Issued May 10, 2022 MIR-22/15

Engine Room Fire aboard Containership *President Eisenhower*

On April 28, 2021, about 0154 local time, the containership *President Eisenhower* was transiting westbound through the Santa Barbara Channel, about 17 miles southwest of Santa Barbara, California, when the vessel experienced an engine room fire.[1] The crew fought the fire using fire hoses and a fixed water mist system, before using the engine room's fixed carbon dioxide fire-extinguishing system, which extinguished the fire. As a result of the fire, the vessel lost propulsion and drifted for several hours before being towed to the Port of Los Angeles. No pollution or injuries among the 22 crewmembers were reported. Damage to the vessel was estimated at $8.22 million.

Figure 1. *President Eisenhower* operating near San Francisco, California, in 2019. (Source: San Francisco Bar Pilots, MarineTraffic.com)

[1] (a) In this report, all times are Pacific daylight 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. DCA21FM026). Use the CAROL Query to search investigations.

Casualty type	Fire/Explosion
Location	Santa Barbara Channel, near Santa Barbara, California 34°14.5′ N, 119°58.7′ W
Date	April 28, 2021
Time	0154 Pacific daylight time (coordinated universal time –7 hrs)
Persons on board	22
Injuries	None
Property damage	$8,223,172 est.
Environmental damage	None
Weather	Visibility 8.7 nm, clear, winds light and variable, seas 1–3 ft, air temperature 66°F, water temperature 56°F, sunrise 0613
Waterway information	Coastal channel, depth 1,560 ft (at casualty site)

Figure 2. Area where fire erupted in the engine room of the *President Eisenhower*, as indicated by the red triangle. (Background source: Google Maps)

1. Factual Information

1.1 Background

The US-flagged, 984-foot-long *President Eisenhower* was built in 2005 by Hyundai Heavy Industries, in Ulsan, South Korea. Originally named the *Hanjin Dallas*, the vessel had a maximum container capacity of 7,471 twenty-foot equivalent units.[2] The vessel was managed by APL Maritime, a subsidiary of American President Lines. It had a single 12-cylinder, slow-speed, direct-drive, diesel main engine rated at 93,120 hp, designed by MAN B&W and manufactured by Hyundai Heavy Industries. The *President Eisenhower* routinely transported cargo between southeast Asia and the west coast of the United States.

The *President Eisenhower* had 13 decks. On the upper deck (continuous main deck), there were two safety storerooms (emergency lockers): one on the port side (A) and the other on the starboard side (B). The safety storerooms acted as muster stations for two emergency squads and housed firefighter outfits, self-contained breathing apparatuses (SCBA), and other equipment necessary to fight a shipboard fire. Squad 1 reported to safety storeroom A, and squad 2 reported to safety storeroom B. The upper deck also housed the fire control station (FCS) midships, where the crew could operate the fuel oil quick-closing valves, ventilation shutdowns, the fixed water mist system, and the fixed carbon dioxide (CO_2) fire-extinguishing system.

1.2 Event Sequence

On April 27, 2021, at 1900, after completing cargo operations, the partially loaded *President Eisenhower* departed the Port of Los Angeles en route to Oakland, California, with a crew of 22.

At midnight, on April 28, the *President Eisenhower* was about 6 miles south of Port Hueneme, California, navigating the northwest-bound traffic lane of the Santa Barbara Channel at a speed of 17.5 knots with the main engine operating at 68 rpm. The navigation watch group consisted of a third mate and two able seamen (AB). The master's night orders included instructions to gradually increase the main engine's speed to a maximum of 80 rpm, so the third mate coordinated with the second engineer (the designated duty engineer), who was in the engine control room (ECR) by means of the shipboard telephone. The first engineer was also in the ECR assisting with the

[2] *Twenty-foot equivalent units* measure the carrying capacity of a containership based on the number of 20-foot-long containers the vessel is capable of loading (standard shipping container lengths are 20 and 40 feet).

preparation of the engine for the ordered rpm. The third mate increased the engine rpm in increments of 4, from 68 rpm up to 80 rpm. Following each step increase, the second engineer locally confirmed that the engine and other machinery had responded appropriately to the change and were operating as desired. This speed increase, also referred to as engine loading, took about 40 minutes.

At 0042, once the engine was operating at 80 rpm, the second engineer and first engineer exited the ECR, and each began to conduct a separate walkthrough round of the engine room to ensure all machinery was operating correctly. At 0052, both engineers returned to the ECR. The third mate stated that at this time, the engineers informed him that the engine and machinery were “looking good.”

The engine room and machinery on board the *President Eisenhower* were automated, controlled, and monitored such that the machinery spaces could be unattended. The ship’s engineers typically worked in and monitored the machinery spaces during the day, and the engine room and machinery spaces were unattended at night. At 0053, the second engineer and first engineer departed the ECR for the accommodation spaces above. The engine room and machinery spaces were put into an “unattended” status with alarms configured to sound on the bridge, in common areas, and in the second engineer’s cabin (because the second engineer was the designated duty engineer on watch). Additionally, the *President Eisenhower* had a closed-circuit television (CCTV) system, with the majority of the system’s video cameras located in the machinery spaces. The crew used desktop computer stations to view the spaces but did not continually monitor them.

