ACCIDENT REPORT

Red Ensign Group

Isle of Man Ship Registry

A Member of the Red Ensign Group

INVESTIGATED BY THE MAIB ON BEHALF OF THE ISLE OF MAN ADMINISTRATION

Report on the investigation of the engine room fire and subsequent fatality on board the liquefied petroleum gas/ethylene carrier *Moritz Schulte* in Antwerp, Belgium on 4 August 2020

VERY SERIOUS MARINE CASUALTY REPORT NO 4/2023 AUGUST 2023

MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

This investigation was carried out by the UK Marine Accident Investigation Branch (MAIB) on behalf of the Isle of Man Administration in accordance with the Memorandum of Understanding between the MAIB and the Red Ensign Group Category 1 registries of Isle of Man, Cayman Islands, Bermuda and Gibraltar.

Extract from

The Isle of Man Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2001 – Regulation 4:

The fundamental purpose of investigating a casualty, an accident, or an incident under these Regulations is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

NOTE

Under Section 4 of the Isle of Man Merchant Shipping Act 1985 a person is required to answer an Inspector's questions truthfully. If the contents of this report were subsequently submitted as evidence in court proceedings then this would contradict the principle that a person cannot be required to give evidence against themselves. Therefore, the Isle of Man Ship Registry makes this report available to interested parties on the understanding that it 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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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

2/E	-	second engineer
2/O	-	second officer (deck)
3/E	-	third engineer
4/E	-	fourth engineer
AB	-	able-bodied seaman
AE	-	auxiliary engine
APT	-	annual performance test
BA	-	breathing apparatus
bar	-	a metric unit of pressure
BSM	-	Bernhard Schulte Shipmanagement (UK) Limited
C/E	-	chief engineer
C/O	-	chief officer
CCR	-	cargo control room
CMS	-	competency management system
CN	-	cyanide
CO	-	carbon monoxide
CO_2	-	carbon dioxide
CRM	-	crew resource management
CSC	-	Crew Service Centre
ECA	-	Emission Control Areas
ECR	-	engine control room
EEBD	-	Emergency Escape Breathing Device
ER	-	engine room
ETO	-	electro-technical officer
HCN	-	hydrogen cyanide
HFO	-	heavy fuel oil
JOC	-	Junior Officers Course
LPG	-	liquefied petroleum gas
m	-	metre
mm	-	millimetre
MAN	-	Maschinenfabrik Augsburg-Nürnberg AG

MGO	-	marine gas oil
Mt	-	metric tonne
MTC	-	Maritime Training Centre
PMS	-	planned maintenance system
PPE	-	personal protective equipment
QDMS	-	quality document management system
SG	-	steering gear
SOLAS	-	International Convention for the Safety of Life at Sea, 1974, as amended
SSOW	-	safe system of work
STCW	-	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (STCW Convention)
SVDR	-	simplified voyage data recorder
TIC	-	thermal imaging camera
UTC	-	universal time coordinated
VHF	-	very high frequency

TIMES: all times used in this report are UTC+2 unless otherwise stated.

Image courtesy of Etienne Verberckmoes (www.marinetraffic.com)

Moritz Schulte

SYNOPSIS

At 0918 on 4 August 2020, the liquefied petroleum gas/ethylene carrier *Moritz Schulte* suffered an engine room fire while discharging a cargo of ethylene alongside the port of Antwerp, Belgium. The newly promoted third engineer, who was working on an auxiliary engine fuel filter, had not effectively isolated the fuel system and both he and an adjacent auxiliary engine's hot exhaust were sprayed with fuel under pressure. The fuel spray penetrated the exhaust insulation and ignited.

Prompt actions by the crew closed down the space to limit the spread of fire. The subsequent crew muster identified that the third engineer was missing and had last been seen in the engine room. The master prohibited the release of the CO_2 fixed firefighting system and ordered the fire party to search for and recover the third engineering officer.

The vessel's search and rescue team made two attempts to enter the engine room, both of which were unsuccessful due to smoke and heat. The third attempt made a sweep of the area of the engine room where it was assessed that the third engineer would be, but he was not found. A shore fire team located him an hour after the start of the fire. He was recovered ashore but died 9 days later from the effects of smoke inhalation.

The investigation found that, despite the vessel having a full range of safe systems of work in place, the third engineer, who had worked for the company for over 5 years, died while attempting an unnecessary job conducted in an unsafe way at an inappropriate time, without a risk assessment and in the absence of any direct supervision of the task.

Analysis of the third engineer's training programme activity log found that only two of the 65 rank-specific tasks he was required to undertake before his promotion to third engineer had been completed with the requisite evidence. It also found that the training system permitted line management to confirm that training had been completed without evidence being provided. This facilitated his promotion twice when he was not ready.

Other findings included a lack of any evidence of poor visibility enclosed space rescue drills or escape drills using Emergency Escape Breathing Devices.

The company's investigation identified 32 actions relating to: communication, crew and competence management, safety management and technical management. The company has since equipped its four vessels that were built before July 2003 with additional Emergency Escape Breathing Devices.

As a result of the actions already taken, no recommendations have been made.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *MORITZ SCHULTE* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Moritz Schulte*
Flag	Isle of Man
Classification society	Lloyd's Register
IMO number/fishing numbers	9220794
Type	Gas carrier
Registered owner	Bernhard Schulte GmbH & Co. KG
Manager(s)	Bernhard Schulte Shipmanagement (UK) Limited
Operator	Unigas International
Construction	Steel
Year of build	2002
Length overall	128.80m
Registered length	121.83m
Gross tonnage	8234
Minimum safe manning	14
Authorised cargo	LPG/Ethylene

VOYAGE PARTICULARS	
Port of departure	Braefoot Bay, Scotland
Port of arrival	Antwerp, Belgium
Type of voyage	Short international
Cargo information	4521Mt Ethylene
Manning	23

MARINE CASUALTY INFORMATION	
Date and time	4 August 2020 at 0918
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	Alongside Terminal 383, Antwerp
Place on board	Engine room
Injuries/fatalities	One fatality
Damage/environmental impact	Localised intensive engine room fire damage
Ship operation	Cargo discharge
Voyage segment	Alongside
External & internal environment	Sunny and clear, a high of 30°C, wind 9mph east-south-east
Persons on board	23

1.2 BACKGROUND

This investigation into a very serious marine casualty was conducted by the Marine Accident Investigation Branch on behalf of the Isle of Man Ship Registry, a member of the Red Ensign Group. The initial part of the investigation was conducted remotely as access to the vessel involved was not possible due to COVID-19 travel restrictions. A visit was achieved later in the investigation to gather physical evidence.

1.3 NARRATIVE

1.3.1 Events prior to the accident

At 1954 on 2 August 2020, the liquefied petroleum gas (LPG)/ethylene carrier *Moritz Schulte* berthed at Esso Terminal 383 in the port of Antwerp, Belgium, with a cargo of ethylene that had been loaded at Braefoot Bay, Scotland. The berthing was immediately followed by a ship/shore safety meeting.

At 0300 on 4 August, the vessel's crew began preparations for the cargo discharge operation. The engine room (ER) preparations involved operating auxiliary engine 2 (AE2) and auxiliary engine 3 (AE3) to provide electrical power for the vessel's hotel services and the cargo discharge pumps. Auxiliary engine 1 (AE1) was left on standby in case additional electrical power was required or another engine developed a fault. At 0318, the cargo discharge operation began.

Between about 0800 and 0815, the ER team gathered in the engine control room (ECR) on the port side of A Platform **(Figure 1)** for a routine toolbox talk to discuss the jobs for that day. The team comprised the second engineering officer (2/E), third engineering officer (3/E) Rajendra Naidu Ponnada, the fourth engineering officer (4/E), who was also the duty engineering officer, the electrical technical officer (ETO), a fitter and an ER wiper. The chief engineering officer (C/E), although not directly involved in the meeting, was also in the ECR inputting information into the machinery planned maintenance system (PMS). The vessel's two gas engineers did not participate in the meeting.

The 2/E led the meeting and informed his team of the company requirement that no jobs were to be undertaken that could compromise the cargo discharge. He then distributed jobs to each member of the team: the 3/E was tasked with routine duties, including checking the running AE2 and AE3. At the end of the meeting, the 3/E stood close to the 2/E and quietly asked him if he could clean the AE1 fuel filters. The 2/E asked if he needed assistance, which the 3/E declined, and the 2/E reiterated that the engine was to remain on standby, which the 3/E acknowledged.

Following the toolbox talk, the C/E gathered the 2/E, 3/E, 4/E and ETO together to explain why he had rejected some of their risk assessments and how to complete them correctly. The 2/E then stayed in the ECR for a few minutes before starting his ER inspection, while the remaining crew members dispersed to conduct their various duties: the 3/E, 4/E and ETO in the ER, the wiper in the workshop and the fitter in the galley.

The 3/E decided to clean the AE1 fuel filters before checking the running AE2 and AE3 and gathered the necessary tools, placing them in a metal tray on the deck between the AE1 fuel filter and the steps leading to the steering gear (SG) watertight

Image courtesy of Bernhard Schulte Shipmanagement

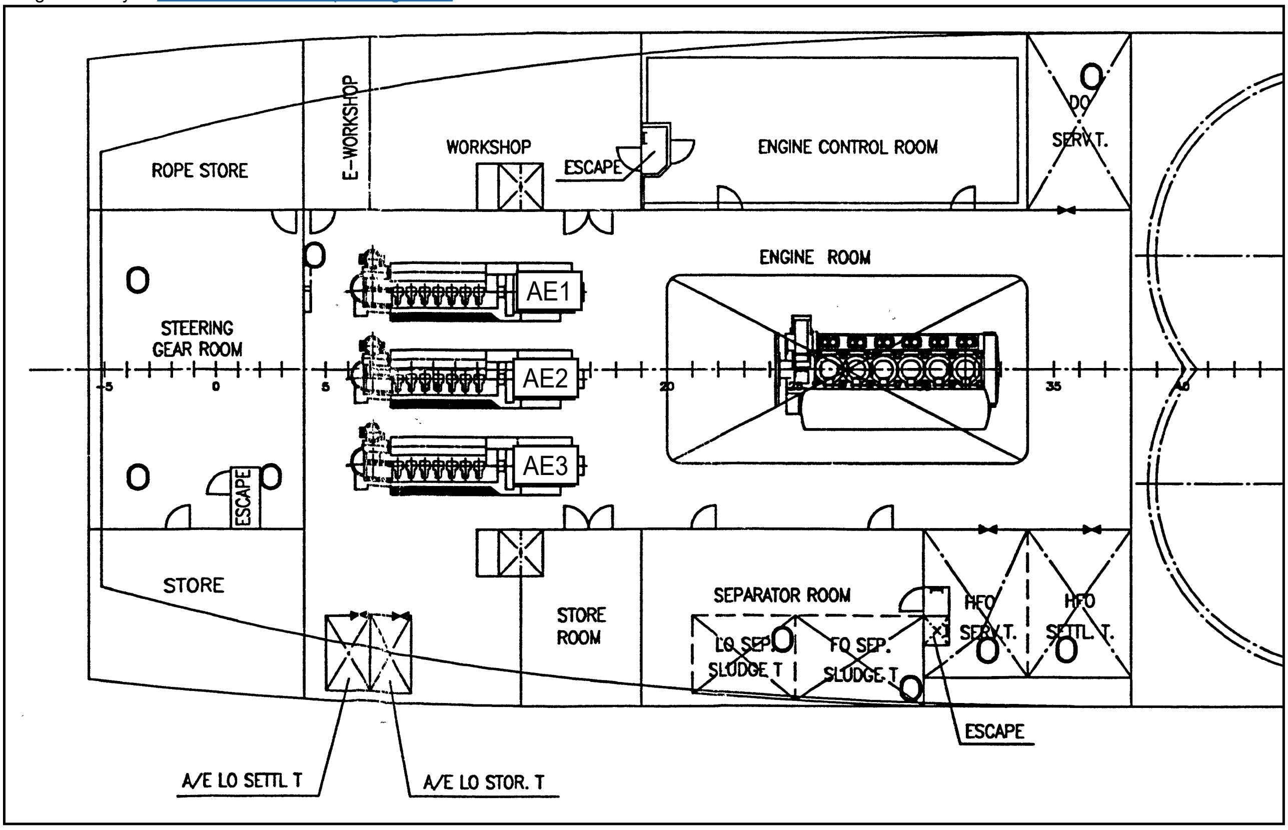


Figure 1: A Platform and engine control room

door. The AE1 fuel filter housing was under the turbocharger at the aft end of the engine **(Figure 2)**, about 1m from AE2's turbocharger **(Figure 3)**. The 3/E undid the two locking screws on the splash shield and removed it from the housing to access the duplex fuel filters, placing the cover on the deck **(Figure 4)**.

At 0900, on his way to the chemical storeroom via the SG watertight door, the wiper saw the 3/E working on the fuel filters. The 3/E was wearing a cotton boilersuit, work boots, gloves and ear defenders. As the 3/E began slackening the left-hand fuel filter cover plate with a ratchet and socket **(Figure 5)** he was also seen by the 4/E. The filter top cover plate was attached to the filter housing by four studs and nuts. The 4/E asked the 3/E if he would like some help, which was declined. Following this, the 4/E spoke to the wiper and they left the 3/E, the 4/E going to the bottom ER deck and the wiper to the workshop.

Post-accident analysis of the scene indicated that:

- The 3/E slackened the rear two nuts and removed the front left-hand nut securing the fuel filter cover plate. As he was undoing the front right-hand nut, the 5.5 bar fuel system pressure lifted the cover and forced the O-ring seal out of its recess, causing it to split **(Figure 6)**.

- The marine gas oil (MGO) sprayed out over a large area, covering the 3/E and reaching the running AE2's turbocharger and exhaust pipework insulated cover **(Figure 3)**. Soon after, the fuel ignited and thick black smoke began to emanate from the AE2 exhaust insulation.

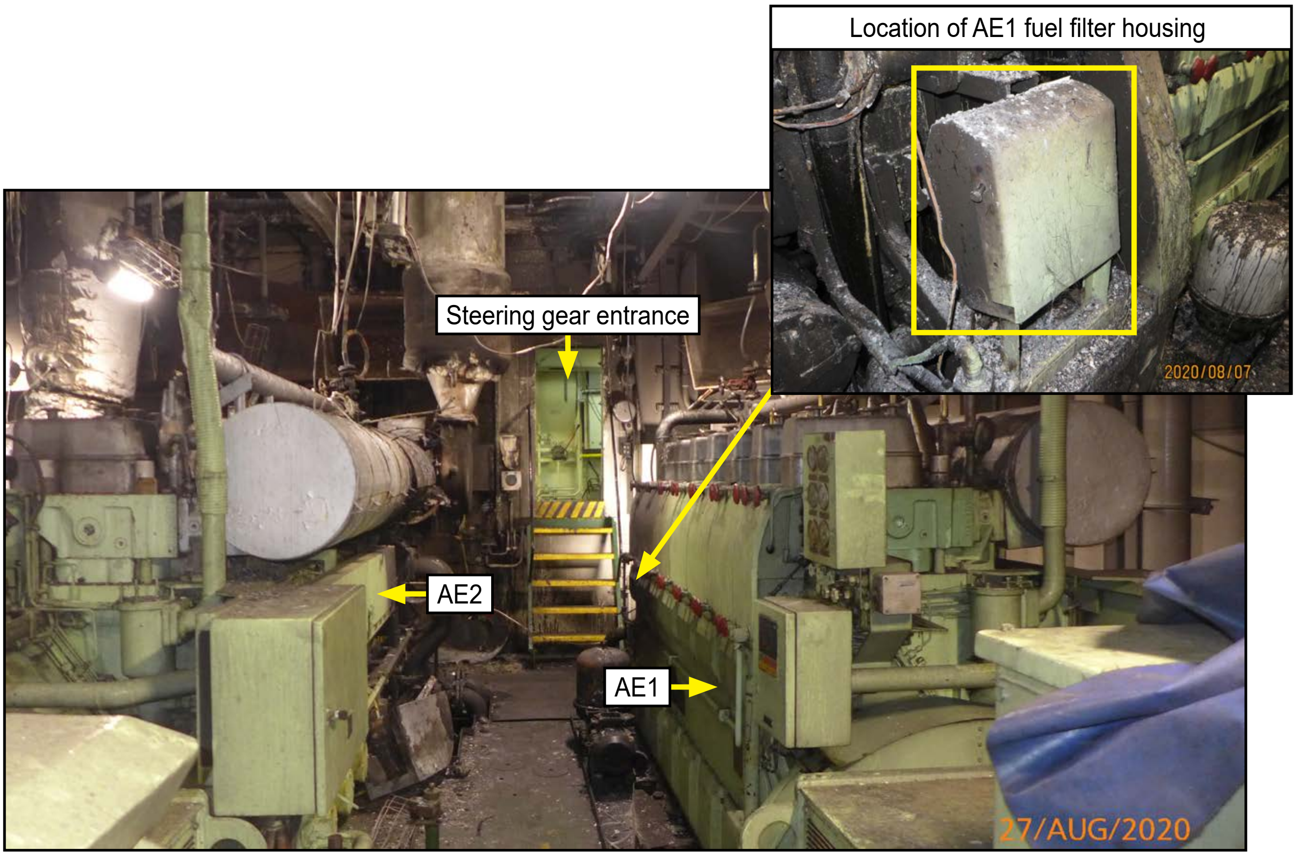


Figure 2: View aft between AE1 and AE2 and (inset) the post-fire AE2 fuel filter housing, representing how AE1 would have looked with its splash shield cover in place

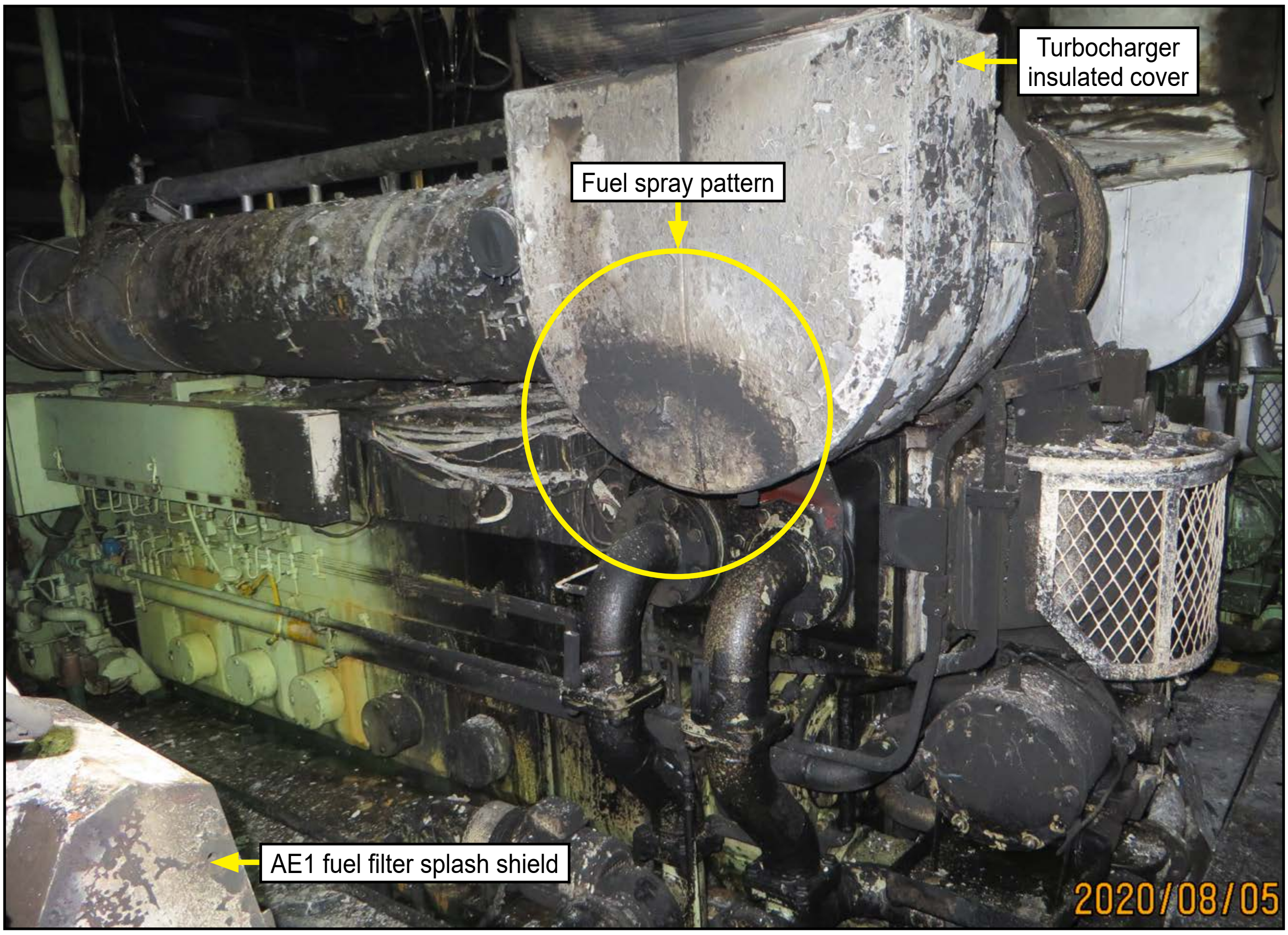


Figure 3: Post-fire AE1 fuel filter splash shield and AE2 turbocharger insulated cover

