Issued November 28, 2023 MIR-23-26

Crane Wire Failure on Cargo Ship *Thorco Basilisk*

On July 23, 2022, about 1440 local time, the cargo ship *Thorco Basilisk* was discharging cargo at the Greensport Terminal on the Houston Ship Channel in Houston, Texas. While off-loading a wind turbine component, the hoisting wire rope on a shipboard crane failed, causing the component to drop onto the vessel's cargo hold tween deck.[1] No pollution or injuries were reported. Damages to the ship and the component were estimated at $3–5 million.

Figure 1. *Thorco Basilisk* underway precasualty. (Source: VesselFinder)

[1] (a) In this report, all times are central daylight time. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA22FM031). Use the CAROL Query to search investigations.

Casualty type	Ship/Equipment/Cargo Damage
Location	Greensport Terminal, Houston Ship Channel, near Houston, Texas 29°44.78'N, 95°11.11'W
Date	July 23, 2022
Time	1440 central daylight time (coordinated universal time –5hrs)
Persons on board	31
Injuries	None
Property damage	$3-5 million est.
Environmental damage	None
Weather	Visibility 10 mi, mostly cloudy, winds southwest 10–13 kts, air temperature 91°F
Waterway information	Shipping channel, berth at terminal, depth 40 ft, channel width about 800 ft (at casualty site)

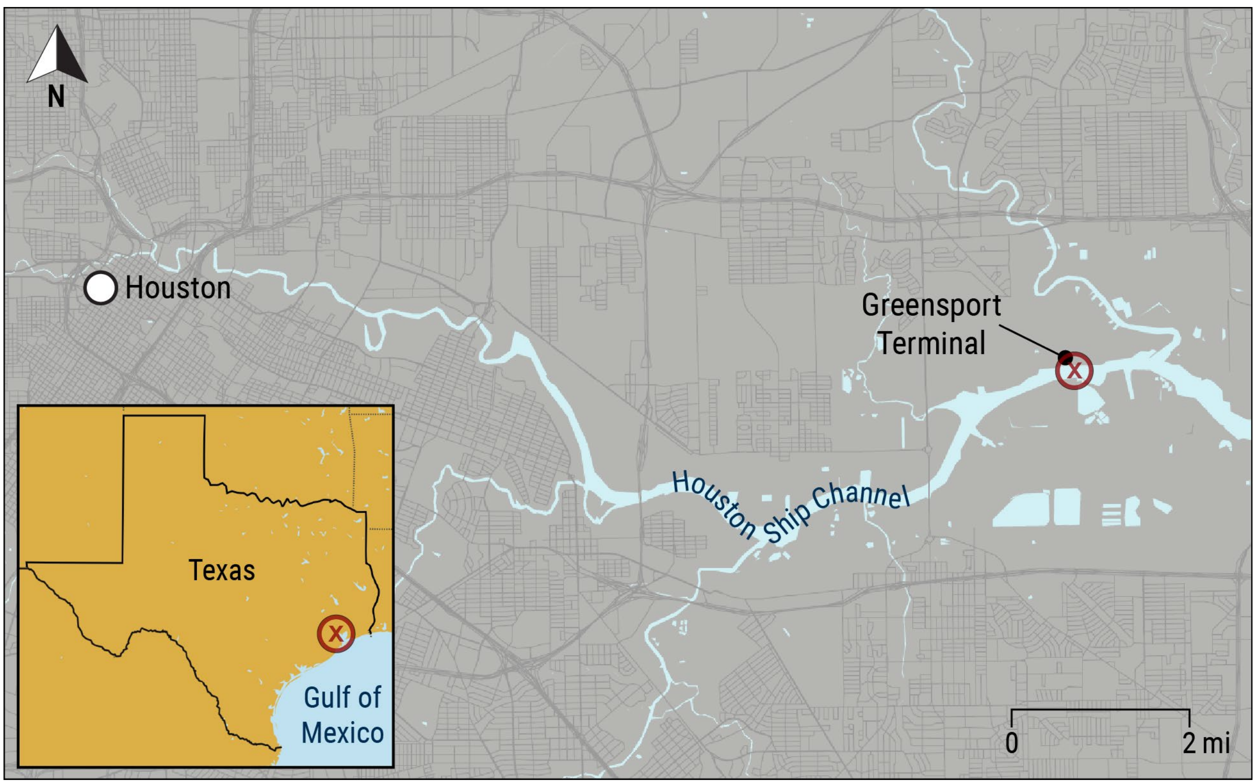

Figure 2. Area where the *Thorco Basilisk* crane equipment failure occurred, as indicated by a red *X*. (Background source: Google Maps)

