Australian Government
Australian Transport Safety Bureau

Engine room fire on board *MPV Everest*

Southern Ocean on 5 April 2021

ATSB Transport Safety Report
Marine Occurrence Investigation (Systemic)
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Addendum

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Executive summary

What happened

On 5 April 2021, a fire broke out in the port engine room of the Bahamas-registered, 145 m multi-purpose vessel *MPV Everest* while en route from Mawson Station, Antarctica to Hobart, Tasmania with 37 crew and 72 Australian Antarctic Division staff on board. The ship's crew responded, and the fire was contained and eventually extinguished using the engine room water mist fixed fire-extinguishing system about 2.5 hours later. The port engine room sustained substantial damage with most of the power generation equipment and machinery located within rendered inoperable. There were no reported injuries or pollution of the sea as a result of the fire. Power and propulsion were subsequently restored using the starboard engine room's machinery and the ship diverted to Fremantle, Western Australia, where it arrived without further incident about a week later.

What the ATSB found

The ATSB investigation found that during a routine fuel transfer operation, *MPV Everest*'s port fuel oil settling tank overflowed into the port engine room exhaust ventilation casing and the port engine room below. The investigation identified that the chief engineer, who was conducting the manual fuel transfer, was experiencing a level of fatigue known to have an adverse effect on performance and probably experienced a lapse in attention which resulted in the manual fuel transfer not being monitored and in the tank overflowing, undetected. The investigation concluded that the fire was a result of the ignition of the overflowing fuel either contacting a hot surface within the casing or igniting due to electrostatic discharge, with the latter being more likely.

The ATSB found that inappropriate engineering watchkeeping practices and characteristics of the ship's integrated automation system, among other factors, reduced the effectiveness of tank alarm(s) leading up to the overflow and that an error in the pump layout of the ship's engine room water mist fixed fire extinguishing system increased the risk of an ineffective response to a fire in the engine room. Furthermore, a lack of engine room fire drills meant that opportunities to evaluate and ensure the ship's readiness to respond to engine room fires and to identify and remedy areas in need of improvement were lost.

The ATSB also identified that the positioning of the fuel oil settling tank air vent pipe terminations within the engine room ventilation casing was not compliant with international regulations and classification society rules. Bureau Veritas (the classification society responsible) design approval processes had not identified any potential risks associated with the positioning of the air vent pipe termination and consequently approved the design.

The investigation also found that the ship's managers, Fox Offshore, had not ensured that *MPV Everest* was adequately prepared for the challenges of operations in the Southern Ocean and Antarctica, nor was the ship's safety management system (SMS) sufficiently mature for these operations or effectively implemented. In addition, Australian Antarctic Division (AAD) pre-charter due diligence arrangements were found to be ineffective at accurately assessing the preparedness of the ship, its crew and SMS for operations in Antarctica. In identifying these factors and considering the events leading up to this accident, the ATSB also acknowledges that the COVID-19 pandemic at the time posed significant and unprecedented challenges to the maritime industry in general and to seafarers in particular.

What has been done as a result

In response to the fire, *MPV Everest*'s settling tank air pipes and other pipes within the engine room exhaust ventilation casings were modified and extended to terminate on an open deck above the casings in compliance with the rules. The ship's electrical enclosures were inspected with deficiencies rectified by the manufacturer and modifications were also made to the water mist system piping to rectify the incorrect pump layout.

Maritime Construction Services (MCS — the parent company of the ship's owners New Orient Marine), commissioned an independent, third-party investigation into the fire. Subsequently, Fox Offshore was relieved of its responsibilities as the ship's managers and MCS took over its management as an interim measure. In February 2023, MCS appointed Northern Marine Ship Management (Northern Marine) as *MPV Everest*'s new managers with a view to improving the safety culture on board.

In addition, MCS advised that in preparing for similar future projects, greater emphasis was to be placed on enhancing the effectiveness of gap analyses and increasing reliance on the use of third-party expertise to ensure ship readiness. Improved crew selection and redundancy processes were also adopted based on the principle that the risk exposure resulting from a crew that was entirely new to the ship was not acceptable.

The ship's new managers, Northern Marine, implemented a new SMS on board, which required that fire drills be planned and conducted in the various spaces onboard on a ship in as realistic a manner as possible and that instruction in the use of safety processes and equipment was included in drills where possible. The SMS also required that drill reports be submitted into an internal system, which allowed shore management to oversee shipboard compliance with the drill requirements. Additionally, *MPV Everest*'s SOLAS fire training manual and fire control plan were amended to accurately reflect all relevant aspects of the water mist fixed fire-extinguishing system's coverage, activation and operation.

Bureau Veritas (BV) presented a case study on the fire to managers of local plan approval offices (LPO) to educate and raise awareness of the accident and its associated contributing factors. According to BV, this resulted in proposed ship designs being assessed more closely and BV is working to implement a formal process to disseminate design review-related safety alerts to LPOs.

The Department of Climate Change, Energy, the Environment and Water and the AAD initiated improved processes to augment pre-charter due diligence arrangements and to manage the use of chartered ships. These included:

- expert physical pre-charter inspections of ships through the engagement of independent maritime subject matter expertise
- reviews of the proposed chartered ship's SMS, historic safety performance and resumes of key vessel personnel
- the engagement of independent maritime subject matter expertise to support the pre-charter/brokering and pre-mobilisation stage
- the development of bridging documents describing the functional links between the chartered ship's SMS and the AAD's SMS with the requirement that this document be appropriately customised and agreed to by the parties addressed in the charter party agreement
- the completion of season and voyage-specific risk assessments and the development of a standard operating procedure for the implementation of the charter party agreement and the mobilisation of chartered ships into service
- general improvements to voyage orders provided by AAD management to the chartered vessel's master and the AAD voyage leader
- the introduction of a biannual risk review into the Department's audit and assurance process where AAD management review risks with the potential to result in fatalities and assess the efficacy of the associated controls
- a restructure of the AAD shipping section to incorporate new roles including a senior person in the role of shipping manager and the introduction of compliance and technical support roles.

Additionally, the AAD introduced a requirement for the reporting of monthly key performance indicators (including incident reports and status of the planned maintenance system) from each chartered ship's operator. The AAD also instructed Serco, the manager and operator of the new

Australian Government-owned Antarctic icebreaker *Nuyina* (which arrived in Australia in October 2021) to review the findings of the ATSB investigation, and the fire investigation commissioned by *MPV Everest*'s owners to ensure that an incident arising from similar circumstances to those on board *MPV Everest* could not occur. In the event that similar hazards or risks were identified, Serco was asked to present a plan on how those matters were to be addressed.

Safety message

Ships operating in the harsh and remote Arctic and Antarctic environments are exposed to several unique hazards. Factors such as the weather, cold temperatures and ice pose significant challenges for mariners and can impact the effectiveness of engineering and deck machinery, emergency equipment, the hull, propulsion system and communication systems.

Additionally, the remoteness of these areas makes any potential rescue and shore response extremely challenging. Therefore, these risks and challenges are most effectively mitigated by ensuring that ships that venture into these waters are operated at the highest levels of preparedness in terms of crewing numbers, expertise, equipment availability and readiness, and emergency response.

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The occurrence

Overview

On 5 April 2021, a fire broke out in the port engine room of the Bahamas-registered, 145 m multi-purpose vessel *MPV Everest* while en route from Mawson Station, Antarctica to Hobart, Tasmania with 37 crew and 72 Australian Antarctic Division staff on board. The ship's crew mounted a response, and the fire was contained and eventually extinguished about 2.5 hours later using the engine room's water mist fixed fire-extinguishing system. The port engine room sustained substantial damage with most of the power generation equipment and machinery located within rendered inoperable. Power and propulsion were subsequently restored using the starboard engine room's machinery and the ship diverted to Fremantle, Western Australia (WA), where it arrived without further incident about a week later.

Departure from Antarctica

On the evening of 31 March 2021, the Bahamas-flagged multi-purpose vessel *MPV Everest* (Figure 1) departed from a location approximately 100 nautical miles (miles)[1] off Mawson research station in the Australian Antarctic Territory, bound for Hobart, Tasmania. There were 37 crew and 72 Australian Antarctic Division (AAD) staff[2] on board for the 3,328 mile passage to Hobart. The ship had been on location for the previous 17 days to effect a changeover of AAD expeditioners and conduct station resupply and refuelling operations by helicopter.

Figure 1: *MPV Everest* in Antarctica

Source: © Lauren Wise/Australian Antarctic Division

On the evening of 3 April, the ship exited polar waters, crossing the 60° S parallel of latitude northbound and continued its passage across the Southern Ocean with about 2,549 miles to go to Hobart.

1 A nautical mile is 1,852 m.

2 AAD staff included expeditioners bound to or from AAD research stations in Antarctica, voyage management staff and logistics personnel, Australian Bureau of Meteorology forecasters and Helicopter Resources personnel.

Activity leading up to the fire

At about 0350 ship's time[3] on 5 April 2021, the duty engineer (second engineer)[4] received a fuel filter high differential pressure alarm for main diesel generator (DG) number 4 in the starboard engine room. At the time, power for propulsion and other services was being provided by main diesel generator number 3 (DG3) in the port engine room and main diesel generator engine number 4 (DG4) in the starboard engine room.[5] The weather at the time was recorded in the bridge logbook as south-south-easterly winds at 18 knots with 2 m seas on a 6 m west-north-westerly swell. The ship was rolling moderately to heavily, as it had been for most of the night and over the preceding days.

In response to the pressure differential alarm, the second engineer stopped DG4, replaced its fuel filters, and restarted it. However, almost immediately, the engineer began receiving alarms including high jacket water temperature alarms, an oil mist pre-warning alarm and an oil mist high concentration alarm, following which the generator shut down. The second engineer started additional generators to maintain electrical power and propulsion before attempting to reset the alarms on DG4.

Shortly before 0600, the chief engineer came to the engine control room (ECR) to relieve the second engineer. The second engineer briefed the chief engineer and advised that while all the earlier alarms had been reset, further investigation was required to establish why DG4 shut down. The chief engineer suspected that there might have been damage to the generator's crankshaft. After the second engineer left, the chief engineer performed a crankcase inspection which confirmed crankshaft damage in DG4 which rendered it inoperable.[6] The chief engineer decided that a priority task that morning would be to transfer the fuel booster pump from DG4 to DG5, thereby restoring at least one main generator in the starboard engine room to service. The chief engineer also recalled the second engineer to the ECR to draft an incident report for the damage to DG4.

By 0800, *MPV Everest* was about 1,075 miles north-east of Mawson station on a north-north-easterly course and making good a speed of 11 knots (Figure 2). The weather at the time was recorded as south-south-easterly winds at 20 knots with 2 m seas on a 6 m west-north-westerly swell. Power for propulsion and services was being provided by DG2 and DG3 in the port engine room and DG6 in the starboard engine room. At the time, the engine room team on duty comprised the chief engineer, a third engineer and an engine rating. In addition, the chief electrician and an electro-technical rating were also intermittently in the ECR, depending on their planned tasks.

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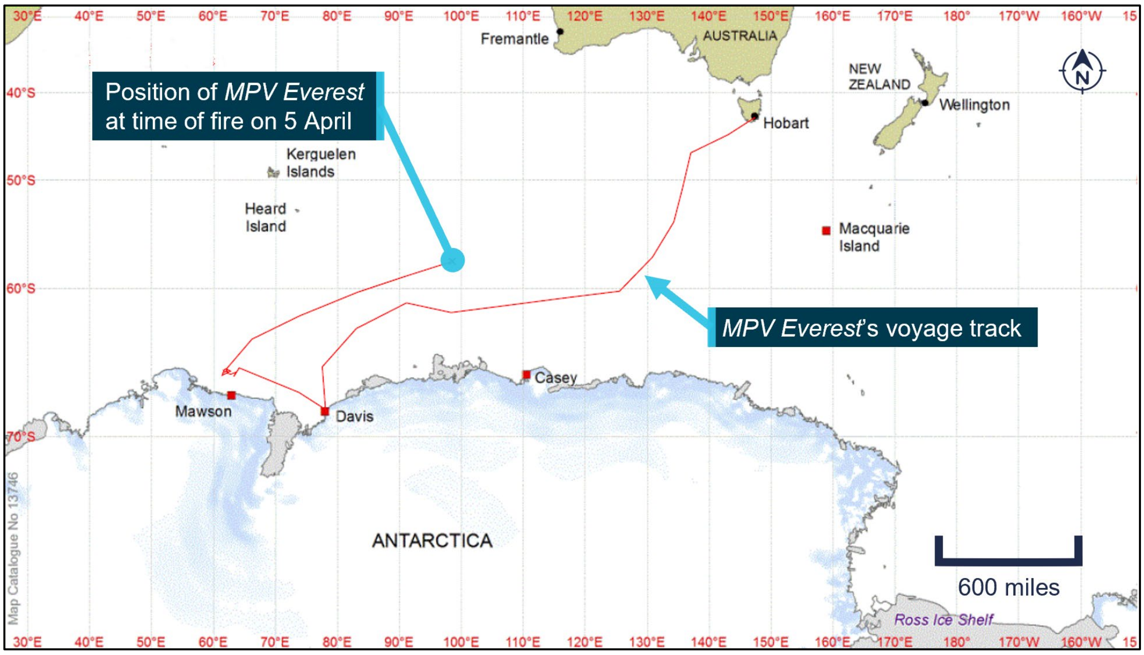
3 All times referred to in this report are ship's time on the day of the fire, which was Coordinated Universal Time (UTC) + 7 hours.

4 *MPV Everest*'s engine room was manned continuously. At the time of the fire, the second engineer kept the 1800-0600 watch while the chief engineer kept the 0600-1800 watch.

5 The ship's electrical power generating plant comprised 4 main 5,530 kW marine diesel generators and 2 secondary 1,825 kW generators distributed in 2 separate engine rooms. One secondary generator (DG1) and 2 main generators (DG2 and DG3) were in the port engine room, and the other main generators (DG4 and DG5) and secondary generator (DG6) were in the starboard engine room. The fuel used on board was marine gas oil, specifically Special Antarctic Blend diesel.

6 At the time, main diesel generator number 5 (DG5 - the other main generator in the starboard engine room) was also inoperative as it required a fuel booster pump, for which no spares were available.

Figure 2: Overview of *MPV Everest*'s area of operation and position at the time of the fire



Source: Australian Antarctic Division, modified and annotated by the ATSB

At about 0926, the chief engineer used the ECR's integrated automation system (IAS) screens to initiate a manual transfer of fuel oil from the number 4 port fuel oil storage tank to the port engine room's fuel oil settling tank (port settling tank). By this time, the second engineer had finished drafting the incident report relating to the damaged generator and left the ECR.

With the fuel transfer underway, the chief engineer and third engineer left the ECR for the starboard engine room to carry out the planned repairs to DG5 while the engine room rating left to carry out routine soundings of tanks. The chief electrician remained in the ECR seated in front of the IAS screens conducting further investigation into the morning's shutdown of DG4 and, sometime later that morning, left to carry out a task on the bridge.

The fire

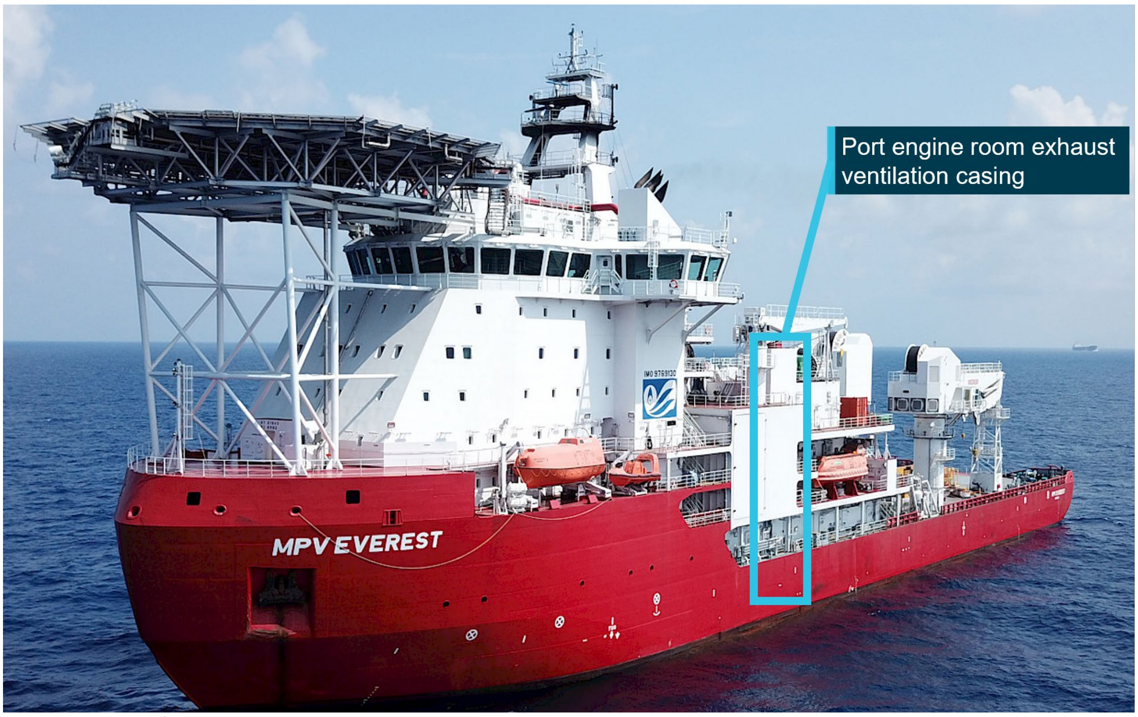
Recorded data from the ship's IAS showed that, at about 1002, the port fuel oil settling tank's high-level signal activated, indicating that fuel levels in the tank had reached 85% of the tank's maximum capacity. At about 1018, the port fuel oil drain tank (port drain tank) level began increasing indicating that fuel in the port settling tank had reached 90% of the tank's capacity and was now overflowing into the port drain tank. At about 1031, the port drain tank's high-level alarm activated indicating that fuel in the tank had reached 50% of the tank's maximum capacity. The recorded data showed that by about 1043, the port drain tank probably reached maximum capacity.

Meanwhile, the ship's master and doctor were in the master's office, located one deck below the navigation bridge (bridge), which overlooked the main and upper accommodation decks aft. At about 1058, they saw large flames erupting from the open louvres in the port engine room's exhaust ventilation casing located one deck above the upper accommodation deck, aft of the accommodation superstructure (Figure 3). At about the same time, AAD staff conducting seabird observations on the bridge also sighted flames aft of the bridge.

A few seconds later, smoke and flame detectors on B-deck in the ship's port engine room activated, followed shortly after by the automatic activation of the B-deck section of the engine room's water mist fixed fire-extinguishing system.

By this time, the master had arrived on the bridge and raised the alarm by making an announcement on the ship's public address (PA) system. The announcement notified all personnel that there was a fire on the ship's port side and instructed all personnel to proceed to their designated muster stations. Shortly after, the general emergency alarm was sounded.[7]

Figure 3: *MPV Everest* – Port engine room exhaust ventilation casing



Note the location of the port engine room exhaust ventilation casing above deck.
Source: Maritime Construction Services, annotated by the ATSB

Outside the exhaust casing, the flames quickly engulfed 2 rubber watercraft and other equipment stowed inboard of the casing and set them alight (Figure 4). Meanwhile, the chief engineer, who was working on DG4 and DG5 (in the starboard engine room) heard the fire detector alarm and other alarms and went to the ECR. There, the chief engineer observed that the IAS indicated active fire detectors in the port engine room. Soon after, the chief engineer, accompanied by the third engineer, went to investigate and, on opening the watertight door to the port engine room, they saw thick smoke and burning material. The chief engineer also noted that the water mist fixed fire-extinguishing system was active. They retreated, shut the watertight door, and returned to the ECR.

[7] The general emergency alarm signal is at least 7 short blasts followed by one long blast on the ship's whistle and repeated on the ship's alarm bell system.

Figure 4: Flames from the port engine room exhaust ventilation casing

Source: Jason Mawbey

At about 1100, the master called the chief engineer on the ship's ultra-high frequency (UHF) radio and advised that they were starting the fire pumps. Shortly after, a UHF radio broadcast from one of the crew advised that the fire was in the ship's emergency generator room (located one deck below and just aft of the port engine room exhaust ventilation casing). The master immediately ordered the ventilation to the emergency generator room be shut and for power to the space to be isolated.

Emergency response

As the AAD personnel began mustering at their stations on the forecastle deck, the engineers started the fire pump(s) while the ship's crew began preparing fire-fighting equipment and worked to extinguish the burning watercraft, boundary cool the exhaust ventilation casing and douse the flames from it with fire hoses. By this time, the second engineer, off-duty third engineer, electro-technical officer (ETO) and engine ratings had made their way to the ECR. On hearing the master's orders to isolate the emergency generator room, the chief engineer instructed the ETO to go to the emergency generator room and shut its fuel quick closing valve (QCV).

Meanwhile the duty third engineer returned to the port engine room and used a portable fire extinguisher on the flames closest to the watertight door with little success. The third engineer then returned to the ECR to get another fire extinguisher, but the chief engineer ordered that there was to be no further entry into the port engine room. The chief engineer called the master on the UHF radio and advised that the fire was in the port engine room. The chief engineer then activated the emergency stops on DG2 and DG3 in the port engine room, isolated all power to the space (port engine room and adjoining spaces including the port medium voltage switchboard room), stopped the engine room supply fans and closed their dampers, and instructed the second engineer to shut the fuel QCVs for the port engine room. Almost immediately after, all UHF transmission on board became disabled and the ability to communicate by UHF radio was lost. The ship's portable survival craft radios were then distributed, and communications between the various emergency response parties were gradually re-established using these very high frequency (VHF) radios.

At about 1106, DG6 in the starboard engine room shut down due to being overloaded. Despite the ship having an emergency generator that was intended to automatically provide electrical power following the loss of primary power generation (see the section titled *Emergency generator*), all power on board, including propulsion, was lost. Almost immediately, the fire pumps stopped, and water supply for the port engine room water mist system switched to water cylinders pressurised by the back-up nitrogen accumulator unit.

In response, the chief engineer went to the emergency generator room and restored the fuel supply to the generator while the chief electrician started it and connected its electrical output to the emergency switchboard. By about 1114, limited electrical power for services was restored using the emergency generator. While recorded data show the water mist system pumps starting automatically, the chief engineer also reported manually activating the water mist system's local release function for the zones covering the engines in the port engine room. At about this time, the chief engineer was also informed that there was very low water pressure in the fire main which they assessed was probably due to an airlock. The chief engineer went to the emergency fire pump and bled the air out, thereby restoring water pressure in the fire main and fire hoses.

Meanwhile, the master used a portable VHF radio to inform the deck fire team (led by the chief mate) that the fire was in the port engine room and asked them to shut the ventilation to the space. The master also made a PA announcement advising all personnel of the location of the fire. Over the course of the next few hours, the master continued making regular PA announcements to provide updates on the situation, on the status of the fire and progress of firefighting activity.

At about 1116, *MPV Everest*'s master broadcast a distress alert[8] using high frequency digital selective calling. At about the same time, the AAD was notified using the ship's satellite telephone. The AAD in turn notified the Australian Maritime Safety Authority's (AMSA) Joint Rescue Coordination Centre (JRCC) of the fire.

At about 1115, the ship's first mate reported that all AAD personnel had been accounted for at the foc'sle muster stations. The master acknowledged the report and requested that the ship's doctor, 2 AAD doctors and ship's crew with designated medical duties be sent to the bridge. Shortly after, the master again asked for an updated headcount as this was needed if they were '…going to use CO_2'. At about 1121, the master tried without success to contact the chief engineer on the VHF radio and on the ship's emergency telephone. The master then made 2 further PA announcements asking the chief engineer to account for all personnel in the engine room as a headcount was necessary 'to release the CO_2' (see the section titled *Emergency response*).

At about 1123, the chief engineer made contact with the bridge using the emergency telephone and informed the master that there were 4 personnel in the ECR. Following this, the master continued to try to establish contact with the various emergency parties to get a full headcount. At 1133, the master made a PA announcement confirming that all personnel had been accounted for. By this time, boundary cooling had commenced on the main deck and upper accommodation deck with fire hoses manned by the ship's crew, the AAD voyage leader and 2 AAD doctors who had been called to the bridge. The AAD doctors gradually became drenched by water spray from a damaged hose and nozzle and were stood down to change into dry clothing.

At about 1134, JRCC contacted *MPV Everest* by satellite phone. The master provided a situation report (SITREP) to AMSA, including the number of personnel on board and that firefighting efforts were ongoing. The master, assisted by the AAD voyage leader, continued to provide regular situation reports to JRCC over the course of the following hours and days (see the section titled *Shore response*).

Meanwhile, the chief mate instructed the bosun and an able seaman (who were the designated firefighters on the muster list) to don fireman outfits and self-contained breathing apparatus (SCBA), approach the port engine room's ventilation louvres and close them. The bosun and able seaman refused, reportedly due to concern for their personal safety, so the duty second mate and off-duty third engineer volunteered. They donned fireman outfits and SCBA sets and, with the

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8 A distress alert or distress call indicates that a vessel or person is threatened by grave and imminent danger and requires immediate assistance.

protection of a water fog blanket from fire hoses, approached the ventilation casing and partially shut 3 ventilation louvres. A fourth louvre on the aft side of the ventilation casing was not shut.

At about the same time, the chief engineer, who was concerned that water was not making it through to the water mist system's nozzles in the port engine room, asked the second engineer to check the system's pumps. The second engineer went to the water treatment room where the water mist system's pumps were located and found that while the pumps were running, the solenoid valves leading to the relevant zones in the port engine room remained shut. The second engineer manually opened the valves to the water mist nozzles for the port engine room and confirmed from the pressure gauges on the lines that water was now flowing through. On the bridge, the master made a PA announcement advising all crew that the fire was being fought with 'a water sprinkler system' and that boundary cooling was underway (Figure 5).

Figure 5: Boundary cooling and firefighting operations on deck

Source: Fox Offshore

At about 1145, the emergency generator unexpectedly shut down, and the ship lost all electrical power for a second time. While the engineers worked to restore power, the duty second mate alerted the chief mate that one ventilation louvre remained open. At about 1151, the chief mate advised the master that the duty and off-duty second mates were preparing to close the aft ventilation louvre on the ventilation casing. Meanwhile, at the AAD voyage leader's suggestion, 2 AAD personnel with firefighting knowledge and experience (including an AAD watercraft operator with professional firefighting experience ashore) were called to the bridge to assist with firefighting.

By about 1200, DG6 in the starboard engine room was started, and its electrical output connected to the emergency switchboard. Once again, recorded data showed the water mist system pumps starting automatically but the second engineer also reported manually activating the system for the zones covering the engines in the port engine room. By this time, the 2 second mates had used a hammer to attempt shutting the 3 inboard ventilation louvres further and also shut the aft ventilation louvre.

At about 1207, the chief engineer called the master and confirmed that the water mist system was operating. By this time, the engineers had also started monitoring the temperature of the port engine room at the watertight door and other access points using an infrared thermometer. Shortly after, the chief engineer advised the master that external monitoring showed that temperatures in the port engine room appeared to be decreasing.

At about 1227, the AAD watercraft operator volunteered to check the ventilation casing louvres were shut. The AAD volunteer firefighter donned a fireman outfit and SCBA set and found that the louvres remained partly open but could not be shut further as the louvres and their closing mechanism were distorted due to heat from the fire (Figure 6). The AAD firefighter also suggested using an AAD thermal camera to monitor the engine room externally and check for hot spots. The master agreed and notified the second engineer that the water mist system and boundary cooling was to be maintained for a further 20 minutes until the reducing temperatures stabilised.

Figure 6: AAD volunteer firefighter checking ventilation louvres

Source: Fox Offshore

At about 1250, the water mist system was stopped and, shortly after, the chief engineer reported a temperature of about 40° C, measured at the port engine room bulkhead. At about 1312, the master made a PA announcement advising all mustered personnel to stand down and have lunch but to remain alert, clothed for cold weather and ready to muster if required.

At about 1400, the chief engineer, electro-technical officer, and the volunteer AAD firefighter entered the engine room with fireman outfits, SCBA sets, a charged fire hose and a portable fire extinguisher. At about 1434, the chief engineer called the master and reported that the fire was extinguished and that they all had safely exited the engine room.

At about 1436, the master made a PA announcement advising all personnel that the fire was extinguished and ordering them to stand down. There were no reported injuries to anyone on board as a result of the fire. The ship's crew began cleaning up and returning firefighting equipment and appliances to readiness. The crew also reported finding fuel in the port main deck save-all where the port drain tank air pipe vent was located (although there were no reports of overflowing fuel prior to the fire). As part of the clean-up after the fire, this fuel was transferred back to fuel storage tanks through the bunker manifold using a portable, compressed air-driven pump.

At about 1440, *MPV Everest*'s master advised JRCC that the fire had been extinguished and that efforts were underway to restore propulsion.

By about 1820 that evening, passage was resumed with power for propulsion and services being provided by DG5 and DG6, located in the starboard engine room (the port engine room and machinery within were unusable due to the fire damage). On the next day, 6 April, the master diverted *MPV Everest* to Fremantle, WA (1,545 miles away), rather than continue to the more distant Hobart (1,950 miles away).

The weather forecast for *MPV Everest*'s projected route over the following days predicted storm force winds, very rough seas (with forecast waves of over 16 m significant wave height), and heavy swells. The ship stopped or slowed down several times over the following days to effect repairs to keep DG5 and DG6 in service and thereby maintain power for services and propulsion. As *MPV Everest* sailed for Fremantle with its master trying to avoid the forecast heavy weather with the limited propulsion capability available, JRCC maintained regular contact with the ship. JRCC monitored the ship's progress, including its stoppages for repairs, provided weather forecast information when required and issued regular SITREPs to the ATSB, AAD and other interested parties.

By 1600 on 9 April, *MPV Everest* was about 926 miles from Fremantle making good a speed of about 10 knots. On the afternoon of 12 April, *GO Spica*, an offshore support vessel contracted by *MPV Everest*'s owners as a precautionary measure to escort the ship to Fremantle, rendezvoused with it.

On the afternoon of 13 April, *MPV Everest* was safely alongside at berth 11 in Fremantle's inner harbour.

Damage assessments

The fire resulted in 2 AAD watercraft being destroyed on deck along with some other associated equipment in the vicinity (Figure 7).

Figure 7: Fire damage on deck including the burnt-out watercraft adjacent to the casing

Source: Fox Offshore

The fire also resulted in substantial damage to the port engine room including to machinery, fixtures, wiring, and electrical enclosures (Figure 8).

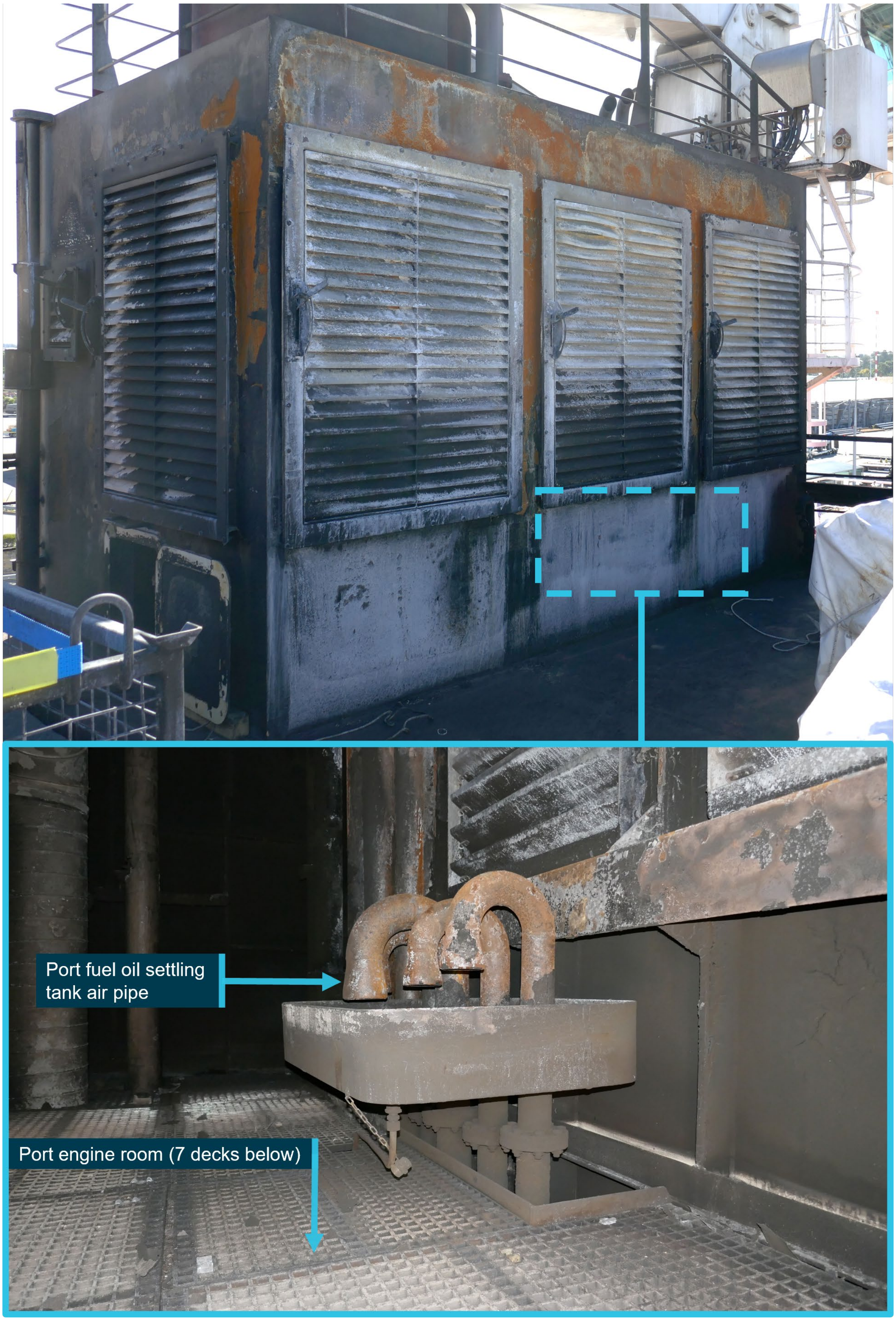
Figure 8: Fire damage inside the port engine room

Source: ATSB

Shipboard investigation

After the fire was extinguished, the fire-damaged port engine room was ventilated, and inspected by the chief engineer and second engineer, among others. During these early inspections, the engineers observed fuel oil pooled in the port engine room as well as fuel dripping down into the engine room from within the exhaust ventilation casing above. On further investigation, the chief engineer identified several pipes passing through the exhaust ventilation casing, with some terminating externally on top of the casing while others terminated internally within the casing (Figure 9). One of the pipes that terminated inside the casing was identified as an air pipe for the port fuel oil settling tank that was being filled prior to the fire.