Figure 4: Post-fire AE1 fuel filter splash shield removed with tools on top

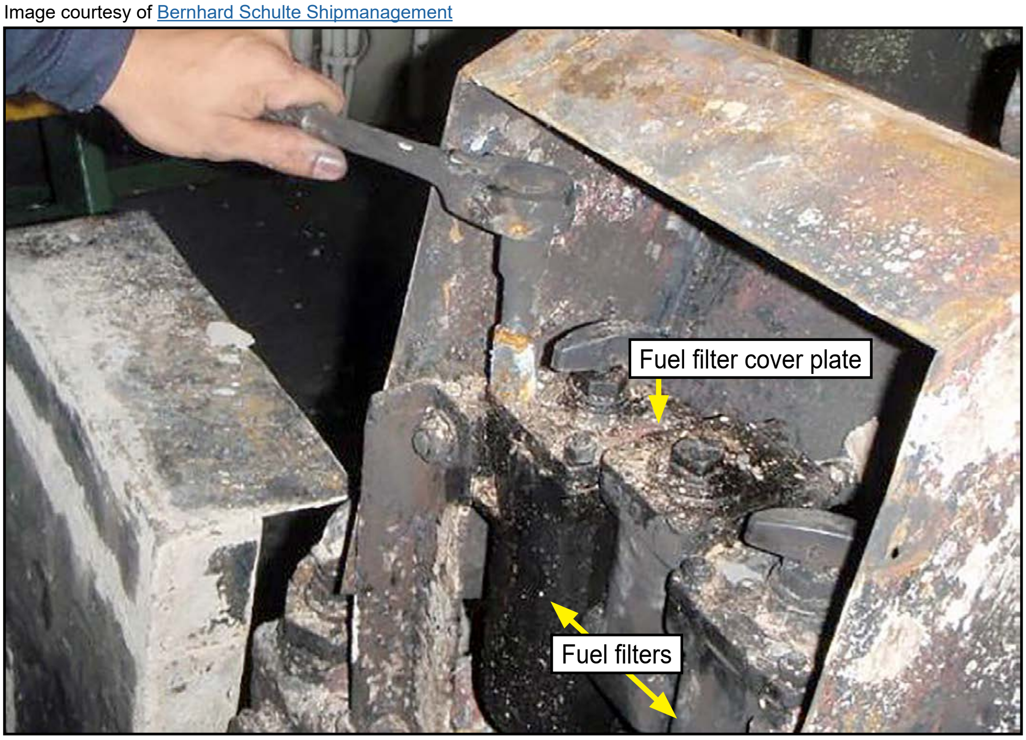
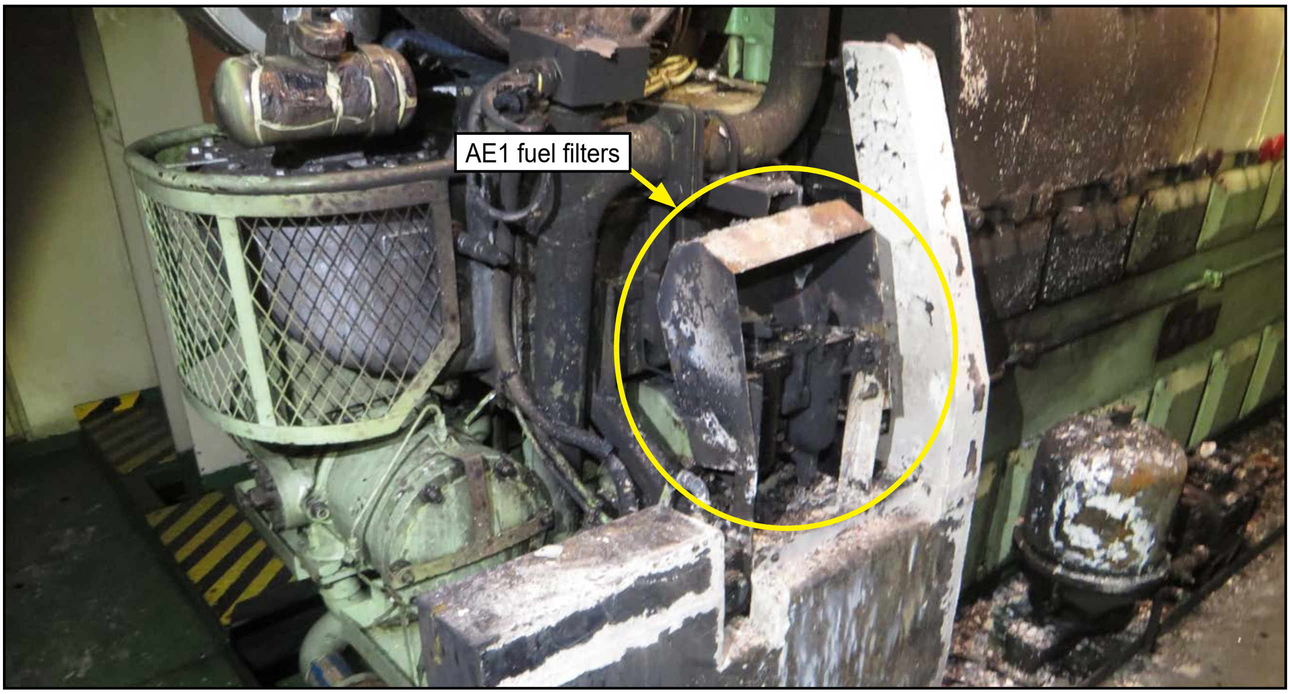
Image courtesy of Bernhard Schulte Shipmanagement


Figure 5: Post-fire reconstruction of fuel filter cover plate removal



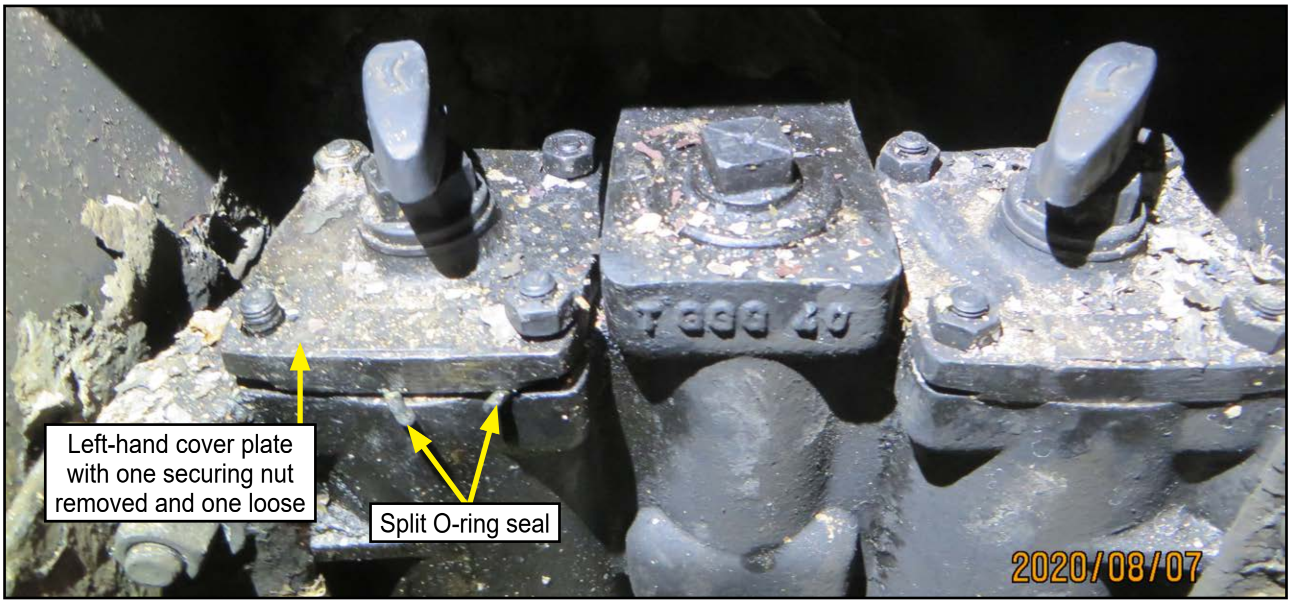


Figure 6: Post-fire AE1 fuel filters

1.3.2 Emergency response

At 0918, the ER fire alarm sounded, which resulted in an immediate emergency shutdown of cargo discharge operations. The 4/E heard the fire alarm and went up to A Platform. Looking aft, he could see thick black smoke in the auxiliary engine (AE) area of the vessel. He held his breath and used the port side stairs **(Figures 7a** and **7b)** to escape from the ER through the smoke. Outside the ER main entrance on the crew alleyway, he stopped the fitter who was about to enter the ER. The 4/E arrived at his muster station **(Figure 8)** on the officers' deck and informed those already present that he had last seen the 3/E near AE1.

The wiper heard the fire alarm from inside the workshop and, looking outside, saw thick black smoke. He escaped to the muster station via the port side main stairs **(Figures 7a** and **7b)** instead of the workshop's emergency escape, holding his breath and using the handrail for guidance. He did not see any flames or the 3/E.

For illustrative purposes only: not to scale

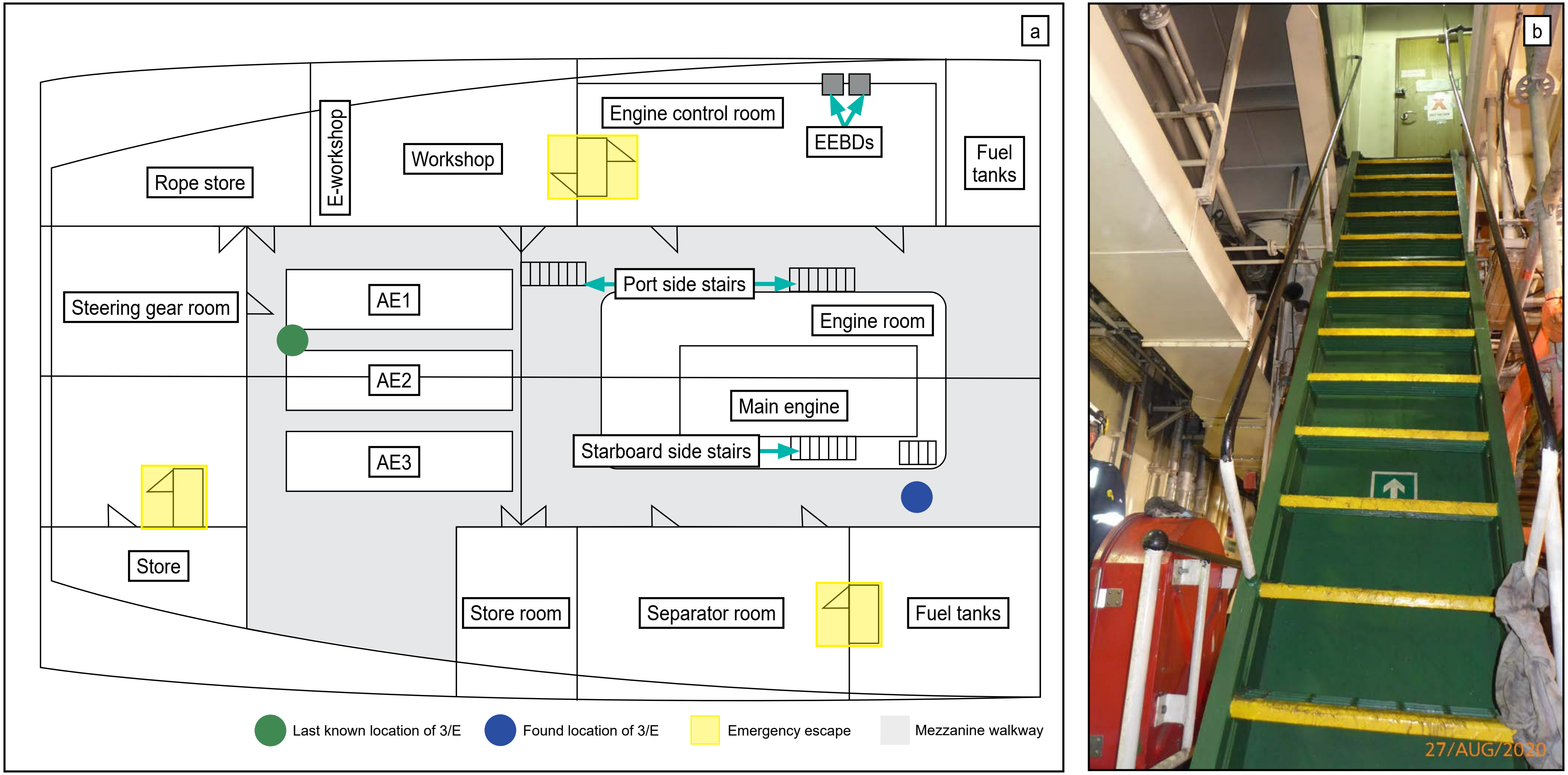


Figure 7: A Platform (a) and port side stairs leading to main deck (b)

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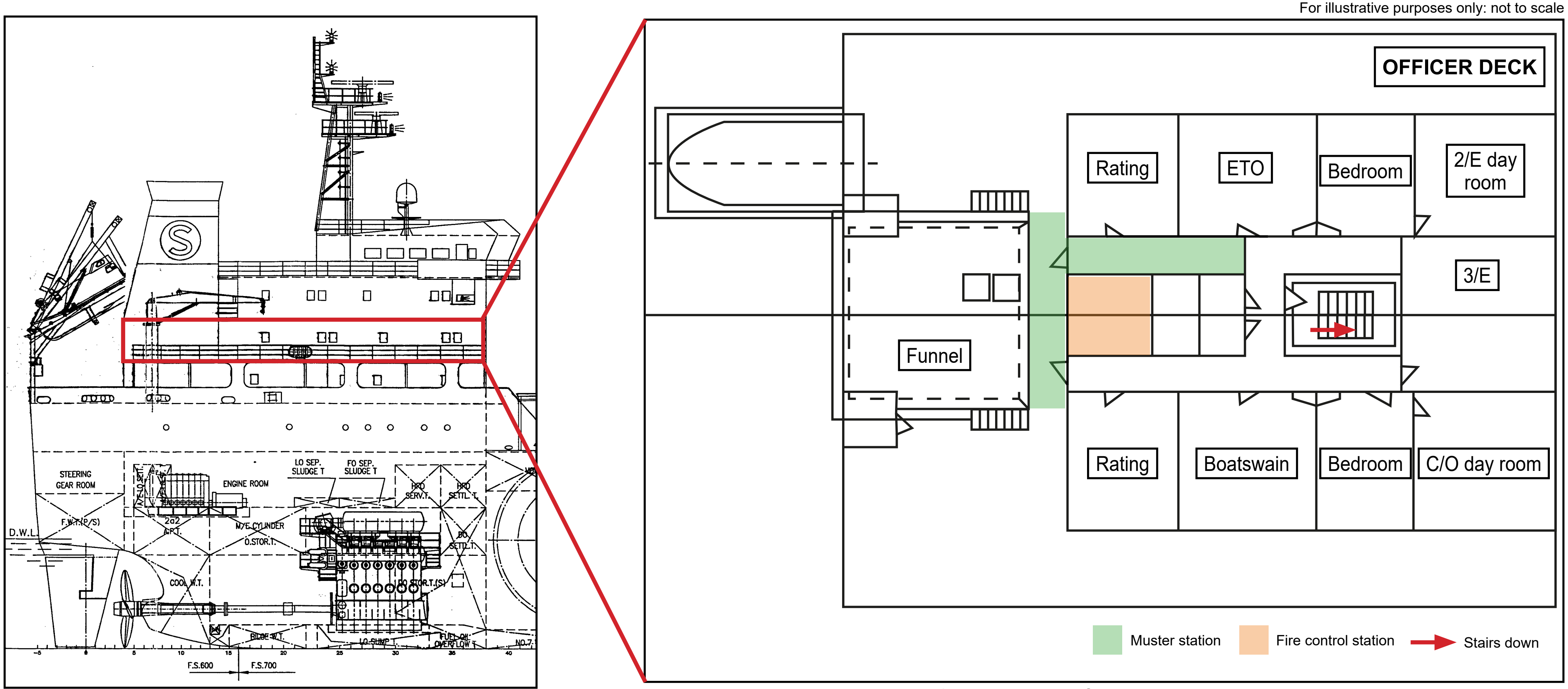

Figure 8: Muster and fire control station location

The ETO went to the ECR when the fire alarm sounded and, like the wiper, saw thick black smoke but no flames around the AEs. He entered the ECR and informed the 2/E of what he had seen. The 2/E left the ECR and saw the smoke around the aft end of A Platform but none on either B Platform or the lower deck. He started to go up the port side stairs **(Figures 7a** and **7b)** above A Platform, but the high temperatures and black smoke caused him to return to the ECR. During this time, the master called the ECR by telephone and spoke to the ETO who confirmed that there was a real fire. The ETO and the 2/E then escaped the ER to the poop deck, via the emergency escape route between the ECR and the workshop **(Figure 7)**, and made their way to the muster station.

The master went to the bridge when he heard the alarm and discovered that the fire control panel was indicating a fire in three ER zones. At 0919, having confirmed with the ETO that there was a fire, the master instructed a third officer to use the public address system to make a ship-wide announcement calling the ship's crew to their muster station. A second ship-wide announcement instructed the 3/E to report to the bridge as soon as possible. The master then requested firefighting assistance from the Port of Antwerp and contacted the company's Designated Person Ashore by telephone.

In the meantime, the C/E had used his very high frequency (VHF) radio to inform the master that he had arranged for the closure of the fuel oil quick closing valves, the stopping of the ER ventilation system fans, the closure of the ER vent flaps and the starting of the emergency generator, and had prepared for the release of the CO_2 fixed firefighting system into the ER. The master prohibited the CO_2 from being released until the 3/E had been found.

By 0928, a search and rescue team, which comprised of the bosun and fitter, was ready to enter the ER to search for the 3/E. The search and rescue team were wearing breathing apparatus (BA) and were under the command of the chief officer (C/O). The fitter carried an Emergency Escape Breathing Device (EEBD) that was to be given to the 3/E when he was located.

A few minutes later, the search and rescue team attempted to enter the ER from the poop deck entrance to the engine casing. A large quantity of smoke and heat was emitted when the team opened the door and their entry was aborted because they could not see their route.

At 0938, the search and rescue team attempted a second entry through the ER main entrance on the main deck port side crew alleyway. Again, the bosun felt unable to proceed due to the intense smoke and, having seen flames on the deck above, he aborted the entry. On leaving the ER the team reported to the C/O that one of the AEs was still running, making communication difficult.

