April 29, 2025 MIR-25-18

# Contact of Bulk Carrier *American Mariner* with Munuscong Channel Junction Light

On March 28, 2024, about 0018 local time, while transiting upbound in the St. Marys River, about 25 miles south of Sault Ste. Marie, Michigan, the bulk carrier *American Mariner* experienced a steering failure and struck the Munuscong Channel Junction Light, a 31-foot-diameter cylindrical concrete structure with a navigation aid on top (see figure 1 and figure 2).[1] The vessel began taking on water; pumps stabilized the flooding. None of the 18 crewmembers on board were injured, and no pollution was reported. Damage to the vessel was estimated at $800,750, and damage to the Munuscong Channel Junction Light was estimated at $1.25 million for repairs.[2]


**Figure 1.** *American Mariner* underway before the contact. (Source: US Coast Guard)

[1] In this report, all times are eastern daylight time, and all miles are statute.

[2] Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA24FM032). Use the CAROL Query to search investigations.

## Casualty Summary

| | |
|---|---|
| **Casualty type** | Contact |
| **Location** | St. Marys River, about 25 miles south of Sault Ste. Marie, Michigan<br>46°10.93' N, 84°5.76' W |
| **Date** | March 28, 2024 |
| **Time** | 0018 eastern daylight time<br>(coordinated universal time -4 hrs) |
| **Persons on board** | 18 |
| **Injuries** | None |
| **Property damage** | $800,750 est. (vessel), $1.25 million est. (light) |
| **Environmental damage** | None |
| **Weather** | Visibility 10 mi, overcast, winds west-southwest 6 mph, air temperature 28°F, sunset 2002, sunrise 0725 |
| **Waterway information** | River; depth about 28 ft |


**Figure 2.** Area where the *American Mariner* struck the Munuscong Channel Junction Light, as indicated by a circled *X*. (Background source: Google Maps)

# 1 Factual Information

## 1.1 Background

The 730-foot-long, US-flagged *American Mariner,* a self-unloading bulk carrier constructed of welded steel, was built by Bay Shipbuilding Company in Sturgeon Bay, Wisconsin, in 1980. Propulsion was provided by two 3,500-hp diesel engines driving a single controllable pitch propeller rated at 7,000 hp. For maneuvering, the vessel was equipped with an electrically driven bow and stern thruster, each rated at 1,000 hp. The vessel was owned by American Steamship Company and operated by Grand River Navigation, Inc. Grand River Navigation began chartering the *American Mariner* in 2021. The vessel operated in the Great Lakes, typically transporting bulk products such as iron ore, grain, and limestone.

The Munuscong Channel Junction Light was an aid to navigation (ATON) comprised of a navigational light and signal mounted on a fixed structure, located in the St. Marys River in Munuscong Lake. It was constructed in 2010 and marked the separation between the upbound Munuscong Channel to the east and the downbound West Neebish Channel to the west. The structure was a 31-foot-diameter cylindrical concrete structure wrapped in sheet pile, bored into the seabed with a lighted navigation aid affixed on top. The lighted navigation aid was a green light, with a flash pattern of two flashes followed by one flash (see figure 3). It was not operational on the evening of the casualty; it was reported to be extinguished on January 9, 2024. The US Coast Guard Local Notice to Mariners contained information about the extinguished light and advised that the ATON's automated identification system was inoperable.