About 0154, one of the ABs on watch (AB1) was on the starboard bridge wing when he noticed smoke coming from an open engine room hatch located a few feet port of midships, below on the upper deck just aft of the house. He quickly entered the bridge and notified the third mate. About the same time, the fire control panel on the bridge alarmed, indicating that a flame or smoke detector in the engine room had activated. The third mate immediately called the captain, who reported to the bridge. Additional detectors were triggered within the engine room, and the vessel’s general alarm automatically activated. Using the CCTV monitor on the bridge, the captain and third mate confirmed that there was an engine room fire. En route to his emergency muster station in the portside safety storeroom, AB1 verbally alerted crewmembers that were off duty in their cabins of the fire in the engine room.

The first and second engineers headed to their emergency squad locker at safety storeroom B. Once there, the second engineer opened the closest engine room door which was a few feet away (slightly port of midships on the upper deck) and saw flames next to the auxiliary boiler on the second deck. Realizing the severity of the fire, he and the first engineer donned firefighter outfits and SCBAs, then attempted to use ABC portable fire extinguishers to quell the fire through the engine room door. They stated that the fire extinguishers were ineffective and they returned to the starboard safety storeroom. The remainder of the crew in emergency squads 1 and 2 had arrived at their respective muster locations and reported that all personnel were accounted for to the bridge.

At 0202, the master began reducing the main engine rpms and slowing the vessel. To escape the smoke that was filling the bridge and the alarms whose noise prevented clear communication, the captain transferred navigational control of the vessel to the starboard bridge wing station, where he was able to control the vessel and communicate, primarily using UHF radio, with the chief mate and emergency squad leaders. About the same time, in anticipation that the firefighting efforts could cause a loss of primary electrical power and lighting, the chief engineer manually started the emergency diesel generator (EDG) and connected it to the emergency switchboard (although the EDG was designed to automatically start and power the emergency switchboard if the vessel lost electrical power, the chief engineer wanted to be proactive).

The *President Eisenhower*'s engine room and machinery spaces were protected against fire by two fixed fire-extinguishing systems: a water mist system and a CO_2 suppression system. The water mist system consisted of a freshwater tank, a pump, and spray nozzles that could deliver water mist to the machinery spaces to cool the flames and surrounding gasses through evaporation, ideally to a point where combustion would not be possible. The CO_2 suppression system consisted of 294 45-kilogram cylinders containing CO_2 gas (there were an additional 50 cylinders designated for the cargo holds) that could be manually released and directed into the engine room and machinery spaces, thus flooding the space with CO_2 and displacing the oxygen needed to maintain a fire.

By 0204, crewmembers from the two emergency squads had charged fire hoses on the exterior of the upper deck and began boundary cooling the engine room casing aft of the house. The second engineer stated that about this time, he noticed the water mist system above the main engine had automatically been activated, and indication lights in the FCS confirmed the system's activation.

About 0210, while continuing to boundary cool the engine casing, the emergency squads planned to make an approach into the engine room via an exterior door on the upper deck. Two ABs from emergency squad 1 noticed the upper deck hatch for the engine room was still open. They closed the hatch and dogged it to stop "oxygen from flowing to the fire." One of the ABs stated that the raised horizontal deck hatch (about 3.5 by 3.5 feet) was traditionally closed while the vessel was away from the dock and that it may have been left open during the recent port visit. The captain stated that on occasion, the chief engineer "crack[ed]" the hatch to facilitate better engine room ventilation.

At 0212, the chief engineer and captain decided to activate the engine room's emergency fuel oil shutoffs and ventilation shutdowns to limit the potential fuel and oxygen available to the fire. The chief engineer initiated both from controls located in the FCS; included were the fuel oil quick-closing shutoff valves and fuel oil pumps for the main engine and diesel electric generators (not including the EDG). The pressurized fuel oil supply to the main engine and generators stopped once they were secured, and the vessel lost propulsion and primary power and lighting.

Over the course of the next 6 minutes, the second engineer and the two ABs from emergency squad 1, who all had donned firefighter outfits and SCBAs, made two separate entries through the exterior upper deck engine room door to fight the fire. Supported by the emergency squads and overseen by the chief mate, the attack team used a 1.5-inch hose and nozzle to spray water down one deck onto the fire, which they observed to be concentrated beside the auxiliary boiler. According to the team, "red and orange" from the fire was the only thing they could see, and "everything else was black." The attack team advanced into the space about 6 feet, but they realized the fire was "too much." Under advisement from the chief mate and chief engineer, the captain decided to prepare for a CO_2 release into the space. As the crew re-mustered on the starboard (windward) side of the vessel, the chief mate ensured all engine room ventilation was secured and engine room doors and engine casing ventilation louvers were closed.

At 0223, following directions posted locally in the FCS, the chief engineer initiated the release of CO_2 into the engine room. On the bridge, the captain notified the US Coast Guard and the vessel's designated person ashore of the *President Eisenhower*'s situation. To alert other vessels in the area, the containership's navigation lights and automatic identification system transmission were changed to indicate that the vessel was not under command and did not have the ability to maneuver.[3]

[3] A vessel that is *not under command* is defined in the *International Regulations for Preventing Collisions at Sea* as "a vessel which through some exceptional circumstance is unable to manoeuvre [maneuver] as required by these Rules and is therefore unable to keep out of the way of another vessel."

