UNITED STATES COAST GUARD

REPORT OF THE INVESTIGATION INTO THE

FLOATING OCS FACILITY - TENSION LEG PLATFORM FPS AUGER LIFEBOAT FALL WITH LOSS OF LIFE ON JUNE 30, 2019

MISLE ACTIVITY NUMBER: 6762997

U.S. Department of Homeland Security
United States Coast Guard

Commandant
United States Coast Guard

U.S. Coast Guard STOP 7501
2703 Martin Luther King Jr. Ave. SE
Washington, DC 20593-7501
Staff Symbol: CG-INV
Phone: (202) 372-1030
Fax: (202) 372-1904

16732/IIA#6762997
December 16, 2021

SHELL AUGER FLOATING OCS FACILITY LIFEBOAT NO. 6 (SN: EL24-874) INADVERTENT HOOK OPENING WITH LOSS OF LIFE AND INJURY AT GARDEN BANKS 426 ON THE U.S. OUTER CONTINENTAL SHELF ON JUNE 30, 2019

ACTION BY THE COMMANDANT

The record and the report of the investigation convened for the subject casualty have been reviewed. The record and the report, including the findings of fact, analysis, and conclusions are approved. The investigation's safety recommendations remain under review. The Commandant's response to the recommendations and any resulting actions will be documented separately. This marine casualty investigation is closed.

NEUBAUER.JASON.DAVID.1170236480
Digitally signed by NEUBAUER.JASON.DAVID.1170236480
Date: 2021.12.16 12:56:19 -05'00'

J. D. NEUBAUER
Captain, U.S. Coast Guard
Chief, Office of Investigations & Casualty Analysis (CG-INV)

U.S. Department of Homeland Security
United States Coast Guard

Commander
Eighth Coast Guard District
Hale Boggs Federal Building

500 Poydras Street
New Orleans, LA 70130-3310
Staff Symbol: (docs)
Phone: (504) 671-2150
Email: Russell.E.Holmes@uscg.mil

16732
25 Jul 2019

MEMORANDUM

From: J. P. Nadeau, RADM
CGD EIGHT (d)

Reply to D8 OCS
Attn of: Russell Holmes, CAPT
(504) 671-2150

To: [redacted] LCDR
Lead Investigating Officer

Subj: FORMAL MARINE CASUALTY INVESTIGATION CONCERNING THE LIFEBOAT INCIDENT ONBOARD THE AUGER

1. Pursuant to the authority contained in Title 46, United States Code (U.S.C.), Section 6301 and the regulations promulgated thereunder, you are to convene a formal investigation for the incident that occurred onboard the offshore production facility AUGER which involved a lifeboat and resulted in two casualties on June 30, 2019. In conducting your investigation, you shall follow, as closely as possible, to the policy guidance and operations procedures for the Coast Guard Marine Investigations Program, as found in the Marine Safety Manual, Volume V, COMDTINST M16000.1A.

2. Due to the scope and complexity of the investigation, I have assigned the following persons to assist you with your investigation. For the purposes of this investigation, the below persons are all designated as investigations officers as defined under 46 C.F.R. 4.03-30, and therefore, shall enjoy the powers outlined in 46 C.F.R. 4.07-5."

    - LT [redacted] Technical Advisor
    - LTJG [redacted] Assistant Investigating Officer

3. Upon completion of the investigation, you will issue a report to me with the collected evidence, the established facts, and conclusions and recommendations. Conclusions and recommendations concerning commendatory actions or misconduct that would warrant further inquiry shall be referred to me, by separate correspondence for the consideration and action as appropriate. A weekly summary of significant events shall be transmitted to me via CGD Eight (docs) while the investigation is in formal session.

4. You will complete and submit your investigative report to me within 210 days of the convening date. If this deadline cannot be met, you shall submit a written explanation for the delay and notice of the expected completion date. You are highly encouraged to submit any interim recommendations intended to prevent similar causalities, if appropriate, at any point in your investigation.

5. As lead investigation officer, you will preside over any public hearing. LT [redacted], District Eight Legal Division, will serve as your legal advisor, and may assist you and your team as you may direct. Additionally, a Recorder will be identified at a later date

for assistance conducting the formal hearing. Further, at your discretion, you may utilize the service of the Coast Guard and other Government-employed subject matter experts.

6. CGD Eight will furnish such funding and technical assistance as may be required by the investigation when deemed appropriate and within the requirements for the scope of the investigation. Your point of contact for funding and technical assistance is LCDR [redacted] CGD Eight (docs) deputy.

#

Copy: CG-INV
CGD EIGHT (dpi)
INCOE

U.S. Department of Homeland Security
United States Coast Guard

Commander
Eighth Coast Guard District

500 Poydras St
New Orleans, LA 70130
Symbol: (d)
Phone: (504) 589-6298

16732

SEP - 6 2019

MEMORANDUM

From: J. P. Nadeau, RADM
CGD Eight (d)

To: [redacted], LCDR
Lead Investigating Officer

Subj: INVESTIGATION CONCERNING THE LIFEBOAT INCIDENT ONBOARD THE AUGER—AUTHORITY CORRECTION

Ref: (a) My Memo 16732 of 25 July 2019

1. The purpose of this memo is correct the authority statement contained in ref. (a). The authority for your investigation of the lifeboat incident onboard the floating Outer Continental Shelf (OCS) facility Auger is 43 United States Code (U.S.C.) § 1348, which directs the Coast Guard to make an investigation into "any death or serious injury occurring as a result of operations" on the OCS.

2. In conducting this investigation, and in accordance with 33 Code of Federal Regulations (C.F.R.) 140.203, you shall continue to use the investigation procedures described in 46 C.F.R. Part 4, and applicable Coast Guard policy.

3. Your authority to issue a subpoena to summon witnesses or compel the production of evidence is 43 U.S.C. § 1348(f) and 33 C.F.R. 140.205.

4. All other provisions of ref. (a) remain in effect.

#

Copy: CG-INV
CGD EIGHT (docs), (dl)
INCOE

U.S. Department of Homeland Security
United States Coast Guard

Commander
Eighth Coast Guard District
Hale Boggs Federal Bldg.

500 Poydras Street
New Orleans, LA 70130
Staff Symbol: d
Phone: (504) 671-2087

16732
November 04, 2020

SHELL AUGER FLOATING OCS FACILITY LIFEBOAT NO. 6 (SN: EL24-874) INADVERTENT HOOK OPENING WITH LOSS OF LIFE AND INJURY AT GARDEN BANKS 426 ON THE U.S. OUTER CONTINENTAL SHELF ON JUNE 30, 2019

ENDORSEMENT AND ACTION BY THE COMMANDER, EIGHTH COAST GUARD DISTRICT

After careful review, I approve the record and the Report of Investigation (ROI), including the findings of fact, analysis, conclusions, and recommendations, subject to the following comments. I recommend this marine casualty investigation be closed.

COMMENTS ON THE REPORT

1. The inadvertent hook opening of a lifeboat aboard the Shell AUGER Floating OCS Facility (FOF), the loss of two lives, and the injury to a third person, was a tragic accident. I offer my sincere condolences to the families and friends of the two offshore workers who lost their lives. The report contains invaluable information which can be used to prevent similar incidents from occurring in the future. Its findings and recommendations are not limited to only lifeboats on OCS facilities and may be extended to lifeboats on other types of commercial vessels.

2. While an unfortunate and preventable chain of events contributed to this casualty, the most significant factor was the degradation and failure of the lifeboat's aft release cable. An annual inspection of the lifeboat was conducted by representatives of the Original Equipment Manufacturer (OEM) less than one month before the accident. The servicing engineers noted corrosion and damage to the aft hook release cable. In their report to the facility operator, the servicing engineers commented "recommend hook release cables," but also stated lifeboat systems were in "correct working order at this time of service, return boats back to service and made ready for use." As outlined in Section 4.2.5.3 of the ROI, the OEM's lead service engineer stated "we told the OIM and marine [superintendent] before we left [that we recommended] that these cables need to be replaced"; however, Shell's job sponsor and the barge supervisor on AUGER did not recall any discussion about the lifeboat's hook release cable. The aft hook release cable was not replaced and the boat remained in service.

3. The OEM's lead service engineer did not recognize the severity of the hazard posed by the corroded and compromised cable. Specifically, he was unaware that the damaged cable might prevent the aft hook from locking properly and permit it to inadvertently open and release the aft end of the lifeboat. Testing and analysis by investigators and other experts after the accident has illuminated the unsafe condition created by the damaged release cable and this means of failure.

4. Thank you to the members of the investigation team for their exhaustive efforts, which included significant engineering research and collaboration with other experts to evaluate the mechanical integrity of the lifeboat and its launching system.

5. I would like to commend the heroics of the Lifeboat Coxswain who, despite being injured himself after falling 80 feet to the water, swam to the inverted lifeboat to try and help others. He risked his own safety by entering the inverted boat and recovered one of the other crewmembers. More formal recognition is under consideration.

ENDORSEMENT ON RECOMMENDATIONS

Safety Recommendation 1. Recommend the Coast Guard Commercial Regulations and Standards Directorate (CG-5PS) develop a working group to look at consolidating lifesaving gear regulations under one subchapter.

Endorsement: I partially concur with this recommendation. 46 CFR Subchapter W does not currently apply to OCS facilities, but had it been applicable, the prescriptive lifesaving gear regulations housed therein may have addressed the latent unsafe condition with respect to the degraded control cable before it resulted in this fatal marine casualty. The proposed working group should identify a strategy to update the lifesaving equipment regulations applicable to OCS facilities. Possible options include (1) adding more prescriptive maintenance requirements to 33 CFR Subchapter N, using those in 46 CFR Subchapter I-A and in 46 CFR Subchapter W as a model, or (2) amending 33 CFR Subchapter N to make the requirements of 46 CFR Subchapter I-A and/or 46 CFR Subchapter W applicable to OCS facilities.

Safety Recommendation 2. Recommend [that the Lifesaving and Fire Safety Division] (CG-ENG-4) review procedures related to release mechanism type approval to ensure all components, to include control cables, are thoroughly addressed in type approval submittals and testing.

Endorsement: I concur with this recommendation. This investigation revealed that failure of a control cable could result in the uncontrolled release of a lifeboat. Commandant (CG-ENG-4) should review 46 CFR 160.133 and associated regulations and procedures, and consider any updates that may be necessary regarding control cables or other components of release mechanisms.

Safety Recommendation 3. Recommend that the Office of Commercial Vessel Compliance (CG-CVC) develop regulations requiring thorough annual inspections (including inspection of entire length of cable) and time-based and/or condition-based replacement. Most appropriately, these regulations would apply to all lifeboats. In the absence of rule-making, the CG-CVC should issue strong recommendations to OEMs and operators that they voluntarily apply the same.

Endorsement: I concur with the intent of this recommendation. I recommend that Commandant (CG-OES) develop standards, applicable to all U.S. vessels and OCS facilities, requiring the annual inspection of the control cables and time-based and/or condition-based replacement. I note that Commandant (CG-INV) issued Safety Alert 03-20 on February 5, 2020, which strongly recommends that lifeboat owners, manufacturers, operators, and service providers implement an inspection regime that allows for cable damage to be identified, and, as necessary, for cables to be replaced in a timely manner.

Safety Recommendation 4. Recommend [that the Lifesaving and Fire Safety Division] (CG-ENG-4) develop regulations that require that all approved components are approved as a system or are designed to work together (e.g. specific winches allowed to be used with a particular davit, release mechanisms allowed to be used in a specific boat, etc.).

Endorsement: I concur with this recommendation. All approvals should ensure that release mechanisms approved under 46 CFR 160.133 properly interface with the launching appliances approved under 46 CFR 160.115 and 160.132. The replacement of any component should require notification and further review of the system by the OCMI and/or Commandant (CG-ENG).

Safety Recommendation 5. Recommend the [Coast Guard Commercial Regulations and Standards Directorate] (CG-5PS) develop regulations that require the maintenance requirements in 46 CFR. [Part] 109 (or similarly structured requirements) to be applicable to FOFs.

Endorsement: I concur with the intent of this recommendation. 46 CFR Part 109 is not applicable to OCS facilities but the more prescriptive maintenance requirements therein may have addressed the latent unsafe condition with respect to the degraded control cable. As discussed above under Recommendation 1, a working group should identify a strategy to update lifesaving gear regulations applicable to OCS facilities.

Safety Recommendation 6. Recommend [the Coast Guard Commercial Regulations and Standards Directorate] (CG-5PS) reevaluate the use of lifeboats as rescue boats. During witness testimony it was noted the freeboard was too high to lift an unconscious person into the boat and the doors were not wide enough to allow two persons to lift an unconscious person through.

Endorsement: I concur with the intent of this recommendation. In accordance with 46 CFR 108.510(b), OCS facilities constructed before October 1, 1996, such as AUGER, are not currently required to have rescue boats. The working group discussed in Recommendation 1 and 5 should determine if all FOFs, regardless of build date, should be equipped with an approved rescue boat.

Safety Recommendation 7. Recommend the [Coast Guard Commercial Regulations and Standards Directorate] (CG-5PS) develop regulations ensuring oversight of lifeboat, winch and davit repairs and modifications for all vessels and facilities not subject to 46 CFR Subchapter W, Lifesaving Appliances and Arrangements.

Endorsement: I concur with the intent of this recommendation. I recommend that Commandant (CG-5PS) consider the development of regulations requiring notification to the cognizant OCMI when an operator intends to conduct repairs or modifications to primary lifesaving equipment on an OCS Facility.

Safety Recommendation 8. Recommend the [Coast Guard Commercial Regulations and Standards Directorate] (CG-5PS) develop policy that ensures OCMIs and their representatives properly evaluate type approved equipment in regards to repairs and modifications (especially as they relate to serviceability and maintaining equipment in an as-approved condition), and that CG-ENG-4 remains engaged appropriately in these activities as necessary after initial approval.

Endorsement: I concur with the intent of this recommendation. I recommend that the Coast Guard Force Readiness Command (FORCECOM) also evaluate Marine Inspector training on this topic, taking into account the information in this report, and if necessary develop training to ensure USCG Marine Inspectors are properly equipped to complete oversight activities.

Safety Recommendation 9. Recommend the D8 OCMI (ocs) update current policy on drill and maintenance requirements for regulated facilities operating on the OCS to best reflect current regulatory requirements.

Endorsement: I concur with the intent of this recommendation. The D8 OCS OCMI published Policy Letter 01-2020, which clarified emergency evacuation drill requirements but did not address the maintenance requirements in 33 CFR 146.15. As noted in my endorsement of Safety Recommendations 1 and 5, I recommend that Commandant (CG-5PS) consider potential updates to lifesaving gear regulations applicable to OCS facilities, particularly with regard to more prescriptive maintenance requirements. In the meantime, I have directed the D8 OCS OCMI to review current guidance and consider the most appropriate means to ensure compliance with the intent of current regulations.

Safety Recommendation 10. Recommend the [Coast Guard Commercial Regulations and Standards Directorate] (CG-5PS), with input and involvement by the OSC NCOE, develop a work group to research/revise regulations and policies and engage with other administrations for input into their management of the following for the offshore oil & gas operations:

- Lifeboat launching
- Drills and competence
- Maintenance

Endorsement: I concur with this recommendation. The work group should include the D8 OCS OCMI. In addition, I recommend this work group reach out to the Bureau of Safety and Environmental Enforcement (BSEE) to evaluate if the above activities should also be incorporated in the Safety and Environmental Management System under 30 CFR 250.1915 and 250.1916.

Administrative Recommendation 1. Recommend the D8 OCMI (ocs), after being routed and reviewed by [the Office of Investigations & Casualty Analysis] (CG-INV), communicate Findings of Concern to the OEM, recommending:

- The OEM update work instructions to automatically replace control cables five years from the date the cables were installed.
- The OEM update all work instructions to better communicate the nature of repair or replacement recommendations, the risk posed by the deficiency, and a recommended timeline for repair or replacement.

- The OEM review and revise their procedures for release mechanism control cable installations and inspections and provide training on the same to their technicians.
- The OEM conduct a review of its hook indicator color coding system to determine whether the current system (red means open; green means closed) is confusing for operators.

Endorsement: I concur with the intent of this recommendation. The investigation revealed the critical importance of the release cable and the necessity to improve the level of oversight and associated training by OEMs. Additionally, this investigation discovered that lifeboat crew members may be confused by the color scheme utilized to demonstrate with "open/closed" on lifeboat hooks, and that this confusion could lead to additional marine casualties. I recommend that Commandant (CG-ENG) notify OEMs of these Findings of Concern and associated recommendations.

Administrative Recommendation 2. Recommend the D8 OCMI (ocs), after being routed and reviewed by [the Office of Investigations & Casualty Analysis] (CG-INV), communicate Findings of Concern to the Operator, recommending:

- The Operator incorporate all OEM recommended maintenance into their maintenance system as mandatory.

Endorsement: I concur with this recommendation. This investigation revealed that it is paramount that emergency gear be kept in good condition at all times, which may have been achieved by promptly acting upon all OEM recommendations. This investigation concluded that the OEM had made a recommendation to the Operator that the control cable in Lifeboat NO.6 be replaced, and that such replacement was not accomplished.

Action: The D8 OCS OCMI will draft an appropriate Finding of Concern to communicate recommendations to the Operator, including incorporation of OEM recommendations into their maintenance system, as well as clarification of roles and expectations between the OEM and the Operator.

Administrative Recommendation 3. Recommend [the Office of Investigations & Casualty Analysis] (CG-INV) issue a Finding of Concern recommending that operators ensure that persons planning, conducting, and overseeing routine lifeboat maintenance have read and are familiar with the applicable lifeboat operations and maintenance manual.

Endorsement: I concur with this recommendation. This investigation highlighted the importance that those crew members charged with regular maintenance and inspection duties be thoroughly familiar with the components of lifeboats with which they interact. With the assistance of the D8 OCS OCMI and the OCS NCOE, CG-INV should communicate this importance to vessel and OCS facility operators via a Finding of Concern.

Administrative Recommendation 4. Recommend [the Office of Investigations & Casualty Analysis] (CG-INV) issue a Finding of Concern recommending operators, with the assistance of the OEM, train crews to ensure they understand how the hook indicators, when installed, function and convey information regarding the condition of the hook. Operators and OEMs should also communicate to crews the need to verify the status of the hook indicator at least two times during the retrieval process: at the water after the falls are connected and immediately after the lifeboat clears the water.

Endorsement: I concur with this recommendation. Commandant (CG-INV) should communicate the importance of ensuring those associated with lifeboat duties on vessels and OCS facilities understand the functions of the lifeboat hook and color position indicators.

Administrative Recommendation 5. [The Office of Investigations & Casualty Analysis] (CG-INV) and [the Office of Commercial Vessel Compliance (CG-CVC)] should widely publicize this investigation's findings related to the hazards posed by compromised control cables to all marine sectors maintaining and operating lifeboats, to include Coast Guard inspectors.

Endorsement: I concur with this recommendation and note that some of these findings have already been disseminated via Safety Alert 03-20. Additionally, the information in this Report of Investigation should be utilized when training CG Marine Inspectors.

Administrative Recommendation 6. [The Office of Commercial Vessel Compliance (CG-CVC)] and [the Lifesaving and Fire Safety Division] (CG-ENG-4) should provide additional guidance to inspectors and the regulated community regarding certificates of approval regulated under 46 CFR 2.75-5. This guidance should include clarity on who they are issued to, how they relate to the sale and production of equipment, the significance of their validity period, and what constitutes replacement in kind of equipment no longer holding a valid approval certificate.

Endorsement: I concur with this recommendation. In the course of this investigation it was discovered that Lifeboat NO.6 had been sold multiples times. As indicated in this Report of Investigation, especially sections 4.3.4.2.1. and 5.10, there is lack of clarity regarding how to correctly apply certain provisions of 46 CFR 2.75 and 46 CFR 160.135-23. Additional guidance for Marine Inspectors would be useful.

Administrative Recommendation 7. Administrative Recommendation 7: Recommend the [Office of Investigations & Casualty Analysis] (CG-INV) issue a Finding of Concern that highlights the benefits of using FPDs during lifeboat launches and retrieval drills.

Endorsement: I concur with the intent of this recommendation. Commandant (CG-CVC and CG-ENG-4), should review the efficacy of utilizing Fall Protection Devices for training and maintenance evolutions.

Administrative Recommendation 8. Recommend that this investigation be closed.

Endorsement: I concur with this recommendation.

JOHN P. NADEAU
Rear Admiral, U.S. Coast Guard
Commander, Eighth Coast Guard District

Enclosure: Investigating Officer's Report 16732 dated June 16, 2020

U.S. Department of Homeland Security
United States Coast Guard

Eighth Coast Guard District
United States Coast Guard

500 Poydras St.
New Orleans, LA 70130
Staff Symbol: OCS
Phone: (504) 671-2106

16732
May 15, 2020

SHELL AUGER FLOATING OCS FACILITY LIFEBOAT NO. 6 (SN: EL24-874) INADVERTENT HOOK OPENING WITH LOASS OF LIFE AND INJURY AT GARDEN BANKS 426 ON THE U.S. OUTER CONTINENTAL SHELF ON JUNE 30, 2019

EXECUTIVE SUMMARY

On Sunday, June 30, 2019, at approximately 10:00 a.m., the aft hook on Shell AUGER's[1] Lifeboat No. 6 inadvertently opened as the lifeboat was being winched into the davit following a quarterly launch and retrieval drill. The lifeboat, still hanging from the forward hook, swung in a pendulum motion away from the facility. A few seconds later, the forward hook separated from the lifeboat and opened, and the lifeboat fell approximately 80 feet, landing inverted in the water. The two persons still onboard the lifeboat when it fell were fatally injured. One person, who was exiting the lifeboat when it released, fell into the water and was injured. The lifeboat was a total loss.

Lifeboat No. 6 was a 33-man 24-foot enclosed, dual-fall lifeboat manufactured by Watercraft America[2] in 1984 and refurbished in 2012. Lifeboat No. 6 was outfitted with a Schat-Harding[3] SeaCure LHR3.5M2 release mechanism.

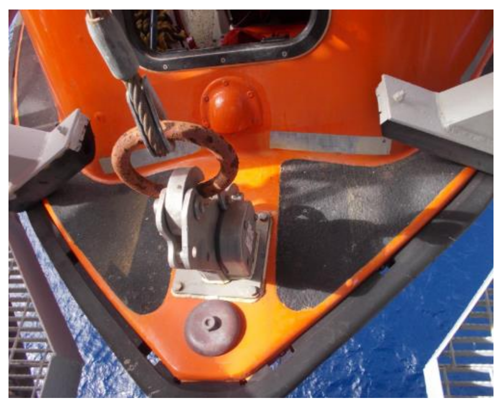


Image 1 (left): Lifeboat No. 6.
Image 2 (above): Photo Lifeboat No. 6 aft hook from 2014. Credits: Palfinger Marine.

The release mechanism was comprised of two hooks, a hook release unit (located inside the lifeboat adjacent to the helm), a hydrostat unit, and three control (push-pull) cables (see Image 3). One control cable connected the hook release unit to the aft hook, the second control cable connected the release unit to the forward hook, and the third control cable connected the release unit to the hydrostat unit.

---

[1] Shell AUGER is a floating OCS facility (FOF) of the tension leg design located in the Gulf of Mexico. It is operated by Shell Offshore
[2] The Watercraft America brand is now owned by Palfinger Marine.
[3] The Schat-Harding brand is also now owned by Palfinger Marine.

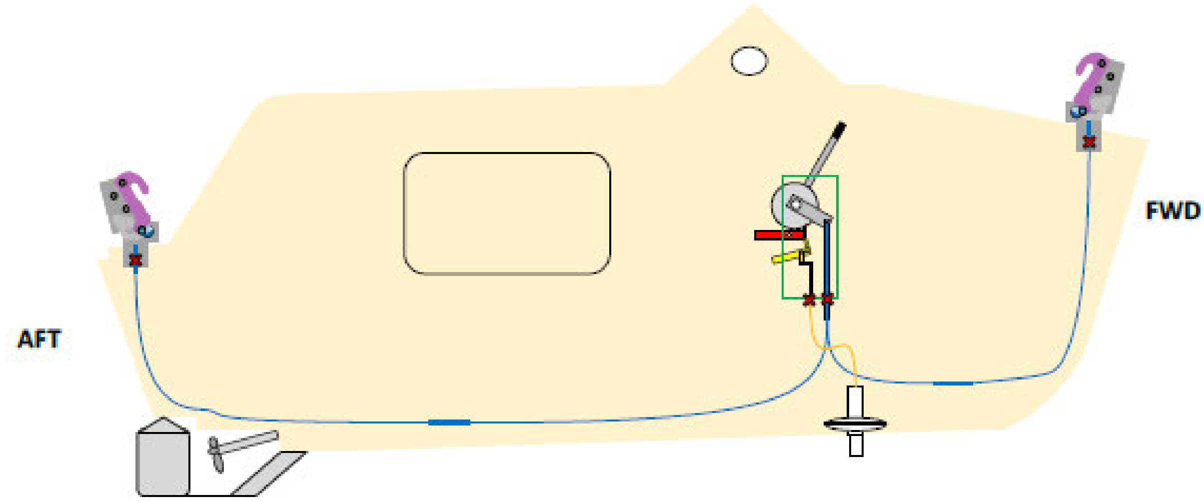


Image 3: Drawing of EL24 outfitted with LHR3.5M2 release mechanism. Credit: Shell.

The hook control cables are heavy duty low friction cables with threaded end fittings and four inches of travel at the end rods (see Image 4). Each cable has an outer conduit and an inner member. The conduit is comprised of three layers: a green plastic cover; steel reinforcement; and a white polyethylene liner. The conduit provides a protected path for the steel inner member. With the ends of the conduit fixed at each terminal point (provided it is not fully compromised), the conduit also controls the travel length of the inner member. The inner member transmits linear motion from the hook release unit to the locking shafts located within the hooks via the end rods.

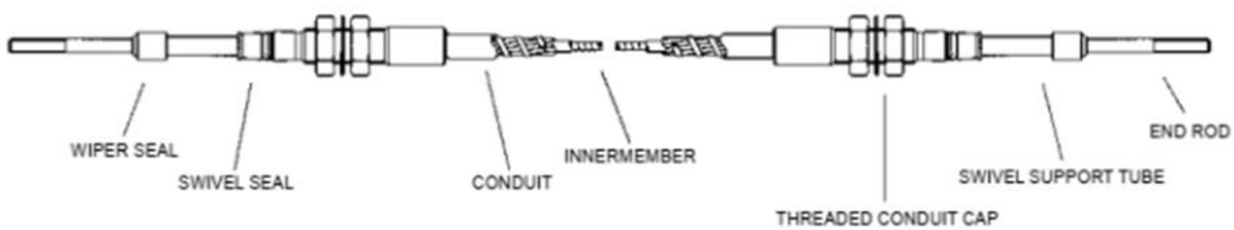


Image 4: Control cable components. Credit:Cablecraft, modified by the USCG.

Generally, the system works in the following manner: When closing or resetting a hook, an operator positioned at the release unit pulls up on the safety lock and pushes forward on the control handle, locking it into place. Consequently, the end rod on the hook end extends. This extension causes the hook's locking shaft to move to the closed or locked position. When opening the hook, the opposite actions and forces apply.

During the course of the investigation, the Coast Guard, Shell, and Palfinger Marine (the original equipment manufacturer or "OEM") identified a previously unknown vulnerability in the system: if all three layers of the conduit of a hook control cable separate or break, during a reset the locking shaft may not return to the fully closed position. Rather, the locking shaft may come to rest at an "almost open" position (see Image 5). In such a position, the hooks can support the weight of the boat and its occupants during retrieval. However, an additional load can cause the locking shaft to rotate to the open position, releasing the hook.

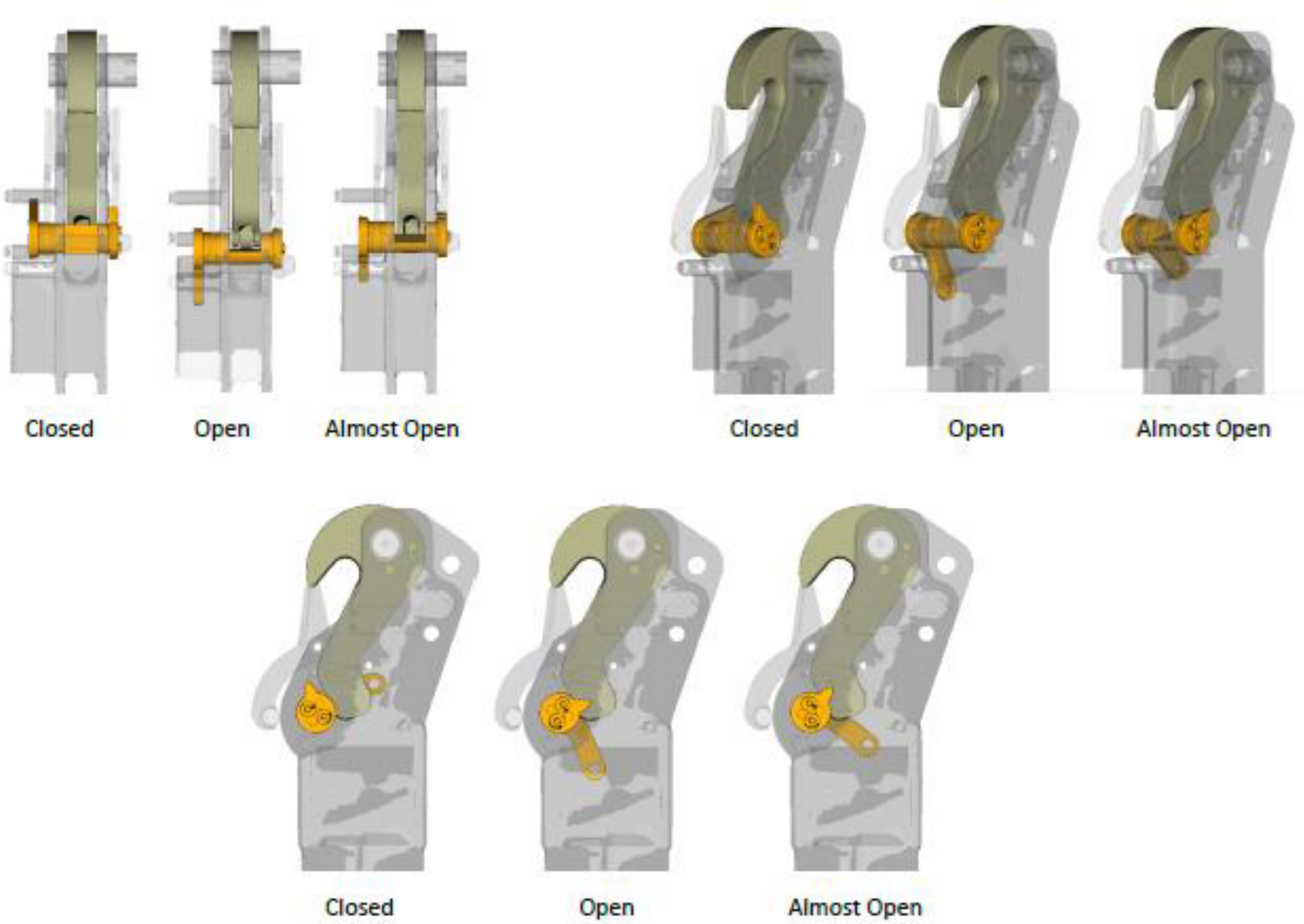


Image 5: Hook cutaway views of LHR3.5M2 hook in closed, open and almost open positions. Locking shaft depicted in yellow. Credit: CG (hook component data provided by DNV-GL).

Image 6: Photograph of damage to Lifeboat No. 6 aft control cable dated June 6, 2019. Credit: Palfinger.

On the morning of June 30, 2019, Lifeboat No. 6 was launched and initially retrieved without incident. However, unknown to the launch crew and boat crew, but documented in an OEM service report completed on or about June 6, 2019, a section of the aft hook control cable conduit was corroded and damaged, although not fully separated.

On the day of the casualty, the crew cycled the hooks (open to closed position) two times while in the water. If a cable conduit is already damaged, the act of cycling exposes the conduit layers to additional stresses, including compression and tension (stretching). It is probable[4] that during the second cycling event, the

[4] In this investigation, Coast Guard investigators use the terms "probable," and "possible" to communicate confidence in certain conclusions. When investigators use the term "probable" it means that after assessing all evidence, they believe the likelihood of the conclusion being true is more likely than not (51% or more). When investigators use the

conduit, already weakened and damaged, separated during the closing action (see Image 7). As a result, when the system was reset, the locking shaft on the aft hook did not return to the fully closed position, but rather, came to rest at an "almost open" position. In this position, the hook could support the weight of the lifeboat and its occupants as the lifeboat was hoisted from the water to the davit. However, at the davit, additional forces applied to the hook and the lifeboat, as a result of the winch pulling the boat against the bumpers, caused the locking shaft to rotate from the "almost open" to the open position. Under load, the aft hook was free to open and release from the lift ring (a ring attached to the end of the fall cable (wire rope); often called the "D" ring). The forward hook, not designed to bear the entire load of the lifeboat or operate outside of specified angles, was unable to sustain the weight of the lifeboat, separated from the hull and eventually opened.