At 0944, the 2/E decided to lead the search and rescue team and he and the fitter, who had replaced his BA cylinder, entered the ER via the secondary entrance near the officers' day room **(Figure 9)**. The 2/E, connected to a lifeline, descended the starboard stairs to A Platform. In thick smoke, and with no visibility, the 2/E and the fitter turned and followed the starboard walkway aft past the separator room and towards AE3 **(Figure 10)**. The 2/E found that AE3 was still running and stopped it locally from its aft end. Through the smoke, the 2/E could see small flames under the turbocharger at the aft end of AE2 and used a CO_2 fire extinguisher to put these

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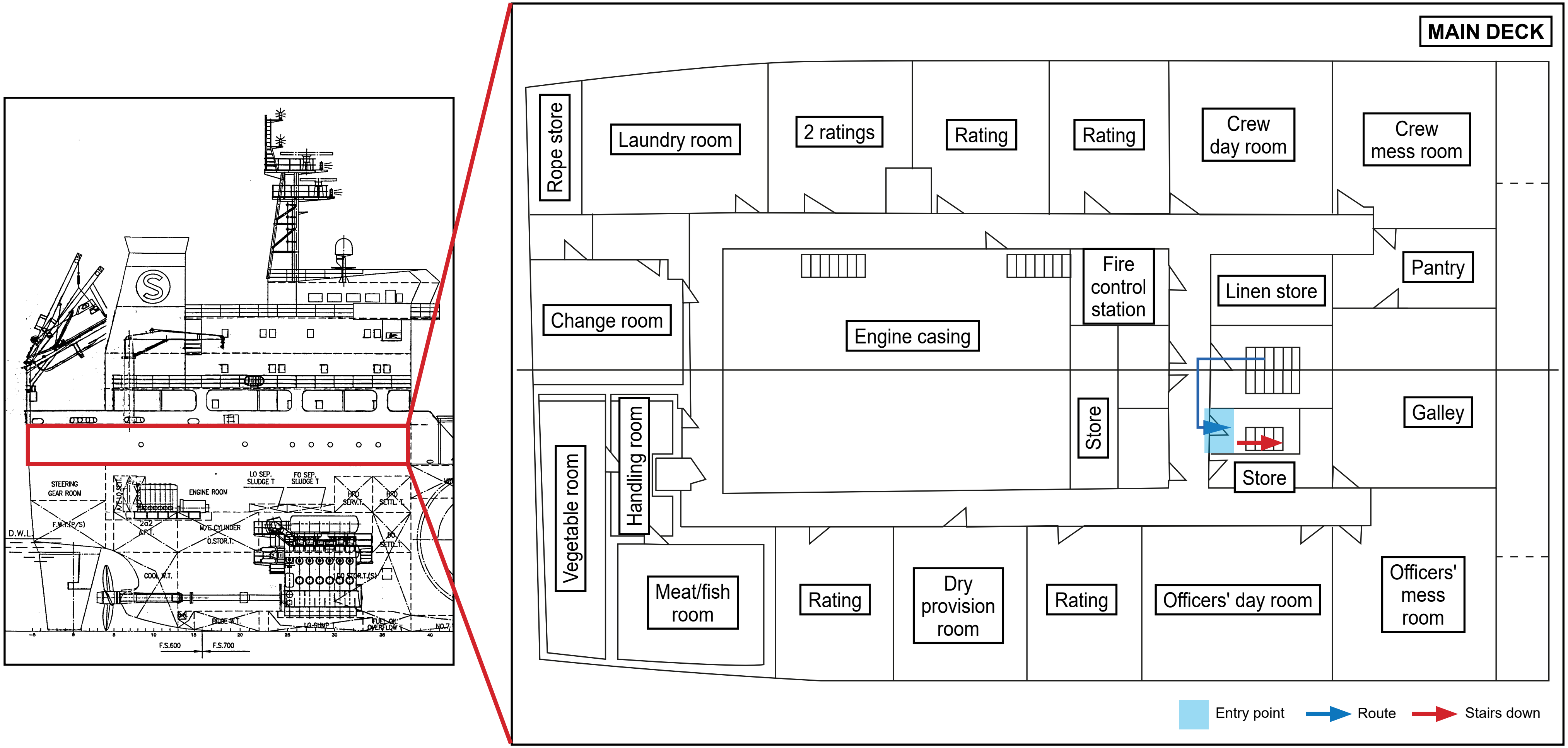

Figure 9: Third attempted entry from secondary entrance near officers' day room

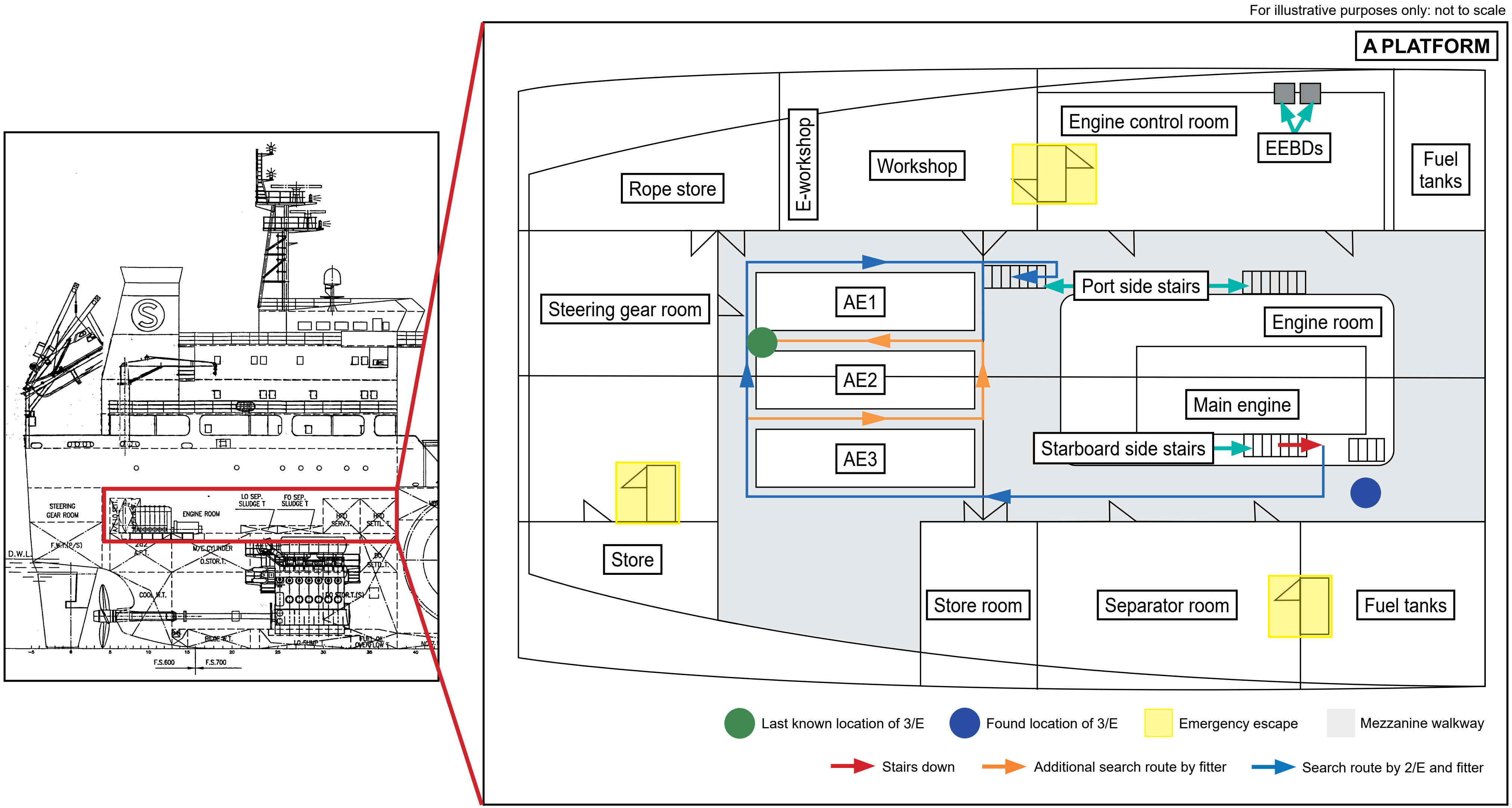

Figure 10: Second engineer's route from starboard access stairwell

out before he walked around AE1. Meanwhile, the fitter walked between AE2 and AE3 and then around the forward end of both AE2 and AE1, meeting the 2/E at the aft end of AE1.

By about 0950, the visibility in the ER had improved to about 2m and the search and rescue team attempted to open the watertight door to the SG room, having not found the 3/E where he had last been seen and thinking that he may have escaped into that space. They were unable to open the watertight door so banged on the door and called out for the 3/E before using the VHF radio to report to the C/O that the 3/E may have been in the SG space.

Moving on from the SG watertight door, the 2/E saw flames above AE2 on the auxiliary boiler flat and the search and rescue team used the aft port side stairs outside the ECR to access the area. The 2/E attempted to extinguish the flames with the same CO_2 extinguisher that he had used earlier, but they kept reigniting. He then used a dry powder extinguisher, which initially seemed to extinguish the fire but it soon reignited. At 0955, after the 2/E had informed the fitter that they needed water to put the fire out, they left the ER via the auxiliary boiler flat door onto the poop deck.

At 0957, the shore-based Antwerp fire and rescue service team, Brandweer Zone Antwerpen, boarded the vessel. At 1006, after the 2/E had briefed them on the ship's fire plan, the 2/E's route and the 3/E's last known location, the fire and rescue team entered the ER via the port side main entrance and descended the stairs to A Platform, adjacent to the ECR.

The bosun and one of *Moritz Schulte*'s gas engineers rigged a fire hose and extinguished the fire on the auxiliary boiler flat. In the meantime, the 2/E and the fitter discussed possible locations where the 3/E might be found. They returned to the poop deck and opened up the SG escape hatch, releasing a lot of smoke from the space, and called for the 3/E without response. An able-bodied seaman (AB) wearing BA then climbed down into the SG room to search for the 3/E; he returned 5 to 10 minutes later and confirmed that the room was unoccupied.

After searching around the A Platform AEs, the Antwerp fire and rescue team proceeded forward along the starboard walkway. Using a thermal imaging camera (TIC), they located the 3/E on the starboard mezzanine walkway, between the heavy fuel oil (HFO) service tank and the stairs to the bottom (floor) plates **(Figure 11)**.

At 1021, the Antwerp fire and rescue team recovered the 3/E to the cargo control room (CCR), where its medical team was located. His breathing was laboured and he was evacuated by ambulance to hospital approximately 20 minutes later, after the medical team had administered oxygen using *Moritz Schulte*'s oxygen resuscitator and ascertained that the 3/E had not suffered any burns. In the meantime, the Antwerp fire and rescue team fought the ER fire and, at 1048, the 2/E reported to the master that it had been extinguished.

At 1054, the Antwerp fire and rescue team advised the master that the ER could be naturally ventilated; the team left the vessel just over an hour later.

Figure 11: Location of third engineer on A Platform starboard mezzanine walkway when found by shore fire and rescue team

The 3/E was placed in a hospital intensive care unit within 2 hours of his rescue from the ER. He had suffered acute cyanide (CN) and carbon monoxide (CO) intoxication; although he was initially stable, his condition deteriorated and he died on 13 August 2020.

1.4 ENGINE ROOM LAYOUT

1.4.1 Engine room machinery spaces

The main machinery spaces were spread across five decks and comprised of the bottom plates, B Platform, A Platform, the main deck and the poop deck.

1.4.2 A Platform

A Platform **(Figure 1)** was an extended mezzanine deck that surrounded the upper part of the main engine, extending aft to AE1, AE2, AE3 and the SG room.

The diesel oil service tank, the ECR and workshop were located on the port side of A platform. The HFO settling and service tanks, separator room and store room were located on its starboard side.

The inboard sides of A platform overlooked the main engine. The stairs that led up to the main deck and down to B platform and the bottom plates were commonly used as ER access routes between decks.

1.4.3 Enclosed emergency escape routes

On the starboard side of the ER was an enclosed escape trunking containing a steel vertical ladder that ran from the bottom plates to the main deck via the separator space. The ladder was accessed at each level via a steel escape door that displayed emergency escape fire pre-plan information **(Figure 12)**.

On the port side of the ER an enclosed escape trunking containing a vertical steel ladder extended from a combined workshop and ECR entrance up to the main deck **(Figure 7a)**.

On the starboard side of the SG room an enclosed escape trunking containing a vertical steel ladder extended up to the poop deck **(Figure 7a)**.

1.5 AUXILIARY ENGINE FUEL SYSTEM

1.5.1 Fuel system

The fuel system for the main engine and AEs incorporated a fuel unit to enable fuel changeover between HFO and marine gas oil (MGO) when entering or leaving Emission Control Areas (ECAs)[1]. Since 2015, *Moritz Schulte* had operated exclusively within the North Sea ECA and used MGO for the main engine and the three Maschinenfabrik Augsburg-Nürnberg AG (MAN) B&W L23/30H AEs. HFO was neither stored nor used on board.

From the MGO service tank the fuel entered the fuel unit, which boosted and filtered the fuel **(Figure 13a)**. The final filtration was provided by the AEs' engine-mounted duplex fuel filters. Isolating ball valves were fitted to the fuel supply and returns for each engine and non-return valves were also fitted to the return lines **(Figure 13b)**.

The fuel pressure provided by the fuel units was displayed on local pressure gauges, but it was not routinely logged. The engine-mounted fuel filters for each AE were fitted with a low fuel pressure alarm and a high differential pressure alarm.

Following the accident the fuel pressure at the engine-mounted fuel filters was found to be approximately 5.5 bar.

1.5.2 Fuel filters

The AEs' engine-mounted filters provided continuous filtration of the fuel supplied to the engine. MAN provided a working card that described how to maintain the filters **(Annex A)**.

The filters were designed such that the filter mesh could be scraped clean in situ and the resulting debris flushed clear of the housing. This was achieved by turning the handles on the top of the filters by hand and opening the filter drain valve at the

[1] Emission control areas (ECAs) are sea areas in which stricter controls were established to minimize airborne emissions from ships, as defined by Annex VI of the 1997 MARPOL Protocol.

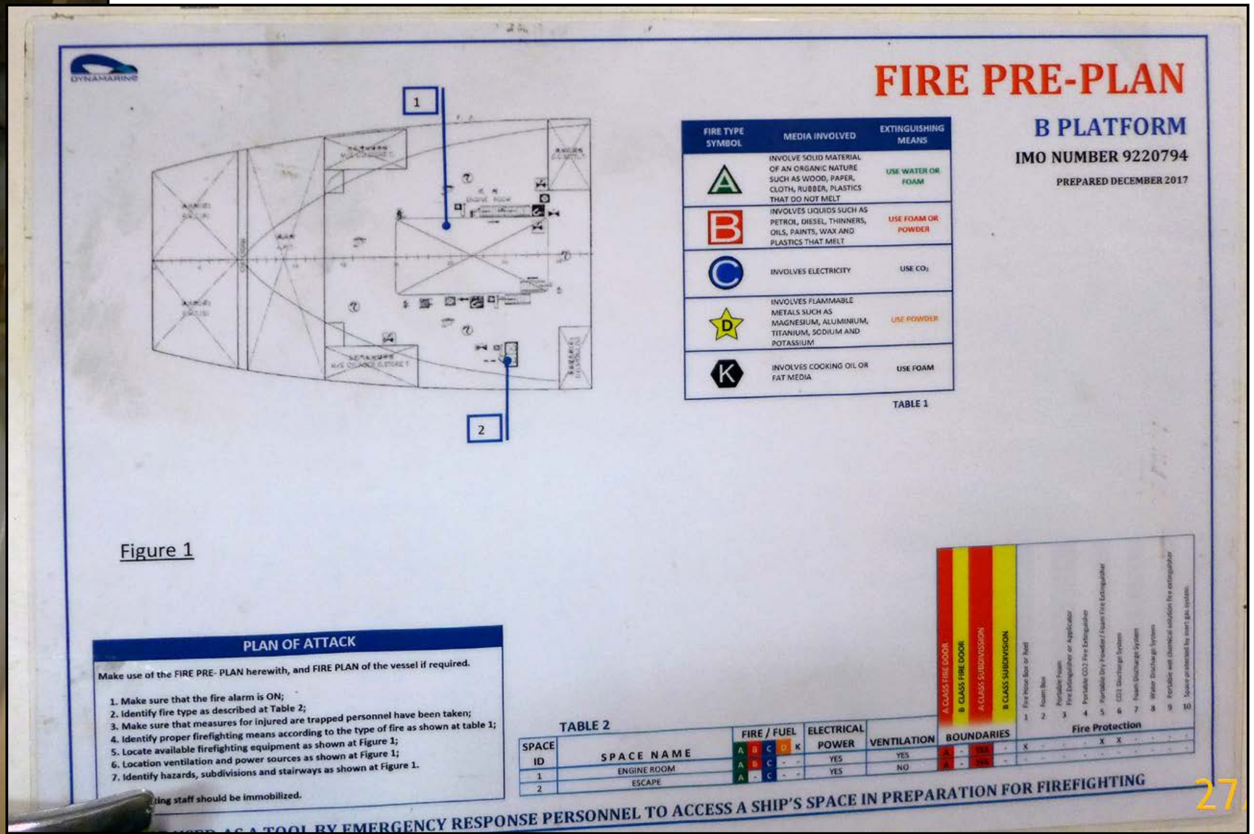

Figure 12: B Platform emergency escape door and escape information

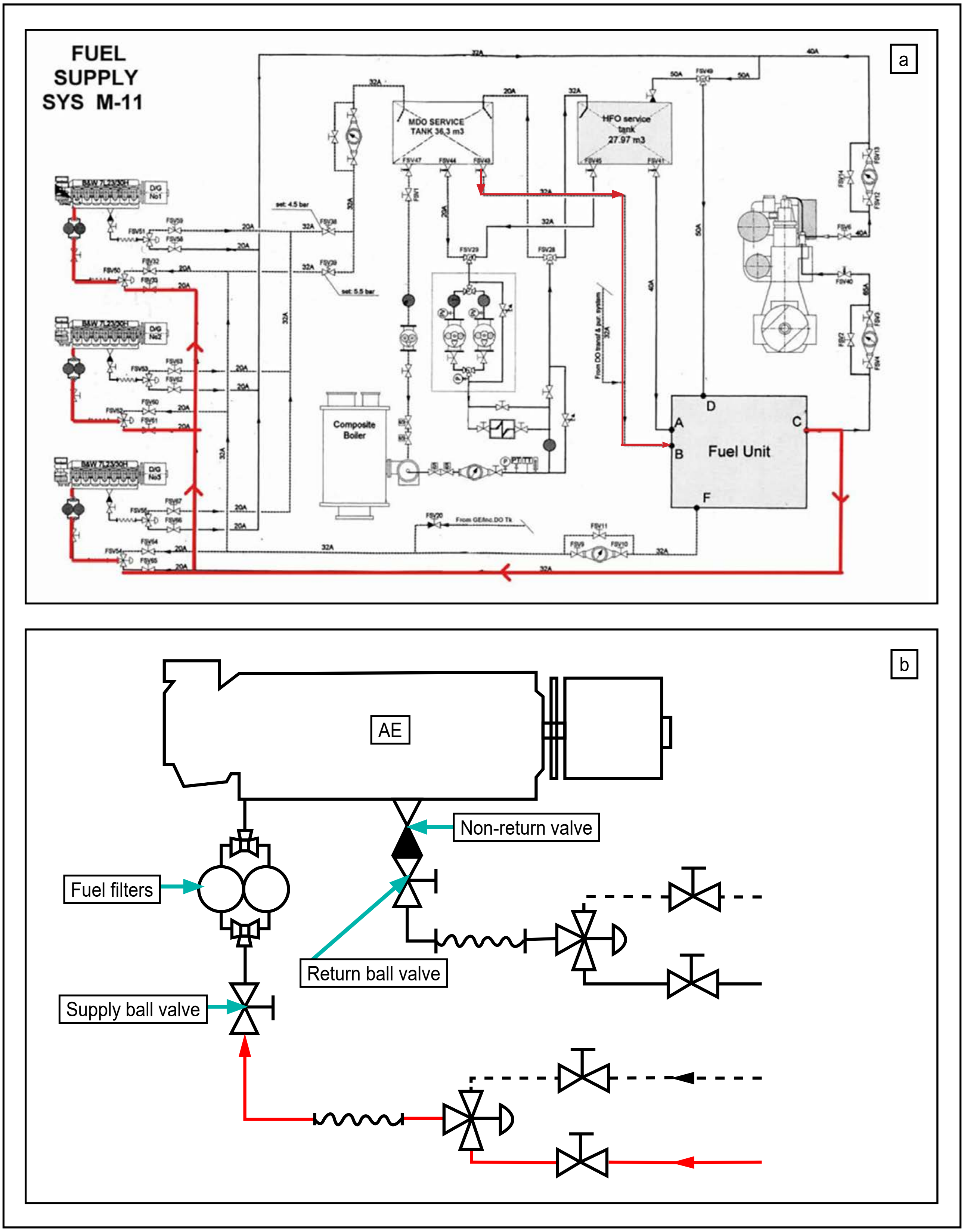

Figure 13: Fuel supply from MGO service tank to AE via fuel unit (a) and fuel supply to AE (b)

bottom of each housing. Some of the ER team referred to this process as *flushing the filters* and the MAN instructions stated that this method of cleaning was sufficient during normal operation.

In the event of the filter drain becoming blocked or the differential pressure across the filter becoming too high, the filter housing would need to be dismantled to extract the filter elements for deeper cleaning. The flushing process was a simpler operation that only required the handles to be turned, and without isolating the fuel supply, while the cleaning operation was more complex and involved dismantling the filter unit and extracting the filter element. For *Moritz Schulte*, using MGO rather than HFO reduced the need for filter element extraction.

