July 9, 2024 MIR-24-17

Engine Room Fire on board Passenger Ferry *Sandy Ground*

Anchorage Channel, New York Harbor
Staten Island, New York
December 22, 2022

Abstract: This report discusses the December 22, 2022, fire aboard the passenger ferry *Sandy Ground* in Anchorage Channel, New York Harbor, near Staten Island, New York. Safety Issues identified in this report include engineering crewmembers' ineffective management of fuel oil day tank levels on the *Sandy Ground*; inadequate training for engineering crewmembers on the use of fuel oil return isolation valves in the fuel oil system; need for a requirement to maintain unimpeded return flow in diesel engine fuel oil return systems; and the need for additional regulatory and classification society guidance on fuel oil return system design. As part of this investigation, the National Transportation Safety Board makes five new safety recommendations to the US Coast Guard and the American Bureau of Shipping.

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Acronyms and Abbreviations

ABS	American Bureau of Shipping
CFR	*Code of Federal Regulations*
EBDG	Elliott Bay Design Group
EOS	engine operating station
ESG	Eastern Shipbuilding Group
IACS	International Association of Classification Societies
MCS	machinery control station
MSC	US Coast Guard Marine Safety Center
NTSB	National Transportation Safety Board
NYCDOT	New York City Department of Transportation
psi	pounds per square inch
SNAME	Society of Naval Architects and Marine Engineers
SOLAS	*International Convention for the Safety of Life at Sea*
VTS	vessel traffic service

Executive Summary

What Happened

On December 22, 2022, about 1654 local time, an engine room fire broke out aboard the passenger ferry *Sandy Ground,* while the vessel was underway in New York Harbor, near Staten Island, New York, with 884 persons aboard. The crew extinguished the fire by activating the engine room's fixed fire extinguishing system. The vessel lost propulsion and electricity, and the crew deployed both anchors. The majority of the passengers transferred to responding Good Samaritan vessels; the *Sandy Ground* was towed to the St. George Ferry Terminal in Staten Island, where the remaining persons on board disembarked. There were no injuries, and no pollution was reported. Damage to the vessel was estimated at $12.7 million.

What We Found

We found that engineering crewmembers on duty at the time of the casualty ineffectively managed fuel oil levels in the vessel's two fuel oil day tanks, causing the difference in the two tanks' levels to sharply increase. To correct this difference in levels, the engineering crewmembers closed the fuel oil return isolation ball valves to both day tanks, causing the fuel oil system to overpressurize and the fuel oil filters on the main engines to rupture. Fuel oil spraying from a ruptured fuel oil filter onto the operating no. 2 main engine ignited, causing a fire to break out in the engine room. After the initial alarms, the engines continued to run, so pressurized fuel oil continued to spray, increasing the severity of the fire. However, the crew's actions to effectively contain and extinguish the fire once the engines were stopped, combined with the quick response of nearby Good Samaritan vessels, resulted in the safe evacuation of all persons on board.

We found that the engineering crewmembers on duty at the time of the casualty were not operating the fuel oil system in accordance with the operator's written guidance. We also found that Staten Island Ferry's training program for engineering crewmembers was inadequate because crewmembers did not receive follow-on instruction after isolation ball valves were installed in the fuel oil return piping. Additionally, because the *Sandy Ground* engineering crewmembers had worked on other Staten Island ferries that were equipped with relief valves in their fuel oil return systems—unlike the *Sandy Ground*—they likely expected that the fuel oil system could not be overpressurized.

We found that, had the *Sandy Ground* been equipped with a pressure relief valve installed in the fuel oil return line, the elevated fuel oil pressure caused by the closed fuel oil return isolation ball valves would have been relieved, and fuel oil system overpressurization would have been prevented. When the fuel oil system drawing (diagram) was initially submitted to the US Coast Guard and American Bureau of Shipping for approval, as was required by regulations, the drawing complied with all applicable regulations and classification rules. However, explicit requirements and guidance for maintaining unimpeded return flow in diesel engine fuel oil return systems would mitigate the risk of a system overpressurization. Additionally, specific guidance on maintaining unimpeded diesel engine fuel oil return flow would provide naval architects and engineers with additional information for the safe design of these systems. Finally, we found that other classification societies would benefit from learning about the circumstances of the engine room fire aboard the *Sandy Ground* in order to share that information with their members so that future vessel designs provide for unimpeded return fuel oil flow.

We determined that the probable cause of the engine room fire aboard the passenger ferry *Sandy Ground* was the design of the vessel's diesel engine fuel oil return system, which included isolation valves that could be regularly adjusted by the crew and, when closed, stopped return fuel oil flow from all operating engines, resulting in the overpressurization of the fuel oil system and the ignition of fuel oil spraying from ruptured fuel oil filters onto the exhaust manifold of a running engine. Contributing to the overpressurization was the operator's inadequate training program on fuel oil system operation, which did not provide follow-on instruction after the installation of fuel oil return isolation valves at the day tanks.

What We Recommended

We recommended that the Coast Guard update marine engineering regulatory requirements applicable to US-flagged vessels to require diesel engine fuel oil return systems be designed to have either unimpeded return flow from the engine or the installation of a pressure relief valve. We recommended that the American Bureau of Shipping similarly revise its rules used to class vessels.

We also recommended that, until regulatory requirements can be updated, the Coast Guard develop and disseminate design guidance for new construction diesel engine fuel oil return systems so they have unimpeded flow from the engine or other arrangements to prevent overpressurization. Additionally, we recommended that the Coast Guard share our related safety alert with marine inspectors so they can ensure existing vessels' diesel fuel oil systems have unimpeded return flow. Finally, we recommended that the American Bureau of Shipping propose to the International Association of Classification Societies that they ensure their rules require diesel engine fuel oil systems to be designed to have unimpeded return flow or other arrangements to prevent system overpressurization.

1 Factual Information

1.1 Event Sequence

1.1.1 Synopsis

On December 22, 2022, about 1654 local time, an engine room fire broke out aboard the passenger ferry *Sandy Ground*, shown below in figure 1, while the vessel was underway in Anchorage Channel, New York Harbor, near Staten Island, New York, with 884 persons aboard.[1] The crew extinguished the fire by activating the engine room's fixed fire extinguishing system. The vessel lost propulsion and electricity, and the crew deployed both anchors. The majority of the passengers transferred to responding Good Samaritan vessels; the *Sandy Ground* was towed to the St. George Ferry Terminal in Staten Island, where the remaining persons on board disembarked. There were no injuries, and no pollution was reported. Damage to the vessel was estimated at $12.7 million.

Figure 1. *Sandy Ground* docked after the fire.

[1] (a) In this report, all times are eastern standard time, and all miles are nautical miles (1.15 statute miles). (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA23FM010). Use the CAROL Query to search investigations.

1.1.2 Ferry Configuration

The *Sandy Ground* was a double-ended ferry with identical pilothouses and propulsion units at each end (see figure 2). This configuration allowed the vessel to approach and leave its slips without turning around. Its "New York end" docked in Manhattan; the "Staten Island end" docked in Staten Island. The pilothouse crewmembers repositioned themselves from one end to the other between transits. Each round trip began at the St. George terminal on Staten Island, which was also where the Ferry Division vessels were docked at night.

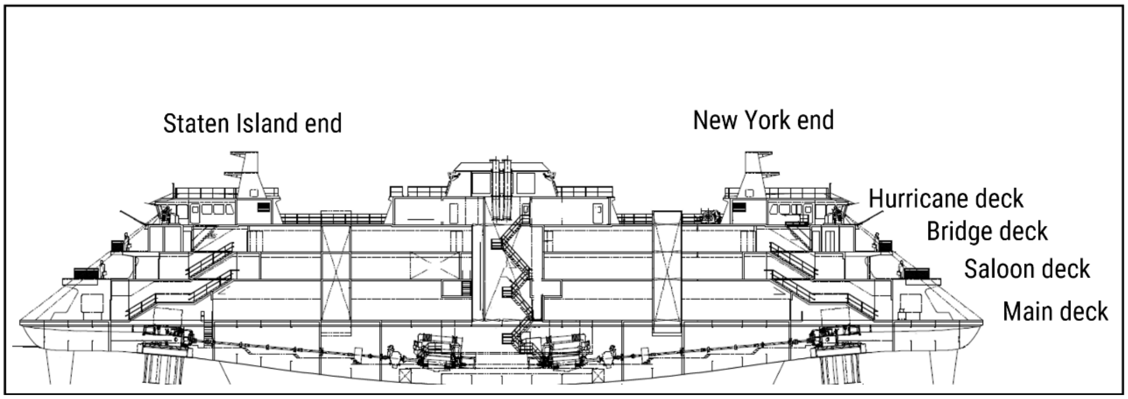

Figure 2. *Sandy Ground* inboard profile. (Background source: New York City Department of Transportation Ferry Division)

The operating manual for the *Sandy Ground* (an Ollis-class vessel) stated that the Staten Island end was considered the stern, and the New York end was considered the bow.[2] Additionally, when looking forward, the starboard side was referred to as the Brooklyn side, and the port side was referred to as the New Jersey side.

1.1.3 Precasualty Events

Throughout the morning and early afternoon of December 22, 2022, the *Sandy Ground* completed 14 trips, ferrying passengers between Manhattan and Staten Island. All four main engines were running, the no. 1 electrical generator was providing electrical power to the vessel, the no. 1 boiler was operating (supplying heat to the passenger areas), and the fuel oil purifier was online (purifying fuel oil from the fuel oil storage tanks) and filling the two fuel oil day tanks. The vessel's two fuel oil day tanks, located on opposite sides of the vessel, supplied diesel fuel directly

[2] The *Sandy Ground* was one of three "Ollis-class" vessels, all of which were designed similarly. The class was named after US Army Staff Sergeant Michael Ollis. See section 1.5.1.

to the four operating engines as well as the operating electrical generator and boiler (see figure 3; section 1.5.4 describes the fuel oil system).[3]

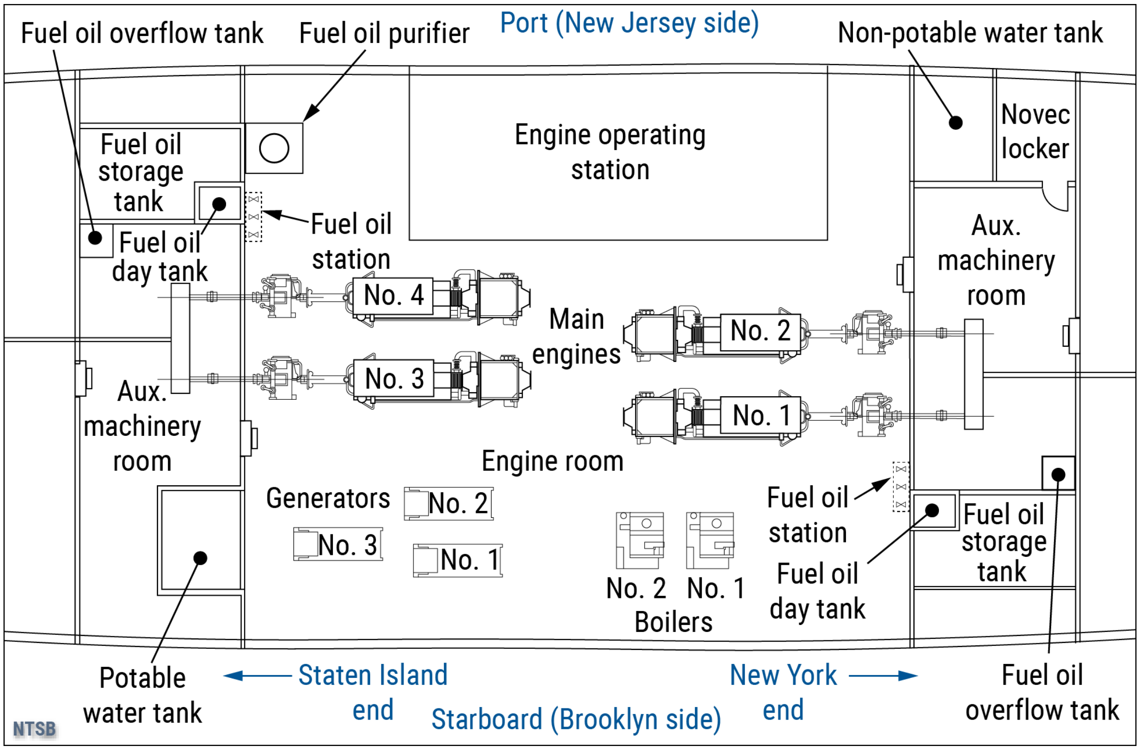

Figure 3. Layout of *Sandy Ground* machinery spaces and fuel oil tanks.

The engine room machinery control station (MCS) in the engine operating station (EOS) remotely recorded the quantity of fuel oil in each storage and day tank as the vessel operated (figure 4 shows an MCS display aboard another vessel of the same class as the *Sandy Ground*). The tanks had high- and low-level alarms, which would alarm on the MCS. Both fuel oil day tanks also were outfitted with a sounding tube and a sight glass (at the fuel oil stations) so engineering crewmembers could locally observe levels; the sight glass consisted of a magnetic float with red, orange, and white gauges that displayed the tank level.

[3] The fuel oil used aboard the *Sandy Ground* was ultra low sulfur, number 2 diesel fuel oil.

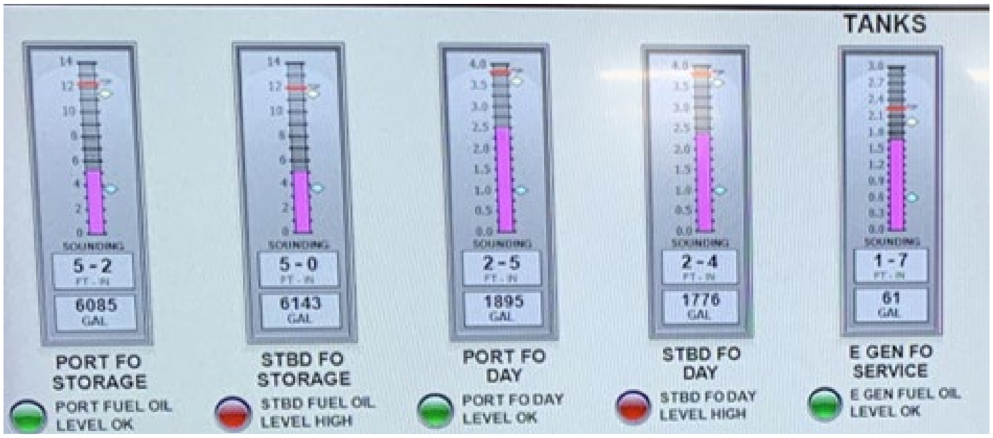

Figure 4. MCS aboard the *SSG Michael H. Ollis*, a vessel of the same class as the *Sandy Ground*, displaying fuel oil storage, day, and service tank levels.

About 1425, the 16 crewmembers of the afternoon shift relieved the morning shift crew at the St. George terminal, and the morning shift crew departed the vessel. The afternoon shift of the deck department consisted of a captain, assistant captain, three mates, and seven deckhands. The afternoon shift of the engineering department consisted of a chief engineer, an assistant engineer, and two oilers (identified as oiler 1 and oiler 2 in this report).[4] All four crewmembers of the engineering department were assigned to stand watch in the engine room throughout their afternoon shift, with the chief engineer in charge of the watch.

When the two oilers came on duty, they checked the two fuel oil day tanks' fuel levels. Oiler 1 estimated that the fuel oil levels in the day tanks differed by about 500 gallons but couldn't recall which tank had more fuel oil. Oiler 2 estimated that the fuel oil level in the starboard day tank was lower by about 500 gallons. However, the MCS recorded the quantity of fuel oil in the port day tank as 1,726 gallons and the quantity in the starboard day tank as 1,721 gallons—a 5-gallon difference—at 1430.

In postcasualty interviews, a chief engineer (not on duty at the time of the casualty) stated that engineering crewmembers monitored the difference between the day tanks' levels because the locations of the port and starboard tanks affected the vessel's "stability." The on-duty chief engineer stated that they (the engine room watch) typically attempted to keep a difference of a "couple hundred gallons" between the two day tanks (other Staten Island Ferry engineering crewmembers stated that crews typically attempted to keep about 2,000 gallons of fuel oil in each

[4] Staten Island Ferry refers to the chief engineer as "chief marine engineer," the assistant engineer as "marine engineer," and oilers as "marine oilers." A marine oiler is an engine room watchstander assisting the credentialed engineers with monitoring and maintaining the vessel's machinery systems.

tank). Oiler 1 stated that, during the first trip, the engineering crewmembers did not make any changes to any valves because they wanted to "see if it [the difference in fuel levels] was going to even out."

After the afternoon watch's first trip of the day, the chief engineer instructed the oilers to even out the fuel oil day tank levels, and the oilers began adjusting valves in the fuel system to balance the levels. There were two sets of three valves (one set at each fuel oil station) that could be adjusted to balance the levels:

- Fuel oil service supply globe valves, when opened, allowed the flow of diesel fuel from the fuel oil day tanks into the operating engines, generators, and boilers.
- Fuel oil purifier discharge valves, when opened, allowed the flow of purified fuel from the outlet of the fuel oil purifier into fuel oil day tanks.
- Fuel oil return isolation ball valves were installed in the return lines of the fuel oil system at the fuel oil day tanks. When throttled, the valves limited the flow of fuel oil in the return lines to the day tanks, and, when closed completely, prevented fuel oil from flowing through the return lines to the day tanks.

