Final Report

FATALITY OF CRANE OPERATOR ONBOARD JACK-UP RIG WEST COURAGEOUS IN THE GULF OF MEXICO ON 24 NOVEMBER 2022

TIB/MAI/CAS.136

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

31 January 2024

The Transport Safety Investigation Bureau of Singapore

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SYNOPSIS

On 24 November 2022, the Singapore registered jack-up rig, West Courageous (WC), was in operating condition at the well location of Maloob I with all three of the retractable legs supported on the seabed. The no.1 deck crane was used to lift bundles of casings from the deck of a workboat to the deck of WC.

A crane operator (OP1) was operating the crane from its cabin for his first lift after taking over from the out-going crane operator (OP2). The upper section of the crane broke off together with crane cabin (with the OP1 in it), machinery and boom and fell into the sea when raising the lift for about half meter above the deck of the workboat. The OP2, who was outside the crane cabin, was also thrown into the sea.

The OP2 was sighted in the water and recovered and sent to shore for medical treatment. The OP1 was recovered from the seabed after five hours and was pronounced dead.

The Transport Safety Investigation Bureau classified the occurrence as a very serious marine casualty.

The metallurgical examination on the remaining part of the pedestal of no. 1 crane revealed a single pass weld of about 20cm long on the pedestal. The preliminary findings from the metallurgical analysis indicated that the pedestal had likely failed due to a fatigue initiated at the toe of the single pass weld which acted as a stress. The 20cm single pass weld was covered by the welded conical housing and was not visible during the daily checks by the crane operators. It was also untraceable as to when the single pass weld was made onto the pedestal of no. 1 crane.

There were five defects discovered on the no.2 and no.3 crane onboard the WC during the post-occurrence damage survey. These defects were not known to the Company and the classification society prior to the incident.

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DETAILS OF VESSELS

Name	West Courageous	Nautla
IMO number	8768452	9394533
Flag registry	Singapore	Mexico
Classification society	American Bureau of Shipping (ABS)[1] / Det Norske Veritas (DNV)[2]	ABS[3]
Ship type	Jack-up rig	Offshore supply vessel
Hull	Steel	Steel
Delivery	2007	2008
Owner/ ISM Manager[4]	Seadrill Courageous De Mexico S. De R.L. / Seadrill Management Ltd.	Bourbon Tamaulipas SA DE CV / Bourbon Tamaulipas SA DE CV
Gross / Net tonnage	7079 / 2123	1517 / -
Dimensions	90.7m (length overall) x 62.8m (breadth) x 7.9m (depth)	57.9m (length overall) x 14m (breadth)
Maximum drilling depth	9144m	N.A.
Legs	3 x 145.4 m square truss / 128 m useable below hull	N.A.
Propulsion	Non-self-propelled	Self-propelled, oil engine(s), electric drive

[1] As per the international management code for safe operation of ships and for pollution prevention – ISM Code, ABS was the Recognised Organisation (RO) for carrying out ISM audit for the vessel and issuance of the Safety Management Certificate, as well as for survey and issuance of other statutory certificates.
[2] DNV was also the RO for carrying out ISM audit for the Company and issuance of Document of Compliance certificate.
[3] ABS was the RO for carrying out ISM audit and issuance of ISM related certificates, as well as for survey and issuance of other statutory certificates.
[4] The “ISM Manager” is referred to as the Company in this investigation report.

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West Courageous
(*Source:* the Company)

Nautla (work boat)
(*Source:* MarineTraffic.com)

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1 FACTUAL INFORMATION

All times used in this report are ship's mean time of West Courageous which was six hours behind the UTC (UTC - 6), unless otherwise stated.

1.1 Sequence of events

1.1.1 On 24 November 2022, the Singapore registered jack-up rig, West Courageous (WC) was in an operating condition[5] at the well location of Maloob I[6], with all three of her retractable legs supported on the seabed. The port side forward deck crane (no.1 crane) was being used to lift bundles of casings[7] from the deck of a Mexican registered work boat, Nautla to the deck of WC.

1.1.2 At about 1743H, the crane operator (OP1) was operating the no.1 crane from its cabin for his first lift after taking over from the out-going crane operator (OP2). When raising the lift for about half meter above the deck of the work boat, the upper section of the crane's pedestal broke off[8] and fell into the sea (see **figure 1**) together with the crane cabin with the OP1 in it.

Figure 1 – View of the remaining lower section of the no.1 crane
(*Source*: the Company)

[5] The Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1989 (the MODU Code). The condition defined in the Code refers to WC at the location for the purpose of conducting drilling operations.
[6] Latitude 19° 35' 07" N and longitude 092° 13' 71" W within the territorial waters of Mexico.
[7] Pipes to be installed in the wellbore and usually cemented in place to retain the borehole dimension and to seal off hydrocarbon and water-bearing formations.
[8] The part of the pedestal broke off included the crane cabin, machinery, and boom.

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1.1.3 The OP2, who was standing outside the crane cabin and about to make his descent from the vertical ladders (see **figure 2**) was also thrown into the sea.

Figure 2 – location of the OP2 referencing to the crane cabin
(*Source*: the Company)

1.1.4 Witnesses[9] working on the deck of WC heard a loud sound as the upper section of the crane fell into the sea and the crane lifting cable became taut before parting soon after. The Offshore Installation Manager (OIM) of WC was notified who in turn activated the emergency alarm for man overboard[10] (MOB) and followed with an announcement for all personnel to muster on deck for a headcount.

1.1.5 Lookouts on the WC were then posted, and lifebuoys were also deployed into the sea in accordance with established MOB procedures. The radio operator on WC made distress broadcasts about the MOB incident over the VHF (very high frequency) radio on channel 16 and requested for search and rescue assistance. Eight vessels[11] which were within 3nm, responded to the distress

[9] Two roustabout who were handling the loads on deck and an assistant crane operator.
[10] A combination of a visual alarm of purple colour flashing light, and the audible alarm consisting of two short different tones.
[11] The Nautla, Don Rodolfo (also an offshore supply vessel), a diving boat Azteca which was supporting the WC and five other commercial vessels.

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call.

1.1.6 The offshore supply vessel Don Rodolfo (DR) which was the closest to the WC responded to the emergency, sounded its general alarm[12], and made an announcement to move all non-essential personnel onboard to muster in its galley.

1.1.7 After the WC notified that the OP1 an OP2 were missing, the DR proceeded to the incident location to look for the missing crew.

1.1.8 At about 1815H, the OP2 was sighted in the water and was recovered by the DR. A medical team was transferred from the WC to the DR and assessed the OP2 as conscious but in a weak condition. A helicopter medivac was then activated while the OP2 was being transferred to the WC. By about 1845H the OP2 was evacuated from the WC by the helicopter to shore for medical assessment and treatment[13].

1.1.9 The search for the OP1 continued by surface assets and underwater by a diving boat. At about 2254H (about five hours after the occurrence), the divers located the OP1 outside the crane cabin which was on the seabed (at a depth of about 80m). The OP1's body was recovered from the water at about 0320H on 25 November 2022 and pronounced dead by the medical team. The OP1's body was thereafter transferred ashore.