During normal operation both filters were in use. The three-way cock between the filters enabled each filter to be isolated in turn, which facilitated filter element removal for manual cleaning while the engine was running.

1.5.3 Fuel filter cleaning

The Bernhard Schulte Shipmanagement (UK) Limited (BSM) PMS job plan for the vessel included a 300 running hours routine for cleaning the AE fuel oil filters. The frequency of cleaning was not formally adjusted in the PMS according to the type of fuel in use, although this was done in practice, and no other jobs for these filters were included on the job plan. The task of fuel filter cleaning was assigned to the 3/E on board all BSM vessels. The procedure for the 300 running hours routine stated:

- *Use proper PPE*
- *Carry out risk assessment and toolbox meeting*
- *Refer makers instructions*
- *Isolate machine and post warning notices and remove after completion*
- *Check the filter condition. Clean/replace the filter element. Replace gaskets & 'O' rings if required*
- *Run engine and check parameters are normal*
- *Update PMS records with regard to findings and spares consumed* [sic]

The PMS did not specify how to isolate the fuel filter, instead it referred the reader to the maker's instructions.

The handover notes from his predecessor, received and acknowledged by the 3/E on 9 June 2020, included the following instruction:

> *Also AEs FO fine filters cleaning is required on a daily basis by turning a cleaning device knob on a filter cover.* [sic]

1.5.4 Fuel filter cleaning history

The PMS records for AE1 fuel filter cleaning and flushing **(Table 1)** showed that the 3/E had previously cleaned the filters on 20 June 2020, when *Moritz Schulte* was on passage, which he recorded with photographs, 623 hours since they had been assessed as not needing to be cleaned by the previous 3/E. On 14 July 2020, at 242 hours, and 31 July 2020, at 326 hours, he recorded flushing the filters. At the time of the accident on 4 August 2020, a further 29 operating hours had passed since the fuel filters had last been flushed and the filters had accumulated 597 hours since they had last been cleaned.

Key:	3/E Rajendra Naidu Ponnada 9 June 2020 to 4 August 2020
	3/E 31 January 2020 to 10 June 2020
	3/E 8 August 2019 to 31 January 2020
	3/E 4 April 2019 to 8 August 2019

Date	Hours run	Hours since last cleaned	Third engineer's comments
04 Aug 20	100912	29	
31 July 20	100883	326	*Cleaned by flushing*
14 July 20	100557	242	*Cleaned by flushing*
20 June 20	100315	623	*Cleaned – Pictures attached*
10 May 20	99692	378	*FO pressure difference across the filter is in normal range, cleaning is not required.*
20 Apr 20	99314	469	*FO pressure difference is in normal range, cleaning is not required.*
07 Mar 20	98845	455	*FO pressure difference is in normal range, cleaning is not required.*
24 Jan 20	98390	301	*AE 1 F.O. Duplex filter was checked and cleaned. Parameters in range. Found to be in good condition.*
08 Jan 20	98089	250	*AE 1 F.O. Duplex filter was checked and cleaned. Tested and parameters in range. Found satisfactory.*
16 Dec 19	97839	259	*AE 1 F.O. Duplex filter was checked. Parameters in range. Found to be in good condition.*
08 Nov 19	97580	277	*AE 1 F.O. Filters were opened, checked and cleaned. Parameters in range after cleaning, found satisfactory.*
22 Oct 19	97303	500	*AE 1 F.O. Duplex filter was opened, checked and cleaned. Found satisfactory.*
18 Sept 19	96803	296	*AE 1 F.O. Filters were checked and cleaned. Found satisfactory.*
26 Aug 19	96507	293	*AE 1 F.O. Filter checked and cleaned. Found satisfactory.*
05 Aug 19	96214	282	*Fuel oil filters cleaned by flushing*
14 July 19	95932	299	*Fuel oil filters cleaned by flushing*
11 June 19	95633	297	*Fuel oil filters cleaned by flushing*
23 May 19	95336	295	*Fuel oil filters cleaned by flushing*
04 May 19	95041	283	*AE 1 Fuel oil filters cleaned by flushing*
12 Apr 19	94758	291	*AE 1 Fuel oil filter was checked*

Table 1: PMS records of AE1 fuel filter cleaning

1.6 POST-FIRE INSPECTIONS

1.6.1 Overview

COVID-19 restrictions prevented MAIB inspectors from travelling to the vessel immediately after the accident. As a result, *Moritz Schulte* was attended by a local surveyor who represented the Scandinavian Underwriters Agency and specialised in hull and machinery surveys. The surveyor supported both the MAIB investigation and the separate fire investigation that was carried out on behalf of the vessel's insurers. The two investigations ran parallel to one another in the initial evidence gathering phase, before physical evidence could be collected from the vessel.

1.6.2 Auxiliary engine 1 fuel system

The front section of the splash shield, which enabled access to the filters, had been removed and the three-way cock between the filters was found partially closed **(Figure 14)**.

The left-hand filter cover, which was attached to the filter body by four studs and nuts, had been slackened by the removal of the front left-hand nut and the partially undone front right-hand nut. Part of the O-ring seal had been forced out of its recess groove and had split **(Figure 15)**.

The fuel supply isolating ball valve was found in the closed position **(Figure 16)**. The fuel return isolating ball valve was found in the open position.

1.6.3 Fuel filter and pipework testing

On 27 August 2020, while the vessel was alongside for repair at Vlissingen, the Netherlands, the complete duplex fuel filter and associated pipework arrangement were removed from AE1 and brought to the UK by the MAIB for examination.

To understand the extent of fuel leakage through the partially removed left-hand filter cover, a 107 litres/minute 20 bar water pump was connected to the supply side pipework. The fuel filter and pipework testing ranged from 2 bar to 7 bar and at 5 bar the water spray reached up to 4m with a height of about 1.6m **(Figure 17)**.

The fuel supply isolating ball valve and the non-return valve on the fuel return side of the pipework were pressure tested to 5.5 bar and found to hold pressure without leakage. The return line isolating ball valve was similarly tested and found to not close fully, resulting in a leak. Further examination of this valve identified ball seal damage.

The gap between the left-hand filter cover and the filter housing was measured and found to be a maximum of 2.66mm at the front and 1.26mm at the rear. The front right-hand stud was found to be loose.

Both duplex filters were removed from their housings and found to be clean. The inlet and outlet ports within the housing were partially open **(Figure 18)** due to the as found three-way cock position; when tested, the cock could be rotated and the ports closed. The failed O-ring seal was in good condition and, apart from where it had split, was still in position **(Figure 19)**.

