REPUBLIC OF THE MARSHALL ISLANDS

Maritime Administrator

SEAFOX DEEMA CASUALTY INVESTIGATION REPORT

Lifting Gear Structural Failure with Fatality

Persian Gulf | 16 March 2020

Official Number: 2098

IMO Number: 8756916

Published by: Republic of the Marshall Islands Maritime Administrator on 17 August 2021

DISCLAIMER

In accordance with national and international requirements, the Republic of the Marshall Islands Maritime Administrator (the "Administrator") conducts marine safety investigations of marine casualties and incidents to promote the safety of life and property at sea and to promote the prevention of pollution. Marine safety investigations conducted by the Administrator do not seek to apportion blame or determine liability. While every effort has been made to ensure the accuracy of the information contained in this Report, the Administrator and its representatives, agents, employees, or affiliates accept no liability for any findings or determinations contained herein, or for any error or omission, alleged to be contained herein.

AUTHORITY

An investigation, under the authority of the Republic of the Marshall Islands laws and regulations, including all international instruments to which the Republic of the Marshall Islands is a Party, was conducted to determine the cause of the casualty.

Maritime Administrator

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LIST OF ABBREVIATIONS

1979 MODU Code	Code for the Construction and Equipment of Mobile Offshore Drilling Units (IMO Resolution A.414(XI))
ABS	American Bureau of Shipping
AOPS	Automatic Overload Protection System
COVID-19	Coronavirus Disease
DNV	Det Norske Veritas
DNV GL	Det Norske Veritas Germanischer Lloyd
ft	Feet
GL	Germanischer Lloyd
IMO	International Maritime Organization
ISM Code	International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code)
kg	Kilograms
m	Meters
MT	Metric Tons
MOPS	Manual Overload Protection System
MODU	Mobile Offshore Drilling Unit
MOU	Mobile Offshore Unit
NDT	Non-destructive Testing
OIM	Offshore Installation Manager
OSV	Offshore Supply Vessel
lbs	Pounds
PPE	Personal Protective Equipment
ROV	Remote Operated Vehicle
SWL	Safe Working Load

PART 1: EXECUTIVE SUMMARY

On 16 March 2020, the Republic of the Marshall Islands-registered, self-elevating, non-self-propelled, accommodation unit SEAFOX DEEMA, operated by Seafox Middle East DMCC (the "Operator"), was engaged in cargo operations with the Republic of Singapore-registered OSV ASTRO SIRIUS (IMO No. 9505223).

SEAFOX DEEMA's starboard pedestal-mounted crane collapsed while it was being used to shift the position of a container that was on board the OSV. The crane cab, gantry structure, and boom fell onto the OSV. It slid overboard and sank with the crane operator trapped in the cab.

A subsequent subsea search located the cab and the crane operator's body was recovered. No crewmembers on board the OSV were injured.

The marine safety investigation conducted by the Republic of the Marshall Islands Maritime Administrator (the "Administrator") identified the following:

1. Causal factors that contributed to this very serious marine casualty include:
   (a) the Operator's procedures for lifting operations did not establish requirements for managing dynamic amplification factors when making offboard lifts;
   (b) the Operator's generic risk assessment for lifting operations did not include the following hazards:
      (i) lifting loads not listed on the cargo manifest;
      (ii) lifting loads with an unknown weight; and
      (iii) using cranes not fitted with safety devices such as an AOPS or MOPS;
   (c) that neither the Operator's procedures nor the generic risk assessment for lifting operations included a requirement for the deck foreman and crane operator to check the item and its weight against the cargo manifest before lifting it;
   (d) the load chart posted in the cab of the starboard crane did not include SWLs for onboard and offboard lifts;
   (e) ineffective onboard implementation of the Operator's procedures for lifting operations, as indicated by:
      (i) a load lift plan not being prepared for the cargo operations;

(ii) overloads that may have occurred during prior lifting operations were not reported; and

(iii) no record that neither the crane's structure was inspected, nor the rated capacity indicator was tested, as required by the Operator's procedures following any overloads that might have occurred; and

(f) ineffective onboard hazards identification and management when planning and conducting lifting operations, as indicated by:

(i) the fact that a container not listed on the cargo manifest was connected to the crane's hook and lifted; and

(ii) the apparent lack of communications between the deck foreman, crane operator, and Saipem S.p.A.'s (hereinafter, "Saipem") Materials Man to confirm the container tag number and weight before connecting it to the crane's hook and lifting it off the OSV's deck.

2. Additional causal factors that may have contributed to this very serious marine casualty include:

(a) the crane manufacturer had not indicated in its service letters addressing the potential for cracks to develop in the upper pedestal near the slewing gear and web plate of cranes, similar in design and construction to the starboard crane, could also apply to the starboard crane until after it failed; and

(b) potential material fatigue related to the age of the crane.

PART 2: FINDINGS OF FACT

The following Findings of Fact are based on the information obtained during the Administrator's marine safety investigation. Due to restrictions on travel, imposed in response to the COVID-19 pandemic, the Administrator was not able to attend on board as part of its marine safety investigation of this very serious marine casualty. All related information available to the Administrator was obtained remotely.

1. Ship particulars: *see* chart to right.

2. SEAFOX DEEMA[1] was built by R.G. LeTourneau, Inc. in 1966 as a self-elevating, non-self-propelled drilling unit. The unit was designed, built, and classed in accordance with the applicable ABS rules in effect at the time.

3. In 1989, the unit underwent a major conversion and change of service from a drilling unit to an accommodation unit.

1 The unit was originally named PENROD 57 and then underwent several name changes before being named SEAFOX DEEMA in 2015.

SHIP PARTICULARS

Ship Name
SEAFOX DEEMA

Registered Owner
Deema LLC

Operator
Seafox Middle East DMCC

Flag State
Republic of the Marshall Islands

IMO No.	Official No.	Call Sign
8756916	2098	V7GH9

Year of Build
1966

Net Tonnage	Gross Tonnage
1,821	6,072

Length x Breadth x Depth
60.8 x 55.7 x 7 meters

Ship Type
Accommodation Vessel/Unit

Classification Society
DNV GL

Persons on Board
Crewmembers: 20
Industrial Personnel: 237

4. In 2004, the unit's registration was transferred from the State of Qatar[2] to the Republic of the Marshall Islands.

5. In 2009, SEAFOX DEEMA changed class from RINA to GL.[3]

6. On 18 June 2018, the Operator assumed operational responsibility of SEAFOX DEEMA. The unit was warm stacked[4] at the time.

7. In May 2019, SEAFOX DEEMA started operating under contract to Saipem in the Qatar Gas North Oil Field in the Persian Gulf offshore of the State of Qatar.