1.2 Experience and qualification of relevant personnel

Onboard the WC

1.2.1 There were 45 crew and 38 industrial personnel[14] onboard the WC. The working languages were English and Spanish[15].

1.2.2 The experience of the relevant personnel onboard the WC are tabulated in the table 1 below.

[12] Continuous short rings with very short periods between.
[13] The OP2 suffered mild to moderate traumatic brain injury, grade II cervical sprain and right shoulder sprain and was discharged on 30 November 2022.
[14] Non-maritime crew workers who are transported or accommodated onboard for the purpose of offshore industrial activities performed onboard other ships and/or offshore facilities.
[15] To cater to the area of operation and that majority of the persons were Mexican.

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Designation onboard	Nationality	Age	Duration onboard (day)	In rank service (Year)	Service in Company (Year)	Working schedule onboard
Offshore Installation Manager (OIM)	North American	50	2	3.9	15	0600-1800
Technical Section Leader (TSL)	Canadian	40	16	3	9	0600-1800
Marine Section Leader (MSL)	Mexican	42	2	3	11	0600-1800
Crane Operator 1 (OP1, deceased)	**Mexican**	**36**	**9**	10	0.42	**1800-0600**
Crane Operator 2 (OP2)	Mexican	38	2	17	8	0600-1800
Assistant Crane Operator (ACO)	Mexican	51	10	12	6	0000-1200
Roustabout 1	Mexican	39	10	13	1	0000-1200
Roustabout 2	Mexican	30	2	3	3	0600-1800

Table 1

1.2.3 The OIM was overall responsible for the health, welfare, and safety of the personnel onboard the installation (WC). The OIM was also responsible for ensuring compliance with the flag administration and classification society requirements.

1.2.4 The MSL was overall responsible for the lifting operations onboard the WC. The TSL was responsible for ensuring implementation of the established maintenance program for all fixed lifting equipment. Both MSL and TSL were reporting to the OIM on matters relating to the lifting operations and equipment respectively.

1.2.5 The crane operators were responsible in taking charge of and ensuring the safety of each lift, planning each lifting operation, selecting appropriate lifting gear, ensuring the lifting appliance and lifting gear were in good condition in accordance with maker's instructions for use, specifications and intended use.

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1.2.6 The OP1 was medically fit (as declared upon boarding the WC) and had been medically certified for his role onboard the WC. The Company was not aware of the OP1 being under any prescribed medicines.

1.2.7 The OP1 had attained various qualification[16] to perform work as an offshore crane operator in the industry. The OP2 too is a qualified crane operator.

1.2.8 Both the roustabouts were deckhands, who were responsible to carry out tasks of the slinger and/or banksman in lifting operations. Both were assisting the OP1 from the deck of WC at the time of occurrence.

Onboard Nautla

1.2.9 The work boat was hired by the client[17] of the Company to provide logistics services[18] to the WC and other jack-up rigs in the area. The details of the crew onboard the workboat was not made available to the investigation team.

1.3 The jack-up rig

1.3.1 The WC is an independent leg cantilever jack-up rig with operational history in the Gulf of Mexico, built by the Keppel AmFELS, Inc. to accommodate 110 persons onboard. The WC is classed as a self-elevating drilling unit with an additional notation of CRC[19]. According to the Company, there were no conversions or modifications carried out to the rig including the three deck cranes, since its delivery in 2007.

1.3.2 At the time of occurrence, the WC was elevated to a normal drilling operation height of 25.6m above the water level known as the working air gap (see **figure 3**).

[16] Basic Training Course for Rigs and Mobile Offshore Units (in December 2019), RigPass (in January 2020), Working at heights (in December 2021), Offshore Crane Operator Certificate (in December 2021), Crane Operator Certificate (in August 2022) and Maintenance and Operations of Electrical Installations (NOM-022-STPS and NOM-029-STPS, in November 2022).
[17] Pemex.
[18] At the time of the occurrence, the Nautla was carrying casings to be supplied to the WC.
[19] Crane Register Certificate, this optional notation given by the ABS signified that the vessel's crane(s) is designed and constructed in accordance with Chapter 2 of the ABS Guide for Lifting Appliances.

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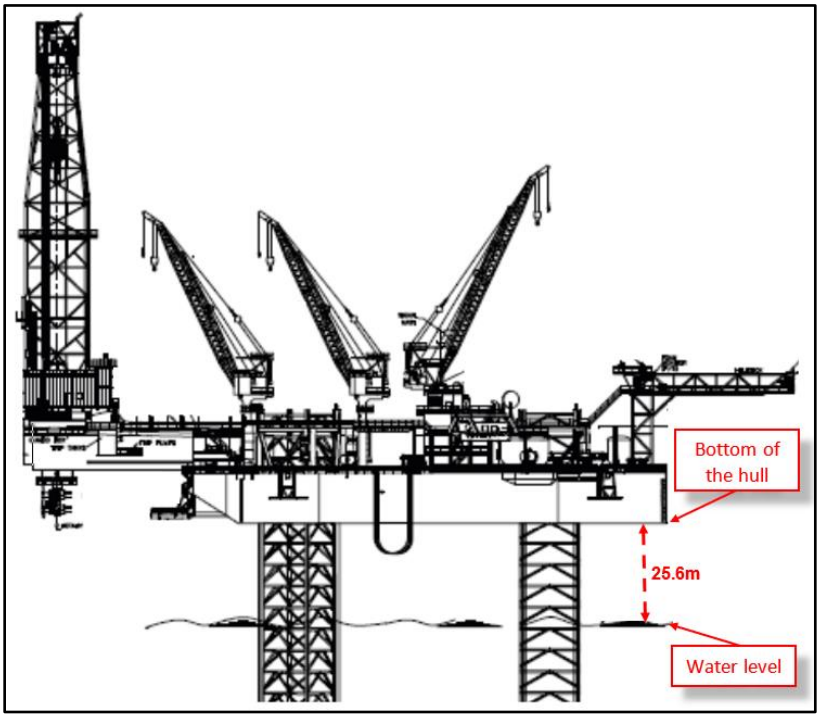

Figure 3 - Side view of the WC taken from the “Outboard Profile Starboard Elevation” plan showing the air gap (from water level to the bottom of the hull)
(*Source*: the Company, annotated by TSIB)

1.4 The deck crane and pedestal

1.4.1 The WC had three heavy duty rated free standing deck cranes (installed from third-party), model PCM-120SS, which were electrically operated and controlled for material handling and hoisting operations. Hoisting, swinging and luffing of the cranes were controlled by solid state controls which provided the crane operator with quick response to commands. The cranes were powered by individual electric DC motor which drove through their respective gear reduction units. The hook, boom and auxiliary machinery were equipped with hydraulically operated disc brakes to hold their respective motions in place. Each crane motion was provided with overtravel protection.

1.4.2 The three cranes were installed at the time of its construction by the shipyard. Two were located on the port side main deck, each at the forward (no.1 crane) and aft (no.2 crane) positions, and the third was at mid-starboard side (no.3 crane) (see **figure 4**).