The chief engineer stated that he hadn't observed the status of the fuel oil system return isolation ball valves when he first arrived on watch.

As the ferry continued to make trips between Staten Island and Manhattan, the engineering crewmembers noticed the difference between the fuel oil levels in the day tanks was increasing. Footage from CCTV cameras in the EOS showed the oilers and the chief engineer had several discussions in the EOS near the MCS screens, which displayed the tank levels.[5] About 1600, the MCS logged a difference of about 550 gallons between the port and starboard fuel oil day tanks: the port fuel oil day tank contained about 1,400 gallons, and the starboard fuel oil day tank contained about 1,950 gallons.

[5] Video of conversations between the oilers and chief engineer were captured on CCTV cameras, but there was no audio recorded. The *Sandy Ground* was outfitted with several CCTV cameras throughout the passenger spaces, exterior decks, and engineering spaces. There were two cameras in the EOS and four cameras in the engine room. The NTSB used footage from these cameras (in conjunction with interviews) to account for the engineering crew's actions on the day of the casualty. The camera above the portside fuel oil station showed the oilers' adjustments to the fuel oil supply globe valve but did not show the fuel oil return isolation ball valve or the fuel oil purifier discharge valve. There were no cameras positioned to show the oilers' adjustments to the valves on the starboard-side fuel oil station. Appendix C provides a full timeline of the engineering crewmembers' actions as captured on the cameras.

At 1602, oiler 2 made several turns in the clockwise (closing) direction of the fuel oil service supply globe valve at the port fuel oil station and then walked toward the starboard fuel oil station (see figure 5). At 1606, the port fuel oil day tank alarmed with a low level. At 1609, oiler 2 returned to the port fuel oil station and made several turns in the counterclockwise (opening) direction of the fuel oil service supply globe valve and then headed in the direction of the starboard fuel oil station. At 1611, the port fuel oil day tank alarmed again with a low level. The engineers acknowledged both alarms on the MCS, and at 1612, the chief engineer disabled the port fuel oil day tank low level alarm using the MCS computer keyboard.[6] At 1613, the starboard fuel oil day tank alarmed with a low level; the chief engineer acknowledged the alarm and then disabled the starboard fuel oil day tank low level alarm. The chief engineer stated that he considered these to be "nuisance alarms." The chief engineer and the assistant engineer looked at the MCS screens for several minutes.

[6] When "acknowledging" an alarm, the engineering crewmembers select the alarm on the computer screen, read it, and press a button to answer the alarm; the alarm then stops ringing/sounding (but remains in visual alarm status, until the condition clears).

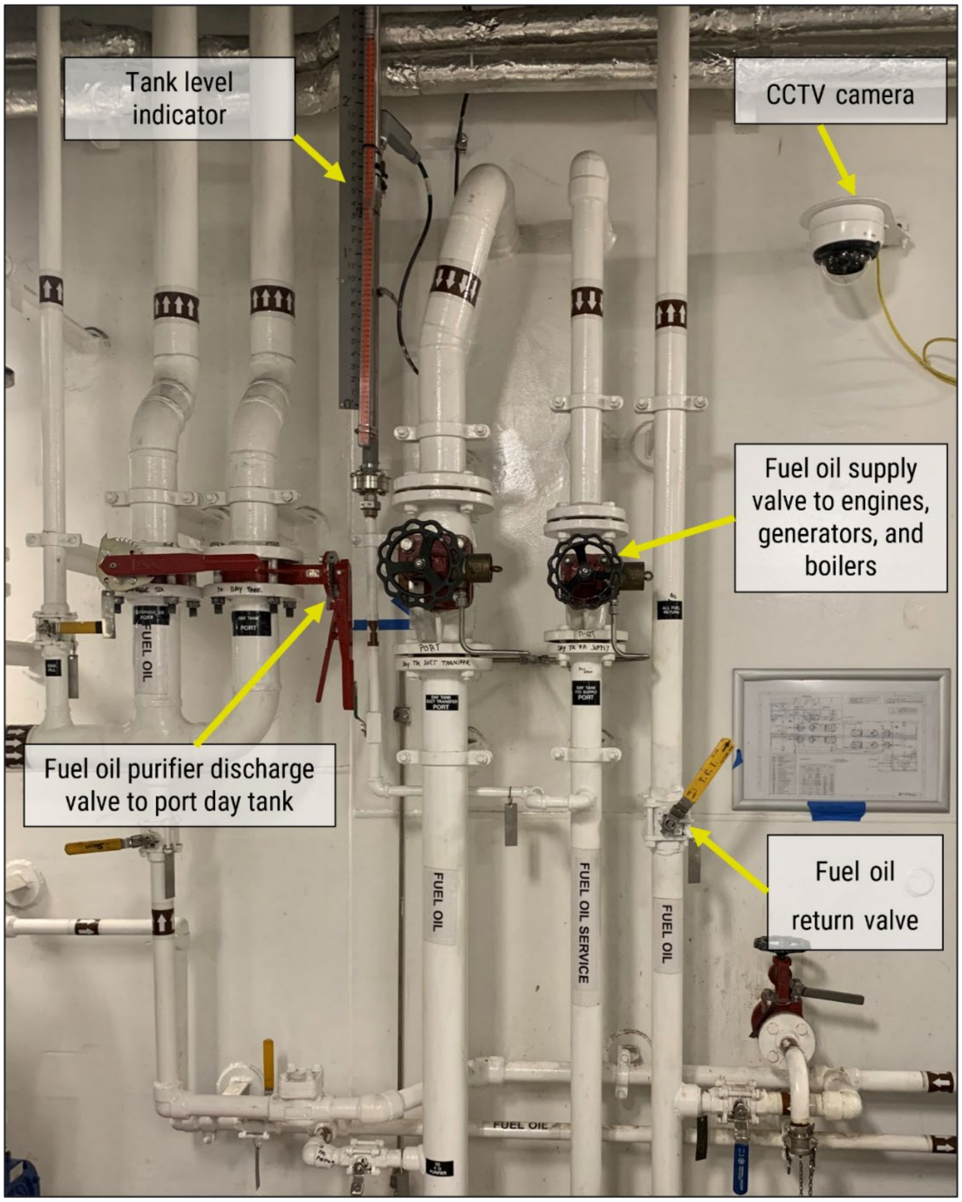

Figure 5. Fuel oil piping at the port (Staten Island end) fuel oil station aboard *SSG Michael H. Ollis*, which was a vessel of the same class as the *Sandy Ground* and had a similar piping arrangement (*SSG Michael H. Ollis* piping shown due to postfire condition of *Sandy Ground* fuel oil station). The fuel oil return valve is a ball-type valve. Note the valve is partially closed (ball valve open-to-close range is 90° and indicated by handle position).

From 1609 to 1640, the two oilers continued to adjust the port fuel oil service supply globe valve with clockwise and counterclockwise turns (as seen on the CCTV camera above the port fuel oil station) in an effort to equalize the two tank levels. The crewmembers also adjusted several other fuel system valves and observed the day tank levels on the EOS MCS display and local tank gauges. Investigators interviewed the *Sandy Ground* chief engineer and oilers 1 and 2 (on duty at the time of the casualty) to determine how they maintained the vessel's fuel oil levels. Oiler 2 said he didn't touch the fuel oil return isolation ball valve on the afternoon of the fire; he was unsure if oiler 1 had adjusted any of the valves. Oiler 1 stated that he believed that he only adjusted one tank valve but couldn't remember if it was the tank with the higher level or lower level. He stated that, "the [fuel oil] return [isolation ball] valve is the one we adjusted, the return, the one with the handle" and was unsure of what valve adjustments oiler 2 was making.

During this time, the vessel completed a transit from Staten Island to Whitehall Terminal in Manhattan, arriving about 1630. While at the terminal, the engines remained idling.

1.1.4 Casualty Events

About 1642, the *Sandy Ground* departed the Whitehall Terminal in Manhattan with 866 passengers and 2 on-duty New York Police Department officers (in addition to the 16 crewmembers) for its scheduled southbound transit to Staten Island. This was the fourth trip for the afternoon crew.[7] Once underway, a deckhand in the Staten Island end wheelhouse played a recorded safety announcement over the public address system. The announcement advised passengers to stay off stairways and landings during docking, listen for instructions from crewmembers over the public address system in the event of an emergency, and contact crewmembers if assistance was needed. The announcement also included the locations of placards containing safety-related information and lifejackets and lifejacket-donning instructions. The vessel then transited about 19 knots with a "strong ebb current" (a receding tide with water moving away from shore) according to the captain. According to the chief engineer, the four main engines were operating at 670 rpm and 92% load, which was a typical engine load.

At 1641, oiler 2 returned to the port fuel oil station and made several turns in the counterclockwise (opening) direction of the port fuel oil service supply globe valve, then headed in the direction of the starboard fuel oil station. At 1643, oiler 1 returned to the port fuel oil station and used a wooden stick to tap on the port fuel oil day tank sight glass. The chief engineer later reported that this was done "to make sure it's [the level's] not stuck." Oiler 2, who had left 2 minutes before, returned to the port fuel station and had a discussion with oiler 1, and then both returned to the EOS and observed the fuel oil tank levels on the MCS displays. At 1647, both oilers left the EOS. Oiler 1 returned to the port fuel oil station and oiler 2 headed in the direction of

[7] The New York Police Department's Staten Island Ferry Security Unit maintains a unit of police officers assigned to perform security-related duties aboard Staten Island ferries and at the terminals.

the starboard fuel oil station. After observing the port fuel oil day tank level, oiler 1 joined oiler 2 at the starboard fuel oil station.

About 1647, 5 minutes after the transit began, multiple alarms for all four main engines sounded simultaneously on the MCS. These alarms included high fuel oil filter pressure differential alarms (the differential alarm sensor was located on the engine-mounted secondary spin-on duplex fuel oil filters on each main engine [see figure 6]); low fuel oil pressure alarms; and "check engine" alarms.[8] At this time, the CCTV camera near the no. 2 main engine showed fuel dripping from the overhead onto the side of the running engine and puddling on the deckplates below (see figure 7).

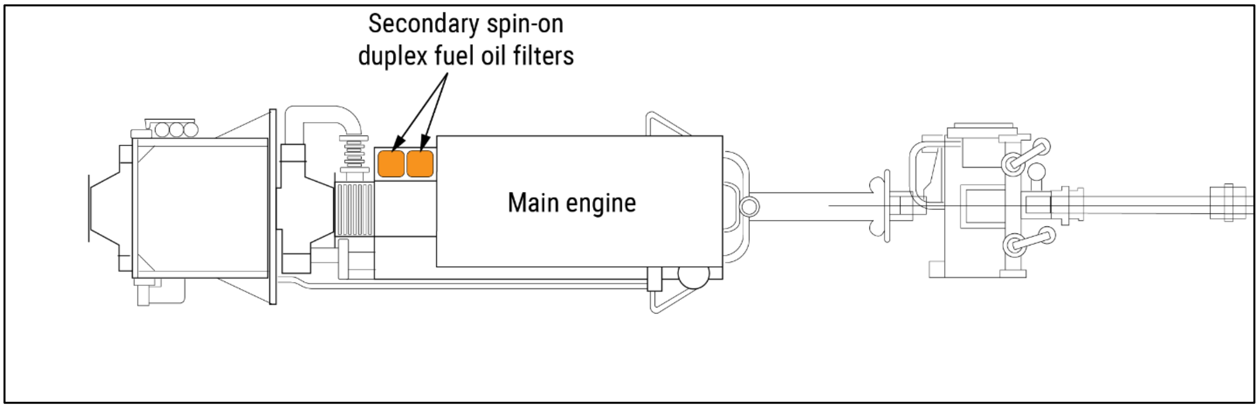

Figure 6. Location of engine-mounted secondary spin-on duplex fuel oil filters (shown as circles) on *Sandy Ground* main engine.

[8] Time stamps for events in the engine room in this report use the clock on the CCTV system. The MCS system server time lagged behind the CCTV system by about 1 minute and 8 seconds. MCS times were identified accordingly for the event and report timeline. See Appendix C for a complete timeline.

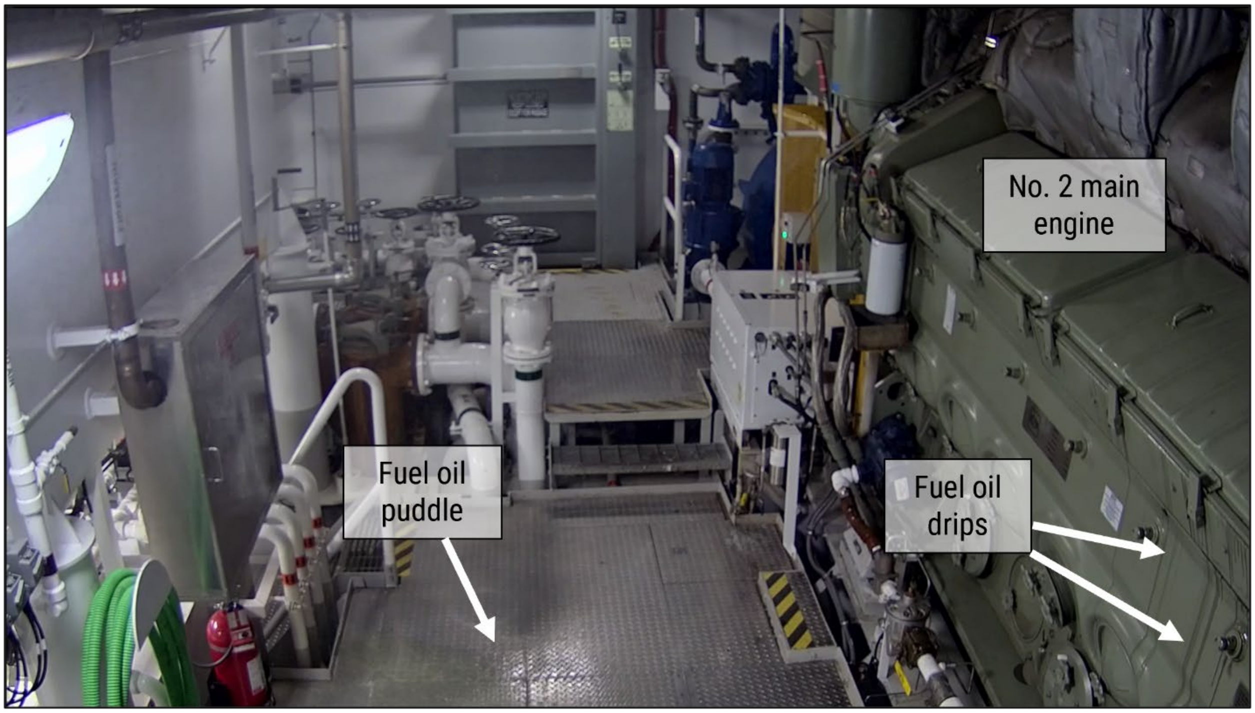

Figure 7. Fuel oil dripping onto the no. 2 main engine and on the adjacent deck in the lower engine room (looking toward the New York end) aboard *Sandy Ground* at 1648. (Background source: NYCDOT Ferry Division)

The chief engineer began acknowledging and silencing alarms on the MCS computer. He stepped out into the engine room and saw fuel oil leaking from the no. 2 main engine secondary duplex spin-on fuel filter assembly and that nos. 3 and 4 main engines had “fuel on them.” The chief engineer returned to the EOS. The oilers, who were in the engine room at this time, told the chief engineer they observed fuel oil spraying from the nos. 3 and 4 main engines. Several alarms displayed on the MCS, including “stop engine” and “check engine,” for all four main engines. About a minute after the initial fuel alarms activated, the vessel’s fire detection system alarmed (the alarm sounded on the fire control panels in both pilothouses and the EOS).[9]

After observing the low fuel oil pressure alarms on all four main engines, the chief engineer called the pilothouse and advised the assistant captain, who was navigating the vessel, of the fuel oil spraying from the engines. He told the assistant captain that they were going “to lose the plant, I’m going to shut down the plant.”

[9] Aboard the *Sandy Ground*, all normally occupied spaces (such as passenger areas, the wheelhouse, and the EOS) had photoelectric smoke detectors, and all normally occupied spaces where there was a likelihood of fire, including the engine room and machinery spaces, had photoelectric smoke and heat detectors. A main fire control panel was located in the Staten Island end pilothouse, one sub-panel was located in the New York end pilothouse, and one sub-panel was located in the EOS. The control panels indicated the location of the emergency.

(The vessel would lose propulsion if the chief engineer shut down the main engines or if they automatically shut down.) The assistant captain contacted the captain via handheld radio, and the captain went to the pilothouse, where the chief engineer advised him by phone of the situation in the engine room.

To determine the source of the fuel spray so they could contain it, the chief engineer directed the oilers to check the alignment of the fuel valves to "make sure everything's lined up right." At 1651, oiler 1 returned to the port fuel oil station and opened the port day tank fuel oil supply globe valve before collecting a handful of rags and heading toward the New York end of the engine room. Oiler 2 and the assistant engineer returned to the EOS, where the assistant engineer told the chief engineer that fuel oil was "hitting the number two [main engine] exhaust manifold" (according to the engine logbook, exhaust temperatures ranged from 624°F to 942°F throughout the afternoon). The chief engineer called the pilothouse again and told the captain that they would most likely lose propulsion and steering. The captain ordered the assistant captain to bring the vessel to a stop.