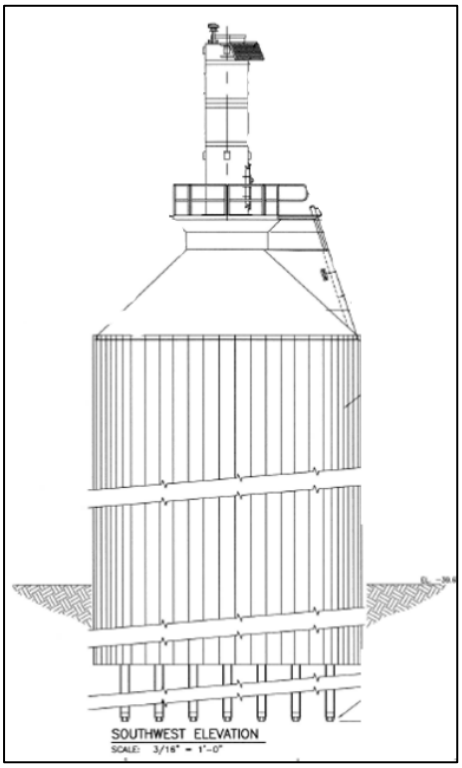


**Figure 3.** Munuscong Channel Junction Light. (Source: Coast Guard)

## 1.2 Event Sequence

On March 26, about 1925, the *American Mariner*, with 18 crewmembers aboard, departed the Bay Shipbuilding Company shipyard in Sturgeon Bay, Wisconsin, following winter layup. The vessel was bound for Silver Bay, Minnesota, on Lake Superior in ballast condition to load the first cargo of the season. During the winter layup period, general maintenance was conducted throughout the vessel, hydraulic technicians completed annual preventative maintenance on the steering gear's hydraulic system, and electronic technicians installed an updated electronic steering control system on the bridge; see section 1.3.3 for more information (see figure 4). Coast Guard inspections and class society surveys, which included testing and inspection of the new steering control stand, were completed. Prior to departing the dock on March 26, the crew completed predeparture functional steering tests.

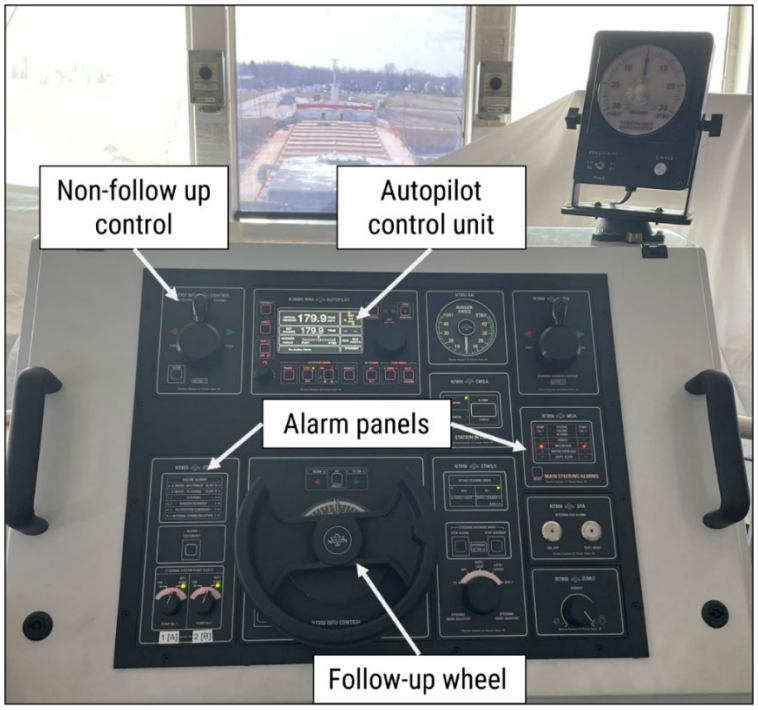


**Figure 4.** Steering control stand panel installed on the *American Mariner* during winter layup.

Since it was the beginning of the season and a new electronic steering control system had been installed on the bridge, the captain conducted steering drills during the transit with two deck watch sections. The captain held the drills to familiarize the deck watch sections with operating the steering system (a ram-type hydraulic steering system consisting of two electrically driven variable-displacement hydraulic pumps that operated the rams, turning the rudder) and instruct them how to react in the event of a steering failure (while referring to the posted emergency steering procedures placard). The captain discussed switching pumps during one-pump

operation and instructed crewmembers to switch the mode of operation from "follow up" (FU) steering to "non-follow up" (NFU) steering and use the corresponding steering controllers.[3]

The captain and deck officers stated that throughout most of the 2-day transit, they used autopilot and one steering pump. While transiting rivers, though, crewmembers would steer the vessel using the FU steering wheel (as seen in figure 4) in hand steering mode and with two steering pumps online (per company policy) for redundancy and faster rudder response. The captain and deck officers specified that when they used two pumps and hand steering during the voyage, the steering system alarm on the bridge sounded intermittently. One deck officer stated that the alarm came from the area labeled "failure alarms" on the left side of the steering control stand panel and that he believed the alarm was a "steering failure" alarm. One engineering crewmember also noted that he observed slight back-and-forth oscillations (known as "hunting") between left and right positions of the steering hydraulic system when two pumps were running during the transit. After receiving the alarms, the deck officers notified the engineer on watch. The engineers checked the steering system locally. They saw no indications of problems; the rudder was responding properly to the input commands.

