Havtil
Havindustritilsynet

Investigation report

Report	
Report title Investigation of an incident with personal injury and gas leak when splitting a blind hub on Statfjord B on 22 April 2023	Activity number 001037074

Security grading	
☒ Public	☐ Not publicly available

Involved	
Team T-1	Approved by/date Kjell Marius Auflem, by authority, head of supervision/15 March 2024
Members of the investigation team [redacted]	Investigation leader [redacted]

Contents

1 Summary

A gas leak and a personal injury occurred on Equinor's Statfjord B (SFB) facility on 22 April 2023 in connection with splitting a blind hub on a new production pipeline. The Norwegian Ocean Industry Authority (Havtil) decided on 24 April 2023 to investigate this incident. In addition to conducting its own investigation, Havtil has provided technical support for the police inquiry into the incident.

Seven people were in the immediate vicinity during splitting of the blind hub on a hydrocarbon system (production pipeline). Another person was on the level below. When the hub was split, it transpired that the system was not depressurised. Pressure in the production line caused the hub (weight 34 kg) to be thrown up about 1.5 metres and to strike a person on the way back down. A metal sealing ring (weight 2.15 kg) between the hub and the production line also fell to the level below. The person struck by the hub suffered a broken nose and jaw, while the person on the level below was hit by the ring without suffering a personal injury.

Under slightly different circumstances, the incident had the potential to cause a fatal accident.

The investigation has identified four nonconformities in connection with the incident:

- inadequate safety-clearance of activities
- inadequate information transfer at shift and crew changes
- lack of information for the relevant users
- planning of the work failed to identify important contributors to ignition source risk.

One improvement point related to the incident has been identified:

- lack of capacity for executing planned activities.

2 Background information

Equinor has implemented several cost-reduction and efficiency-enhancement processes in recent years, and established a field life extension (FLX) business area on 1 April 2020 for facilities in the late-life phase. These include SFB. The FLX organisation's *maintenance and technical integrity* unit has overall responsibility for such work on the Statfjord field facilities.

2.1 Description of facility and organisation

Statfjord has been developed with the Statfjord A, Statfjord B and Statfjord C production platforms, which all have a support structure and storage cells in concrete. The field extends across the boundary between the NCS and the UK continental shelf in the Tampen area of the North Sea.

Ranked as the largest oil discovery in the North Sea, Statfjord is one of the oldest producing fields on the NCS. Its Norwegian share lies in blocks 33/9 and 33/12 in production licence 037. The field is operated by Equinor.

SFB is an integrated drilling, production and quarters platform, standing in 145 metres of water at the southern end of the field. Its plan for development and operation (PDO) was approved in 1976, and the platform came on stream on 5 November 1982.

Figure 1 Statfjord B. (Source: Equinor)

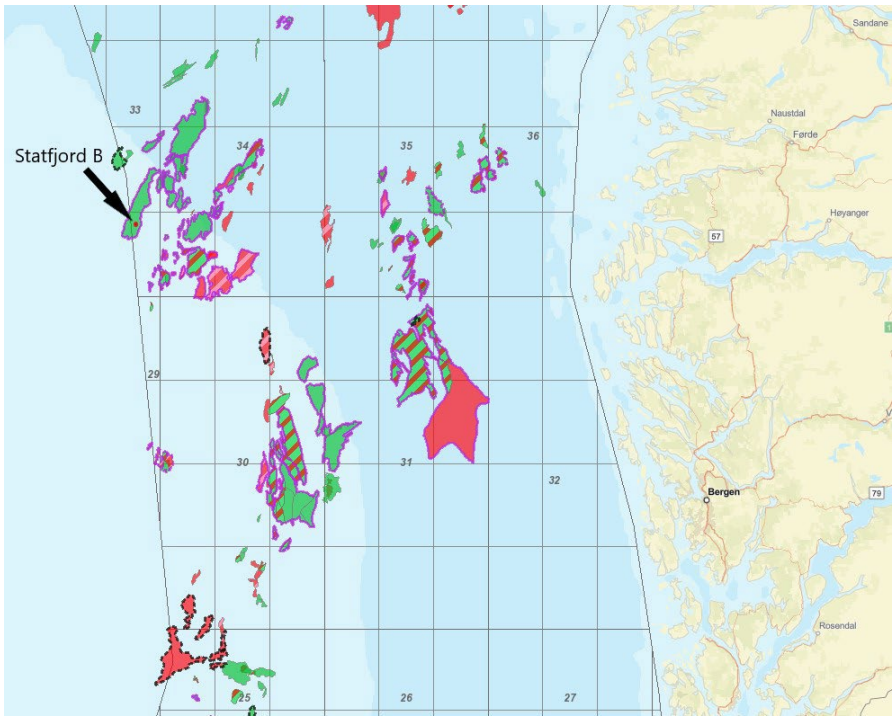

Figure 2 Map of the area. (Source: Norwegian Offshore Directorate)

