Issued November 3, 2022 MIR-22-28

# Grounding of Towing Vessel *Marquette Warrior*

On November 21, 2021, about 1210 local time, the towing vessel *Marquette Warrior*, with nine crewmembers, was pushing 35 loaded dry cargo barges downbound on the Lower Mississippi River near Greenville, Mississippi, when the online electrical generator failed and the vessel subsequently lost steering. [1] Several barges grounded on the riverbank, and four barges were damaged, including a hopper barge that partially sank. No pollution or injuries were reported. Damage to the vessel, barges, and cargo was estimated at $1,242,500.


**Figure 1.** *Marquette Warrior* underway before the casualty. (Source: Warren Underwood)

[1] (a) In this report, all times are central standard time, all miles are statute miles, and speeds are speed over the ground. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA22FM005). Use the CAROL Query to search investigations.

| | |
|---|---|
| **Casualty type** | Grounding/Stranding |
| **Location** | Lower Mississippi River, mile 538, Greenville, Mississippi<br>33°22.33′ N, 91°06.68′ W |
| **Date** | November 21, 2021 |
| **Time** | 1210 central standard time<br>(coordinated universal time –6 hrs) |
| **Persons on board** | 9 |
| **Injuries** | None |
| **Property damage** | $1,242,500 |
| **Environmental damage** | None |
| **Weather** | Visibility 10 mi, clear, winds south-southwest 11 kts, air temperature 72°F |
| **Waterway information** | River, channel width about 1,200 ft, current 4-5 mph, river gage 17.5 ft and rising |

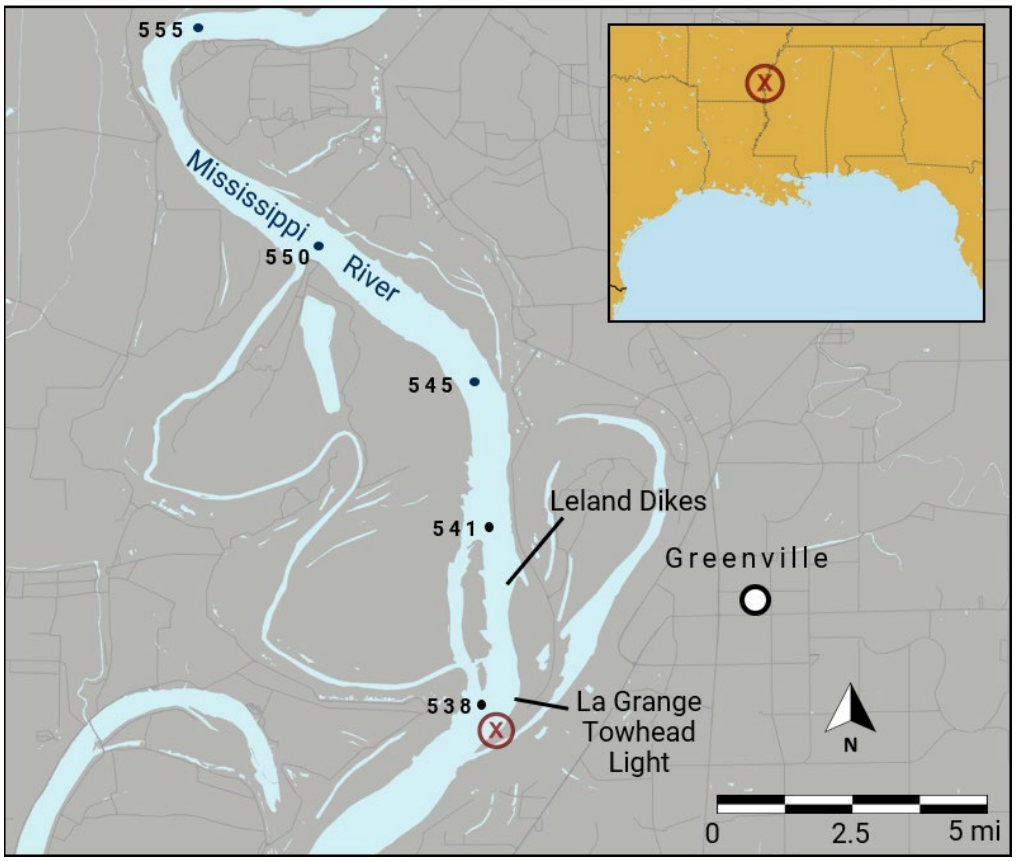


**Figure 2.** Area where the *Marquette Warrior* tow grounded, as indicated by a red *X*. (Background source: Google Maps)

