August 1, 2023 MIR-23-16

Collision between Cargo Ship *Damgracht* and Cargo Ship *AP Revelin*

On August 21, 2022, about 1045 local time, the cargo ship *Damgracht* was inbound in the Sabine Pass Outer Bar Channel en route to Beaumont, Texas, and the cargo ship *AP Revelin* was outbound when the two vessels collided near Port Arthur, Texas.[1] There were no injuries to the *Damgracht*'s 16 crewmembers nor to the *AP Revelin*'s 19 crewmembers, and no pollution was reported. Damage to the *AP Revelin* was estimated at $3.4 million, and there were no reported damage costs for the *Damgracht*.

Figure 1. Cargo ships *Damgracht* (*above*) and *AP Revelin* (*below*) anchored after the collision.

[1] (a) In this report, all times are central standard time, and all miles are nautical miles (1.15 statute miles). (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA23FM038). Use the CAROL Query to search investigations.

Casualty type	Collision
Location	Sabine Pass, Port Arthur, Texas 29°37.52′ N, 93°49.3′ W
Date	August 21, 2022
Time	1045 central standard time (coordinated daylight time –5 hrs)
Persons on board	16 (*Damgracht*), 19 (*AP Revelin*)
Injuries	None
Property damage	$3.4 million est.
Environmental damage	None
Weather	Visibility 10 mi, mostly cloudy, winds from the south at 8 kts, air temperature 88°F, humidity 72%, morning twilight 0623, sunrise 0648
Waterway information	Channel, depth about 40 ft at casualty site

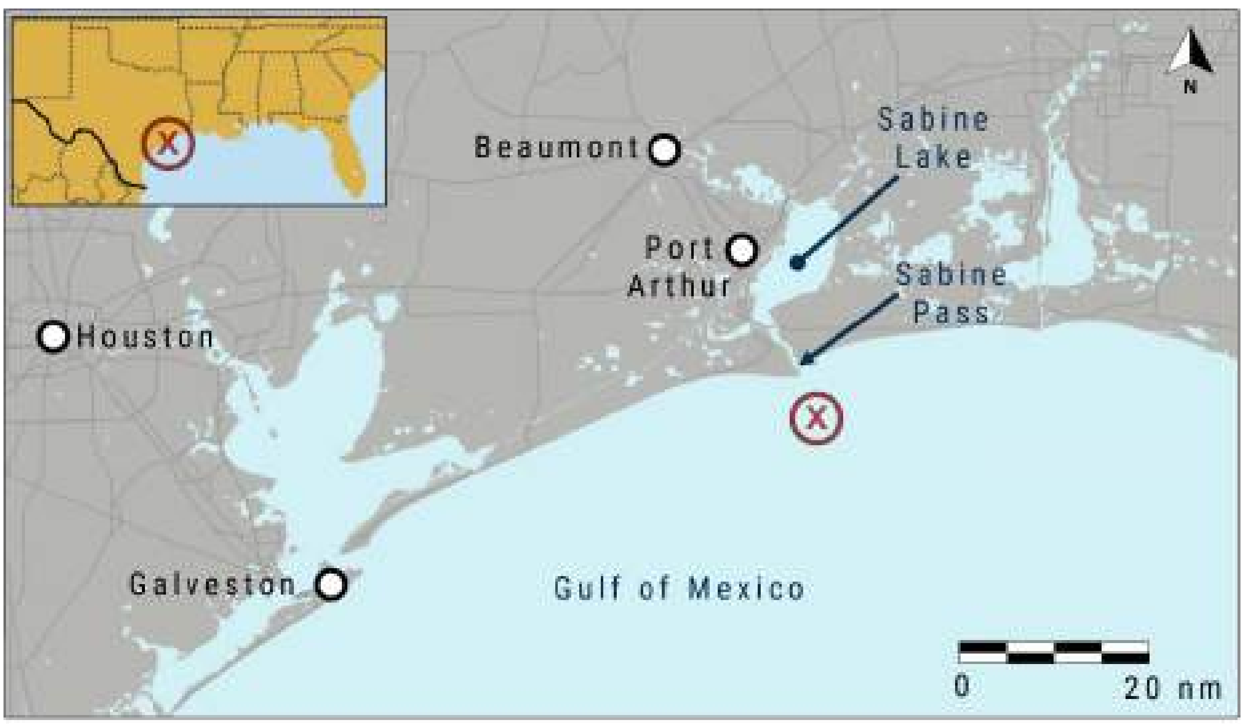

Figure 2. Area where the *Damgracht* collided with the *AP Revelin*, as indicated by a red *X*. (Background source: Google Maps)

1 Factual Information

1.1 Background

The 515-foot-long, steel-hulled, Netherlands-flagged cargo ship *Damgracht* was built in 2009 at Jinling Shipyard in Nanjing, China, and was operated by Spliethoff Beheer B.V. The vessel's propulsion was provided by a single controllable-pitch propeller driven by an 11,265-hp medium-speed diesel engine, supplemented during maneuvering with a 1,140-hp bow thruster. The bow thruster was powered by the main engine's shaft generator. The vessel was classified as a "Finnish-Swedish Ice Class 1A" vessel, and its holds were strengthened to carry heavy cargo.[2]

The 590-foot-long, steel-hulled, Croatian-flagged bulk cargo ship *AP Revelin* was built in 2016 at Qingshan Shipyard in Wuhan, China, and was operated by Atlantska, Plovidba. The vessel was equipped with a single propeller driven by an 8,180-hp diesel engine.