Figure 9: Port engine room exhaust ventilation casing (inset photo: close-up of internal vent pipes)



Source: ATSB

The inspections also found quantities of liquid fuel pooled in the save-all around the port settling tank's goose neck vent pipe termination (Figure 10). The chief engineer's investigation concluded that the port settling tank that was being filled had overflowed from the tank's goose neck air pipe termination in the upper level of the port engine room exhaust ventilation casing and that the fire had resulted from the ignition of this overflowing fuel.

Figure 10: Fuel in port settling tank air pipe save-all

Photo taken by shipboard staff following the fire showing liquid fuel in the port settling tank air pipe save-all.
Source: Fox Offshore

Activity in Fremantle

Following the ship's arrival in Fremantle and disembarkation of all AAD staff, *MPV Everest* was attended by ATSB investigators, AMSA surveyors and representatives of several other interested parties, including the ship's classification society and its flag State. *MPV Everest* was detained by AMSA pending work to repair some of the fire damage sustained by the ship and to restore the ship's engine room fixed fire-extinguishing capability. The port engine room could not be repaired in Fremantle, nor could DG4 (in the starboard engine room) be restored to operational use. The ship was subsequently required to develop a passage plan and risk assessment for a single voyage to a repair yard in Singapore with an escort tug as a contingency.

On 2 May, AMSA released *MPV Everest* from detention. Early on 3 May, the ship departed Fremantle for Singapore accompanied by an escort tug, *Lanpan 26*. On 15 May, *MPV Everest* arrived safely off Singapore and anchored for about a week to meet Singaporean quarantine requirements. The ship then sailed to Sembawang shipyard and over the following weeks, underwent extensive repairs to rectify the damage sustained due to the fire.

Context

MPV Everest

The ship

MPV Everest is a Bahamas-registered, ice class, dynamically-positioned, multi-purpose vessel, built by Keppel Singmarine in Singapore in 2017. The ship was owned by New Orient Marine,[9] a subsidiary of Luxembourg-based Maritime Construction Services (MCS) and, at the time of the fire, managed by Singapore-based Fox Offshore. In October 2021, about 5 months after the fire, MCS assumed direct responsibility for the safety management and operation for the ship.

MPV Everest was equipped with the necessary navigational, firefighting, lifesaving and communication equipment required by the International Convention for the Safety of Life at Sea (SOLAS)[10] for a ship of its size and operations. The ship was equipped with a Furuno VR-7000 voyage data recorder (VDR) from which information useful to the investigation was recovered.

Classification societies

During its design and construction phase, *MPV Everest* was 'dual classed'[11] with Bureau Veritas (BV) and the Russian Maritime Register of Shipping (RMRS). A working agreement between BV and RMRS defined the responsibilities of the 2 classification societies with respect to various class notations required by the shipowner and specified which classification society's rules would be applicable for their respective class notations. Among other matters, the working agreement delegated responsibility for plan approval and surveys relating to the ship's hull and piping, fire safety and dynamic positioning (DP) to BV while RMRS was given responsibility for the ship's ice class, electrical equipment and unattended machinery space (UMS) notations. Following construction, the ship was 'double classed'[12] with BV and RMRS.

MPV Everest was built to the RMRS 'Arc5' standard, which indicated the ship's capability for navigation in ice.[13] In accordance with the ship's dual classification agreement, the ship was also issued with BV's equivalent ice class notation of 'ICE CLASS 1A SUPER'.

Polar Code compliance

The International Code for Ships Operating in Polar Waters (Polar Code) was developed to supplement existing International Maritime Organization (IMO) instruments in order to increase the safety of ships' operations and mitigate the impact on the people and environment in remote, vulnerable and harsh polar waters. The code acknowledged that polar water operations may impose additional demands on ships, their systems and operation beyond the existing requirements of relevant binding IMO instruments.

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9 New Orient Marine, International Maritime Organization (IMO) Company Number 5903526. The IMO database identified *MPV Everest* as the sole ship owned by the company.

10 International Maritime Organization, 2014, The International Convention for the Safety of Life at Sea (SOLAS) 1974, as amended, IMO, London.

11 A 'dual classed' vessel is a vessel which is classed with 2 classification societies between whom there is a written agreement regarding sharing of the scope of work, reciprocal recognition of surveys carried out by each of the societies on behalf of the other and full exchange of information on the vessel's class status and survey reports.

12 A 'double classed' vessel is a vessel which is classed with 2 classification societies, where each classification society works as if it is the only society with which the ship is classed. Each classification society conducts the required surveys in accordance with its own requirements and schedule.

13 The 'Arc5' ice category mark indicated that the ship was capable of independent navigation in young open arctic ice up to 0.8 m thick in winter and spring, and up to 1.0 m thick in summer and autumn as well as navigation in a navigable passage astern of an icebreaker in young arctic ice up to 0.9 m thick in winter and spring and up to 1.2 m thick in summer and autumn.

The code is mandatory under both SOLAS and MARPOL[14] conventions. It covers a range of requirements related to design, construction, equipment, operations, training, search and rescue, and environmental protection matters relevant to ships operating in polar waters. The Polar Code entered into force on 1 January 2017.

The code identified several hazards that could lead to elevated risk for ships operating in polar waters including:

- low temperatures and darkness
- high latitudes (and their effect on navigation and communication systems)
- remoteness and possible lack of accurate and complete hydrographic data and information
- reduced availability of navigational aids and seamarks
- limited readily deployable search and rescue facilities, delays in emergency response and limited communications capability
- potential lack of ship crew experience in polar operations, with potential for human error
- potential lack of suitable emergency response equipment, with the potential for limiting the effectiveness of mitigation measures.

In order to establish procedures or operational limitations, an assessment of the ship and its equipment was required to be carried out. The Polar Code stated that the risk level within polar waters could differ depending on factors such as the geographical location and time of the year and that mitigating measures required to address identified hazards could vary and be different in Arctic and Antarctic waters. The code also stated that while Arctic and Antarctic waters have similarities, there are also significant differences and, that the legal and geographical differences between the 2 areas need to be considered.

In September 2020, in preparation for the AAD charter, *MPV Everest* was assessed by RMRS for compliance with the structure, equipment, fittings, radio arrangements, and material requirements of the Polar Code. The ship was subsequently issued with Polar Code certification under the authority of the Bahamas flag administration. The ship's Polar Code certificate categorised *MPV Everest* as a category B ship,[15] with a maximum expected time of rescue of 5 days.

Polar water operational manual

The Polar Code required ships to carry a polar water operational manual to provide the owner, operator, master and crew with sufficient information regarding the ship's operational capabilities and limitations in order to support their decision-making process. The manual was required to include procedures for:

- voyage planning (to avoid ice or temperatures exceeding the ship's design capabilities)
- means of addressing any limitations of the hydrographic, meteorological and navigational information available
- operation of equipment required under the code
- implementation of special measures to maintain equipment and system functionality under low temperatures.

A copy of *MPV Everest*'s polar water operational manual was provided to the ATSB by the ship's owners on request. The 113-page manual provided a detailed description of the Russian Arctic, Arctic seas and straits, including information on Arctic geography, weather patterns, ports of refuge, routing and communication, and navigation performance.

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[14] International Maritime Organization, 2022, The International Convention for the Prevention of Pollution from Ships (MARPOL) 1973, as amended, IMO, London.

[15] A category 'B' ship is a ship not included in category 'A' and designed for operation in polar waters in at least thin first-year ice (first-year ice from 30 cm to 70 cm thick), which may include old ice inclusions. A category 'A' ship is one designed for operation in polar waters in at least medium first-year ice.

There was no information in the manual about operations in the Southern Ocean or the Antarctic.

Training

The Polar Code also introduced minimum requirements for the training and qualifications of masters and deck officers of ships operating in polar waters which became mandatory under the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention)[16] on 1 July 2018. This introduced a requirement for basic and/or advanced polar waters training depending on factors such as the officer's rank, type of ship and the nature of operating conditions.

Additionally, the Nautical Institute's[17] Ice Navigator Training Accreditation and Certification Scheme complemented training required for masters and deck officers under the Polar Code. While participation in the scheme was not mandatory, it represented industry best practice and resulted in the award of internationally recognised qualifications. The scheme built upon the basic requirements of the Polar Code and accompanying STCW amendments, with a focus on ship handling and ice operations, aimed at ensuring that ships' officers were not only trained but also experienced in operating in ice at sea.

Compliance with the scheme involved undergoing basic polar waters training and obtaining practical or simulated experience operating in ice conditions and initially resulted in the award of an Ice Navigator Level 1 certificate. Completion of the advanced polar waters training and further practical experience at sea in ice resulted in the award of an Ice Navigator Level 2 certificate, which was the highest level of qualification available under the scheme.

There were no mandatory or other training requirements for engineers of ships operating in polar waters.

History

MPV Everest was delivered in December 2017 but remained in the shipyard for another year while commissioning works progressed. The ship was managed by its owners (New Orient Marine) until January 2018 when Fox Offshore was engaged as the ship's technical and safety manager. In December 2018, the ship was chartered for about a month to assist with the location and attempted recovery of the cockpit voice recorder from the wreckage of Lion Air Flight 610 in Indonesian waters before returning to anchor off Singapore. From September to December 2019, the ship was engaged in sub-sea construction work in Indonesia before returning to anchor. During the periods when the ship was at anchor, it was manned by a reduced crew complement.

In March 2020, *MPV Everest* was chartered by the Australian Antarctic Division (AAD) to undertake 2 voyages to Antarctica over the course of the southern summer to resupply and effect personnel changes at the Australian research stations in Antarctica (Casey, Davis, and Mawson stations).

In July 2020, *MPV Everest* departed Singapore for Busan, Republic of Korea (South Korea) and subsequently to Kholmsk, Russia. The ship then undertook sub-sea construction work in the Kirinskoye gas condensate field, off Sakhalin Island in the Sea of Okhotsk, until 20 November when it departed for dry dock. On 24 November, *MPV Everest* arrived in Samkang, South Korea where it was dry docked. On 1 December 2020, following 2 weeks of quarantine, most of *MPV Everest*'s crew for the AAD charter joined the ship while in dry dock.

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16 International Maritime Organization, The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended, IMO, London.

17 The Nautical Institute is an international professional organisation for maritime professionals.

Antarctic operations

On 7 December 2020, the ship was re-floated and, the following day departed South Korea for Australia. The ship's previous master, second mate and chief electrician sailed with the new crew to Australia for an extended hand-over en route and to assist with familiarisation of the ship.

On 28 December, *MPV Everest* called at Burnie, Tasmania to take bunkers (fuel) before departing for Hobart, Tasmania. On 31 December, the ship arrived in Hobart. Over the following days, more crew joined the ship, AAD personnel embarked and supplies for the AAD Antarctic research stations were loaded.

On 9 January 2021, *MPV Everest* departed Hobart for Casey station in Antarctica. The ship arrived off Casey on 18 January and, by 27 January, had completed re-supply and changeover of Casey station personnel and departed for Hobart. On 29 January, while en route back to Australia, a fire broke out in the ship's battery compartment (see the section titled *Shipboard incidents and risk events*). The fire was extinguished using portable fire extinguishers and the ship continued its voyage, arriving in Hobart without further incident on 4 February.

On 10 February, *MPV Everest* departed Hobart for Davis and Mawson stations in that order. By 23 February, the ship arrived off Davis and, by 8 March, had departed for Mawson. By 12 March, *MPV Everest* had arrived off Mawson, but ice conditions prevented the ship from getting closer than about 80 miles from the station. Over the course of the following 2.5 weeks, re-supply operations and changeover of Mawson station personnel were conducted using its helicopters over the ice.[18] On 31 March, *MPV Everest* departed Antarctica for Hobart and the fire occurred 5 days later.

Ship's crew

MPV Everest had a multi-national crew of 37 from 12 countries, including Polish, Dutch, Russian, Finnish, Latvian, Estonian, and Indonesian nationals.

The ship's crew complement for the Antarctic voyages exceeded the requirements in the ship's minimum safe manning document. The deck crew complement comprised the master, a chief mate, a first mate, 2 second mates, an ice pilot, a bosun and 3 able seamen. All the ship's deck officers joined the ship on 1 December 2020 while dry docked in South Korea, with the exception of the ice pilot who joined on 5 January 2021 in Hobart before its first voyage to Antarctica.

At the time of the fire (see the section titled *Engineering challenges*), the engineering crew complement comprised the chief engineer, a second engineer, 2 third engineers, a chief electrician, an electro-technical officer (ETO), and 3 engine ratings (an oiler, a motorman and an electro-technical rating). All the ship's engineers joined the ship on 1 December 2020 in the dry dock, with the exception of the second engineer who joined the ship on 9 February 2021 in Hobart, after its first voyage to Antarctica.

Master

The master held Polish and Dutch master's certificates of competency and the equivalent Bahamas certificate of recognition. The master had about 21 years of seagoing experience as a qualified deck officer with about 6 years' experience as master. Their seagoing experience was generally on board vessels associated with the offshore oil and gas industry such as offshore supply vessels (OSVs), anchor handling tug supply (AHTS) vessels, drills ships, offshore installations and other specialised DP ships. This was the master's first time working with Fox Offshore and also their first time on board *MPV Everest*.

The master had completed basic and advanced training for ships operating in polar waters in September 2020 (prior to joining *MPV Everest*). The master also held an Ice Navigator Level 2

[18] *MPV Everest* carried 2 containerised Eurocopter AS350B3 helicopters (recovered on board after wintering at Davis station) as well as AAD-contracted personnel to maintain and operate these helicopters.

certificate issued by the Nautical Institute (NI) although this was issued in October 2021 (after their time on board *MPV Everest*). The master had previous experience in ice on board research ships in the Arctic and about a month's experience in the Antarctic on board a Polish sail training ship during a voyage to the Polish Antarctic Station Arctowski, located on King George Island.

Chief mate

The chief mate held a Russian master's certificate of competency and the equivalent Bahamas certificate of recognition. The chief mate had about 23 years of seagoing experience with over 10 years as master on ships of various types, including roll-on/roll-off ships, offshore DP vessels and icebreakers. This was their first time working with Fox Offshore and also their first time on board *MPV Everest*.

The chief mate had completed basic and advanced training for ships operating in polar waters in June 2019. The chief mate also held an NI Ice Navigator Level 2 certificate and had previous ice experience in the Arctic. This was their first time working in the Antarctic.

First mate

The first mate held a Russian master's certificate of competency and the equivalent Bahamas certificate of recognition. They had over 29 years of seagoing experience. The first mate had completed basic and advanced training for ships operating in polar waters, held an NI Ice Navigator Level 2 certificate and had previous experience working in ice in the Arctic. This was their first time working with Fox Offshore, their first time on board *MPV Everest* and their first time working in the Antarctic.

Ice pilot

The ice pilot held an Estonian master's certificate of competency and the equivalent Bahamas certificate of recognition. They had completed basic and advanced training for ships operating in polar waters, held an NI Ice Navigator Level 2 certificate and had extensive experience working in ice in the Arctic. This was their first time working with Fox Offshore, their first time on board *MPV Everest* and their first time working in the Antarctic.

Other deck officers

The duty and off-duty second mates held Russian officer of the watch certificates of competency and the equivalent Bahamas certificates of recognition. This was their first time working with Fox Offshore, their first time on board *MPV Everest* and their first time working in the Antarctic.

Both second mates had completed basic training for ships operating in polar waters and had previous experience working in ice in the Arctic. The duty second mate had also completed advanced training for ships operating in polar waters and held an NI Ice Navigator Level 2 certificate.

Chief engineer

The chief engineer held a Dutch chief engineer's certificate of competency and the equivalent Bahamas certificate of recognition. They had over 27 years of seagoing experience, with the last 15 years as chief engineer. Their seagoing experience was generally on board DP semi-submersible drilling rigs, DP drills ships, sub-sea constructions vessels, heavy lift ships and other specialised DP ships.

This was their first time working with Fox Offshore, their first time on board *MPV Everest* and their first time working in polar waters and in ice.

Second engineer

The second engineer held a Latvian second engineer's certificate of competency and the equivalent Bahamas certificate of recognition. They had over 18 years of seagoing experience with the last 8 years in the rank of second engineer. Their seagoing experience was served on board various types of merchant ships and DP vessels.

This was their second trip on board *MPV Everest* with Fox Offshore and their first time working in polar waters and in ice.

Other watchkeeping engineers

The third engineer on duty at the time of the fire held an Indonesian chief engineer's certificate of competency and the equivalent Bahamas certificate of recognition. They had about 18 years of seagoing experience and this was their first time working with Fox Offshore, their first time on board *MPV Everest* and their first time working in polar waters and in ice.

The off-duty third engineer held an Indonesian second engineer's certificate of competency and the equivalent Bahamas certificate of endorsement. They had about 13 years of seagoing experience and this was their second trip on board *MPV Everest* with Fox Offshore and their first time working in polar waters and in ice.

Chief electrician

The chief electrician held a Finnish electro-technical officer's certificate of competency and the equivalent Bahamas certificate of recognition. They had over 44 years of seagoing experience with the last 21 years as chief electrician. The chief electrician had worked with Fox Offshore and on board *MPV Everest* since the ship was built and had been assigned to the ship for the previous 4 years.

The chief electrician had previous experience working in ice in the Arctic, but this was their first time in the Antarctic.

Electro-technical officer

The electro-technical officer (ETO) held a Russian electro-technical officer's certificate of competency and the equivalent Bahamas certificate of recognition. They had about 19 years of seagoing experience and this was their first time working with Fox Offshore and their first time on board *MPV Everest*.

The ETO had previous experience working in ice in the Arctic, but this was their first time in the Antarctic.

Safety management system

MPV Everest was managed and operated by Singapore-based Fox Offshore from the time of the ship's commissioning, with shore management personnel based in Singapore, the Netherlands, Indonesia, and South Korea.

The International Safety Management (ISM) Code[19] requires companies to provide for safe practices in ship operations, to assess all identified risks to ships, personnel and the environment and, to establish appropriate safeguards against these risks. The code aims to achieve this by requiring companies to develop, implement and maintain a safety management system (SMS), with instructions and procedures to ensure the safe operation of ships, to prepare for and respond to emergencies and to verify compliance with the SMS.

Fox Offshore held a valid document of compliance[20] and *MPV Everest* held a valid safety management certificate,[21] both issued by BV on behalf of the Bahamas' Administration.

MPV Everest operated under the Fox Offshore SMS, titled the Vessel Management System. The SMS consisted of policies, statements and various manuals, with supporting plans, checklists,

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[19] International Maritime Organization, 1995, International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) as amended, IMO, London.

[20] A document of compliance (DOC) is issued to a company (or organisation), which complies with the requirements of the ISM Code.

[21] A safety management certificate (SMC) is issued to a ship to signify that the company and shipboard management operate in accordance with the approved SMS.

forms, documents and publications. The manuals were divided into generic manuals and ship-specific manuals that were designed to be specific to *MPV Everest*. The generic manuals included a management manual, safety manual and operations manual while ship-specific manuals included an on-board emergency manual, SOLAS fire training and safety training manuals and the ship's DP manual.

Management manual

Fox Offshore's management manual stated that the company specialised in supporting 'high-tech' vessels within the offshore oil, gas and construction industry. The company's senior management team comprised the chief executive officer, chief operating officer, technical superintendent and designated person ashore. The manual stated that the one of the principal objectives of the senior management team was to ensure that the SMS was effectively implemented, complied with, resourced and improved.

The management manual stated that all vessels were to be manned by certified, qualified and medically fit personnel and that, when transferred to a new vessel or position, crew were to be thoroughly familiarised with their new roles. It also required all new crew to be provided with an introduction to the company SMS. In particular, it stated that where the master was recruited externally, extra care was to be taken to ensure they were familiar with the SMS. Most of *MPV Everest*'s officers and crew who were engaged for the AAD charter, including the master and chief engineer, were new to the ship and Fox Offshore. However, there was no evidence of familiarisation with the SMS being provided before they joined the ship.

Examination of crew induction and familiarisation records indicated that all new crew had been familiarised with relevant firefighting and lifesaving information as well as their duties and work space on board.

The management manual required the master to review the SMS annually and report any findings, defects or request for change to the company. However, inaccuracies in several ship-specific manuals (see the section titled *Emergency preparedness and fire safety*) indicated that this was not being carried out effectively.

The management manual also included procedures for compliance with fatigue management regulations (see the section titled *Fatigue*).

Operations manual

The operations manual provided further detail and procedures relating to the safe operations of the company and ship. The manual required ships to develop ship-specific emergency prompts for various emergency situations including fire (see the section titled *Emergency preparedness and fire safety*).

The operations manual required the master to develop standing orders setting out the master's expectations of what was required of watchkeeping officers at sea and in port. The standing orders were required to be submitted to the operations manager ashore for review and all watchkeeping officers were to read, understand and sign the orders on board. On board *MPV Everest*, standing orders signed by the ship's deck officers dating back to December 2017, were found on the ship's bridge. However, the orders had not been developed by the new master but appeared to be existing standing orders developed by a previous master. While the orders appeared to have been endorsed by several of the ship's previous masters (evidenced by their signatures), the document was not signed by the ship's new master. The standing orders also did not include any reference to polar navigation or navigation in ice, nor was there any other substantial guidance or procedures in the operations manual or other manuals relating to operations in ice.

The operations manual also required the chief engineer to develop standing instructions covering their expectations on engineering practice. The chief engineer's standing instructions also had to be submitted to the technical superintendent ashore for review. The manual directed the chief engineer to consider several principles in drafting their standing instructions including that maintenance and repairs could be carried out by the watchkeeping engineer provided it did not interfere with normal watchkeeping and that the chief engineer was to be informed of any abnormality in machinery performance. The chief engineer’s standing instructions largely reflected these considerations and were signed by the chief engineer and all engineering staff.

There was no evidence of the master’s standing orders and the chief engineer’s standing instructions being reviewed or approved by the operations manager ashore.

The operations manual also included procedures related to the management of critical spare parts on board and the planned maintenance system (see the section titled *Engineering challenges*).

Safety manual

The safety manual documented requirements for the systematic reporting of shipboard safety observations, the conduct of safety meetings and guidance on the requirements for drills and exercises on board (see the section titled *Emergency preparedness and fire safety*).

Some relevant safety observations documented on board during the time the ship was chartered by the AAD included:

- the absence of de-icing equipment on board resulting in some life-saving and firefighting equipment being unavailable
- the forward bridge window heater not being operational and with no spares on board
- the installed search lights on the monkey island being unacceptable for ice navigation.

The safety manual required monthly safety meetings to be held and attended at a minimum by the master, the safety officer and department representatives. The safety meetings were intended to ensure safe operations across the various departments and also to provide a medium for all staff to present safety concerns.

A review of safety meeting minutes indicated that meetings were held monthly as required. Some relevant, recurring points of discussion recorded in consecutive monthly safety meeting minutes included:

- the need to improve safety practice in the conduct of man overboard drills
- the poor quality of internet on board resulting in difficulty downloading navigation chart and publication corrections and safety flashes as well as its impact on the crew’s ability to communicate with their families.

Shipboard incidents and risk events

In the time between *MPV Everest*’s departure from South Korea in December 2020 and the ship’s arrival at the repair yard in Singapore following the fire, the following incidents and risk events were recorded on board:

19 December 2020

On 19 December 2020, while at sea en route to Australia, the port fast rescue craft (FRC) was lowered and launched as part of a man overboard drill. Shortly after launching, the FRC crew advised that the engine had stopped, that the boat was taking on water in the engine compartment and that assistance was required. The FRC and its crew were subsequently recovered safely. The occurrence was not recorded as an incident although a drill report was filed. The occurrence was subsequently attributed to an unsatisfactory repair of a component in the engine compartment and poor maintenance.

20 December 2020

On 20 December 2020, while at sea en route to Australia, a smoke detector activated in the ship’s aft winch control room with smoke observed emanating from the compartment. The fire alarm was sounded, crew mustered, ventilation shut down and the space electrically isolated. A fire team, wearing fireman outfits and self-contained breathing apparatus, entered the space and found a smouldering circuit breaker thermal relay unit in a motor control centre (MCC) enclosure. The circuit breaker was removed and the thermal relay isolated.

The shipboard investigation found that one of the MCC's breakers had likely come loose in the electrical enclosure as a result of a period of prolonged disuse. The investigation recommended a review and long-term isolation of all live but unused switchboards.

23 December 2020

On 23 December 2020, while at sea en route to Australia, the starboard FRC was prepared for launching as part of a man overboard drill. As the FRC davit was swung out, the FRC release hook wire was found twisted and was subsequently cut to facilitate the launching of the boat. Shortly after launching, the FRC crew advised that the engine had stopped, that the boat was taking on water in the engine compartment and that assistance was required. The FRC and its crew were subsequently recovered safely. The occurrence was subsequently attributed to an unsatisfactory repair of a component in the engine compartment and poor maintenance.

29 January 2021

On 29 January 2021, while in polar waters en route from Casey station to Hobart, a fire broke out in *MPV Everest*'s battery room located above the bridge deck. On activation of the battery room fire detector and the fire alarm on the bridge, the 2 second mates were sent to investigate and found smoke and flames emanating from the space. The ship's fire alarm was sounded, public address announcement made, and all personnel (including AAD staff) mustered. While the deck fire team was readied, the second mates extinguished the fire using portable fire extinguishers.

The ATSB marine occurrence brief MB-2021-001 summarised the incident and the findings of the subsequent shipboard investigation. The investigation found that, as the ship rolled heavily in rough weather, metal straps securing several batteries failed resulting in the batteries falling to the deck. The fire was subsequently ignited by short circuits in the batteries. While most were secured by metal brackets, some batteries that had been received about 5 months earlier were secured by less robust metal straps.

4 April 2021

On the evening of 4 April 2021, while en route from Mawson station to Hobart in rough weather, a remotely operated vehicle (ROV) and its tether management system broke free of their securing in *MPV Everest*'s ROV hangar. In addition, 2 smaller ROVs also moved out of their stowed positions. Over the following hours, members of the ship's crew assisted by AAD personnel, worked to restrain and re-secure the equipment. The incident resulted in damage to the ship's railings, gratings, hydraulic oil drums and the ROV tether. The dive technician's report on the incident noted that the equipment was not properly secured due to the absence of satisfactory securing points for the ROVs and the tether management system in the ROV hangar, and due to the lack of proper securing equipment.

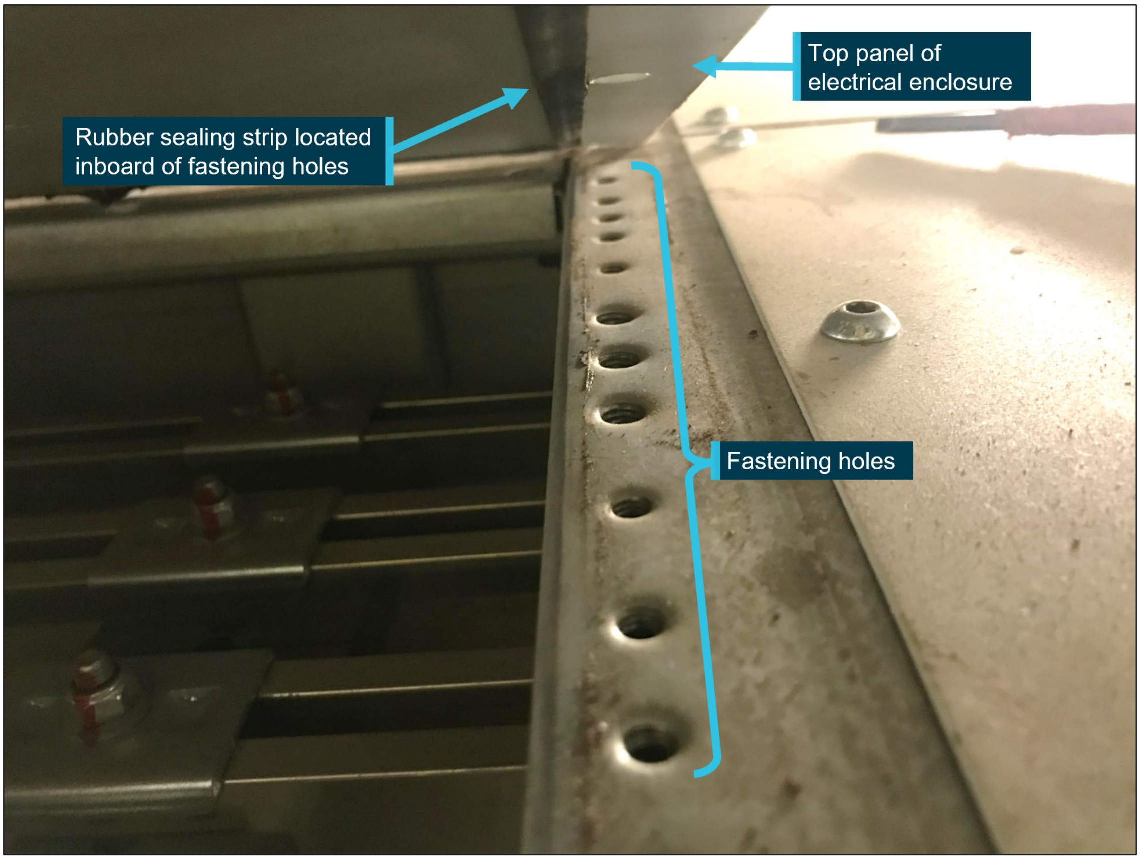
There were several other reported instances of damage due to inadequately secured equipment in the accommodation (such as furniture, computers and printers) and on deck (such as the spare anchor and crane hooks). However, these were not recorded as incidents and were managed as part of the ship's operations.

20 May 2021

On 20 May 2021 (following the fire), while at anchor off Singapore awaiting berthing at the repair yard, a failed pressure switch fitting on a seawater cooling pump in *MPV Everest*'s starboard pump room resulted in a pressurised jet of water being directed upwards at the deckhead. The water dispersed in all directions including downwards onto the top of a motor control centre (MCC) in the vicinity of the pump. Internal examination of the electrical enclosure found significant water ingress had drenched almost all internal circuitry and electrical components. The water ingress was found to have resulted in electrical arcing, short circuiting and a minor explosion resulting in a hole in the rear of the enclosure.

The shipboard investigation found that the enclosures were incorrectly constructed, that the top panels were not adequately sealed and that there were gaps between adjacent panels. Sealing gaskets intended to prevent the entry of fluids were located inboard of fastening holes thereby providing an unimpeded path for fluid ingress (Figure 11).

Figure 11: Top of pump room electrical enclosure



Note that only about 3 fastening holes on each side of the top panel are used to secure the panel to the enclosure leaving the remaining fastening holes empty.
Source: Fox Offshore, annotated by the ATSB

Further inspection found that other similar electrical enclosures, including those in the fire-affected port engine room, were likewise deficient. These were subsequently rectified by the manufacturer during the ship's stay in the repair yard in Singapore.

Inspections

Flag State inspection

On 24 June 2020, the Bahamas Maritime Authority conducted an annual flag State inspection of *MPV Everest*. The inspection report noted that all statutory certificates were in order and that records relating to the ship's SMS, planned maintenance system (PMS), safety meetings and drills were inspected and also found in order. The inspection included a fire drill (for a fire in the ship's paint locker), a lifeboat drill and testing of the emergency alarms, emergency fire pump and emergency generator, all of which were recorded as being satisfactory. The report also noted that the water mist system was inspected, that it was set up to operate automatically and that the system's nozzles were found to be in the correct positions to allow for immediate operation.