8. The unit is certificated in accordance with the 1979 MODU Code.

Deck Cranes

9. SEAFOX DEEMA had three deck cranes *(see Figure 1)*. The port and starboard cranes were manufactured by Marathon LeTourneau and were installed when the unit was built. The aft crane was manufactured by Manitowoc and was installed when the unit underwent the major conversion.

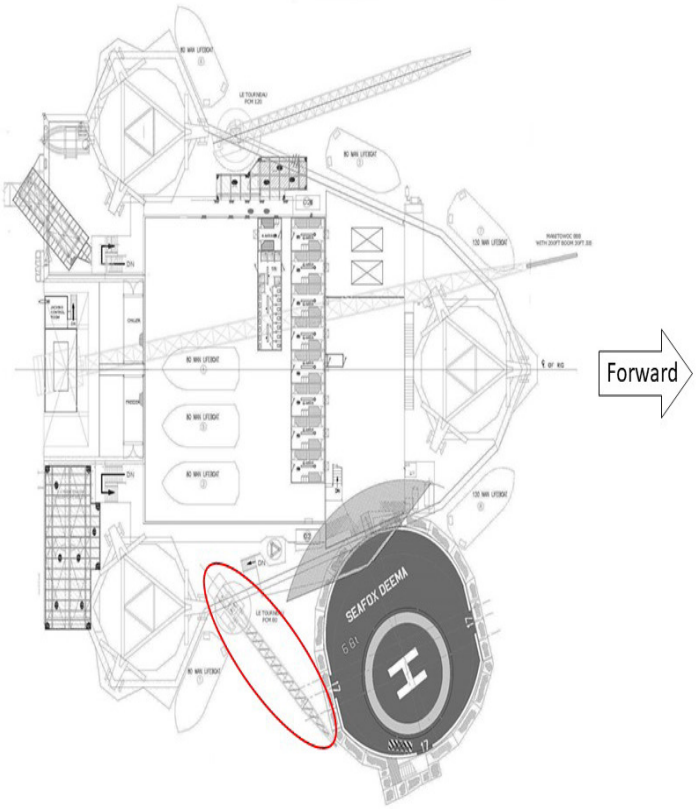

Figure 1: Top deck of SEAFOX DEEMA showing the location of the three deck cranes. The starboard crane (circled in red) was located aft of the helideck. Source: Seafox, SEAFOX DEEMA, General Arrangement – Top Deck, Drawing SF-DEEMA-GA-007, issued 6 May 2015.

2 The unit was originally registered in the United States. Its registration was then changed to the State of Qatar.

3 In 2013, GL merged with DNV to become DNV GL. Prior to the change of Classification Societies, the unit had been classified by RINA.

4 While warm stacked, a crew remained on board the unit and all equipment remained operational.

10. The starboard side crane was a Marathon LeTourneau Series RD-80 AS pedestal mounted, electric deck crane with a 100 ft (30.4 m)[5] boom. The manufacturer reported that minimum life cycle (service life) or forces associated with dynamic amplification factors, horizontal loading, and angular lead loading were not considered while designing the crane. These are design factors that current industry standards and Classification Society rules require to be considered when designing pedestal-mounted cranes for installation on offshore structures.[6]

11. No documented alterations of the crane's structure had been made since it was installed.

12. Based on the manufacturer's manual, the SWL range for the starboard crane was between 83,000 lbs (37.6 MT) at a working radius of 20 ft (6.1 m) and 13,832 lbs (6.3 MT) at a radius of 90 ft (27.4 m). The maximum design loading moment was 800 ft tons (221 m MT).[7]

13. The starboard crane had a rated capacity indicator (or safe load indicator) that displayed the angle and radius of the boom and corresponding SWL as well as the actual load. The crane had a monitoring system that activated an audible and visual alarm when the SWL for a given radius was exceeded, and an emergency stop switch that tripped the main breaker.

14. The starboard crane was not fitted with an AOPS or a MOPS.[8] Requirements for these systems were not adopted until after this crane was built and were not made retroactive.

15. A revised load chart was prepared for the crane in 2013 after replacing the crane's hook block. The SWL of the new hook block was 17.0 MT *(see Figure 2)*. It was reported that this was the load chart posted in the crane's cab.

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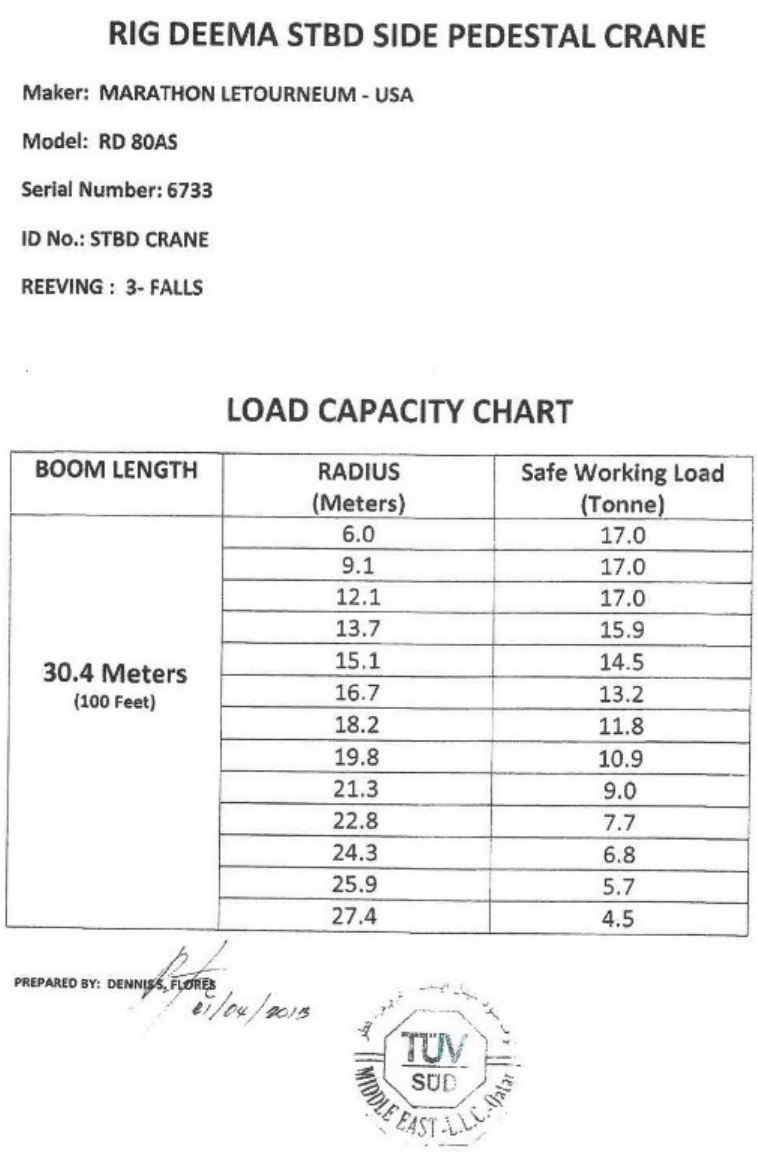
5 The specifications included in the manufacturer's maintenance instructions for the crane are in United States customary units. References to these specifications will include both the United States customary unit and the metric equivalent.