Image courtesy of Skua Marine Ltd

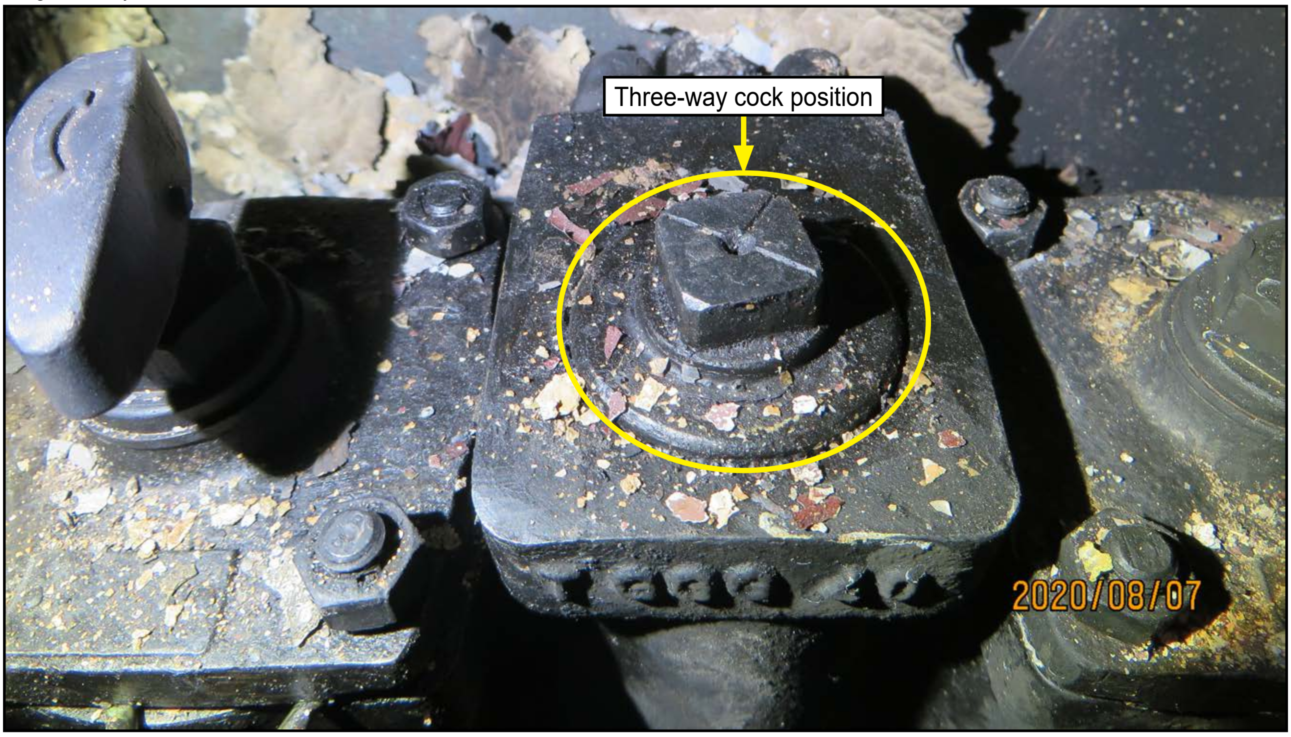

Figure 14: AE1 fuel filters, showing three-way cock position as found post-fire

Image courtesy of Skua Marine Ltd

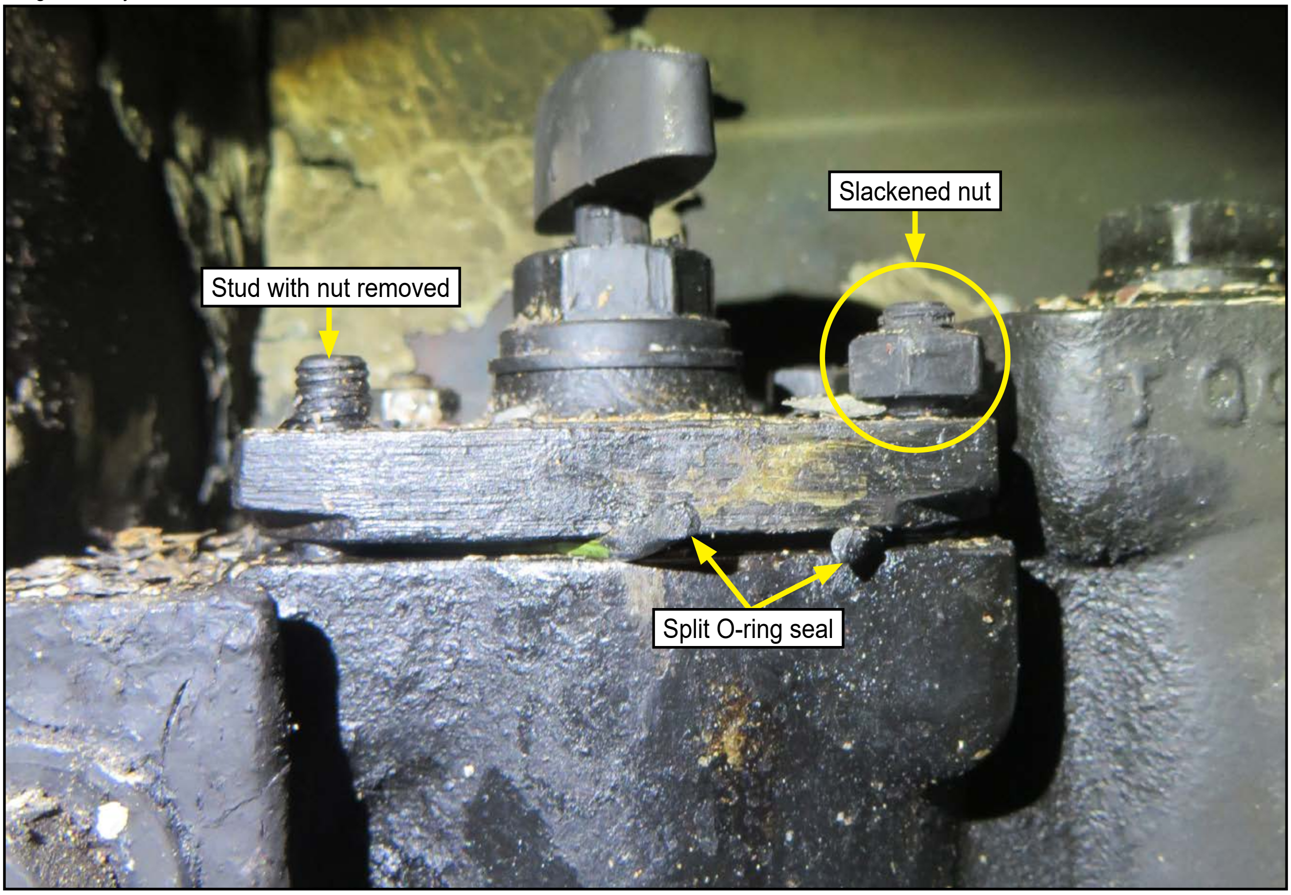

Figure 15: AE1 left-hand fuel filter cover and split O-ring seal

Image courtesy of Skua Marine Ltd

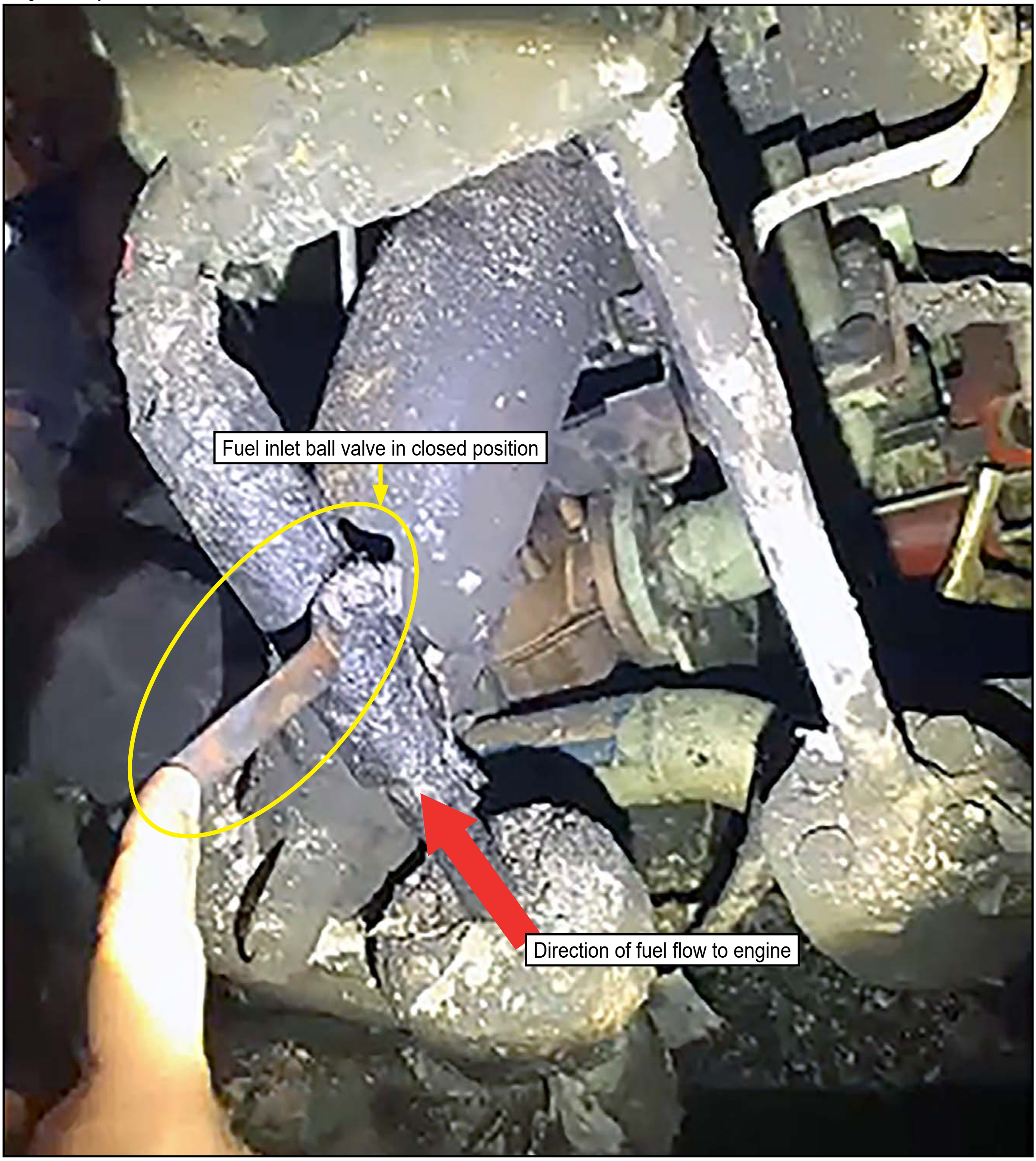

Figure 16: AE1 fuel supply isolating ball valve

Figure 17: AE1 left-hand fuel filter leakage test

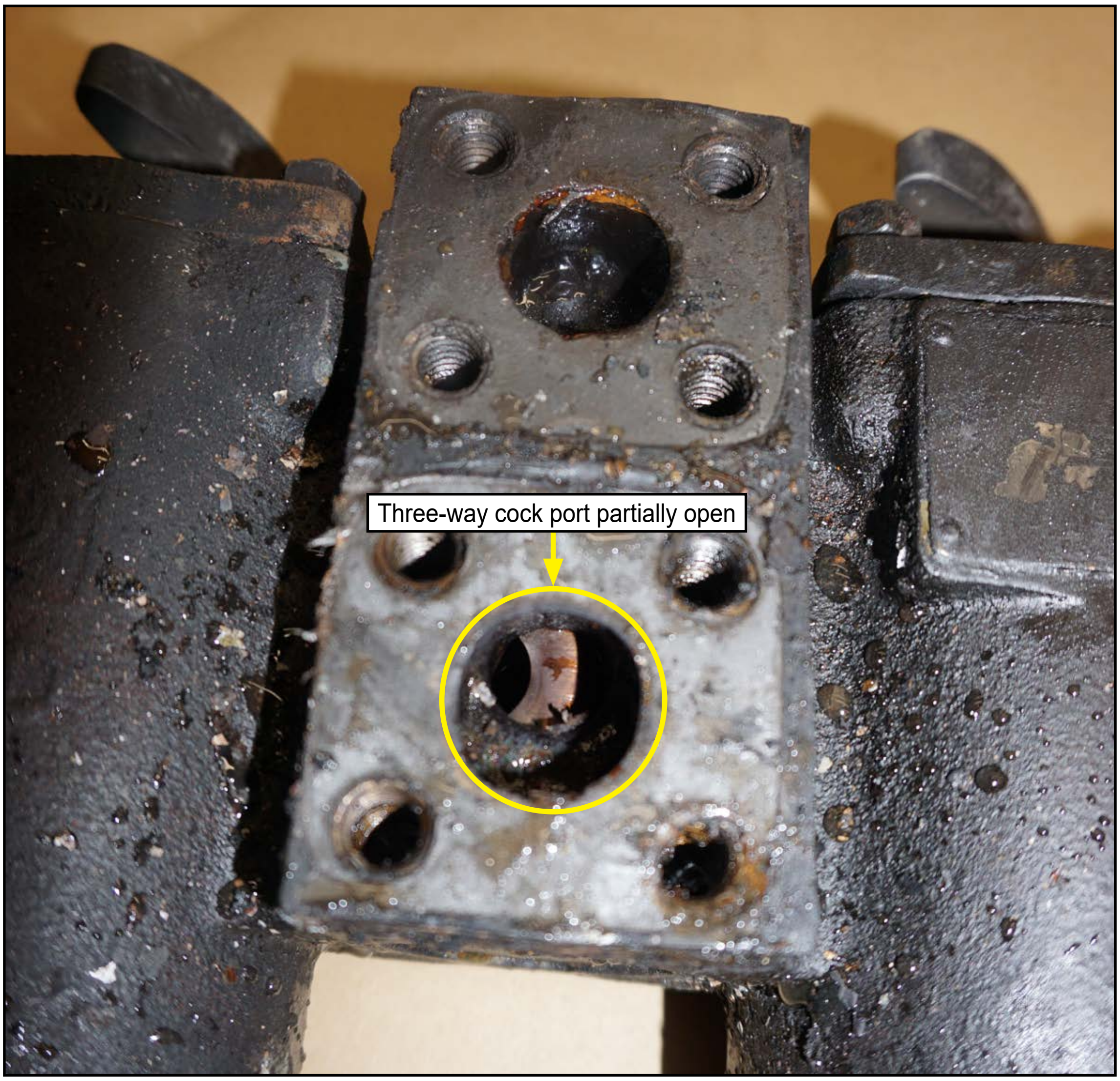

Figure 18: AE1 fuel filters three-way cock ports partially open

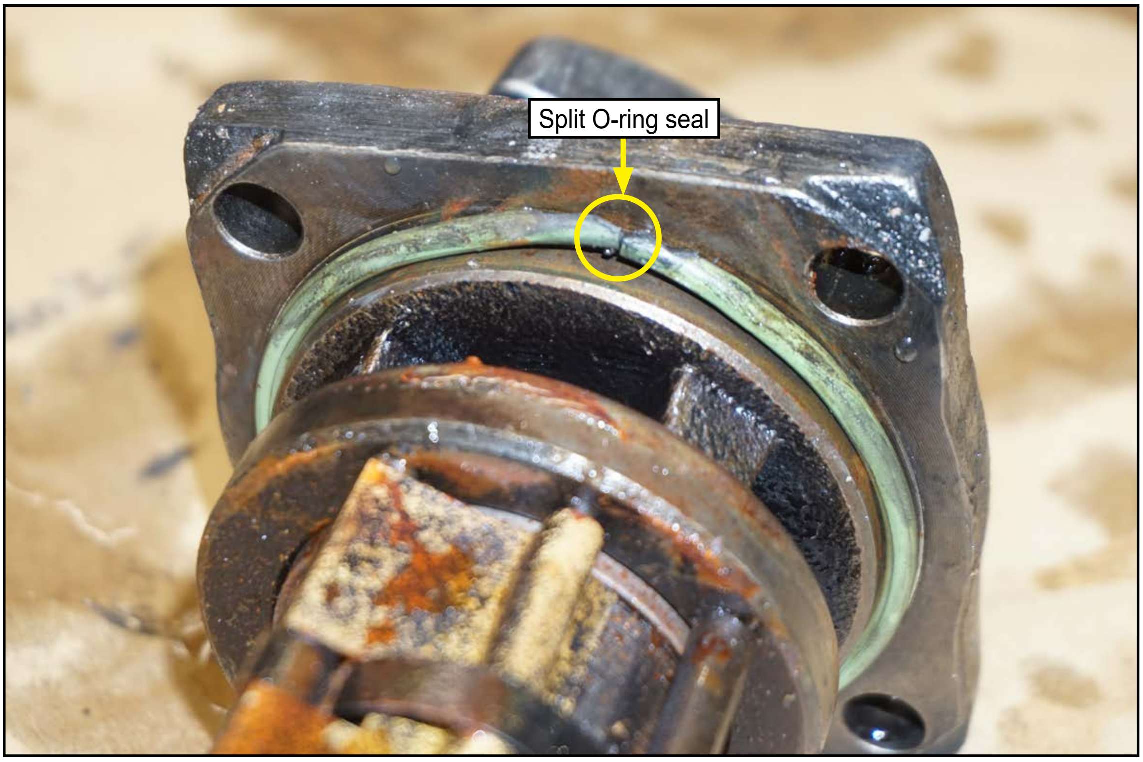

Figure 19: AE1 left-hand fuel filter cover plate O-ring seal

1.6.4 Auxiliary engine 2 exhaust insulation and cladding

The running AE2's exhaust temperature was approximately 370°C, significantly higher than the MGO autoignition temperature of approximately 250°C.

The International Convention for the Safety of Life at Sea 1974, as amended (SOLAS) Chapter II-2, Regulation 4 – Probability of Ignition[2] – required that:

2.2.6.1 Surfaces with temperatures above 220°C which may be impinged as a result of a fuel system failure shall be properly insulated.

2.2.6.2 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.

The exhaust pipework and turbochargers of the three AEs were protected by lagging insulation, which was covered by a thin galvanised sheet steel heat shield riveted together to form a homogenous barrier. The exhaust uptake pipework above the turbocharger heat shield was lagged **(Figure 20)**.

Image courtesy of Skua Marine Ltd

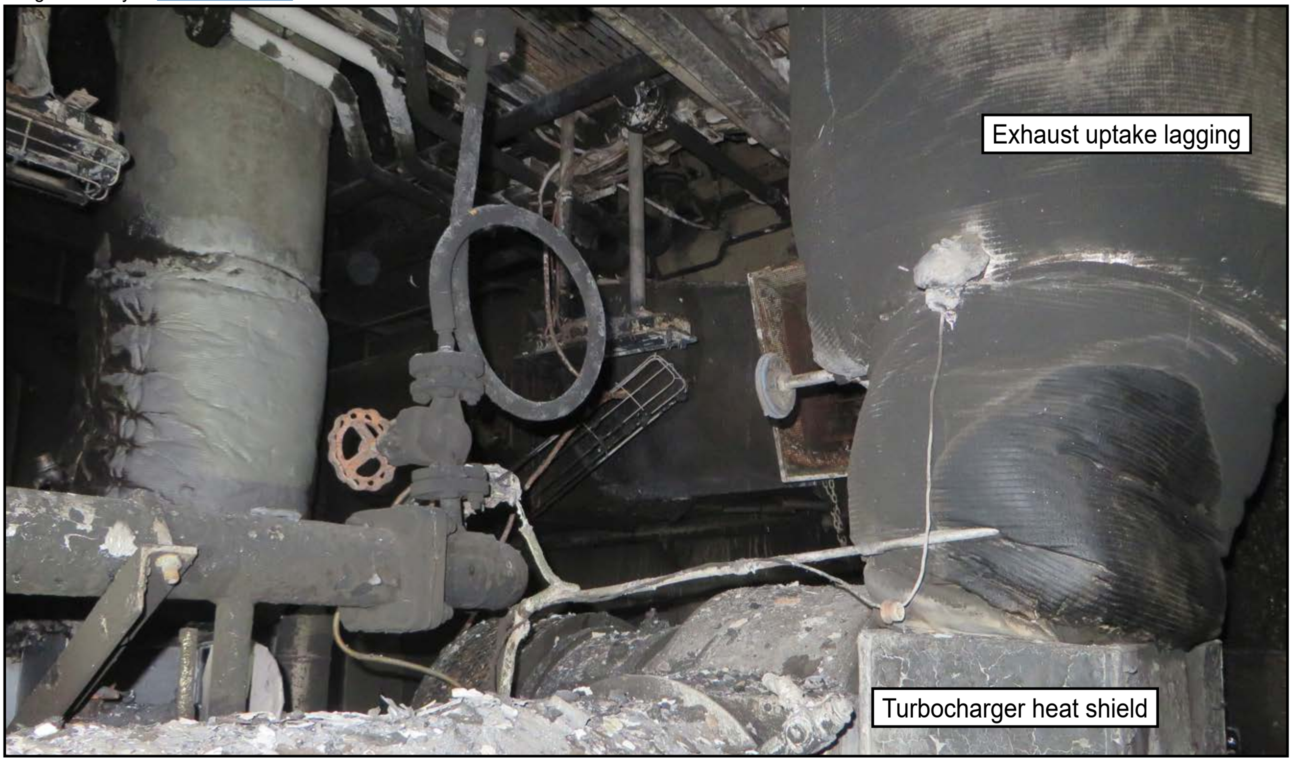

Figure 20: AE2 exhaust insulation

Moritz Schulte's crew used an infrared thermometer to take regular hot-spot temperature measurements. These checks were intended to identify any degradation of the insulation that might lead to the exposure of high temperature exhaust pipework.

Inspection of AE2's exhaust insulation in the turbocharger area identified 30mm to 60mm gaps between adjacent sections of the exhaust sheet plating and that of the turbocharger **(Figure 21)**, which exposed the exhaust pipe/turbocharger inlet flange connection. A 10mm gap from the top of the turbocharger heat shield to the base of the uptake lagging was among other gaps identified.

[2] https://www.gov.uk/government/publications/solas-chapter-ii-2

Additional exposed exhaust components included an unlagged valve on the turbocharger water-washing drain connection at the base of the turbocharger, which protruded almost 40mm beyond the heat shield **(Figure 22)**.

Image courtesy of Skua Marine Ltd

Figure 21: AE2 gaps in heat shields and exposed exhaust flange

Image courtesy of Skua Marine Ltd

Figure 22: AE2 exposed turbocharger water washing drain connection

1.6.5 Fire damage

The fire was relatively short in its duration, but intense. It was localised at the aft end of the ER, around the aft end of AE1 and AE2 on A Platform and the entrance to the SG room. The fire had spread upwards, causing heat-related damage to the equipment on the boiler platform above the AEs **(Figures 23a** and **23b)**. Heavy smoke damage was prevalent elsewhere.

Image courtesy of Skua Marine Ltd

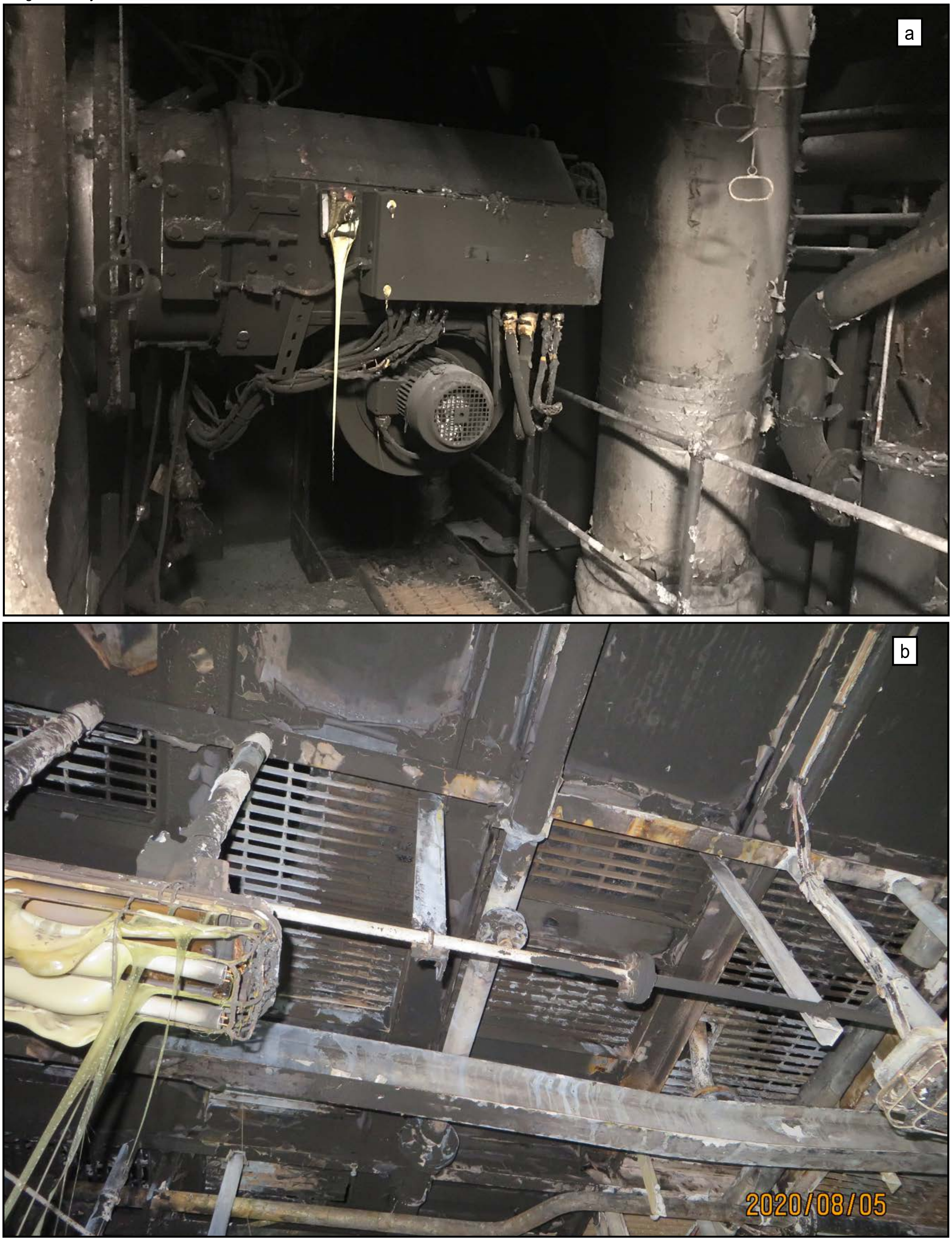

Figure 23: Boiler platform fire damage (a) and view up to boiler platform from auxiliary engines (b)

1.7 *MORITZ SCHULTE* CREW

1.7.1 The crew

The 23 crew members on board *Moritz Schulte* comprised of nine nationalities, which were mainly East European and African but also South American, Indian and Asian. The nine crew within the ER department were made up of seven nationalities.

1.7.2 The master

The Russian master began his seagoing career in 1997 and had worked almost exclusively on LPG/ethylene carriers. In 2006, he joined BSM as a second officer (2/O). He was promoted to master in 2013 and joined *Moritz Schulte i*n 2018. At the time of the accident, he had completed eight 3-month contracts on board *Moritz Schulte* and one contract on board *Philine Schulte*.

1.7.3 The chief engineer

The Ukrainian C/E began his seagoing career in 1997 and had worked almost exclusively on LPG/ethylene carriers. In 2001, he joined BSM as a 3/E and was promoted to C/E in 2014. He joined *Moritz Schulte* in June 2016 and had since completed seven contracts on board. At the time of the accident he was 3 months into his eighth contract on board *Moritz Schulte*, having joined the vessel on 20 May 2020. The C/E held an STCW III/2 Certificate of Competency, attained in November 2016.

1.7.4 The chief officer

The Ukrainian C/O began his seagoing career with BSM, joining as an able seaman in 2006, and had worked almost exclusively on LPG/ethylene carriers. From 2009 until 2019 he worked for other companies. He returned to BSM in January 2019, as a C/O. Since August 2019, he had completed two consecutive contracts on board *Moritz Schulte*. At the time of the accident he was 3 months into his third contract on board *Moritz Schulte*, having joined the vessel on 9 May 2020.

1.7.5 The second engineer

The Venezuelan 2/E began his seagoing career in 2002 and had worked exclusively on LPG/ethylene carriers. In 2015, he joined BSM as a 3/E and gas engineer. In 2016, he was promoted to 2/E. Since June 2018, he had completed three contracts on board *Moritz Schulte*, each with a duration of 3 to 5 months. At the time of the accident he was 5 months into his fourth contract on board *Moritz Schulte*, having joined the vessel on 11 March 2020. The 2/E held an STCW III/2 Certificate of Competency, attained in April 2018.

1.8 THE THIRD ENGINEER

1.8.1 Training and seagoing experience

Rajendra Naidu Ponnada was born in 1989 and came from a small village in the eastern state of Andhra Pradesh, India. In 2011, he completed a mechanical engineering course at the GMR Institute of Technology in Rajam, India. In January 2012, he gained a Bachelor of Science (Nautical Science/Marine Engineering) from the Vishwakarma Maritime Institute in Pune, India.

In July 2012, Mr Ponnada began his seagoing career as a trainee on board a container ship and after two trips, totalling nearly 11 months, he undertook various maritime training courses in India. On 9 October 2014, he attained an engineering watch officer Class IV licence (STCW III/1), which was subsequently verified through the STCW certificate verification system and endorsed by the Isle of Man Government.

In January 2015, Mr Ponnada joined BSM as an engineer assistant and completed several contracts on board various vessels, as shown in **Table 2**. From 24 December 2016 until February 2017, he was medically signed off work due to back pain. For family-related reasons, he did not return to sea until July 2017.

Rank	Vessel	Vessel Type	From	To	Duration
3rd engineer	*Moritz Schulte*	LPG/ethylene	09/06/2020	04/08/2020	1 month 26 days
4th engineer	*Zita Schulte*	LPG/ethylene	11/10/2019	19/02/2020	4 months 9 days
4th engineer	*Zita Schulte*	LPG/ethylene	30/09/2018	29/01/2019	4 months 0 days
4th engineer	*Dorothea Schulte*	LPG/ethylene	27/03/2018	10/08/2018	4 months 15 days
4th engineer	*Edzard Schulte*	Chemical/oil	12/07/2017	10/01/2018	5 months 30 days
4th engineer	*Johann Schulte*	LPG	03/12/2016	24/12/2016	0 months 22 days
Junior 4th engineer	*Elisabeth Schulte*	Chemical/oil	29/04/2016	27/09/2016	5 months 0 days
Junior 4th engineer	*Auguste Schulte*	Container	01/11/2015	15/01/2016	2 months 15 days
Engineer assistant	*Auguste Schulte*	Container	24/09/2015	31/10/2015	1 month 8 days
Engineer assistant	*Auguste Schulte*	Container	22/01/2015	04/08/2015	6 months 14 days

Table 2: 3/E's shipboard experience with BSM

Evidence indicated that, in 2019, he attended a maritime training establishment in India to sit exams for an engineering Class II (STCW III/3) qualification; however he did not complete the exams. In the same year, Mr Ponnada was married.

Shipboard responsibilities

The 3/E's responsibilities included the maintenance and operation of the AEs, fuel purifiers, emergency generator, emergency fire pump, lifeboat and rescue boat engines, fuel bunkering and fuel transfer.

Performance appraisals

Senior shipboard officers were required to conduct a performance appraisal for each staff member during their time on board. The C/E and 2/E held this responsibility within the engineering department.

Between obtaining his Class IV licence and promotion to 4/E, Mr Ponnada had completed two trips as an engineer assistant and two trips as a junior 4/E. Excerpts from his appraisals included the following comments:

> *He hardworking person but still showing skills like Engine assistant. Can perform tasks only under engineers supervision.* [sic]
> (21 December 2015, rank: engineer assistant)

> *The gent must be more prepared physically and psychically for this job and rank.* [sic]
> (12 January 2016. rank: junior 4/E)

> *Junior 4th Engineer is a very polite and very active man always willingly to help any other person.* [sic]
> (16 July 2016, rank: junior 4/E)

> *He is good engineer with some potential and ability for further developing and promotion in a nearest future.* [sic]
> (23 August 2016, rank: junior 4/E)

> *Good Engineer. compliance with Company Procedures and requirements.* [sic]
> 27 September 2016 (Rank: junior 4/E)

Subsequent appraisals at the rank of 4/E, before his promotion to 3/E, included the following comments:

> *He perform his duties very well during this contract. He shows that he is experienced 4th Engineer, always willing to work. He is carrying his job without supervision. I would like to sail with him in the future.* [sic]
> (8 August 2018)

> *He needs much, much more experience. However he is willing to learn and to help all time. A lot of jobs, maintenances carried out by him still need to be supervised by Senior Engineer.* [sic]
> (1 November 2018)

> *He can be promoted for 3E position when BSM procedures (CMS, Promotional training, est.) will be completed.* [sic]
> (24 January 2019)

> *has shown very good progress in engineering knowledge and skill. Could be promoted to position Trainee 3rd Engineer on BSM LPG fleet in nearest future.* [sic]
> (29 January 2020)

On 26 June 2020, an appraisal by the *Moritz Schulte* 2/E stated that the newly promoted 3/E had:

> *…shown knowledge on ER routine and duties according to 3E rank. Still on familiarization with vessel equipment and systems. He shown responsibility and collaboration with engine crew.* [sic]

The 2/E identified *Efficient Operation of Marine Diesel Engines* as a training need at this early stage of the 3/E's time on board. *Moritz Schulte*'s C/E had not been required to comment on the 3/E's appraisal but found the 3/E reticent to speak and unforthcoming.

An internal review of the appraisals issued across the BSM fleet since a new staff appraisal system came into force during 2018 found that there were no recorded negative comments or indications of poor performance.

<u>Vessel familiarisation checklist</u>

BSM required that all new joiners completed its three part Familiarisation Checklist. Part A was expected to be completed within 48 hours of the new joiner signing on, Part B before the new joiner was assigned emergency duties and Part C within 2 weeks of embarking.

Part C, item 4, *Master / Chief Engineer interview – discuss company and standing orders, expectations and ambitions*, stated that:

> *Officers must fully understand the Master's, Chief Engineer's and company's expectations, including safe working practices, whilst working on board and expected behaviours.* [sic]

On 10 June 2020, one day after the 3/E signed on, all three sections of the vessel familiarisation checklist had been completed and countersigned by the 2/O (as training officer), 2/E and C/E.