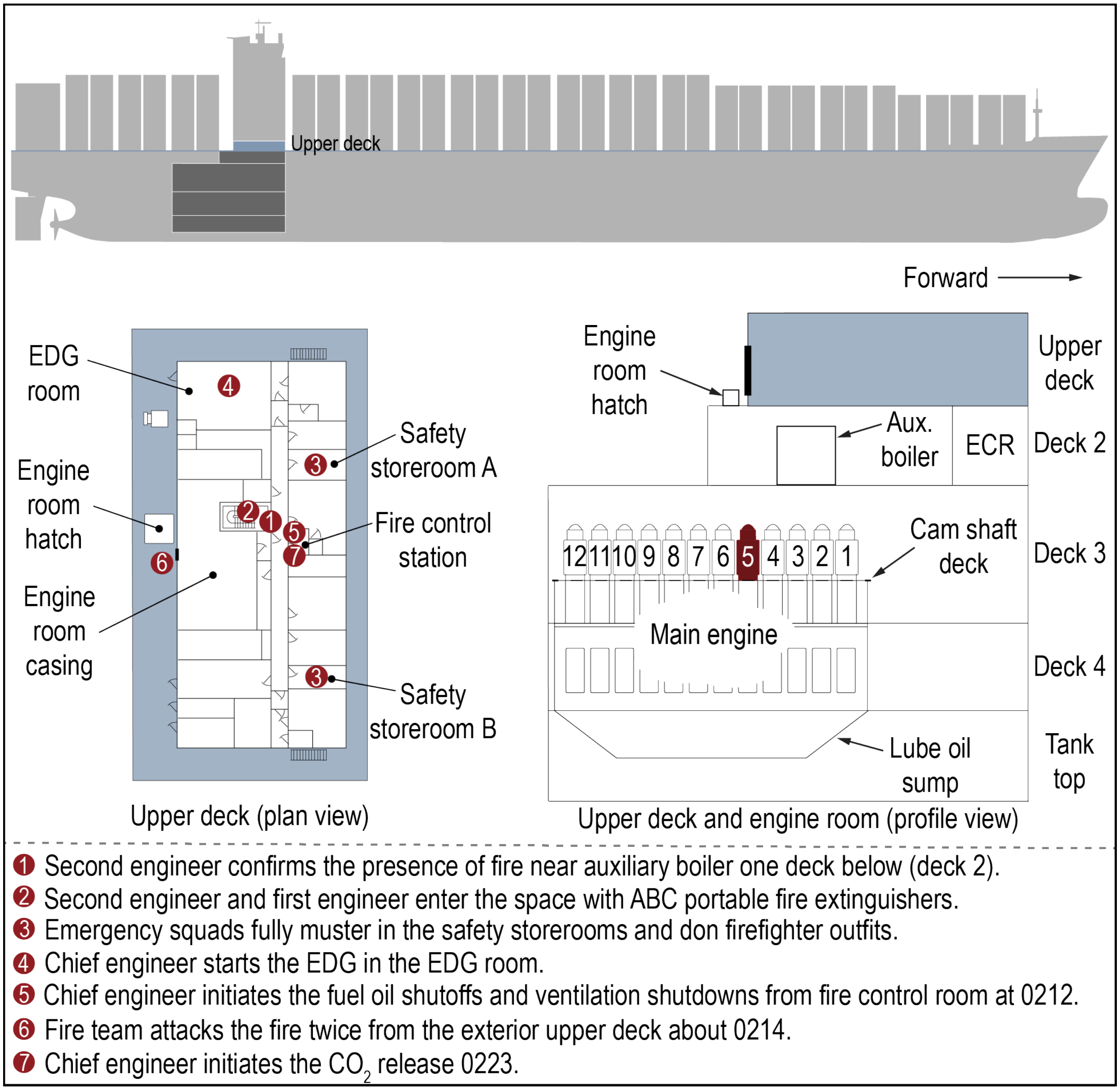

Figure 3. Profile view of the *President Eisenhower* (*top*). Plan view of the upper deck showing the sequence of events during the fire (*left*). Profile of the upper deck and engine room decks with the origin of fire highlighted (*right*).

The crew could not see on the CCTV monitors whether the fire had been extinguished following the CO_2 release, since many cameras near the fire were damaged. They knew that any attempted entry into the space could potentially admit oxygen into the space and cause a reflash, so they ensured that all doors, hatches, and other ventilation sources remained shut and off. Throughout the remainder of the morning, the crew allowed time for the CO_2 to saturate the area and continued boundary cooling on the external engine room bulkheads on the upper deck.

Without propulsion, the *President Eisenhower* drifted north toward the California coastline about 11 miles away. The captain maintained communications with both the Coast Guard, who by mid-morning had the 87-foot-long cutter *Blackfin* on location, and the vessel's company management ashore, who arranged tugboats to assist the vessel and notified their contracted marine salvor of the situation. Once notified, the salvor dispatched a specialized team of five professional marine firefighters to assist the crew.