The FLX organisation is presented in the chart below

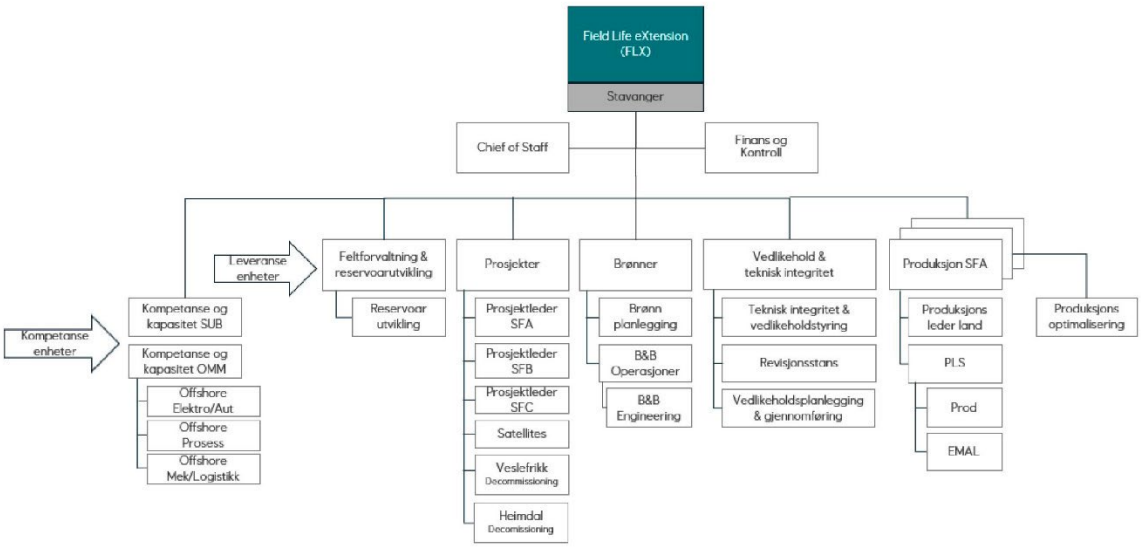

Figure 3 Organisation of FLX. (Source: Equinor)

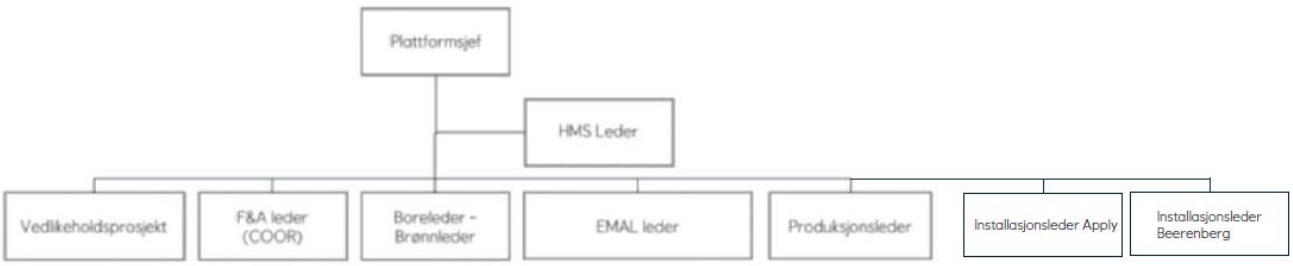

Figure 4 Organisation of Statfjord B. (Source: Equinor)

2.2 Position before the incident

SFB was in normal operation at the time of the incident on 22 April 2023. The work operation to be carried out related to a modification project where older production pipelines in carbon steel were being replaced with corrosion-resistant piping in stainless steel (316L).

In addition, the production pipeline from well B-18 was to be rerouted as part of a conversion from water alternating gas (WAG) injection to production.

There were 180 people on SFB. Before the incident, people scheduled to participate in executing planned maintenance and modification activities were taken out on strike and therefore unavailable. The strike was called off on 20 April 2023.