Image 7: Photograph of aft control cable after casualty. Photograph documents separation of three layers of the conduit: the green plastic cover; a steel wire; and a white polyethylene liner. Credit: DNV-GL.

The investigation team determined that the initiating event for this casualty occurred when the locking shaft on the aft hook moved from the "almost open" to the open position, which in turn caused the aft hook to open under load and release from the lift ring. Subsequent to the initiating event, the forward hook, bearing the entire load of the lifeboat, separated from the hull and opened. The lifeboat fell approximately 80 feet, with two persons still onboard, and landed inverted in the water.

The primary causal factor that directly contributed to the casualty was the complete separation of the aft hook control cable conduit surrounding the inner member.

Other causal factors include, the: 1) the operator and/or OEM's failure to replace the aft hook control cable after it was identified as damaged; 2) the operator and/or OEM's act of allowing Lifeboat No. 6 to stay in service after the aft hook control cable was identified as damaged; 3) the operator's, OEM's, and regulators' lack of knowledge that a compromised hook control cable could allow a locking shaft to stop at a position short of fully closed after reset; 4) the operators and OEM's lack of effective communications related to roles and responsibilities; and 5) operator's and OEM's focus on function-based inspections vice condition-based inspections, as related to the control cables.

Contributing factors include the lack of systems, policies or regulations in existence to ensure that control cables are properly monitored and changed out in accordance with the OEM's recommendations and/or best industry practices.

term "possible," it means that after assessing all the evidence, they believe that the conclusion is feasible but cannot be declared probable.

U.S. Department of Homeland Security
United States Coast Guard

Eighth Coast Guard District
United States Coast Guard

500 Poydras St.
New Orleans, LA 70130
Staff Symbol: OCS
Phone: (504) 671-2106

16732
July 13, 2020

SHELL AUGER FLOATING OCS FACILITY LIFEBOAT NO. 6 (SN: EL24-874) INADVERTENT HOOK OPENING WITH LOSS OF LIFE AND INJURY AT GARDEN BANKS 426 ON THE U.S. OUTER CONTINENTAL SHELF ON JUNE 30, 2019

INVESTIGATING OFFICER'S REPORT

1. Preliminary Statement

1.1. This Outer Continental Shelf (OCS) casualty investigation was conducted and this report was submitted in accordance with Title 33, Code of Federal Regulations (CFR), Subpart 140.203, and under the authority of Title 43, United States Code (USC), Chapter 1348. In accordance with Title 33, Code of Federal Regulations (CFR), Subpart 140.203, the investigators followed the procedures set forth in Title 46, Code of Federal Regulations (CFR), Part 4, insofar as practicable.

1.2. On July 25, 2019, Commander, Eighth Coast Guard District issued the enclosed convening order directing me to thoroughly investigate the June 30, 2019 casualty involving the Shell AUGER Lifeboat No. 6 that resulted in the death of two crew crewmembers and injury to a third crewmember. See Enclosure (1).

1.3. The following personnel participated in the formal investigation: Lead Investigating Officer - LCDR [redacted] Investigations National Center of Expertise; Assistant Investigating Officer - LT [redacted] Sector New Orleans; Legal Advisor – LT [redacted] Eighth Coast Guard District. Mr. [redacted] Outer Continental Shelf National Center of Expertise, Mr. [redacted], Outer Continental Shelf National Center of Expertise, and Mr. [redacted] CG-ENG-4, served as subject matter experts.

1.4. The Coast Guard designated two parties-in-interest: Shell Offshore, Inc., as owner and operator of the lifeboat (hereinafter referred to as "Shell" or "operator"); and Palfinger Marine, the original equipment manufacturer (OEM) (hereinafter referred to as "Palfinger" or "OEM").

1.5. The Coast Guard was the lead federal agency for initial evidence collection activities and led all efforts to recover additional evidence at the casualty site. The Coast Guard provided the Bureau of Safety and Environmental Enforcement (BSEE) with briefs, as appropriate. However, BSEE did not participate in the investigation.

1.6. The Coast Guard did not hold any public hearings.

1.7. In this investigation, Coast Guard investigators use the terms "probable," and "possible" to communicate confidence in certain conclusions. When investigators use the term "probable" it means that after assessing all evidence, they believe the likelihood of the conclusion being true is more likely than not (51% or more). When investigators use the term "possible," it means that after assessing all the evidence, they believe that the conclusion is feasible but cannot be declared probable.

1.8. Unless otherwise indicated, references to time in this report are listed as 24-hour time and reflect Central Daylight Time (CDT), Coordinated Universal Time, offset of minus five hours.

2. Facility and Vessel Involved in the Casualty

Figure 1. AUGER, July 2019. Photo credit: USCG.

Official Name	FPS AUGER
Facility Type	Floating OCS Facility
Official Number	CG030693
Location	Gulf of Mexico, Garden Banks Block 426
Water Depth	2,860 feet
OCS Lease	G-OCS-08241
Owner	Shell Offshore Incorporated
Subtype	Tension Leg Platform
Regulatory Length	338 feet
Delivery Date	6 December 1993

Figure 2: Lifeboat No. 6. Photo credit: Palfinger Marine.

Serial Number	EL24-874/3/84
Manufacturer	Watercraft America[1]
Type	Lifeboat
Lifeboat Station	Lifeboat Station No. 6
Hook Release System	Schat-Harding[2] SeaCure LHR3.5M2
Style	Totally enclosed lifeboat – tanker version
Propulsion Type	Motor
Length	23.87 feet[3]
Breadth	8.75 feet
Capacity	33 persons
Year Built (Completed)	1984
Year Refurbished	2012

3. <u>Deceased, Missing, and/or Injured Persons</u>

Relationship to Vessel	Sex	Age	Status
Boat Crew Person 2	Male	[redacted]	Deceased
Boat Crew Person 3	Male	[redacted]	Deceased
Lifeboat Coxswain	Male	[redacted]	Injured

[1] The Watercraft America brand is now owned by Palfinger Marine.
[2] The Schat-Harding brand is also now owned by Palfinger Marine.
[3] Length and breadth per the data plate.

4. **Findings of Fact**

4.1. The Casualty:

Launch Preparations

4.1.1. On June 30, 2019, at or around 0930, the designated mechanics, ballast control operator (BCO) and electrician assigned to the floating OCS facility AUGER mustered near lifeboat stations on the starboard side on the lower deck for purposes of carrying out that day's assigned task: completing the quarterly lifeboat launch and retrieval drills for three lifeboats, specifically: Lifeboats 6, 7, and 8. On the day prior, June 29, 2019, AUGER crewmembers had launched and retrieved three of the facility's other lifeboats.

4.1.2. Seven crewmembers mustered. Of the seven persons who mustered, six had taken part in the previous day's launches and retrievals. In accordance with Shell policy, one member of the crew, on that day the BCO, led the assigned men through a job safety analysis (JSA), a written form intended to assist persons discuss, assess and mitigate risks related to operational tasks. No additional risks, beyond those inherent in the operational task, were identified.

4.1.3. Collectively, the group decided that they would first launch and retrieve Lifeboat No. 6, a 24-foot dual-fall totally enclosed lifeboat. The group also worked together to designate the four crewmembers that would enter the boat and serve as boat crew and the three crewmembers that would stay on the facility and serve as the launch crew. Collectively, the boat crew was comprised of the Coxswain, Boat Crew Person 1, Boat Crew Person 2, and Boat Crew Person 3. The launch crew was comprised of the Electrician, the BCO, who on that day was assigned to work the winch manually upon retrieval of the lifeboat, and a Launch Crew Person.

4.1.4. Earlier, the Electrician had unplugged Lifeboat No. 6's battery charger and completed his checks. Accordingly, once the JSA was complete, the four boat crew members entered the boat. Once inside, they conducted final checks of the boat, assumed their designated seats, and prepared for launch.

4.1.5. On deck, the Electrician moved to his place by the electric winch control. The Launch Crew Person and BCO stood by ready to support the launch.

Launch

4.1.6. After getting permission from the control room, the Coxswain started the engine. The Coxswain found the brake release cable difficult to pull, so he enlisted the help of Boat Crew Person 1. Together, they pulled the brake release cable, which caused the boat to lower into the water. At the water, the Coxswain stayed connected to the fall cables just long enough to check the steering and confirm that the new rudder packing was not leaking. Once complete, the Coxswain set to releasing the hooks. He lifted the red safety lock at the release unit and simultaneously pulled the hook release handle toward him. The forward and aft hooks opened and the lift rings (often

Figure 3: Lifeboat No. 6 release unit. Credit: Palfinger, dated 2016.

called “D” rings) separated from the hooks. The Coxswain maneuvered the boat away from the facility.

4.1.7. The Coxswain noted that the currents were minimal and the sea state was calm. The Electrician called the launch “picture perfect.”

4.1.8. After getting underway, the boat crew tested the water spray system (i.e., sprinklers) and ensured the engine and hull were fit for service. Once the checks were complete, the boat crew opened the doors, allowing air to circulate inside the hot lifeboat and prepared to reset or close the hooks back to the locked position.

<u>Resetting</u>

4.1.9. Boat Crew Persons 1 and 3 exited the lifeboat through its doors and walked along the gunnels (or gunwales) of the boat toward the forward and aft hooks, respectively (see Figure 5). After coordinating with the Coxswain, they verified that the forward and aft hook tails were correctly positioned for retrieval. Inside the boat, the Coxswain pulled up the red safety lock and pushed the hook release handle away from him until it locked. The hooks were now reset, locked and ready for retrieval.

Figure 4: Lifeboat No. 6 in water but still hooked up to fall cables. Credit: Palfinger, dated 2015.

Figure 5: Lifeboat No. 6 in the water. Persons riding on gunnels. Credit: Palfinger, dated 2015.

4.1.10. The Coxswain recalled cycling through the resetting process two times that day for purposes of allowing Boat Crew Person 2, who was training on the lifeboats, to observe a second release and reset cycle.

4.1.11. After completing the second and final reset, the Coxswain gave the locked handle a shake, one manner that he used to confirm that the handle was locked and the hooks reset. From his seat in the boat, the Coxswain could see the forward hook. He could see the flat face of the locking shaft, confirming, in his mind, that the front hook was reset. Orally, he called out to Boat Crew Persons 1 and 3 and asked them to confirm that their hooks were reset.

4.1.12. Boat Crew Person 1 had watched the hook locking shaft roll back into place. He looked for and saw the flat face of the locking shaft (see Figure 6). To him, this indicated that the locking shaft was in the correct position and the hooks were correctly reset. He also said he would generally look at the hook indicator on the side of the hook. He noted that if in the closed position, the arrow should be in the red; if in the open position, the arrow would indicate in the green.[4]

Figure 6: The "flat face" of the locking shaft on a LHR 3.5M2 hook (image does not depict Lifeboat No. 6's hook). Credit: CG.

4.1.13. Boat Crew Person 1 and 3 called back to the Coxswain, confirming that their hooks were reset.

4.1.14. In total, the lifeboat was in the water for approximately 10-15 minutes.

<u>Retrieval</u>

4.1.15. On deck, three persons remained: the Electrician, the BCO and the Launch Crew Person. While the boat was in the water and away from the facility, the Electrician tested the front and aft limit switches. Pushing up on the limit switches with a boat hook, the launch crew sought to simulate the forces of a lifeboat coming up into the davit. As they lifted the switches, the electric winch shut off, as designed to do, confirming that both limit switches were in good working order.

4.1.16. The Coxswain radioed to the deck to lower the fall cables; the BCO released the winch brake and lowered the cables. The Coxswain maneuvered the lifeboat under the davit, lining the forward and aft hook up with the forward and aft fall cables.

4.1.17. Boat Crew Persons 1 and 3, still outside the lifeboat and standing on the gunnels, grabbed the lift rings with boat hooks. Once both boat crew persons had their lift ring in hand, they stood on the gunnels next to their assigned hooks and pushed their lift ring through the hook link locks (i.e., keepers) at the same time[5]. Boat Crew Person 1 shouted training tips to Boat Crew Person 2 who watched from the door area.

4.1.18. The Coxswain visually confirmed that the forward lift ring was attached. Still, he called out to Boat Crew Person 1, "Are you good?" Boat Crew Person 1 replied, "Yeah, we are good," or words to that effect. The Coxswain did not have a clear line of sight to the aft hook. He yelled out to Boat Crew Person 1, "Is [Boat Crew Person 3] good?" Boat Crew

[4] When the indicator is in the green, the hook actually closed or locked. When it is in the red, it is open. It is unclear whether Boat Crew Person misspoke at the interview or didn't understand how the system operated.

[5] On the AUGER, there are two methods that boat crews use to hook up the lifeboat. One method is to open the front and aft windows, stand up in the window, grab the lift ring hanging at the end of the falls cable and push it through the hook keeper, effectively attaching the lift ring and hook. Boat crews can also verify hook resets and connect the lift rings to the hooks from the windows, installed for the purpose of hook access. The second, as described above, involves the crew hooking up while standing on the gunnels. While the OEM recommends the window method, crews complain that this method put them at risk for being hit by a swinging fall cable. The benefit to the window method is that the crews can better assess the location of the hook indicator, located on the side of the hook. The method used by the boat crew on this day, while not in accordance with OEM recommended procedures, was not a causal factor to the casualty.

Person 1 called out to Boat Crew Person 3, "You got it?" Boat Crew Person 3 replied, "I got it." The Coxswain was trained to obtain redundant confirmation, so he hollered out again seeking confirmation again that the lift rings were attached. Boat Crew Persons 1 and 3 again confirmed that their lift rings were attached.

4.1.19. The Coxswain was not in a hurry. The currents being calm, the lifeboat did not drift, but rather, stayed right under the falls. From the Coxswain's perspective, the men at the hooks also took their time.

4.1.20. Boat Crew Persons 1, 2 and 3 re-entered the boat. The boat crew took their seats and put on their seat belts.

4.1.21. The Coxswain later characterized the evolution, up to that time, as nearly "perfect."

4.1.22. Just before 1000, at the request of the boat crew, the Electrician bumped the electric winch and removed the slack from the fall cables. After communicating with the boat crew, the Electrician raised the boat approximately five to ten feet above the water. He kept the boat there for several seconds, allowing the boat to steady and ensuring that the hooks would bear the load of the lifeboat. The boat did not rock and the hooks held. Accordingly, the Electrician pushed the electric winch motor button and brought the boat up toward the davit. Generally, it takes only one to two minutes for the lifeboat to be winched from the waterline to the deck, absent any stops to reduce longitudinal swinging.

4.1.23. The Electrician watched the lifeboat as it was raised. He saw the lifeboat reach the limit switches. As the limit switch "opened," the electric motor turned off. Lifeboat No. 6 was not yet seated in the forward and aft bumpers. In order to prevent the boat from being pulled too hard into the bumpers, the limit switches were set to open and turn off the electric winch when the boat was approximately 6-12 inches below the bumpers. [6]

4.1.24. The Electrician stepped back from the electric winch motor button and threw up his hands to notify the BCO that it was his time to hand crank the lifeboat to the bumpers and the lifeboat's final stowed position.

4.1.25. The Electrician and the Launch Crew Person removed the handrails at the starboard side of the lifeboat. With the lifeboat almost even with the deck, Boat Crew Person 1 exited the lifeboat.

[6] Based on measurements taken after the casualty, there is some evidence that when the limit switches opened on the day of the casualty, the aft part of the boat was already to the bumpers, while the forward part was still hanging up to 7.5 inches below bumpers. While the evidence solidly supports the fact that the lifeboat was not wholly level, modeling conducted by DNV-GL and Plastic Services Network (PSN), two firms hired to conduct independent forensic testing of the evidence, did not support the investigators' initial findings regarding to what degree the lifeboat was offset. The Coast Guard's final conclusions regarding cause are not determinative on the lifeboat being offset at all, only on the fact that the aft part of the lifeboat reached the bumpers at some point during the retrieval/stowage process. For the reasons above, the Coast Guard has elected not to analyze the potential offset. More information on the Coast Guard's analysis can be found in Enclosure (2) and Paragraph 5.4 Below. DNV-GL's and PSN's modeling and analysis can be found in Enclosure (3).

4.1.26. The winch is located on a raised landing above the forward end of the lifeboat (see Figure 7). The BCO reached the winch by climbing a ladder. At the winch, he inserted the handle and started to crank. The winch at Lifeboat Station No. 6 had recently been changed out. While the new winch was not "new," it had been refurbished in or around 2018 and was in significantly "newer" condition than the previous winch at Lifeboat Station No. 6. Furthermore, it was a more powerful winch: the new winch was converted to a model 9300XL, rated for 9300 kg; while the old model, a 7800XL was rated for only 7800 kg. To the BCO, the winch model looked identical. However, he did note that it was easier to operate. Later, he recalled that it felt "smooth" and "like butter." He observed, "Where the old one had like maybe two pounds of resistance . . . this one had like a half pound of resistance against it."

Figure 7: Lifeboat Station No. 6 davit. Figure depicts raised landing where winch is located. Credit: Palfinger, dated May 2015.

4.1.27. The BCO later recalled that he made four revolutions with the winch handle. He watched the Electrician, who was standing on the deck below, and waited for confirmation that the lifeboat was seated against the bumpers. Meanwhile, the Electrician was busy on deck working to put away boat hooks and retrieve gear from the lifeboat.

4.1.28. The Coxswain was the next person to exit the boat. As he exited, he noted that Boat Crew Person 2 and Boat Crew Person 3 were out of their seats in the aft part of the lifeboat.

<u>Aft Hook Opening</u>

4.1.29. The BCO continued to hand crank the winch. With the Coxswain now blocking his view of the Electrician, the BCO called out to the Coxswain to ask whether the lifeboat was seated in bumpers yet. The BCO later noted that resistance on the winch never changed.

4.1.30. As the Coxswain exited, but before he could fully balance his weight on the deck, a loud sound emitted from the aft part of the boat. The witnesses described the sounds in the following terms: "a crunching popping," "wood breaking," "a shotgun," "a pop," "fiberglass cracking," and "something letting go."

4.1.31. The aft hook opened, and the boat released from the aft lift ring and fall cable. The Coxswain, not fully balanced on the platform, fell into the water directly below the davit. The aft part of the boat dropped toward the water, and the lifeboat swung out away from the facility on the forward hook, traveling in a pendulum motion. The front hook separated from the boat and released, and the boat fell 80 feet and landed inverted into the water. The below drawings depict the winching and falling sequence (See Figures 8-12; all figures credited to Shell):

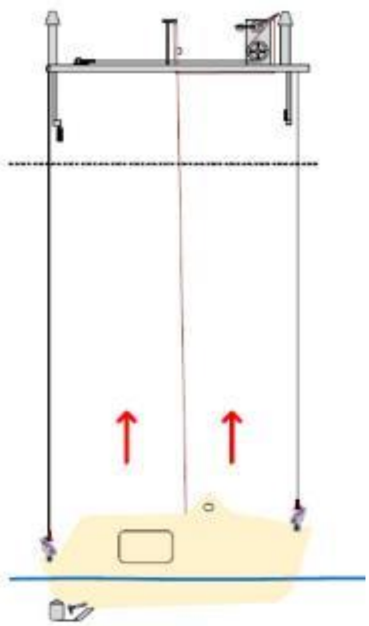


Figure 8: Quarterly lifeboat checks complete, the crew hooks the lifeboat back onto the falls.

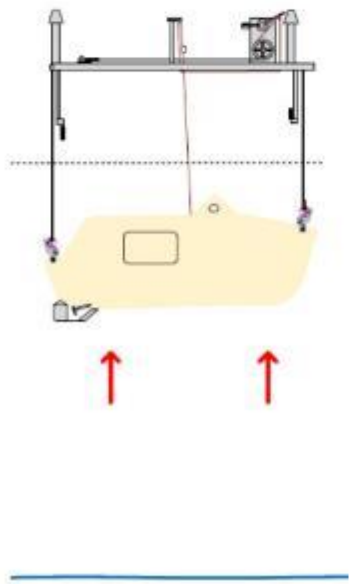


Figure 9: The lifeboat is winched upward using the electrically powered winch.

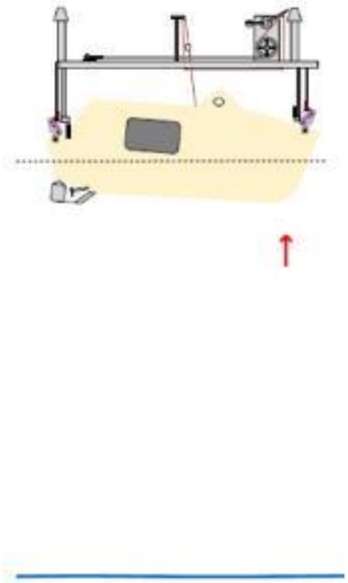


Figure 10: The electrical winch stops when a limit switch is activated. The boat is manually winched to its final position against the forward and aft davit bumpers.

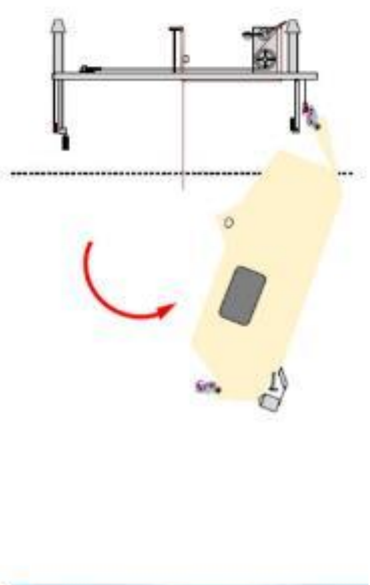


Figure 11: The aft hook releases and the lifeboat swings placing all the weight onto the forward hook.

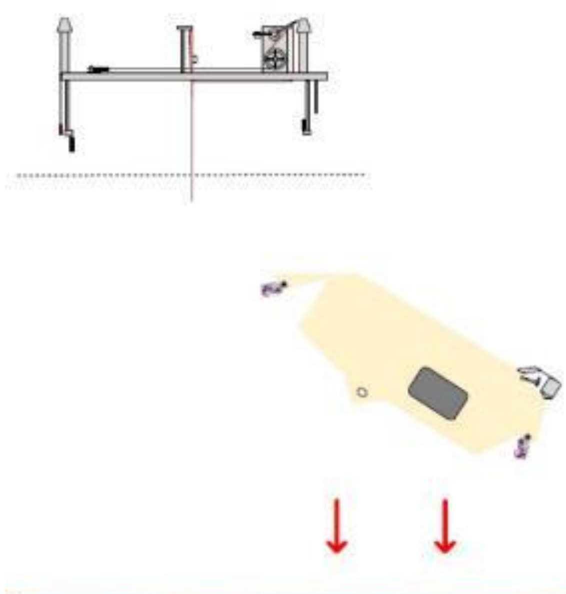


Figure 12: The forward hook, not designed to bear the entire load of the lifeboat or operate outside of specified angles, was unable to sustain the weight of the lifeboat, separated from the hull and eventually opened. The lifeboat fell and landed inverted in the water.

Personnel Recovery

4.1.33. The Coxswain survived the fall. Upon resurfacing, he immediately located Lifeboat No. 6, floating inverted in the water, and started to swim over to the lifeboat. The bow of the boat was split open.

4.1.34. The Coxswain entered the lifeboat through the split in the hull. He navigated through debris to access the aft end of the lifeboat. After several attempts, the Coxswain located Boat Crew Person 2 and Boat Crew Person 3. It took him several tries, however, eventually, he removed Boat Crew Person 2 from the wrecked lifeboat. He was unable to retrieve Boat Crew Person 3.

4.1.35. At 1003, the AUGER crew launched Lifeboat No. 5 for rescue.

4.1.36. At or around 1007, the crew on Lifeboat No. 5 recovered the Coxswain and Boat Crew Person 2 from the water. The crew of Lifeboat No. 5 found it difficult to lift Boat Crew Person 2 from the water and through the lifeboat door. Eventually, they were successful. At 1018, Lifeboat No. 5 was retrieved and back onboard AUGER.

4.1.37. At 1029, Lifeboat No. 5 was launched again. At 1039, the crew retrieved Boat Crew Person 3 from Lifeboat No. 6. At 1047, Lifeboat No. 5 was back onboard AUGER.

4.1.38. The three injured crewmembers were evacuated by helicopter to hospital facilities on land.

4.1.39. Per the coroner, Boat Crew Person 2 and 3 both drowned as a likely result of blunt force injuries sustained due to their fall to the water.

Lifeboat Recovery

4.1.40. At 1114, an offshore supply vessel secured Lifeboat No. 6 with lines, ensuring the lifeboat did not sink before it could be recovered.

4.1.41. On July 2, in accordance with a Coast Guard approved salvage plan, contractors commenced salvage operations. On July 5, 2019, Lifeboat No. 6 arrived in Port Fourchon, LA. Before it was lifted from the sea, the boat was fully photo and video documented. Once in Port Fourchon, the Coast Guard video documented the evidence.

4.1.42. On July 9, 2019, after the Coast Guard approved the transportation plan, Lifeboat No. 6 was transferred to a Shell warehouse in Harvey, LA.

4.1.43. On August 6, 2019, after receiving permission from the Coast Guard, Shell transferred the lifeboat’s release mechanism (hooks, release unit, cables and interconnecting components) and helm station to DNV-GL Materials and Corrosion Technology Center Casualty Investigation Section (DNV-GL) Lab in Dublin, OH for forensic testing.

4.1.44. On November 5, 2019, after receiving permission from the Coast Guard, Plastic Services Network (PSN), a company contracted by DNV-GL for specialized analysis requested by Shell, removed multiple coupons (test samples) from the fiber reinforced plastic (FRP) hull of Lifeboat No. 6 and transported the coupons to its facility in Erie, PA for forensic testing and modeling.

4.1.45. Evidence that has not been transferred to DNV-GL or PSN remains in Harvey, LA.

4.2. Additional/Supporting Information:

4.2.1. Shell AUGER Floating OCS Facility Information

4.2.1.1. The AUGER is a floating OCS facility (FOF) [7] located at Garden Banks block 426 in the Gulf of Mexico. Floating OCS facilities are also commonly referred to as a floating offshore installations (FOI). AUGER is owned and operated by Shell Offshore.

4.2.1.2. AUGER was placed into service in 1994. The AUGER is a tension leg platform (TLP) attached to the seabed in approximately 2,860 feet of water.

4.2.1.3. The AUGER is not a vessel or a mobile offshore drilling unit (MODU). However, at the time of the casualty, the AUGER had a valid Certificate of Inspection (COI).

4.2.1.4. The AUGER COI allowed for a maximum of 225 persons on the facility.[8] On the day of the casualty, there were 135 persons on AUGER.

4.2.1.5. Generally, the crew is rotated on a 14-day on and 14-day off schedule. AUGER is operated, maintained and supported offshore by Shell employees and contractors from a myriad of companies, including Danos.[9]

4.2.1.6. In June 2019, AUGER maintained 10 lifeboats. Lifeboats 1-5 were designated as the primary lifeboats; Lifeboats 6-10 were designated as alternates.

4.2.1.7. AUGER had only one model EL24 lifeboat. Aside from the EL24, the AUGER maintained two Watercraft EL28 lifeboats; two Schat-Harding MCB24 lifeboats; one Schat-Harding EL26; and four Survival Systems International (SSI) lifeboats. The Watercraft and Schat-Harding lifeboats are all dual-fall lifeboats; the SSI lifeboats are single-fall.

4.2.1.8. Lifeboat No. 6 was located on the 175' deck (starboard lifeboat area) of AUGER. The distance from the 175' deck to the mean waterline is 80 feet.

4.2.1.9. The AUGER's COI required 10 certified lifeboatmen to operate the lifeboats in the event of an evacuation.

4.2.2. Lifeboat and Release Mechanism Original Equipment Manufacturer

---

[7] A floating OCS facility (FOF)[7] is defined as a buoyant OCS facility securely and substantially moored so that it cannot be moved without a special effort. This term includes tension leg platforms and permanently moored semisubmersibles or shipshape hulls but does not include mobile offshore drilling units and other vessels. 33 C.F.R. § 140.10.
[8] According to the 2018 Emergency Evacuation Plan, the facility can accommodate a maximum of 210 persons.
[9] Of the seven persons directly involved in the casualty, three worked for Danos and four worked for Shell.

4.2.2.1. On June 30, 2019, Palfinger Marine was the original equipment manufacturer (OEM) for Lifeboat No. 6 and its release mechanism; it was also the OEM for AUGER’s other five dual-fall lifeboats onboard AUGER. Palfinger Marine is a part of the Palfinger Group, a multinational company based in Austria. Palfinger Marine USA Inc. has offices in the United States, including a lifeboat sales, servicing, construction and repair facility in New Iberia, Louisiana.

4.2.2.2. Lifeboat No. 6 was built by Watercraft America in 1984. At some point, Schat-Harding acquired the Watercraft America brand. In 2013, Schat-Harding became Harding Group. Finally, in June 2016, Palfinger acquired Harding Group. Palfinger currently owns approximately 30 brands, including Watercraft America, Schat-Harding and Harding.

4.2.3. <u>Lifeboat Station No. 6</u>

4.2.3.1. Lifeboat Station No. 6 is located on the starboard side of the lower deck of AUGER. Generally, for davit launched lifeboats such as Lifeboat No. 6, a lifeboat station is understood to be comprised of a davit, a winch, and a lifeboat.

4.2.3.2. <u>Lifeboat No. 6</u>

<u>General</u>

4.2.3.2.1. Lifeboat No. 6, bearing serial number EL24-874/3/84 (hereinafter referred to as EL24-874 or Lifeboat No. 6) was a totally enclosed 23.87’ self-righting fire-protected lifeboat and with rated capacity of 33-persons. It was constructed of fiber reinforced plastic (FRP) with foam filled buoyancy units. Its overall dimensions were: 23.87’ x 8.75’ x 3.25’; it was marked with U.S. Coast Guard approval #160.035/487/0.

Figure 13: Lifeboat No. 6 data plate. Credit: CG.

4.2.3.2.2. According to Lifeboat No. 6's data plate, the Condition A weight was 7,212 lbs.; its Condition B weight was 13,306 lbs.[10]

4.2.3.2.3. AUGER has always had an EL24 model lifeboat at Lifeboat Station No. 6, however, in 2012 the original boat, bearing serial number EL24-1184[11], was switched out for EL24-874.

4.2.3.2.4. The Coast Guard obtained some, but not all, information related to the use and maintenance of the EL24-874 before 2012. In early 1984, the EL24-874 was placed into service on an offshore facility at High Island (HI) 462. OEM (Watercraft America) inspection records for the years 1984, 1987, 1988 and 1989 evidence to no significant issues or damage.

4.2.3.2.5. At some point between 1989 and 2011, Eni Petroleum, an Italian-based energy company, purchased the EL24-874. Evidence collected suggests that the vessel was out of service from in or around 1999 to 2011. By 2011, the boat was in storage onshore in Slidell, LA.

4.2.3.2.6. In March 2011, Shell contracted with Schat-Harding to refurbish the hulls and replace the release mechanisms on four AUGER lifeboats, including Lifeboat No. 6 (then the EL24-1184). Rather than remove the EL24-1184 from AUGER and leave the AUGER down a lifeboat station (which would require AUGER to reduce persons on board), Shell agreed to purchase a refurbished EL24 lifeboat from Schat-Harding. Eventually, the EL24-1184 was transferred to Schat-Harding, and Shell received a credit for the trade-in.

4.2.3.2.7. In September 2011, as part of its plan to provide Shell with a refurbished lifeboat, Schat-Harding purchased the EL24-874 from Eni.[12] In sales documents, Schat-Harding noted that: 1) a portion of the keel cooler and keel were crushed; 2) the rudder was bent; 3) the boat was missing air bottles; 4) in the aft seats and PVC areas, there was swollen fiberglass, and 5) the engine contained possible water contamination.

4.2.3.2.8. On October 5, 2011, the EL24-874 was moved from a storage yard in Slidell, LA to the Schat-Harding facility in New Iberia, LA. From November 2011 to April 2012, the EL24-874 underwent refurbishment at the Schat-Harding facility. In addition to significant work related to repairing, replacing and refreshing exterior and interior fittings, the work scope included: 1) installation of SeaCure LHR3.5M2 release mechanism including installation of new forward and aft hook release cables and hydrostat cable; and 2) installation of new lift shoes (i.e., keel shoes).

[10] Condition A weight is weight of the lifeboat, excluding fuel, equipment, or persons. Condition B weight is the loaded weight including the weight of occupants. Lifeboat No. 6's Condition B weight is based on a POB weight of 165 lbs.

[11] That vessel is currently in storage at the Palfinger Marine facility in New Iberia, LA.