Port State inspection

On 5 February 2021, following *MPV Everest*'s return to Hobart after the first voyage to Antarctica, AMSA port State inspectors boarded the ship and conducted a port State inspection. The inspection included testing of various fire dampers, radio equipment, lifeboat engines, emergency steering, emergency fire pump and emergency generator. The inspection also included examination of random extracts from the ship's emergency response manual and emergency drill records. The AMSA port State inspection did not identify any deficiencies.

The ship's previous port State inspection was conducted by the Maritime and Port Authority of Singapore on 10 December 2018. The inspection identified 4 minor deficiencies.

Engine room and fuel oil system

Engineering redundancy

MPV Everest is a class 3, dynamically-positioned (DP3) ship. Dynamic positioning (DP) is a vessel capability where a computer-controlled system automatically maintains a vessel's position and heading by directing its propellers and thrusters accordingly. The ship's DP3 equipment class required that the ship have redundancy such that no single fault in an active component or system would cause the system to fail and lose position. It also required the ship to be able to withstand fire or flooding in any one compartment without losing the ability to maintain propulsion.

MPV Everest's DP system comprised 2 separate redundancy groups with thrusters distributed between the 2 so as to provide the necessary redundancy. Therefore, *MPV Everest* was designed and built with 2 separate engine rooms—port and starboard. Engines, switchboards, and fuel, lubrication, cooling, and ventilation systems were duplicated in each engine room and the engine rooms were segregated such that fire or flooding in a single engine room would only result in the loss of a single redundancy group.

Propulsion

MPV Everest's propulsion is provided by 6 electrically driven thrusters as follows:

- 2 fixed-pitch 5,500 kW azimuth thrusters aft (port and starboard)
- a controllable-pitch 600 kW tunnel thruster aft
- a retractable 3,000 kW fixed-pitch azimuth thruster forward
- 2 controllable-pitch 2,700 kW tunnel thrusters forward.

Electrical power for the thrusters and other shipboard services was provided by:

- 4 Rolls-Royce (Bergen) B32:40V12ACD 5,530 kW diesel generators
- 2 Rolls-Royce (Bergen) C25:33L6ACD 1,825 kW diesel generators.

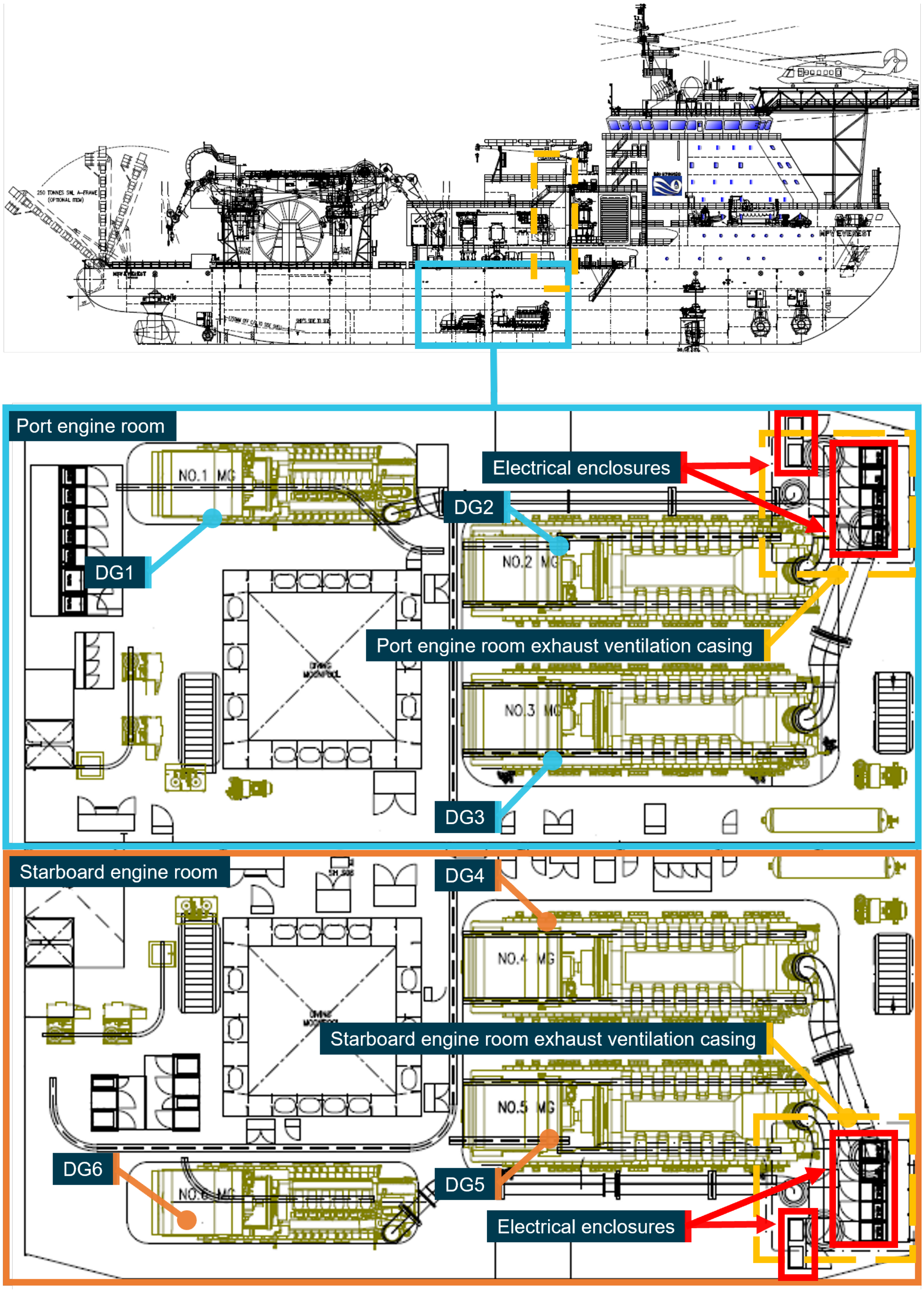
The 2 secondary 1,825 kW diesel generators (DG) were numbered DG1 and DG6 while the 4 main 5,530 kW generators were numbered DG2, DG3, DG4 and DG5. These were evenly split between the port and starboard engine rooms with DG1, DG2 and DG3 in the port engine room and DG4, DG5 and DG6 in the starboard engine room. The layout of the port and starboard engine rooms and their components were mirror images of each other (Figure 12).

Port engine room

In the port engine room, DG1 was located outboard at the aft end of the engine room with DG2 and DG3 located side by side, forward and inboard of DG1 (Figure 12). The engine room floor was just above tank-top level with an upper mezzanine deck known as B-Deck. The upper deckhead of the engine room was formed by the underside of A-Deck. The primary means of access to the port engine room was a watertight door at the forward end of B-Deck that led into the port medium voltage switchboard room and then to the engine control room (ECR).

At the port, forward corner of the engine room B-Deck, there were 2 electrical cabinets—a 440 V motor control centre (MCC 3A) and a 440 V power distribution board (PDB 3).

Figure 12: *MPV Everest* – Engine rooms



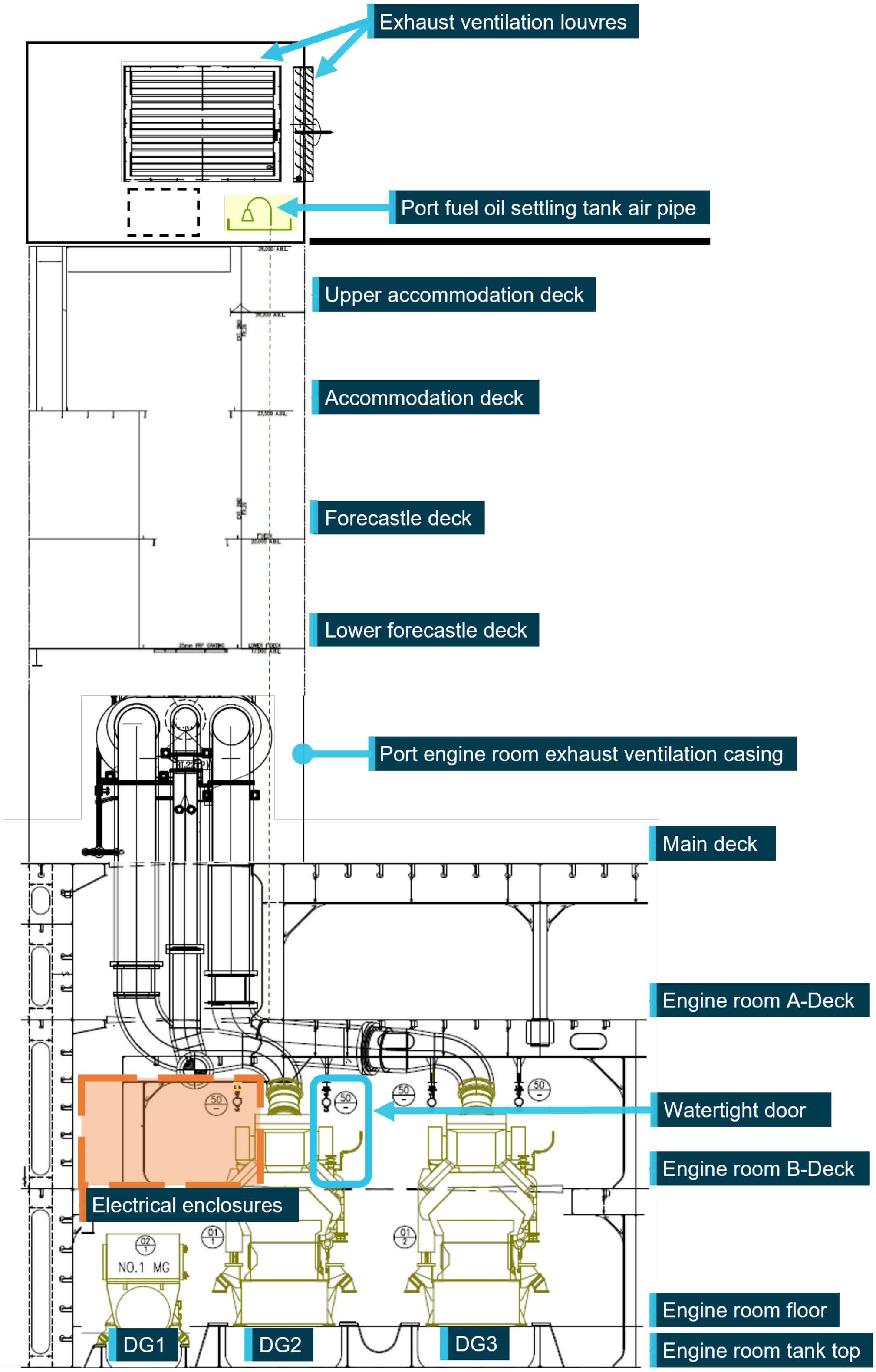
Source: Fox Offshore, annotated and modified by the ATSB

Exhaust ventilation casing

At the port forward corner of B-Deck, almost directly above the MCC and PDB, was the opening of the port engine room's exhaust ventilation casing. The casing extended vertically upwards from the deckhead to a deck just above the upper accommodation deck level (Figure 13). The intervening decks inside the casing were either open or composed of fibre-reinforced plastic (FRP) gratings.

The port engine room was equipped with 2 supply fans which created a positive pressure in the space. The resulting airflow created a strong updraft through the exhaust ventilation casing which exited through the ventilation louvres of the casing above the upper accommodation deck. The exhaust trunkings of all 3 generators led forward to the port corner of B-Deck where they turned upwards and entered the exhaust ventilation casing. The trunkings continued up to just above the main deck level where they turned and exited the ventilation casing through its forward bulkhead to continue to the ship’s funnels.

Figure 13: Port engine room and exhaust ventilation casing (looking forward)



Source: Fox Offshore, modified and annotated by the ATSB

In addition to the exhaust trunkings of the ship's generators, air vent pipes for several engine room fuel oil tanks and other spaces also passed through the exhaust ventilation casing. These pipes ran vertically upwards with 5 pipes terminating inside the upper level of the casing while 11 pipes continued upwards, penetrated the deckhead and terminated externally above the ventilation casing. The following air vent pipes terminated in goose neck vents inside the upper level of the port engine room exhaust ventilation casing:

- port fuel oil day tank
- port fuel oil settling tank
- number 1 fuel oil purifier air vent
- number 2 fuel oil purifier air vent
- port boiler fuel oil day tank.

The gooseneck ends of the settling tank, day tank and purifier vents were sited within a save-all with a capacity of about 150 L. The save-all had a small drainpipe that drained any accumulated fluid to the sludge tank. The boiler day tank vent was sited separately within a smaller save-all (Figure 14).

Figure 14: Arrangement of air pipes within port exhaust ventilation casing

Source: ATSB

Fuel oil tanks

MPV Everest's fuel oil storage capacity consisted of 11 storage tanks, with a combined fuel storage capacity of about 4,448 cubic metres (m^3). The ship's DP3 redundancy arrangements meant that the port and starboard engine rooms each had their own independent, segregated fuel oil system.

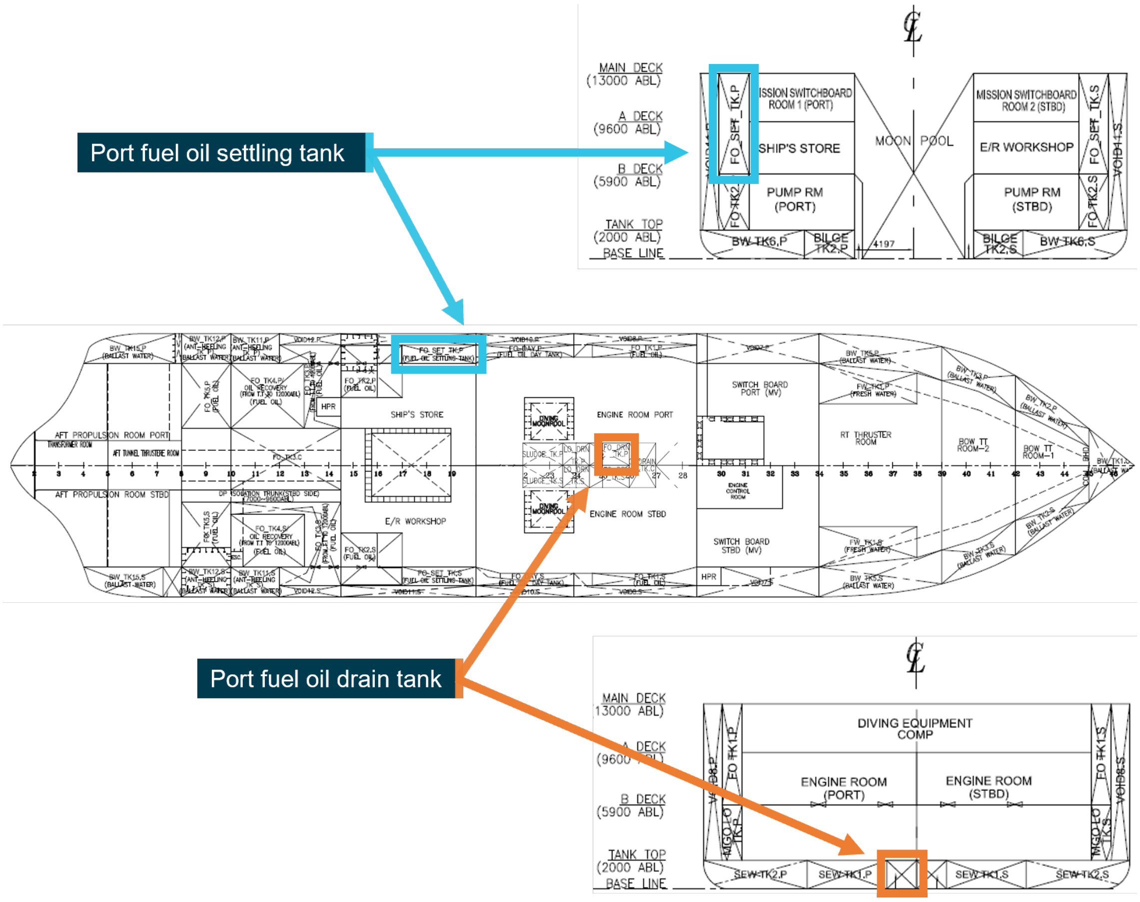
From the storage tanks, fuel was transferred to the settling tanks using the diesel oil transfer pumps. The ship was equipped with 2 diesel oil transfer pumps, each with a rated capacity of 30 m^3 per hour. Either pump could be used to transfer fuel to the port and starboard fuel oil settling tanks.

In the settling tanks, heavier impurities in the fuel settled to the bottom due to gravity. Fuel was then purified by 2 fuel oil purifiers in each engine room and delivered to each engine room's day tank for supply to the generators and to the boiler day tanks for the boilers.

Port fuel oil settling tank

The port fuel oil settling tank (port settling tank) had a capacity of 122.7 m^3 and was located in the port engine room extending from the main deck down to B-Deck and sited inboard of a void space on the port side (Figure 15).

Figure 15: Relative locations of port settling tank and port drain tank

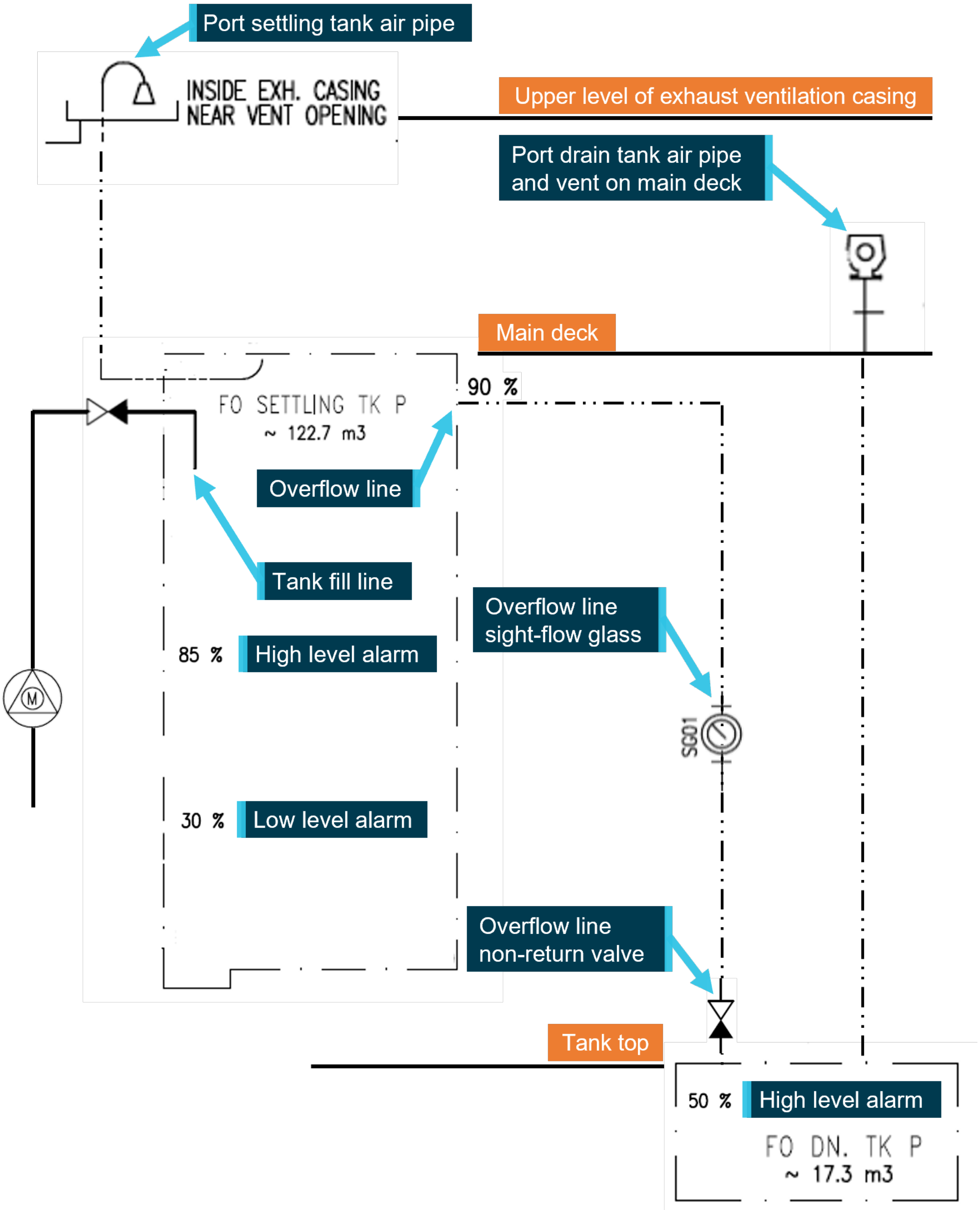


Source: Fox Offshore, modified and annotated by the ATSB

The tank was fitted with level sensors and transmitters with high and low level alarms. The low level alarm sensor was set to activate when fuel levels in the tank reached 30% of tank volume and the high level alarm sensor level was set at 85% of tank volume. As a safety measure, when fuel levels in the tank reached 90% of tank volume, an outlet drained fuel via a non-return valve to the port fuel oil drain tank (Figure 16). The overflow line was also fitted with a sight-flow glass (located in the engine room store) on a vertical section of the port settling tank's overflow line. There was no flow alarm fitted to the overflow line, nor was one required.

An air pipe for the port settling tank ran upwards through the port engine room exhaust ventilation casing and terminated in a goose neck vent within a save-all inside the casing just above the upper accommodation deck level (see Figure 13 and Figure 17).

Figure 16: Port settling tank and drain tank schematic



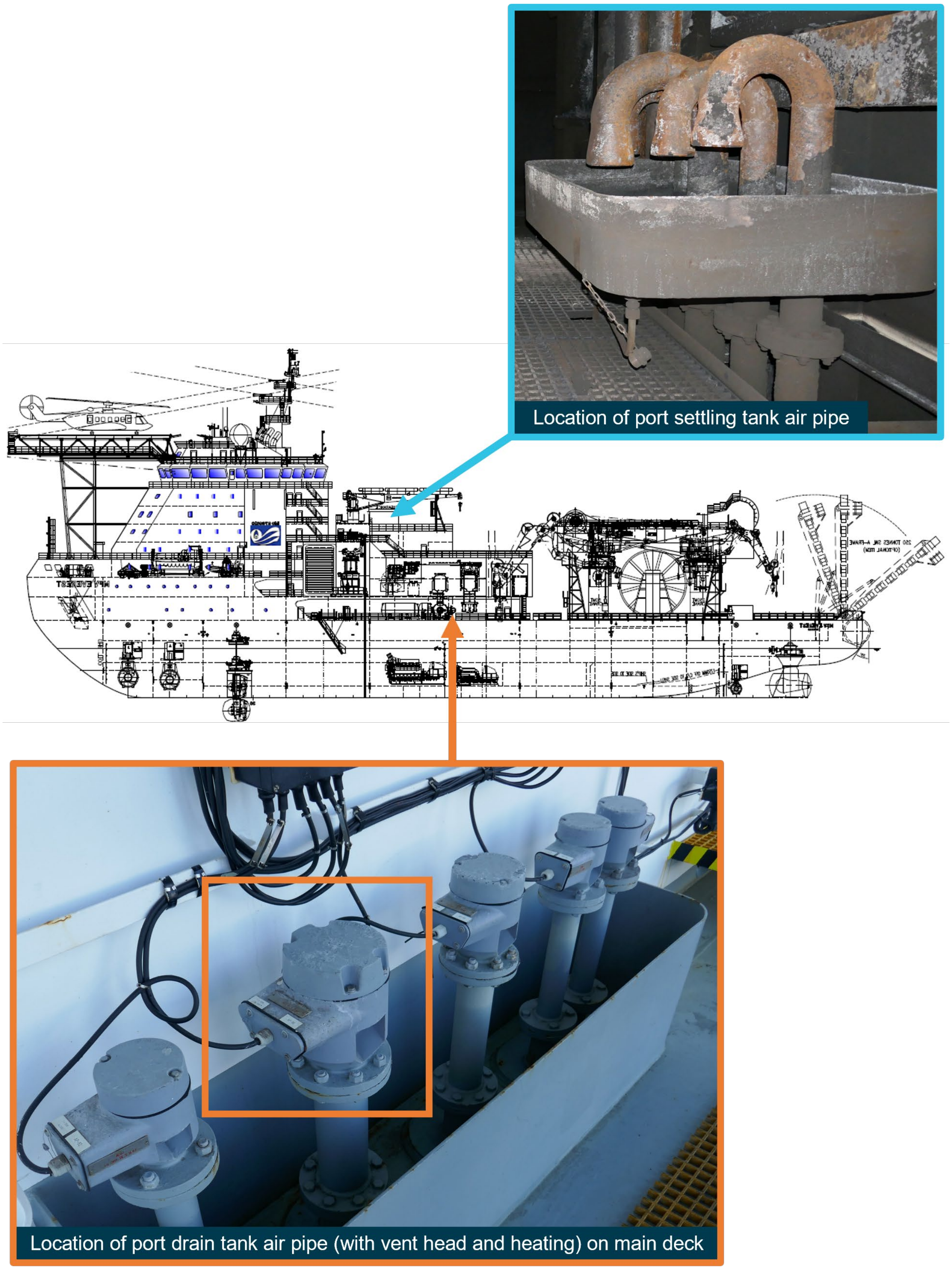
Source: Fox Offshore, modified and annotated by the ATSB

Port fuel oil drain tank

The port drain tank was a double-bottom tank located amidships to port of the centreline (Figure 15). The tank had a capacity of 17.3 m^3 and a high level alarm sensor set at 50% of tank volume.

The port drain tank air pipe terminated in a vent head located externally on the main deck near the port accommodation ladder (Figure 17). The drain tank and its vent head were both respectively at a lower level than the settling tank and the settling tank's air pipe in the ventilation casing. The vent head was fitted with an automatic closing device (float), a flame screen and an electric heating element. The vent head heating could be controlled automatically (by a thermostat located on the main deck aft) or operated manually from control cabinets. The vent head heater was most probably to have been in automatic mode at the time of the fuel transfer.

Figure 17: Relative positions of port settling tank and port drain tank air pipes



Source: Fox Offshore and ATSB

Fuel oil type

The fuel in use on board *MPV Everest* at the time of the fire was Special Antarctic Blend (SAB) diesel. SAB diesel is a fuel used for diesel engines operating in cold weather conditions. The SAB diesel was bunkered in Hobart and stored in the ship's number 4 port fuel oil storage tank, with various quantities intended for delivery to the AAD's Antarctic stations. Contractual agreements between the ship's owners and the AAD allowed for the use of surplus SAB diesel as fuel on board the ship.

Integrated automation system

MPV Everest's integrated automation system (IAS) was designed, manufactured and installed by ASEA Brown Boveri (ABB) in Singapore. The IAS's functionality included:

- alarms and monitoring of tanks, pumps, piping, machinery and other ship systems
- remote operation of valves and pumps
- control of bilge, ballast and fuel systems
- automatic control of machinery including engines and drive systems.

The IAS was operated through interfaces comprising a screen, keyboard and mouse, which were located around the vessel including the ECR and bridge. There were 2 IAS interfaces in the ship's ECR.

Fuel oil transfer

Fuel oil transfers on board *MPV Everest* were undertaken using the IAS. Fuel transfers to the port settling tank could be undertaken in 2 modes—automatic and manual.[22]

When the automatic transfer mode was selected, the diesel oil transfer pump started automatically when fuel levels in the port settling tank reduced to 50% of tank volume and stopped automatically when fuel levels reached 80% of tank volume. Tests conducted in the repair yard after the fire and interviews with the ship's engineers established that the automatic transfer worked satisfactorily. The ship's previous chief engineer also confirmed that the automatic transfer worked and that they generally conducted fuel transfers in automatic mode with a few exceptions (such as when stripping the last of the fuel from a storage tank).

When the fuel transfer was being conducted in manual mode, the pump was started manually using the IAS system. The person conducting the transfer (or another delegated person) had to monitor the tank's level and stop the pump once the desired tank level was reached. If the pump was not stopped, the fuel transfer would continue, and tank levels would continue to rise.

Sequence of events

On the morning of 5 April 2021, the chief engineer used one of the ship's IAS screens in the ECR to commence a routine fuel oil transfer from the number 4 port fuel oil storage tank to the port settling tank. The exact amount of fuel in the port settling tank at the time is not known, however it was estimated to be about 85 m^3.

The chief engineer elected to conduct the fuel transfer in manual mode, as was their practice on board, by using the IAS to open the necessary valves and start the number 1 diesel oil transfer pump. At interview, the chief engineer stated that they preferred conducting fuel transfers manually because, in their opinion, the IAS's 50% low level setting (which triggered the initiation of the automatic fuel transfer to the settling tanks) was too low and did not allow sufficient time for the fuel to settle satisfactorily.[23]

At about 0926, following the initiation of the fuel transfer, the chief engineer left the ECR with the third engineer to work in the engine room. About 90 minutes later, the chief engineer was alerted to the fire by the sound of several alarms in the ECR.

Table 1 below provides a brief sequence of events with respect to the fuel transfer based on ASTB analysis of the IAS logs, alarm data and other recorded data:

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22 For the purposes of this report, the narrative will focus on the port engine room's settling tank, piping and systems noting that the starboard engine room had an identical arrangement.

23 Proprietary protections in the IAS software meant that amendments to system settings such as tank levels that triggered automatic transfers or delays for the activation of tank alarms could not be easily amended on board.

Table 1: Fuel oil transfer events and alarms

Ship's time	Event/alarm
0926:00	Number 1 diesel oil transfer pump started
0927:30	Fuel level in port settling tank begins increasing
1002:40	Port settling tank high level signal active (indicating fuel at 85% of tank volume)
1018:00	Fuel level in port drain tank begins increasing (indicating fuel at 90% of port settling tank volume)
1030:53	Port drain tank high level alarm generated (indicating fuel at 50% of tank volume)
1043:30	Estimated time port drain tank was full
1052:50	Estimated time port settling tank was full and probably began to overflow from vent pipe
1058:21	Engine room B-deck flame detector activated, and alarm generated
1058:30	First engine room B-deck smoke detector activated, and alarm generated
1058:37	Second engine room B-deck smoke detector activated, and alarm generated
1058:38	Water mist system (forward port main engine sector) automatically activated
1106:26	Shipboard loss of power (black-out) and stoppage of number 1 diesel oil transfer pump

Analysis of the recorded data indicated that the port settling tank probably began to overflow just before 1053 (although it is possible that it started to overflow as early as 1051). The pump almost certainly continued to run until it was stopped by the shipboard loss of power at about 1106. Therefore, based on the pump's rated capacity, it is likely that about 6,500 litres of diesel fuel overflowed from the port settling tank air pipe in that time.

Tank level alarms

The IAS was configured to monitor various system variables (such as tank levels, engine temperatures or oil pressures) and when the variable deviated from a pre-configured range or setpoint, the system generated an alarm.

When a variable such as a tank level sensor signal deviated from its normal range by either exceeding the high level setpoint or falling below the low level setpoint, an alarm was generated. This resulted in an audible alert being generated in the ECR, with the alarm displayed on the IAS screen and printed in the alarm log.

When the engine room was being operated in 'attended' mode, tank level alarms only sounded in the ECR as they were categorised as 'non-critical' alarms.[24]

The alarm's audible alert was silenced by acknowledging the alarm at the IAS screen in the ECR. Acknowledged alarms remained displayed on the IAS alarm list. If the alarm was then accepted, it remained displayed while the monitored variable remained outside its normal range. When the variable returned within its normal range, the alarm disappeared from the alarm list. However, if the alarm was only acknowledged (silenced), but not accepted, the alarm remained displayed on the alarm list, even if the variable returned to within its normal range.

If an alarm that was acknowledged (but not accepted), had its associated variable return to its normal range and then deviate from it again, the alarm would sound again and need to be acknowledged again to silence it. If the variable then returned to its normal range a second time before deviating and generating an alarm for the third time (without the alarm being accepted), the alarm would sound again. However, after the variable triggered the alarm for the third time, the IAS designated the variable as 'Abnormal'. Once a variable was assigned the 'Abnormal' status,

[24] Alarms categorised as 'critical' alarms included steering gear alarms, bilge alarms and machinery alarms and these sounded in the ECR as well as in the engine room. In the event the ship was operated in unattended machinery space (UMS) mode, all engineering alarms sounded in the ECR, engine rooms, public spaces, bridge and the duty engineer's cabin.

the IAS stopped monitoring the variable, effectively isolating it. The variable would remain isolated with no further alarms being generated for that variable until the original alarm(s) were accepted.

IAS recorded alarm data indicated that while there was a port drain tank high level alarm in the time leading up to the fire, there was no port settling tank high level alarm generated, despite the tank's high level sensor activating at about 1002.

Examination of the port settling tank's alarm history showed that the tank's high level alarm was triggered 3 times on the evening before the fire (probably due to the ship's rolling) and resulted in the tank's high level variable being designated 'Abnormal'. The variable remained in an 'Abnormal' state at the initiation of, and during, the fuel transfer. Consequently, there was no alarm generated when the port settling tank's fuel level exceed 85% because the variable was effectively isolated and not being monitored by the IAS.

