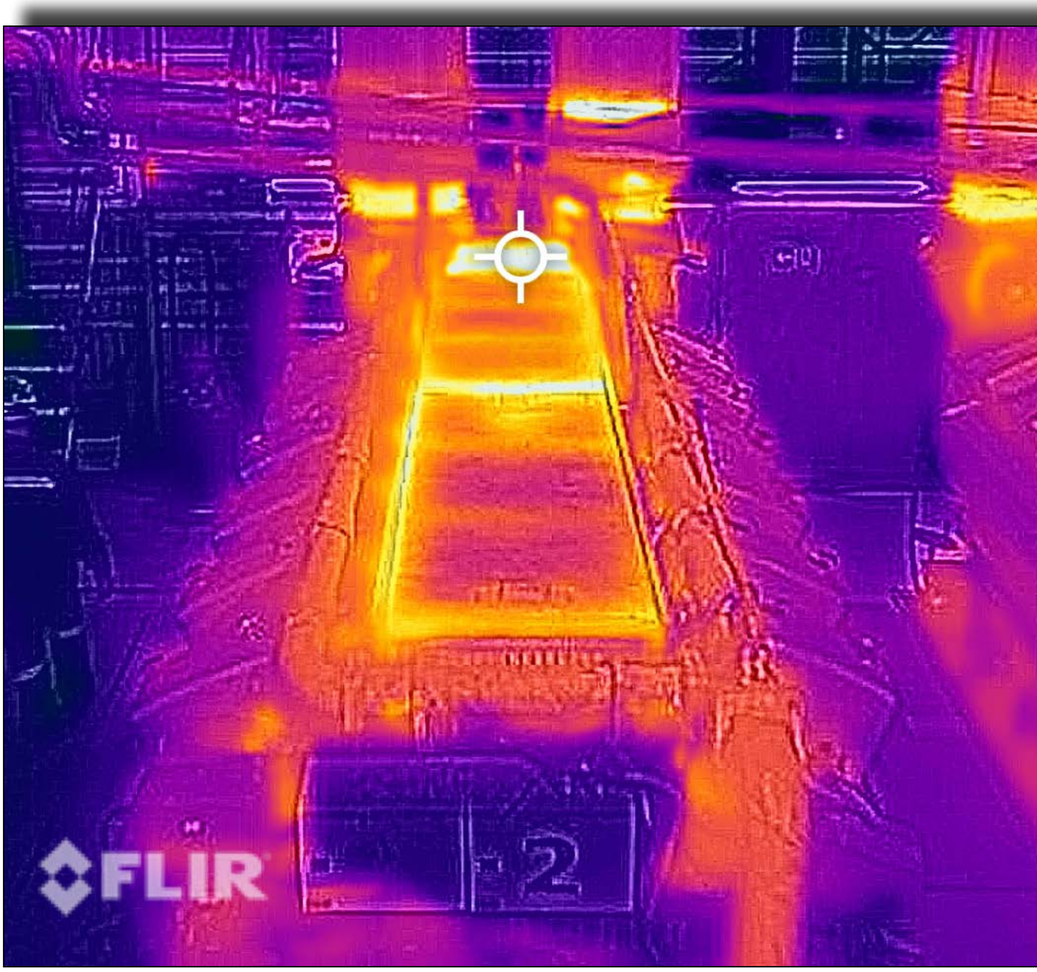
ACCIDENT REPORT

MARINE ACCIDENT INVESTIGATION BRANCH

Report on the investigation of an engine room fire on board the roll-on/roll-off passenger ferry *Stena Europe* while approaching Fishguard, Wales on 11 February 2023



SERIOUS MARINE CASUALTY | REPORT NO 20/2024 | DECEMBER 2024

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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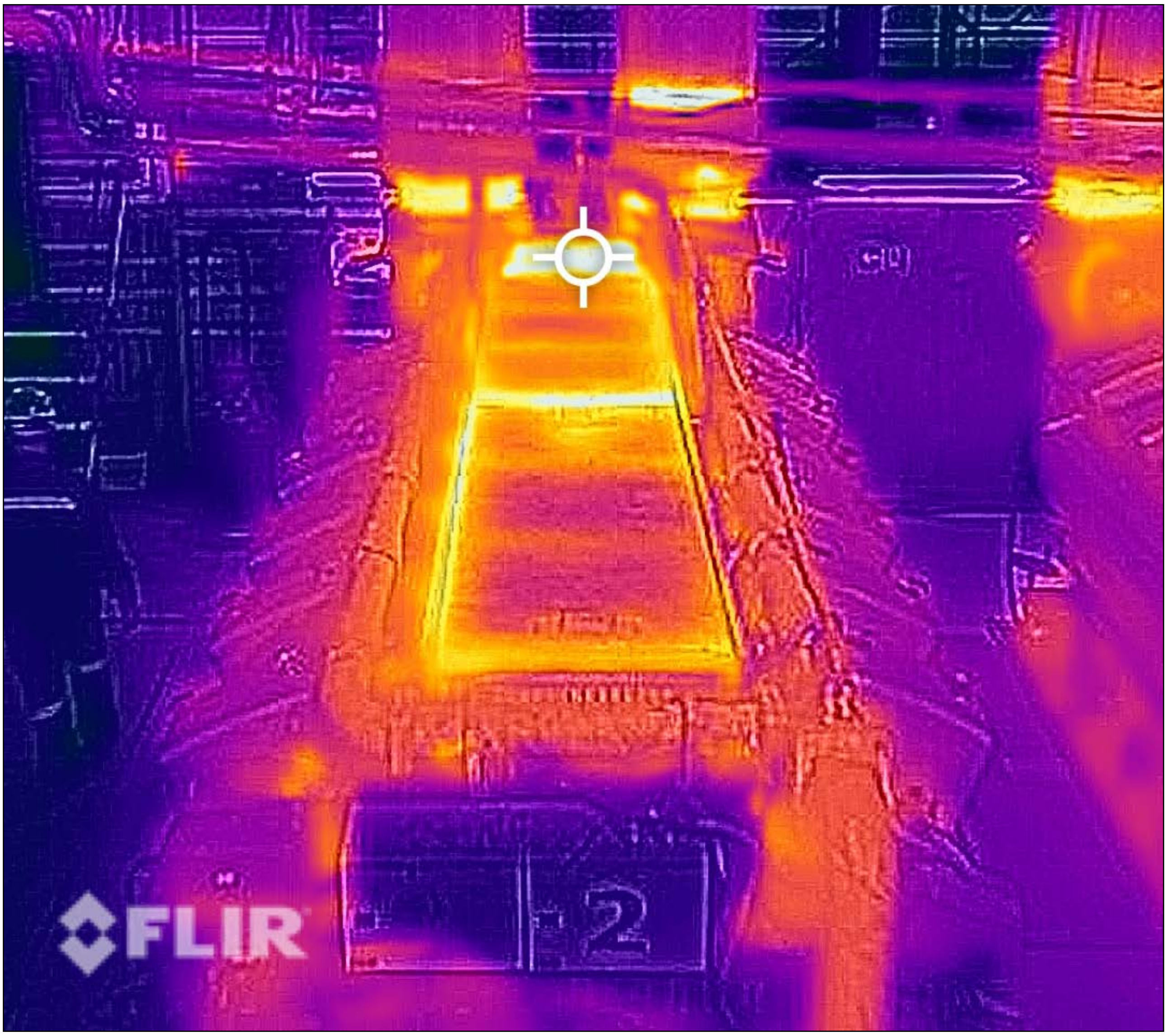

Thermographic image of a main engine on *Stena Europe*

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

°C	-	degrees Celsius
2/E	-	second engineer
3/E	-	third engineer
3/O	-	third officer
BA	-	breathing apparatus
C/E(d)	-	chief engineer (day)
C/E(n)	-	chief engineer (night)
DNV	-	Det Norske Veritas
ECR	-	engine control room
IMO	-	International Maritime Organization
ME	-	main engine
MSC	-	Maritime Safety Committee
PPE	-	personal protective equipment
QCV	-	quick closing valve
ro-ro	-	roll-on/roll-off
SOLAS	-	International Convention for the Safety of Life at Sea, 1974, as amended
TIC	-	thermal imaging camera
UTC	-	universal time coordinated

TIMES: all times used in this report are UTC unless otherwise stated.

SYNOPSIS

At 2115 on 11 February 2023, a fire started in the engine room of the UK registered roll-on/roll-off passenger ferry *Stena Europe* as it approached Fishguard, Wales on passage from Rosslare, Ireland. The fire caused significant damage to the port main engine room and rendered one of its four main engines inoperative for several weeks. The fire was caused by fuel leaking under pressure from the fuel system of main engine number 3 and igniting on an exposed hot surface. No one was injured and there was no pollution.

The investigation found that the fuel had ignited on part of the engine's exhaust system that had a surface temperature of over 400°C. The post-accident inspection on board *Stena Europe* identified that much of the protective shielding around the fuel systems on all engines was in a poor condition or missing, and exposed hot surfaces of over 220°C were found on all running engines.