# 1. Factual Information

## 1.1 Background

The 166-foot-long line-haul towing vessel *Marquette Warrior* was owned and operated by Marquette Transportation Company. Line-haul boats are generally larger towing vessels with higher horsepower, used for towing over large distances between major ports. Line-haul tows can be as large as 40 or more barges. The *Marquette Warrior* was powered by two 16-cylinder EMD 710G7C diesel engines that produced a combined 8,000 hp and connected to two propellers via reduction gears.

## 1.2 Event Sequence

On the morning of November 21, the *Marquette Warrior* was transiting downbound on the Lower Mississippi River north of Greenville, Mississippi, pushing a 1,000-foot-by-245-foot tow consisting of 35 loaded dry cargo hopper barges arranged five wide and seven long. The barges contained soybeans, beans, rice, and corn to be delivered to several facilities farther south. The crew consisted of a captain, pilot, mate, engineer, cook, two deckhands, and two deckhand trainees.[2] The captain and pilot rotated navigation watches (6 hours on, 6 hours off), with the captain taking the 0500–1100 and 1700–2300 (front) watches, and the pilot taking the 1100-1700 and 2300–0500 (back) watches. According to the crew, the transit was unremarkable, and there were no issues with the vessel's operation until the time of the casualty.

About 1040, the pilot relieved the captain from the navigation watch. At 1150, the vessel and tow passed mile 541 and entered a section of the river known as the Leland Dikes, which stretched for about 3.5 miles down river. The pilot stated the current was a "very swift" 4-5 mph in that area, making navigation challenging. At that time, aided by the river current, the *Marquette Warrior* was traveling about 10 mph.

About 1200, the vessel's engineer, who primarily performed engine room preventive maintenance and rounds during the day, returned to the engine room from having lunch in the galley and noticed that the upper engine room lights were flickering. He proceeded to the main switchboard, located in the engine control room, to

[2] *Pilot* is a term used aboard towing vessels on inland waterways for a person, other than the captain, who navigates the vessel.

investigate. He observed a ground fault indication on the switchboard and suspected that the fault might have been the reason for the flickering lighting.[3]


**Figure 3.** Main switchboard located in the engine control room aboard the *Marquette Warrior*. (Source: Marquette Transportation Company)

In an effort to determine the cause of the ground fault, the engineer opened several electrical breakers to isolate nonessential equipment. However, the fault did not go away, and the lights continued to flicker. Using the vessel's intercom system, the engineer then called the pilot in the wheelhouse to inform him of the lighting issue. The engineer also asked the pilot to push up against the riverbank so he could troubleshoot in a safer, controlled condition. The pilot was still navigating the vessel through the Leland Dikes at 10.5 mph. He informed the engineer that it would be another 25-30 minutes before he could safely push the tow in on a bank and stop the vessel. The pilot then radioed the on-watch deck crew on the barges and requested that they return to the towboat to assist the engineer with troubleshooting and to ensure they were not on the barges in the event of an issue. Immediately after his call with the pilot, the engineer walked forward to the galley to inspect the lighting. As he arrived in the galley, the lights on "the whole boat started flashing." The engineer returned to the engine room, where he was met by the mate. The engineer called the wheelhouse again and

[3] A *ground fault* is an inadvertent contact between an energized conductor and ground or a grounded equipment frame.

informed the pilot that he suspected there was an issue with the online (port) electrical generator set (genset) and the vessel needed to stop so he could switch online gensets. He said he asked the pilot to stop the vessel because he knew that the process to switch online gensets would cause a temporary loss of vessel power. The pilot stated that the tow was still not in an area where they could safely stop.