On March 27, about 2200, prior to entering the St. Marys River, the crew started the second hydraulic steering pump per company policy and operated the steering system in hand steering mode using the FU steering wheel. The captain stated that the frequency of steering alarms diminished once the vessel entered the river, as the vessel was not using as much rudder and was making slight heading changes. The bow thruster and stern thruster were in the off position during the transit.

Just after midnight on March 28, the *American Mariner* was transiting upbound in the St. Marys River in Munuscong Lake and approaching the Munuscong Channel Junction Light. According to the captain, they were transiting "below the 14 mph speed limit," with the captain, second mate, and wheelsman on the bridge (see figure 5). To maneuver around the Munuscong Channel Junction Light and into the upbound channel, the wheelsman used about 20–30° of right rudder to "start the jog"

[3] A *non-follow up* (NFU) *lever* is used for immediate rudder control, where the rudder only moves when the lever is engaged and stops when the input is released. A *follow-up* (FU) *system* is used for precise and continuous rudder positioning where the system ensures the vessel's rudder is held at an exact input position until a new input is provided. Typically, vessels are operated in follow-up mode.

around the light, and once he saw the vessel begin to swing to starboard, he counter steered to port using about 20–25° of left rudder.

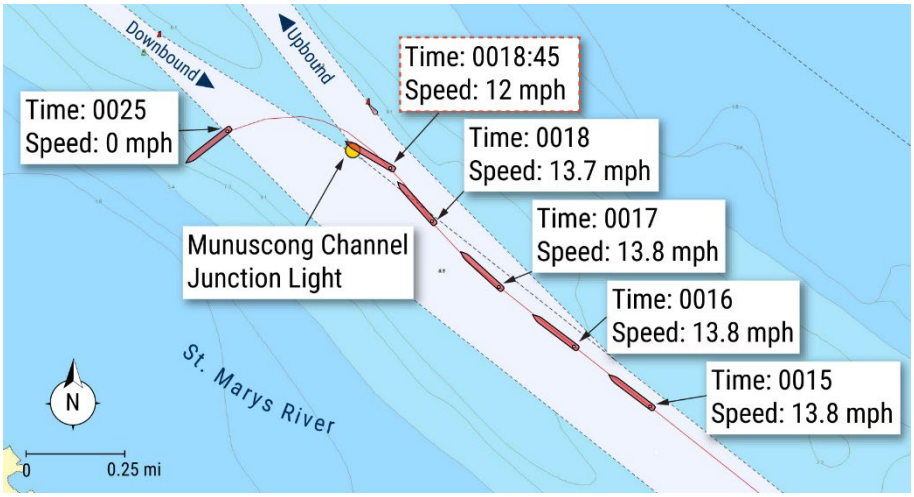


**Figure 5.** *American Mariner*'s automatic identification system trackline and upbound transit in St. Marys River on March 28, 2024. Munuscong Channel Junction Light is not to scale. (Background source: MadeSmart)

About 0018, the wheelsman alerted the captain and second mate that the rudder was stuck about 20° left and he had lost steering control. No alarms were activated at the time of the loss of steering control. The captain directed the wheelsman to switch to NFU steering mode to manually control the rudder, but changing to NFU had no effect. The vessel began to veer to port, and the captain ordered the second mate to drop the stern anchor. The captain brought the main engine throttle to full astern to reduce the vessel's speed and its rate of turn. The second mate ran down to the stern, released the brake on the anchor, and let out an estimated one shot of anchor chain (90 feet).

Within about 15 seconds of the deck crew noticing the loss of steering control, the port bow of the *American Mariner*, moving about 12 mph, struck the Munuscong Channel Junction Light. The bow lookout on watch in the crow's nest stated that he felt the impact and then received the command from the bridge (via handheld radio) to drop the starboard anchor. He released the brake but could not recall how many shots were let go.