Oiler 2 collected absorbent pads, oiler 1 returned to the EOS, and together they entered the engine room. Oiler 1 stated that he used absorbent pads to attempt to contain the fuel oil spray from the secondary spin-on duplex fuel filters on the no. 1 main engine, but the "pressure was so much that [he] could not hold it."

At 1654, when the *Sandy Ground* was near buoy 30 in Anchorage Channel, about 12 minutes after departing Manhattan, CCTV footage showed a fire breaking out on the exhaust manifold of the no. 2 main engine (see figure 8 and figure 9). Oiler 1, in the engine room by the no. 1 main engine, smelled smoke and saw fire. The fire spread onto the upper covers of the engine, and embers began falling from the overhead.

Figure 8. Initial fire breaking out on exhaust manifold on no. 2 main engine at 1654 (*above*) and fire on the no. 2 main engine at 1655:26 (*below*) looking toward the New York end. (Background source: NYCDOT Ferry Division)

Figure 9. Approximate track of *Sandy Ground* through New York Harbor. The area where the engine room fire broke out on board the vessel is indicated by a circled *X* (Background source: Google Maps)

The chief engineer informed the captain of the fire. He stated that he believed the engines had been stopped, since the MCS screens were displaying red alarms for the engines. Between 1654:36 and 1654:58 on the MCS screen, all four main engines alarmed with "common engine shutdown."

About 1655, the assistant captain steered the vessel to the center of the channel, made a PAN-PAN call, and contacted New York Vessel Traffic Service (VTS) on VHF radio.[10] VTS watchstanders broadcast the *Sandy Ground*'s situation on channel 13.

As seen in CCTV footage, at 1656:17, the shaft of the no. 4 main engine came to a stop. The vessel lost propulsion (the electrical generators continued to run). After the vessel stopped, the captain directed the mate to lower the New York end anchor. The captain then ordered the Staten Island end anchor to be deployed and

[10] *PAN-PAN* is a VHF radio transmission indicating that there is an urgent situation but no immediate danger to a person's life or to the vessel. The vessel or station transmitting the message begins by saying "Pan-pan, Pan-pan, Pan-pan" and follows with the urgent message.

contacted the US Coast Guard and the ferry's shoreside management team to advise them of the situation.

Smoke began filling the engine room. The chief engineer ordered the engineering crewmembers to evacuate the EOS to the main deck via the EOS escape hatch, and the assistant engineer and oilers climbed up the escape ladder.

About 1658, the crew in the pilothouse stopped ventilation fans and closed ventilation dampers to the engine room via the emergency stop buttons located in the pilothouse. The chief engineer activated the two emergency fuel shutoff valves, stopping the flow of fuel oil to machinery—the main engines, generators, and boilers—located in the engine room, and, as a result, the generator and boiler shut down, and the vessel lost electricity. The lights in the EOS went out, and the CCTV recording in the engine spaces ended. The chief engineer exited the EOS via the escape hatch.

Upon loss of electrical power, the emergency generator automatically started, and emergency power circuits were restored throughout the vessel. The captain sounded the general alarm and made announcements over the public address system to advise the passengers of the fire in the engine room. After exiting the EOS, the chief engineer requested the pilothouse crew start the emergency fire pump and directed the engineering crewmembers to position a fire hose by the engine room door on the main deck for boundary cooling.

About 1700, the emergency generator shut down unexpectedly, leaving the *Sandy Ground* without any electrical power (section 1.9.1 details the operator's investigation into the failure of the emergency generator). After requesting permission from the captain, the chief engineer went to the auxiliary machinery space in the New York end and manually activated the vessel's Novec fixed fire extinguishing system—which protected the engine room, EOS, and the emergency diesel generator space—into the engine room (the system could also be activated remotely from the EOS).[11] The chief engineer then went up to the hurricane deck to investigate the loss of emergency power and found the emergency generator was stopped. He was unable to restart the emergency diesel generator. He informed the captain that emergency power could not be restored. The captain ordered deck crewmembers to distribute lifejackets to the passengers and prepare for evacuation.

[11] The system used 3M Novec 1230 fire-protection fluid, which was designed to flood a protected area and extinguish a fire by rapidly removing heat after discharging through fixed nozzles as a gas. The fluid was stored as liquid in cylinders pressurized by nitrogen. Novec 1230 was designed to evaporate without damaging any equipment.

At this time, the engine room was sealed off, and none of the crew entered the space again (the exact time the fire was extinguished is unknown).

1.2 Response

Police, fire, and Coast Guard boats; two nearby towing vessels, the *Mister Jim* and *Charles James*; and three other ferries, the *River Sprinter*, *Franklin Delano Roosevelt*, and *Great Eagle*, that had been near the *Sandy Ground*'s position responded to the broadcasts from the *Sandy Ground* crew and VTS personnel. While the mates and deckhands aboard the *Sandy Ground* distributed lifejackets to the passengers and ushered them to the main deck to depart the *Sandy Ground*, the *Mister Jim* and *Charles James* held the *Sandy Ground* in position, and the ferries positioned themselves to take turns conducting bow-to-bow transfers of passengers.

The *River Sprinter* was the first vessel to position its bow against the *Sandy Ground*'s bow. About 1725, *Sandy Ground* passengers began transferring to the *River Sprinter*; the *River Sprinter* took 138 passengers. Next, the *Franklin Delano Roosevelt* took 558 passengers (see figure 10), and the *Great Eagle* took 120 passengers (accounting for 816 of the 884 persons on board the *Sandy Ground*). The decks of the *Sandy Ground* and the *Franklin Delano Roosevelt* were about the same height, so passengers could walk from one vessel to the other. The other two ferries were smaller and had a lower freeboard, so passengers had to step down as they were disembarking the *Sandy Ground*.[12]

[12] *Freeboard* is the vertical distance between a vessel's waterline and the highest watertight deck.

Figure 10. Evacuation of passengers from the *Sandy Ground* to the *Franklin Delano Roosevelt*. (Source: NYCDOT Ferry Division)

About 1745, the captain noticed the wind increasing from the north and determined the ferry had begun to drag anchor toward Staten Island. He stated that "because the wind picked up, it [the water in the harbor] got a little choppier." Due to the deteriorating weather conditions, he called off the evacuation of the vessel while the *Sandy Ground* still had about 50 passengers remaining aboard. The three ferries that had already evacuated *Sandy Ground* passengers transported them to the St. George Ferry Terminal in Staten Island.

Firefighters from the New York Fire Department boarded the vessel via a fireboat and evaluated the scene. They advised that the engine room remain sealed off for 24 hours after the Novec had been released.

Towing vessels took the *Sandy Ground* under tow, and, at 1825, the ferry was moored at the St. George Ferry Terminal, where the remaining 50 passengers, 16 crewmembers, and 2 on-duty police officers disembarked. (Later that evening, at the captain's request, cameras at the boarding terminals were used to count each passenger as they disembarked the Good Samaritan ferries and the *Sandy Ground*, validating that all persons that had been on board were accounted for.)

1.3 Injuries

There were no injuries. Two crewmembers reported smoke inhalation; they were transported to a local hospital and later released.[13]

1.4 Damage

After the vessel returned to the dock and the engine room was cleared for safe entry, Staten Island Ferry management, technicians, *Sandy Ground* crewmembers, and Coast Guard and National Transportation Safety Board (NTSB) investigators examined the damaged areas of the engine room.[14] They found the engine-mounted secondary spin-on duplex fuel filter assemblies that had been in service (online) at the time of the casualty on all four main engines were each distorted at the connection points where the filters sealed against the filter bases. The gasket on the no. 1 main engine secondary spin-on duplex engine-mounted secondary fuel filter had ruptured and protruded out of the sealing surface in the direction (outboard) of the no. 2 main engine (see figure 11).

[13] The National Transportation Safety Board uses the International Civil Aviation Organization injury criteria in all of its casualty reports, regardless of transportation mode. A serious injury is a nonfatal injury that requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; results in a fracture of any bone; causes severe hemorrhages, nerve, muscle, or tendon damage; involves any internal organ; or involves second- or third-degree burns, or any burn affecting more than 5% of the body surface.

[14] The NTSB and Coast Guard worked jointly to investigate this casualty; throughout this report, "investigators" refers to both NTSB and Coast Guard investigators.

Figure 11. Damage (circled) found on secondary spin-on duplex fuel oil filters from each of the four main engines after the casualty. The no. 1 main engine has a protruding gasket in the direction (outboard) of the no. 2 main engine, and the nos. 2, 3, and 4 main engine filter housings are distorted.

More than 60 electrical power and control cables were damaged by fire and heat above and around the no. 2 main engine and in the adjacent main deck machinery casing (see figure 12). The no. 2 main engine had smoke and fire damage to the exhaust manifold insulation and to the exterior components. Several deck plates and their supporting steel frames were distorted due to the heat of the fire. As a result of the fire, the *Sandy Ground* incurred an estimated $12.7 million in total costs for repairs.

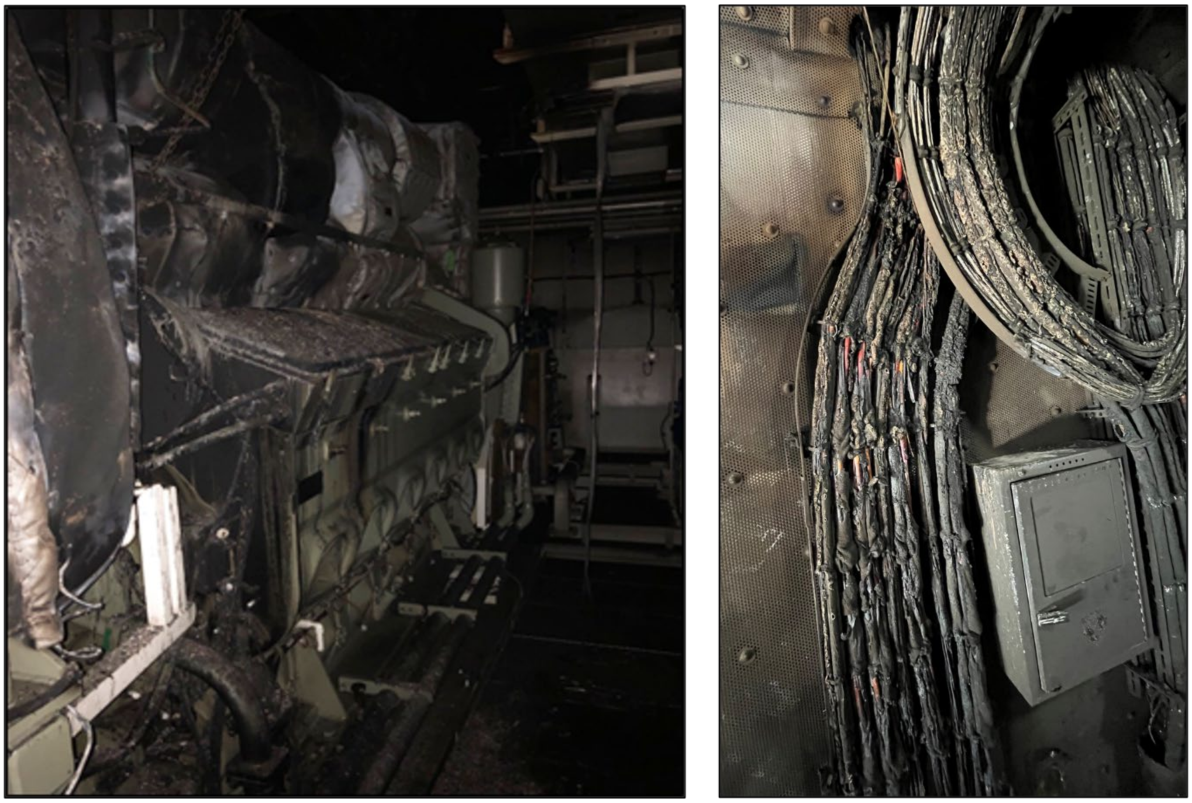

Figure 12. (*Left to right*) No. 2 main engine and damaged electrical cables in the machinery casing above no. 2 main engine after the casualty.

1.5 Vessel Information

1.5.1 General

The 304-foot-long, multi-deck, steel-hulled, US-flagged passenger ferry *Sandy Ground* was the second of three Ollis-class ferries built for the New York City Department of Transportation (NYCDOT) by Eastern Shipbuilding Group (ESG) (figure 2 shows the vessel's profile and decks). It was commissioned, or "delivered," in December 2021 and put into service on June 17, 2022. Staten Island Ferry (an operating division of NYCDOT) operated the *Sandy Ground* and other two Ollis-class vessels (the *SSG Michael H. Ollis* and the *Dorothy Day*). The *Sandy Ground* provided commuter service in New York City between Staten Island and lower Manhattan.[15] The *Sandy Ground* had capacity for 4,500 passengers and 16 crewmembers. Table 1

[15] The first Ollis-class vessel, the *SSG Michael H. Ollis,* went into service in February 2022, and the third Ollis-class vessel, the *Dorothy Day,* had been delivered to NYCDOT but was not yet in service at the time of the casualty.

shows the vessel particulars for the *Sandy Ground*. NYCDOT operates a total of 11 ferries in New York harbor.

Table 1. Vessel Particulars

Vessel	*Sandy Ground*
Type	Passenger (Ferry)
Owner/Operator	NYCDOT / NYCDOT, Staten Island Ferry Division (Commercial)
Flag	United States
Port of registry	New York, New York
Year built	2022
Official number (US)	1299657
IMO number	N/A
Classification society	American Bureau of Shipping
Length	304.2 ft (92.7 m)
Breadth (max.)	69.0 ft (21.0 m)
Draft (casualty)	13.0 ft (4.0 m)
Tonnage	4,669 GRT / 5,919 GT ITC
Engine power; manufacturer	4 x 2,495 hp (1,861 kW); EMD 710GC/L12ME23B diesel engines
Persons on board	884

1.5.2 Classification and Inspection

The *Sandy Ground* was registered as a US-flagged vessel. In accordance with the regulations in Title 46 *Code of Federal Regulations* (*CFR*) Chapter I, Subchapter H, which govern the construction, outfitting, and operation of US-flagged passenger vessels 100 gross tons or more, the Coast Guard inspected the *Sandy Ground* for issuance of a certificate of inspection, which was valid for 1 year.[16] The Coast Guard

[16] See 46 *CFR* Chapter I, Subchapter H and 46 *CFR* Chapter I, Subchapter H, Part 71, Inspection and Certification.

conducted inspections of the *Sandy Ground* and its systems during construction and, after delivery, issued the vessel a certificate of inspection on May 5, 2022.

The American Bureau of Shipping (ABS), one of several nongovernmental classification societies that establish and maintain standards for the construction and operation of ships, classed the *Sandy Ground* and the other two Ollis-class vessels. ABS reviewed plans and documentation before and during construction to ensure they met applicable classification standards in place at the time. Throughout the build period, ABS surveyed the vessel and witnessed critical testing. Upon completion, ABS issued the *Sandy Ground* a certificate of classification.

1.5.3 Propulsion and Electrical Systems

The ferry's propulsion was provided by two cycloidal propellers, one at each end of the vessel.[17] Each propeller was mechanically driven by two EMD 12V 710 Series E 23B main diesel engines. Three 430-kilowatt Caterpillar C18 diesel generators provided electrical power. The *Sandy Ground* was outfitted with a 395-kilowatt emergency generator located on the hurricane deck, which, upon loss of electrical power, would automatically start its diesel engine, electrically connect to the emergency switchboard, and provide power to emergency circuits.

1.5.4 Fuel Oil System

1.5.4.1 System Arrangement

Ollis-class vessels, like the *Sandy Ground*, were outfitted with two 15,640-gallon fuel oil storage tanks and two 2,808-gallon fuel oil day (service) tanks. The port fuel oil storage tank and the port fuel oil day tank were located on the Staten Island end of the engine room. The starboard fuel oil storage tank and the starboard fuel oil day tank were located on the New York end of the engine room. Each fuel oil day tank had an overflow pipe that directed fuel to their adjacent storage tanks. Each storage tank had an overflow pipe that led to an overflow tank (shown in figure 3). Each of the fuel oil tanks had an independent vent with piping that led to an exterior space on the main deck.

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[17] A cycloidal propeller consists of a large rotating horizontally configured circular disk beneath the vessel, driven by the main propulsion engine. The disk is fitted with a series of controllable pitch blades protruding vertically downward from the disk. The magnitude and direction of thrust are determined by the rotational speed of the disk, and the direction of thrust is determined by the positioning of the blade angles.

The fuel oil system consisted primarily of a fuel transfer pump, supply and return piping, and a purifier. The port and starboard fuel oil day tanks supplied fuel oil to the main diesel engines, diesel engine-driven electrical generators, and heating boilers, also referred to as "consumers" (see figure 13). The fuel oil supply system was equipped with a cross-connect valve, which could be used to separate equipment between day tanks. When the supply cross-connect valve was closed, the port day tank supplied the nos. 3 and 4 main engines and nos. 2 and 3 generators, while the starboard day tank supplied the nos. 1 and 2 main engines, no. 1 generator, and both boilers.

