PETROLEUMSTILSYNET

Investigation report

Report	
Report title Investigation of dropped riser joint on *West Bollsta* on 17 October 2020	Activity number 404011004

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Involved	
Team T-F	Approved by/date Irja Viste-Ollestad/5 March 2021
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1 Summary

An incident took place on Seadrill's *West Bollsta* facility while running a riser on Saturday 17 October 2020. It occurred when a riser joint was to lifted from a horizontal to a vertical position, and into the spider in the rotary table. When the joint was almost vertical, the hydraulic riser running tool (HRRT) lacked sufficient grip on it. As a result, the joint dropped and came to rest between the two V doors on the drill floor, tearing off parts of the V door on one side. Much of the buoyancy elements around the joint were damaged or ripped off. The joint was 22.9m long and weighed 26.5 tonnes.

The joint dropped into the red zone, but could with a minor change in direction have struck the driller's cabin, where six people were present when the incident occurred. Two other people were on the drill floor close to the impact area. Although outside the red zone, they could also have been hit had the joint dropped differently.

The Petroleum Safety Authority Norway (PSA) decided on Monday 19 October 2020 to investigate the incident. The investigation team's mandate included clarifying the course of events and assessing direct and underlying causes, with the emphasis on technical, operational and organisational conditions – often designated human, technology and organisation (HTO) factors.

Several deficiencies in the HRRT were revealed by the investigation, along with shortcomings in expertise, management and follow-up of equipment on *West Bollsta*. No single cause of the incident has been identified, but the investigation has concluded that it resulted from a combination of several technical, operational and organisational factors.

Nine nonconformities have been identified, relating to:

- design of lifting equipment
- correction of earlier nonconformities and orders
- continuous improvement
- management system
- procedures for executing work

- organisation and exercise of roles and responsibilities
- risk assessments and measures
- maintenance of lifting equipment
- expertise.

The investigation has found that Seadrill has failed to correct the nonconformities identified and orders issued earlier by the PSA in relation to the company's operations on the Norwegian continental shelf (NCS). These conditions may have been relevant to the incident, and are covered in detail under nonconformity 10.1.2

In the PSA team's view, the Covid-19 position and the company's response to that have not been a contributory factor in the incident.

2 Background information

A riser joint came free during a lifting operation at 17.59 on 17 October 2020 and dropped from an almost vertical position to the drill floor on *West Bollsta* (Seadrill). This incident occurred in connection with preparations for drilling an exploration well, which involved making up a riser string for subsequent attachment to a blowout preventer (BOP).

2.1 Description of facility and organisation

After securing an acknowledgement of compliance (AoC) in October 2020, *West Bollsta* was involved at the time of the incident with the first of 10 planned drilling operations for Lundin.

A Moss Maritime CS60 type, this unit ranks as the world's largest mobile semi-submersible drilling facility and was ordered by and built for Dolphin Drilling Ltd at the Hyundai Heavy Industries yard in Korea under the name *Bollsta Dolphin*. The yard took over ownership when Dolphin cancelled the contract before the facility was completed, and laid it up from October 2015. Acquired by Northern Drilling in December 2017, the facility was under contract to drilling contractor Seadrill at the time of the incident. It was completed for operation in 2020 and flies the Norwegian flag. It is managed on the NCS by Seadrill's operations organisation in Stavanger.

Photo 1: from https://www.vesselfinder.com.

2.2 Local conditions

When the incident occurred, *West Bollsta* was located on the Polmak prospect, well 7221/4-1, in the southern Barents Sea. Weather conditions on the day of the incident were steady with a strong north-easterly breeze, significant wave heights of about 3.5 metres and good visibility. The facility was positioned into the wind with moderate motion on board.

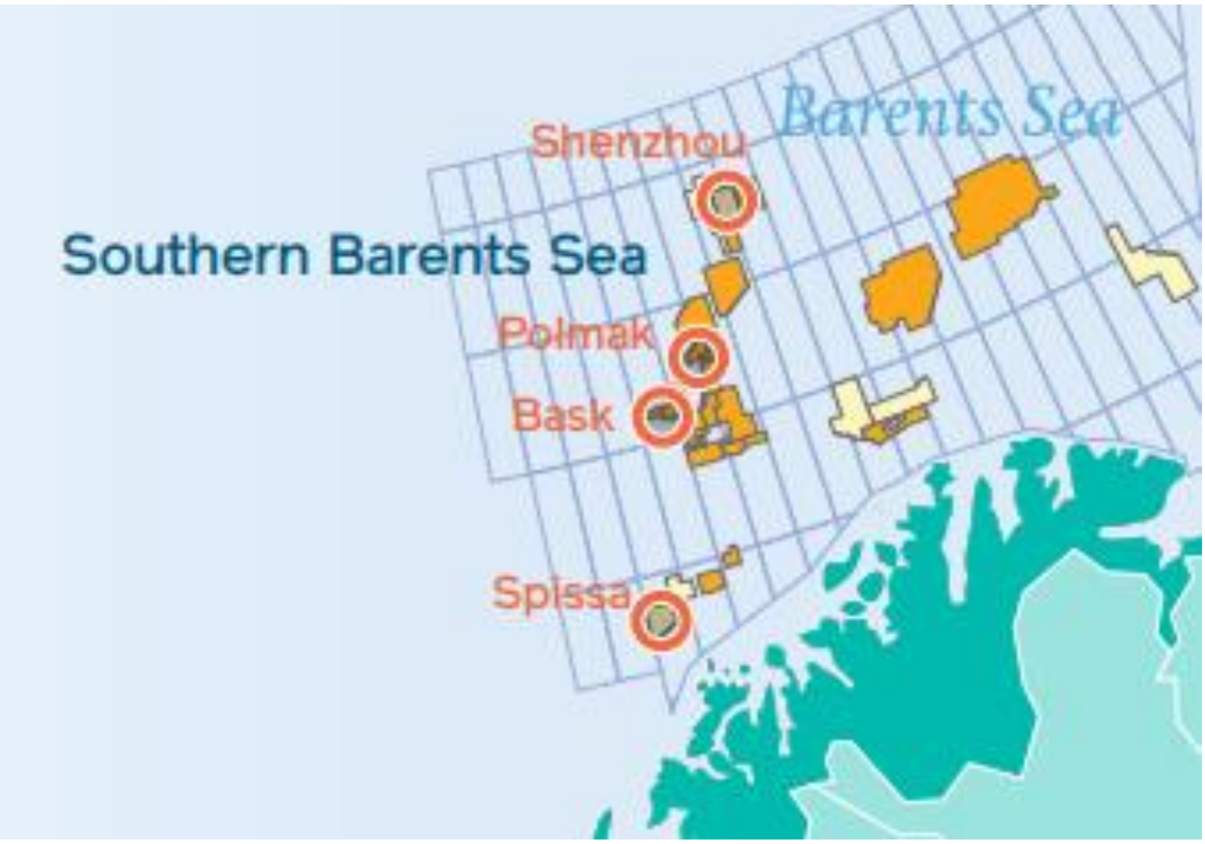


Figure 1: from https://www.offshore-mag.com/drilling-completion/article/14092838/lundin-petroleum-targets-nine-norwegian-prospects-with-2020-drilling-lineup.

Abbreviations and terms

AoC	Acknowledgement of compliance
Barrier	Measure intended to identify conditions which could lead to faults, hazards or accidents, prevent a specific course of events from occurring or developing, influence a course of events in an intended direction or limit harm and/or losses
BOP	Blowout preventer
Cyberbase	Drilling control system
DSL	Drilling section leader (senior toolpusher)
DVR	Design verification report
(H)RRT	(Hydraulic) riser running tool. Specially designed lifting accessory for risers. See also SDLA
HTO	Human, technology, organisation
Joint	Section of pipe used to make up a riser
NCS	Norwegian continental shelf
NOV	National Oilwell Varco, supplier of Cyberbase
PSA	Petroleum Safety Authority Norway
Rotary/spider	Star-shaped tool in the rotary table opening used to grip the drill string during making up/breaking out
SDLA	Specially designed lifting accessory in the drilling area
SWL	Safe working load

TBRA	Task-based risk assessment. Seadrill's safe job analysis (SJA), with associated form which must be completed
Toolpusher	Assistant driller, leads work on the drill floor
Top drive	Hoisting arrangement for a drilling machine
V door	Opening into the drill floor

3 The PSA's investigation

Composition of the investigation team
Torbjørn Gjerde - logistics and emergency preparedness (investigation leader)
Reidar Sune - logistics and emergency preparedness
Eva Hølmebakk - occupational health and safety

3.1 Mandate for the investigation

The PSA's mandate for the investigation was as follows.

a) Clarify the incident's scope and course of events (with the aid of a systematic review which typically describes time lines and incidents).
b) Assess the actual and potential consequences
    1. harm caused to people, material assets and the environment
    2. the potential of the incident to harm people, material assets and the environment.
c) Assess direct and underlying causes.
d) Identify nonconformities and improvement points related to the regulations (and internal requirements).
e) Discuss and describe possible uncertainties/unclear points.
f) Discuss barriers which have functioned (in other words, barriers which helped to prevent a hazard from developing into an accident or which reduced the consequences of an accident).
g) Assess the player's own investigation report.
h) Prepare a report and a covering letter (possibly with proposals for the use of reactions) in accordance with the template.
i) Recommend – and normally contribute to – further follow-up.

3.2 Conduct of the investigation

The investigation team travelled out to *West Bollsta* on Tuesday 20 October and received a briefing from the Seadrill and Lundin investigators who had arrived a couple of days before. On the same day, the PSA team inspected the drill floor area where the incident had occurred. The joint had then been removed and lay on the riser deck. The post-incident position was well documented by photographs.

Nine interviews were conducted offshore with personnel who had been present in the drilling area during the incident, were involved in the relevant operation or had previously been involved with the equipment. Management responsible for the drilling and deck area, personnel from the supplier of the HRRT and the Cyberbase service engineer, who was on board, were also interviewed. In addition, one interview was conducted with personnel from the Seadrill land organisation.

As part of its investigation, Seadrill/Lundin tested the relevant HRRT offshore without a load. This was led by the Seadrill/Lundin investigation team and a representative from Cameron, with the PSA team as observers. NOV was also present and assisted during the test, which was intended to provide a better understanding of how the HRRT functioned. The PSA was also interested in the drill floor area's physical configuration and in how signals from the control system during the operation were presented to the driller in the cabin.