The vessel was equipped with two gensets that provided power to electrical equipment and lighting on board. Each genset consisted of a diesel engine coupled to and driving a 139-kilowatt Marathon model 431, 3-phase, 480-volt electrical alternator. The 3-phase, 480-volt power produced by the onboard gensets was wired to a main switchboard and then distributed to various electrical equipment and systems on the vessel, such as motorized pumps, fans, and step-down transformers that reduced the voltage to 120 volts to power lighting and lower-voltage circuits. Each genset was sized to power the entire vessel independently, and the switchboard and electrical bus were configured so that either genset could do so. However, both gensets could not be on the bus together. The process to switch which genset powered the towboat required the engineer to manually start the offline genset, then open the main breaker for the online genset—leaving the vessel momentarily without electrical power. Once the power to the main bus was interrupted, the running offline (oncoming) genset's main breaker could be closed, bringing the genset online and supplying the main switchboard (and the vessel) with electrical power.

During normal operations, hydraulic rams moved the *Marquette Warrior*'s steering rudders. The pressurized hydraulic fluid required to move the rams was supplied by one of two 3-phase, 480-volt electric-motor-driven hydraulic steering pumps. Only one of these motor/pump combinations would run at a time, and they were started and stopped from the wheelhouse or locally at the motor/pump in the engine room from a motor controller panel. If power was lost, the 480-volt electric motors that drove the steering pumps would stop, automatically restarting once power was restored.

About 1205, 5 minutes after the engineer first notified the pilot of an electrical issue, the pilot attempted to initiate a turn to starboard at the La Grange Towhead Light and realized that the rudders were not responding. The pilot immediately radioed the mate, who was with the engineer, and informed them that the vessel had lost steering. After sounding the general alarm, the pilot attempted to change over the hydraulic steering pumps using a switch in the wheelhouse, but it had no effect. Using the main engine throttles in the wheelhouse, the pilot brought the engines astern to slow the vessel's speed.

