AVIATION HIGHWAY MARINE RAILROAD PIPELINE

Adopted: August 17, 2022

MIR-22/19

Engine Room Fire aboard Bulk Carrier *Roger Blough*

Sturgeon Bay

Sturgeon Bay, Wisconsin

February 1, 2021

Abstract: This report discusses the February 1, 2021, engine room fire aboard the *Roger Blough* while the bulk carrier was docked in winter layup at the Fincantieri Bay Shipbuilding facility on Sturgeon Bay, Wisconsin. Safety issues identified in this report include the lack of a fire-activated quick-closing valve on the fuel oil piping to the burner on the furnace in the engine room, lack of regulations governing furnace installation and operation on board certain vessels, and inadequate notification to onboard personnel of a fire. As part of its investigation, the National Transportation Safety Board makes three new safety recommendations to the US Coast Guard, the American Bureau of Shipping, and Key Lakes Inc.

Contents

Figures

Tables

Acronyms and Abbreviations

ABS	American Bureau of Shipping
ANSI	American National Standards Institute
NFPA	National Fire Protection Association
NTSB	National Transportation Safety Board
UL	Underwriters Laboratory

Executive Summary

What Happened

On February 1, 2021, about 0131 local time, a fire started in the engine room on the *Roger Blough* during the dry bulk carrier's winter layup at the Fincantieri Bay Shipbuilding facility on Sturgeon Bay, Wisconsin. The cargo-unloading conveyor belts subsequently ignited, causing extensive damage throughout the aft section of the vessel. The shipkeeper on board departed the vessel without injury. Firefighters extinguished the fire later that afternoon. No pollution was reported. Damage to the *Roger Blough* exceeded $100 million.

What We Found

The fire on board the *Roger Blough* originated at the burner inside the diesel oil-fired furnace, which had been installed in the engine room to heat the space during the winter. The 65-pound burner assembly, typically used in furnaces for heating shoreside buildings, was mounted onto the furnace's air tube with an aluminum coupling.

About a month before the casualty, the chief engineer believed the furnace was not working. Believing the ignitor was not properly set, the vessel's two engineers removed and reinstalled the furnace's burner several times during their attempts to repair the furnace. When they were unable to do so, the furnace company's technical representative was contacted and repaired the furnace soon afterward. However, the repeated removal and reinstallation of the burner assembly during attempts to repair the furnace may have damaged the mounting coupling and thereby led to its eventual failure.

Among the fire damage and debris, investigators found the burner assembly detached from the air tube and resting on the bottom of the burner enclosure. The fuel supply line to the burner was also found fractured. It is likely that, when the mounting coupling fractured, the furnace's burner assembly became detached from the air tube and fell, which likely bent and fractured the fuel supply line to the burner, thereby allowing fuel to spray onto the operating burner and ignite within the enclosure.

The National Fire Protection Association recommends that burner assemblies like the type installed on the *Roger Blough* have a fire-activated quick-closing valve on the inlet fuel oil piping next to the burner. When installed, this type of valve has a thermally activated mechanism that shuts the valve in the presence of fire to stop further flow of fuel to the burner. Had the burner assembly on the *Roger Blough* been fitted with a fire-activated quick-closing valve on its inlet fuel oil piping, the fuel feeding the furnace fire would have been stopped and thus the fire likely would not have spread so rapidly.

There are no regulations regarding winter layup procedures for commercial vessels operating in the Great Lakes. According to a survey administered by US Coast Guard Sector Lake Michigan following the casualty, about 12 of the 37 commercial vessels operating on the Great Lakes use diesel oil-fired furnaces during the layup period. The lack of regulations or classification standards related to diesel oil-fired air heating furnace construction, installation, safety shutdowns, and system alarms poses a risk to life and property if the equipment is not installed and maintained to standards similar to those in place for other oil-fired equipment.

When the fire erupted at nighttime, the wireless monitoring and notification system temporarily installed on the vessel for the layup period activated the alarm panel in the crew's accommodation spaces and then notified the designated contacts. The shipkeeper, the only person on board (and who was not listed as a designated contact), was awakened 7 minutes later by the alarm from the smoke detector inside his stateroom as thick black smoke filled it. He departed the vessel without injury as the fire was spreading throughout the engine room and up through the aft house of the *Roger Blough*. If the shipkeeper on board had been listed among the designated contacts to receive alerts about system failures, he likely would have been awakened earlier and thus may have had an opportunity to extinguish the fire before it spread through the vessel.

We determined that the probable cause of the engine room fire aboard the bulk carrier *Roger Blough* was likely the repeated removal and reinstallation of the furnace's burner that led to the failure of its mounting coupling, resulting in the operating burner dropping to the bottom of its enclosure and fracturing the fuel supply line, which allowed diesel fuel to ignite. Contributing to the casualty was the absence of a fire-activated automatic fuel oil shutoff valve on the fuel oil inlet piping before the burner, which would have stopped the fuel feeding the fire shortly after it started and limited the spread of the fire.

What We Recommended

As a result of this investigation, we made a recommendation to the Coast Guard to require that furnace installations on vessels be inspected to comply with National Fire Protection Association recommendations and to develop standards requiring installation of other types of shutdown mechanisms or safety alarms. We made a similar recommendation to the American Bureau of Shipping, which conducts oversight examinations for vessels like the *Roger Blough*. Lastly, we made a recommendation to the owner of the *Roger Blough*, Key Lakes Inc., to ensure that their designated contacts list includes each shipkeeper living and working on a vessel during layup.

1. Factual Information

1.1 Event Sequence

1.1.1 Synopsis

On February 1, 2021, about 0131 local time, a fire started in the engine room on the *Roger Blough*, shown in figure 1, during the dry bulk carrier's winter layup at the Fincantieri Bay Shipbuilding facility on Sturgeon Bay, Wisconsin.[1] The cargo-unloading conveyor belts subsequently ignited, causing extensive damage throughout the aft section of the vessel. The shipkeeper on board departed the vessel without injury. Firefighters extinguished the fire later that afternoon. No pollution was reported. Damage to the *Roger Blough* exceeded $100 million.

Figure 1. *Roger Blough* under way before the fire. (Source: US Coast Guard)

1.1.2 Background

The *Roger Blough*, an 858-foot-long, US-flagged bulk carrier, was constructed of steel in 1972 by the American Ship Building Company in Lorain, Ohio. Designed to operate exclusively on the Great Lakes and referred to as a "laker" within the maritime industry, the roughly 22,000-gross-ton vessel was owned by Key Lakes Inc. and operated by Great Lakes Fleet. It was powered by two SEMT Pielstick diesel engines, each producing 7,100 horsepower and driving a single propeller through a gear box. There were six decks on the aft section of the vessel: from top to bottom, the weather deck;

[1] (a) In this report, all times are central standard time, and all miles are statute miles. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA21FM015). Use the CAROL Query to search investigations.

poop deck; spar deck, where the crew's accommodation spaces were located; main deck; operating deck; and lower deck. The engine room spanned both the operating and lower decks.