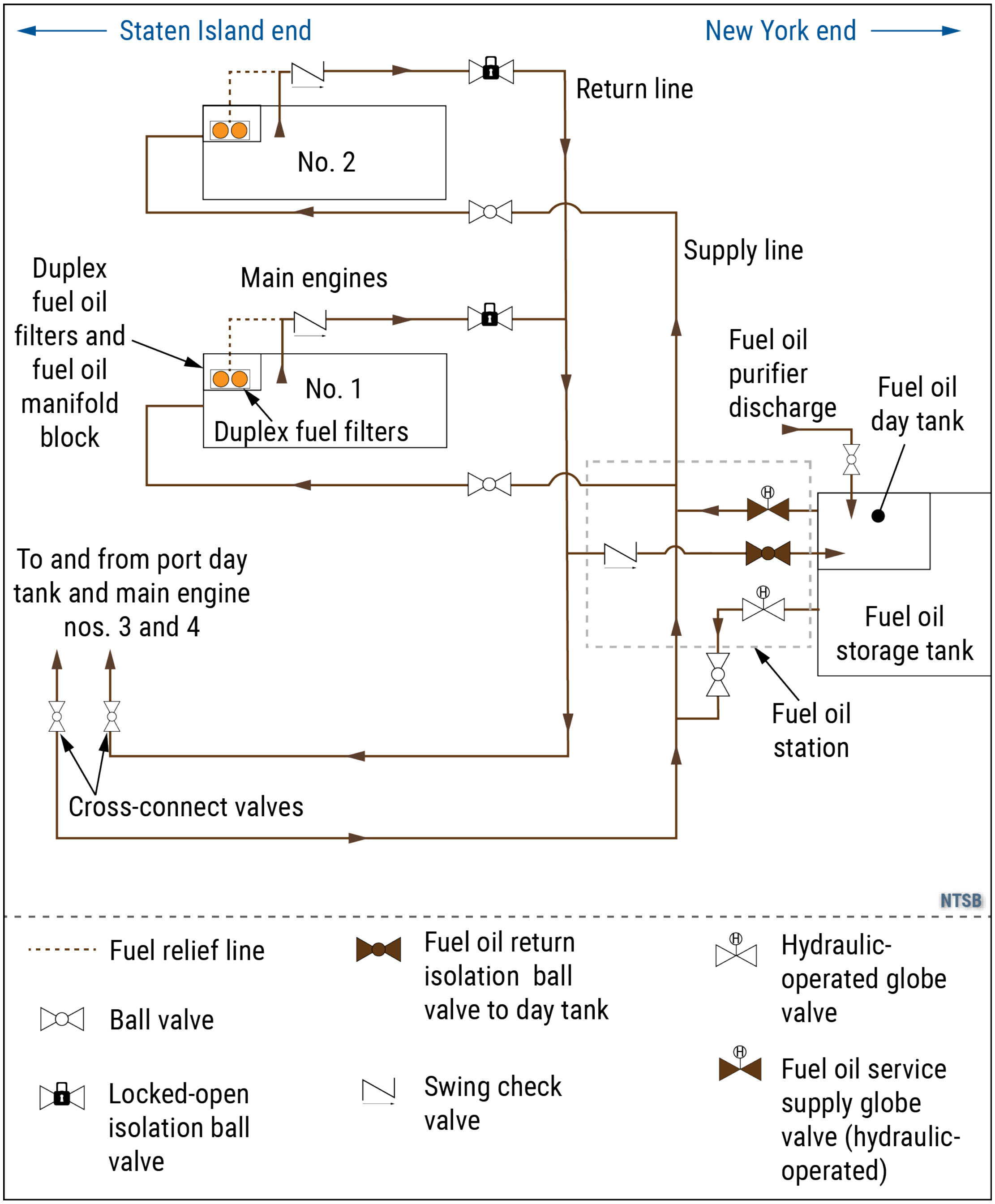

Figure 13. Simplified fuel oil piping drawing showing only engine nos. 1 and 2 for clarity. (The boilers and generators are not shown; see Appendix D for a more detailed drawing showing the fuel oil piping system.)

The fuel oil return system provided a path for unburned, excess fuel that had not been consumed by the main engines, generators, or boilers back into the top of both fuel oil day tanks. The fuel oil return system was also equipped with a cross-connect valve, which could be used to isolate equipment between day tanks. The vessel's main electrical switchboard was equipped with a bus tie to allow for split bus operation and thus separation of the electrical switchboards. With the fuel cross-connect valves closed and the electrical bus ties open, the *Sandy Ground* could be operated as separate, independent power plants.[18]

The vessel was equipped with a fuel oil purifier located on the port side of the Staten Island end of the engine room. The purifier could take suction from the storage tanks, day tanks, or overflow tanks and could discharge purified fuel oil to any of the tanks. Typical operation while underway was to line up the fuel oil purifier to replenish day tank fuel consumed by the engines, generators, and boilers by taking fuel suction from both storage tanks and discharging into both day tanks. Due to the proximity of the fuel oil purifier to the portside fuel oil day tank (on the Staten Island end), *Sandy Ground* engineering crewmembers stated that, when discharging purified fuel oil to both day tanks simultaneously, the fuel oil purifier discharge valve had to be throttled to equalize the quantity of fuel being delivered to the day tanks.

Staten Island Ferry engineers stated that they normally kept the supply cross-connect valve open aboard the Ollis-class vessels, and therefore both day tanks supplied fuel oil at the same time to all the main engines, generators, and boilers. The engineers said that normally the return cross-connect valve was open as well, so excess fuel from all engines could return to either day tank. Similarly, the Staten Island Ferry Engineer's Operating Manual stated that the fuel service system for the main diesel engines "normally receives and returns fuel from both F.O. [fuel oil] day tanks simultaneously." Chief engineers from the fleet stated that they used both day tanks to reduce the potential for contamination hazards and to keep "a full head [of fuel] on both" tanks. They stated that the additional fuel quantity was considered a backup fuel supply; one chief engineer stated that by using two day tanks, there was "less load on the system as far as having to suck everything out of one side." Additionally, one of the chief engineers stated that if one day tank was full and one was empty, there may be a concern about vessel stability because the fuel oil day tanks were on opposite sides of the vessel.

The supply pipes from the fuel oil day tanks were each equipped with a hydraulic-operated quick closing valve at their respective tank that could be activated remotely from the EOS to stop the flow of fuel oil to the main engines, generators, and boilers in an emergency.

[18] An *electrical bus* is a physical part of an electrical switchboard. (The term bus is a shortened form of bus bars, which are the metal bars physically located within the switchboard.) The bus connects the power produced by generators to systems/devices that require electrical power. A *bus tie* connects two or more electrical buses together.

For each main engine, fuel from the port and starboard day tanks passed through primary duplex suction strainers to an engine-driven, positive displacement fuel pump that delivered pressurized fuel oil of about 90 psi to the fuel oil manifold block at the top right front of the engine through the engine-mounted secondary spin-on duplex fuel filter manifold block.[19] The pair of secondary fuel oil filters consisted of two identical spin-on filter elements in a parallel arrangement with a lever to designate the filter in service.

After passing through the spin-on filter, the pressurized fuel oil supplied the engine's electronically controlled fuel oil injectors on each cylinder, with excess fuel not used by the injector pumps directed into the engine's fuel oil return line, through a check valve and locked-opened ball valve at each engine, and back into the common fuel oil return line to the day tanks.[20] In the return lines, just before each day tank, there were two valves—a fuel oil return system check valve and return isolation valve—which, when opened, allowed excess, unburned fuel oil from the operating diesel engines to return to the fuel oil day tanks.

Fuel oil supply headers, mounted on each bank of the main engines, transported fuel oil from the engine-mounted secondary fuel filter assembly to the individual cylinder fuel injectors. Similarly mounted fuel oil return headers transported unburned fuel oil from the engines to the day tanks. Each engine's engine control system, (which controlled engine speed for different load conditions by varying the amount of fuel oil injected into the cylinders) connected to sensors that monitored the pressures of the fuel oil in and out of the fuel oil filters as well as the temperature of the fuel oil entering the engine. Two fuel oil pressure sensors were mounted on the fuel oil filter manifold block. One sensor monitored fuel oil supply pressure into the fuel oil filters. The other sensor monitored fuel oil supply pressure after the filter before entering the engine. The electronic control module monitored the data from the fuel oil pressure sensors and controlled the metering and timing of fuel injection.

The engine-mounted fuel oil filter manifold block (which the secondary fuel oil filters were attached to on the main engine) contained drilled passages with check valves and 120-psi relief valves built into it. The relief valves were designed to open when system pressure in the fuel oil supply line between the fuel oil pump and the injectors exceeded 120 psi. The engine-mounted fuel oil system relief valve outlet

[19] A *positive displacement fuel oil pump* provides a constant flow at fixed speed, regardless of changes in pressure.

[20] A *check valve* allows fluids to flow in only one direction. A *ball valve* is a quarter-turn valve that uses a hollow, perforated, and pivoting ball to control the flow of fluid through it.

piping from each main engine connected into the common return piping system before the isolation valves at the fuel oil stations (by the fuel oil day tanks). Each main engine was outfitted with a check valve on its fuel oil return line (to prevent fuel oil backflow from other engines) and a locked-open isolation valve (to be closed only when the engine was not operational) in the return piping so the engine could be serviced while the other engines continued running.

1.5.4.2 Construction and Plan Approval

In 2016, before construction of the Ollis-class vessels, like the *Sandy Ground*, Elliott Bay Design Group (EBDG), a marine engineering and naval architecture firm contracted to design the vessels, submitted a pre-contract fuel oil piping drawing (diagram no. 14079-200-261-1, Revision B, dated February 8, 2016) to ABS to review for compliance with applicable classification society rules as part of the requirements for the vessel's classification. ABS approved the drawing in February 2016; their approval was accompanied by a letter dated February 23, 2016, stating that "since the request for Class has not been developed and authorization from USCG [US Coast Guard] has not been obtained, the above drawing has been reviewed only for compliance with the applicable requirements of the *ABS Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways 2015*."

EBDG also submitted the same pre-contract fuel oil piping drawing to the Coast Guard Marine Safety Center (MSC) for review, as required by 46 *CFR* Chapter I, Subchapter H.[21] The submitted fuel oil piping drawing included isolation (shutoff) ball valves in the fuel oil return lines to both fuel oil day tanks. According to the MSC, they referred to Procedure Number E1-10, "Review of Fuel Oil Systems" (plan review guidance) to determine the information required to be submitted for a review of fuel oil system arrangements. This procedure referenced the regulations in 46 *CFR* Chapter I, Subchapter F (Marine Engineering), which are applicable to fuel oil system installations on US-flagged vessels.[22] After reviewing the drawing for compliance with these regulations, the MSC approved the fuel oil piping drawing for Ollis-class vessels for compliance with 46 *CFR* Chapter I, Subchapter H and Subchapter F in July

[21] According to the regulations in 46 *CFR* Chapter I, Subchapter H, before a US-flagged passenger vessel is constructed, vessel plans must be submitted to, and approved by, the Coast Guard MSC, which reviews the plans for compliance with the applicable regulations.

[22] See 46 *CFR* Chapter I, Subchapter F. Coast Guard regulations and related guidance (procedure E1-10) contain requirements for diesel fuel oil systems as well as other types of fuel systems, including oil, burner fuel-oil service systems, and gasoline fuel systems. ABS rules similarly include requirements for both diesel fuel oil systems and other types of fuel systems. This investigation only focused on the diesel fuel oil systems.

2016. This approved drawing was made part of the contract with ESG, the shipyard that constructed the *Sandy Ground* and other Ollis-class vessels.

In March 2017, the *Sandy Ground* was contracted for construction, and subsequently, ESG submitted a new fuel oil piping drawing to ABS (diagram no. 219-261-01, Revision A, dated July 20, 2018). In the drawing, the isolation (shutoff) ball valve in the return line at each day tank (included in the 2016 drawing approved by the MSC and ABS) had been replaced with a check valve. According to a manager from the shipyard, the isolation ball valves were "removed at some point during the detailed engineering and development of the systems designs by the engineering group completing the detail design." In July 2018, the shipyard submitted the same updated fuel oil system drawing to the Coast Guard. This drawing also had the check valves in the fuel oil return lines to the fuel oil day tanks (no isolation [shutoff] ball valves were depicted). The Coast Guard approved the drawing for compliance with 46 *CFR* Chapter I, Subchapter H in August 2018 with no comments. ABS also approved the drawing in August 2018. The MSC had not received for review/approval any updated plans reflecting additional valves (beyond the check valves) for the day tanks in the fuel oil service return piping on the *Sandy Ground* after August 2018.

According to NYCDOT, the drawings that had been submitted by ESG were reviewed by Staten Island Ferry management, the company hired by NYCDOT to oversee the construction, and EBDG. Upon each review, the isolation ball valves were noted to be missing, and Staten Island Ferry management requested they be re-inserted per the contract. However, this was not done following each review, and the *Sandy Ground* was constructed with check valves in the fuel oil return lines before the common lines returned to the top of each day tank, which corresponded to the latest versions of fuel oil system drawings approved by both the MSC and ABS. According to Staten Island Ferry shoreside managers, "there was always an intent to have the ability to regulate day tank levels by throttling the returns [using the isolation ball valves]." Therefore, a month before the *Sandy Ground* was placed in service, in May 2022, at Staten Island Ferry management's request, the shipyard installed the fuel oil return isolation ball valves per the approved contract drawing.[23] However, this revision was not approved by ABS or the Coast Guard. The fuel oil return isolation

[23] On May 26, 2022, an ABS surveyor attended and reported upon the installation of ball valves in the fuel oil system return lines. The installation was based upon an owner-provided drawing, Fuel Oil Piping Diagram 219-261-01 Revision B, which was not reviewed or approved by ABS. The installation of the ball valves was permissible under the ABS rules at the time of the modification. According to ABS, the surveyor tested the installation and found it to be satisfactory.

ball valves were installed on the *SSG Michael H. Ollis* (the other in-service Ollis-class vessel) in June 2022 (the vessel entered service in February 2022).[24]

After the casualty, investigators found the most current drawing of the fuel oil piping system aboard the vessel was stamped "as built" and "for review only" (diagram no. 219-261-01 Revision D, dated December 11, 2020). As in the 2018 drawing submitted to the Coast Guard and ABS for review, this 2020 drawing included only check valves in the fuel oil return lines.

According to engineers from the MSC, at the time of the casualty, there was no regulation "preventing or requiring the use of [an isolation (shutoff)] valve in the fuel return line." At the time of the fire, Ollis-class vessels, like the *Sandy Ground*, were not outfitted with a pressure relief or pressure-reducing valve in the fuel oil return system lines to the port and starboard fuel oil day tanks—each vessel only had a pressure relief valve in the fuel oil manifold block on each engine, which was piped into the common return line. According to the MSC, there was "no direct regulation for the installation of pressure relief valves in fuel oil systems."[25] The MSC stated that typically, return lines are "low-pressure systems, draining into a tank at ambient pressure."

According to ABS, the vessel's classification society, the *Sandy Ground* plans were contracted to be compliant, and reviewed for compliance, with the 2017 ABS rule book, *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways* (2017 ABS Steel Rules) (ABS 2017).[26] These rules required "positive closing valves" on oil tanks when the line is subjected to a static head of oil

[24] The *Dorothy Day* was delivered in September 2022; at the time of the casualty, it had not yet entered service.

[25] Two previous classes of Staten Island ferries (Barberi and Molinari) with fuel oil tanks and supply and return system designs similar to the Ollis class were equipped with pressure relief valves on the fuel oil system return line to the day tanks; on the Barberi class, the relief valves were set at 44 psi, and on the Molinari class, the relief valves were set at 2 psi. When the set point of the relief valves was exceeded, the relief valves opened and routed the fuel oil around the fuel oil return isolation valves and into the day tanks.

[26] According to ABS, Part 4 of the 2017 ABS Steel Rules—which detailed vessel systems and machinery requirements—was applicable for the new construction plan review in March 2017. However, because ABS applied the notation "+A1, Passenger Vessel, River Service, +AMS," to the vessel, Chapter 7 of the 2017 ABS Steel Rules, Part 5C—which detailed additional hull construction, machinery, and safety equipment requirements, not contained elsewhere in the Rules, to class a vessel as a passenger vessel—took precedence over Part 4. The Maltese Cross symbol (+) combined with the "A1" classification, indicated the vessel had been built under ABS survey for hull and machinery. The full designation "+A1, Passenger Vessel" was assigned for vessels designed and specifically fitted for carriage of passengers and built to the requirements of Chapter 7 of Part 5C.

from the tank.[27] Because the *Sandy Ground*'s fuel oil return lines entered at the top of the fuel oil day tanks, they were not subject to a static head from fuel oil, and positive closing valves were not required. The fuel oil return piping from the main engines to the day tanks met the requirements for passenger vessels in the 2017 ABS Steel Rules and Chapter 7 of Part 5C.

1.5.4.3 Engine Manufacturer Return Line Guidance

According to the engine manufacturer's marine product guide for the main engines aboard the *Sandy Ground*, "return fuel leaving the engine should be routed to the top of the main fuel tank without shutoff [isolation] valves."

