November 16, 2023 MIR-23-25

Engine Room Fire aboard Tank Vessel *Endo Breeze*

On April 29, 2022, about 1913 local time, a fire started in the engine room of the 600-foot-long chemical tank ship *Endo Breeze* while the vessel was transiting outbound from Linden, New Jersey, through the Raritan Bay West Reach channel, to Bay Ridge Anchorage.[1] The crew extinguished the fire using the engine room's fixed carbon dioxide fire extinguishing system. As a result of the fire, the vessel lost propulsion and was anchored in the channel. No pollution or injuries were reported. Damage to the vessel was estimated at $1.2 million.

Figure 1. The *Endo Breeze* underway after the casualty. (Source: Martin Klingsick @ Shipspotting.com)

[1] (a) In this report, all times are eastern daylight time, and all miles are nautical miles. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA22FM016). Use the CAROL Query to search investigations.

Casualty type	Fire/Explosion
Location	Raritan Bay West Reach Channel, Raritan Bay, New Jersey 40°30.15′ N, 74°9.89′ W
Date	April 29, 2022
Time	1913 eastern daylight time (coordinated universal time –4 hrs)
Persons on board	20
Injuries	None
Property damage	$1.2 million est.
Environmental damage	None
Weather	Visibility 8 mi, overcast, winds east 19 mph, gusts 26 mph, air temperature 59°F, water temperature 51°F
Waterway information	Channel, project depth 35 ft