Following the contact with the light, after both anchors dropped, the vessel came to a stop on the edge of the downbound channel. The deck officers notified the Coast Guard and the ship's operating company over the VHF radio and cell phone, respectively. Immediately after the contact, the engineers took control and tried to operate the steering system locally, but the rudder would not move. Both main hydraulic pumps remained operational. The chief engineer engaged the trick wheel

(emergency local control), but he was unable to move the rudder. The first engineer noticed that the connecting rod between the no. 1 control motor and the lever arm for the main steering pump stroke control was not moving as it was supposed to (see section 1.3.2 for more information on the control motors). The chief engineer obtained permission from the shoreside port engineer to separate the linkage from the control motor to the main pump, isolating the no. 1 control motor. Once disconnected, the steering system properly responded to input commands.

Deck crewmembers sounded the vessel's forward tanks and reported water ingress in the forepeak tank and the no. 1 port ballast tank. Crewmembers started ballast pumps to dewater the affected spaces and were able to stabilize the water levels in the forepeak and the no. 1 port ballast tank. In addition, engineering crewmembers replaced the no. 1 steering control motor with a spare. After replacing the no. 1 control motor, the steering system responded to steering commands.

The *American Mariner* remained anchored, and a salvage company arrived later that day to assess the damage and develop a transit plan. The salvage company surveyed the hull using a remotely operated vehicle. The following day, the vessel transited under its own power to a nearby anchorage outside the channel for further damage assessments.

## 1.3 Additional Information

### 1.3.1 Damage

The vessel suffered damage to the hull plating and internal framing below the waterline to the forepeak tank and the no. 1 port ballast tank (see figure 6). Damages were estimated at $800,750.

**Figure 6.** Damage to the port side of the *American Mariner* (circled) after striking the Munuscong Channel Junction Light. (Source: Coast Guard)

Initial underwater scans performed by the US Army Corps of Engineers indicated damage to the seabed foundation and underwater structure of the Munuscong Channel Junction Light, which caused the structure to lean from its originally constructed orientation (see figure 7). According to the Coast Guard Civil Engineering Unit, the estimated cost for repairs was $1.25 million, and the cost for replacement was estimated at $2.2 million due to the remote location of this ATON and mobilization costs for in-water work. As of the date of this report, repairs have not been made to the Munuscong Channel Junction Light.

**Figure 7.** Upper portion of the Munuscong Channel Junction Light after being struck by the *American Mariner*. (Source: Coast Guard)

## 1.3.2 Steering Control System

The steering system of the *American Mariner* consisted of two electrically driven, variable displacement hydraulic pumps that took suction of hydraulic oil from a sump through a 125-micron suction filter (see figure 8).[4] The system was equipped with directional valves and system relief valves, set at 2,300 pounds per square inch. A control motor, via mechanical linkages, mechanically adjusted the stroke of each of the main hydraulic pumps. Per the third-party technician, the control motor would move the mechanical linkages to "put oil through the cylinders to move the rudder to a specific degree."