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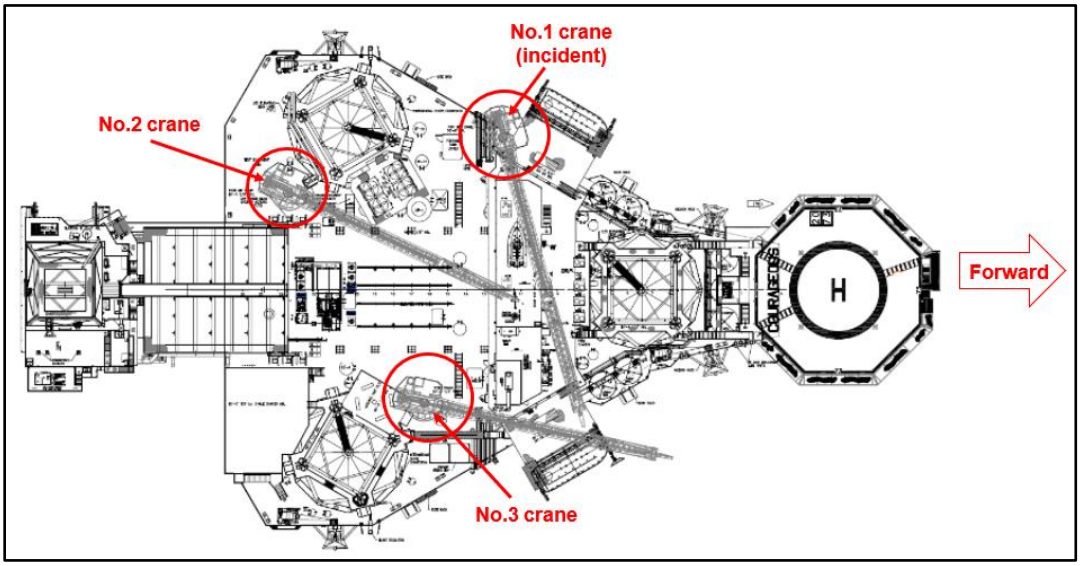

Figure 4 – Deck view of the WC taken from the "General Arrangement Top Plan" (*Source*: the Company, annotated by TSIB)

1.4.3 The specifications of the three cranes[20] are as per table 2.

	No.1 crane	No.2 crane	No.3 crane
Location on board	At main deck port forward between frames 11-13	At main deck port aft between frames 23-24	At main deck mid-starboard between frames 16-17
Make	LeTourneau	LeTourneau	LeTourneau
Model	PCM-120SS	PCM-120SS	PCM-120SS
Serial No.	PC12023	PC12021	PC12022
Description of gear	Pedestal mounted, electric revolving crane with 120ft (36.58m) boom rated for 37.8mt at 7.6m radius	Pedestal mounted, electric revolving crane with 100ft (30.48m) boom rated for 44.6mt at 6.7m radius	Pedestal mounted, electric revolving crane with 100ft (30.48m) boom rated for 44.6mt at 6.7m radius
Date last test and examination by ABS	02 June 2022	02 June 2022	02 June 2022
Total running hours as on 23 November 2022	93584 hours	87808 hours	87756 hours

Table 2 – Specification of the deck cranes

[20] The total running hours of no.1 crane was about 6% more than no.2 and no.3's due to the longer boom length (120ft) and proximity to the side of the hull which provided better visibility.

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1.4.4 The height of the no.1 crane's pedestal from the main deck to the top of pedestal was 14m. The pedestal was a carbon steel pipe of 48 inches (≈1.2m) diameter and 1.25 inches (≈3.1cm) wall thickness, containing a double submerged arc welded longitudinal seam.

1.4.5 The crane cabin was provided with an alarm system which included electrical power failure and limit switch indication[21]. The control panel for no.2 crane (same design as the incident crane) is shown in **figure 5**, which included an emergency stop button (11) and an emergency hoist release button (7) to immediately stop the lifting operation. Limit switch alarm indicator would provide aural warning to the crane operator, e.g. boom angle radius and boom limit switch activated.

No.	Description of the selections or controls
1	Load rating chart for the crane (with maximum permitted loadings specified)
2	SWL onboard lifts at different boom angle and working radius
3	Swing joystick control to left or right
4	Hoist lower or raise joystick control
5	Boom lower or raise joystick control
6	Hoist selection – main or auxiliary
7	Emergency hoist release
8	Limit switches
9	Drive system fail warning light (view blocked by the joystick)
10	Warning acknowledge switch
11	Emergency stop button
12	Digital SWL and warning indicator

Figure 5 – Layout of the control panel (inside the no.2 crane cabin)
(*Source*: the Company)

1.4.6 A digital safe working load (SWL) and warning indicator (12 in **figure 5**)

[21] According to the manual, this limit was set within the safe working load of the crane and provided a visual and aural warning to the operator in the cabin.

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installed on the left raised post next to the control panel was directly facing the crane operator. The SWL and warning indicator provided digital readings of hook load, curve, radius and SWL (see **figure 6**) to the crane operator. The crane operator could compare the digital readings with the load rating chart (1 and 2 in **figure 5**) to see if they were within limits. The white needle within the SWL and warning indicator provided direct analog indication on whether the lift was within or exceeded the SWL, e.g. the white needle in green zone (within SWL) and the white needle in red zone (exceeded SWL). The actual readings, or any alarms, preceding the occurrence were unknown to the investigation team as the cabin sank after falling into the water and had not been recovered by the time of publishing this report.

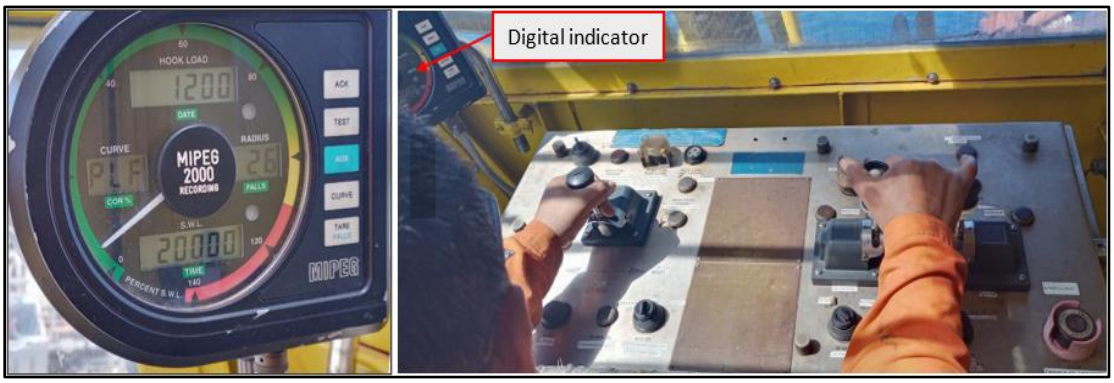

Figure 6 – View of the digital SWL and warning indicator (on the left) and reenactment of crane operator operating the crane while checking the indicator readings
(*Source*: the Company)