The PSA team reviewed governing documents related to the equipment and personnel involved, as well as operational procedures and other documentation.

Seadrill's investigation and further tests of the relevant equipment on land were followed up from November 2020 until the Seadrill report was received by the PSA on 11 January 2021.

The HTO investigation method has been used as the basis of the PSA team's work.

4 Course of events

4.1 Design phase and ordering/installation of the equipment

West Bollsta was ordered by Dolphin Drilling Ltd from Hyundai Heavy Industries in Korea. Delays in the construction process led Dolphin to cancel the contract with Hyundai, and the yard laid up the unfinished facility in 2015. It was sold by Hyundai in December 2017 to Northern Drilling, which entered into an agreement in 2018 with Seadrill that the latter would complete and operate *West Bollsta*. Completion began at Hyundai in 2018 and continued at a Tenerife yard before final work by Semco Maritime at Hanøytangen in Bergen. Installation and completion of third-party equipment took place in the spring of 2020.

4.2 Preparations for operation in Norway before the incident

Testing to prepare for operation and familiarisation programmes for Seadrill personnel were conducted following delivery of *West Bollsta* from Hyundai until it was ready to drill the first well for Lundin. Most of the personnel on board during the incident had participated in these programmes. An AoC was also sought, and the facility readied for operation on the NCS. These preparations included having an enterprise of competence on board to check that all lifting equipment was correctly certified and complied with the regulations. Deficiencies in the form of missing certificates were identified for the type of lifting equipment involved in the incident both in the PSA's AoC processing and by the enterprise of competence.

4.3 The actual incident

There were 136 people on board when the incident occurred. This was the first well to be drilled, and a number of these people were involved in the preparations. Running and retrieving riser and BOP were viewed as a critical operation, which called for experience and good routines. It was also regarded as a job done regularly with each well and a routine operation. This represented the first time for both facility and crew that the operation was carried out on *West Bollsta* since the facility entered service.

The joint dropped during the incident was 22.9 metres (75 feet) long and weighed 26.5 tonnes. Functions of a riser include connecting the drilling facility to the well. The number of joint joints to be made up depends on the water depth. Plans for this operation involved coupling 15 joints to connect the facility to the BOP and the well on the seabed.

Work prior to the incident concentrated on preparing to couple the BOP to the bottom joint in the riser string.

The incident occurred when lifting the first joint. The first step was to fetch the joint from the riser deck. It was then to be placed horizontally on a catwalk and moved in through one V door on the drill floor, where the HRRT hanging from the top drive in the drilling machine would be locked on, and the joint would be lifted from horizontal to vertical position. Once vertical, the plan was to lower it into the star-shaped spider in the rotary table opening on the drill floor and let it hang down towards the sea. This operation would then be repeated with the second joint, which would be made up with the one suspended in the spider. The BOP would then be coupled to the bottom of the two joints before being sunk below the splash zone. Joints would continue to be added until the BOP could be landed and installed on the seabed wellhead.

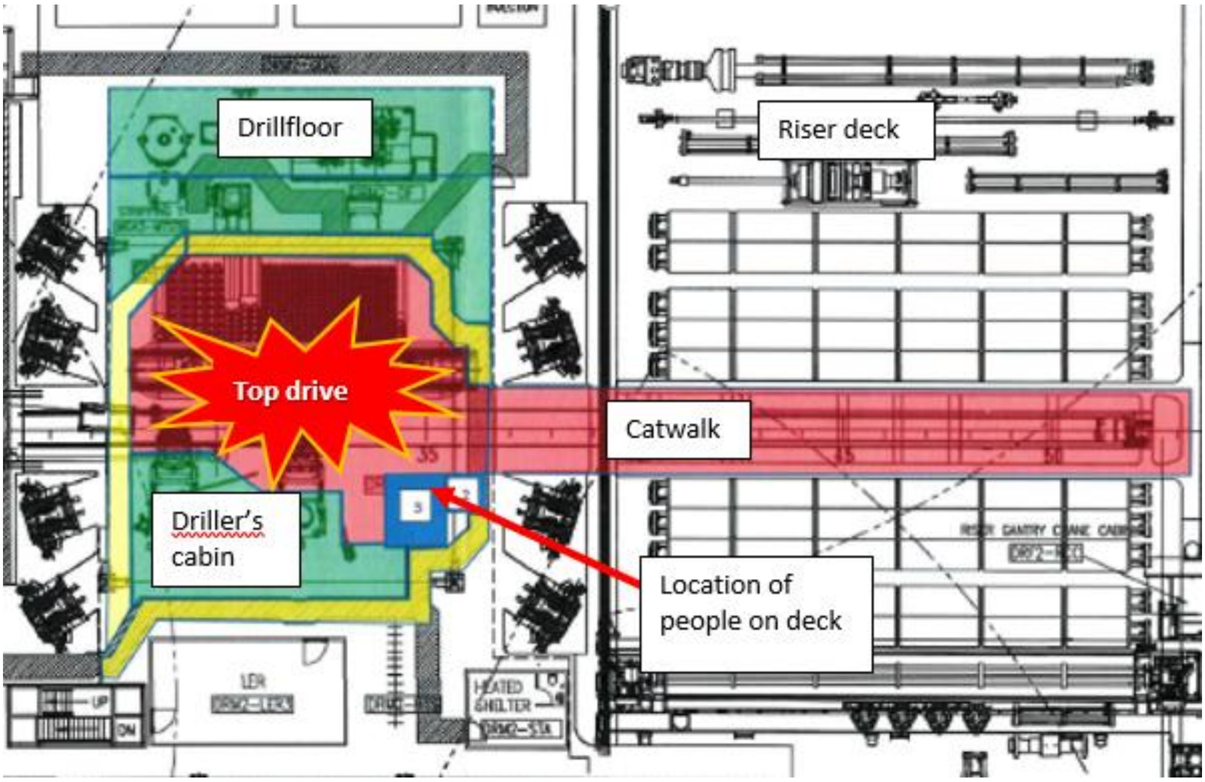


Figure 1: Plan of the West Bollsta *drill floor showing the drill floor, riser deck, catwalk, top drive, driller's cabin, safe place for observation during lifting and the area where the joint dropped.*

While the first joint was being lifted from horizontal to vertical, it became detached from the HRRT. The joint was almost vertical and dropped to the drill floor where it lay on the spider between the two V doors. It tore off parts of the V door on the other side of the drill floor towards the riser deck, and much of the buoyancy elements around the joint were damaged or ripped off.

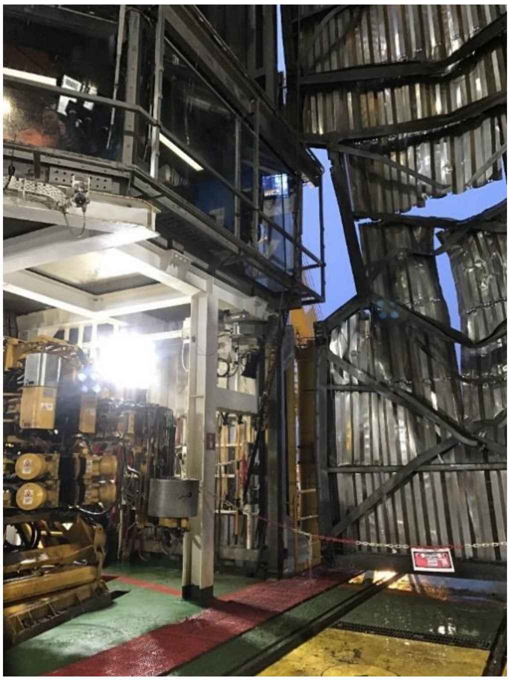


Photo 2: Driller's cabin and damage to the V door where the joint struck. Photo by the PSA team,.

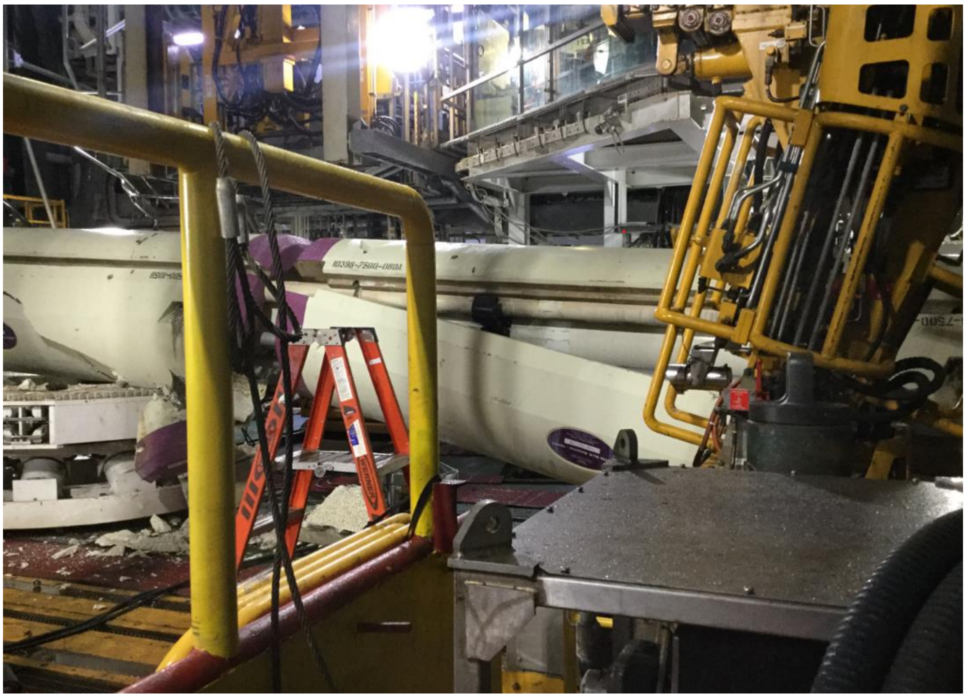


Photo 3: The joint lying on the drill floor and on top of the spider after the incident. The driller's cabin can be seen at the top in the background. From Seadrill's presentation of the incident.