1. Factual Information

1.1 Background

The *Thorco Basilisk* was a 530-foot-long, steel-hulled cargo ship built in 2013 by Wuhuxinlian Shipbuilding in WuHu, China. The vessel was owned by MV Basilisk AG and managed by Blue Squared AG (both companies were based in Bern, Switzerland). The vessel was operated by Auerbach Marine and under charter to BBC Chartering.

The vessel's cargo holds (numbered from forward to aft) could be configured with removable steel decking pieces (referred to as pontoons) to accommodate cargo of different sizes. When assembled, the pontoons would form decks (referred to as tween decks) to support cargo. The vessel was equipped with three MacGregor GL deck cargo cranes positioned on the port side—with crane no. 1 located nearest to the bow, crane no. 2 about midships, and crane no. 3 nearest the superstructure. The three deck cranes were each certified to a safe working load (SWL) of 80 metric tons (88 US tons) and were primarily used to on- and off-load cargo from the vessel's cargo holds and to shift the tween deck pontoons in each hold.

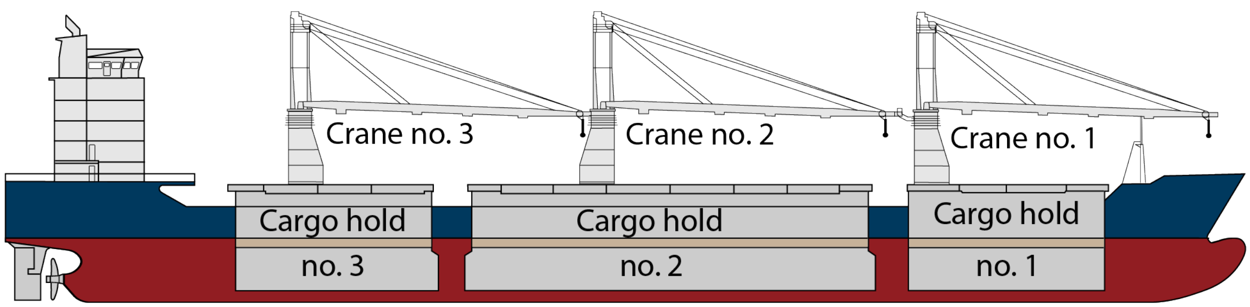

Figure 3. Profile view of the *Thorco Basilisk*. Tween decks in each hold at the time of the casualty are shown in brown.

1.2 Event Sequence

From June 20 to 22, 2022, a total of 11 Nordex Delta 4000 wind turbine nacelles were loaded into the *Thorco Basilisk*'s cargo holds while the vessel was docked in Rostock, Germany.[2] Each nacelle measured 41.9 feet long, 14.1 feet wide, and 13.1 feet high, and each weighed 69 metric tons (76 US tons). According to the vessel's loading plan, six nacelles were in cargo hold no. 1 and five were in cargo hold no. 3. The nacelle

[2] A *nacelle* is the housing behind the rotor blades and hub at the top of a wind turbine tower. It contains all the wind turbine's electrical generating components, including the generator, gearbox, drive train, and brake assembly.

units were loaded using shore cranes because, according to the *Thorco Basilisk* chief mate, the shore cranes were faster and had a higher lifting capacity than the ship's cranes.

About a month later, on July 22, the *Thorco Basilisk* docked at the Greensport Terminal (dock 4) in Houston to off-load the wind turbine nacelles and other wind turbine components. On July 23, about 0645, a crew of stevedores arrived at the terminal to prepare to off-load the cargo. Before boarding the *Thorco Basilisk*, the stevedores participated in a job safety analysis brief led by the superintendent. The job safety analysis addressed the day's work plan and hazards, and it ensured all personnel were equipped with the appropriate personal protective equipment. The ship's crewmembers were not directly involved in the cargo lifting operations. However, the *Thorco Basilisk* second officer was on cargo watch, observing the operations on board the vessel.