At 1402, the 4,700-hp tugboat *Teresa Brusco* arrived alongside the *President Eisenhower*, which was about 3.5 miles from shore, and began pushing the containership back into the Santa Barbara Channel. About the same time, another vessel carrying the marine firefighting team arrived. At 1658, the firefighting team boarded the *President Eisenhower* and were briefed on the vessel status and events by the vessel's captain and officers.

The firefighting team saw "flickering" on CCTV footage from several engine room cameras that were still functioning and thought there may still have been a small fire. They stated that since a forward-looking infrared thermal imaging camera registered low temperature readings on the exterior engine room bulkheads, and it had been about 17 hours since the CO_2 was released into the engine room, they were confident that the primary fire had been suppressed.

The firefighting team and crew devised a plan for entry into the engine room to investigate the flickering. At 1908, the first engineer and a member of the marine firefighting team (wearing firefighter outfits and SCBAs) entered the ECR and then the engine room via the starboard passageway on the second deck and discovered that the "flickering" was an alarm light and not a fire. They continued to take temperature readings of the entire engine room; most of the readings were between 80–90°F. The highest temperature recorded was 156°F in the area around the main engine's no. 5 cylinder, and atmospheric readings indicated low levels of oxygen and high levels of volatile organic compounds (toxic byproducts of combustion).

At 1914, the *Shirley C,* a towing vessel that had arrived on scene, began towing the *President Eisenhower* the 100 miles back to the Port of Los Angeles, with several tugboats standing by. Under guidance and with assistance from the marine firefighting team, the crew slowly began naturally ventilating the space by opening vents and hatches to clear the volatile organic compounds.

By the morning of April 29, the engine room was deemed safe for entry. Later that morning, the crew managed to start two of the vessel's main diesel electrical generators and return primary power and lighting to the portions of the vessel that were undamaged by the fire. At 2000, the *President Eisenhower* arrived in the Port of Los Angeles, and by 2358, the ship was secured alongside pier 46.

1.3 Additional Information

1.3.1 Regulatory Guidance

The *President Eisenhower* was required to adhere to the regulations in the *International Convention for the Safety of Life at Sea* (SOLAS), which state that "surfaces with temperatures above 220°C [428°F], which may be impinged as a result of a fuel system failure shall be properly insulated."[4]

In June 2017, the Coast Guard issued Marine Safety Alert 06–17, "Fuel Spray Fire – Déjà Vu, Prepare and Prevent it from Happening to You!" The alert recommended that vessel owners and operators regularly examine all heat sources, particularly with respect to engine exhausts, and "ensure all insulation, blankets, and lagging are maintained and kept tight."

1.3.2 CCTV

After the casualty, investigators reviewed the vessel's recorded CCTV footage of the main engine and the auxiliary boiler. The footage showed that at 0124:00, 30 minutes before the fire started, ultra-low sulfur diesel oil (fuel being consumed by the main engine at the time of the fire) spray was observed around the no. 5 cylinder. The spray varied in intensity but remained visible up to its ignition at 0154:19, at which point the fire increased in intensity very quickly.

Within 1 minute, cardboard and wooden boxes containing spare parts that were being stored next to the auxiliary boiler, directly above the no. 5 cylinder, also caught on fire. Five minutes after the fire started, the main engine video was no longer visible due to thick smoke in the engine room. The auxiliary boiler video showed fire continuing to consume the boxes and adjacent combustible materials for about 15 minutes, until it too was obstructed by thick smoke.

[4] Chapter II-2, Regulation 4– *Probability of Ignition*

Figure 4. CCTV screen captures of the main engine showing fuel spray in the area around the no. 5 cylinder about 30 minutes (*clockwise*) before the fire, the moment the fire started, and the progression (time stamps are 4 hours ahead). (Background source: APL)

Video analytic technology exists that is designed to utilize standard CCTV video to detect fuel mist and spray in real time and alert the crew prior to any ignition and fire. This technology was not required aboard the *President Eisenhower*, and whether the vessel's existing CCTV system was compatible with this technology is unknown. DNV, the *President Eisenhower*'s classification society, has guidance for ships on methods to prevent fire in machinery spaces and highlights the importance of rapid oil leak detection systems. One system listed as an acceptable method for rapid oil leak detection is "automatic oil leak detection by video analytics."[5]

1.3.3 Postcasualty Investigation

Damage assessments and repair cost estimates were conducted by the company, the main engine manufacturer, and other general ship repair contractors. Most of the fire damage to the main engine was from the engine's cam shaft deck upwards and was concentrated between cylinder nos. 3 and 7, with nos. 4, 5, and 6 experiencing the most severe damage. The damage continued up and through the grating above the main engine, where the auxiliary boiler was located, and up through the engine room casing.

[5] DNV, "Rapid oil leak detection system," *Rules for classification: Ships (DNVGL-RU-SHIP)*, July 2019, amended February 2020.

Heat from the fire deformed the steel rail for the engine room crane located above the main engine. Electrical wiring, sensors, and insulation located in the area were also heavily damaged.