In 1995, Wärtsilä, the engine manufacturer, had identified that the fuel system on this model of engine was prone to leakage and had made a modification available to improve the system. The manufacturer's complete modification had been installed on one of *Stena Europe*'s four main engines. The fuel systems on the remaining three main engines had been partially modified. Repairs made to the damaged engine since the fire have included the manufacturer's modification to fully upgrade the fuel system, and rectification of missing or damaged shielding.

The Maritime and Coastguard Agency has been recommended to submit a paper to the International Maritime Organization proposing an amendment to Maritime Safety Committee Circular 1321 to introduce a requirement for the use of thermographic equipment to identify hot surfaces exceeding 220°C that could be impinged by pressurised oil.

Recommendations have also been made to Stena Line Ltd to review the use of the existing defect reporting functions within its fleetwide planned maintenance system and how its chief engineers conduct class-related equipment inspections; to introduce the use of thermal imaging cameras on all vessels within its fleet; and to promulgate details of this accident throughout its fleet.

SECTION 1 – FACTUAL INFORMATION

1.1 PARTICULARS OF *STENA EUROPE* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Stena Europe*
Flag	UK
Classification society	Det Norske Veritas
IMO number	7901760
Type	Passenger/car ferry
Registered owner	Stena Line Ltd
Manager(s)	Stena Line Ltd
Construction	Steel
Year of build	1980
Length overall	149.02m
Registered length	131.6m
Gross tonnage	24,828
Minimum safe manning	21
Passenger rating	1,254
VOYAGE PARTICULARS	
Port of departure	Rosslare, Ireland
Port of arrival	Fishguard, Wales
Type of voyage	International
Manning	59
MARINE CASUALTY INFORMATION	
Date and time	11 February 2023 at 2115
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Approaching Fishguard, 52°0'43"N 004°59'25"E
Place on board	Port main engine room
Injuries/fatalities	None
Damage/environmental impact	Fire damage in engine room
Ship operation	On passage
Voyage segment	Arrival
External & internal environment	Calm sea; dry; air temperature 8.5°C; light winds
Persons on board	88 passengers, 59 crew

1.2 NARRATIVE

1.2.1 Passage from Rosslare

At 1757 on 11 February 2023, the roll-on/roll-off (ro-ro) passenger ferry *Stena Europe* **(Figure 1)** departed Rosslare, Ireland, using three of the vessel's four main engines. The ferry was heading for the port of Fishguard, Wales and the crossing would take about 3.5 hours **(Figure 2)**. On the bridge were the night master, a third officer (3/O) and a helmsman. In the engine control room (ECR) were the night chief engineer (C/E(n)), a third engineer (3/E), a fourth engineer and a motorman. At 2101, the 3/O on the bridge called the ECR and asked the C/E(n) to start the fourth main engine in preparation for arrival into Fishguard. The C/E(n) started main engine 3 (ME3) and, after checking it was running without fault, clutched it into the port gearbox. At 2106, the 3/O asked the C/E(n) to go to standby[1] for arrival.

Image courtesy of Stena Line Ltd

Figure 1: *Stena Europe*

Image courtesy of Google Maps

Figure 2: The accident location

[1] A state of readiness for the vessel to manoeuvre with all available propulsion machinery running and available to use.

At 2114, a low fuel oil pressure alarm sounded in the ECR for the port main engine fuel system. The port standby fuel supply pump then started automatically, which triggered an alarm in the ECR. At 2115, several fire and smoke detectors in the port engine room and the funnel casing were activated that sounded alarms on the bridge and in the ECR. The C/E(n) told the 3/E and motorman to go to the port engine room and investigate the fire alarms.

1.2.2 Engine room fire

At 2116, the 3/E and motorman carefully opened the watertight door at the forward end of the port engine room. As soon as the door was opened slightly, they saw a large fire at the front inboard side of ME3. They returned to the ECR and reported their observation to the C/E(n). The 3/E started the water mist system[2] for the port engine room at the control panel and activated the engineer's emergency call and manual fire alarm. The C/E(n) declutched ME3 and stopped it. The C/E(n) then stopped the fuel pump supplying both ME1 and ME3 before calling the bridge to inform them of the fire and its location.

On the bridge, the night master told the helmsman to steer a course to take the vessel away from Fishguard harbour and asked the 3/O to broadcast "*This is not a drill, working party red, close up*" through the crew areas only.

At 2117, the day master, who was the senior master on board, heard the engineer's emergency call in their cabin and went to the bridge. At 2119, the 3/O transmitted a "Mayday" distress call on very high frequency radio channel 16. At the same time, the day chief engineer (C/E(d)) left their cabin in response to the engineer's emergency call and reported to the bridge, where they received a situation brief from the day master before going to the ECR.

The bridge team received reports from several passengers of a large fireball coming out of the funnel. The day master responded to these reports by making an all-area announcement using the ship's public address system, requiring all passengers to vacate the upper deck and to remain inside the ship. The 3/O instructed the deck fire team to start boundary cooling the funnel from the upper deck **(Figure 3)**.

Image courtesy of Fishguard RNLI

Figure 3: Boundary cooling of *Stena Europe*'s funnel casing

[2] Used to suppress or extinguish fires by discharging high-pressure water through specialised nozzles that atomise the water and create a mist.

1.2.3 Emergency response

The C/E(d), second engineer (2/E) and several other engineering crew arrived in the ECR having heard the engineer's emergency call, the announcement from the day master or the fire alarm. After a briefing on the situation by the C/E(n), the C/E(d) ordered the port engine room air supply fans to be stopped and the fire dampers to be closed. The C/E(d) also instructed the 3/E and the motorman to don firefighting suits and breathing apparatus (BA) to form an engine room fire team.

Both chief engineers went to the auxiliary engine room and prepared a nearby water hose reel in readiness for use **(Figure 4)**. Once they were in position at the forward watertight door to the engine room the door was opened; it was immediately apparent that the water mist system had extinguished most of the fire and only small, isolated pockets of flames remained. The C/E(d) then stepped into the space through the watertight door close to the forward end of ME3.

The C/E(d) intended to trip the quick closing valve (QCV) for the fuel supply to ME3 situated in the port engine room. The C/E(d) was not wearing any personal protective equipment (PPE) or BA and was prevented from getting close to the valve as the smoke-filled area was too hot. The C/E(d) retreated back through the watertight door, from where the C/E(n) was spraying water onto the remaining pockets of fire. Once they were out of the space, the watertight door was closed.

The fire had damaged cabling in the port engine room and rendered the telephone systems inoperative. The C/E(n) used their ultrahigh frequency radio to contact the bridge team and requested the operation of the remote QCVs by the control located at the aft end of the bridge. A member of the bridge team activated the closing mechanism for the fuel valves of all four main engines.

When the 2/E and the engine room fire team arrived in the auxiliary engine room the fire team entered the port main engine room through the watertight door with the charged water hose. The engine room fire team extinguished a fire on the upper walkway.

While the deck fire team continued boundary cooling the funnel from the upper deck, the C/E(n), a motorman and an electrician arrived to investigate further. The C/E(n) and the motorman checked the starboard access door to the funnel casing before making an entry. Once inside they saw flames in the upper section of the funnel. The C/E(n) told the motorman and the electrician to liaise with the deck fire team to fight the fire inside the funnel casing. The C/E(n) returned to the ECR and radioed the bridge team to inform them of the secondary fire and the action being taken to extinguish it.