A self-unloading cargo system on board the vessel was used to transport iron ore from the cargo holds to a reception facility ashore. The cargo holds had slanted sides that allowed ore to pour onto the port- and starboard-side conveyor belts running below them through hydraulically controlled gates at the bottom of the holds. The two belts extended in tunnels about 642 feet from the forwardmost cargo hold to the engine room (see figure 2). The conveyor belts passed through the engine room via "trunks" that angled up to the poop deck. The inclined conveyor system then transferred the cargo to the two respective self-unloading booms on the spar deck aft of the engine room.

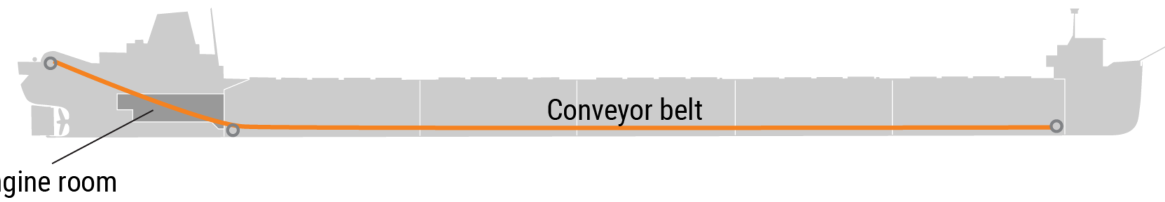

Figure 2. Simple profile of the *Roger Blough* showing the conveyor belt system.

During the winter months when the Great Lakes are frozen, making them impractical to navigate, most commercial vessels stop operating and enter a winter layup. Work that cannot be accomplished when a vessel is in operation, such as steel repair and engine maintenance, is commonly conducted during this period. At the time of the casualty, the *Roger Blough* had been in a layup status at the Fincantieri Bay Shipbuilding shipyard since July 2020, due to limited contracts resulting from the COVID-19 pandemic (see figure 3). In anticipation of returning the vessel to service, shipyard work was being conducted only during the workweek.

Figure 3. The shipbuilding facility where the *Roger Blough* was docked during winter layup, as indicated by a red *X*. (Background sources: Google Maps, Google Earth)

While in layup, a laker typically has a shipkeeper assigned for the winter to manage shipyard work, monitor the vessel, and notify the operator of conditions that could potentially damage the vessel, such as water ingress, machinery issues, or a vessel's heating system. For the *Roger Blough*, two shipkeepers–one was a credentialed second engineer, and the other was a handyman (shipkeeper no. 1 and 2, respectively)–were assigned to assist with work being conducted on the vessel. The shipkeepers lived aboard the vessel, typically working 8 hours a day, and were allowed to depart as needed.

1.1.3 Casualty Events

On Friday, January 29, 2021, shipkeeper no. 2 reported to the *Roger Blough* for his first day aboard; shipkeeper no. 1 had already been aboard for 2 months. The following day, both shipkeepers conducted engine room cleaning and made gaskets for the water piping systems. On Sunday, January 31, shipkeeper no. 1 departed the vessel at 0900 to attend a weeklong training session. Shipkeeper no. 2, who was living in the bosun's room on the starboard side of the spar deck in the aft house, departed the vessel at 1900; after returning, he went to bed around 2200.[2] He did not recall any problems on board the vessel around this time.

The *Roger Blough* had a fixed carbon dioxide (CO_2) fire-extinguishing system to suppress fires in the engine room; the system was disconnected during winter layup due to the risk of an accidental discharge with workers in the space. Six portable B-II fire extinguishers and one semiportable CO_2 fire extinguisher were also in the engine room.[3]

As a safety measure during this layup period, the vessel operator had installed temporarily in the engine room a wireless monitoring and notification system comprised of two smoke detectors, air blower pressure indicators for the sea chest, and bilge-level indicators.[4] The temporary monitoring and notification system was intended to ensure notification when no crewmembers were on board standing watch on the bridge or in the engine room to monitor the vessel's vital systems. Engine room equipment, such as the vessel's diesel oil-fired hot air furnace, was not connected to the temporary monitoring system. An alarm panel for the temporary monitoring system was mounted in a passageway on the ship's spar deck, port side, in the accommodation spaces near the crew's staterooms. If any issues were detected, the system would activate an audible/visual alarm locally at the panel and notify three designated cell phone contacts via a text message. Another temporary system of smoke detectors was in the crew's accommodation spaces, including individual staterooms, and sounded locally; it was not connected to the monitoring system.

On February 1, at 0131, the monitoring and notification system recorded an alarm indicating there was smoke in the engine room. In the next minute, the system notified the designated contacts: the shipyard's gate guard, shipkeeper no. 1 (who was not on the vessel), and the cell phone for the *Roger Blough* (located in the chief engineer's office). The gate guard noted the alarm and proceeded to the vessel to investigate.

The system was signaled by a smoke detector for the monitoring and notification system on the deck above the furnace (the operating deck). However, the smoke detector in the engine room, which was located on the same deck as the furnace and was 15 feet away, did not signal the system. (No postcasualty testing could be conducted on the engine room smoke detector due to the fire damage.)

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[2] The *bosun*, or *boatswain*, is the highest ranking nonofficer in the deck department.

[3] *B-II* is a portable fire extinguisher weighing 10–15 pounds rated for use on such flammable liquids as grease, gasoline, and oil. It meets the Coast Guard's requirement for a Type B, Size 2 fire extinguisher.

[4] A *sea chest* is an enclosure inside the underwater portion of the hull that is opened to the sea and fitted with a strainer plate. Machinery systems draw seawater for machinery cooling, fire, or sanitary systems from the chest. During freezing winter conditions, an *air blower* keeps the sea chest ice-free.

About 0138, shipkeeper no. 2 woke to the sound of the smoke detector alarm inside his stateroom and discovered his stateroom was filled with thick, black smoke. Shipkeeper no. 2 then proceeded to the exterior poop deck, where he saw the responding shipyard's gate guard. Due to the heavy smoke, the shipkeeper, who had no firefighting-protection equipment, did not attempt to reenter the *Roger Blough* but instead disembarked the vessel via the gangway. The gate guard, having observed the smoke on board emanating from the aft house of the vessel, contacted the Sturgeon Bay Fire Department.