1.9 BERNHARD SCHULTE SHIPMANAGEMENT

1.9.1 Overview

At the time of the accident, BSM managed a fleet of over 600 vessels. The organisation comprised of:

- approximately 400 vessels under full management; technical and crewing
- approximately 200 vessels under partial management; crewing only
- 11 Ship Management Centres (SMC), each with its own Document of Compliance, to which BSM provided a variety of services and functions
- 24 Crew Service Centres (CSC)
- 4 Maritime Training Centres (MTC).
- approximately 18,000 seafarers and 2,000 shore-based employees across the globe.

1.9.2 *Moritz Schulte* management arrangements

Moritz Schulte was managed by BSM (British Isles) as one of the SMCs. With over 30 years' ship management experience, BSM (British Isles) was an approved Isle of Man flag representative that provided statutory management services from its offices located in Newcastle and on the Isle of Man.

As an SMC, BSM (British Isles) provided technical and crew management services to 15 customers and vessels, including specialised vessel types such as LPG/ liquefied natural gas carriers, chemical/product carriers and drilling vessels.

1.9.3 Vessel crewing arrangements

While the SMC was the seafarers' point of contact when they were on board a ship, the CSC was the point of contact for all shore-based activity. The role of the CSC was to act as a local manning agency and propose registered seafarers for vacancies.

The SMCs also liaised with the ships' masters for on board matters that related to crew activity and welfare, which included:

- appraisals
- the onboard competency management system
- the management of Videotel training.

Mumbai CSC was BSM India's recruitment headquarters and over 4,250 of its registered seafarers were employed on various types of vessel. There were a further six BSM India branch offices nationwide.

Mumbai CSC employed nationals from India, Bangladesh, Sri Lanka and Pakistan and offered services that included:

- selection and recruitment of officers and ratings
- arrangement of advanced training and STCW courses
- contract formalities
- supply of safety and work equipment.

Candidates for junior officer promotion required the approval of BSM fleet personnel management while senior officer promotion was approved by BSM fleet management. The promotion criteria for junior officer positions was outlined in BSM's crewing, fleet and training manuals. The desirable attributes for promotion included the candidate achieving at least two recommendations in their appraisal reports and a 100% activity log in the competency management system (CMS).

The responsibilities of fleet personnel group services included:

- operational oversight of CSCs
- operational oversight of BSM maritime training centres

- monitoring the compliance of all corporate fleet personnel procedures
- providing on board training support through designated training masters
- developing and improving company crewing systems and tools.

In 2017, as part of a series of online media interviews[3] on the state of the shipping industry's crew supply and maritime training, a BSM fleet personnel director identified a global shortage of qualified officers (approximately 16,500 in 2015, projected to exceed 145,000 by 2025) and an excess supply of ratings. The director considered the consequences to include a lack of quality crew and relevant certification available and a need to address this imbalance. In response to these identified issues, BSM had focused on the enhanced level of crew training provided to meet the demand of increasingly complex ship systems and identified that qualified, well-trained professional seafarers could also command the higher pay rates that were needed to retain them.

The fleet personnel director recognised that the right social and cultural mix was needed for crew to work together effectively and commented that BSM had enhanced its crew training to better develop its available supply of ratings to meet the growing demand for qualified officers.

1.9.4 Competency management system

The BSM CMS provided a comprehensive online crew training and development package. It comprised of training and personnel manuals, simulators, training modules and oversight of progress via individual activity logs, which required the provision of suitable evidence before being signed off by senior officers. The CMS framework consisted of four separate sections:

- Core competencies
- Key competencies
- Emergency response, drills and security duties
- Promotion

CMS content relating to crew safety training included the following titles:

- *Understanding and practicing safety culture.*
- *Apply BBS[4] principles in the work place and off watch and carry out BBS Observations.*
- *Understanding the stop-work authority process and have confidence to exercise if required (Speak Up).*
- *Safely use an EEBD for escape purposes.* [sic]

[3] https://youtu.be/u8oBv4fJZMM

[4] Behaviour Based Safety.

Once all tasks and promotion items within each competency area were complete and signed off on the individual's activity log, the system would indicate that the crew member was eligible for promotion. The crew member, their on board head of department and the responsible fleet personnel officer had oversight of the learning progress that had been made for each competency and could monitor its status.

An evaluation guideline was used by the crew member, their assessor, the master or C/E to identify what needed to be done to achieve each competency. A completed task was recorded in the activity log, which included space for the assessor to add comments.

Additionally, the CMS required the activity log for engineers to demonstrate a level of competence that met STCW Table A-III/1[5]. There was no evidence of this in Mr Ponnada's activity log at the rank of 4/E and it remained incomplete at the time of the accident.

The training programme required Mr Ponnada to complete 65 rank-specific tasks before his promotion to 3/E, of which only two records demonstrated the requisite evidence:

- participate in rescue boat launching and recovery
- conflict resolution.

1.9.5 Post-accident review

BSM carried out a comprehensive review of its CMS following the accident. The range of issues that were identified included:

- Mismatched promotion conditions across the three key manuals. For example, the training manual specified attendance and completion of a Junior Officers Course (JOC) at a company MTC as mandatory although this was not a requirement within the other two manuals.
- Inadequate CMS assessment of promotion tasks; the system allowed the user to bypass the evidence required to sign off a completed task.
- Modules overwritten on completion, including where no evidence was recorded in the activity log or there was a change of rank. Many CMS tasks were required to be repeated each trip.
- Eight instances where the Videotel reference in the *training required* section had been withdrawn or replaced by a new reference, none of which were updated in the CMS evaluating guidelines.
- Sign-off by senior officers without any record of the requisite evidence.
- The fleet personnel department's misplaced belief that the CMS and a training manual checklist had superseded the 4/E to 3/E promotion checklist.

[5] Specification of the minimum standard of competence for officers in charge of an engineering watch in a manned engine room or designated duty engineers in a periodically unmanned engine room.

- Lack of consideration shown towards the 3/E's previous appraisal comments, including his auxiliary engine knowledge as an area of weakness, during subsequent job planning or supervision of his activities.

BSM fleet personnel management used the activity logs signed by the on board assessors to evidence that the applicant met the promotion criteria for 100% completion of the training programme.

BSM's procedures included promotion checklists for engine rating to junior engineer, 4/E to 3/E and 3/E to 2/E. No such checklist existed for promotion from junior engineer to 4/E, nor was there a 4/E job description.

1.9.6 Third engineer promotions

In October 2016, Mr Ponnada advised BSM's crewing department that he no longer wished to return to sea as a junior engineer and wanted promotion; in December 2016, he joined his next ship as 4/E. His training and appraisal status at the time of this promotion was as follows:

- he had received two promotion recommendations from two C/Es
- there was no evidence of completed promotion checklists
- the CMS activity log contained no evidence to support tasks signed off by the assessor and evaluated by the C/E as complete
- he had not attended a mandatory junior officer's course at a company MTC.

Evidence suggested that Mr Ponnada attempted the STCW III/3 second engineer's qualification during 2019; however, no qualification certificate was issued and BSM was not informed of his attempt.

Before his 2020 promotion to 3/E, Mr Ponnada's competency overview showed that all CMS modules had been completed throughout 2018. However, these had been signed off by his respective C/Es despite unfulfilled criteria for each task, an incomplete activity log and supporting records not having been maintained. In addition:

- the checklist for promotion from 4/E to 3/E position had not been completed
- the two recommendations for promotion appeared to be those used for his earlier promotion to 4/E
- he had not attended a JOC at an MTC.

1.10 SAFE SYSTEMS OF WORK

1.10.1 Overview

Moritz Schulte operated under BSM's safety management system. This incorporated the planned maintenance system (PMS) and included an extensive documentary requirement to demonstrate the application of safe systems of work (SSOW).

1.10.2 Planned maintenance system

All BSM fleet vessels operated an in-house Class approved[6] PMS. The system was ship-specific, managed on board by the C/E and monitored ashore by the fleet team. The PMS provided job descriptions and procedures based on manufacturers' operating manuals and recorded all activities undertaken.

Each engineer was required to open the PMS to identify the jobs to be carried out that day. The C/E was responsible for closing completed job orders in the PMS.

Maintenance intervals were occasionally adjusted based on condition monitoring results. The post-accident review of the shipboard PMS and machinery records identified that this condition-based maintenance approach had not been applied to the engine-mounted fuel filters. No change had been made to reflect the manufacturer's instructions to turn the AE fuel filter handles based on engine operating parameters, nor that the vessel was operating on MGO or that the frequency of filter cleaning might be less often than the 300 hours specified.

1.10.3 Risk assessment and permit to work

The on board risk assessments for *Moritz Schulte* totalled more than 500 and covered all forms of activities. The risk assessments specific to engineering were meant to be completed by the relevant engineer when jobs were identified in the PMS, before the work was undertaken. The engineer was also required to complete permits to work, which were signed off by the C/E. The BSM Safety Management Manual *Permit to work – working on pressure systems* **(Annex B)** procedure required the preparation of a work plan and risk assessment that considered, among other things, depressurising the system, system isolation, and the competency of the staff involved. The procedure also referred to the application of *tag-in/tag-out*[7] procedures.

A post-accident documentation review found that some of the risk assessment and permit to work procedures in the engine department were inaccurate. It also highlighted discrepancies in that PMS tasks were marked as complete despite no risk assessment and permit to work records to verify this.

The PMS required the 3/E to specify whether a fuel filter cleaning risk assessment had been completed. Between April 2019 and August 2020, the AE1, AE2 and AE3 fuel filters had been reported as cleaned 59 times, of which the risk assessment was marked as completed 18 times. However, examination of the risk assessment module for that period found no completed risk assessments for AE1, AE2 and AE3. There was also no evidence to show that any fuel filter maintenance permits to work were issued. For example, a risk assessment was marked as complete for the AE1 300-hour routine fuel oil filter cleaning on 20 June 2020, carried out by the 3/E, for which no risk assessment or permit to work was completed. On 4 August 2020, no risk assessment or permit to work were in place for any work conducted on the AE1 fuel filters.

[6] A Class approved and audited planned maintenance system incorporates regular surveys of machinery on the basis of intervals between overhauls recommended by the manufacturer, documented operational experience and a condition monitoring system, where fitted.

[7] Also known as lock-out/tag-out.

1.10.4 Lock-out/tag-out

The technical operations manual provided the following instruction for lock-out/tag-out responsibilities on certain categories of equipment as part of the permit to work procedure:

1) The C/E is responsible for tagging and locking out

2) Conduct familiarisation with all crew in the use of lock out/tag out equipment

3) Apply lock out/tag out when working on following systems:

a) Machinery and electrical equipment

b) Pressurised pipelines

Caution: Isolate, de-pressurise and render hazardous energy sources inoperative before starting to work on them. [sic]

On the 59 occasions that the AE1, AE2 and AE3 fuel filters had been noted as cleaned between April 2019 and August 2020, no lock out/tag out procedures had been completed for the pressurised fuel system.

1.10.5 Stop-work system

Moritz Schulte operated a 'stop-work' system, empowering any crew member who witnessed a colleague performing an unsafe operation to issue a 'stop-work' card. The system was explained to new crew members during their familiarisation training. Since December 2016, three 'stop-work' cards had been issued, all related to deck operations.

1.10.6 Auditing

As a gas/chemical tanker on contract to oil majors, *Moritz Schulte* was regularly subjected to a range of external and internal inspections and audits. On 27 January 2020, an internal audit was conducted in Grangemouth, which was one of its last company audits before the fire.

The audit identified a number of shortcomings, mostly relating to documentary control practices, including:

A failure to follow procedures/instructions; inadequate communication/information; inadequate maintenance/inspection records; lack of competence and inadequate leadership, relating to:

- *A variety of ER documentation that had not been completed by various engineers*
- *An overdue PMS monthly routine*
- *Uncontrolled documentation of obsolete procedures*
- *Incomplete and inaccurate enclosed space permit issue*

- *No enclosed space permit issue for an enclosed space drill*
- *Unsigned official ship records*

In most cases, the corrective action included the requirement to provide evidence of the completed actions to close out the audit findings.

1.11 EMERGENCY PREPAREDNESS

1.11.1 Muster lists

Two separate and differing vessel muster lists were located on board *Moritz Schulte*, one at the muster station and one in the December 2019 quality document management system (QDMS). The two documents differed in respect to the roles assigned to several of the key personnel involved in the 3/E's rescue attempts: the muster list at the muster station stated that the bosun's duty was to assist a firefighter with donning a fire suit, while the QDMS put him in charge of boundary cooling.

In the event of an ER fire, the roles assigned to the C/E, 2/E and the fitter also differed between the vessel muster list and the QDMS. Although the C/O assumed control of the search and rescue operation, this was contrary to his assigned role on either of the muster lists.

1.11.2 Firefighting and enclosed space rescue drills

Moritz Schulte was equipped with five firefighting outfits, two at the fire control station, two on the forecastle and one on the bridge. Nine breathing apparatus (BA) sets were available.

Emergency drills were programmed in a yearly planner and regularly conducted. Fire and enclosed space rescue drills for the period before the fire in 2020, and their associated completion comments, were reviewed by BSM and are summarised in **Table 3**.

The CMS also included various competencies to be demonstrated in respect to ER fires, including:

- *Escape from a smoke-filled ER (simulated)* and its sub-category:
    - *10392: locate the escape shaft and climb out from the ER.*
- *Participate as part of the Fire Fighting Team* and its sub-category:
    - *10394: carry out correct firefighting tasks. (simulated through realistic drills),* and
- *Use an Emergency Escape Breathing Device (EEBD)* and its sub-category:
    - *10390: safely use an EEBD for escape purposes.*

There are no records of the 3/E having completed any of these tasks before promotion to either 4/E or 3/E.

Date	Time	Drill Scenario	Drill Frequency	Comments on Drill Report
28 June 2020	Drill reported to have begun at 1030 and ended at 1036	Fire on mast riser	Yearly	*All crew gathered at the aft part of the gas house and the C/O carried out an explanation on how to operate the mast riser extinguisher system.* *All 23 crew reported as in attendance.*
28 June 2020	Drill reported to have begun at 1030 and ended at 1043	Fire in cargo tank	6-monthly	*Instructions to each squad (Emergency/ Special/Support) are organized. Boundary cooling and entry with BA set recorded. Master explains the importance of good communications.* *All 23 crew reported as in attendance.*
28 June 2020	Drill reported to have begun at 1530 and ended at 1545	Fire in compressor room	6-monthly	*Boundary cooling, entry with BA set and use of fire extinguisher included. No reference to which crew donned fireman's outfits.* [sic] *All 23 crew reported as in attendance.*
28 June 2020	Drill reported to have begun at 1530 and ended at 1550	Enclosed space entry and rescue	2-monthly	*Drill was carried out at the emergency escape trunking on portside instead of an enclosed space due to sheltered location against heavy weather. Smoke divers enter the trunking and search for the wiper. Person evacuated using stretcher and rope and tackle.* [sic] *All 23 crew reported as in attendance.*
11 July 2020	Drill reported to have begun at 1335 and ended at 1345	Rescue drill	3-monthly	*Explanation on how to attend to a casualty was given by 2/O. Minutes of completion suggest explanation was provided. Debriefing by master suggest a rescue had been carried out which makes the report inconsistent.* [sic] *All 23 crew reported as in attendance.*
11 July 2020	Drill reported to have begun at 1530 and ended at 1600	Fire in galley	6-monthly	*Boundary cooling, smoke divers prepared, and preparation of medical equipment reported. Fire extinguished with extinguisher (simulated). New joiners reported as familiar with firefighting equipment.* [sic] *All 23 crew reported as in attendance.*

Table 3: Fire and enclosed space rescue drill records

1.11.3 Location of Emergency Escape Breathing Devices

As part of a ship's safety equipment, the primary purpose of EEBDs was to enable crew to escape from a smoke-filled compartment. EEBDs were required to provide a minimum air supply of 10 minutes and were mandatory under SOLAS for ships where a safety equipment certificate applied.

SOLAS 2000 Amendments (Chapter II-2, Part D, Regulation 13) introduced the requirement for EEBDs. Section 4.3.1 stated that:

> *On all ships, within the machinery spaces,* [EEBDs] *shall be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of fire. The location of* [EEBDs] *shall take into account the layout of the machinery space and the number of persons normally working in the spaces.*

Section 4.6 of IMO MSC/Circular 849 (8 June 1998) – Guidelines for the Performance, Location, Use and Care of EEBDs – specified that:

> *Unless personnel are individually carrying EEBDs, consideration should be given for placing such devices along the escape routes within the machinery spaces or at the foot of each escape ladder within the space.*

IMO MSC/Circular 1081 (13 June 2003) – Unified Interpretation of the Revised SOLAS Chapter II-2, which applied to vessels built on or after 1 July 2003, included the following:

> *Regulation 13.4.3 Emergency escape breathing devices (EEBD)*
>
> *1. This interpretation applies to machinery spaces where crew are normally employed or may be present on a routine basis.*
>
> *2. In machinery spaces for category A containing internal combustion machinery used for main propulsion, EEBDs should be positioned as follows:*
>
> > *.1 one (1) EEBD in the engine control room, if located within the machinery space;*
> >
> > *.2 one (1) EEBD in workshop areas. If there is, however, a direct access to an escape way from the workshop, an EEBD is not required; and*
> >
> > *.3 one (1) EEBD on each deck or platform level near the escape ladder constituting the second means of escape from the machinery space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).*
> >
> > *Alternatively, a different number or location may be determined by the Administration taking into consideration the layout and dimensions or the normal manning of the space.*

Moritz Schulte was built in 2002 and was equipped with six EEBDs. One each was placed at the entrance doors to the port and starboard emergency escapes on the bottom deck of the engine room **(Figure 24)**. Two EEBDs were located in the ECR on A Platform and two in the CCR on the poop deck.

The ER escape routes and locations of the EEBDs were clearly marked on *Moritz Schulte*'s fire control and safety plan. When the 4/E and the fitter began their escape from A Platform, their nearest EEBD was in the ECR **(Figure 25)**.

Figure 24: EEBD location at the entrance to the bottom deck emergency escape

For illustrative purposes only: not to scale

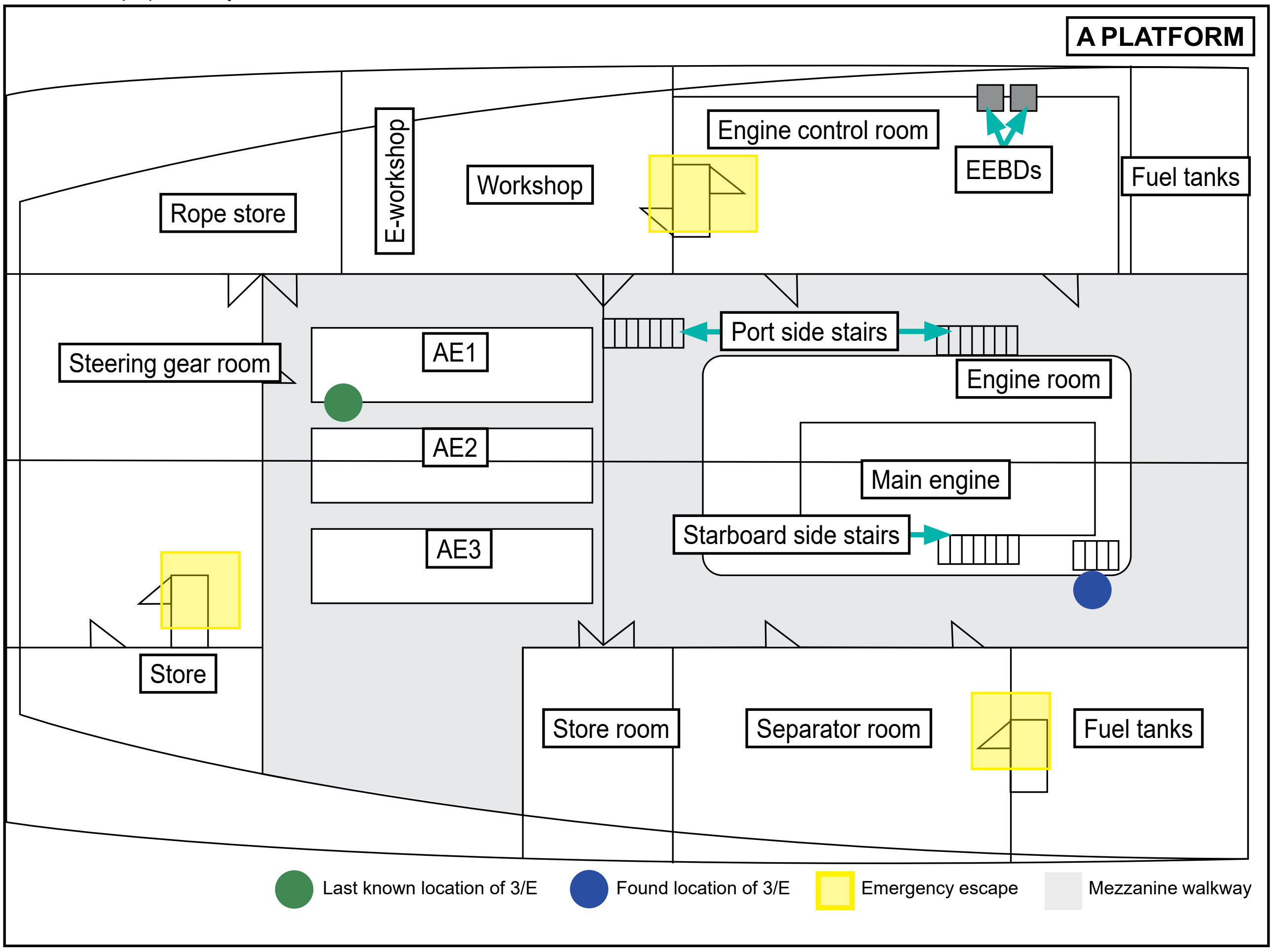

Figure 25: A Platform fire control and safety plan

1.12 SIMPLIFIED VOYAGE DATA RECORDER RECOVERY AND DATA

Moritz Schulte was equipped with a Kelvin Hughes MDP-A5 simplified voyage data recorder (SVDR), which was installed in June 2006. The most recent annual performance test (APT) was undertaken on 31 January 2020. A data download was carried out on 2 July 2020 and the SVDR had been operational thereafter.