[12] This sale and subsequent refurbishment raises questions related to whether OEMs and OCMIs have been properly interpreting and applying type approval requirements as found in 46 C.F.R. § 2.75-1(b). Historically, the Coast Guard OCMIs have not become involved in resale issues and have allowed refurbishments. However, CG-ENG-4 interprets 46 C.F.R. § 2.75-1(b) as requiring Coast Guard approval for resales and refurbishment of Coast Guard approved requirement.

4.2.3.2.9. On April 11, 2012, the EL24-874 was successfully load tested. In June 2012, the lifeboat was put into service onboard AUGER.

Hook Release Mechanism

4.2.3.2.10. The EL24-874 was originally outfitted with a Viking release mechanism. In 2012, during the refurbishment, Schat-Harding installed two identical Schat-Harding brand "SeaCure" LHR3.5M2 hooks, marked with approval number 160.133/52/0, one forward and one aft.

4.2.3.2.11. The forward and aft hooks on EL24 model boats are vertically offset by approximately 20 inches. Of the six dual-fall boats on AUGER, Lifeboat No. 6 was the only lifeboat with a vertical hook offset.

4.2.3.2.12. The LHR3.5M2 release mechanism is rated for 3.5 tonnes (metric tons) and is the smallest of the dual-fall release mechanism in the SeaCure line manufactured by Schat-Harding. The system consists of two hooks (Figure 14 below), a release unit (i.e. control station; Figure 15 below), a hydrostat unit and three separate control cables that connect the hooks and hydrostatic unit to the release unit. Figure 16 shows the location of the components in the Watercraft EL24 lifeboat.

Figure 14: Profile view of LHR hook. Credit: Palfinger.

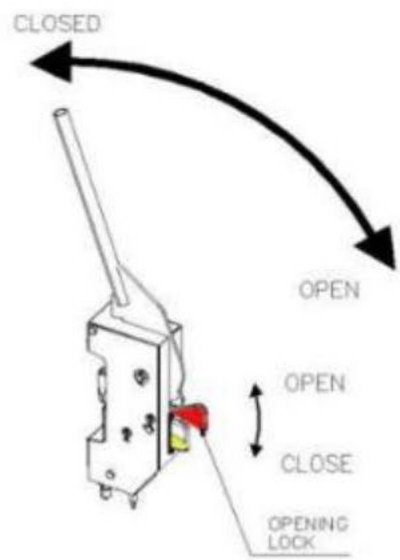


Figure 15: Release unit with safety lock (opening lock) shown in red and hydrostatic locking level shown in yellow. Credit: Palfinger & CG.

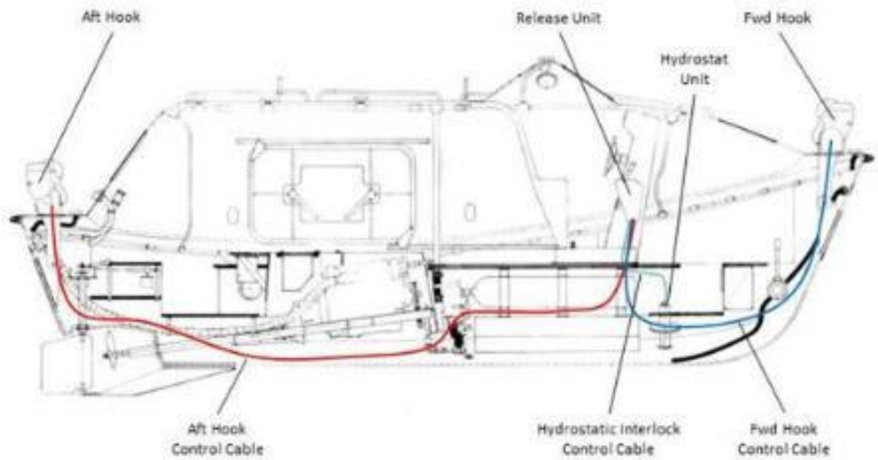


Figure 16 (left): Release mechanism components. Credit: CG.

System Functioning

4.2.3.2.13. As noted above, the release mechanism is comprised of two hooks, a hook release unit, a hydrostat unit, and three control (push-pull) cables. One control cable connects the hook release unit to the aft hook, the second control cable connects the release unit to the forward hook, and the third control cable connects the release unit to the hydrostat unit.

4.2.3.2.14. In a traditional waterborne release, once the lifeboat is in the water, water pressure is placed on the hydrostat unit via a thru-hull fitting. That pressure pushes up on a diaphragm inside the hydrostat unit, which pushes on the control cable between the hydrostat unit and the release unit hydrostatic interlock. With the interlock now disengaged, the release unit safety lock (red handle) can be operated. The hooks can then be opened (released) from the fall cables by lifting up on the safety lock and pulling back on the release handle.

4.2.3.2.15. In an emergency release, the system functions in a similar manner, except that the operator must override the hydrostatic interlock by breaking a protective safety glass cover and manually lift up on the hydrostatic release lock (yellow handle). While holding the interlock in an open (lifted) position, the safety lock (red handle) is lifted and the release handle can then be operated.

4.2.3.2.16. The operation of the release lever on the release unit rotates the locking shafts of the hooks via the forward and aft hook control cables. The opening action of the lever pulls the control cables, rotating the locking shaft to the open position, allowing the hook roller to pass through the opening (i.e., notch) in the locking shaft, releasing the hook from the fall cables. The closing action of the lever on the release unit pushes the cables, rotating the locking shaft to the closed position when resetting the hooks. The release unit is designed in a way that the hooks are to open simultaneously and the release lever will lock in both the closed and open positions, when the system is properly adjusted.

4.2.3.2.17. When the system is properly reset (in the closed position) and the locking shaft and hook roller are contacting at the correct location, the position indicator on the side of the hook will show in the green. If the position indicator is in the red, the locking shaft is either in the open position or "almost open" position.

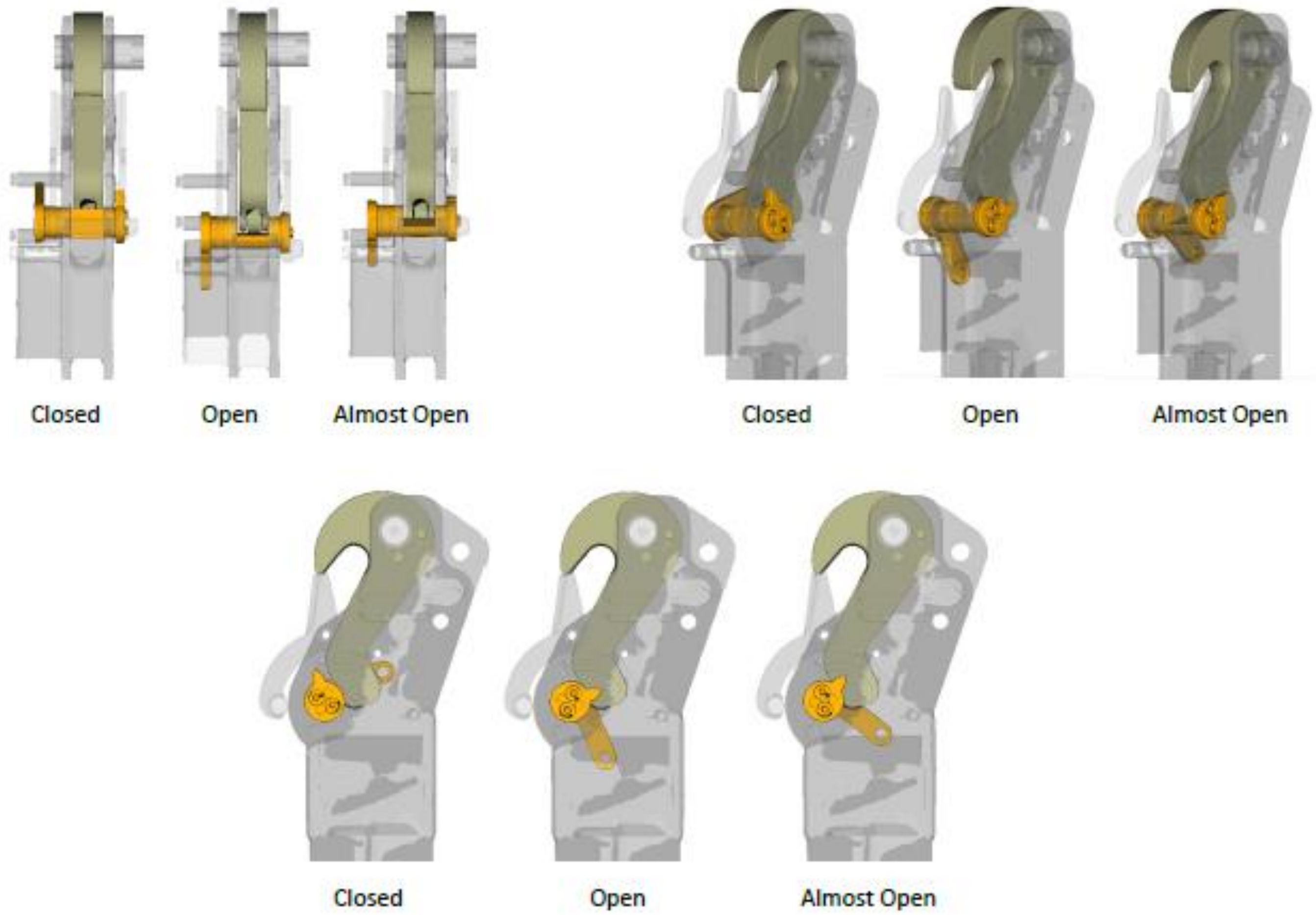


Figure 17: Hook cutaway views of LHR3.5M2 hook in closed open and almost open positions. Locking shaft depicted in yellow. Credit: CG.

<u>On-Load and Off-Load Release Capabilities</u>

4.2.3.2.18. Lifeboat release mechanisms are often generalized as purely off-load or on-load/off-load designs. Off-load hooks utilize the weight of the lifeboat to hold the hooks in a fully closed position and are not designed to release the lifeboat while there is a load on the hook. Conversely. on-load/off-load hooks rely on separate components (e.g. locking shaft) to prevent the movable portion of the hook from opening until a deliberate action is taken (e.g. operating the release handle) because they are designed to open regardless of whether there is a load on the hook or not. Mechanically, this means that the hooks want to open when a load is applied and there is a mechanism preventing it from doing so. Therefore, on-load/off-load designs will also have an interlock (e.g. hydrostatic release) to assist in preventing an accidental release. Per the IMO and Coast Guard, all lifeboats built after June 1, 1986 must have both on-load and off-load capabilities. The LHR 3.5M2 release mechanism is a USCG approved on-load/off-load design. In the LHR 3.5M2 hook, the rotating locking shaft prevents the hook from opening. When the lift ring is engaged in the hook and upward force is applied, the hook tail and roller will attempt to rotate to the open position, but will make contact with the locking shaft (when in the locked, or closed, position), preventing the hook from opening.

4.2.3.2.19. A normal off-load release operation describes how the hooks can be released once a lifeboat is waterborne with no load on the hooks and without any manual action required to separate the lifting ring from the hook.

4.2.3.2.20. An emergency release operation describes how the hooks can be released from the falls with a load on the hooks (e.g. before the lifeboat is waterborne or tension is on the falls from an external force). This on-load release is inherently hazardous and is only used when an off-load release can't be used. In order to conduct an on-load release, a safety interlock must be bypassed by multiple, deliberate and sustained actions to release the boat prior to it being waterborne.

4.2.3.2.21. The OEM operating manual and safety placards for LHR3.5M2 hooks warn operators that "the risk of serious injury or death must be considered if the boat is to be dropped into the water" in an on-load release.

Resetting Procedures

4.2.3.2.22. Resetting is the process of closing and locking the hooks to prepare the lifeboat to be lifted back into the davit. For LHR3.5M2 hooks, the process requires a minimum of three people: one person at each hook and one person at the release unit. During release, the tension of the lift ring or the maneuvering of the boat away from the fall cables can cause the hook to become "fouled" (i.e., the pivoting portion of the hook flips into an inverted position). A person must manually rotate the hook, moving the tail of the hook back through the notch, and into position behind the locking shaft. After all persons are in their correct positions, the OEM recommends:

- Lock the hooks by using the central release unit;
- Lift up the safety/ opening lock;
- Push the release handle until it returns to fully closed position;
- Let go of safety lock, it will automatically return to its correct position;
- Verify that hooks are properly locked. Indicator in green sector on both hooks;
- Verify that release handle is locked in closed position.[13]

[13] Palfinger, "Installation, Operation, and Maintenance Manual," Rev. 14 (Feb 1, 2018).

Control Cables

4.2.3.2.23. Lifeboat No. 6 had Cablecraft brand push-pull cables installed in 2012. The push-pull cables operate by providing a means of transmitting linear motion from the release unit to the forward and aft hooks.

4.2.3.2.24. The aft hook control cable was a Cablecraft 315-HTT-4-276-10mm cable, a heavy-duty low friction cable with threaded end fittings and four inches of travel at the end rods. The cable measured 276 inches or 23 feet long.

4.2.3.2.25. The construction and components of the control cables are shown in Figures 17 and 18. All external components (conduit cap, support tube and end rod) are stainless steel. The metal components in the conduit (steel band and steel strands) are galvanized and sealed from the outside environment by the outer jacket (cover) and a series of seals from the conduit cap to the end rod. The inner member consists of steel strands and banding, with a thin outer cover that is hydraulically crimped to the end rods and moves within the polyethylene liner of the conduit.

4.2.3.2.26. The inner member transmits linear motion through the end rod. The end rod has two ends: one end attaches to a clevis that is pinned to the release unit and the other end attaches to a clevis that is pinned to the hook locking shaft. The support tube limits the amount of travel in the end rod; the end rods on Lifeboat No. 6 could move approximately 4 inches in either direction.

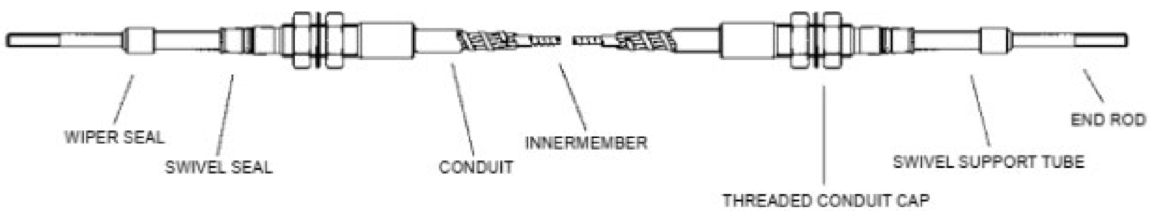


Figure 18: Control cable components. Credit: Cablecraft, modified by USCG to represent cables in Lifeboat 6.

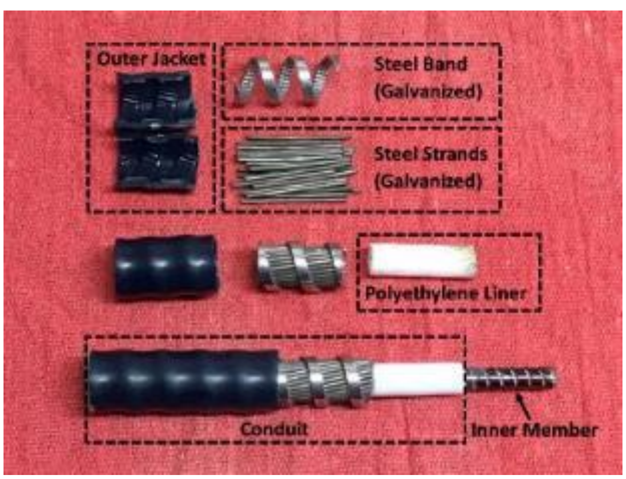


Figure 19 (left): Control cable cutaway and conduit components. Credit: CG.

4.2.3.2.27. The following table documents control cable manufacturer and specifications:

Cablecraft® Control Cable Data https://www.cablecraft.com/cables/control-cable-assemblies/ https://www.cablecraft.com/wp-content/uploads/2018/03/CMC9008_Push-Pull-Standard-Flyer.pdf		
Cable Use	Model No.	Description
Fwd Hook	315HTT-4-158-10mm	Low Friction EXT Cable with stainless steel exposed fittings, threaded rod ends (M10 x 1.5), 4" cable travel & 158" overall length
Aft Hook	315HTT-4-276-10mm	Low Friction EXT Cable with stainless steel exposed fittings, threaded rod ends (M10 x 1.5), 4" cable travel & 276" overall length
Hydrostatic Interlock	315LTT-2-59-6mm	Low Friction EXT Cable with stainless steel exposed fittings, threaded rod ends (M6 x 1.0), 2" cable travel & 59" overall length

Figure 20: Cablecraft Control Cable Data. Credit: Cablecraft, as formatted by CG.

4.2.3.3. Davit

4.2.3.3.1. The Lifeboat Station No. 6 davit was a gravity-release Watercraft America model 24' WOD davit system with serial number 2321, marked with U.S. Coast Guard approval #160.032/221/1. The davit was installed on AUGER in 1991 and was original to the facility. A gravity-release means that the lifeboat can launch into the water by its own weight; no external power source is needed to position the lifeboat in the launch position.

4.2.3.3.2. The fall cables were replaced in May 2019. On May 27, 2019, Palfinger service engineers conducted a dynamic 110 % (i.e., 1.1) load test on Lifeboat Station No. 6 (utilizing the lifeboat during the test).

4.2.3.4. Winch

4.2.3.4.1. Prior to May 2019, Lifeboat Station No. 6 was outfitted with a Schat-Watercraft model BE7800 XL winch, gravity lowered, electrically hoisted, marked with U.S. Coast Guard approval #160.015/161/0. In May 2019, the winch was replaced with a refurbished Schat-Watercraft USA model BE 7800XL, modified to a 9300XL.[14]

4.2.3.4.2. On June 30, 2019, the winch in service on Lifeboat Station No. 6 was a Schat-Watercraft USA model BE 7800XL, modified to a 9300XL. In effect, Palfinger converted a BE 7800XL winch to a larger and stronger model; the converted model rated for 9300 kg, vice the original 7800kg.

4.2.4. Post-Accident Assessment and Testing of Lifeboat Station No. 6

4.2.4.1. The lifeboat and gear were documented in the days following casualty but before salvage. Photographs and video were taken, including underwater video. After

[14] See Footnote 11.

salvage, the lifeboat and gear were heavily documented at its initial landing location in Fourchon, LA and after relocation to Harvey, LA. 3-D scans were conducted in Harvey, after the lifeboat hull was raised to gain access to the gear inside. Later, after gear was transferred to DNV-GL's Dublin, OH lab, DNV-GL conducted extensive examination of the lifeboat release mechanism and portions of the fiberglass hull. Similarly, the davit and winches were documented by photography and 3-D scans. The findings are summarized below:

4.2.4.2. Lifeboat No. 6 Hull

4.2.4.2.1. The bow end of the hull split, and the bow hook was torn free of the hull (see Figures 21). The bow split arrested approximately halfway along the length of the boat.[15] The patch that pulled out is consistent in shape with a previous repair made to the FRP around the bow hook (see Figure 21).

Figure 21: Bow hook and surrounding FRP post-casualty. Credit: CG.

4.2.4.2.2. The canopy became detached from the hull and was not recovered. Additional cracks were found in the hull and the keel.

4.2.4.2.3. DNV-GL took composite samples of the lifeboat hull. It conducted fractographic analysis on three samples (see Figure 22) taken from areas evidencing cracks or damage for purposes of identifying the mode of failure. DNV-GL concluded that the damage was "consistent with brittle failure mode and indicative of a fast fracture from a dynamic event."[16] In other words, the damage was indicative of damage sustained as a result of a fall vice bending or flexing from a static overload event.

Figure 22: Sampling locations for fractographic analysis. Credit: DNV-GL.

[15] The split may be the result of several factors/causes, including impacting the water, floating semi-free in the GoM for nearly a week and opening during lift/recovery.
[16] DNV-GL U.S., "Auger Lifeboat 6 Incident" (May 22, 2020), at pg. 42.

Figures 23 (above) and 24 (right): Photographs of Lifeboat No. 6 taken on July 5, 2019 during salvage operations. Credit: Shell.

4.2.4.3. <u>Aft Hook</u>

4.2.4.3.1. The aft hook was found still attached to the lifeboat. The hook was in the open and unlocked position.

4.2.4.3.2. During testing, DNV-GL sought to identify where the hook roller would have contacted the locking shaft on Lifeboat No. 6's aft hook at or near the time of the casualty. To accomplish this, DNV-GL disassembled Lifeboat No. 6's hook and installed Lifeboat No. 6's locking shaft on an exemplar hook. The clevises and bulkhead nuts were set in the as-found condition of Lifeboat No.6's hook components. Their processes and findings are described below:

> "Figure [25] contains photographs of the locking shay from the Subject Aft Hook installed (a) inn the Subject Aft Hook and (b) installed on the Exemplar Hook with the clevises and bulkhead nuts set to the as-found condition of the subject components. In both cases, the Subject Release unit was in the closed position and the Exemplar Cable was used. No load was applied.
>
> The blue markings were produced by placing articulating paper between the hook roller and locking shaft contact location. The green line is the contact location between the hook roller and the locking shaft when the arm of the locking shaft is placed in the fully closed position (i.e. the arm of the locking shaft is in contact with the standoff for the locking shaft cover, see Figure [26]). The degrees of rotation from the green line to the flat of the locking shaft is 60°.
>
> A yellow line is located between the green and red lines. The yellow line indicates the contact location between the hook roller and locking shaft when the release unit is closed, but the locking shaft arm is rotated as far as possible towards the open orientation. This was of interest as it was noted that this situation occurred when the Subject Aft Hook was released to the open position and then reset (i.e. there is some travel in the push-pull cable possible even though the Subject Release Mechanism is in the locked position). The degrees of rotation from the yellow line to the flat of the locking shaft is 42°. The red line is consistent with the area of significant corrosion and wear, which suggests that, for a portion of the service history, the hook roller and locking shaft were

in contact at this location. The degrees of rotation from the red line to the flat of the locking shaft is 36°."[17]

4.2.4.3.3. As a result of the testing, DNV-GL opined:

"The position of the red line relative to the green and yellow line may have been created in two possible ways: (1) under load, the location of contact between the hook roller and the locking shaft rotates to a more open position or (2) the failure in the Subject Aft Cable."[18]

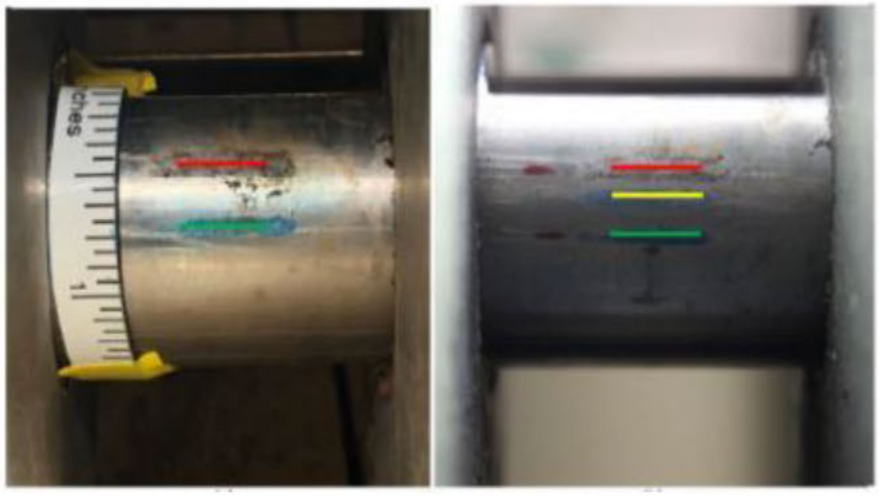


Figure 25a (left) and 25b (right): Lifeboat No. 6 locking shaft. Credit: DNV-GL.

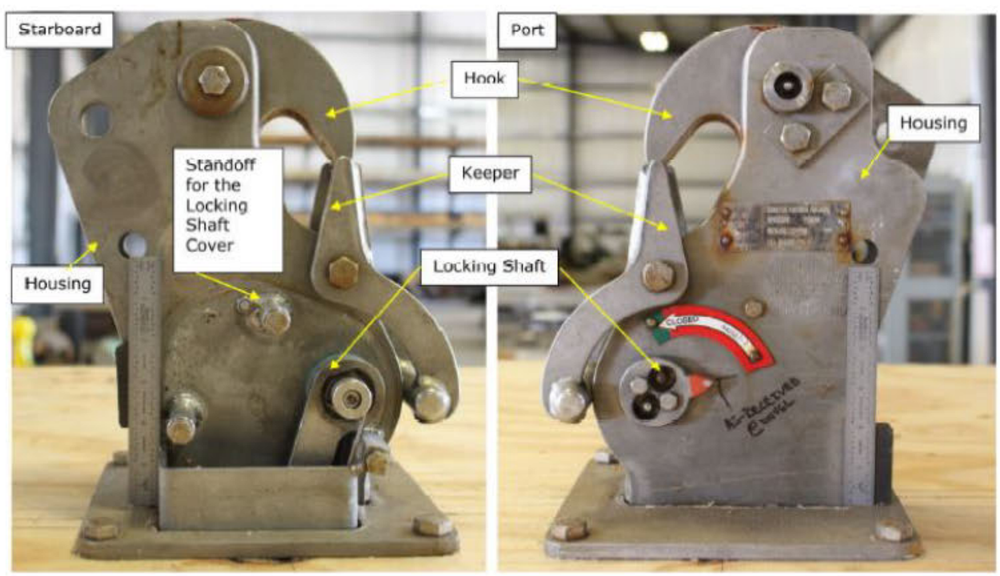


Figure 26: Photographs of the aft hook with the locking shaft removed. Credit: DNV-GL.

4.2.4.4. <u>Aft Cable</u>

4.2.4.4.1. The aft cable was found still attached to the aft hook and release unit. No damage was found at the connection points to the aft hook or hook release station. Damage to the green cover was found (a) 3.70 feet to 4.10 feet, (b) 4.70 feet to 5.70 feet, and (c) 8.10 feet to 8.60 feet from the conduit cap at the aft release station.

[17] DNV-GL at pgs. 19-20.
[18] DNV-GL at pg. 20.

DNV-GL inspected the damage and concluded the damage was sustained either during or after the casualty.

4.2.4.4.2. Significant damage to the aft control cable was found approximately .72 to 1.34 feet from the hook release station conduit cap. The outer green conduit cover, steel strands and polyethylene liner were totally separated. Only the inner member remained intact (see Figure 27).

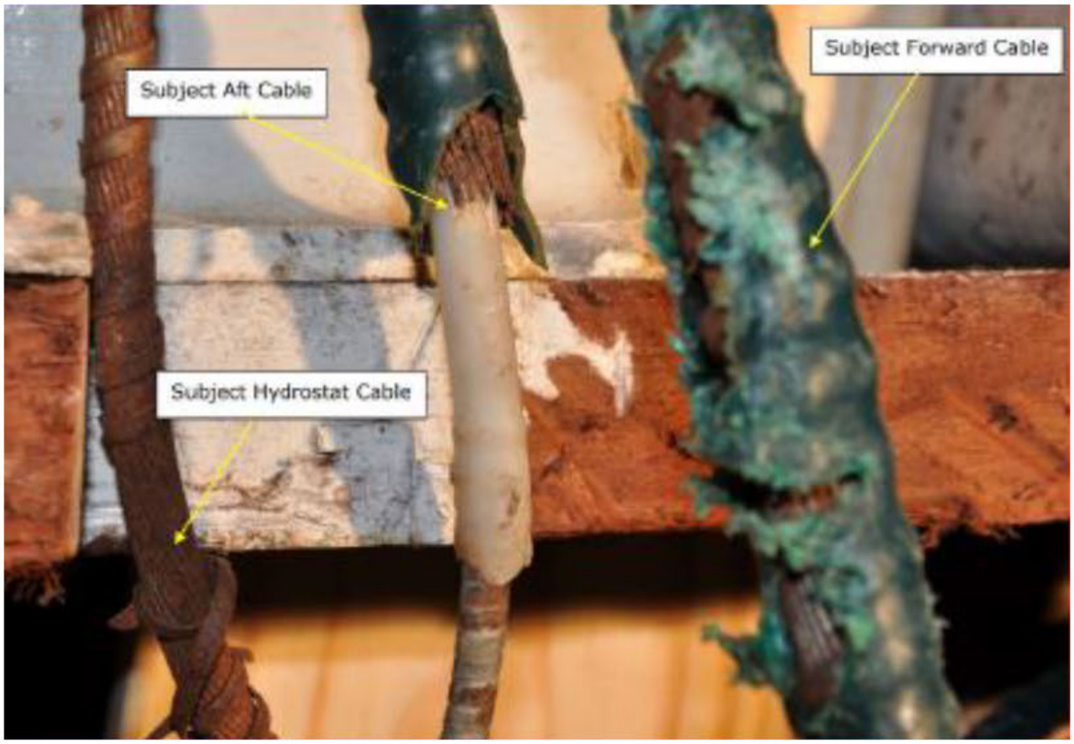


Figure 27: As-found condition of Lifeboat No. 6 control cables after reassembly at DNV-GL facility. Credit: DNV-GL.

4.2.4.4.3. At its facility, DNV-GL conducted extensive analysis on the three outer layers of the aft control cable.

4.2.4.4.4. DNV-GL removed an analyzed the plastic green conduit cover. DNV-GL conducted light microscopy, taking light photomicrographs of the conduit cover after matching the fractures surfaces at the failure (see Figure 28). DNV-GL witnessed "abrasive wear, i.e. chafing, of the external surface [of the cover]. This damage corresponds to the location of contact with the opening cut in the helmsman's console and the Subject Aft Cable." [19] Based on its observations, DNV-GL concluded "mechanical damage in the form of impact, gouging, and / or rubbing was likely the primary cause(s) of failure of cover layer. With the cover layer compromised, water could ingress leading to the corrosion of the conduit."[20]

[19] DNV-GL at pg. 29.
[20] DNV-GL at pg. 29

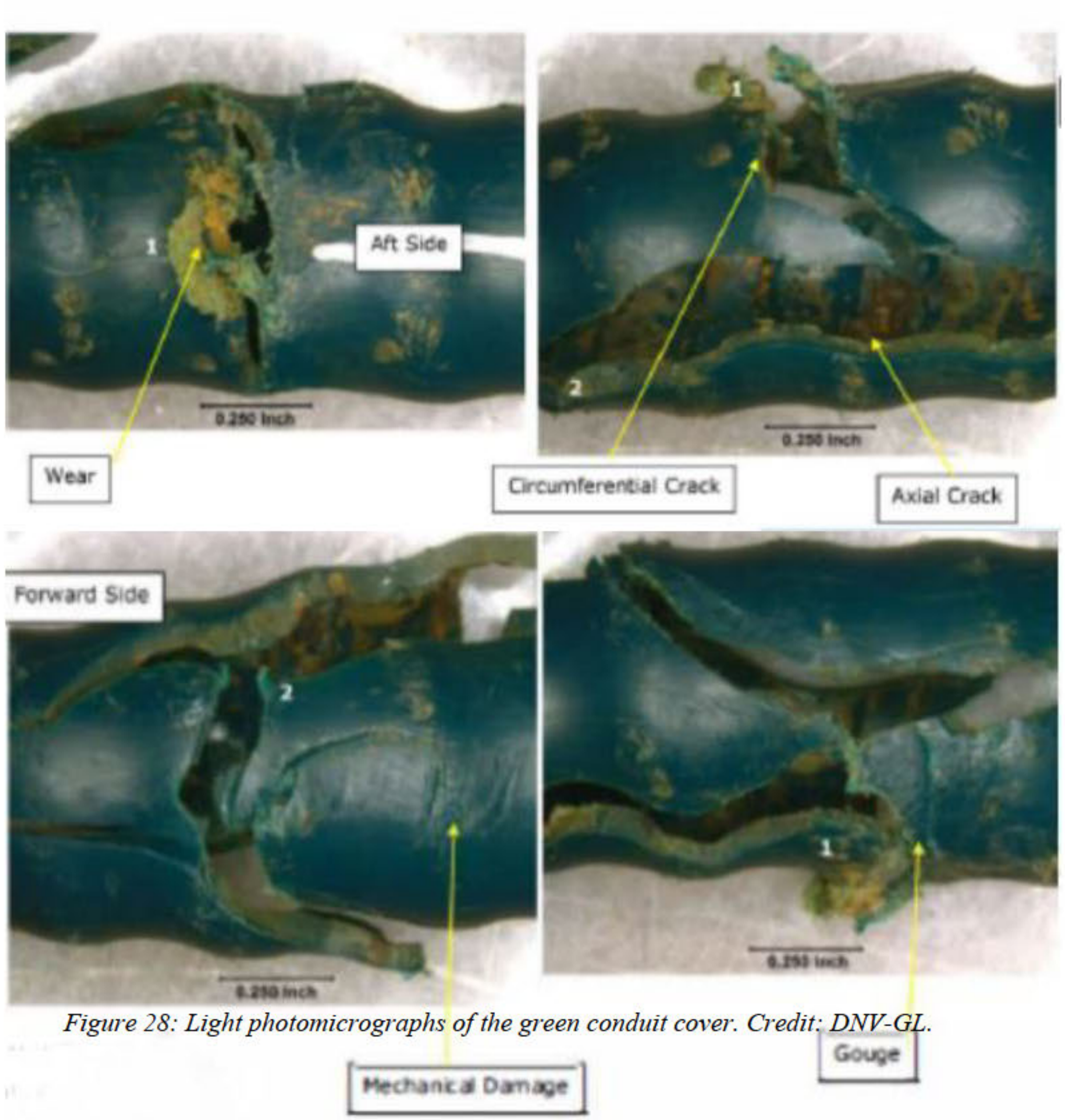


Figure 28: Light photomicrographs of the green conduit cover. Credit: DNV-GL.