6 See for example API Specification 2C, Offshore Pedestal-mounted Cranes, seventh edition (issued March 2012). It is noted the first edition of API Specification 2C was published in 1971.

7 The United States customary system of measure uses the short ton, which is equal to 0.907 MT.

8 AOPS and MOPS are both systems that protect the crane against overload and over-moment by reducing the load-carrying capacity and allowing the hook to be pulled away from the crane. AOPS is activated automatically and is intended to protect against overloads that occur too quickly for the crane operator to respond. In contrast, MOPS is activated manually by the crane operator and is intended to protect against overloads that occur gradually.



RIG DEEMA STBD SIDE PEDESTAL CRANE

Maker: MARATHON LETOURNEUM - USA

Model: RD 80AS

Serial Number: 6733

ID No.: STBD CRANE

REEVING : 3- FALLS

LOAD CAPACITY CHART

BOOM LENGTH	RADIUS (Meters)	Safe Working Load (Tonne)
30.4 Meters (100 Feet)	6.0	17.0
	9.1	17.0
	12.1	17.0
	13.7	15.9
	15.1	14.5
	16.7	13.2
	18.2	11.8
	19.8	10.9
	21.3	9.0
	22.8	7.7
	24.3	6.8
	25.9	5.7
	27.4	4.5

PREPARED BY: DENNIS S. FLORES 01/04/2013

TÜV SÜD MIDDLE EAST L.L.C. Qatar

Figure 2: Load chart posted in the Crane's Cab.

16. The rated capacity indicator was calibrated based on the 2013 load chart.

17. Neither the load chart in the manufacturer's manual, the SWL chart posted in the crane cab, nor the rated capacity indicator distinguished between onboard (static)[9] lifts and offboard (dynamic)[10] lifts.

18. The 1979 MODU Code, § 12.1.6 requires (where applicable) that a load chart and boom angle indicator be provided for each crane on board a MODU. The 1979 MODU Code does not specify whether the load chart should be based on the SWL for onboard lifts, offboard lifts, or both.

9 A static, or onboard, lift is defined as "lifting a load from and to the deck of the platform/vessel that the crane is mounted on." See API Specification 2D – Operation and Maintenance of Offshore Cranes, Seventh Edition, December 2014 (API Specification 2D), paragraph 3.1.62.

10 An offboard or dynamic lift is defined as "lifting a load from or to anywhere not on the platform/vessel that the crane is mounted on (from/to supply boats for example)." See API Specification 2D, paragraph 3.1.40.

19. It was reported that when conducting offboard lifts, the crane operators typically account for dynamic amplification factors by dividing in half the SWL for the radius at which the lift will take place. It was also reported dynamic forces were not considered as a critical element during lifting operations.

Cargo Operations

20. On the morning of 16 March 2020, SEAFOX DEEMA was scheduled to conduct cargo operations using the starboard crane with ASTRO SIRIUS.

21. The manifest for the planned cargo operations included tag numbers, a description of the contents, and declared weight of each container that would be offloaded from ASTRO SIRIUS to the unit. The actual weights of the containers were not verified when the containers were loaded on board the OSV.[11]

22. In preparation for the planned cargo operation, the Deck Foreman conducted a Toolbox Talk with the crane operator, the two riggers, and Saipem's Materials Man. They reviewed the cargo manifest for the planned cargo operation and the Operator's generic risk assessment for crane operations involving transfers to and from a supply vessel.[12] They also reviewed:

    (a) the required PPE;

    (b) the need for good communications during the operation;

    (c) not to drop the loads when completing a lift;

    (d) not to stand below suspended loads; and

    (e) the need to secure the work area to prevent others from entering it.

23. A permit to work was issued after the Toolbox Talk was completed.

24. It was reported that the planned operation was considered routine and that a load plan with the sequence and laydown area for each lift was not prepared.

25. Just after lunch, the crane operator visually examined the welds connecting the crane to the deck and conducted a test of its controls as required by the Operator's procedures. No problems were reported.

26. At 1245,[13] SEAFOX DEEMA began routine cargo operations with ASTRO SIRIUS. The cargo offloaded from the OSV was checked against the cargo manifest by the Deck Foreman and Saipem's Materials Man.

27. The reported weather was good, with winds from the east at 10 knots and seas of less than 1 m.

28. It was reported that ASTRO SIRIUS maintained station with its stern approximately 4-5 m off SEAFOX DEEMA and appeared to have only a slight pitch and roll.

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11 Industry guidance for conducting lifting operations includes a recommendation that the crane operator verify the hook load, which consists of the weight of the planned load and rigging, is within the crane's rated load at the radius at which it is to be lifted. See API Specification 2D, paragraph 4.2.1.3.

12 Details of this generic risk assessment are addressed later in the report.

13 Unless otherwise specified, all times are the unit's local time (UTC +3).

29. The first three lifts were completed without incident. The details of these lifts are summarized below.

    (a) First lift: An empty 10 ft14 container was offloaded to the stern of the OSV on the port side. The weight of the container and the lifting radius were not reported.

    (b) Second lift: A loaded 10 ft food container located on the OSV's port side, approximately 10-12 m forward from the stern, was lifted to SEAFOX DEEMA. Based on the cargo manifest the weight of the food container was 10 MT.15 The lifting radius was about 20 m.

    (c) Third lift: A 10 ft half container that was located approximately 10-12 m forward of the OSV's stern was shifted from the centerline to the port side. The listed weight of this container was 6 MT. The lifting radius was about 20 m.

30. It was reported that there were no communications between the Deck Foreman, the crane operator, and Saipem's Materials Man about either the container identification or weights of the first three loads before they were connected to the hook by the OSV's crew.

31. After the first three planned lifts, the crane operator was directed to shift a 20 ft half container located at the stern of ASTRO SIRIUS on the centerline directly forward about 10-12 m to clear an area to land a personnel basket.[16]

32. The tag number of this container was VGE-50. It was not included on the cargo manifest. The markings on the container indicated it was 4 MT when empty and that it could be loaded with 10 MT of material.