The charterer at the time of the casualty decided to use the ship's cargo cranes for off-loading (using the shore cranes would incur additional costs). Before beginning operations, the stevedore superintendent and port captain reviewed the ship's crane certifications—including 5-year load testing certificates (from DNV-GL, the vessel's classification society) for the three cargo cranes—and determined that they were "good to go." The superintendent accepted the use of the *Thorco Basilisk*'s shipboard cranes for the off-loading operation.

Before operations began, stevedores stationed themselves on board the vessel, including a crane operator, a five-person crew inside the cargo hold led by a foreman, and a five-person crew on deck led by a walking foreman. The stevedore superintendent, port captain, and shoreside workers were positioned on the pier during the off-loading operation. The stevedore crane operator visually inspected the cranes on the vessel; he stated that he did not notice anything out of the ordinary.

At 0715, off-loading operations began. Working with the other stevedores on board the vessel, the crane operator used crane no. 3 to off-load five nacelle units and other components from the tween deck in cargo hold no. 3.

Figure 4. Exemplar Nordex Delta 4000 wind turbine nacelle in another vessel's cargo hold rigged in accordance with manufacturer-recommended guidance. (Source: Nordex)

Next, the crane operator off-loaded drive train units and five additional nacelle accessory units from the main cargo hold below the cargo hold no. 3 tween deck. Throughout off-loading operations, the stevedores (both on board and ashore) communicated with each other using a combination of radios, flagging, and hand signals. The stevedores completed off-loading of cargo hold no. 3 without incident at 1020.

At 1200, cargo operations resumed; the stevedores used crane no. 1 to off-load three 15-metric-ton (16-US-ton) containers from the top of cargo hatch no. 1. At 1230, the stevedores used crane no. 1 to begin off-loading three nacelle units from the cargo hold no. 1 tween deck. They removed two of the nacelle units without incident and rigged a third nacelle with slings and shackles in preparation for resuming work after breaking for lunch at 1300.

About 1400, the stevedores completed an afternoon job safety analysis meeting to again go over the lifting operation and ensure that all personnel had appropriate personal protective equipment. Following the job safety analysis meeting, cargo operations resumed from the cargo hold no. 1 tween deck with the same stevedore crew and nacelle unit that had been rigged with slings and shackles before the lunch break. At

1438, before the lift, the stevedore foreman verified the lifting equipment was arranged in accordance with nacelle manufacturer guidance.

At 1440, with the nacelle rigging secure and attached to the crane hook, the crane operator began to hoist the nacelle unit from the cargo hold no. 1 tween deck using crane no. 1. When the nacelle reached a height between 3 and 6 feet above the deck (still within cargo hold no. 1), the hoisting wire rope parted, causing the nacelle to drop and fall onto the tween deck. Based on accounts from the stevedores in the cargo hold, the nacelle unit landed flat on the deck. Immediately after impact with the deck, the crane hook, hoisting wire rope, and block fell down and then through the fiberglass top of the nacelle, damaging the external housing as well as internal components. The five-person stevedore crew inside the cargo hold, who had been standing about 5–6 feet from the impact, were uninjured.

Following the drop, the stevedore crew inspected the rigging equipment inside the nacelle; they did not find any failures to the slings or shackles.

The port captain halted cargo operations at 1445. After all stevedores were accounted for, the superintendent held a safety standdown meeting and dismissed them for the day.

The following day, on July 24, the port captain and the *Thorco Basilisk* crew decided to off-load the damaged nacelle and the remaining cargo using a shore crane. To prepare for the use of the shore crane, the crew repositioned the vessel at the pier so that the shore crane could more easily reach the cargo. On July 25, the stevedores returned to the vessel and off-loaded the remaining cargo, including the damaged nacelle unit.

1.3 Additional Information

1.3.1 Damage

The nacelle sustained damage to its outer fiberglass housing structure and its internal components, including the yaw bearing, hydraulic unit, electrical component top boxes, transformers, and main converter. The nacelle's rear transport frame was also damaged from the impact with the tween deck.

Damages to the vessel included indentations to two of the pontoons making up the tween deck in cargo hold no. 1, including damage to the substructures and side plate in cargo hold no. 1.