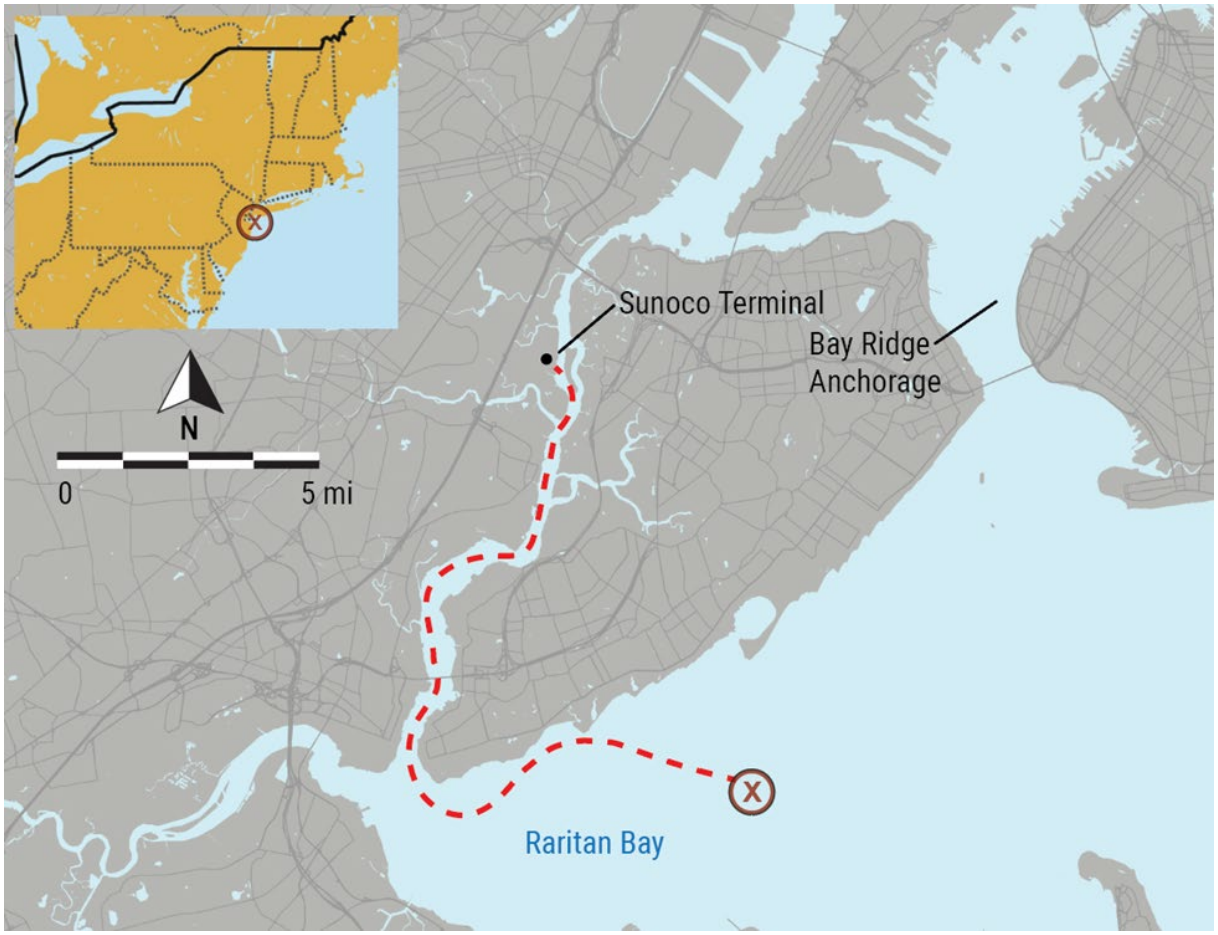

Figure 2. *Endo Breeze* outbound route and location where the fire occurred, as indicated by a red *X*. (Background source: Google Maps)

1. Factual Information

1.1 Background

The *Endo Breeze* was a 600-foot-long tank vessel designed for transporting chemicals and oil products, with seven cargo tanks and a carry capacity of 52,969 metric tons. The vessel's propulsion system consisted of two MAK (Caterpillar Motoren GmbH) 8-cylinder, M-32 C, medium-speed (600 rpm) diesel engines rated at 5,149 hp per engine. The engines were connected to a gear that drove a single controllable pitch propeller.

The Malta-flagged vessel was built in Brodotrogir Shipyard, Croatia, and delivered on October 29, 2003. Originally named *Tapatio,* the vessel was sold in 2018 to Endo Two Maritime Ltd and came under the management of Columbia Shipmanagement GmbH, from Hamburg, Germany.

1.2 Event Sequence

On April 29, 2022, about 1305, *Endo Breeze*'s crew completed a bulk liquid cargo discharge of reformate, a gasoline blending stock, at Sunoco Terminal in Linden, New Jersey. The master and deck department crew prepared the vessel for departure to the upper New York Bay, to anchor at the Bay Ridge Anchorage to complete bunkering operations (resupply fuel oil) by barge.

At 1600, the chief engineer ordered the second engineer to prepare the main propulsion diesel engines for departure. Meanwhile, the fourth engineer made a round of the machinery spaces and completed the vessel's engine room departure checklist. At 1617, the second engineer reported all systems to be operating in a satisfactory condition, and, at 1636, main propulsion control was given to the bridge, with the engines in standby.

About 15 minutes later, under command of a docking pilot, *Endo Breeze* began unmooring operations. The tug *Kirby Moran* made fast on the port bow. At 1724, the docking pilot released the tug and departed shortly thereafter.

The *Endo Breeze* continued outbound with a Sandy Hook pilot at the conn and the captain, helmsman, and lookout also on the bridge. At 1800, the third officer relieved the second officer, with no reported issues or concerns passed down during their turnover. The chief engineer was in the engine control room along with the second engineer, while the fourth engineer and oiler made rounds of the machinery spaces.

At 1911, the *Endo Breeze* rounded the turn in the Seguine Point Bend (near green buoy no. 27), about 0.3 miles east of Seguine Point, Staten Island, New York. After the

vessel turned onto the Raritan Bay West Reach Channel at 7.7 knots with the propulsion system operating at half ahead (6-pitch setting), the pilot ordered full ahead, and the third officer brought the bridge lever to full ahead (a 7.5-pitch setting).