Table 2 below lists recorded alarms associated with the port settling tank high level variable on the day of the fire and the previous evening.

Table 2: Port settling tank high level alarms

Date	Time	Alarm	Status
4 April 2021	1647:10	Fuel Oil Set Tank P (Alarm H)	ACT[1]
4 April 2021	1647:23	Fuel Oil Set Tank P (Alarm H)	RTN[2]
4 April 2021	1702:16	Fuel Oil Set Tank P (Alarm H)	ACT[3]
4 April 2021	1702:29	Fuel Oil Set Tank P (Alarm H)	RTN
4 April 2021	1707:26	Fuel Oil Set Tank P (Alarm H)	ACT
4 April 2021	1707:40	Fuel Oil Set Tank P (Alarm H)	ABL
5 April 2021	1108:29	Fuel Oil Set Tank P (Alarm H)	ACT

[1] 'ACT' indicates an alarm requiring operator attention.
[2] 'RTN' indicates that the variable being monitored has returned to within its normal range.
[3] 'ABL' indicates that the variable has been designated 'Abnormal' and is therefore not being monitored by the IAS.

There were no procedures, guidance, instruction or other administrative mechanism in place to ensure that 'Abnormal' variables were made active again before commencing an operation (such as a fuel transfer) where safety depended on the variable being monitored by the IAS.

Port drain tank high level alarm

The chief engineer recalled hearing several alarms sound in the ECR on the morning of the fire while they were working in the starboard engine room. They also noted that the alarms were being silenced which indicated that someone in the ECR was acknowledging the audible alarms. While there was no port settling tank high level alarm generated, a port drain tank high level alarm which had the potential to warn engineers of the situation, was generated at 1030:53 (about 22 minutes before the estimated time that the port settling tank overflowed) and was acknowledged without its significance being recognised.

The duty watchkeeping engineers (chief engineer and third engineer) were in the starboard engine room working and the off-duty second engineer and third engineer were resting. This meant that a non-watchkeeping member of the ship's engineering team (probably the chief electrician or an engine rating) acknowledged the port drain tank alarm without investigating its significance or notifying the chief engineer.

The overflow

Shortly after the port settling tank's high level sensor activated at 1002, fuel levels in the tank increased to 90% and began overflowing into the port drain tank. At about 1030, the port drain tank's high level alarm activated and by 1043, the tank was likely full. Further fuel entering the tank should have overflowed through the drain tank vent head into the save-all on the main deck. Subsequently however, fuel levels began to rise past 90% in the port settling tank, and eventually overflowed through the goose neck vent into the port engine room's exhaust ventilation casing (see Figure 16 and Figure 17).

While at the repair yard in Singapore, the ship's owners engaged a marine surveyor to examine the drain tank, its air pipe and vent head. Examination of the drain tank vent head showed that the vent head was working normally with the wire gauze flame screen clear and unobstructed. Similarly, the drain tank air pipe was inspected by camera and checked by blowing compressed air through and found to be clear of any obstructions. The surveyor's examination also concluded that there was no trace of fuel having ever entered the air pipe although shipboard accounts of the fire dispute this conclusion as fuel was found in the port main deck save-all after the fire.

Examination of the vent head heating system found the heater in working condition when operated in manual mode. However, it was identified that heat was not developed in the vent head when the heating system was operated in automatic mode. The investigation identified that the thermostat, which controlled the heater in automatic mode, was not working as it was incorrectly electrically terminated.

Inspection of the ship's bridge logbook showed that air temperatures in the days leading up to the fire hovered around 0° C. Air temperatures the night before and the morning of the fire also remained just above freezing point. Weather entries also showed 6-7 m swells from the west-north-west (from the direction of the ship's port beam) in the 12 hours before the fire. It is likely that the drain tank vent head on the main deck was subject to freezing spray and build-up of ice in the days and nights preceding the fire. The failure of the tank vent head heater system meant that any built-up ice on the vent head likely remained frozen, either partially or fully blocking the port drain tank air vent pipe. This likely restricted the flow of overflowing fuel out of the port drain tank air pipe resulting in fuel levels in the settling tank rising in the settling tank air pipe and overflowing within the exhaust ventilation casing.

Fuel oil management plan

MPV Everest's SMS required the development of a fuel oil management procedure and that a fuel oil management manual was on board. While there was no evidence of these documents, there was a fuel oil management plan on board. The plan largely comprised procedures for bunkering and for ensuring compliance with international emission control regulations. The plan also included a section covering the internal transfer of fuel with some of the relevant guidance, requiring that fuel was to:

- be tested for water and bacteria before being used on board
- be transferred to the settling tanks, then to the purifier and to the day tanks
- remain in the settling tanks for at least 12 hours.

Additionally, the fuel oil:

- settling tanks were to be sampled at the drain cock and checked for water every 12 hours and the checks logged in the engine room logbook
- day tank were to be sampled at the drain cock and checked for water every 12 hours and the checks logged in the engine room logbook.

The plan did not include any guidance on the conduct of fuel transfers either by manual or automatic means, or of the associated risks and safety measures. There was also no guidance or checklists covering any special precautions that might be necessary when conducting fuel transfers in polar waters, such as checking that the air pipe vent head heating element was operating as required or that tank vent heads were ice-free.

There were no entries in the engine room logbook to indicate that the required fuel sampling and water checks were being conducted as required.

Air pipe design

SOLAS regulations, specifically Chapter II-2, sets out the fire protection, fire detection and fire extinction regulations for ships. The stated objectives of the regulations included the prevention of fire and explosion, reducing the risk to life caused by fire and to reduce the risk of damage caused by fire to the ship, its cargo and the environment. Regulations in Part B of Chapter II-2 were directed at preventing the ignition of combustible materials or flammable liquids by, among other means, controlling leaks of flammable liquids and preventing the accumulation of flammable vapours. These regulations included arrangements for the storage, distribution, and use, of fuel, lubricating oil and other flammable oils.

In particular, the regulations[25] stated:

> Provisions shall be made to prevent overpressure in any oil tank or in any part of the oil fuel system, including the filling pipes served by pumps on board. Air and overflow pipes and relief valves shall discharge to a position where there is no risk of fire or explosion from the emergence of oils and vapour and shall not lead into crew spaces, passenger spaces nor into special category spaces, closed roro cargo spaces, machinery spaces or similar spaces.

SOLAS regulations also required that ships be designed, constructed and maintained in compliance with the structural, mechanical and electrical requirements of a classification society recognized by the Administration.

Classification society rules

MPV Everest's dual classification working agreement between Bureau Veritas (BV) and the Russian Maritime Register of Shipping (RMRS) delegated responsibility for the ship's fire safety and hull and piping arrangements to BV. Consequently, BV classification society rules applied to these arrangements and systems.

BV classification society rules were consistent with SOLAS regulations on the subject of preventing overpressure in oil tanks[26] and stated that:

> Provisions are to be made to prevent overpressure in any oil tank or in any part of the fuel oil system. Any relief valve is to discharge to a safe position.

On board *MPV Everest*, the means to prevent overpressure in the port settling tank was the overflow pipe leading to the port drain tank which was fitted with a non-return valve (Figure 16). The port drain tank in turn was fitted with an air pipe which led to the open main deck. The design of the overflow system also complied with other classification society rules relating to the capacity of the drain tank, tank level alarms and installation of a sight-flow glass in the overflow line.

The use of the non-return valve on the settling tank's overflow line necessitated another means of supplying air to the settling tank during fuel oil transfer operations. Consequently, a pipe from the settling tank was provided, sited within a save-all located inside the engine room exhaust ventilation casing. BV stated that the open end of the pipe was located well above the drain tank air pipe, situated close to ventilation louvres and was not intended for overflow or venting purposes.

The ATSB requested clarification from BV as to whether the pipe was an 'air pipe' for the purpose of class rules. In response, BV advised that the definitions and meanings of pipe-systems were based on the functionality and associated risk in the specific design. BV also stated that, during the review of the ship's plans, no risk of fuel oil overflow from the settling tank air pipe was identified with regard to the normal operations of the ship.

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25 SOLAS Ch II-2/Reg 4.2.2.4

26 Bureau Veritas, 2014, Rules for the classification of steel ships, Part C - Machinery, Electricity, Automation and Fire Protection, Chapter 1, Section 10 – Piping systems, 11 Fuel oil systems, 11.3.2 Provision to prevent overpressure.

Nevertheless, classification society rules for the arrangement of air pipes of flammable oil tanks[27] also reflected SOLAS regulations and stated that:

> Air pipes from fuel oil and thermal oil tanks are to discharge to a safe position on the open deck where no danger will be incurred from issuing oil or gases.

RMRS rules were similarly consistent with SOLAS and BV rules for piping systems. However, RMRS advised that given the distribution of responsibilities under the dual classification working agreement, RMRS was not involved in the approval of arrangements for the fuel oil settling tank air pipe arrangement.

Class design approval processes

During the design and approval process of shipbuilding, the shipyard drafts plans for the ship and its various systems based on the shipowner's requirements. These plans are submitted to the classification society for review and validation by surveyors at the society's local plan approval offices (LPOs). LPO surveyors review plans against the society's rules and, where required, challenge elements of the shipyard's proposed design by issuing technical comments. The shipyard is then required to either justify or rectify the issues raised in the comment.

LPO surveyors are granted individual delegations under the authority of the classification society based on factors such as their theoretical and practical training, job experience and completion of qualifying examinations. There are 3 primary levels of delegations (levels 1, 2 and 3) each with different levels of autonomy with respect to the approvals of ship plans. Specifically, all LPO surveyors could carry out plan approvals however level 1 surveyors had 100% of their work supervised, level 2 surveyors had 50% of their work supervised and level 3 surveyors had 10% of their work supervised.

Approval of MPV Everest*'s plans*

The settling tank air pipes were originally designed by the shipyard to terminate externally above the engine room exhaust ventilation casings. However, the ship's owners requested that the design be modified such that the pipes terminated inside the casing (to prevent icing). The shipyard modified the ship's plans as requested by the owner and submitted the plans to BV for review and approval.

The technical comment document for the review of *MPV Everest*'s fuel oil transfer, overflow, purifier and auxiliary service piping system drawing showed no comments relating to the settling tank pipe and its location inside the exhaust ventilation casing.

The technical comment document for the review of the ship's tank air vent piping system included a request for the shipyard to confirm that the location and arrangement of vent pipes for fuel oil settling tanks (among others) were such that there was no risk of ingress of seawater or rainwater in the event of a broken pipe. The yard's response to this comment was that the settling tank vent was located inside the engine room exhaust ventilation casing and that consequently, there was no risk of seawater ingress. This justification was accepted and there were no further challenges made with regard to the siting of the settling tank air pipes.

Representatives of the ship's builders advised the ATSB that, to the extent of their knowledge, this particular siting of the settling tank air pipes was a one-off design feature.

Engineering challenges

Hand-over in South Korea

The conduct and effectiveness of the hand-over from *MPV Everest*'s existing crew to the crew for the AAD charter was limited by restrictions imposed by the coronavirus disease 2019 (COVID-19)

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[27] Ibid. 9 Air, sounding and overflow pipes, 9.1.7 Special arrangements for air pipes of flammable oil tanks.

pandemic (see the section titled *Influence of the COVID-19 pandemic*). The chief engineer reported that there was limited face-to-face interaction during the hand-over, but that the departing chief engineer provided detailed hand-over notes.

The chief engineer reported several observations from the departing chief engineer's hand-over notes that were indicative of the suboptimal state of the ship and its engineering systems. For example, the hand-over notes advised the relieving chief engineer that:

- there was no permanent technical superintendent assigned to the vessel [a technical superintendent was assigned to the ship in late 2020 but it had largely operated without one until then]
- the commissioning of the vessel had left a lot of open issues
- new issues were being discovered regularly due to the poor commissioning of the vessel
- the water mist system had a major error in pump layout and connections.

Planned maintenance system

The ISM Code required companies to establish procedures to ensure the ship was maintained in accordance with the relevant regulations. To achieve this, the company was required to ensure that inspections were held at regular intervals, that corrective action was taken to rectify any non-conformances and that records of these activities were maintained. The code also required the company to identify equipment and technical systems, the sudden operational failure of which, could result in hazardous situations and provide specific measures in the SMS aimed at promoting the reliability of these systems. These responsibilities were generally met through the implementation and use of a planned maintenance system (PMS) on board comprising a risk-based operational maintenance routine and a database of machinery, equipment and fittings, among others.

The SMS designated the chief engineer as the responsible person for ensuring timely completion of PMS jobs. The chief engineer was also required to compile and submit a list of overdue PMS jobs to the technical superintendent ashore on a monthly basis. The technical superintendent was responsible for oversight and monitoring of the PMS and for ensuring its effectiveness. However, there was no evidence that the progress of the PMS was monitored from ashore or that overdue PMS jobs were monitored on a monthly basis.

MPV Everest utilised a PMS software system known as 'TM Master'. Evidence indicated that there were nearly 300 overdue PMS jobs by the end of January 2021 with the number reported to be increasing daily. An examination of the PMS system by the ATSB on 15 April 2021 found that over 1,800 PMS jobs had been completed between December 2020 and April 2021. However, the ATSB also found over 160 overdue PMS jobs extending into the previous year. Similarly, an examination conducted as part of the shipowner's investigation on 29 April 2021 found 858 jobs due for completion with at least 650 jobs overdue, extending over the previous months and into 2020. These overdue jobs were not limited to the engineering department but included deck, safety and electrical jobs.

Tank inspections

The SMS required that the ship's tanks be inspected as scheduled in the ship's PMS. However, there was no evidence of scheduled tank inspections in the PMS for the fuel oil settling tanks, service tanks and the emergency generator fuel tank.

Spare parts

The relieving chief engineer was advised (in hand-over notes) that the ship's PMS was challenging, with many spare parts listed multiple times or connected to the wrong or missing components, with information such as serial numbers missing. The system's descriptions for many routine maintenance tasks were also reported to be wrong, incomplete or ambiguous.

The SMS's operations manual required that the PMS be used to identify, monitor and maintain a satisfactory inventory of the ship's critical spares. However, the chief engineer reported significant challenges relating to a general shortage of spare parts and equipment on board with some examples below:

- In early March 2021, the fuel oil booster pump for DG5 in the starboard engine room was replaced with the sole available spare booster pump on board. About 2 weeks later, on 18 March, the pump failed again resulting in DG5 being rendered inoperative.
- Following the fire, DG5 (operating with a fuel oil booster pump obtained from the damaged DG4) and DG6 were the sole remaining operational generators providing power for shipboard services and propulsion. However, there were several occasions during the ship's passage to Fremantle when DG6 had to be shut down and repaired due to water leaks from the generator's cooling water manifold. The manifold was temporarily repaired using a clamp from DG1 in the fire-affected port engine room.
- In the port engine room, the pre-lubrication pump for DG3 was inoperative with no spare pump available on board. This meant that DG3 could not be kept in stand-by mode for DP operations and could only be started manually (the chief engineer used the stand-by lubricating oil pump to start DG3 when required).
- The fuel filters on the ship's diesel generators required replacement relatively frequently however, by the time *MPV Everest* arrived in Fremantle, the ship's stock of filters had reduced to a critically low level.

There were also several other anecdotal accounts of a shortage of spare parts for the ship's cranes, tugger winches, and FRCs. In addition, a general shortage of lashing and securing equipment on board was reported by the ship's crew and AAD staff.

Workload and complexity

MPV Everest was a highly complex ship with a broad range of capabilities, including the various systems, equipment and machinery that allowed the vessel to operate in ice. The chief engineer reported that the workload and engineering situation on board was challenging from the outset.

MPV Everest was built in Singapore and largely operated in the tropics or in ice-free waters off Sakhalin Island. The voyages to Antarctica were the first time the ship was operated in ice and many challenging engineering issues emerged, including issues related to cooling systems, newly installed 3-way regulating valves, water production, steam systems, and icing of sea chests. This workload was further exacerbated by issues such as manning, the design of the ship's IAS system, the PMS and weather conditions.

Engineering complement

The planned complement of engineering watchkeepers for *MPV Everest*'s AAD charter called for a chief engineer, 2 second engineers and 2 third engineers. An additional second engineer was added as a contingency in the event that one of the second engineers had to be relieved at short notice in the challenging crewing environment of the COVID-19 pandemic. The non-watchkeeping members of the ship's engineering team comprised the chief electrician, ETO and engine ratings.

The working arrangements called for 2 second engineers to keep 12-hour watches (assisted by a third engineer and an engine rating) while the third second engineer undertook day work. The chief electrician kept the 0600-1800 watch assisted by the electro-technical rating while the ETO kept the 1800-0600 watch. The chief engineer was responsible for oversighting the engineering department, maintenance as per the ship's PMS and procurement of spare parts among other things. During the port call at Hobart following the end of the first voyage to Antarctica, one of the second engineers disembarked on compassionate grounds and another was replaced as part of a planned crew change. The ship subsequently departed for Antarctica with 2 instead of 3 second engineers.

On 23 February, when the ship arrived at Davis station, one of the second engineers was declared unfit for engineering watchkeeping duties and relieved of their engineering duties. This left only one second engineer available for duty and, hence, the chief engineer assumed the other 12-hour watch.

From then on, the sole remaining second engineer kept the 1800-0600 watch while the chief engineer kept the 0600-1800 watch in addition to their other oversighting responsibilities.

Watchkeeping practices

MPV Everest's SMS required the chief engineer to ensure that engine room watchkeeping arrangements were adequate to maintain a safe engineering watch and that the engineer in charge of the watch was not to be assigned, and did not undertake, any task or duty that could interfere with their watchkeeping duties.

On the morning of the fire, the chief engineer was aware that a non-watchkeeping engineer was acknowledging and accepting alarms. The chief engineer acknowledged that a non-standard practice had developed on board of allowing non-watchkeeping engine room staff, in particular the ship's highly experienced chief electrician, to acknowledge and accept engineering alarms. The chief engineer reported that they tolerated this practice as it allowed the duty watchkeeping engineers to focus on work in the engine rooms without having to frequently attend to alarms in the ECR. The development and tolerance of this practice of convenience was attributed to several different factors including the:

- high workload and complexity associated with the ship's engineering systems
- reduced manning of the engineering team
- IAS design which restricted the audible alert for most alarms to the ECR
- high number and frequency of engineering alarms.

Interviews with the ship's engineers identified that a key factor that influenced engineering practice on board was the volume of alarms generated. For example, ATSB analysis of data showed that, in the 24-hour period of 4 April 2021, with the ship out of polar waters and steaming on passage for Hobart, there were 197 engineering alarms generated (an average of 1 every 7 minutes). The categorisation of tank level alarms as non-critical alarms meant that many alarms including ballast and fuel tank level alarms only sounded in the ECR. To effectively monitor these alarms would have required a watchkeeping engineer to be permanently stationed in the ECR which in turn reduced the number of personnel available for maintenance and repairs.

Alarm fatigue

Li and others (2017) explain that alarm fatigue refers to a distrust or neglect of triggered alarms.[28] Alarm fatigue occurs when a person is exposed to a large number of frequent alarms and becomes desensitised to them, potentially resulting in longer response times or crucial alarms being missed altogether. The research went on to explain that system design plays a large role in reducing alarm fatigue and restoring operators' trust in the system.

In circumstances where an alarm sounds even if no actual failure conditions exists, it can result in operator mistrust in the system and consequently, disuse of the system (Wickens and Holland, 2000).[29] Incidents may then occur because a valid alarm was ignored or because an alarm drawing attention to a critical condition was never announced in the first place because the system had been turned off previously.

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28 Li F, Lee CH, Xu G, Chen CH, Khoo LP. A QFD-enabled conceptualization for reducing alarm fatigue in vessel traffic service centre. In Transdisciplinary Engineering: A Paradigm Shift 2017 (pp. 821-828). IOS Press.

29 Wickens CD, and Hollands, JG, 2000. Engineering Psychology and Human Performance, Prentice Hall, New Jersey, USA.

Of the 197 alarms recorded on 4 April 2021, about 30 resulted in the monitored variable being designated 'Abnormal' (including the port settling tank).

On board *MPV Everest*, fuel tank and ballast tank high level audible alarms were frequently generated in the ECR, particularly when the ship was rolling (due to the associated movement of fluid activating the tank's high level sensors). The IAS's application of the 'Abnormal' designation inhibited the generation of such repetitive alarms. Ship's engineers, including the chief engineer, indicated that they were aware of the IAS's application of the 'Abnormal' designation and the consequent isolation of the monitored alarm variable. Further, interview evidence indicated that frequently occurring alarms (such as tank alarms) were sometimes intentionally acknowledged (silenced) but not accepted and that this practice had developed so as to allow these alarms to be designated 'Abnormal' thereby reducing further incidence of such alarms.

Unattended machinery space operations

MPV Everest was approved and equipped for unattended machinery space (UMS) operations. Effective UMS operations use automation systems to allow for better fatigue management for engineers, flexibility in watchkeeping arrangements and the ability to better allocate resources to maintenance and other work. However, *MPV Everest* was operated exclusively in 'attended' mode, with engineering watchkeepers on duty at all times, including while steaming on passage. The high number and frequency of engineering alarms was one of the factors that made it impractical to operate the ship in UMS mode thereby necessitating attended engine rooms at all times.

Fatigue

The International Maritime Organization (2019)[30] defined fatigue as:

> A state of physical and/or mental impairment resulting from factors such as inadequate sleep, extended wakefulness, work/rest requirements out of sync with circadian rhythms and physical, mental or emotional exertion that can impair alertness and the ability to safely operate a ship or perform safety-related duties.

Fatigue is a hazard because it affects everyone regardless of skill, knowledge and training and may affect a seafarer's ability to do their job effectively and safely. The effects of fatigue can be particularly dangerous in the transportation sector, including the aviation and maritime industry.

Fatigue can be caused by any one or more of a range of factors including:

- lack of sleep (or inadequate restorative sleep)
- poor quality of sleep and rest
- staying awake for long periods
- stress
- excessive workload (strenuous or prolonged mental and/or physical exertion)
- inadequate food and fluid intake
- adverse environmental conditions (extremes of temperature, low light levels, vibration, rolling/pitching and confined spaces)
- periods of monotony or boredom.

Fatigue can have a range of effects on human performance, including decreased short-term memory, slowed reaction time, decreased work efficiency, reduced motivational drive, increased errors of omission, lapses in attention, increased distractibility and reduced vigilance and reaction time.

[30] International Maritime Organization, 2019, MSC.1/Circ.1598 Guidelines on Fatigue, London, United Kingdom.

Reviews of fatigue research have made the following observations:

- a common symptom of fatigue is a change in the level of acceptable risk that a person tolerates, or a tendency to accept lower levels of performance and not correct errors
- most people need 8 hours sleep each day to achieve maximum levels of alertness and performance
- fatigue is cumulative
- there is a discrepancy between self-reports of fatigue and actual fatigue levels, with people generally underestimating their level of fatigue.

An analysis of seafarer survey data dealing with the impact of fatigue on cognitive functioning and safety (errors of attention, memory and action), contained in a Cardiff University seafarer fatigue study,[31] showed that:

> ...those who reported high levels of fatigue were at a greater risk of making frequent cognitive failures. Frequent cognitive failures were also more likely to be reported by: those doing shorter tours of duty; those doing 6 or 12 hour shifts; those with poor sleep quality; those exposed to physical or environmental hazards; those with high job demands; those with high levels of stress at work; officers; and older workers.
>
> These findings suggest that, as well as general fatigue risk factors, seafaring is subject to additional specific fatigue risk factors that are particularly linked to poorer cognitive function.

Fatigue management

MPV Everest's management and safety manuals both addressed the subject of fatigue. The safety manual described the acute and chronic consequences of fatigue and emphasised that work was to be planned to ensure that personnel were receiving adequate hours of rest. The manual also described several measures that were to be taken into consideration to reduce the potential of personnel becoming fatigued including ‘minimising the possibility of extended rotations through effective crew management’.

The management manual required the master to ensure that the fitness for duty requirements of the STCW Code were complied with by ensuring that the ship's work and watchkeeping schedule allowed for each crew member to be satisfactorily rested. The SMS reflected the rest hour requirements of the STCW Code, specifying that minimum hours of rest should not be less than 10 hours in any 24-hour period and not less than 77-hours in any 7-day period, and required the master to ensure that hours of rest were recorded for all crew. Additionally, the chief engineer’s standing instructions also stated that all staff were to record their respective hours of rest.

Recorded hours of rest

The ATSB determined that the chief engineer’s rest hour records did not accurately reflect their hours of work and rest. Examination of the chief engineer’s rest hour records for the days in April leading up to the fire consistently showed the hours between 1800-0600 logged as hours of rest. However, the records also showed the chief engineer at rest between these hours on the day of the fire and in the days following the fire, which certainly was not the case. The chief engineer’s records for the months of January, February and March were similarly inaccurate and unrealistic and showed a uniform trend of the hours between 1800-0600 marked as rest hours without allowance for other activities such as drills, port calls and emergencies.

Assessment of the rest hour records of other crew showed similar unrealistic trends of their off-duty hours logged as rest hours regardless of participation in other necessary work activities during those periods.

[31] Smith, A. Allen, P. Wadsworth, E. Seafarer fatigue: The Cardiff Research programme. Centre for Occupational and Health Psychology, Cardiff University. November 2006.

For example, the rest hours records for the off-duty second engineer and second mate showed them at rest on 29 January 2021 during the time of the battery room fire and ensuing emergency muster involving all personnel. Similarly, the second engineer's rest hour records show them resting at the time of the fire on 5 April. Analysis of records for other crew similarly show them at rest during drills and emergency musters that were recorded as having been attended by all personnel.

Biomathematical fatigue models

Biomathematical models are tools for predicting crew fatigue levels based on a scientific understanding of the factors that contribute to fatigue.[32]

The ATSB primarily uses 2 software programs— Fatigue Avoidance Scheduling Tool (FAST®) and FAID Quantum—in seeking to quantitatively predict fatigue risk. Each tool has its own specific applications and limitations.

FAST

FAST is a software decision aid designed to assess and forecast performance changes induced by sleep restriction and time of day. No planning software, including FAST, can predict fatigue or fatigue-induced errors in all cases or for all individuals. The tool can only forecast the effects of sleep and circadian rhythms on performance and cannot account for other factors that alter performance such as training, experience, stress, illness, or other variables that are known to affect performance.

The FAST software predicted that, on the morning of the fire, the chief engineer would have started their watch with an effectiveness criterion of around 58%.[33] This improved for a brief period in the early morning, before declining to around 59% again at 0926 (the time the fuel transfer commenced). At this time, the model predicted a lapse index of 8.5 and a reaction time factor[34] of 171%.

Lapses are excessively long reaction times associated with 'micro-sleeps'. As effectiveness decreases, the probability of lapses increases. During an average day in a well-rested person, the lapse index averages 1.0 and ranges from about 0.2 to 1.5. A lapse index of 8.5 means that lapses are 8.5 times more likely than would be expected during an average day in a well-rested person.

At 1058 (the time the fire broke out), the FAST model predicted an effectiveness of around 57%.

The FAST analysis flagged the low level of sleep in the previous 24 hours, the chronic sleep debt[35] and the hours awake as the primary contributing factors to the calculated score.

FAID Quantum

FAID does not predict fatigue but rather predicts sleep opportunity, based on the chief engineer's interview evidence.

A FAID score indicates different levels of fatigue exposure for different work hours and can provide an indication of the likelihood of performance impairment associated with fatigue. The higher the FAID score the higher the fatigue exposure. For example, a standard 40-hour work week (Monday to Friday 0900-1700) results in a FAID score of 41 while a 40-hour week of night shifts (Monday to Friday 2300-0700) results in a FAID score of 97. Scores between 80-100 (high fatigue likelihood) have been compared to a level of fatigue-related impairment after 21-24 hours

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[32] Civil Aviation Safety Authority, 2014, Biomathematical Fatigue Models Guidance Document, Canberra, Australia.

[33] An effectiveness criterion below 65% represents performance effectiveness after 2 days and a night of sleep deprivation. Under these conditions, no one can be expected to function well on any task (Paul, Hirsh and Miller, 2010).

[34] Reaction time factor is a value that is the average reaction time, expressed as a percent of the average reaction time of a well-rested person.

[35] Chronic sleep debt is the cumulative number of hours of sleep that have been missed since the last time the sleep reservoir was full.

of continuous sleep deprivation. Performance at this level has also been argued to be comparable to performance at a blood alcohol content (BAC) of 0.05 percent (Dawson and Reid, 1997).[36]

The ATSB's FAID analysis showed that from the time the chief engineer commenced work to the time of the manual fuel transfer and subsequent fire, they were operating with a peak FAID score of 106.

Conclusion

Biomathematical modelling using FAID and FAST both predicted a reduction in the chief engineer's alertness around the time of the manual fuel transfer and the fire.

Sleep

Inadequate quantity and quality of sleep is a primary contributor to fatigue. Most people generally require 7-8 hours of sleep to achieve a maximum amount of alertness and performance. Inadequate sleep can result in acute or chronic sleep debt, which is the difference between the amount of sleep you should be getting, and the amount acquired below that. Sleep debt can be cumulative and can result in degraded performance (Orlady & Orlady, 1999, Hawkins, 1993). While many of the effects of fatigue generally only appear after substantial levels of sleep deprivation, even the loss of sleep for one night can have negative effects on several aspects of human performance.

The chief engineer kept the 0600-1800 watch and reported that on completion of their watch, they usually went to bed between 2000-2100 and typically obtained about 6 hours of sleep. They usually woke between 0330-0400 and worked for a while in their office before having breakfast and presenting in the ECR for their watch at about 0545.

The ATSB interview of the chief engineer included obtaining a 72-hour history of their work and rest hours. The night before the fire, the chief engineer reported not getting any sleep primarily due to the ship's rolling and, by the morning of the fire, they had probably been awake for 25-30 hours. Over the previous 2 nights, it is likely that the chief engineer had obtained 5-6 hours of medium quality sleep each night.

Workload

Workload is described by Wickens and Hollands, 2000:[37]

> Mental workload characterises the demands of tasks imposed on the limited information processing capacity of the brain in much the same way that physical workload characterises the energy demands upon the muscles. In any resource-limited system, the most relevant measure of demand is specified relative to the supply of available resources.

Humans are limited in the amount of new information their brain can process at once. Once this limit of cognitive resources has been reached their performance starts to decline with increased error rates and delayed responses, thus resulting in cognitive overload and thus mental fatigue. The relationship between workload and fatigue can be complex, predominantly as both underload and overload can contribute to fatigue (Grech, Neal, & Geo, 2009).[38] ATSB fatigue information outlines that both the cognitive and physical demands of the work, as well as pace/time pressure can all impact upon an individual's fatigue levels.

In the 40 days before the fire, the chief engineer kept a daily 12-hour engineering watch in addition to their significant responsibilities as head of the engineering department. The chief engineer also

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36 Dawson, D., Reid, K. Fatigue, alcohol and performance impairment. Nature 388, 235 (1997).

37 Wickens CD, and Hollands, JG, 2000. Engineering Psychology and Human Performance, Prentice Hall, New Jersey, USA.

38 Grech M. R., Neal A., Yeo G., Humphreys M., Smith S. (2009). An examination of the relationship between workload and fatigue within and across consecutive days of work: Is the relationship static or dynamic? Journal of Occupational Health Psychology, 14, 231–242.

reported that several factors contributed to an extremely challenging workload for the engineering department in general and for the chief engineer specifically. This included the:

- limitations on the hand-over in dry dock in South Korea
- fact that most crew, including the chief engineer were new to the ship and to polar operations
- reduction in manning levels following the first voyage to Antarctica
- design and set-up of the ship's IAS and alarm systems as well as more general engineering issues.

On the morning of the fire, the damage to DG4 and the ensuing loss of power generation redundancy caused the chief engineer additional stress and increased their workload further.

Distraction

Distractions during the completion of a task increase the likelihood of error. Distractions can be related to the task or from some external, unrelated source or event. An individual, or team, can also become completely occupied (fixated) with one event or task and therefore distracted from other tasks or operations requiring attention.

On the morning of the fire, the chief engineer determined that there was significant, irreparable crankshaft damage to DG4. To restore redundancy on board, the chief engineer decided that repairing DG5 using parts from the damaged DG4 was a priority task. The chief engineer then commenced a routine fuel transfer before starting work to restore DG5 to service, which most probably distracted them from monitoring the ongoing fuel transfer.

Summary

Based on reported sleep history alone, it is likely the chief engineer was experiencing a level of fatigue known to have an effect on performance due to lack of recent sleep.

The chief engineer had been performing watchkeeping duties as well as chief engineer duties for 40 days prior to the fire and had been onboard the ship for about 4 months. It is likely that this influenced cumulative fatigue, however without accurate sleep and rest data for the weeks prior to the fire this aspect was not examined in detail. Nevertheless, it is likely that the chief engineer's alertness was reduced due to a number of other factors including the high workload and high stress environment on board, lack of sleep and distraction by the task of repairing DG5.

