# National Transportation Safety Board
**Washington, D.C. 20594**

## Marine Accident Brief

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| **Accident No.:** | DCA-06-MF-016 |
| **Vessel:** | M/V *Massachusetts*, 87.6 feet long, 99 gross tons, aluminum construction, built in 1988 |
| **Accident Type:** | Engineroom fire |
| **Location:** | Boston Harbor, Massachusetts |
| **Date:** | June 12, 2006 |
| **Time:** | 1615 eastern daylight time[1] |
| **Owner/Operator:** | Massachusetts Bay Lines |
| **Damages:** | $800,000 |
| **Complement:** | 4 crew, 65 passengers |
| **Injuries:** | 2 minor (passengers) |

## Synopsis

On Monday afternoon, June 12, 2006, the commuter ferry *Massachusetts* (figure 1) was en route from Rowe's Wharf in Boston Harbor to Hingham, Massachusetts, carrying 65 passengers and 4 crewmembers, when a fire broke out in the engineroom. The *Massachusetts*, owned and operated by Massachusetts Bay Lines, was inspected and certificated by the U.S. Coast Guard under the small passenger vessel regulations at 46 *Code of Federal Regulations* (CFR) Parts 114-122 (subchapter K).[2] The vessel's certificate of inspection (COI), valid for 5 years, was issued on November 14, 2002.[3] The COI allowed a total of 350 persons on board, including 346 passengers (adults and children) and 4 crewmembers (a master and 3 deckhands). At the time of the fire, the *Massachusetts* was operating pursuant to a subcontract with Boston Harbor Cruises, which had a 5-year contract with the Massachusetts Bay Transit Authority to provide

[1] Times in this brief are given in eastern daylight time according to the 24-hour clock.

[2] Small passenger vessels are defined by Title 46 *United States Code* section 2101 as vessels of less than 100 gross tons that carry more than 6 passengers, including at least 1 passenger for hire. "Passenger for hire" is defined as "a passenger for whom consideration is contributed as a condition of carriage on the vessel, whether directly or indirectly flowing to the owner, charterer, operator, agent, or any other person having an interest in the vessel." Title 46 CFR subchapter K governs small passenger vessels that are certified to carry more than 150 passengers or have accommodations for more than 49 overnight passengers.

[3] Sector Boston was the local Coast Guard office in charge of inspecting the *Massachusetts*. The vessel's last drydock (hull) examination was on October 20, 2005.

ferry service between Rowe's Wharf and Hingham Shipyard. The contract specified that vessels had to comply with Coast Guard requirements.

The *Massachusetts* crew was alerted to the fire about 1615, when the ferry was near the Long Island Bridge (figure 2), by black smoke at the stern and an engine high-water-temperature alarm. The vessel did not have, and was not required to have, an engineroom fire detection system. The master maneuvered the vessel into shallow water southeast of the bridge, anchored, and waited for firefighters. Before a fireboat from the Boston Fire Department's marine unit arrived, all the passengers safely transferred to the *Laura*, another commuter vessel in the vicinity. The fireboat extinguished the fire. The accident did not result in any serious injuries or fatalities.[4] Damage, estimated at $800,000, was confined mostly to the engineroom.

**Figure 1.** Commuter ferry *Massachusetts* at Rowe's Wharf, Boston. (Photo courtesy Massachusetts Bay Lines)

[4] One passenger suffered an asthma attack brought on by smoke inhalation and was treated at the scene. Another passenger was treated and released at a local hospital for minor smoke inhalation and a spike in a preexisting blood pressure condition.


**Figure 2.** Commuter route of *Massachusetts* between Rowe's Wharf and Hingham Shipyard. Accident site is at anchor symbol southeast of Long Island Bridge.

## Accident Narrative

**Engine Repair.** At 1230 on June 12, after completing three morning commuter runs and two sightseeing tours of Boston Harbor, the *Massachusetts* left Rowe's Wharf and traveled 15 minutes away to a dock at Charlestown, Massachusetts. The master had arranged that morning to meet the company's marine repair contractor at the Charlestown dock because the *Massachusetts* was experiencing a number of mechanical problems. The repair shop had three employees (diesel mechanic, welder, and mechanic-in-training), in addition to the owner. The diesel mechanic had been employed at the shop for almost 12 years and normally worked on the Massachusetts Bay Line vessels. He said that his knowledge of diesel repair and maintenance had been acquired solely through on-the-job experience and estimated that 80 percent of the diesel engines he worked on were manufactured by Detroit Diesel. The *Massachusetts* was powered by four 675-horsepower, 12-cylinder turbocharged model 12V-71 Detroit Diesel engines and had two generators (see "Vessel Information" section for details).

The diesel mechanic met the *Massachusetts* at the dock. The *Massachusetts* master and the mechanic discussed the work to be performed—(1) examining the starboard outboard engine for excessive blowby (venting) of combustion gases through the valve cover breathers;[5] (2) examining the port generator for sparking, which a crewmember had reported over the weekend; and (3) examining the port inboard engine, which had been idling at a higher speed than normal.

For the first item, the mechanic diagnosed a leaking head gasket on the starboard outboard engine, which he and the master decided to defer repairing until later in the week.[6] The owner of the repair shop arrived while the mechanic was working on the second item, examining the port generator. Although the mechanic found no sparking on the generator, the master decided to use only the vessel's starboard generator until a marine electrician could examine the port generator.

For the third item, the port inboard engine, the shop's owner advised the mechanic to look for a faulty injector, which the mechanic said he agreed might be the cause of the high idle speed. The owner left the vessel before the mechanic started work on the port inboard engine. The mechanic said that he removed the inboard valve cover to check the six fuel injectors on that side of the engine (figure 3). His inspection revealed that the injector on the No. 3 cylinder was faulty. The mechanic proceeded to replace the injector. First, he removed the fuel supply and return lines ("jumper lines") connected to the injector.[7] Then he unbolted the fasteners holding the injector to the engine, removed the faulty injector, and bolted another in its place.

The mechanic stated that in replacing an injector on a Detroit Diesel engine of that type, no calibrations or settings were necessary once the new injector was in place. He had access to the manufacturer's service manuals but said, "Generally, I don't need them," noting that he had memorized the torque specifications. He told investigators that he used a torque wrench to torque the rocker stand bolts to 104 foot-pounds[8] and the injector hold-down clamp to 25 foot-pounds. He said that he did not use a torque wrench on the fuel lines because "If you overtighten them, you could split the side of the fuel line." The engine manufacturer's service manual warns, "When installing fuel jumper lines, *Do Not Overtighten*."[9]

The mechanic told investigators that after replacing the injector on the No. 3 cylinder, he ran the engine with the valve cover off to "inspect the fuel lines to make sure they're not leaking." The engine manufacturer's service manual warns that leaking fuel oil can dilute the lubricating oil and damage the engine:

[5] Each of the two valve covers on each engine was fitted with a breather to release vapors that might build up in the crankcase.

[6] Before leaving on the first commuter run the morning of the fire, the master had replaced the impeller in the cooling-water pump for the starboard outboard engine, which had been overheating.

[7] Each injector had two steel jumper lines: one leading from the fuel supply line into the inlet side of the injector, and the other leading from the outlet side of the injector to the fuel return line and then back to the fuel tank.

[8] One foot-pound is 1 pound of force acting through a distance of 1 foot in the direction of the force.