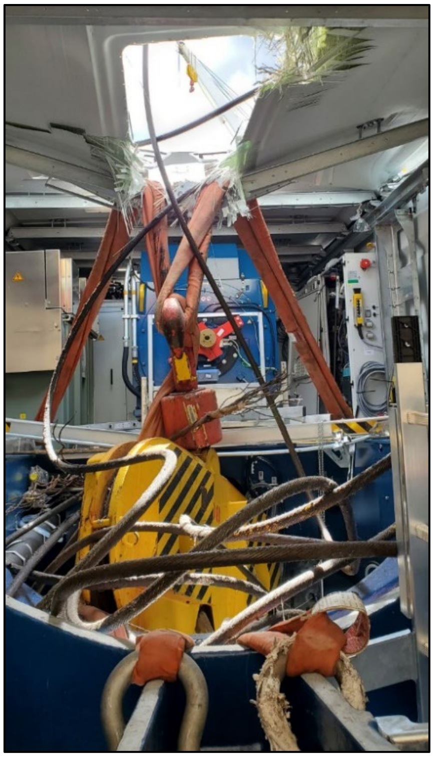


Figure 5. Crane no. 1's block smashed into the top of the damaged nacelle (*left*) and its parted wire rope on the crane side (*right*). (Source: US Coast Guard)

1.3.2 Postcasualty Actions

Following the casualty, the *Thorco Basilisk* crew cut the parted wire rope and secured the crane until repairs could be made and new wire rope installed. A postcasualty damage survey conducted by DNV-GL directed that cargo crane no. 1 be secured and not used until the wire rope was replaced and crane no. 1 be load tested by the classification society. The *Thorco Basilisk* continued to operate using the undamaged cranes (nos. 2 and 3), calling on additional ports before arriving in Hamburg, Germany on August 30. Between August 30 and September 5, technicians from the crane manufacturer, MacGregor, inspected each of the three cargo cranes and replaced the crane wire ropes on all three cargo cranes.

1.3.3 Nacelle Rigging

Each nacelle was secured to a front and rear transport frame. The company that manufactured the nacelles provided the stevedore company with rigging procedures, which described the attachment procedure, attachment points, sling and shackle arrangements, and lift ratings for all lifting gear. According to the procedures, securement of the nacelle to the crane hook involved four slings and five shackles connected to four internal attachment points; to access these attachment points, personnel had to physically enter the nacelle. The procedures also provided detailed drawings and pictures showing the steps to secure the nacelle and the arrangement of lifting components. The company that manufactured the nacelles also provided the stevedore company with the necessary rigging equipment, slings, and shackles.

The rigging equipment was previously tested and certified on April 8, 2022 (less than 3 months before the casualty). According to the stevedore superintendent, on the day of the casualty, the port captain oversaw the attachment of the first nacelle to verify adherence to the nacelle manufacturer's procedures and ensure that the crew foreman understood them. Subsequent lifts were rigged and verified under the supervision of the cargo hold stevedore foreman.

1.3.4 Hoisting Wire Rope Examination

VEROPE manufactured the hoisting wire rope used on crane no. 1 and classified it as "VEROTOP-P left hand lang's lay wire rope."[3] The wire rope was 1.5 inches (38 millimeters) in nominal diameter, constructed of 37 strands with seven wires per strand, with a plastic-coated core. In 2008, a sample of the wire rope (later installed on the *Thorco Basilisk*) was tested to a breaking strength of 1,374 kilonewtons, or 140 metric tons (154 US tons).

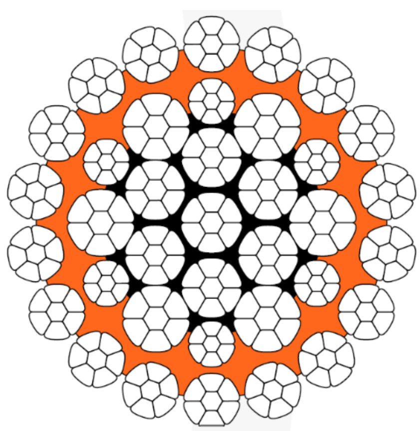

Figure 6. Cross-section diagram of wire rope used on board *Thorco Basilisk* showing strands, with plastic-coated core shown in orange. (Source: Verope Technical Brochure)

The crane manufacturer stated that the wire rope, as originally installed, had a safety factor of 4.44 at the crane's 80-metric-ton SWL. The hoisting wire rope had been used since its installation on board the *Thorco Basilisk* in 2013, or for about 9 years (DNV-GL Standard, DNV-ST-0377, Shipboard Lifting Appliances, specified the maximum

