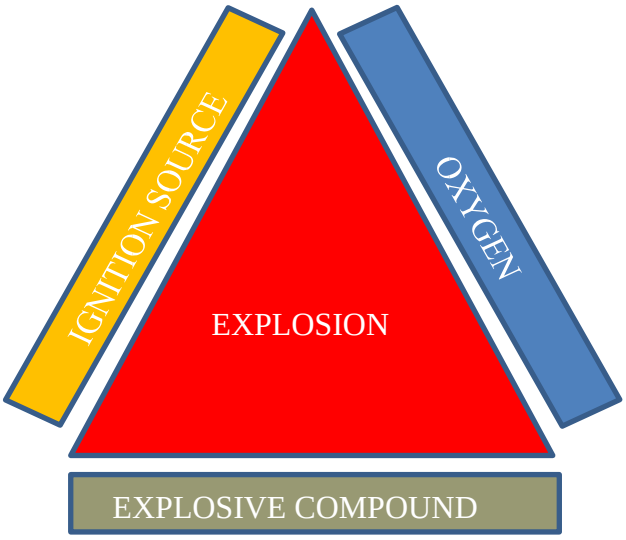


Figure 2 Triangle of An Explosion

A backfire due to the sudden combustion of the oil accumulated in the combustion chamber following an attempt to fire the boiler is a very common incident. Backfiring causes neither serious damage nor injury. However, in cases of excessive accumulation of oil and oil vapor in the combustion chamber, the risk of this backfire intensifying and turning into an explosion rises. On the other hand, a risk analysis indicates that no one should stand on the cover of the boiler as a precautionary measure against a possible explosion.

After such an incident, the ship operator has reminded all vessels in its fleet that risk analyses should be done for service calls and that vessels should be inspected for compliance and verification for two years.

3.3 Work Permit

The work permit is a process that should be followed by the master or the chief engineer authorized by him to review and take precautions for hot working, cold working, working under high voltage, working at height, and repairing the boilers that are pressurized vessels against the risk of explosion based on safety and the work permit system available in the corporate procedures. In this case, it was alleged but not proved that the ship's crew checked the work permit.

After this incident, the ship operator reminded all vessels in its fleet that the requirements of the work permit system should apply to service calls and that the vessels would be inspected for compliance and verification for two years.

3.4 Periodic Boiler Inspections

The technical manual of the boiler burner states that the manufacturer's representative or authorized staff must technically inspect the burner once a year in accordance with DIN 4755 Safety Principles for Oil Firing Installations. The Class Society records show that the Class Society essentially inspected the burner for operation and safety for the last three years.

3.5 Fuel Leakage to Combustion Chamber

Due to the need for hot water capacity for tank washing and cleaning and the operation of that ship in Ukraine voyages outside the ECA Zone, as mentioned above, the service was called for switching from ULSFO to VLSFO by indicating that "the system is completely going off when the fuel oil (FO) switch is selected on the boiler panels". Firstly, one solenoid valve (Image 5) was replaced on the boiler, and the boiler was fired with the existing nozzle of 200 kg/h by adjusting the necessary settings and observed to operate smoothly for 2-3 hours. Subsequently,

the nozzle with a capacity of 200 kg/h on the boiler burner was removed to increase the heating capacity of the boiler upon the request of the ship and replaced with a nozzle (Image 6) with a capacity of 250 kg/h, which was brought from the ship's store but not proven to be an original spare part.

The boiler is capable of generating energy of 2300 Kw or 1,978,000 kcal/h. The hourly fuel requirement of said boiler is calculated as approximately 229 kg/h when the 85% efficiency and the lower calorific value of the MGO are considered as 10,200 kcal.

