

Investigation report

Report	
Report title Investigation of the incident on <i>Maersk Invincible</i> when tubular stands became detached from the fingerboard	Activity number 400012006

Security grading		
<input checked="" type="checkbox"/> Public	<input type="checkbox"/> Restricted	<input type="checkbox"/> Strictly confidential
<input type="checkbox"/> Not publicly available	<input type="checkbox"/> Confidential	

Involved	
Team TF-mobile	Approved by/date Irja Viste-Ollestad/5 March 2019
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1 Summary

On 11 November 2018, while the *Maersk Invincible* drilling facility was carrying out operations in well 2/8-N-4, two tubular stands made up with swell packers (hereafter stands) became detached from the fingerboard and fell out across the drill floor. The upper part of the stands fell across to the opposite side of the derrick and hit the stand building guide arm. Their lower sections slid and hit the windshield and parts of the structure by the gangway on the fingerboard side of the drill floor. Each stand was 38 metres long and weighed about 1 300 kilograms. A swell packer was installed midway along each stand.

The incident caused no injury to personnel. People were present in the area around the drill floor. When the drilling crew understood that the stands were in motion, however, it was decided to erect cordons to prevent access to the drill floor.

A decision to investigate the incident was taken by the Petroleum Safety Authority Norway (PSA) on 13 November 2018.

The cause of the incident was the failure of the locking mechanism on the fingerboard to operate as intended. A strong wind was also blowing in the area at the time of this incident. This led to two stands detaching from the fingerboard and falling out across the drill floor.

The design of the relevant section of the fingerboard with latches is intended for use with casing. It is not suitable for the smaller dimensions of stands incorporating swell packers.

Nonconformities

Three (3) nonconformities were identified:

- inadequate risk assessment and decision basis
- inadequate experience transfer within the company
- inadequate locking mechanism on the fingerboard.

Several incidents involving different types of tubulars falling out of fingerboards have occurred. This and earlier incidents demonstrate a need for learning and experience transfer both within and across the companies.

2 Background information

2.1 Description of facility and organisation

Maersk Invincible is a type CJ70 XLE (4) rig built at Daewoo Shipbuilding & Marine Engineering (DSME) between 2014 and 2016.

The drilling facilities were delivered by National Oilwell Varco (NOV). Owned by Maersk A/S, the facility is operated by Maersk Drilling Norge AS. An acknowledgement of compliance (AoC) was issued on 1 April 2017.

Maersk Drilling Norge AS secured a five-year contract in 2017 from Aker BP for *Maersk Invincible*. This involves plugging and abandonment of wells on Valhall DP and drilling injection and production wells on Valhall's north and south flanks.

The height from the drill floor to the fingerboard is specified as 33 metres.

At the time of the incident, *Maersk Invincible* was engaged on a completion operation in a water injection well on Valhall DP.



Fig 1: Artist's impression of a Maersk type CJ70 XLE jack-up rig.

2.2 Position before the incident

Eight stands with swell packers, each with a total length of 38 metres and weighing 1 300 tonnes, were made up in the main section of the derrick in the days before the incident occurred (see the figure below).

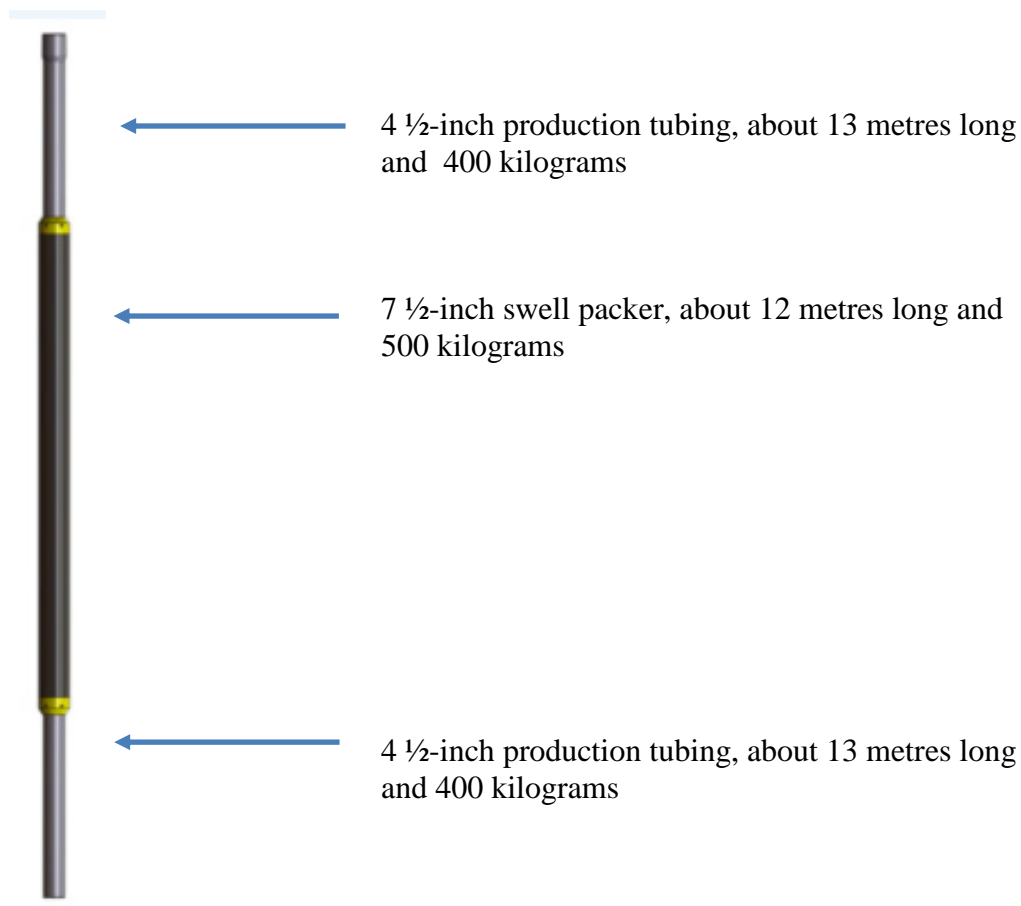
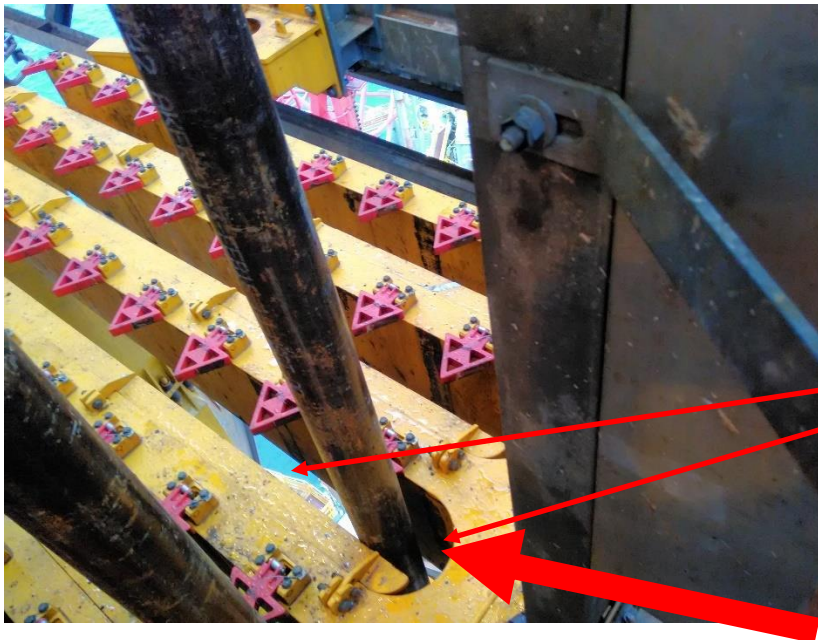