1.5 The lifting load and operation

1.5.1 At the time of occurrence, the Nautla was positioned at the port side of the WC (see **figure 7**).

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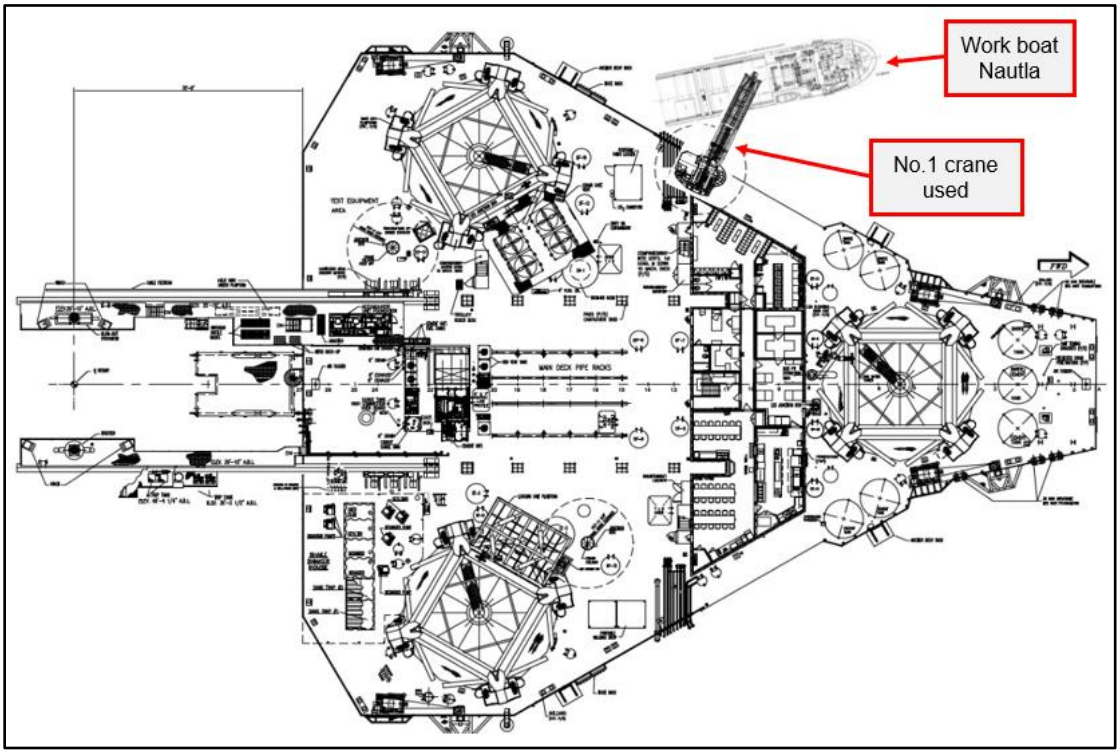

Figure 7 – Annotation of the Nautla's approximate position during the lifting operation using no,1 crane of WC (*Source*: the Company)

1.5.2 There were 266 pieces of casings to be lifted from the work boat onto the WC. The lifting arrangement was made to lift in bundles of three casings each time. Each pipe was about 0.3m[22] diameter x 14m[23] in length and weighed about 1500 Kg. The total weight of one bundle was about 4500 Kg. The whip line was used for the lifting operation.

1.5.3 The bundle of three casings were tied together by two wire slings at the ends (see **figure 8**), and the wire slings were then connected to the hook of no.1 crane for lifting onto the WC.

[22] 11-7/8 inches.
[23] 45.94 feet.

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Figure 8 – View of the casing bundles stowed onboard the Nautla
(Source: the Company)

1.5.4 For the lifting operation, visual and radio communication were established onboard the WC, where the assistant crane operator was providing hand signals to the crane operator. The roustabouts were assisting to handle the lift on deck.

1.5.5 The deckhand(s) onboard the Nautla used a tagline to guide the bundle of casings and coordinate with the assistant crane operator to facilitate the lifting operation. There were no communication issues reported between the WC and the Nautla prior to the incident for the lifting operation.

1.5.6 According to the Company, 21 lifts had been completed by the OP2 (out-going crane operator). At the time of incident, it was the first lift performed by the OP1 using the same no.1 crane. The lifting angle of no.1 crane boom was approximate 51 degrees[24] at the time of lifting the bundle of casings when the crane cabin dropped into the sea.

1.6 Relevant crane operating instructions

1.6.1 An Operating and Service Manual (Manual) for the crane was issued on 8 May 2012 by the crane manufacturer and approved by the Classification Society (CS), which contained information about the crane operating procedures such as pre-operation inspection. The Manual highlighted that, before the beginning

[24] Information given by the Company after obtaining from the witnesses and the OP2.

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of each day, the crane operator should perform the daily inspections, special attention should be placed on the following items:

- Visually examine the main and auxiliary hooks for deformation and function of the safety latch;
- Visually check all wire ropes for deterioration and damage;
- Visually check the crane for loose or missing bolts, pins, keepers or damaged sheaves;
- Check the operator's cabin or remote controls for the proper load chart for the particular crane;
- Check the weight and angle indicator for proper settings and function;
- For cranes equipped with load monitoring systems, be sure to check warning lights and horns.

1.6.2 The "Operator Functions" section of the Manual stated the various crane limits shown at the display panel that could be configured by users, such as the load, angle and radius limits and if the set limits are reached, audible alarms would sound and crane control system was to be shut-off.

1.6.3 According to the Manual, the crane was equipped with a load moment indicator[25] system to provide the operator with information necessary to safely operate the crane within the maximum permitted loadings specified on the Load Rating Chart[26]. The load moment indicator system functioned by monitoring the load applied to the crane and continuously comparing this load with the maximum permitted load for each crane position.

1.7 The safety management system

1.7.1 The Company managed only mobile offshore drilling units (MODU) registered with various flag Administrations, i.e. Bahamas, Norway, Panama and Singapore. The West Intrepid, West Oberon and WC were Singapore flagged MODUs. A full-term Document of Compliance was issued to the Company by DNV on 19 July 2021 based on an audit completed on 23 April 2021 and it was valid until 5 May 2026. The last annual verification audit for this issuance was

[25] Also known as rated capacity indicator which is a monitoring device to warn crane operator when the load lifted exceeds the crane manufacturer's allowed lifting capacity. It was installed above the item 12 in figure 5 facing the operator on WC.

[26] A pre-calculated chart provided by the crane manufacturer to illustrate the lifting capacity, which is dependent on factors like lifting range, boom angle, etc. and pasted on the crane cabin for easy reference of the crane operator. The chart helps the crane operator ensure that the crane does not exceed its lifting capacity.

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carried out on 8 April 2022.

1.7.2 The audit report of last annual verification on 8 April 2022 indicated the closure of four Non-Conformities (NCs) and six Observations, arising from previous audit on 23 April 2021, after verifying the corrective actions taken by the Company. The investigation team noted that one NC was related to the lack of resources and shore-based support to manage the NCs and overdue maintenance[27]. This NC was closed after the Company increased its oversight by the Operations Vice President and the use of dashboard to track shipboard maintenance status.

1.7.3 A full-term Safety Management certificate was issued by the CS to the WC on 14 December 2019, based on the audit completed on the same date and was valid until 12 December 2024. The last intermediate verification was conducted on 26 October 2022 at Campeche Oil Field, Mexico.