Origin and cause of the fire

Examination of fire scene

Following *MPV Everest*'s arrival in Fremantle, ATSB investigators, including those with a background in marine operations and data recovery, attended the ship to conduct interviews and collect other evidence. ATSB investigators were also accompanied by a fire investigator from Airservices Australia (ASA)[39] engaged as a subject matter expert under the *Transport Safety Investigation Act 2003*. The fire investigator examined the port and starboard engine rooms, accessible areas of the port engine room exhaust ventilation casing and fire-affected areas outside the ventilation casing louvres. For reasons relating to safety and accessibility, areas of the port engine room and casing had been cleaned following the fire. This included cleaning of fuel and fuel residues and removal of some fire-affected materials, debris, and equipment. While this impacted to some extent on assessing the evidence, the following is a summary of relevant observations from these examinations.

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[39] Airservices Australia is a government-owned organisation responsible for, among other things, aviation rescue firefighting services.

Port engine room – Tank top

The port engine room tank top showed mild sooting increasing from aft to forward. There was increased sooting observed on the forward, upper surfaces of DG2 and DG3, with DG2 more heavily affected than DG3. Colour changes to polycarbonate light fittings on this deck indicated that temperatures had reached at least 145° C. At the forward end of the tank top, there was evidence of fuel at deck level and damage to plastic fixtures there indicated that temperatures had been higher forward than further aft.

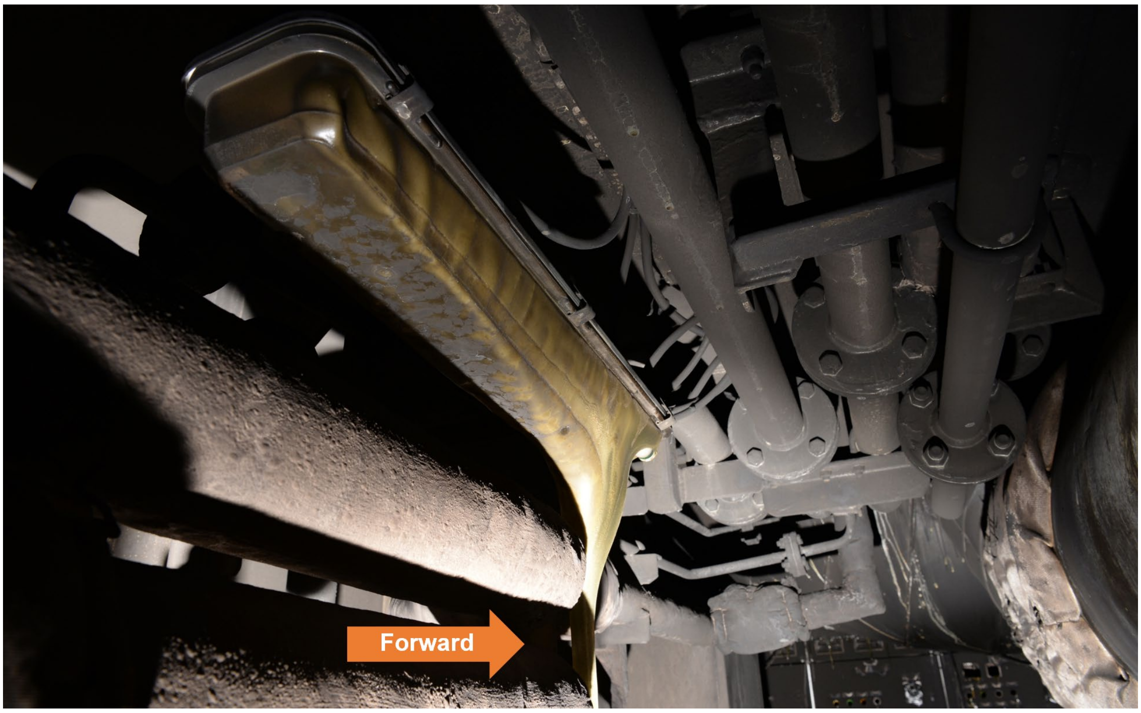
Port engine room – B-Deck

B-Deck generally showed increasing thermal damage and soot density from aft to forward, increasing with height. Colour changes to light fittings on the centreline bulkhead (on the starboard side of the port engine room) indicated temperatures had reached at least 145° C with no evidence of thermal damage to electrical cabling and pipework in this area. In the middle of the engine room, melted light fittings indicated temperatures of up to 300° C with cabling showing signs of sooting but only minimal thermal damage. On the port side, the forward end of a light fitting was melted while the aft end was intact but deformed indicating increased temperatures forward (Figure 18). Similarly, paint on handrails on centreline of the engine room was heavily sooted but intact whereas paint on the handrails on the port side had either decomposed or blistered with the extent of the damage increasing moving forward.

At the forward end of the port engine room, light fittings located on the bulkhead displayed complete decomposition of the light fittings indicating temperatures here had exceeded 480° C. Soot density and thermal damage both increased moving from starboard to port towards the area where the exhaust ventilation casing ascended upwards from the engine room. Lagged pipework in this area displayed areas of thermal cracking increasing with height indicating rising thermal temperatures from deck to deckhead.

There was no fire or thermal damage to DG1, DG2 or DG3 although sooting density increased on DG2 and DG3 from aft to forward.

Figure 18: Light fitting on B-Deck



Source: ATSB

DG exhaust trunking

The exhaust trunkings for the 3 diesel generators comprised a metal exhaust duct surrounded by insulation material contained within an exterior galvanised sheet metal cover with brace joinery securing the trunking at various locations. The section of exhaust trunking emerging from DG3 showed sooting but no sign of oxidation while the corresponding section from DG2 showed sooting, unburnt diesel residue and some evidence of surface combustion on lagged areas. The exhaust trunking emerging from DG1 showed no thermal damage, with sooting increasing from aft to forward.

All 3 exhaust trunkings showed heavy sooting. The underneath of the trunking for all 3 generators had zinc oxide trails, particularly where the trunking bent upwards to enter the exhaust ventilation casing indicating localised surface temperatures above 450° C. The upper surfaces of DG2's trunking showed evidence of increased oxidisation, presenting as orange oxides, indicating that the surface temperature was above 750° C, particularly around the location of the brace securing (Figure 19).

Figure 19: Upper surfaces of DG2 exhaust trunking

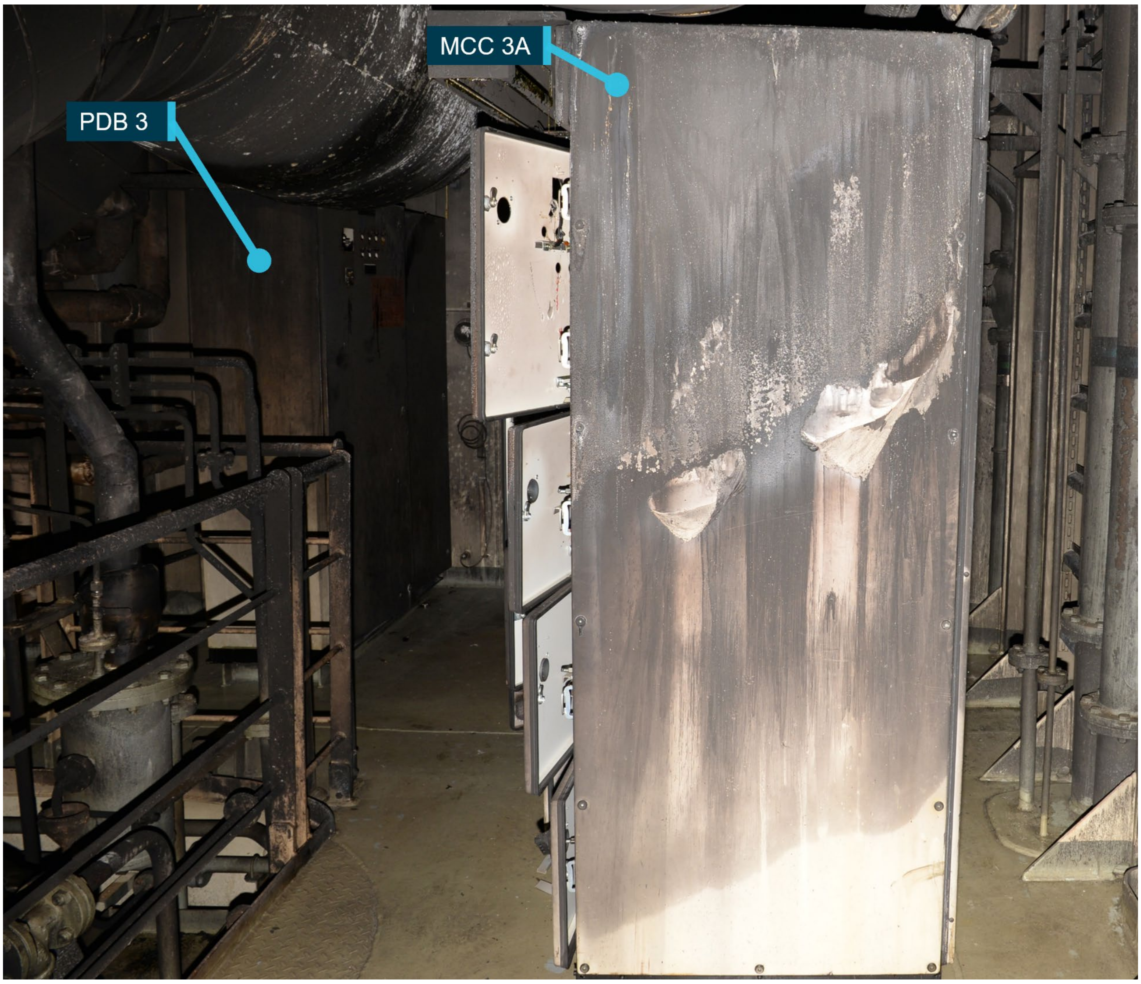
Source: ATSB

Electrical enclosures

The external surfaces of the power distribution board on B-Deck (PDB 3) showed thermal damage to all surfaces. Almost all indicators, lights and switches had fallen into the cabinet and the single intact switch had melted and charred indicating direct flame contact. The interior showed no signs of combustion within the cabinet, other than localised charred plastics and thermal damage to the upper door seals. There was no evidence of arcing of the lights, gauges, and switches. There was sooting present across the PDB's bus bars but no signs of arcing. There were signs of diesel residue throughout the interior and pooled liquid diesel was present at the bottom.

The external surfaces of the 440 V motor control centre (MCC 3A) showed more thermal damage to the upper and aft-facing surfaces. The top of the enclosure showed increased thermal damage on the starboard side below the exhaust trunking of DG2 and DG3. The front of the enclosure (consisting of 5 columns of doors) showed more thermal damage to the starboard side than the port side. The port side doors showed more thermal damage to lower door surfaces, indicating combustion at deck level, while the starboard doors showed even thermal damage to both upper and lower door surfaces indicating combustion occurring above the cabinet and at deck level. The starboard end of the MCC presented with increased thermal damage radiating from lower to higher surfaces (Figure 20).

Figure 20: Electrical enclosures at forward end of B-Deck



Source: ATSB

The interior of the MCC had mild sooting throughout with intact door seals showing minor thermal damage. There was melting and charring of switches and indicator lights but no evidence of arcing. A bank of indicator lights in the third column showed deeper charring than others and was removed by the ATSB for analysis. However, further examination did not identify any obvious signs of arcing or short circuiting. There was liquid diesel at the bottom of the MCC enclosure.

Exhaust ventilation casing – A-Deck

The space within the port engine room exhaust ventilation casing at the A-Deck level generally showed sooting throughout, although bulkhead paint was intact and not blistered. The deck was constructed of FRP grating and showed increased thermal damage to its upper surfaces. Various pipes, including the port settling tank air pipe passed through this space and showed signs of sooting, but with paintwork largely intact.

The exhaust trunkings of all 3 generators passed upwards through this space and were covered in sections of synthetic fabric insulation. The insulation on DG1's trunking showed signs of sooting but no combustion. The insulation on DG2's trunking showed signs of sooting and combustion, with the upper section of insulation showing evidence of having been soaked in fuel. Similarly, the upper section of insulation on DG3's exhaust trunking also showed evidence of soaked fuel. There was a gap between the upper and lower sections of insulation on DG3's exhaust trunking, exposing a flanged joint where 2 sections of the trunking were bolted together (Figure 21). There was oxidisation present on the exposed section of the flange with the burn pattern indicative of being affected by airflow from right to left. The section of insulation located above the exposed flange showed signs of combustion with oxidisation and burn patterns radiating upwards and outwards indicative of an upwards airflow.

Figure 21: Gap in sections of insulation on exhaust trunking of DG3

Source: TMC Marine, modified and annotated by the ATSB

Exhaust ventilation casing – Main deck

At the main deck level, the exhaust trunkings of the 3 generators bent and exited the ventilation casing through the forward bulkhead thereby presenting a horizontal profile with respect to the vertical casing. The deck consisted of an FRP grating with a small section of steel deck bounding the space with evidence of liquid diesel present. The deckhead above was partially composed of FRP grating and a steel deck.

The exhaust trunking of DG1 showed mild signs of zinc oxidisation on the side facing DG2's trunking, indicating surface temperatures were over 450° C. The exhaust trunking of DG2 and DG3 included a section of fabric insulation about midway through the space just below the bend. The insulation showed signs of combustion and evidence of being fuel soaked. The trunkings showed mild signs of zinc oxidisation below the insulation indicating surface temperatures of over 450° C. Above the insulation, the trunkings showed signs of increased oxidation evidenced by the presence of orange iron oxides indicating surface temperatures over 750° C. The increased oxidation continued along the horizontal sections of the trunking to their exit forward.

Exhaust ventilation casing – Lower forecastle deck

This section of the ventilation casing included a watertight access door which showed signs of combustion with decomposed paint, heavy sooting, and oxidisation but no fire penetration to the exterior. The bulkheads bounding the space showed a clear demarcation between lightly and heavily sooted areas indicating a boundary between areas affected by the fire plume and hot gas. Pipework in the forward end of the space were more heavily affected, with oxidisation greater near the deck increasing upwards indicating direction of the thermal source (Figure 22). Pipework located aft showed heavy sooting and accumulated unburnt diesel residue.

Figure 22: Interior of exhaust ventilation casing at lower forecastle deck level

FRP grating deck replaced on board prior to investigator access.
Source: ATSB

Cable trays located in the upper area of this space showed more combustion damage in the centre of the space (in the path of the airflow upwards) than near the bulkheads. Cables at the forward end of the space were the most fire-affected with the clean burning of the cable inner and outer sheath indicative of direct flame contact and surface temperatures exceeding 650° C.

Exhaust ventilation casing – Forecastle, accommodation and upper accommodation decks

The section of the ventilation casing comprising the forecastle, accommodation and upper accommodation decks had no FRP grating, although the space was partially delineated by a steel deck at the accommodation deck level (Figure 23). Several of the pipes transiting these levels bent at the accommodation deck level before continuing vertically upwards. Pipework at the forward end of the space showed even fire damage along their length with damage greater on the side facing the centre of the casing. Horizontal sections of pipe showed heavy oxidisation with minimal sooting, indicating this area was subject to direct flame and hot gases. The oxidisation was also heavier on the upper surfaces of these pipes with visible oxidised liquid trails to lower surfaces, indicative of combusting liquid fuel falling from above. Evidence of clean burn areas at the accommodation deck level and increased levels of sooting indicated areas affected by direct flame and hot gases.

Figure 23: Forecastle deck, accommodation deck and upper accommodation deck

Photograph taken looking upwards from the lower forecastle deck. The visible grating at the top of the uppermost level of the exhaust ventilation casing where the port fuel oil settling tank air pipe and save-all was located.
Source: ATSB

Exhaust ventilation casing – Upper level (Exterior)

The engine room exhaust ventilation casing terminated in a compartment on the upper accommodation deck. Access to the interior of the casing was by a manhole on the aft bulkhead. The exterior of the outboard bulkhead (port side) showed a radiating fire pattern with the highest intensity of damage at the aft end decreasing moving forward.

Airflow from the engine room exited the ventilation casing by means of 4 ventilation louvres—3 on the starboard side of the casing facing inboard and one louvre aft of the casing. The louvres could only be opened or closed manually by means of levers on the exterior of the casing. The ventilation louvres on the inboard bulkhead showed greater oxidisation and thermal damage than the aft louvre. The lower sections of the inboard louvres showed heavy sooting while the upper sections showed evidence of clean burning and complete decay of paintwork indicating temperatures over 650° C and contact with direct flame and hot gas.

The external deck which formed the upper boundary of the ventilation casing contained goose-neck terminations of 11 pipes with 3 each in 2 save-alls and the rest terminating on the open deck (Figure 24). The goose-neck pipe terminations showed heavy sooting particularly on the side facing inboard. The deck itself showed large areas of paint damage and oxidisation. Handrails around the deck showed evidence of metal deformation due to thermal stress.

Figure 24: Top of exhaust ventilation casing

Source: ATSB

Exhaust ventilation casing – Upper level (Interior)

Inside the exhaust ventilation casing, the deck was composed of FRP grating which showed increased thermal damage to its upper surfaces. Burnt fibres from the deck grating in an area of clean burn remained in a vertical position indicating airflow from below.

The interior showed heavy sooting forward on the port bulkhead with thermal damage and a clean burn pattern evident aft. There was heavy sooting on the starboard bulkhead below the louvres with evidence of a clean burn on the louvres themselves indicating direct flame contact. Similarly, all pipework including the port settling tank vent pipe in the save-all showed oxidisation, indicating direct flame contact (Figure 25). The deckhead showed heavy sooting and increased thermal damage in the centre and aft areas.

Figure 25: Interior of exhaust ventilation casing (upper level)

Source: ATSB

Area outside exhaust ventilation casing louvres

The area outside the exhaust ventilation casing was used as a storage area for various pieces of equipment. The equipment included 2 rigid hull inflatable boats (RHIB) with outboard motors, Yokohama fenders with attached chains and shackles and several pallet cages with smaller fenders, cordage, and other equipment (Figure 26). Examination of this area showed general fire damage extending about 5 m from the ventilation louvres. The RHIBs were located directly outside the 3 ventilation louvres and generally showed greater fire damage on the side facing the louvres.

Figure 26: Boats, fenders and other equipment outside casing

Source: Fox Offshore

CCTV footage

There were several closed-circuit television (CCTV) cameras sited at various locations on board, including in the engine room, beneath the port bridge wing, looking aft at the main deck port crane and on the forecastle. At the time of the fire, the engine room CCTV cameras were not operational.

The port bridge wing camera was pointed out to sea and did not cover the exhaust ventilation casing however footage from this camera captured a plume of black smoke after the initial eyewitness sighting of flames from the ventilation casing.

Witness accounts and mobile phone footage

On the morning of the fire, personnel on the bridge included the 2 second mates and 3 AAD staff stationed on the port side of the bridge conducting seabird observations. The AAD staff were the first to sight the fire and captured mobile phone footage and photos of the flames and smoke.

VDR audio and eyewitness accounts indicated that there was an initial deflagration[40] event, with flames emanating from the inboard ventilation louvres of the casing, 3-4 seconds before recorded data showed the activation of the smoke and flame detectors in the engine room. Shortly after, witnesses reported hearing the fire alarm sounding.

Photos and video footage captured after the initial deflagration showed the RHIBs on the upper accommodation deck alight and smoke (but no flames) issuing from the louvres.

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40 Propagation of a combustion zone at a velocity that is less than the speed of sound.

Figure 27: Photo taken just after initial deflagration

Source: Jason Mawbey

Footage captured about 35 seconds later showed a further deflagration event with large flames issuing from the ventilation louvres. Based on the above evidence, it was estimated that the initial deflagration occurred at about 1058:17 and the second deflagration occurred about 40 seconds later, at about 1058:57 (Figure 4).

Fire investigation

Based on the available evidence, the investigation identified the following 4 potential ignition scenarios:

- spontaneous ignition
- electrical arcing and spark discharge
- hot surface ignition
- electrostatic ignition.

Spontaneous ignition

Spontaneous ignition occurs when an organic material reacts with oxygen to emit heat and continues to do so until thermal runaway[41] occurs, resulting in the ignition of the material.

The tendency of a liquid fuel to ignite due to spontaneous heating depends on its flash point temperature (FP)[42] and its relationship to the fuel's automatic ignition temperature (AIT).[43] SAB diesel has a FP of 75° C and an AIT of about 232° C.[44] Generally, liquids with a FP below 80° C

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[41] Thermal runaway: An unstable condition when the heat generated exceeds the heat losses within the material to the environment.

[42] Flash point temperature (FP) is the lowest temperature at which a liquid will emit sufficient vapours to support a momentary flash (but not sustained combustion) across its surface when an ignition source is introduced.

[43] Automatic ignition temperature (AIT) is the minimum temperature to which a flammable mixture must be raised to initiate combustion without any external ignition source (such as a spark or flame).

[44] The manufacturers of SAB diesel, British Petroleum (BP), could not provide an AIT for the product. Consequently, an AIT of about 232° C was estimated as being suitable based on an assessment of diesel products with a similar cetane index and flash point temperature.

evaporate readily and therefore possess little to no tendency to self-ignite. Empirical calculations also indicated that SAB diesel does not have the propensity to undergo self-heating at normal temperatures.[45] Spontaneous heating of diesel could occur under elevated temperature conditions (such as fuel soaked insulation on generator exhaust trunking). However, the time required for such heating would generally be greater than the 5.5 minutes between the tank overflowing and the activation of the first flame detector. There was also no identified physical evidence of spontaneous combustion within the fire scene.

Therefore, it was considered unlikely that spontaneous ignition was the source of ignition.

Electrical arcing and spark discharge

Electric currents have the potential to deliver a charge that, if sufficiently high, can result in either an electric arc (sustained) or spark (unsustained), which can ignite flammable products.

Examination of electrical circuits, light fixtures and other cabling in the exhaust ventilation casing and on the engine room's B-Deck did not identify any visible signs of arcing or short circuiting. The PDB and MCC on B-Deck were examined to check for signs of arcing or short circuiting. Both electrical enclosures were fire affected externally and showed signs of sooting and pooled diesel internally. However, there were no obvious signs of arcing or short circuiting and there was no evidence of internal combustion within these electrical enclosures. Furthermore, the flame detector on B-Deck in the port engine room did not activate until about 4 seconds after the first deflagration event above at the ventilation louvres.

Therefore, it was considered unlikely that electrical arcing or spark discharge was the source of ignition.

Hot surface ignition

Hot surface ignition is a type of ignition where evaporated fuel vapours are ignited by contact with a hot surface at or above the fuel's AIT. In addition to the fuel's AIT, hot surface ignition is dependent on several other variables including the shape and surface area of the heated surface, quantity of fuel exposed, fuel flow, air flow and the fuel's residence time.

SAB diesel had a lower flammable limit (LFL) of 0.7% and an upper flammable limit (UFL) of 5%.[46] Overflowing fuel would have been agitated and rapidly dispersed by the upward, positive pressure airflow resulting in the formation of a vapour cloud. In most areas of the engine room and the ventilation casing, it is likely that the LFL of the fuel was not achievable primarily due to the strong airflow upwards. However, it is likely there were areas shielded by obstructions from the airflow, where fuel splashed or settled and where the fuel/air mixture may have been optimal.

In *MPV Everest*'s engine room, the exhaust trunkings of DG2 and DG3 within the exhaust ventilation casing were the primary hot surfaces of concern. At the A-Deck level, there was a gap between the upper and lower sections of insulation on DG3's exhaust trunking exposing a flanged joint. Exhaust gas temperatures for DG2 and DG3 (which were operating on the morning of the fire) were recorded in the engine room logbook as being 374°–378° C. Examination of the exposed joint found a distinct oxidisation mark on the upper flange with the section of insulation above showing charring, signs of combustion and distinct fire patterns indicating combustion leading back to the oxidised area. While the temperature at the exposed joint would have been lower than the recorded exhaust gas temperatures of about 378° C, it is possible, with sufficient time, that ignition of the fuel occurred here. Fire development would initially have been localised but then progressed up to the horizontal section of the exhaust trunking at main deck level.

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45 Linder and Seibring developed an empirical relationship whereby the tendency of a liquid fuel to ignite readily is expressed by the spontaneous heating parameter 'Z' (where Z=AIT÷[AIT-FP]). Fire hazard tests conducted by American, British, and European standards found that self-ignition occurred for all liquids having a Z value greater than 1.55. SAB diesel was estimated to have a Z value of about 1.40.

46 The flammable range of a fuel, defined by the fuel's LFL and UFL, describes the minimum and maximum concentrations of fuel vapour in air that will ignite in the presence of an ignition source.

Calculations show that it is unlikely that a fire at this level would have been capable of igniting the fuel vapour cloud within the ventilation shaft given the sustained airflow within.

It is possible that the fire on the exhaust trunking could have ignited other fuel deposits such as on the horizontal cable tray at the lower forecastle deck level which subsequently resulted in the deflagration observed by eyewitnesses. However, the initial ignition and fire on the exhaust trunking would have produced smoke which should have been visible to the eyewitnesses on the bridge and on CCTV footage prior to the deflagration event. There were no such eyewitness reports or CCTV footage of smoke. Furthermore, the fire developing on the trunking would likely have resulted in burning droplets of fuel raining down to the engine room B-Deck and setting off the flame and smoke detectors there. However, detector activation did not occur until after the first deflagration event.

Electrostatic ignition

Liquid hydrocarbons under certain conditions can accumulate static electricity, with the potential for subsequent static discharge in a flammable fuel/air mixture. Static electricity represents electric charges that are 'static' with the charge collected on the surface and not continually flowing in an electrical current (current electricity). There are several identified mediums of static electrification in liquid hydrocarbons. For example, electrostatic charges can be generated in hydrocarbon liquids being pumped through pipes and during splashing or spraying of liquid hydrocarbons. Intense static electric fields, in particular, can be generated where the fuel is rapidly separated (such as by the airflow in the ventilation casing) resulting in the creation of drops, aerosols, or mists. If the generated charge is significant an electrical discharge may occur.

The conductivity of a liquid determines the liquid's capacity to generate static charges with lower conductivity improving its ability to accumulate charge. Generally, diesel is an excellent static accumulator with very low conductivity, however SAB diesel had added conductivity improvers thereby allowing charge accumulation to be minimised.[47] Nevertheless, semi-conductive liquids can accumulate charge if charging rates are extremely high, when they are rapidly separated or where they are effectively isolated from ground.

On the morning of the fire, fuel first overflowed from the port settling tank's air pipe into the save-all, where it splashed and was agitated, probably resulting in foaming. Foams share similar traits to aerosols, are highly flammable, oxygen enriched and capable of holding intense electric charges. Splashing, agitation and foaming probably also occurred once the save-all was full and started to overflow. As the overflowing fuel flowed downward, it was subject to various forces which probably contributed to the rapid separation and intense static electrification of the fuel including the flow of fuel over and through the FRP grating of the decks and impacting surfaces within the casing. The upward airflow from the engine room ventilation almost certainly created fuel mists and aerosols which are also capable of intense electrification. Studies have shown that fuels mists and aerosols can ignite even where temperatures are below the FP of the fuel.

It is likely that the overflow of fuel gave rise to an electrostatically charged fuel vapour cloud within the ventilation casing and also extending externally in the vicinity of the ventilation louvres. It is also likely that the fuel vapour cloud outside the ventilation louvres contained a finer mist and aerosol than the cloud inside the casing.

The area outside the ventilation louvres was used as a storage area with several isolated conductors identified that were capable of accumulating a charge from the charged fuel vapour cloud. These isolated conductors included the propeller and shroud of the RHIB (stored using rubber tyres as dunnage) and shackles on other insulated equipment. These isolated conductors

47 Liquids can be categorised by their electric conductivity which is measured in picosiemens/meter (pS/m). Conductive liquids are those with a conductivity greater than 10,000 pS/m, while semi-conductive liquids have a conductivity between 50 pS/m and 10,000pS/m and non-conductive liquids have a conductivity below 50 pS/m. Generally, diesel has a very low conductivity (less than 5 pS/m) while SAB diesel was classified as a semi-conductive liquid with a conductivity of about 437 pS/m.

were in the vicinity of grounded metal conductors such as the ship's superstructure, storage cages and other equipment thereby providing an avenue for an electrostatic discharge and spark to occur. Calculations showed that the charged vapour cloud had sufficient charge and time to transfer charge into numerous grounded and isolated conductors that were located within the boundary areas of the fuel vapour cloud. The calculated transferred charges were also found to have sufficient charge to produce discharge energies required to ignite the surrounding flammable vapours. It is possible that static discharge from conductors occurred numerous times during the 5.5 minutes between the tank overflowing and the first deflagration, although ignition probably only occurred when a spark discharge occurred within the flammable limits of the vapour cloud.

This electrostatic discharge within the flammable vapour cloud probably resulted in ignition of the cloud. This initial deflagration event probably resulted in rapid combustion of the available fuel aerosols, mist and droplets. It probably also resulted in flaming droplets making their way down to the engine room and activating the fire detectors. There were signs of localised sustained combustion outside the ventilation casing, notably around the RHIBs and there may have been localised sustained combustion within the casing as well.

Once a secondary flammable vapour cloud developed sufficiently, a second deflagration probably occurred. It is likely that ignition of the secondary vapour cloud was due to contact with a localised fire, located either internal or external to the ventilation casing, with sustained combustion occurring thereafter.

Static electricity has been identified as a factor in numerous incidents that have resulted in deaths, injuries, and property damage across a range of industries and settings worldwide.[48] A report published by the Fire Protection Research Foundation in August 2021 identified 89 incidents since 2001 where static electricity caused an ignition or an explosion.[49] The report's findings also indicate that the number of incidents involving static electricity is probably far greater and more common than reported or documented. Static electricity is an ever-present hazard across many industries, although it is likely that most incidents are minor and result in little damage. However, when conditions align, such as when a flammable vapour mixture in the right concentration is exposed to a static discharge of sufficient energy, severe consequences can result.

Conclusion

It was considered unlikely that spontaneous ignition or electrical arcing (and associated spark discharge) was the source of ignition for the fire. While it was possible that the fire started as a result of hot surface ignition, as discussed above, electrostatic ignition was considered the more likely source of ignition.

Emergency preparedness and fire safety

Emergency manual

MPV Everest's emergency response manual formed part of the ship's SMS. The manual was intended to guide the ship's master and crew in effectively responding to a shipboard emergency. The manual required the development and implementation of ship-specific emergency prompts for use as aide-memoires to ensure critical steps were not forgotten in emergencies. The manual also directed that these emergency prompts were to be utilised during emergency drills and training.

MPV Everest's emergency response manual included prompts (in the form of checklists) for various emergency scenarios, including fire. While the manual's cover page carried *MPV*

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48 Jesse Roman, 2022. 'One spark', National Fire Protection Association Journal (2022).

49 Ioana Sandu, Francesco Restuccia, 2021. Static Electricity Incident Review, Fire Protection Research Foundation (2021). Massachusetts, USA.

Everest's name, metadata from the document indicated a different ship (*Jascon 25 - Emergency Response Manual*).[50]

Furthermore, the emergency prompt for fire in *MPV Everest*'s emergency response manual contained incorrect information. For example, the prompt indicated that the ship's engine room and paint locker were protected by a carbon dioxide (CO_2) fixed fire-extinguishing system, and directed the discharge of CO_2 in the event of fire in these spaces. However, the ship's engine room and paint locker were protected by a water mist fixed fire-extinguishing system. Similarly, on the subject of fire drills, *MPV Everest*'s SMS directed that drills were to include assessment of, among other things, the 'Use of CO_2 in the engine rooms, danger involved and precautions to be taken…'.

The emergency prompt for fire also instructed all emergency response personnel to tune their ultra-high frequency (UHF) radios to channel 1 in an emergency whereas actual shipboard practice was to use channel 5.

Drills and training

MPV Everest's SMS stated that shipboard drills were to be used for training and to assess the ship's emergency response plans and the ability to respond to an emergency on board. It also directed that emergency plans and checklists were to be used during drills and exercises. These plans and checklists had to be reviewed by the master and other personnel, their accuracy and effectiveness assessed, and the plans improved, if necessary. In particular, the SMS specified that drills were to be varied, realistic and, so far as practicable, conducted as if there were an actual emergency.

Fire drills

MPV Everest's SMS reflected SOLAS and the Bahamas Maritime Authority's (BMA) requirements for mandatory drills. SOLAS required that every crew member participate in at least one abandon ship and one fire drill every month. SOLAS also required that fire drills be planned such that consideration was given to the various emergencies that could occur depending on the type of ship.

The Australian Maritime Safety Authority's (AMSA) Marine Order 21[51] gave effect to SOLAS regulations relating to emergency drills and were applicable to foreign vessels in Australian waters. The marine order specified that the master was required to carry out drills for fires in the ship's engine rooms and that drills were to include practice in shutting all ventilators for the area involved in the mock fire.

The frequency of fire, abandon ship and other emergency drills conducted on board *MPV Everest* were largely in compliance with the relevant requirements. However, *MPV Everest*'s record of drills showed that no engine room fire drills had been held in the 4 months of the ship's AAD charter. The last drill held on board the ship involving a machinery space was on 31 January 2021 and involved the starboard boiler room. The record of the drill showed that the simulated fire was extinguished using portable extinguishers and that it did not involve familiarisation or training with the space's water mist fixed fire-extinguishing system.

Analysis of on board training records going back to January 2020 similarly showed no fire drills involving either the port or starboard engine rooms.