The board in the emergency response room showed a wind strength at SFB of 26 knots and a significant wave height of 1.3 metres. Weather conditions on the incident day had no negative effect on helicopter flights

2.3 Abbreviations

AT	Area technician/operator
CCR	Central control room
DB&B	Double block and bleed
ESD	Emergency shutdown
ET	Executing technician
ICC	Isolation confirmation certificate
LEL	Lower explosive limit
NCS	Norwegian continental shelf
PA	Public address
P&ID	Piping and instrumentation diagram
Permit Vision	Digital tool for processing WPs
PPE	Personal protective equipment
SAR	Search and rescue
Shift Vision	Digital tool for handovers
SFB	Statfjord B
Toolbox talk	Before work starts, executing personnel and the area technician jointly conduct a systematic review of the worksite where the job is to be done
WAG	Water alternating gas
WO	Work order
WP	Work permit
XMT	Xmas tree

3 The Havtil investigation

Havtil was notified by Equinor on 22 April 2023 about the incident on SFB. While splitting a blind hub on a new production pipeline, bolts were loosened with confined pressure in the pipe. Energy released meant that one of the executing personnel was hit by components and suffered facial injuries. The executing personnel were employed by Moreld Apply. The injured person was flown ashore by SAR helicopter at 12.13 for onward transport to hospital and follow-up.

A Teams meeting with participation by Equinor and Havtil took place on 24 April 2023, when Equinor representatives gave a short briefing on the incident.

Havtil decided on the same day to investigate the incident, and an investigation team was appointed. The purpose was to establish the direct and underlying causes of the incident, to learn lessons from it, and to help prevent similar events from recurring.

3.1 Mandate and composition of the investigation team

The following mandate was adopted for the investigation team.

a. *Clarify the incident's extent and course of events (with the aid of a systematic review which typically describes the time line and events)*
b. *Assess the actual and potential consequences*
    1. *harm caused to people, material assets and the environment*
    2. *potential harm to 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 aspects*
f. *Discuss barriers which have functioned (in other words, those which have helped to prevent a hazard from developing into an accident, or which have 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 The investigation team

Composition of the investigation team

[redacted]	Occupational health and safety
	Logistics and emergency preparedness (only on land)
	Process integrity
	Process integrity, investigation leader

The investigation team arrived on SFB at about 12.30 on Tuesday 25 April 2023, together with the police.

Equinor's own investigation team came out during the same period Havtil was there.

3.3 Method

The investigation was conducted through interviews with personnel in SFB's offshore organisation, verifications and inspections on the facility, and a review of governing documents and other documentation relevant to the incident. Equinor's investigation report was also reviewed.

Investigation of the incident was led by the south-western Norway police district. Two tactical and two technical investigators flew to SFB on 25 April 2023. The Havtil team was asked to support their work, and participated in seven interrogations and in inspections on board. The team also conducted some interviews with personnel on SFB without the police being present. It returned to land on 27 April 2023.

The team interviewed the injured person on 15 May 2023.

A meeting was held on 31 May 2023 with the onshore and offshore organisations related to SFB, where a presentation and clarifications of the work done ahead of the incident were given and associated isolation plans provided. Equinor also answered clarifying questions which had been submitted to it ahead of the meeting.

The documents requested and received in connection with the investigation are listed in chapter 15.

4 Modification well B-18

4.1 Scope of modification work

Modification projects which included replacing older production pipes in carbon steel with new corrosion-resistant piping in stainless steel (316L) had been under way for some time on SFB. This work was nearing completion on well B-18.

The production pipeline from well B-18 was also to be rerouted as part of a conversion from WAG injection to production. Existing pipelines for B-18 WAG and pipelines tied into manifolds for B-13 were removed ahead of installing new production pipelines. Installation of the production line for B-18 was almost finished. The line was tied to the production, low-pressure (LP) and test manifolds using tie-in points for the former B-13 well. Leak testing of the pipe had been done. Remaining work involved installing the final pipe spool to hook up the production line to the wellhead. Moreld Apply was the contractor implementing this modification project.

The diagram below provides a simplified presentation of the scope of work related to installing a new production line from the new B-18 wellhead/Xmas tree to the manifolds. It shows the blind hub to be split and the hook-up spool to be installed on the incident day, as well as the pressure transmitter (PT) already installed for measuring pressure in the production pipeline.