After the fire, investigators discovered that on the morning of April 27, before the vessel's departure, a new section of 17.3-millimeter-diameter steel fuel oil return tubing for the main engine was installed by the second engineer on the no. 5 cylinder (the section had developed a pinhole leak about 2 months before and had been patched until new tubing could be procured). The section of tubing had been fitted in the shipyard during the new build process and was not available from the engine manufacturer as an original equipment manufacturer (OEM) part. The new tubing was sourced locally and professionally bent by a shoreside fabrication shop to match the existing tubing. The new tubing was connected to the existing fuel oil return tubing using a compression fitting on each end.[6] Because the new section of tubing did not come with compression fittings attached, new fittings—specifically, a ferrule and compression nut for each end of the tubing—had to be used by the engine crew to complete the installation.

Typical for compression fittings, a ferrule needs to be permanently clamped, or "swaged," onto the new tubing to facilitate sealing. The second engineer completed this swaging process while he installed the new section of tubing at the engine. He stated that he had never had to replace a section where a new ferrule needed to be swaged onto the steel tubing. He also said that during the installation, the new section of tubing did not line up easily to its securing brackets and that he had to temporarily remove some brackets to facilitate better alignment. Methods to verify whether a ferrule had been properly swaged included loosening the compression fitting nut and visually inspecting the ferrule, and pressure testing the associated system (because the fuel pipe was not OEM, there was no manufacturer procedure for replacing the return line). Following the installation, the second engineer and first engineer used the main engine fuel pump to pressure-test the associated system to about 116 pounds per square inch (the normal operating pressure) for about an hour. Both engineers inspected the tubing and fittings for leaks during this period, and none were identified. No one other than the second engineer checked the tightness of the compression fittings or condition of the swaged ferrules.

[6] Typical compression fittings are made up of the three elements: a compression nut, a ferrule, and a compression fitting body. A section of tubing is inserted into the end of the fitting, and the nut is tightened, forcing the ferrule into the fitting body. As the ferrule moves axially into the fitting body, the body's angled shape radially compresses the end of the ferrule onto the outer diameter of the tubing. The radial compression creates a leak tight seal between the fitting, ferrule, and tubing.

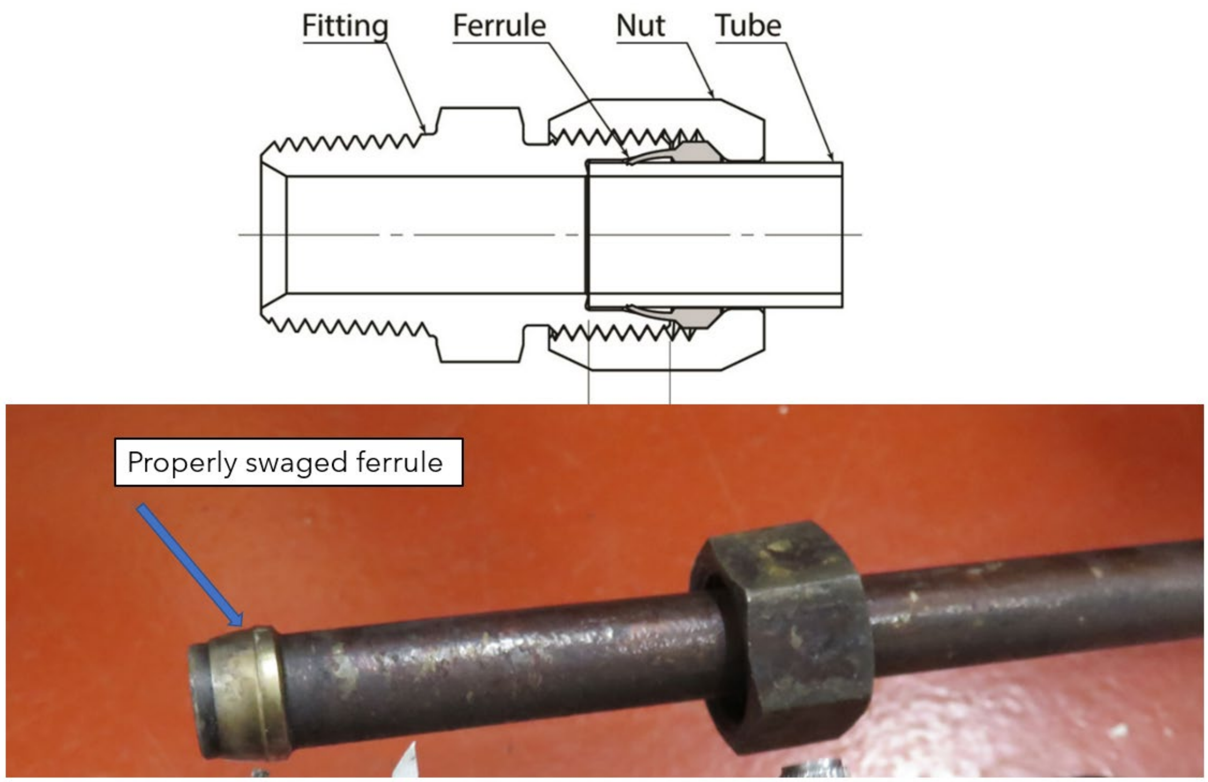

Figure 5. Cross-sectional diagram of typical compression fitting and body (*top*). Properly swaged ferrule on the *President Eisenhower*'s old section of fuel oil return tubing (*bottom*). (Top source: Worldwide Fittings)

A postcasualty examination of the vessel showed the newly installed fuel oil return tubing for the no. 5 cylinder had completely disconnected from the body of the compression fitting closest to the cylinder cover. The compression nut for the fitting was able to be loosened by hand, and the ferrule was not swaged onto the tubing. In addition, an engine exhaust compensator flange for the no. 5 cylinder, which was about 48 inches away from the separated tubing, was not insulated or shielded by sheet metal. Main engine data indicated that at similar engine loads as when the fire started, exhaust gas temperatures reached about 600°F.