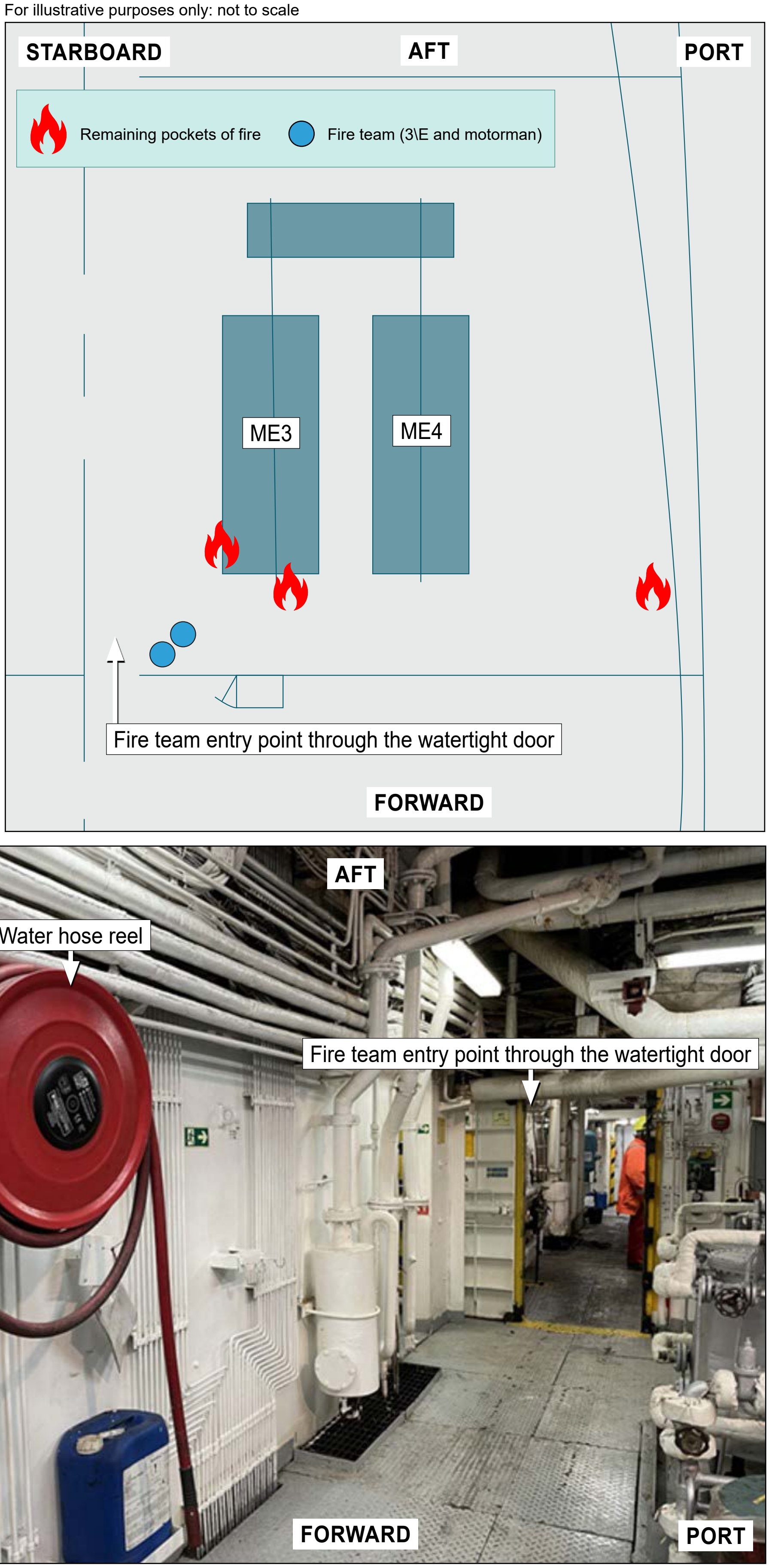

Figure 4: Water hose reel and (inset) the port main engine room

1.2.4 Berthing in Fishguard

The three running engines were starved of fuel due to the closure of the QCVs for all the main engines. The C/E(d) visually checked the QCV for ME3 was closed and requested that the bridge team reset the remote QCV lever on the bridge for all the main engines. Once the lever on the bridge was reset, the QCVs for ME1, ME2 and ME4 were opened, and the starboard fuel pump started.

At 2237, the day master berthed *Stena Europe* without incident using ME1 and ME2 powering the starboard propeller shaft and the bow thrusters. Once secured alongside, the bow ramp was lowered to allow the Mid and West Wales Fire and Rescue Service to board. Several firefighters entered the engine room and funnel casing spaces and used thermal imaging cameras (TIC) to check for any remaining hot spots.

1.3 ENVIRONMENTAL CONDITIONS

The weather conditions on the evening of 11 February 2023 were dry, with an air temperature of 8.5°C, light winds from the west, and a slight sea.

1.4 POST-ACCIDENT INSPECTION

An inspection of the port engine room the day after the fire identified that the seat of the fire was at the inboard front end of ME3 **(Figure 5)**. Closer inspection revealed an exposed fuel pipe flanged connection partially covered by incomplete shielding **(Figure 6)**. One of the two flange securing screws was found to be missing, and the sealing O-ring was observed protruding from the joint **(Figure 7)**. This was identified as the source of fuel leakage for the fire.

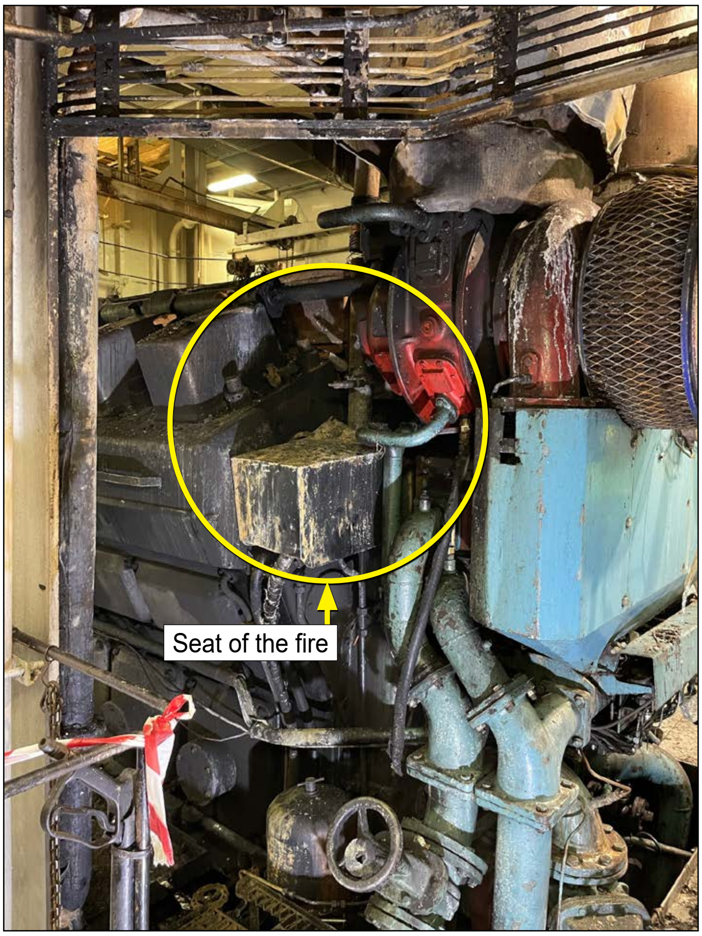

Figure 5: The seat of the fire at the front inboard end of ME3

Behind the cylinder head of B bank unit number 6, the protective insulated shielding was found to be displaced. This exposed the exhaust manifold **(Figure 8)**, which had an operating temperature of over 400°C and was identified as the most likely source of ignition for the fire.

Investigators found that anti-splashing tape had not been used on the pressurised oil systems of any of the main or auxiliary engines, and identified many areas where shielding was either missing, poorly fitted or damaged to the point of providing inadequate protection.