1.2 Event Sequence

On August 19, 2022, after unloading a portion of its cargo, the *Damgracht* departed Houston, Texas, en route to Beaumont, Texas, to offload the remainder of its cargo of bags of cement and spare parts for a power plant. About 1535 on August 20, when the vessel reached the sea buoy in the Sabine Bank Channel, a Sabine Pass pilot boarded the vessel to maneuver it into the port of Beaumont.

About an hour later, about 1624, the *Damgracht* was near buoy 29 of Sabine Bank Channel when the engine crew received a "main engine low cooling water pressure" alarm and a "high cooling water temperature" alarm. The crew reduced load on the engine, but the cooling water temperature continued to increase, and the alarm persisted, resulting in an automatic emergency shutdown of the engine when the cooling water reached the high alarm limit of 110°C (230°F). The captain stated that they used the "momentum of the ship to steer it out of the channel," and the crew anchored the vessel near buoy 29. About an hour later, tugboats arrived and towed the *Damgracht* to a fairway anchorage to the east of the Sabine Bank Channel (the pilot left the vessel later that evening).

[2] This notation, assigned by the vessel's classification society, indicated the vessel was constructed with additional hull strengthening as well as other arrangements that enabled the vessel to navigate through specific ice conditions.

While the vessel was anchored, the engine crew determined the no. 6 cylinder head gasket had failed and needed to be replaced.[3] To prepare the engine for this maintenance, the crew began cooling the engine about 1630 that afternoon by shutting down the lube oil purifier and its heater. They also started the turning gear (which used a geared electric motor to rotate the engine at a slow speed) and started a standby lube oil pump (with no heaters energized) to circulate lube oil through the engine for about 2 hours.

About 1830, after the engine had cooled down, the engine crew stopped the turning gear and the standby lube oil pump. They drained the cooling water from the engine and began removing the no. 6 cylinder head to access the failed gasket. They installed a shipboard spare head gasket and a spare cylinder head on the no. 6 cylinder. After the repair was completed, the engine crew opened all the crankcase doors to clean and inspect the crankcase sump, refilled the engine's cooling water system, and began preheating the engine using an electric heater in the cooling water system. About 2330, the engine crew started the main engine and completed operational testing for about 30 minutes at 500 rpm with no load (the controllable pitch propeller was set at zero pitch). Afterward, they cooled the engine for about 15 minutes and opened the doors of the crankcase to check for leaks and any abnormalities. Finding none, they restarted the engine for another operational test and ran it for about 90 minutes before shutting it down at 0135. The lube oil purifier and its heater were online through the night and the following morning.

On August 21, about 0815, a Sabine pilot with about 6 years of experience boarded the *AP Revelin*, which had been docked at pier no. 4 in the Port of Port Arthur, Texas, since August 13 and was loaded with a cargo of 32,500 tons of wood pellets bound for Immingham, England. After conducting the master/pilot exchange, the pilot navigated the vessel off the dock and proceeded outbound about 0845.[4] The *AP Revelin* transited down the Sabine River, passing through the Sabine Jetties, and into the Outer Bar Channel at 10 knots.

About 1010 the same day, the engine crew aboard the *Damgracht* started the main engine in preparation to maneuver the vessel into the port of Beaumont. At 1020, a Sabine pilot boarded the vessel as the crew was hoisting the anchor. The pilot, who had about 3 years' experience, estimated that he had completed about

[3] A *cylinder head gasket* provides a seal between the engine block and cylinder head and seals the combustion gasses within the cylinders to prevent lube oil and cooling water in the cylinder liner cooling water passages leaking into the cylinders.

[4] A *master/pilot exchange* is required at the start of pilot transits and includes discussion of the vessel's navigational equipment, any limitations of maneuverability, available engine speeds, berthing maneuvers, intended course and speed through the waterway, anticipated hazards along the route, weather conditions, composition of the bridge team and deck crew both forward and aft including bow lookout, and so on.

750 trips in Sabine Pass. During the master/pilot exchange, the pilot asked the captain about the status of the main engine after the previous day's repairs. The captain advised that the crew had conducted routine maintenance on the main engine and that everything was "in good working order to transit the channel."