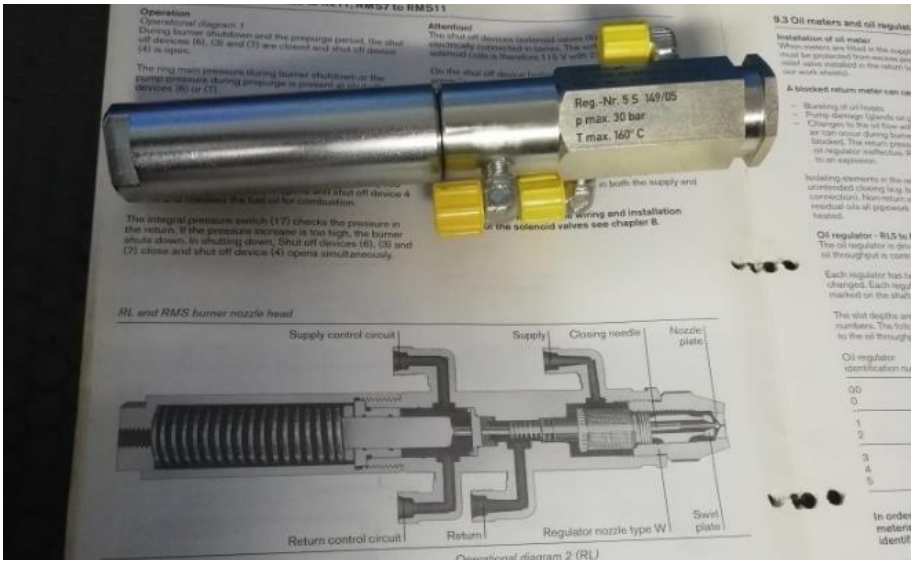


Image 5 Spare Nozzle Unit – Illustration

Image 6 Replacement Solenoid Valve and Nozzle

Finally, after the nozzle was replaced, the boiler was tried to be fired, and when the concentration of MGO vapor and air in the combustion chamber exceeded the LEL limit value indicated above,

an explosion took place with ignition. The force of the explosion ejected the cover with a diameter of approximately 2 m and weighing 1500 kg, which was fixed to the body with 8 M16 bolts, and the burner of the boiler (Figure 3, Figure 4) from their places, and the Service Technician who was on top of the damaged (Image 7, Image 8, Image 9) was seriously injured, and the Second engineer who was nearby sustained minor injuries.

Image 7 Damage to Boiler Cover After Explosion

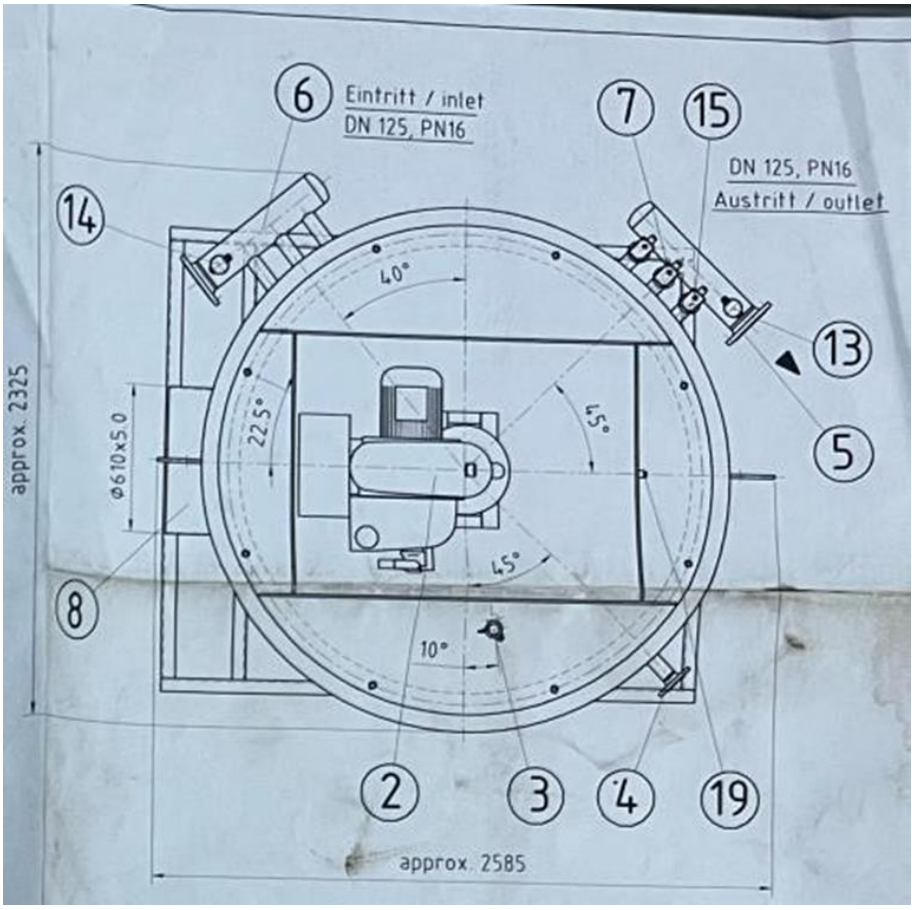


Figure 3 Connection of the Boiler Cover to the Boiler Body with 8 M16 Bolts and Cover Dimensions