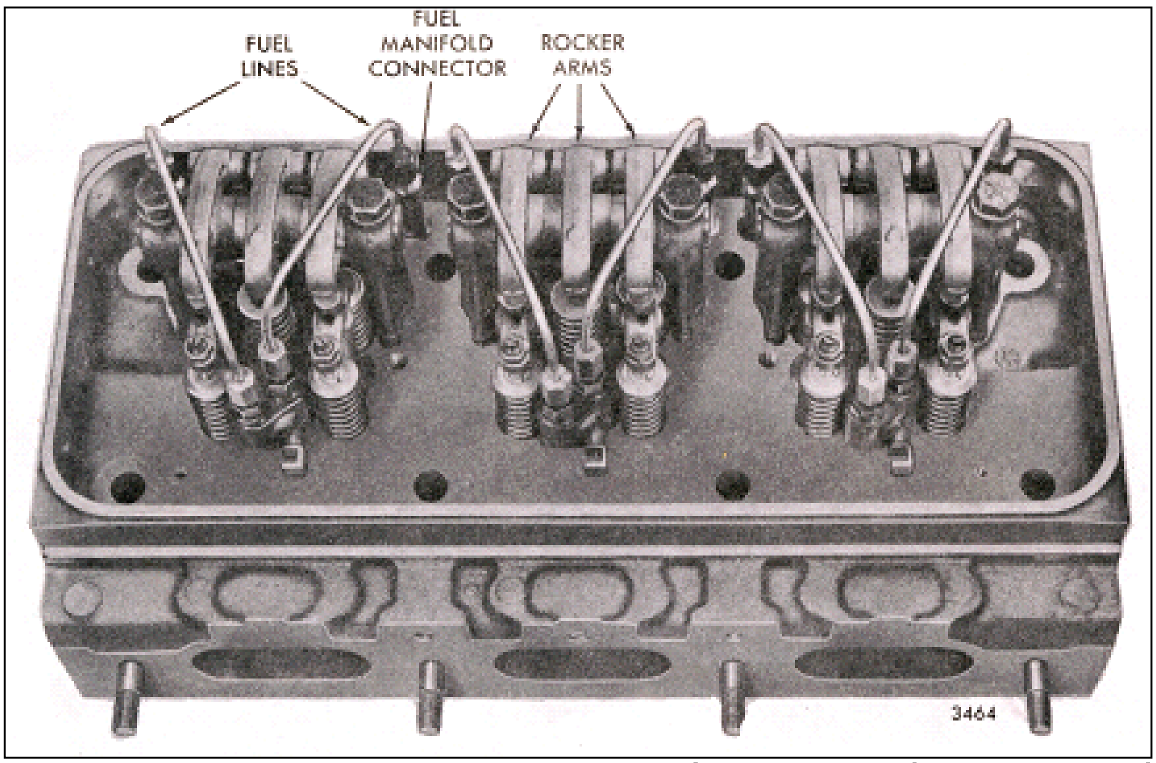
[9] Detroit Diesel Corporation, *V-71 Service Manual*, section 2.0, "Shop Notes" (Detroit, Michigan: 1989), p. 2-13.

> Maintenance and service personnel should be aware that severe engine damage could result from fuel oil leakage into the lubricating oil and should therefore follow proper procedures when removing, handling and installing fuel jumper lines . . . .

The manual also warns specifically of the fire danger posed by undetected leaks in the fuel jumper lines:

> Severe fuel leakage, if not detected, can also result in an over-filled crankcase (oil pan) which can cause an abnormal amount of fuel and lubricating oil vapor to escape from the engine and crankcase breathers. An abnormal concentration of fuel and lube oil vapors is flammable and could ignite in a closed engine compartment.

The procedure in the manufacturer's service manual for ensuring that fuel jumper lines are securely in place after replacing the lines is to run the engine with the valve cover off, which makes it possible to observe the jumper lines for any leaks. A Detroit Diesel marine service engineer stated that running the engine with a disconnected fuel jumper line would be like "'running a garden hose inside the engineroom." If the valve cover was off, the mechanic should have been able to see fuel leaking from the jumper line that investigators found disconnected after the fire (see "Wreckage" section).




Detroit Diesel Corporation, *Diesel V-71 Service Manual*

**Figure 3.** Typical fuel injector assembly in Detroit Diesel engine cylinder.

The master said that the idle on the port inboard engine was back to normal after the mechanic changed the injector. The mechanic completed his work between 1430 and 1500, according to the master, and left the vessel about 1530. The *Massachusetts* then departed Charlestown to begin its afternoon commuter schedule. The master said that he ran only the two outboard engines on the return trip to Rowe's Wharf, but that he always used all four engines on the commuter runs.

**Departure.** Back at Rowe's Wharf, the *Massachusetts* boarded 65 passengers for the 1600 trip to Hingham Shipyard. Before departing, the master, who had been employed by Massachusetts Bay Lines for over 20 years, delivered a passenger safety briefing over the vessel's public address system. The master informed passengers about the location and type of lifesaving equipment on board and told them to follow crewmembers' instructions in case of emergency.[10] According to data from Logan International Airport, about 5 miles away, skies were clear, with unrestricted visibility at 10 miles and a broken cloud cover, the air temperature was 71° F, and winds were from the southeast at 12 knots.

The *Massachusetts* departed the dock on schedule (1600), running on all four engines, with the mate at the helm. Soon after leaving Rowe's Wharf, the master went to the engineroom to bleed air from the air conditioning system. He said that he did not detect anything out of the ordinary. He then returned to the pilothouse.

**Fire.** About 1615, the upper deck deckhand entered the pilothouse to report black smoke at the vessel's stern. At the same time, the high-water-temperature alarm for the port inboard engine sounded. The mate stopped the port inboard engine and slowed the remaining three engines from 2000 to 1300 rpm, as directed by the master. The master went to the engineroom to investigate.

The master said that when he opened the door to the starboard ladderway leading to the engineroom, he encountered heavy smoke and immediately closed the door. He went to the phone at the main deck bar and called the pilothouse, informing the mate of the situation and instructing him to shut down two of the remaining engines. The mate shut down the port outboard engine, which had already lost some power, and the starboard outboard engine, leaving only the starboard inboard engine running.

On his way back to the pilothouse, the master directed the main deck passengers and the main deck deckhand to go to the upper deck and told the deckhands to give the

[10] Federal regulations at 46 CFR 122.506 require, in part, that before getting under way on a voyage or as soon as practicable thereafter, the master will ensure that "suitable public announcements are made informing all passengers" where emergency exits and lifejackets are located and how lifejackets should be donned. The *Massachusetts* carried 366 adult lifejackets and 36 child lifejackets, stored in marked compartments underneath the bench seats throughout the interior accommodation spaces on both decks, as required by regulations (46 CFR 117.78).

Eight 22-person lifefloats were stowed on the roof of the upper deck cabin, four on each side. According to 46 CFR 117.204, vessels certificated to operate on a coastwise route within 3 miles of land "may be provided with life floats of an aggregate capacity that will accommodate at least 50% of the total number of persons permitted on board." Lifefloats are buoyant apparatus that have a line attached around the outside. Survivors in the water can hold onto the line. The apparatus is not designed to keep survivors out of the water.

passengers lifejackets. One of the passengers happened to be a Coast Guard officer commuting home. The master told the Coast Guard officer about the fire and asked for his help in contacting the Coast Guard. The officer used his cell phone to alert the local Coast Guard office, Sector Boston, about the fire.