About that time, the second engineer and the fourth engineer, who were conducting a round of the engine room, smelled fuel oil and saw a haze in the air near the starboard main diesel engine. The second engineer approached the starboard engine and noticed fuel oil on the deck near the outboard side of the starboard engine. He opened the no. 4 cylinder fuel injector pump cover of the starboard main engine and determined that the fuel mist was coming from the aft end of the engine, near the no. 1 cylinder. When he opened the no.1 cylinder fuel injector pump cover, high-pressure fuel oil sprayed from the no. 1 fuel injection pump banjo tube into the air near the turbo charger and exhaust manifold.[2]

Figure 3. (*Left*) Location of the turbo charger relative to the no. 1 fuel pump cover. (*Right*) Location of fire on the starboard engine with fuel pump covers nos. 1 and 4 left partly opened. (Source: US Coast Guard)

To reduce the fuel spray, the second engineer placed a shop rag over the banjo tube, then he and the fourth engineer quickly proceeded to the engine control room to notify the chief engineer of the situation. Both fuel pump covers were left partially open.

At 1913, the chief engineer and second engineer called the master from the control room to tell him they needed to shut down the starboard engine (leaving the port engine engaged), which would result in reduced propeller pitch, and therefore

[2] A *banjo tube* is a type of fitting designed for routing liquids in high-pressure systems. It consists of a tube (pipe) connected to the system (host fitting) by two banjo bolts (hollow bolts), allowing fluid to transfer. The tube has spherical ends with sliding fit surfaces; the bolts are adjusted independently, so, unlike standard pipe fittings, banjo fittings do not have to be rotated relative to the host fitting.

reduced thrust. Meanwhile, the fourth engineer left the control room and proceeded one deck below (to the deck that overlooked the main propulsion engines), where he observed a fire near cylinder no. 4 on the starboard engine. The fire spread toward him quickly, reaching the bottom of his shoes on the next deck up. The fire alarm sounded in the engine control room and bridge when the flame and smoke detectors activated in the lower engine room.

The chief engineer, who was still on the phone with the master, saw the fire on the closed-circuit video monitor in the control room and told the bridge, "fire in the engine room, we need to stop the engines, zero pitch now." At 1914, he pressed the main propulsion engine emergency stop button for each main engine. All engine room personnel immediately evacuated the engine room space and control room. After evacuating the engine room, the second engineer secured all ventilation, pumps, fuel and lube oil quick-closing valves, and some auxiliary machinery to the engine room from the remote panel located outside of the engine room. Shortly thereafter, the vessel lost primary electrical power supplied from the two online diesel generators (located in the engine room). The emergency diesel generator started automatically to restore power to critical electrical systems and emergency lighting powered from the emergency electrical bus.

About the same time the chief engineer pressed the emergency stop buttons, the master notified the pilot of a fire in the engine room, the third officer used the ship's intercom system to notify the crew, and all personnel reported to the muster location at the main deck passageway. At 1919, all watertight doors, engine room ventilation, and accommodation ventilation were reported closed to the bridge.

At 1921, after all personnel were accounted for, the chief engineer activated the engine room's fixed carbon dioxide (CO_2) fire extinguishing system from the remote-control station in the changing room just outside the engine room. The engine room's fixed CO_2 fire extinguishing system coverage consisted of 100 45-kg bottles of CO_2.

Meanwhile, on the bridge, the pilot and master decided to emergency anchor in the Raritan Bay Channel. At 1922, the captain gave the order to drop the starboard anchor, releasing 4 shots (360 feet) of anchor chain into the water. The master notified the company's qualified individual, designated person ashore, agent, and the US Coast Guard of the emergency. The pilot also made notifications and followed up with local fire boats and available tugs to assist the vessel. The vessel anchored on the inbound side of the Raritan Bay West Reach channel near red buoy no. 14.

The crew could not determine whether the fire had been extinguished following the CO_2 release because the closed-circuit camera lens near the fire was obscured as a result of the fire. They knew that any attempt to enter the space could potentially admit

oxygen into the engine room and cause a reflash, so the chief engineer and second engineer ensured that all doors, hatches, and ventilation sources remained secured.