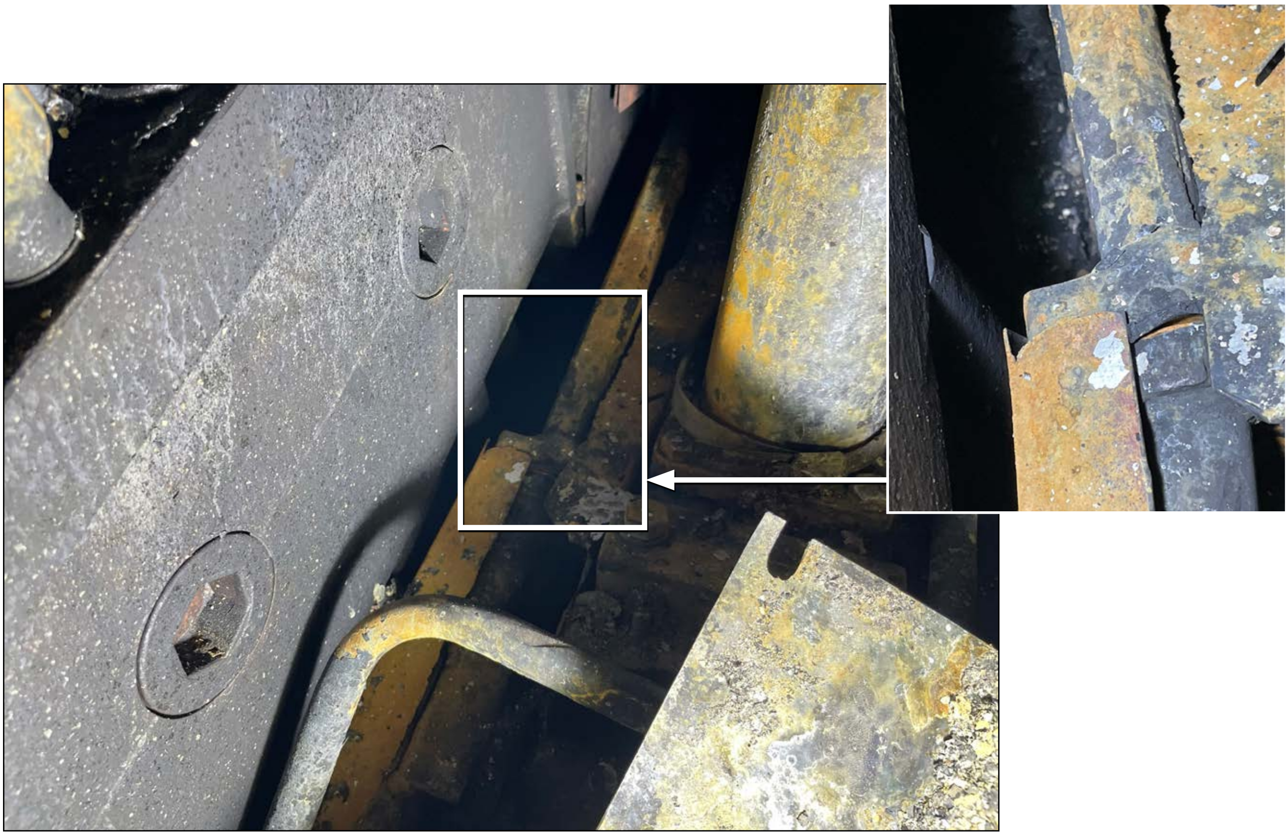

Figure 6: Incomplete shielding with exposed fuel pipe flange connection

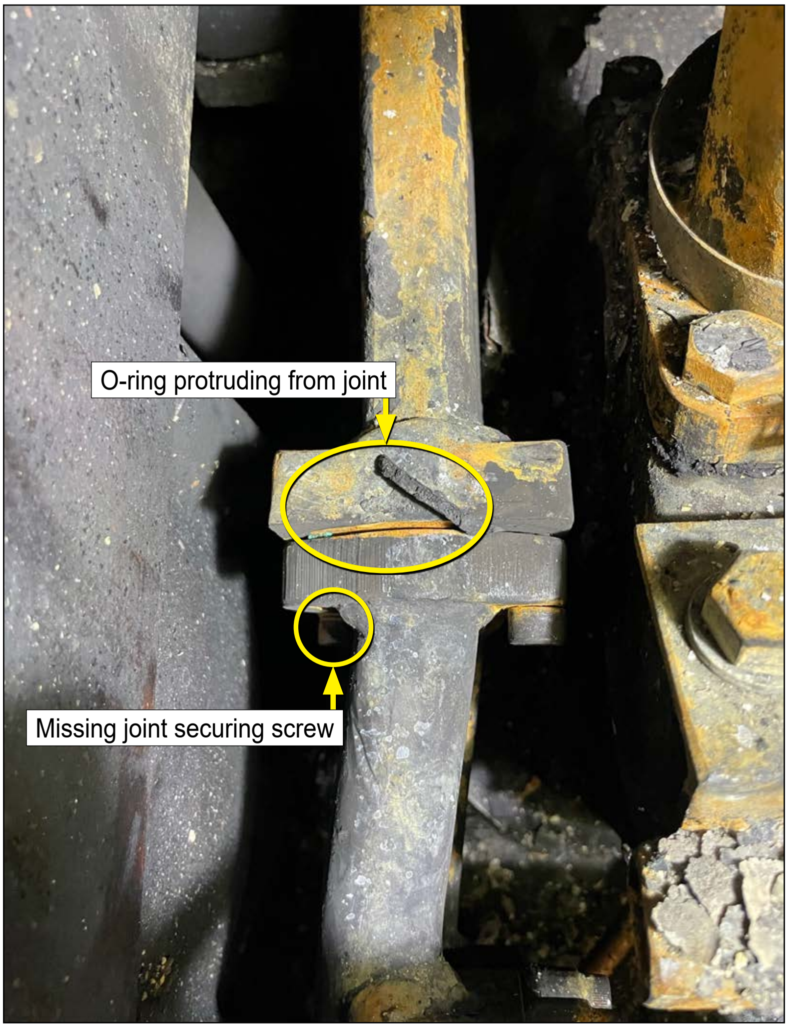

Figure 7: Fuel system joint

Figure 8: Protective insulated shielding behind B bank unit number 6 and (inset) the most likely source of ignition

1.5 *STENA EUROPE*

1.5.1 General

Stena Europe was a UK registered ro-ro passenger ferry built in 1980 and was classed by Det Norske Veritas (DNV). The vessel was certified to carry 1,254 passengers and had operated on a scheduled service between Rosslare and Fishguard for over 20 years.

Propulsion power was provided by four V12 Wärtsilä VASA 32 (VASA 32) medium speed diesel engines rated at 3840 kilowatts, running at a nominal speed of 800 revolutions per minute. These were configured in two separate engine rooms: ME1 and ME2 in the starboard engine room, ME3 and ME4 in the port engine room. Each pair of engines was connected to a reduction gearbox that drove a controllable pitch propeller **(Figure 9)**.

From 2014 to 2018, *Stena Europe*'s technical management had been outsourced to Northern Marine ship management. Since September 2018, the technical management for the vessel was undertaken by its owners, Stena Line Ltd (Stena).

For illustrative purposes only: not to scale

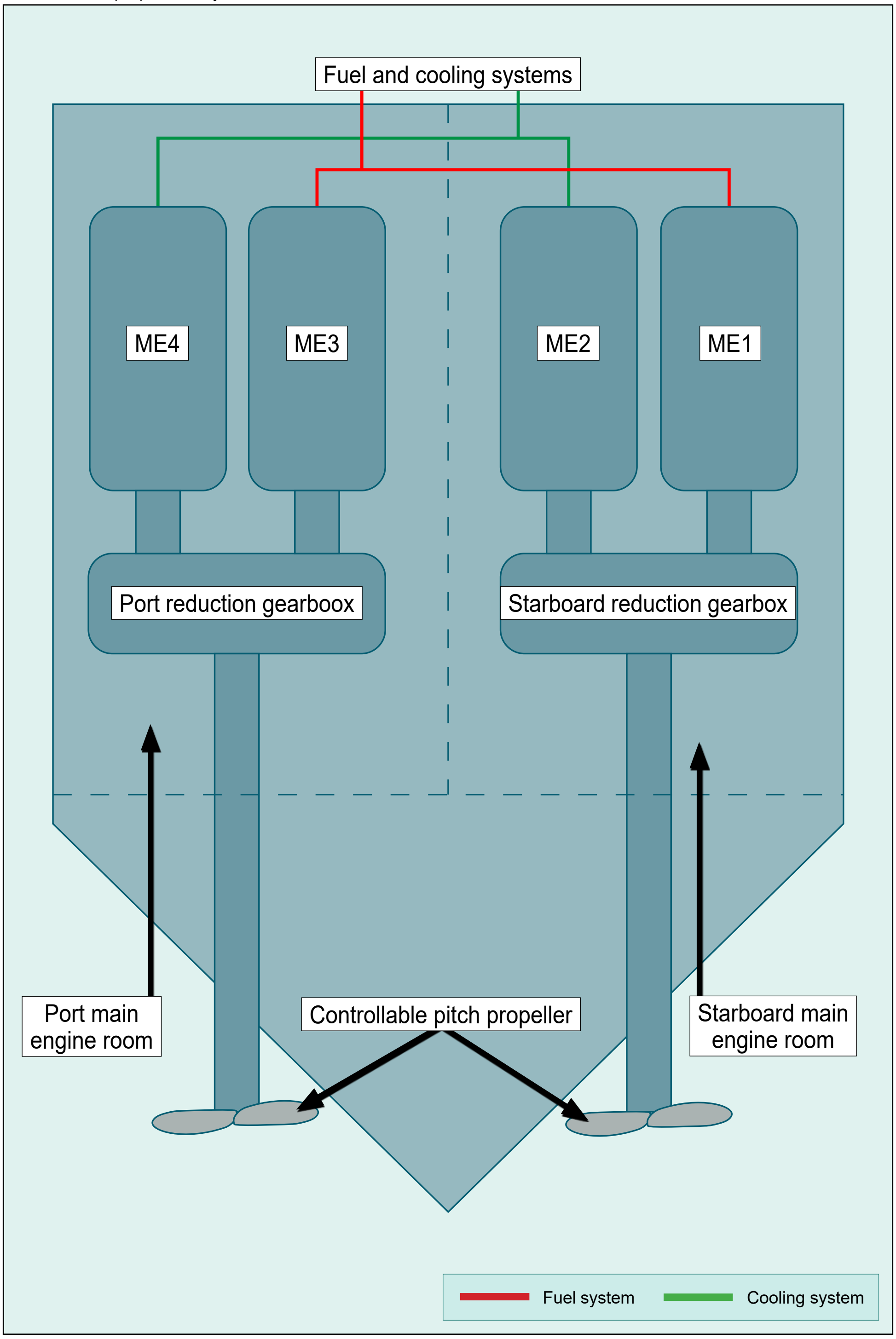

Figure 9: The propulsion arrangement

1.5.2 Manning

Stena Europe's safe manning certificate required a minimum crew of 24. There were 59 crew on board on 11 February 2023. The crew worked equal rotations of either one week on/one week off or two weeks on/two weeks off. The watchkeeping bridge and engine room staff worked 12-hour shifts with start times staggered throughout the day. All bridge and engine room officers were either British or Irish, all spoke English as their first language, and there were no issues with spoken communication. All officers were appropriately qualified for their roles on board. Stena had experienced a significant turnover of staff, especially in the engine department. This had resulted in the regular ship's crew being frequently required to train temporary crew hired through an agency or new permanent staff, adding to their already high workload.