1.5.4.4 International Standards

Investigators reviewed other standards for diesel engine fuel piping systems. The *International Convention for the Safety of Life at Sea* (*SOLAS*) requires vessels to have an isolation valve in the return piping from each individual engine, where a means of isolating the fuel return piping from each engine is provided.[28] The intent of this requirement is to allow for maintenance to be performed on an offline engine in multi-engine machinery spaces while other engines remain in operation.

Although the *Sandy Ground*, which was not a *SOLAS* vessel, was not required to meet this standard, the vessel's fuel return system did have an isolation valve (locked open) on the return line for each engine. These locked open valves met the intent of the *SOLAS* requirement. The two fuel oil return isolation ball valves that each led to a fuel oil day tank were not installed to isolate individual engines (the valves were installed to regulate fuel oil levels in the fuel oil day tanks).

According to ABS, the fuel oil return arrangement on the *Sandy Ground* was common for vessels not subject to *SOLAS*.

[27] (a) A *positive closing valve* is a shutoff (isolation) valve that, in the closed position, does not allow the flow of product in either direction. (b) *Static head* refers to the pressure resulting from a column of liquid acting under gravity.

[28] See ABS's *Rules for Building and Classing Marine Vessels*, July 2023, derived from *SOLAS* Chapter II-2/Regulation 4.2.2.5.5, which states that in multi-engine installations that are supplied from the same fuel source, a means of isolating the fuel supply and spill piping to individual engines shall be provided. Additionally, the means of isolation shall not affect the operation of the other engines and shall be operable from a position not rendered inaccessible by a fire on any of the engines.

1.5.4.5 Maintenance

At the time of the casualty, the main engines had about 2,200 operating hours on them. The engine-mounted secondary spin-on duplex fuel oil filter elements had been replaced on all four main engines as part of the preventative maintenance program on August 22, 2022. According to shoreside managers and vessel crewmembers, there had been no operational concerns with the fuel oil system aboard the vessel, and all maintenance was up to date.

1.6 Waterway Information and Environmental Conditions

The casualty occurred in Anchorage Channel in New York Harbor, where the depth was about 45 feet. About the time of the fire, there was a 3-knot ebb current, with east-northeast winds at 13 mph. Skies were overcast, and visibility was 10 miles. The recorded air temperature was 44°F, and the water temperature was 46°F. Sunset occurred at 1632, and civil twilight occurred at 1703.

1.7 Key Personnel Information

1.7.1 Postcasualty Toxicological Testing

Alcohol and other drug testing was conducted for all crewmembers aboard *Sandy Ground* following the casualty in accordance with postcasualty requirements and the operator's drug and alcohol policy; all yielded negative results.

1.7.2 Qualifications

The chief engineer aboard the *Sandy Ground* at the time of the casualty had worked for Staten Island Ferry for 32 years with about 10 years as a chief engineer. The chief engineer told investigators that he had worked about 10 days aboard the *Sandy Ground* and about 30 days on another vessel of the same class, the *SSG Michael H. Ollis*. He had previous shipboard experience in the US Navy and aboard towing vessels and had also worked for a machine repair shop. The chief engineer had been previously assigned to another vessel that was out of service on the day of the casualty, and then he was reassigned to the *Sandy Ground* to fill in for another engineer.

Oiler 1 had spent almost 18 years on deep sea vessels and had worked for Staten Island Ferry for 17 years and 8 months. On the day of the casualty, oiler 1 was referred to as the afternoon shift's "senior marine oiler." Oiler 1 stated that he had worked aboard the *Sandy Ground* and the *SSG Michael H. Ollis* two or three times each.

Oiler 2 had worked for Staten Island Ferry for 17 years as an oiler and had been a gas turbine technician in the US Navy. Oiler 2 estimated that he had made about 10 trips on the *Sandy Ground* and was regularly scheduled on the *SSG Michael H. Ollis*, where he had more trips logged.

1.7.3 Work Schedules

Staten Island Ferry engineering crews were not assigned to a particular vessel on a recurring schedule, nor were there regular teams assigned to vessels. Rather, they worked aboard vessels as needed on a day-to-day basis, as the jobs were assigned through a bidding process. Some of the crewmembers stated that they had worked with the same four-person team previously, but due to operations and sailing schedules, they could be placed on other vessels with other crewmembers. Shoreside port engineers with current chief engineer licenses would work aboard the vessels occasionally to fill vacancies.

The two oilers on duty at the time of the casualty each reported working 12 hours on the day before the casualty (December 21) and 10 hours the day before that (December 20). The chief engineer reported working 12 hours on the day before the casualty and 12 hours the day before that.

1.7.4 Training

Staten Island Ferry implemented a safety management system (SMS) on all ferries in its fleet to ensure safe operations and working conditions, establish safeguards to mitigate identified risks, and ensure standardized and unambiguous procedures for each crewmember during both routine and emergency operations. The Staten Island Ferry SMS required drills, training, and safety meetings to be performed at regular intervals.

Staten Island Ferry management stated that regular SMS training was conducted on the vessels, during which attendance was taken and recorded. The vessel crews conducted regular safety meetings and emergency drills. Fire and emergency drills were carried out aboard the vessels weekly, as mandated by Staten Island Ferry's Emergency Procedures Manual. Twice a year, according to Staten Island Ferry's emergency procedure matrix, a ferry-to-ferry transfer drill was held using Staten Island ferries. Before the fire, Staten Island Ferry had not completed an exercise that included vessels other than Staten Island ferries. However, the SMS included checklists advising the crew how to conduct transfers from ferry to ferry or to other vessels.

During construction of the first Ollis-class ferry, the *SSG Michael H. Ollis*, Staten Island Ferry management created positions to serve as subject matter experts for the new class of vessels and referred to them as “training officers” (two captains and two chief engineers were chosen to be training officers). These training officers familiarized themselves with the vessel, participated in testing and trials of the *SSG Michael H. Ollis*, and developed a training manual, approved by shoreside management, with operational procedures for the crewmembers in the fleet for the operation of the new class of vessels. The training officers also developed an engineering pamphlet with pertinent operational information that was passed out to employees as they trained.

After the first of the Ollis-class vessels, the *SSG Michael G. Hollis*, was delivered to NYCDOT in Staten Island, and before it was placed in service, the engineering training officers conducted training aboard the Ollis-class ferries with chief engineers, assistant engineers, and oilers. According to the engineering training officer, the training took about 4 days. After the training, each individual was required to complete a practical assessment form in the presence of, and signed off by, the training officer. The assessment form included generic engineering operational tasks applicable to all classes of Staten Island ferries, as well as class-specific tasks that were unique to each vessel class. An SMS training muster sheet recorded attendance for “Ollis training,” and the four engineering crewmembers aboard the *Sandy Ground* on the day of the fire had completed training between December 2021 and February 2022. The chief engineer recorded 36 hours of training, oiler 1 had 16 hours, and oiler 2 had 20 hours. Initially, when training had started on the first Ollis-class vessels, the fuel oil return isolation ball valves had not yet been installed (as-built check valves remained in the fuel oil return lines at the fuel oil stations), and there were no documented training records after the valves were installed in May 2022.

An engineering training officer stated that crewmembers were trained to regulate fuel oil levels on the Ollis-class day tanks by filling them with the fuel oil purifier—taking fuel oil from the storage tank and discharging it to the day tank. The training officer said that in order to equally maintain the levels in the two day tanks, engineering crewmembers were instructed to adjust the fuel oil purifier discharge valves at both fuel oil stations as needed (which would alter the amount of fuel being delivered into each day tank from the fuel oil purifier), and oiler 2 confirmed that he had been trained to operate the fuel oil purifier discharge valve. Investigators also interviewed six other oilers from the Staten Island Ferry fleet, and all recalled being instructed to use the fuel oil purifier discharge valve to control the levels in the day tank. However, several oilers recalled being instructed by training engineers to adjust the fuel oil service supply globe valve (if needed) to control the level in the day tank.

Additionally, oiler 1 (on duty at the time of the casualty) stated that he was trained to adjust the fuel oil return isolation ball valves to control the flow of return fuel oil, and several of the fleet oilers interviewed after the casualty stated they used the fuel oil return isolation ball valves to regulate levels for the fuel oil day tanks.[29] They stated that this was typically accomplished by keeping one fuel oil return isolation ball valve fully opened (typically at the starboard fuel oil station) and throttling the port fuel oil return isolation ball valve as necessary. The chief engineer on duty at the time of the casualty stated he believed one of the two fuel oil return isolation ball valves was always kept wide open, and the other was used to adjust the flow of fuel oil, but he wasn't sure which tank was supposed to have the wide-open valve. He further stated he was "confused with this new boat."

The training chief engineer stated that crewmembers operating on previous classes of vessels, which were equipped with pressure-relief valves in the fuel oil return piping systems, regulated the levels with the fuel oil return isolation ball valves, so if the crewmembers closed the fuel oil return isolation ball valves, "it's just going to recirc[ulate] back to the tank." When asked if there would be a situation in which the fuel oil return isolation ball valve should be operated on the Ollis-class vessels, the training chief engineer replied, "I would like to say no," and recommended to use the fuel oil purifier fill valve "… as much as you possibly can." However, the chief training engineer stated that in certain situations, if one side was filling slower than the other, she would "operate the fuel oil return [isolation] ball valve at this point or just close off the [fuel oil purifier] fill [valve]" on this tank.

During their training, each engineering crewmember received a copy of the Staten Island Ferry Engineers Operating Manual, which contained a chapter of safety precautions. For fuel oil systems, the manual warned that incorrect valve line-up may cause "equipment damage, contamination of fuel oil, personnel injury, or damage to the environment. The fuel oil section of the "Machinery Systems" chapter advised that when the ferry was in operation, valves for the "in use" day tanks were to remain open. The valves were only to be closed to switch tanks or when all machinery was secured.

[29] The NTSB notes that the isolation ball valves were not installed on the Ollis-class vessels at the time of training, so it is not clear when this training occurred.

1.8 Postcasualty Testing and Electronic Data Review

After the casualty, to determine what might have distorted the engine-mounted secondary spin-on duplex fuel oil filters, the NTSB examined the check valves installed on each of the main engines and in the fuel oil return piping system and verified that they were all installed correctly and were operating properly. Compressed air was applied to the fuel oil return piping system to verify that the piping was free of any blockages that could have restricted return fuel oil flow; no obstructions were found. The NTSB also examined both fuel oil day tanks after they had been emptied and found them to be clean and free of any debris or blockages in the piping system. Additionally, the Coast Guard Marine Safety Laboratory took samples of fuel oil from the day tanks for analysis and identified the fuel oil to be "representative of source samples." After arriving on scene, the NTSB found the fuel oil return isolation ball valves for both fuel oil day tanks in the open position. It is unknown when the valves were opened. The chief engineer aboard the *Sandy Ground* told investigators that he believed "too much back pressure" in the fuel oil system had caused an overpressurization of the fuel oil system that resulted in the rupturing of the engine-mounted secondary spin-on duplex fuel oil filter on each of the engines.

Data from the MCS log showed that, on the day of the casualty, the port fuel oil day tank level declined from about 1,700 gallons at 1430 when the afternoon crew came on watch to about 1,300 gallons at the time of the fire (see figure 14). The level in the starboard fuel oil day tank rose from about 1,700 gallons (at 1430) at the start of the watch to nearly 2,000 gallons before it began to decline about 1625.

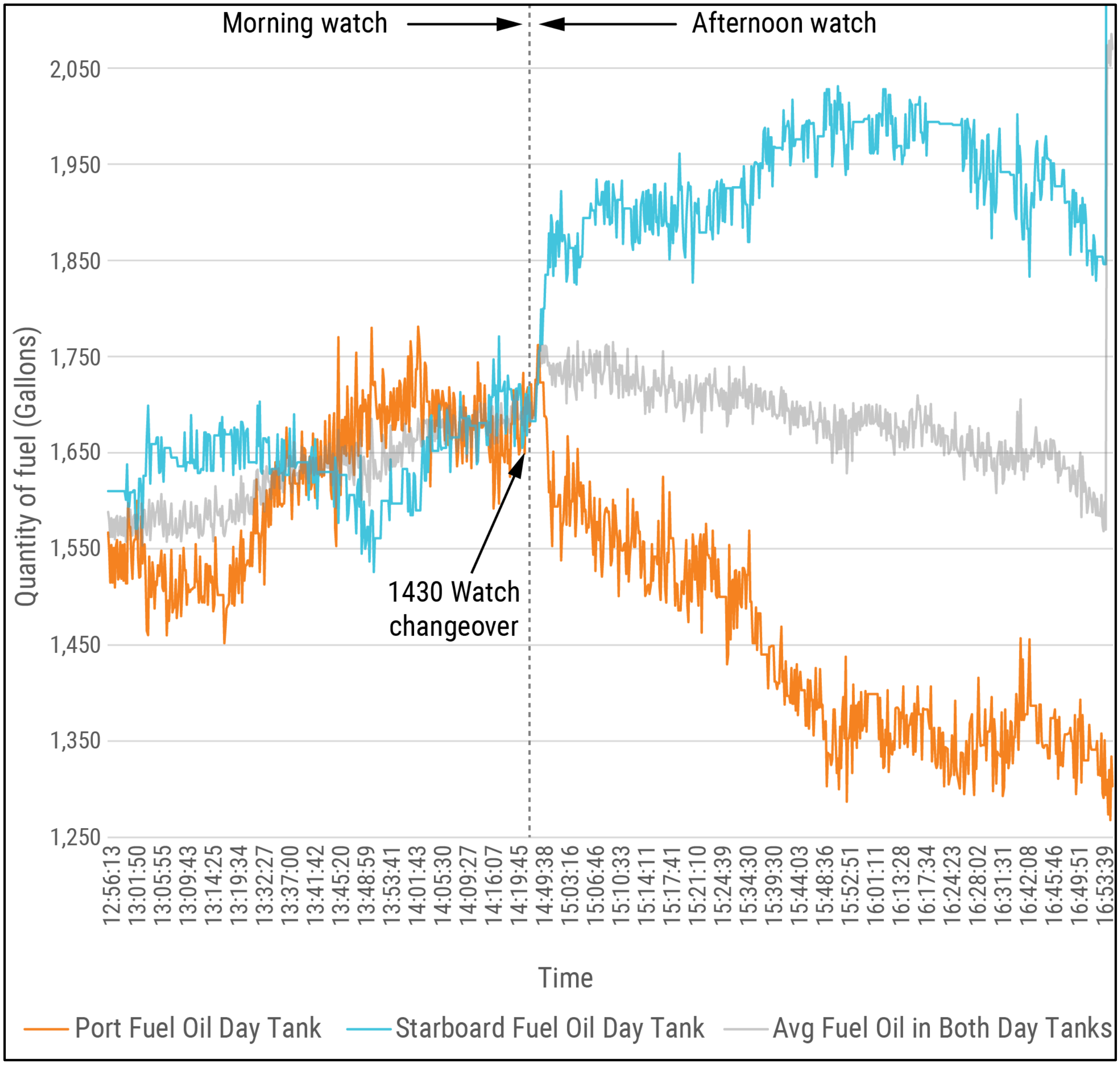

Figure 14. Graphic representation of fuel oil quantities in port fuel oil day tank and starboard fuel oil day tank. Average fuel oil in both tanks, calculated by NTSB, is depicted in gray. (Data source: *Sandy Ground* MCS).

Investigators reviewed the engine room alarm and monitoring electronic log of the engine performance data for the *Sandy Ground*. At 1646:50, the fuel oil pressure differential across the secondary fuel oil filters alarmed with a high alarm on all four engines, followed 2 seconds later by a low pressure alarm—measured at the outlet of the secondary fuel oil filters—on all four main diesel engines. Until this time, while the engines were running, the fuel oil pressure on each main engine was between 87 psi and 92 psi (as measured at the inlet of the fuel oil filter manifold block). At the time of the first alarm, the fuel oil pressure on all four engines increased to the maximum sensor value of 148 psi simultaneously.

1.9 Postcasualty Actions

1.9.1 Emergency Generator

During the casualty, the emergency generator automatically started upon the loss of electrical power but then automatically shut down when it detected an electrical fault. After the casualty, Staten Island Ferry maintenance personnel investigated the failure of the emergency generator and found a blown fuse in the control circuit of the emergency generator switchboard. An engineering maintenance manager stated that the fuse blew because of a shorted electrical cable that provided 120-volt power to a light in the EOS indicating "emergency generator running." Engineers from Staten Island Ferry shoreside management stated that the electrical cable was routed through the engine room near the no. 2 main engine and had been damaged by the heat of the fire and shorted the electrical conductors. After the fuse blew and interrupted electrical power to the emergency generator control circuit, the generator's protection device sensed a loss of one phase of electrical power, alarmed, disconnected from the emergency bus, and shut down the generator.

As a result of the casualty, the port engineering department developed an engineering modification to the emergency switchboard control wiring to provide over-current protection and isolation of the "emergency generator running" indicating light cable routed outside of the emergency switchboard from affecting the electrical operation of the emergency generator. In June 2023, fuses were installed in the emergency generator control circuit for the "emergency generator running" indicating light in the EOS aboard the *Michael H. Ollis* and the *Dorothy Day*, and in October 2023, the modification was completed on the *Sandy Ground*.