1.7.4 According to the flag Administration's records, there were no Flag State Control and Port State Control[28] inspections conducted in the past five years prior to the occurrence. There was no other exemption given to the WC under the MODU Code, except not requiring carriage of immersion suits[29] as the WC was operating between latitudes 30º north and 30º south. The Company shared a Port State Control inspection report on the WC issued by SEMAR[30] on 15 February 2022. The three deficiencies raised in SEMAR's report were not related to the deck cranes. The Company also shared one general inspection report[31] (in Spanish) carried out by its client, PEMEX Marine, on 16 August 2022.

1.7.5 The Company's Safety Management System (SMS) procedures had a section on "lifting operations", which set the minimum requirements for all lifting operations and the safe use of fixed, portable and loose lifting equipment. The Rig Manager and the OIM were responsible to ensure that these procedures were applied onboard the rig, in this case the WC.

1.7.6 One of the requirements for lifting operations was for checks to be conducted

[27] One of the MODUs (the WC was not being sampled) was sampled and presented 79 overdue planned maintenance items without associated risk assessment(s). There was lack of oversight by the management of these overdue items.
[28] No records were found from Tokyo MOU, Paris MOU, Caribbean MOU and Latin-America Agreement website.
[29] A protective suit which reduces the body heatless of a person wearing it in cold water. Immersion suit is required by the SOLAS Convention, Chapter III, Regulation 7, Personal life-saving appliances.
[30] Secretariat of the Navy in Mexico, the Unit of the Captain of the Port Office and Maritime Affairs.
[31] The inspection was not specific to the three cranes, but general condition of the WC.

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by users of the lifting equipment to ensure they are in a good condition before and after use. The checks consisted of a visual check of the lifting equipment, function test in accordance with maker's recommendations, including the emergency stop device. Any faults or defects were to be reported to the MSL and TSL.

1.7.7 A checklist on "Pre-use or Daily Walk Around Inspections and Services" extracted from the Operating and Service Manual was used by the Company, to guide the crane operator(s) to conduct the checks and to log down the date of the check. One of the items in this checklist was to check the general overall condition of the crane and support structure and to look for signs of damages. Log records for all three deck cranes sighted by the investigation team for the period between 15 and 24 November 2022 indicated that all items in the checklist were ticked "Okay" and no defects or faults were marked or required any attention.

1.7.8 According to the lifting operation procedures, the minimum number of personnel involved in a lift was three persons, and a task-based risk assessment (TBRA) was also required to be conducted. During the execution of a lifting operation, if there was a change in operational conditions or in the assumptions on which the risk assessment was based, the operation was to be ceased while a new risk assessment was being conducted and the necessary corrective or preventive safety measures were implemented.

1.7.9 The same lifting operation procedures also highlighted that each lifting operation shall be planned by personnel with relevant competence to ensure safe execution taking hazards into consideration.

1.7.10 The procedures further stated that a lift is categorised as either routine[32] or critical[33], with respective control measures in place. On the day of the incident, the lifting of casings was considered as routine which required a toolbox talk prior to the lift, review of a risk assessment (RA), identification of roles within the lifting team, and a re-assessment of the operation if there was any change in the lifting operation. A record of RA form sighted by the investigation team

[32] The definition of routine lift is to be within the normal parameters of the lifting equipment, the load has typical shape and configuration with appropriate centre of gravity, standard rigging arrangements, lifting over non-sensitive areas, in suitable environmental conditions and within operational skill level of the lifting appliance operator.
[33] Examples of critical lifts are lifting of personnel, heavy lift which is over 80% of main block capacity, tandem lifts, high wind, sea/swell state, risk of fire, high cargo cost as defined by rig management, non-standard rigging or load arrangements, subsea lifts.

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indicated that a permit to work was issued for the lifting of casings operation on 24 November 2022, which included the conduct of a toolbox talk for personnel involved in the operation and the RA with control measures.

1.7.11 A sub-section procedure of "offloading and back loading supply vessels", stated that the crane operator was required to take note of the significant wave height and loads exceeding the crane's nominal capacity stated in the dynamic load chart were not to be lifted. On the occurrence day, the loads being lifted were within the nominal capacity of the crane. The hull of WC was above the sea water level, the dynamic loads were only applicable when the bundle of casings was lifting from the workboat.

1.7.12 The SMS procedures prohibited consumption of alcoholic beverage onboard its fleet of jack-up rigs.

1.8 Classification society requirements and survey

1.8.1 All the three cranes and their associated equipment had been certified by the CS in compliance with their Guide for Certification of Lifting Appliances (updated in February 2007) and API 2C 6th edition[34].

1.8.2 According to the certificate of test and examination of cranes issued by the CS on 2 June 2022, the retesting survey was carried out on 29 May 2022 and witnessed by the attending surveyor, the results of the SWL at various boom radii for both main and auxiliary hoists[35] of no.1 crane were as recorded in table 3:

[34] Specification for offshore pedestal mounted cranes made by the American Petroleum Institute (API), which was effective in September 2004. This specification was to provide standards for offshore pedestal mounted cranes suitable for use in drilling and production operations.
[35] Refer to the main lifting link and whip link when used for lifting.

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For jib crane radius at which the proof load was applied		Proof load applied (tons)	Safe working load (for jib cranes at radius shown in Column 1) (tons)
Main Hoist	36 ft (75.10°)	30.07	25.07
	70 ft (57.10°)	14.98	11.99
	95 ft (41.10°)	9.76	7.81
Auxiliary Hoist	45 ft (60.40°)	14.2	11. 3
	60 ft (56.60°)	14.2	11.3
	75 ft (45.3°)	14.2	11.3

Table 3 – SWL of no.1 crane from the retesting survey
(*Source*: the CS)

1.8.3 According to the Register of Lifting Appliances issued to the WC on 27 May 2021 by the CS, the records indicated that the first survey for all three cranes carried out on the 8 February 2007 were 'satisfactory'. 5-yearly renewal surveys had been carried out on 11 June 2012, 13 June 2017 and 29 May 2022. All three surveys conducted and marked 'satisfactory', which had been duly documented in the Register.

1.8.4 Apart from the 5-yearly renewal surveys, the CS also carried out inspections[36] on the three cranes annually from 2008 to 2022 and all were marked 'satisfactory'.

1.8.5 The same Register of Lifting Appliances also revealed that two additional surveys with 'satisfactory' remarks were conducted for the no.1 crane (incident crane) on 5 November 2009 (due to the lower boom brace and lacing repairs), and on 28 June 2013 (after repairs to the crane pedestal's connection to the main deck plating and associated load tests). There were two additional repairs on the no.1 crane relating to the boom, and after each repair, retesting of no. 1 crane was carried out by the CS on 27 May 2021 and 18 December 2021. According to the CS, there were no records of any repair or welding at the

[36] The inspection involved visual checks of the crane structures, such as the pedestal, and other lifting accessories such as lifting chains, rings, hooks, shackles, and swivels. Non-destructive test would be carried out when the visual check revealed poor condition or when requested by the owner of the crane.

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external surface of the no.1 crane pedestal (where the pedestal broke off) in the past.