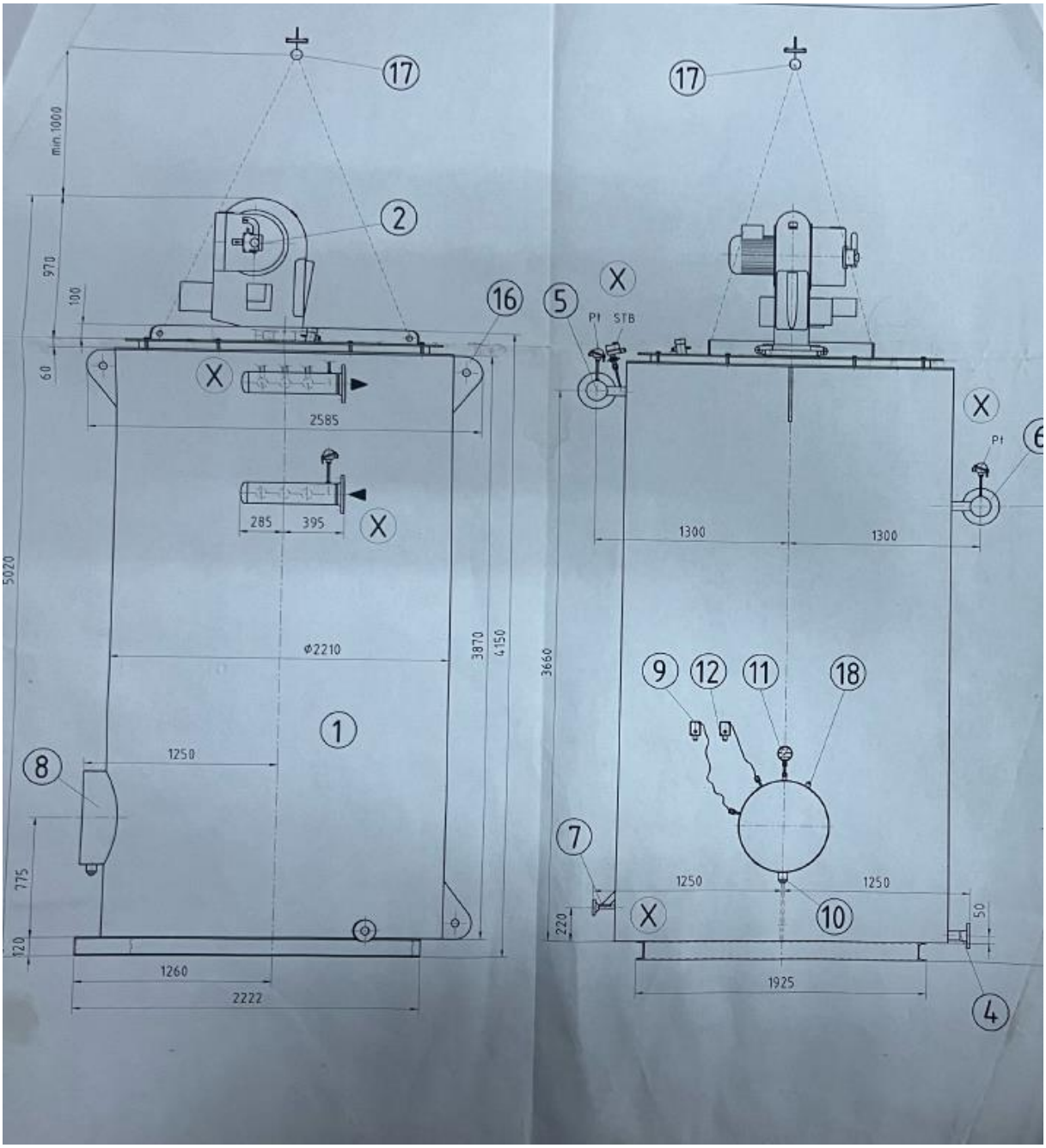
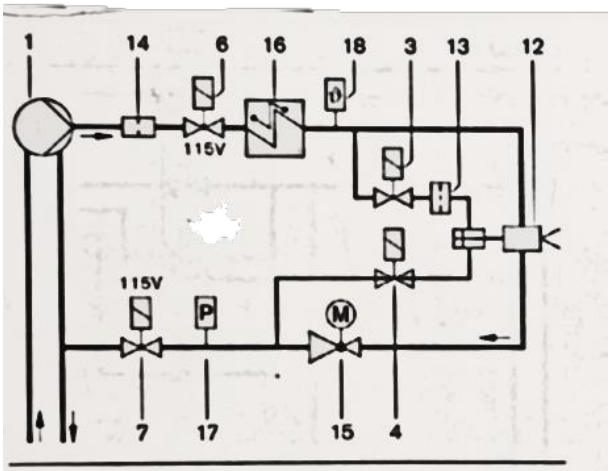