33. The cargo manifest did include one 20 ft half container. The tag number was VGE-57 and its stated weight was 5.5 MT. The maximum lifting radius for this load was about 22 m.

34. There was also no indication of any communications regarding the identification of the 20 ft half container or its weight between either the Deck Foreman, crane operator, Saipem's Material Man, or personnel on board the unit and ASTRO SIRIUS before it was connected to the hook.

35. At 1316, the crane operator lifted the 20 ft half container approximately 2 m above the deck of ASTRO SIRIUS and began moving it forward by luffing the boom.

36. At 1319, the half container fell onto ASTRO SIRIUS' deck. It landed about 6 m forward from where it had been loaded on the OSV *(see Figure 3)*. Within seconds, the cab with the crane operator inside, boom, and gantry of the starboard crane fell, landed on the OSV's port quarter, slid overboard, and sank in 50 m of water.

14 The cargo manifest indicates the size of the containers in ft.

15 All weights were listed on the cargo manifest in kg. To facilitate comparison to the load chart, they have been converted to MTs.

16 The unit's crewmembers conducting the cargo operations had not previously been aware that a personnel transfer would be conducted.

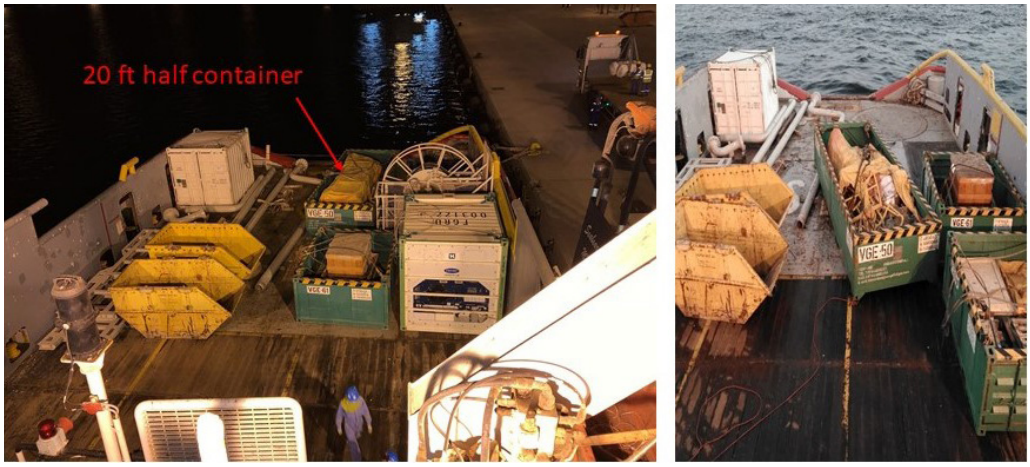

Figure 3: Aft deck of ASTRO SIRIUS showing the location of the 20 ft half container and reel (left) after being loaded on board at Ras Laffan, the State of Qatar for transport to SEAFOX DEEMA. The same 20 ft half container after it fell onto the deck (right).

37. The hook disconnected from the sling between the time that the container and crane fell onto the deck of ASTRO SIRIUS and when the crane sank.

38. None of the personnel who remained on board SEAFOX DEEMA after the crane fell or crewmembers on board ASTRO SIRIUS reported receiving any injuries.

39. The reel that was supposed to be transferred to SEAFOX DEEMA and the 10 ft empty container that had been offloaded to ASTRO SIRIUS during the first lift were pulled overboard by the boom as it slid off the OSV *(see Figure 3)*.

Incident Response

40. The General Alarm was sounded on both SEAFOX DEEMA and ASTRO SIRIUS immediately after the crane sank.

41. The OIM went to the Radio Room on board SEAFOX DEEMA and called ASTRO SIRIUS. After being informed that all the OSV's crewmembers were accounted for and that none had been injured, he asked the ASTRO SIRIUS's Master to launch their fast rescue boat to search for the crane operator.

42. The OIM then directed lookouts be posted to search for the crane operator. He also ordered the launching of SEAFOX DEEMA's fast rescue boat.

43. At 1326, the OIM notified the Panama-registered dive support vessel MERMAID ENDURER (IMO No. 9484778), which was operating in the area of the incident and requested assistance searching for the crane operator.

44. By 1330, both the unit's and OSV's fast rescue boats had been launched and began searching for the crane operator.

45. At 1346, MERMAID ENDURER had launched an ROV and started a sub-sea search for the crane operator. By 1600, the crane cab with the operator inside was located on the sea floor. It was reported the operator was deceased.

46. At 2021, the OIM contacted the Master of MERMAID ENDURER and requested assistance recovering the crane operator's body. Dive operations were started within approximately one hour.

47. At 2202, the crane operator's body had been recovered and was taken on board MERMAID ENDURER. The body was then taken ashore and repatriated.

Crane Pedestal Post-Incident Inspection

48. The lower section of the starboard crane pedestal along with the slewing gear and web plate remained connected to SEAFOX DEEMA after the incident. The pyramid structure[17] located at the top of the pedestal was missing *(see Figure 4)*.

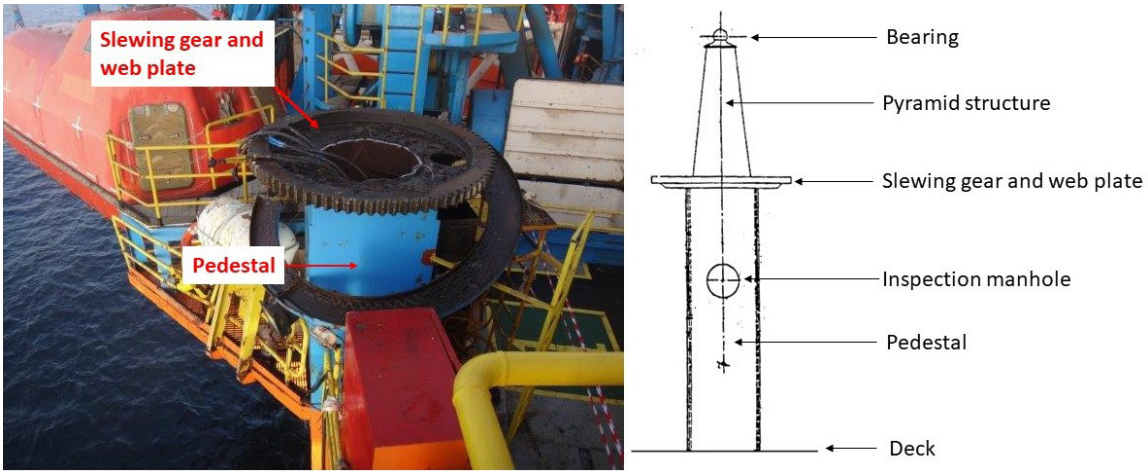

Figure 4: The starboard deck crane pedestal with slewing gear and web plate after the incident (left). A drawing of the pedestal showing the pyramid structure (right).