Fig 2: Illustration of a stand with swell packer (from Aker BP).

The eight stands were stored in the derrick to await the next phase of the completion operation. Based on experience and friction calculations from earlier operations which have involved running swell packers, it was decided to reduce the number of planned swell packers in the well by two. It was then decided to store the excess swell packers on the Aux side of the derrick, and they were placed innermost in fingerboard row 3 (see figure 3). These were the two stands which later became detached from the fingerboard.



Where the stands involved were positioned before the incident.

Wind direction specified at the time of the incident.

Fig 3: Position of the stands involved before the incident.

The wind strength on 11 November 2018 was 35 knots, gusting to 38 knots. It was blowing directly towards the direction of fall for the stands.

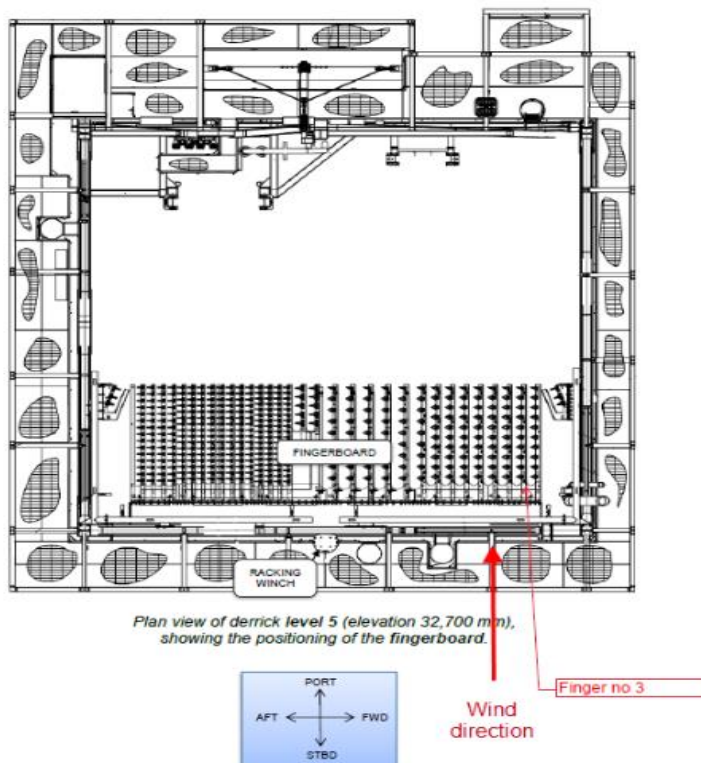


Fig 4: Wind direction at the time of the incident (from Maersk)

2.3 Abbreviations and definitions

Aux derrick - preparation/auxiliary side of the derrick

Bellyboard - fingerboard installed in the centre of the derrick to support tubulars

Fingerboard - multi-armed protruding installation, in this case 33 metres above the drill floor, with latches, tailored to accommodate various dimensions of made-up tubulars

Frank's – service company with special tong systems for making-up tubular stands

Liner – spacer/shim

NOV – National Oilwell Varco

OD – outer diameter

OIM – offshore installation manager

PB – product information bulletin

Tubular stand – made-up lengths of tubular goods

Protector – in this case, protection for threads on the stands

Setback – storage space for tubular stands on the drill floor

Stand – several lengths of tubular goods screwed together to make up a longer section. A triple comprises three tubular lengths screwed together with a predetermined torque

Stand building guide arm – remotely operated hydraulic arm in the Aux derrick used for making up tubular stands

Swell packer – used to isolate zones in the reservoir. A surrounding rubber seal swells out and tightens against the casing in the well when it comes into contact with hydrocarbons.