Figure 4 Connections and Components of Boiler Body

Pos.No	Designation and technical data	
	Flanges DIN 2633	
19	Drain for oil sump	1/2"
18	Socket	1/2"
17	Provides girder for top installation Top with burner approx. 1500kg	YARD
16	Ring bolts No.2 After installation to use for fixing the heater	
15	Safety temperature limiter	ATHs-SE 70
14	Resistance thermometer, inlet	Pt 100
13	Resistance thermometer, outlet	Pt 100
12	Safety temperature limiter	ATHf 70
11	Thermometer, 1/2"	0 - 500°C
10	drainage	R 1"
9	Safety temperature limiter	ATHf 70
8	Exhaust gas connection	DN 600
7	drain	DN 20
6	Inlet	DN 125
5	Outlet	DN 125
4	Connection for leakage alarm	DN 50
3	Inspection glass with CO2 connection	1/2"
2	Burner	RMS 9 ZMD
1	Thermal transfer heater	DWE 2300 V 87
	contents , litre	1285
	Weight empty , kg	6650

Image 8 Boiler Cover After Explosion

Image 9 Nozzle and Electrodes as a Result of Explosion



1 Pump without integral solenoid valve
2 Solenoid valve type 121C2323 9 W coil (normally closed) Rp 1/8"
3 Solenoid valve type 121K2421 19 W coil (normally closed) Rp 1/8"
4 Solenoid valve type 122K9321 19 W coil (normally open) Rp 1/8"
5 Solenoid valve type 121K6220 20 W coil (normally closed) Rp 1/4"
6 Solenoid valve type 321H2322 20 W coil (normally closed) Rp 3/8"
7 Solenoid valve type 121G2320 20 W coil (normally closed) Rp 3/8"
8 Two stage EL nozzle head (without integral shut off device)
9 Three stage EL nozzle head (without integral shut off device)
10 Nozzle head R (without integral shut off device)
11 Two stage nozzle head M (with integral shut off device)
12 Nozzle head R (with integral shut off device) in flow and return
13 Restricting orifice
14 Filter
15 Oil regulator
16 Oil preheater
17 Pressure switch 0 10 bar (set to 5 bar for EL set to 7 bar for MS) Return
18 Thermostat

Line Diagram 3 Line Diagram of the Burner RMS9

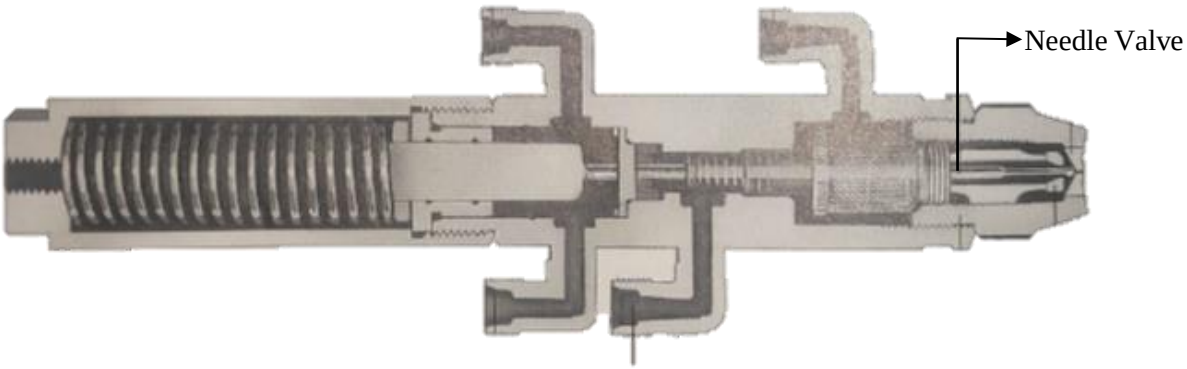


Image 10 Cross Section of Nozzle Unit

Image 11 Disassembled Nozzle Unit

The fuel system works as follows: According to Line Diagram 3, solenoid valves 6 and 7 connected in series in the RMS burners are simultaneously energized and fuel circulation is opened. When the fuel temperature reaches the appropriate value, the solenoid no. 3 opens, solenoid no. 4 closes, and the atomized fuel is injected through the nozzle into the combustion chamber after the fuel circulation has been completed.

The shut-off apparatus at the nozzle head functions as a safety mechanism in the direction of flow and return line. Therefore, the system protection (Image 10 and Image 11) at the nozzle activates and prevents the fuel from leaking into the combustion chamber. The nozzle represents the final safety stop of the system. In case of leakage in the needle valve of the nozzle, it is considered that fuel and vapor accumulate in the combustion chamber.