1.8.6 According to the CS, any damage, failure, deterioration, or repair to lifting appliances covered by this certification Guide, which affects or may affect the certification, is to be submitted by the owners or their representatives[37] for examination by a surveyor at the first opportunity. If this is not reported to the CS, the issued certifications may subject to cancellation. All repairs found necessary by the attending surveyor are to be carried out to the surveyor's satisfaction. These requirements are also restated in part 7-9-45/11.3 of the CS' Rules for Survey After Construction. When asked, the Company confirmed they were aware of these requirements, the crew onboard its jack-up rigs were instructed by Directives and procedural requirements[38] to report defects that would affect certification to the Company and subsequently to the CS. All lifting appliances had been inspected under the yearly and 5-yealy surveys as required by the CS.

1.8.7 The CS also clarified that when repairs or renewals, including welding and or replacement of major structural components were required to be made to the load bearing structures or permanent fittings of cranes, the repairs were to be carried out to the satisfaction of the attending surveyor. Depending on the nature, location, and severity of the damage, this may require the support of the designer, OEM and/or the engineering division of the CS.

1.8.8 The CS further confirmed that all welding must be done by approved procedure. Damage associated with a primary structural member (such as the crane pedestal), required a proof load test[39] to be carried on completion of repairs.

1.9 Damage survey after the occurrence

1.9.1 After the occurrence, a surveyor from the CS conducted a damage survey on the WC between 25 November 2022 and 6 January 2023 to assess the extent of the damages resulted from the parting of upper section of the no. 1 crane. The relevant details of the survey are captured in the subsequent paragraphs.

[37] The Company and officer in-charge of the operation and maintenance of the lifting appliances onboard WC.
[38] The Directive and procedural requirements were not provided to the investigation team as the Management Company of the WC had been changed after the occurrence.
[39] In accordance with 7-9-45/1.5 of ABS Rules for Survey After Construction.

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No.1 crane

1.9.2 The uppermost section of the crane pedestal, king post, gantry cab, latticed boom and hoisting equipment were found missing (had fallen into the sea). The crane's pedestal plate (tube) was found broken at the base metal approximately 150mm above the fillet weld of the fix gearwheel. No circumferential weld seam was noted in the part of material broken nor in the crane's drawings provided onboard the WC.

1.9.3 At the location of the crane, various damages were caused by the fallen upper section of the crane such as the port side lifeboat station and platform.

1.9.4 A separate metallurgical examination was carried out by a third party on the remaining part of the pedestal to find out the mode of failure (see paragraph 1.10).

No.2 crane

1.9.5 One indication[40] of 32mm in length was detected in the peripheral weld seam approximately 2850mm above main deck at the port side of the pedestal.

1.9.6 The indication was gouged and rewelded by qualified welders in accordance with the welding procedures approved by the CS, using approved materials and welding consumables. Thereafter non-destructive test was carried out to the satisfaction of the attending surveyor.

No.3 crane

1.9.7 On the no.3 crane, the following defects were found:

a) one surface indication of 100mm on the pedestal's spacer plate outer edge butt weld with main deck plating.

b) one indication of 50mm in length on the peripheral weld seam approximately 1350mm above main deck.

1.9.8 The two indications were gouged, rewelded and tested to the satisfaction of the

[40] Refers to a technical term, i.e. an observation detected by attending technicians, who are qualified third parties (non-ABS surveyors), periodically conducting both visual examination and surface/volumetric non-destructive examination to confirm the soundness of weldments on lifting appliances. The indication needs to be rectified or repaired by a suitable process if it is outside the acceptance criteria.

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attending surveyor following the same procedures as those for the no.2 crane.

1.9.9 Two more indications for the no.3 crane were detected in the vertical weld seam located at the starboard side of the pedestal, one of 30mm in length and another indication was of 40mm in length. However, both indications were found within the acceptance criteria of the standard applied for evaluation by the CS. The CS remarked that unrepaired indications were subject to examination annually to verify that there was no growth or propagation.

1.9.10 Upon completion of the damage survey, the WC was recommended to retain its Class.

1.10 Metallurgical analysis of the incident crane pedestal

1.10.1 According to the Company, after the occurrence, the metallurgical analysis on the remaining lower portion of the no.1 crane pedestal was carried out by a reputed laboratory.

1.10.2 A visual inspection was carried out on the lower portion of the crane pedestal, and measurements of the wall thickness and outside diameter were taken to identify any apparent flaws on the pedestal fracture surface. Tests were also conducted on the entire crane pedestal to determine the presence, extent and directionality of any ovality or deformation.

1.10.3 A portion of the fracture surface was removed for examination to determine the origin of the fracture. Two fracture surface samples were removed for microscopic analysis and tensile testing of the metal specimens from the crane pedestal. Steel samples were removed from the crane pedestal to determine the chemical composition of the base and weld metals.

1.10.4 The preliminary findings from the metallurgical analysis indicated that the pedestal had likely failed due to a fatigue initiated at the toe of a single pass weld (see **figure 9a**), which acted as a stress concentrator. The evidence for the fatigue included the presence of beach and ratchet marks (see **figure 9b**) on the fracture surface of the pedestal. There were no unusually high hardness values measured within the base metal of the pedestal. High hardness values up to 48 Rockwell C Hardness[41] were measured within heat affected zones

[41] It's a measuring system of non-destructive metallurgical testing that determines hardness and strength of the steel. Hardness ratings follow a predetermined chart which is commonly named as the Rockwell C scale. The higher the number on the scale, the harder the steel is, and may become brittle.

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from the single weld pass adjacent to the fracture. Results from the mechanical and steel/weld chemistry analysis were not made available to the investigation team, at the time of publishing this report.

Figure 9a – View of the single pass weld and fracture location at incident crane pedestal (*Source*: the Company)

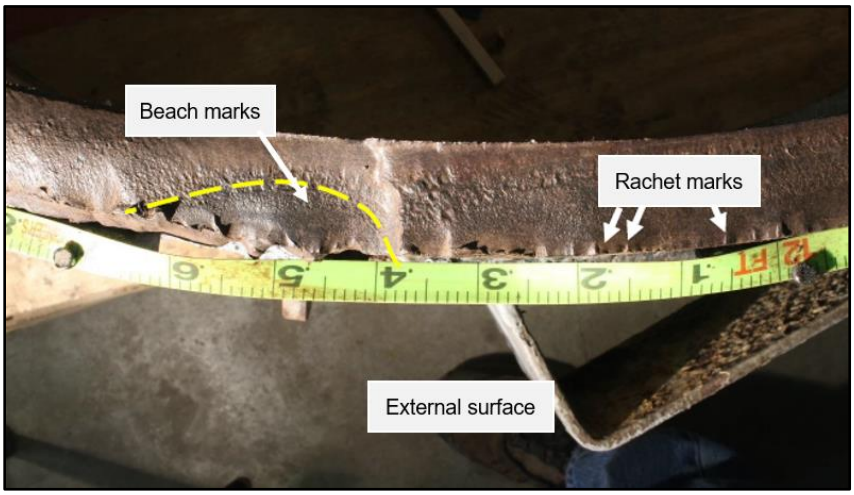

Figure 9b – Presence of the beach and ratchet marks on the fracture surface of the pedestal (*Source*: the laboratory's metallurgical analysis report)

1.10.5 According to the Company, the single pass weld, about 20cm in length, at a position of about 230cm above the platform which was on the external surface of the pedestal and suspected to be a repair weld. This single pass weld was covered by a welded conical housing which was at a vertical height of 25cm (see **figure 10**) and was not visible during the daily checks. An external surface

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breaking flaw (see **figure 11**) of about 3cm was visible on the single pass weld during the magnetic particle testing after the occurrence.