At 1030, the *Damgracht* got underway, heading inbound up the Sabine Bank Channel approaching the Outer Bar Channel. The pilots of the *Damgracht* and *AP Revelin* communicated over VHF radio and made arrangements to meet port-to-port in the Outer Bar Channel near buoys 33 and 34, about a mile seaward of the jetty entrance. The width of the channel in this area was about 800 feet.

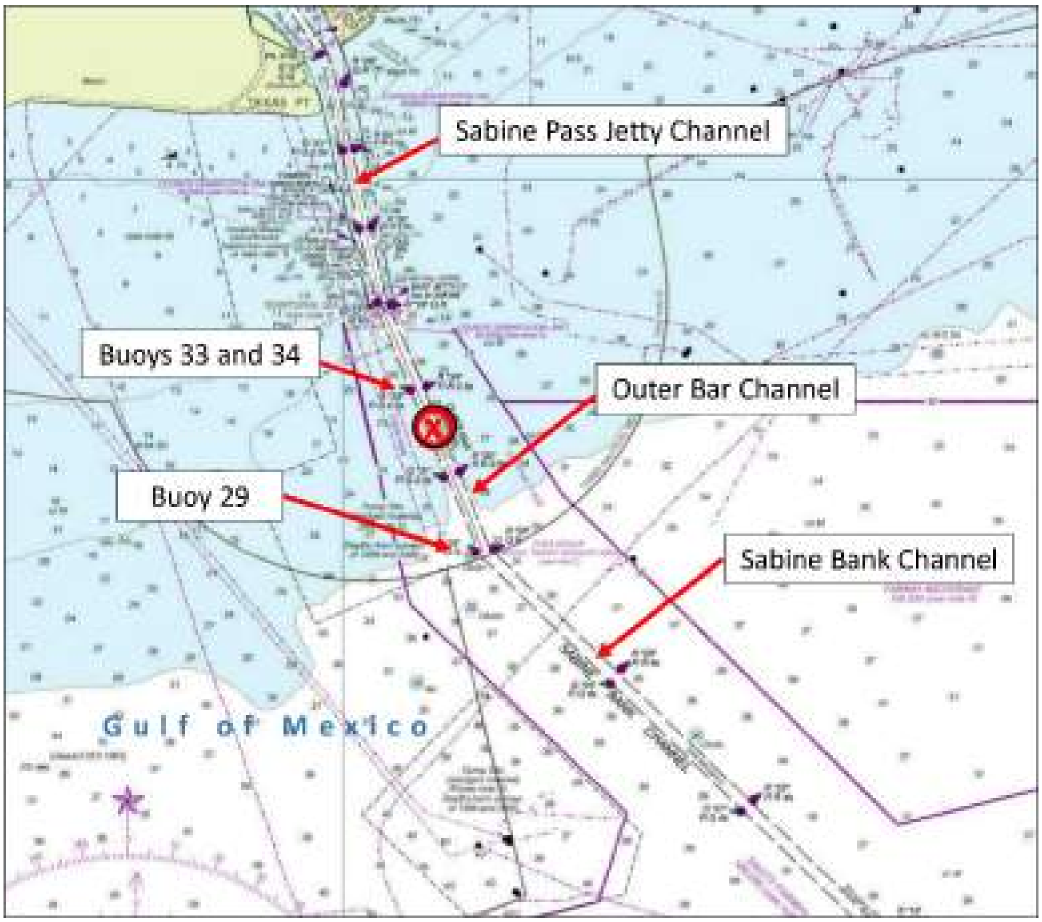

Figure 3. Area where the *Damgracht* and the *AP Revelin* transited and where their pilots planned to meet at buoys 33 and 34. (Background source: NOAA Chart 11341)

About 1043, when the two vessels were about a half mile apart, the oil mist detector (OMD) on the *Damgracht*'s main engine sensed "high oil mist density," activating the alarm and immediately shutting the engine down, thus causing the *Damgracht* to lose propulsion. The engine shaft-driven electrical power take-off generator, which had been online and powering the bow thruster, stopped producing power, and therefore, the thruster stopped as well. The vessel's other independent diesel engine-driven electrical generators were unaffected and maintained power for the remaining machinery and electrical systems.

When the OMD alarmed, the chief engineer aboard the *Damgracht* was on the lower level of the engine room near a local control station, which included an alarm panel for the main engine and associated systems. The control station was located alongside the main engine by the OMD. The chief engineer observed the OMD and saw solid red LEDs on the display window of the OMD, indicating a mist density of about 10%, and did not notice any flashing alarm LEDs indicating any faults with the OMD. He began checking engine conditions and troubleshooting the OMD.