At 0102 on 4 August 2020, while *Moritz Schulte* was alongside in Antwerp, the SVDR activated. At 0338, around 30 minutes after cargo discharge started, the SVDR stopped recording. The SVDR manufacturer attended the vessel after the accident and was unable to retrieve any data from it. On 1 October 2020, a new SVDR was fitted.

1.13 SIMILAR ACCIDENTS

1.13.1 *Finlandia Seaways* – catastrophic main engine failure

On 16 April 2018, the pre-2003 built Lithuanian registered roll-on/roll-off cargo vessel *Finlandia Seaways* suffered a catastrophic main engine failure that caused serious structural damage to the engine and a fire in the ER (MAIB Report 2/2021[8]). The vessel's 3/E, who was on duty in the ER at the time, suffered serious smoke-related lung, kidney and eye injuries during his escape via the secondary means of escape up the funnel. He was fortunate to survive given that there were no EEBDs on his escape route. The vessel's owners took a number of actions after this accident, including the issue of a fleet safety bulletin that instructed crews to assess safe means of escape from the engine room and the location and number of EEBDs with respect to MSC/Circ.1081.

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

SECTION 2 - ANALYSIS

2.1 AIM

The aim of the analysis is to determine the contributory causes and circumstances of the accident in order to make recommendations to prevent similar accidents occurring in the future.

2.2 THE ACCIDENT

Moritz Schulte suffered an ER fire when an uncontrolled release of pressurised MGO fuel from the AE1 fuel filter sprayed onto the hot exhaust of the adjacent AE2.

The fuel penetrated through gaps in the protective shielding around the exhaust pipework and made contact with the high-temperature surfaces of the exhaust manifold, causing it to ignite.

The 3/E was unable to escape the ER and died 9 days later in hospital.

2.3 RELEASE OF FUEL

The fuel was released because the 3/E attempted to clean the AE1 fuel filters without first effectively isolating them from the pressurised fuel supply.

The post-accident AE1 fuel filter valve arrangement was found as follows:

- Closed fuel supply isolating ball valve, which isolated the engine and meant that it was no longer on standby.
- Partially closed three-way cock between the filters, which did not prevent fuel passing to the left-hand fuel filter.

It is unknown when these valves had been operated. However, had the isolating ball valve been closed before the 3/E started to remove the left-hand filter cover, a minimal amount of fuel would have been released as the pressure in the isolated system would have immediately dropped from 5.5 bar to zero. Given the extent of the subsequent fire and that the fuel spray was powerful enough to reach the AE2 turbocharger in sufficient quantity to find gaps in the exhaust insulation and ignite, the 3/E must have closed this valve after the fuel release occurred. Due to his position in front of the filter unit, it is likely that he was soaked in fuel before he was able to isolate the system.

The three-way cock may have been moved to the partially closed position before work started on the filter in an attempt to both complete the intended task and comply with the 2/E's instruction not to isolate the engine. Alternatively, the 3/E may have tried to close it once the fuel spray started. In either event, post-accident testing found that its partially closed position made little difference to the amount of fuel released. However, the three-way cock was designed so each filter could be isolated in turn and, correctly operated, it would have prevented the unintended release of fuel.

The 3/E's decision to remove the AE1 fuel filter elements without first isolating the fuel from the filter assembly demonstrated significant shortfalls in his understanding of machinery systems.

2.3.1 Ignition of fuel

The fuel sprayed onto the AE2 turbocharger insulation after it was released under pressure from the AE1 left-hand fuel filter. However, as required by SOLAS, the insulation should have prevented the fuel from reaching hot surfaces.

The AE2 exhaust insulation was in generally good condition, although it had some gaps at the junction between the exhaust pipes and the turbocharger and from the turbocharger to the exhaust uptake. It is likely that fuel penetrated through those gaps to the hot pipework, where it ignited. However, given the volume of fuel released in the form of a spray, it is highly likely that ignition would have occurred eventually even with better exhaust protection.

The PMS included temperature monitoring of the exhaust insulation system. The tool used provided spot rather than area measurement to identify higher than acceptable temperatures. Hence, unless the device was pointed at a gap between insulation panels, it would not identify an area of weak insulation.

Engine exhaust insulation can degrade due to factors such as maintenance, age and vibration, leading to gaps in coverage. These may not be obvious and are easily missed by simple point measurements. More reliable means of testing for hot spots include the use of TICs.

2.3.2 Inability to escape the engine room

In understanding and recognising that people do not normally wish to have an accident while doing their job, then equally they will attempt to minimise the consequences when an incident occurs.

Once fuel began to spray from the filter, it is clear that the 3/E attempted to reduce the danger by closing the fuel supply isolating ball valve, probably under increasing levels of stress. Due to the location of this valve, he would have been covered with fuel while locating and closing it. It is also possible that this fuel entered his eyes, causing swelling, pain and loss of vision.

Although he was successful in shutting the isolating valve, fuel had already entered gaps in the AE2 exhaust insulation and would have quickly ignited. The point at which the 3/E left the area is unknown, but the thick toxic smoke from the fire would have significantly reduced his vision and caused him immediate breathing difficulties. In combination with high stress levels and possible fuel in his eyes, the 3/E is likely to have become disorientated.

From his position at the aft end of AE1, the 3/E had several routes available through which to escape. Whichever route he was seeking, it is apparent that he was overcome by the toxic smoke before he could escape.

2.3.3 Chances of survival

The 3/E was rescued from the ER just over an hour after the alarm sounded, during which time he would have been breathing toxic fumes. The cause of death medical report stated: *smoke inhalation with CN and CO intoxication*. Cyanides, such as hydrogen cyanide (HCN) and carbon monoxide (CO), are common combustion products.

Smoke inhalation is responsible for more fire-related deaths than burns. CN is very toxic and prevents the body from using oxygen properly. Substantial exposure may rapidly lead to unconsciousness, fitting, coma and death. CO is known to displace oxygen from haemoglobin, resulting in decreased oxygen-carrying capacity in the blood.

The critical factor for survival of fire victims affected by CN and CO is rapid extraction from the toxic atmosphere. Finding and removing the 3/E from the ER sooner would likely have increased his chances of survival.

The first two search and rescue entries were unsuccessful, and the poor visibility meant that the 2/E and fitter did not see the 3/E when they arrived at A Platform. The shore-based Antwerp fire and rescue service team found the 3/E through the use of a TIC. Had *Moritz Schulte* been equipped with a TIC, and with suitably trained on board fire teams drilled in its use, it is possible that the 3/E could have been found earlier. However, there was no requirement for the vessel to be equipped with a TIC nor are commercial vessels commonly equipped with them.

2.4 CLEANING AUXILIARY ENGINE 1 FUEL FILTERS

2.4.1 Overview

Moritz Schulte had a full range of SSOW in place, including a comprehensive PMS, risk assessments, permits to work including lock-out/tag-out procedures, ‘stop-work’ procedures and qualified engineers with additional company-specific training under the CMS. Despite this, a qualified engineer who had worked for the company for over 5 years died while attempting an unnecessary job, in an unsafe way, at an inappropriate time, without undertaking a risk assessment and in the absence of direct supervision of the task.

2.4.2 The decision to clean the fuel filters

The 300 hours PMS routine for the AE engine-mounted fuel filters was not aligned with the manufacturer’s instructions. Neither the frequency nor the procedure had been reviewed since the vessel started operating solely on MGO and the on board practices had adapted in response.

It was apparent from both the 3/E handover notes and the PMS cleaning records that the majority of 3/Es had followed the manufacturer’s instructions to flush the filters, rather than the more detailed cleaning task described in the PMS job plan and manufacturer’s documented instructions. The absence of any AE fuel supply records for lock out/tag out procedures having been undertaken before working on any pressurised pipework, as required by the technical operations manual and SMS permit to work, further confirmed this. Additionally, and despite 18 instances in which a risk assessment was marked as completed, corresponding risk assessments were unavailable for the 59 fuel filter cleaning records logged since April 2019. As the PMS did not include a requirement for flushing the filters, there was no reference to any associated risk assessments for that operation.

The drift in operation between the task as stated in the PMS and the task as completed by a succession of 3/Es resulted in Mr Ponnada having to choose between following the brief handover notes left for him, adhering to the PMS procedure or discussing the issue with the 2/E. The first time he cleaned the fuel filters, on 20 June 2020, *Moritz Schulte* was on passage and there was no requirement for the AE to remain available for use. Although he did not follow the documented procedures on that occasion, as evidenced by the PMS records, there was no indication of any fuel release and so he must have successfully isolated the filters on that occasion.

After joining *Moritz Schulte* on 9 June 2020, Mr Ponnada seems to have taken a different approach to the regularity with which filter flushing and cleaning was completed. He recorded the AE1 filters as being cleaned, with supporting photographs, on 20 June 2020, 623 hours since the previous 3/E had assessed these as not needing to be cleaned. He then recorded two consecutive filter flushing events, on 14 July at 242 hours and on 31 July at 326 hours, before attempting to clean the filters 4 days later, on 4 August, after a further 29 operating hours. At that time, the filters had accumulated 597 hours since he cleaned them on 20 June. In the absence of any indication that he regularly flushed the three AE's fuel filters, the operating hours that had accumulated and been recorded by the 3/E for flushing and cleaning suggests that he believed that flushing should occur at around 300 hours and cleaning at around 600 hours. There is no other information to substantiate this theory. It is unclear why the 3/E did not discuss the task with the 2/E on the day of the accident; however, it is known that he understood the difference between flushing and cleaning and considered the task to be time critical. His decision to open the filters for disassembly and cleaning without first isolating them appears to have been a misguided attempt to maintain AE1's availability in case additional electrical power was required.

2.4.3 Planned maintenance system

The *Moritz Schulte* PMS was comprehensive; however there were a number of issues around AE filter maintenance and records. The inconsistency between the manufacturer's instructions and the PMS had not been identified, despite the vessel having operated on MGO since 2015. In addition, the PMS instructions had not been amended to reflect a condition-based maintenance approach as referenced in the technical operations manual.

The decision by the majority of the 3/Es to ignore the PMS procedure for the AE fuel filter cleaning task in favour of the manufacturer's cleaning instructions could be seen as the practical application of good engineering knowledge. Nevertheless, a thorough review and audit of the PMS would give confidence in its ability to provide a clear, unambiguous and up-to-date reflection of the maintenance activities on board and determine the relevance of some of the associated requirements.

2.4.4 Supervision on board

The 3/E had previously opened and cleaned the AE filters so it is likely that the 2/E and C/E expected him to be competent to do so again. However, there was no evidence of either the 3/E or his predecessors having completed risk assessments for this task in the past. On the morning of the accident the C/E had explained to various ER staff why he had rejected some of their risk assessments and so it is clear that these were being completed in some circumstances. The absence of any completed risk assessments for the cleaning of the AE fuel filters went unchallenged by the C/E and 2/E, indicating some gaps in the supervision of safe systems of work within the ER.

The vessel's senior engineering staff also do not appear to have recognised that the 3/Es were not completing the cleaning task in accordance with the PMS. Given that risk assessments, permits to work and lock out/tag out procedures required approval by the senior engineering staff before work started, it is apparent that the failure to implement the required SSOW was compounded by inadequate supervision by senior officers.

The AE1 fuel filters had been recorded as being flushed 29 running hours before the accident and cleaned 597 running hours before. The 2/E did not question the 3/E's intentions when he asked if he could clean the AE1 fuel filters and declined the offer of assistance. Proactive supervision, including being inquisitive, is essential in a potentially dangerous workplace; in this instance, given the 3/E's identified training need was *Efficient Operation of Marine Diesel Engines*, effective oversight might have included a check of the PMS and clarification of what work the 3/E was about to undertake and how he planned to do it.

2.4.5 Supervision from ashore

Risk assessments, permits to work and other procedural documentation can support a SSOW. However, an overreliance on documentation and procedure over individual responsibility and competence can lead to dependence on documentary compliance at the expense of practical risk management.

BSM had more than 500 risk assessments and permits to work on board its ships, covering all aspects of safety at work. However, as demonstrated by the internal audit on 27 January 2020, it was apparent that senior ER officers sometimes did not follow company procedures. The corrective action identified by BSM often included the requirement to provide evidence that actions had been completed, exacerbating many of the issues found. There was no evidence to show that BSM had sought to understand the noncompliance with procedures and the reasons remain unclear. However, the volume of the documentary requirements is likely to have been a contributory factor.

Comprehensive and complete procedural documentation disseminated to vessels from ashore can present a number of significant challenges. For *Moritz Schulte*, these included:

- BSM's ability to manage the maintenance and dissemination of updates that did not conflict with other procedures;
- Procedures that were irrelevant to the way in which the work was carried out
  - on board practices may have evolved, as in this case, from the procedures
  - written procedures may conflict with equipment manufacturers' procedures, causing confusion;
- Unclear methods for those on board to alter or refresh centrally-produced procedures;
- The unwillingness of crews to dedicate time to completing multiple risk assessments and permits, particularly for jobs carried out frequently or easily; and
- A perception of excessive management and control, leading to a loss of individual responsibility and accountability for safety.

2.5 POWER-DISTANCE EFFECT ON WORKPLACE COMMUNICATION

In common with many ships, the range of nationalities on board *Moritz Schulte* meant that although English was the vessel's working language it was not the first language of anyone on board. There was no evidence in this case to suggest that the standard of spoken English led to a direct lack of comprehension. However, it was highly likely that nuanced, candid conversations leading to full common understanding, or recognition of potential barriers to that understanding, would have been difficult to achieve.

Moritz Schulte's C/E found the 3/E reticent to speak and unforthcoming. There was a reluctance to discuss or ask questions about the jobs the 3/E either was or had been working on and he had to be prompted to engage. During the routine toolbox talk on the morning of the accident the 3/E spoke quietly and responded with little detail when the 2/E questioned him about the jobs he had planned; conversely, the 3/E was considered amicable and friendly among the crew. When the 3/E asked if he could clean the fuel filters on AE1 the 2/E would have immediately recognised that removing the filters' splash shield and turning the filter handles, i.e. flushing, was barely a 5-minute job. It did not require a risk assessment or permit to work and could be done with the engine on standby. However, the 3/E's request appeared to raise some suspicion in the 2/E's mind about the 3/E's intentions as he emphasised the need for AE1 to remain on standby. Why the 2/E did not query the 3/E's plans further is unclear. Conflict avoidance can be significant in how some nationalities relate to others, resulting in a reluctance to speak confidently or raise an issue that the recipient might not want to hear. Such deference may also mask a lack of knowledge that, if drawn attention to, could lead to loss of respect from a manager and have a potentially negative impact on job retention and career prospects.

Workplace power-distance relationships occur when there is uneven distribution of power between lower ranks (usually younger, less qualified and less experienced) and higher ranks (usually older, more qualified and more experienced); international benchmarking research[9] suggests that the nationalities of *Moritz Schulte*'s crew had a greater propensity towards this. In relationships where a greater hierarchy exists, managers are expected to direct, and subordinates expect to be told what to do and are expected to know how to do their jobs; this can negatively affect the willingness of subordinates to speak up. In this case, the 3/E was newly promoted to a responsible position on a new ship with new crew. He was expected to know his job function and to decide his work schedule. The 3/E would have expected a large degree of management and supervision; however, those in higher ranks did not appear to account for the influence of power-distance on either his approach to tasks or his understanding of company procedures and the safety hazard this might pose. In the absence of firm direction of his activities, it is likely that the 3/E considered it inappropriate to seek help to improve his ability to safely conduct tasks.

When a company promotes an active accident prevention work environment, such as using a 'stop-work' system, key to its effectiveness is that crew are supported to recognise both the responsibility afforded by such a system and its benefits for all concerned. In this case, further accident prevention barriers were circumvented by the reluctance of both the newly joined 4/E and the wiper to question the 3/E's activities when they saw him removing the filter cover. The organisation should recognise cultural preferences for speaking up within a multinational workforce

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[9] Hofstede, G., Hofstede, G. J. and Minkov, M. (2010) *Cultures and Organizations: Software of the Mind, Third Edition*. New York: McGraw-Hill Professional.

and manage them appropriately. It is also important to recognise that 'stop-work' systems require constant reinforcement and are regarded as a supportive safeguard rather than effective barrier, in part due to the issues identified by this accident.

Communication breakdowns in potentially hazardous environments can be fatal and so it is essential that senior officers fully understand what their junior crew are planning to do and how to manage them effectively, particularly during unsupervised work on potentially high-risk systems.

2.6 SKILLS, KNOWLEDGE AND EXPERIENCE

The 3/E was performing an unnecessary task based on his understanding of an inadequate PMS procedure and had turned away the support that was offered to help him safely complete the work. This indicated that the 3/E was unaware he had chosen an unsafe system of work that posed a significant danger to the vessel, its crew and, ultimately, himself. The 3/E's skill, knowledge and experience of the task and safe engineering practices was therefore a contributory factor in this accident.

2.6.1 Third engineer's engineering skills

Among the many training modules bypassed by the 3/E was the STCW Code Table A-III/1, which assessed the minimum standards of competence for engineers. One such competence was *Maintenance and repair of shipboard machinery and equipment*, for which the evaluation criteria required the 3/E to demonstrate his *Dismantling, inspecting, repairing and reassembling equipment is in accordance with manuals and good practice*. In the absence of a documented critical assessment it appeared that the 3/E's performance appraisals were the only means used to evaluate his on board engineering skills.

The significant variations between the appraisals of the 3/E's performance completed by his senior engineers when he was employed in the rank of 4/E highlighted significant concerns. In late 2015 and early 2016, the appraisals stated that the 3/E's skills, physical and psychological abilities limited his job function; from mid-2016, his appraisals stated that he was a good engineer, complied with company procedures and was ready for promotion. The 3/E's sudden improvement was either missed by personnel managers or not considered during his assessment for promotion to 3/E.

Given what is now known about the 3/E's willingness to bypass the CMS and on board training requirements, and the positive change in his performance appraisal comments within such a short timeframe, it is almost certain that the later appraisals were an inaccurate reflection of the 3/E's skills.

The unrealistically positive comments recorded by his line managers in the 3/E's performance appraisals directly contributed to the 3/E being promoted beyond his skill set, doing a task for which he did not have the skills. This was dangerous given the responsibility he held for the maintenance and operation of industrial machinery. Honest appraisals based on a well-developed competency framework and tactful line management discussions provide shore management with a clear picture of crew skills and capabilities from which to determine suitable candidates for promotion.

2.6.2 Third engineer's ship knowledge

The 3/E's actions and his choice of escape route raise questions about his knowledge of the ship's engine room, machinery and systems, especially given his willingness to bypass the shipboard familiarisation process. Part A of the three-part Familiarisation Checklist was to be completed within 48 hours of joining and the remaining parts within 2 weeks. The 3/E had signed off the full checklist within one day of joining and it had been countersigned by the 2/O, 2/E and C/E on the same day. However, 16 days later, the appraisal comments from the 2/E indicate that he considered the 3/E was still in the process of familiarising himself. The 3/E's familiarity with a *Moritz Schulte* sister vessel would not have ensured his understanding of the differences in machinery, systems or processes between the two ships. It was unclear why the senior officers bypassed company procedures and their collective failure to verify the 3/E's requisite shipboard knowledge indicated a systemic weakness in the company's safeguards designed to prevent such actions.