Figure 4. Stern of the *Roger Blough* during firefighting efforts. (Source: Coast Guard)

The first units from the fire department arrived at 0143 to fight the fire, which was starting to expand into the galley on the poop deck (see figure 4). Upon assessing the fire, firefighters determined it had traveled through the port and starboard conveyor belt trunks that angled up to the poop deck, to the aft cargo-unloading booms on the spar deck below, and throughout the engine room on the lower deck. The fire was extinguished later that day at 1300. It did not spread to any of the neighboring vessels.

1.2 Injuries

The shipkeeper was the only person aboard the *Roger Blough* when the casualty occurred. He escaped the vessel without injury.

Table 1. Injuries sustained in the *Roger Blough* casualty.[5]

Type of Injury	Crew (Shipkeeper)
Fatal	0
Serious	0
Minor	0
None	1

1.3 Damage

Estimated damage to the *Roger Blough* exceeded $100 million.

The fire investigation discovered extensive damage throughout the engine room spaces as well as to parts of the aft house, self-unloading cargo booms, and the section of the conveyor belt trunks passing through the engine room (see figure 5, right). US Coast Guard investigators noted that most of the fire damage in the engine room was centrally located on the lower deck near the furnace and on the level above leading up to the stack (operating deck).[6] On the lower level, there was significant smoke and thermal damage in and around the furnace. Nearby metal objects did not burn but sustained thermal damage on surfaces facing the furnace. There was also extensive smoke and thermal damage above the furnace where the portside conveyor belt trunk was located. A closer examination of the furnace showed extensive thermal damage specifically at the burner enclosure, where there was noticeable discoloration of the metal structure and significant soot (see figure 5, left). When the enclosure was opened by investigators, the burner showed significant fire damage, including melting and warping of the cast aluminum framing. The soot line was primarily above the burner

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

[6] Due to COVID-19 travel restrictions, NTSB investigators were unable to initially respond to the casualty site. Investigators from the Coast Guard conducted the investigation. (See Appendix A.)

assembly, which was resting on the bottom of the enclosure, while below and behind it, there were no indications of soot or heat damage.

Figure 5. Furnace with burner enclosure outlined (*left*), and fire-damaged conveyor belt within the conveyer belt trunk above the furnace (*right*). (Source: Coast Guard)

Investigators found the burner assembly detached from the air tube and resting on the bottom of the burner enclosure. The fuel supply line was connected to the burner with a compression fitting from the fuel supply line tubing to a short pipe (a few inches) located at the underside of the burner assembly that threaded into the burner body. The threaded pipe, which had bent about 10° to the right when facing the burner assembly, was fractured. The location of the fuel supply line fracture was before the burner's fuel shutoff solenoid valve (see bottom inset of figure 6). The 4,144-gallon storage tank that supplied fuel to the furnace was found empty after the fire.

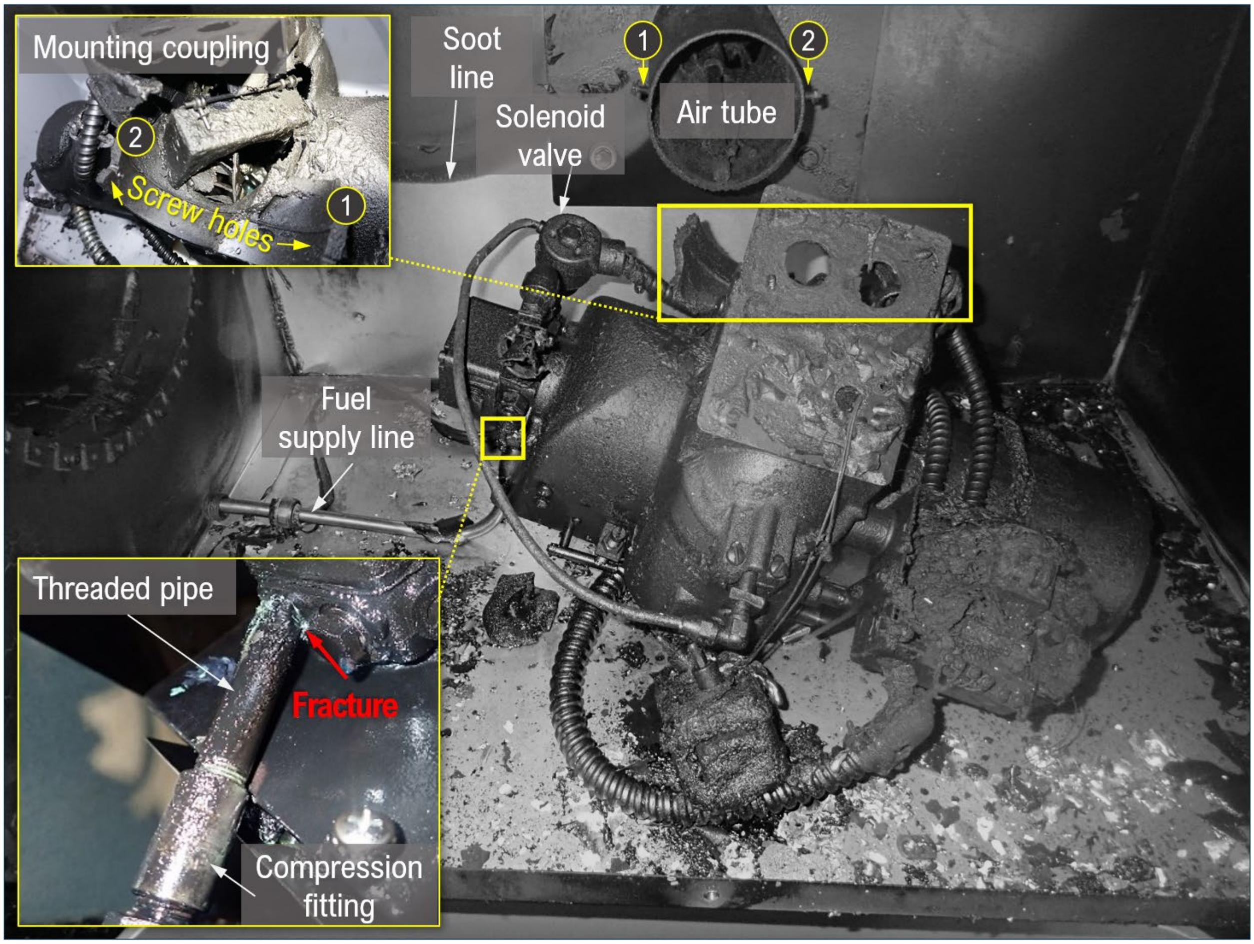

Figure 6. Photo of the fire-damaged burner detached from the air tube, lying on the bottom of the enclosure, shows the fracture point where the fuel supply pipe threaded into the burner assembly (*bottom inset*) and the fractured mounting coupling (*top inset*, interior view). (Source: Coast Guard)

In addition, the burner's aluminum mounting coupling, which overlapped onto the steel air tube by a half inch, was fractured on both sides at the hole for each set screw used to secure it to the air tube (see also figure 6, top inset; nos. 1 and 2 indicate the location of the screws). The fracture separated the top part of the coupling from the bottom. The two set screws were found still threaded into the air tube. The technical service manager from the burner manufacturer, who had worked for the company for 27 years, said, "I haven't seen a failure like this before." Except for the mounting coupling, no other structures or framing supported and held the burner in place.