1.9.2 Fuel Oil System Operation

As a result of their investigation of the fire, Staten Island Ferry management issued a safety alert on January 26, 2023, to captains and chief engineers, communicating corrective action and identifying best practices for vessel fuel oil systems, including a directive that at least one fuel oil return isolation ball valve must be in the fully open position at all times, and one engineering crewmember should be assigned to maintain, monitor, and adjust fuel oil service tank levels during their watch. Also, in the month following the fire, Staten Island Ferry notified the Coast Guard that a senior port engineer, or their designee, would meet with engineering crews upon reassignment to the Ollis-class vessels to review proper fuel oil valve operations.

Staten Island Ferry revised the marine oiler practical assessment to include a demonstration of "knowledge of main engine and auxiliary machinery fuel and lube systems, oil levels, oil type requirements as well as operating temperatures, pressures, and tank levels." The operator also updated the Ollis-class engineering training pamphlet to advise, in red letters, that the fuel oil return isolation ball valve to each day tank was required to be "always open." Management also stated that they would continue their review of their current safety management procedures for possible revision to address any new risks identified during the investigation. They would also conduct continued SMS training and sharing of best practices identified for the casualty, including communication, emergency response, anchoring procedures, and resource management.

Additionally, as requested by Staten Island Ferry management, EBDG submitted and received regulatory approval to install pressure relief valves, which had been installed in previous classes of ferries, in the fuel oil return piping systems aboard the Ollis-class vessels. The Coast Guard MSC approved the modification, with the "understanding that the shutoff valves will remain open while the vessel is operating." Due to the regulatory requirements for performing hot work around fuel oil piping systems, the operator planned to complete the work during the Ollis-class vessels' next shipyard availability period. Two 4-psi relief valves were to be installed aboard each of the Ollis-class vessels—one at each fuel oil day tank in the area where the pipe entered the tank. While the *Sandy Ground* was undergoing repairs from the casualty, the relief valves were installed in the fuel oil return piping.

1.9.3 Additional Safety Meetings and Training

Staten Island Ferry management reported that, after the *Sandy Ground* casualty, they began including in safety meetings a review of vessel fuel oil return valve operations and best practices for effective drills and training. In SMS training sessions coordinated by the captains, the operator included a review of the annual NTSB publication, *Safer Seas Digest: Lessons Learned from Marine Investigations*, focusing on relevant marine casualties. Additionally, refresher training sessions were conducted for vessel fixed firefighting systems, including a review of the NTSB's report, *Engine Room Fire aboard Passenger Vessel* Natchez (NTSB 2023). Staten Island Ferry management further distributed safety newsletters to the fleet with guidance on emergency preparedness and crowd control, as well as updates on the *Sandy Ground* incident.

2 Analysis

2.1 Introduction

On December 22, 2022, about 1654 local time, an engine room fire broke out aboard the passenger ferry *Sandy Ground*, while the vessel was underway in New York Harbor with 884 persons aboard. The crew extinguished the fire by activating the engine room's fixed fire extinguishing system. The vessel lost propulsion and electricity, and the crew deployed both anchors. The majority of the passengers transferred to responding Good Samaritan vessels; the *Sandy Ground* was towed to the St. George Ferry Terminal in Staten Island, where the remaining persons disembarked.

This analysis evaluates the following safety issues:

- Engineering crewmembers' ineffective management of fuel oil day tank levels on the *Sandy Ground* (section 2.2)
- Inadequate training for engineering crewmembers on the use of fuel oil return isolation ball valves in the fuel oil system (section2.3)
- Need for a requirement to maintain unimpeded return flow in diesel engine fuel oil return systems (section2.4)
- Need for additional regulatory and classification society guidance on fuel oil return system design (section2.4)

Having completed a comprehensive review of the circumstances that led to the casualty, the NTSB excluded the following as casual factors:

- *Alcohol or other drug use by the crew*. All crewmembers on board the *Sandy Ground* at the time of the casualty tested negative for alcohol and other tested-for drugs.
- *Weather and waterway conditions at the time the fire broke out*. The vessel was underway in 13-mph winds from the north with a 3-knot ebb current. Skies were overcast, visibility was good, and there was no evidence the weather or waterway conditions impacted the crew or vessel when the fire broke out on the day of the casualty.
- *Impairment of the chief engineer or two oilers due to fatigue*. The chief engineer and two oilers on duty at the time of the casualty worked

10-12 hours the day before the casualty and had 12–14 hours of nonwork time before beginning their shift on the day of the casualty, thus giving them sufficient time for rest.

Thus, the NTSB concludes that none of the following were factors during the casualty transit: (1) alcohol or other drug use by the crew; (2) weather and waterway conditions at the time the fire broke out; or (3) impairment of the chief engineer or two oilers due to fatigue.

2.2 Fuel Oil System Overpressurization

As the *Sandy Ground* operated throughout the day on December 22, completing transits between Staten Island and Manhattan, the four operating diesel propulsion engines, one electrical generator, and one boiler consumed fuel oil drawn from two fuel oil day tanks. To operate the fuel oil system and maintain the levels in the day tanks, the engineering crewmembers had to monitor the levels in the vessel's day tanks (port and starboard), and, if needed, adjust fuel oil system valves to keep the levels relatively equal (within a few hundred gallons). The engineering crewmembers obtained tank levels via a remote monitoring system (MCS) in the EOS as well as locally at each tank's sight glass during engine room rounds.

When the afternoon engineering watch took over from the morning watch at 1430, the MCS indicated a difference of 5 gallons between the two day tanks. Over the next four transits and during the casualty transit, as the ferry continued to operate, the engineering crewmembers observed substantial differences in the fuel oil levels of the vessel's two fuel oil day tanks, and the total amount of fuel oil in the day tanks (combined amount) decreased steadily—contrary to the engineering crew's typical practice of keeping about 2,000 gallons in each tank (see figure 14). The chief engineer, who was in charge of the watch at the time, directed the two oilers on watch to balance the levels of fuel oil in the day tanks. As seen on CCTV, the oilers spent a significant amount of time (over 40 minutes) attempting to balance the levels of the two fuel oil day tanks. They adjusted several valves at both fuel oil stations and adjusted the fuel oil service supply globe valve to the engines, generators, and boilers on the port day tank several times. They also adjusted the fuel oil purifier discharge valves as well as the fuel oil return isolation ball valves to both the day tanks. However, while there were several conversations between the engineering crewmembers (chief engineer and oilers) in the EOS, investigators were unable to determine what they discussed, and during postcasualty interviews, neither oiler recalled the other oiler informing them which valves they adjusted. Additionally, the chief engineer did not provide clear direction to the oilers regarding how to regulate fuel oil tank levels or which specific valves to operate.

Similar to bridge resource management, engine room resource management describes how engineering crews use available resources to execute engine room tasks efficiently and safely. The main principles of engine room resource management include effective team communication, leadership, maintenance of a shared situational awareness, and considerations for team knowledge and experience. The lack of direction from the chief engineer, combined with the engineering crewmembers' misunderstanding the tank levels and lack of communication between the oilers, led to inconsistent fuel oil service supply globe and fuel oil return isolation ball valve operation on both fuel oil day tanks. The engine room crewmembers on board the *Sandy Ground*, including the chief engineer and oilers, each held a different understanding of the fuel oil system configuration and the operating procedures to manage the fuel oil levels and likely did not fully understand how the system functioned. As such, the engineering crewmembers' shared situational awareness of the fuel oil system configuration and how to effectively regulate the fuel oil tank levels was reduced as adjustments were made.

The fuel oil levels diverged sharply: according to the MCS, the port fuel oil day tank level declined about 400 gallons from the time the afternoon crew came on watch to the time of the fuel oil pressure differential alarms during the casualty transit, and the level in the starboard fuel oil day tank rose about 300 gallons before it began to decline about 1625 (29 minutes before the fire started at 1654). The starboard day tank had about 1,850 gallons, and the port day tank had about 1,300 gallons (both had a 2,808-gallon capacity)—over twice the difference in amount that they strived to maintain (200 gallons) between the tanks. Therefore, the NTSB concludes that the on-duty engineering crewmembers' ineffective engine room resource management resulted in a sharp increase in the difference in levels between the two fuel oil day tanks.

According to the *Sandy Ground*'s engine performance data, beginning at 1647 (when alarms activated during the casualty transit for the main engines' fuel oil supply systems on all four engines), the pressure of the fuel oil supplied by the engine-driven positive displacement fuel oil pump to the injectors in each main diesel engine sharply increased to 148 psi, reaching the maximum pressure of the sensor (until this time, the fuel oil pressure for each engine was between 87 and 92 psi). This sharp increase in pressure indicates that unburned fuel oil had no means of freely flowing from the four running engines back into the day tank and was causing the pressure to increase in the return piping system and supply piping.

As the increased pressure in the return line backed up into the supply piping, each of the four main engines' engine-mounted secondary spin-on duplex fuel oil filters became exposed to this elevated pressure. The pressure of the fuel oil system quickly rose, reaching the 120-psi internal relief valve setting in the fuel oil filter manifold blocks. Although the engine-mounted fuel oil filter manifold blocks contained pressure relief valves—to mitigate the risk of overpressurization—each of the relief valves was piped into the same common fuel oil return system piping that was already rising in pressure. Therefore, the fuel oil pressure relief valves within the fuel oil filter manifold blocks could not relieve pressure into the return lines as intended.

A postcasualty examination found the secondary spin-on duplex fuel oil filter assemblies on all four main engines were distorted at the connection points where the filters sealed against the filter bases. Additionally, the gasket on the no. 1 main engine secondary fuel oil filter had ruptured and protruded out of the sealing surface, indicating the fuel oil system had experienced overpressurization. In fact, all four running main engines had a high fuel oil pressure differential alarm, which was followed 2 seconds later by a low fuel oil pressure alarm, indicating that the excessive fuel oil pressure was instantly released through the ruptured filter gaskets into the engine spaces.

Postcasualty examination revealed that the check valves installed on each of the main engines' fuel oil return piping had been correctly installed and were operating properly. Additionally, the common return piping system from the engines to the day tanks was found free of any obstructions that could have restricted return fuel oil flow, and the day tanks were clean and free of debris or blockages. Thus, the only possible scenario that could have led to the overpressurization was the complete closure of the fuel oil return isolation ball valves to both fuel oil day tanks, which would have prevented any return fuel oil from flowing freely into either of the fuel oil day tanks. Therefore, the NTSB concludes that, in their ongoing response to correct the divergence in the *Sandy Ground*'s fuel oil day tank levels, the on-duty oilers closed both the port and starboard day tank fuel oil return isolation ball valves, causing the fuel oil system to overpressurize and, subsequently, the secondary duplex fuel oil filters to rupture.

The fuel oil filters began spraying fuel oil from the areas where they had ruptured. The directional distortions found on the fuel oil filter assemblies after the casualty indicated that:

- the fuel oil from the no. 1 main engine would have sprayed outward toward the port side and onto the adjacent running no. 2 main engine, including onto the exhaust manifold on the upper portion of the engine;

- fuel oil from the no. 2 main engine would have sprayed back toward the no. 2 engine;

- fuel oil from the no. 3 main engine would have sprayed outboard from the engine and forward toward the New York end (starboard side); and
- fuel oil from the no. 4 main engine would have sprayed inward back onto the no. 4 engine.

The postcasualty examination of the damage found that the no. 2 main engine exhaust manifold insulation and exterior components sustained smoke and fire damage. While the no. 2 engine was operating, the temperature of its exhaust manifold, which was wrapped in insulation blankets, would have been similar to the combined cylinder exhaust temperatures of the *Sandy Ground* engines—which ranged from 624°F to 942°F, depending on engine load. This surface temperature of the exhaust manifold would have provided an ignition source for the fuel oil spraying from the no. 1 main engine directly onto the heated surface of the no. 2 main engine's exhaust manifold between the joints of the insulation (see figure 15). Therefore, the NTSB concludes that the engine room fire started when fuel oil sprayed from the ruptured secondary duplex fuel oil filter of the no. 1 main engine onto the no. 2 main engine's exhaust manifold and ignited.

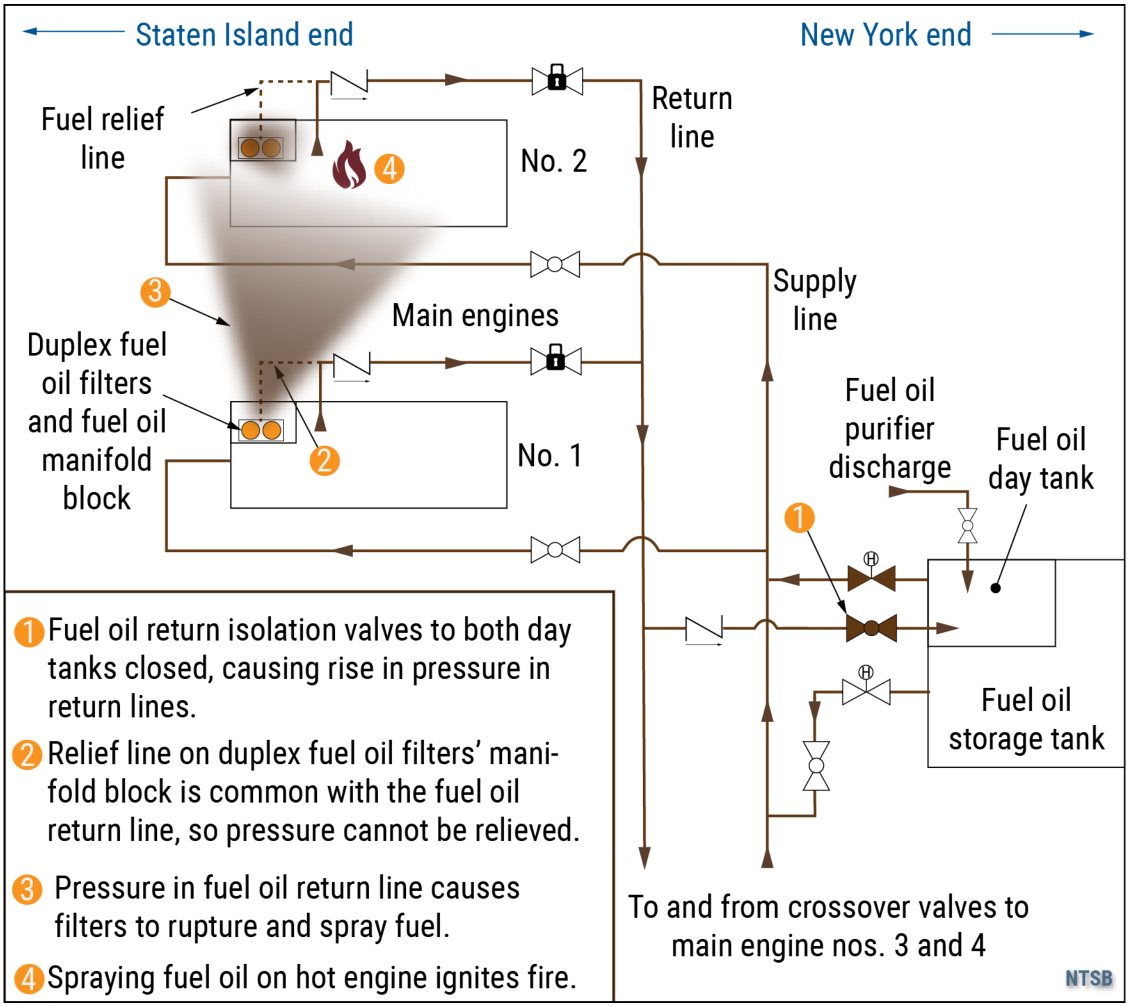

Figure 15. Simplified New York end main engine fuel oil supply/return system drawing for *Sandy Ground* and sequence of events leading to overpressurization and fire.

After receiving the high fuel oil filter pressure differential alarms, the low fuel oil pressure alarms on all four operating engines, and observing fuel oil spraying from the engines, the chief engineer notified the assistant captain in the pilothouse that the vessel might lose propulsion; he also attended to the alarms on the MCS. The chief engineer believed that the engines had shut down because the MCS screens displayed red alarms for the engines. If the main engines had been stopped, the attached, engine-driven fuel oil pumps would have stopped, too, cutting off the fuel oil supply and reducing the fuel oil spray. However, CCTV footage reviewed after the casualty showed that the output shaft on the no. 4 main engine continued to rotate, indicating the no. 4 main engine—and the other three main engines—continued running. Because the engines continued to run, they continued to spray fuel oil into the engine room from the time of the initial fuel oil system alarms at 1647 until about 1656, when CCTV recorded the shaft of the no. 4 main engine coming to a stop (the four main engines began shutting down about 1654 after they alarmed with "common engine shutdown"). The continuous spray of pressurized fuel oil during those 9 minutes provided additional fuel oil for the fire. The NTSB concludes that the delay in shutting down the main engines led to pressurized fuel oil continuing to spray from the ruptured secondary duplex fuel oil filters after the fire broke out, thereby feeding and increasing the severity of the fire.