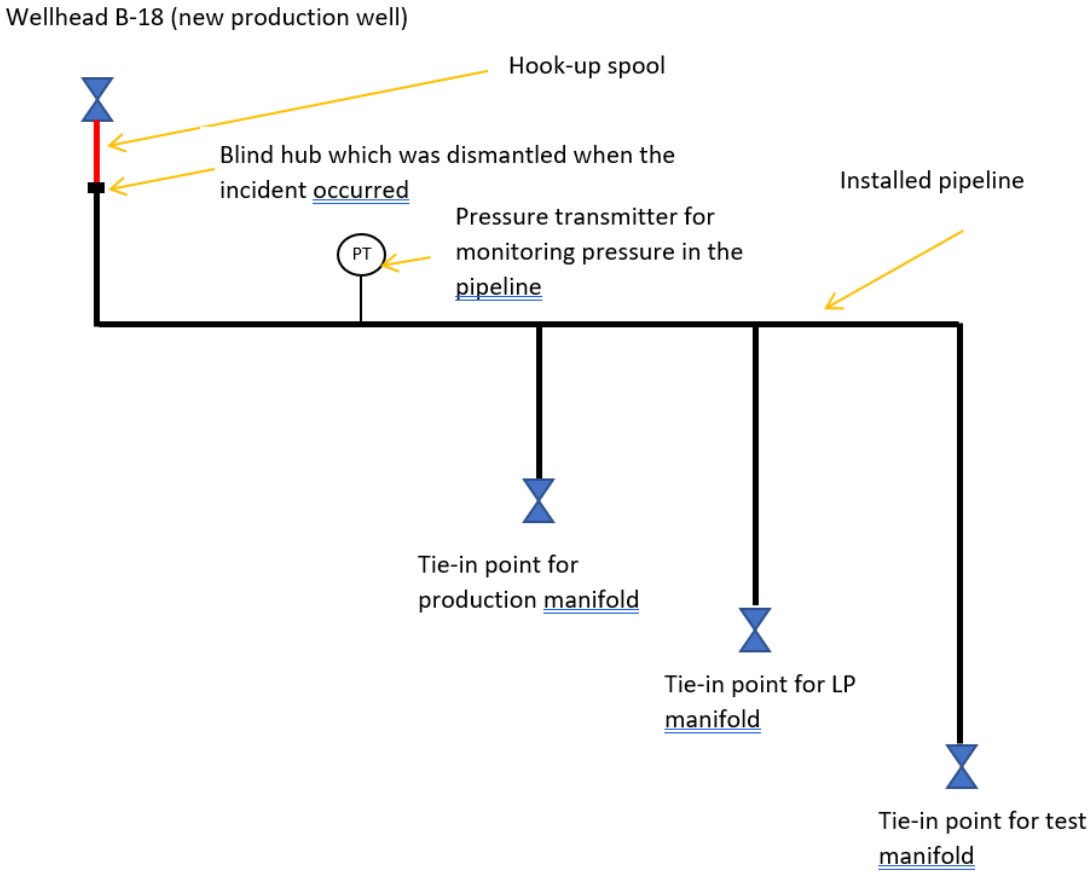

Figure 5 Scope of installation work related to a new production line from the new B-18 wellhead/Xmas tree to the manifolds. The diagram shows the blind hub to be split and the hook-up spool to be installed on the incident day.

4.2 Information on incident-relevant equipment installed in the modification project

Pressure transmitter

The PT 11809 pressure transmitter for monitoring pressure in the production pipeline was not operational at the time of the incident, having been shut off on 18 March 2023 ahead of a leak test of the new production line. It was tested against the CCR and completed on 9 April 2023.

On 22 April 2023, in the wake of the incident, a different type of blind hub with a top-mounted bleed valve was installed on the production pipeline. PT 11809 was also opened to the production pipeline. The pressure transmitter then showed a new pressure buildup in the pipeline, and the read value stabilised at around 0.7 bar.

Design solution for chemical injection

SFB has different design solutions for chemical injection lines. Old (unmodified) wells have a solution without a check valve between the tie-in point and the production pipeline (see the example in the illustration of the technical solution presented in figure 6).