49. It was reported that a visual examination of the welds connecting the pedestal to the unit did not reveal any apparent cracks or other indications of weld failures.

50. The fracture occurred in the middle of the plates that had formed the pyramid structure just above the welds connecting the slewing gear and web plate to the pedestal. The visual inspection of the fracture surface identified an area that had been previously welded *(see Figure 5)*.

17 The bearing on which the crane's gantry structure, cab, and boom sits is located at the top of the pyramid structure, or kingpost.

Figure 5: Top of the remaining section of the pedestal and a close-up of the area where the weld was found. The welded area is circled in red.

51. The visual inspection also identified an area stained by grease, an indication of a possible crack *(see Figure 6)*.

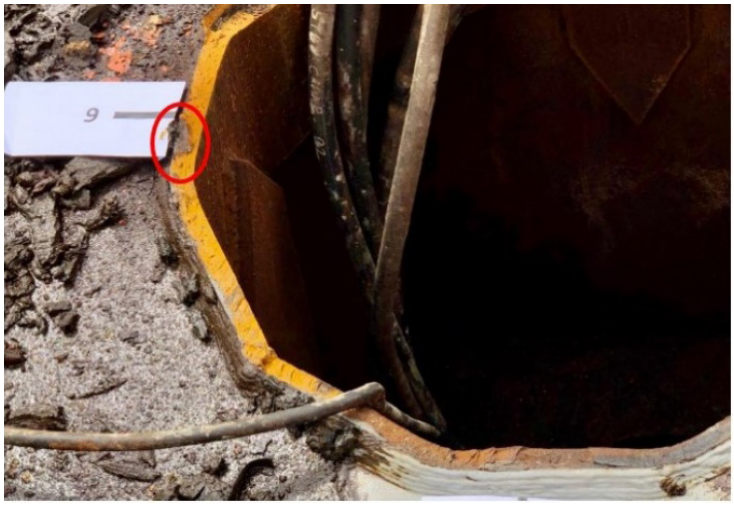

Figure 6: Top of the remaining section of the pedestal showing the area stained by grease (circled in red).

52. A review of the Operator's maintenance records for the starboard crane, since taking over operational responsibility for SEAFOX DEEMA in 2018, did not identify any reports of material failures or defects. Further, no malfunctions of the rated capacity indicator had been reported.

Post-incident Inspection of 20 ft Half Container and Loose Lifting Gear

53. The 20 ft container's weight was 7.7 MT when weighed after being offloaded after ASTRO SIRUS returned to port.

54. When the container was inspected after the incident, the four-leg bridle was found intact and connected to the four lifting eyes on the container's corners. No damage was observed on the lifting eye that had been connected to the crane hook.

55. The crane's luffing wires, hook, and lifting wire were found intact. No damage to the hook was reported.

Damage to ASTRO SIRIUS

56. ASTRO SIRIUS received relatively minor damage on the port side aft. This included damage to the deck plate on the port side between frames Nos. 10 and 15, a dent on top of the port side crash rail, and some scratches. In addition, the deck boards were damaged between frames Nos. 20 and 25 where the 20 ft half container landed.

Unit Personnel Experience and Qualifications

57. Neither the Deck Foreman nor the crane operator were part of the marine crew on board SEAFOX DEEMA and did not hold Republic of the Marshall Islands seafarer documentation.

58. The Deck Foreman had ten years of experience working in a supervisory role in the offshore industry and had been with the Operator for eight months. It was reported that he was experienced with lifting operations. He had most recently completed a basic rigger safety training course conducted by GL Industries in February 2020.

59. The crane operator had worked in the offshore industry for nine years and had been a crane operator for four years. He had been with the Operator for 11 months. He had completed International Association of Drilling Contractors approved training as a Grade I, Stage III operator[18] of fixed offshore cranes with a maximum capacity of 200 MT on 22 March 2019. This certificate was valid for one year and expired on 21 March 2020. He had also completed a basic offshore crane operator safety course conducted by GL Industries in April 2019.

Prior Cargo Operations

60. The starboard crane had last been used on 12 March 2020 when cargo operations were conducted with ASTRO SIRIUS. The manifest for this operation included two 20 ft containers with declared weights of 6.5 MT and 8 MT, two 10 ft containers with declared weights of 3 MT and 8 MT, two food containers each with a declared weight of 8 MT, a garbage skip containing spare parts that had a declared weight of 3 MT, and an empty garbage skip with a declared weight of 1 MT.

61. A review of manifests for cargo operations conducted in the four months prior to the incident all included loads that weighed between 8-10 MT, plus several other containers and items weighing less.

62. Personnel on board SEAFOX DEEMA and Masters of OSVs with which the unit operated reported that containers weighing between 8-10 MT had been loaded at the aft end of the OSVs. Unit personnel said that the operating radius of the crane was generally between 8-10 m when lifting these containers.

63. Unit personnel reported that the crane may have overloaded during some of these lifts. It was not reported if any overloads that might have occurred were due to the crane's SWL being exceeded based on the radius of the lift, or because the weight of the load being lifted exceeded the crane operator's unofficial adjustment for dynamic amplification factors.[19]

18 A person with a Grade I, Stage III qualification is permitted to operate a crane independently.

19 Dynamic amplification factors are forces that can act on a crane during a lift. These include forces imposed by motions of the vessel on which the crane is mounted, motions of the supply vessel, etc. See API Specification 2D, §§ 5.3 and 5.4.

64. Any overloads that might have occurred were not documented as required by the Operator's procedures, which are discussed later in this report. In addition, there is no record that the crane's structure was inspected, and the rated capacity indicator tested as required by the Operator's procedures after any of the overloads that might have occurred.

Crane Inspections

65. The cranes on board SEAFOX DEEMA were subject to regular inspections by the unit's crew.[20] These included daily visual inspections of the welds connecting the pedestal to the deck and the visible parts of the crane's external structure. The inspection records for the starboard deck crane did not indicate that any defects were observed during these inspections.

66. As required by the 1979 MODU Code, § 12.1.5 and the Republic of the Marshall Islands Mobile Offshore Standards (MI-293), § 6.11.1, the crane was subject to annual inspections and testing, as well as recertification inspections every five years. These inspections were conducted by DNV GL and its predecessor GL since 2009.