3 The PSA's investigation

Composition of the investigation team

Semsudin Leto - HSE management discipline

Egil Sørensen - drilling and well technology discipline

Svein Horn - drilling and well technology discipline (onshore part)

Ola Heia - drilling and well technology discipline (investigation leader)

The investigation team arrived on *Maersk Invincible* during the morning of 14 November 2018. After arrival and a safety briefing, a kick-off meeting was held where the OIM gave a short briefing on the incident and what had been done subsequently. The reason and mandate for the PSA's investigation were presented by the team. Interviews were held with personnel involved and selected managers with responsibilities related both directly and indirectly to the incident.

Eight interviews were conducted on 14-15 November 2018.

Documentation provided and requested was reviewed on both days. A verification of the maintenance management system for Maersk equipment involved was implemented in cooperation with the technical supervisor.

Maersk has earlier experienced several incidents with stands falling out of the fingerboard on similar facilities with the same drilling package supplier. These incidents therefore also formed part of the underlying documentation for the investigation.

Following its stay on *Maersk Invincible*, the investigation team has held meetings with Maersk Drilling Norge AS at Forus and NOV in Kristiansand.

4 Course of events

Maersk Invincible was conducting operations in the 2/8-N-4 injection well on 11 November 2018. Two made-up stands were placed in row three (3) on the fingerboard in the Aux derrick. These stands were 38 metres long and weighed about 1 300 kilograms. See figure 2.

Around **22.50**, the crew on the drill floor and in the driller's cabin heard the sound of metal banging against metal. This lasted for a couple of minutes. After another couple of minutes, a member of the drilling crew discovered that the stands had worked their way outwards in the fingerboard and had passed several latches. The movement stopped for a brief period before continuing. Two people were sent up the derrick to see if they could find out why the stands were moving outwards, in order to halt the uncontrolled movement if possible. People on the drill floor erected cordons to prevent access to the deck.

At **22.55**, the stands had worked their way completely out of the fingerboard. They became detached, slid over the drill floor and hit various items of equipment before coming to rest. The stands were then inspected and secured to prevent further movement. One of the swell packers had been bent in the fall. Protectors on both stands had been damaged.

The stands were moved to the cantilever deck on 13 November 2018.

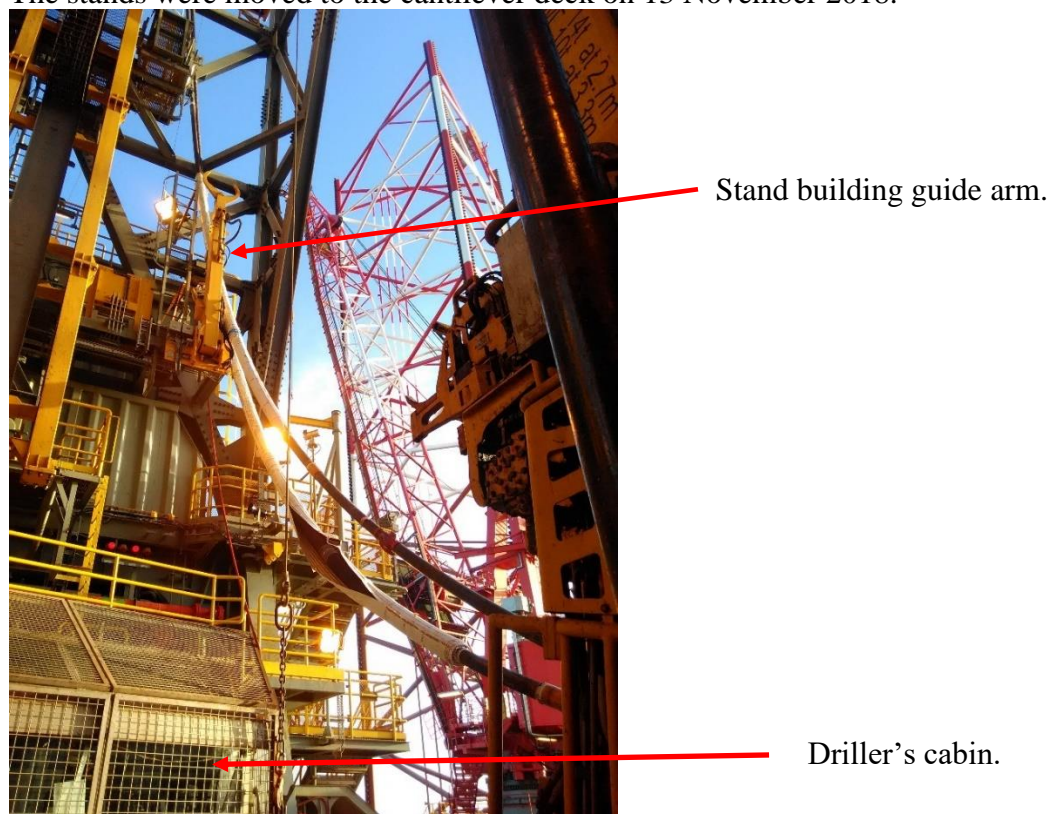


Fig 5: Location of the stands looking towards the driller's cabin and stand building guide arm after the incident.

Fig 6: Location of the involved stands, looking towards the fingerboard.