4.2.4.4.5. DNV-GL also conducted scanning electron microscopy (SEM) of the conduit cover. The resulting images showed "crack arrest marks and initiation sites . . . The initiation sites on the external surface are coincidence with the thinnest parts of the cover, which coincide with the binder wire of the conduit. The initiation sites on the external surface suggest that a force was exerted circumferentially at the internal surface. It is suspected that this force was associated with an increase in volume that results when steel corrodes. This voluminous corrosion product exerts a force on the cover from the inside. Hence, the fatigue is a consequence of mechanical damage to the cover, water ingress, and corrosion of the conduit."[21]

4.2.4.4.6. DNV-GL analyzed the steel wire layer. It found severe corrosion on the release unit side of the layers and reddish-brown deposits near the failure and white deposits away from the failure. The strand wires at the failure have a reduced cross-sectional area, either from corrosion or necking. The binder wire has been corroded away at the failure." [22]

[21] DNV-GL at pg. 29.
[22] DNV-GL at pg. 30.

4.2.4.4.7. DNV-GL conducted light microscopy of the white polyethylene liner (see Figure 29). DNV-GL noted in the light photomicrographs:

> "Fracture paths are primarily circumferential in nature. The previously noted tearing and buckling are visible in the micrographs. The buckling suggests that the liner layer had been compressed; however, the morphology of the fracture surfaces indicate that the tube failed in tension. Additionally, a thinned area on the aft side of the Subject Hook Release side of the failure is visible. A reddish-brown, embedded particle, as well as reddish brown deposits, are visible near the failure on the external surface of the liner. Punctures are visible on the aft side of the Subject Aft Hook side of the failure, and correlate with the size and spacing of the individual wires that make up the conduit."[23]

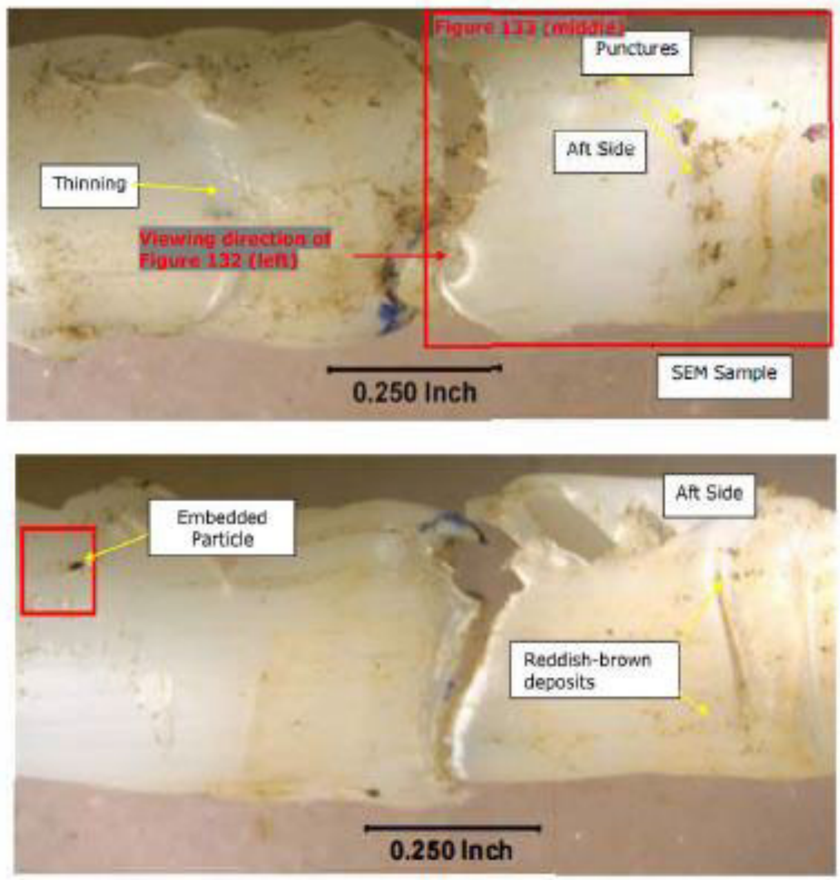
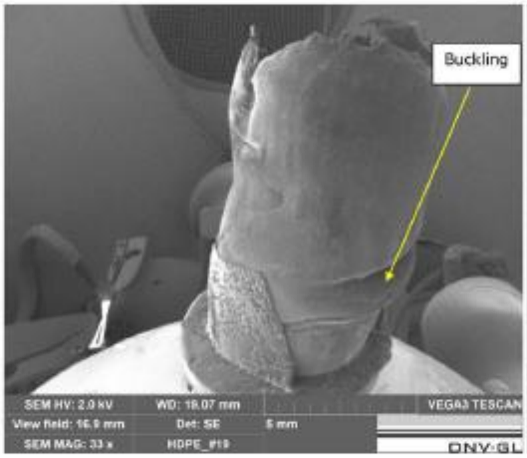


Figure 29: Light photomicrographs of the white polyethylene liner. Credit: DNV-GL.

4.2.4.4.8. DNV-GL also took images of the compromised area using a SEM (see Figure 30). DNV-GL found evidence of necking at the fracture location, indicating that the tensile load applied to the liner was not extremely fast. According to DNV-GL, fast loading conditions of polyethylene result in little to no necking corresponding to a brittle fracture. DNV-GL found that some areas of the fracture surface exhibited minimal necking, which, in their opinion, likely corresponded to the final areas of overload. DNV-GL also took a closer look at the punctures and

[23] DNV-GL at pg. 34.

found the punctures spaced 35 to 45 mils from one another, which is similar to the spacing identified between the tips of the corroded conduit wires.[24]



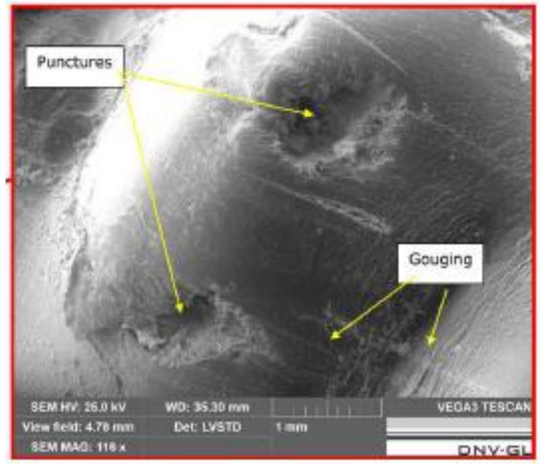


Figure 30: SEM images of white polyethylene liner. Credit: DNV-GL.

4.2.4.5. Release Unit

4.2.4.5.1. The release unit was found in the closed position. Of note, the release handle was found to lock in the closed position, but would not lock in the open position. While not thought to be a causal factor in the casualty, it is evidence that the cables were not adjusted to OEM specifications.

4.2.4.6. Forward Hook and Cable

4.2.4.6.1. The forward hook was found in the open position[25], dangling from the lifeboat, attached to the boat by the control cable. The forward hook control cable showed damage at the conduit cap, exposing the inner member (see Figure 31). The outer green cover, wire, and white polyethylene liner did not show significant mechanical damage.

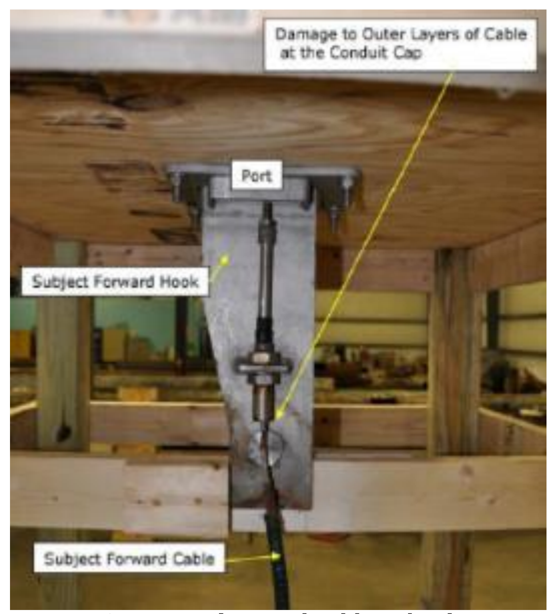


Figure 31: Forward control cable at hook conduit cap. Credit: DNV-GL.

[24] DNV-GL at pg. 34.
[25] The open position was determined to be secondary and due to the events relating to the separation of the hook from the hull of the boat (i.e., extreme forces applied directly to the control cable, which separated the conduit from the conduit cap and allowed the inner member to rotate the locking shaft).

4.2.4.7. Davit

4.2.4.7.1. The fall cables and lift rings of Lifeboat Station No. 6 were intact.

4.2.4.8. Winch

4.2.4.8.1. The winch appeared to be in working order.

4.2.5. Safety and Maintenance Programs, Policies and Operations

4.2.5.1. Palfinger

Hook Installation, Operation and Maintenance Manual

4.2.5.1.1. Palfinger maintains an "Installation, Operation, and Maintenance Manual" for the LHR model hooks, including the LHR3.5M2. Revision 15 was issued on February 12, 2018 and was the revision in effect on June 30, 2019. Shell AUGER had a copy of the manual through its third revision, dated December 17, 2010.

4.2.5.1.2. The manual provides operators a recommended weekly and monthly inspection schedule. Additionally, the manual outlines the requirements for annual and 5-yearly inspections. The expectation is that the operator will complete the weekly and monthly inspections and the OEM[26] will complete the annual and 5-yearly inspections.

4.2.5.1.3. As part of the weekly maintenance schedule, the OEM recommends, among other things, that operators:

- Check for damage and corrosion;
- Check that the locking shaft is in the closed position;
- Check the (hook control) cables for external damage. Pay special attention to the moveable part between connection at the tension lock and cover of the cable.

4.2.5.1.4. As part of the monthly maintenance schedule, the OEM recommends, among other things, that operators:

- Open the hook using the release handle. Check all functions.

4.2.5.1.5. As part of the annual maintenance schedule the OEM service technician or other designated service provider is instructed to, among other things, conduct a:

- Visual inspection of hook release system and "Hanging Off eye;"

[26] This section of the manual references MSC.1/Circ.1206 as the authority to require OEM servicing. MSC.1/Circ.1206 does not apply to FOF; FOFs are not required to use services of OEM.

- Test of the on-load release function of hooks;
- Test of the hooks for simultaneous opening.

4.2.5.1.6. As part of the 5-yearly maintenance schedule the OEM service technician or other designated service provider is instructed to, among other things:

- Strip and clean all parts;
- Replace (hook control) cables and torsion spring;

  The manual states that replacement "shall" occur; it is not couched as a "recommendation."

- Test lifeboat with 1.1 x safe working (SWL) load[27];
- After every test, check the release (control) cables. Pay special attention to the moveable part for damage.

4.2.5.1.7. The Coast Guard obtained several versions of the "Installation, Operation, and Maintenance Manual" for the LHR models hooks. Between January 1, 2010, when the first edition of the manual was issued and February 12, 2018, when the version in effect at the time of the casualty was issued, the OEM went through at least three corporate ownership changes. The manual was edited to reflect new labels and other minor changes were made, however, all versions direct control cables to be replaced every five years.

4.2.5.1.8. The lead service engineer who conducted the 2018 and 2019 annual inspections of the Lifeboat No. 6 started with Schat-Harding in 2013 and continued on with the company during its several corporate ownership changes. During an interview with the Coast Guard conducted on September 26, 2019, he noted that when he first started with Schat-Harding, he would bring hook control cables with him on 5-yearly inspections and would automatically replace the cables. He does not recall when the policy or procedure changed, but he noted that currently, hook control cables are only changed at the request of the customer or when an issue is noted. He noted that most customers don't request that hook control cables be changed out at five years, unless other circumstances require them to change out the cables.

4.2.5.1.9. During the Coast Guard's investigation, Shell was asked how it used Palfinger's "Installation, Operation, and Maintenance Manual" for the LHR model hooks to schedule maintenance events. The Coast Guard received written responses back from Shell Offshore's Specialty Engineering Manager and Maintenance Engineer. They responded:

[27] It is understood the safe working load is based on the "B" weight of the boat, not the safe working load of the release hooks.

> "Shell did not have access to Palfinger's "Installation, Operation and Maintenance Manual" prior to the incident, and the requirements in that manual were not part of TIMMS[28] preventative maintenance requirements or loaded into SAP[29]. TIMMS and SAP did however require annual inspections of all Palfinger lifeboats. Shell expected Palfinger to perform all needed preventative maintenance required by its manual during the annual inspection, such as the replacement of hook release cables every five years if that is what its manual required for EL-874 or any other lifeboat, or make specific recommendations to Shell regarding what preventative or corrective maintenance should be performed and when it should be performed."

4.2.5.1.10. During the Coast Guard investigation, the third revision of the manual was found onboard AUGER.

4.2.5.1.11. In Lifeboat No. 6, the hook control cables were routed under the FRP molded seat pan. According to the Palfinger service engineers, it can be difficult to inspect the entire length of cable unless the cable is disconnected and pulled out. Per the OEM manual, hook cables are disconnected only during the 5-yearly inspection.

<u>Work Instructions</u>

4.2.5.1.12. Palfinger maintains instructions for the different tasks conducted by its service engineers. Work instructions are intended to instruct Palfinger trained and certified personnel on the proper way to perform maintenance on Palfinger brand systems. Palfinger service engineers receive a copy of each relevant work instruction in their work package before each job. The service engineers interviewed in this investigation said that they review the work instructions before jobs, but do not print out hard copies.

4.2.5.1.13. Instruction F-10080 is the "Annual and 5-yearly inspection and commissioning of lifeboats" instruction. The instruction obtained by the Coast Guard has an effective date of September 25, 2017. The instruction states that during annual and 5-yearly inspection: "It is recommended to have both control cables and hydrostat cable renewed every 5 years." It is couched as a recommendation, as opposed to the LHR3.5M2 "Installation, Operation, and Maintenance Manual," where replacement is couched as a requirement.

4.2.5.1.14. Instruction F-10449 is the "Annual and 5-yearly inspections of LHR Hooks" instruction. The instruction obtained by the Coast Guard has an effective date of March 1, 2017.

4.2.5.1.15. Instruction F-10449 advises service engineers, as part of the 5-yearly examination, to discover, inspect and clean the hook systems. Further, the instruction recommends that service engineers replace both control cables and hydrostat cables. Similar to Instruction F-10080, replacement is expressed as a recommendation, not a requirement.

[28] Technical Integrity & Maintenance Strategy Standards (TIMMS)
[29] Systems, Applications and Products in Data Processing (SAP)

Service Forms

4.2.5.1.16. Service engineers are required to fill out service reports for every job. Service reports allow the service engineers to, in a narrative fashion, provide a detailed description of their work tasks and findings. In June 2019, Palfinger was utilizing form F-11196; the form had a version date of April 4, 2019.

4.2.5.1.17. The current version of the service report asks service engineers to assign a “who” for each finding, comment or recommendation, designating either the party who accomplished a task or should complete a future task. Previous versions of the form asked service engineers to not only designate the “who” of future actions, but also asked service engineers to designate “when” an action was required.

LSA Equipment Checklists

4.2.5.1.18. When conducting inspections involving certain International Life-saving Appliance (LSA) Code equipment, service engineers also use Palfinger’s “Checklist for LSA Equipment (TELB + davit) in accordance with the IMO Circular MSC.1/Circ.1206/Rev. 1. Annex 1, Appendix.[30]” The checklist is meant to serve as a job aid for service engineers conducting annual and 5-yearly inspections on certain lifeboat systems. The checklists are then attached to the service reports. While SOLAS is not applicable to most of AUGER’s lifesaving appliances, Palfinger, as well as other service providers, bases their checklists off of the IMO’s instruments, such as MSC.1/Circ.1206/Rev.1, as a “standard”.

4.2.5.1.19. The checklist contains a series of checks or actions that must be completed and notes the frequency for the checks or actions (1Y or 5Y). It also informs the service engineer of the appropriate renewal or replacement schedule for certain items. Items that are recommended for replacement or renewal are marked R1Y or R5Y; when renewal or replacement is mandatory, the items are marked M1Y or M5Y. In assessing the condition of different items, service engineers are limited to three options: “OK,” “Not OK or “NA.”

4.2.5.1.20. In accordance with their LSA checklist, service engineers must annually check (1Y) the condition and/or operation of control cables, to include free movement and corrosion. The checklist recommends that cables be changed out on a 5-yearly basis (R5Y).

4.2.5.1.21. The Coast Guard interviewed four service engineers during its investigation. During the interviews, the service engineers commented on the limitations of the LSA Checklist. The lead service engineer on Lifeboat No. 6’s June 2019 annual inspection told Coast Guard investigators:

> “Somewhere in our checklists it asks us about the function of the release system. Somewhere in the [checklist] there is something about cables. We have

[30] While Palfinger references IMO Circular MSC.1/Circ.1206/Rev. 1. Annex 1, Appendix for lifeboat inspections, the EL24 was not approved to international requirements (i.e., the LSA Code via 46 C.F.R. §160.135); they were approved under §160.035 (now obsolete). AUGER was not required to have lifeboats under approval series 160.135.

> to mark "OK" because the release cable works. Whether it has got rust on it or corrosion, it works. That is what it is asking: Does it work?. . . If those hooks are opening and closing, I can't make [the customer] change it because it is working."

4.2.5.1.22. Another service engineer noted that he found the term "OK" and "NOT OK" vague. He continued that while certain items may be damaged, and in his mind, "not right," the same items may also be functional. He noted that many operators focus on whether an item is functional, rather than focusing on its condition. He continued: "There needs to be a more clear understanding of how your boat can remain in service and what actually constitutes it not being able to be used."

<u>Communications</u>

4.2.5.1.23. Palfinger maintains a relation and communications policy in an effort to unify its commercial approach to communications. Generally, Palfinger seeks to limit the amount of information service engineers directly provide to facility crews/customers. Service engineers may discuss damages and changes to work scope with customers. However, for significant issues, the service engineers are to contact the Palfinger office, and Palfinger office personnel are expected to manage most external communications with customers.

4.2.5.1.24. When Palfinger service engineers conduct work on AUGER, they are assigned a Shell sponsor. The sponsor's role is to make sure the service engineers have the necessary tools and comply with Shell's policies and procedures.

4.2.5.1.25. At the end of the job, the service engineers provide the operator with a service report and related forms and conduct an oral debrief. The Palfinger office also receives a copy of the service report, related forms, and any pictorial documentation obtained.

4.2.5.1.26. If a service engineer notes a discrepancy, he or she can make recommendations to the operator, generally by noting it on the report form. For significant issues, the service engineer will also contact the Palfinger office.

4.2.5.1.27. From a service engineer's perspective, they can't require an operator to fix anything. During Coast Guard interviews, all four service engineers interviewed expressed, in some fashion, the sentiment that: "[We] can't really make the customer do anything. It is their boat. All we can do is tell them what we find." The service engineers were quick to point out that if they identified a serious issue, they would work to correct the issue before leaving the facility. If the operator pushed back, the service engineer could engage with the Palfinger service office.

4.2.5.2. <u>Shell</u>

<u>Technical Integrity & Maintenance Strategy Standards</u>

4.2.5.2.1. Shell maintains a TIMMS system. TIMMS provides Shell's preventative maintenance strategy by equipment type or group. The preventative maintenance requirements in TIMSS for AUGER lifeboats are built by Shell's Engineering

Technical Authority based on several sources, including the Gulf of Mexico Performance Standard Template (GoM PST)(which provides minimum assurance activities for safety critical equipment), Shell's Preventative Maintenance Library (PML)(which provides more detailed preventative maintenance activities/standards), federal regulatory requirements, and OEM best practices. In the context of lifeboats, the latter is based on best practices common to lifeboat manufacturers and does not reference a specific manufacturer.

4.2.5.2.2. The preventative maintenance requirements in TIMSS are implemented through the Maintenance Execution Process, which leverages the SAP software to facilitate planning and scheduling of preventative and corrective work orders. The TIMMS preventative maintenance requirements are loaded into SAP and the schedules are built by Shell's Maintenance Execution Team. SAP issues work orders based on those schedules for the performance of the maintenance work. Once an assigned task is completed, the worker makes an entry in SAP documenting completion of the task and the time required to do so. SAP work orders have a scheduled completion date. The completion date is tracked in facility status reporting (FSR), which assigns a green, amber or red designation depending on how close the open work order is to the scheduled completion date. The status of work orders designated in FSR as amber or red are addressed during the daily production meeting.

<u>Lifesaving Equipment</u>

4.2.5.2.3. Shell maintains a Lifesaving Equipment (LS-MU-04 Lifeboats) document as part of its TIMMS. The document contains lifeboat operation, inspection and maintenance requirements. The document states that "lifeboats should be maintained at a minimum frequency as specified by CG regulations, and as prescribed by the manufacturer." It further requires that the manufacturer's instructions for onboard maintenance of the lifeboat and release gear must be onboard and include a schedule of periodic maintenance.

4.2.5.2.4. Shell offshore crews, OEM, or other qualified third parties are tasked with conducting the maintenance activities on the lifeboats. Relevant maintenance tasks include:

- <u>Lifeboat Inspection and Function Tests:</u> Lifeboat inspection and function tests are conducted on a weekly basis. During the tests crews conduct a visual inspection of the lifeboats, verify critical lifeboat contents, function check lifeboat engines and function check the davit. During the weekly inspections, specific to control cables, mechanics are directed to: "Verify the control cables move freely." Per Shell policy, its Lifeboat inspection and function tests were driven by its interpretation of Coast Guard regulatory requirements found in 33 CFR Subchapter N and 46 C.F.R. § 109.301.

- <u>Lifeboat Launch and Retrieval Tests:</u> Lifeboat launch and retrieval tests are conducted on a quarterly basis. During the tests, crews conduct a visual inspection of the lifeboats, verify critical lifeboat contents, function check lifeboat communications and systems, and launch and retrieve the lifeboats. Per Shell policy, its lifeboat launch and retrieval tests were driven by its interpretation of Coast Guard regulatory requirements found in 33 CFR Subchapter N and 46 CFR 109.213(d)(3).

- 3rd Party Lifeboat Launch and Run Test: 3rd party lifeboat launch and run tests are conducted on an annual basis. During the tests the OEM or other qualified third party function check the release mechanism, engine, lifeboat water spray system and davit limit switches. Per Shell policy, its 3rd party lifeboat launch and run tests were driven by its interpretation of Coast Guard regulatory requirements found in 46 C.F.R. § 109.301, 46 C.F.R. § 108.553(g), and 46 C.F.R. § 108.553(h).

- Lifeboat Davit Cable Change Out and Run Test: Lifeboat davit cable change out and run tests are conducted on a 5-yearly basis. During the tests the OEM or other qualified third party to verify the lifeboat descent rate is within regulatory limits; function check the release mechanism, engine, lifeboat water spray system and davit limit switches; replace the davit cables; and load test the lifeboat. Per Shell policy, its lifeboat davit cable change out and run tests were driven by its interpretation of Coast Guard regulatory requirements found in 46 C.F.R. § 94.25, 46 C.F.R. § 109.301, 46 C.F.R. 108.553(g), and 46 C.F.R. §108.553 (h).

4.2.5.2.5. Shell Offshore maintains a lifeboat launch and retrieval operational process for lifeboats in the Gulf of Mexico. The document, dated October 2017, directs the following steps when launching and retrieving a lifeboat (See Figure 32):

Role	Step	Action
Lifeboat Commander/ Electrician	1	With all personnel out of the craft, check the launch appliances by lowering the craft 10-15 ft, raising the craft again, carefully checking the limit switches and electrical disconnect, then securing in the launch mechanism/position. The Electrician shall stand by the push-button and disconnect in case of failure.
All on and entering Craft	2	Put on life jackets, take position inside the craft, and buckle seat belts.
Lifeboat Commander and Assistant	3	Orally review launch procedures.
	4	Check instruction signs, fuel, radios, and emergency equipment.
Lifeboat Commander	5	Start engine.
	6	Lower craft into water. **CAUTION: Do not run the engine for longer than 3–5 minutes if the craft is not in water.**
	7	Release craft from lowering cables, following instructions posted in craft.
	8	Maneuver craft away from platform to a pre-designated rally point.
	9	Operate all equipment to ensure proper functioning, including sprinkler deluge and breathing air pressure systems.
	10	Ensure that hook assemblies are reset per posted instructions in craft before maneuvering craft into retrieval position.
	11	Maneuver craft under launch cables.
	12	Place hoisting cable "D" rings in hooks.
	13	Recheck hook assembly to ensure that mechanism is locked.
	14	Signal person on platform to operate winch motor and raise craft from water until limit switches activate.
Platform Crew Member	15	Observe cable spooling as the craft is being raised to ensure the cable spools properly on the drum.
	16	Manually operate the boat winch to raise the lifeboat to stowage position.
Lifeboat Commander	17	Check craft to ensure that all controls are left in ready position.
Entire Crew	18	Disembark the lifeboat.
Lifeboat Commander	19	Ensure that seawater is flushed out of the system.

Figure 32: Lifeboat Launch and Retrieval Process, Shell Document, OPS0178, Rev 5.2. Credit: Shell

4.2.5.2.6. The release and resetting instructions mentioned in Steps 7 and 10 were posted on the steering console. Copies are those procedures are reproduced in Figures 33 and 34 below.

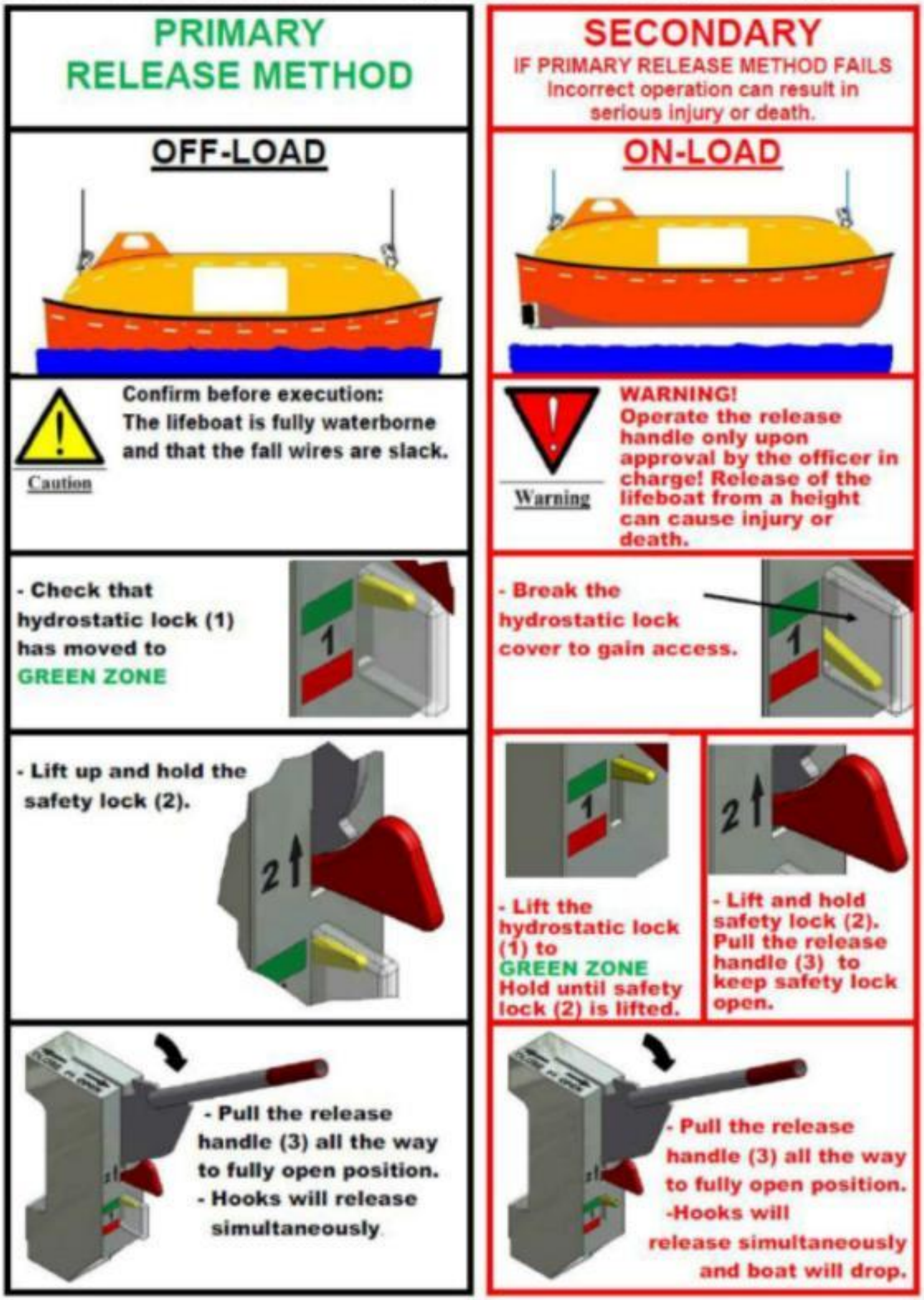


Figure 33: Release instructions posted in Lifeboat No. 6. Credit: Palfinger.

Figure 34: Resetting instructions posted in Lifeboat No. 6. Credit: Palfinger.

Shell Relationship With OEM

4.2.5.2.7. According to Shell Offshore's Specialty Engineer Manager and Maintenance Manager, the OEM plays a vital role in maintaining lifeboat systems on Shell offshore facilities:

> "OEMs such as Palfinger play an integral role in the inspection, servicing, maintenance and repair of the lifeboats it manufactures. Shell expects OEMs to either perform all needed preventative and corrective maintenance consistent with the OEM's policies and procedures or make specific recommendations to Shell that such preventative and corrective maintenance be performed."

4.2.5.2.8. When issues are noted by an OEM, according to Shell:

> "OEM service engineers are expected to address the results of their annual inspections with facility personnel, such as the Barge Supervisor or BCO, and make specific recommendations to Shell regarding any preventative and/or corrective maintenance that should be performed on each lifeboat. A copy of the OEM's findings is maintained in hard-copy form on the facility, the completion of an annual inspection is entered in SAP, and recommendations can be credited in SAP for the issuance of work orders."

4.2.5.2.9. As noted above, the OEM service engineer's primary point of contact during an inspection or service call is the job sponsor. According to Shell, the Barge Supervisor, BCO and/or Planner scheduler are typically involved in the selection of a job sponsor. The primary consideration is selecting a sponsor with lifeboat experience (usually a mechanic who inspects and maintains lifeboats) and the workload of the available employees with that experience.

4.2.5.2.10. The barge supervisor also engages with the OEM service engineer. According to the barge supervisor onboard AUGER during Palfinger's 2019 annual inspection, "As a BCO or Barge Supervisor, you typically have a pre-job meeting to discuss the scope of the OEM's work and a post-job meeting to discuss the results of the OEM's work. Depending on the result, particularly if a lifeboat needs to be taken out of service, the post-job meeting will include the OIM."

4.2.5.3. Lifeboat No. 6 Maintenance Events

OEM (Palfinger) Maintenance Activities

2019 Annual Examination

4.2.5.3.1. From June 5-10, 2019, two Palfinger Marine service engineers were onboard AUGER to conduct annual inspections on six lifeboat systems, including Lifeboat No. 6.

4.2.5.3.2. On June 6, 2019, during their inspection of Lifeboat No. 6, the service engineers found, what they described as "rust," "swelling" and "corrosion" damage on the aft hook release cable (see Figure 35). The compromised portion of the cable was located running through a notch on the starboard side of the coxswain's console, just below the release unit.

4.2.5.3.3. In response, the service engineers took a photo of the damage and called back to the Palfinger Marine office in New Iberia, LA.

Figure 35: Photo of Lifeboat No. 6 aft control cable. Taken on June 6, 2019. Credit: Palfinger.