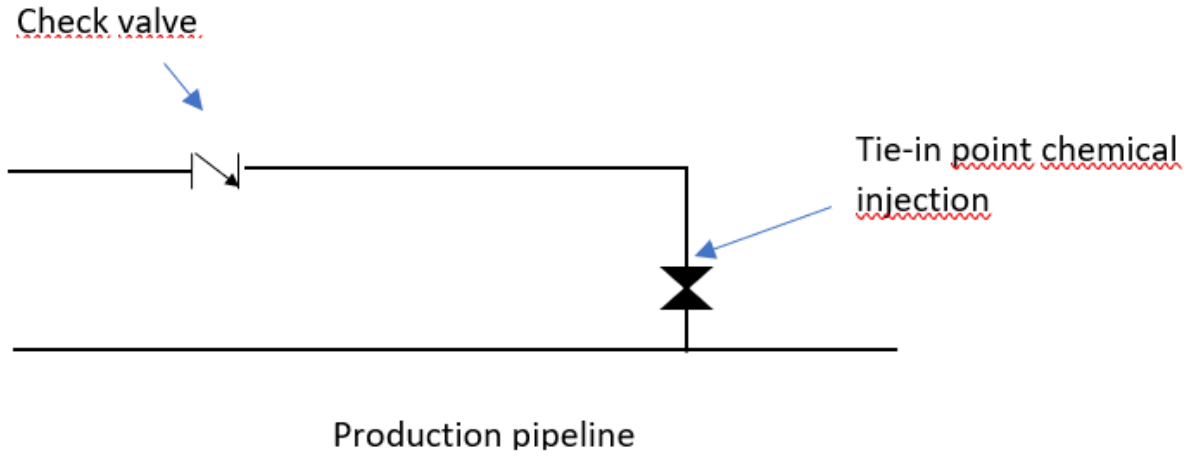

Figure 6 "Old" type of chemical injection valve, where the check valve is installed upstream of the chemical injection point.

New wells (where older production pipelines in carbon steel are replaced by corrosion-resistant piping) are fitted with "new" double block and bleed (DB&B) valves featuring a built-in check valve. See figure 7.

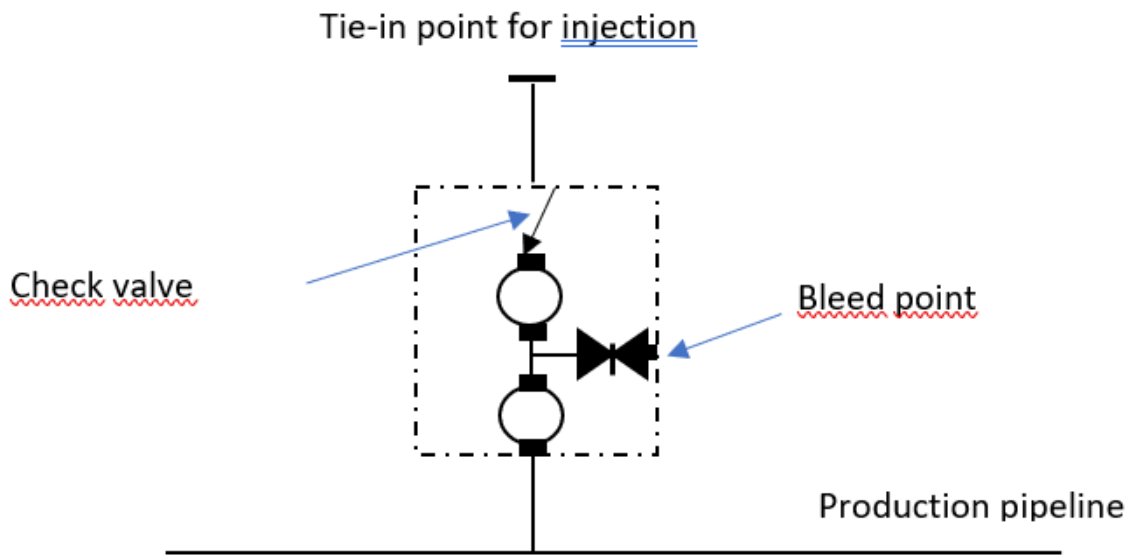

Figure 7 Diagram of the "new" DB&B valve, where the check valve is installed in the valve cavity. Injection takes place through a pipe nozzle. The check valve prevents backflow of gas or liquid from the production pipeline.

The "new" DB&B valve type with built-in check valve was installed in this modification project.

This "new" type DB&B valve is labelled with a red arrow. The Havtil team has been informed that the latter shows the direction of flow through the valve/check valve. The "old" type of valve is not marked in this way.

The "new DB&B valve type with check valve is marked in several places on the P&ID for well B-18 (after modification). See the extract from the P&ID in figure 8.