It cannot be known whether the 3/E's attitude towards engine room familiarisation contributed to his inability to escape. However, his apparent willingness to ignore company rules and procedures, as others on board had done, demonstrated a lack of awareness and understanding of the implications of doing so. The rapid countersigning by senior officers to verify the 3/E had completed his familiarisation indicates they also did not understand the safety value of the process and, instead, viewed it as a compliance activity.

2.6.3 Competency management system

BSM provided a comprehensive CMS to manage crew competency[10] and support and assist the crew development and promotion process. However, a review of the CMS identified several issues, including:

- Misalignment between the system's various manuals meant that it was unclear what training was mandatory prior to promotion.
- Senior officers were able to sign off training modules without confirming evidence of their completion.
- There was no job description for the 4/E position and no documented criteria for promotion from junior engineer to 4/E.
- The appraisal process was ineffective in that seafarers' promotion suitability or additional training needs went unchecked.

The decision to promote the 3/E did not consider his engineering qualification and whether it met the requirements for the responsibilities of the rank. BSM personnel management depended on a complete CMS training record, which relied on crew members accurately updating their own training and development, and two positive appraisals before recommending a seafarer for promotion. The CMS did not help to identify that the 3/E had not completed a JOC or that he had completed only two of the 65 rank-specific training modules, indicating that the system had not fully captured the technical competencies needed for the role. Additionally, the 3/E did

[10] Competency is defined by the Chartered Institute of Professional Development as *the behaviours (and technical attributes where appropriate) that individuals must have, or must acquire, to perform effectively at work*. This can include the demonstrable outputs required of a role, as well as behaviour, attitude and skills needed to do the role.

not have to meet any competence requirements for communication behaviours against which managers could have assessed his performance. The CMS shortfalls enabled the 3/E to bypass the required training and gain promotion twice without demonstrating/providing the requisite evidence of his suitability.

BSM's vessel management portfolio comprised 400 vessels in full management, 200 in crew management, a network of 11 ship management centres, 24 CSCs and 4 maritime training centres in over 30 locations. Its workforce included 18,000 seafarers and 2,000 shore-based employees across the globe. At the time of the accident there was a global shortage of qualified officers, a situation that BSM recognised and predicted to worsen, which would threaten its ability to achieve the required manning on board its vessels. It is unknown whether this influenced the decision to promote the 3/E at his own request. Nevertheless, this fatal accident has demonstrated the risk of promoting candidates without satisfactory evidence of their competence in terms of technical and behavioural skills, knowledge and experience. Performance evaluation relies on open discussion with someone of any nationality about areas of competence, personal development and promotion prospects. Feedback should be imparted in a manner that is both effective for the individual and sensitive to their cultural background so as to maximise the opportunity for management to make effective employment decisions based on reliable evidence. Effective performance communication between crew and managers also reduces the risk of competency issues leading to a safety issue or incident. Similar adjustments might also apply for training methods that require the sharing of honest perceptions and expectations about other people.

2.7 EMERGENCY PREPAREDNESS AND RESPONSE

Firefighting in enclosed spaces in dense, toxic smoke and heat with machinery noise limiting communications, while wearing cumbersome PPE, is difficult and stressful. Trying to find a missing colleague in these circumstances would increase this stress; however, the search and rescue operation for the 3/E demonstrated a lack of planning for such an emergency.

2.7.1 Shipboard drills

Fire and rescue drills were a regular part of shipboard training on board *Moritz Schulte* but were shown to be the subject of unsatisfactory programming and/or inaccurate recording.

The drill reports summarised in **Table 3** show that, on the 28 June 2020, the entire crew appear to have attended two separate drills at the same time, in different locations. Furthermore, the drill reports record a duration of between 6 and 20 minutes for each of the four drills conducted in total that day, without allowing for the overlap of the simultaneous drills. In any event, the length of these drills is too short for adequate training of a full ship's company participating in three different fire scenarios and an enclosed space rescue.

Of the two summarised rescue drills, the first, on 28 June, lasted 20 minutes, during which a wiper was located and recovered on a stretcher via an emergency escape trunking and rope and tackle. The second, on 11 July, lasted 10 minutes, from which it is unclear if a practical recovery was completed. Neither drill was long enough to enable participants to familiarise themselves with the difficulty of locating a casualty in a large area, nor were they completed in reduced visibility.

There was no evidence that the crew had practised rescue from an enclosed space in poor visibility at any time on board *Moritz Schulte*. The crew had neither been effectively trained in their designated emergency roles and related procedures nor given the opportunity to explore how to respond to unexpected events during drill exercises.

Hence, proper planning and preparation for such events is imperative if the missing crew has any chance of being found and recovered alive, and responding effectively to the impact of a fire itself. In addition to drills, tabletop exercises and walking through a drill with the fire team to consider the various permutations that could arise is highly beneficial. However, *Moritz Schulte*'s fire and rescue plan (i.e. try and find the 3/E at his last known location) could have been improved if a recognised search pattern had been followed from the point the fire team entered the engine room. Consequently, the response did not get off to the best of starts.

If emergency drills do not routinely test the understanding of assigned duties or include realistic practise scenarios, it is unlikely that a ship's crew will be able to deal with a real emergency situation.

2.7.2 Muster list roles

The roles of several key crew members involved in this emergency response differed between the *Moritz Schulte* onboard muster list and the QDMS muster list.

Both muster lists assigned control of deck fire operations to the C/O. The C/O's role on the muster list was to take control of deck fire operations. Although he recognised that a member of the engineering department should lead the fire party, he was unclear why he assumed control of the rescue party over the 2/E who was also present. His subsequent decision to direct the bosun to lead the rescue party was likely due to familiarity and the need for clear communication. However, the bosun's deck-focused normal areas of work made him relatively unfamiliar with the ER and his muster list roles would have meant he was unpractised in the task.

The bosun, accompanied by the fitter, led the first and second unsuccessful entry attempts to search for the missing 3/E. The 2/E led the third search attempt, again accompanied by the fitter. While this would have ensured that the team had greater familiarity with the ER, it removed the 2/E from his role of providing operational oversight.

The different muster list roles combined with the mismatched positions assumed at the time of the accident resulted in an ineffective emergency response. Crew members were unfamiliar with their duties and were tasked inappropriately, causing delays, and contributing to the uncoordinated nature of the attempted rescue.

2.7.3 Escape routes and Emergency Escape Breathing Devices

Only the 2/E and ETO made use of an emergency escape route from the ECR. The wiper and the 4/E escaped the ER via their normal exits, holding their breath to do so despite the availability of other escape routes. EEBDs were available in the ER but were not located on their chosen escape paths.

The 3/E did not attempt to use an EEBD to support him in his escape, nor did he appear to have attempted to escape using any of the emergency escape routes. The limited time spent on familiarisation and the lack of realistic drill scenarios or ER emergency escape route practice is likely to have contributed to his decision to choose an unsuccessful means of escape.

Although it was a requirement of both the CMS and vessel familiarisation process, there was no evidence to suggest that the crew had ever practised escaping from the ER using all possible escape routes or EEBDs. It is recognised that people will naturally become fixated on one familiar escape route when in a state of stress and panic, often remaining oblivious to other alternatives. Consequently, regular practice and drills ensure that such options are not ignored in an emergency.

EEBDs are intended to be used to escape a compartment where airflow is compromised, not as a means of rescue. The *Moritz Schulte* fire team were the only individuals to use EEBDs during the fire and attempted rescue of the 3/E, having taken them with the intention of giving one to the 3/E when located. Significantly, the EEBDs were not used by the crew who escaped the engine room.

It is unknown whether the 3/E would have used an EEBD had one been available on his escape route. The nearest EEBDs were on A Platform in the ECR. Two EEBDs were located on the bottom deck of the engine room, although going further down into an engine room would have contradicted the instructions given during fire escape training. Stairwells were the most commonly used entry and exit routes and it is possible that the 3/E may have been able to escape alive had these routes been equipped with EEBDs that the engine room crew were trained to use.

Moritz Schulte was built in 2002 and was not required to comply with IMO MSC/Circular.1081, applicable to vessels built on or after 1 July 2003. Had compliance been required, *an EEBD on each deck or platform level near the escape ladder constituting the second means of escape from the machinery space* would have applied. This would have included placing EEBDs on A Platform, near the stairwells.

SECTION 3 - CONCLUSIONS

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

1. *Moritz Schulte* suffered an engine room fire when an uncontrolled release of pressurised MGO fuel from an AE fuel filter sprayed onto the hot exhaust of an adjacent AE. [2.2]

2. The fuel was released as a result of the 3/E's attempt to open and clean the AE1 fuel filters without first isolating them from the pressurised fuel supply. His decision to remove the AE1 fuel filter elements without first isolating the fuel from the filter assembly demonstrated significant shortfalls in his understanding of machinery systems. [2.3]

3. Gaps in the exhaust heat shields were not identified because a spot rather than area temperature measurement tool, such as a TIC, was used without due consideration of the gaps between the heat shield material. [2.3.1]

4. The critical factor for survival of fire victims affected by HCN and CO is rapid extraction from the toxic atmosphere. It is likely that finding and removing the 3/E from the ER sooner would have increased his chances of survival. Had the vessel been equipped with a TIC, and suitably trained on board fire teams drilled in its use, it is possible the 3/E could have been found earlier. [2.3.3]

5. The 3/E, who had worked for the company for over 5 years, died while attempting an unnecessary job, in an unsafe way, at an inappropriate time, without undertaking a risk assessment and in the absence of any apparent supervision. [2.4.1]

6. The AE fuel filter PMS cleaning routine had not been amended to reflect a condition-based maintenance approach and was not aligned with the manufacturer's instructions. Neither the cleaning frequency nor the procedure had been reviewed in light of the vessel operating solely on MGO. [2.4.2, 2.4.3]

7. There was no evidence of a risk assessment having ever been completed for the cleaning of the fuel filters, indicating some gaps in the supervision of safe systems of work in the ER. [2.4.4]

8. BSM had not sought to understand the reasons why senior shipboard officers were bypassing company procedures after internal audits had identified these failings. [2.4.5]

9. It is likely that, in the absence of active direction or supervision of his work, the 3/E did not clarify his intentions or seek help to conduct the task of cleaning the fuel filters due to a perceived workplace power-distance hierarchical structure. Communication breakdowns in potentially hazardous environments can be fatal and so it is essential that senior officers fully understand what their junior crew are planning to do and how to manage them effectively, particularly during unsupervised work on potentially high-risk systems. [2.5]

10. The significant differences in the 3/E's appraisals that were completed by his senior engineers when he was employed in the rank of 4/E were either missed by personnel managers or not considered during his assessment for promotion to 3/E. Given what is now known, it is almost certain that the later appraisals were an inaccurate reflection of the 3/E's skills. This directly contributed to the 3/E being promoted beyond his skill set. [2.6.1]

11. It cannot be known whether the 3/E's attitude towards engine room familiarisation contributed to his ability to escape. However, his willingness to ignore company rules and procedures demonstrated a lack of awareness and understanding of the implications of doing so. The rapid countersigning by senior officers to verify the 3/E had completed the familiarisation indicates they also did not understand the safety value of the process and, instead, viewed it as a compliance activity. [2.6.2]

12. The company's competency management system was insufficiently effective as the 3/E was able to bypass the BSM training requirement and gain promotion twice without adequate evidence of his suitability. This, along with the bypassing of company procedures on board and the lack of verification of the 3/E's shipboard knowledge, indicates a systemic failure in the company's safeguards [2.6.2, 2.6.3]

13. Fire and rescue drills on board *Moritz Schulte* were the subject of unsatisfactory programming and/or inaccurate recording. [2.7.1]

14. The roles of several key crew members during this emergency response differed from those described in both the vessel's muster list and the quality document management system muster list, causing delays and contributing to the uncoordinated nature of the attempted rescue. [2.7.2]

15. There was no evidence that the crew had practised escape or rescue from an enclosed space in poor visibility at any time on board *Moritz Schulte* or had ever practised escaping from the ER using all the possible escape routes or EEBDs, despite this being a requirement of the CMS and the vessel familiarisation process. [2.7.3]

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

1. Retrospective compliance with IMO MSC/Circular.1081 on the unified interpretations relating to *Regulation 13.4.3 Emergency escape breathing devices* would have required an EEBD to be placed near the stairwells that led from the area in which the 3/E was working. [2.7.3]

SECTION 4 - ACTION TAKEN

4.1 MAIB ACTIONS

The **MAIB** has, in conjunction with a Scandinavian Underwriters Agency surveyor and Burgoynes fire investigators:

- removed the AE1 fuel filters and associated pipework
- examined and undertaken pressure and leakage tests on the AE1 fuel filters and associated pipework arrangement
- examined the 3/E's overalls for fuel contamination
- issued an interim report in August 2021.

4.2 ACTIONS TAKEN BY OTHER ORGANISATIONS

Bernhard Schulte Shipmanagement (UK) Limited has supplied and fitted additional EEBDs to the four vessels built before July 2003 – *Moritz Schulte*, *Clamor Schulte*, *Johann Schulte* and *Wilhelm Schulte*. It has also completed the following actions to:

- Conduct meetings with all UK Ship Management Centre office employees, emphasising the importance of a robust safety culture;
- Conduct additional training on SMS compliance, risk assessment, lock-out/tag-out procedures, PMS, drills and firefighting for all *Moritz Schulte* officers and crew;
- Review its UK fleet muster lists for consistency and alignment with QDMS, and across the fleet, to aim for standardisation;
- Undertake a fleetwide review of the effectiveness of firefighting communications equipment and torches;
- Provide *Moritz Schulte* with a TIC to undertake hot spot measurements, and conduct a feasibility study with owners to supply them to all vessels; and
- Provide fuel filter cleaning information and instructions on the filter splash shields and access plates to enable filter flushing without removal of the cover.

The **Bernhard Schulte Shipmanagement** group has also undertaken corrective actions across all its Ship Management Centres under the headings of communication, crew and competence management, safety management and technical management, including to:

- Debrief groupwide fleet personnel on follow-up of appraisals, MMS and associated procedures.
- Ensure each superintendent completes the IMO Model course 1.30[11] for onboard assessment, including interpersonal skill training.
- Review and overhaul the CMS and associated procedures, to provide clarity of requirements, consistency and adequacy of the system, including records maintenance and evidence of activities.
- Review and revise the crewing and training manuals to identify procedural gaps relevant to the CMS, promotion of seafarers and missing job descriptions, and to the fleet personnel manual regarding the CMS activity log and feedback.
- Review the risk assessment for fuel oil filter cleaning.
- Amend the annual drill planner to include search and rescue in a smoke-filled environment.
- Address fuel filter cleaning through a behaviour-based safety focus.
- Develop a comprehensive engineering assessment to evaluate and promote robust engineering practices, identify training needs and provide proper supervision for junior members of the engineering team.
- Amend the frequency and sequence of the fuel filter PMS procedures to accurately reflect the order in which they are completed, and the relevant lock-out/tag-out procedures.

[11] This course is primarily intended for any person conducting in-service assessment of competence of a seafarer on board. These would usually comprise senior shipboard officers (management level) but may also be suitable for shipboard personnel at operational level or experienced shore-based instructors with sufficient onboard expertise.

SECTION 5 - RECOMMENDATIONS

In view of the actions already taken, no recommendations have been made.

Annex A

Manufacturer's instructions for disassembly, cleaning and assembly of fuel oil split filter

Safety precautions:

- ■ Stopped engine
- ■ Shut-off starting air
- ☐ Shut-off cooling water
- ■ Shut-off fuel oil
- ☐ Shut-off cooling oil
- ☐ Stopped lub. oil circul.

Description:

Disassembly, cleaning and assembly of fuel oil split filter.

Starting position:

Related procedure:

Manpower:

Working time : 1/2 hour
Capacity : 1 man

Data:

Data for pressure and tolerance (Page 500.35)
Data for torque moment (Page 500.40)
Declaration of weight (Page 500.45)

Special tools:

Plate no	Item no	Note

Hand tools:

Ring and open end spanner, 13 mm.
Ring and open end spanner, 17 mm.
Kerosene, gas oil or similar.

Replacement and wearing parts:

Plate no	Item no	Qty. /

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1) During normal operation both filters should be in operation, single operation only to be used when dismantling one of the filters for manual cleaning or inspection.

2) Normally the filters are cleaned during operation by turning the handle, (1) see fig 1, on the filter housing top a couple of turns. (clockwise).

Simultaneously with turning of the handle, the drain cock, (2) in bottom of the filter housing should be opened in order to drain of the dirt being scraped of the filter element, (3).

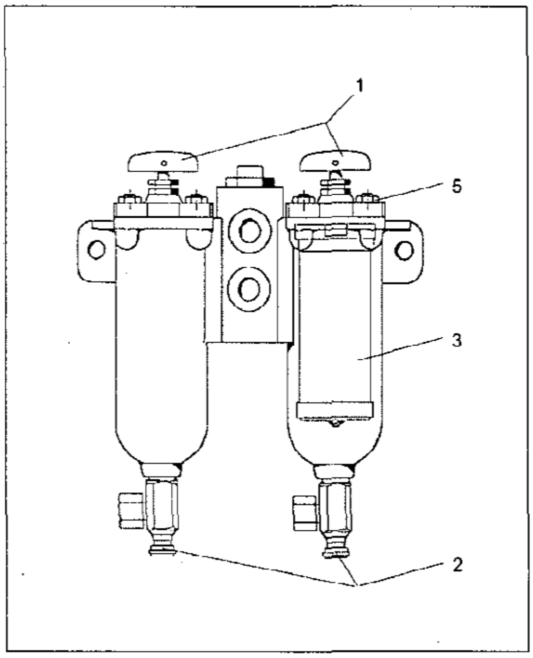

Fig 1 Fuel oil split filter

3) Position of three way cock, see fig 2.

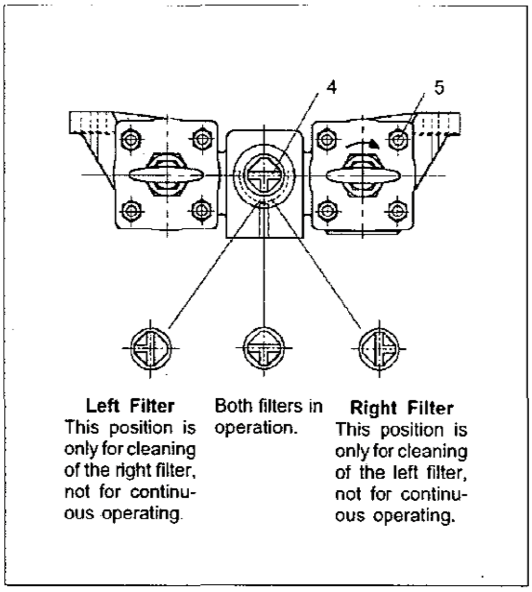

Fig 2. Fuel oil split filter (top view).

Note: Shut-off fuel oil, before dismantling filter element.

4) If no drainage occurs when the drain cock is opened, the filter housing should be dismantled for manual cleaning. Remove the nuts (5), and take out the filter element (3).

5) Clean the filter element in kerosene gas oil or similar and blow it dry with working air.

6) Mount the filter element again.

7) The filter element itself should never be dismantled, but has to be replaced if damage or mal function is experienced.

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Bernhard Schulte Shipmanagement Safety Management Manual: *Permit to Work – working on pressure systems*

Permit to work – working on pressure systems

Note: This is for all work on pressure systems, pressurised pipelines and containment systems.

1) Prepare a work plan and risk assessment considering:
   a) Scope of work
   b) Depressurising of the system
   c) Draining, cleaning and purging
   d) System isolation
   e) Blanking / de-blanking
   f) Pressurising the system after verfiying its integrity
   g) Emergency procedures
   h) Hazards resulting from the nature of the substance within the system
   i) Competency of staff involved
   j) PPE and other safety equipment
2) Apply tag-in / tag-out procedures
3) Responsible officer approves the Permit for Working on Pressure Vessels
4) Hold tool box meeting with all persons involved in the job
5) Team leader signs to confirm understanding
6) Master issues the Permit for Working on Pressure Vessels
7) Post a copy of the Permit for Working on Pressure Vessels at the work place
8) Carry out the job

9) After completion of job:

   a) Remove Permit for Working on Pressure Vessels from work place

   b) Return site to safe and operational condition

   c) Master or nominated person closes Permit for Working on Pressure Vessels

   d) File the documentation

■■ Completed ■■

Marine Accident Report