1.4 Vessel Information

1.4.1 General

The *Roger Blough* was an 858-foot-long, US-flagged bulk carrier constructed of steel in 1972 by the American Ship Building Company in Lorain, Ohio.

Table 2. Vessel particulars.

Vessel	*Roger Blough*
Type	Cargo, dry bulk (Bulk carrier)
Flag	United States
Port of registry	Duluth, Minnesota
Year built	1972
Official number (US)	533062
IMO number	7222138
Classification society	American Bureau of Shipping
Length (overall)	858.0 ft (261.5 m)
Beam	105.1 ft (32.0 m)
Draft	27.9 ft (8.5 m)
Tonnage	22,041 GRT
Engine power; manufacturer	2 x 7,100 hp (5,294 kW); 16PC2V-400 SEMT Pielstick diesel engines
Persons on board	1

1.4.2 Furnace Installation and Fuel Supply System

To prevent piping and equipment in the engine room from freezing during the winter, the *Roger Blough* had a diesel oil-fired hot air furnace located port side in the forward section of the engine room. The Powrmatic CA-100 furnace, which was also referred to as a "winter" furnace, maintained the ambient temperature in the engine room by blowing heated air through a ventilation duct system. A furnace company installed the furnace on February 26, 2020, replacing the original furnace, and tested it to ensure proper operation. The installer found the furnace's typical operating functions were satisfactory, including pre-purging of the furnace before ignition (to purge any combustible gases), burner ignition, and post-purging. After air was purged from the furnace, the electric blower supplying the combustion air to the furnace stopped, as intended. In addition, the safety systems, such as the “Flame failure,” “Motor delay OFF,” “Lockout,” and overheating shutdown alarms, were tested to ensure the furnace control system would activate the burner’s fuel shutoff solenoid valve to stop fuel ignition. All tests were passed. After installation, the furnace was not operated until December 2020, about 2 months before the fire.

Figure 7 provides a simplified section view of the ship (looking forward). The location of the furnace relative to the portside conveyor belt trunk—which passed over the furnace—and the flow of fuel from the diesel fuel oil storage tank to the furnace are shown. The storage tank, also in the engine room, was located on the operating deck, a deck above the furnace. The fuel supply line had a manually operated shutoff valve at the tank that could be closed remotely during an emergency from the starboard side of the poop deck. Next to the furnace, about 10 inches away, another manual shutoff valve on the fuel supply line as it entered the burner enclosure could isolate the furnace from the fuel system but could only be operated locally. Lastly, a fuel shutoff solenoid valve on the burner assembly would close and stop pressurized fuel from entering the furnace’s combustion chamber in the event of a signal from the furnace’s control system.

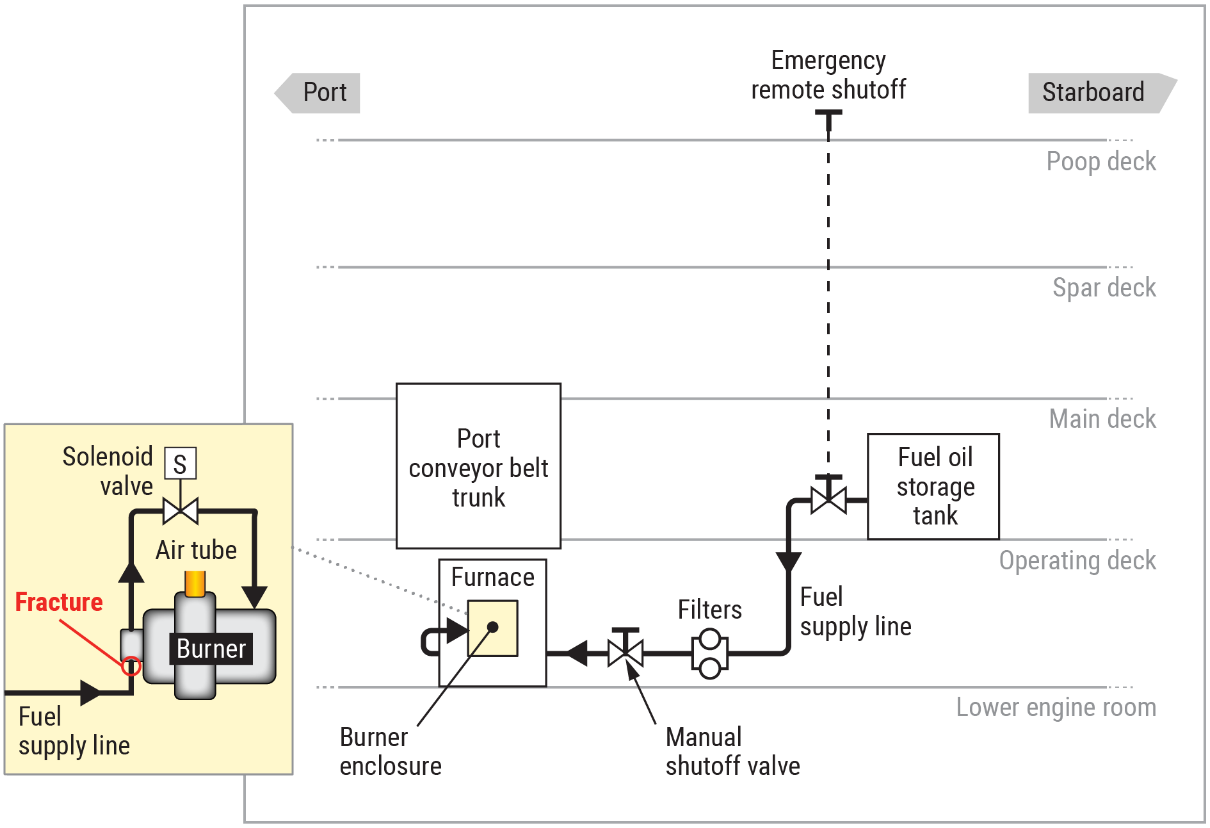

Figure 7. Simple section view of the engine room with arrangement of the furnace's fuel supply (not to scale).