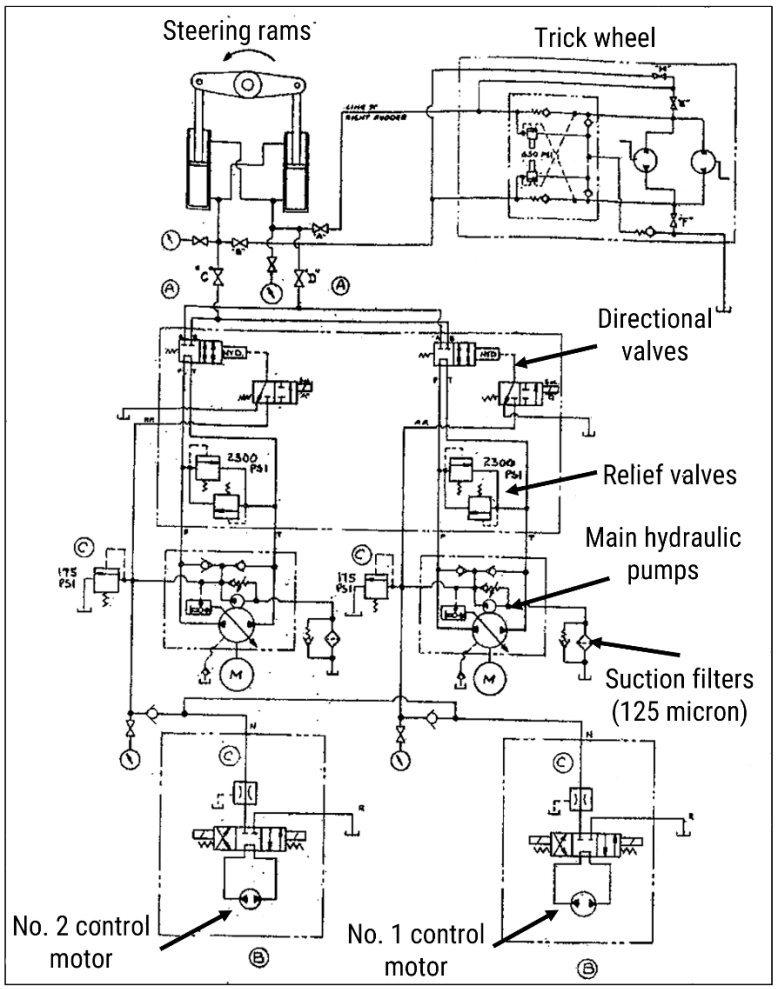


**Figure 8.** Diagram of hydraulic piping and components for the steering system aboard the *American Mariner*. (Background source: Grand River Navigation, Inc.)

[4] A 125-micron filter element can capture particles up to 0.0049 inches (0.1250 millimeters) in diameter in the mesh.

The output shafts of both control motors connected to input shafts in the trick wheel gear box assembly via couplings. The output shafts from the trick wheel gearbox were connected to the swash plate of the main steering pump via mechanical linkages to control the stroke and adjust the output flow of the main pumps to the main hydraulic steering rams, which rotated the rudder to a desired angle (see figure 9).

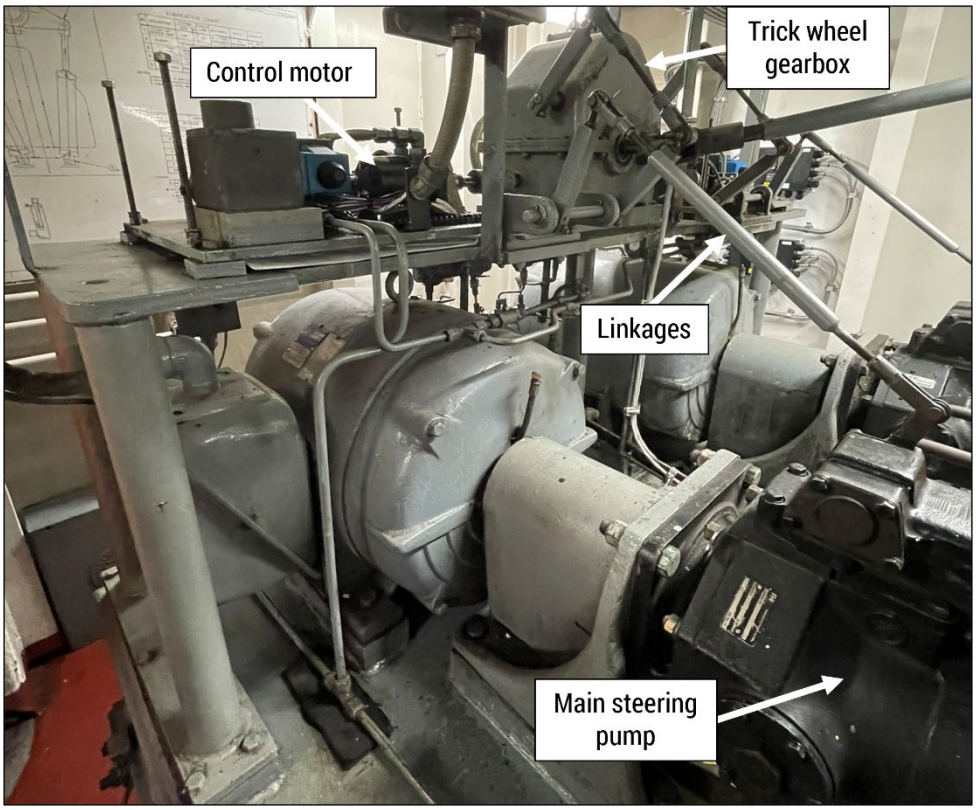


**Figure 9.** Steering gear arrangement aboard *American Mariner*.

### 1.3.3 Layup Period Steering Gear Hydraulic System Maintenance

During the 2023–2024 winter layup period, the vessel's operating company contracted third-party technicians to perform annual preventative maintenance on the steering gear hydraulic system. Technicians from the hydraulic service company had been performing maintenance on Great Lakes vessels like the *American Mariner* for over 30 years. This service was completed on February 21, 2024.