Figure 3 below presents the sequence of events with the joint which was to raised from a horizontal to a vertical position. The joint lay on the catwalk while its top was attached to the HRRT. At the front end of the catwalk, the joint is guided by "gorilla arms" which support it during the lift. The sequence then shows how the joint became detached from the HRRT and fell to the spider.

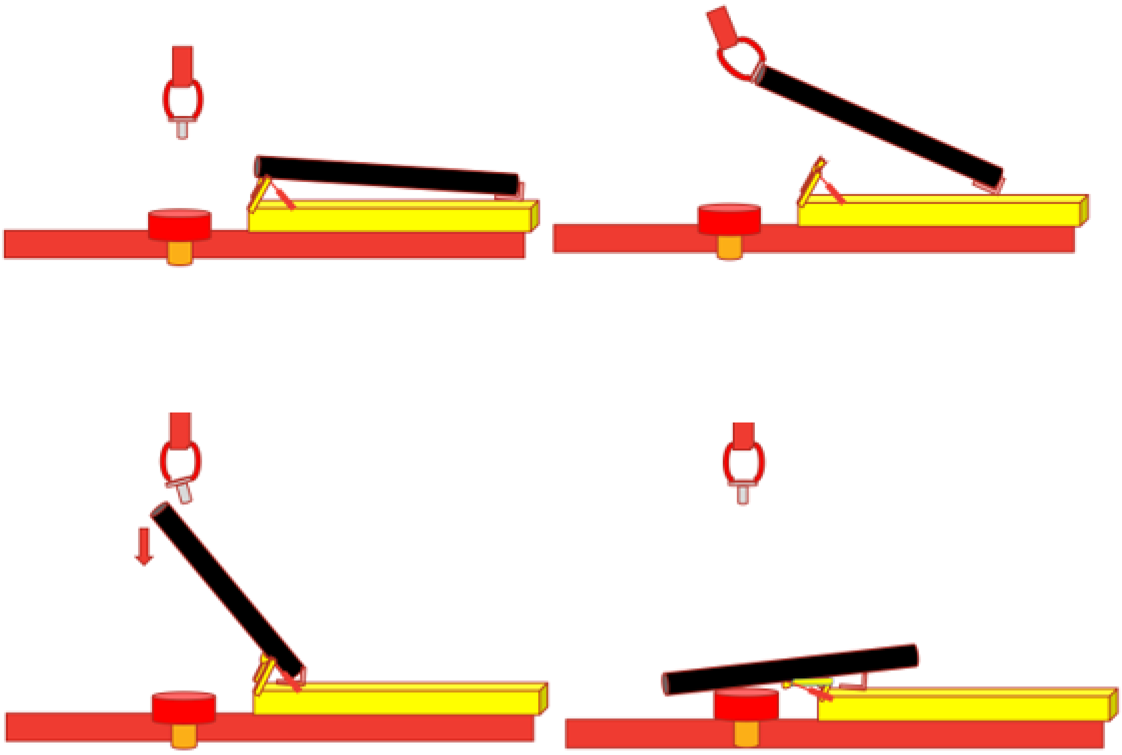


Figure 2: The catwalk with joint being lifted by the HRRT. From Lundin's presentation of the incident.

Photo 4: How the gorilla arms installed on the catwalk for handling joints were bent by the weight of the joint after the incident. Photo taken by the PSA investigation team.

4.4 After the incident

Immediately after the incident, personnel on board were informed over the public address (PA) system of what had happened on the drill floor and that nobody was injured. It was decided not to activate an emergency response, since the incident did not have a potential for further escalation.

Seadrill, Lundin and the PSA decided to investigate. The police have been in dialogue with the PSA, and established a case for possible investigation of the incident.

4.5 Time line

The time line from immediately before the incident until subsequent testing.

Date	Time	Activity
9 Oct	Day shift	The day-shift subsea engineer checked that the HRRT was suitable for the job. Everything reportedly functioned as it should, with no leaks.
17 Oct	Day shift	A TBRA was conducted by the shift which planned to participate during the operation.
17 Oct	Afternoon	The HRRT was connected to the drilling machine’s top drive. Problems were encountered with a quick coupling which refused to connect the HRRT to the hydraulic cylinder.
17 Oct	About 17.00	The on-board hydraulic technician came to look at the coupling. When interviewed, he said there was nothing wrong with it, but that one of the couplings was not properly connected. Once the HRRT was connected to the top drive, crew saw water and hydraulic oil running from the joint but assumed that they came from earlier operations.

Date	Time	Activity
		The tool was tested several times. Its secondary lock was initially a little slow but worked after lubrication. The locking function was tested six-seven times. The driller, who did not take part in the TBRA, signed the form as a final approval.
17 Oct	17.00-18.00	The joint was brought up to the V door and connected to the HRRT. The roustabout saw that the joint was run into the drill floor and could see that the HRRT was tight against the joint edge. The driller began to lock the HRRT and was notified on the screen in his cabin that it had locked. He asked the roustabout closest to the tool to check that it was locked. The roustabout saw that the plate for the secondary lock rotated, and confirmed on that basis that the locking was OK. The driller began to raise the joint to the vertical.
17 Oct	**17.59**	**The joint dropped onto the spider.**
17 Oct	18.10	The PA system announced that an incident had occurred on the drill floor, and that nobody appeared to have been injured.
17 Oct	18.20	The management was informed. It was decided that there was no need to activate emergency response plans and establish a response organisation, since the incident did not have a potential for further escalation.
17 Oct	22.33	The PSA was notified of the incident.
17-18 Oct	Night	NOV acquired data about the incident from the Cyberbase log.
19 Oct		The PSA decided to investigate the incident and was in dialogue with the police.
2 Dec		The HRRT was tested on land by Subsea Services with representatives from Seadrill, Lundin and Axess AS (enterprise of competence).

5 Technical, organisational and operational conditions with riser handling

This chapter addresses technical, operational and organisational conditions related to the incident, and the interaction between them.

5.1 Technical set-up for riser handling on *West Bollsta*

The investigation team has looked at equipment and technical systems related to joint handling on *West Bollsta*. Functionality, integrity and robustness of these systems are described to provide a better understanding of the actual incident.

5.1.1 The HRRT and insertion in a joint

The device used to connect the joint to the drilling machine's top drive was a specially designed lifting accessory (SDLA) – a collective term for equipment intended to lift drilling equipment. This HRRT was specially tailored to the joint, and both were manufactured and delivered by Cameron.

The HRRT included the following components:

- profiled split lock ring
- piston – expanded the split lock ring so that the profile on the ring became lodged in a lifting groove inside the joint
- indicator rods (four) – attached to the piston, with two functions:
    - part of the locking mechanism
    - provided a visual indication that the piston was down and the HRRT was locked
- secondary lock with lock-ring – held the piston with indicator rods in the locked position inside the joint.

Figure 4 presents a simplified diagram of the way the HRRT connected to the joint. The tool's purpose was to lock to the joint so that the latter could be lifted. The HRRT and its attachment to the joint were supposed to have sufficient strength to lift the whole string with several joints and the BOP when these were made up.

Figure 3: Simplified diagram of the joint in green and the HRRT in lilac, red, yellow and grey.

The HRRT was positioned inside the joint so that the profile on the split lock ring coincided with the groove on the joint's inner wall. Attached spacer blocks ensured that joint and tool were the right distance apart. These spacer blocks are not shown in diagram, but can be seen in photo 6.

Tool and joint were locked together by clamping the profile on the split lock ring to the groove in the joint wall. The split lock ring was expanded with the aid of a piston. This was fitted on top with four indicator rods which moved with the piston. The investigation found no tolerance nonconformities on the HRRT and the joint.

The secondary lock comprised a lock-ring to be rotated over the rods when the latter were down and the split lock ring was in contact with the joint grove. This meant the piston could not move up and the split lock ring with profile was unable to disengage from the grove. The rods stuck up through holes in the lock-ring in unlocked position. During locking, the rods were drawn down into the HRRT and the lock-ring rotated so that the rods could not penetrate through the holes.

Piston and secondary lock-ring were operated hydraulically.

Photo 5 shows the top of the relevant HRRT in locked position. Alongside the proximity switch and activation plate is one of the holes which made it possible to see one of the rods on the piston if the tool was unlocked. The photograph also shows the secondary lock-ring, an alignment mark applied in green paint, and the handle which permitted manual operation of the secondary lock plate. These are described in sections 5.1.2 and 5.1.3