By that time, the vessel had passed south of the Long Island Bridge. The master relieved the mate at the helm and ordered him and one deckhand to the bow to prepare to drop anchor. The mate instructed the other deckhand to help.

**Passenger Evacuation.** Meanwhile, the master used very-high-frequency (VHF) channel 13[11] to contact the commuter ferry *Laura*, operated by Boston Harbor Cruises. The *Laura* was about 1/2 mile south, en route from Hingham to Rowe's Wharf with three passengers on board. The *Massachusetts* master told the *Laura* master that his vessel had an engineroom fire and asked the *Laura* to come alongside and receive his passengers "expeditiously." The *Laura* immediately altered course to assist the *Massachusetts*.

The Coast Guard officer entered the pilothouse and reminded the master to turn off the engineroom's ventilation supply blowers.[12] After turning off the blowers, the master navigated the *Massachusetts* just outside the channel to the east, about 1/2 mile south of the Long Island Bridge (figure 2), and ordered the mate to drop the anchor. After the vessel was anchored, the master sent the mate to the main deck to close the emergency fuel shutoff valves, located in the bar area. The deckhands returned to the upper deck to attend to the passengers, and the master turned off the inboard starboard engine. The generator shut down from fuel starvation about 30 seconds after the mate closed the emergency fuel shutoff valves.

About 1630, the *Laura* came alongside the *Massachusetts* and tied up on the starboard side. The *Massachusetts* crew then led the vessel's 65 passengers, wearing lifejackets, down the forward starboard ladder to the main deck and out through the starboard forward side door directly onto the *Laura*. Once on board the *Laura*, the Coast Guard officer again used his cell phone to call Sector Boston about the fire. The transfer of passengers was orderly, taking around 5 minutes, according to crew statements. The *Massachusetts* crew did not remember counting passengers as they left the vessel, but a count was taken and logged on board the *Laura*. At 1635, the *Laura* untied from the *Massachusetts* and moved to a safe distance. After the state police boarded and checked for casualties, the *Laura* departed for Hingham Shipyard.[13]

**Crew Decision on Firefighting.** Once the passengers had transferred to the *Laura*, the master and crew discussed fighting the fire themselves. The *Massachusetts* carried approved firefighting equipment, including seven fire extinguishers[14] and two fire

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[11] Marine radio channel for communication between the navigation bridges of vessels.

[12] The two blowers that supplied air to the engineroom could be turned off from the bridge, but because the supply and exhaust ducts had no ventilation dampers, airflow through the ducts to the fire could not be restricted.

[13] When the passengers reached Hingham, members of the Hingham Fire Department checked them again for injuries.

[14] One B-I portable fire extinguisher was kept in the pilothouse, and six B-II portable fire extinguishers were placed throughout the ship, including two mounted in the engineroom. Class B extinguishers are

pumps, both located in the engineroom and run by the generators,[15] capable of providing a stream of water to any space on the ship by way of two fire stations (one behind the bar on the main deck and one at the top of the interior ladderway). The master stated, "I flatly decided we weren't going to open either engineroom door. We weren't going to do anything to give the fire any oxygen." Throughout the accident, the master's prudent decisions promoted the safety of his passengers and crew.

**Police Boat.** Meanwhile, the *Protector*, a police boat from Quincy, Massachusetts,[16] had been approaching the Long Island Bridge from the southwest when the crew observed the *Massachusetts* "dead in the water with smoke showing from its stern." About 1635, the *Protector* came alongside the *Massachusetts* on the port side, and the *Massachusetts* mate told the *Protector* crew that the engineroom was on fire. Police on board the *Protector* immediately notified the Coast Guard, using VHF channel 16,[17] and requested a fireboat. The *Protector* crew also notified Quincy police headquarters about the fire. At approximately 1645, at the Coast Guard's request, the crew transferred from the *Massachusetts* to the *Protector*, which remained on scene but at a distance from the burning vessel.

**Emergency Response.** According to emergency records provided by the Boston Fire Department, the dispatch operations center (known as "Fire Alarm") received nearly simultaneous calls reporting the *Massachusetts* fire from the Coast Guard (at 1641) and Quincy police (at 1642). At 1644, the center dispatched the fire department's marine unit to the Long Island Bridge from its station at Burroughs Wharf in Boston's North End, about 6 nautical miles from the accident site.

After receiving the call from the dispatch center, marine unit personnel boarded the vessel *Firefighter* and were under way in 2 or 3 minutes, according to the pilot.[18] At 1656, the dispatch center dispatched Engine Company 2 and Ladder Company 19 to the Paul W. Conley terminal, located at the southeast end of the reserved channel[19] in South Boston, to be picked up by the marine unit. At 1703, the dispatch center dispatched the District 6 fire chief to the Conley terminal, also to be picked up by the marine unit. Firefighters told investigators that it took 10 minutes to load personnel and gear at the terminal.

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intended for fires involving flammable liquid, grease, or gas. B-I extinguishers hold 2.5 pounds of dry chemical; B-II extinguishers, 10 pounds of dry chemical.

[15] The fire pumps could be started only by entering the engineroom. Fire pumps on small passenger vessels built after March 11, 1996, are required to "be capable of both remote operation from the operating station and local operations at the pump" (46 CFR 118.300[e] and 181.300[e]). These regulations did not apply to the *Massachusetts* because it was built in 1988.

[16] A small city about 7 miles southeast of downtown Boston.

[17] Channel 16 (156.8 megahertz), which the Coast Guard monitors continuously, is the international calling and distress frequency.

[18] The marine unit's other vessel, the *St. Florian*, was out of service because an electrical problem had drained its batteries. According to the marine unit's standard operating procedures, the smaller, faster *St. Florian* would normally have been launched first, with the *Firefighter* following later and land companies deploying if necessary.

[19] A dredged, unmarked channel lined with freight terminals.

The *Firefighter* (maximum speed 9 to 10 knots) arrived at the accident scene at 1730 and approached the burning *Massachusetts* on its port side. All passengers and crew had disembarked. The *Firefighter* crew noted heavy black smoke coming out the vents and doorways at the *Massachusetts*'s stern. Vessels were already on scene from the Quincy Police Department (the *Protector* and the *Guardian*), the Massachusetts Environmental Police Department, the Massachusetts State Police, and the Coast Guard (which had launched a 41-foot utility boat from Station Pt. Allerton, about 2 nautical miles east of the accident site[20]). A MassPort fireboat[21] also stood by. The District 6 fire chief assumed on-scene command.

The *Firefighter* was secured to the *Massachusetts* and five firefighters went on board. According to the fire chief, the firefighters placed a 2 1/2-inch-diameter fire hose down each of the two engineroom ventilation shafts on the aft main deck, with two men operating each hose. Because of the intensity of the fire (the fire chief said the main deck had "steam coming out of the carpet"), firefighters could not enter the engineroom. They poured water into the engineroom and pumped firefighting foam down the port engineroom ventilation shaft, but their actions did not extinguish the fire.