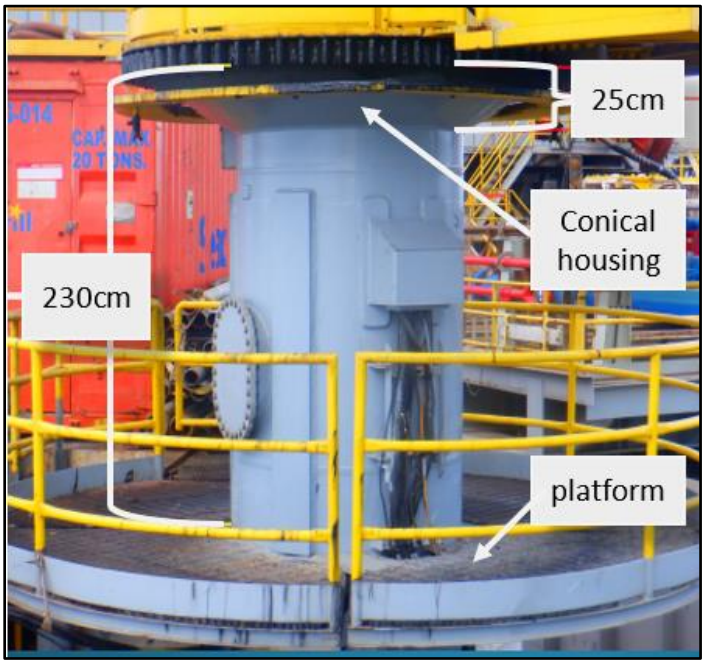

Figure 10 – Height and location of the welded conical housing of the no.3 crane on WC for illustration (*Source*: the Company)

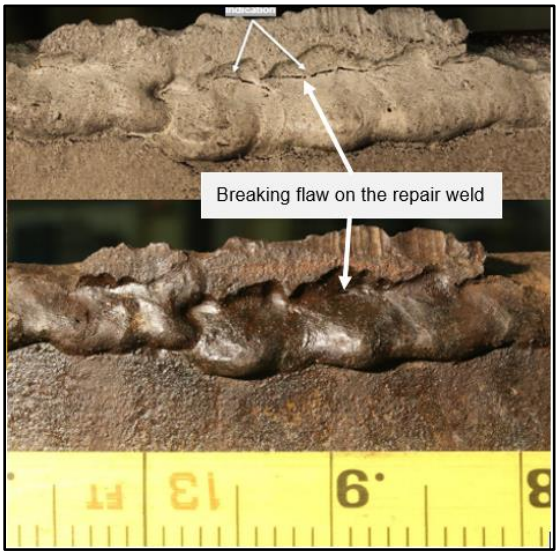

Figure 11 – Presence of the breaking flaw on the repair weld (*Source*: the laboratory's metallurgical analysis report)

1.10.6 The circumference and outer diameter measurements carried out on the cabin and deck ends of the pedestal (where accessible) were noted to be consistent

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at 384cm and about 120cm respectively.

1.10.7 The Company shared that the 20cm single pass weld was not mentioned in any documentation received by them and was not in the original design drawing[42].

1.11 Laboratory test of damaged material from incident crane

1.11.1 After the occurrence, a part of the damaged portion of the material from the incident crane was sent by the Company for testing at another laboratory, results of which were not made known to the investigation team at the time of publishing this report.

1.12 Environmental condition

1.12.1 According to the ship's log onboard the WC, the visibility was about 10.5nm, experiencing southwesterly wind was at about 10 knots. The sea was moderate at a height of about 1-1.5m with about 3 knots current.

[42] Attempts to contact the crane manufacturer were unsuccessful. Hence, it could not be verified if the single pass weld was done before the no. 1 crane was installed on the WC in 2007.

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2 ANALYSIS

2.1 The incident and environment condition

2.1.1 The no.1 crane was a heavy duty rated deck crane having safety protection features for ensuring a safe lifting operation, such as being equipped with hydraulically operated disc brakes to hold respective motions in place, overtravel protection for each crane motion.

2.1.2 As a routine task, the toolbox talk for the lifting operation and the risk assessment with control measures were carried out on 24 November 2022, the OP1, OP2, assistant crane operator and roustabouts were briefed about the lifting operation. A permit to work was also issued for the same operation as required by the Company's SMS procedures.

2.1.3 At the last retesting survey on 29 May 2022, the SWL of the no.1 crane auxiliary hoist for the jib at a radius between 56.6º degrees and 45.3º was tested to be at 11.3 tons. On the occurrence day, each casing being lifted was about 4.5 tons and the lifting angle of no.1 crane boom was approximate 51º. Thus, it is deemed that the no. 1 crane was operated as per its design and function.

2.1.4 Prior to the occurrence, there were no reports of malfunction of the no.1 crane or its associated equipment. 21 lifts of the casing bundles had been safely performed by the OP2 before handing over the crane operation to the OP1. The pre-use or walk around inspections carried out by the OP1 and OP2 on the day of the incident as well as in the past on the general conditions of the crane did not reveal any anomalies.

2.1.5 The investigation team thus opined, with the available evidence, that the lifting operation was in line with the Company's established lifting operation procedures. The WC was operating with all three retractable legs supported on the seabed and the environmental condition at the time of the incident was calm, the investigation team ruled out the impact of the weather causing the failure of the crane.

2.1.6 The investigation team noted from the preliminary findings of the metallurgical analysis conducted on the lower section of the crane pedestal that remained onboard the WC, that there was a high probability of metal fatigue, as indicated by the beach and ratchet marks (see figure 9b) on the fracture surface of the pedestal. This fatigue, which acted as a stress concentrator, was likely to have

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been initiated from a single pass weld (see figure 9a).

2.1.7 While the mechanical and steel chemistry analysis and material test were still ongoing at the publish of this report, and the wish to salvage the upper section of the crane pedestal from the seabed, there may be more examinations or tests to be carried out by the Company. Nevertheless, the investigation team opined that the preliminary findings stated in the laboratory's metallurgy analysis are reasonable and probable, i.e. the failure of the no.1 crane was likely caused by metal fatigue of the pedestal initiated from the single pass weld and spread around the pedestal over time and reached to the breaking point when the OP1 took over the lifting operation.

2.1.8 The investigation team reserves its opinions for any other possible contributing factors, such as material failure and/or latent defects in design. For that, the investigation team may consider reopening this marine safety investigation for further analysis if there were other findings, subsequently.

2.2 Fatigue of a weld

2.2.1 Weld is a critical construction-related activity for a new build or maintenance repair which is generally used to fuse two or more metals together by means of heat, pressure, or both. However, welds tend to be brittle and may result in accident if any slight failure on the welded joints. Components of a deck crane onboard a jack-up rig such as pedestal would experience a spectrum of stresses while operating. Cracks may occur and grow over a period at an area of welded joint. If a crack has developed and not detected early and appropriate measures are not taken, it can increase in size and propagate within a short period of time, thus reducing its loading capacity drastically in part or as a whole.