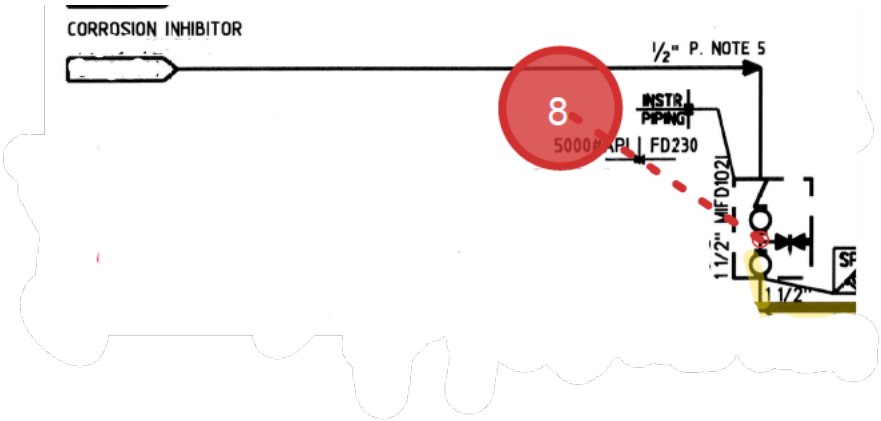

Figure 8 Extract from the P&ID for well B-18 after installation of the "new DB&B valve type. (Source: Equinor)

4.3 Information relevant to the incident

Overview of the status for parameters on the incident day, 22 April 2023:

- internal pipe volume from blind hub to manifolds (LP/HP/test) is estimated at 1.6 m^3.
- Archived metering data shows that pressures at the time of the incident were 21.0 bar production manifold, 19.2 bar LP manifold and 20.8 bar test manifold.

Considerable use of overtime and extended time offshore has been registered over several years.

- From April 2022 to April 2023, personnel with responsibilities/duties in the CCR, on the module deck or as discipline lead worked 198 days in excess of 14 days.
- It emerged during the investigation that much time was spent finding solutions to replace process and CCR personnel who were unavailable. People on board were then often asked to serve days or a week extra.

The above-mentioned strike which was called off in the same period as the incident meant that the number of WPs subsequently dealt with was higher than usual since work put on hold from lack of personnel could then be executed.

5 Planning and execution of work on hydrocarbon systems

Equinor has internal requirements for planning and execution of work on hydrocarbon systems. Their main elements are:

- isolation confirmation certificate (ICC)
- work permit (WP)
- preparations in the field before activation of the WP
- execution of the work.

Work processes and checklists are described at several places in Equinor's governing documentation and checklists (*Handbook for safe work in the petroleum industry*). Sections 5.5.1, 5.2.1, and 5.3.1 below briefly summarise the various work processes relevant to the incident.

Equinor also refers to Offshore Norge's guidelines 143 *Recommended guidelines on training for work on HC systems* and 088 *Recommended guidelines for common model for work permits*, which provide guidance on practice for executing this type of work.

5.1 Isolation plan

5.1.1 Equinor's work processes, best practice and routines

When doing work on hydrocarbon systems, requirements are set for planning the activity, isolation and reinstatement. The relevant activities include:

- preparation and approval of an isolation plan
- setting and verifying the isolation plan in the field, including marking of valves in the open/closed position
- following up active isolation plans in operation.

<u>Prepare isolation plan</u>
Equinor's *Prepare isolation plan* work process (OM105.07.01.01) has been received by the Havtil team as a basis for its investigation. This process includes requirements for preparing an isolation plan ahead of work on hydrocarbon systems and applies to SFB. The specified purpose of the process is to plan isolation of energy and hazardous media in order to work safely on systems and equipment.

The work process includes requirements on:

- what an isolation plan should contain (ref R-19019)
- approved physical barriers when working against pressurised systems (double barriers, blinds, single barriers and so forth) (ref R-18586).
- routines for ensuring follow-up of active isolation plans (ref R-101969)
- updating an isolation plan if it is inadequate for the work to be done (ref R-101970).

<u>Set, verify and approve isolation</u>
The team has also received the *Set, verify and approve isolation* work process (OM105.07.01.02). Its purpose corresponds to that for *Prepare isolation plan* – in

other words, to plan isolation of energy and hazardous media in order to work safely on systems and equipment. The work processes includes requirements on:

- expertise in operating valves and setting barriers (ref R-6237), with reference also made to Offshore Norge's guideline 143 *Recommended guidelines on training for work on HC systems*
- risk assessment of whether confined volume, both within and outside the isolation plan, which may pose a risk (ref R-102097)
- approved physical barriers when working against pressurised systems (double barriers, blinds, single barriers and so forth) (ref R-18586)
- regular inspection of bleed points, which are registered/logged in the ICC (ref R-18586
- marking of isolation in the field to avoid misunderstandings in the isolation plan or between different isolation plans or WPs with colour coding (red status field for closed and green for open) and WO number for the specific job (ref R-19020)
- valves forming a barrier in the ICC must be leak tested and show acceptable tightness (ref R-19024)
- the area technician must always have an overview of all active isolation plans affecting their own area (ref R-19033).