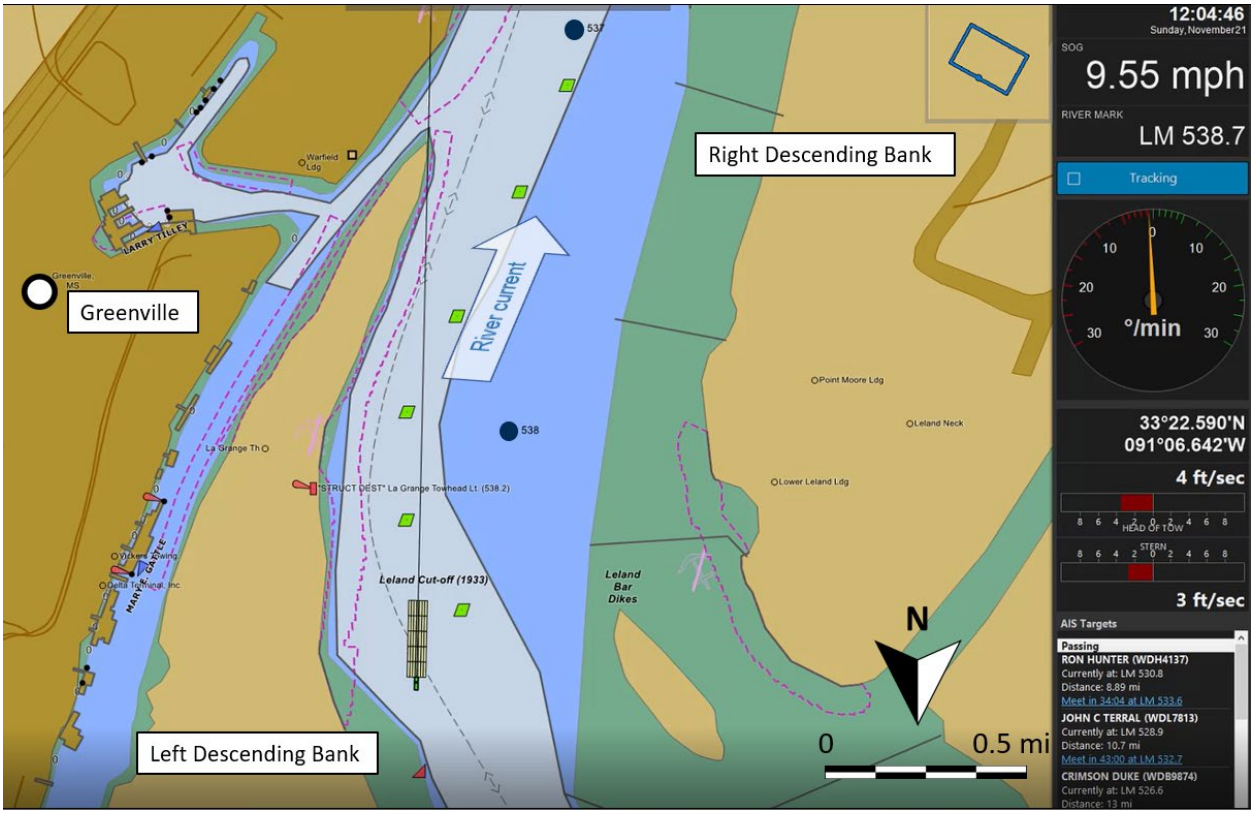


**Figure 4.** Electronic chart system screenshot from the *Marquette Warrior* during the casualty, showing the tow about 1205, when the vessel lost steering. (Source: Marquette Transportation Company)

After becoming aware that the vessel had lost steering and still suspecting an issue with the online (port) genset, the engineer began switching over to the starboard genset, a process that he said took "a few minutes." About 1208, the engineer had successfully switched gensets and informed the pilot. The pilot observed that he had regained steering control. With the vessel traveling at 7.6 mph and still backing down, the pilot, who had been joined in the wheelhouse by the captain, attempted to steer the vessel to starboard around the turn.

About 1210, traveling down river about 5 mph, the forward port barges in the *Marquette Warrior*'s tow grounded at mile 538 on the left descending bank, and the tow began to push up onto the bank.[4] The tow then started to rotate in the current. The pilot, realizing that the section of navigable river was not wide enough for the tow to rotate around safely, maneuvered the vessel to purposely part the wires holding it to the tow

[4] The inland towing industry refers to the shorelines of Western Rivers as the left and right banks when traveling (facing) downriver. The left bank is called the left descending bank, and the right bank is called the right descending bank.

(break the vessel out of tow) and prevent the vessel and tow from being broadside to the swift river current and potentially capsizing. After separating the vessel from the tow, the barges in the tow began to also split from one another.

Following the grounding, the *Marquette Warrior*, aided by several nearby Good Samaritan vessels, corralled the scattered barges and rebuilt the tow. Four of the barges sustained damage, mostly to their rake bottoms and side shell plating, with the steel plating being dented or inset. One barge partially sank and was later salvaged; its bean cargo was contaminated with water and was declared a loss. The total damage to the barges was estimated to be $215,000, and the lost cargo was estimated to be worth $1,020,000. The *Marquette Warrior* also sustained an estimated $7,500 in damage as a result of the casualty.

**Figure 5.** A barge that grounded and partially sank following the casualty. (Source: Marquette Transportation Company)

## 1.3 Additional Information

### 1.3.1 Crew Experience

The pilot on watch at the time of the casualty had been on board the *Marquette Warrior* for 2 days. He had worked for Marquette for 22 years on many of their other vessels. He held a US Coast Guard credential for master of inland waters and would sail as either captain or pilot while on board. He had navigated the section of river

where the casualty occurred four times, on other vessels, in the month before the casualty.

The vessel's engineer at the time of the casualty had been on board for 19 days. He did not hold a Coast Guard credential, nor was it required. He had been in the maritime industry for about 5 years, working for Marquette the past 2 years, predominantly as an engineer.

### 1.3.2 Vessel Refit

In January 2021, the *Marquette Warrior* started a 9-month refit and refurbishment at a shipyard. The project consisted of the refurbishment of the accommodations, replacement of wasted steel on the hull, and, as described by a representative from the shipyard, a "complete electrical replacement of all wiring and electrical devices." Every electrical cable throughout the vessel was changed out, according to a Marquette port engineer.

Included in the work was the replacement of the two hydraulic steering pumps and motors, with new units purchased and supplied by the original equipment manufacturer. They were installed by the shipyard and tested satisfactorily before use.