Firefighting assets arrived on scene about 2000, and Fire Department of the City of New York (FDNY) vessel fire pumps provided water to the *Endo Breeze*'s fire main via the vessel's international shore connection flange. FDNY deemed the engine room unsafe for entry for about 48 hours to inhibit potential for reflash. On May 1 at 1500, FDNY personnel and a marine chemist entered the engine room, deemed the fire to be extinguished, and assessed the engine room as safe for entry.

1.3 Additional Information

1.3.1 Damage

Most of the fire damage was located on the lower engine room platform near the top end of the starboard main propulsion engine. The fire damage was concentrated between cylinder nos. 1, 2, and 3 on the outboard side with no. 1 experiencing the most severe damage. Motor controllers and associated wiring located directly outboard of the starboard engine were also damaged. There was also damage to the main lube oil pumps, main lube oil auto filters, and separator pumps.

Figure 4. (*Left*) Smoke and fire damage to the upper engine room postcasualty. (*Right*) Fire origin and damage to the starboard engine and upper engine room postcasualty.

The fire damage continued upward and through the grating above the starboard engine to the lighting fixtures and fire/smoke/flame detection system sensors in the overhead, and up through the engine room exhaust trunk casing. Damage to the vessel was estimated at $1.2 million.

1.3.2 Main Engine Fuel Injection Pumps

Eight fuel injection pumps on the engine top end injected fuel at high pressure to their respective cylinders. Fuel at lower pressure was supplied to each injector pump at 58 psi (4.0 bar) by a fuel supply line (pipe). The injector fuel pumps on the *Endo Breeze* were designed to be interchangeable and could be installed on any cylinder.

The banjo tube was only installed on the no. 1 cylinder fuel injector pump for each engine. The fuel supply line ended at the no. 1 cylinder fuel injector pump with a sealing flange; the corresponding return line was capped with a lid. The fuel lines were interconnected by a banjo tube secured by two banjo bolts, which provided a path for fuel oil not used in the supply line to circulate into the return line, which ultimately returned it to the diesel oil day tank.

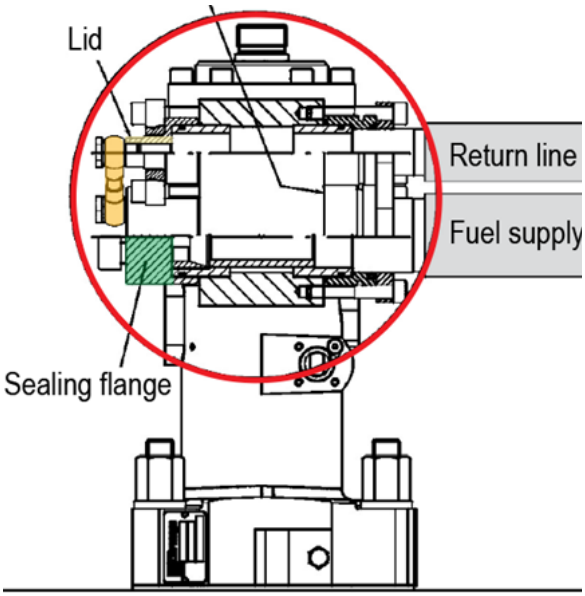

Figure 5. Image from the MAK Maintenance and Repair Manual referencing the no. 1 fuel oil injector pump piping components. (Background source: MAK)

1.3.3 Fuel Injector Pump Maintenance

The day before the casualty, the second engineer, aided by a motorman and wiper, performed maintenance on the starboard main engine in accordance with the company's planned maintenance material management system. Per the system, inspections on the nos. 1 and 8 fuel pumps were due in April.