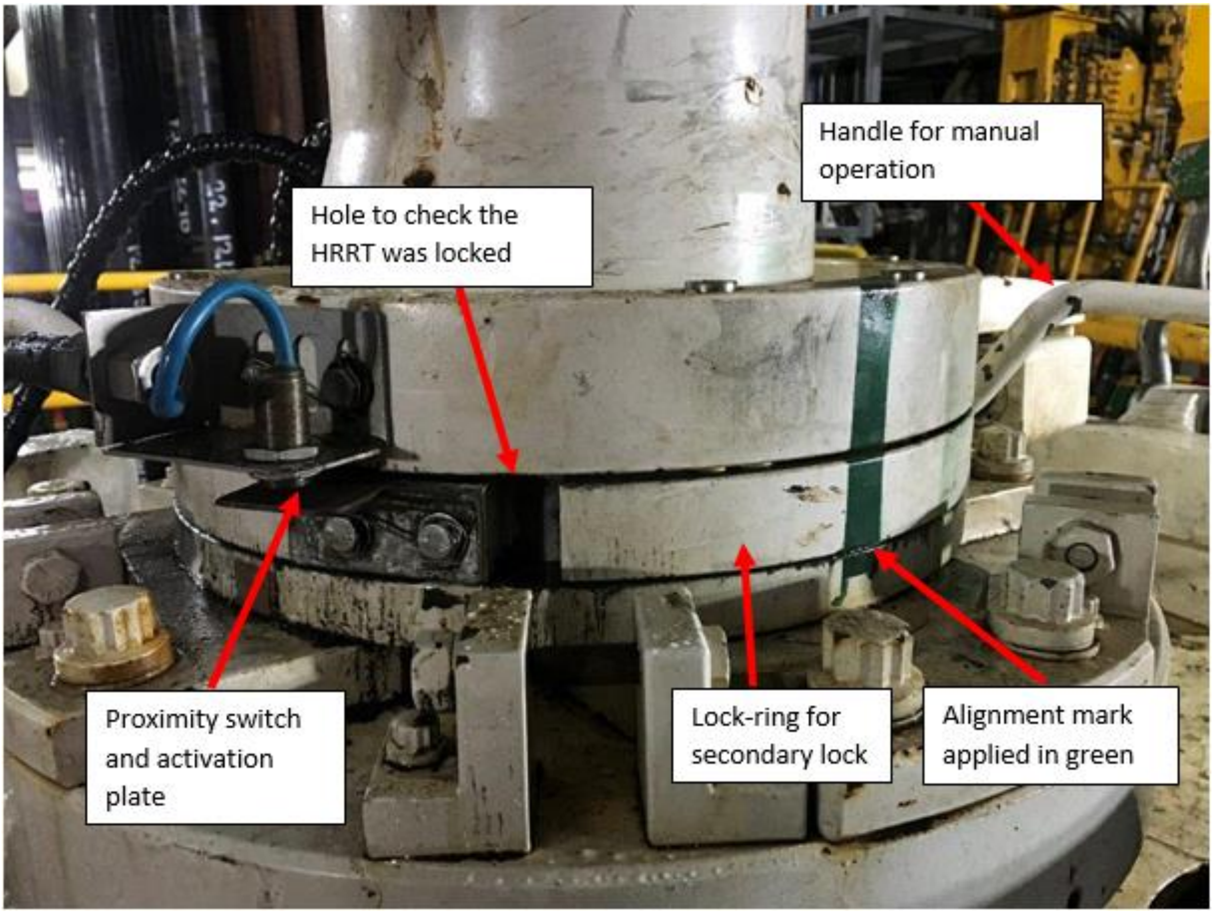


Photo 5: The HRRT involved in the incident. Taken on board by the PSA investigation team.

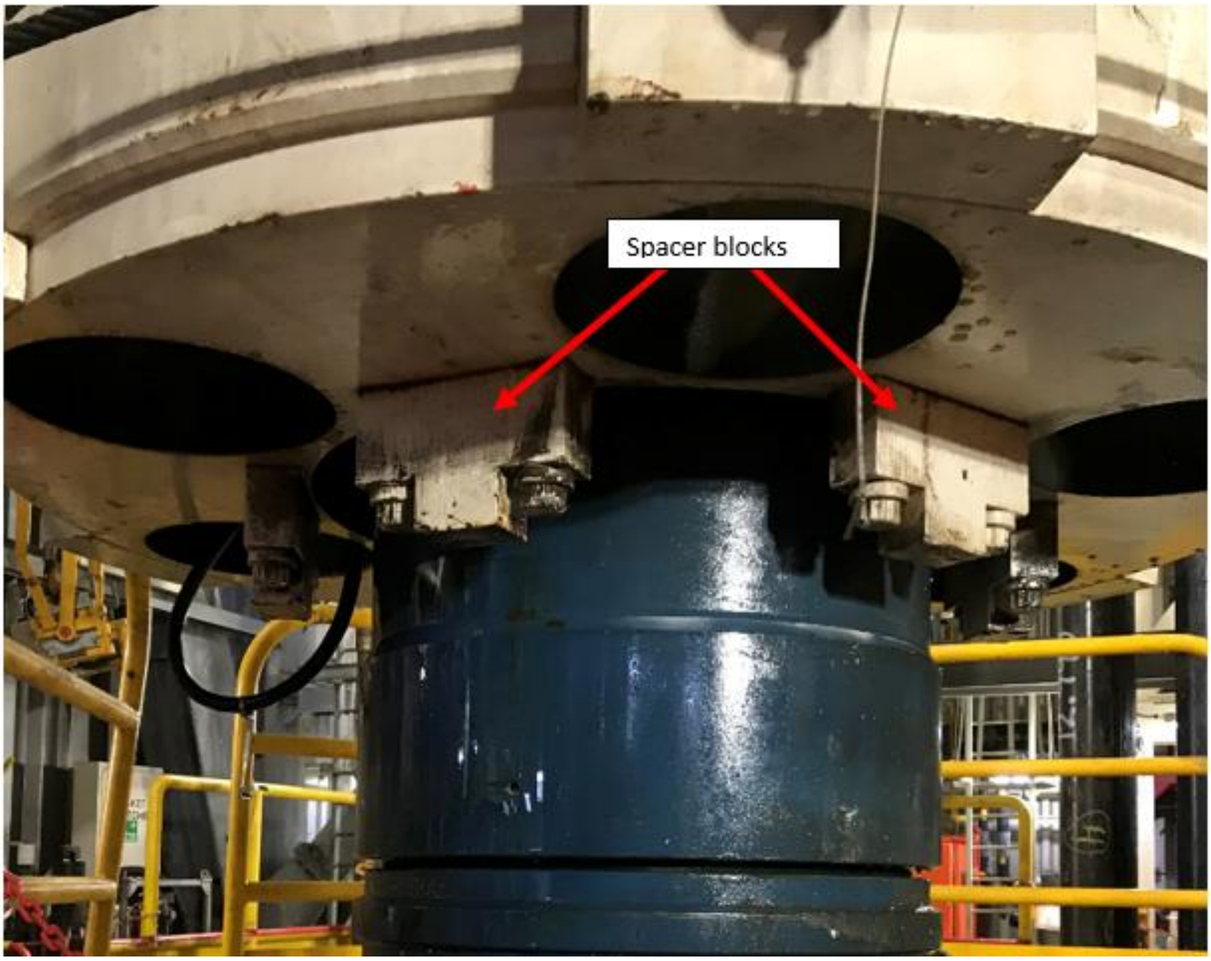


Photo 6: The spacer blocks (red arrows) and part of the split lock ring in blue. Taken on board by the PSA's team.

5.1.2 Verification of locking

Before the lifting operation began, a check was to be made that the spacer blocks were clamped tight against the joint's edge and that the HRRT was locked to the joint.

It was not possible to make an external visual check to see that the profile on the split lock ring was in contact with the groove in the joint. Locking was checked visually with the aid of the secondary lock by inspecting the indicator rod, which was visible at close hand through holes in the side of the HRRT. See photo 5. When the rod was withdrawn into the tool, it indicated that the piston was down and had expanded the locking-ring profile into the joint groove.

A proximity switch with activation plate was also installed to give an electric signal to the HRRT operator when the secondary lock was activated. The activation plate was positioned on the secondary lock-ring, and rotated with the latter when the lock was activated. Moving the activation plate beneath the proximity switch activated it. This signal was transmitted via the Cyberbase computer programme which presented the various functions to the driller on the control panel in the cabin. The switch was part of a solution developed by NOV and Hyundai, and not included in Cameron's original delivery. That emerged from technical clarifications between Hyundai and NOV in *Technical Query 550-TQ-DOL-HHI-0116*. The investigation has been unable to obtain information about how Cameron originally specified the proximity switch solution.

The investigation found several weaknesses in the design and operation of this switch, which had an important safety function in reporting to the operator whether the secondary lock was activated. It comprised an on/off switch activated when the HRRT locked. That occurred when a metal activation plate attached to the lock-ring for the secondary lock came close to the switch and activated it. This was only a simple switch, so it was not possible to establish whether the system had a fault or the switch was deactivated in the off position. No monitoring was conducted with the switch to check that it functioned as it should. The activation plate was also very large and the secondary lock-ring did not have to rotate much to activate the switch.

In addition to the signal from the proximity switch to the driller's control system, a small light also showed by the actual switch. It emerged from interviews that this light could be seen from the cabin. When it was not visible, the secondary lock was supposed to activated. It also emerged that crew on board had found that the switch did not always function. It could signal to the driller that the HRRT was not locked when it actually was, and vice versa. Personnel on board had painted an alignment mark on the HRRT which was intended to make it easier to verify that the secondary lock-ring was rotated to the right position when the tool was locked. The mark comprises two stripes painted on the HRRT. One rotated with the secondary lock-ring while the other was on the fixed section of the tool. When in locked position, the stripe on the secondary lock-ring was immediately over the fixed stripe, creating a vertical line which could be seen from a distance of a few metres.

5.1.3 HRRT control system

The investigation found that a lack of clarity existed about changes to the logic of the locking functions for the HRRT being used when the incident occurred. While the HRRT was originally ordered with a hydraulic locking mechanism and manual secondary lock, Cameron changed the tool at the request of the customer and before delivery so that the secondary lock mechanism could also be operated hydraulically from the driller's cabin. The intention was to avoid having personnel in the red zone while the HRRT was in use. Delivered to a number of customer, the hydraulic secondary lock was a standard conversion set developed by Cameron.

It emerges from the technical query between *West Bollsta* builder Hyundai and Cyberbase supplier NOV, cited in section 5.1.2 above, that neither had a clear perception in advance of what the hydraulic circuit and logic for the primary and secondary locks should be like. It also emerged from the technical query that this was not described in Cameron's equipment delivery either. It was therefore unclear to NOV how this should be programmed.

The investigation found that the hydraulic system for the secondary lock released the pressure intended to hold this lock in place after about 10 seconds. The lock was still activated, but after 10 seconds it could be deactivated mechanically because no hydraulic pressure was keeping the lock-ring closed. Deactivating the secondary lock involved rotating the lock-ring back, so that the indicator rods keeping the piston inside the HRRT could rise again. The secondary lock could therefore be deactivated while the joint was being lifted.

Several hydraulic hoses connected the HRRT with the top drive. One theory which emerged during testing was that the handle on top of the HRRT could have become tangled with the hoses during lifting and opened the secondary lock. Tests showed that it was possible to open the secondary lock-ring manually without much force.

5.1.4 Third-party certificates and verifications

Certificates for the relevant HRRT involved the incident were requested as part of the investigation in order to check whether these were valid in relation to applicable requirements for this type of SDLA. The following certificates and documents were presented.

- Design verification report DVR-D32755-J-3968 from DNV GL, dated 1 October 2014. This verifies that the HRRT was designed pursuant to the requirements in API 8C *Drilling and Production Hoisting Equipment 5th edition,* which covers lifting equipment used in drilling facilities.
- Certificate N1415B5R for hydraulic running and test tool assembly with double lock grooves and secondary mechanical lock from DNV GL, dated 16 September 2015. This shows that the HRRT was certified and found to comply with DNV-OS-E101, Drill Plant, revision October 2013.
- Certificate of conformance no 14348 issued by Sub Sea Services, dated 18 March 2020, which refers to DNV-OS-E101.