[3] In *lang's lay ropes*, the lay direction of the wires in the strands is equal to the strands in the rope. In regular lay ropes, the lay direction of the wires in the strands is opposite to the lay direction of the strands in the rope.

period of employment for running rigging as 10 years).[4] Investigators were not able to determine where the wire was stored before its installation. No reference diameter of the wire rope was available following installation on board the vessel.[5]

After the casualty, the National Transportation Safety Board had sections of the wire rope examined and evaluated: two sections from either side of the fracture where the rope had parted (crane side and block side) and a sample section taken from the eye connected to the crane lifting block. The wire rope was evaluated based on DNV-GL Standard DNV-ST-0377, "Shipboard Lifting Appliances" and ISO 4309:2017, "Cranes-Wire Ropes-Care and Maintenance, Inspection and Discard." The discard criteria contained in these two documents addressed issues related to wire deformation, crushing, corrosion, and visible broken wires. Additionally, the diameter of the wire rope samples was measured at set intervals to capture changes in the wire rope's nominal diameter.

Figure 7. *Thorco Basilisk* parted hoisting wire rope (crane side of fracture). (Source: Engineering Systems Inc)

The resulting report concluded that the primary failure mechanism of the hoisting wire rope was corrosion and wear, followed by "monotonic ductile overload failure" of the remaining wire cross sections. The report noted that the wire rope sections exhibited "a significant level of external corrosion" with a severity rating of about 60%; a severity rating of 100% would require that the wire rope be discarded. However, because a reference diameter from when the wire rope was installed on board the *Thorco Basilisk* was unavailable, a quantitative severity rating based on uniform decrease in wire rope

[4] *Running rigging* is defined in DNV-ST-0377 as "wire ropes passing over rope sheaves of guide rollers, or wound on winches, irrespective of whether or not the ropes are moved under load."

[5] *Nominal diameter* refers to the diameter designated by the manufacturer. *Reference diameter* is determined by measuring a section of rope not subject to bending after the rope has been broken in. This measurement is used in calculations to determine a rope's level of wear.

diameter from wear could not be assigned. Examination of the external condition of the wire rope samples showed "obvious uniform corrosion," and that the wires visually displayed "roughness and pitting," with the most severe corrosion observed nearest to the fracture location. Examination of internal corrosion also revealed "uniform corrosion of internal surfaces" visible near where the wire rope became unraveled.