67. Since 2015, the cranes were also subject to regular inspections in accordance with Qatar Petroleum's Lifting Equipment Regulation (DOC No: QP-REG-Q-001, revision 5) and referenced standards.[21] These inspections were also conducted by DNV GL.

68. Only the exterior surfaces of the pyramid structure can be inspected or subject to NDT when the cab and gantry are in place. Inspections and NDT of the interior of the pyramid structure and the upper portion of the slewing gear and web plate can only be conducted when the cab and gantry are removed. Typically, this is only done every five years during recertification inspections. The last recertification inspection was conducted in 2015. There is no record of any defects having been observed during this inspection.

69. The most recent annual inspection of the unit's cranes was conducted by DNV GL on 5 May 2019. All three cranes were found in satisfactory condition. The next inspection was due 27 April 2020.

70. The last load test of the starboard crane was conducted on 8 May 2019 and witnessed by DNV GL.[22] During this test, a load of 125% of SWL was applied at a minimum radius of 9.1 m, and intermediate radius of 21.3 m, and a maximum radius of 27.4 m. The rated capacity indicator was also checked during this test. The crane was found satisfactory for further use.

71. In April 2019, eddy current testing[23] of the crane pedestal foundation welds and main structural connections was completed. No indications of defects were detected.[24]

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20 The planned maintenance included daily, weekly, monthly, semi-annual, annual, and five-year inspection and maintenance requirements.

21 The referenced standards included API's Specification 2C – Offshore Pedestal-mounted Cranes and Specification 2D – Operation and Maintenance of Offshore Cranes. GL Nobel Denton WLL is the contractor accepted by Qatar Petroleum for inspection of offshore cranes. Some of these inspections are documented on DNV GL forms, whereas load tests are documented using the legacy GL Industries logo.

22 Satisfactory load tests at 125% of SWL were conducted as part of the five-year recertification inspection in 2015 and again in 2016 and 2017.

23 Eddy current testing is a form of NDT that employs electromagnetic induction to detect flaws in the material being examined. It can also be used for a variety of other purposes, including material and coating thickness measurements, material identification, and establishing the heat treatment condition of certain materials.

24 Eddy current testing of these joints were also conducted as part of the recertification inspection completed in 2015, 2016, and 2018. No defects were reported.

72. On 20 February 2020, representatives of Sparrows Offshore Group Limited (hereinafter, "Sparrows") attended SEAFOX DEEMA to conduct an evaluation of the unit's cranes. This evaluation included a review of available certificates, reports of testing and inspections, and a detailed inspection of the cranes.

73. Findings that were noted during Sparrows inspection of the starboard deck crane included that there was wear on the slewing gear teeth and pinion that was causing the crane to jerk while being slewed and that the calibration certificate for the rated capacity indicator was not available on board.[25] An internal inspection of the pedestal and pyramid was not conducted since an Enclosed Space Entry Permit was not available during the time that the Sparrows' representatives were on board the unit.[26]

74. It was recommended that NDT of the interior and exterior of the pyramid structure be conducted during the five-year recertification inspection.

Operator's Procedures

75. The Operator's procedures for lifting operations provided general guidance to ensure they are conducted safely.[27] Among other things, these procedures require:

    (a) preparing load lift plans;

    (b) identifying planned travel paths of loads and laydown areas;

    (c) erecting barriers around the planned work area;

    (d) verifying existing environmental conditions are within safe operating parameters;

    (e) using proper PPE;

    (f) proper communications (use of radio and hand signals); and

    (g) completing pre-lift visual examinations of the crane's foundation and testing its controls.

76. These procedures also require holding a Toolbox Talk to discuss the Operator's generic risk assessment for crane operations involving transfers to and from a supply vessel, and preparation of task specific risk assessment.

77. The Operator's procedures also require that overloads be reported, that the crane be inspected, and the rated capacity indicator tested after any overloads.

78. The Operator's procedures did not establish requirements for managing dynamic amplification factors.

79. The Operator's generic risk assessment for crane operations involving transfers to and from a supply vessel identifies common risks associated with each step that needs to be completed and the required control measures. It also includes mitigation measures to be taken if something goes wrong.

80. Risks associated with using a crane to conduct operations with an OSV and required controls that are identified on the generic risk assessment are as follows:

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25 The rated capacity indicator had last been calibrated in 2016. Other findings included that proof certificates and inspection reports were not available on board and that it needed general maintenance.

26 The report did not document the reason why the referenced permit was not available.

27 Because SEAFOX DEEMA is a non-self-propelled unit, the requirements of the IMO's ISM Code are not applicable.

Risks	Required Controls
• Crane failure/breakdown • Equipment failure • Overload/shock loading • Collision with surrounding obstacles/ obstructions • Environmental conditions • Crane wire snagging on OSV	• Pre-use inspections of the crane and functional checks of its safety devices, including the AOPS and MOPS for sea state lifting, by the crane operator • Operation of the crane in a safe and controlled manner and in accordance with the manufacturer's instructions • Determination by the crane operator that the wind speed, sea state, and visibility are within safe operating parameters • Adhering to the lifting plan and Toolbox Talk while conducting the operation • Never exceeding the SWL/rated capacity of the crane and lifting equipment • Maintaining proper communications between the crane operator and the Deck Foreman

81. The generic risk assessment does not include lifting loads that are not included on the cargo manifest or lifting loads with an unknown weight as risks associated with crane operations.

82. Nor do the controls for addressing risks associated with crane operations include a requirement for the Deck Foreman and Crane Operator to check the item and its weight against the cargo manifest before lifting it.

83. An additional risk not addressed by the generic risk assessment is conducting lifting operations with a crane not fitted with safety devices such as an AOPS or MOPS, or both.

Manufacturer Service Letters

84. On 26 November 2001, the manufacturer issued service letter SIL M-113, that was applicable to its PCM-120-AS cranes.[28] The letter was issued after cracks in the weld connecting the slewing gear plate to the pedestal had been identified during an inspection of a 20-year old crane. The stated cause of these cracks was fatigue. It was noted that these cracks could cause a potentially catastrophic failure.

85. The manufacturer recommended that owners of PCM-120-AS cranes more than 15 years old have them inspected by ABS. It was also advised that the inspection would consist of a visual exam and magnetic particle testing to the extent the weld connecting the pyramid structure to the pedestal was accessible.

86. On 28 January 2002, the manufacturer issued a second service letter, SIL M-114 recommending that all PCM-120-AS cranes be subjected to external and internal magnetic particle testing and internal ultrasonic testing during an inspection conducted by ABS. The letter included an inspection procedure detailing the locations where this testing should be conducted. It did not indicate if these inspections should be conducted on a recurring cycle. It also included guidance for installing a manhole in the pedestal so that the internal inspections could be conducted.