Engine diagnostics performed the previous week showed that the engine's nos. 1 and 7 cylinders' fuel injectors exhibited abnormally low exhaust gas temperature differentials for the cylinders. With concurrence and approval from the chief engineer, the second engineer replaced nos. 1 and 7 fuel injectors as well as nos. 1 and 8 fuel injector pumps after inspecting them. The procedure in the manufacturer's manual for disassembly and replacement of injector pumps first required the removal of the fuel oil supply (distribution) and return (collective) lines, which terminated at the no. 1 cylinder fuel oil injector pump.

The reassembly procedure identified the correct placement of the sealing flange and lid to the no. 1 cylinder fuel injector pump for the fuel supply and return piping. The procedure also listed the proper torque values for the fasteners during reassembly. Step 2.3 specified, "make sure that the cone remains in correct position during the tightening."

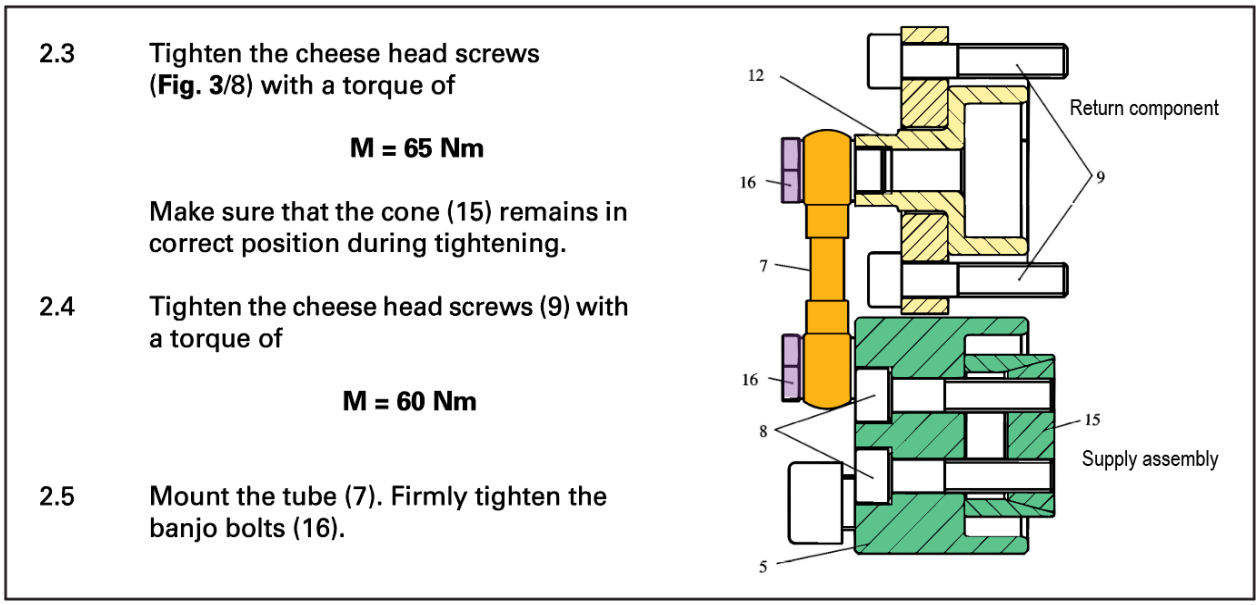

Figure 6. No. 1 fuel oil injector pump reassembly procedure and diagram of piping components. The banjo tube (orange) connects the fuel pump supply line assembly (green) to the return component (yellow). (Background source: MAK)

The second engineer told investigators that he followed the procedure and ran the main diesel engine (under no load, not engaged) to inspect for leaks after replacing the two fuel oil pumps. He did not find signs of leaks or other issues. He also told investigators that, while the banjo tube and bolts were reused from the disassembled injector fuel pump, all consumable items (washers, o-rings, and gaskets) were replaced with new original equipment manufacturer spare parts.

When investigators contacted the engine manufacturer, North America MAK, for additional information on the affected components, the service manager noted that the banjo tubes and bolts "are not to be replaced unless they get damaged," and that there were no recalls for the banjo tube components.