These documents show that third parties have verified that the HRRT has been built in accordance with the requirements in the referenced norms, but do not approve the use for the equipment for lifting operations. The requirement for certifying equipment for use with lifting operations is that it must be conducted by an enterprise of competence approved by the Norwegian Labour Inspection Authority. Furthermore, certification must accord with the requirements in Norsok R-003N annexes E and H. These include requirements for documentation and the certification process. Seadrill was made aware of the certification deficiencies both through the PSA's consideration of its AoC application and by the enterprise of competence when it certified the HRRT on board in the spring of 2020. It emerged from the investigation that crew on *West Bollsta* were not aware of this. They thought the above-mentioned documentation was sufficient to use the HRRT for lifting.

It emerges from all these documents that the equipment referred to is the variant of the HRRT with a manual secondary lock rather than the hydraulic version which was involved in the incident. No documentation has been presented to the PSA team which shows that a third party has verified the HRRT with a hydraulic secondary lock in relation to relevant norms.

5.2 Operational and organisational conditions the drill floor

The investigation team has looked at the division of responsibility and what assignments the various roles have had on the drill floor in connection with riser handling. It has also looked at performance-influencing factors which could have been significant for personnel being able to do their intended jobs. Such factors largely embrace HTO interactions, and those relevant in this investigation included training, workload, human-machine interfaces, familiarisation, division of roles and responsibilities, communication, checking, weather, light and the availability and user-friendliness of procedures, documents and control systems.

5.2.1 Personnel with roles related to riser handling

For personnel to be able to fulfil their role as a barrier or part of one, this must be clearly defined and understood for the various work assignments.

Seadrill had a step-by-step procedure (Run BOP, doc no SSP87-0060) for riser handling which defined roles and responsibilities between personnel in the drilling department. This specified that:

- the DSL had the overall responsibility, including verification that all necessary checklists had been reviewed before running a riser with a BOP
- the toolpusher should distribute all checklists and check they were complete
- the driller should organise personnel on deck as well as completing and signing all checklist steps carried out
- the subsea supervisor and engineer should check the equipment via dedicated pre-check lists
- other drill-floor personnel were not named in the list of responsibilities and roles presented on the first page of the document.

Verification of the secondary lock had to be done by personnel who were on deck fairly close to the equipment. According to item 14 in the step-by-step procedure, the assistant driller or the subsea supervisor were to verify and then confirm to the driller that the hydraulic primary and secondary locks were in place and active. It emerged during the investigation that, contrary to the procedure, the division of duties, roles and responsibilities on the drill floor was not normally agreed before an operation began. Roles were allocated during execution, depending on who was available.

5.2.2 Communication and information on riser handling

Risk assessment
Risk assessments are intended to help identify operational risk in order to implement the necessary technical, operational or organisational barriers required for a job.

The assistant driller led the TBRA, also known as a toolbox talk, ahead of the joint lift. During the TBRA on 8 October 2020, the driller was not present because they had other work to do in the cabin. This person has the operator role during a lifting operation and therefore a special responsibility to manage and take care of safety and to identifying hazards with the lift. The final three points in the TBRA were categorised as red risks – work in the red zone on the drill floor, the risk of a dropped joint and its potential threat to equipment and personnel, and "first time in operation". The driller was responsible for all actions in the TBRA.

User manual and work description
Checklists and procedures must be easily available and understandable by the user. These are aids for describing what must be done so that personnel can play their role as barriers or equip them to secure the necessary barriers before executing the operation. That calls for the right information to be available at the right time for personnel who have been assigned a role in the operation.

It was difficult for personnel on board to obtain a unified and exact understanding of risks and requirements relating to the various work operations from the documents available and training given. Step-by-step procedures were unfinished, and the user manual was inaccurate and hard to access. The step-by-step procedure had few photos/illustrations, and did not make it clear how HRRT locking was to be verified.

The documents dealing with the HRRT provided no explanation of how locking and verification of the secondary lock was to be done with the relevant equipment.

- The icons in Cyberbase and their various phases were not described in the user manual or the step-by-step procedure.
- Nor did the step-by-step procedure correspond with the description of locking in the user manual.
- Item 6 on installation in Cameron's TC9440 document specified that personnel should manually insert the locking pin in the lock hole.
- Coloured illustrations of the locking mechanism in the document from Lundin showed the indicator rod in red.

The rod was not coloured as implied in the illustrations, there was no manual locking pin, and the green alignment mark painted on board was not shown in the illustration or described in the text of any of the documents. No other descriptions were available of how the relevant HRRT should be locked and verified. Documents to be used by the personnel for verifying the secondary lock did not accord with how the mechanism actually looked after the design had been changed.

All Seadrill's procedures and checklists for the drill floor were in English, but communication on deck and in the driller's cabin was primarily in the Norwegian spoken by most crew members. That could have been a supplementary reason why risk was not communicated in a way which allowed ambiguities to be picked up and addressed

Driller and control system in the cabin
The driller's cabin on *West Bollsta* had a direct line of sight with adequate light to see equipment on the drill floor. Although the modified HRRT was intended to eliminate the need for work in the red zone when handling joints, locking neverthless had to be verified by drill floor personnel.

The Cyberbase control system used by the driller to control the hydraulic lock and maintain an overview of whether the HRRT was locked had two modes on the screen in the cabin – Unlock and Lock.

When the driller received the all-clear signal from the deck that the HRRT was fully inside the joint, he pressed the RRT Lock icon on the screen. The locking sequence is presented in table 1 below.

A grey icon means that the function is not active, white that it is active, and grey with a white bar that it is being implemented.

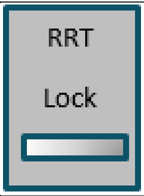
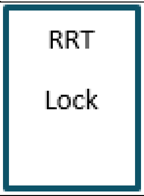
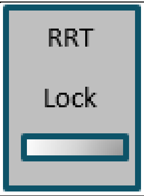
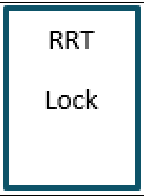
	Driller presses RRT Lock to initiate the locking sequence.
	The system applies pressure to the split lock ring, which expands into the grove in the joint (primary lock).
	The split lock ring is in the groove, with the HRRT locked tight to the joint. The icon is white while waiting for the system to activate the secondary lock automatically.
	The system activates the secondary lock and the lock-ring rotates over the indicator rods.
	When the proximity switch is in the right position, the system signals that the secondary lock is activated and the driller can start lifting the joint.

Table 1 Locking sequence in Cyberbase.

In addition, an icon for unlocking the tool, marked "RTT Unlock", was positioned beside the RTT Lock icon. The icons for locking and unlocking the HRRT are identical – only their text differentiates them.

Following conversion from manual to hydraulic secondary locking, the locking mechanism was designed for everything to be controllable hydraulically after the HRRT was correctly positioned in the joint. The human-machine interface in Cyberbase was designed in such a way that the driller received ambiguous signals of activation, deactivation and faults when locking the HRRT. The reliability of the proximity switch was also uncertain.

It also emerged during the investigation that the driller could see a small light by the locking mechanism's proximity switch before the split lock ring was in position. He was not supposed to see this light when the HRRT was locked in the joint.

The driller has – and must have – confidence in the technology he uses, and in the roustabouts knowing what they are doing when they check locking in the field.

Alarms warning the operator of abnormalities must be easy to understand and differ clearly from other information. The system told the driller nothing about the need for any assessment or action during the lift. Presentation of information from the proximity switch on the screen in the cabin, the light by the proximity switch which was not visible, together with oral verifications the driller received from the drill floor, gave no warning that the locking mechanism was not engaged or had moved out of the locked position.

5.2.3 Training and expertise

Personnel must be familiar with the requirements set for the safety-critical jobs they are to do. Each individual and group must be placed through teaching and training in a position to discharge their assignments.

West Bollsta was a new drilling facility. This meant that its crew had been composed fairly recently, and that many of them had received training in and familiarisation with new equipment during the months before the incident. The time spent completing the facility for operation had been used in part for teaching about and simulator training with riser handling. But deficiencies in governing documents and procedures meant that conditions for full and uniform training were poor.

Simulator training
All Seadrill's drillers, assistant drillers and toolpushers, some of the drill floor workers and drilling optimisers had reportedly received simulator training. The relevant HRRT was new to the facility's crew and not part of the simulator training, which had involved a traditional lifting device. On the other hand, the driller's display in the simulator was more or less identical with the one on board.

On-the-job training and trial operation
When the facility was berthed before moving to the drilling location, some of the shifts trialled operation of the equipment with riser joints. This training was not documented. The HRRT used during the trial suffered a hydraulic leak, and was therefore replaced with a similar tool which was being utilised when the incident occurred.

Seadrill's training matrix requires all drilling personnel (except drilling optimisers) to take training modules *BOP & Riser Handling System I-038* and *BOP/Riser/Diverter – Run & Retrieve E-012*. Questions asked after training to verify the competence of drilling personnel were generic for all Seadrill's facilities, and not specific for the equipment on an individual facility. It was therefore impossible to know whether personnel were familiar with the way the HRRT locking mechanism functioned on *West Bollsta*.

6 Potential of the incident

6.1 Actual consequence

The joint dropped into the red zone while two people were on the drill floor close to the impact area. However, they were outside the red zone in an area regarded as safe.

On dropping, the joint damaged the V door to the pipe deck and some of the equipment used to transport and handle the joint from the riser deck to the drill floor – including the gorilla arms. The joint was also damaged and had to be replaced.

All drilling work ceased on *West Bollsta* after the incident, and it took almost a week for normal activity to resume.

6.2 Potential consequences

The joint dropped into the red zone, but could with only a minor change in direction have struck the driller's cabin, where six people were present when the incident occurred, or outside the red zone of the drill floor where personnel were also to be found. One or more of these people could then have been seriously injured or killed.

7 Direct and underlying causes

During the investigation offshore, neither the PSA nor the Seadrill investigation teams found any technical deficiencies in the equipment which could have led to the incident. Nor were any found with the HRRT or joint during testing and inspection on land. The team has therefore worked on the basis of three possible theories.