The service report stated that both main directional valves and all four high-pressure relief valves on the main hydraulic system were disassembled, inspected, and resealed. (This process included the installation of new O-rings.) No damage or contamination was found, and all spool clearances were normal. Both main hydraulic pumps were tested for efficiency and were found to be 96% efficient.

All relief valves were confirmed as set to 2,300 pounds per square inch as per hydraulic diagrams, and no adjustments were made. The technicians reported that the hydraulic fluid level was checked and found to be at an appropriate level. The service report noted that the ship's crew had changed the 125-micron suction filters on February 5, 2024, and, therefore, the service technicians did not remove or change the filter elements.

The manufacturer's recommended maintenance of the steering system included ensuring proper oil was used at the specified level. Hoses and fittings were to be checked regularly for leaks, and the oil was to be changed (with filtered or strained oil) if the color of the oil changed or at least once a year. The oil filter was equipped with an indicator gauge to show the condition of the filter, and the filters were to be replaced based on their condition. Since chartering the vessel, the operators had sent in samples of the steering system oil for analysis annually. Each time, the results stated "all elements are acceptable" and that the "oil is reusable." A work order summary for the steering system identified that annual inspections, as well as unscheduled maintenance, had been completed.

## 1.3.4 Postcasualty Testing

### 1.3.4.1 Steering Control System Evaluation

Later on the day of the casualty, third-party hydraulic technicians arrived aboard the anchored vessel and inspected the removed no. 1 control motor with ship's engineers. The third-party technicians reported that the motor would not rotate by hand and was "severely locked." One of the technicians used a hammer to separate the gear assembly, and a "non-metallic black piece of material" was found lodged between the inner and outer gear machining and gear housing. The chief engineer described the debris, saying it looked like "either gasket material or a sliver of an O-ring," and was about the size of a "quarter of a pencil eraser." The debris found inside the no. 1 control motor was retained for further testing (see figure 10). Section 1.3.4.2 provides more information about testing performed on the debris found in the no. 1 control motor.

**Figure 10.** Debris (circled) found in no. 1 steering gear control motor aboard the American Mariner. (Source: Coast Guard)

On April 1, a technician from the company that had installed the steering control system on the bridge of the *American Mariner* during the winter layup period emailed the vessel's captain and chief engineer with an evaluation of the intermittent alarms that had been received from the steering control system while underway. The technician determined that with two hydraulic pumps running, the system was "oversteering" (rudder traveling more than commanded) and the "force of the [water] current and both hydraulic pumps running pushed the rudder to bounce off the end stops causing a false steering alarm." When a slight opposite steering command was received, the alarm cleared. The technician concluded that some of the control settings needed fine-tuning. The technician assisted the crew with adjusting and recalibrating the sensitivity settings of the electronic steering control system. After making these changes, and while running the replacement no. 1 control motor installed immediately after the casualty, all alarms cleared, and the system operated normally.

On April 25, technicians (from the company that worked on the ship during winter layup) and the ship's engineers opened the access cover to the steering system's hydraulic oil sump to inspect the condition of the oil and the sump. The service technician noted "a fair amount of unknown materials, both ferrous and non" at the bottom of the sump, and that the access cover was covered in gasket material and a type of silicone sealant. On September 1, technicians removed a brown O-ring from a directional valve to be used as an exemplar sample for comparative testing.

The service technician provided a plan to install a 10-micron filter (which has a finer mesh than the 125-micron filter) in the hydraulic control system to filter the

hydraulic oil being fed to the control motors. He stated that other Great Lakes vessels with similar steering systems have additional filters in the control circuit (the hydraulic piping that fed the control motors). The filter was intended to be located before the steering flow control valve for the hydraulic supply for both control motors and would include an electric pressure differential switch, which, if the filter became clogged, would send an alarm signal to the existing steering control panel. The hydraulic company also developed a plan (delivered in a service report) for disconnecting the steering control tie rod from the pump, which would allow for manual control of the pump direction in an emergency. As of the date of this report, these modifications had not yet been implemented aboard the *American Mariner*.