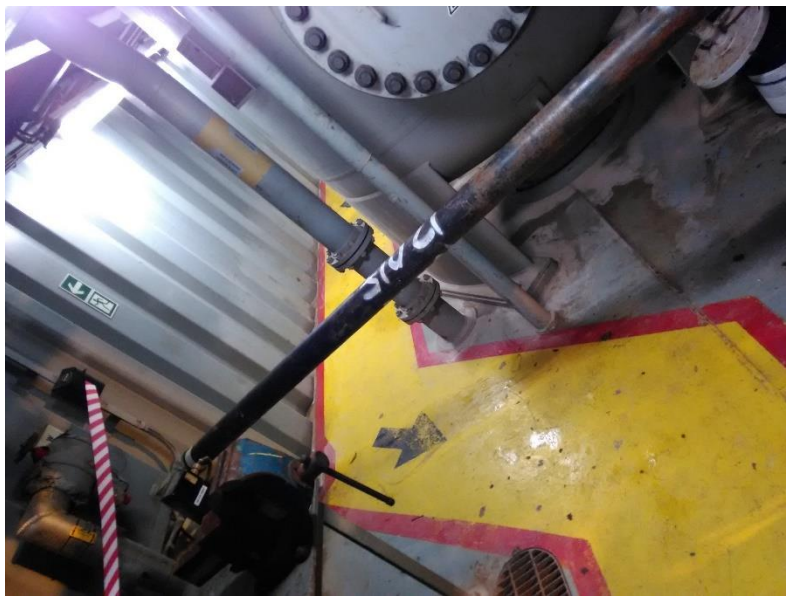
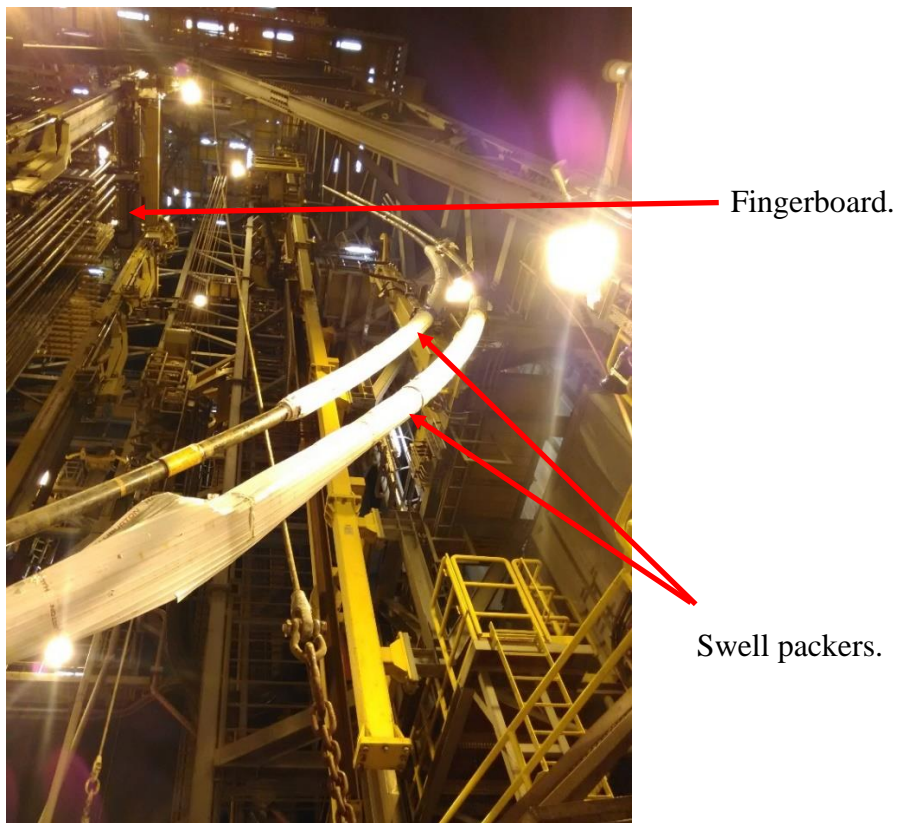


Fig 7: The lower section of the 4 ½-inch tubing halted against the wall to the left of gangway.

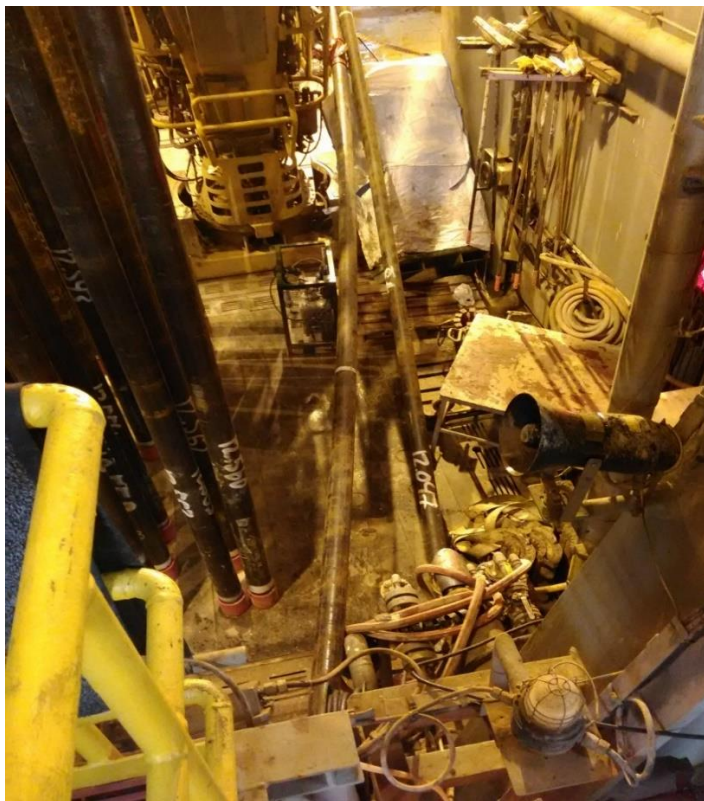
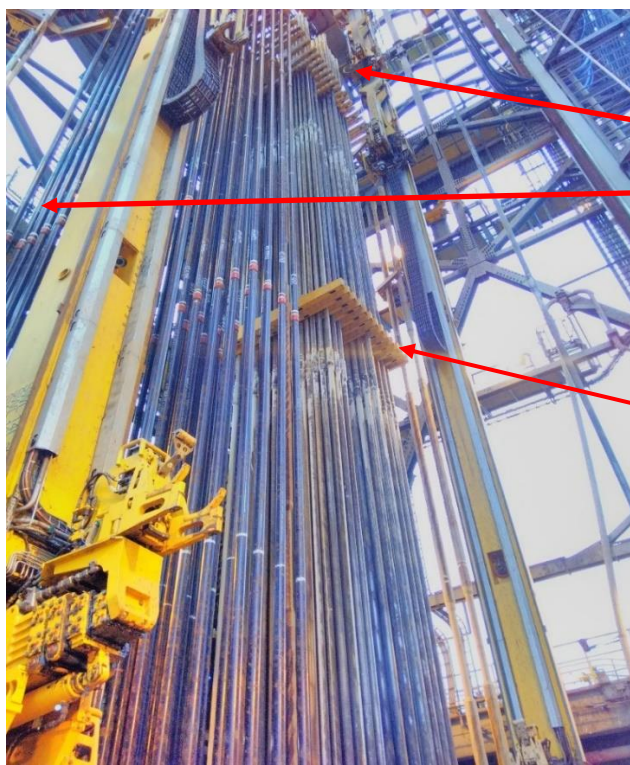