4.2.5.3.4. The lead service engineer was interviewed in person by the Coast Guard on September 23, 2019. About the aft control cable, he noted:

> "It had some rust and corrosion around the end caps. There was some rust and corrosion along the Teflon outer casing . . . There was some swelling inside the cable itself. So when we looked at it I called my office and talked with them about it. I was told to inform our sponsor and the OIM or marine supervisor. So we showed our sponsor, if I remember his name was [Name of sponsor] . . . We showed him; he was informed. We told the OIM and marine [superintendent] before we left [that we recommended] that these cables need to be replaced . . . So we can't make anyone do anything."

4.2.5.3.5. In the service report, the service engineers wrote, "Recommend hook release cables" (see Figure 36). No amplifying information was provided. The service report concluded with the following comments: "Performed 5 year annual on 6 systems. All systems found to be [in] correct working order at this time of service, return boats back to service and made ready for use" (See Figure 36).

4.2.5.3.6. During the Coast Guard investigation, a copy of the June 2019 service report was found onboard AUGER in Lifeboat No. 6's maintenance file.

Station	Findings & Comments	Action by who?
L/B#6	recommend hook release cables	
	recommend port hole windows replaced	
	Port air bottle to small, recommed replace with OEM spec bottle	

Performed 5 year annuals on 6 systems
All systems found to be correct working order at tthis time of service, return boats back to service and made ready for use.
L//B 2,6,7,&8, Have had new winches changed out at earlier date with new fall wire and 1.1 load test.

Figure 36: Excerpt from AUGER's June 2019 annual inspection service report. Prepared by Palfinger. Credit: Palfinger.

4.2.5.3.7. The accompanying LSA checklist noted the condition/operation of the release cables as "OK" (See Figure 37).

				#6
3.3.11	Check condition/operation of release cables (free movement, corrosion)	1Y	RSY + P	OK

Figure 37: Excerpt from AUGER's June 2019 Checklist for LSA Equipment. Prepared by Palfinger. Credit: Palfinger.

4.2.5.3.8. In March 2020, the Coast Guard presented Shell with some additional questions. The Shell employee who served as Palfinger's job sponsor for the June 2019 annual inspection was asked about the compromised control cable. The Coast Guard received responses back on April 1, 2020. In his reponse, the job sponsor wrote: "I don't recall Palfinger employees mentioning any damage to the aft control cable or providing photos of any cable damage."

4.2.5.3.9. In March 2020, the Coast Guard asked the barge supervisor who participated in the June 2019 annual inspection debrief about Palfinger's recommendations to replace Lifeboat No. 6's control cables. He replied:

> "I met with the lead Palfinger engineer on Tuesday, June 11, 2019. I do not recall a discussion of Lifeboat No. 6's hook release cables, and I do not recall

> the engineer making any specific recommendations regarding the replacement of the cables. The only specific issues I recall discussing were the starter on Lifeboat no. 2 and the GRP cracks on 6,7 . . . I also asked whether the cracks or any other issues prevented any lifeboat from being placed back into service, and the Palfinger engineer said all lifeboats could be returned to service. Had the Palfinger engineer discussed the need to take any lifeboat out of service due to its condition or the need for a repair, such as compromised release cables, I would have immediately elevated the discussion to include the OIM. For other issues, I would follow the recommendations of the OEM, and either have a mechanic address the issue at the time and, if it could not be addressed with available equipment and personnel, a notification would be written in SAP and a work order issued. I do not recall any recommendations that required specific action by Shell other than the Lifeboat No. 2 starter."

4.2.5.3.10. No person from AUGER took action on Palfinger's recommendation to replace Lifeboat No. 6's control cables.

4.2.5.3.11. The lead service engineer told the Coast Guard during an interview: "We recommended that [the cable] be replaced . . .We can't make nobody do anything. . . We informed Shell that the cables need to be replaced. It is recommended that they be replaced every five years."

4.2.5.3.12. In that same interview, the service engineer was asked about the dangers posed by compromised or corroded cables. He answered: "I have never seen one break…not saying they haven't or they won't. The way the hook is designed, if the cable breaks, the hooks will never open.[31] You would have to walk to the hook and manually open it by hand."

4.2.5.3.13. The assistant service engineer on the job was also asked about the danger posed by compromised release cables. He told the Coast Guard: "Until recently[32], I thought they would freeze up and would not open the hook."

4.2.5.3.14. The service engineers did not have easy access to the actual age of the cable. Asked by the Coast Guard how they could obtain such information, the assistant service engineer noted that he could find the information by reviewing the notes contained in past service reports and seeking to determine the original installation date.

<u>May 2019 Winch Change-Out</u>

4.2.5.3.15. From May 13-27, 2019, two Palfinger Marine service engineers were assigned to perform a winch installation and 5-yearly inspection on Lifeboat Stations Nos. 2 and 6. When they arrived offshore, they identified that the new winches shipped to the AUGER in anticipation of installation were the wrong size. After significant back and forth, the service engineers ultimately replaced Lifeboat No. 6's then-existing winch, a BE 7800XL, for a recently refurbished BE 7800XL

[31] If the inner member of a hook control cable parts, the torsion spring is designed to hold the locking shaft in a closed position.
[32] At the time of the interview, a third party had briefed him on the Coast Guard, Shell and Palfinger's preliminary findings that a compromised control cable could contribute to an unintentional hook opening.

that was modified to a 9300XL. In effect, the “new” winch looked from the outside to be near identical to the old model winch; however, the winch was modified such that it was rated for 9300 kg vice 7800 kg.

4.2.5.3.16. While the initial work scope directed the service engineers to conduct a 5-yearly inspection on Lifeboat Stations No. 2 and 6, the service engineers stated that after they arrived onboard AUGER, the work scope was amended. Only certain tasks associated with the 5-yearly inspection, as noted in Instruction F-10449, were completed. New fall cables were installed and a 1.1 load test[33] was completed and documented. However, tasks related to dismantling, inspecting, and cleaning, and testing the forward and aft hooks, were not completed.

4.2.5.3.17. When the service engineers tasked with conducting the June 2019, annual inspection of Lifeboat Station No. 6 were interviewed by the Coast Guard, they expressed their understanding that Lifeboat Station No. 6 had received a complete 5-yearly inspection in May.

4.2.5.3.18. There is some evidence that after fall cable installation, the lifeboat was not hanging “level” in the davit. Witnesses observed that the forward end of the boat hung lower than the rear. Investigators measured the lengths of the fall cables, maintenance pendants and limit switches to try to determine how the boat was hanging on the day of the casualty. Measurements taken by Shell evidence that the forward end of the boat was hanging lower. DNV-GL and PSN were asked to model what would happen to Lifeboat No. 6 if the winch operator continued to manually winch the boat after the aft end was already seated in the aft bumpers. DNV-GL and PSN’s modeling could not validate the numbers provided by Shell. More detailed information is contained in DNV-GL’s report attached as an Enclosure (3) to this report.

<u>2015 - 2018 Annual Inspection</u>

4.2.5.3.19. Lifeboat No. 6 received annual inspections by the OEM in June 2018, June 2017, June 2016, and June 2015. During each inspection the cables were found in working condition. Their service reports contain no reference to control cable damage or corrosion. The Coast Guard reviewed available photographs, however, neither the Coast Guard nor Palfinger could locate any additional photographs of the relevant cable section.

<u>2014 Annual Examination</u>

4.2.5.3.20. On or around June 24, 2014, a Harding (later Palfinger) service engineer conducted an annual examination of Lifeboat No. 6. The service engineer noted that the forward keel shoe was pulling through the hull and an aft hook canopy repair had failed. Further, a GRP patch had separated from the deck. While the service engineer found the lifeboat, davit and winch serviceable, during July

[33] In a 1.1x load test, water bags are positioned in the lifeboat and filled to bring the total weight to 1.1 (or 110%) x the B-weight (fully loaded) weight. The boat is then lowered. Once the boat has reached its maximum lowering speed and before the lifeboat enters the water, the winch break is abruptly applied. Generally, this procedure is followed three times during the a 1.1x load test.

2014, the lifeboat was taken off AUGER and sent to the Harding facility in New Iberia, LA for repairs.

4.2.5.3.21. In evaluating the damage to Lifeboat No. 6 at the New Iberia facility, Harding conducted a root cause analysis. On July 17, 2014, Harding documented its findings as:

> "At the facility, Harding determined by a visual inspection the damage was not structural. There was no visual indication of damage to the interior area of the hook foundation. The two vertical cracks were determined to be delamination from a previous repair to the exterior of the hook foundation. No cracks were found to penetrate in the exterior or interior laminate schedule of the Life Boat. The composite material was removed between the two vertical cracks to verify a previous repair was performed incorrectly. The root cause was from a previous incorrect repair and the continued excessive tension of the Lifeboat being pulled into the davit. The original repair was required due to the Lifeboat being pulled into the davit too tight over an extended period of time. This action forced the forward hook foundation area to indent toward the interior of the life boat. This facilitated a repair but was performed incorrectly. Due to the fact no composite repairs were required during the refurbishment of the Life Boat or during installation of the new release mechanisms at our facility with no indications of any repairs performed previously no investigation of the forward bow area would have been initiated.
>
> It has been verified the limit switches were required to be adjusted during the last annual inspection . . .The lifeboat being repaired at the New Iberia facility appears to have continued the history of being pulled too tight into the davit.
>
> The repair required the original repair to be removed and the correct procedure performed. Additional layers of composite materials were applied to the interior to stiffen the bow area in order to reduce damage of the Lifeboat Boat if being stored in the davit incorrectly."

4.2.5.3.22. After repairs were made, the lifeboat was returned to operation on the AUGER.

<u>2014 Photograph of Aft Control Cable</u>

4.2.5.3.23. During the investigation, Shell provided the Coast Guard with photographs of the area of aft control cable at the release unit (see Figures 37 and 38). Shell proffered that the photographs were taken in 2014. There is some evidence of chaffing on the green conduit cover at the area of eventual failure.

Figures 38 (left) and 39 (right): Photos of aft control cables in or around 2014. Credit: Shell.

2012 - 2013 Annual Inspections

4.2.5.3.24. In June 2012 and May 2013, the OEM conducted annual examinations of Lifeboat Station No. 6. During both inspections the cables were found in working condition. The service reports contain no reference to control cable damage or corrosion.

Operator (Shell) Maintenance Events

Weekly Lifeboat Inspection and Function Tests

4.2.5.3.25. Evidence obtained from Shell indicate that crews completed the weekly lifeboat inspection and function test each week, up to and including the week before the incident. The Coast Guard collected no evidence supporting the fact that the condition of Lifeboat No. 6's aft hook control cable was ever documented during the weekly tests as an issue or a cause for replacement.

Quarterly Lifeboat Launch and Retrieval Tests

4.2.5.3.26. Evidence obtained from Shell indicate that crews completed the quarterly lifeboat launch and retrieval tests each quarter. Lifeboat No. 6 was launched and retrieved on the following days in the two years prior to incident:

- Third Quarter 2019 - June 30, 2019 (Casualty)
- Second Quarter 2019 – March 22, 2019
- First Quarter 2019 – Not conducted due to weather
- Fourth Quarter 2018 – October 28, 2018
- Third Quarter 2018 – July 30, 2018

- Second Quarter 2018 – April 28, 2018
- First Quarter 2018 – Not conducted due to weather

4.2.5.3.27. The Coast Guard collected no evidence supporting the fact that the condition of Lifeboat No. 6's aft hook control cable was ever documented during the quarterly tests as an issue or a cause for replacement.

4.2.5.4. Spot Inspections of Other AUGER Lifeboats

4.2.5.4.1. In September 2019, the Coast Guard and Shell removed and inspected the hook release control cables from AUGER's Lifeboat No. 7 and Lifeboat No. 8 after the lifeboats were decommissioned. After an initial inspection, the cables were wrapped and sent to DNV-GL in Ohio for further analysis. The findings are summarized below.

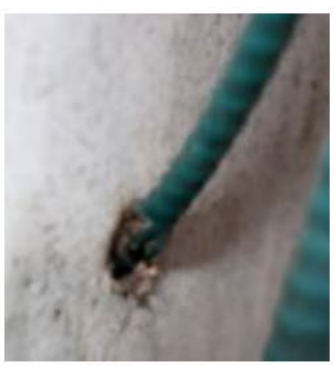
Lifeboat No. 7

4.2.5.4.2. Lifeboat No. 7 was a Schat-Watercraft model EL28 lifeboat bearing serial number 1183 fitted with a LHR6M2 release mechanism.

4.2.5.4.3. During the Coast Guard's September 2019 visual inspection of the cables, the Coast Guard witnessed that a small area of the hydrostat cabling was corroded and damaged (See Figure 40).

4.2.5.4.4. Palfinger had inspected Lifeboat No. 7 in June 2019 and June 2018. Neither service report makes reference to control cable damage or contains a recommendation for replacement.

4.2.5.4.5. At DNV-GL, the cables were inspected again. DNV-GL documented damage all the way through the conduit cover and steel wire layers (see Figure 41). As with Lifeboat No. 6's aft hook control cable, DNV-GL found that the cracking of the green conduit cover was a likely result of fatigue due to the expansion of the corroding wire layer. [34]



Figures 40 (left) and 41 (right): Photos of Lifeboat No. 7 hydrostat control cable. Credit: CG and DNV-GL.

[34] DNV-GL at pg. 39.

Lifeboat No. 8

4.2.5.4.6. Lifeboat No. 8 was a Schat-Watercraft model EL28 lifeboat bearing serial number 1182. It was fitted with a Schat-Harding LHR6M2 release mechanism.

4.2.5.4.7. During the Coast Guard's September 2019 visual inspection of the cables, the Coast Guard witnessed that a small section of the forward hook control cable was torn and bulging; corroded wires could also be seen (see Figure 42).

4.2.5.4.8. Palfinger conducted an annual inspection on Lifeboat No. 8 in June 2019. While the control cables were marked as "OK" on the LSA checklist, like the cables on Lifeboat No. 6, Palfinger recommended that Shell replace the hook release cables.

4.2.5.4.9. Palfinger conducted annual inspections on Lifeboat No. 8 in June 2018. The 2018 annual inspection service report makes no references to control cable damage and does not contain a recommendation for replacement.

4.2.5.4.10. At DNV-GL, the cables were inspected again. DNV-GL documented tears through the outer layer of the green conduit cover (see Figure 43). Rust and corrosion was present on the outer layers of the steel wire, however, the steel wires were still mostly intact (as opposed to the cables found on Lifeboats Nos. 6 and 7).

Figures 42 (left) and 43 (right): Photos of Lifeboat No. 8 forward control cable. Credit: CG and DNV-GL.

Training and Experience

4.2.5.5. Palfinger Training Program

4.2.5.5.1. Palfinger's training program includes a combination of on-the-job training and resident training programs. Palfinger runs a DNV-certified maritime training center in the Netherlands. From its training center, Palfinger runs a series of basic and advanced courses for Palfinger service engineers and third parties working on Palfinger brand equipment.

LSA Basic

4.2.5.5.2. LSA Basic training is a five-day resident training course. It is a mandatory course for all Palfinger service engineers. The course covers the release systems, lifeboats, winches and davits, inspection and maintenance, service reports, and rules and regulations.

LSA Advanced (Refresher)

4.2.5.5.3. LSA Advanced is a five-day resident training course for persons who have previously attended LSA Basic or have significant relevant work experience. The training consists of a recap LSA Basic and updates on products and procedures.

LSA Multi-Brand Basic and Advanced

4.2.5.5.4. Multi-Brand Basic and Multi-Brand Advanced Trainings are each three-day resident courses. The courses allow Palfinger Marine service engineers to gain the competencies necessary to service non-Palfinger LSA equipment. The course covers, among other topics: LSA Multi-Brand procedure, multi-brand hook systems, multi-brand boat systems, multi-brand davits and winches, multi-brand hook modifications, diagnostic test and results, and common causes of LSA accidents.

4.2.5.6. Palfinger Service Engineers Training and Experience

Service Engineers who conducted the June 2019 Annual

4.2.5.6.1. The lead service engineer on the June 2019 annual inspection started working for Schat-Harding in 2013. For his first year of employment, he shadowed a senior service engineer. Since that time, he has attended a series of resident courses, including the LSA Basic (initial), LSA Basic (advanced); LSA Advanced and; Multi-Brand Basic and Multi-Brand Advanced Training. He also served as the lead service engineer on Lifeboat No. 6’s 2018 annual inspection.

4.2.5.6.2. The assistant service engineer started working for Palfinger in or around June 2018. Before Palfinger, he spent 13 years working for a non-OEM multi-brand lifeboat service provider. He attended Palfinger’s LSA Basic training in February 2019 and was certified by Palfinger to service its lifeboat equipment.

Service Engineers who conducted the May 2019 Winch Change-Out

4.2.5.6.3. The lead service engineer on the May 2019 winch change-out started working for Palfinger in 2014. Before Palfinger, he spent 4 years working for a different lifeboat servicing company. He has attended six resident courses administered by Palfinger, Harding or Schat-Harding, to include: LSA Basic; LSA Advanced; and several non-routine courses held to educate service engineers on newly purchased brands.

4.2.5.6.4. The assistant service engineer on the May winch change-out also started working for Palfinger in 2014. Before Palfinger, he worked as a mechanic. He attended Palfinger’s LSA Basic training.

4.2.5.7. Shell Training Program

Proficiency in Survival Craft

4.2.5.7.1. Shell administers its own Coast Guard-approved Proficiency in Survival Craft (PSC) course at its training center in Robert, Louisiana. Persons who complete the course satisfy the requirements of training, practical demonstration and written examination requirements of 46 CFR 12.407(b)(3) for a Lifeboatman endorsement; the PSC and Rescue Boats other than Fast Rescue Boats training and standards of competence requirements of 46 CFR 12.613(b)(3); applicable sections of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) code and U.S. Coast Guard Navigation and Vessel Inspection Circular (NVIC) 04-14.

4.2.5.7.2. Shell's PSC course is 37.5 hours in length and contains a combined 90 minutes on the theory of launching systems and releasing systems and 12 hours of practical Lifeboat Davit and Simulator Operation experience.

4.2.5.7.3. Shell sends individuals to PSC training if they are in a designated lifeboatman role on a Shell asset or if the asset opts to train them to be prepared for a role. Generally, contractors do not attend PSC training unless they are asked to satisfy a lifeboatman role on an asset.

Maintaining Lifeboats and Survival Craft

4.2.5.7.4. Based on the evidence collected in the investigation, Shell's training program for the maintenance of lifeboats and survival craft consists of the providing the relevant mechanics with appropriate check-lists and policy documents; ensuring crews have access to OEM provided installation, operations, and maintenance manuals; and encouraging on-the-job training experience.

4.2.5.8. Shell Crew Training and Experience

4.2.5.8.1. The Coxswain worked as a mechanic for Shell onboard AUGER. He started working for Shell in June 2011, but spent some time working on AUGER as a contractor before becoming a Shell employee. His entire time with Shell was spent working on the AUGER. He held a lifeboatman endorsement to his merchant mariner's credential (MMC). He attended Shell's PSC course in November 2016.

4.2.5.8.2. Boat Crew Person No. 1 worked as a mechanic for Shell. He started on AUGER in 2003, working first for a contractor before being hired by Shell in 2011. Overall, at the time of the incident, he had twenty years of offshore experience. He held a lifeboatman endorsement to his MMC. He attended Shell's PSC course in March 2017.

4.2.5.8.3. Boat Crew Person No. 2 worked as a mechanic for Danos, as a Shell core contractor onboard AUGER.

4.2.5.8.4. Boat Crew Person No. 3 worked as a mechanic for Shell. He had worked for Shell onboard AUGER since January 2013; before that time, he worked as a Shell contractor. He held a lifeboatman endorsement to his MMC. He attended Shell's PSC course in May 2013 and again in February 2019.

4.2.5.8.5. The Ballast Control Operator (BCO) worked for Shell. He started as a mechanic in 2013, and became a BCO in 2018. He had worked onboard AUGER since 2013. He held a lifeboatman endorsement to his MMC. He attended Shell's PSC course in March 2014.

4.2.5.8.6. The Electrician worked for Shell. He started on AUGER in 1998, working first as a contractor before being hired by Shell in 2008. He held a lifeboatman endorsement to his MMC. He attended Shell's PSC course in March 2017.

4.2.5.8.7. The Launch Crew Person worked as a mechanic for Danos, as a Shell core contractor onboard AUGER. He has worked on AUGER since 2010.

4.2.6. Post Casualty Drug and Alcohol Testing

4.2.6.1. The four uninjured crew directly involved in the casualty (the three-launch crew and Boat Crew Person 1) were tested for drugs within 8 hours after the casualty. All results were [redacted] The four uninjured crew were also screened for alcohol on June 30, 2019; however, it is unclear when the tests took place. All tested [redacted] for alcohol.

4.2.6.2. The two deceased crewmembers (Boat Crew Person 2 and 3) received post-mortem toxicological screenings. Both tests were [redacted] for the presence of alcohol or drugs.

4.2.6.3. The injured crewmember (Coxswain) was screened for alcohol on the day of the casualty. Test results were [redacted] Drug testing was delayed as a result of his injuries. The drug test, conducted on July 15, 2019, was [redacted].

4.2.7. Post-Casualty Function and Forensic Testing

OEM, Operator and Coast Guard Testing at Harvey, LA

4.2.7.1. In July 2019, the Coast Guard, Shell, and Palfinger conducted several functional experiments utilizing an exemplar release mechanism. The experiments took place at the Shell facility in Harvey, LA. The purpose of the experiments was to test several causal theories.

4.2.7.2. At the facility, the Shell investigation team constructed a test jig, comprised of exemplar hooks, release unit, and control cables. The construction team utilized the general arrangement drawings of the model EL24 lifeboat in building the jig.

4.2.7.3. During the testing, the Coast Guard, Shell and Palfinger developed three primary theories that either explained in whole, or in part, the casualty. The theories include:

4.2.7.3.1. Theory 1: The outside layers of the aft control cable of the hook release mechanism were compromised, leading to subsequent failure of the white polyethylene liner containing the inner member of the cable.

4.2.7.3.2. Theory 2: The aft control cable of the hook release mechanism was parted (outer layers and white liner), limiting the travel of the inner member of the cable when the release handle is moved to the closed position. The locking shaft of the aft hook was barely in the closed position when the boat was being winched out of the water. The hook opened when the boat was being winched into the davit bumpers.

4.2.7.3.3. Theory 2a: Winching of the lifeboat into the aft davit bumpers compromised the structural integrity of the components supporting the engine, resulting in the engine or adjacent components to contact the aft cable and pull the cable, rotating the aft locking shaft into the open position (due to the compromised condition of the aft control cable). Theory 2a was developed as a supplemental theory with the result of continued analysis of the evidence; it was developed well after the first three theories were articulated.

4.2.7.3.4. Theory 3: The aft ring was on the tip of the aft hook while the boat was being winched out of the water. The ring slipped off the hook when the boat was being winched into the davit bumpers.

4.2.7.4. As a result of the initial findings, Shell, with Coast Guard approval, contracted with DNV-GL for independent forensic testing of the component parts in order to obtain additional data and test certain hypotheses.

DNV-GL

4.2.7.5. In August 2019, Shell, with Coast Guard concurrence, contracted with the DNV-GL Materials and Corrosion Technology Center Casualty Investigation Section in Dublin, Ohio to conduct forensic testing of the component parts. Shell managed the contract with DNV-GL, and the Coast Guard maintained active oversight during the duration of the testing. The Coast Guard reviewed the scope of work, received regular briefs from DNV-GL and spent more than four weeks on-site at DNV-GL's facility.

4.2.7.6. DNV-GL performed two site visits to the Harvey facility to inspect the components associated with the incident. The visits took place July 29-August 2, 2019 and October 3, 2019.

4.2.7.7. In August, the subject release mechanism and associated artifacts, including the forward and aft hooks, hydrostat; forward, aft, and hydrostatic control cables, and release unit were shipped to DNV-GL's facility in Dublin, Ohio. Further, terminal lengths of wire ropes from Lifeboat Station No. 6's falls and attached lift rings were sent.

4.2.7.8. DNV-GL also received exemplar artifacts, including a hook of the same design (later revision and type approval series) and control cables of the same design. Utilizing subject and exemplar materials, DNV-GL constructed a mock-up of the Lifeboat No. 6 release mechanism. The mock-up was used for functional testing of subject and exemplar components.

4.2.7.9. In summary, DNV-GL found:

> "The results of the investigation indicated that the unintended release of the Aft Hook of Lifeboat 6 was a result of a degraded and compromised aft control cable.

> The control cable exhibited significant corrosion, full penetration around the circumference of the structural wire layer (conduit) allowing for externally applied loads to rotate the locking shaft of Subject Aft Hook to an open position.
>
> Failure of the Subject Aft Cable is suspected of progressing in the following manner: (1) mechanical damage to the cover due to contact between the control cable and the helmsman's console, (2) water ingress leading to significant corrosion of the wire layer, (3) voluminous corrosion product resulting in fatigue of the cover layer and the cover opening further, and (4) buckling and elongation of the liner layer as a repetitive action associated with the functioning of the control cable. Due to the damage to the Subject Aft Cable, the locking shaft of the Subject Aft Hook was not fully closed (i.e. in a slightly more open position) requiring less rotation to release the hook. The compromised conduit would have allowed for external loads applied to the push-pull cable that is directly linked to the locking shaft, thereby rotating the locking shaft to an open position."[35]

4.2.7.10. DNV-GL's final report is attached as Enclosure (3) to this Report of Investigation.

Coast Guard Experiment

4.2.7.11. On January 14, 2020, the Coast Guard conducted a series of three experiments in order to test the hypotheses developed by Shell, Coast Guard and Palfinger investigators in July 2019. A detailed report of the experiments is attached as Enclosure (2) to this report.

4.2.7.12. The Coast Guard utilized an EL24 lifeboat (hereinafter referred to as MSTC Lifeboat No. 1) with a SeaCure LHR3.5M2 model release mechanism at the Marine Survival Training Center (MSTC) in Lafayette, LA. MSTC Lifeboat No. 1 was equipped with the same model Cablecraft control cables as Lifeboat No. 6. MSTC did not maintain records on the age of its control cables, however, anecdotally, the MSTC Director recalled that the control cables were installed in or around 2015 or 2016.

4.2.7.13. MSTC is a marine, offshore, and aviation survival training facility associated with the University of Louisiana, Lafayette. MSTC Lifeboat No. 1 serves as a primary training lifeboat. MTSC Lifeboat No. 1 is used during three classes per month, every month of the year. The hooks are cycled (opened/closed) an average of forty times per class. In all, the control cables of MSTC Lifeboat No. 1 were likely newer than the cables on Lifeboat No. 6, by up to two years. However, MSTC Lifeboat No. 1's control cables had seen significantly more operational cycles than the control cables present on Lifeboat No. 6.

4.2.7.14. The Coast Guard identified early on that the testing in Harvey did not factor in how the age of the cables or the routing of the cables may have impacted the test results.

4.2.7.15. The purpose of the experiment was to determine:

[35] DNV-GL at pgs. 53-54.

- The forces necessary to operate the release mechanism with various loads on the hooks, as the force required to operate the release unit translates into force applied to/through the control cables;

- How operation of the release lever would affect the polyethylene liner of the control cable (e.g. stretch, distortion and/or breakage), with the outer layers of the cable conduit in a damaged/compromised condition; and

- How a separated polyethylene liner affects the position of the locking shaft (cam) of the hook with the control cable installed in the same model boat and routed in the same manner as that of AUGER Lifeboat 6.

Further tests were developed to document what would happen when additional force was applied to the hook with the release system in a compromised state (i.e., locking shaft rotated between the closed and open positions due to a separated polyethylene liner in the control cable).

4.2.7.16. During the first experiment, Coast Guard personnel sought to determine the amount of cable travel needed to rotate the locking shaft from a fully closed position to the open position. It also sought to determine the closed locking shaft position when utilizing the release unit to close (reset) the hook.

The results of the experiment are summarized in Figure 44 below:

Measurement Description	Locking Shaft Position	Position Indicator Mark	Release Unit Condition	Distance (mm)
Cable length at release unit	Max closed	A	Disconnected	160
Cable length at release unit	Open (no load)	B	Disconnected	255
Cable length at release unit	Closed (as found)	C	Connected	260
Locking shaft fillet to hook roller	Max closed	A	Disconnected	17
Locking shaft fillet to hook roller	Open (no load)	B	Disconnected	N/A
Locking shaft fillet to hook roller	Closed (as found)	C	Connected	12

Figure 44: Summary of Experiment 1 results. Credit: CG.

4.2.7.17. As part of the second experiment, Coast Guard personnel sought to determine and document the locking shaft movement with control cable damage, and determine and document the control cable reaction and/or failure through release unit actuation (hook open/close cycles) with various levels of cable damage.

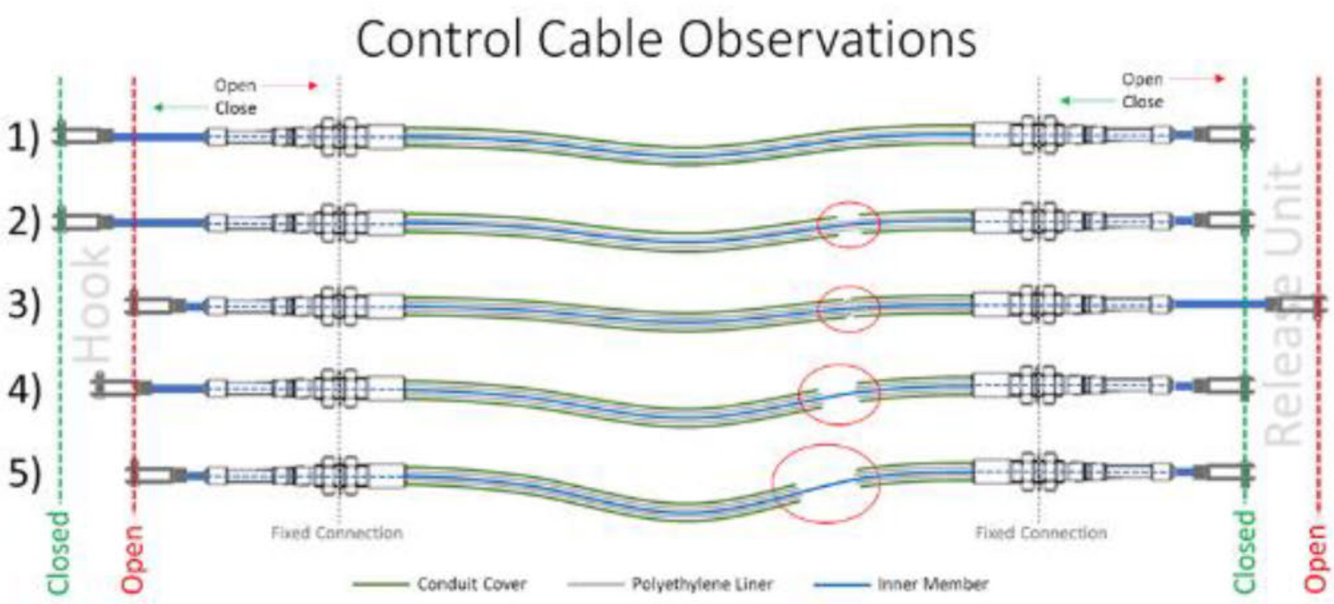
The results of the experiment are summarized in Figure 45 below:

Measurement Following:	Release Handle Position	Conduit Separation[1] (mm)	Position Indicator Mark	Locking Shaft Position
Initial removal of conduit cover, steel band & steel strands	Closed	9	C	Closed
First open action (liner compression)	Open	6	-	Open
First close action (liner tension)	Closed	12	-	-
Two (2) open/close cycles	Closed	13	2x	Closed[3]
Twelve (12) open/close cycles[2]	Closed	16	12x	Closed[3]
Cut 1/8 of the liner circumference & two (2) open/close cycles[4]	Closed	17	-	Closed
Cut an additional 1/8 of the liner & completed one (1) open/close cycle	Closed	48	2nd Cut/ Break	Closed[5]
One (1) open/close cycle after liner separation	Closed	91.5	-	Open

[1] Conduit separation was measured between the cuts to the conduit cover
[2] See Step 6 for progression of separation and liner distortion noted
[3] Locking shaft was closed, but creeping toward open.
[4] Additional liner distortion noted.
[5] Closed, but nearing open.

Figure 45: Summary of Experiment 2 results. Credit: CG.

4.2.7.18. Figure 46 summarizes the Coast Guard's control cable observations throughout the experiments:



1) Hook closed with release handle locked in closed position (cable intact).
2) Hook closed with release handle closed. Conduit cover and steel layer removed (9 mm) with liner intact.
3) Hook open with release handle open (liner compression noted during testing).
4) Polyethylene liner failed during closing with 48 mm of conduit separation and locking shaft in partially-closed position (i.e., closed/locked, but almost open).
5) Subsequent release unit actuation after initial liner break extended conduit separation to 91 mm and would not rotate the locking shaft (i.e., hook remained open).

Figure 46: Control cable observations. Credit: CG.