28 As previously stated, it was an RD-80 AS model crane that failed on board SEAFOX DEEMA.

87. In the second letter the manufacturer also recommended that cranes be de-rated pending completion of the recommended inspections and any repairs that might be necessary. The de-rated load chart included with the service letter represented a 34% reduction of the original SWL.

88. Following the failure of the starboard crane on board SEAFOX DEEMA, the manufacturer informed the unit's Operator that the recommendations in these service letters could also apply to RD-80 AS cranes since the design of the pedestal and pyramid was similar to the PCM-120-AS crane design.[29] The manufacturer did not say why the service letters mentioned only the PCM-120-AS cranes.

89. During the post-incident inspection, it was observed that the manhole discussed in service letter SIL M-114 had been installed in the starboard crane pedestal. During this inspection, it was also observed that the weld material and possible crack *(see Figures 5 and 6)* were in the areas discussed in the service letters.

PART 3: ANALYSIS

The following Analysis is based on the above Findings of Fact.

Crane Failure

The cab, gantry, and boom of SEAFOX DEEMA's starboard deck crane, along with the suspended load, fell onto the aft deck of ASTRO SIRIUS during a routine offboard lift. The cab with the operator still in it, gantry, and boom slid off the deck of ASTRO SIRIUS and sank in 50 m of water. The crane's hook disconnected from the load sometime between when the crane fell on the OSV's deck and when it slid overboard.

When inspected after the incident, the four-leg bridle was found intact and connected to the four lifting eyes on the container. No damage was observed on the lifting eye that had been connected to the crane hook. Further, the crane's boom, luffing wires, hook, and lifting wire were all found intact. This indicates that the failure originated in the pedestal rather than in another structural component such as the loose lifting gear.

The pedestal sheared off just above the slewing gear and web plate *(see Figures 4 and 5)*. This is an area where the crane's manufacturer had previously determined that a different model crane with a similar design was prone to fatigue cracking that could cause a potentially catastrophic failure. The manufacturer made this determination after cracks were found during an inspection of a 20-year-old crane.

Based on the inspection of the pedestal following the incident, indications of a prior repair and a possible crack were found at different locations on the fracture surface *(see Figures 5 and 6)*.

Crane Design and Construction

The starboard pedestal crane was designed and built in accordance with the standards that were applicable when SEAFOX DEEMA was constructed in 1966. Factors such as minimum life cycle or forces associated

29 Although the general designs were similar, the manufacturer did indicate that the there were differences in the shape of the pyramid structure, the thickness of the steel plate, and the diameter of the bearing located at the top of the pyramid.

with dynamic amplification factors, horizontal loading, and angular lead loading were not required, nor were they taken into consideration during the design of the crane. Current industry standards require that such factors be taken into consideration during the design of pedestal mounted cranes intended for use on offshore structures.

No modifications are known to have been made to the crane's structure since it was installed on board the unit.

Inspections

Although the starboard crane on board SEAFOX DEEMA received regular inspections by the unit's crew and third-party inspectors, there is no indication that these inspections included periodic detailed inspections or NDT of the pyramid structure above the slewing gear. Further, after the starboard pedestal crane failure the Operator was informed by the crane's manufacturer that the service letters they had issued when cracks were identified on a PCM-120-AS crane could also apply to RD-80 AS cranes. There is no indication that DNV GL was previously aware that these service letters could also apply to RD-80 AS cranes.

Based on the information available, third-party inspectors did not note the fact that the load chart posted in the cab of the starboard crane did not include SWLs for onboard and offboard lifts.

Operator's Procedures and Risk Assessment

The Operator's procedures for lifting operations provided general guidance for ensuring they are conducted safely. They did not include procedures for managing dynamic amplification factors. The crane operators on board SEAFOX DEEMA stated that they would account for dynamic amplification factors when conducting offboard lifts by dividing in half the SWL for the radius at which the lift would take place. However, the crane operators also stated that dynamic forces were not considered as a critical element during lifting operations.

The Operator's generic risk assessment for lifting operations did not identify lifting loads not included on the cargo manifest or lifting loads with an unknown weight as a risk associated with lifting operations. Similarly, it did not include a prohibition against lifting unidentified loads or loads with an unknown weight as a required control.

As stated previously, the 20 ft half container that was being lifted when the starboard crane failed was not included on the manifest for the cargo operations being conducted between SEAFOX DEEMA and ASTRO SIRIUS on 16 March 2020. Further, there is no indication that any of the personnel on board the unit recognized the risk associated with lifting this container before it was connected to the crane's hook.

The Operator's generic risk assessment addressed the use of cranes not fitted with safety devices such as an AOPS, MOPS, or both as an additional risk associated with crane operations.

Although the Operator's procedure and controls included on the generic risk assessment address the need for maintaining good communications between the Deck Foreman and the crane operator, neither included

a requirement for the Deck Foreman and crane operator to check the item and its weight against the cargo manifest before lifting it.

The Operator's procedures required that overloads be reported. They also required that the crane's structure be inspected, and the rated capacity indicator tested after any overloads that might occur. Although unit personnel reported that some overloads might have occurred during lifting operations conducted on SEAFOX DEEMA, there is no indication that any of these were reported, that the crane was inspected, or that the rated capacity indicator was tested afterwards.

Crane Operations

The cargo operations planned for 16 March 2020 were considered routine. A load plan with the sequence and laydown area for each lift was not prepared in advance as required by the Operator's procedures for lifting operations.

The three lifts that were completed without incident and the lift being made when the incident occurred were all offboard or dynamic lifts. This is because they involved lifting a load from or to another vessel rather than between different locations on board SEAFOX DEEMA. A summary of each of these four lifts is shown in the following table:

Lift No.	Description	Weight (MT)	Lifting Radius (m)	SWL on Load Chart (MT)	SWL Adjusted for Dynamic Factors (MT)*
1	10 ft empty container	Not reported	10	17	17
2	10 ft food container	10	20	10.6	10.6
3	10 ft half container	6	20	10.6	10.6
4	20 ft half container	5.5†	22	8.4	8.4
		7.5±	22	8.4	4.2

* *Based on correction factor reportedly used by crane operators to account for dynamic forces.*

† *Weight of container with tag No. VGE-57 that was declared on cargo manifest.*

± *Actual weight of container with tag No. VGE-50 that was being lifted. This weight was determined when the container was weighed after being offloaded at Ras Laffan, State of Qatar.*

Given the empty weights of the 10 ft half container (1.7 MT), the 10 ft food container (2.1 MT), and the 20 ft half container (4 MT),[30] the empty 10 ft container that was offloaded to ASTRO SIRIUS during the first lift would not have exceeded the crane's SWL, even when adjusted to account for dynamic forces. Although none of the last three lifts exceeded the SWL on the load chart, they all exceeded the crane's SWL when adjusted for dynamic forces using the correction factor reportedly used by the unit's crane operators.