1.4.3 Burner Assembly and Operation

Figure 8. Burner assembly with pedestal support. (Source: Carlin Combustion Technology)

On the *Roger Blough*, the Carlin 601CRD oil burner assembly, which weighed 65 pounds and was typically used in furnaces for heating shoreside buildings, was Underwriters Laboratory (UL)-listed and complied with the American National Standards Institute (ANSI)/UL 296 UL Standard for Safety Oil Burners (see figure 8).[7] Based on the manufacturer's instructions, it was to be installed in accordance with National Fire Protection Association (NFPA) 31 (Standard for the Installation of Oil-Burning Equipment) and ANSI/NFPA 70 (National Electric Code) standards as well as all applicable local codes. Encased in a sheet-metal enclosure, the burner assembly was comprised of a burner housing fitted with a mounting coupling, an air blower and motor, a fuel pump unit, a system controller, an ignitor, and a combustion head assembly. The fuel passed through a pipe within the air tube, which supplied the furnace with combustion air, to a nozzle where the flame was maintained and provided heat to the air box. There, ambient air was heated before being distributed within the engine room by ventilation fans and ducts.

The cast aluminum burner housing was designed to be mounted on the furnace's horizontally positioned air tube or, for some installations, to be supported by a pedestal (see figure 9). In the furnace of the *Roger Blough*, it was mounted to the air tube with a coupling, an arrangement that did not require the pedestal. A technical service manager from the manufacturer, Carlin Combustion Technology, told investigators that while the burner can be mounted without the pedestal, it is common practice for installers to use the pedestal to provide support below the burner to ensure it will not move. The company that installed the furnace submitted to the vessel's owner a furnace design proposal that did not include the pedestal support for the burner.

[7] *ANSI* is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States.

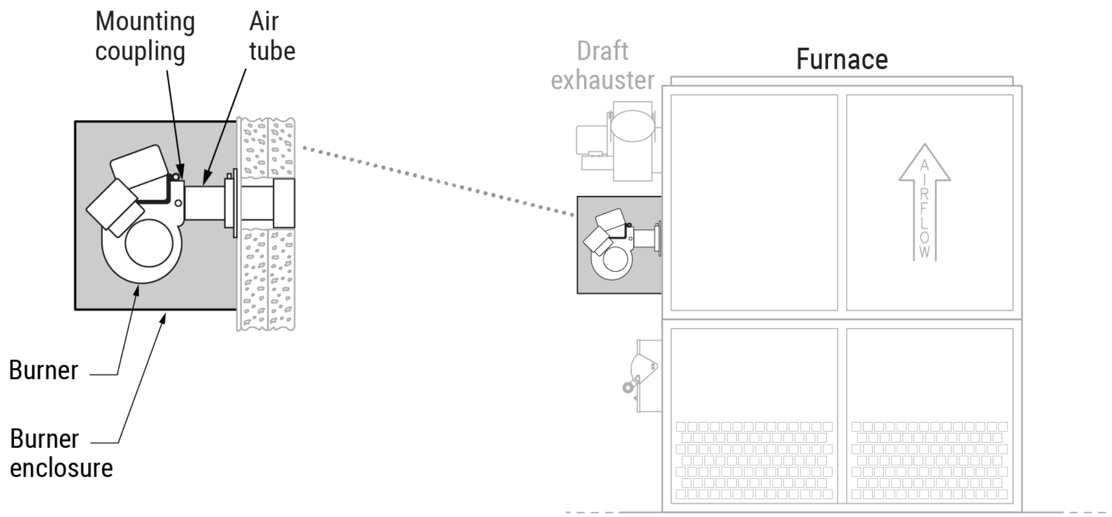

Figure 9. Diagram showing the burner assembly within the enclosure as mounted on the furnace on board the *Roger Blough*.

About a month before the fire, the chief engineer thought that the furnace was not operating. He and the second engineer (shipkeeper no. 1), who were still working on board the vessel, noted that the burner was not igniting. The chief engineer and second engineer evaluated the reason why the fuel was not igniting and believed that the ignitor was not properly set. (Neither crewmember was trained on how to troubleshoot problems with the burner, nor did they consult the instruction manual.) As part of their attempt to adjust the ignitor, they removed and reinstalled the burner several times. To remove the burner, a compression fitting from the fuel supply line tubing to a short pipe that threaded into the burner body (located a few inches from the burner) had to be disconnected.

When the two crewmembers were unable to resolve the issue after testing the burner, they contacted the technical representative from the company that installed the furnace. On December 29, 2020, the technical representative repaired the system while on site: the electrodes for the ignitor were too far apart, preventing the spark from forming and igniting the fuel. Once the issue was corrected, the furnace began operating again after going through the startup procedure.

1.5 Industry Overview

1.5.1 Furnace Regulations

There are no regulations regarding winter layup procedures for commercial vessels operating in the Great Lakes. According to a survey administered in June 2021 by Coast Guard Sector Lake Michigan, about 12 of the 37 commercial vessels on the Great Lakes used diesel oil-fired furnaces during the layup period.

The NFPA recommends that burner assemblies like the type installed on the *Roger Blough* have a fire-activated quick-closing valve on the inlet fuel oil piping next to the burner. When installed, this type of valve has a thermally activated mechanism that shuts the valve in the presence of fire to stop further flow of fuel to the burner. This valve is typically installed in furnaces on boilers on board Coast Guard-inspected commercial vessels. The burner assembly on the *Roger Blough* did not have a quick-closing valve.

The NFPA's recommendation is targeted toward furnace systems installed in shoreside buildings rather than on commercial vessels; the Coast Guard does not require that furnace installations on vessels be inspected to comply with NFPA recommendations, nor does it have any standards requiring installation of other types of shutdown mechanisms or safety alarms. The Coast Guard and the American Bureau of Shipping (ABS), which respectively conducted inspections and oversight examinations for the *Roger Blough*, and do so for other similar lakers, have standards for the electrical wiring supplying power to both the furnace and the burner as well as for the fuel system connected to them. However, they do not have any regulations or guidance for installation of the furnace's burner or for a quick-closing valve, nor do they inspect this equipment, unlike other fuel-fired equipment installed on vessels such as boilers, incinerators, and thermal fluid heaters, which have regulations for remote and/or automatic shutdown of the fuel system.

1.6 Waterway Information

Sturgeon Bay connects to Lake Michigan by the Sturgeon Bay Ship Canal. At the site of the casualty, the bay was 0.6 miles wide and 20 feet deep.

1.7 Environmental Conditions

At the time of the casualty, the sky was cloudy with visibility at 10 miles. Winds blew from the north at 7 knots. The air temperature was 23°F, and the water temperature was 36°F.