The pilot aboard the *Damgracht* broadcast over VHF radio that the *Damgracht* had "lost everything" (meaning the vessel had lost propulsion) as the vessel started veering to port. The pilot on the *Damgracht* ordered hard right rudder and instructed the captain to "sound the danger signal" (five short blasts on the vessel's whistle). The pilot confirmed the rudder's response on the rudder angle indicator, but, despite maintaining hard right rudder, the bow of the *Damgracht* continued veering to port, across the channel, and toward the path of the outbound *AP Revelin*.

After hearing the *Damgracht* pilot's VHF radio broadcast, the pilot of the *AP Revelin* ordered the vessel's rudder hard to starboard and an increase of main engine speed by 10 rpm in an attempt to maneuver away from the approaching *Damgracht*. The pilot monitored his portable pilot unit and the vessel's electronic navigation systems and observed the *Damgracht* through the wheelhouse windows. He believed the *Damgracht*'s rate of turn to port appeared to increase and the vessel continued to approach the *AP Revelin*.

After the hard right rudder command, the pilot aboard the *AP Revelin* noticed that the vessel's bow started turning to starboard; he stated he was hoping the *AP Revelin* was "gaining a faster rate of turn to starboard to give the *Damgracht* plenty of room." As the *Damgracht* continued to approach, the pilot aboard the *AP Revelin* ordered the rudder to midship, and then ordered a hard left rudder command to "lift" (or swing) the vessel's stern to starboard and away from the oncoming vessel since he believed "the only way to avoid contact with the *Damgracht* would be to raise the *AP Revelin*'s port quarter."

The *Damgracht* continued to head toward the *AP Revelin*, and, about 1045, with the *Damgracht* moving at a speed of 7.4 knots and the *AP Revelin* at 9.3 knots, the bow of the *Damgracht* struck the port quarter of the *AP Revelin*, peeling back about 40 feet of the *AP Revelin*'s hull plating forward of the transom and wrapping it around the stern. About the same time, the chief engineer of the *Damgracht* verified that the main engine bearing temperatures and crankcase pressures were normal, opened the cover of the OMD measuring chamber, wiped the area of the infrared lights, and reset the OMD. The chief engineer did not notice any abnormalities when wiping the chamber. About 1046, the chief engineer restarted the engine and notified the captain that propulsion was restored to maneuver the vessel.