1.6 MAIN ENGINE FUEL SYSTEM

1.6.1 General

The fuel system on the VASA 32 engine consisted of internal and external pipework. The internal pipework connected the fuel supply and return rails to each cylinder's fuel pump and was contained inside a hot box[3]. The external part of the system was located at the non-drive end of the engine and consisted of the fuel pressure regulating valve, which maintained a system pressure of 7 bar, and pipework that supplied and returned fuel from the internal fuel rails on the A and B banks of the engine **(Figure 10)**.

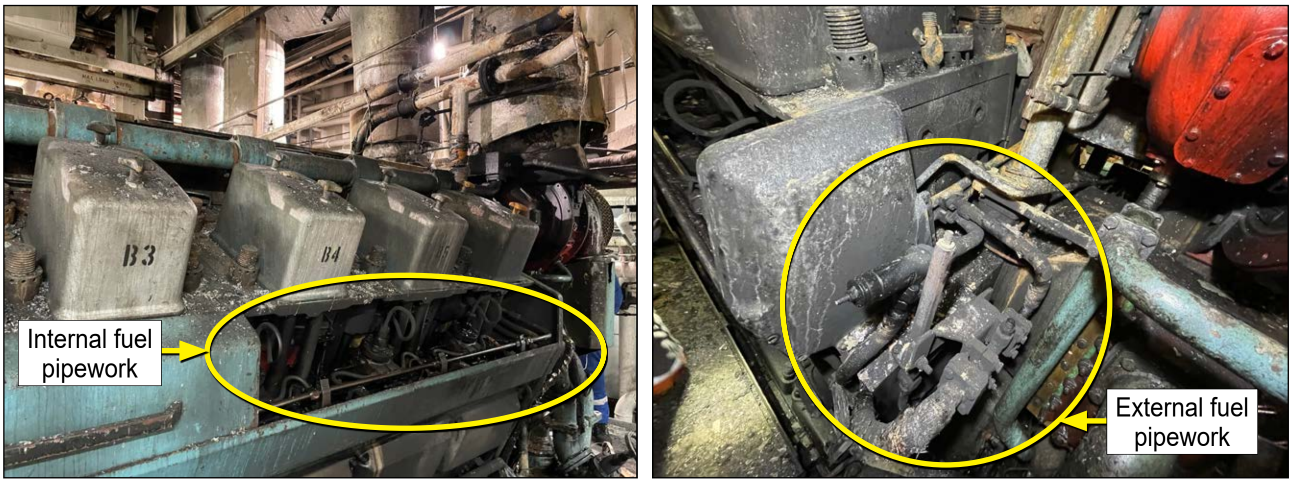

Figure 10: Fuel system arrangement on the VASA 32 engine

1.6.2 Technical bulletin and modification

In 1995, Wärtsilä had issued a technical bulletin titled *Safety aspects on and maintenance of fuel supply system of VASA 32.* The bulletin highlighted several incidents of serious fuel leaks from the low-pressure fuel supply system, some of which had resulted in fires. The bulletin stated that:

> *Originally the fuel pipes between the banks at the free end of the engine had flanges made for two screws only. The present pipe design have flanges with four screws offering a considerably safer solution.* [sic]

The technical bulletin also made operators of Wärtsilä engines aware that Wärtsilä offered a classification society approved modification to change the flange connections on existing systems from the two-screw to a four-screw design **(Figure 11)**.

Until 2012, Wärtsilä disseminated its service letters and technical bulletins to operators by email and in printed form. Since 2013, publications had been made available through an online portal. Stena had not subscribed to Wärtsilä's online portal before the *Stena Europe* fire. The company's technical management team at the time of the fire was unaware of the existence of the fuel system modification technical bulletin.

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[3] A covered area containing the engine's fuel pumps and the fuel lines to and from them to prevent fuel from spraying or leaking onto hot surfaces and protect against fire.

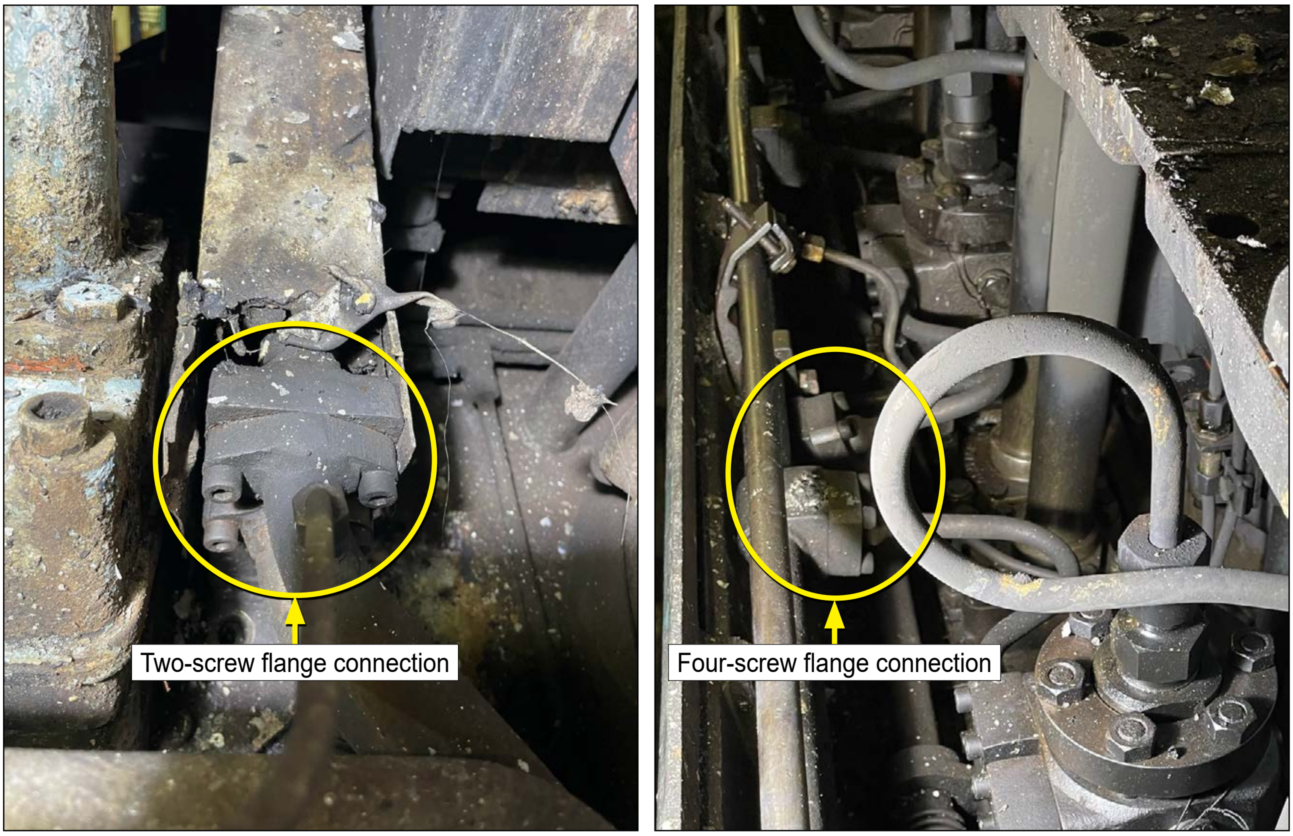

Figure 11: Fuel system flange connections

1.6.3 Modifications to the fuel systems on *Stena Europe*'s main engines

The flanges on the internal section of the fuel system were regularly disturbed during maintenance of the fuel pumps. In 2003, Stena, with assistance from Wärtsilä, modified the internal sections of the fuel systems of all four main engines on *Stena Europe*.

In around 2013/2014, ME1 was taken out of service and the external section of the fuel system was modified after the engine experienced frequent fuel leaks. Problems encountered during the course of the project meant that this took much longer than planned and ran over budget as a result. Consequently, the planned modifications to the external sections of the fuel systems on the other three main engines were put on hold.

It was reported that there were no further fuel leaks following the modifications made to the internal fuel systems of all four main engines, or on the external fuel system on ME1 following its modification.

1.6.4 Two-screw flange connection

Over time, the blind screw threads[4] in the two-screw flanges suffered from wear due to vibration and fretting that caused the screws to loosen and reduced their clamping force. Consequently, the system pressure could dislodge the O-ring from its groove in the flange and allow fuel to leak from the joint.

[4] A threaded hole that is only cut partially through the cross section of the material.