1.8 Related Casualty

Previously, the National Transportation Safety Board (NTSB) investigated another casualty involving an engine room fire that occurred on a bulk carrier while the vessel was in winter layup. On February 16, 2019, a fire was reported on the *St. Clair* while the vessel was docked at the CSX TORCO Iron Ore Terminal at the mouth of the Maumee River in Toledo, Ohio. The estimated damage to the vessel exceeded $150 million; there were no injuries. The NTSB determined that the probable cause of the fire was the ignition of combustible material in the vicinity of an engine room workshop likely due to the use of portable space heaters or smoldering smoking materials, which spread to other areas of the vessel. Contributing to the extent of the fire damage was the lack of operating procedures for continuous active monitoring of the vessel while in layup status.

2. Analysis

2.1 Introduction

At the time of the casualty, the *Roger Blough*, a bulk carrier designed to operate exclusively on the Great Lakes, had been in winter layup with no reported issues. However, about a month before, the vessel's diesel oil-fired furnace, which had been installed in the engine room to heat the space during the winter, had stopped operating; it was repaired soon afterward. When the fire erupted at nighttime, the wireless monitoring and notification system temporarily installed on the vessel for the layup period activated the alarm panel in a passageway within the crew's accommodation spaces and then notified the three designated contacts. The shipkeeper, the only person on board (and who was not listed as a designated contact), was awakened 7 minutes later by the alarm to the individual smoke detector inside his stateroom as thick black smoke filled it. By the time the fire department arrived 12 minutes after the designated contacts were notified, the shipkeeper had departed the vessel without injury as the fire was spreading throughout the engine room and up through the aft house of the *Roger Blough*.

Safety issues identified in this report are as follows:

- the lack of a fire-activated valve on the fuel oil piping to the burner on the furnace in the engine room (section 2.3),
- the lack of regulations governing furnace installation and operation on board certain vessels (section 2.4), and
- inadequate notification to onboard personnel of a fire (section 2.5).

Having completed a comprehensive review of the circumstances that led to the casualty, the investigation excluded the following as a causal factor:

- Shipyard work. While the Roger Blough was undergoing repair work and maintenance by both the shipyard workers and the two shipkeepers in the days before the casualty, there was no evidence that the work and maintenance conducted had any bearing on the circumstances leading up to the fire.

Thus, the NTSB concludes that shipyard work while the vessel was in winter layup was not identified as a safety issue for the casualty.

2.2 Burner Assembly

Investigators noted that the fire pattern within the engine room showed extensive smoke damage at the lower level and at the level above leading up to the stack. On the lower level, there was significant smoke and thermal damage within and surrounding the furnace on the port side. Investigators found that metal objects nearby did not burn but sustained thermal damage on surfaces facing the furnace. There was also extensive thermal and smoke damage to the area just above the furnace where the portside conveyor belt trunk was located. A closer examination of the furnace clearly showed extensive thermal damage at the enclosure that encased the burner, where there was noticeable discoloration of the metal structure and significant soot. Therefore, while there was damage throughout the engine room, given the fire pattern and damage on the lower level noted by investigators, the NTSB concludes that the fire originated at the burner inside the diesel oil-fired furnace in the engine room.

The instruction manual from the burner manufacturer required that the burner installation comply with NFPA 31 and ANSI/NFPA 70 standards as well as all applicable local codes. The furnace on the *Roger Blough* had been newly installed by a furnace company in February 2020, about a year before the casualty. All operating functions, including the burner ignition, were tested and found to be satisfactory. Known as a "winter" furnace for its seasonal layup, the furnace was not operated until December 2020.

About a month before the February 2021 casualty, the chief engineer thought the furnace was not working. The chief engineer and the second engineer (shipkeeper no. 1) examined the system and believed that the ignitor was not properly set and needed to be adjusted. To adjust the ignitor, they removed and reinstalled the furnace's burner several times, although they were not familiar with the furnace arrangement and did not consult the manual. When their efforts did not resolve the issue, they contacted a technical representative from the furnace company. The technical representative fixed the system, enabling the furnace to resume normal operations.

After opening the burner enclosure, investigators found the burner inside was extensively fire-damaged and detached from the air tube, lying on the bottom of the enclosure. The oil burner assembly installed on the *Roger Blough*, which was UL-listed and complied with the ANSI/UL 296 standards, was outfitted with an aluminum mounting coupling that held the 65-pound unit onto the horizontally positioned steel air tube. During the postcasualty investigation, the mounting coupling was found fractured on both sides where the hole for each set screw had secured it to the air tube. The top part of the coupling had separated from the bottom part, although the two set screws were found still threaded into the air tube. The technical service manager stated that in nearly 3 decades working for the manufacturer, "I haven't seen a failure like this before."

It is possible that the cast aluminum mounting coupling was damaged during the repeated removal and reinstallation of the burner assembly, which could occur if it were twisted or not pulled directly off the air tube, causing a strain on both set screw holes. Another possibility is that the set screw holes may have been fractured if the set screws were overtorqued during tightening. Over the next month, these fractures could have expanded as the furnace heated and cooled until they reached a point where the coupling could no longer support the weight of the burner assembly.

The NTSB also considered whether the threaded pipe to the fuel line could have failed first and the ensuing fire caused the failure of the coupling. Multiple attempts to repair the burner by the crewmembers and the technical representative altogether would have involved repeatedly disconnecting the compression fitting between the fuel line tubing and the threaded pipe to the burner to remove the burner. If the fracture to the pipe had occurred at the threaded connection when the burner assembly was removed by the ship's crew and the service technician, about late December 2020, it likely would have led to a fuel leak that manifested sooner than a month later when the fire occurred.

Furthermore, investigators found the soot line inside the burner enclosure was distinguishable above the burner assembly, which was resting on the bottom of the enclosure (see figure 6). This demarcation indicated that an uncontrolled fire occurred after the burner assembly disconnected from the air tube in the furnace and fell; had the fire erupted while the burner assembly was still connected to the air tube, the soot line would have been higher. Thus, it is likely that the coupling was the initial failure point. Therefore, the NTSB concludes that the repeated removal and reinstallation of the burner assembly during the ship's engineers' attempts to repair it without consulting the manual or the manufacturer may have damaged the mounting coupling and thereby led to its eventual failure.

Following the failure of the coupling, the burner dropped to the bottom of the enclosure. As a result, the weight of the burner assembly likely caused the vertically oriented fuel supply line and pipe connected to its underside to bend downward and fracture at the point where the pipe was threaded into the burner assembly. Because this fracture was located before the burner's internal pump and fuel shutoff solenoid valve, fuel under head pressure from the fuel oil storage tank a deck above released into the enclosure. Therefore, the NTSB concludes the furnace's burner assembly became detached from the air tube and fell when the mounting coupling fractured, which likely bent and fractured the fuel supply line to the burner, thereby allowing fuel to spray onto the operating burner and ignite within the enclosure.