4.2.7.19. After obtaining data related to how a compromised cable would affect the position of a locking shaft after a reset, the Coast Guard conducted experiments to determine and document if additional forces applied to the hook, with the control cable in a compromised state (locking shaft incrementally rotated closer to an open position) will force the locking shaft to move into the open position and allow the hook to release with the:

- Lifeboat weight plus 4 persons (weight on the day of the incident);
- 110% of the B weight of the lifeboat; and
- 150% of the B weight of the lifeboat.

The results of the experiment are summarized in Figure 47 below:

Locking Shaft/Position Indicator Orientation for Test	Release Handle Position	Test Weight Applied[1]	Position Indicator Mark	Locking Shaft Position
Mark for "Break" from Experiment 2, Step 11	Closed	(a)	Break	Closed[2]
		(b)		Closed[2]
		(c)		Closed[2]
1 mm past break, toward open (B)	Closed	(a)	Dot 1	Closed[2]
		(b)		Closed[2]
		(c)		Closed[2]
2 mm past break, toward open (B)	Closed	(a)	Dot 2	Closed[2]
		(b)		Closed[2]
		(c)		Closed[2]
3 mm past break, toward open (B)	Closed	(a)	Dot 3	Closed[2]
		(b)		Closed[2]
		(c)		Closed[2]
4 mm past break, toward open (B)	Closed	(a)	Dot 4	Closed[2]
		(b)		Closed[2]
		(c)		Closed[2]
5 mm past break, toward open (B), Steps 7-9	Closed	(a)	5 mm	Closed[2]
		(b)	Rollover	Forced Open[3]
		(c)	N/A	N/A

[1] See Table 9 for weight calculations; (a) = Lifeboat plus 4 persons (day of incident); (b) = 110% of the Condition B Weight; (c) = 150% of the Condition B Weight

[2] Closed, but nearing open.

[3] Locking shaft was forced open by increasing weight on the hook and no other forces applied to any component of the system (confirmed results with subsequent tests.

Figure 47: Summary of experiment 3 results. Credit: CG.

4.2.7.20. In summary, the results of the Coast Guard's experiments show that a separation in the conduit of a control cable, while cycling the release lever, can result in the hook locking shaft stopping between the open and closed positions ("**B**" and "**C**" positions, respectively, on Figure 48).

Figure 48: Locking shaft positions during experiment. Credit: CG.

However, it must be emphasized that after the initial liner failure and separation, any further cycling of the system will result in the locking shaft remaining in the open position. With a failed liner, the friction forces cause the cable conduit to freely extend, rendering the system unable to rotate the locking shaft to the closed position. This prevents the hooks from locking, rendering them unable to hold any load.

With the locking shaft in a partially-closed (i.e., "almost open") position immediately following conduit separation, the hook can still support the weight of the lifeboat and the occupants. Additionally, if the locking shaft is in a position that is relatively close to the open position, the hooks can support the weight of the boat, though an additional load can cause the locking shaft to rotate and allow the hook to open. The force of cable separation alone will not rotate a locking shaft under load.

4.2.8. Fall Preventer Devices and Locking Pins

4.2.8.1. Fall preventer devices (FPDs), as the name suggests, are systems that are designed to prevent the unintentional release of a lifeboat from the fall cables. Generally, FPDs fall into two categories: 1) strops or slings, and; 2) locking pins or training locks.[36]

4.2.8.2. Strops or slings are made of strong synthetic fiber with a strength which provides for a factor of safety of at least six, based on the total weight of the lifeboat when loaded with its full complement of persons and equipment. Strops and slings can be used to minimize the risk of injury or death by providing a secondary alternate load path in the event of failure of the on-load hook or its release mechanism or of accidental release of the on-load hook.[37]

4.2.8.3. A locking pin, also referred to as a safety pin or training lock, usually takes the form of a pin that can be inserted into a pre-drilled hole in the hook. In general, when inserted, the pin prevents the locking shaft from rotating and opening the hook.

[36] Some persons elect to categorize locking pins and training locks as Secondary Safety Devices (SSDs). However, the IMO categorizes locking pins and training locks as FPDs. Accordingly, the Coast Guard will do the same in this report.
[37] IMO, "Guidelines for the Fitting and Use of Fall Preventer Devices (FPDs)", MSC.1/Circ. 1327 (June 11, 2009) p. 1.6

Risks Associated with FPDs

4.2.8.4. FPDs present certain risks to crews. If not removed after drills or training FPDs can hinder an emergency evacuation as they prevent release of the hooks from the falls lift rings. Further, some express concern that use of FPDs will diminish a crew's confidence in the reliability or safety of lifeboat systems.

IMO Policy on the Use of FPDs

4.2.8.5. The IMO Maritime Safety Committee (MSC) has released several circulars discussing the use of FPDs. The MSC's recommendations on the use of FPDs have always been couched in the context of temporary measures pending upgraded systems.

4.2.8.6. On June 11, 2009, the IMO Maritime Safety Committee issued Circular 1327, Guidelines for the Fitting and Use of Fall Preventer Devices (FPDs). The MSC noted in the circular:

> "The use of FPDs should be considered as an interim risk measure, only to be used in connection with existing on-load release hooks, at the discretion of the master, pending the wide implementation of improved hook designs with enhanced safety features."

4.2.8.7. Similarly, on May 27, 2011 the IMO Maritime Safety Committee issued Circular 1392, Guidelines for Evaluation and Replacement of Lifeboat Release and Retrieval Systems. The circular recommended the use of FPDs for SOLAS vessels using lifeboats not yet compliant with LSA Code revisions. The MSC's recommendation was to use FPDs *until* the system was found compliant.

Coast Guard Policy on the Use of FPDs

4.2.8.8. On March 4, 2014, the Coast Guard issued CG-ENG Policy Letter No. 01-14, Lifeboat Release Mechanism: Policy on Implementation of New SOLAS Regulation III/1.5 and IMO Circular MSC.1/CIRC. 1392. CG-ENG's guidance paralleled the IMO's guidance:

> "IMO guidance clearly states that FPDs are intended to be used only as an interim risk mitigation measure for existing on-load release hooks until such time that improved design and performance criteria are implemented. As such, since the use of FPDs can introduce certain operational risks, we recommend their use only until it can be confirmed that installed release mechanisms are 'compliant.'"

4.2.8.9. CG-ENG Policy Letter No. 01-14 was intended to provide interim guidance pending implementation of SOLAS Regulation III/1.5 and IMO Circular MSC.1/CIRC. 1392. It was not intended to serve as blanket policy on FPDs.

4.2.8.10. Commandant (CG-ENG-4) has approved several release mechanisms since 2014 with locking pins as part of the approved design. However, the Coast Guard has no current guidance on whether operators should use FPDs as a risk reduction technique when launching or retrieving lifeboats.

Use on the Lifeboat No. 6

4.2.8.11. The SeaCure LHR3.5M.2 hooks installed on Lifeboat No. 6 were pre-drilled for locking pins but did not have this optional device installed.

4.2.8.12. Shell does not have a policy regarding fall preventer devices or secondary safety devices for lifeboats on AUGER.

4.2.8.13. In response to questions from the Coast Guard, Shell replied that it is not aware of any company decision not to use fall preventer devices or secondary safety devices on AUGER lifeboats.

4.3. Regulatory Framework

4.3.1. Floating OCS Facilities

4.3.1.1. As discussed above, AUGER is tension leg platform (TLP), a permanently moored floating structure used for offshore oil and natural gas production in deep water. A TLP falls under the definition of a floating OCS facility (FOF) as defined in 33 C.F.R. § 140.10.

4.3.1.2. The Coast Guard's – and other federal agencies' – authority to issue regulations for FOFs are drawn from the Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. § 1333(a)(1). Passed in 1953, OCSLA extends the Constitution and laws of the U.S. to the seabed and subsoil of the Outer Continental Shelf and to "all artificial islands, and all installations and other devices permanently or temporarily attached to the seabed which may be erected thereon for the purpose of exploring for, developing, or producing resources therefrom ..." 43 U.S.C. § 1333(a)(1).

4.3.1.3. Although primary responsibility for OCS supervision is given to the Secretary of Interior, OCSLA grants the Secretary under which the Coast Guard is operating the authority to promulgate and enforce "such reasonable regulations with respect to lights and other warning devices, safety equipment, and other matters relating to the promotion of safety of life and property" on the devices specified in 43 U.S.C. § 1333(d)(1).

4.3.1.4. The OCS surrounds the entire United States. However, the Gulf of Mexico supports most commercial OCS activity. For that reason, the Eighth Coast Guard District (D8) employs an OCS Officer in Charge, Marine Inspection (OCMI). 33 C.F.R. § 3.40-5. The OCS OCMI reports up to the Commander, Eighth Coast Guard District. This O-6 billet, in addition to OCMI responsibilities and authorities outlined in 46 CFR Subchapter A, develops OCS policy within the D8 area of responsibility, oversees industry and partner engagement, and supports units executing missions on the OCS. There are 12 OCS inspector and one OCS investigator billets spread out over six D8 units, most located at Sector New Orleans. These inspectors are assigned to their respective Coast Guard units; however, they receive tasking and policy direction from the D8 OCS OCMI. Additionally, the personnel at the OCS National Center of Expertise, located in Houma, Louisiana, provide training and expertise.

4.3.1.5. FOFs are inspected under 33 C.F.R. Subchapter N; portions of 46 C.F.R. Subchapters I-A, F, J, and S; portions of 33 C.F.R. Subchapters C and O; and, various Coast Guard Headquarters, D8 Policy Letters and NVICs. In June 2019, the Coast Guard was in the practice of issuing Certificates of Inspection (COIs) to FOFs subject to United States authority. Issuance of these documents attested that the units met the applicable regulatory requirements.

4.3.2. Lifesaving on Floating Offshore Facilities

4.3.2.1. The requirements of 33 C.F.R. Subchapter N, Outer Continental Shelf Activities, apply to FOFs, including lifesaving gear on FOFs.

4.3.2.2. Specific to operations, FOFs must comply with 33 CFR Part 146, Subparts A and B.

4.3.2.3. FOFs do not meet the regulatory definition of a vessel or a MODU. However, 33 C.F.R. § 143.120 requires that FOFs meet the MODU plan approval regulations in Subpart C of 46 C.F.R. Part 107 and design and equipment regulations in 46 C.F.R. Part 108, as well as the vessel marine and electrical engineering regulations at 46 C.F.R. Subchapter F and 46 C.F.R. Subchapter J, respectively.

33 CFR Part 146

4.3.2.4. 33 C.F.R. Part 146, Subpart A touches on maintenance. 33 CFR 146.15(a) states that "The emergency equipment provided, regardless of whether or not required by this subchapter, shall be maintained in good condition at all times. Good operating practices requires replacement of expended equipment, as well as periodic renewal of those items which have a limited period of effectiveness."

4.3.2.5. 33 C.F.R. Part 146, Subpart B provides very general regulations related to emergency drills on manned OCS facilities, including FOFs. 33 C.F.R. § 146.125(c). reads:

> *Emergency evacuation drills.* The following emergency evacuation drills must be conducted:
>
> (1) At least once a year, all the elements of the Emergency Evacuation Plan (EEP) under § 146.140 relating to the evacuation of personnel from the facility must be exercised through a drill or a series of drills. The drill(s) must exercise all of the means and procedures listed in the EEP for each circumstance and condition described in the EEP under § 146.140(d)(9).
>
> (2) At least once a month, a drill must be conducted that demonstrates the ability of the facility's personnel to perform their duties and functions on the facility, as those duties and functions are described in the EEP.

4.3.2.6. 33 CFR §146.125(a) requires emergency drills to be conducted once per month "…as if an actual emergency existed." The Coast Guard has generally accepted the lowering, launching, and operating of the lifeboats in the water on a quarterly basis as cited in 46 CFR §109.213(d)(3).

46 CFR Part 109

Maintenance

4.3.2.7. 46 C.F.R. Part 109 outlines the operations requirements for mobile offshore drilling units (MODUs) operating under the U.S. flag. With the exception of the operating manual requirements at 46 C.F.R. § 109.121, 46 C.F.R. Part 109 is not applicable to FOFs. However, many operators, such as Shell, historically followed the maintenance requirements outlined in other relevant sections of 46 C.F.R. Part 109, including 46 CFR § 109.301 and 46 C.F.R. § 109.213. Further, as noted above in paragraph 4.3.2.6., the Coast Guard has used 46 C.F.R. Part 109 to inform policy interpreting 33 CFR §146.125.

4.3.2.8. 46 CFR § 109.301 outlines the regulations related to operational readiness, maintenance, and inspection of lifesaving equipment.

4.3.2.9. 46 CFR § 109.301(d) requires a weekly visual inspection and engine run test.

4.3.2.10. 46 CFR § 109.301(e) requires a monthly inspection consisting of an equipment check.

4.3.2.11. 46 CFR §109.301(f) requires an annual inspection consisting of a thorough inspection and cleaning of the boat, davit, winch, fall and other launching appliance.

4.3.2.12. 6 CFR § 109.301(i) requires that launching appliances and release mechanisms be serviced at the interval recommended in the OEM's instructions or as set out in the planned maintenance program. It also requires lifeboat and rescue boat release mechanisms to receive a thorough examination by properly trained personnel familiar with the system at each inspection for certification (i.e., 5 years).

Drill Requirements

4.3.2.13. 46 CFR § 109.213(d)(3) requires lifeboats to be launched once a quarter. The regulation reads "each lifeboat must be launched with its assigned operating crew aboard and maneuvered in the water at least once every 3 months, during an abandonment drill.[38]"

4.3.2.14. 46 CFR § 109.213(d)(1)(v) and (d)(2) require crews to lower at least one boat during every abandonment drill. However, this regulation is not typically enforced by the Coast Guard on FOFs.

4.3.3. D8(ocs) Policy Letters

4.3.3.1. The D8 OCS OCMI uses policy letters to clarify Coast Guard regulations. The OCS OCMI's policy letters are applicable to OCS facilities in the D8 Area of Responsibility (AOR).

4.3.3.2. D8(ocs) Policy Ltr 04-2016 Rev. 1 was issued on May 7, 2018 by the D8 OCS OCMI. The document attempted to clarify the D8 OCS OCMI's policy regarding how the Coast Guard expected operators to comply with 33 C.F.R. § 146.125 and the Coast

[38] The Coast Guard has always enforced the 3-month launches, but has not required it to be with the assigned crew.

Guard's policy on alternatives to lifeboat loading. This was the policy in effect at the time of the casualty.

4.3.3.3. The policy directed inspectors to verify that operators of manned facilities engaged in OCS activities were conducting launch and retrieval drills on a quarterly basis. If weather prevented a launch and retrieval, the policy allowed operators to operate the hook release system while the lifeboat is on properly arranged/rated hanging-off pendants. The policy directed inspectors to issue deficiencies to operators not in compliance with the quarterly launch and retrieval requirement.

4.3.3.4. The policy also explicitly allowed operators to obtain Coast Guard approval for alternatives to lifeboat loading, in accordance with the Offshore Operator's Committee (OOC) Guidance Document USCG-052018, Rev. 1, Alternatives to Lifeboat Loading.

4.3.3.5. In June 2019, Shell Offshore was not implementing an alternative to quarterly launching drills. Accordingly, it required its facilities, including AUGER, to, unless prohibited by weather, launch and recover each lifeboat each quarter. On June 30, 2019, the AUGER crew was engaged in a quarterly lifeboat launch and retrieval drill.

4.3.3.6. On May 19, 2020, the D8 OCS OCMI issued Policy Letter 01-2010, "Emergency Evacuation Drills on Manned Facilities With Lifeboats." The policy canceled Revision 1 of D8(OCS) Policy Letter 04-2016 dated 07 May 2018. The policy communicated the OCMI's understanding of the requirements of 33 CFR 146.125(c)(1) to mean that all lifeboats aboard a facility, shall, at a minimum, be launched annually with the assigned lifeboat crew in order to fulfill the requirements of the annual emergency evacuation drill required by the unit's Emergency Evacuation Plan (EEP).

4.3.4. Regulatory Framework: Lifesaving Equipment

Coast Guard Approval Process

4.3.4.1. Coast Guard ENG-4 is charged with ensuring that lifesaving equipment used on vessels subject to inspection by the United States meets specific design, construction, and performance standards. See 46 U.S.C. § 3306. The Coast Guard carries out this charge through the approval of lifesaving equipment in accordance with 46 C.F.R. § 2.75.

4.3.4.2. The Coast Guard focuses on three matters when reviewing the validity of a certificate of approval issued in accordance with 46 C.F.R. § 2.75. The matters are intended to "provide a control over the quality of such approved items." 46 C.F.R. § 2.75(b).

4.3.4.2.1. First, "Commandant's approvals are issued to persons, partnerships, companies, or corporations who offer for sale specific items of safety equipment, materials, or installations, or intend them for their own or others' use." 46 C.F.R. § 2.75-1(b). Accordingly, only the entity identified on the certificate of approval may sell an approved piece of equipment.

Second, approvals are "valid for a period of five years from the date on the certificate of approval." 46 C.F.R. § 2.75-1(d). All sales of equipment fabricated to the conditions on the certificate of approval, and marked as USCG approved, must occur during this period.

Third, COAs are "subject to suspension and/or cancellation if it is found the item offered, sold, or used as Coast Guard approved differs in any detail from the item as described in the certificate of approval and referenced material." 46 C.F.R. § 2.75(d). "The Commandant's approvals apply only to those items constructed or installed in accordance with applicable requirements, and the details as described in the documents granting specific approval." 46 C.F.R. § 2.75(b). In other words, the approved equipment must be maintained and utilized in its "as approved" condition. "For example, if an item is manufactured with changes in design or material not previously approved, the approval does not apply to such modified item." Id.

4.3.4.3. Coast Guard Commandant, Commercial Regulations and Standards Directorate, Office of Design and Engineering Standards, Lifesaving and Fire Safety Division (CG-ENG-4) is responsible for developing and implementing regulations and policies related to life boat design standards. Additionally, ENG-4 issues certificates of approval for lifesaving equipment.

4.3.4.4. The approval process includes: pre-approving lifesaving equipment designs, overseeing prototype construction, witnessing prototype testing, and monitoring production of the equipment for use on U.S. vessels. See 46 C.F.R. Part 159. At each phase of the approval process, the Coast Guard sets specific standards to which lifesaving equipment must be built and tested. Third parties, referred to as independent laboratories, often assist the Coast Guard in its approval process by performing or witnessing tests and inspections, as well as witnessing production, as authorized by the Coast Guard. See 46 C.F.R. §159.007.

4.3.4.5. 46 C.F.R. Part 160 contains the regulations related to the approval of lifesaving equipment.

4.3.4.6. FOFs, like AUGER, are not vessels. However, they must comply with the lifesaving equipment design standards set out in 46 C.F.R. Part 108, Subpart E. FOFs are required to carry Coast Guard approved lifeboats. However, carriage requirements will vary depending on when the facility was built.

4.3.4.7. Lifeboat No. 6's SeaCure LHR3.5M2 release mechanism was approved under approval series 160.133; see 46 C.F.R. 160.133. In 2011, the EL24-874 was retrofitted with the SeaCure LHR3.5M2 release mechanism. At the time, the retrofit was not approved. However, in October 2015, Palfinger applied for and received approval to retrofit existing, in service EL24s with the SeaCure LHR3.5M2 release mechanism.

4.3.4.8. Since 2011[39], the Coast Guard approves lifeboats and release mechanisms to the requirements in 46 C.F.R. Subparts 160.135 and 160.133, respectively. Both of these subparts incorporate by reference the IMO LSA Code, Chapter IV, among other domestic and international standards. See 46 CFR § 160.135-5 and § 160.133-5.

4.3.4.9. Commandant (CG-ENG-4) has granted approval to certain equipment under obsolete approval series 160.035 and 160.033 for replacement-in-kind only. This

[39] See 76 FR 62987.

allows those regulated vessels still authorized to carry equipment under these approval series to replace worn out or damaged equipment. However, the EL24 lifeboat under Certificate of Approval (COA) 160.035/487/0 or 160.035/487/1, nor the 7800 or 9300 series of winches under COA 160.015/161 were ever granted an approval for replacement-in-kind, and Commandant (CG-ENG-4) does not have a record of one being applied for an approval.[40] The latest version of the EL 24 certificate of approval, number 160.035/487/3, expired on February 17, 1993. The latest version of the certificate of approval for the 7800 and 9300 series of winches, number 160.015/161/0, expired on August 1, 1999. Neither of these certificates have been reinstated since expiring.

4.3.4.10. Lifeboat No. 6's SeaCure LHR3.5M2 release mechanism held an approval by the Coast Guard under approval number 160.133/52/0, issued on July 22, 2010. The release mechanism for the entire system approved under 160.133/52/0 do not, and were not required to, comply with the IMO LSA Code revisions that entered into force on July 1, 2012[41]. A later version of the LHR3.5M2 complying with the latest amendments to the LSA Code, was approved by Commandant (CG-ENG-4) under approval number 160.133/52/1, dated April 3, 2013. This COA has expired and has not been renewed by Palfinger.

<u>International Maritime Organization</u>[42]

4.3.4.11. The International Maritime Organization (IMO) is the United Nations specialized agency with responsibility for the safety and security and the prevention of marine and atmospheric pollution by ships. The United States is a member State to the IMO. The Coast Guard represents the United States at the IMO. The Marine Safety Committee (MSC) of the IMO considers matters related to, among other things, maritime safety procedures and requirements.

4.3.4.12. The International Convention for the Safety of Life at Sea (SOLAS) is a maritime treaty developed, and maintained, by the IMO. The IMO first adopted the SOLAS Convention in 1914. However, the modern working version is SOLAS Convention, 1974, as amended. SOLAS specifies minimum standards for the construction, equipment and operation of ships, compatible with their safety. The United States is a party to SOLAS.

4.3.4.13. A SOLAS vessel is any vessel in which SOLAS applies, namely a passenger ship engaged on an international voyage or a non-passenger ship of 500 gross tonnage or more engage on an international voyage. FOFs are not SOLAS vessels.

4.3.4.14. Chapter III of SOLAS establishes the regulations for the carriage and performance requirements for lifesaving equipment and their "arrangements" for cargo and passenger ships subject to SOLAS. The International Life-Saving Appliance (LSA)

---

[40] The Coast Guard acknowledges that there is confusion among OCMIs and OEMs regarding the in-kind replacement process.

[41] See IMO Resolution MSC.320 (89) and CG-ENG Policy Letter No. 01-14, dated march 4, 2014. MSC.320 (89) amends the LSA, but that amendment does not extend to the IBR as listed for the CG Type Approval. PL 01-14 does not apply to FOFs.

[42] While the majority the of the information contained in this section does not apply to FOFs or the OCS, with the exception of type approval portions, many OEMs, including Palfinger, voluntarily adhere to IMO regulations as best practices. Further, IMO regulations influence both Coast Guard rulemaking and policy setting.

Code is a mandatory IMO instrument under SOLAS III Regulations 4 and 34 providing specific technical requirements for the approval of life-saving appliances. It specifies design, construction, and performance requirements for lifesaving equipment, including launching appliances, release mechanisms, survival craft, rescue boats, and automatic disengaging devices. It has been amended several times since it entered into force on July 1, 1998.

4.3.4.15. The IMO has published the Revised recommendation on testing of life-saving appliances ("Revised Recommendation on Testing") as IMO Resolution MSC.81(70), adopted on December 11, 1998. It is a non-mandatory IMO instrument that nonetheless supports the LSA Code as the IMO's standard for prototype testing as well as installation testing of required lifesaving appliances. It too has been amended several times since it was adopted. Both the LSA Code and the Revised Recommendation on Testing are published together in an IMO Publication entitled, "Life-Saving Appliances". Both the LSA Code and the Revised Recommendation on Testing, are incorporated by reference in the applicable approval standards in 46 CFR Subchapter.[43]

4.3.4.16. The Coast Guard issues regulations to enforce the requirements of Chapter III of SOLAS. The Coast Guard considers these IMO standards to represent the best available standards for lifesaving appliances and to be appropriate for lifesaving appliances for all vessels subject to inspection by the United States. In 2011, the Coast Guard issued an interim rule seeking to harmonize its regulations for certain lifesaving equipment with international standards by incorporating the IMO standards into regulations in 46 C.F.R. Part 160.

4.3.4.17. As noted above, FOFs are not SOLAS vessels. Even though SOLAS is not applicable, the LSA code is incorporated by reference in 46 CFR Subchapter Q, the regulations governing approval of lifesaving appliances on board US vessels. The Coast Guard removed many of the regulations for domestic life-saving appliances in the 2011 rule-making, thus the LSA regulations became relevant to lifeboats, rescue boats, launching appliances (davits & winches), and release mechanisms for new-build lifeboats and rescue boats and liferafts (hooks), regardless if it is positioned on a SOLAS vessel or not.

4.3.4.18. The IMO LSA code makes brief mention of control cables. Resolution MSC.320 (89),[44] adopted on May 20, 2011[45] amending the LSA Code notes:

> "The mechanism shall not be able to open due to wear, misalignment and unintended force within the hook assembly or operating mechanism, control rods or cables as may be connected to, or form part of the hook assembly and with trim of up to 10° and a list of up to 20° *either* way.
>
> All components of the hook unit, release handle unit, control cables or mechanical operating links and the fixed structural connections in a lifeboat shall be of material corrosion resistant in the marine environment without the need for coatings or galvanizing. Design and manufacturing tolerances shall be such that anticipated wear throughout the service life of the mechanism shall not adversely affect its

[43] IBR only through LSA Code, 2010 edition.
[44] Not covered by the IBR at §133-5(c).
[45] Resolution MSC.320 (89) was adopted after Lifeboat No. 6's release mechanism was placed into service.

proper functioning. Mechanical operating links such as control cables shall be waterproof and shall have no exposed or unprotected areas."

The Control cables are also referenced in the Revised Recommendation on Testing, in amendments from Resolution MSC.321(89), also adopted on May 20, 2011.[46] See Resolution MSC.81(70), amended, Part 1, paragraphs 6.9.4.1, 6.9.4.4, 6.9.5.

4.3.4.19. Resolution MSC.402(96), [47] entered into force on January 1, 2020 as a mandatory instrument under SOLAS Chapter III[48], adds the requirement that cables for control and release must be thoroughly examined for satisfactory condition and operation after the annual operational test of the winch brake.

5. Analysis and Opinions

5.1. Most Common Causes of Lifeboat Casualties Excluded

At the onset of the investigation, there was no clear indication as to what caused Lifeboat No. 6 to fall. The five witness statements unambiguously established this basic series of events: 1) the aft hook opened, without any apparent human intervention; 2) loud sounds emanated from the lifeboat either immediately before or contemporaneous with the aft hook opening; 3) the lifeboat swung in a pendulum motion away from the facility, still connected to the forward hook; 4) the lifeboat released from the forward fall; and 5) the lifeboat fell inverted into the water.

The most common lifeboat casualty causal factors were quickly eliminated. First, the Coast Guard excluded the most common LHR hook reset failure modes: situations where the locking shaft, as a result of human error or mechanical failure, never closes. In such cases, the hooks, once attached to the falls, will open; the hooks cannot support a load. However, in the present case, the locking shaft did close, at least enough such that the lifeboat hooks managed to bear the weight of the lifeboat and its occupants as it was winched from the waterline to the davit.

Second, the Coast Guard excluded the possibility that the hook release handle was inadvertently actuated by a person inside the lifeboat. The LHR hooks contain two safety locks that, in most cases, should prevent any person from inadvertently actuating the release handle when the lifeboat is under load. In the present case, when the lifeboat was found, the release handle was in the closed and locked position, presenting some evidence that it was not actuated or opened. Further, according to the Coxswain and Boat Crew Person 1, no person was near the release handle at time of release, making it unlikely that anyone was able to manipulate, accidently or otherwise, the release handle or safety locks before the casualty. Finally, the hooks are adjusted to open simultaneously. If the release handle was actuated, the forward and aft hooks should have both opened. In the present case, the aft hook opened first. The forward hook opened, but as a consequence of the aft hook opening. The hooks had been cycled twice that day, and there was no evidence that the hooks were not timed to open simultaneously.

[46] Not covered by the IBR at §133-5(c).
[47] Not applicable to FOFs.
[48] See NVIC 03-19.

Third, based on the as-found condition of the lifeboat, the Coast Guard excluded the possibility that the aft hook or connections to the hull (lift shoe or FRP) suffered a catastrophic failure. The aft hook and lift shoe remained firmly attached to the lifeboat. Unlike the forward part of the boat, which split along the bow, the structure of the aft end of the lifeboat was in relatively good condition.

Fourth, the Coast Guard excluded the possibility that the casualty was a result of the davit, falls, or winch failure. The falls, lifting rings and davit structure remained intact. The witnesses agreed that the winch and limit switches operated as designed. In the above manner, the Coast Guard was able to exclude the most common causes of lifeboat casualties.

Analysis of Actions, Events and Conditions Determined to be a Direct Cause of the Casualty

5.2. Effect of a Separated Hook Control Cable Conduit

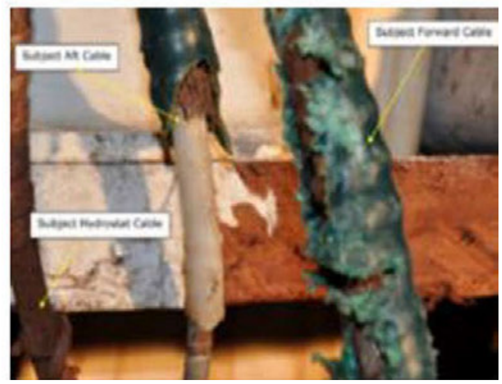


Figure 49: Lifeboat No. 6's aft hook control cable after the casualty. The aft cable is in the center of the picture. Credit: CG.

Early in the investigation it was noted that the aft hook control cable conduit was found in a separated condition, leaving only the inner member exposed. Shell investigators, aided by Palfinger Marine and Coast Guard investigators, developed a theory that if a hook control cable conduit separated, the separation could affect the travel of the cable's inner member when the release handle was moved from the open to closed position. In initial testing, the group observed that if a control cable, similar to that shown in Figure 49, is damaged all the way through the outer layers, leaving the traveling inner member exposed, forces applied directly on the separated outer layers can cause the traveling inner member to pull on each of its ends (see Figures 50 and 51). As the separated outer layers pull apart, the cable's end rod at the hook can move, which in turn can rotate the locking shaft inside the hook. If the locking shaft rotates enough, the hook can release, even without an operator touching the release handle or overriding the

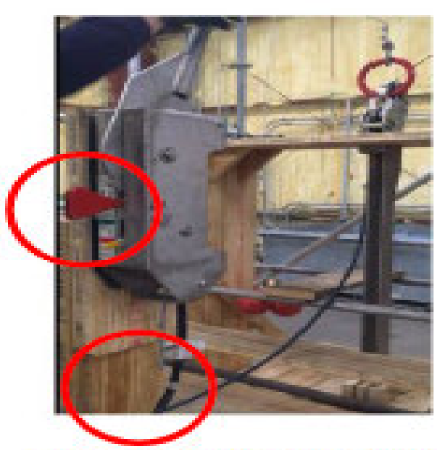


Image 50: The release handle is in the locked and closed position. However, the cable is damaged.

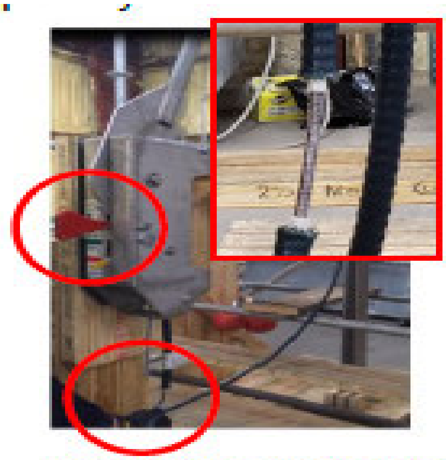


Image 51: Forces cause the outer layers of the cable to separate. The release handle stays closed.

interlocks (see Figures 52 and 53). The initial testing was conducted in a warehouse using a testing jig and new cables.

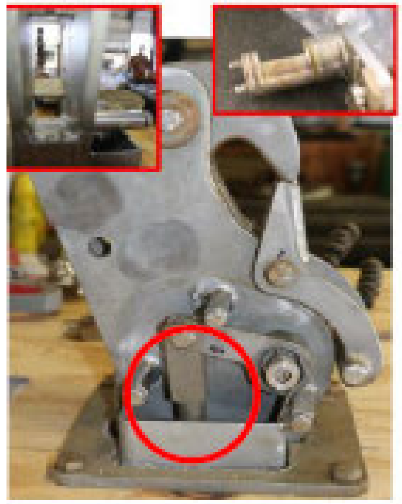


Image 52: At the hook end, the cable end rod moves. This causes the locking shaft to rotate.