Also completed was the refurbishment of both gensets' alternators. To facilitate this, the shipyard workers uncoupled the two alternators from their respective diesel engines and disconnected the electrical cable leads from the alternators' terminal blocks that connected the alternators to the main switchboard. The two alternators were then shipped to a shoreside facility that specialized in alternator and motor refurbishment. During the refurbishment process, each alternator was dismantled and inspected. The internal components were electrically tested to ensure proper functioning. A general cleaning was conducted, the units were baked in a specialized industrial oven to remove any internal moisture, and then new insulating varnish was applied to the windings. All bearings were replaced, and the alternators were reassembled. The winding leads from the alternators were secured to the terminal blocks using lock washers and 1/2-inch nuts. The voltage of the alternators was also changed from 3-phase, 208 volts to 3-phase, 480 volts, which was within the original equipment manufacturer operating parameters. To ensure that the alternators' electrical and mechanical functions were satisfactory, they were bench-tested. Once refurbished and successfully tested, the alternators were packaged up and sent back to the vessel, where they were installed by shipyard electricians.

The *Marquette Warrior* completed a satisfactory sea trial period in early October 2021, and the vessel returned to normal service.

### 1.3.3 Port Genset

#### 1.3.3.1 Precasualty

Two weeks before the casualty, on November 7, the port genset shut down while running, and the vessel lost power. The vessel's engineer (the same engineer as the day of the casualty) determined the cause of the shutdown to be a failed 12-volt direct current electrical relay within the genset's diesel engine starting circuit, which he replaced with an onboard spare. During the repair, he also completed the company's preventive maintenance work order titled "E475 Generator Electric End Maintenance – Monthly." The work order listed two questions that the engineer was required to answer, ensuring that the task was completed:

> (1) was the electrical cover [panel] on the generator electric end [alternator] removed and all wires/connections checked for wire fray, chaffing and loose connections, and
>
> (2) were cooling air screens cleaned and free of oil and debris?

The engineer certified that he had completed this work. Following the casualty, the engineer said that while completing the maintenance on November 7, he did not have to use any wrenches to tighten (or check) connections, and he did not observe anything out of the ordinary.

At the time of the casualty, the port genset had been running for 72 hours since the relay failure and preventive maintenance, without incident. It had run a total of 675 hours (about 28 days) since it had been refurbished.

#### 1.3.3.2 Postcasualty

Suspecting an issue with the port genset, the vessel's engineer notified the company's port engineer, who arrived on board within a few hours of the casualty with a new alternator. The port genset's alternator was changed out and shipped back to the company's facility for inspection. The port engineer who assisted the vessel's engineer with the replacement indicated that he observed "burnt terminals" on the terminal block within the alternator and determined this to be the cause of the failure. The fiber terminal block had threaded steel studs (posts) where the leads from the alternator's windings, the main switchboard, sensing wires, and current transformers were secured with 1/2-inch nuts and lock washers. Once the damaged alternator arrived at the company's facilities, it was inspected by a supervisory port engineer, who also said he observed multiple burnt wires. He suspected that a loose wire may have been the reason for the alternator failure.