Firefighters sought help from the *Massachusetts* crew, now on the Quincy police boat *Protector,* in finding better engineroom access. The mate and two deckhands of the *Massachusetts* transferred from the *Protector* to the Quincy police boat *Guardian*, and the *Protector* delivered the master to the *Firefighter*. The master told the firefighters about "soft patches" (metal hatches) in the main deck, directly above the engines, that could be opened. Firefighters removed enough screws so they could pry open the hatch over the port inboard engine and fight the fire from above. Their efforts filled the engine compartment with water nearly to the main deck level, above the tops of the engines. Out of concern for the vessel's stability, the fighters began pumping water out of the engineroom. After they had lowered the water level by 5 to 6 feet, the firefighters entered the engineroom and checked for hot spots. At 1848, firefighters reported that the fire appeared to be out but set a reflash watch in case the fire should reignite. Firefighters left the scene at 2040.

**Aftermath.** The *Massachusetts* crew, which had transferred to the Coast Guard 41-foot utility boat, was transported to the Hingham Shipyard dock, arriving at 2130. The *Massachusetts* was taken under tow by a local harbor tug at 2240 and moved to a pier at Deer Island (figure 2).

## Vessel Information

The *Massachusetts*, a double-deck vessel constructed entirely of aluminum (figure 4**)**, was built for Massachusetts Bay Lines by Gulf Craft, Inc., of Patterson, Louisiana. The builder began construction in 1987 and delivered the *Massachusetts* in

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[20] The Coast Guard utility boat arrived at the accident scene at 1649, according to the Coast Guard station log.

[21] A fire and rescue boat launched from Logan International Airport.

1988. Massachusetts Bay Lines immediately put the vessel to use in the Boston Harbor commuter trade.

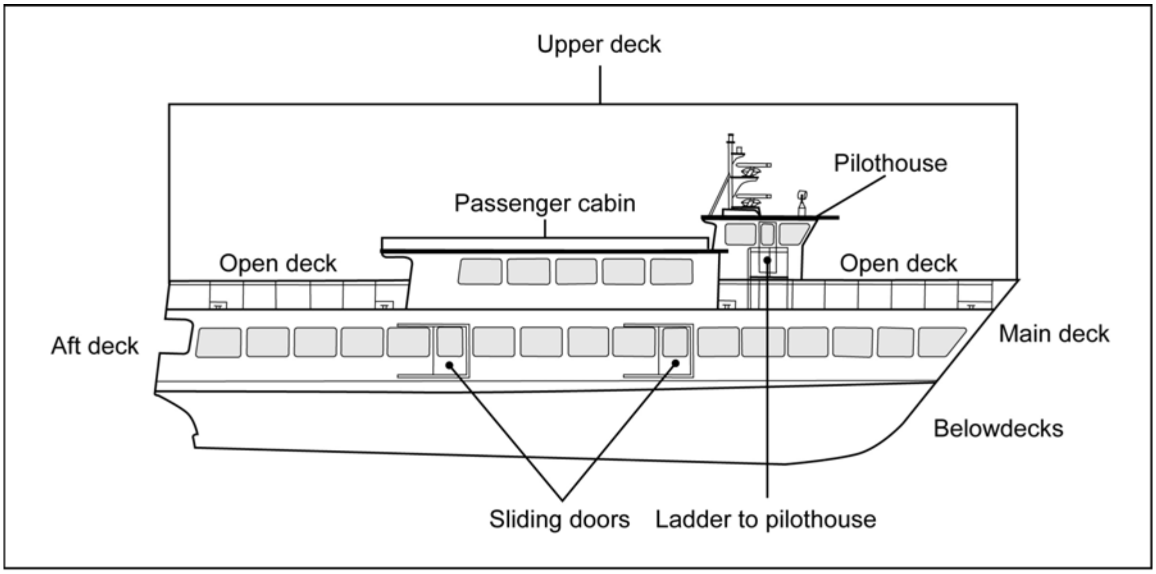


**Figure 4.** Profile view of the *Massachusetts*. Passengers were carried in the enclosed cabins on the main and upper decks.

The enclosed pilothouse at the bow of the vessel was accessed by a short ladder from the upper deck. The pilothouse was equipped with the following navigation and communication equipment: X-band and S-band Furuno® radars,[22] two Raytheon® VHF radios, an International® depth sounder, a Magellan® global positioning system unit, a horn, a searchlight, and a compass.

A control panel in the pilothouse registered alarms for high water temperatures in individual engines and for high water in the compartments equipped with bilge alarms. The pilothouse was also equipped with an engineroom air high-temperature alarm.[23] A public address system in the pilothouse was used to communicate with passengers and crew throughout the vessel and to deliver predeparture safety briefings and other announcements.

The upper deck contained both fixed and movable chairs for passenger seating. An enclosed passenger section in the middle contained a bar. The upper deck was connected to the main (lower) deck by an exterior ladderway (stairway) on the port side aft and by an interior ladderway on the starboard side forward.

The main deck was almost entirely enclosed to protect commuters from the weather. Seating consisted of chairs placed throughout and fixed seats in the forward

[22] Marine radars are available in X-band (shorter wavelength, greater resolution) and S-band (longer wavelength, longer range).

[23] According to the Massachusetts Bay Lines's general manager, the device was installed as original equipment and intended to warn the operator if the air temperature rose in the engineroom, possibly signifying an overheated engine. The device was not regularly tested or logged. The vessel master was not certain whether the alarm sounded during the fire.

area. A small bar/serving area was located amidships on the starboard side. Next to the bar were the emergency fuel shutoff levers for the propulsion engines and generators, as well as a fire station containing a fire hose. Restrooms were located at the aft end of the main deck. A small open deck aft of the restrooms allowed crewmembers to handle the lines during docking. Two sliding doors on each side of the main deck provided egress from the vessel. Passengers and crew could also exit through the door at the stern that led to the open deck.[24]

The belowdecks area was divided into six compartments separated by transverse watertight aluminum bulkheads extending upward from the bilges to the main deck (figure 5). The forwardmost compartment (forepeak) contained anchor rope and spare lines. The next compartment (forward compartment) contained a sewage holding tank and macerator pump.[25] Aft of the forward compartment was a space that was used to store supplies such as coffee and also contained a small workshop; it was accessible from the main deck by a ladderway forward of the bar area.

Immediately behind the work/storage space was a narrow compartment that held the fuel tanks and potable water tanks. Aft of that was the engineroom, accessed by ladderways forward of the restrooms on each side of the main deck. The engineroom could also be accessed from the main deck by unscrewing any of four large hatches, one over each engine (as shown in figure 5). The aftmost belowdecks compartment (lazarette) contained exhaust piping, a hydraulic cylinder for the steering system, and the vessel's hot water heater. Each of the belowdecks compartments contained a bilge suction well. The lazarette, engineroom, work/storage space, and forepeak were also equipped with high-water bilge alarms.

The engineroom contained four 675-horsepower Detroit Diesel engines direct-coupled to individual drive shafts through reduction gears. The two outboard engines were mounted approximately 2 feet higher than the two inboard engines. Each engine had two turbochargers, inboard and outboard, and 12 cylinders, each fitted with a fuel injector. No. 2 diesel fuel was drawn from the fuel tank into the fuel pump, where it was forced under pressure through a fuel filter and then through the fuel lines into the injectors. According to a Detroit Diesel marine engineer, the pressure on the fuel lines at the injectors ranged from 5 psi at engine idle to 55 psi at full engine throttle. Surplus fuel went from the injectors through return lines and back to the fuel tank.