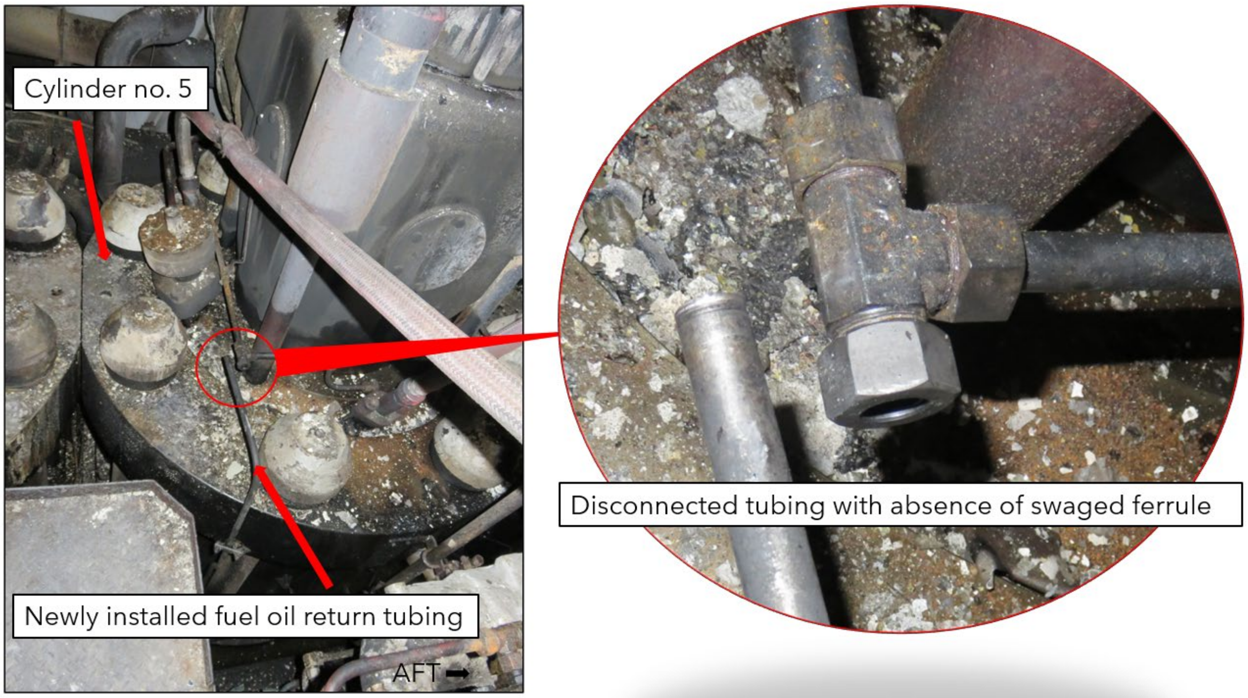

Figure 6. Cylinder no. 5 and the disconnected, newly installed fuel oil return tubing.

After the fire, the engine manufacturer determined that the fire had started when fuel oil from the disconnected return tubing on the no. 5 cylinder sprayed fuel oil onto the exposed surface of a flange for the exhaust valve compensator (expanding/flexible bellows-type exhaust piece between the cylinder and engine exhaust manifold). The service report completed by the manufacturer also indicated that the "insulation for the exhaust compensator flanges for all cylinder units was found insufficient and sheet metal not covering the flanges." The report concluded that "all surfaces with a temperature above 220°C [have] to be properly insulated" and the reason for the disconnected fuel return tubing on cylinder no. 5 was "likely due to incorrect assembly in way of insufficient tightening" of the compression fitting, or the "ferrule was not mounted correctly, i.e., the pipe was not fully inserted through the steel ferrule at tightening."