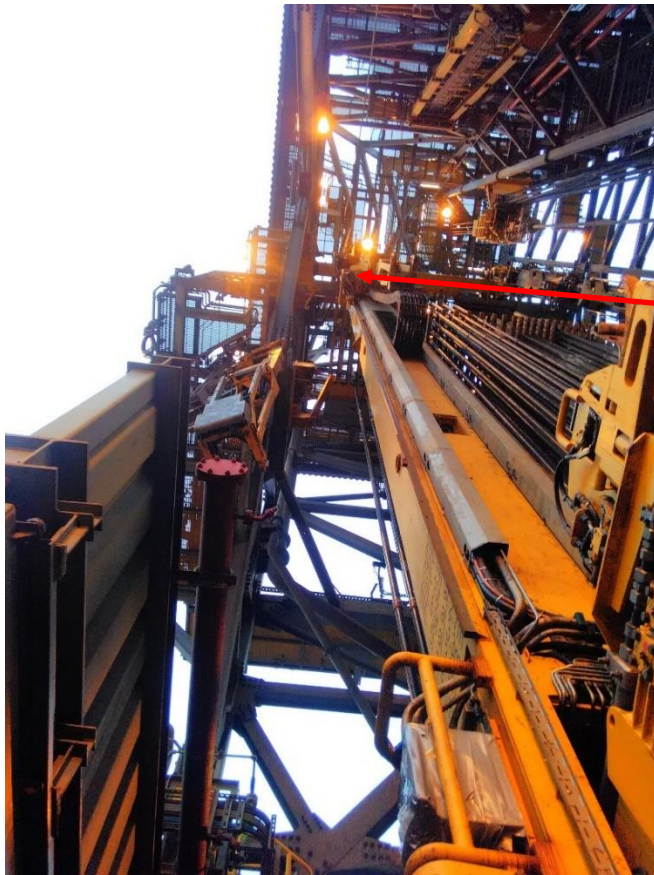
Fig 8: The stand on the left stopped against a wall by a gangway. The one on the right halted in a drain gutter. At the top of the photograph, the stands are leaning against the control panel belonging to pipe-handling company Frank's (white tarpaulin) which has been overturned.



Fingerboard.
Stands in the Aux derrick.

Bellyboard.

Fig 9: Stands stored vertically in the derrick with the bellyboard in their centre.



Fingerboard involved in the incident.

Fig 10: Fingerboard involved in the incident viewed from below.

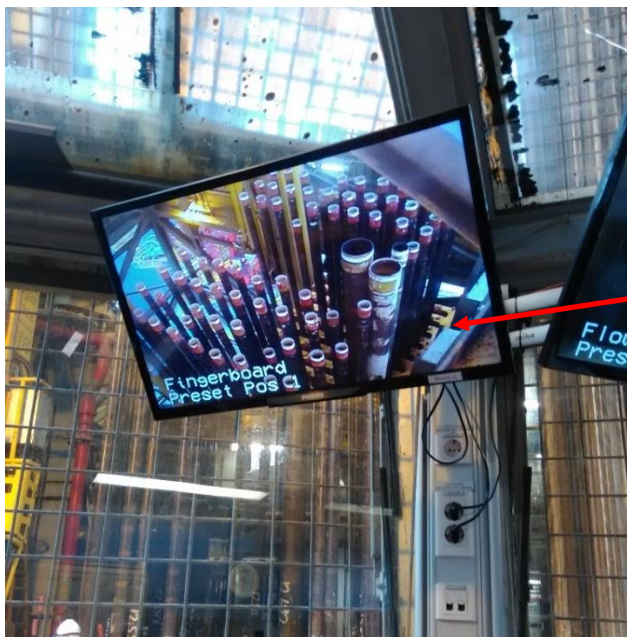


Fig 11:
Overview of parked stands. The fingerboard seen from above. The monitor in the driller's cabin viewed from the driller's position.