[24] The *Massachusetts* met the requirements for emergency egress applicable at the time it was built (46 CFR 177.15-1, in effect until March 1990) and the requirements now in effect (46 CFR 115.500). The earlier requirements stated: "all vessels shall be provided with not less than two avenues of escape from all general areas accessible to the passengers or where the crew may be quartered or normally applied, so located that if one is not available the other may be. At least one of the avenues of escape shall be independent of watertight doors. Windows and windshields of sufficient size and proper accessibility may be used as one avenue of escape." Current regulations are that "each space accessible to passengers or used by the crew on a regular basis must have at least two means of escape, one of which must not be a watertight door" (46 CFR 116.500[a]). Only one means of escape is required in certain circumstances, such as from deck areas of less than 322 square feet (46 CFR 116.500[p]). For further information on the history of small passenger vessel regulations, see the "Fire Protection Regulations" section of this brief.

[25] A macerator pump breaks up waste solids and empties the sewage holding tank.

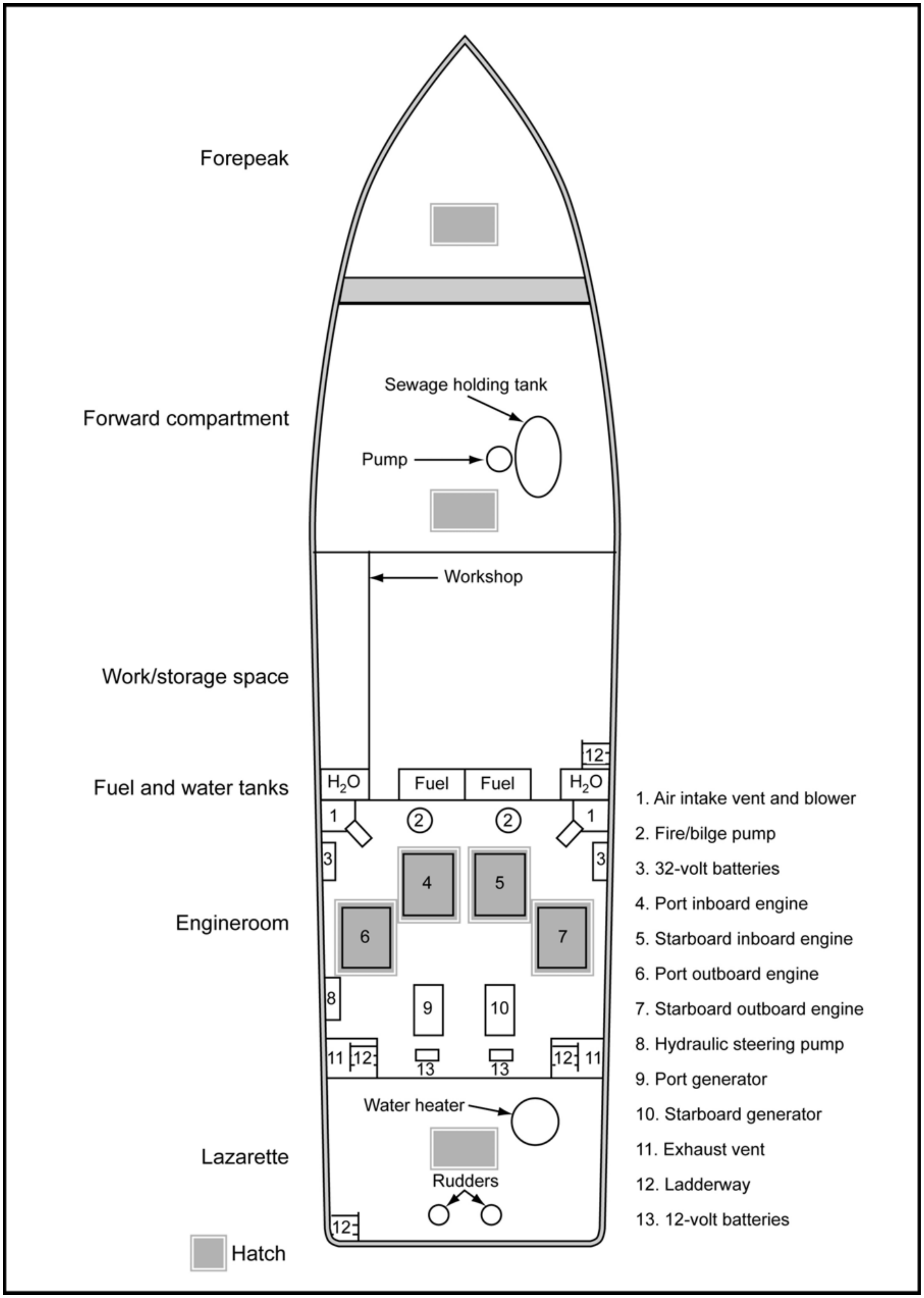


**Figure 5.** Belowdecks plan of the *Massachusetts* showing compartments and equipment. Shaded areas indicate hatches (covered openings) in the main deck that provided belowdecks access.

The engines were cooled by water whose temperature was automatically controlled by a thermostat. According to the engine manufacturer's service manual, the thermostat sounded an alarm if the water temperature exceeded 215° F. Areas that were not water-cooled, such as the outside of the exhaust manifold, reached a maximum temperature of 600° F under ordinary operating conditions, according to a Detroit Diesel marine service engineer.

Engine lubricating oil was drawn by suction from the oil pan and into the oil pump, where it was pressurized. The pressurized oil flowed to the cylinder block, providing lubrication for the bearings, pistons, gears, and other moving parts. In addition to the standard oil filters mounted on the engine block, each engine had an external oil filter, mounted on the engineroom bulkhead and connected to the engine by oil lines running along the engineroom deck.

Electrical power was produced by two three-cylinder Detroit Diesel generators, each producing 30 kilowatts of power. The generators were generally used one at a time and were alternated daily. On the day of the fire, the starboard generator was online. The port generator was idle, awaiting service.

The vessel had an electrohydraulic steering system. Rudder commands from the pilothouse steering wheel went to the pump control in the engineroom, which would change the hydraulic cylinder position in the lazarette. The hydraulic cylinder was linked to two rudders that would move simultaneously. Other equipment in the engineroom included two 12-volt battery banks (aft) and two 32-volt battery banks (forward) for supplying direct-current power to vessel equipment. The engineroom also contained two bilge pumps that could also operate as emergency fire pumps and other piping and pumps used in the vessel's engineering systems.

The engineroom ventilation system consisted of two air intake vents in the forward part of the engineroom, one port and one starboard, and two exhaust vents at the rear. The forward intake vents provided forced ventilation through aluminum ducts fitted with electric blowers. The rear vents, which shared the ladderway shafts, provided natural exhaust.

## Wreckage

Investigators examined the wreckage of the *Massachusetts* between June 13 and June 21, first at Deer Island in Boston Harbor and then at a berth in Chelsea, Massachusetts, where the vessel was taken after the fire. Investigators examined the exterior and interior spaces of the vessel, both abovedecks and belowdecks. The engines and generators were inspected for the integrity of their components and the overall degree of fire damage. Potential sources of combustible material, such as hydraulic fluid, fuel distribution lines, and lubricating oils, were also examined to determine whether they were involved in the fire.

### *Structural Damage*

The pilothouse and upper deck were not damaged by the fire. The exterior of the main deck exhibited soot stains at the ventilation grills on both sides of the vessel, more pronounced on the starboard side (figure 6). The carpet in the interior of the main deck was charred on the port side, next to the port engineroom air intake duct. Seven windows around the main deck were broken (firefighters had broken them to vent smoke while fighting the fire), and surfaces on the upper and main decks were dusted with soot.