Training sessions

SOLAS also required that all crew be provided with regular training and instruction in the operation and use of the ship's fire-extinguishing appliances at the same intervals as drills and that all the

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[50] The IMO database identified *Jascon 25*, currently named *Telford 25* (IMO number 8770106), to be a 2007-built, Gibraltar-registered pipe-laying crane vessel with no known links to Fox Offshore.

[51] Marine Orders are legal instruments made by AMSA pursuant to powers under Commonwealth legislation. They are also described as regulatory instruments or legislative regulations.

ship's lifesaving and fire-extinguishing appliances be covered within any period of 2 months. Analysis of on board training going back to January 2020 showed no training sessions involving the engine room's water mist fixed fire-extinguishing system.

Fixed fire-extinguishing system

Design, functions and coverage

MPV Everest was equipped with a high pressure water mist fixed fire-extinguishing system designed and manufactured by Ultra Fog.

The water mist system, as designed, comprised a fresh water reservoir, a low pressure/high volume pump (600 litres/min at 3 bar) which transferred water to a feeder tank. From this tank, up to 4 high pressure pumps (with an additional spare pump) supplied water to a high pressure manifold which in turn supplied the required nozzles in the various firefighting zones (at a pressure no less than 100 bar).

In the event the fresh water reservoir ran dry, the system was capable of being supplied with sea water via the fire main. As a further contingency, the system included an accumulator unit consisting of 2 water cylinders (50 litres) and 3 nitrogen cylinders (67.5 litres) connected directly to the high pressure manifold on the pump unit. In the event power to high pressure pumps was lost or if there was an interruption of the water supply, the nitrogen propelled the water in the cylinders through to the nozzles and provided at least 1 minute of fire-extinguishing capability in the largest protected space.

SOLAS regulations required that the water mist system be capable of automatic (for ships approved for UMS operations) as well as manual release and that the water mist system be capable of rapid operation, while also reducing the risk of accidental discharge. The system was arranged to provide local application capability (to provide localised fire suppression in areas of fire hazard such as over the generators, fuel oil purifiers and boilers) as well as total flooding of protected space(s).[52]

The spaces protected by total flooding capability were: [53]

- port engine room
- starboard engine room
- aft tunnel thruster room
- port propulsion room
- starboard propulsion room
- retractable thruster room
- diving chamber complex
- diving equipment compartment
- dive emergency generator room
- number 1 bow tunnel thruster room
- number 2 bow tunnel thruster room
- emergency generator room
- port boiler room
- starboard boiler room.

The equipment and machinery protected by the water mist system's local application capability had push button activation points located near these zones. Activation of these zones resulted in

[52] SOLAS Ch II-2/Reg 10

[53] The paint locker and chemical lockers were also protected by the water mist system but the SOLAS fire training manual stated that they were restricted to automatic release only (on the detection of fire within those spaces).

water being supplied only to the nozzles protecting the particular machinery and equipment. When total flooding was activated, all nozzles in the protected space were supplied with water. Local and total flooding could also be remotely activated from 3 control panels located on the bridge, ECR and fire control station, as well as locally from the water mist system pump starter panel (located in the engine room's water treatment room).

In addition to the manual push-button release capability, *MPV Everest*'s system was also designed to activate water release automatically in the event a flame detector and a smoke detector activated in the same coverage area.

MPV Everest's engine room fixed fire-extinguishing system also incorporated a bilge firefighting foam system which automatically activated when total flooding of the port or starboard engine rooms was activated. The bilge foam system consisted of a high pressure/low volume pump (290 litres/min at 12 bar) which supplied water through an eductor to the port and starboard engine room bilge section valves connected to the foam injector tanks. Each engine room was provided with 2 foam injector tanks, each containing 68 litres of foam concentrate.

Installation error

The engine room fixed fire-extinguishing system on board *MPV Everest* was incorrectly installed at the time of the ship's commissioning and remained so at the time of the fire. The low pressure/high volume pump designed to supply the water mist system feeder tank was instead connected to the bilge foam system, while the foam system's high pressure/low volume pump supplied the feeder tank.

Annual inspections of the system by authorised maintenance providers had failed to identify the incorrect installation, although hand-over notes to the ship's chief engineer indicated that it was identified prior to the ship's dry dock in South Korea in December 2020. A job to rectify the issue was included in the docking scope of work but was later cancelled for reasons that could not be determined. The ship subsequently went into service on the AAD charter with the incorrectly installed pumps, with the issue only rectified after the fire when the ship was in the repair yard in Singapore in June 2021.

Interviews with the ship's chief engineers indicated that the error in pump installation was more likely to impact the operation of bilge foam system than the water mist system. Recorded data from the water mist system's alarm log indicated that water mist was automatically released for the port engine room's DG2 local application zone as a result of the activation of a flame detector and a smoke detector in the area. While the chief engineer reported manually activating other local zones within the port engine room during the response to the fire, it appears unlikely that total flooding of the space was activated. Consequently, it is unlikely that the bilge foam system was activated during the fire.

Drawings and pump technical data sheets in the water mist system installation and operation manual described the correct pump specifications and layout. However, the manual also included a specification sheet which attributed the wrong pumps to the 2 systems.

Documentation

There were 3 primary shipboard sources of documented information on the operation, coverage and functionality of *MPV Everest*'s water mist fixed fire-extinguishing system:

- Water mist system manual
- SOLAS fire training manual
- Ship's fire control plan.

Examination of these documents identified inconsistencies or incomplete information relating to the system. The fire control plan omitted to indicate that a water mist system release panel was located on the bridge. Additionally, the fire control plan and SOLAS training manual indicated that the aft transformer room was protected by the water mist system while the water mist system manual made no reference to this space. There was also no mention or description of the automatic release capability of the system in the engine rooms in any of these documents.

Additionally, similar to the ship's emergency response manual, metadata from the SOLAS fire training manual indicated a different ship (*Jascon 25 – SOLAS Fire Training Manual*).

Emergency response

SOLAS required that activation of a water mist fixed fire-extinguishing system should not require engine shutdown, closing of fuel oil tank outlet valves, evacuation of personnel or sealing of the space.[54]

On the day of the fire, the water mist system was triggered automatically by the activation of the port engine room B-deck flame and smoke detectors. The activation of the system and release of high-pressure water mist was also visually confirmed by the chief engineer and third engineer when initially investigating the fire alarms.

However, analysis of bridge VDR audio showed that the master consistently requested information and made decisions in the belief that the ship was equipped with a CO_2 fire-extinguishing system. This included at least 8 references about the intention to use or release 'CO_2' accompanied by requests for a head count and instructions to seal the engine room. While a head count and sealing of the space on fire are routine elements of any shipboard fire response, VDR audio clearly established that the master pursued these steps in the belief that CO_2 was to be released. Early reports to AMSA's Joint Rescue Coordination Centre (JRCC) as well as planning and briefings ashore similarly reflected the misunderstanding that the ship was equipped with a fixed CO_2 system (this information was later corrected).

The master's first mention of a 'water sprinkler system' was at 1146, about 48 minutes after the fire broke out. Following a telephone conversation with the chief engineer at 1207, the master made no further mention of a CO_2 system and only referred to the 'water mist system'. Interviews with other ship's officers and engineers also showed varying levels of familiarity with the operation and functionality of the water mist system. For example, both the chief electrician and chief mate were unaware that the water mist system was capable of being activated automatically and believed it could only be activated manually.

Emergency muster

SOLAS regulations required ships to post a muster list detailing, among other things, the ship's alarm signals, actions in the event of the various emergencies and emergency duties.

The muster list was also required to be revised if there was a change in the crew which necessitated an alteration. However, there was no amendment made to *MPV Everest*'s muster list to reflect the fact that there was only one second engineer available for duty. Consequently, the muster list in use designated the (unfit) second engineer as the commander of the engine room fire team and they accordingly mustered at their designated muster station in the ROV winch room. The engine ratings, who were also members of the engine room fire team, proceeded directly to the ECR instead of their muster station in the ROV winch room. The duty third engineer, whose muster station was also the winch room remained in the ECR while the off-duty third engineer, chief electrician and ETO reported to the ECR, which was their designated muster station. As a result, for a period of time during the initial response to the fire, almost the entire engineering complement of 9 personnel were in the ECR and separated from the fire only by the port medium voltage switchboard room.

On deck, the chief mate was the only member of the deck fire team who mustered at the designated muster station (the deck fire control station). The remaining members of the deck fire team responded variously by reporting to the bridge, the accommodation deck or by setting up

[54] International Maritime Organization, 2010, MSC.1/Circular1387 – Revised Guidelines for the Approval of Fixed Water-Based Local Application Fire-Fighting Systems for Use in Category A Machinery Spaces.

hoses and commencing boundary cooling at their own initiative. The designated firefighters on the deck fire team were the bosun and an able seaman but when directed by the chief mate to don their fireman outfits and prepare to shut the ventilation casing louvres, both refused. This task was eventually carried out by the duty second mate and off-duty third engineer. However, only the 3 inboard ventilation louvres were initially closed as they were probably unaware of the existence of the aft louvre, which was not closed until much later.

Emergency generator

SOLAS regulations required that ships have an emergency source of electrical power capable of supplying electrical power, for a certain period, to services deemed essential for safety in an emergency. Where the emergency source of electrical power was an emergency generator, it had to be capable of starting automatically and supplying the required load to the emergency switchboard within 45 seconds of the failure of the main source of electrical power. The services required to be supplied by the emergency generator (for a period of at least 18 hours) included, among others, emergency lighting at key locations around the ship, a fire pump and communication systems.

MPV Everest was equipped with a Caterpillar C32 diesel engine-driven emergency generator with a rated power output of 800 kW at 1,800 rpm. The generator, its 16 m^3 fuel tank and the emergency switchboard were located in a compartment on the accommodation deck (aft of, and one deck below, the upper level of the port engine room exhaust ventilation casing). The room was also fitted with an automatic polar air damper which controlled the flow of cooling air to the emergency generator.

MPV Everest's emergency generator failed to perform as required during the response to the fire. The generator was initially isolated, and its fuel quick closing valve shut, on the master's orders in the incorrect belief that the fire was in the emergency generator room. Following the first total loss of power on board at about 1106, fuel supply to the generator was restored and it was manually started. At about 1114, the emergency generator came on load and supplied the emergency switchboard for a short period however it failed to reach, and maintain, operating speed and subsequently shut down about 30 minutes later following several alarms.

It was subsequently found that the emergency generator's fuel filters were clogged, probably as a result of bacterial contamination, which resulted in the generator being starved of fuel. Following the fire, the generator's fuel tank was drained, re-filled and the emergency generator tested however the generator once again shut down following a high temperature alarm. Further investigation identified that an electrical issue with the compartment's polar air damper restricted the flow of cooling air to the generator, resulting in high temperature alarms and the subsequent shutdown of the generator.

While records indicated that the generator was regularly tested as part of the ship's planned maintenance and safety routines, it was generally not run on load for extended periods of time. Furthermore, there were no scheduled tasks in the ship's PMS for the testing of the emergency generator fuel tank for the presence of bacterial contamination.

Radio communications

MPV Everest's designated emergency communications system was channel 5 on the ship's ultra-high frequency (UHF) radio communication system. Shortly after the fire broke out, the chief engineer isolated all power to the port engine room, including to the port medium voltage switchboard room (adjoining the port engine room). This was immediately followed by the loss of the ship's UHF communication system. The ship's crew then transitioned to using the survival craft very high frequency (VHF) radios and communications were quickly re-established.

Subsequent investigation identified that the UHF system's repeaters were supplied through the port engine room's medium voltage switchboard room, but that this was not known to the ship's crew at the time of the fire. The isolation of power to the port engine room and medium voltage switchboard room resulted in the loss of the UHF system, which hampered early efforts to communicate and coordinate the response to the fire.

The master reported that the reliability of emergency communications (both UHF radio and ship's telephones) had been a recurring concern with shortcomings identified and communicated to the ship's managers following the aft winch control room fire on 20 December 2020. However, there had been no corrective action implemented by the time of the engine room fire on 5 April 2021.

Electrical enclosures

ATSB examination of the fire-affected port engine room found liquid diesel fuel pooled inside the MCC and PDB electrical enclosures on B-Deck.

The classification society responsible for plan approvals and surveys of the ship's electrical equipment (including surveys of materials, equipment and components) was RMRS. Its rules required electrical equipment such as switchboards, control gear and motor starters to comply with ingress protection (IP) ratings depending on their location on board.[55] For example, the required IP rating for electrical equipment and their enclosures located in engine and boiler rooms (such as MCC 3A and PDB 3 in the port engine room) was IP 22.[56] The IP 22 rating required the equipment enclosures to be constructed such that they were protected against drops of falling liquid, which should have no harmful effect when an enclosure was inclined up to 15° from the vertical.

Similarly, the required IP rating for electrical equipment located where there was an increased danger of liquid and mechanical damage (such as in ballast pump rooms) was IP 44. The IP 44 rating required the equipment to be constructed such that liquid splashed from any direction should have no harmful effect. Furthermore, installation of such equipment in spaces where there was danger of liquid spraying, cargo dust, serious mechanical damage, aggressive fumes and/or explosive vapour or gas mixtures (such as ventilation trunks) was not advised. Similarly, these IP rating requirements for electrical equipment were also reflected in BV classification society rules.[57]

While MCC 3A and PDB 3 in the fire-affected port engine room were not installed in a ventilation trunk, they were installed directly beneath the exhaust ventilation casing, where the enclosures were exposed to diesel droplets falling from above. The presence of liquid diesel inside the 2 electrical cabinets indicated that the cabinet was not adequately protected against fluid ingress in accordance with the required IP rating. Despite that, there was no evidence that the ingress of diesel into the MCC and PDB contributed to the fire, or any other harmful consequence.

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55 Russian Maritime Register of Shipping, 2014, Rules for the classification and construction of sea-going ships, Volume 2, Part XI - Electrical Equipment, Section 2 – General requirements, 2.4 Structural requirements and protection of electrical equipment, Table 2.4.4.2.

56 The International Electrotechnical Commission (IEC) standard 60529 defines the degrees of protection provided by enclosures. The ingress protection (IP) code is composed of 2 numerals with the first numeral rating the protection against solid objects ranging from 0 (no protection) to 6 (no ingress of dust) and the second numeral rating the enclosure's protection against liquids from 0 (no protection) to 9 (high-pressure hot water from different angles).

57 Bureau Veritas, 2014, Rules for the classification of steel ships, Part C - Machinery, Electricity, Automation and Fire Protection, Chapter 2, Section 3 – System design, 4 Degrees of protection of the enclosures, Table 2 Minimum required degrees of protection.

Figure 28: Fuel pooled inside electrical enclosures on B-Deck in the port engine room

Source: ATSB

The MCC and PDB enclosures on board *MPV Everest* were designed, manufactured and installed by Z-Power in Singapore. The fire-affected electrical enclosures in the port engine room and the seawater affected cabinet in the starboard pump room were replaced and repaired respectively in the repair yard in Singapore. Subsequently, Z-Power was engaged to carry out a detailed inspection of other electrical switchboards and enclosures on board to ensure they were properly sealed against water ingress. The inspection identified 7 other MCCs and PDBs that required remedial work to ensure they were appropriately sealed.

Australian Antarctic Division

The Australian Antarctic Program (AAP) was established in 1947 as the National Antarctic Research Expeditions. The Program comprised a range of activities, interests and capabilities including scientific research, logistics, transport and administration of the Australian Antarctic Territory. The Australian Antarctic Division (AAD) is a division of the Australian Government's

Department of Climate Change, Energy, the Environment and Water (the Department),[58] based in Kingston, Tasmania, and it leads, coordinates and delivers the AAP.

Australia maintains 3 year-round research stations in Antarctica—Casey, Davis and Mawson—and one on sub-Antarctic Macquarie Island. The population at each station varies between 40-100 expeditioners over summer, and between 15-20 over the winter months. The AAD utilises air and sea transport to get expeditioners to and from the research stations. Flights[59] carrying passengers and cargo operate from Hobart, Tasmania to Wilkins Aerodrome, near Casey research station each summer and smaller fixed wing aircraft and helicopters enable travel within the continent. However, shipping is the primary means by which personnel, equipment, fuel and supplies are transported to and from Antarctica. In addition, ships are used as platforms to conduct scientific research as well as coastal and sub-sea surveys.

Australian Antarctic shipping

Since the establishment of the AAP, several ships have been chartered to support the delivery of the Program. In 1989, the Research Survey Vessel (RSV) *Aurora Australis* was built for the AAD at the Carrington Slipways in Newcastle, New South Wales. *Aurora Australis* served as the AAD's primary supply vessel for over 3 decades, conducting over 150 scientific research and resupply voyages in that time.

In May 2017, the construction of a new Australian Antarctic icebreaker, *Nuyina*, commenced at the Damen Shipyards in Romania. *Nuyina* was to assume the role of the AAD's primary supply vessel following the planned conclusion of *Aurora Australis*' service with the AAD in early 2020. However, by November 2019, delays in *Nuyina*'s construction resulted in the AAD conducting contingency planning to seek alternate supply ship options for the next season, with the conclusion of *Aurora Australis*'s service occurring in March 2020.[60]

Request for Tender

On 26 November 2019, the Department published a request for tender (RFT) seeking a suitable ship to resupply Australia's Antarctic stations for the 2020/2021 season. The Department's RFT required that the:

- proposed ship be Polar Code compliant
- ship meet AMSA and international safety and environmental requirements appropriate to the work to be undertaken
- tenderer provide details of their experience providing the services to other organisations that are similar or relevant to the services being sought
- tenderer provide details of their management capability and capacity
- tenderer should provide details of any shipping accidents and serious incidents relating to the tenderer or related entities within the last 5 years
- tenderer was to ensure that the ship carried adequate equipment and spares for Antarctic service

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58 At the time of fire, the AAD's parent Department was the Department of Agriculture, Water and the Environment, established on 1 February 2020. This Department was preceded by the Department of the Environment and Energy (19 July 2016 to 1 February 2020) and superseded on 1 July 2022 by the Department of Climate Change, Energy, the Environment and Water.

59 The flights are operated by a Skytraders Airbus A319-115LR and a Royal Australian Air Force C17-A Globemaster III.

60 The IMO database showed that, in September 2020, ownership of *Aurora Australis* passed from P&O Maritime Services (Australia) to P&O Maritime Logistics (United Arab Emirates) and that in March 2022, the ship was sold to Apeliga Holdings (Cyprus) and renamed *Aurora Dubai*. The database showed that, at the time of writing, the Cyprus-registered *Aurora Dubai* was owned by Apeliga Holdings and managed and operated by Felucca Maritime Services (United Arab Emirates).

- Department may require the master to use any special Antarctic blend fuel stored on the vessel as fuel oil for the vessel.

Regarding the operating crew, the RFT further required that:

- only crew experienced in operations in the Arctic or Antarctic would be employed, and that the tenderer would endeavour to maintain continuity of officers and crew for the duration of the charter
- a full crew list and a resume of the experience of such proposed crew would be provided to the Department in advance
- for navigation officers proposed for the vessel, the resume was to include their age, position on board, qualifications held and previous ice experience (particularly Antarctic) including the number of voyages undertaken (including the areas and the time of year).

Response to RFT

On 20 December 2019, MCS (the parent company of *MPV Everest*'s owners – New Orient Marine), submitted a response to the RFT proposing *MPV Everest* for the role of Antarctic supply ship. The MCS response to the RFT included general details about *MPV Everest*, the ship's specifications and capabilities, proposed crew numbers, a summary of the company's experience in managing offshore work and a description of 2 of *MPV Everest*'s previous charters. To demonstrate management capability and capacity, MCS provided an organisational chart and evidence of the existence of specific procedures related to:

- business integrity
- ethics policy
- project management
- risk assessment and management
- emergency response
- purchasing and procurement.

In response to the requirement that the tenderer should provide details of any shipping accidents and serious incidents, the MCS response noted that there was an incident investigation procedure in place.

The response to the RFT also noted that *MPV Everest* did not have a Polar Code certificate, but that this certification could be arranged. Additionally, in seeking to provide evidence of polar experience, MCS provided a brochure from its parent company, MRTS,[61] which had polar experience.

On 24 March 2020, the AAD and MCS signed an agreement to charter *MPV Everest* to undertake voyages to Antarctica at the end of 2020.

Suitability survey

In June 2020, the AAD commissioned a survey of *MPV Everest* to assess the ship's suitability for its intended scope of operations. On 6 July 2020, the ship was attended by an AAD-appointed surveyor while alongside in Jurong, Singapore. The surveyor inspected the ship and examined its certificates, equipment and records. The surveyor made a few minor observations, but no deficiencies were noted and the report subsequently concluded that the ship was suitable for the intended purpose.

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[61] Mezhregiontruboprovodstroy Joint Stock Company (MRTS JSC) is a Russian subsea construction company headquartered in Moscow, Russia.

Planning and risk management

As part of the AAD's planning for the use of *MPV Everest*, a risk assessment was conducted, which identified several potential risks. In addition to risks related to the management of COVID-19 on board, some of the more relevant risks identified by the AAD included that:

- *MPV Everest* would be unable to be mobilised into the AAP
- the vessel would be unable to obtain Polar Code certification
- the vessel would become beset in ice during Antarctic operations
- the SMS used on board *MPV Everest* did not meet compliance
- *MPV Everest*'s crew was not experienced in Antarctic operations.

While each identified risk was associated with several existing and proposed risk controls, some of the more relevant measures and controls documented by the AAD, to address the identified risks included:

- the development of a project implementation plan and appointment of a project officer to manage the mobilisation of *MPV Everest* into the AAP
- fortnightly meetings to discuss the mobilisation of the ship into the AAP and monitor progress against relevant implementation plans
- the engagement of a surveyor to attend and undertake an inspection of the ship [with no issues subsequently identified]
- MCS development of a Polar water operational manual
- AAD provision of cold environment specialist assistance in the development of ship's Polar water operational manual and monitoring of the development and submission of the manual to the classification society
- MCS engagement of an experienced Australian ice pilot (with AAD input) to assist in Antarctic vessel navigation
- that MCS had an SMS covering all aspects of vessel operations including vessel crewing, fatigue, maintenance, ship specific procedures, risk management processes and incident reporting
- AAD review of MCS procedures and provision of AAD standard operating procedures to MCS
- AAD standard operating procedures and the presence of an AAD voyage management team on board
- crew to be used by MCS for the AAD charter would have extensive experience in operating this ship
- MCS crew had extensive experience operating in remote and isolated Arctic regions off Russia and Europe
- the conduct of AMSA port State control inspections.

Several of the proposed risk control measures were either not implemented or could not be achieved. For example, the contents of the polar water operational manual developed for the ship was not relevant to operations in the Antarctic and the crew used for the AAD charter were almost all new to the vessel, to Fox Offshore and to the Antarctic.

The AAD charter party agreement imposed strict polar medical requirements on the ship's crew that were in excess of the medical standards generally applicable to seafarers. This resulted in several crew who were experienced with the ship being rejected by the AAD's Polar Medicine Unit, amplifying existing difficulties such as uncertainty associated with crew movements and the duration of crew sea service periods on board caused by the pandemic (see the section titled *Influence of the COVID-19 pandemic*). These led to a significantly reduced recruitment pool of crew members who were familiar with the ship and its operations.

The AAD's project implementation plan called for MCS to provide 2 teams to crew *MPV Everest*. The first team was to join the ship in South Korea, sail to Australia and operate the ship until it returned to Hobart following the first voyage to Antarctica. Meanwhile, the second team was to remain in Hobart as a contingency (see the section titled *Influence of the COVID-19 pandemic*). Following the first voyage, the second team was to relieve the first team for the next voyage to Antarctica while the first team remained ashore as a contingency.

The progress of the plan was reviewed at fortnightly meetings commencing in July 2020. Over the following months, it became increasingly evident that travel restrictions and other measures aimed at managing the spread of COVID-19 posed a significant challenge to implementing several of the proposed risk controls, particularly those related to crewing. In November 2020, the requirement to retain a contingency crew in Hobart was removed by the AAD due to logistical and cost considerations, and the relief of crews between the first and second voyages to Antarctica did not occur. While a second engineer did travel to Australia to join the ship after the first voyage, almost all of the crew who joined in South Korea remained on board for the entire charter.

The implementation plan identified Fox Offshore as the ship's operational managers and noted that Fox Offshore's shipboard SMS would be used.

Influence of the COVID-19 pandemic

The first human case of a novel coronavirus was identified in December 2019 in Wuhan, China and, by 13 January 2020, the first confirmed case of the virus outside China was reported in Thailand. On 30 January, the World Health Organization (WHO) declared the outbreak a public health emergency of international concern and, on 11 March, the WHO declared COVID-19 a pandemic. As the virus spread, nations introduced strict controls on the movement of people, including measures such as mandatory quarantine, testing, isolation and lockdown requirements.

The first case of COVID-19 in Australia was reported in Victoria on 25 January 2020, followed by 3 further cases in New South Wales on the same day. On 2 March, the first confirmed case of the virus in Tasmania was reported. By 12 March, every Australian state and territory had recorded confirmed cases of the virus. On 19 March, individual states in Australia, beginning with Tasmania, began implementing strict interstate border control measures and restrictions on the movement of people. On 20 March, Australia closed its borders to all non-residents and non-Australian citizens. The escalating situation and the measures introduced to control it had a profound effect on the maritime industry and seafarers over the following months.

In managing the mobilisation and integration of *MPV Everest* into the AAP, significant effort was directed at managing the risk posed by the COVID-19 pandemic and to preventing the virus' entry into Antarctica. The AAD's COVID-19 plan noted that *MPV Everest* presented a potential single, critical point of failure in the AAD's COVID-19 strategy. A single confirmed case of the virus on board the ship would have necessitated aborting the ship's voyage and returning to port, thereby risking the closure and evacuation of Antarctic research stations if they could not be supplied.

The AAD COVID-19 plan included specific risk controls directed at *MPV Everest* including that:

- contact between outgoing and incoming crew was to be avoided in South Korea
- any confirmed cases of COVID-19 among the ship's crew required the affected individuals to be replaced
- there was to be no shore leave during the ship's port calls at Hobart
- there were to be no crew changes during the ship's port call in Hobart after the first voyage to Antarctica.

On board observations

The planning, coordination and management of the AAD station re-supply operations was overseen by an AAD voyage management team, led by a voyage leader and supported by several other personnel. The voyage leader had authority over all AAD personnel on board the ship and, while the master's authority was absolute in matters of safety, they were required to work collaboratively with the voyage leader to achieve the objectives of the voyage.

The voyage leader's report made several recommendations in response to concerning instances, anecdotal accounts and observations related to the:

- master's knowledge of the ship's capabilities, navigation and operations in the Antarctic, and suitability for AAD operations
- conduct of musters and drills on board
- state of repair and condition of generators, availability of spare parts and their influence on redundancy
- condition of *MPV Everest*'s fast rescue craft
- inadequate securing of equipment on board and availability of securing and lashing gear
- familiarity of shipboard crew with AAD standard operating procedures
- sea-keeping ability and excessive rolling of *MPV Everest* and its suitability for operations in the Southern Ocean.

Post-accident action

Following the fire, the Department commissioned an independent investigation into the accident led by a third-party expert familiar with both charter party contract management and maritime safety. The findings of the investigation resulted in several changes to the Department's chartering processes, including:

- the introduction of an improved process for the completion of pre-charter due diligence arrangements
- updates to the proforma contractual elements of the charter party agreement as used by the Department, with the revised agreement more directly speaking to a range of SMS requirements
- the development of a proforma bridging document that describes the functional links between the charter party's SMS and AAD's SMS
- the completion of season and voyage specific risk assessments
- general improvements to voyage orders as provided to the vessel's master and the AAD voyage leader including clarification of whom reports what to whom and when.

Additionally, the AAD commissioned an independent review of the effectiveness of its procurement process and procedures for current and future chartering processes. The review identified areas of process improvement relating to:

- pre-qualification thresholds for tenderers/prime contractors, requiring demonstrable capability in ship operations
- incorporating workplace health and safety requirements across the end-to-end procurement, evaluation, implementation and operation processes
- augmenting of due diligence of prime and sub-contractor experience, capability and safety performance during the tender evaluation process
- development of standard operating procedures for implementation and mobilisation of charter vessels
- AAD emergency response procedures aboard charter vessels.

That review made recommendations with the objective of providing AAD with a framework to ensure that:

- ice-class vessels chartered from the international shipping market were fit for purpose and delivered into service with appropriately trained crews, and with robust technical support

- workplace health and safety obligations were integrated between AAD and the chartered vessel and provided AAD with visibility of safe voyage operations
- risk was assessed, controlled and transparently reported throughout the deployment.

The review also recommended that the AAD engage a maritime subject matter expert to evaluate tenderer capability and experience, in conjunction with the technical evaluation of the vessel and that the scope of experience and capability evaluations should be expanded to include organisation structure, and comparable assets under management.

Shore response

Response to MPV Everest *fire*

At about 1128 on 5 April,[62] following receipt of *MPV Everest*'s distress alert and the AAD notification of the fire, JRCC notified the Australian Defence Force's (ADF) Headquarters Joint Operations Command (HQJOC)[63] and Maritime Border Command (MBC)[64] of the incident. JRCC requested HQJOC and MBC transmit hourly high frequency (HF) and very high frequency (VHF) digital selective calling distress relays until further notice.

At about 1139, JRCC submitted a request for ADF assistance by email to HQJOC followed by a phone call about 2 minutes later. Having considered the request, at 1156, HQJOC responded stating there were insufficient factors driving an ADF response under the circumstances and that planning activity would proceed pending receipt of further information. HQJOC planning and scoping activity eventually identified very limited feasible ADF air or maritime options for rendering assistance to *MPV Everest*.

As JRCC continued to work to identify suitable options to assist *MPV Everest*, the ship continued to provide regular SITREPs on an approximately hourly basis. At the time of the fire, *MPV Everest*'s location in the Southern Ocean was about 1,100 miles from Mawson station and about 1,560 miles from mainland Australia (2,060 miles from Hobart and 1,720 miles from Fremantle).

JRCC activity included gathering ship's plans and other details from the AAD, sourcing meteorological information, identifying suitable civilian aviation and maritime assets, and contacting other regional marine rescue coordination centres (RCC) capable of assisting in the Southern Ocean. These included South Africa, France, China, Russia, New Zealand, and the United States. Subsequent advice from these RCCs as well as from other national Antarctic programs indicated that there were limited options available for immediate assistance. At about 1235, JRCC tasked a Sky Traders[65] aircraft to prepare to deploy out of Perth, Western Australia to *MPV Everest*'s location.

At about 1303, following discussion with JRCC, Austral Fisheries directed the Australian fishing vessel *Cape Arkona*, located off Heard Island and McDonald Islands, (about 925 miles from *MPV Everest*'s position) to proceed to *MPV Everest*'s location. At about 1316, the AAD confirmed that AMSA maintained operational control and responsibility for the coordination of the response and the AAD continued to provide support and information as required.

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62 The Australian Maritime Safety Authority's Joint Rescue Coordination Centre (JRCC) is located in Canberra, Australian Capital Territory, which maintained Australian Eastern Standard Time (AEST: UTC + 10 hours). However, times relating to JRCC events, actions, and decisions are referenced to ship's time in this report.

63 Headquarters Joint Operations Command (HQJOC) is located in Bungendore, New South Wales. HQJOC plans, controls, and conducts military campaigns, operations, joint exercises, and other activities to meet Australia's national objectives.

64 Maritime Border Command (MBC) is located in Canberra, Australian Capital Territory. MBC is a joint ADF and Australian Border Force agency responsible for Australian civil maritime security operations and may provide assets to assist during search and rescue operations.

65 Sky Traders is a provider of specialist aviation services, including Antarctic aviation, to the Australian Federal Government.

At about 1440, *MPV Everest*'s master advised JRCC that the fire had been extinguished and that efforts were underway to restore propulsion. JRCC subsequently stood down *Cape Arkona* and the Sky Traders aircraft.

Australian search and rescue arrangements

The International Civil Aviation Organization (ICAO) and the IMO coordinate member States' efforts on a global basis to provide an effective worldwide system of search and rescue (SAR) services. JRCC Australia in Canberra has responsibility for the coordination of SAR in the Australian search and rescue region (SRR). The Australian SRR region covers the Australian continent and large areas of the Indian, Pacific and Southern Oceans as well as the Australian Antarctic Territories, an area of about 53 million square kilometres encompassing one tenth of the earth's surface.

In Australia, the national SAR system involves Commonwealth, State and Territory authorities and organisations. At the Commonwealth level, AMSA (the Australian SAR authority) and the ADF are the relevant SAR organisations, and the national search and rescue manual is the standard reference document for use by all Australian SAR authorities and agencies.

SAR in the Antarctic and Southern Oceans

A memorandum of understanding (MOU) between AMSA and the AAD set out the division of responsibilities for SAR activities in the Antarctic and Southern Oceans. The MOU acknowledged that the size of Australia's Antarctic region, its remoteness from major centres, sparseness of available resources and extremes of weather meant that response options were generally limited and that SAR operations in these areas may be challenging and protracted.