5 Potential of the incident

Actual consequence

The incident caused no personal injuries. Material damage was a broken hydraulic connection in the stand building guide arm as well as damage to a connection box and a light fitting in the setback area and on the swell packer.



Fig 12: Damaged light fitting in the setback area.

Potential consequences

The person who was engaged in securing the area on the drill floor was a few metres away when the incident occurred. However, he managed to reach safety behind a wall when the stands slid.

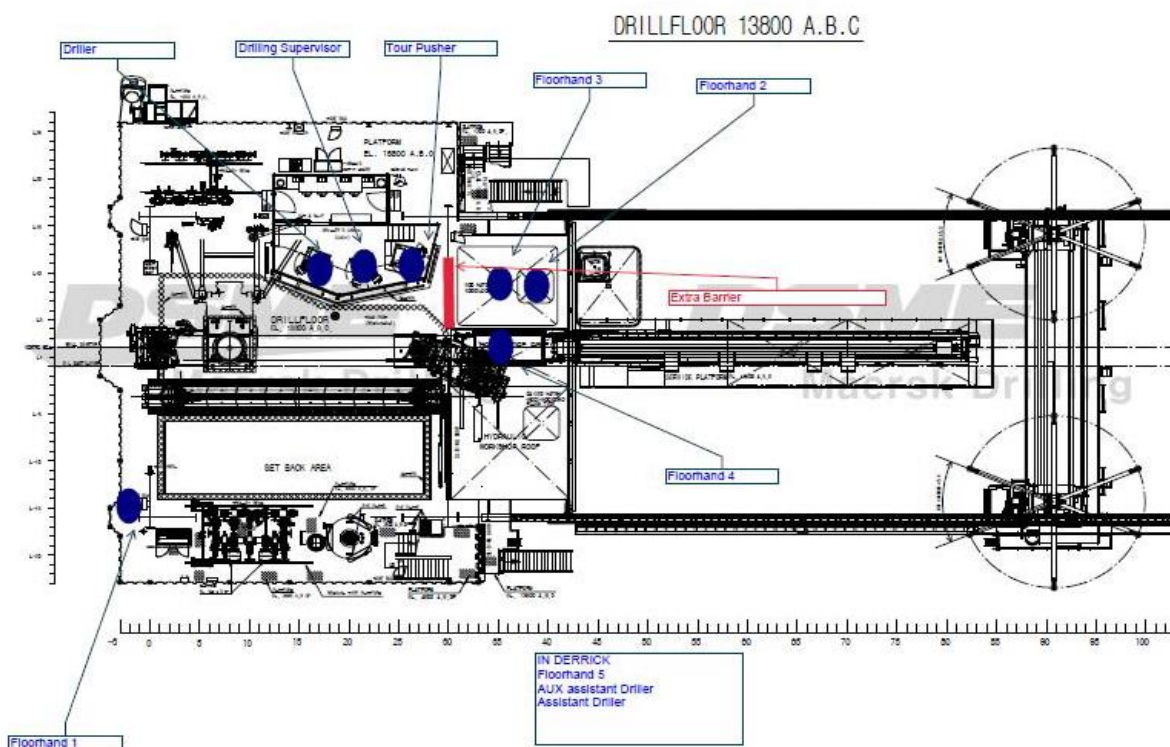


Fig 13: Position of personnel when the incident occurred. (from Maersk): 1 Drilling supervisor, 2 Tour pusher, 3 Driller, 4 Floorhand 1, 5 Floorhand 2, 6 Floorhand 3, 7 Floorhand 4, 8 Floorhand 5, 9 Aux assistant driller, 10 Assistant driller.

6 Direct and underlying causes

Direct cause

The cause of the incident was that the locking mechanism on the fingerboard failed to work as intended under the conditions prevailing at the time.

While the fingerboard is located about 33 metres above the drill floor, the stands involved in the incident are roughly 38 metres long. The stands therefore extended about four metres above the fingerboard. The fingerboard had 10 latches spaced 368 millimetres apart from centre to centre. The two stands were placed in the two innermost latches, so there were eight locked latches between them and the end of the fingerboard.

The wind (with a strength of 35 knots gusting to 38 knots) created a rising vertical swaying motion in the stands. It was blowing directly towards the fingerboard latches and pushed the stands against these. As a result, the latches were “worked” open from below until the stands could move uncontrollably along the fingerboard.

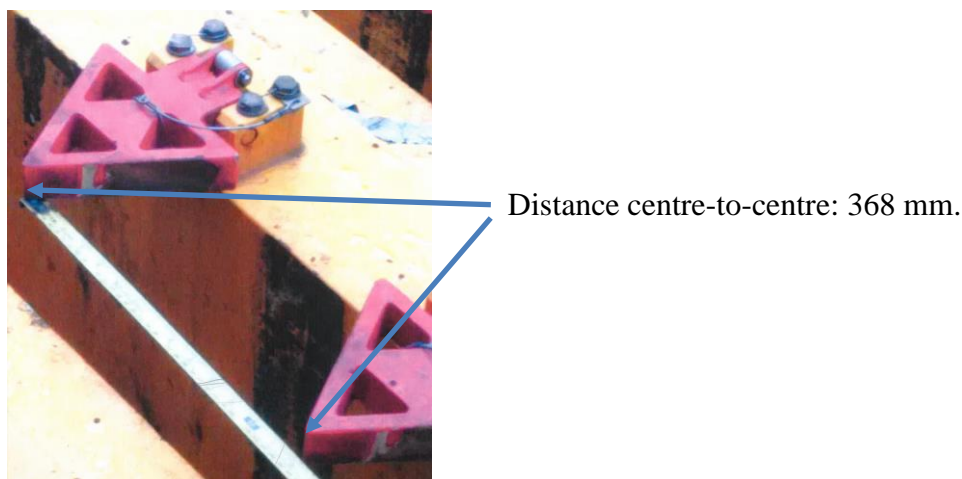


Fig 14: Close-up with distance measurement of the latches involved.