The tag number of the container being lifted when the crane failed was VGE-50. The cargo manifest for the cargo operations being conducted between SEAFOX DEEMA and ASTRO SIRIUS did not include a

30 The empty weights of these containers can be seen in Figure 3 when it is enlarged.

container with this tag number. Only 20 ft half container listed on manifest had tag number VGE-57. The declared weight of this container was 5.5 MT.

Based on the available information, there is no indication that the Deck Foreman, crane operator, or Saipem's Materials Man recognized that the container, VGE-50, was not included on the cargo manifest before it was connected to the crane's hook. Similarly, there is no indication that there were any communications between the personnel on board the unit and the OSV's crew that this container was not on the cargo manifest before it was connected to the hook.

It is not known if the crane operator checked the crane's rated capacity indicator (or safe load indicator) to verify the 20 ft half container's weight when starting the lift.

Given the available information, the cargo transfers conducted in the four months before this incident included containers weighing 8-10 MT. It was reported that these containers had been loaded on the stern of the OSVs with which these lifting operations were conducted. The lifting radius was 8-10 m. The crane's SWL at these radii was 17.0 MT. These would have been offboard lifts and each container that weighed more than 8.5 MT would have exceeded the crane's SWL when adjusted for dynamic forces using the correction factor reportedly used by the unit's crane operators.

PART 4: CONCLUSIONS

The following Conclusions are based on the above Findings of Fact and Analysis and shall in no way create a presumption of blame or apportion liability.

1. Causal factors that contributed to this very serious marine casualty include:
   (a) the Operator's procedures for lifting operations did not establish requirements for managing dynamic amplification factors when making offboard lifts;
   (b) the Operator's generic risk assessment for lifting operations did not include the following hazards:
      (i) lifting loads not listed on the cargo manifest;
      (ii) lifting loads with an unknown weight; and
      (iii) using cranes not fitted with safety devices such as an AOPS or MOPS;
   (c) that neither the Operator's procedures nor the generic risk assessment for lifting operations included a requirement for the deck foreman and crane operator to check the item and its weight against the cargo manifest before lifting it;
   (d) the load chart posted in the cab of the starboard crane did not include SWLs for onboard and offboard lifts;
   (e) ineffective onboard implementation of the Operator's procedures for lifting operations, as indicated by:
      (i) a load lift plan not being prepared for the cargo operations;

(ii) overloads that may have occurred during prior lifting operations were not reported; and

(iii) no record that the crane's structure was inspected, and the rated capacity indicator was tested, as required by the Operator's procedures following any overloads that might have occurred; and

(f) ineffective onboard hazards identification and management when planning and conducting lifting operations, as indicated by:

(i) the fact that a container not listed on the cargo manifest was connected to the crane's hook and lifted; and

(ii) the apparent lack of communications between the deck foreman, crane operator, and Saipem's Materials Man to confirm the container tag number and weight before connecting it to the crane's hook and lifting it off the OSV's deck.

2. Additional causal factors that may have contributed to this very serious marine casualty include:

(a) the crane manufacturer had not indicated in its service letters addressing the potential for cracks to develop in the upper pedestal near the slewing gear and web plate of cranes similar in design and construction to the starboard crane could also apply to the starboard crane until after it failed; and

(b) potential material fatigue related to the age of the crane.

PART 5: PREVENTIVE ACTIONS

In response to this very serious marine casualty, the Operator has taken the following Preventive Actions.

1. Reviewed and revised the standard operating procedures for lifting operations on board self-elevating units. The revisions included guidance to address dynamic amplification factors.

2. Reviewed and revised the risk assessments for lifting operations to better address overload hazards. The revisions included addressing lifting unidentified loads and loads with an unknown weight.

3. Posted load charts in the cabs of all cranes on board all units in the Operator's fleet that include the SWLs for onboard, offload, and critical lifts.

4. Conducted a risk assessment to evaluate the risk of fatigue in crane structures similar to the PCM-120-AS and:

(a) identified appropriate mitigation measures; and

(b) reviewed and revised the inspection cycles and their scope during periodic inspections to incorporate the identified mitigation measures and establish a maximum period between fatigue analysis evaluations and NDT of crane structures.

5. Reviewed cranes on board other units in its fleet to identify other designs that might be susceptible to hidden structural damage.

6. Established and implemented a plan to improve safety culture on board its units and the onboard personnel's understanding of hazards during lifting operations.

7. All OIMs and crane operators were briefed regarding the importance of setting maximum operating limits before conducting lifting operations.

8. Reviewed and revised checklists for lifting operations to reduce the potential incorrect operation of cranes.

9. Distributed a lessons learned circular addressing hazards during lifting operations that was distributed to all units in its fleet for discussion during on board safety meetings.

PART 6: RECOMMENDATIONS

The following Recommendations are based on the above Conclusions and in consideration of the Preventive Actions taken by the Operator and DNV GL.

1. It is recommended that DNV:[31]

   review and, as deemed appropriate, revise its inspection procedures considering the causal factors that were identified as having contributed or may have contributed to this very serious marine casualty.

2. It is recommended that the Administrator:

   recommend that operators of Republic of the Marshall Islands-registered MOUs constructed before the adoption of industry standards requiring factors such as minimum life cycles and dynamic loading, be considered during the design of pedestal-mounted cranes for use on offshore structures and consider taking the following actions to:

   (a) contact the crane manufacturer to obtain any pertinent safety bulletins or service letters and ensure copies are available on the unit;

   (b) request the unit's Classification Society or competent third-party assess the structural condition of the crane and its pedestal, including kingpost with specific attention given to areas of the pedestal structure where visual inspections are difficult or that cannot be accessed routinely;

   (c) incorporate recommended measures, including periodic NDT, received from the manufacturer, the Classification Society, or competent third party into the MOU's preventative maintenance and inspection system; and

   (d) review with OIMs, crane operators, and other personnel who may be involved in planning or conducting lifting operations the importance of conducting lifting operations according to the established procedures and manufacturer's recommendations to reduce the potential for structural failures.

The Administrator's marine safety investigation is closed. It will be reopened if additional information is received that would warrant further review.

31 On 21 March 2021, DNV GL's name was changed to DNV.