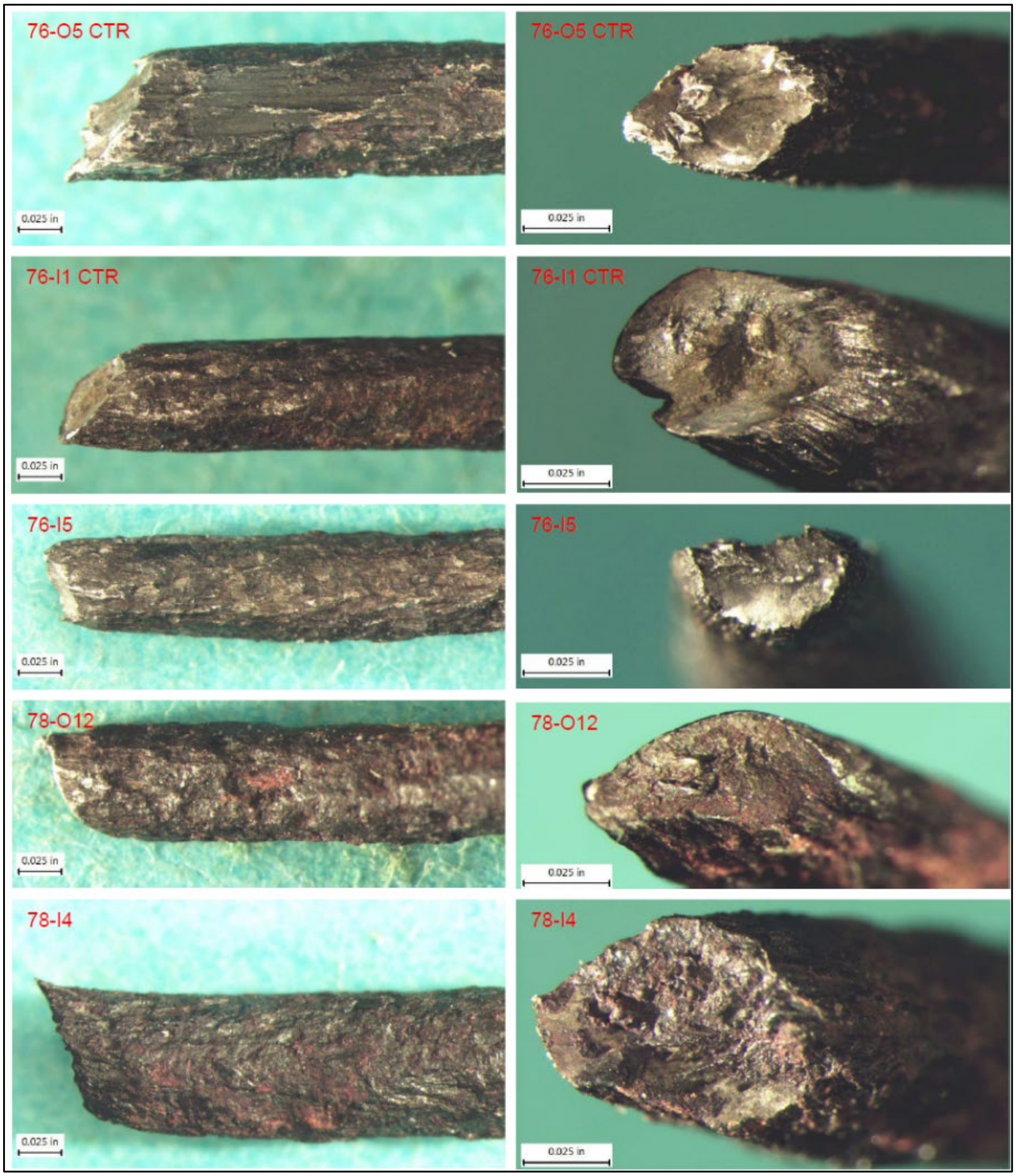

Figure 8. Views of wire ductile fractures from the side (*left*) and perpendicular to the fracture surface (*right*) found in strands of the failed wire rope. (Source: Engineering Systems Inc)

The report noted a localized increase of about 10% in wire rope diameter near the eye connecting to the lifting block and stated this increase would warrant discard (replacement). The report also stated that there were no broken wires on the examined segments, and the visible signs of external corrosion could not be fully appreciated (observed) until the grease was removed.

1.3.5 Crane Use, Maintenance, and Inspections

1.3.5.1 Crane Use

In the 2 months leading up to the casualty, cargo crane no. 1 was not used for cargo. It was primarily used to move the tween deck pontoons, which each weighed about 32 metric tons (35 US tons). According to the *Thorco Basilisk* chief mate, the day of the casualty was the first time during his 2 months on board that crane no. 1 had been used for "heavy lifts."

1.3.5.2 Planned Maintenance System

As part of the vessel's safety management system, a planned maintenance system (PMS) tracked maintenance tasks on board the vessel, noting the date and crewmember who completed the maintenance activity along with any notes. The PMS also tracked the time intervals for which each maintenance task was to be completed. There was a separate section in the PMS for each of the cargo deck cranes outlining the maintenance tasks to be completed for each crane's wire ropes and sheaves. The chief officer was responsible for each of these tasks.

The PMS required daily "checks" (visual inspections) of the crane's wire ropes to ensure they were sufficiently greased. The PMS stipulated that these checks could be completed monthly if the crane was not used.

The PMS further required monthly inspections, which involved paying out as much wire rope as possible on the deck and completing a visual exam of the length of the wire rope to identify any deformations, broken wires, or other visual damage. The crew also function-tested the wire sheaves and lubricated and greased the wire ropes monthly.

A technical manual from the wire rope's manufacturer, Verope, stated that "applying the new lubricant without removing the existing lubrication, which is often dried out and has lost its lubricating effect, defeats the purpose of the operation," and that "a rope that is free of surface dirt should be inspected more closely to detect possible defects." According to the master, wire rope relubrication was completed primarily by hand, and personnel used a bosun's chair to access the length of the wire ropes; however, the crew would not fully remove the existing grease before relubrication, stating that the crew "cannot wash and remove all the grease."[6] The crew did not use any specialized equipment to clean the wire ropes or remove existing grease before relubricating them.