The NTSB previously investigated a similar engine room fire aboard the towing vessel *Mary Lynn* while it was underway on the Upper Mississippi River near St. Louis, Missouri, in May 2021. The NTSB found that the probable cause of the fire was:

> … the overpressurization of the fuel day tank (which did not have an independent vent) and a main engine fuel return system when the fatigued chief engineer inadvertently left the day tank overflow valves to the storage tanks closed, which ultimately led to ignition of spraying diesel fuel from a main engine's fuel system onto an uninsulated engine component (NTSB 2022).

The NTSB is issuing a Safety Alert to vessel operators about the importance of understanding diesel engine fuel oil system return design and operation to prevent overpressurization of fuel oil systems. The Safety Alert is available on NTSB.gov. See the Safety Alerts listing or search for "SA-094."

2.3 Engineering Crew Training

Between December 2021 and February 2022, the *Sandy Ground* engineering crewmembers on duty at the time of the casualty completed initial training related to Ollis-class ferries (like the *Sandy Ground*) and their operation. This training included instruction on how to regulate fuel oil day tank levels and practical (hands-on) assessments. During their training, each on-duty engineering crewmember received the Staten Island Ferry Engineers Operating Manual. According to the manual, incorrect valve line-up could cause equipment damage. The manual advised that when the ferry was in operation, valves for the in-use day tanks should remain open and should only be closed to switch tanks or when all machinery was secured. However, while oiler 2 stated that he had not adjusted the fuel oil return isolation ball valve in the time leading to the casualty, oiler 1 stated that he had adjusted this valve. Additionally, as stated in section 2.2, without any other source of blockage in the fuel oil system, the on-duty oilers' closure of both fuel oil return isolation ball valves (leading to the day tanks) was the cause of the system's overpressurization. Therefore, the NTSB concludes that the engineering crewmembers on duty at the time of the casualty did not operate the fuel oil system in accordance with the operator's written guidance, which resulted in the system's overpressurization.

An engineering training officer stated that, at the time of the engineering crewmembers' initial training, which took place on the *SSG Michael H Ollis*, engineering crewmembers were instructed to adjust the fuel oil purifier discharge valves at both fuel oil stations as needed to maintain equal fuel oil levels in the two day tanks. After the casualty, the training officer also stated that crewmembers could use the fuel oil return isolation ball valves to make further adjustments, but this was not taught in the training. Additionally, shoreside managers stated that "there was always an intent to have the ability to regulate day tank levels by throttling the returns [isolation ball valves]." However, the training the engineering crewmembers received could not have included instruction on how to use these valves to make adjustments, or cover precautions and the consequences of closing them, because at the time, there were no fuel oil return isolation ball valves installed. These valves were not installed on the *Sandy Ground* until May 2022, 5–6 months after the crewmembers had completed their initial training (the valves were installed on the *SSG Michael H Ollis* in June 2022). After their initial training, the on-duty engineering crewmembers received no formal follow-on training to address the installation of the fuel oil return isolation ball valves. The addition of the fuel oil return isolation ball valves introduced inconsistencies between the fuel oil system configuration presented during initial training and the actual configuration on board the *Sandy Ground* the day of the casualty. These inconsistencies led to nonstandard operation among crewmembers and ambiguity on how to maintain the day tank fuel oil levels. Effective follow-on training after the addition of the fuel oil return isolation ball valves would have ensured that crewmembers were aware of the modification, understood the current system configuration, and were made aware of the consequences of closing the return valves.

Additionally, there was no consistent understanding of how to operate the fuel oil system among Staten Island Ferry engineering crewmembers. The two on-duty oilers each described being trained in different methods of controlling fuel oil levels in the day tanks. Oiler 1 recalled being instructed to use the day tank fuel oil return isolation ball valves, and oiler 2 recalled being instructed to use the day tank fuel oil purifier discharge valve and to not adjust the fuel oil return isolation ball valves. Other Staten Island Ferry oilers (not on duty at the time of the casualty) interviewed after the casualty stated that they were instructed to use the fuel oil purifier discharge valve to control day tank levels. Others said they recalled being instructed to adjust the fuel oil service supply globe valves to control the levels. Given the lack of consensus among Staten Island Ferry engineering crewmembers, the NTSB concludes that Staten Island Ferry's training program for engineering crewmembers assigned to Ollis-class ferries was inadequate because crewmembers had different perceptions about how to balance the day tank fuel oil levels, and they did not receive follow-on instruction after isolation ball valves were installed in the fuel oil return system, which resulted in the overpressurization of the system on the day of the casualty.

The chief engineer did not appear to understand the layout and design of the fuel oil system. He stated that he wasn't sure which fuel oil return isolation ball valve was supposed to be left open and which one should be adjusted for tank level management and that he was "confused with this new boat." Further, as noted above, oiler 1 adjusted the wrong valve.

The engineering crew on watch at the time of the casualty had all worked on other classes of Staten Island ferries (Molinari- and Barberi-class) that had pressure relief valves built into the fuel oil return lines (unlike the Ollis-class vessels). On these ferries with relief valves, the fuel oil return isolation ball valves could be closed, and when the pressure reached the relief valve pressure setting, fuel oil would flow around the isolation valve back to a dedicated tank, thus avoiding any risk of fuel oil return or fuel oil system overpressurization. Because of this safety feature, and relief valve settings that were well below the fuel oil system high-pressure alarm, the engineering crewmembers likely would not even be aware when the return line pressure had exceeded the relief valve settings and subsequently been relieved. The pressure relief valves built into the fuel oil return systems on the other classes of ferries effectively provided an unimpeded path for excess fuel oil to travel back to vented fuel oil tanks. Given their actions on the day of the casualty, the on-duty engineering crewmembers on the *Sandy Ground* were clearly not aware of the ramifications of closing the return isolation ball valves in the system. A training officer who trained Staten Island Ferry engineering crewmembers stated that, in previous classes of Staten Island ferries that had fuel oil systems containing relief valves, "If they close those returns [isolation valves], it's [the fuel oil] just going to recirc[ulate] back to the tank [due to the relief valve]." Therefore, based on their previous experience on vessels with pressure relief valves, the engineering crewmembers may have been conditioned to believe that the fuel oil system on the *Sandy Ground* could not be overpressurized. The NTSB concludes that, because Ollis-class vessels' fuel oil return systems were designed without relief valves, unlike previous classes of Staten Island ferries, the *Sandy Ground* engineering crewmembers on duty at the time of the fire likely had an expectation that the fuel oil system could not be overpressurized.

After the casualty, Staten Island Ferry management issued a safety alert to captains and chief engineers identifying best practices for vessel fuel oil systems. Additionally, the operator revised their oiler training program, updated the Ollis-class engineering training manual to advise that fuel oil return isolation ball valves to the day tanks were required to be "always open," and arranged for relief valves to be installed.

2.4 Regulatory and Classification Society Oversight of Fuel Oil System Design

As stated in section 2.2, in the *Sandy Ground* casualty, the oilers closed both day tank fuel oil return isolation ball valves, causing fuel oil system overpressurization. This overpressurization led to the rupturing of the engine fuel oil filters, which caused fuel oil to spray, igniting a fire.

According to the Society of Naval Architects and Marine Engineers (SNAME) publication, *Marine Engineering*, if a vessel with diesel engine fuel oil return systems must have shutoff (isolation) valves, the system design must account for them in other ways. SNAME states:

> If it is necessary to install shutoff valves in the [fuel oil] return line, a pressure relief valve should be installed to by-pass the valve and discharge to one of the service tanks in case the valve is inadvertently closed while the engine is running (SNAME 1980).[30]

Marine Engineering further states, "it is possible for the pressure to build up in a closed return line to the point of rupturing the pipe, spraying fuel oil into the engine room, and possibly starting a fire."

The manufacturer (EMD) for the *Sandy Ground* main engines produced a marine product guide; these guides are intended to be used by vessel designers when considering engine installation and engine supporting systems. The marine product guide for the *Sandy Ground* main engines advised that "return fuel leaving the engine should be routed to the top of the main fuel tank without shutoff [isolation] valves."

Staten Island Ferry determined that, for operational reasons, the Ollis-class ferries should be fitted with fuel oil return isolation valves before the day tanks to regulate day tank levels by throttling these valves. Further, contrary to SNAME's recommendation, the Ollis-class vessels did not have a means to relieve the pressure in the fuel oil return line after the oilers closed both fuel oil return isolation valves, and the secondary duplex fuel oil filters' pressure relief valves were piped into the same common fuel oil return system lines (as opposed to independent piping). Without a means to relieve the pressure, the system overpressurized, and, as SNAME suggested could happen, fuel oil sprayed and ignited a fire. The NTSB, therefore, concludes that, had the *Sandy Ground* fuel oil system been equipped with either a pressure

[30] SNAME is a professional society of individuals serving in maritime and offshore industries dedicated to the exchange of knowledge related to engineering in the marine industry.

relief valve installed in the fuel oil return line or an independent return line from the main engines' fuel oil manifold block relief valves to a tank, the elevated fuel oil pressure caused by the closed fuel oil return isolation ball valves would have been relieved and a fuel oil system overpressurization would have been prevented.

In accordance with the regulations in 46 *CFR* Chapter I, Subchapter F, which detail requirements for marine engineering, the Coast Guard reviews design plans (drawings) for all domestic passenger vessels to ensure compliance with applicable regulations as well as guidance for systems or equipment used on board a vessel. In 2016, the naval architecture design firm contracted to design Ollis-class vessels (which included the *Sandy Ground*) submitted a pre-contract fuel oil system drawing to the Coast Guard. The Coast Guard, through its MSC, reviewed and approved the drawing, which included an isolation ball valve in the common fuel oil return line to each fuel oil day tank.

When reviewing the drawing for Ollis-class vessels, the MSC referenced Coast Guard procedure E1-10, "Review of Fuel Oil Systems," which provides guidance regarding the information required to be submitted to the MSC for review of fuel oil system diagrams (MSC 2022). The document listed the requirements for materials used and installations. However, this reference did not include guidance on whether isolation valves should be allowed or pressure relief valves used in fuel oil return systems. Additionally, according to the Coast Guard MSC, there were "no direct regulations [at the time of the vessel's construction] relating to the installation of pressure relief valves in fuel oil systems."

The vessel's classification society, ABS, also reviewed the 2016 pre-contract fuel oil system drawing, which showed the isolation ball valves in the fuel oil return lines. They certificated the drawing in accordance with the 2015 ABS *Rules for Building and Classing Steel Vessels for Service on Rivers and Intracoastal Waterways*. These rules had no specific requirement for pressure relief valves, nor did they have a requirement to prevent or require the use of isolation valves in fuel oil return systems.

After the 2016 reviews, the Ollis-class vessels' drawing was later modified to replace the isolation ball valves in the return line to each day tank with check valves. This occurred during the contracted shipyard's detailed development of the system's design by the engineering group. ABS reviewed the new 2018 fuel oil system drawing for compliance with the 2017 ABS *Rules for Building and Classing Steel Vessels on Rivers and Intracoastal Waterways* and approved it. These rules also had no specific requirement for pressure relief valves, nor did they have any requirements related to the use of check valves in fuel oil return systems. The shipyard also submitted the updated 2018 drawing to the Coast Guard for review, and in August 2018, ABS and the Coast Guard MSC approved the diagram as submitted.

Therefore, at the time they were submitted to the Coast Guard and ABS, the diagrams for the Ollis-class vessels' (including the *Sandy Ground*'s*)* fuel oil systems complied with applicable marine engineering regulations and ABS classification requirements. The NTSB concludes that, despite the vessel's fuel oil system complying with Coast Guard regulations and ABS rules, the presence of fuel oil return isolation ball valves in the *Sandy Ground*'s diesel engine fuel oil return system allowed for return flow to be blocked and the system to overpressurize.

As stated in section 2.2, after the *Sandy Ground* was constructed, an isolation ball valve was installed, in addition to the check valves, in the fuel oil return lines from the engines before each of the two day tanks at the request of the operator.

During plan review, professional engineers and naval architects review submitted system diagrams and associated design specifications and then determine if the drawings meet the guidance and standards provided in rules or regulations. Although there is a specific known risk of overpressurization in diesel engine fuel oil return systems should the return flow be restricted or blocked—as evidenced by both engine manufacturer (EMD) and SNAME guidance—there is currently no specific guidance in ABS rules or Coast Guard regulations on the installation of valves in diesel engine fuel oil return systems. Specific guidance on the use of valves and pressure-reducing/relief valves in the fuel oil return system would clearly convey to plan reviewers, vessel designers, and vessel operators the potential risk from restricting diesel engine fuel oil return flow and eliminate this risk at the design stage. This casualty shows that, although plan reviews of Ollis-class vessels, like the *Sandy Ground*, were correctly performed by the Coast Guard and ABS, the operator of the Ollis-class vessels had a fuel oil system design that could be inadvertently overpressurized by the crew during vessel operation. In fact, the operator requested that ball-type isolation valves be installed in the fuel oil return system—in addition to the check valves that had been fitted at shipyard delivery. If there was a requirement for unimpeded flow, reviewers would have recognized the design problem and required that the owner, or the owner's vessel designer, submit an alternate valve arrangement for the diesel engine fuel oil return system. Therefore, the NTSB concludes that explicit requirements and guidance for maintaining an unimpeded return flow in diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps, including the installation of a pressure relief valve with unimpeded return to a service tank, would mitigate the risk of a system overpressurization and engine room fire. Therefore, the NTSB recommends that the Coast Guard revise 46 *CFR* Chapter I, Subchapter F to require new construction diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps to be designed to have an unimpeded return flow from the engine to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization. The NTSB also recommends that ABS ensure their fuel oil piping rules used to class vessels require new construction diesel engine fuel oil systems supplied by positive displacement fuel oil pumps be designed to have unimpeded return flow from any single or multiple consumers to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization.

ABS is one of 12 member classification societies that comprise the International Association of Classification Societies (IACS). Each member classification society maintains a set of rules and standards for classing vessels, and the 12 IACS member societies class over 90% of the world's merchant shipping tonnage.[31] Additionally, IACS develops and reviews minimum technical requirements—called Unified Requirements—for the design, construction, maintenance, and survey of ships to ensure widespread, uniform application of these requirements. Each Unified Requirement ratified by IACS is incorporated into each member society's rules and standards. IACS also works within the International Maritime Organization—the United Nations agency responsible for regulating maritime transport—to provide technical support and develop unified interpretations of international statutory regulations developed by the International Maritime Organization's member states. The NTSB concludes that other classification societies would benefit from learning about the circumstances of the engine room fire on board the *Sandy Ground* in order to share that information with their members so that future vessel designs provide for unimpeded return fuel oil flow. Therefore, the NTSB recommends that ABS share the circumstances of the engine room fire on board the *Sandy Ground* with IACS and propose that IACS advise its member organizations to ensure their rules require new construction diesel engine fuel oil systems supplied by positive displacement fuel oil pumps be designed to have unimpeded return flow from any single or multiple consumers to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization.

The Coast Guard provides guidance on vessel construction, stability, and systems for vessel designers and operators to reference. This guidance is based on regulations and Coast Guard policy and is typically used by vessel designers (such as naval architecture and marine engineering firms) and operators when drafting and submitting drawings/vessel designs to ensure they comply with required applicable regulations and policies. An example of this type of guidance is the plan review guidance typically used by the MSC when reviewing drawings—such as E1-10, which the MSC took into account when reviewing the *Sandy Ground* fuel oil system drawings (this guidance did not prevent or require the use of an isolation valve in the

[31] See https://iacs.org.uk/about-us/ for more information about IACS.

fuel oil return line). This guidance is publicly available on the Coast Guard MSC website and can be updated as appropriate, such as when policy or regulations change. The NTSB concludes that specific guidance on maintaining unimpeded diesel engine fuel oil return flow would provide naval architects and engineers with additional information for the safe design of these systems. Therefore, the NTSB recommends that the Coast Guard, pending the implementation of a regulatory requirement, develop design guidance for new-construction diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps so they have unimpeded return flow from the engine to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization, and disseminate this guidance to the MSC. Additionally, the NTSB recommends that the Coast Guard share Safety Alert-094 with marine inspectors so they can ensure existing vessels with diesel engine fuel oil systems supplied by positive displacement fuel pumps have unimpeded return flow to prevent overpressurization.

2.5 Crew Emergency Response

The *Sandy Ground* crew responded to the fire by anchoring the vessel, making an emergency broadcast over VHF radio—alerting nearby vessels and VTS to the situation—distributing lifejackets to passengers, and preparing passengers to transfer to responding vessels. Additionally, the deck crew remotely shut down the engine room ventilation fans and closed their dampers, sealing off the engine room and containing the fire. The chief engineer then activated the emergency fuel oil shutoff valves in the EOS for the fuel oil day tanks, eliminating further fuel oil supply to the engine room, and released the fixed firefighting system, which successfully extinguished the fire.

Within a half hour of the *Sandy Ground* emergency broadcast, Good Samaritan vessels had responded to the scene and quickly began transferring *Sandy Ground* passengers. After most of the passengers transferred to Good Samaritan vessels, the captain noticed the wind speed increasing from the north and the water getting "choppier," causing the vessel to drag anchor. The deteriorating conditions made it increasingly difficult for the assist tugs to hold the *Sandy Ground* in position. In response, the captain decided to call off the evacuation and have the vessel towed to the terminal in Staten Island, where the remaining persons on board disembarked. All persons on board were safely evacuated. The NTSB concludes that the *Sandy Ground* crew's actions, combined with the quick response by nearby Good Samaritan vessels, resulted in a timely and safe evacuation of all persons on board.