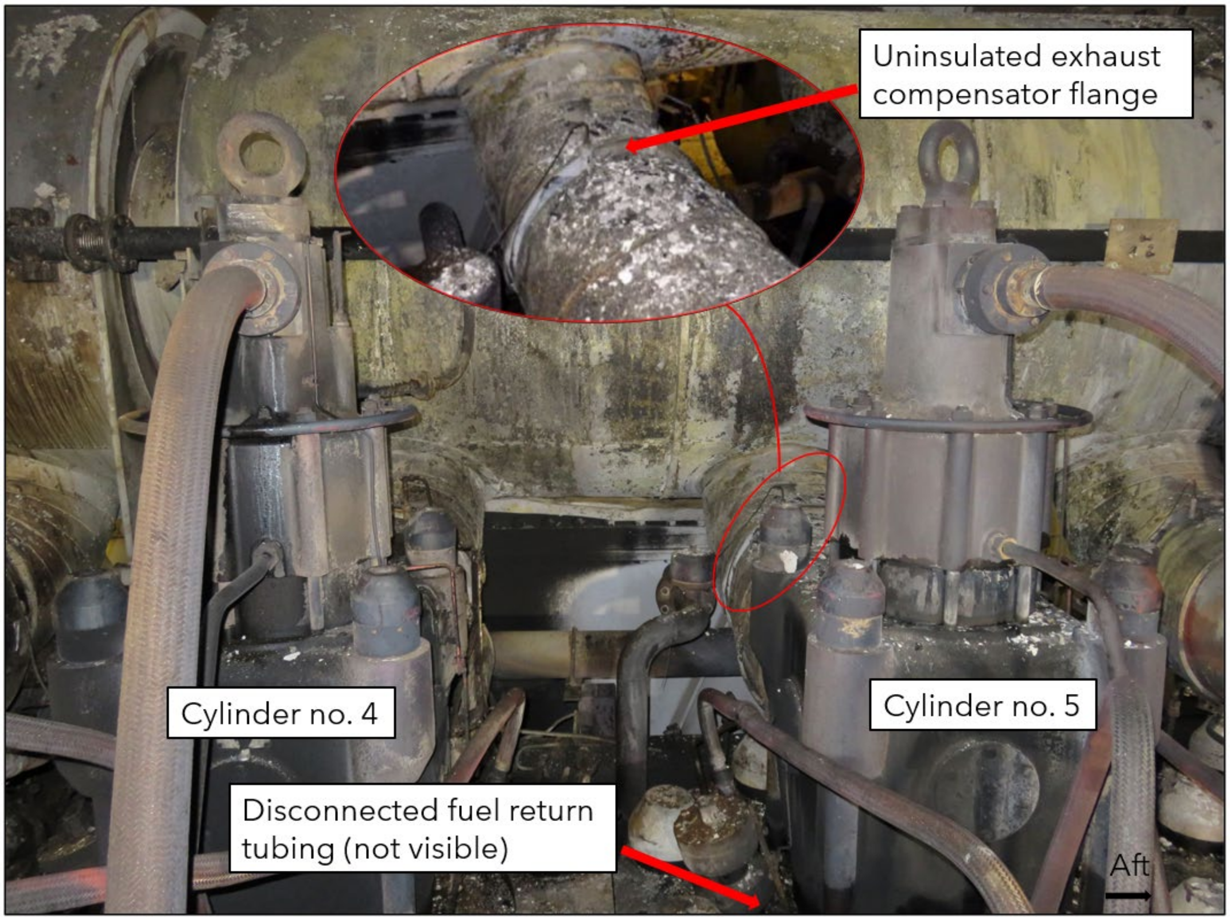

Figure 7. Main engine cylinder no. 5 uninsulated exhaust compensator flange in relation to the disconnected fuel return tubing.

1.3.4 Crew Training

As part of their merchant mariner credentialing, the *President Eisenhower*'s crew had received specialized marine firefighting training prior to sailing aboard the vessel. This training required knowledge, understanding, and proficiency in a variety of simulated shipboard fire situations, and competence in the response, fighting, and extinguishing of fires. While on board the vessel, as per Coast Guard regulations and company policy, the crew participated in weekly emergency training, often including fire scenarios. Following the fire, the team leader for the salvor's marine firefighting team, who had 48 years of experience in the field, stated that he thought that the vessel's crewmembers were "very well trained," and that that their decision, preparation, and activation of the ship's fixed CO_2 system to extinguish the fire "was just textbook perfect."

1.3.5 Related Casualties

On December 8, 2015, an engine room fire broke out on board the containership *Gunde Maersk* near Seattle, Washington.[7] The NTSB determined that the probable cause of the fire was "an improperly installed fitting on a fuel line supplying a fuel injector pump for auxiliary engine no. 1."

On January 16, 2017, the vehicle carrier *Alliance St. Louis* was under way in the Gulf of Mexico when a pipe plug on the fuel pump for the main engine's no. 6 cylinder came loose, resulting in fuel spray onto the engine's hot exhaust gas pipe manifold, and the atomized fuel quickly ignited.[8] The NTSB determined that the probable cause of the fire was "improper tightening of a pipe plug on the top cover of the no. 6 cylinder fuel pump housing."

2. Analysis

CCTV footage showed that about 0124, while the containership *President Eisenhower* was under way at night, ultra-low sulfur diesel fuel began spraying in the area around the main engine's no. 5 cylinder, about 30 minutes before the fire started. The engine room was unattended at the time, and the leaking fuel went unnoticed. Although not installed aboard the *President Eisenhower*, CCTV video analytic technology exists that can be integrated into an existing system. This technology was approved by the vessel's classification society as an acceptable method to identify fuel mist in real time and alert the crew of the dangerous situation. Had this technology been in use aboard the *President Eisenhower*, because of the length of time fuel was spraying before ignition (30 minutes), there is a chance the fire could have been avoided.