The second engineer told investigators that he had previous experience working on these types of injector fuel pumps and their associated fuel piping systems on MAK engines, and he had done similar work on marine medium-speed diesel engines over his 17 years in the maritime industry. He was on his third contract with this class of vessel for the same company, totaling 10 months of prior service.

1.3.4 Fuel Injector Pump Examination

Investigators conducted a postcasualty examination of the no.1 fuel injector pump and associated fuel piping and banjo tube where the second engineer first observed the oil leak. When investigators compared the port and starboard engines' no. 1 fuel pumps, they found a slight offset (resulting in misalignment to the fuel injector pump body) of the starboard main engine's banjo tube. They also found a fracture near the top portion of the inboard side of the banjo tube mounting surface to the sealing flange.

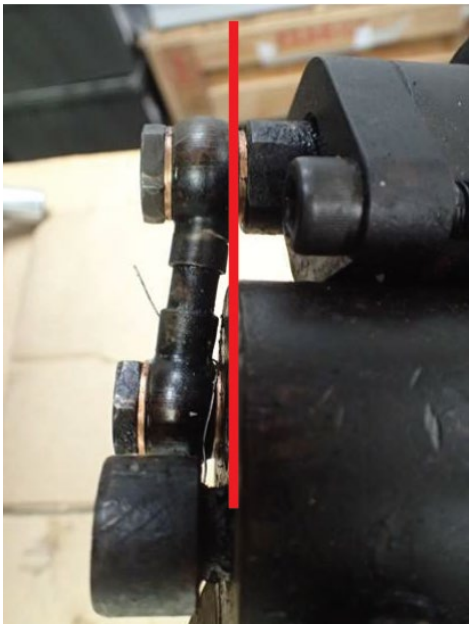

Figure 4. Banjo tube connected to the sealing flange and lid of no. 1 cylinder fuel injector pump assembly showing misalignment. (Source: QC Metallurgical, Inc.)

1.3.5 Metallurgical Report

Parties to the investigation, including the vessel owner and the Coast Guard, agreed to third-party testing to further document the postcasualty condition of the fasteners and sealing surfaces of the banjo tube to the sealing flange and lid. On July 7, 2022, QC Metallurgical, Inc., a third-party testing and consulting service company, produced a data analysis report on the observed conditions of the banjo tube fracture, banjo bolts characteristics, and washers, and noted the following:

> The banjo tube was cleaned and inspected under stereomicroscope. Observed was that the tube was bent to accommodate the offset of the tubes. Machine mark line[s] were noted longitudinal to fracture. On both ends cracks are on the stressed side of where the tube was mounted.

The condition of the banjo bolts and threads was listed as "good." The banjo bolts' overall lengths were the same, and the upper and lower copper washers' (crush) thicknesses were similar.

Figure 8. The fractured banjo tube. (Source: QC Metallurgical, Inc.)

2. Analysis

While the chemical tank ship *Endo Breeze* was maneuvering outbound through the Raritan Bay West Reach channel, a fire broke out in the engine room. The second engineer was conducting a round of the engine room when he smelled oil. He told investigators that when he opened the no. 1 cylinder fuel injector pump cover to investigate, fuel oil sprayed into the air from the no. 1 fuel injection pump banjo tube, which was near the operating engine's exhaust manifold. As the engineers were calling the master to shut down the engine, the fourth engineer saw a fire on the starboard engine. Investigators found the fire pattern and surrounding heat damage near the outboard side of the starboard main propulsion engine at the no. 1 cylinder fuel injector pump to be consistent with the second and fourth engineers' accounts of the event. Based on the fire damage and the engineers' observations, oil spray from the banjo tube leak made contact with nearby hot surfaces on the starboard engine's exhaust manifold and ignited.