- Theory 1: the locking mechanism was fully engaged with the joint, but disengaged at a point during the lift from horizontal to vertical.
- Theory 2: the locking mechanism was only partially engaged when lifting the joint from horizontal to vertical began
- Theory 3: the locking mechanism was not engaged with the riser when lifting the joint from horizontal to vertical began.

7.1 Theory 1: locking mechanism fully engaged with the joint

This possibility is described in section 5.1.3 on the HRRT control system. Engagement between the split lock ring and the joint may have deactivated if the secondary lock-ring rotated to its open position early in the lift, while the joint was virtually horizontal. This must in the event have happened at that point because Cameron says further loading would have a self-locking effect on the mechanism. As a result, even if no forces were holding the split lock ring in the locked position, it would not revert to the unlocked position by itself when locked and loaded.

The investigation has not succeeded in producing such a deactivation, even though a number of tests were conducted with the tool for that purpose.

7.2 Theory 2: locking mechanism partly engaged with the joint

At an early stage in the investigation, the possibility was considered that the locking mechanism might only have engaged partly with the joint because activation was attempted without the HRRT being fully inserted in the joint. This theory was quickly rejected on the basis of the condition of the HRRT and joint, as well as the way the mechanism functioned. No traces were found in the joint which suggested that there had been direct contact with its wall.

To be certain that this theory could not be the cause of the incident, a test was also conducted with another similar HRRT on board which involved trying to lock the HRRT without it being correctly positioned inside a joint. This proved impossible. The piston could not descend in the HRRT, and was thereby unable to expand the split lock ring. Since the HRRT was not engaged with the joint, it could not be lifted.

7.3 Theory 3: locking mechanism not engaged with the joint

It emerged from the investigation that both user manual and procedures lacked an accurate description of the locking mechanism and how personnel on board could check that it was engaged. Nor had the personnel received any form of formalised training in this. The actual verification is described in sections 5.1.1 and 5.1.2 on the HRRT and installation in a joint and verification of locking respectively, where it also emerged that technical deficiencies exist in the system for reporting to Cyberbase that the system is locked and lifting can begin.

Tests on *West Bollsta* after the incident showed that feedback from the proximity switch to Cyberbase was unreliable. When the locking sequence started, the tests on land showed that even a small motion in the secondary locking lock-ring could produce an inaccurate signal to Cyberbase that the tool was locked. Testing also found that this could happen in cases were the HRRT was not sufficiently inserted into the riser. If the HRRT was not fully inserted, the split lock ring's profile would be clamped to the joint wall and thereby fail to engage with the groove in the latter. Thereby the piston would also be unable to move down the split lock ring and the indicator rods could not descend into the HRRT and be locked in place by the secondary lock-ring. Rotating the latter would be halted by the rods sticking up through their holes. However, the lock-ring would move a few millimetres before being halted by the rods. This small movement might be enough for the proximity switch to signal Cyberbase that the HRRT was locked.

Combined with the fact that personnel who participated in the operation lacked adequate understanding and knowledge of how they should check a successful locking, this could have meant that both driller and roustabout thought the HRRT was locked even though that was not the case. The light the driller could see by the proximity switch could have been deactivated or hidden if the switch was close enough to show the locked position. It emerged from interviews that roustabouts who confirmed a successful locking out in the field saw the secondary locking lock-ring moving and assumed that the operation was successful. Given the absence of a descriptive procedure which explained to the roustabout step by step what was to be checked, and the failure to provide the latter with formalised and adequate training, a possibility exists that they confirmed locking in error.

This theory builds on the consideration that, although the locking mechanism was at one point fully inserted in the riser and the spacer blocks were tight against the joint, a displacement could have occurred later. This must have happened between the time the roustabout saw that the HRRT was inserted in the joint when it entered the drill floor, and when they observed the secondary lock-ring rotate during the actual verification. Testing on land shows that, if the HRRT was inserted in the joint and was not hanging from the top drive, it would be at an angle of between two to 2.2 degrees against the joint. During the test, the HRRT was withdrawn to create a gap of 20mm between the upper spacer block and the top edge of the joint. The bottom edge of the joint was thereby 3.3mm from the lower spacer block. Under these conditions, the HRRT was unable to lock to the joint during the test on land. This is shown in the diagram and photo below, which are taken from the Sub Sea Services test report.

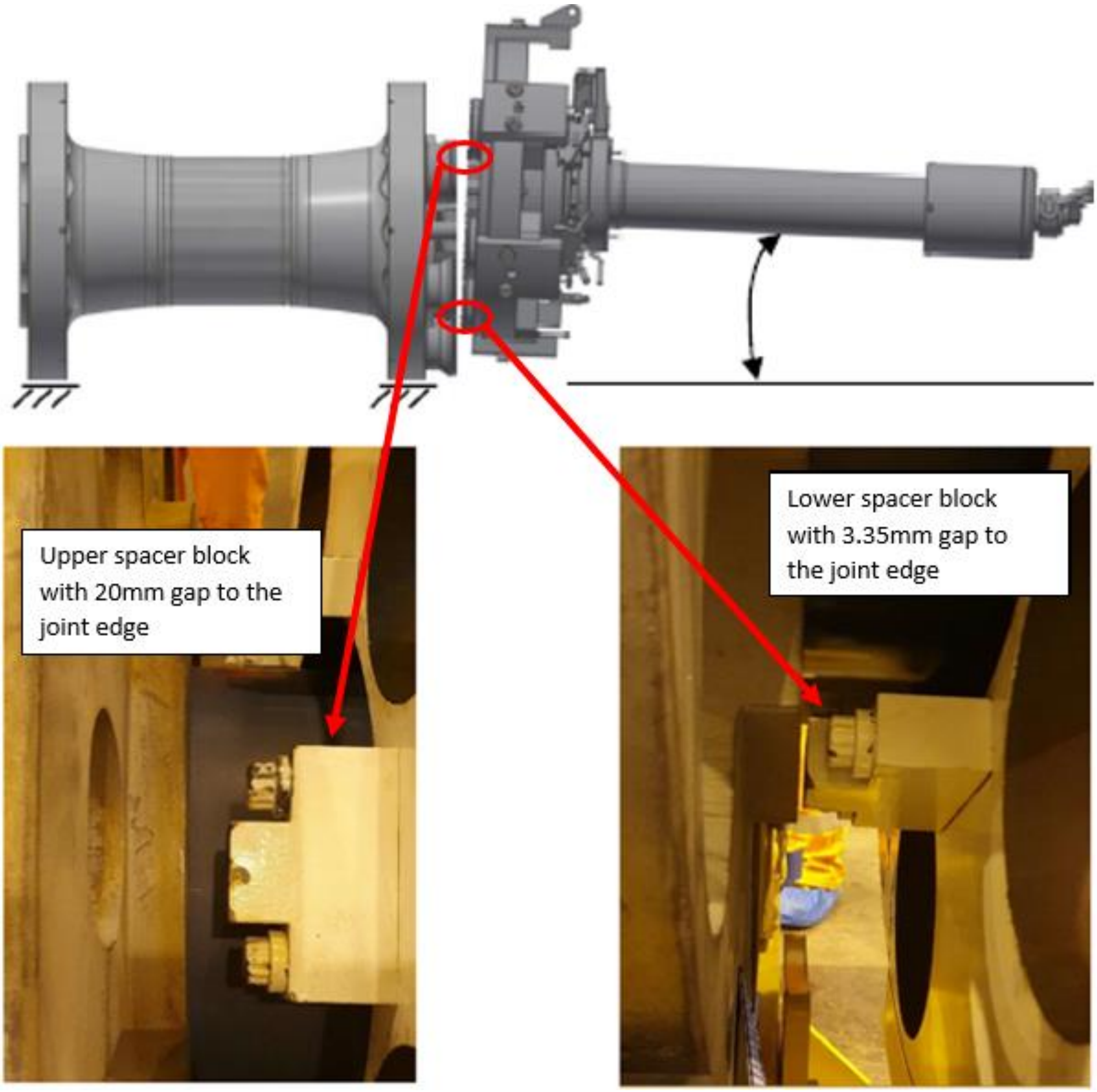


Photo 7 Testing on land.

Seadrill's investigation has concluded that this is the most probable cause of the incident.

7.4 Underlying causes

Viewed overall, technical, organisational and operational conditions have contributed to the incident. The PSA team has looked at several factors influencing performance and at their interaction, which may have been significant for the ability of the organisation and personnel to work in a safe and managed way. Briefly, these are:

- Seadrill's management system did not accord with the regulations and standards
- the company had not followed up previously identified nonconformities related to logistics

- risk understanding, risk assessment and the decision basis for the activity were inadequate
- roles and responsibilities were not clarified ahead of the work operation
- compliance with requirements in the regulations and Seadrill's own governing documents was inadequate
- procedures for lifting equipment and operations in the drilling area contained errors and deficiencies
- training and competence of lifting-equipment users on the drill floor were inadequate
- lifting equipment had technical deficiencies and lacked user documentation
- the technical design of the proximity switch gave incorrect signals to the driller
- poorly designed human-machine interface in Cyberbase for HRRT locking
- HRRT was not certified as lifting equipment by the enterprise of competence
- unclear division of responsibility between supplier, yard and customer over controlling the HRRT in Cyberbase.

8 Similar incidents with SDLAs in the drilling area

Many serious incidents have occurred on both fixed and mobile facilities with materials handling of equipment for use in drilling operations on the drill floor. Examples of some which posed a major potential hazard are:

- *Stena Don* 2005 – dropped riser
- *Transocean Searcher* 2007 – dropped BOP and riser
- *West Epsilon* 2007 – dropped casing
- Heidrun 2008 – near miss with dropped completion string
- Gullfaks C 2009 – dropped downhole equipment
- Heidrun 2009 – dropped riser
- *Stena Don* 2009 – dropped riser
- *Deep Sea Atlantic* 2009 – dropped casing
- Njord 2010 – dropped telescopic tubing
- *Mærsk Giant* 2010 – dropped end protector
- Heidrun 2010 – dropped riser
- *West Venture* 2015 – dropped locking mechanism on pipe plug Jotun B 2018 – dropped riser
- *West Bollsta* 2020 – dropped riser joint.