Table 1. Thorco Basilisk PMS tasks in 2022 for crane no. 1 and specific crew notes. (Source: Blue Squared AG)

Tasks (interval)	Most Recent Entries Before Casualty
Checks (daily, before operation, or monthly, if not used)	July 4: Carried out. June 2: Carried out.
Checks and grease (every 1 month)	July 4: Carried out. June 2: (no notes)
Wire ropes inspection (every 500 hours or 6 months)	July 13: Carried out. June 22: Wire ropes and wire sheaves were greased one month ago. Condition is good. June 2: Carried out.
Wire sheaves inspection (every 500 hours or 6 months)	July 13: Done. June 23: Checked. Condition is ok. June 3: Checked. Greased and in good condition.
Wires and hooks check (every 3 months)	June 27: Carried out. Steel (*sic*) enough grease and good condition.

In the 2 days following the casualty, DNV-GL class surveyors completed an International Safety Management (ISM) audit of the vessel's PMS as well as a damage assessment on board the *Thorco Basilisk*. The audit found two non-conformities: (1) in the response immediately following the casualty, the crew did not notify the flag state or class society in a timely manner in accordance with the operating company's emergency contingency plan; and (2) there were no maintenance items in the vessel's PMS for wire rope replacement intervals. The audit noted that the crane hoisting wire ropes had not been replaced since vessel delivery in 2013 (DNV-GL class rules for hoisting wire ropes required these ropes be replaced every 10 years). The audit recommended that the company define maintenance intervals for all crane wire rope renewals and update the vessel's PMS. The audit also noted that the vessel's safety management system (SMS) manual had not been updated after the vessel's June 2022 transition to a new PMS.

[6] A *bosun's chair* is a device comprised of lines and a seat used to suspend a person to perform work on difficult-to-reach areas, typically aloft or alongside the hull of a vessel.

Following the casualty, the operating company added crane wire rope replacement intervals of every 5 years to the *Thorco Basilisk*'s PMS.

1.3.5.3 Crane Inspections

Per DNV-GL classification rules, the cargo cranes were required to be surveyed annually and load tested every 5 years. During annual surveys, which took about an hour to complete, a DNV-GL surveyor typically visually inspected the crane structure, wire ropes, connections, drums, and operator cabin. A DNV-GL crane surveyor told investigators that, typically, measurements of the wire rope (diameter) were not taken, and there were no means by which to inspect the internal condition of the wire rope. The most recent annual survey of the vessel's three cargo cranes was completed on April 4, 2022. The surveyor made two remarks, but neither was related to the condition of the wire ropes for cargo crane no. 1. The 2021 annual inspection of all three cargo deck cranes was completed from February 13 to February 17, 2021, in Long Beach, California, with no issues noted.

The most recent 5-year load test for all three cargo deck cranes was completed on August 3, 2018, certifying all three cranes to a maximum SWL of 80 metric tons (88 US tons). An additional load test was completed on crane no. 1 on November 18, 2019, for re-certification following repairs to the crane pedestal and crane ladder. During this load test, crane no. 1 was again certified to a SWL of 80 metric tons (88 US tons) at a maximum radius of 19 meters (62 feet) from the crane base.

1.3.6 Personnel

The crane operator working on the day of the casualty was employed by the stevedore company. His primary job was as a crane operator. He had 15 years of experience exclusively operating shipboard cranes. His training consisted of on-the-job experience through previous employers.

He stated that the crane on the *Thorco Basilisk* was like other cranes he had used before, and he was familiar with how to operate it. The crane operator said that the indicator in the crane cab showed the weight of the load as 62 metric tons (68 US tons).

2. Analysis

On the day of the casualty, the stevedores were using crane no. 1 to off-load a wind turbine nacelle from the *Thorco Basilisk* when the crane's hoisting wire rope parted, causing the nacelle to drop and fall onto the cargo hold tween deck. The wind turbine nacelle weighed 69 metric tons (76 US tons), or 86% of crane no. 1's SWL of 80 metric tons (88 US tons) at no greater than 19 meters (62 feet) from the crane base (as certified by DNV-GL in 2019). During the lift, the nacelle was not hoisted outside of cargo hold no.1 and was therefore within the 19-meter radius prescribed for the SWL by DNV-GL in the 2019 load test certificate. Additionally, crane no. 1 had completed two identical lifts just before the casualty lift without incident. A sample of the wire rope had previously been tested to a maximum breaking strength of 1,374 kilonewtons, or 140 metric tons (154 US tons). The manufacturer stated that the wire rope as originally installed had a safety factor of 4.44 at the crane's 80-metric-ton SWL. Therefore, crane no. 1 should have been able to complete the lift of the nacelle load.