It is considered that the accumulation of fuel and vapor inside the boiler, which would have triggered a severe explosion, was due to the nozzle of 250 kg/h which was subsequently installed. Following the subsequent nozzle replacement, the fuel leakage/inflow into the combustion chamber must be checked with appropriate procedures, and ventilated sufficiently, and after making sure that the environment is safe, the repair and combustion process must be initiated.

While getting outsourced service on board, it is considered that the ship’s crew should not leave the initiative entirely to the service provider for risk assessment and safety considerations related to risk mitigation but rather should assume an active role and take measures to prevent the casualty as a supervisor against the risks.

3.6 Fire Response and Emergency Procedures After Casualty

Following the boiler explosion, a minor fire broke out in the vicinity and was extinguished quickly by the effective response of the ship’s crew by spraying water from the fire line.

The injured personnel were transferred to the hospital by dialing 112 and calling an ambulance.

SECTION 4 CONCLUSIONS

4.1 Since the conversion system of the thermal oil boiler from MGO to FO was inoperative, the ship operator called for service.

4.2 There was no evidence that the risk was assessed by the service provider before the maintenance and repair of the boiler, that the safety considerations were thoroughly discussed by the ship and the service provider together, or that adequate precautions were taken to ensure safety.

4.3 The solenoid valve of boiler No. 2 on board was replaced; it was operated after maintenance and adjustments and was observed to operate normally. Subsequently, a nozzle with 250 kg/h was fitted instead of a nozzle with 200 kg/h to increase the capacity.

4.4 After the boiler was put into operation after the nozzle was fitted, a powerful explosion took place in the boiler when the fuel vapor accumulated in the boiler reached a certain value.

4.5 The force of the explosion ejected the boiler cover that was connected with 8 M16 bolts and nuts and the burner mounted on it.

4.6 The Boiler Technician who was standing on the boiler cover was seriously injured and the Second Engineer who was nearby sustained minor injuries.

4.7 A fire broke out in the boiler section, and the ship's crew responded to it with water and extinguished it in a short time before it grew.

4.8 The boiler and burner manufacturers refrained from inspecting the boiler and burner parts involved in the casualty.

4.9 The ship resumed her voyage upon the confirmation of the class society that the ship could safely navigate with boiler No. 1 in operating condition.

4.10 The destroyed parts and the burner of boiler No. 2, which was damaged after the casualty, were renewed and put into operation after being cleared by the Class Society on 23/03/2023 and are still in use.

SECTION 5 ACTIONS TAKEN

The Ship Operator took the following actions:

5.1 After the occupational casualty, the Expert Trainer went on board and delivered recurrent training on operating permit requirements and risk assessment.

5.2 All vessels in the corporate fleet were warned about operating license requirements and risk assessment. Future ship inspections were reported to focus on these issues.

5.3 The service reports from the same service provider in the past were reviewed and noted that none of the anomalies related to the identification of the causes of such an explosion were identified, and the boiler maintenance/repair and service provider had never experienced such an explosion in the past.

5.4 Safety briefings about the casualty were sought from the boiler and burner manufacturers, but they refused to collaborate.

5.5 Other businesses in the same industry were contacted to see whether they had any similar experiences, but no information was received.

5.6 The corporate investigation report, which analyses the consequences of this casualty and contains corrective and preventive actions, has been sent to the fleet ships for implementation.

5.7 A Corporate Newsletter on safe operation, maintenance instructions and lessons learned was published and displayed next to the boilers of all ships in the fleet and the Engine Control Room.

SECTION 6 RECOMMENDATIONS

The following recommendations are directed by considering the analysis and conclusions obtained from the casualty investigation.

The Ship Operator is recommended to:

25/07-23 Assume an active role in taking the necessary precautions for safety by assessing the risk while getting service on all ships in their fleet and considering that the ship's crew should be more careful when surveilling and supervising,

26/07-23 Review the system of supplying spare parts to ships, the manufacturer's guarantee, and the effectiveness of the follow-up system, especially in the supply of critical spare parts,

The Boiler Maintenance and Repair Service Provider is recommended to:

27/07-23 Assess the risks before starting hazardous works such as boiler maintenance and repair and take necessary measures to lower it to an acceptable risk level, although this type occupational accident occurred on board the ship for the first time,

The Chambers of Shipping (IMEAK DTO, Mersin DTO) are recommended to:

28/07-23 Circulate this report to their members who operate tankers.