The swell packers had an external diameter of 7 ½ inches and weighed roughly 100 kilograms more than a normal length of 4 ½-inch tubing. A larger diameter with more windage, combined with the fact that the centre of gravity was in the middle of the stand, very probably created accelerating swaying and uncontrolled motion in the stands.

Latches on the fingerboard arm were triangular, with a 45-degree angle to the direction of fall for the stands. In the team’s view, this very probably made it easier to open the latches. Measurements also show that there was space for two stands between two latches, which gives relatively substantial room for movement. (4 ½ inches equals 101.6 millimetres and 101.6×2 equals 203.2 millimetres, while the measured distance was 368 millimetres).

The loads from the uncontrolled motions probably caused the latches to be pressed into a fully open position. The stands then moved on at an accelerating swinging rate in the direction of fall towards the next latch. The stands acquired a steadily rising angle of inclination, with an increasing sway motion the further along the fingerboard row they came. Increased angle with growing sway increased the force, which in turn meant that the three final latches were unable halt the movement of the stands out of the fingerboard.

Underlying causes

The latches are designed for casing, which means that this position is not suitable for “non-standard” stands with the dimensions of the tubing involved in the incident. It emerged from a meeting with NOV on 13 December 2018 that the rigidity of the stands had not been assessed in connection with the design and user manual for the latches on the fingerboard. This fingerboard solution has been specially developed to be as flexible as possible in connection with effective operation of the pipehandling process.

As a result of this and other incidents, NOV explained that stands with an OD smaller than seven inches should not be placed in a fingerboard unless combined with a bellyboard – a fingerboard installed in the middle of the derrick to support stands. This will be communicated to all their customers who have this fingerboard solution. NOV reported that it does not get much feedback from customers concerning incidents with its equipment. Deliveries from NOV include more than 250 of this type of fingerboard solution since 1998 without many reports of incidents.

A certification process has existed since 2010 for fingerboards delivered to mobile facilities. This process is conducted by the relevant classification society for the facility. NOV has no system for passing on information to the classification societies which certify fingerboards.

The user manual and other available documentation on the use of the fingerboard provided no indication that the relevant stands could not be positioned as they were before the incident.

A product information bulletin was issued by NOV in late October 2018. This contained points intended to prevent such incidents. This NOV bulletin was registered in Maersk’s maintenance programme, but the risk assessment of it subsequently proved to be inadequate.

NOV operates with three levels of bulletins. This example was not issued as a safety bulletin, but as product information. That could have been a contributory reason why the information it contained was not perceived or assessed as critical.

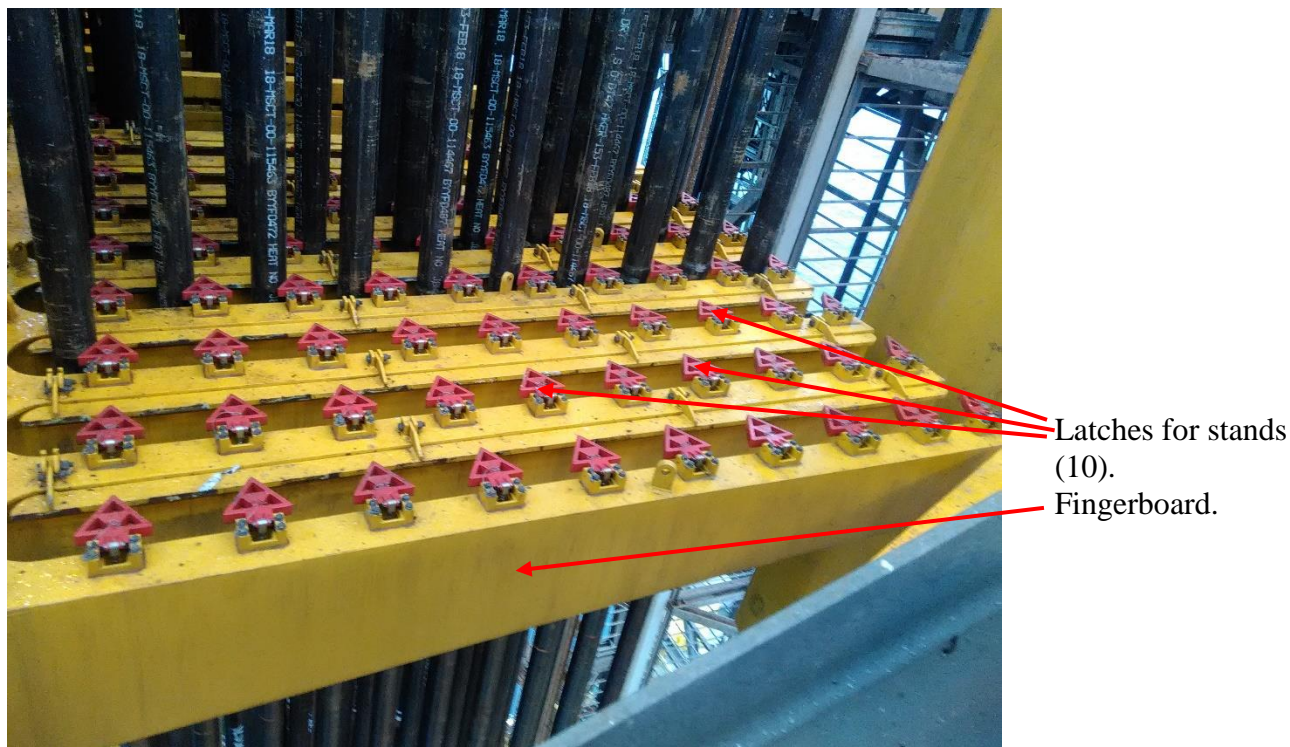


Fig 15: Fingerboard on the Aux side of the derrick. The 4 ½-inch production tubing with swell packer was stored in the second row without stands, in the centre of photograph.