To determine the cause of the banjo tube leak, investigators examined the engine's no. 1 cylinder fuel injector pump and discovered a slight offset (misalignment) on the affected banjo tube assembly. The second engineer had replaced the no. 1 fuel injection pump earlier that day. He told investigators that he followed the manufacturer's manual reassembly procedure, which required components to be tightened in a specific order to maintain alignment. However, if he tightened the banjo tube bolts before properly tightening the sealing flange and/or lid assembly to their specified torques, the pump sealing flange and/or lid assembly may not have been evenly aligned when the

banjo tube was installed. Because investigators found an offset on the banjo tube assembly, it is likely that the engineer did not correctly follow the manufacturer's reassembly procedure for the fuel injector pump.

The banjo tube was sent for third-party metallurgical testing. Metallurgical testing did not find any material or dimensional issues with the banjo tube bolts or other involved parts. However, testing found that the tube had bent to accommodate the offset, and fractures on both ends of the tube itself—where it connected to the sealing flange and lid—were discovered. Therefore, stresses associated with the offset likely caused the banjo tube to bend and fracture, causing the oil leak.

After replacing the fuel oil pumps, the second engineer ran the main diesel engine (under no load) to inspect for leaks and found no signs of leaks or other issues from the fuel oil pumps or associated piping. This is likely because the banjo bolts' sealing surfaces provided a sufficient seal during the short, no-load testing. But when the main engine was fully loaded with a full-ahead order, the expanding stresses (due to heat) caused the banjo tube to fracture. Therefore, although the second engineer properly tested the repair, the misalignment that led to the banjo tube failure only manifested once the engine was given a high load.

The vessel's fire-detection and alarm system activated and notified the crew moments after the start of the fire, and the crew responded by quickly activating fuel pump shutoffs and ventilation shutdowns to restrict the spread of the fire by limiting oxygen and fuel to the main engine room. The chief engineer's quick activation of the ship's fixed CO_2 system effectively extinguished the fire. Additionally, the crew kept the engine room sealed until the fire was confirmed to be out, which prevented reflash. The crew's effective response limited damage and prevented injuries.

3. Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the engine room fire aboard the chemical tank ship *Endo Breeze* was a main engine fuel injector pump replacement that was not conducted in accordance with manufacturer procedures, which resulted in a high-pressure fuel spray that ignited off the engine exhaust components.

3.2 Lessons Learned

Diesel Engine Maintenance

The NTSB has investigated several recent casualties involving mechanical or fuel line fitting failures that led to engine room fires following maintenance of shipboard diesel engines. The engine room fire in this casualty illustrates what can happen when equipment manufacturers' recommended maintenance procedures are not followed. In this case, not following the tightening sequence described in the diesel engine manufacturer's manual led to the misalignment and failure of a high-pressure fuel connection on an engine's fuel injector pump's assembly.

Due to the high risk of fire associated with pressurized fuel, when working with diesel engine components, it's critical to carefully follow manufacturer assembly procedures and review manufacturer manuals and guidance on a regular basis to ensure familiarity with correct maintenance procedures.

Containing Engine Room Fires

The crew of the *Endo Breeze* effectively contained the spread of a main engine room fire by removing fuel and oxygen sources and communicating effectively. To prevent engine room fires and ensure they are effectively contained, operators should provide mariners realistic scenario-based training, including training that covers engine room emergencies. This training should also cover procedures for effectively shutting down machinery, fuel oil, lube oil, and ventilation systems, as well as boundary monitoring.

Vessel	*Endo Breeze*
Type	Cargo, Liquid Bulk (Chemical tanker)
Owner/Operator	Endo Two Maritime Ltd/Columbia Ship Management GmbH (Commercial)
Flag	Malta
Port of registry	Valletta, Malta
Year built	2003
Official number (US)	9239977
IMO number	9239977
Classification society	DNV-GL
Length (overall)	600.0 ft (182.9 m)
Breadth (max.)	106.0 ft (32.2 m)
Draft (casualty)	18.9 ft (5.75 m)
Tonnage	26,914 GT ITC
Engine power; manufacturer	2 x 5,149 hp (3840 kW); MAK (Caterpillar Motoren GmbH) diesel engines

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

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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 DCA22FM016. 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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