2.3 Fire-Activated Fuel Valve

The fuel oil storage tank, located a deck above the furnace (on the operating deck), provided a continuous flow of fuel to the fire until the 4,144-gallon tank was emptied. The fuel in the storage tank supplying the furnace could be isolated locally at the tank, by closing a manual valve, or remotely, via the emergency shutoff on the starboard side of the poop deck. However, the burning of the rubber conveyor belt generated thick, black smoke throughout the interior and exterior of the aft section of the vessel, and the heat of the fire would have prevented the shipkeeper from entering the engine room to shut off the valve at the furnace. Also, due to the smoke and heat passing through the decks just above the starboard-side conveyor belt trunk, the shipkeeper, who had no firefighting-protection equipment, would not have been able to access the remote fuel tank shutoff valve.

In the event the furnace control system detected a failure, the furnace had safety shutdowns, including an automatically activated solenoid valve on the burner assembly that stopped pressurized fuel from entering the furnace's combustion chamber. However, because the fracture in the fuel supply line occurred before the burner's internal pump and fuel shutoff solenoid valve, gravity would have supplied a flow of fuel from the fuel oil supply tank above even if the valve had activated and closed. As stated above, this flow of fuel continued to feed the fire until the fuel was expended.

This casualty shows the location of a fire-activated quick-closing valve is critical to the safety of the system; in this case, the fuel supply line failed before the solenoid valve, and fuel sprayed onto the burner causing the fire. A fire-activated quick-closing valve located on the fuel supply line next to (before) the burner is an automatic means for shutting down fuel in case of a catastrophic burner failure; the NFPA recommends such valves for burner assemblies like the type installed on the *Roger Blough*. Further, this valve is typically installed in furnaces on boilers on board Coast Guard-inspected commercial vessels. For shoreside use, a quick-closing valve is located on the fuel supply line next to the burner and has a thermally activated mechanism that, in the presence of fire, shuts the valve to stop further flow of fuel to the burner. Therefore, the NTSB concludes that had the burner assembly on the *Roger Blough* been fitted with a fire-activated quick-closing valve on its inlet fuel oil piping, as recommended by the NFPA for shoreside building installations, the fuel feeding the furnace fire would have been stopped and thus the fire likely would not have spread so rapidly.

2.4 Furnace Regulations

When the burner assembly's mounting coupling failed, it initiated a sequence of events resulting in extensive fire damage to the bulk carrier. Other oil-fired equipment installed on Coast Guard-inspected commercial vessels, specifically the automatic auxiliary boilers and incinerators, must comply with the following regulations—

- **Title 46 *Code of Federal Regulations* 63.15-7(a):** "an audible alarm must automatically sound when a flame safety system shutdown occurs," along with a visual alarm indicating the system failure.

- **Title 46 *Code of Federal Regulations* 56.50–65(f):** quick-closing valves installed on the fuel supply line must be accessible to the operator or remotely controlled.

Similarly, ABS' Rules for Building and Classing Marine Vessels released in January 2022 has requirements for shutting down the fuel oil systems for boilers, incinerators, and thermal fluid heaters in case of a fire.

- **Chapter 4, section 1/11.3 and chapter 7, section 2/1.9.7(iv):** fuel oil service pumps must be fitted with a remote "means of control" located outside of the engine room so that "fired equipment" may be stopped in the event of a fire within that space.
- **Chapter 4, section 1/11.5.2(a):** an "actuation" of a fuel shutoff must alert the operator of the situation by "visual and audible alarms."

Although furnaces like the one installed on the *Roger Blough* are oil-fired equipment, there is no regulatory guidance or requirements for their installation on Coast Guard-inspected commercial vessels. This casualty demonstrates that furnaces can present fire safety risks. If the bulk carrier's furnace had met regulations or class rules similar to those for other oil-fired equipment, this compliance likely would have resulted in a remote and/or an automatic fire-activated quick-closing valve on the inlet fuel oil piping outside the burner enclosure. The vessel's furnace/burner fuel supply was fitted with only a nearby manual (hand-operated) shutoff valve. In addition, had the furnace control system been connected to the ship's monitoring and notification system, and an installed alarm activated, the designated contacts for the system's alarms would have been alerted immediately following the failure of the furnace's burner.

When the new furnace was installed on board the *Roger Blough*, it was not required to undergo any plan review or an installation inspection by the Coast Guard or by ABS. There were also no Coast Guard or ABS standards for—

- how the furnace was to be constructed and arranged.
- how the burner was to be mounted and supported.
- whether the fuel system required a fire-activated automatic fuel oil shutoff valve.
- what safety alarms and shutdowns should be included.
- what audible or visual alarms, both locally and remotely, are required to notify crewmembers of a furnace failure when the vessel is under way or in layup.

These types of standards and plan reviews can mitigate fire and safety risks for shipboard oil-fired equipment. Therefore, the NTSB concludes that the lack of Coast Guard regulations or ABS classification standards related to diesel oil-fired air heating furnace construction, installation, safety shutdowns, and system alarms poses a risk to life and property if the equipment is not installed and maintained to standards similar to those in place for other oil-fired equipment. Therefore, the NTSB recommends that the Coast Guard develop regulations and guidance for diesel oil-fired air-heating furnaces on board Coast Guard-inspected commercial vessels that address plan review, installation, operational inspection, system shutdowns, and alarm notifications. In addition, the NTSB recommends that ABS develop classification standards for diesel oil-fired air-heating furnaces on board ABS-classed commercial vessels that address plan review, installation, operational inspection, system shutdowns, and alarm notifications.

2.5 Personnel Notification

The temporary wireless monitoring and notification system installed for the vessel's winter layup period was connected to the two smoke detectors in the engine room. Once activated, the system sent a text message to the designated contacts and had an audible and visual alarm at a panel in a passageway on the ship's spar deck, port side, near the crew's accommodation spaces. The system was not designed to activate an alarm system throughout the vessel. On the night of the casualty, this panel alarmed first due to the engine room smoke detector activating, but it did not wake the shipkeeper, who was instead alerted by a smoke detector inside his stateroom (which sounded locally but was not connected to the monitoring and notification system).

The shipkeeper on board was not one of the designated contacts and therefore did not receive an immediate text notification of the fire from the wireless monitoring and notification system. About 7 minutes after the wireless system had alerted the three designated contacts, the shipkeeper woke to the alarm of the smoke detector installed in his quarters. By that time, the fire had expanded, and thick, black smoke had filled his room. The heat generated from the fire growing inside the furnace transferred to the portside conveyor belt trunk overhead. At some point, the heat of the fire ignited the conveyor belt, which was constructed of rubber material that had an average ignition temperature of 384°F. The ignition of the conveyor belt provided the fire a path within the trunk to spread up into the aft house of the *Roger Blough.* Asleep and alone on the vessel at the time of the fire, the shipkeeper also would not have been alerted in the event of another system on the bulk carrier failing.