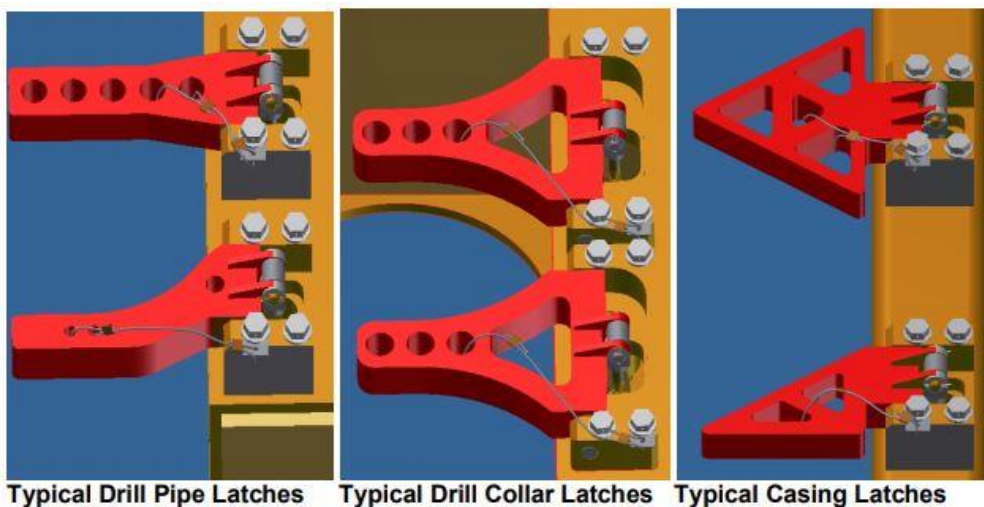


Fig 16: Various types of latches. The variant on the right was the one in use during the incident (designed for casing).

7 Observations

The PSA's observations fall generally into two categories.

- Nonconformities: this category embraces observations where the PSA has identified a breach 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.

8 Non-conformities

8.1 Risk assessment and decision basis

Inadequate risk assessment and decision basis after receipt of NOV bulletin.

Grounds

Product information bulletin 1000012596-PIB Rev 01 from the supplier was not risk-assessed. This emerges from work order: 67524. Relevant specialists were not involved. This meant the risk assessment was inadequate.

Three similar incidents were registered in Synergi from Maersk facilities operating off Norway. These were not identified or used in connection with the risk assessment.

Requirement

Section 11 of the management regulations on basis for making decisions and decision criteria

8.2 Experience transfer within the company

No experience transfer has occurred within Maersk from similar incidents involving the same equipment.

Grounds

No provision has been made for experience from the company's own operations and those of others, with similar equipment, to be used in improvement work. Three similar incidents were registered in Synergi from Maersk facilities operating off Norway. These were not assessed in connection with this operation.

Requirement

Section 15 of the management regulations on information

8.3 Locking mechanism in the fingerboard

The latches were unable to withstand the loads they were subject to when using stands with swell packers under the given wind conditions.

Grounds

Swaying and motion in parked stands caused the latches to open so that the stands became detached. See chapter 6.

Requirement

Section 10, paragraph 1, litera c of the facilities regulations on installations, systems and equipment

9 Barriers which have functioned

Assessments were made by the crew as the incident developed which led to the drill floor being cordoned off, thereby preventing people from moving about in the area.

10 Discussion of uncertainties

The investigation team takes the view that stands with small dimensions, even in moderate winds, could develop uncontrolled and accelerating motions. The absence of a bellyboard will reinforce this effect and increase the possibility of stands falling out of the fingerboard.

11 Assessment of the player's investigation report

Maersk investigated the incident itself, and its report was completed on 6 December 2018.

The report identified that uncontrolled motion in the stands, combined with strong winds, was the main cause of the incident.

Underlying causes dealt with the lack of guidelines for positioning stands and the design of the latches on the fingerboard. A number of specific proposals for further follow-up were listed in the report to avoid a repetition of similar incidents.

The PSA considers that observations in this report coincide with those made in its own investigation report.

12 Documentation

The investigation has drawn on the following documents.

- Information following an undesirable incident on *Maersk Invincible*, 11 November 2018
- Fingerboard latches
- Documentation in connection with the investigation on *Maersk Invincible* concerning maintenance – bulletin pipe handling – manufacturer’s bulletin
- Documentation concerning undesirable incident on Valhall *Maersk Invincible*, 11 November 2018 – images and Synergi case
- Updated 12 November 2018, 22.00, 1990186 Tubing across derrick
- Incident investigation mandate – Tubular with swell packers detached
- Valhall north flank drilling programme 2/8-N-4/water injector
- Photograph of fingerboard measurements
- North flank drilling programme
- Mandate for investigation, *Maersk Invincible*
- Product information bulletin from NOV
- Consent application, north flank
- AoC application, *Maersk Invincible*
- Swell packer specification
- Well schematic
- Maersk Drilling deviation procedures
- Maersk Drilling MOC procedure
- Maersk Drilling access to red zones and restricted areas
- HTO diagram
- Earlier incidents related to fingerboards
- Maersk Drilling investigation report 001/June 2017

13 Appendices

A: Overview of personnel interviewed

B: Schematic overview of the course of events