The listed incidents all had a big potential for harming personnel and equipment. Several were investigated by the PSA, which also followed up internal company investigations of others. The investigations and their follow-up through meetings and audits revealed a great deal of similarity in direct and underlying causes between the incidents, including:

- inadequate requirements for design and fabrication
- design deficiencies
- equipment not built to prevent incorrect use
- difficult to check correct installation/engagement between running tool and load
- inadequate/incomplete/missing user manuals
- inadequate knowledge of and training in the way the running tool worked
- lack of risk assessment when using the equipment
- lack of requirements for following up and checking the equipment.

The PSA's investigation of the dropped riser joint on *West Bollsta* has seen that many of the direct and underlying causes identified in earlier incidents with this type of equipment on the NCS are also to be found in this case.

9 Regulatory clarifications for *West Bollsta* in connection with the AoC application

Mobile facilities are subject to section 3 of the framework regulations on the application of maritime regulations in the offshore petroleum activities. This means that maritime regulations may be applied for maritime conditions on board. To operate on the NCS, drilling facilities like *West Bollsta* must have an AoC as specified in section 25 of the framework regulations. An AoC application and its evaluation must accord with the regulations and with the *Handbook for Acknowledgement of Compliance*. Requirements for lifting equipment are specified in section 69 of the facilities regulations on lifting appliances and lifting gear. Section 1, litera a of the facilities regulations notes that section 3 of the framework regulations does not apply to provisions regarding drilling and process equipment. Section 69 of the facilities regulations also applies to mobile facilities with regard to lifting appliances and lifting gear on the drill floor. See guidelines, which recommendation the use of annex D to Norsok R-002.

Where the relevant lifting equipment involved in the incident is concerned, an RRT of this type is included Norsok R-002 and defined as an SDLA subject to specific requirements applicable to lifting equipment.

Facilities with an AoC are otherwise subject to the activities regulations. This means that section 92 of these regulations on lifting operations, which refers in its guidelines to Norsok R-003N on safe use of lifting equipment, provides guidance on such matters as how lifting operations are to be organised, planned and executed. It also gives guidance on how lifting equipment – including devices classified as an SDLA – are to be followed up both technically and operationally.
Seadrill has chosen to apply Norsok R-003N on safe use of lifting equipment and Norsok R-002 on lifting equipment as requirements in its management system.

Key provisions in the petroleum regulations dealing with risk, barriers and work processes also apply. In its West Bollsta *Application for Acknowledgement of Compliance (AoC)/IADC HSE Case, rev 1*, Seadrill confirms its compliance with those parts of the PSA regulations which the investigation team has applied when assessing its observations.

10 Observations

The PSA's observations fall generally into two categories.

- Nonconformities: this category embraces observations where the PSA has identified breaches of the regulations.
- Improvement points: these relate to observations where deficiencies are seen, but insufficient information is available to establish a breach of the regulations.

10.1 Nonconformities

10.1.1 Design of lifting equipment

Nonconformity
The HRRT was not designed for the conditions it was intended to be used with.

Grounds
The PSA team identified a number of deficiencies in the design of the HRRT.

- The secondary lock could be deactivated while the joint was being lifted, which meant the locking mechanism was not secured with a double barrier against losing the load.
- No SWL was shown on the HRRT, nor was this indicated in any documentation. It was also unclear which SWL applied for lifting joints from horizontal to vertical. This does not appear in any of the documentation received by the PSA team, nor was anything marked on the HRRT.
- The locking mechanism was not designed to provide a clear and unambiguous indication that the HRRT was locked. Without detailed knowledge of the tool, it was easy – despite the provision of four inspection holes for indicator rods – to misinterpret whether the secondary lock was activated. Furthermore, a visual inspection through the holes required personnel to stand very close to the tool in order to determine that the piston was down.
- A proximity switch was mounted on the secondary lock to signal to the operator that it had been activated. This mechanism comprised a single switch, and a fault in this could signal that the HRRT was locked even when it was not, and vice versa. No indication was provided if the tool was unlocked, and no provision was made to detect faults in the system.
- The user manual lacked a description of how personnel could check that the HRRT was locked.
- The user manual was not in Norwegian.

- The product declaration from the manufacture did not reference Norsok R-002.

Requirement
Section 69 of the facilities regulations on lifting appliances and lifting gear, see the guidelines referring to Norsok R-002

10.1.2 Correction of earlier nonconformities and orders

Nonconformity
Failure to follow up and correct previously identified nonconformities and orders.

Grounds
Several of the observations in this investigation report have been reported by the PSA in the form of nonconformities and improvement points to Seadrill after earlier audits and investigations.

An overview of earlier nonconformities which are most relevant to the incident is provided below.

- Report from AoC audit of logistics on *West Bollsta*, 24 March 2020.
  - <u>5.1.2 Certification of lifting equipment in the drilling area</u> – certification lacking for lifting equipment in the drilling area.
- Report from audit of maintenance management, logistics, working environment and worker participation, and emergency preparedness, *West Hercules*, 9 April 2019.
  - <u>5.2.2 Maintenance of lifting equipment</u> – enterprise of competence: deficiencies in systems intended to ensure follow-up or competent control of lifting equipment.
  - <u>5.3.1 Management system for cranes and lifting</u> – contradictory requirements and ignorance of requirements in the management system for safe lifting operations.
  - <u>5.3.2 Responsibility and authority</u> – person responsible for lifting operations – their responsibility and role did not correspond with the description in governing documentation.
  - This report also contained the following order: "Review and assess the effect of measures adopted and implemented on all facilities with an AoC which are Seadrill's responsibility in Norway following an order issued after an audit of *West Phoenix* from 9 to 11 January 2018. This work must include an analysis of why deficiencies in the management system and associated work processes have not been identified and corrected on *West Hercules*."

- Report following an audit related to emergency preparedness, logistics, maintenance management and working environment on *West Phoenix*, 9 February 2018.
    - 3.3.1 Responsibility and authority – person responsible for lifting operations: practice on board regarding responsibility and role as the responsible person for lifting operations did not accord with the description in governing documents.
    - 3.4.2 Maintenance of lifting appliances – deficiencies in the maintenance management system and lack of maintenance for lifting appliances. Part of the evidence for this nonconformity was inadequate follow-up of findings from competent control.
- Report following an audit on *West Epsilon* in the logistics and working environment areas, 25 January 2016.
    - 5.1.1 Responsibility and authority – person responsible for lifting operations: practice on board regarding responsibility and role as the responsible person for lifting operations did not accord with the description in governing documents.
    - 5.1.2 Expertise – inadequate expertise, lack of training and drills, and deficiencies in the systems intended to ensure this.
    - 5.1.4 Maintenance – deficiencies were identified with maintenance and with the systems intended to ensure adequate maintenance. Part of the evidence for this nonconformity was inadequate follow-up of findings from competent control.

Requirement
Section 22 of the management regulations on handling of nonconformities

10.1.3 Continuous improvement

Nonconformity
Inadequate continuous improvement on *West Bollsta* with regard to materials handling and experience transfer from Seadrill's other facilities on the NCS.

Grounds
Learning and improvement across facilities in the organisation have been inadequate for correcting nonconformities. The investigation has also seen that earlier orders have not been fully followed up in accordance with the company's response to the PSA.

See nonconformity 10.1.2 for the grounds.

Requirement
Section 23 of the management regulations on continuous improvement

10.1.4 Management system for lifting operations

Nonconformity
Seadrill had not ensured that procedures related to lifting operations and equipment were formulated and applied in a way which fulfilled their intended functions.

Grounds
Local procedures are a requirement in Norsok R-003N annex C. The procedure for safe use of lifting equipment on *West Bollsta* described how lifting operations on the facility should be conducted a safe way. This was an annex to Norsok R-003N, and functioned as a local procedure. However, the investigation team could not see that it fully described all the supplements relevant for safe lifting operations on *West Bollsta*. Furthermore, information conflicts existed between the requirements in the Norsok R-003N and local procedures. Examples identified by the investigation in relation to lifting operations on the drill floor included the following.

- Roles and responsibilities were not adequately described. It was unclear which positions had the various roles, nor did the role descriptions correspond with the descriptions in Norsok R-003N annex A.
- The system for colour coding of lifting equipment differed from the one described in Norsok R-003N annex H. However, interviewees confirmed that Norsok R-003N was used for colour coding of lifting equipment on board.

The user manual for the HRRT was deficient, since the tool in the manual did not correspond with the one used on board. It emerged from the investigation that the locking mechanism for the secondary lock on the HRRT had been converted before delivery by Cameron. The manual described a manual secondary lock, while the one on *West Bollsta* was hydraulic. This meant the description of how personnel should verify locking of the HRRT was inaccurate. Furthermore, the manual was only available in English. Norsok R-003N and Seadrill's local procedure for lifting operations both required Norwegian to be used. The PSA team inquired about a nonconformity process for this condition, but was told it had not been carried out.

Requirements
Section 24 of the activities regulations on procedures
Section 17 of the framework regulations on the duty to establish, follow up and further develop a management system
Section 92 of the activities regulations on lifting operations, see the guidelines referring to Norsok R-003N on safe use of lifting equipment

10.1.1 Procedures for executing work

Nonconformity
The procedure for running a riser with a BOP was not formulated in such a way that it functioned as intended.

Grounds
The step-by-step procedure for running a riser with a BOP (Run BOP) did not describe what was actually to be checked in order to determine that the locking mechanism was locked tight to the joint before the lift. According to the section on connecting the HRRT (Install RRT), it was sufficient for the driller to receive a signal via the screen on the control panel that the lock was activated. The next section in the procedure dealing with making up two joints (Make double joint of riser to BOP) specified both that the driller should receive a signal on his screen and that personnel on the drill floor should check and confirm that the tool was locked tight to the joint. Neither the step-by-step procedure nor the user manual explained or showed how to check that the locking function was activated.

Furthermore, the procedure specified that the check and confirmation from the drill floor were to be carried out either by the subsea engineer or the assistant driller. The PSA team learnt that the practice was for one of the roustabouts to carry out verification and confirm locking to the driller.

The step-by-step procedure was only available in English. Both Norsok R-003N and the Seadrill local procedure for safe use of lifting equipment on *West Bollsta* required Norwegian to be used. The PSA team inquired about a nonconformity process for this condition, but was told it had not been carried out.