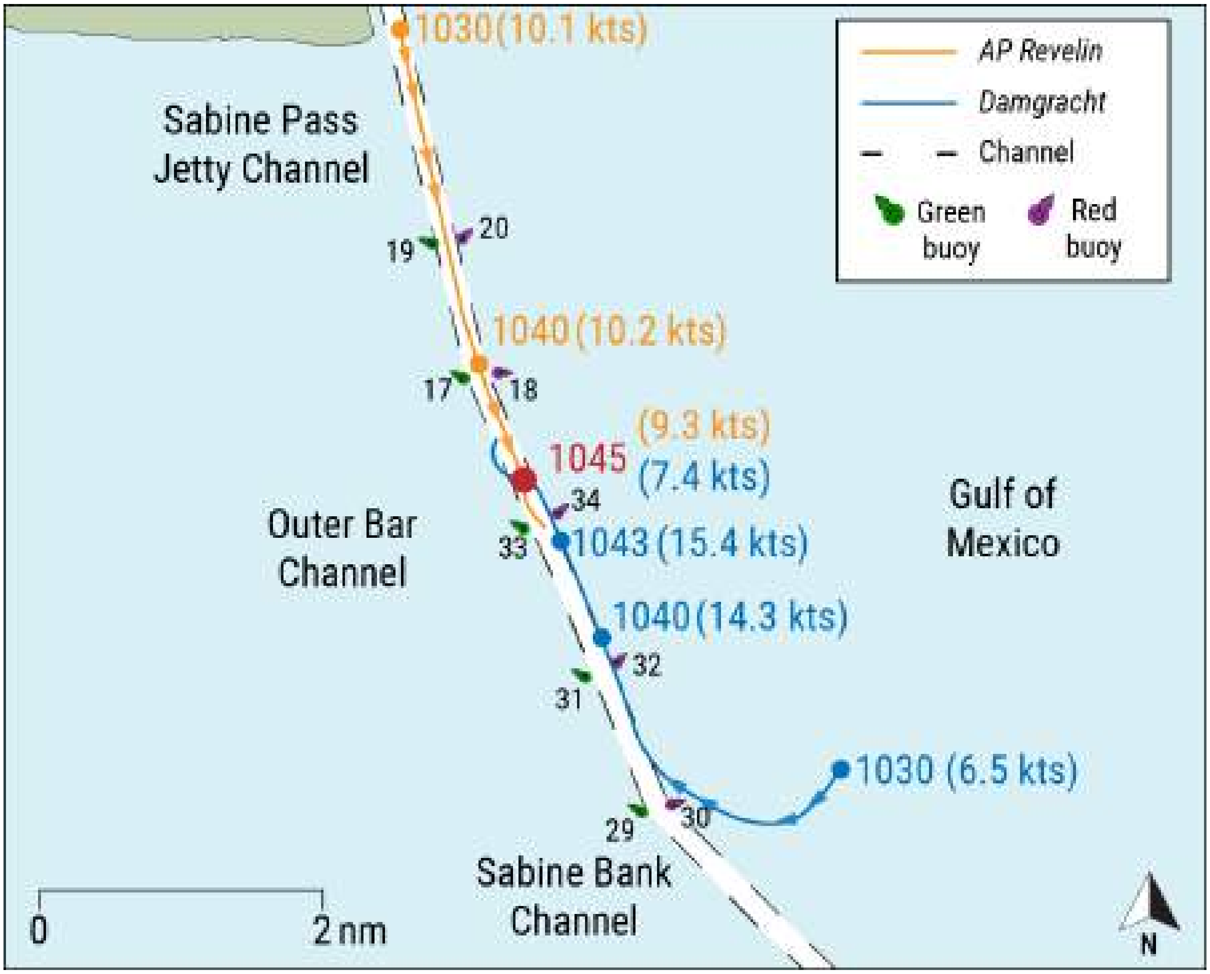

Figure 4. Area where the *Damgracht* lost propulsion (1043) and collided with the *AP Revelin* (1045), as indicated by a red circle. (Background source: NOAA chart 11341)

After the collision, the pilot aboard the *AP Revelin* determined the vessel still had propulsion and steering, and he "stabilized" the vessel (adjusted its heading and got back into position) in the channel. The captain mustered the crew and began work to ensure the hull was intact and no water ingress or pollution had occurred. Both pilots informed the Port Arthur Vessel Traffic Service of the collision, and both vessels transited under their own power to a fairway anchorage.

Once anchored after the collision, the *Damgracht*'s engineering crew conducted maintenance on the OMD: they cleaned the unit, replaced the filters, and adjusted the air flow. The chief engineer verified that the air pressure to the OMD air jet had been set within the correct range (60–80 millimeters of water). The engine crew did not find any irregularities nor any evidence that the OMD had malfunctioned or required repairs. The crew also inspected the lube oil purifier after the collision and found that it was operating properly. The chief engineer stated that he believed the OMD had triggered a false alarm since there were no indications of high bearing temperatures or elevated crankcase pressures. According to the vessel's logbook, after the collision, the engine crew replaced about 25% of the lube oil in the main engine lube oil sump (approximately 750 gallons), which had a capacity of about 11 cubic meters (2,900 gallons).

1.3 Additional Information

1.3.1 Damage

Following the collision, surveyors conducted damage assessments on both vessels. The *AP Revelin* sustained damage on the port, aft section of the stern deck, the freefall lifeboat and its davit structure, engine room store bulkhead, side shell and transom plating, and portside freshwater tank.

Figure 5. Damaged stern area of the *AP Revelin* after the collision.

Surveyors inspected the bow of the *Damgracht* and found that the upper port side of the bow above the anchor pocket had indents that were "smooth without sharp knuckles" and that no cracks were revealed. They "evaluated and found acceptable" the damage in the supporting structure.

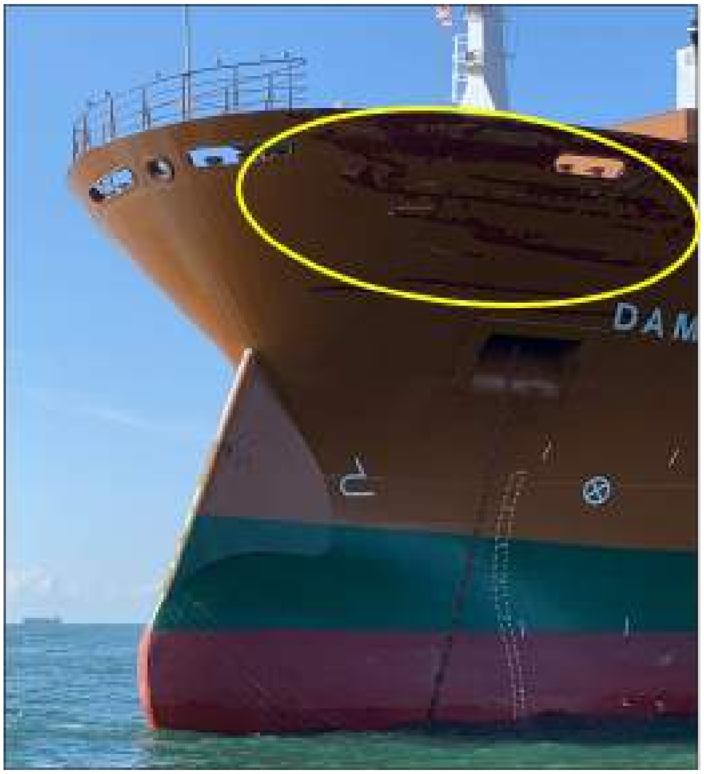

Figure 6. Port bow of the *Damgracht* after the collision with damage circled in yellow.