On 29 January 2023, two weeks before the fire, the same flange that caused the fire in *Stena Europe*'s ME3 fuel system had loosened, resulting in fuel spraying across the engine. The engineer on watch spotted the leak and stopped the engine. The O-ring and screws were replaced, and the joint's integrity was tested before the engine was returned to service.

1.6.5 Damage to main engine 3

At the time of the fire, ME3 had accumulated a total of 169,118 running hours since new. On 13 February 2023, a Wärtsilä service superintendent attended the vessel to assess the damage to ME3. The superintendent completed a condition report that included recommendations for the work required to safely return the engine to service:

> *I highly recommend that all fuel oil LP lines be up graded to four bolt flanges on all Vasa 32 engines on board this vessel as per Wartsila recommendations. Wartsila have the documentation, bulletins and knowledge to support this upgrade.* [sic]

Most of the recommended inspection and replacement works were completed under the supervision of the Wärtsilä superintendent. The external low-pressure fuel system was inspected and sealing O-rings were replaced. The original two-screw flange arrangement was refitted due to a long lead time for the new component parts required to modify the system to the four-screw arrangement, which were ordered at the time the work was being completed. ME3 returned to operational service on 17 May 2023.

The external section of the fuel system on ME3 was subsequently modified to the four-screw flange arrangement in August 2023, and the component parts needed to modify the external sections of the fuel systems on ME2 and ME4 were ordered.

1.7 STENA LINE LTD DEFECT REPORTING SYSTEMS

Stena operated a computerised safety management system (SMS) hosted within a programme called DOCMAP. Additionally, vessels used a computerised planned maintenance programme that included a defect reporting function. Stena's shore management reviewed the defect reports, actioning them as appropriate. Within the SMS, *Defect Reporting* document SMM-0255 defined a defect as:

> *… a part of the ship's structure, systems or equipment which is broken, faulty or missing which has the potential to affect the technical integrity and the safe operation of the ship.*

The document stated that the defect reporting system:

> *… shall also ensure that the Designated Person and the Technical and Operations Manager are made aware of any critical /significant defects which could affect the safe operation of the vessel. This fulfils notification requirements and promotes effective close-out.*

The document also instructed that:

> *Minor defects which can be quickly and easily rectified on board do not need to be reported. However, regularly recurring minor defects must be reported so that proper analysis and resolution can be made.*

The main engine fuel systems experienced regularly recurring defects, which the ship's engineers had repeatedly reported using the DOCMAP system. The frequency of the leakage incidents had gradually resulted in reduced reporting through DOCMAP. No evidence was found by investigators, nor provided by the company, to indicate that management visits or formal audits had identified the high incidence of fuel system leaks reported in DOCMAP.

1.8 PLANNED MAINTENANCE AND SURVEY

1.8.1 Planned maintenance

Stena Europe's planned maintenance system included a work order for a 5-yearly survey of the main engines' fuel pressure pipes that was required by DNV. Between 23 June 1993 and 23 August 2019, there were seven completed ME3 work order entries for this survey item. The last completed entry included a narrative comment: *Survey carried out Dry Dock Turkey April 2019 in conjunction with 24,000hr service of engine, all found to be ok*. There were no annotations to the other six entries.

The work order for this survey item stated:

> *Record all results, readings and observations in the Planned Maintenance System.* And*;*
>
> *Refer to the makers manual sections stated for further details and instructions.*

The version of the Wärtsilä manual held on board *Stena Europe* for the VASA 32 engines did not include a section outlining instructions for surveying the fuel system. The 2,000 operating hours maintenance schedule in the most recent version of the VASA 32 engine manual required the fuel system surveyor to, *Check that all pipes and clamps are securely fastened and that all related screws are tight*.

At the time of the fire, the engineering officers on board *Stena Europe* did not know when the main engine fuel systems had last been surveyed and were unclear on how the survey of the fuel systems should be undertaken.

1.8.2 Det Norske Veritas survey requirements

In its rules for fire prevention in engine rooms DNV referred to the applicable SOLAS regulations (see section 1.10) and required the completion of class-related items to be assigned to and credited by the C/E on board.

The DNV Rules for Classification Part 7, Chapter 1 – Fleet in Service, Survey Requirements for Fleet in Service – section 7, part 3, section 3.2.3 stated:

> *Crediting options*
>
> *Machinery component surveys may be credited based on documented maintenance history presented by the chief engineer. The following conditions apply:*
>
> *a) The owner/manager is responsible for ensuring that the chief engineer is qualified to register and carry out maintenance on all class related machinery items.*
>
> *Guidance note: See ISM Code, STCW Section A-III/1 as amended.*

The chief engineer shall be the responsible person for the follow-up of the machinery maintenance onboard.

The work order in the planned maintenance system for the 5-yearly survey of the main engine fuel system was delegated to the 2/E on board *Stena Europe*, contrary to the DNV rules. The guidance note in the DNV rules referred to the level of qualification required to credit class-related items. The note incorrectly stated the qualification required as STCW III/1, the level for an officer in charge of the engineering watch, rather than STCW III/2, which was a C/E certification.

1.9 POST-ACCIDENT INSPECTIONS

Following the fire Stena identified several unsafe areas on the vessel's other engines. Rectification work was carried out, and the lagging was improved and reinstated. The company checked for hot spots using an infrared spot thermometer and were confident that all hot spots had been eradicated.

On 18 April 2023, investigators travelled on board *Stena Europe* from Fishguard to Rosslare to carry out further investigation work. A tour of the engine room was undertaken to view the remedial works completed on the shielding of the fuel systems and the insulation of hot surfaces on ME1, ME2 and ME4. The investigators carried out a thermographic inspection using a TIC and immediately identified exposed hot surfaces exceeding 220°C on all the ferry's running engines. Some exposed surface temperatures exceeded 400°C **(Figure 12)**.

Stena Europe was equipped with two thermal imaging cameras that were kept on the bridge and formed part of the firefighting equipment. They were not used for the purpose of hot spot detection in the machinery spaces.

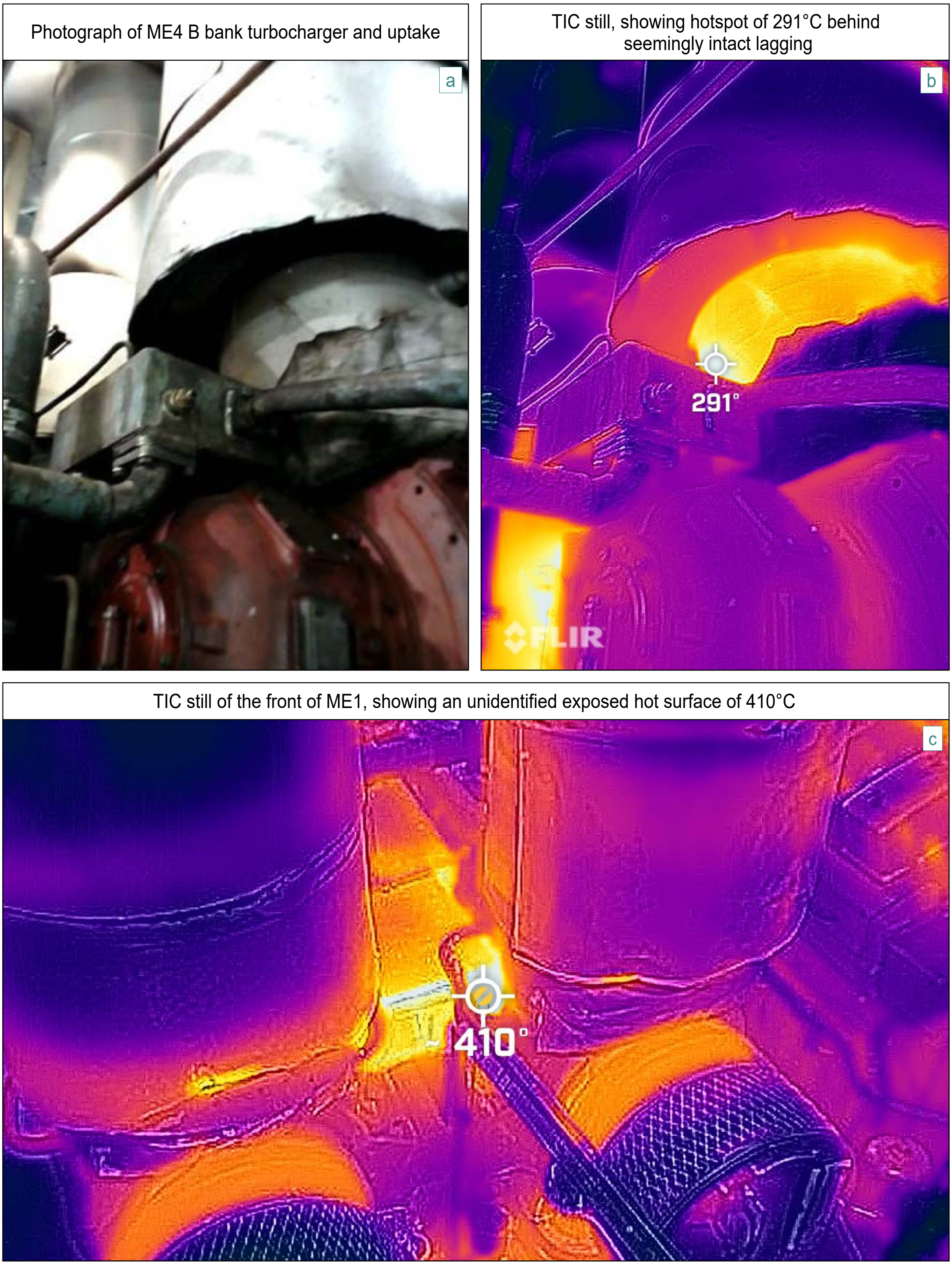

Figure 12: Exposed hot surfaces in the engine room identified using a TIC

1.10 REGULATIONS AND GUIDANCE

On the prevention of fires on board ships, Chapter II-2, Regulation 4 of the extant SOLAS Convention[5] required, among other things, that.