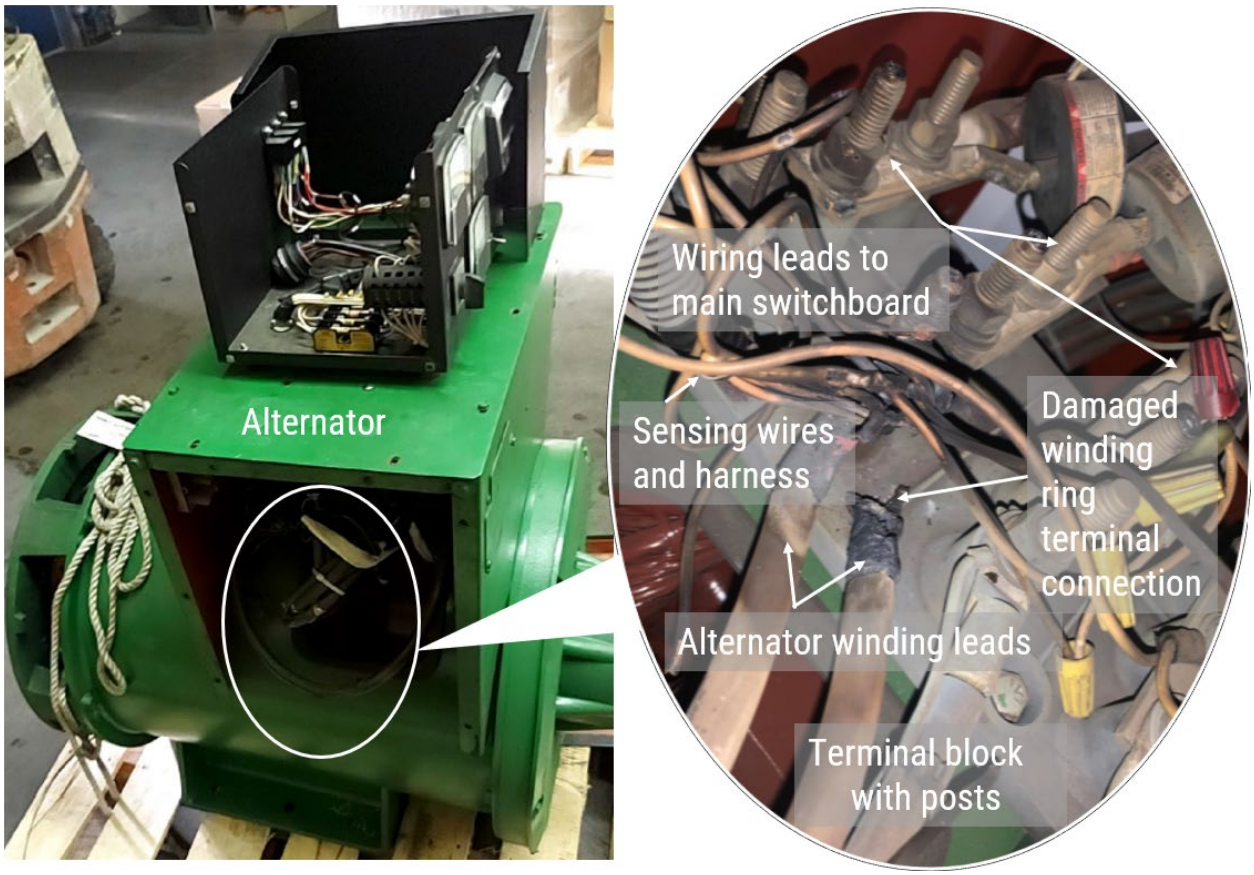


**Figure 6.** Port alternator with side cover removed *(left)* and close-up of terminal block (*right*), after being taken from the *Marquette Warrior* postcasualty. The control box (with cover removed) is mounted on the top panel. (Sources: Warden Electric [*left*], Marquette Transportation Company [*right*])

The company then sent the failed alternator to the same company that had refurbished the unit several months prior for inspection and repair. The repair facility personnel observed a burnt winding lead terminal connection (ring terminal connection) that had become separated from the terminal block post (also identified by the port engineers). They also identified that three of the center posts on the terminal block had arcing residue built up on their tops, indicating that an item had been coming in contact with them. Further, a wiring harness containing sensing wires, which led from the terminal block up into the control box, mounted on the top panel of the alternator, was "blown completely in half." They suspected that this wiring harness, normally routed clear of the terminal block posts, had been lying across the posts, rubbing through the jacketing of the harness and eventually through the wires' insulation. Once the bare sensing wires contacted the posts (studs), arcing occurred. They compared this arcing to a welding arc, where small bits of the metal wire would be deposited onto the posts. An electrician from the repair facility also explained that, along with the arcing, excess heat would deteriorate the insulation for the wires attached to the terminal block. The repair

facility personnel suspected the wire insulation deteriorated over a prolonged period, until a point where the arcing and heat became severe enough to cause the winding terminal connection to fail. The electrician suspected that, during this period, there would have been flickering lights and fluctuations in the vessel's voltage and amperage.

An electrical supervisor from the shipyard who reviewed pictures of the burnt and disconnected winding lead terminal connection after the casualty suspected that once the alternator terminal connection failed and became separated from the terminal block post, the alternator would no longer be able to supply 3-phase power. He expected that there would have been heavy fluctuations of the alternator's voltage and amperage output, as well as the flickering of the vessel's lights. Additionally, the 3-phase electric motors for the steering pumps (and all other 3-phase equipment) would not have been able to produce any torque and would have stopped (a condition known as single-phasing motor).