Routines for following up ICC plans on SFB (information received from Equinor, dated 11 May 2023)

- Crew handover
  Every Wednesday (the day before returning to shore), process technicians are assembled area by area to compose and write the crew handover (Shift Vision) and review ICCs in their area (Permit Vision). The meeting is attended by both those going ashore and those remaining offshore. Crew handover is intended to ensure relevant information is passed to the arriving shift.
- New-on-board meeting
  Every Thursday, when the new shift arrives, the process technicians gather again for a new-on-board meeting in the CCR to review administrative changes and status, long-term WPs/disconnections and the status of active ICCs. (Actions are specified in the event of nonconformities.)

  The discipline lead for operations conducts an overall review of ICCs (Permit Vision) ahead of the new-on-board meeting to check status of plans which are set and long-term ICCs, and cleans up the "draft" list.

  An area technician is expected to be updated at all times about active ICCs in their area (ref OMC20 I.24 *Area responsibilities*).

5.1.2 Isolation plan for the relevant activity

The activity of splitting the blind hub and installing the hook-up spool to wellhead B-18 was part of AO26054174 *Well B-18 hook-up inst piping/structure*. No separate isolation plan was established for splitting the hub/installing the spool in relation to this WO.

Two isolation plans for M04 well B-18 were available in Permit Vision.

1. Status "active": ICC1575520 *M04 B-18 Dismantle hook-up spool* associated with AO26054173.
2. Status "temporarily changed": ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list* associated with AO26054239.

1. ICC1575520 *M04 B-18 Dismantle hook-up spool* – status "active"

The isolation plan used when the blind hub was to be split and the hook-up spool installed on wellhead B-18 was ICC1575520 *M04 B-18 Dismantle hook-up spool*. This plan was not relevant for the job. It was prepared before removing water injection flowline 06''-WI-57118-FD230, which was hooked up to Xmas tree/XMT B-18 WAG (WAG well now replaced by new production well B-18). This isolation plan had been prepared for completed WO AO26054173. It should have been removed and the P&ID with red-line markup which showed the changes delivered to the CCR. The isolation plan status was "active" from 21 January 2023.

2. ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list* – status "temporarily changed"

The second isolation plan, ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list* was prepared ahead of an N_2/helium leak test from hook-up to manifold (AO26054239), and had the status "temporarily changed" because alterations had been made to the original plan. The changes were that the bleed valve was set open to the flare on valve HV11315 (new tag number HV11815) against the LP manifold, and the valve against open drain, which represented the bleed point in the isolation plan, was closed on 17 March 2023.

It emerged from the investigation that the isolation plan was wrong with regard to marking in the field. That applied to point no 9, scale inhibitor valve, where the tag was hung on the wrong valve – a DB&B valve for future connection, which was a corresponding valve not included in the isolation plan.

The Havtil team was informed that, had isolation plan ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list* not been changed and remained with "active" status in Permit Vision, the production line would have been depressurised when the blind hub was to be split on the incident day.

Follow-up of ICC plans in operation

Shift Vision, used at crew handover, specified that the temporary change to isolation plan ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list* was intended to stop hydrocarbons entering the flowline, since there was a leak in valve HV11315 to the LP manifold. This valve was the barrier against the LP manifold. Logging in Shift Vision from 29 March 2023 showed that the open drain remained closed. Information that the bleed valve was connected to the flare because of a small internal leak between the LP manifold valves was not included. From 5 April 2023, logging in Shift Vision did not include information that the isolation plan was "temporarily changed" (open drain closed). The only information was that the ICC was set. Important details related to changes in the isolation plan were thereby not included at the crew change (logging in Shift Vision used with handovers between shifts).