Surveyors also reported that the *Damgracht*'s engineering crew "clean[ed] and thorough[ly] examined" the main engine crankcase and replaced air flow filters on the OMD. The main engine was tested by the engine crew in the presence of a class surveyor from the local control station and remote bridge station with satisfactory results. The main engine was considered fully operational from both control stations and normal vessel maneuverability was restored.

1.3.2 Oil Mist Detector

The main engine of the *Damgracht* was equipped with a Schaller Automation model VN115/87 OMD. The purpose of an OMD is to protect an engine against damage in the event of overheating crankshaft components, such as bearings or pistons (hot spots). Such hot spots create an oil mist that can ignite, causing a crankcase explosion, which can seriously injure personnel and result in an engine room fire. The OMD on the *Damgracht* measured the crankcase atmosphere by drawing out continuous samples through headers directed through an opacity measuring track. In this measuring track, infrared light determined the opacity (turbidity) of the drawn crankcase samples. The OMD on the *Damgracht* was rated to operate at a maximum of 90% relative humidity and was equipped with a heating system in the measuring head to warm up the sample crankcase gas flowing through the top of the measuring head to avoid condensation of water (especially in high humidity or low temperature conditions).

A regulated compressed air supply was connected into the OMD jet air pump to draw crankcase atmosphere samples into the measuring head. The manufacturer provided instructions to calibrate the suction pressure to a range of 60 to 80 millimeters of water (about 0.23 inches of mercury) by adjusting the compressed air pressure to ensure a proper flow rate of sampled crankcase atmosphere. The display window had a vertical scale with LEDs that identified the opacity percentage of the sample. Additionally, 14 LEDs were programmed to identify failures when blinking. An opacity sensitivity adjustment dial was located at the bottom of the display window; the operating manual warned that modifications were "only permitted by consultation with the manufacturer."

The OMD was designed to shut down the engine immediately when an oil mist alarm was sensed "in order to minimize immediate or consequential damages." The OMD aboard the *Damgracht* did not have an override switch that could delay or disable the shutdown function.

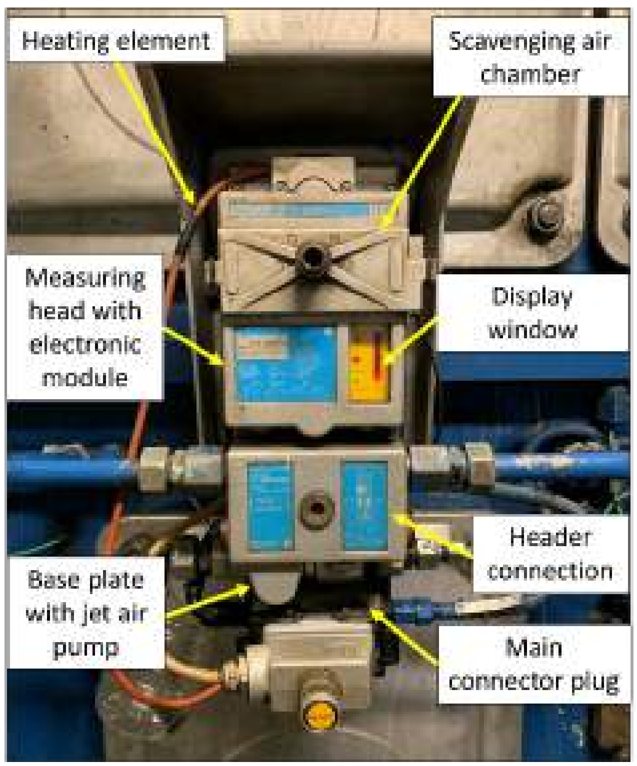

Figure 7. Main engine oil mist detector aboard the *Damgracht*

According to the manufacturer, condensation of water could "trigger a false high oil mist alarm when small droplets of water were detected by the optical measuring track" and subsequently, the engine would shut down. The manufacturer stated that excessive oil was also a reason for false alarms, especially when oil drops fell through the measuring head across the infrared light beam (the detector reacted to turbidity caused by oil drops).

In 2007, before the *Damgracht* was built, the manufacturer of the OMD later installed aboard the *Damgracht* released a safety bulletin regarding high-humidity operations. The bulletin stated:

> The oil mist detector (OMD) may trigger false alarms due to high humidity in the crankcase and condensed water in the OMD system suction pipes. The humidity/water buildup increases when the engine is started for the first time after being out of operation for several hours (e.g. during the night). If the lubricating oil has water content above the permissible limit, the oil mist detector will "perceive" high humidity (water droplets) in the optical path. A good practice would be to inspect the lubricating oil separators for any water contamination to the clean side of the oil or find out whether there could be cooling water leaks. Sometimes water droplets can be seen inside the measuring head when opening the inspection cover. Also, water may be found in the pipe connection box/valve box, causing false alarms.