Requirements
Sections 24, paragraph 2 of the activities regulations on procedures, and section 92 on lifting operations, see the guidelines referring to Norsok R-003N on safe use of lifting equipment

10.1.2 Organisation and exercise of roles and responsibilities

Nonconformity
No assurance had been obtained that the organisation and exercise of roles and responsibilities were being complied with, so that they fulfilled their intended function.

Grounds
It emerged from interviews with management that they were not familiar with what the roles of "operational responsible" and "technical responsible" persons involved pursuant to Norsok R-003N annex A. Seadrill has opted to use Norsok R-003N on safe use of lifting equipment as a requirement in its management system. Nor was the PSA team able to see that these roles functioned on board as described in Norsok R-003N. The following are some examples.

- The operational responsible person on the drill floor was not familiar with the requirements in Norsok R-003NN annex A, and also lacked sufficient knowledge to see to it that lifting operations were conducted in accordance with regulatory requirements and the Norsok R-003N standard. Furthermore, the operation to lift the riser with the aid of the HRRT was not identified as a lifting operation by the operational responsible person.

- The technical responsible person on the drill floor was not familiar with the requirements in Norsok R-003N annex A. Nor were they aware of the requirement to follow up findings of a competent control in accordance with Norsok R-003N annex H. Furthermore, the technical responsible person was not aware that the HRRT was classified as lifting equipment.

The roles of roustabout and driller were not clarified ahead of lifting operations in accordance with the requirements on roles and responsibilities in Norsok R-003N annex A. In the team's view, the driller was the operator of the HRRT while the roustabout who confirmed that it was locked tight to the joint had the banksman role. Interviewees reported that the most readily available roustabout was asked to provide this confirmation. No clear division of roles and responsibilities existed between the operator (driller) and the banksman (available roustabout).

It also emerged that Seadrill, even at the time of the investigation, did not have personnel in the land organisation with responsibility for and expertise on crane operations and lifting equipment.

Requirements
Section 24 of the activities regulations on procedures, and section 92 on lifting operations, see the guidelines referring to Norsok R-003N on safe use of lifting equipment
Section 5, paragraph 5 of the management regulations on barriers, with guidelines

10.1.3 Risk assessments and measures

Nonconformity
Risk analysis ahead of lifting the joint failed to provide an integrated and nuanced picture of the risk associated with lifting operations on the drill floor. The decision basis was thereby inadequate for assessing or implementing necessary measures.

Grounds
The TBRA for lifting the joint conducted shortly before the incident identified the following risk in the "On the day risk" box: "First time in operation". Despite this, the TBRA was approved and the job received the green light without specifying and documenting which risk-reducing measures were to be implemented. It emerged during the investigation that people on board were familiar with the risks associated with the equipment. Little of this was communicated, and was therefore not assessed in the TBRA. Examples of risks inadequately assessed include the following.

- The TBRA for lifting the joint was conducted without the driller, even though the latter led the lifting operation and acted as operator of the top drive which lifted the joint.
- The driller signed the TBRA form afterwards even though they had not participated in the assessment. This emerged from an interview with the driller.
- Personnel on board were aware of deficiencies in the step-by-step procedure for the job and in the user manual for the equipment. This was not addressed as a risk in the TBRA.
- Which person was going to verify to the driller that the HRRT was locked tight to the joint had not been clarified ahead of the lift. The step-by-step procedure did not specify how personnel should check that the tool was locked tight.
- It emerged from interviews that the roustabout who conducted the check lacked sufficient knowledge about what was to be checked and why.
- Several interviewees commented that they had been uncertain about the locking mechanism on the HRRT and how this should be checked. They made the following observations.
    - The HRRT lacked a mechanical locking pin, which they thought would have made it safer.
    - The design of the HRRT meant the driller could not rely on the screen report that it was locked. This was known among drilling personnel. They reported that it was possible to turn the locking signal on and off by shaking the HRRT when it was in locked position during testing.
    - To make it easier to check that the HRRT was locked, the drilling personnel themselves had painted two stripes on the tool. When these were in line with each other, they gave a visual indication that the locking was in order. These lines were called the alignment mark.

Given the points listed above, the TBRA carried out was inadequate. Organisational and operational barriers were insufficiently assessed or understood, which contributed to an inadequate basis for implementing necessary measures.

Requirements
Sections 5, 13 and 17 of the management regulations on barriers, with guidelines, on work processes and on risk analyses respectively

10.1.4 Maintenance of lifting equipment

Nonconformity
Seadrill had not ensured that the HRRT was maintained so that it was able to perform its required functions in all phases of its service life.

Grounds
Maintenance for lifting equipment includes an initial certification by an enterprise of competence in order to ensure that it is capable of performing its required function before being taken into use. In its annual inspection for 2019, the enterprise of competence had required Seadrill to have the HRRT certified by 1 February 2020. See report no 256512-02-262-01_00 from Axess AS. Furthermore, the PSA's AoC inspection of 24 March for logistics issued a nonconformity on lack of certification in the drilling area. See PSA case 2020/145-30 nonconformity 5.1.2. The HRRT is included in this nonconformity. In its response to the investigation team, Seadrill reported that the nonconformity should have been corrected before *West Bollsta* became operational. The team cannot see that a nonconformity process for using the HRRT had been conducted on *West Bollsta*.

Nor did *West Bollsta* have reception routines for SDLAs which ensured that these were certified, documented and utilised in accordance with the regulatory requirements. When the team requested certificates from the enterprise of competence for the equipment, it was presented with several certificates covering compliance between design and regulatory requirements for equipment used in drilling operations. Personnel on board were not aware that the HRRT was subject to special requirements for certification and inspection, and that this should be done by the enterprise of competence.

Requirements
Sections 45 and 92 of the activities regulations on maintenance and on lifting operations respectively
Section 22 of the management regulations on handling of non-conformities

10.1.5 Expertise

Nonconformity
Seadrill had not ensured that personnel at all times had the expertise needed to carry out activities in accordance with the HSE legislation.

Grounds
Seadrill did not ensure that users of SDLAs were familiar with the user guidelines and restrictions. Training did not cover the HRRT which was on board, and no documentation was available on who had received training.

- Seadrill's expertise requirements are specified in the PRO-00-0510 procedure on competence assurance. The system included a dedicated expertise matrix called SkillsVX to ensure that the expertise requirements in Norsok R-003N were met. A review of the system revealed that it included neither SDLAs in general, nor the HRRT involved in the incident in particular.
- Interviewees also confirmed that no specific training had been provided for this type of equipment, other than that some of the crew had trained in its use on *West Bollsta* before the facility became operational. This training was not documented.
- The simulator training which had been given was with a traditional RRT, while the HRRT actually on board was new to personnel on the facility.

A new type of RRT with hydraulic locking, combined with the lack of documentation, created a poor basis for full and uniform training.

Requirement
Section 21 of the activities regulations on competence, see the guidelines referring to Norsok R-003N

11 Barriers which have functioned

The investigation has revealed that a number of factors contributed to the incident. However, the team has concluded that the following barriers contributed to preventing the incident from leading to a serious or fatal accident:

- operational barriers: using the red zone on the drill floor kept people out of the area where the joint landed
- mechanical barriers: the drill floor and deck structures were so robust that the joint did not fall through them.

12 Discussion of uncertainties

No technical faults were found in the HRRT, the control system or the field instrumentation which could individually account for the incident. Nor was any evidence found that the equipment was operated in such a way that it could have led to the joint coming loose during the lift.

In the PSA team's view, the incident is attributable to the interaction between technical, organisational and operational factors. However, it has been unable to identify a clear cause or to confirm one of the theories spelt out in chapter 7.

13 Assessment of the player’s investigation report

Seadrill has investigated the incident with Lundin’s participation, and its investigation report was ready on Monday 11 January 2021. Seadrill has not identified the direct technical cause of the incident, but has worked on the basis of three theories to explain why the HRRT came loose from the joint.

1. The HRRT was locked to the joint, but became disconnected during the lift
2. The HRRT was partially locked to the joint, and came loose during the lift because of gravitational forces
3. The HRRT was not locked to the joint, and came loose during the lift because of gravitational forces.

The PSA team consideres these theories to have been the most probable, and has based its work on the same three.

Seadrill’s report concludes that the third option is the most probable, and describes technical evidence which supports this conclusion. But uncertainties also attach to this theory. The investigation report also presented underlying HTO factors which may have contributed to the incident. Seadrill’s investigation did not arrived either at a clear cause or a confirmation of the theories.

The investigation report describes several specific proposals for further follow-up in order to prevent the recurrence of such an incident.

In the PSA team’s view, observations in the Seadrill report largely coincide with those made in its own investigation report.

14 Appendices

A: Documents utilised in the investigation
B: Overview of personnel interviewed

Appendix A: The following documents have been utilised in the investigation

17 October 2020 DP printscreens
17 October 2020 StormGeo weather forecast
550-TQ-DOL-HHI-0116 - Rev 17 Confirmation of RRT latch unlatch in dril.._
255114-02-207-01-Field Service Report Seadrill GAP cpl R01
256512-02-262-01_01 *West Bollsta*_LEC_Field Service Report (2)
113049178-01 Hydraulic Running Tool
Binder information
Bollsta Subsea Daily 09.10.2020
Cameron dropped riser open queries
Verification test of HRRT rev2.docx
DIR-37-0085 Lifting Operation
Dropped riser-timeline rig management
EB 950 D Rev A2 preservation planned maint long term riser
HRRT Approval SK-199368-10
Job description drilling section leader
Job description marine section leader
Job description technical section leader
Job description toolpusher
PRO-87-0198 Safe use of lifting equipment
SeadrilL-#14014529-v2-Cameron_-_Operation_&_maintenance_manual_for_riser running tool
SeadrilL-#14014529-v2-Cameron_-_operation_&_maintenance_manual_for_riser
Sensor inductive proximity
SK-154159-21_REV 03 HRRT secondary lock
SK-154159-22 secondary lock
Synergi 1476016 flash alert
TR-SSS-14512_Rev_1
West Bollsta – investigation plan
West Bollsta competencies
Cameron product reliability communication PRC-015
West Bollsta - HRRT evaluation summary 10 30 2020 Cameron
West Bollsta dropped riser v. Final 11.01.2021