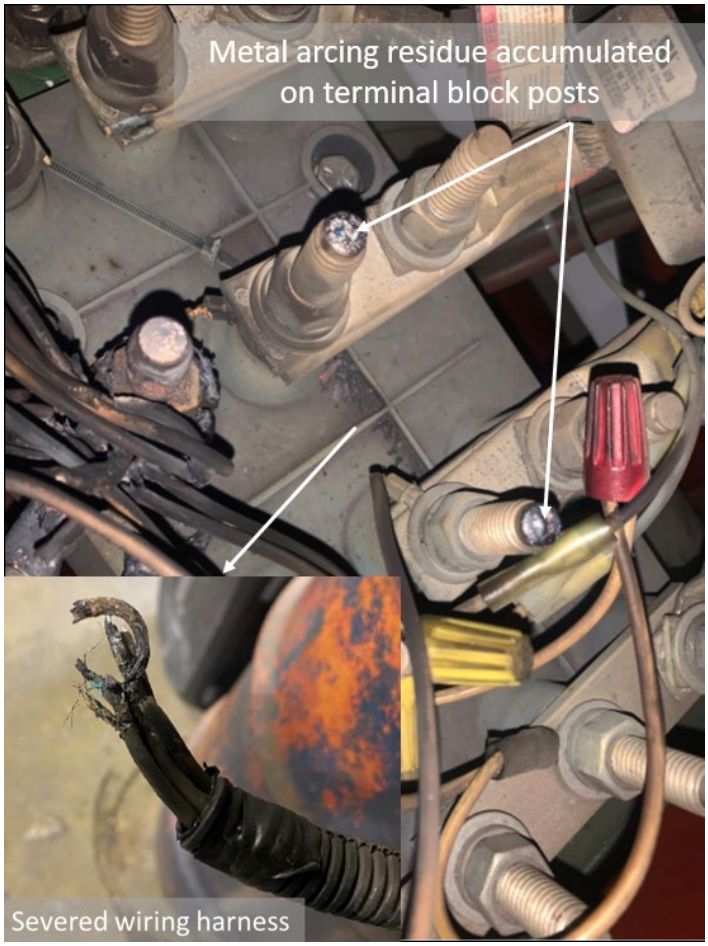


**Figure 7.** Port alternator terminal block showing metal arcing residue on the terminal block posts. Inset shows the severed wiring harness. (Source: Marquette Transportation Company)

# 2. Analysis

## 2.1 Loss of 3-phase Electrical Power, Loss of Steering, and Grounding

The engineer observed flickering lights and a ground fault indication on the main switchboard, and he attempted to identify and isolate any equipment that might have been causing the fault. Suspecting a potentially serious problem with the electrical system, the engineer appropriately contacted the pilot in the wheelhouse to request he stop the vessel so the engineer could troubleshoot. Given the size of the tow (35 barges), the vessel's speed (10.5 mph), and location of the tow at the time (Leland Dikes), the pilot was not able to stop the vessel. Thinking of the safety of the deck crew on the barges and that the engineer might need assistance, the pilot called the deck crew back onto the vessel, which likely prevented injuries to crewmembers during the subsequent casualty.

After additional troubleshooting and only 5 minutes after becoming aware of a problem, the engineer identified that there was an issue with the online (port) genset. Knowing that changing over gensets required the vessel to momentarily lose power, he again requested that the pilot stop the vessel. At the same time, the pilot noticed that he had lost steering control. He immediately sounded the general alarm and ordered astern propulsion of both engines to slow the vessel's speed. Hearing that the vessel had lost steering, the engineer decided to switch online gensets—even though the vessel was not stopped. Within 3 minutes, the vessel regained 3-phase power and steering. Although the engineer resolved the electrical issue by switching gensets and restored steering relatively quickly, the swift current and limited maneuverability of the large tow prevented the pilot from avoiding grounding when the vessel lost its ability to steer while navigating a turn.

## 2.2 Port Alternator Casualty

The *Marquette Warrior* lost electrical power about 2 weeks before the casualty, when the port genset tripped offline. The onboard engineer investigated the issue, and he identified and replaced a faulty relay within the 12-volt starting circuit. Because this failure was within the 12-volt direct current circuit, it was likely unrelated to the failure of the port genset on the day of the grounding.