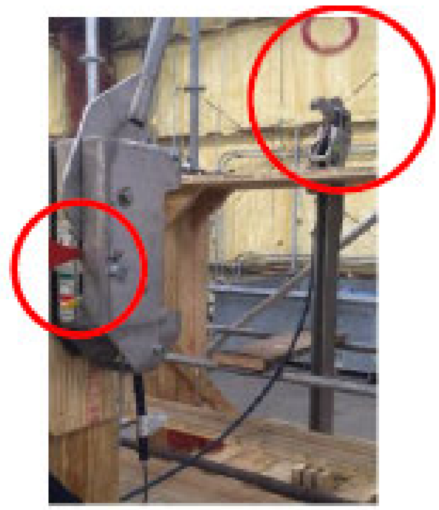


Image 53: If the locking shaft turns enough, the hook will release, even as the release handle stays locked.

The Coast Guard attempted to validate the testing using worn cables (seeking to better replicate the condition of Lifeboat No. 6's 7-year-old cables) installed in an EL24 lifeboat with LHR 3.5M2 hooks and routed similar to those of Lifeboat 6. As discussed in the findings of fact above, the Coast Guard's experiments at MSTC showed that a separation in the conduit of a control cable, while cycling the release unit from open to closed (resetting), can result in the hook locking shaft stopping between the open and closed positions. With the locking shaft in an "almost open" position immediately following conduit separation, the hook can still support the weight of the lifeboat and the occupants. However, in that position an additional load can cause the locking shaft to rotate from the "almost open" to open position.

However, in subsequent cycles after initial separation, the locking shaft did not return to the "almost open" position. With a failed liner, the friction forces cause the cable conduit to freely extend, rendering the system unable to rotate the locking shaft to the closed position. This prevents the hooks from locking, rendering them unable to hold any load.

Figures 54-59 below present a graphical representation of the effects of a compromised control cable, as witnessed during the Coast Guard's experiment at MSTC.

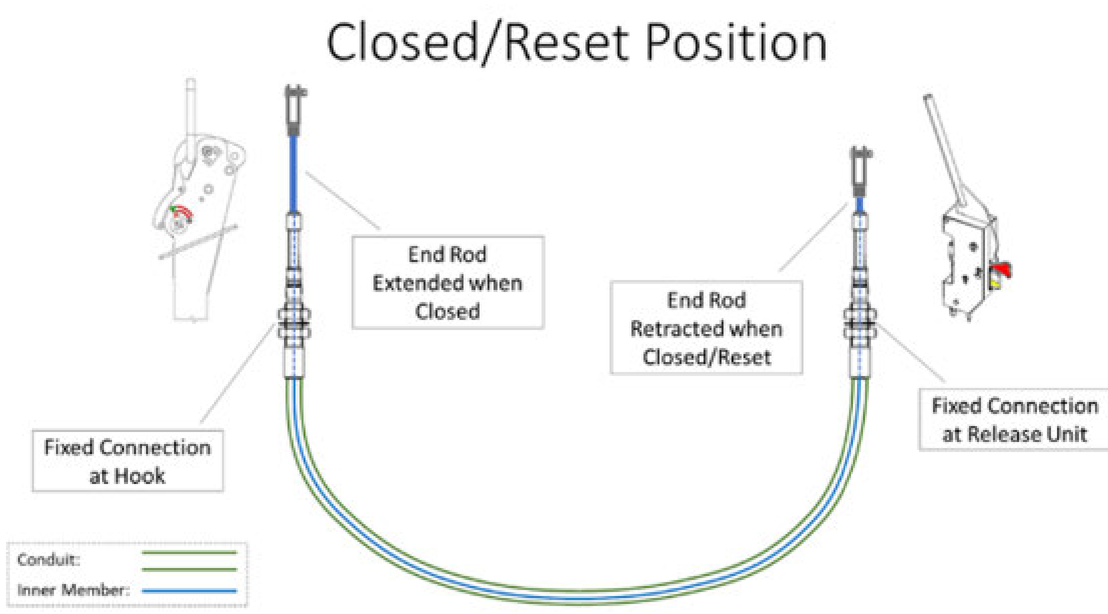


Figure 54: In this figure, the hook is closed or locked. There is no damage to the cable. Credit: CG.

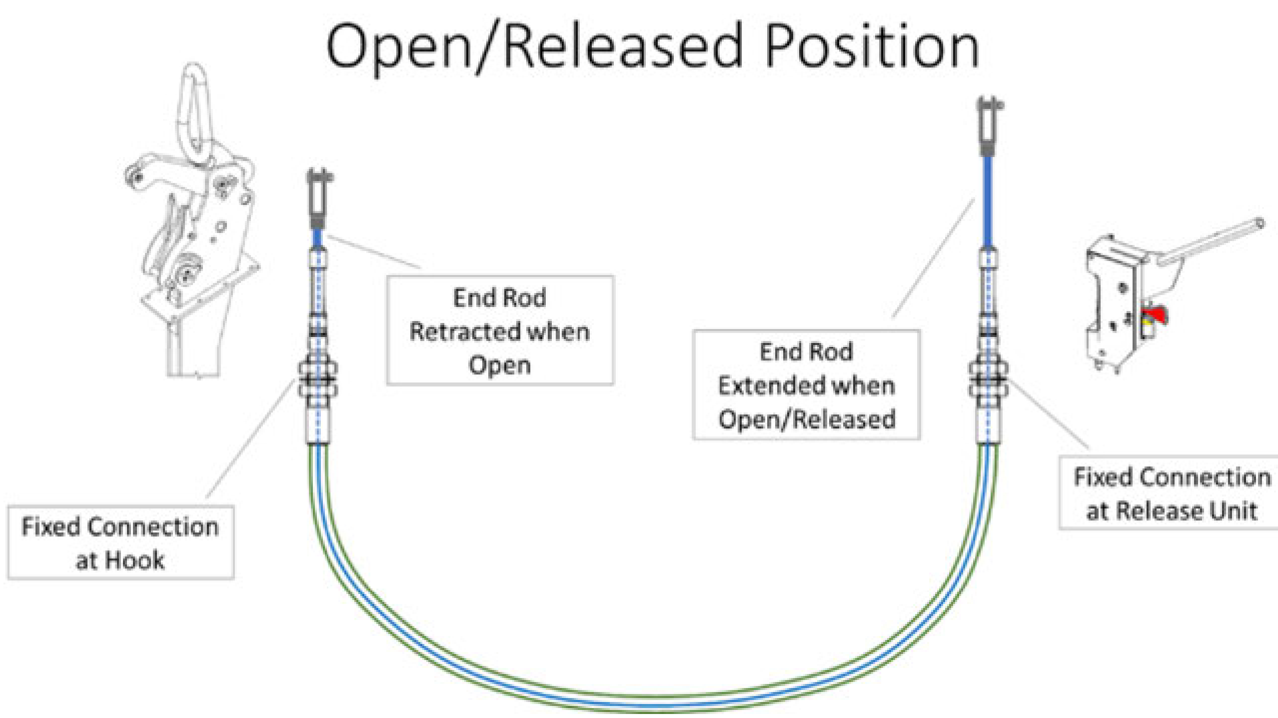


Figure 55: In this figure, the hook is open. There is no damage to the cable. Credit: CG.

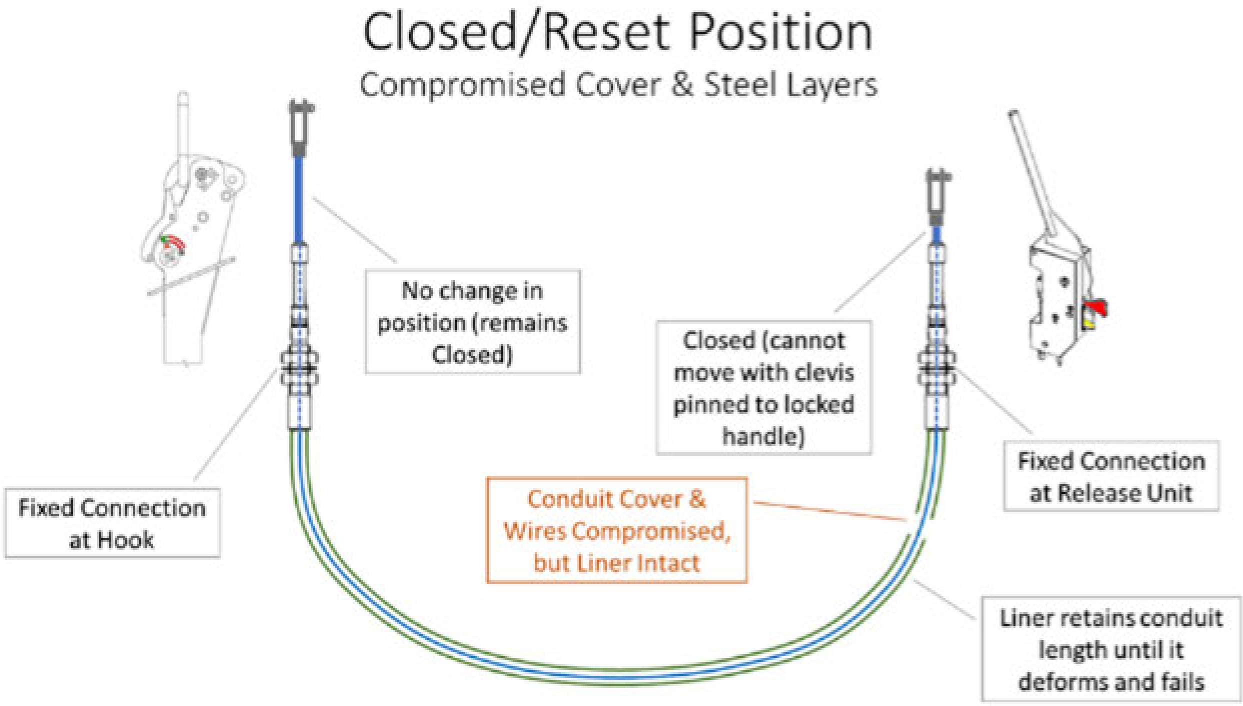


Figure 56: In this figure, the hook is closed or locked. The conduit is damaged, but the white polyethylene liner is intact. Credit: CG

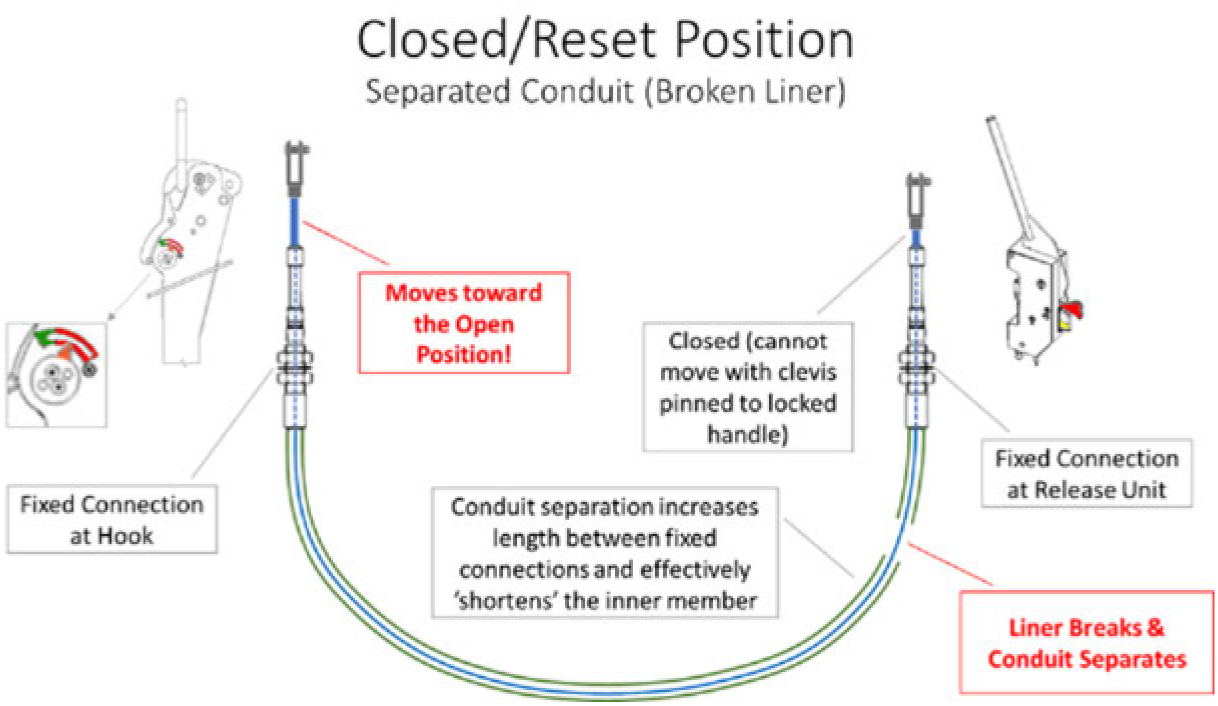


Figure 57: In this figure, the conduit separates. After an initial reset, the locking shaft now rests at an "almost open" position. Credit: CG

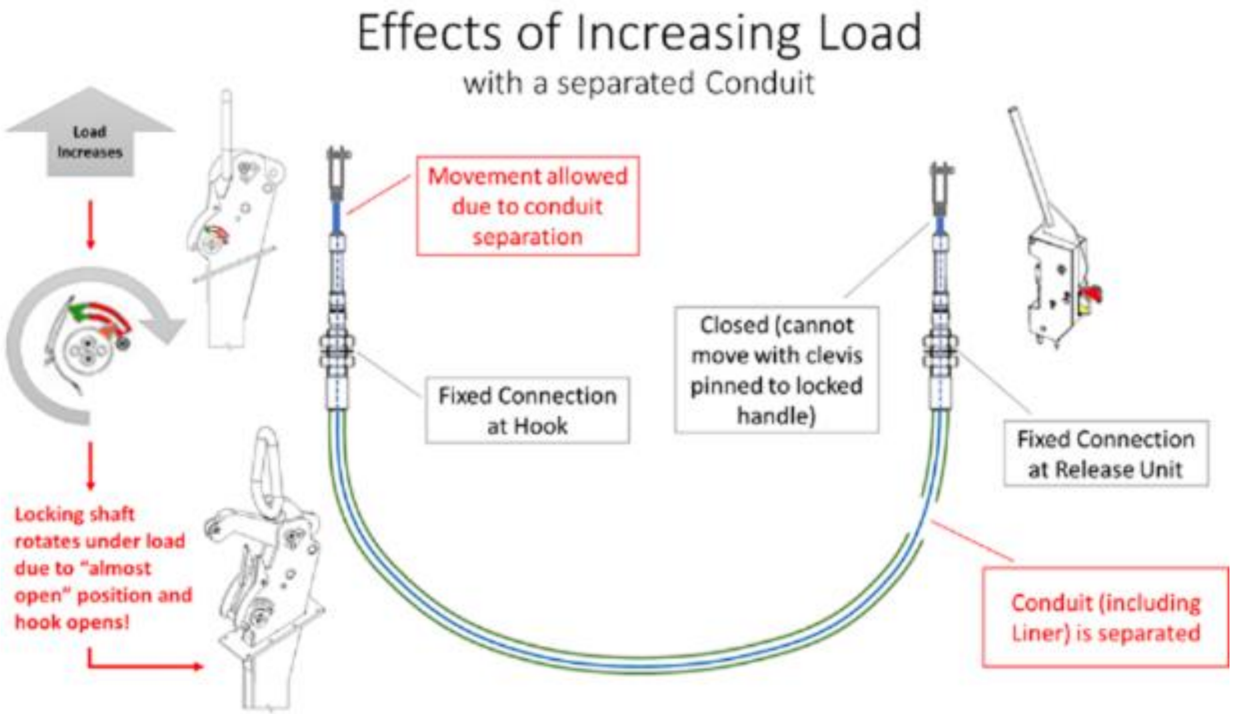


Figure 58: In this figure, the load is increased on the hook, as a result the locking shaft turns from "almost open" to open. Credit: CG

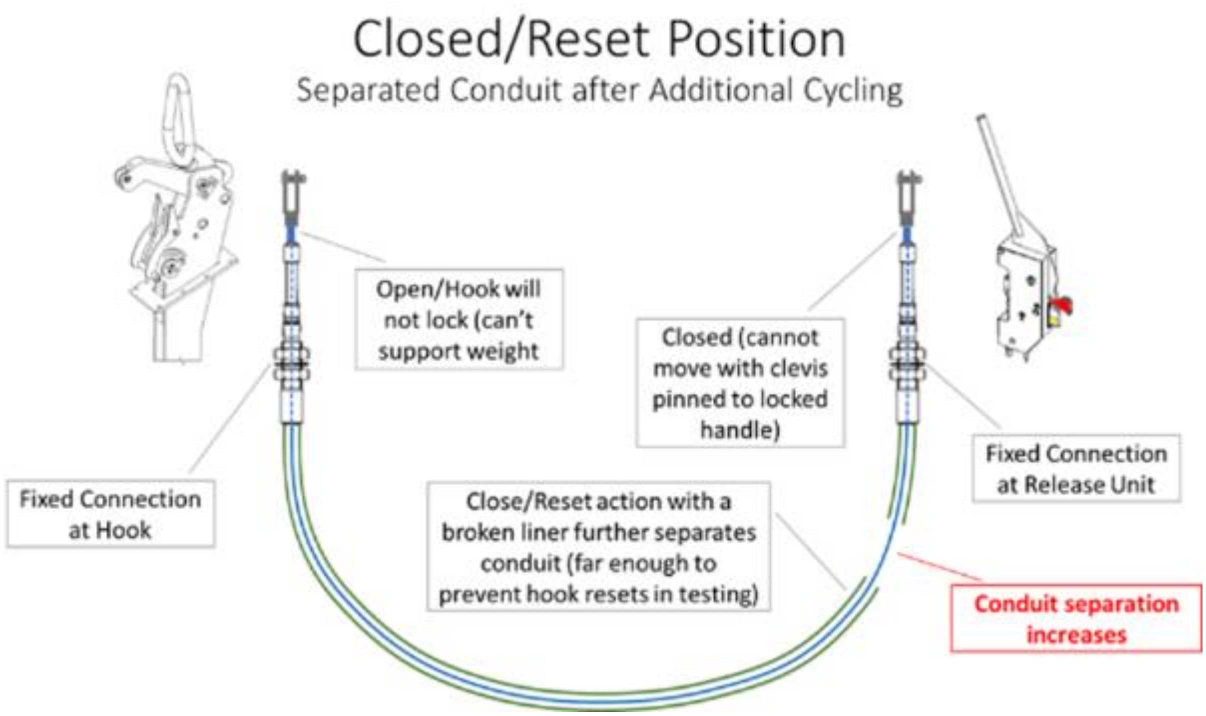


Figure 59: In the Coast Guard experiment, after one reset with a separated cable, the hook would not lock again. The conduit separation was so great that the locking shaft would not return to the "almost open" position, rather, upon reset, it would return to the open position. Credit: CG

In summary, there are two positions that the locking shaft in the LHR3.5M2 can take after conduit separation and subsequent cycling: “almost open” and open. The investigation team determined that the locking shaft won’t return to the “almost open” position a second time. If exposed to a second reset, it will rest in the open position. In the “almost open” position, the locking shaft can be forced to open with application of an additional or increased load. In the open position, the hook won’t reset. In the former case, while inadvertent hook opening is not inevitable, the risk is significant.

5.3 Cable Conduit: Mechanism of Damage and Separation

Lifeboat No. 6’s aft control cable was installed in or around 2012 during the installation of the LHR 3.5M2 release mechanism. It is a fair assumption that the cable was in a new, uncompromised condition when it was installed. Shell Offshore provided the Coast Guard with a copy of a photograph purportedly taken of the area in question in 2014. The photograph shows how the aft control cable was routed through a fiberglass cutout on its way to the release unit. The photograph is of low quality; however, the photograph appears to show early evidence of chaffing damage to the green conduit cover. Even if damage can’t be confirmed in the 2014 photograph, the photograph serves as some evidence that the conduit, for at least part of its operational life, was resting and potentially rubbing against fiberglass, creating a possible mechanism for damage.

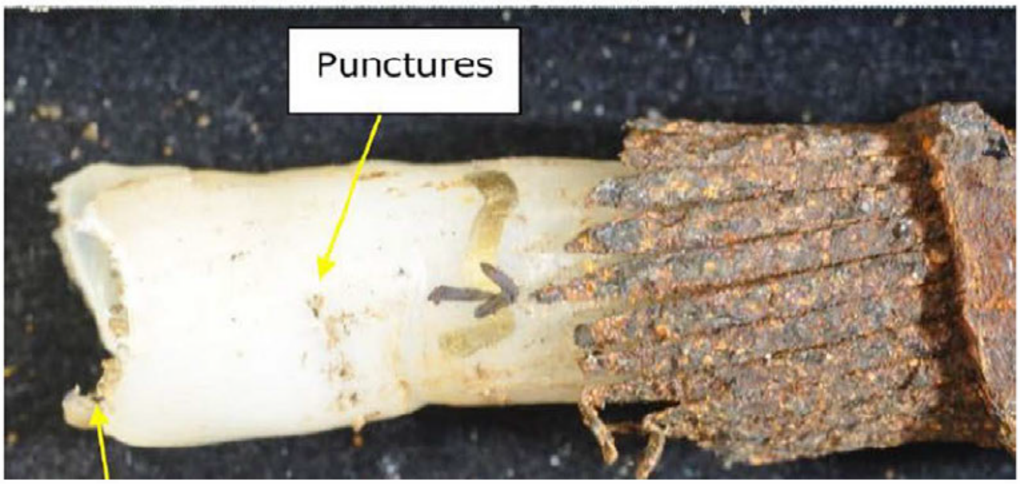
The photograph supports DNV-GL’s analysis related to the initial mechanism of conduit damage. According to DNV-GL’s analysis, the initial damage to the green cover came in the form of mechanical damage as a result of gouging, impacting and/or rubbing to the outer green cover. It is unknown how long it took for the mechanical damage to compromise the plastic of the green cover. However, once the plastic cover was compromised, water could ingress, and corrosion (i.e. environmental damage) of the streel wire layer could commence. As the steel wires corroded, the corrosion byproduct caused the wires to expand. This expansion eventually caused the green cover to burst and tear.

Once the steel wire was damaged, the white polyethylene liner also became vulnerable to damage. As demonstrated in the Coast Guard’s experiment and validated by DNV-GL’s testing, when the white polyethylene liner is no longer surrounded by an intact steel wire layer, the liner has the tendency to compress and stretch when a hook is opened and closed, respectively (see Figure 59). Further, broken steel wires can puncture the liner, especially during compression, causing additional damage and further weakening the liner. In the year of the incident (i.e, 2019), the Coast Guard estimates that the aft control cable was used to open and close the aft hook at least five times.

DNV-GL found evidence of buckling, tearing and punctures (see Figure 61) at the site where the white polyethylene liner on Lifeboat No. 6’s aft control cable liner broke. Together, and in absence of an alternative explanation for the break, the evidence discussed above strongly supports the finding that the mechanism of breakage was the combined effect of cycling (compressing and stretching) and puncturing the white polyethylene liner.

Figure 60 (far left) and 61 (right): The white polyethylene liner evidencing forces of compression and stretching after the wire layer is fully compromised. These photos were taken during the Coast Guard's experiment at MSTC. Credit: CG.

Figure 62 (below): Puncture marks found on the polyethylene liner of Lifeboat No. 6's aft control cable. Credit: DNV-GL.



5.4. Cable Conduit: Timing of Separation

It is likely impossible to determine with precision when the white polyethylene liner separated. Based on the evidence collected and as analyzed below, it is highly probable that the white polyethylene liner separated on the morning of June 30, 2019, during the system's second and final reset of the day.

On June 6, 2019, when Palfinger took the photo of the compromised section of the aft control cable, the steel wire layer of the aft control cable was significantly corroded. As DNV-GL notes in its report, corrosion leads to a reduction of cross-sectional area. It would have only worsened between June 6 and June 30, 2019. It is probable that on June 30, 2019, when Lifeboat No. 6 was launched into the water, the steel wire layer had little, if any, tensile strength remaining. It is further probable that under the corroded steel wires, the white polyethylene liner was, while not separated, already compromised.

Figure 63: Lifeboat No. 6's aft control cable on June 6, 2019. Credit: Palfinger.

As the Coast Guard experiment demonstrated, after the conduit separates, it is possible for the locking shaft to return to an "almost open" position." However, upon an additional reset or cycling, the locking shaft will not rotate sufficiently; rather, it will stay in the open position. If the conduit had separated at some point before the launch or during the first reset of the morning, during the second reset, it is unlikely that the locking shaft would have closed at all. In an open position, the hooks would not bear weight and the crew would not have been able to retrieve the lifeboat, at least not in that condition. Accordingly, it is probable that separation occurred on the morning of June 30, 2019, during the system's second and final reset of the day.

If the polyethylene liner parted as a result of the casualty (post-lifeboat fall), the Coast Guard is unable to explain, based on the evidence collected, the cause of the casualty.

5.5. Additional Forces Applied to Cable and/or Hook

The pre-casualty separation of the white polyethylene liner, in itself, does not explain why Lifeboat No. 6's aft hook opened. On June 30, 2019, during retrieval, the hooks held the load of the lifeboat from the waterline to the davit. This is evidence that the locking shaft had locking d sufficiently to hold the tail of the aft hook, likely only in a "partially closed" position, although probably "almost open." An additional force on the hook release system was necessary. This additional force could have been applied to either: 1) the hook, resulting in the locking shaft rotating to the open position; or 2) the control cable, resulting in additional separation of the cable conduit and thus movement of the locking shaft toward open.

The Coast Guard cannot, with certainty, identify the additional force that caused the locking shaft to open. However, based on the evidence considered, including the result of the Coast Guard's testing, it is probable that the additional forces applied by the winch to the hook, when the boat contacted the davit bumpers, served as the additional factor that eventually caused the locking shaft to open. In coming to this conclusion, the Coast Guard considered the evidence related to what was occurring at the time of the casualty (manual winching) and the sounds heard by witnesses ("fiberglass cracking," "wood breaking," and "a crunching popping"). Finally, the Coast Guard's testing at MSTC demonstrated that forces, resembling the forces that would be placed on a hook and lifeboat as a lifeboat was pulled into the bumpers by a winch, could cause a locking shaft in the "almost open" position to open.[49]

The Coast Guard cannot exclude the possibility that a force was applied directly to the cable leading to additional separation of the conduit, which in turn would translate to a pulling force on the end rod and rotation of the locking shaft toward the open position. However, it found no evidence that this occurred.

5.6. The Aft Control Cable was Identified as Compromised in Early June but was Not Replaced

The OEM's service engineers identified the aft control cable as compromised on June 6, 2019. The service engineers made a recommendation to Shell, the operator, to replace Lifeboat No. 6's control cables. Shell did not replace the cables. The Coast Guard

[49] While the evidence collected shows that the boat may have been uneven and contacted the aft bumpers first, Coast Guard testing showed that any increasing force, such as a level boat contacting all bumpers, could force the locking shaft to open with a compromised control cable. It is possible that the aft bumper contacting first resulted in the forces on the aft hook increasing faster than what may happen with a level boat hitting all bumpers at the same time.

identified six issues that *may*, in part, explain why Lifeboat No. 6 stayed in service with a compromised control cable.

5.6.1. <u>Lack of Knowledge that a Separated Control Cable Could Affect the Rotation of a Locking Shaft</u>

Prior to this casualty, the service engineers who worked on Lifeboat No. 6 had two ideas of the risks posed by a compromised control cable: a cable could seize or a cable could completely part. In the first instance, if a cable is rusted or corroded, it can seize up. In such cases, the cable would not transmit linear motion. In the case of a cable completely parting, similar to above, the cable can't transmit linear motion. In the case of total separation, the torsion spring will hold the locking shaft in a closed position. As with a seized cable, to open the hook, a person would need to manually open the locking shaft. None of the known risks involved the potential that a compromised cable could result in an inadvertent hook opening under load, as occurred in the present case. Shell boat crews and maintenance personnel had similar, albeit slightly less sophisticated, understandings of the dangers posed by compromised control cables.

To the Coast Guard's knowledge, Shell's investigation team was the first to consider the theory that a compromised control cable could cause the locking shaft to turn. The lack of knowledge related to the risks posed by compromised cables drove many actions, including the Palfinger service engineers' decision to recommend the lifeboats be put back into service with an outstanding control cable replacement recommendation.

5.6.2. <u>Control Cables are Often Overlooked by Operators, OEMs, and Regulators</u>

While the evidence suggests that no person understood that a compromised control cable could cause a locking shaft to turn, there is evidence that control cables, for years, have not received the appropriate amount of scrutiny from regulators, operators or OEMs.

In 2001, the United Kingdom Marine Accident Investigation Branch (MAIB) published "Safety Study 1/2001: Review of Lifeboat and Launching System's Accidents." Related to operating cables, the MAIB wrote:

> "The MAIB has found…that [operating cables] can seize if the stranded wire becomes corroded. This can result in the on-load release hook failing to close properly when being reset. This in turn has resulted in inadvertent release later. Once corroded these cables cannot be repaired effectively, and have to be replaced. The evidence shows that management and crews are often unaware that such replacement is necessary."

Control cables are an essential part of the release mechanism. However, for FOF's there are no specific regulations related to the lifeboat control cables maintenance, testing or replacement. 46 C.F.R. §109.301 provides some general language related to servicing of release gear. [50]

At the operator level, regulations can motivate action and attention; lack of regulations can result in the opposite. For example, in the case of Lifeboat No. 6, the falls cables were maintained and replaced every five years, as authorized by the OCMI,[51] and the OEM's recommended maintenance schedule. Shell had a system in place to track falls cables (lifeboat davit cables) in SAP. However, Shell did not track the age of Lifeboat No. 6's control cables and there no evidence that Shell requested or made an effort to replace the control cables in the seven years the cables were in operation.

According to the senior Palfinger service engineer from the June 2019 annual inspection, when he first started working for Schat-Harding in 2013, service engineers changed out control cables automatically during a lifeboat's 5-yearly inspection. This action was in accordance with the LHR hook operations and maintenance manual, and arguably, an OEM best practice. However, at some point, the requirement was watered down to a recommendation and instead of automatically changing out control cables, cables were only changed out on request. Arguably, had there been a regulatory requirement to replace the control cables at the 5-year life mark, similar to falls cables, Schat-Harding, and later Palfinger, would not have changed its practice.

The lack of regulatory requirements coupled with the difficulty and cost of inspecting and replacing control cables makes it likely that operators and OEMs are not tracking, inspecting and replacing cables as appropriate. When the Coast Guard spot checked the other Palfinger lifeboats on AUGER after the casualty, it found two additional lifeboats (7 & 8) with noticeable damage to the control cables. Both systems had received annual examinations in June 2019. Palfinger service engineers had recommended that Shell replace the cables on Lifeboat No. 8. However, similar to Lifeboat No. 6, the lifeboat was placed back into service and no action was taken on the recommendation.

It is possible that knowledge of the risks posed by compromised control cables may inspire operators and OEMs to conduct more frequent and thorough inspections of lifeboat control cables and, as necessary, replace them.[52] However, regulators serve an important role for operators and OEMs, creating new rules, as appropriate, and providing necessary oversight. The Coast Guard can take the lead on educating members of the maritime community to the risks posed by control cables and, as appropriate, instituting new rules.

5.6.3. OEM and Operator Communication Regarding Roles and Expectations

Shell's lifeboat maintenance strategy relies heavily on the OEM. According to Shell's Specialty Engineering Manager and Maintenance Engineer: "Shell expects OEMs to either perform all needed preventative and corrective maintenance consistent with the

[50] As discussed above, the Coast Guard has elected by policy to impose the requirements of 46 C.F.R. § 109.301 to FOFs. Although not required by regulations, generally, Shell worked to ensure that Lifeboat No. 6 was inspected and maintained in accordance with 46 C.F.R. § 109.301.
[51] As discussed earlier, the Coast Guard, in the past, has imposed the requirements of §109.301 on FOFs. However, OCMIs can, and did in the case of AUGER, grant deviations from the 4 year requirement found in 46 C.F.R. §109.301.
[52] In January 2020, Coast Guard issued Safety Alert, 3-20, addressing the risks posed by compromised control cables.

OEM's policies and procedures or make specific recommendations to Shell that such preventative and corrective maintenance be performed."

Reliance on the OEM is consistent with industry practice. It is also a critical element of a sound maintenance strategy. As acknowledged by the Coast Guard in NVIC 03-19, "Maintenance, Thorough Examination, Operational Testing, Overhaul and Repair of Lifeboats and Rescue Boats, Launching Appliances and Release Gear," in recent years[53]:

> "Life-saving appliances have become more sophisticated, providing increased capabilities better able to deal with different possible types of shipboard casualties . . . While this equipment provides greater functionality, they also come with greater complexity, and consequently are more difficult and critical to maintain properly. Ship operators now rely more heavily on specially trained personnel, outside of the ship's crew, to maintain their life-saving appliances."