The MOU essentially delegated responsibility for overall coordination of maritime SAR activities in the Antarctic and Southern Ocean areas of the Australian SRR to AMSA. While the MOU delegated responsibility to the AAD for maritime SAR activities related to AAD-sponsored operations, it also allowed for this responsibility to be transferred to AMSA in the event coordination of the response was beyond AAD capabilities (as occurred during this incident). Under the MOU, the AAD could also request ADF operational support for AAD-led SAR and emergency response operations.[66] For AMSA-led SAR operations, ADF support requests went through existing AMSA-ADF arrangements (by liaison between JRCC and the HQJOC).

ADF Southern Ocean SAR plan

The ADF Southern Ocean SAR Plan covered ADF responsibilities, capabilities and other factors that influence ADF's ability to provide SAR response and support in Antarctic and Southern Ocean waters. Under the plan, the ADF is responsible for the provision of SAR response for all ADF and visiting foreign military forces in the Australian SRR as well as SAR for deployed ADF personnel and assets outside of the Australian SRR (subject to the approval of the relevant nations).

ADF assets may also be requested to assist in Australian-led civilian SAR operations. However, the ADF is not obliged to automatically respond to a request for assistance from JRCC for a civilian SAR incident that is not in the immediate response range of an ADF unit.

The plan noted that for the greater part of these waters, there were no dedicated SAR assets and in general, they would need to be deployed across long distances requiring up to 5-6 days' sailing to reach some areas of the Southern Ocean depending on weather, sea and ice conditions. The plan also acknowledged that, in the Australian SRR, factors such as the particular circumstances of the Southern Ocean, Antarctica and its meteorological and ice conditions, the scarcity of support, and the limited infrastructure meant that there was added complexity to the deployment of SAR assets.

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[66] The ADF's Operation Southern Discovery encompasses ADF support to the Australian Antarctic Program and the Australian Antarctic Division.

ADF aviation assets capable of responding to a Southern Ocean SAR incident were exclusively fixed wing aircraft, capable of equipment drop and search and observation functions but no 'rescue' capability.

Naval surface assets also face significant challenges when it comes to operating in and responding to SAR incidents in the Southern Ocean due to limitations on the availability of ice-strengthened vessels, the need for winterisation of available vessels and the distances and duration involved in the response. Additionally, factors such as sea temperatures, sea state, and ice all place stresses on vessel hulls and engines and may significantly reduce the serviceable lifetime if operating in Antarctic or sub-Antarctic waters, even for short periods.

JRCC/ADF interaction

Generally, requests for military assistance in support of civilian SAR operations are to occur via the JRCC liaison with HQJOC.

In the event of a civil SAR response where JRCC considers that the ADF can assist, the practice was for JRCC to call the HQJOC joint operations room (JOR) watch commander to advise of the situation and the expected tasking. The watch commander was responsible for objectively analysing the situation and balancing any request for assistance against impacts to ADF operational capability. The JOR then scoped the circumstances of the SAR incident including location and expected tasking, contacted the service representatives to determine the disposition of appropriate forces and operational impacts and notified the chain of command as appropriate. The JOR watch commander decided if ADF assistance was feasible in the circumstances and advised JRCC of the outcome following which JRCC decides on whether to issue a formal request for ADF assistance.

In the *MPV Everest* accident, JRCC submitted a request for assistance to ADF followed by a phone call to HQJOC. The request resulted in the ADF undertaking planning and scoping activity to identify potential aviation and naval assets capable of assisting *MPV Everest*.

ADF planning subsequently identified that available aviation assets were unable to meet the scale of survival equipment that would have been required for *MPV Everest*'s complement of 109 personnel. While there was scoping activity conducted for an aircraft with basic capabilities deploying from Perth, Western Australia, ultimately very limited options were identified owing primarily to factors such as distance and aircraft capability.

ADF planning activity for a maritime response was similarly informed by the scope of potential response capabilities such as the possibility that all 109 personnel would need to be taken onboard, the need to tow *MPV Everest* and the need for medical assistance. However, it was subsequently concluded that a surface response was not feasible based on the available vessels and the transit time to *MPV Everest*.

Similar occurrences

Over the years, the ATSB has investigated 3 fires involving Antarctic re-supply ships. While the specific factors that contributed to these fires were different to those in this investigation, all 3 fires involved elements of the ship's engines or fuel system.

Aurora Australis

22 July 1998

On 22 July 1998, a fire broke out in the engine room of the Australian-registered Antarctic research and supply vessel *Aurora Australis*. At the time, the ship was at the Antarctic ice edge about 1,300 miles south of Tasmania with 54 expeditioners and 25 crew on board. The fire, located at the forward end of the port main engine, around the turbocharger, was attacked by engineers using portable extinguishers and apparently extinguished while the engine was stopped, and the fire alarms sounded. However, a few minutes later, a fireball erupted, and the engineers were forced to evacuate the engine room.

The expeditioners and crew were mustered, fire teams deployed, the engine room's Halon fixed fire-extinguishing system activated, and a distress message was broadcast. About 13 hours after the fire broke out, the engine room was ventilated, and inspected. Over the next 3 days, the ship's crew carried out repairs to restore propulsive power to the starboard engine and electrical power to ancillary equipment. *Aurora Australis* arrived back in Hobart on 31 July, under its own power.

The ATSB transport safety investigation report number 135 found that the fire was caused by diesel fuel from a split in the flexible fuel hose in the spill line from the main engine coming into contact with a component of the port engine turbochargers. The investigation found that the failure of the hose was due to age and 'wear and tear', and there was no record of approval from the manufacturer, the classification society or AMSA regarding the fitting of the hoses. The investigation also identified that the Halon system had only partially discharged due to a poor electrical design and that a high turnover of engineering staff had resulted in lack of continuity in maintenance of the Halon system and a loss of knowledge relating to the fitting of the hoses.

14 January 1999

On 14 January 1999, a fire broke out in the engine room of *Aurora Australis* shortly after departing Fremantle for Antarctica with 16 expeditioners and 24 crew on board. The ship's engines were stopped, alarm sounded, crew mustered, fuel quick closing valves shut, and vents and fans stopped. The engine room's Halon fixed fire-extinguishing system was activated, and an urgency message was broadcast. Entry was made into the engine room about 3 hours later and several hours were spent checking the space and cooling any hot spots that were found with fire hoses. The port engine was eventually re-started, and the ship made its way back to Fremantle escorted by a tug, arriving without further incident the next day.

The ATSB transport safety investigation report number 143 found that the fire was caused by the failure of a flanged joint on the starboard main engine fuel supply pipework with the resulting spray of diesel fuel igniting on the turbochargers or exhaust pipework. The investigation identified that the flanged joint failed after 2 of its 4 screws failed in fatigue, and the other 2 had worked loose.

L'Astrolabe

On 11 November 2006, a fire broke out in the engine room of the French-registered Antarctic supply ship *L'Astrolabe* while en route from the French Antarctic base at Dumont d'Urville to Hobart. The ship's crew operated the remotely operated fuel quick closing valves, which shut down the main and auxiliary engines, isolated all ventilation to the engine room, and then activated the engine room's halocarbon gas fixed fire-extinguishing system. The fire was declared extinguished about an hour after it began and a few hours later, propulsion was restored and the ship resumed passage for Hobart, arriving without further incident 2 days later.

The ATSB transport safety investigation report number 234 found that the fire was the result of a spray of diesel fuel from a leak in the starboard main engine fuel system that had been ignited by contact with the hot surfaces on the engine. The investigation also found that the ship's procedures for re-entry into the engine room after the operation of the fixed fire-extinguishing system did not adequately consider the time required to cool the fire scene and did not provide the master with adequate guidance about when to safely re-enter the space.

Safety analysis

Introduction

On 5 April 2021, a fire broke out in the port engine room of the Bahamas-registered, 145 m multi-purpose vessel *MPV Everest* while en route from Mawson Station, Antarctica to Hobart, Tasmania with 37 crew and 72 Australian Antarctic Division staff on board. The ship's crew responded, and the fire was contained and eventually extinguished using the engine room's water mist fixed fire-extinguishing system about 2.5 hours later. The port engine room sustained substantial damage with most of the power generation equipment and machinery located within rendered inoperable. There were no reported injuries or pollution of the sea as a result of the fire. Power and propulsion were subsequently restored using the starboard engine room's machinery and the ship diverted to Fremantle, Western Australia, where it arrived without further incident about a week later.

This analysis will consider the factors and circumstances leading up to the uncontrolled overflow of fuel oil in the ship's engine room, the fire mechanism, the effectiveness of the shipboard response and general emergency preparedness on board. The analysis will also consider elements of the ship's design, the effectiveness of *MPV Everest*'s safety management system (SMS), the extent to which the ship and its crew were prepared for Antarctic operations and the effectiveness of the Australian Antarctic Division's (AAD) pre-charter due diligence and risk management arrangements.

Finally, in considering the circumstances of this accident, it is important to recognise that the impact of the COVID-19 pandemic and associated restrictions on the maritime industry was significant. Seafarers shouldered a heavy burden during the pandemic in maintaining global trade and sustaining operations that required maritime capabilities. Disruptions to travel and quarantine measures adversely affected the ability to relieve crews and effect crew changes in a timely manner leading to uncertainty and extended time served on board, while restrictions on shore leave forced seafarers to remain on board in port. These factors, along with the general operational hazards of seafaring, particularly in the Southern Ocean and Antarctica, all played a part in creating a stressful environment and increasing the risk of fatigue for all those on board *MPV Everest*.

The fire

Fuel oil overflow

On the morning of the fire, the chief engineer manually initiated a routine fuel oil transfer from a storage tank to the port settling tank using the integrated automation system (IAS) in the ship's engine control room (ECR) to start the diesel transfer pump. The chief engineer then left the ECR to carry out repairs to a diesel generator in the starboard engine room.

The diesel transfer pump continued to run until it was eventually stopped by the loss of shipboard power about 1.5 hours after it was started. Recorded data from the IAS showed fuel levels in the port settling tank increased to 85% of the tank's capacity, which activated the tank's high level sensor signal (but not the associated high level alarm). The fuel level in the settling tank continued to increase until it reached 90% of tank capacity and overflowed to the port drain tank. IAS data showed the port drain tank level increasing, followed by the activation of the port drain tank high level alarm. Fuel levels continued to increase in the port drain tank until the tank was full and the settling tank level began to increase once again (see the section below titled *Port fuel oil drain tank air vent*).

Shortly after, personnel on the ship's navigation bridge observed flames and smoke from the ventilation louvres of the port engine room's exhaust ventilation casing. A few seconds later, the IAS recorded the activation of smoke and flame detectors, as well as the automatic release of the water mist system, on B-Deck in the port engine room in the vicinity of the exhaust ventilation casing.

After the fire was extinguished, inspections of the fire-affected engine room found fuel dripping down into the space from within the port engine room's exhaust ventilation casing. Further investigation identified that the port settling tank air pipe terminated within the upper most level of the casing and that the save-all within which the pipe was located contained fuel. The upper level of the ventilation casing, where the settling tank air pipe termination was located, connected directly with the engine room several decks below. Fuel and fuel residue was also identified on all intervening decks and structures located within the casing leading down to the engine room below where fuel was also found.

The unchecked transfer of fuel to the port settling tank resulted in the overflow of fuel from the tank's air pipe in the port engine room exhaust ventilation casing and provided the fuel for the fire.

Manual fuel transfer

Fuel oil transfers on board *MPV Everest* could be conducted manually or automatically. In the automated transfer mode, the IAS would initiate the fuel oil transfer when fuel levels in the settling tank dropped to 50% of tank capacity or below. The system would then automatically stop the transfer pump thereby ceasing the filling of the tank when fuel levels reached 80% of tank capacity. The automated transfer and its associated safety mechanisms were verified to be operating correctly and fuel transfers had been conducted safely in the past using the automatic transfer mode.

The chief engineer's decision to conduct the fuel transfer manually was based on their personal and professional preference and was standard practice during their tenure on board. However, to be conducted safely, manual transfers required close supervision as the pump would continue to run and tank(s) would continue filling until the pump was stopped. The ship's SMS and fuel oil management plan offered no specific guidance on the risks, benefits or safety measures associated with manual or automatic fuel transfers.

In this case, after starting the pump and initiating the transfer, the chief engineer left the transfer unmonitored to carry out other tasks. The chief engineer also did not delegate another engineer to monitor the operation, nor was anyone else informed of the transfer in progress. There were other safety measures in place to alert personnel that a tank was being filled past safe levels, such as tank high level alarms and the overflow drain tank. However, in this instance, these measures failed, and the transfer continued unchecked until the settling tank overflowed.

Design of port fuel oil settling tank air pipe

The main objective of the International Convention for the Safety of Life at Sea (SOLAS) is to specify minimum standards for the construction, equipment and operation of ships to ensure an adequate level of safety. In meeting these objectives, SOLAS included regulations aimed at controlling the leaks of flammable liquids, limiting the accumulation of flammable vapours and preventing the ignition of combustible materials or flammable liquids.

Flag States are responsible for ensuring that ships under their flag comply with the requirements of the Convention. In practice, this is achieved by designing, constructing and maintaining ships in compliance with the requirements of a classification society recognized by the flag State. *MPV Everest* was classed with Bureau Veritas (BV) and the Russian Maritime Register of Shipping (RMRS) under a working arrangement, with BV responsible for design plan approval and survey at the shipyard of the ship's hull and piping systems, among others.

SOLAS regulations required that oil tanks be provided with a means of preventing overpressure. They also required that air pipes discharge to a position where there was no risk of fire or explosion from the emergence of oils and vapours, and that it should not lead to machinery spaces. BV rules were consistent with the SOLAS regulations and required that air pipes discharge to a safe position on the open deck where no danger would be incurred from issuing oil or gases.

MPV Everest's fuel oil settling tanks were fitted with an overflow pipe (to prevent over-pressurisation) which led to a drain tank fitted with an air pipe which terminated in a save-all on the open main deck. However, the settling tanks were also fitted with pipes whose purpose was to allow air into the settling tanks during fuel transfer operations. The settling tank air pipes were sited inside the engine room exhaust ventilation casing which were contiguous with the port and starboard machinery spaces several decks below. While the air pipes were situated in save-alls, the capacity of the ship's transfer pumps and limited volume of the save-all meant that, in the event fuel issued from the air pipe, it would inevitably overflow into the ship's machinery spaces, as occurred during this fire.

According to BV, settling tank air pipes were not intended for the egress of fuel, nor was such a risk identified or foreseen in the course of the normal operation of the ship. Nevertheless, had the air pipes been sited to discharge to a safe position on the open deck, in compliance with the SOLAS regulations and class rules, it is likely that the engine room fire would have been prevented.

Port fuel oil drain tank air pipe

The port fuel oil drain tank, and its air pipe on the main deck, were mandated measures aimed at mitigating the risk of overfilling and over pressurisation of the port settling tank. However, in this case, the drain tank filled with fuel overflowing from the settling tank, followed by the fuel level in the settling tank increasing past the tank's maximum capacity and overflowing into the ventilation casing and engine room.

Subsequent investigation identified that the thermostat for the port drain tank air pipe vent head's heating element (installed to prevent the icing over of the vent head's wire gauze flame screen) was not operational. Furthermore, weather and sea conditions in the hours and days before the fire were conducive to the port drain tank air vent head being subject to spray and icing. The drain tank vent head heating was believed to be in automatic mode which relied on the operation of the thermostat to initiate the generation of heat and melting of any ice blocking the vent head's flame screen. In the absence of vent head heating, it is likely that any icing of the flame screen either partially, fully or temporarily obstructed the port drain tank vent head resulting in the overflow of fuel from the settling tank air pipe.

Shipboard accounts indicated that some fuel was found in the main deck save-all where the port drain tank air pipe vent was located. This allowed for the possibility that the overflow of the settling tank could not be exclusively attributed to the icing over the vent head alone but possibly to some other hydrostatic, environmental or mechanical factors, or combination of factors, either separately or in conjunction with the vent head icing. Nevertheless, the majority of evidence, including the inoperative thermostat, prevalent weather and IAS data leading up to the overflow support the likelihood that the port drain tank air pipe vent head was probably obstructed, by icing over of the vent head's flame screen. This probably hindered, at least temporarily, the unobstructed flow of air and fuel through the port drain tank air pipe vent head and contributed to the overflow of fuel through the settling tank air pipe.

Ignition

The first indications of a fire on board *MPV Everest* were the sighting of flames issuing from the ventilation louvres of the port engine room's exhaust ventilation casing. Following this initial deflagration, eyewitness accounts and mobile phone footage showed a brief lull during which there was smoke issuing from the louvres while watercraft and other equipment located just outside the louvres burned. This was followed by the activation of fire detectors on B-Deck in the port engine room and a further deflagration event with flames once again emanating from the louvres.

It is estimated that up to 6,500 litres of fuel probably overflowed from the port settling tank air pipe into its save-all. This fuel flowed out of the save-all, down into the casing and into the port engine room below. As the fuel made its way down, it settled on and in various structures within the casing, including on an exposed section of DG3's exhaust trunking, on light fittings, cable trays and electrical enclosures in the port engine room below. The casing was also subject to a strong updraft of ventilation air which would have resulted in the rapid separation and static electrification of the fuel as well as the formation of fuel mists and aerosols which would have been expelled through the ventilation louvres.

Based on the available circumstances evidence, the investigation identified 4 potential ignition scenarios as follows:

- spontaneous ignition
- electrical arcing and spark discharge
- hot surface ignition
- electrostatic ignition.

The investigation considered it unlikely that either spontaneous ignition or electrical arcing (and associated spark discharge) was the source of ignition for the fire. There was no identified physical evidence of spontaneous combustion within the fire scene, nor did the investigation identify any obvious signs of arcing, short circuiting or internal combustion associated with electrical equipment in the affected spaces.

It was however considered possible that the fire was ignited as a result of hot surface ignition from exposure of fuel to the exposed surface of DG3's exhaust trunking. Evidence of oxidation at the exposed section of exhaust trunking indicated that combustion had occurred at this location, and it was possible that the fire developed further and ignited a flammable vapour cloud in the casing. However, evidence associated with such a scenario, including early development of smoke and the activation of engine room fire detectors before the conflagration event was not supported by accounts and recorded data.

The investigation found that the available evidence supported the conclusion that electrostatic ignition was the probable source of ignition of the fire on board *MPV Everest*. The overflowing fuel subject to agitation and misting due to the strong airflow in the casing probably resulted in the formation of an electrostatically-charged flammable vapour cloud. The area outside the ventilation louvres (where the vapour cloud was being expelled) was used as a storage area with several isolated and grounded metal conductors located in close proximity to each other. Calculations showed that the charged vapour cloud had sufficient charge and time to transfer charge into several grounded and isolated conductors located within the boundary areas of the fuel vapour cloud. An electrostatic discharge probably occurred with a grounded object, which ignited the vapour cloud and resulted in the fire.

Fatigue

In the time leading up to the fire, the chief engineer was experiencing a level of fatigue known to have an adverse effect on performance due to a lack of recent sleep.

The chief engineer reported that they obtained no sleep the night before the fire due to the ship's rolling. By the time of the fire, they had probably been awake for about 25-30 hours and it is very likely the chief engineer was experiencing an acute sleep debt. Biomathematical modelling confirmed this, showing a predicted reduction in their alertness around the time of the fuel transfer and fire. This would almost certainly have impacted the chief engineer's performance and would have contributed to fatigue-related errors affecting memory, particularly short term memory (of the fuel transfer in progress) and attention (distraction by another task). In this case, the chief engineer probably suffered a lapse in attention and/or was distracted from the task of conducting the manual fuel transfer and forgot to monitor the progress of the manual fuel transfer.

It is also possible that the chief engineer was experiencing a cumulative sleep debt after performing watchkeeping duties as well as chief engineer duties for 40 days prior to the fire as well as having worked on board the ship in challenging conditions for 4 months. Additionally, other factors including high mental and physical workload, stress and distraction probably contributed to the chief engineer experiencing a reduced level of alertness.

Shipboard emergency response

Fire drills, training and emergency preparedness

In addition to the various factors that contributed to the fuel oil overflow and ignition of the fire, there were elements of the ship's emergency preparedness and fire safety that made the response to the fire more challenging and less effective, and increased safety risk in general.

SOLAS and the ship's flag State regulations required regular fire drills to be held with consideration given to the various potential emergencies on board. The Australian Maritime Safety Authority (AMSA) provided further clarity by specifying that shipboard fire drills were to include drills for fires in the engine room. The regulations were also consistent in requiring drills to be realistic and conducted as if there were an actual emergency on board. While *MPV Everest*'s SMS did not specifically mandate engine room fire drills, it was largely consistent with SOLAS regulations with regard to drills and instruction and reflected the general requirement that drills be realistic and varied. The regulations also required instruction in the use of the ship's firefighting and life-saving appliances be provided at the same intervals as drills.

In the 4 months leading up to the fire, there had been no fire drills conducted in the ship's engine rooms, nor was there evidence of training sessions covering the engine room's water mist fixed fire-extinguishing system. With a few exceptions, all the officers and crew who joined the ship for the duration of the AAD charter, were new to the ship. Consequently, when the fire broke out, most of the ship's officers and engineers, including the master and chief engineer, had not participated in an engine room fire drill on board the ship.

The conduct of a realistic engine room fire drill would have offered an opportunity for the ship's crew to practice the response to such an emergency and build confidence in their abilities to respond to a fire in that space. It would also have allowed the crew to identify any challenges associated with the response to a fire in the engine room.

For example, during the response, the designated firefighters in the deck fire team (bosun and able seaman) refused to carry out their duties. This resulted in the second mate and third engineer assuming their roles and proceeding to close 3 of 4 ventilation louvres on the casing. However, they omitted to close the fourth louvre on the aft side of the casing most probably due to not being familiar with the vents and their location.

Analysis of the ship's voyage data recorder (VDR) audio, recorded during the emergency response, identified that the master consistently used the term 'CO_2' (carbon dioxide) to refer to the engine room's water mist fixed fire-extinguishing system. In addition to the demanding responsibilities of command, the master was subject to similar stress and fatigue risk factors as many of the crew, particularly during the emergency response. Although it is possible that, under these circumstances, inadvertent reference to 'CO_2' could be made, VDR audio and interview evidence certainly indicated that this was not the case and the master's decision-making and planning, at least initially, was based in the incorrect belief that the engine room was equipped with a CO_2 system. The automatic activation of the engine room water mist system meant that the master's misunderstanding had no impact on the overall response. However, it increased the risk of flawed decision-making resulting in inappropriate actions and response. It also initially resulted in incorrect information being provided to shore authorities and increased the risk of adversely influencing their planning and response.

The emergency prompt for engine room fires required by the SMS also incorrectly indicated that the ship's engine room was equipped with a CO_2 fixed fire-extinguishing system. Similarly, there were inconsistencies, relating to the coverage, operation and activation of, the water mist system, across the water mist system manual, SOLAS fire training manual and ship's fire control plan. While it is possible the master's misunderstanding was influenced by the incorrect emergency prompt, a realistic engine room fire drill would have allowed the crew to identify the error and to review the accuracy and effectiveness of the ship's emergency prompts. It would also have allowed the master, other officers and crew the opportunity to familiarise themselves with the operation, coverage, capabilities and limitations of the water mist system and identify inaccuracies in supporting documentation.

Another example of a situation where a realistic fire drill would have allowed an opportunity for improvement was the failure of the ship's ultra-high frequency (UHF) radio communication system. During the early stages of the response to fire, power to the engine room and adjacent medium voltage switchboard room was isolated. This inadvertently and unexpectedly resulted in power loss to the UHF system's repeaters, which effectively disabled the system. While the crew re-established communications quickly and effectively using survival craft radios, a drill involving simulated isolation of power to the affected spaces and subsequent analysis of affected services, would have allowed the crew to better prepare by designating a back-up communication system or by building additional redundancies into the system.

Water mist system

MPV Everest's engine room water mist fixed fire-extinguishing system was incorrectly installed during the ship's commissioning and remained so at the time of the AAD charter and fire. The error resulted in the bilge foam flooding system's eductor pump being installed to supply the reservoir from which the water mist system's high pressure pumps drew water and vice versa. This issue with the pump layout was known before the ship was dry docked in South Korea. However, the issue was not rectified, and the ship subsequently sailed to Antarctica with the incorrectly arranged pumps.

The general consensus among the ship's engineers was that the incorrect arrangement was unlikely to have had a significant adverse effect on the operation of the water mist system. However, the potential effect of the incorrect pump arrangement on the performance and effectiveness of the bilge foam system was unknown. While this error did not adversely influence the water mist system's performance in this fire, it increased the risk of an ineffective firefighting response in the event of a fuel oil fire in the engine room bilges.

Emergency generator

MPV Everest's emergency generator failed to operate consistently for the required duration. While the generator was started, it ran for a short time before shutting down probably due to contamination in the generator's fuel tank and an electrical issue with its automatic damper resulting in a restricted flow of cooling air. While the ship's engineers were able to start a generator in the starboard engine room and supply the emergency switchboard, the failure of the emergency generator left the ship without power and without the means to fight the fire for a brief period of time.

Electrical enclosures

Electrical enclosures including motor control centres and power distribution boards in *MPV Everest*'s engine room were found to be inadequately sealed against ingress of fluids. During examination of the fire-affected port engine room, evidence of fuel ingress and pooled diesel fuel was found inside electrical enclosures in the ship's port engine room. There was no evidence to indicate that the fuel inside was ignited by electrical arcing or spark discharge within the cabinets. However, a separate occurrence a few weeks after the fire resulted in seawater entering an electrical enclosure in the ship's pump room causing a minor explosion, short circuiting and arcing. This incident highlighted the increased risk posed by electrical enclosures that were inadequately sealed against fluid ingress.

Engineering watchkeeping

In the time leading up to the fire, as fuel levels in the port settling tank rose, no high level alarm was generated. This was because the port settling tank level variable had been designated 'Abnormal' the previous evening, effectively isolating it. This feature of the IAS was known to ship's engineers and was arguably a reasonable control measure intended to address alarm fatigue. It was also likely that practice on board had developed to allow the IAS to designate the alarm variables as 'Abnormal' thereby serving to reduce the incidence of alarms. However, there was no mechanism or process in place to ensure that 'Abnormal' variables were reinstated and monitored by the IAS before commencing an operation (such as a fuel transfer), the safety of which depended on IAS alarms. Consequently, the port settling tank high level variable remained isolated during the fuel transfer and an alarm that had the potential to alert the watchkeeping engineer to an imminent tank overflow was not generated.

On board *MPV Everest*, audible alerts for most alarms, including tank level alarms were only generated in the ship's ECR. This design characteristic, combined with the high volume and frequency of engineering alarms, necessitated having an engineering watchkeeper in the ECR at all times to acknowledge, accept and manage alarms. However, the ship's complement of available watchkeeping engineers was restricted to the chief engineer, second engineer and 2 third engineers. Further, the workload on board was generally high (and particularly so on the morning of the fire) and dedicating an engineer to managing alarms in the ECR would have reduced the resources available for planned maintenance and necessary work to keep machinery and systems operational. Consequently, it had become accepted practice on board for non-watchkeeping engineers, such as the chief electrician, to acknowledge and accept alarms.

About 22 minutes before the port settling tank overflowed, a port drain tank high level alarm was generated. This would have triggered an audible alert in the ECR and a visual alert on the IAS screen. The chief engineer who was in the starboard engine room reported hearing audible alarms being generated in the ECR and subsequently being acknowledged (silenced). This almost certainly included the port drain tank high level alarm, although the ATSB could not conclusively establish who silenced the alarm. The significance of this alarm should have been immediately apparent to a watchkeeping engineer. However, the alarm was silenced, most probably by a non-watchkeeping member of the ship's engineering team, without consideration of its significance, and without further investigation.

Search and rescue in the Southern Ocean

The Southern Ocean is known for its strong winds, cold temperatures, intense storms and rough seas. Most of these waters are remote and offer limited access to safe harbours, ports or sheltered waters with very low volumes of other shipping traffic. All these factors contribute to the significant challenge of mounting effective search and rescue (SAR) operations for ships in distress in these waters.

Following notification of the fire, Australia's Joint Rescue Coordination Centre (JRCC) assumed overall coordination of, and responsibility for, the shore response. Although the fire was eventually extinguished and propulsion restored, the initial scope of JRCC planning necessitated consideration of the need for towage assistance to recover the ship and its complement, and for SAR in the event the ship had to be abandoned.

JRCC efforts to seek and identify suitable surface and/or aviation assets in a position to render assistance to *MPV Everest* were timely, appropriate and expansive. However, despite these efforts, only very limited practical options could be identified. Coordination with the rescue coordination centres of other countries bordering Australia's SAR region and with other nations' Antarctic programs did not identify any merchant ships or other vessels in a position to assist. Similarly, planning by the Australian Defence Force (ADF) identified very limited aviation or maritime options owing primarily to factors such as distance, associated transit time to *MPV Everest*, and the availability and capabilities of aircraft and naval vessels.

Ultimately, a vessel of opportunity, the fishing vessel *Cape Arkona* which was about 3-4 days steaming from *MPV Everest*'s position, was the most suitable surface asset identified and was diverted to assist *MPV Everest*. While an aircraft was also readied, its utility would have been limited to observation, communication and possibly providing material aid. At the time, *MPV Everest*, with 109 persons on board, was over 1,500 miles from mainland Australia, without power or propulsion, with a major engine room fire and very rough weather forecast. In the event the fire could not be brought under control and/or *MPV Everest* had to be abandoned, any ensuing SAR and recovery operations would have been extremely challenging, with a successful outcome far from assured.

MPV Everest

Safety management system

MPV Everest was managed by Fox Offshore and operated under a Fox Offshore SMS from the time of the ship's commissioning in 2017. The shipboard SMS, while comprehensive, showed evidence of being immature, subject to inadequate or ineffective review and was not effectively implemented on board.

Manuals in the ship's SMS, such as the emergency response manual and SOLAS fire training manual included incorrect reference to other ships. The emergency response manual's emergency prompt for engine room fires also incorrectly referred to a CO_2 fixed fire-extinguishing system instead of the ship's water mist system.

The SMS identified the technical superintendent as a key member of the senior management team ashore with several responsibilities related to ensuring shipboard compliance with the SMS. However, while a technical superintendent was appointed and assigned to the vessel for the AAD charter, the ship had largely operated without one until that time. The technical superintendent was responsible for maintaining oversight of the ship's planned maintenance system (PMS), to identify outstanding work or overdue jobs, and to liaise with the chief engineer to identify solutions to complete the work or jobs. However, a significant number of overdue jobs steadily accumulated in *MPV Everest*'s PMS over the course of the AAD charter and Antarctic voyages.

MPV Everest was built as an ice-class ship and Polar Code certification was obtained in mid-2020 in preparation for the AAD charter. The ship's polar water operational manual, intended to support the master and crew when operating in polar waters, was aimed solely at operations in the Arctic and included no information on operations in the Antarctic. Whilst Arctic and Antarctic waters have a number of similarities, there are also significant differences including the weather, seasonal extent and nature of ice and proximity of ports of refuge and rescue. The ship's officers met the training requirements of the Code but had no experience operating in the Antarctic (with the exception of the master's brief experience some 20 years previously). Furthermore, neither the SMS, nor the master's standing orders included any guidance, instructions or procedures for operations in ice.

The SMS placed a responsibility on the ship's master to ensure that the vessel's work and watchkeeping schedule allowed for each crew member to be satisfactorily rested. The SMS also required the master to ensure that hours of rest were accurately recorded for all crew. However, at the time of the fire, the chief engineer was experiencing a level of fatigue known to have an adverse effect on performance. Furthermore, records of hours of rest for the chief engineer and other crew were found to be inaccurate and unrealistic.

SMS directions on drills and training and instruction in the use of firefighting equipment were also found to be inconsistently complied with. There was also no familiarisation in the use or contents of the SMS provided to the ship's crew, most of whom were working with Fox Offshore, and on board *MPV Everest*, for the first time.

Preparedness

Following *MPV Everest*'s delivery in December 2017, the ship had largely remained idle, at anchor off Singapore. The ship undertook 2 short charters in tropical waters and a 6-month charter in ice-free waters off Sakhalin Island before mobilising for the AAD charter. However, evidence indicated that there were still several unresolved issues from the ship's commissioning, including the ship's IAS and alarm system, the PMS and the engine room water mist system.

The ship's voyages to Antarctica were the first time that the ship, its equipment and machinery were subject to operations in ice. This resulted in many engineering challenges and a high workload environment on board, particularly for the ship's engineering complement. However, stringent AAD medical requirements and other difficulties due to the COVID-19 pandemic resulted in a situation where almost all the ship's officers and engineers were new to the ship and to operations in the Antarctic. In particular, the chief engineer had not worked on the ship or in ice previously. The ship's owners and managers sought to mitigate this risk by providing an extended hand-over (during the voyage from South Korea to Australia) for some key shipboard roles and by including additional personnel (including an additional second engineer) in the crew complement. However, the chief engineer did not have the benefit of an extended hand-over and, by the time the ship arrived in Antarctica on its second voyage, the ship's complement of 3 second engineers had reduced to a single second engineer capable of maintaining an engineering watch. Furthermore, the planned retention of a contingency crew in Hobart was cancelled and plans for crew relief after the first voyage to Antarctica did not eventuate, probably due to difficulties, restrictions and costs associated with the COVID-19 pandemic. These various factors combined with issues such as the design of the ship's IAS alarm system and the inability to practically operate the ship in the unattended machinery space mode further contributed to the high workload environment and increased the risk of crew fatigue.