3 Conclusions

3.1 Findings

1. None of the following were factors during the casualty transit: (1) alcohol or other drug use by the crew; (2) weather and waterway conditions at the time the fire broke out; or (3) impairment of the chief engineer or two oilers due to fatigue.

2. The on-duty engineering crewmembers' ineffective engine room resource management resulted in a sharp increase in the difference in levels between the two fuel oil day tanks.

3. In their ongoing response to correct the divergence in the *Sandy Ground*'s fuel oil day tank levels, the on-duty oilers closed both the port and starboard day tank fuel oil return isolation ball valves, causing the fuel oil system to overpressurize and, subsequently, the secondary duplex fuel oil filters to rupture.

4. The engine room fire started when fuel oil sprayed from the ruptured secondary duplex fuel oil filter of the no. 1 main engine onto the no. 2 main engine's exhaust manifold and ignited.

5. The delay in shutting down the main engines led to pressurized fuel oil continuing to spray from the ruptured secondary duplex fuel oil filters after the fire broke out, thereby feeding and increasing the severity of the fire.

6. The engineering crewmembers on duty at the time of the casualty did not operate the fuel oil system in accordance with the operator's written guidance, which resulted in the system's overpressurization.

7. Staten Island Ferry's training program for engineering crewmembers assigned to Ollis-class ferries was inadequate because crewmembers had different perceptions about how to balance the day tank fuel oil levels, and they did not receive follow-on instruction after isolation ball valves were installed in the fuel oil return system, which resulted in the overpressurization of the system on the day of the casualty.

8. Because Ollis-class vessels' fuel oil return systems were designed without relief valves, unlike previous classes of Staten Island ferries, the *Sandy Ground* engineering crewmembers on duty at the time of the fire likely had an expectation that the fuel oil system could not be overpressurized.

9. Had the *Sandy Ground* fuel oil system been equipped with either a pressure relief valve installed in the fuel oil return line or an independent return line from the main engines' fuel oil manifold block relief valves to a tank, the elevated fuel oil pressure caused by the closed fuel oil return isolation ball valves would have been relieved and a fuel oil system overpressurization would have been prevented.

10. Despite the vessel's fuel oil system complying with US Coast Guard regulations and American Bureau of Shipping rules, the presence of fuel oil return isolation ball valves in the *Sandy Ground*'s diesel engine fuel oil return system allowed for return flow to be blocked and the system to overpressurize.

11. Explicit requirements and guidance for maintaining an unimpeded return flow in diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps, including the installation of a pressure relief valve with unimpeded return to a service tank, would mitigate the risk of a system overpressurization and engine room fire.

12. Other classification societies would benefit from learning about the circumstances of the engine room fire on board the *Sandy Ground* in order to share that information with their members so that future vessel designs provide for unimpeded return fuel oil flow.

13. Specific guidance on maintaining unimpeded diesel engine fuel oil return flow would provide naval architects and engineers with additional information for the safe design of these systems.

14. The *Sandy Ground* crew's actions, combined with the quick response by nearby Good Samaritan vessels, resulted in a timely and safe evacuation of all persons on board.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the engine room fire aboard the passenger ferry *Sandy Ground* was the design of the vessel's diesel engine fuel oil return system, which included isolation valves that could be regularly adjusted by the crew and, when closed, stopped return fuel oil flow from all operating engines, resulting in the overpressurization of the fuel oil system and the ignition of fuel oil spraying from ruptured fuel oil filters onto the exhaust manifold of a running engine. Contributing to the overpressurization was the operator's inadequate training program on fuel oil system operation, which did not provide follow-on instruction after the installation of fuel oil return isolation valves at the day tanks.

4 Recommendations

4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations.

To the US Coast Guard:

> Revise Title 46 *Code of Federal Regulations* Chapter I, Subchapter F to require new construction diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps to be designed to have an unimpeded return flow from the engine to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization. (M-24-5)

> Pending the implementation of a regulatory requirement, develop design guidance for new-construction diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps so they have unimpeded return flow from the engine to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization, and disseminate this guidance to the US Coast Guard Marine Safety Center. (M-24-6)

> Share Safety Alert-094 with marine inspectors so they can ensure existing vessels with diesel engine fuel oil systems supplied by positive displacement fuel pumps have unimpeded return flow to prevent overpressurization. (M-24-7)

To the American Bureau of Shipping:

> Ensure your fuel oil piping rules used to class vessels require new construction diesel engine fuel oil systems supplied by positive displacement fuel oil pumps be designed to have unimpeded return flow from any single or multiple consumers to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization. (M-24-8)

Share the circumstances of the engine room fire on board the *Sandy Ground* with the International Association of Classification Societies (IACS) and propose that IACS advise its member organizations to ensure their rules require new construction diesel engine fuel oil systems supplied by positive displacement fuel oil pumps be designed to have unimpeded return flow from any single or multiple consumers to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization. (M-24-9)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

THOMAS CHAPMAN
Member

ALVIN BROWN
Member

J. TODD INMAN
Member

Report Date: July 9, 2024

Appendixes

Appendix A: Investigation

The US Coast Guard was the lead federal agency in this investigation. The National Transportation Safety Board (NTSB) learned of this casualty from the Coast Guard on December 22, 2022, and an NTSB investigator arrived on scene in New York, New York, on December 26. While on scene, the NTSB participated with the Coast Guard in joint interviews of Staten Island Ferry managers, *Sandy Ground* crewmembers who were aboard the vessel at the time of the casualty, and other Staten Island Ferry vessel crewmembers who had worked aboard the Ollis-class vessels. Investigators also gathered documentation relevant to the casualty.

The Coast Guard, New York City Department of Transportation–Staten Island Ferry, and the American Bureau of Shipping were parties to the investigation.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation–

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the US Coast Guard

M-24-5
Revise Title 46 *Code of Federal Regulations* Chapter I, Subchapter F to require new construction diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps be designed to have an unimpeded return flow from the engine to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Regulatory and Classification Society Oversight. Information supporting (b)(1) can be found on pages 47–49; (b)(2) can be found on pages 47–49; and (b)(3) is not applicable.

M-24-6
Pending the implementation of a regulatory requirement, develop design guidance for new-construction diesel engine fuel oil return systems supplied by positive displacement fuel oil pumps so they have unimpeded return flow from the engine to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization, and disseminate this guidance to the US Coast Guard Marine Safety Center.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Regulatory and Classification Society Oversight. Information supporting (b)(1) can be found on pages 50–51; (b)(2) can be found on pages 50–51; and (b)(3) is not applicable.

M-24-7
Share Safety Alert-094 with marine inspectors so they can ensure existing vessels with diesel engine fuel oil systems supplied by positive displacement fuel pumps have unimpeded return flow to prevent overpressurization.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Regulatory and Classification Society Oversight. Information supporting (b)(1) can be found on pages 50–51; (b)(2) can be found on pages 50–51; and (b)(3) is not applicable.

To the American Bureau of Shipping

M-24-8
Ensure your fuel oil piping rules used to class vessels require new construction diesel engine fuel oil systems supplied by positive displacement fuel oil pumps to be designed to have unimpeded return flow from any single or multiple consumers to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Regulatory and Classification Society Oversight. Information supporting (b)(1) can be found on pages 47–49; (b)(2) can be found on pages 47–49; and (b)(3) is not applicable.

M-24-9
Share the circumstances of the engine room fire on board the *Sandy Ground* with the International Association of Classification Societies (IACS) and propose that IACS advise its member organizations ensure their rules require new construction diesel engine fuel oil systems supplied by positive displacement fuel oil pumps be designed to have unimpeded return flow from any single or multiple consumers to a vented tank, or, if the vessel design requires isolation valves in the fuel oil return line, other arrangements to prevent overpressurization.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Regulatory and Classification Society Oversight. Information supporting (b)(1) can be found on page 50; (b)(2) can be found on page 50; and (b)(3) is not applicable.

Appendix C: Timeline of Events

Table C-1. Timeline of engineering crew interactions regarding fuel oil tank system line-up and tank levels on December 22, 2022.[1]

Time	Crew Action
1422	The afternoon shift relieves the morning shift.
1435	The morning shift oiler has a discussion with the chief engineer and assistant engineer in the engine operating station (EOS).
1439	The morning shift oiler and assistant engineer go to the port fuel oil station and appear to be discussing its piping design and/or line-up.
1444	Oiler 2 at the port fuel oil station.
1445	Oiler 2 at the starboard fuel oil station.
1535	Oiler 2 and chief engineer, in the EOS, appear to discuss the fuel oil tank system and/or line-up.
1537	Oilers 1 and 2, in the EOS, appear to discuss fuel oil service tank levels.
1541	Oiler 2 goes to the port fuel oil station, then starboard fuel oil station.
1602	Oiler 2 at the port fuel oil station for about 4 minutes. Oiler 2 makes right/clockwise turns to port fuel oil service day tank fuel oil supply globe valve.
1606	Oiler 2 goes to the starboard fuel oil station.
1607	The chief engineer and assistant engineer look at [remote] fuel tank TLI [tank level indicator] readings in EOS.
1609	Oiler 2 goes to port fuel oil station. Oiler 2 makes left/counterclockwise turns to port fuel oil service day tank fuel oil supply globe valve.
1610	Oiler 2 goes to starboard fuel oil station.
1614	Oiler 2 goes to port fuel oil station.
1615	The assistant engineer exits EOS to make routine round of machinery space(s) and looks at port fuel oil tank levels while making round. The assistant engineer and oiler 2 go to starboard fuel oil station.
1617	Oiler 2 returns to the port fuel oil station.
1618	Oiler 1 joins oiler 2 at the port fuel oil station.

Time	Crew Action
1619	Oiler 2 goes to the starboard fuel oil station.
1624	Oiler 2 goes to the starboard fuel oil station.
1626	The chief engineer and oiler 2 have a discussion in the EOS. Oiler 1 returns to the port fuel oil station and makes right/clockwise turns to the port fuel oil service day tank fuel oil supply globe valve.
1628	Oilers 1 and 2 at the port fuel oil station. Oiler 1 makes right/clockwise turns to the port fuel oil service day tank fuel oil supply globe valve.
1629	Oiler 2 goes to the starboard fuel oil station.
1630	Oiler 1 returns to the port fuel oil station. Oiler 1 makes left/counterclockwise turns to the port fuel oil service day tank fuel oil supply globe valve.
1633	Oiler 1 returns to the EOS.
1634	Oiler 2 returns to the EOS, and a discussion regarding tank levels ensues.
1637	Oiler 2 goes to the port fuel oil station to trace system.
1641	Oiler 2 makes left/counterclockwise turns to the port fuel oil service day tank fuel oil supply globe valve.
1642	Oiler 2 goes to the starboard fuel oil station.
1643	Oiler 1 goes to the port fuel oil station.
1644	Oiler 2 returns to the port fuel oil station, and Oilers 1 and 2 discuss the fuel oil valve line-up.
1645	Oilers 1 and 2 move their discussion to the aft EOS vestibule.
1646	Oilers 1 and 2 return to the EOS and regard fuel oil tank levels on [MCS] screen.
1647	Oilers 1 and 2 leave the EOS. Oiler 1 goes to the port fuel oil station, and oiler 2 goes to the starboard fuel oil station. After looking at the port fuel oil tank level, oiler 1 joins oiler 2 at the starboard fuel oil station.
1648	The chief engineer answers alarms for "Main Engine Low Fuel Oil Pressure" on the alarm monitoring system.
1650	Oiler 1 goes to the port fuel oil station and turns/adjusts valve(s). Oiler 2 returns to the EOS.

Time	Crew Action
1651	Oiler 1 returns to the port fuel oil station and again turns/adjusts valve(s).
1652	Oiler 1 goes to the starboard fuel oil station. The chief engineer sends oiler 2 to the port fuel oil station to check the system line-up.
1653	The assistant engineer returns to the EOS from his round, entering the engine room from the main deck passenger space access door, and informs the chief engineer that fuel oil is spraying.
1654	The engine room fire begins and is visible on a CCTV camera near main engine no. 2 as a small, orange light. Oiler 2 goes to the port tank, and oiler 1 returns to the EOS and reports the fire.
1655	Oilers 1 and 2 exit the EOS to look at the fire and prepare to evacuate the EOS.
1658	Chief engineer activates emergency fuel shutoff valves located in the EOS before exiting through the EOS escape hatch.

[1]All times and actions are based on the US Coast Guard and Staten Island Ferry management's review of footage from CCTV cameras in the engine room and machinery spaces.

Appendix D: *Sandy Ground* Fuel Oil System

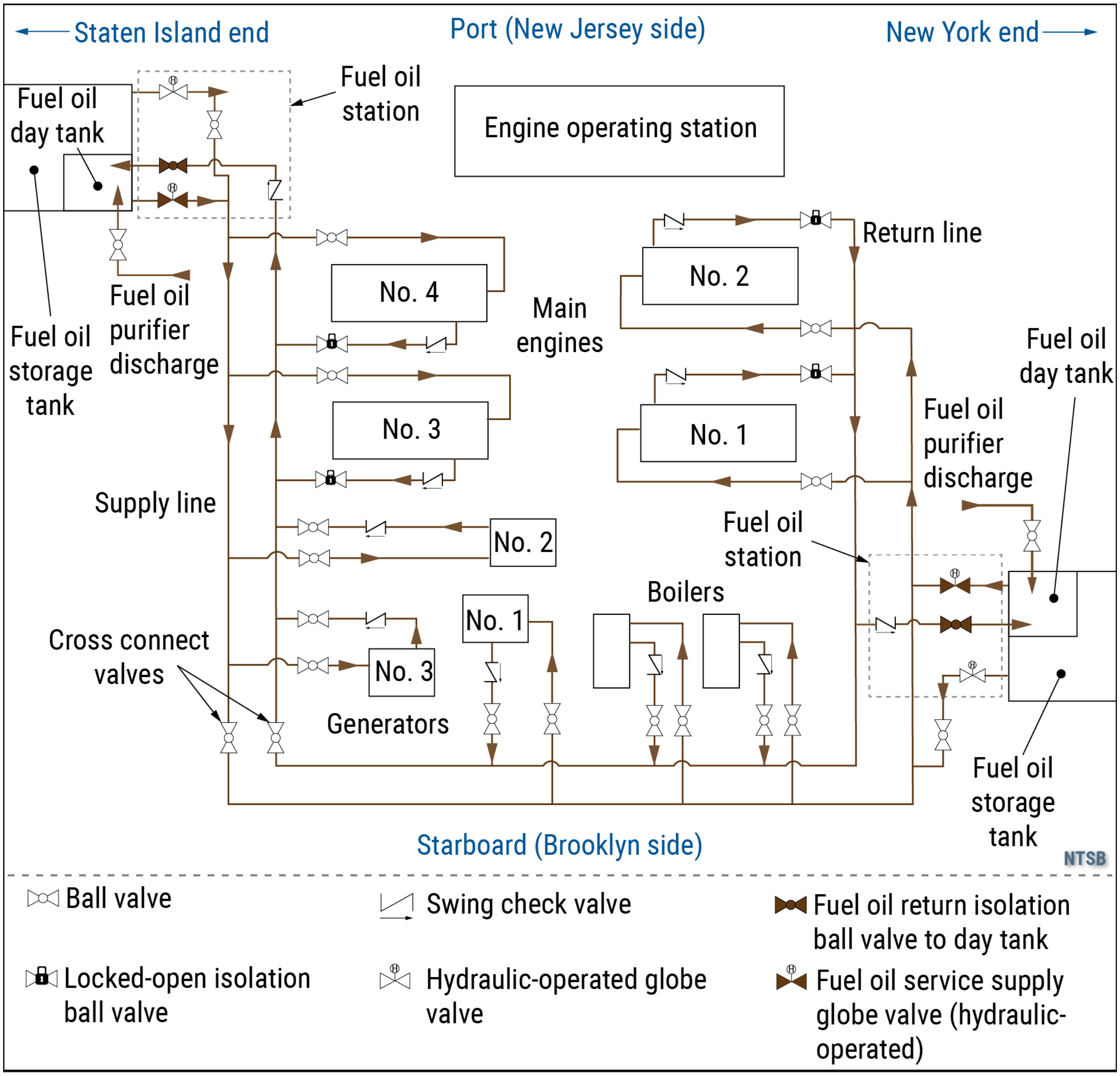

Figure D-1. Fuel oil piping drawing for the *Sandy Ground* at the time of the casualty, showing the fuel oil supply and return arrangement for the four main engines, three generators, and two boilers to and from the day tanks located on the outboard sides of the engine room.

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Casualty type	Fire/Explosion
Location	Anchorage Channel, New York Harbor, near Staten Island, New York 40° 39.2′ N, 74°03.2′ W
Date	December 22, 2022
Time	1654 eastern standard time (coordinated universal time –5 hours)
Injuries	2 minor
Property damage	$12.7 million est.
Environmental damage	None

NTSB investigators worked closely with our counterparts from **Coast Guard Sector New York** throughout this investigation.

The NTSB is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in the other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

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For more detailed background information on this report, visit the NTSB Case Analysis and Reporting Online (CAROL) website and search for NTSB accident ID DCA23FM010. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting –

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