Shock loading can occur when a sudden movement, or jerk, of a suspended load causes rapid acceleration and deceleration, creating a dynamic force that exceeds the static load. Shock loading may overcome the SWL, or load limitations, of a wire rope and crane. The crane operator did not note any issues with the crane, nor did he observe any sudden movements of the load. Additionally, immediately following the casualty, stevedores inspected the internal connections and rigging components for failures (which could have introduced a shock load) and found no issues with any of the equipment. Therefore, there is no evidence that the hoisting wire rope or the crane were shock-loaded—either through sudden crane movement or failure of nacelle rigging—in such a way as to create a dynamic load on the wire rope during the lift.

After the casualty, samples of crane no. 1's hoisting wire rope were examined to determine what had caused the wire rope to fail. The examination noted a localized increase in wire rope diameter near the eye and stated this increase would warrant discard (replacement). However, based on stevedores' and vessel crew's statements, investigators determined that the increase in diameter near the eye occurred postcasualty when the lifting block fell through the fiberglass housing of the nacelle unit and therefore had not contributed to the failure of the wire rope. The examination also found significant external corrosion, as well as roughness and pitting, and "uniform corrosion of internal surfaces" of the hoisting wire rope. This corrosion and wear caused some of the individual wires comprising the strands of the hoisting wire rope to part (fail) when crane no. 1 lifted the nacelle unit, subsequently causing the strand and then the remaining wire strands to become overloaded and fail.

The postcasualty wire rope analysis report stated that visible signs of external corrosion could not be fully appreciated until the grease was removed. DNV-GL surveyors completed annual surveys of the *Thorco Basilisk* cargo cranes and their associated wire ropes, but these surveys primarily involved visual inspections limited to obvious indications of wear (such as broken wires, visible corrosion, or observable degradation to outer strands and surfaces) and therefore would not have identified the corrosion. The wire rope had been regularly maintained in accordance with the operating company's PMS, and the required daily and monthly checks had been performed according to maintenance records; however, the vessel's PMS did not require the removal of grease from the wire rope (as recommended by the manufacturer). Without removing the grease to examine the wire rope, the corrosion on the wire rope could not be detected.

The hoisting wire rope was 14 years old and had been in use for 9 years. Although the wire rope was still within the 10-year period of use prescribed in DNV-GL standard DNV-ST-0377, the postcasualty failure report stated, "the wire rope was near the end of its service life and probably should have been discarded." After the casualty, the operating company updated their PMS to require crane wire rope replacement every 5 years.

3. Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the failure of the hoisting wire on the cargo ship *Thorco Basilisk*'s crane was undetected corrosion and wear in strand wires.

3.2 Lessons Learned

Maintenance of Wire Ropes

Saltwater and humid ocean air cause corrosion of metals, presenting challenges for the maintenance of high-strength steel wire ropes on vessels. A deteriorated wire rope directly affects a crane's ability to safely and reliably handle loads up to the crane's rated capacity (safe working load). Therefore, diligent inspection, maintenance, and management of wire ropes are essential. Working wires should be changed at recommended intervals, or more frequently, depending on operating conditions and use.

Vessel	***Thorco Basilisk***
Type	Cargo, General (Multi-purpose)
Owner/Operator	MV Basilisk AG/Auerbach Marine (Commercial)
Flag	Switzerland
Port of registry	Basel, Switzerland
Year built	2013
Official number (US)	N/A
IMO number	9539377
Classification society	DNV-GL
Length (overall)	529.7 ft (161.5 m)
Breadth (max.)	82.7 ft (25.2 m)
Draft (casualty)	26.2 ft (8.0 m)
Tonnage	14,859 GT ITC
Engine power; manufacturer	13,545 hp (10,101 kW); Doosan Man B&W 6S50MC-C

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Houston-Galveston** throughout this investigation.

For more detailed background information on this report, visit the NTSB Case Analysis and Reporting Online (CAROL) website and search for NTSB accident ID DCA22FM031. 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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