2.2.2 Beach marks are macroscopic fatigue features marking an interruption in the propagation of a fatigue cracking progress, the present of these features are evidence to identify fatigue fractures. Rachet marks are formed when multiple fatigue origins are near each other. A crack starts at each origin and a ridge is formed creating the rachet mark when cracks meet. High stress levels and sharp stress concentrations often result in a series of ratchet marks. The preliminary findings of the metallurgical analysis indicated a fatigue initiated at the toe of a single pass weld as evidenced by these marks on the fracture surface of the pedestal of the no.1 crane.

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2.2.3 These marks on the pedestal metal surface were not visually identifiable, this fatigue of the single pass weld could not be seen during the daily checks and inspections as the single pass weld was under the welded conical housing. Similarly, the breaking flaw may also not easily be seen by naked eyes unless testing carried out by tools such as non-destructive tests.

2.2.4 Fatigue failure of a weld is less likely a result of the strength of the metal but often due to poor design, incorrect welding procedure, use of inappropriate materials and poor workmanship. As clarified by the vessel's CS, it is important for all repairs and renewals including welding to be made to the load bearing structures or permanent fittings of cranes onboard a vessel are done by qualified welders, using approved materials and welding consumables, an approved procedure and to carry out non-destructive test to the satisfaction of the attending surveyor. It is also important for such welds be regularly inspected by structure professionals to ensure its integrity and fit for continual usage.

2.3 The origin of the single pass weld

2.3.1 There were no records of the single pass weld that the Company was able to trace (neither documents or maintenance records onboard the WC nor the original design drawing). The vessel's CS also did not have records of this single pass weld at the external surface of the no.1 crane pedestal.

2.3.2 The investigation team considered the present of the single pass weld may be from one of the followings –

(a) The single pass weld could be present since installation. As the single pass weld was covered by the welded conical housing and at a height of about 2m above the platform, it was not known to the Company and the CS. The investigation team further understands that such a weld was not present on the other two deck cranes (no.2 and no.3) on the WC (see footnote 39 for the method used).

(b) The single pass weld could have been a repair made onboard after the crane was installed on the WC during the course of its operation in the past 15 years.

2.3.3 Given that 20cm single pass weld was underneath the welded conical housing, the investigation team deemed that it is unlikely that the single pass weld was

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a repair onboard the WC. The reason being that to make a repair weld, one has to know that there was a crack at that location. To repair the crack, the welded conical housing has to be removed. Thus, it is more likely that the single pass weld was present since installation.

2.3.4 Although daily visual checks are to be performed by the crane operators, being covered by the welded conical housing, it is not possible for the crane operators to find out the crack developed on the single pass weld.

2.3.5 It is thus important that any welding repairs that affect the structural integrity of lifting equipment be properly documented for a proper workflow process to inspect the weld regularly to detect any development of crack.

2.4 Incidental observations

2.4.1 The CS' Rules for Survey After Construction, stated in part 7-9-45/11.3, requires that any damage, failure, deterioration, or repair to lifting appliances covered by CS' Certification Guide, which affects or may affect the certification, to be submitted by the owners or their representatives for examination at the first opportunity. If this is not reported to the CS, the issued certifications may subject to cancellation. The investigation team noted that the single pass weld was not known to the Company and hence not reported to the CS. Similarly, there were several indications observed by the CS' post occurrence damage survey which were not known to the Company and hence not reported to the CS.

2.4.2 The Company was aware of the requirements to report to the CS for defects and issues affecting the structural integrity onboard the WC. The Company also indicated that the Directives and procedural requirements for the defect reporting were given to the crew of jack-up rigs. However, the investigation team opined that the crew onboard were not experts to identify defects which would affect the certification of the crane, they were also not experts to determine what defects to be reported for further examination by the CS' surveyor. As such, some defects could be left unchecked / addressed accordingly.

2.4.3 As lifting operation is routine task which subjects the structural member, such as the pedestal, of the crane to high stress and load. Though the deck cranes had been inspected and surveyed yearly and 5-yearly according to the CS'

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requirements and carried out daily inspections by the crane operator, there were still indications undiscovered. It is thus, deemed desirable for the Company to review its existing inspection and survey programme for deck cranes installed on all its jack-up rigs.

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3 CONCLUSIONS

From the information gathered, the following findings are made. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

3.1 The no.1 crane failed at its pedestal and its upper section broke off and fell into the sea when the casing was lifted about half metre above the deck of work boat by the OP1, who fell into the sea together with the cabin. The OP1 was located outside the crane cabin about five hours later and found dead. The OP2, who was outside the crane cabin also fell into the sea but was recovered and survived.

3.2 There were no abnormalities reported on the no.1 crane prior to the occurrence. There were 21 lifts done by the OP2 before the OP1 took over the lifting operations. All the casing were about 4.5 tons each, well below the SWL of 11.3 tons of the no.1 crane auxiliary hoist.

3.3 The lifting operation at the time of occurrence complied with the Company's lifting operation procedures and within the permitted environmental condition.

3.4 The pedestal failure of the no.1 crane was likely due to a fatigue initiated at the toe of a single pass weld at the lower part of the pedestal of the no.1 crane. The single pass weld was covered by the welded conical housing and was not visible during daily checks by the crane operators.

3.5 Both the Company and the CS did not have record of the single pass weld on the no. 1 crane. Attempts to contact the crane manufacturer were unsuccessful. Hence, it could not be verified if the single pass weld was done before the no. 1 crane was installed on the WC.

3.6 Post occurrence damage survey performed by the CS found five indications[43] on the no.2 and no. 3 cranes. These indications were not known to the Company and the CS prior to the incident. It is desirable for the Company to review its existing inspection and survey programme for early detection of defects on the crane structure.

[43] Of the five indications, three were repaired and two were not as they were within the CS' acceptance criteria but subject to annual examination to monitor if there were any further deteriorations.

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4 SAFETY ACTIONS

During the course of the investigation and through discussions with the investigation team, the following safety actions were initiated by the relevant stakeholders.

4.1 Actions taken by the Company

4.1.1 After the occurrence, the Company carried out a comprehensive inspection[44] on the no.2 and no.3 cranes onboard the WC and also on the cranes of other two similar jack-up rigs in the fleet with same type of crane and model. All eight cranes were inspected, and there was no single pass weld detected.

4.2 Actions taken by the CS of the WC

4.2.1 After the occurrence, the CS reviewed the past maintenance reports, and carried out a thorough inspection on the structures of the remaining two deck cranes (no.2 and no.3 cranes) and performed load tests.

[44] The Phased Array Ultrasonic Testing (PAUT) inspection method was used to detect for anomalies on the surface of the pedestals of the other two deck cranes, the inspection also expanded to check the whole extent of the thickness of those pedestals. Attending surveyor from the CS was present for the inspection of no.2 and no.3 cranes onboard WC.

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5 SAFETY RECOMMENDATIONS

A safety recommendation is for the purpose of preventive action and shall in no case create a presumption of blame or liability.

5.1 For the Company (the ISM Managers of West Courageous):

5.1.1 To review the existing inspection and survey programme to ensure defects on crane structure can be discovered at early stage. **[TSIB Recommendation RM-2024-01]**

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