The OMD operating manual contained three preventative maintenance tasks pertaining to the model installed on the *Damgracht*. Monthly, the suction air pressure in the measuring head was to be checked to verify it was in the proper range. Quarterly, the sintered bronze filter in the measuring head was to be replaced, and the infrared filter glasses and the two fresh air bores were to be cleaned.[5] Annually, the sintered bronze filter in the pressure reducer was to be replaced.

Investigators reviewed OMD maintenance records from 2020 up to the date of the casualty. The vessel's operating company required a job order titled "Inspect and Test Oil Mist Detector" to be completed monthly. The job description specified: "Inspect oil mist detector and test if it is functioning correctly. If necessary, replace air filters and readjust airflow through measuring unit." The vessel's computerized maintenance program recorded that the crew had conducted numerous routine maintenance tasks in the 3-year period requested by investigators. In 2022, up to the date of the collision, seven maintenance activities were logged in the maintenance program. On August 17, about 4 days before the collision, the electronic maintenance log contained an entry stating that the required monthly maintenance on the OMD had been completed with no comments.

1.3.3 Weather

Historic weather reports indicated that, while the *Damgracht* was anchored outside the Sabine Bank Channel near Port Arthur on the evening of August 20, the

[5] A *sintered filter* is porous metallic part manufactured by mixing and fusing copper and metal alloys at high temperatures to achieve porosity and creating a mesh.

air temperature was about 78°F, the dew point about 74°F, and humidity level about 85%. After midnight on August 21, and until the time of the collision, the temperature rose to about 88°F, the dewpoint increased to about 78°F, and the humidity increased to about 95%, peaking at 97% about 0700 in the morning. The chief engineer stated that it was “very humid at night,” and the captain described the humidity as “extreme” while anchored and conducting repairs on the main engine. At the time of the collision, the humidity was 72%.

2 Analysis

On August 21, 2022, while the cargo ship *Damgracht* was transiting inbound in the Outer Bar Channel of Sabine Pass near Port Arthur, the vessel's main engine shut down due to "high oil mist density" sensed by its OMD, and, as a result, the *Damgracht* lost propulsion. The vessel maintained electrical power and rudder control, but the bow thruster was disabled since it was only supplied power by the main engine shaft generator.

With the abrupt loss of propulsion, while transiting at 15 knots, the *Damgracht* began veering to port into the path of the outbound *AP Revelin*, which was about a half mile away and was transiting about 10 knots. The pilot aboard the *Damgracht* immediately took steps to notify nearby vessels and maneuver the vessel—he broadcast the loss of propulsion over VHF radio, directed the captain to sound the "danger" signal, and ordered the rudder hard to starboard. However, he was unable to alter the vessel's heading, since his rudder commands were unable to counter the vessel's veering to port due to the lack of propeller wash passing over the functioning rudder and the disabled bow thruster. Without a means for the pilot to maneuver the vessel, the *Damgracht* continued to head across the channel and into the path of the *AP Revelin*.

Upon hearing the VHF broadcast, the pilot aboard the *AP Revelin* immediately took action to avoid the approaching *Damgracht*. He ordered hard starboard rudder and increased engine rpm, and the *AP Revelin* began turning to starboard. As the *Damgracht* came closer, he ordered hard port rudder to swing the vessel's stern away from the approaching vessel. However, because there was only a half mile between the two vessels when the *Damgracht* lost propulsion, and, given the speed at which the two vessels had been transiting, there was not enough time for the *AP Revelin* pilot's evasive actions to be effective in avoiding a collision. About 2 minutes after the *Damgracht*'s engine failure, its bow struck the port quarter of the *AP Revelin*.

The previous afternoon, the *Damgracht*'s main engine had alarmed (due to low cooling water pressure and high cooling water temperature) and shut down, causing a loss of propulsion. The crew anchored the vessel, and that evening, the engine crew cooled down the main engine, disassembled the no. 6 cylinder head, and found a failed cylinder head gasket. When the cylinder head gasket failed, high-temperature, high-pressure gas likely escaped from the combustion chamber into the crankcase and into the cooling water system, reducing the effectiveness of the cooling system and causing the engine to overheat. The gasket failure also likely allowed products of combustion and cooling water to leak into the cylinder from the cylinder liner's cooling water passages and contaminate the engine's lube oil system.