**Figure 6.** Smoke damage to outside of *Massachusetts*'s main deck, starboard side.

In the engineroom, the pattern of damage indicated that a hot smoke layer had formed throughout the space and radiated heat to the components below it. Plastic light fixtures and the insulation on wiring cables close to the overhead (main deck) had melted, with similar damage on the tops of machinery and other items, such as the insulation lining the overhead and bulkheads. The aluminum ventilation duct to the fresh air intake on the engineroom's port side had melted,[26] and the blower had fallen to the deck below.

Thermal damage was most severe above and beside the port inboard engine. Above the engine, aluminum bars approximately 1/4 inch thick and 2 inches deep that spanned the length of the overhead were melted and sagging, and a vertical aluminum column extending from the floor to the overhead had softened, fractured, and bent out of alignment. Between the port and starboard inboard engines, a hole approximately 1 1/2 feet in diameter had melted through the aluminum decking, and the decking's support structure was melted and deformed (figure 7).

[26] Most aluminum alloys start to melt at about 1,000° F.

**Figure 7.** Melted and deformed floor supports and decking next to port inboard engine, looking down. (Large green hose on right and small green garden hose behind it were inserted to control water in bilges after accident; neither was part of vessel's normal equipment.)

### *Equipment Damage*

**Engines.** The most extensive fire damage was to the port inboard engine, which had especially severe thermal damage on the inboard side.[27] In that area, the valve cover was deformed, and the gasket protruded from underneath (figure 8). After removing the valve cover, investigators found a disconnected fuel jumper line to the injector on the No. 3 cylinder (figure 9).

[27] Refer to figure 5 for engineroom layout.

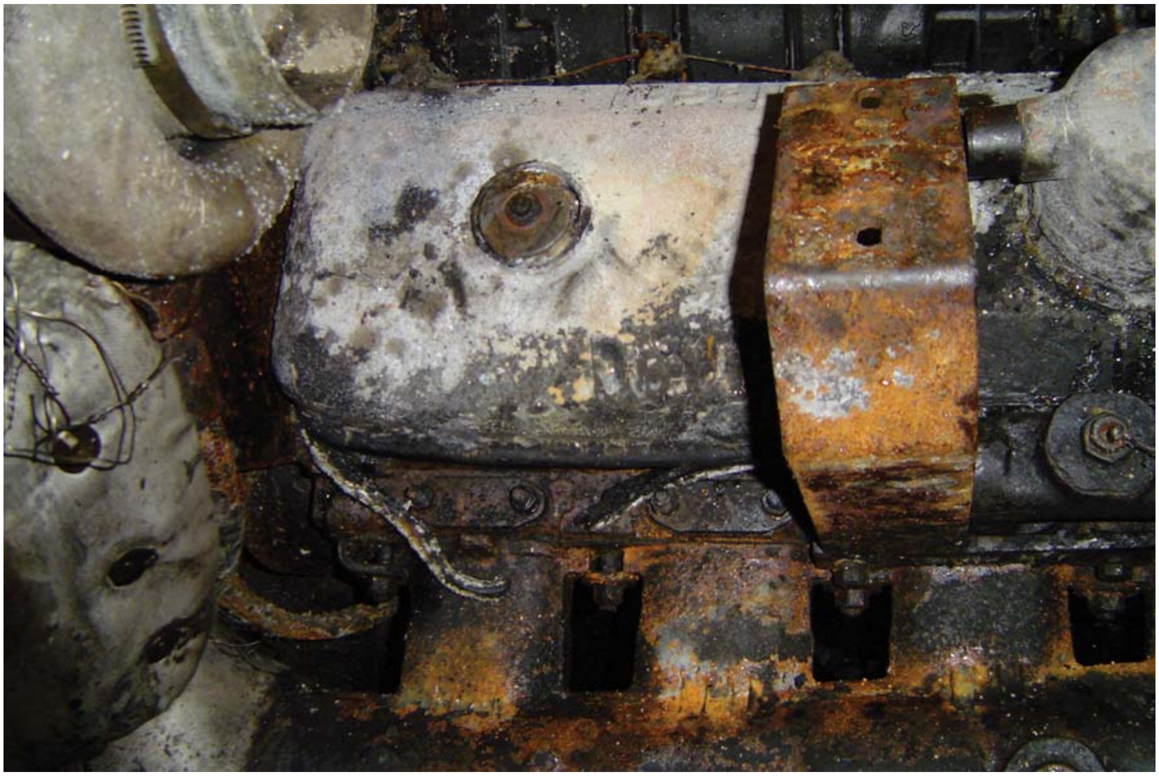

**Figure 8.** Inboard valve cover and protruding gasket, port inboard engine.

The wire-reinforced rubber fuel and lubricating lines on the port inboard engine were burned through or missing. Only the wire reinforcement remained on the fuel line at the top of the engine that ran to the return fuel cooler. The oil return line from the external oil treatment system was burned through and lying in the bilge, and an oil line was missing on the inboard side of the engine block. Plastic components of the fuel and oil filters were melted or missing, and the paint on the engine block had burned off, blackening the engine.

The turbocharger on the inboard side of the port inboard engine showed severe damage to aluminum elements such as the air intake manifold leading away from the turbocharger, which was heavily oxidized, deformed, and sagging. The compressor blades on the inside of the inboard turbocharger were blackened and heat-deformed.

Fire damage to the port outboard, starboard inboard, and starboard outboard engines was generally limited to burned-through water-coolant lines, which consisted of wire-reinforced rubber, and melted plastic wiring insulation. Firefighting efforts had filled the engine compartment with salt water and submerged all the engines, rendering them inoperable.