A postcasualty examination of the vessel showed that a compression fitting on the end of a newly installed section of fuel return tubing had disconnected, causing the fuel oil to spray (the return system pressure was 116 pounds per square inch). For 30 minutes, the fuel continued to spray, and eventually, it ignited off a hot surface and started a fire. Ultra-low sulfur diesel fuel is a highly combustible liquid with a standard flashpoint of 140°F and an average autoignition temperature of 428°F.[9] To prevent combustible liquids, such as diesel fuel, from contacting surfaces that exceed

[7] *Fire Aboard Containership* Gunde Maersk, Marine Accident Brief NTSB/MAB-16/24. Washington, DC: NTSB.

[8] *Fire aboard Vehicle Carrier* Alliance St. Louis, Marine Accident Brief NTSB/MAB-18/08. Washington, DC: NTSB.

[9] The standard flashpoint of a combustible liquid is determined experimentally under laboratory conditions. The actual flashpoint can be reduced as much as 100°F when the combustible liquid is splashed or aerosolized.

temperatures of 428°F, SOLAS regulations require that such components be properly insulated, and the Coast Guard issued a Marine Safety Alert in 2017 to mariners recommending that they regularly check heat sources to verify compliance. However, after the fire, investigators found that an exhaust valve compensator flange on the no. 5 cylinder—which was subject to internal engine exhaust temperatures greater than 428°F (often as high as 600°F)—near the disconnected fuel return tubing end was exposed and not insulated. Therefore, it is likely that the unshielded and uninsulated exhaust valve compensator flange acted as an ignition source for the spraying diesel fuel.

The postcasualty examination of the disconnected fuel oil return tubing and failed compression fitting revealed that the compression fitting's sealing ferrule was not sufficiently swaged to the steel tubing. A representative from the engine manufacturer determined that this was likely due to incorrect tightening of the compression fitting, or the ferrule was mounted incorrectly—in essence, the pipe was not fully inserted through the ferrule at tightening. The second engineer, who had never completed an installation in which a new compression fitting ferrule needed to be installed onto steel tubing, acknowledged having difficulties while completing the installation. After the installation, he pressure-tested the system for about an hour, during which no leaks were identified. He could have also loosened the compression fitting nut and visually inspected the ferrule to verify it had been successfully swaged to the tubing after tightening the compression nut. Had he done so, he likely would have identified that the ferrule had been improperly swaged.

The crew's response to the fire was timely and effective, and their activation of the ship's fixed CO_2 system to extinguish the fire was such that a specialized marine firefighter concluded it "was just textbook perfect." The vessel's fire-detection and alarm system activated and notified the crew moments after the start of the fire. Within 10 minutes, the crewmembers were fully mustered, and the fire teams had run out fire hoses and started boundary cooling. The crew had the foresight to quickly close the upper deck engine room hatch, and they coordinated and activated fuel oil shutoffs and ventilation shutdowns to subdue the fire by limiting oxygen and fuel to the space. The captain clearly communicated with the Coast Guard and vessel management ashore so a coordinated emergency response could be quickly arranged. The fire teams made two controlled entries into the engine room and identified the fire as being too large to be fought using fire hoses. Further, they released the fixed CO_2 system in a controlled manner, continuously monitoring the space, ensuring that all ventilation sources to the engine room remained secured, conducting boundary cooling, and allowing the CO_2 to function as designed.

3. Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the engine room fire aboard the containership *President Eisenhower* was a crewmember insufficiently swaging a compression fitting ferrule during the installation of fuel oil return tubing for a main engine's cylinder, allowing an end of the tubing to disconnect and spray fuel oil onto a nearby unshielded and uninsulated cylinder exhaust component.

3.2 Lessons Learned

Rapid Oil Leak Detection

Rapid oil leak-detection systems are a valuable tool that can be used to prevent fire in machinery spaces. Video analytic technology is designed to use standard CCTV video to detect fuel mist and spray in real time and alert the crew before any ignition and fire. This technology is supported by class societies as an acceptable method for identifying leaks and can be integrated with existing CCTV systems. Had this technology been in use aboard the *President Eisenhower*, the spraying fuel oil may have been detected well before the fire developed.

Containing Engine Room Fires

The crew of the *President Eisenhower* effectively contained the spread of a main engine room fire by removing fuel and oxygen sources, cooling boundaries, and communicating effectively. These efforts show the importance of realistic scenario-based training, including engine room emergencies, which involve shutting down machinery, fuel oil, lube oil, and ventilation systems, as well as boundary monitoring, to quickly contain and suppress engine room fires, which can spread to other spaces and/or cause a loss of propulsion and electrical power.

Vessel	***President Eisenhower***
Type	Cargo, general (Containership)
Flag	United States
Port of registry	Wilmington, Delaware
Year built	2005
Official number (US)	1284569
IMO number	9295220
Classification society	DNV
Length (overall)	983.9 ft (299.9 m)
Beam	140.2 ft (42.8 m)
Draft (casualty)	41.5 ft (12.65 m)
Tonnage	82,794 GT ITC
Engine power; manufacturer	93,120 hp (69,440 kW); MAN B&W/ Hyundai Heavy Industries, 12K 98 MC-C, slow-speed diesel engine

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Los Angeles/Long Beach** throughout this investigation.

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