Additionally, the work related to the engine repair of the failed gasket resulted in the interior sections (crankcase doors, cylinder head) of the engine being opened and exposed to humid conditions. Ambient air conditions that evening (and into the following morning) averaged about 90% humidity and were “extreme,” according to the crew. In humid conditions, a higher concentration of airborne water molecules can enter the engine and be absorbed by the lube oil, especially when an engine is cool. After the repairs, the crew used the engine’s cooling water system to preheat the engine and put online the lube oil purifier (with its heating system). The crew tested the engine for about 30 minutes and again opened the crankcase for inspection. The engine went through several temperature changes throughout the evening and following morning due to operational conditions during maneuvering, as well as being cooled for maintenance, operated for testing, cooled down for inspection, and then heated the morning before departure. Temperature changes can cause water vapor to condense and change back into a liquid and form droplets, which can collect in the lube oil sump.

Typically, normal quantities of moisture in an engine crankcase evaporate when the engine is started and reaches operating temperatures. On the morning of the collision, the crew started the main engine about 1010, and the engine ran for about 30 minutes before the OMD alarmed and automatically shut down. Due to the ambient air conditions the engine was exposed to during repairs and cooling water that had likely leaked into and contaminated the lube oil from the failed gasket, it is likely that higher levels of water entered the crankcase than could be removed overnight by the lube oil purifier or evaporate from the heat of the running engine in the short time it was tested post repair.

When the OMD indicated a high oil density alarm during the casualty transit the following morning, the chief engineer verified that there were no elevated bearing temperatures or high crankcase pressure, opened the OMD measuring chamber cover, wiped the sensing glass, reset the unit, and restarted the engine. Any abnormalities or impurities on the sensing glass may have been an indication of actual high oil density. However, the chief engineer found none while wiping the sensing glass; the main engine operated without incident after he restarted it, and the vessel transited without issue to the anchorage. Additionally, after the collision, routine maintenance was performed on the OMD, including cleaning, filter changes, and air pressure verification, and about 25% of the lube oil in the main engine sump was replaced. The OMD was successfully tested, and no issues were reported. (Routine maintenance on the OMD had been completed 4 days before the collision with no issues reported.) Therefore, it is likely that the OMD had triggered a false alarm after sensing water vapor that had condensed in the sample. The water vapor was likely present from cooling water that had entered into the lube oil system after the gasket failed the day before and from the ambient air conditions (high humidity) during the maintenance completed the previous evening to repair the gasket.

3 Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the collision between the cargo vessel *Damgracht* and the cargo vessel *AP Revelin* was the *Damgracht*'s loss of propulsion caused by an automatic shutdown of the main engine due to a false alarm, likely triggered by water vapor sensed by the oil mist detector shortly after engine maintenance was completed to replace a failed cylinder head gasket during high-humidity conditions.

3.2 Lessons Learned

Oil Mist Detector Precautions After Engine Maintenance

When certain engine components, such as cylinder head gaskets, fail, cooling water can be introduced into engine lube oil systems. Ambient air conditions, such as high humidity or extreme cold temperatures, can also increase the water content within engine lube oil sumps. The elevated quantity of water in lube oil systems can trigger false alarms in engine crankcase oil mist detectors (and lead to an engine shutdown) due to water droplets passing through the measuring track or the filter glass detecting condensation (mistaking it for oil mist). After an engine's crankcase is opened and exposed to these conditions during maintenance and repair, it is good practice for engine crews to inspect and test the lubricating oil system for water intrusion and ensure lube oil purifying equipment is functioning properly to remove any water or other contamination in the lube oil.

Vessel	*Damgracht*	*AP Revelin*
Type	Cargo, General	Cargo, Dry Bulk
Owner/Operator	Rederij Damgracht / Spliethoff Beheer B.V. (Commercial)	Fortune Mudanjiamg Shipping Limit. / Atlantska Plovidba d.d. (Commercial)
Flag	Netherlands	Croatia
Port of registry	Amsterdam, Netherlands	Dubrovnik, Croatia
Year built	2009	2016
Official number (US)	N/A	N/A
IMO number	9420784	9694696
Classification society	Lloyds Shipping Register	Croatian Register of Shipping
Length (overall)	514.9 ft (156.9 m)	590.4 ft (180.0 m)
Breadth (max.)	74.8 ft (22.8 m)	104.9 ft (32.0 m)
Draft (casualty)	26.6 ft (8.1 m)	31.2 ft (9.5 m)
Tonnage	13,588 GT ITC	25,494 GT ITC
Engine power; manufacturer	1 x 11,265 hp (8,400 kW); Wartsila 8L46C diesel engine	1 x 8,180 hp (6,100 kW); MAN B&W 5S50ME-B9.3 diesel engine

NTSB investigators worked closely with our counterparts from **Coast Guard Marine Safety Unit Port Arthur** throughout this investigation.

National Transportation Safety Board
Records Management Division, CIO-40
490 L'Enfant Plaza, SW
Washington, DC 20594
(800) 877-6799 or (202) 314-6551