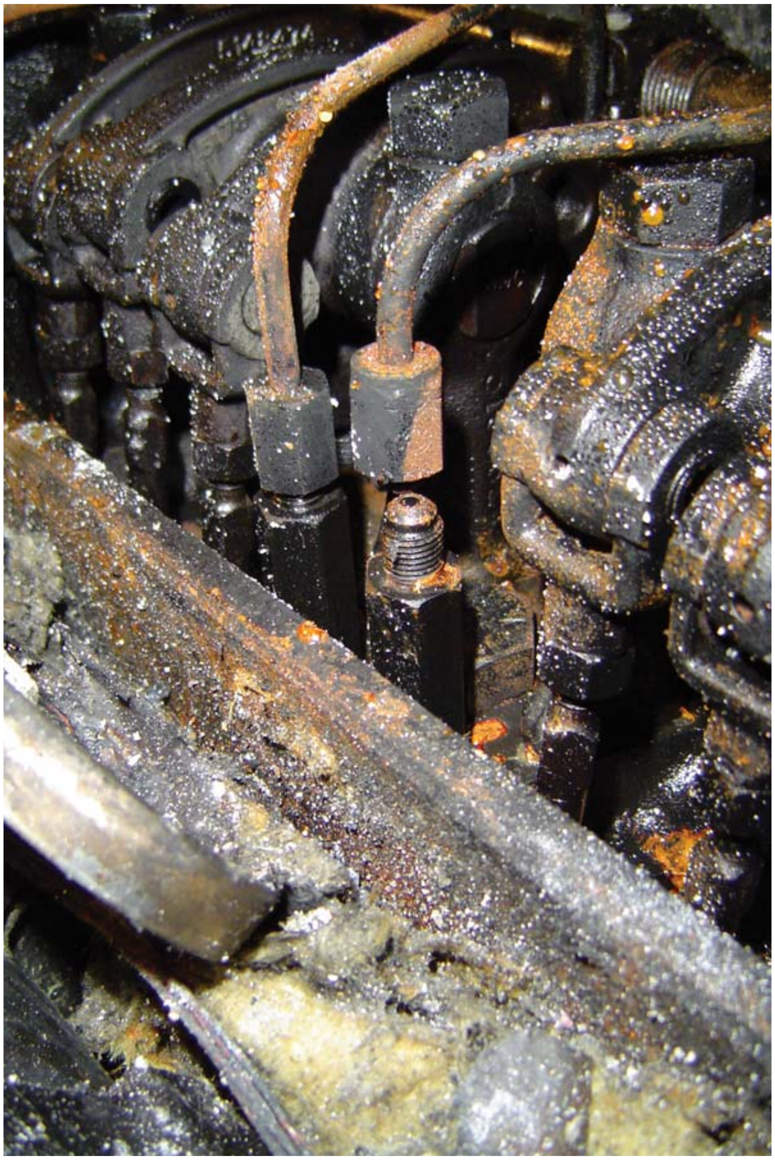

**Figure 9**. Disconnected fuel line on No. 3 cylinder of port inboard engine.

**Other Equipment.** The wire-reinforced rubber coolant lines at the top of both generators were burned through, but other generator components, such as steel fuel supply and return lines, oil lines, wiring, and paint, were undamaged by the fire. Only the batteries on the forward starboard side of the engineroom showed signs of thermal damage. The cables to and from the battery banks had lost insulation along their runs, but investigators found no evidence of arcing against conductive surfaces or between the conductors themselves.

The two hydraulic steering gear pumps and the four stainless-steel hydraulic lines that ran through the engineroom showed no signs of damage or leaks. The hydraulic reservoir, which was toward the rear of the engineroom, was undamaged and full of hydraulic fluid.

## Origin of Fire

When investigators examined the wreckage of the *Massachusetts*, they discovered, as described above, that one of the fuel jumper lines on the port inboard engine was disconnected. The disconnected jumper line had been attached to the fuel injector on the No. 3 cylinder on the engine's inboard side. The fuel jumper line and its mating surface were sent to the Safety Board's materials laboratory in Washington, D.C., for examination. The examination found no mechanical damage to the threads of the connector fittings or any other mechanical reason for the jumper line to have become disconnected. Fuel leakage from the disconnected fuel jumper line would have allowed fuel to flow to the engine crankcase, accumulate, escape through the crankcase vent, contact the hot surface of the exhaust manifold below, and ignite.

The exhaust manifold was not cooled and, under ordinary operating conditions, reached a temperature of about 600° F. However, the engine would have been running hotter than normal because the lubricating oil had been diluted by the fuel oil from the leaking jumper line.[28] The fuel would autoignite (ignite by heat without spark or flame) at a temperature of 637° F, according to the product's material safety data sheets. The fuel's ignition temperature (the temperature at which spark or flame will cause fuel to burn) was 494° F.[29] The exterior of the exhaust manifold leading from the overheated engine would have exceeded both temperatures.

## Personnel Information

The 55-year-old master of the *Massachusetts* on the day of the accident was the vessel's permanent master.[30] He had worked aboard the vessel during its construction in the shipyard, and he had delivered it to Boston Harbor on its completion in 1988. He held a Coast Guard license as "master of steam, motor or auxiliary sail vessels of not more than 100 gross tons upon near coastal waters" reissued in February 2005. In addition to his duties regarding daily operation of the *Massachusetts*, he was responsible for the material condition of the vessel, arranged for repairs, and ensured that the repairs were satisfactory. He operated the vessel 4 days a week—Monday, Tuesday, Thursday, and Friday. He said that he reported to work at 0600 and generally left work about 1845. On weekends, he usually went to bed around 2300 and got up about 0730. He characterized his work/rest periods as "pretty routine" and said that there had been no events to affect his schedule before the accident.

The mate, age 27, started work with Massachusetts Bay Lines as a deckhand in May 1997. He held a Coast Guard license as "master of steam or motor vessels of not

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[28] The Detroit Diesel service manual states (section 2.0, "Shop Notes," p. 11): "Always check the fuel system for leaks after injector or fuel pipe replacement and any time the fuel connections under the rocker cover are suspected of leaking. Failure to correct a serious fuel leak in this area can lead to dilution of the fuel oil and bearing and/or cylinder kit [components] damage."

[29] National Fire Protection Association, *Guide for Fire and Explosion Investigations,* NFPA 921 (Quincy, Massachusetts: 2004).

[30] Each of the seven vessels operated by Massachusetts Bay Lines had one permanently assigned master who was in charge of the vessel's operation, maintenance, and repair.

more than 100 gross tons upon near coastal waters" reissued in March 2006 but served as the mate on the *Massachusetts* when the permanent master operated the vessel. He normally worked 50 to 55 hours per week. He said that 3 days before the accident (Friday), he went to bed about 0030. The next day, he worked two cruises, one in the afternoon and one that began Saturday night and lasted until 0230 Sunday morning. He finished work about 0400 and went to bed about 0445. He said that he went to bed about 2200 or 2230 on Sunday and felt rested when he got up Monday morning at 0430, his usual time.

The lower deck deckhand, age 55, had been employed as a deckhand for approximately 8 months. All his marine experience had been on the *Massachusetts.* His duties involved line handling, serving coffee to passengers on the main deck, counting passengers as they boarded, and checking the engineroom at the midpoint of each commuter trip, near the Long Island Bridge. He said that before he started the job, the master had taken him on a "walkthrough" of the vessel's emergency equipment, engineroom, and procedures for shutting down the fuel supply in an emergency. After starting the job, he took part in man-overboard drills with the master and for the Coast Guard, and he had also watched safety training videos.

The upper deck deckhand, age 20, had been employed by Massachusetts Bay Lines for 3 weeks—her first maritime employment. She said that the master had given her a familiarization tour of the vessel and pointed out the storage areas for the lifejackets and other safety equipment but that she had not yet participated in any emergency drills at the time of the accident. Her responsibilities included line handling, assisting passengers, and serving drinks at the upper deck bar.

## Toxicological Testing

None of the crewmembers was tested for the presence of alcohol after the fire.[31] Sometime before 1700 on June 12, the general manager of Massachusetts Bay Lines attempted to reach the contractor who conducted toxicology testing for the company, but no one answered the contractor's afterhours telephone number. When the crew arrived in Hingham about 2130 on board a 41-foot Coast Guard utility boat, the company president met them and transported them to a local hospital for testing. The hospital emergency room was too busy to conduct the tests, and a hospital employee advised the crewmembers to return the next day.

About 0900 on the morning of June 13, the crewmembers were taken to the office of the testing contractor, where they provided urine specimens for drug testing. The contractor did not conduct alcohol testing because too much time (16 hours) had elapsed

[31] Postaccident alcohol and drug testing is required by Federal regulations at 46 CFR 4.06 for any accident meeting the criteria of a serious marine incident, defined at 46 CFR 4.03-2 as (a) a marine casualty or accident that results in any of the following: (1) one or more deaths, (2) injury that requires medical treatment beyond first aid and renders the individual unfit to perform routine duties, (3) property damage exceeding $100,000, (4) actual or constructive total loss of an inspected vessel, or (5) actual or constructive total loss of any uninspected vessel that exceeds 100 gross tons; (b) discharge of 10,000 or more gallons of oil into U.S. waters; or (c) the release of a reportable substance into the environment of the United States.

since the accident. Test results for all four crewmembers were negative for the five drugs of abuse (marijuana, cocaine, opiates, amphetamines, and phencyclidine) for which screening in postaccident testing is required by Federal regulations at 46 CFR 16.113 and elsewhere. The drug tests were administered within the required time limits.