Due to the heavy smoke and heat caused by the spreading fire, the manual shutoff valve and the emergency remote shutoff to the fuel oil supply tank would have been inaccessible. Therefore, the NTSB concludes that although he escaped the vessel without injury, if the shipkeeper on board had been listed among the designated contacts to receive alerts from the temporary monitoring and notification system installed on the vessel for winter layup, he likely would have been awakened earlier and thus may have had an opportunity to shut off the fuel and extinguish the fire before it spread through the vessel.

For a previous casualty involving an engine room fire on board the bulk carrier (laker) *St. Clair* during winter, the NTSB determined that the lack of operating procedures for continuous active monitoring of the vessel while in layup status contributed to the extent of the fire damage, which amounted to more than $150 million. The *St. Clair* and *Roger Blough* casualties show that engine room fires while in layup status pose a substantial threat to personnel and property. Further, when fire notification to shipkeepers on board vessels during layup is delayed, the response is delayed, and the potential growth of a fire increases. Therefore, the NTSB recommends that the owner of the *Roger Blough*, Key Lakes Inc., ensure that the designated contacts list includes each shipkeeper living and working on a vessel during layup.

3. Conclusions

3.1 Findings

1. Shipyard work while the vessel was in winter layup was not identified as a safety issue for the casualty.
2. The fire originated at the burner inside the diesel oil-fired furnace in the engine room.
3. The repeated removal and reinstallation of the burner assembly during ship's engineers' attempts to repair it without consulting the manual or the manufacturer may have damaged the mounting coupling and thereby led to its eventual failure.
4. The furnace's burner assembly became detached from the air tube and fell when the mounting coupling fractured, which likely bent and fractured the fuel supply line to the burner, thereby allowing fuel to spray onto the operating burner and ignite within the enclosure.
5. Had the burner assembly on the *Roger Blough* been fitted with a fire-activated quick-closing valve on its inlet fuel oil piping, as recommended by the National Fire Protection Association for shoreside building installations, the fuel feeding the furnace fire would have been stopped and thus the fire likely would not have spread so rapidly.
6. The lack of US Coast Guard regulations or American Bureau of Shipping classification standards related to diesel oil-fired air heating furnace construction, installation, safety shutdowns, and system alarms poses a risk to life and property if the equipment is not installed and maintained to standards similar to those in place for other oil-fired equipment.
7. If the shipkeeper on board had been listed among the designated contacts to receive alerts from the temporary monitoring and notification system installed on the vessel for winter layup, he likely would have been awakened earlier and thus may have had an opportunity to shut off the fuel and extinguish the fire before it spread through the vessel.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the engine room fire aboard the bulk carrier *Roger Blough* was likely the repeated removal and reinstallation of the furnace's burner that led to the failure of its mounting coupling, resulting in the operating burner dropping to the bottom of its enclosure and fracturing its fuel supply line, which allowed diesel fuel to ignite. Contributing to the casualty was the absence of a fire-activated automatic fuel oil shutoff valve on the fuel oil inlet piping before the burner, which would have stopped the fuel feeding the fire shortly after it started and limited the spread of the fire.

4. Recommendations

4.1 New Recommendations

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

To the US Coast Guard:

1. Develop regulations and guidance for diesel oil-fired air-heating furnaces on board US Coast Guard-inspected commercial vessels that address plan review, installation, operational inspection, system shutdowns, and alarm notifications. (M-22-1)

To the American Bureau of Shipping:

2. Develop classification standards for diesel oil-fired air-heating furnaces on board American Bureau of Shipping-classed commercial vessels that address plan review, installation, operational inspection, system shutdowns, and alarm notifications. (M-22-2)

To Key Lakes Inc.:

3. Ensure that the designated contacts list includes each shipkeeper living and working on a vessel during layup. (M-22-3)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

BRUCE LANDSBERG
Vice Chairman

THOMAS CHAPMAN
Member

Report Date: August 17, 2022

Appendixes

Appendix A: Investigation

The US Coast Guard was the lead federal agency in this investigation. The National Transportation Safety Board (NTSB) learned of the casualty from the Coast Guard on the afternoon of February 1, 2021. Due to COVID-19 travel restrictions, the NTSB investigator was unable to respond to the site. The NTSB investigator remotely joined Coast Guard-led interviews of the vessel port coordinator, port engineer, chief engineer, second engineer, and the shipkeeper, as well as the furnace company's technical service manager and technician. Investigators also reviewed furnace installation plans and servicing reports, the temporary wireless monitoring and notification system log, fire damage photos, and drone video.

Following the fire, access to the vessel was prohibited due to asbestos insulation mitigation, which prevented the NTSB investigator from boarding the vessel and examining the interior of the vessel's engine room. The burner assembly was removed by the Coast Guard and stored at a secure location for further study by the parties of interest.

Parties of interest to the Coast Guard investigation included Key Lakes Inc., the vessel owner. The Coast Guard and Tweet/Garot Mechanical Inc., the installer of the furnace on board the *Roger Blough*, were named parties to the NTSB investigation; Key Lakes Inc. declined to be a party to the NTSB investigation.

Appendix B: Consolidated Recommendation Information

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

For each recommendation–

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

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

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

To US Coast Guard

M-22-1

> Develop regulations and guidance for oil-fired air-heating furnaces on board US Coast Guard-inspected commercial vessels that address plan review, installation, operational inspection, system shutdowns, and alarm notifications.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4 Furnace Regulations. Information supporting (b)(1) can be found on pages 19-21; (b)(2) is not applicable; and (b)(3) is not applicable.

To American Bureau of Shipping

M-22-2

> Develop classification standards for oil-fired air-heating furnaces on board American Bureau of Shipping-classed commercial vessels that address plan review, installation, operational inspection, system shutdowns, and alarm notifications.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4 Furnace Regulations. Information supporting (b)(1) can be found on pages 19-21; (b)(2) is not applicable; and (b)(3) is not applicable.

To Key Lakes Inc.

M-22-3

> Ensure that the designated contacts list includes each shipkeeper living and working on a vessel during layup.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5 Personnel Notification. Information supporting (b)(1) can be found on pages 21-22 (b)(2) can be found on pages 21-22; and (b)(3) is not applicable.

References

National Transportation Safety Board (NTSB). 2020. *Engine Room Fire aboard Bulk Carrier* St. Clair. Marine Accident Brief NTSB/MAB-20/15. Washington, DC: NTSB.

Casualty type	Fire/Explosion
Location	Sturgeon Bay; Sturgeon Bay, Wisconsin 44°50.58′ N, 087°23.13′ W
Date	February 1, 2021
Time	0131 central standard time (coordinated universal time –6 hours)
Injuries	None
Property damage	>$100 million est.
Environmental damage	None

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