Precautions shall be taken to prevent any flammable liquid that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces;

Surfaces with temperatures above 220°C which may be impinged as a result of a flammable oil system failure shall be properly insulated; and

Oil fuel lines shall not be located immediately above or near units of high temperature, including boilers, steam pipelines, exhaust manifolds, silencers or other equipment required to be insulated…As far as practicable, oil fuel lines shall be arranged far apart from hot surfaces, electrical installations or other sources of ignition and shall be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the sources of ignition.

On the control of flammable oils, the Maritime Safety Committee (MSC) document MSC.1/Circular.1321[6] – Guidelines for Measures to Prevent Fires in Engine-Rooms and Cargo Pump-Rooms, stated:

Spray shields should be fitted around flanged joints, flanged bonnets and any other flanged or threaded connections of oil fuel and lubricating oil systems having an internal pressure exceeding 0.18 N/mm^2 which have the possibility of being in contact with potential ignition sources by direct spray or by reflection. The purpose of spray shields is to prevent the impingement of sprayed flammable oils onto a high temperature surface or other source of ignition.

On the design and Installation of spray shields, MSC.1/Circular.1321 guided that:

Many types of spray shields are possible to avoid spray at flanged connections. For example, the following may be treated as a spray shield:

1. thermal insulation having sufficient thickness;

2. anti-splashing tape made of approved materials. Caution should be taken to avoid using the anti-splashing tape in areas of high temperature so as to maintain its adhesive characteristics. In case of rewrapping of the new tape, the surface area of the tape should be clean and dry; and

Anti-splashing tape or other equivalent method may be treated as spray shield on threaded connections. Additionally, the use of sealing tape at thread of union joint is strongly recommended to prevent spray. [sic]

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[5] International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended – Part 1 –Chapter II-2 – Construction: Fire Protection, Fire Detection and Fire Extinction – Part B –Prevention of Fire and Explosion – Regulation 4 – Probability of Ignition.

[6] Guidelines for Measures to Prevent Fires in Engine-Rooms and Cargo Pump-Rooms: Part 3, Chapter 1, section 2.1, issued 11 June 2009.

On control of the ignition source, Chapter 2 of MSC.1/Circular.1321 instructed:

> *A regular check of equipment or material should be made to confirm that the insulation is correctly installed. When maintenance or repair to equipment has been carried out, checks should be made to ensure that the insulation covering the heated surfaces has been properly reinstalled or replaced. Special attention should be paid to the following:*
>
> - *insulation areas where vibration may be present;*
> - *discontinuous part of exhaust gas piping and turbo charger; and*
> - *other suspect parts.*

1.11 PREVIOUS/SIMILAR ACCIDENTS

Since 2015, the MAIB has received 65 reports of engine room fires attributed to a flammable liquid igniting on an exposed hot surface.

1.11.1 Previous incidents involving Stena Line Ltd

In the two years preceding this fire, the MAIB recorded three other fires on Stena vessels, all caused by a flammable liquid being sprayed onto an exposed hot surface of over 220ºC. At least one of these incidents required the activation of the vessel's hi-fog fire suppressant system.

1.11.2 *Finlandia Seaways* – engine failure and subsequent fire

In April 2018, the Lithuania registered ro-ro cargo vessel *Finlandia Seaways* suffered a catastrophic major engine component failure that resulted in the ejection of heavy engine parts from the crankcase and release of hot oil vapours into the engine room and a subsequent fire (MAIB report 2/2021[7]).

The investigation found that a connecting rod small end, which was a class surveyable item, had fractured. The maintenance to the connecting rods had not been recorded properly and Lloyd's Register was not informed of the damage caused to the small ends during overhaul, or that connecting rods had accumulated more running hours than recommended by the engine manufacturer.

A recommendation was made to DFDS Seaways AB-Lithuania (2021/102) to: Review and improve how its chief engineers conduct class-related equipment examinations as part of the Continuous Survey Machinery cycle to ensure that examinations are conducted thoroughly and reported accurately.

[7] https://www.gov.uk/maib-reports/engine-failure-and-subsequent-fire-on-ro-ro-cargo-vessel-finlandia-seaways-with-1-person-injured

1.11.3 *Moritz Schulte* – engine room fire

In August 2020, the Isle of Man registered gas carrier *Moritz Schulte* suffered an engine room fire when an uncontrolled release of pressurised fuel from an auxiliary engine fuel filter sprayed onto the hot exhaust of an adjacent engine (MAIB report 4/2023[8]). The fuel was released as a result of an engineer's attempt to open and clean the engine's fuel filters without first isolating them from the pressurised fuel supply.

Gaps in the exhaust heat shields were not identified because a spot rather than area temperature measurement tool, such as a thermal imaging camera, was used without due consideration of the gaps between the heat shield material.

8 https://www.gov.uk/maib-reports/engine-room-fire-on-lpg-carrier-moritz-schulte-with-loss-of-1-life

SECTION 2 – ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 OVERVIEW

Stena Europe experienced a fire on one of its main engines due to an uncontrolled release of pressurised fuel. Similar to the *Moritz Schulte* accident, the fuel sprayed onto the engine's exposed exhaust manifold, which was operating at a temperature exceeding 220°C.

In this section of the report the reasons why the fuel was released and subsequently ignited, and the contributory factors to this accident will be analysed.

2.3 MAIN ENGINE FUEL SYSTEM SAFETY

2.3.1 Modifications

Wärtsilä had recognised that there was a design weakness in the fuel system's two-screw flanges on the early VASA 32 engines. This was addressed in 1995, when the manufacturer offered a modification solution by replacing the two-screw flange connection with a four-screw securing arrangement.

The opportunity to schedule the modifications to *Stena Europe*'s remaining three engines was missed when ME1's fuel system was modified after a series of fuel leakages while under the management of Northern Marine. Further, the 2018 change in the technical management of the vessel meant that previously accumulated knowledge that the fuel systems of three of *Stena Europe*'s four main engines were operating with inherent leakage problems was lost.

Stena had not subscribed to the Wärtsilä service portal so its management team was unaware of various important technical bulletins, including the recommended fuel system modification for the VASA 32 and service letters that the engine manufacturer had issued. This resulted in potential upgrades to improve the safety of the vessel being missed.

2.3.2 Maintenance

The day after the fire, investigators noted that anti-splashing tape was not used on *Stena Europe*'s low-pressure oil systems, and many areas of shielding, lagging and insulation were in a poor state of repair or missing. *Stena Europe* was over 40 years old and maintaining compliance with SOLAS regulations was reportedly challenging. Anti-splashing tape is used to mitigate the risk of pressurised oil leaking. The lack of its use on board indicated that Stena was not dealing with the hazard effectively. Although the ship's engineering crew were well aware of the use of anti-splashing tape on other vessels, it could not be determined why anti-splashing tape was not used on *Stena Europe*.

The condition of the insulation, shielding and spray protection on all *Stena Europe*'s engines appeared to have degraded over time, most likely due to the cycle of its removal and refitting during maintenance. Ship's crew and visiting shore management had become accustomed to the condition of the protection in place and no longer recognised that machinery in the engine room was poorly protected, possibly due to the age of the vessel.

The inspection element of MSC.1/Circular.1321 was poorly followed. This meant that shielding was incorrectly fitted or repaired, which created a high risk of fire in the event of a fuel leak. Stena's use of spot thermometers to verify SOLAS compliance was evidently inadequate.

2.3.3 Defect reporting and management oversight

The regular leaks on *Stena Europe*'s main engine fuel systems were historically reported in the vessel's DOCMAP system. However, this had stopped over time and the crew instead repaired the leaks and recorded them locally in the engine room logbook. The relatively high turnover and heavy workload of engine room crew had resulted in defect reporting being considered a low priority, which had led to the requirements in SMS document SMM-0255 not being met. Further, shore management had not identified either the problems of recurring leaks or the lack of defect reporting during visits or audits.