#### 1.3.4.2 Debris Spectroscopy

On June 24, 2024, a third-party laboratory conducted nondestructive spectroscopic testing of the debris found in the no. 1 control motor after the motor was opened and inspected. The three pieces of debris (two black pieces and one dull red piece), measuring between 2 to 4 millimeters (0.08 to 0.16 inches) in length, were submitted for testing. The laboratory used Fourier transform infrared (FTIR) spectroscopy as well as energy dispersive spectroscopy (EDS) to determine the chemical and elemental composition of the debris.[5] The two black pieces were an infrared spectral match to polyvinylidene fluoride (PVDF), and the presence of oxygen, fluorine, magnesium, calcium, and other trace elements was detected. The dull red piece of debris was an infrared spectral match to polypropylene (PP) with fillers, and the presence of oxygen, iron, silicon, copper, zinc, and other trace elements was detected.

[5] *Fourier transform infrared* (*FTIR*) *spectroscopy* is a method for identifying chemical composition of a material by measuring how a material absorbs and transmits infrared light. *Energy dispersive spectroscopy* (*EDS*) is a microanalytical technique used to identify and quantify the elemental composition of a material by measuring the energy of characteristic X-rays emitted from a sample when bombarded with electrons.

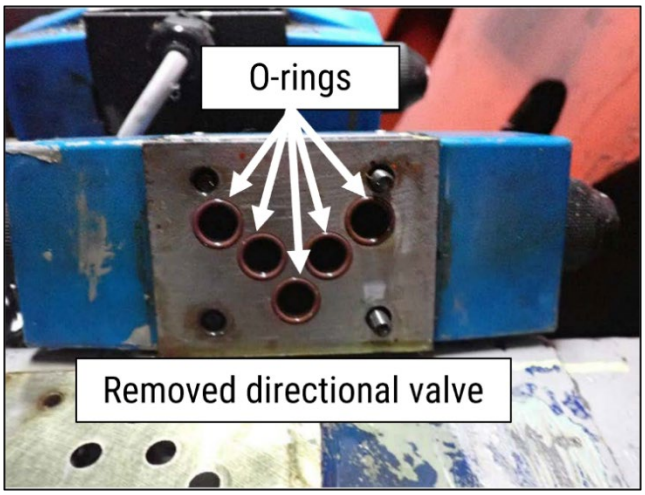


**Figure 11.** Removed directional valve from *American Mariner* showing the replaced O-rings during winter layup. (Source: Grand River Navigation, Inc.)

On September 23, 2024, the third-party laboratory released a summary of results for FTIR spectroscopy and EDS testing performed on one of the brown O-rings that had been installed during winter layup maintenance and two types of sealing materials (one green and one black) that had been previously removed from the *American Mariner* by technicians for comparative purposes (figure 11). The FTIR analysis determined that the exemplar O-ring material was PVDF, and the EDS analysis of the exemplar O-ring found the presence of carbon, oxygen, fluorine, calcium, and other trace elements, including barium and zinc. The FTIR analysis of the green sealing material found the material to be consistent with silicone-based thread sealant, and the EDS analysis confirmed the presence of silicon. The exemplar black sealing material was determined to be silicone rubber sealant with calcium carbonate filler. The EDS of the sealing material confirmed the presence of calcium.

# 2 Analysis

On March 28, the bulk carrier *American Mariner* struck the Munuscong Channel Junction Light in the St. Marys River near Sault Ste. Marie, Michigan, after the steering gear locked the vessel's rudder at 20° left.

The vessel was on its first voyage of the season following its winter layup period, during which hydraulic technicians performed annual preventative maintenance on the ship's steering gear hydraulic system and electronic technicians installed a new steering electronic control system stand on the bridge. Coast Guard inspections and class society surveys, which included testing and inspection of the new steering control system, were completed. Before departing on March 26, the crew completed predeparture functional steering tests.