Following the grounding, company engineers removed and visually inspected the genset's Marathon model 431 alternator and then sent it to the company that had recently refurbished the unit for additional inspection and repair. A shipyard electrical supervisor who viewed photos of the damaged alternator after the casualty reported that a ring terminal connection for one of the alternator's winding leads was burnt and had

failed, causing the alternator to lose one of its phases and the steering pump motors (and all other 3-phase equipment) to stop due to a lack of available torque. Electricians from the company that had recently refurbished the alternator also observed the burnt and damaged ring terminal, and in addition they discovered arcing metal residue on three terminal block posts and a severed wiring harness. According to the electricians, this indicated that the wiring harness had been lying across, rubbing against, and eventually arcing to the terminal block posts for a prolonged period. All parties involved agreed that the way the alternator failed would have caused fluctuations in the alternator output voltage and amperage and that the vessel likely would have experienced flickering lights.

The ring terminal connection that was observed to be burnt and damaged following the casualty had been secured to the terminal block post while being refurbished. According to the alternator servicing facility, a lock washer was used to prevent inadvertent loosening of the connection. The electrical alternator unit was then bench-tested satisfactorily. When shipyard electricians later installed the port genset's alternator in the vessel, there was no need for them to touch the winding leads on the terminal block, as these only needed to be changed if the voltage of the unit was to be altered, something that had already been completed. The shipyard would have only connected the outgoing leads to the terminal block, which did not show signs of failure after the casualty. The unit field tested satisfactorily following shipyard installation. Also, the vessel's engineer stated that during a recent preventive maintenance inspection of the port genset alternator, he did not need to use a wrench to tighten connections. Because the alternator only had 675 hours (about 28 days) of operating time since being refurbished, it is unlikely that the genset's winding terminal connection that was burnt and damaged had become loose.

The November 7 preventive maintenance performed by the vessel's engineer required the removal of the port genset alternator's cover panel to inspect "all wires/connection" for wire fray, chaffing, and loose connections. Electricians' analysis of the alternator following the casualty indicated that the most likely cause of the failure was rubbing or chaffing of the sensing wiring harness, which led to arcing between terminal block posts, heat buildup, insulation failure, and eventual winding ring terminal failure. Because the onboard engineer did not notice any damage within the terminal box or to the sensing wiring harness during his inspection, it is likely the chaffing of the wiring harness took place over the 72 hours the genset ran between the November 7 maintenance inspection and the casualty on November 21. While it is possible the wiring harness could have shifted onto the terminal posts due to vessel vibrations, it is more likely that the wiring harness was inadvertently displaced during the vessel engineer's preventive maintenance inspection on November 7 and went unnoticed during his reinstallation of the cover panel.

# 3. Conclusions

## 3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the grounding of the towing vessel *Marquette Warrior* was a loss of steering, likely due to a wiring harness within an electrical generator that was improperly positioned during a maintenance inspection, resulting in the harness contacting the terminal posts, eventually causing the loss of 3-phase electrical power to the steering pump motors.

## 3.2 Lessons Learned

### Electrical Equipment Maintenance

Proper operation and maintenance of electrical equipment is required to avoid damage to vessel critical systems and prevent potentially serious crew injuries, particularly for electrical systems with high and medium voltage and equipment with uninsulated and exposed components. Electrical equipment should be installed, serviced, and maintained by qualified personnel familiar with the construction and operation of the equipment and the hazards involved.

| Vessel | *Marquette Warrior* |
|---|---|
| **Type** | Towing/Barge (Towing vessel) |
| **Flag** | United States |
| **Port of registry** | St. Louis, Missouri |
| **Year built** | 1975 |
| **Official number (US)** | 560979 |
| **IMO number** | N/A |
| **Classification society** | American Bureau of Shipping |
| **Length (overall)** | 166.0 ft (50.6 m) |
| **Beam** | 45.0 ft (13.7 m) |
| **Draft (casualty)** | 9.6 ft (2.9 m) |
| **Tonnage** | 779 GRT |
| **Engine power; manufacturer** | 2 x 4,000 hp (2,983 kW); EMD 16-710G7C III diesel engines |

NTSB investigators worked closely with our counterparts from **Coast Guard Marine Safety Detachment Vicksburg** throughout this investigation.

The National Transportation Safety Board (NTSB) is an independent federal agency dedicated to promoting aviation, railroad, highway, marine, and pipeline safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974, to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID DCA22FM005. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting–

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