Still, roles and responsibilities must be communicated and understood. In the present case, Shell's understanding of the OEM's role was not effectively communicated and/or shared or understood by the OEM. To achieve success, Shell's policies relied on a *highly directive* OEM. It is not entirely clear at what level the communication break-down occurred: at the Shell or Palfinger management level or Shell or Palfinger crew/service engineer level. What is clear is that Palfinger's service engineers, the persons charged with inspecting the lifeboats and writing the service reports, did not share Shell's understanding of their role. Palfinger's service engineers, while entirely competent, understood their role to be less directive and more advisory. They made recommendations but, to their understanding, the operator was ultimately the "decider" on what was fixed. This may explain, in part, why the Palfinger service engineers made a recommendation to replace the control cables, but took no independent action to initiate their replacement. It may also explain, but not fully excuse, Shell's failure to take action on Palfinger's recommendation.

The Palfinger service engineer's understanding of their role must also be analyzed through the lens of the commercial nature of the operator / OEM relationship. The operator/OEM relationship, at its core, is a business service relationship. The OEM provides a professional service to the operator. Operators, if they are unhappy with the OEM, can obtain the services of a different lifeboat servicing company[54]. The relationship structure may inhibit OEM and service providers from being too directive in regard to certain maintenance or repairs, especially issues that they believe don't necessarily pose an immediate risk to safety or operations.

Shell maintained a sound maintenance strategy on paper. However, as a result of poor communications, Shell was not able to operationalize its maintenance strategy. Shell and Palfinger personnel, both critical groups in the system Shell designed to maintain Lifeboat No. 6, did not share a common understanding of roles and responsibilities. As

[53] NVIC 03-19 is not applicable to FOFs.

[54] While original equipment manufacturers (OEMs) can certify third parties to work on its branded equipment, for FOFs, third party providers are not required to be authorized or have any affiliation with the OEM for domestic lifeboats. Accordingly, despite the fact that there is only one "OEM", operators have options in regard to lifeboat servicing providers.

a likely result, no one from either group acted to replace Lifeboat No. 6's compromised control cables or take the lifeboat out of service until a repair could be made.

5.6.4. Function-Based Maintenance Vice Condition-Based Maintenance

While Palfinger service engineers did not understand that a compromised cable could result in an inadvertent hook opening, they were aware of other risks posed by corroded and compromised control cables. Still, service engineers did not take more aggressive action to replace the control cables, and in the end, recommended that the lifeboat be put back into service. This recommendation can be attributed, in part, to Palfinger's focus on the functionality of the lifeboat system vice the condition of the system.

The damage to the aft cable, as documented on June 6, 2019, was not repairable, meaning the cables needed to be replaced; a patch or repair was not an option. Further, as a result of the system's constant exposure to moisture and the elements, the cable condition would continue to deteriorate. Assessing simply the condition of the cables, not the functionality, the cables needed to be replaced.

However, Palfinger's service engineers all expressed their opinion that their ultimate role was to assess the functionality of equipment, in other words: did it work? As a result, in June 2019, despite the fact that the aft control cable was found compromised and corroded, the service engineers determined that Lifeboat No. 6 was "found to be [in] correct working order at this time of service" and endorsed returning the boat "back to service."

The checklist followed by the service engineers required the service engineers to "Check condition/operation of release cables (free movement, corrosion)." Palfinger service engineers had three options to choose: "OK," "NOT OK," and "NA." The Palfinger service engineers could have selected "NOT OK" to document the condition of control cables found to be rusted and corroded. However, culturally, the service engineers would only select "NOT OK," if the cable damage prevented the operation of the release mechanism. In the present case, the service engineers believed that the system would still function.

Shell AUGER's barge supervisor had access to a copy of the Palfinger service engineer's report. However, he apparently did not read it, instead relying on his discussion with the service engineers and their statement that the lifeboats could be returned to service.

5.6.5. OEM Service Forms

Palfinger managed a document library of service report, recommendation and debrief forms. Through the forms, Palfinger standardized the way in which service engineers conduct inspections and communicate their findings with others. In the case of Palfinger's service report and recommendation forms, the forms did not require service engineers to note the priority or timing of a repair. While service reports provide a place for service engineers to note who is responsible for a repair or action, this section was often left blank. Finally, there was no requirement that the service engineers provide context or reasoning for recommended repairs. In the present case, Palfinger service engineers recommended that Shell replace Lifeboat No. 6's control cables, however, they did not note when the repair should be made, who was responsible for the repair, or explain why the repair was needed.

5.6.6. Age of Cables

Lifeboat No. 6's release mechanism control cables were installed in March 2012 during the lifeboat's refurbishment. By June 2019 the cables had been installed for over seven years. However, neither the Palfinger service engineers nor Shell had easy access to this information. According to Palfinger service engineers, in order to obtain the age of the control cables, they would have had to review years of service records to locate the installation date. According to Shell, it was not tracking the age of the cables; rather, it wholly relied on the OEM for this information.

In accordance with all versions of Palfinger's "Installation, Operation and Maintenance Manual," the control cables are supposed to be replaced every five years. Palfinger service engineers did not replace the cables in 2017. Based on the evidence, it appears that the cables were not changed out for two reasons. First, as noted above, Palfinger did not make information regarding age of the existing cables readily available to its service engineers. Accordingly, the service engineers did not flag the cables as being beyond their recommended service life. Second, while the "Installation, Operation and Maintenance Manual" directed that cables be changed at five years (couched as a *shall*), Palfinger Work Instruction F-10080[55] and Checklist for LSA Equipment both couch the replacement as a recommendation. From the Coast Guard's interviews, it is clear that the service engineers were familiar with the "Installation, Operation and Maintenance Manual" however, in practice, they followed the work instructions and checklist. Accordingly, even if the service engineer knew the age of the control cables, it is likely that they would have only replaced the cables if, in the opinion of the service engineer, the cable's function was found unsatisfactory and/or the operator requested or agreed to replacement.

Replacement aside, making the age of the control cables readily available to the service engineers and operators is a good practice. Even if the cables were not changed out at the five-year mark, the cables' age would have served as an important data point in Palfinger's recommendation to Shell to replace the cables. In the present case, because the service engineers did not have the age of the cables, the fact that the cables were compromised *and* in service more than two years beyond what Palfinger recommended or required was never discussed.

Shell also had an opportunity to track the cable's age. Shell maintains a Lifesaving Equipment (LS-MU-04 Lifeboats) document as part of its TIMMS. It is applicable to tension leg platforms, like AUGER. The document states that "lifeboats should be maintained at a minimum frequency as specified by CG regulations, and as prescribed by the manufacture." It further requires that the manufacturer's instructions for onboard maintenance of the lifeboat and release gear must be onboard and include a schedule of periodic maintenance. As discussed above, the LHR hooks had a "Installation Operation and Maintenance Manual," and a copy was onboard AUGER. The manual included a schedule of periodic maintenance that directed replacement of control cables

[55] *Annual and 5-yearly inspection and commissioning of lifeboats*, Version number: 0.9, valid from September 25, 2017

every five years. Had Shell integrated Palfinger's service schedule into its SAP system, it may have triggered replacement in 2017. Shell's assertion that it was wholly the OEM's responsibility to track the age of the cables and replace, as necessary, is, in the opinion of the Coast Guard investigators, wrong. As Shell tracks other routine maintenance events in SAP, it could and should track the age of control cables.

5.7. Fall Preventer Devices (FPDs)

The SeaCure LHR3.5M2 hook was pre-drilled for a training lock, a type of FPDs. In the case of the LHR3.5M2, the training lock, when inserted, prevents the locking shaft from turning. In the present case, a training lock, if used, would have prevented the locking shaft from opening. If the crew was unable to insert the training lock, that fact would have alerted the crew that there was a problem with the locking shaft position/hook reset. Of course, the latent unsafe condition – the compromised cable – would still exist.

The AUGER casualty brings to the surface, again, the unanticipated or unknown risks presented by mechanical systems. In NOSAC's 2015 Report on Lifeboat Safety, the authors wrote: "No mechanical system is perfect. Lifeboat casualty data has proven that even well-maintained systems operated by qualified and certificated personnel can still fail."

FPDs can reduce the risk of inadvertent releases. Of course, FPDs present some risks, namely they can reduce the confidence of crews in the safety of lifeboat systems and, if not removed after drills or training, can slow down or prevent evacuation during an emergency. However, the risks presented by FPDs can be mitigated by making crews comfortable with FPDs and instituting procedures to make sure the FPDs are removed and properly secured during non-use. Further, as the majority of accidents occur during drills or training, it is possible to limit FPD use to only non-emergency situations and still reduce overall risk. Overall, it is the opinion of the investigators in this case, that the benefits of use outweigh the dangers.

Analysis of Actions, Events and Conditions Determined Not to be a Direct Cause of the Accident

5.8. Forward Hook Opening

Lifeboat No. 6 eventually fell to the water because the aft and forward hooks, for different reasons, inadvertently opened. The Coast Guard reviewed several investigative reports involving cases where one hook in a dual-fall release system opened; in most, but not all cases, the other second hook usually inadvertently opened or ripped out of the hull too. In a dual-fall arrangement, one hook and its associated structural connections in a lifeboat are not required by design to bear the entire weight of the lifeboat beyond expected even keel (i.e., level) launching and recovery.

In the present case, after the casualty, the forward hook was found open, with the locking shaft in the closed position. The control cable was unthreaded from the hook locking shaft clevis and the cable conduit was separated at the cable's conduit cap to conduit connection at the hook. The hook control cable was the only thing connecting the hook to the lifeboat and preventing the forward hook from being lost. The evidence suggested that the forward hook was opened by the separation of the conduit at the conduit cap and the pulling force of the falling lifeboat on the inner member, as the hook and lift shoe separated from the hull, which opened the locking shaft and released the hook from the forward fall.

Evidence also indicated that the clevis unthreaded due to the weight of the hook causing a spinning motion as it came taught on the control cable below the lifeboat wreckage (the jam nut was not tight against the clevis and allowed the inner member/cable end to loosen from the clevis). Once the clevis separated, the torsion spring returned the hook locking shaft to the closed position, with the hook still in the released position (i.e., hook tail and roller in front of the locking shaft).

5.9. Operators Lack of Reliance on OEM's Installation, Operation and Maintenance Manual

Palfinger maintained an "Installation, Operation, and Maintenance Manual" for the LHR model hooks. It contained, among other things, a maintenance schedule for the hooks. As part of the schedule, Palfinger recommended that crews conduct weekly inspections of the control cables. The manual also states that control cables needed replacement every five years.

In developing its lifeboat preventative maintenance requirements and schedules, Shell referenced best practices common to lifeboat manufacturers. However, Shell did not integrate specific OEM recommendations for individual lifeboats. Accordingly, some of the maintenance behaviors relevant for to this casualty were never adopted by Shell.

The operations and maintenance manual is required with type approved appliances (with the 2011 regulations changes), but there is no regulatory requirement to use or comply with those manuals. However, the manuals provide valuable information on best practices for operating and maintaining equipment.

As in the findings of fact above, Palfinger recommended that mechanics check control cables for corrosion on a weekly basis. Shell's AUGER's crews conducted weekly checks of the lifeboats. However, the Weekly Lifeboat Inspection and Function Check checklist they followed only directed them to ensure the cables could move freely.

In the case of Lifeboat No. 6, Shell had a system in place to ensure that the lifeboat's control cables were replaced every five years (SAP) in accordance with the OEM requirements. However, the maintenance execution team elected not to use the OEM's maintenance schedule. Accordingly, the requirement to replace cables every five years was never entered into SAP.

OEM's are best placed to provide guidance on maintaining and operating its own equipment. The Coast Guard ensures OEM manuals are readable, useful, and usable. It is a best practice to incorporate OEM recommendations when developing a maintenance strategy.

After the casualty, Shell told the Coast Guard that it expected the "OEMs to either perform all needed preventative and corrective maintenance consistent with the OEM's policies and procedures, or make specific recommendations to Shell that such preventative and corrective maintenance be performed." While the OEM is certainly a partner in maintaining the emergency equipment, like lifeboats and release mechanisms, 33 CFR 146.15(a) places the responsibility for maintaining emergency equipment in good condition on all times on the operator.

5.10. Modification and Refurbishment of Coast Guard Approved Equipment

The Coast Guard equipment approval regulations and processes are intended to provide a control over the quality of approved items. See 46 C.F.R. 2.75-1(b). Accordingly, it strictly regulates the sale and modification of approved equipment. In the present case, the EL24-874 was sold by Eni, an entity not identified on the certificate of approval (COA), to Schat-Harding. Schat-Harding refurbished the EL24 and conducted an unapproved retrofit of the LHR3.5 hooks, and then sold it to Shell as an approved system. All of above was conducted well after the EL24-874's approval had expired. The Coast Guard had similar concerns with the refurbishment of the winches, also approved equipment. All of above was done with the knowledge and tacit approval of the cognizant OCMI. However, the actions raise questions as to whether OEMs, OCMIs and Coast Guard inspectors are interpreting the regulations related to type approved equipment in the manner intended by the regulations' drafters.

When conducting inspections, Coast Guard inspectors are directed to verify that equipment is approved. However, the Coast Guard does not train its inspectors on the nuances of the approval regulations. In the case of AUGER's Lifeboat No. 6, inspectors were likely aware that the lifeboat was changed out at some point for a refurbished model. However, no inspector ever raised it as an issue.

The Coast Guard investigators don't, at this point, believe that the issues related to the COAs were causal to the casualty. However, investigators found that OEMs, OCMIs, and inspectors and CG-ENG-4 are not in alignment as to how 46 C.F.R. § 2.75-1 should be applied. The potential consequences of the confusion are significant enough that the Coast Guard investigators wanted to raise the issue so that the issue can be addressed.

6. **Conclusions**

6.3. Determination of Cause:

6.3.1. Initiating Event: The Coast Guard investigation team determined that the initiating event for this casualty occurred when the locking shaft on the aft hook moved from the "almost open" to the open position, which in turn caused the aft hook to open under load and release from the lift ring. Based on the evidence collected and evaluated, it is probable that on the morning of June 30, 2019, the crew cycled (open to closed position) the hooks two times while in the water. The cable conduit, already compromised, was exposed to additional stresses, including compression and stretching. It is probable that during the second cycling event, the conduit, already weakened and damaged, separated during the closing action. As a result, when the system was reset, the locking shaft on the aft hook did not return to the fully closed position, but rather, came to rest in an "almost open" position. In this position, the hook could support the weight of the lifeboat and its occupants. It is probable that, once at the davit bumper, additional forces applied to the hook and the boat, as a result of the winch pulling the boat up against the bumpers, caused the locking shaft to rotate from the "almost open" to the open position. Under load, the aft hook was free to open and release from the lift ring. The forward hook and its connections inside the boat, not designed to bear the entire load of the lifeboat beyond an even keel[56], was unable to sustain the weight of the lifeboat at the extreme angle, separated from the hull and eventually opened.

The primary causal factors include:

6.3.2. The complete separation of the aft hook control cable conduit surrounding the inner member.

6.3.3. In the weeks, and probably months, before the casualty, the aft control cable was in a compromised condition. This latent unsafe condition was discovered by Palfinger service engineers on June 6, 2019 during Lifeboat No. 6's annual inspection. Palfinger service engineers recommended that Lifeboat No. 6's control cables be replaced. Shell did not act to replace the cables. As discussed in part, this failure act may have been a result, in part, of the overarching statements made by Palfinger service engineers in the same report that "all systems [were] found to be [in] correct working order" and the lifeboats could be returned to service.

6.3.4. The lack of knowledge among operator, OEM, Coast Guard regulators, and other persons and entities responsible for maintaining, operating and regulating lifeboats that a hook control cable with a compromised conduit could result in a locking shaft failing to completely close after reset. The lack of knowledge was not the result of a lack of training and experience. Rather, it appears, it was an unknown hazard until Shell investigators initially identified the effects of a separated control cable conduit on the cable function.

6.3.5. Hook control cables have been overlooked by operators, OEM, and regulators. As a result, the Coast Guard has not issued regulations or recommendations specific to the replacement or maintenance of control cables.

6.3.6. Shell's lifeboat maintenance strategy relies heavily on the OEM. However, Shell's expectations were never effectively communicated to the OEM's service engineers, the persons actually inspecting the lifeboats.

6.3.7. The OEM, and to some extent the operator's, focus was on function-based inspections rather than condition-based inspections.

Contributing factors include:

6.3.8. The age of the control cables was not known by Palfinger service engineers or Shell AUGER crews who made the recommendations and decisions, respectively, about replacement of the control cables. The information, while available to both Palfinger service engineers and AUGER crew, was difficult to access. It is reasonable to conclude that had that information been readily available or sought out, Palfinger service engineers and Shell AUGER crews could have made more informed – and possibly different – recommendations and decisions regarding replacement.

[56] In a dual fall arrangement, one hook and its connections in the boat should by design sustain up to 6 times the weight of the boat on an even keel. In the case of the AUGER, the lifeboat was not on an even keep at time of failure.

6.3.9. Subsequent Event Number 1 to the initiating event was the lifeboat swinging out in a pendulum motion away from the facility after the aft hook released. In this condition, the entire weight of the lifeboat was placed on the forward hook area. For a brief moment, the forward hook stayed locked and attached to the forward fall cables as the boat swung. Shortly thereafter, before the lifeboat could lose its forward momentum and swing back toward the facility, the forward hook ripped from the hull and released from the forward fall. Examination of the evidence found the forward hook to be open, with the locking shaft in the closed position. The control cable was unthreaded from the hook locking shaft clevis and separated at the cable's conduit cap to conduit connection. The hook control cable was the only thing connecting the hook to the lifeboat and preventing the forward hook from being lost. The evidence suggested that the forward hook was opened by the separation of the conduit at the conduit cap and the pulling force of the falling lifeboat on the inner member, which opened the locking shaft and released the hook from the forward fall. Evidence also indicated that the clevis unthreaded due to the weight of the hook causing a spinning motion as it came taught on the control cable below the lifeboat wreckage (the jam nut was not tight against the clevis and allowed the inner member/cable end to loosen from the clevis). Once the clevis separated, the torsion spring returned the hook locking shaft to the closed position, with the hook still in the released position (i.e., hook tail and roller in front of the locking shaft).

Dual fall lifeboats are designed to share the load of the lifeboat between the forward and aft hooks. One release hook (and its associated structural connections to the hull) is not designed – or required by design standards – to sustain the entire weight of the lifeboat on a single hook beyond anything other than an even keel. In this case, the lifeboat was hanging vertically on a single hook in an orientation that applied forces to the hull approximately 90° from the intended position of operation and application of forces. In the cases reviewed by the Coast Guard, most, but not all, cases involving the inadvertent release of one hook in dual-fall system resulted in the subsequent release of the boat from the other fall, as a result of a hook, FRP or fall cable failure.

6.3.10. Subsequent Event Number 2, was the boat falling approximately 80 feet to the water and landing inverted in the water.

6.3.11. Subsequent Event Number 3, was the death of the two persons still inside and the injury to the one person who fell to the water, while in process of disembarking the lifeboat to the deck of AUGER.

6.4. Evidence of Act(s) or Violation(s) of Law by Any Coast Guard Credentialed Mariner Subject to Action Under 46 U.S.C. Chapter 77: This investigation did not identify evidence that would support referral of any Coast Guard Credentialed Mariner to action under 46 USC Chapter 77.

6.5. Evidence of Act(s) or Violation(s) of Law by U.S. Coast Guard Personnel, or any other person: This investigation did not identify evidence that would support referral of any Coast Guard person to action under U.S.C. Title 18 or 10 U.S.C. Chapter 47, the Uniform Code of Military Justice.

6.6. Evidence of Act(s) Subject to Civil Penalty: This investigation did not identify evidence that would subject any person or entity to a civil penalty.

6.7. Evidence of Criminal Acts: This investigation did not identify evidence that would support referral of criminal acts under United States laws to the U.S. Attorney or other entity.

6.8. Need for New or Amended U.S. Law or Regulation:

This marine casualty confirms the need to create the following:

6.8.1. The Coast Guard does not maintain regulations for lifesaving gear based on gear type. Rather, Coast Guard regulations related to lifesaving equipment are specific to the vessel or facility on which the lifesaving gear is installed. In practice, this means that lifesaving gear on a MODU operating in the OCS is subject to strict time-based operational and maintenance requirements outlined in 46 C.F.R. Part 109. However, the same type and model lifesaving gear, if installed on a FOF in the OCS, may be subject to the vague “good condition” requirements of 33 C.F.R. § 146.15. Variations continue when one looks at requirements as applied to inspected vessels. The best solution would be to consolidate all operations and maintenance requirements for lifesaving gear in a separate chapter, making appropriate concessions depending on the operational environment. Addressing this issue would take a massive rewrite of the existing regulations. However, moving forward, it would make it vastly easier to update regulations, ensuring that all crews and mariners receive the protections of updated best practices. As it currently stands, some mariners and crews, operating on operational platforms with newer regulations, benefit from regulations that reflect the latest understanding best practices, while others operate on vessels utilizing lifesaving gear still subject to regulations implemented in the 1950s.

6.8.2. Currently, equipment is approved as individual components, not as a system. The equipment is designed by OEMs to work in concert, however, the Coast Guard approval regulations allows operators to mix-and-match equipment. Recommend the Coast Guard develop regulations that require that all approved components are approved as a system or are designed to work together (e.g. specific winches allowed to be used with a particular davit, release mechanisms allowed to be used in a specific boat, etc.).

6.8.3. Currently, the only regulations that apply to maintenance requirements for lifesaving gear on OCS facilities, including FOFs, is 33 C.F.R. § 146.15. These regulations are vague and generic, stating emergency equipment, “shall be maintained in good condition at all times. Good operating practices require replacement of expended equipment, as well as periodic renewal of those items which have a limited period of effectiveness.” 33 C.F.R. § 146.15. There are no specific timed requirement for inspections or replacement of key gear. It creates confusion. In this space, the Coast Guard has sought to apply 46 C.F.R. § 109 regulations, intended to apply to MODUs, through policy – formal and informal. The 46 C.F.R. § 109 regulations are more robust and, without a doubt, in application to FOFs result in better safety outcomes. However, the Coast Guard’s manner of using a substantive regulation to fill the void left in 33 C.F.R. § 146.15 is questionable and may be a violation of the notice and comment requirements of 5 U.S.C 553(b)(3)(a). In speaking with industry stakeholders during the investigation, they also dislike policy letters and favor the development of clear regulations. The cleanest path to improving safety is to issue clear and comprehensive regulations related to the maintenance and operations of lifesaving gear on OCS facilities. 46 C.F.R. § 109 is a good model.

6.8.4. Historically, control cables have been overlooked by regulators, including the Coast Guard and IMO. As a result, OEMs and operator often overlook control cables, too.

Regulations requiring thorough annual inspections (including inspection of entire length of cable) and time-based and/or condition-based replacement would improve lifeboat safety.

6.8.5. Currently, there are not regulations that require Coast Guard oversight of repairs and modifications to lifesaving systems on OCS facilities.[57] Repairs and modifications of lifesaving equipment was not found to be causal to this investigation. However, the Coast Guard was alarmed at the lack of oversight related to modifications and repairs of lifesaving equipment. Regulations are recommended to ensure appropriate regulatory oversight.

6.9. Unsafe Actions or Conditions which, although could not be determined to be Causal Factors, Cannot Be Eliminated as Potential Contributing Factors:

6.9.1. Boat Crew Person 2, the person responsible for verifying the reset of the aft hook, died during the casualty. As a result, the Coast Guard was unable to determine whether he confirmed the reset by looking at the hook indicator, as recommended by the OEM. The Coast Guard's experiment strongly suggests that the hook angle indicator was likely showing in the red (open position) after the final reset. Therefore, it can't be eliminated as a potential contributing factor that the Boat Crew Person did not check the hook indicator or, like Boat Crew Person 1, was confused as to what the colors meant (red means open; green means closed). It is possible that if Shell had a checklist or system in place to ensure that boat crews checked the hook position indicator, and the boat crews had followed the checklist or procedure, the crew probably would have been alerted to a problem with the reset of the hook/locking shaft position.

6.9.2. Fall preventer devices (i.e., training locks) while approved for the LHR3.5M2 hook model under a different approval number, were not in use.

6.9.3. In accordance with Palfinger's "Installation, Operation, and Maintenance Manual" for the LHR model hooks, the control cables should have been replaced after five years. According to the known installation/ in-service date (April 2012), replacement should have occurred in April 2017. The Coast Guard was not able to identify when the aft cable was first compromised or the timeline for corrosion or damage. Accordingly, the Coast Guard can't determine that newer cables would have prevented the casualty. However, it is fair to conclude that new cables, installed in either 2017 at the five-year mark or in 2019 during the May inspection (originally scoped as a 5-yearly inspection), would have been in better condition than the cable that lead to the casualty and less likely to fail under similar conditions.

6.9.4. The OEM can improve communications with its customers by ensuring all relevant information related to a recommended repair (i.e., repair, basis, "due" date, and responsible party) is communicated in its written service reports.

7. Actions Taken Since the Casualty

7.1. As discussed above in paragraph 5.3.3.6, On May 19, 2020, the D8 OCS OCMI issued Policy Letter 01-2010, "Emergency Evacuation Drills on Manned Facilities With Lifeboats."

[57] 46 C.F.R. Part 199 applies to passenger vessel, large cargo vessels, and SOLAS vessels, but cuts out most OCS vessels and facilities.

The policy canceled Revision 1 of D8(OCS) Policy Letter 04-2016 dated 07 May 2018 (the policy in effect at the time of the casualty). The policy communicated the OCMI's understanding of the requirements of 33 CFR 146.125(c)(1) to mean that all lifeboats aboard a facility, shall, at a minimum, be launched annually with the assigned lifeboat crew in order to fulfill the requirements of the annual emergency evacuation drill required by the unit's Emergency Evacuation Plan (EEP).

7.2. On February 5, 2020, the Coast Guard issued Safety Alert 3-20. The Coast Guard highlighted the importance of control cables as part of a lifeboat release mechanism and recommended that lifeboat owners, manufacturers, operators and service providers inspect control cables for damage and replace as necessary.

7.3. On September 11, 2019, the Coast Guard Commercial Regulations and Standards Directorate (CG-OES-2) tasked the National Offshore Safety Advisory Committee (NOSAC), a federal advisory committee, to:

- Review the 2015 NOSAC Final Report (Titled" Safety of Persons Assigned to Lifeboats During Launching, Recovery and Maintenance Activities for Mobile Offshore Drilling Units and Floating Offshore Installations Working on the U.S. Outer Continental Shelf") and update any recommendations that have become dated or that need to be modified.

- Research and identify potential modifications that could be added to already required lifeboat equipment (SOLAS equipment) and lifeboat arrangements that would be more appropriate for lifesaving appliances installed on an OCS unit.

- Identify potential design flaws for lifeboats, rescue craft, and their launching and recovery arrangements that, if addressed, would enhance the safety of the lifeboat and or rescue craft including launching and recovery from an OCS unit, including;

    - Analyzing Mobile Offshore Drilling Unit (MODU) requirements from 46 CFR Subchapter I-A for suitability to floating OCS units.

    - People on Board (POB) standard (weight/body size) etc. (Federal Register Docket ID: USCG-2012-0848).

- Recommend suggested changes to existing regulations and or policies governing lifeboats and or rescue craft to address the unique operational issues found on OCS units.

- Recommend suggested changes or alternatives for competency assurance/training for crews serving on OCS units and lifesaving equipment testing.

- Provide any additional recommendations that the subcommittee believes are relevant to this tasking.

CG-OES-2's tasking is not related to the AUGER casualty, however, the report, if it follows the tasking, will address many of the issues that the AUGER investigation team identified as needing attention. NOSAC is scheduled to complete its task by September 9, 2020.

8. **Recommendations**

8.1. Safety Recommendations:

8.1.1. Safety Recommendation 1: Recommend the Coast Guard Commercial Regulations and Standards Directorate (CG-5PS) develop a working group to look at consolidating lifesaving gear regulations under one subchapter.

8.1.2. Safety Recommendation 2: Recommend CG-ENG-4 review procedures related to release mechanism type approval to ensure all components, to include control cables, are thoroughly addressed in type approval submittals and testing.

8.1.3. Safety Recommendation 3: Recommend that the Office of Commercial Vessel Compliance (CG-CVC) develop regulations requiring thorough annual inspections (including inspection of entire length of cable) and time-based and/or condition-based replacement. Most appropriately, these regulations would apply to all lifeboats. In the absence of rulemaking, the CG-CVC should issue strong recommendations to OEMs and operators that they voluntarily apply the same.

8.1.4. Safety Recommendation 4. Recommend the CG-ENG-4 develop regulations that require that all approved components are approved as a system or are designed to work together (e.g. specific winches allowed to be used with a particular davit, release mechanisms allowed to be used in a specific boat, etc.).

8.1.5. Safety Recommendation 5. Recommend the CG-5PS develop regulations that require the maintenance requirements in 46 C.F.R. § 109 (or similarly structured requirements) to be applicable to FOFs. NOSAC's report, due September 9, 2020, can help inform this process.

8.1.6. Safety Recommendation 6. Recommend CG-5PS reevaluate the use of lifeboats as rescue boats. During witness testimony it was noted the freeboard was too high to lift an unconscious person into the boat and the doors were not wide enough to allow two persons to lift an unconscious person through.

8.1.7. Safety Recommendation 7. Recommend the CG-5PS develop regulations ensuring oversight of lifeboat, winch and davit repairs and modifications all vessels and facilities not subject to 46 C.F.R. Subchapter W, Lifesaving Appliances and Arrangements.

8.1.8. Safety Recommendation 8: Recommend CG-5PS develop policy that ensures OCMIs and their representatives properly evaluate type approved equipment in regards to repairs and modifications (especially as they relate to serviceability and maintaining equipment in an as-approved condition), and that CG-ENG-4 remains engaged appropriately in these activities as necessary after initial approval.

8.1.9. Safety Recommendation 9: Recommend the D8 OCMI (ocs) update current policy on drill and maintenance requirements for regulated facilities operating on the OCS to best reflect current regulatory requirements.

8.1.10. Safety Recommendation 10: Recommend the CG-5PS, with input and involvement by the OSC NCOE, develop a workgroup to research/revise regulations and policies and engage with other administrations for input into their management of the following for the offshore oil & gas operations:

- Lifeboat launching;
- Drills and competence; and
- Maintenance.

8.2. Administrative Recommendations:

8.2.1. Administrative Recommendation 1: Recommend the D8 OCMI (ocs), after being routed and reviewed by CG-INV, communicate Findings of Concern to the OEM, recommending:

8.2.1.1. The OEM update work instructions to automatically replace control cables five years from the date the cables were installed.

8.2.1.2. The OEM update all work instructions to better communicate the nature of repair or replacement recommendations, the risk posed by the deficiency, and a recommended timeline for repair or replacement.

8.2.1.3. The OEM review and revise their procedures for release mechanism control cable installations and inspections and provide training on the same to their technicians.

8.2.1.4. The OEM conduct a review of its hook indicator color coding system to determine whether the current system (red means open; green means closed) is confusing for operators.

8.2.2. Administrative Recommendation 2: Recommend the D8 OCMI (ocs), after being routed and reviewed by CG-INV, communicate Findings of Concern to the Operator, recommending:

8.2.2.1. The Operator incorporate all OEM recommended maintenance into their maintenance system as mandatory.

8.2.3. Administrative Recommendation 3: Recommend CG-INV issue a finding of concern recommending that operators ensure that persons planning, conducting and overseeing routine lifeboat maintenance have read and are familiar with the applicable lifeboat operations and maintenance manual.

8.2.4. Administrative Recommendation 4: Recommend CG-INV issue a finding of concern recommending operators, with the assistance of the OEM, train crews to ensure they understand how the hook indicators, when installed, function and convey information regarding the condition of the hook. Operators and OEMs should also communicate to crews the need to verify the status of the hook indicator at least two times during the retrieval process: at the water after the falls are connected and immediately after the lifeboat clears the water.

8.2.5. Administrative Recommendation 5: CG-INV and CG-CVC should widely publicize this investigation's findings related to the hazards posed by compromised control cables to all marine sectors maintaining and operating lifeboats, to include Coast Guard inspectors.

8.2.6. Administrative Recommendation 6: CG-CVC and CG-ENG-4 should provide additional guidance to inspectors and the regulated community regarding certificates of approval regulated under 46 CFR 2.75-5. This guidance should include clarity on who they are issued to, how they relate to the sale and production of equipment, the significance of their validity period, and what constitutes replacement in kind of equipment no longer holding a valid approval certificate.

8.2.7. Administrative Recommendation 7: Recommend the CG-INV issue a finding of concern that highlights the benefits of using FPDs during lifeboat launches and retrieval drills.

8.2.8. Administrative Recommendation 8: Recommend that this investigation be closed.

[redacted]
Lieutenant Commander, U.S. Coast Guard
Investigating Officer

Enclosures: (1) Convening Order
(2) USCG Testing of LHR3.5M2 Release Mechanism
(3) DNV-GL U.S's AUGER Investigation