Stena management had not fully established the link between previously reported fires on board other Stena vessels due to leakage of flammable liquids and the hazard posed by frequent fuel leaks on three of *Stena Europe*'s four main engines. Consequently, there was a lost opportunity to learn lessons and apply further mitigations to reduce the risks of fuel leakage by initiating the manufacturer's recommended upgrade from the two-screw to the four-screw flange connections.

2.4 HOT SPOT MONITORING

Stena's practice of measuring the temperature of running engines using an infrared spot thermometer had not identified the significant hazard posed by exposed surfaces of over 220°C that still existed post-accident after the insulation and shielding were replaced.

The use of infrared spot thermometers in engine spaces limited their effectiveness as they could only provide an indication of the temperature of the spot where the thermometer was pointed. The investigators' use of thermal imaging cameras to highlight *Stena Europe*'s continued hot spot hazard to Stena management resulted in re-evaluation of the local insulation provision.

It can be difficult to demonstrate compliance with the requirement of MSC.1/Circular.1321 to identify areas with a surface temperature exceeding 220°C. The use of thermographic equipment rather than spot thermometers to conduct surveys would improve hot spot identification and facilitate the IMO requirement for running machinery checks to ensure the insulation covering the heated surfaces has been properly reinstalled or replaced.

2.5 CREDITING CLASS ITEMS

The DNV rules were unclear about who on board was authorised to credit class item surveys (section 1.8.2). However, classification societies relied on the professionalism and experience of ship's staff to complete survey jobs on their behalf and to the best of their ability. Consequently, while an attending surveyor would look for evidence in the planned maintenance system that class survey items had been completed, they would be unaware whether the work had been carried out thoroughly, if at all.

The 5-yearly DNV survey of the fuel system and shielding was delegated to the ship's crew using a crediting option and the planned maintenance work order had been signed off by ship's staff as having been completed every 5 years over the past 30 years. However, there were scant records of the surveys and just one comment added to the work order despite regular leakage issues on the main engine fuel systems.

The work order guidance directing engineers to the manufacturer's handbook did not contain any details of how to survey the fuel system. The rarity of the task and limited guidance meant that the crew of *Stena Europe* had little awareness of how to conduct a main engine fuel system survey and what checks should be included. This likely led to the engineers making a judgement on how to approach the task. The *Finlandia Seaways* investigation identified similar issues, including the C/Es incorrectly recording the maintenance to the engine's connecting rods and the classification society not being informed of the damage that was found.

2.6 EMERGENCY RESPONSE

It is unclear why the C/E(d) entered the burning machinery space without any PPE or BA when a fully protected fire team was on its way to the scene and could be used to enter the space and carry out such tasks as closing the QCV. The role of the C/E(d) was to command and control the actions of others during the response to the fire and this would have been practised during training and drills. A safer course of action would therefore have been for the C/E(d) to assess the situation, consider the various options, and then send the protected fire team into the space.

SECTION 3 – CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. *Stena Europe* experienced a fire on one of its main engines due to an uncontrolled release of pressurised fuel. The fuel sprayed onto the exposed exhaust manifold that was operating at a temperature exceeding 220°C when a screw in a two-screw flange within the fuel oil pipework loosened. [2.2]

2. The fuel oil spray was allowed to reach the hot surface because the joint was not protected by anti-splashing tape or shielding and fuel was able to escape forcefully. [2.3.2]

3. The engine manufacturer's recommended fuel system modification had been fitted to the external fuel system of just one of *Stena Europe*'s four main engines. The opportunity to fit the modified flange connection to the external fuel systems on the remaining engines was missed and the risk of fuel leakage remained high. [2.3.1]

4. Much of the insulation and shielding on all of *Stena Europe*'s engines was in a poor state of repair or missing completely. The ship's crew and shore management had become accustomed to this condition over time, possibly due to the age of the vessel, leading to machinery in the engine room being inadequately protected. [2.3.2]

5. Stena's practice of measuring the temperature of running engines using an infrared spot thermometer had not identified the significant hazard posed by temperatures of exposed surfaces exceeding 220°C that still existed post-accident after replacing insulation and shielding. [2.4]

6. The on board staff responsible for fuel system inspections on the main engines, which were credited towards a DNV survey, had insufficient awareness of the task, and the planned maintenance system and manufacturer's manual provided limited guidance. [2.5]

7. Stena's SMS did not identify that the requirement for defect reporting in document SMM-0255 was not being met with regard to the problems of recurring leaks. [2.3.3]

8. Stena's management had not fully established the link between recent fires on vessels within the Stena fleet due to fuel leakage and the hazard posed by frequent fuel leaks on three of the four main engines on board *Stena Europe*, so missed the opportunity to initiate the manufacturer's recommended upgrade from the two-screw to the four-screw flange connections. [2.3.3]

3.2 SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. It can be difficult to demonstrate compliance with the requirement of MSC.1/Circular.1321 to identify areas with a surface temperature exceeding 220°C. The use of thermographic equipment rather than spot thermometers to conduct surveys

would improve hot spot identification and facilitate the IMO requirement for running machinery checks to ensure the insulation covering the heated surfaces has been properly reinstalled or replaced. [2.4]

2. The C/E(d) put themselves and others at risk when they entered the main engine room without wearing PPE or BA despite a fully protected team being on its way to the scene. [2.6]

SECTION 4 – ACTION TAKEN

4.1 ACTIONS TAKEN BY OTHER ORGANISATIONS

Stena Line Ltd has:

- On 13 February 2023, issued a fleetwide safety flash **(Annex A)**, highlighting the need to assess hot spots and properly risk assess any maintenance jobs with the potential to cause oil to spray. Stena's management encouraged the use of the thermal imaging cameras already on board all Stena vessels for the purpose of regular hot spot monitoring and detection in machinery spaces.

- Modified the external fuel piping on ME3 to incorporate four-screw flanges.

- Repaired or replaced the shielding and lagging around the external fuel systems and hot surfaces and fitted anti-splashing tape to all joints on the low-pressure fuel systems on all of *Stena Europe*'s operational engines.

- On 7 June 2023, engaged a third-party contractor to undertake a SOLAS compliance verification thermographic survey following ME3's return to service on 17 May.

- Undertaken a review of its company SMS and implemented a review process to manage service bulletins and technical service letters from all manufacturers of main engines and auxiliary engines within the Stena fleet.

SECTION 5 – RECOMMENDATIONS

The **Maritime and Coastguard Agency** is recommended to:

2024/170 Submit a paper to the International Maritime Organization proposing an amendment to Maritime Safety Committee.1/Circular.1321 to introduce a requirement for the use of thermographic equipment to identify exposed surfaces with temperatures above 220°C, which could be impinged in the event of a pressurised oil system failure.

Stena Line Ltd is recommended to:

2024/171 Review the use of the existing defect reporting functions within the planned maintenance system on vessels within its fleet to ensure that defect reports and remedial actions can be tracked readily.

2024/172 Review and provide training to improve how its chief engineers conduct class-related equipment inspections that are credited to class surveys to ensure that inspections are conducted thoroughly and reported accurately.

2024/173 Promulgate details of this accident to all ships within its fleet to emphasise the importance of training and highlight the hazards of entering a fire-damaged space without the correct personal protective equipment.

2024/174 Introduce the use of thermal imaging cameras to all Stena vessels with appropriate functionality for the detection of exposed hot surfaces of over 220°C within machinery spaces.

Safety recommendations shall in no case create a presumption of blame or liability.

Annex A

Stena Line Ltd safety flash

Validity:

Area:	All
Vessel Type:	All
Flag:	All
Date:	2023-02-13
Period of Validity:	Until further notice

Title: Fire in Engine Room – Fuel leakage

Within a short period of time two incidents have taken place on our vessels where emergency fire situations have emerged in the engine room as a result of leaking fuel oil being sprayed on to hot surfaces.

The first incident can be attributed to the pressure cleaning of leaked oil that subsequently was sprayed onto a hot surface nearby. The second incident was a result of a leak from the main engine return valve that sprayed on to an adjacent hot surface. A full investigation of both occurrences is ongoing.

SOLAS II-2 Regulation 4, 2.2.6 § states the following:

"Surfaces with temperatures above 220°C which may be impinged as a result of fuel system failure shall be properly insulted […] Precautions shall be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces."

Action points:

All vessels are requested to:

- Use FLIR camera or IR thermometer (or other available means) to assess hot spots and any additional lagging that may be required and rectify accordingly.
- Ensure that risk assessments, both comprehensive and last minute, are conducted before any work is carried out that involves the potential of oil being sprayed or shifted on-board. An on-board meeting with concerned crew shall be held emphasising the importance a last-minute risk assessment and why it must be conducted.
- When all items are done Vessles are asked to comment and report back in the separate Microsoft Form (link available in the reference section, left hand of the document).

Marine Accident Report

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