The ship's SMS was not mature with incorrect information or incomplete information in several documents related to emergency response and firefighting. Furthermore, several elements of the SMS were not effectively implemented on board resulting in inadequate management of fatigue, difficulty complying with the ship's PMS schedule and an inadequate stock of spare parts and securing equipment on board.

At least 2 relatively serious incidents on board (the battery room fire and damage to the remotely operated vehicle) were directly related to the inadequate securing and preparation of the ship for operations in the Southern Ocean. While the ship was certified as complying with the Polar Code, several safety observations identified inadequacies in the ship's equipment for operations in polar waters. For example, the ship's searchlights were not adequate for operations in ice and there was a lack of de-icing equipment and spares for the bridge window heaters. Additionally, the ship's polar water operational manual did not include any information on the Antarctic.

The effectiveness of the engine room's water mist fixed fire-extinguishing system and the redundancy offered by the segregated starboard engine room were, respectively, instrumental in successfully extinguishing the fire and enabling the ship to restore propulsion. However, the unrectified error in the layout and installation of the ship's water mist system meant that the ship deployed to the Antarctic with a potentially defective fixed fire-extinguishing system. Furthermore, at the time of the fire, only one of the 3 generators (a secondary generator – DG6) in the starboard engine room was operational. There were multiple repairs required to restore DG5 to service (using parts from the damaged DG4) and to maintain DG6 in service, to ensure that propulsion could be maintained en route to Fremantle.

The harsh weather and seas of the Southern Ocean and the significant challenges involved in finding refuge or obtaining assistance necessitate the highest levels of readiness and preparation for ships intending to operate in these waters. However, *MPV Everest* was inadequately crewed, equipped and prepared for the challenges of operations in the Southern Ocean.

Australian Antarctic Division

As detailed above, *MPV Everest*'s SMS was not mature and was inconsistently and ineffectively applied on board. Furthermore, the ship was inadequately prepared for the rigours of operations in the Southern Ocean. The ship had not operated in ice and none of the officers had operated in the Antarctic previously. Consequently, the ship encountered challenges in terms of machinery, equipment, crewing and workload. AAD pre-chartering vetting and due diligence processes and procedures were neither effective nor adequately scoped to identify indicators of the above safety factors associated with *MPV Everest*'s SMS and preparedness for Antarctic operations.

The Department's post-fire investigation identified several areas requiring improvement and resulted in the introduction of an improved process for the completion of pre-charter due diligence arrangements. This included a review of any proposed chartered ship's SMS and historic safety performance, the engagement of independent maritime subject matter expertise to support the pre-charter, brokering and pre-mobilisation stages of procurement and the review of qualifications of key shipboard personnel. The investigation also triggered a review of the effectiveness of the AAD's procurement process and procedures for current and future chartering processes.

The review identified areas of process improvement relating to thresholds for tenderers requiring demonstrable capability in ship operations, augmentation of due diligence of sub-contractor capability and safety performance and developing standard operating procedures for implementation and mobilisation of charter vessels. The review also made recommendations intended to provide the AAD with a framework to ensure that chartered ice-class vessels are fit for purpose and delivered into service with appropriately trained crews, and robust technical support.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

Safety issues are highlighted in bold to emphasise their importance. A safety issue is a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the engine room fire on board *MPV Everest* that occurred in the Southern Ocean on 5 April 2021.

Contributing factors

- During a routine fuel transfer operation, *MPV Everest*'s port fuel oil settling tank overflowed resulting in the ingress of fuel oil into the ship's port engine room exhaust ventilation casing and into the port engine room below.
- The fire started when overflowing fuel from the port fuel oil settling tank ignited. The ignition was either due to overflowing fuel contacting a hot surface within the port engine room exhaust ventilation casing or due to an electrostatic discharge igniting a flammable vapour cloud, with the latter scenario considered more likely.
- The chief engineer's decision to conduct the routine fuel oil transfer in manual mode, without monitoring it or delegating another engineer to monitor it, circumvented the automated transfer mode's safety controls and resulted in the overflow of fuel.
- In the time leading up to the fire the chief engineer was experiencing a level of fatigue, due to a lack of recent sleep, known to have an adverse effect on performance. Consequently, they probably experienced a lapse in attention, which resulted in the manual fuel transfer continuing unchecked and the port settling tank overflowing undetected.
- Although unknown to the ship's engineers at the time of the fuel oil transfer, the thermostat controlling the automatic operation of the port fuel oil drain tank air vent head's electric heating element was inoperative and probably had been so for some time. Consequently, during the filling of the port fuel oil settling tank, it was probably partially or fully obstructed by ice over the vent head's flame screen. This probably hindered the unobstructed flow of air and fuel through the drain tank's air vent head and contributed to the overflow of fuel through the settling tank's air pipe.
- **Bureau Veritas' (the classification society responsible) design approval processes had not identified any potential risks associated with the positioning of the fuel oil settling tank air vent pipe termination within *MPV Everest*'s engine room ventilation casing. Consequently, it approved this design and siting of the air vent pipe that, in concert with other contributing factors, resulted in overflowing fuel from the pipe being directly introduced into the ship's machinery spaces.** (Safety issue)

Other factors that increased risk

- *MPV Everest*'s emergency generator failed to supply the emergency switchboard consistently and for the required duration probably due to contamination of the generator's fuel supply and a malfunction of its cooling system. Consequently, firefighting resources such as the emergency fire pump and the engine room water mist fixed fire-extinguishing system were unavailable for a short period of time until an alternative generator could be started to supply the emergency switchboard.
- The shipboard ultra-high frequency radio communication system designated for emergency use failed unexpectedly during the fire due to the isolation of electrical power to the port engine room undertaken in the course of the emergency response. The loss of the communication system hindered shipboard emergency communications and the coordination of early firefighting efforts, including making it more difficult to account for all personnel.
- The master had an incorrect understanding of the type of the ship's engine room fixed fire-extinguishing system, believing it was a carbon dioxide system instead of the water mist system fitted. This increased the risk that firefighting efforts could have been hindered while unnecessary measures associated with the activation of a gas system were taken.
- **While fire drills conducted on board *MPV Everest* exceeded the minimum number required by regulations, none practised an engine room fire, nor was there was any evidence of onboard training and instruction being provided in the use of the engine room water mist fixed fire-extinguishing system. Consequently, several crew members were unfamiliar with the operation of the system and opportunities to evaluate the ship's emergency preparedness and remedy areas in need of improvement were lost.** (Safety issue)
- Inappropriate engineering watchkeeping practices on board, influenced by factors such as workload, crewing, and the characteristics of the ship's integrated automation system reduced the effectiveness of this system and increased the risk that appropriate personnel would not be alerted to engineering conditions and events requiring attention.
- **Electrical enclosures in *MPV Everest*'s engine rooms allowed the ingress of fuel into the enclosures and did not meet the responsible classification society fluid ingress protection standards intended to reduce the associated risk of harmful effects and damage.** (Safety issue)
- **The engine room water mist fixed fire-extinguishing system on board *MPV Everest* was incorrectly installed. This increased the risk of an ineffective response in the event of a bilge fire.** (Safety issue)
- **Inconsistent, incorrect or missing information related to aspects of *MPV Everest*'s water mist fixed fire-extinguishing system, including the spaces covered by the system and its design/operation, in multiple ship's documents increased the risk of the crew incorrectly responding to a fire.** (Safety issue)
- ***MPV Everest*'s managers at the time of the fire, Fox Offshore, had not ensured that the ship was adequately manned, equipped or prepared for the hazards of operations in the Southern Ocean and Antarctica.** (Safety issue)
- ***MPV Everest*'s safety management system (SMS) was neither sufficiently mature for its operations nor had it been implemented effectively or consistently on board the ship at the time of the fire. Further, safety oversight by Fox Offshore, the ship's managers, had not been effective in monitoring and ensuring compliance with the SMS.** (Safety issue)
- **The Australian Antarctic Division's pre-charter due diligence arrangements were ineffective at accurately assessing the suitability and level of preparedness of *MPV Everest*, its crew and its safety management system for operations in Antarctica.** (Safety issue)

Other findings

- In the event of an abandonment, factors such as distance, weather, and availability of suitable search and rescue assets would have made any potential rescue of *MPV Everest*'s complement extremely challenging, with a successful outcome far from assured.

Safety issues and actions

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues. The ATSB expects relevant organisations will address all safety issues an investigation identifies.

Depending on the level of risk of a safety issue, the extent of corrective action taken by the relevant organisation(s), or the desirability of directing a broad safety message to the marine industry, the ATSB may issue a formal safety recommendation or safety advisory notice as part of the final report.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation. The initial public version of these safety issues and actions are provided separately on the ATSB website, to facilitate monitoring by interested parties. Where relevant, the safety issues and actions will be updated on the ATSB website as further information about safety action comes to hand.

Fire drills and training

Safety issue description

While fire drills conducted on board *MPV Everest* exceeded the minimum number required by regulations, none practised an engine room fire, nor was there was any evidence of onboard training and instruction being provided in the use of the engine room water mist fixed fire-extinguishing system. Consequently, several crew members were unfamiliar with the operation of the system and opportunities to evaluate the ship's emergency preparedness and remedy areas in need of improvement were lost.

Issue number:	MO-2021-003-SI-01
Issue owner:	Fox Offshore and Maritime Construction Services
Transport function:	Marine: Shipboard operations
Current issue status:	Closed – Adequately addressed
Issue status justification:	The amendments to the ship's drill procedures, particularly the requirement for the conduct of realistic drills in various spaces on board the ship, and shore oversight of shipboard drills through review of completed drill reports and during internal audits, should adequately address this safety issue.

Proactive safety action taken by Maritime Construction Services

Action number:	MO-2021-003-PSA-181
Action organisation:	Maritime Construction Services
Action status:	Closed

On 31 August 2023, Maritime Construction Services (MCS) advised the ATSB that following the fire, it commissioned an independent third-party investigation. Subsequently, Fox Offshore was relieved of its responsibilities as the ship's managers (in October 2021 - about 5 months after the fire), and MCS temporarily took over management of the ship as an interim measure.

In February 2023, MCS appointed Northern Marine Ship Management as *MPV Everest*'s new managers and implemented a new shipboard safety management system (SMS). In submission to the draft report, MCS advised the ATSB that shipboard drills are carried out in accordance with the shipboard SMS's drill schedule which required that:

- fire drills are planned such that consideration is given to regular practice in various emergencies that may occur depending on the type of ship and cargo
- drills should be conducted in the various compartments and spaces on board
- drills be conducted in as realistic a manner as possible
- instruction in the use of safety processes and equipment is included in drills where possible
- applicable drill checklists are used during drills
- drill reports are completed and submitted to the ship's managers following every drill
- drills that cannot be conducted as scheduled are deferred, with the reasons for the deferral and the new scheduled date recorded and reported to the ship's managers.

On 3 October 2023, MCS further advised that drill reports were submitted to shore management for verification of compliance with drill requirements and that the conduct of drills and exercises were also checked during internal shipboard audits.

The ATSB's review of drill reports for fire drills conducted on board in 2023 showed evidence of compliance with the requirements of the drill schedule detailed above, including the conduct of machinery space fire drills and training sessions in the use of the water mist system.

The ATSB had also provided Fox Offshore a copy of the draft report to allow it the opportunity to review the report and make submissions, but received no response from Fox Offshore.

Construction of electrical enclosures

Safety issue description

Electrical enclosures in *MPV Everest*'s engine rooms allowed the ingress of fuel into the enclosures and did not meet the responsible classification society fluid ingress protection standards intended to reduce the associated risk of harmful effects and damage.

Issue number:	MO-2021-003-SI-02
Issue owner:	Fox Offshore and Maritime Construction Services
Transport function:	Marine: Shipboard operations
Current issue status:	Closed – Adequately addressed
Issue status justification:	The inspection, identification and rectification of electrical enclosures with inadequate sealing arrangements should adequately address this safety issue.

Proactive safety action taken by Maritime Construction Services

Action number:	MO-2021-003-PSA-182
Action organisation:	Maritime Construction Services
Action status:	Closed

On 5 February 2022, Maritime Construction Services (MCS) advised the ATSB that, during post-fire repairs in Singapore in July 2021, Z-Power automation (the manufacturers of the ship's electrical enclosures) was engaged to inspect electrical enclosures in the ship's machinery spaces. The inspection identified 7 electrical enclosures with inadequate sealing arrangements, which were subsequently rectified by the manufacturers and the shipyard.

Installation of water mist system pumps

Safety issue description

The engine room water mist fixed fire-extinguishing system on board *MPV Everest* was incorrectly installed. This increased the risk of an ineffective response in the event of a bilge fire.

Issue number:	MO-2021-003-SI-03
Issue owner:	Fox Offshore and Maritime Construction Services
Transport function:	Marine: Shipboard operations
Current issue status:	Closed – Adequately addressed
Issue status justification:	The modification of *MPV Everest*'s water mist system to rectify the incorrect pump layout should adequately address this safety issue.

Proactive safety action taken by Maritime Construction Services

Action number:	MO-2021-003-PSA-183
Action organisation:	Maritime Construction Services
Action status:	Closed

On 18 November 2021, Maritime Construction Services (MCS) advised the ATSB that, during post-fire repairs in Singapore in June 2021, modifications were made to the water mist system piping to rectify the incorrect pump layout. The water mist fixed fire-extinguishing system was subsequently subject to inspection and testing by the manufacturer (Ultra Fog) and was found to be operating satisfactorily.

Fire safety documentation

Safety issue description

Inconsistent, incorrect or missing information related to aspects of *MPV Everest*'s water mist fixed fire-extinguishing system, including the spaces covered by the system and its design/operation, in multiple ship's documents increased the risk of the crew incorrectly responding to a fire.

Issue number:	MO-2021-003-SI-04
Issue owner:	Fox Offshore and Maritime Construction Services
Transport function:	Marine: Shipboard operations
Current issue status:	Closed – Adequately addressed
Issue status justification:	The review and update of *MPV Everest*'s mandatory fire training manual and fire control plan to accurately reflect all relevant aspects of the water mist fixed fire-extinguishing system's coverage, activation and operation should adequately address this safety issue.

Proactive safety action taken by Maritime Construction Services

Action number:	MO-2021-003-PSA-184
Action organisation:	Maritime Construction Services
Action status:	Closed

On 31 August 2023, Maritime Construction Services (MCS) advised the ATSB that following the fire, it commissioned an independent third-party investigation. Subsequently, Fox Offshore was relieved of its responsibilities as the ship's managers (in October 2021 - about 5 months after the fire), and MCS temporarily took over management of the ship as an interim measure.

In February 2023, MCS appointed Northern Marine Ship Management as *MPV Everest*'s new managers. MCS advised the ATSB that *MPV Everest*'s mandatory fire training manual and fire control plan were reviewed and amended to accurately reflect all relevant aspects of the water mist fixed fire-extinguishing system's coverage, activation and operation.

The ATSB had also provided Fox Offshore a copy of the draft report to allow it the opportunity to review the report and make submissions, but received no response from Fox Offshore.

Bureau Veritas design approval

Safety issue description

Bureau Veritas' (the classification society responsible) design approval processes had not identified any potential risks associated with the positioning of the fuel oil settling tank air vent pipe termination within *MPV Everest*'s engine room ventilation casing. Consequently, it approved this design and siting of the air vent pipe that, in concert with other contributing factors, resulted in overflowing fuel from the pipe being directly introduced into the ship's machinery spaces.

Issue number:	MO-2021-003-SI-05
Issue owner:	Bureau Veritas
Transport function:	Marine: Shore-based operations
Current issue status:	Closed – Adequately addressed
Issue status justification:	The safety action taken by Bureau Veritas to raise awareness of the fire and its contributing factors, in particular the siting of the fuel oil settling tank air pipe, among its local plan approval offices (LPO) should serve to increase the effectiveness of future risk assessments associated with ship design plan approvals. Additionally, evidence provided to the ATSB of ship's plans with a similar fuel oil tank air pipe design feature, which was assessed and challenged by the LPO, resulting in the design being modified to comply with BV rules, supports the effectiveness of the safety action. Finally, the action taken by Fox Offshore and Maritime Construction Services in modifying the air pipes to terminate externally effectively eliminates the hazard associated with the positioning of the pipes on board *MPV Everest*. Therefore, the ATSB considers that this safety issue has been adequately addressed.

Proactive safety action taken by Bureau Veritas

Action number:	MO-2021-003-PSA-185
Action organisation:	Bureau Veritas
Action status:	Closed

On 8 September 2023, Bureau Veritas (BV) advised the ATSB that a case study on the fire was presented to local plan approval office (LPO) managers and to BV global operational representatives at BV's annual seminar to raise awareness of the accident and its associated contributing factors. LPO managers were required to pass on learnings from the case study to their respective teams. BV advised that this had resulted in proposed designs of this nature being assessed more closely and, as evidence, provided an example where plans for a ship with a similar air pipe design, submitted by a shipyard for BV approval, were challenged and resulted in appropriate revision of the drawing and the location of the pipe. Additionally, BV advised that it is working to implement a process to formally disseminate safety alerts to LPOs for matters related to design review.

Preparedness of *MPV Everest*

Safety issue description

MPV Everest's managers at the time of the fire, Fox Offshore, had not ensured that the ship was adequately manned, equipped or prepared for the hazards of operations in the Southern Ocean and Antarctica.

Issue number:	MO-2021-003-SI-06
Issue owner:	Fox Offshore and Maritime Construction Services
Transport function:	Marine: Shore-based operations
Current issue status:	Closed – Adequately addressed
Issue status justification:	The safety action taken by Maritime Construction Services and the ship's new managers (Northern Marine Ship Management) should adequately address this safety issue as the actions are directed at aspects of the ship's management and operations relevant to the risks identified by the ATSB.

Proactive safety action taken by Maritime Construction Services

Action number:	MO-2021-003-PSA-186
Action organisation:	Maritime Construction Services
Action status:	Closed

On 31 August 2023, Maritime Construction Services (MCS) advised the ATSB that following the fire, it commissioned an independent third-party investigation. Subsequently, Fox Offshore was relieved of its responsibilities as the ship's managers, and MCS temporarily took over management of the ship as an interim measure.

In February 2023, MCS appointed Northern Marine Ship Management (Northern Marine) as *MPV Everest*'s new managers with a view to improving the safety culture on board. MCS advised that in preparing for similar future projects, greater emphasis was to be placed on enhancing the effectiveness of gap analyses and increasing reliance on the use of third-party expertise to ensure ship readiness. Improved crew selection and redundancy processes were also adopted based on the principle that the risk exposure resulting from a crew that was entirely new to the ship was not acceptable.

In addition, MCS advised that in the event of the ship's trading area changing (for example, to polar waters), a full change management process would be triggered to identify potential gaps in procedures, manning and equipment that need to be addressed. The change management process tools would be used to ensure that effective control measures and gap analyses were conducted with relevant third-party expertise (including polar expertise) engaged as required.

The ATSB had also provided Fox Offshore a copy of the draft report to allow it the opportunity to review the report and make submissions, but received no response from Fox Offshore.

Safety management system

Safety issue description

MPV Everest's safety management system (SMS) was neither sufficiently mature for its operations nor had it been implemented effectively or consistently on board the ship at the time of the fire. Further, safety oversight by Fox Offshore, the ship's managers, had not been effective in monitoring and ensuring compliance with the SMS.

Issue number:	MO-2021-003-SI-07
Issue owner:	Fox Offshore and Maritime Construction Services

Transport function:	Marine: Shore-based operations
Current issue status:	Closed – Adequately addressed
Issue status justification:	The safety action taken by Maritime Construction Services and the ship's new managers (Northern Marine Ship Management) should adequately address this safety issue as the actions are directed at aspects of the ship's management and operations relevant to the risks identified by the ATSB.

Proactive safety action taken by Maritime Construction Services

Action number:	MO-2021-003-PSA-187
Action organisation:	Maritime Construction Services
Action status:	Closed

On 31 August 2023, Maritime Construction Services (MCS) advised the ATSB that following the fire, it commissioned an independent third-party investigation. Subsequently, Fox Offshore was relieved of its responsibilities as the ship's managers and MCS temporarily took over management of the ship as an interim measure.

In February 2023, MCS appointed Northern Marine Ship Management (Northern Marine) as *MPV Everest*'s new managers with a view to improving the safety culture on board. MCS advised that the Northern Marine safety management system (SMS) was mature and appropriately supplemented by ship-specific procedures with a dedicated technical superintendent appointed to support the ship and regular meetings scheduled between shore and ship to proactively manage emerging shipboard issues. Additionally, when a new ship is introduced to the Northern Marine fleet, a fleet safety specialist physically attends the ship to ensure that the crew is fully familiarised with the SMS before it proceeds to sea.

In preparing for future projects, greater emphasis was to be placed on enhancing the effectiveness of gap analyses, increasing reliance on the use of third-party expertise to ensure ship readiness. Improved crew selection and redundancy processes were also adopted based on the principle that the risk exposure resulting from an entirely new crew was not acceptable. In addition, MCS advised that in the event of the ship's trading area changing (for example, to polar waters), a full change management process would be triggered to identify potential gaps in procedures, manning and equipment that need to be addressed. The change management process tools would be used to ensure that effective control measures and gap analyses were conducted, with relevant third-party expertise (including polar expertise) engaged as required.

The ATSB had also provided Fox Offshore a copy of the draft report to allow it the opportunity to review the report and make submissions, but received no response from Fox Offshore.

Australian Antarctic Division

Safety issue description

The Australian Antarctic Division's pre-charter due diligence arrangements were ineffective at accurately assessing the suitability and level of preparedness of *MPV Everest*, its crew and its safety management system for operations in Antarctica.

Issue number:	MO-2021-003-SI-08
Issue owner:	Australian Antarctic Division and Department of Climate Change, Energy, the Environment and Water
Transport function:	Marine: Other
Current issue status:	Closed – Adequately addressed
Issue status justification:	The safety action taken by the Department of Climate Change, Energy, the Environment and Water, and by the Australian Antarctic Division, to improve the

	pre-charter due diligence and procurement arrangements should address this safety issue.

Proactive safety action taken by the Department of Climate Change, Energy, the Environment and Water

Action number:	MO-2021-003-PSA-188
Action organisation:	Department of Climate Change, Energy, the Environment and Water
Action status:	Closed

On 28 November 2022, the Department of Climate Change, Energy, the Environment and Water (the Department) advised the ATSB that, following an investigation into the fire, the Department initiated a number of changes to the way it identifies, engages with and manages chartered ships and their managers/operators, as follows:

- The introduction of an improved process for the completion of pre-charter due diligence arrangements, including:
  - an expert physical pre-charter inspection of the ship and the tracking of inspection deficiencies through to close-out
  - a review of any proposed chartered ship's safety management system (SMS) and historic safety performance
  - a review of resumes of key personnel to be used on the ship (completed by the Australian Antarctic Division's shipping section for the purpose of providing assurance of each individual's level of experience, qualifications and competencies)
  - the engagement of independent maritime subject matter expertise to support the pre-charter/brokering and pre-mobilisation stage.
- Updates to the contractual elements of the charter party agreement used by the Department, with the revised agreement directly addressing a range of SMS requirements.
- The development of a comprehensive 'bridging document' that describes the functional links between the chartered ship's SMS and the Australian Antarctic Division's (AAD) SMS with the requirement that this document be appropriately customised and agreed to by the parties addressed in the charter party agreement.
- The completion of season and voyage specific risk assessments with the intent that the voyage specific assessments will holistically address the interactions between the chartered ship, the AAD and third parties.
- General improvements to the voyage orders provided to the vessel's master and the AAD voyage leader by AAD management including clarification of who reports what to who and when.

Proactive safety action taken by the Australian Antarctic Division

Action number:	MO-2021-003-PSA-189
Action organisation:	Australian Antarctic Division
Action status:	Closed

On 28 November 2022, the Australian Antarctic Division (AAD) advised the ATSB that, following an independent review of the effectiveness of its procurement process and shipping standard operating procedures for current and future chartering processes, several areas of process improvements were identified relating to:

- pre-qualification thresholds for tenderers/prime contractors, requiring demonstrable capability in ship operations

- incorporating workplace health and safety (WHS) requirements across the end-to-end procurement, evaluation, implementation and operation processes
- augmenting 'due diligence' of prime and sub-contractor experience, capability and safety performance during the tender evaluation process
- developing standard operating procedures for implementation and mobilisation of chartered ships
- AAD emergency response procedures aboard chartered ships.

The review also made several recommendations aimed at providing the AAD with a framework to ensure that ice-class ships chartered from the international shipping market were fit for purpose and delivered into service with appropriately trained crews, and robust technical support. The framework also sought to ensure that work health and safety (WHS) obligations between the AAD and chartered ships were integrated providing the AAD with visibility of safe voyage operations and assurance that risk was assessed, controlled and transparently reported throughout the deployment.

The AAD adopted, (or was in the process of adopting), several recommendations including that:

- the AAD engage a maritime subject matter expert to evaluate tenderer capability and experience, in conjunction with the technical evaluation of the ship, with the intention of providing greater depth to the legal and technical 'due diligence' phases of chartering/procurement processes
- the scope of the experience and capability evaluation should be expanded to include organisation structure, sub-contracting relationships, and comparable assets under management
- the AAD develop and maintain a ship inspection questionnaire for subject matter experts or appropriately qualified third-party ship inspectors to perform before delivery
- the AAD develop a standard operating procedure for the implementation of the charter party and mobilisation of the ship into service.

Additionally, the AAD also:

- introduced a biannual risk review into the Department's WHS audit and assurance process where AAD management review risks with the potential to result in fatalities and assess the efficacy of the associated controls
- restructured the AAD shipping section to incorporate new roles including a senior person in the role of shipping manager and the introduction of compliance and technical support roles
- introduced a requirement for scheduled weekly meetings with each chartered vessel's operator prior to and during the vessel's deployment
- introduced a requirement in the bridging documents for the reporting of monthly key performance indicators [including incident reports and reports on the planned maintenance system] from each chartered ship's operator
- established a requirement for experienced ice pilots to be embarked aboard commercially chartered ships in addition to the minimum manning requirements.

Safety action not associated with an identified safety issue

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. All of the directly involved parties are invited to provide submissions to this draft report. As part of that process, each organisation is asked to communicate what safety actions, if any, they have carried out to reduce the risk associated with this type of occurrences in the future. The ATSB has so far been advised of the following proactive safety action in response to this occurrence.

Additional safety action by Maritime Construction Services

On 18 November 2021, Maritime Construction Services (MCS) advised the ATSB that, during post-fire repairs in Singapore in June 2021, class-approved modifications were made to the air pipes of the port and starboard settling tanks, day tanks, boiler day tanks and purifier sludge tanks.

These air pipes, which previously terminated within the engine room exhaust ventilation casings were modified and extended to terminate externally on the open deck above the engine room exhaust ventilation casings in compliance with the rules. The air pipe terminations were located within a suitably sized save-all, water drains fitted to the pipes to prevent water ingress in the event of damage and tank vent heating systems installed to comply with the ship's ice-class notations.

Additional safety action by Bureau Veritas

Bureau Veritas required that *MPV Everest*'s modified air vent pipes be fitted with de-icing systems as well as alarms to indicate faults in the de-icing systems. A condition of class was placed directing that the ship was not to be operated in arctic regions or in areas where there was risk of having frozen or blocked air vent pipes until such systems were in place.

Additional safety action by the Australian Antarctic Division

The Australian Antarctic Division (AAD) instructed Serco, the manager and operator of the new Australian Government-owned Antarctic icebreaker *Nuyina* (which arrived in Australia in October 2021) to review the findings of the ATSB investigation, and the fire investigation commissioned by *MPV Everest*'s owners to ensure that an incident arising from similar circumstances to those on board *MPV Everest* could not occur. In the event that similar hazards or risks were identified, Serco was asked to present a plan on how these matters were to be addressed.

General details

Occurrence details

Date and time:	5 April 2021 – 1058 ship's time [UTC +7 hours]	
Occurrence class:	Accident	
Occurrence categories:	Fire/explosion	
Location:	Southern Ocean	
	Latitude: 58.0200º S	Longitude: 098.0480º E

Ship details

Name:	*MPV Everest*	
IMO number:	9769130	
Call sign:	C6CZ6	
Flag:	Bahamas	
Classification society:	Bureau Veritas and Russian Maritime Register of Shipping	
Departure:	Mawson station, Australian Antarctic Territory	
Destination:	Hobart, Tasmania	
Ship type:	Multi-purpose vessel/Diving support vessel	
Builder:	Keppel Singmarine	
Year built:	2017	
Owner(s):	New Orient Marine, Singapore	
Manager:	Fox Offshore, Singapore	
Gross tonnage:	21,943	
Deadweight (summer):	7,189 t	
Summer draught:	8.2 m	
Length overall:	145 m	
Moulded breadth:	30 m	
Moulded depth:	13 m	
Main engine(s):	4 x Rolls-Royce (Bergen) B32:40V (5,530 kW) 2 x Rolls-Royce (Bergen) C25:33 (1,825 kW)	
Total power:	25,770 kW	
Speed:	13 knots	
Injuries:	Crew – 0	Passengers – 0
Damage:	Substantial damage to port engine room, 2 watercraft and other loose equipment destroyed on deck.	

Glossary

AAD	Australian Antarctic Division
AAP	Australian Antarctic Program
ADF	Australian Defence Force
AHTS	Anchor handling tug supply (vessel)
AIT	Automatic ignition temperature
AMSA	Australian Maritime Safety Authority
ASA	Airservices Australia
BAS	British Antarctic Survey
BMA	Bahamas Maritime Authority
BV	Bureau Veritas
CCTV	Closed-circuit television
CO_2	Carbon dioxide
DG	Diesel generator
DP	Dynamic positioning
ECR	Engine control room
ETO	Electrical-technical officer
FAID	Fatigue assessment tool by InterDynamics
FAST	Fatigue avoidance scheduling tool
FP	Flash point temperature
FRC	Fast rescue craft
FRP	Fibre-reinforced plastic
HF	High frequency (radio)
HQJOC	Headquarters Joint Operations Command
HSEQ	Health safety environment and quality
IAS	Integrated automation system
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
IP	Ingress protection (standards)
ISM	International Management Code for the Safe Operation of Ships and for Pollution Prevention, 1995, as amended
JOR	Joint Operations Room
JRCC	Joint Rescue Coordination Centre
LFL	Lower flammable limit
LPO	Local plan approval offices
MARPOL	The International Convention for the Prevention of Pollution from Ships, 1973, as amended

MBC	Maritime Border Command
MCC	Motor control centre
MCS	Maritime Construction Services
NI	Nautical Institute
OSV	Offshore supply vessel
PA	Public address (system)
PDB	Power distribution board
PMS	Planned maintenance system
QCV	Quick closing valve
RCC	Rescue Coordination Centre
RFT	Request for tender
RHIB	Rigid hull inflatable boat
RMRS	Russian Maritime Register of Shipping
ROV	Remotely operated vehicle
RSV	Research Survey Vessel
SAB	Special Antarctic Blend (diesel)
SAR	Search and rescue
SCBA	Self-contained breathing apparatus
SITREP	Situation report
SMS	Safety management system
SOLAS	The International Convention for the Safety of Life at Sea, 1974, as amended
SRR	Search and rescue region
STCW	Standards of Training, Certification and Watchkeeping for Seafarers, 1995, as amended
UFL	Upper flammable limit
UHF	Ultra-high frequency (radio)
UMS	Unattended machinery space
VDR	Voyage data recorder
VHF	Very high frequency (radio)

Sources and submissions

Sources of information

The sources of information during the investigation included:

- ABB Singapore
- Airservices Australia
- Australian Antarctic Division
- Australian Defence Force
- Australian Maritime Safety Authority
- Bahamas Maritime Authority
- British Antarctic Survey
- Bureau of Meteorology
- Bureau Veritas
- Community and Public Sector Union
- Department of Climate Change, Energy, the Environment and Water
- directly involved Australian Antarctic Division staff and expeditioners onboard *MPV Everest*
- directly involved officers and crew of *MPV Everest*
- Fox Offshore
- Keppel Singmarine
- Kuiper International
- Maritime Construction Services
- recorded data from the ship's voyage data recorder
- Russian Maritime Register of Shipping
- TMC Marine
- video footage and other photographs taken on the day of the fire.

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Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- ABB Singapore
- Australian Antarctic Division (AAD)
- Australian Defence Force (ADF)
- Australian Maritime Safety Authority (AMSA)
- Bahamas Maritime Authority (BMA)
- Bureau Veritas (BV)
- Department of Climate Change, Energy, the Environment and Water (DCCEEW)
- directly involved Australian Antarctic Division staff and expeditioners onboard *MPV Everest*
- directly involved officers and crew of *MPV Everest*
- Fox Offshore
- Maritime Construction Services (MCS)
- Russian Maritime Register of Shipping (RMRS).

Submissions were received from:

- AAD
- AMSA
- BMA
- BV
- DCCEEW
- directly involved Australian Antarctic Division staff and expeditioners onboard *MPV Everest*
- directly involved officers and crew of *MPV Everest*
- MCS.

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, international agreements.

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.