The *Massachusetts* master was not tested for alcohol within the time limits of the regulations, in part because he remained at the accident scene to assist the firefighters (he helped them gain access to the engineroom). According to 46 CFR 4.06 ("Mandatory Chemical Testing Following Serious Marine Incidents Involving Vessels in Commercial Service"), paragraph 4.06-1(d),

> The requirements of this subpart shall not prevent vessel personnel who are required to be tested from performing duties in the aftermath of a serious marine incident when their performance is necessary for the preservation of life or property or the protection of the environment.

On June 20, 2006 (8 days after the *Massachusetts* fire), new Coast Guard regulations (46 CFR 4.06-3) went into effect requiring alcohol testing within 2 hours of a serious marine accident.[32] Coast Guard headquarters informed the Safety Board on August 24, 2006, that the new regulations will be enforced by levying civil penalties against any marine employer who fails to conduct the alcohol testing as prescribed.[33] Failing to collect urine specimens for drug testing within 32 hours of an accident, as required by the regulations, will also result in civil penalties. Since the fire, Massachusetts Bay Lines has acquired saliva test kits for alcohol testing and has trained its office staff and vessel crews to use the kits.

The Safety Board placed the issue of improving postaccident drug and alcohol testing in the marine industry on its "Most Wanted" list in 2002. The list is intended to increase the public's awareness of, and support for, action to adopt safety steps that can help prevent accidents and save lives. Because of the new Coast Guard regulations for crew drug and alcohol testing after serious marine incidents, the Board removed the issue from its "Most Wanted" list on November 14, 2006.

## Fire Protection Regulations

The *Massachusetts* had the firefighting equipment (fire pumps, hoses, and portable extinguishers) required by its COI. The vessel was not equipped with fixed fire

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[32] The Safety Board recommended this and other improvements to the Coast Guard's regulations regarding postaccident toxicological testing in a special investigation report issued in 1998 (National Transportation Safety Board, *Postaccident Testing for Alcohol and Other Drugs in the Marine Industry and the Ramming of the Portland–South Portland [Million Dollar] Bridge at Portland, Maine, by the Liberian Tankship* Julie N *on September 27, 1996*, Special Investigation Report NTSB/SIR-98/02 [Washington, DC: NTSB, 1998]).

[33] To test for alcohol, either a breath, blood, or saliva (but not urine) specimen can be collected. Internal Coast Guard directives require Coast Guard personnel to conduct the alcohol tests if the marine employer does not or cannot conduct them within 2 hours.

suppression or detection systems in its engineroom, nor (as explained below) was it required by Coast Guard regulations to have such systems.[34]

When the *Massachusetts* began operating in 1988, the Coast Guard inspected vessels of less than 100 gross tons that could carry more than six passengers (that is, small passenger vessels) according to regulations at 46 CFR subchapter T.[35] On March 11, 1996, after a lengthy rulemaking process, a complete revision to the regulations governing small passenger vessels went into effect. In its rulemaking, the Coast Guard significantly changed the organization of the regulations. Vessels carrying 150 or fewer passengers continued to be regulated by subchapter T (46 CFR Parts 175-185). New subchapter K (46 CFR Parts 114-122) was created for regulations pertaining to small passenger vessels, such as the *Massachusetts*, that were permitted to carry more than 150 passengers.

Under the revised regulations, new vessels (defined at 46 CFR 114.400 as those built after March 10, 1996) were required to be equipped with a fixed gas fire extinguishing system and an approved fire detecting system for any spaces containing propulsion machinery.[36] Vessels built before the revised regulations took effect ("existing vessels") that had a hull or machinery space boundary made of combustible material such as wood or fiber-reinforced plastic (fiberglass), which the Coast Guard considered a higher risk category, were required to be retrofitted with fixed fire extinguishing and detecting systems by March 11, 1999.[37] The Coast Guard did not require retrofitting all existing vessels because "it would have a substantial cost impact on the small passenger vessel industry."[38]

Thus, existing vessels whose hulls were made of noncombustible material such as steel or aluminum, including the *Massachusetts*, were subject to the previous regulations, which required a fixed fire extinguishing system in the machinery and fuel tank spaces only if a vessel was powered by gasoline or other fuel having a flash point of 110° F or lower. Because it was constructed before the revised regulations went into effect and

[34] Massachusetts Bay Lines has had Coast Guard–approved fixed fire suppression and detection systems installed in the rebuilt engineroom of the *Massachusetts*.

[35] The initial subchapter T regulations were promulgated in the *Federal Register* of October 5, 1957. Originally, subchapter T regulated vessels of 65 feet or less in length. In 1963, subchapter T was revised to include vessels (known as subchapter T-L vessels) that were more than 65 feet long and had a gross tonnage of less than 100.

[36] Title 46 CFR 118.400 (a) and (c).

[37] *Federal Register*, vol. 59, no. 9 (January 13, 1994), p. 2046.

[38] The original notice of proposed rulemaking required only existing fiberglass vessels to have fixed fire extinguishing and detecting systems. The Coast Guard stated that it had studied casualty data and determined that fires on fiberglass vessels accounted for 34 percent of machinery space fires from 1981 to 1986, although such vessels composed only 20 percent of the small passenger vessel fleet, yielding a fleet percentage to fire percentage ratio of 1.7:1 (*Federal Register*, vol. 54, no. 18 [January 30, 1989], p. 4436). Wooden vessels were originally excluded from the requirement for fixed fire extinguishing and detecting systems because their ratio was lower (1.25:1), but they were added in the supplemental notice (*Federal Register*, vol. 59, no. 9 [January 13, 1994]) because of comments received. Vessels made of steel or aluminum were found to have "much lower" ratios and were not included in the requirement.

because its hull was aluminum, the new fire detection and suppression requirements did not apply to the *Massachusetts*.

## Probable Cause

The National Transportation Safety Board determines that the probable cause of the fire on board the *Massachusetts* was the ignition of diesel fuel by contact with a hot engine surface, which occurred because a fuel line attached to a fuel injector was not properly connected during engine maintenance by a contract mechanic. Contributing to the extent of the damage was the absence of a fixed fire detection and suppression system, which precluded the crew from receiving timely notification of the fire and which allowed the blaze to spread throughout the engineroom.

## Recommendation

As a result of its investigation into the fire on board the *Massachusetts*, the National Transportation Safety Board makes the following safety recommendation.[39]

**To the U.S. Coast Guard:**

> Require that all small passenger vessels certificated to carry more than 49 passengers, regardless of date of build or hull material, be fitted with an approved fire detection system and a fixed fire suppression system in their enginerooms. (M-07-1) (Supersedes Safety Recommendations M-02-6 and M-02-8.)

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**Adopted: March 20, 2007**

[39] For more information, see the Safety Board's safety recommendation letter to the Coast Guard, available on the Board's website <www.ntsb.gov>.