During the voyage leading up to the contact, alarms for the vessel's steering system sounded intermittently on the bridge while the crew was operating in hand steering and running both steering pumps. Crewmembers investigated the alarms but could not determine the cause, and the rudder appeared to properly respond to input commands. Additionally, the steering hydraulic system was found to be hunting between left and right positions while the two pumps were running. Once electronic technicians recalibrated the steering control system after the casualty, the steering alarms and hunting conditions no longer occurred—indicating likely issues with the newly installed control system's calibration of parameters.

Immediately after the casualty, crewmembers inspected the steering system and determined that the no. 1 control motor (which controlled the stroke of the main hydraulic pump) within the vessel's steering system had failed. The motor was dissembled, and a piece of black, pliable debris was found to be lodged in between the rotating gears of the control motor, preventing it from rotating properly. Once seized, the control motor's corresponding linkages to the main steering pump remained stationary, preventing the main steering pump from changing output pressure and locking the rudder in its last ordered position at 20° left. Once a replacement control motor was installed, the steering system responded properly to steering commands from the bridge.

During a postcasualty inspection of the hydraulic sump, technicians noted a "fair amount of contamination of unknown materials, both ferrous and non" within the hydraulic oil. The suction filters were rated at 125 microns, meaning that particles larger than 0.125 millimeters (0.005 inches) would be captured in the mesh of the suction filter elements. The debris found inside the no. 1 control motor ranged from about 2–4 millimeters (0.08–0.16 inches) in length. Therefore, since the debris was

larger than the mesh size of the filter and would have been captured, the debris likely did not originate from within the hydraulic sump of the steering system.

A FTIR analysis found that the two black pieces of debris from the steering system's no. 1 control motor and an exemplar O-ring (replaced on the directional valve during the winter layup period the month before the casualty) were PVDF; however, results from another type of analysis, EDS, differed. Additionally, the colors of the materials differed: the debris found in the no. 1 control motor was black and the exemplar O-ring was brown. Because the debris was not an exact match to the exemplar O-rings, it is possible that a similar type of PVDF O-ring used previously within the hydraulic system or a material from another component in the system downstream of the suction filters could have been dislodged during operation. Therefore, the origin of the debris found in the no. 1 control motor could not be positively identified, which indicates that the debris likely came from another hydraulic system component that was circulating through the unfiltered portion of the hydraulic control system.

It cannot be determined whether conditions that triggered the alarms from the newly installed control system and/or the hunting condition contributed to debris that caused the failure of the no. 1 control motor. The additional heat generated by, and material wear on, the steering system as it constantly hunted for position while running on two pumps in an attempt to adjust to ordered steering commands could have been potential factors.

Within 20 seconds of noticing the steering gear locked at 20° left, deck crewmembers brought the engine from full ahead to full astern and dropped anchors. The bow thrusters and stern thrusters were not online during the river transit, nor were they required to be. However, even if running, with the vessel's speed about 13 mph, the thrusters would not have effectively changed the vessel's heading. Although the deck crewmembers quickly used all available means to avoid striking the Munuscong Channel Junction Light, they could not stop the vessel or make any corrective course changes.

# 3 Conclusions

## 3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the contact of the bulk carrier *American Mariner* with the Munuscong Channel Junction Light was O-ring-type material debris in the steering gear system's hydraulic oil becoming lodged within a control motor, which caused it to seize, resulting in the rudder locking at its last ordered position.

## Vessel Particulars

| Vessel | *American Mariner* |
|---|---|
| **Type** | Cargo/Dry Bulk (Bulk carrier) |
| **Owner/Operator** | American Steamship Co./Grand River Navigation, Inc. (Commercial) |
| **Flag** | United States |
| **Port of registry** | Wilmington, Delaware |
| **Year built** | 1980 |
| **Official number (US)** | 619736 |
| **IMO number** | 7812567 |
| **Classification society** | American Bureau of Shipping |
| **Length (overall)** | 730.0 ft (222.5 m) |
| **Breadth (max.)** | 78.0 ft (23.8 m) |
| **Draft (casualty)** | 12.5 ft (3.8 m) fwd, 22.5 ft (6.9 m) aft |
| **Tonnage** | 15,396 GRT |
| **Engine power; manufacturer** | 2 × 3,500 hp; EMD L20-645-E7 diesel engines |

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Northern Great Lakes** throughout this investigation.