Leaks in valve HV11315 (barrier against the LP manifold had been recorded for some time). Logging in Shift Vision related to modification work for the new B-18 production line revealed leak challenges with the valve from 19 February 2023. The last log entry in Shift Vision related to the valve leak was on 29 March 2023. From then until the incident on 22 April 2023, nothing was registered about how the leak in valve HV11315 was being followed up (no entries were made in Shift Vision related to valve leakage). The status of the leak in the valve which serves as a barrier against the LP manifold was thereby unknown on the incident day.

5.2 Work permit

5.2.1 Equinor's work processes

A WP provides written permission to execute a defined job at a specific place on a facility. Using a WP system requires ensuring that all conditions related to the risk of a work operation are taken into account. Activities in the WP system include:

- application for a WP, prepared on the basis of information in a WO
- application for a WP assessed, given advance approval/coordinated with other activities, and approved
- activation of WP
- closure of WP.

Equinor has described the WP process in governing document OM105.01 – *Work permit (WP) – upstream offshore*. The WP work process is intended to ensure that barriers are established which collectively ensure that accidents and injuries are prevented, and includes requirements on the WP level for different activities.

A WP level 1 is required for activities associated with high risk and for work which requires coordination and clearance at facility level. Jobs associated with high risk include work on hydrocarbon systems (ref R-20000).

Application for a WP prepared on the basis of information in a WO (ref R-12109, R-21938)

According to the process description, a WP will normally be prepared by the entity responsible for doing the work. The WP applicant must describe the work, identify risks and propose operational and safety preparations for the specific job. When working on a hydrocarbon system, an isolation plan must be attached to the WP.

Application for a WP assessed, given advance approval/coordinated with other activities, and approved (ref R-20018, R-20017, R-40004 and R-12109).

The WP system is based on the internal control principle. This means that several independent parties are involved in approving, checking, coordinating and managing activities. Applications for WPs on SFB are assessed, given advance approval/ coordinated with other activities, and approved accordingly at scheduled daily meetings. Participants in the latter include the discipline, the production and HSE managers, and the offshore installation manager (OIM).

Activation of WP

Various activities are required before a WP is activated, such as:

- before the job begins, executing personnel and the area technician must jointly conduct a systematic review of the work to be done (ref R-19763)
- all portable pneumatic tools must be connected to a shutdown junction box so that the air supply is closed on a single low gas detection (ref I-110465)
- check that the worksite is secured and the necessary isolations are done, which includes verifying the isolation plan and checking that the system is depressurised (ref R-20032, R-20033 and R-20037)
- check that the WP is correctly filled out and that the work can be done (ref R-20039).

The *Set, verify and approve isolation* work process (OM105.07.01.02) includes a requirement to check isolation and pressure blowdown before work starts (ref R-19031). This is intended to ensure that the system is fully depressurised before starting work, and includes the following.

- Before the work starts, the executing personnel and area technician must jointly check and confirm that the system/equipment has been shut down and depressurised. The need for cleaning must be assessed.
- The area technician must demonstrate in the field that all equipment/systems concerned are depressurised. This must be confirmed in two places as close as possible to the work site with the aid of appropriate bleed valves (or exceptionally with a bleed valve and manometer).

In addition, the team has received a description of the activities included under "check and confirm that the system/equipment is shut down" (e-mail received on 11 May 2023). This states: "The area technician and executing personnel go through the

ICC plan set in the field, with the area technician showing/explaining which preparations have been made (N_2 flushing/steaming, etc) and which valves are barriers, and demonstrating with bleed valves that the system is depressurised.

"The area technician is present when splitting equipment."

Furthermore, the *Handbook for safe work in the petroleum industry* is issued to everyone on SFB. Intended to assist executing personnel on the facility, this incorporates the *11.0 HC and pressurised system* checklist, which includes the following checkpoints:

- ensure that relevant documentation is available, such as isolation drawings/ valve and blind lists/marked-up drawings
- verify mechanical isolation
- demonstrate in the field that affected equipment is depressurised.

The handbook also includes the 4.2.5 *Work on hydrocarbon system* requirement matrix from Offshore Norge's guideline 088 *Recommended guidelines for common model for work permits*.

Closure of WP
When the job has been completed, the WP must be closed.

5.2.2 WP for the relevant activity

Application for a WP prepared on the basis of information in a WO
Applications were submitted for the same WP on both 20 and 21 April 2023, since the work was postponed for a day while awaiting installation of the new B-18 wellhead.

The WP for the activity of splitting a blind hub and installing a hook-up spool – *Work on hydrocarbon system: M04 Apply: Splitting on B18 to remove blind hub* – has the following description: "A blind hub in the flowline is to be split for installing hook-up spool to Xmas tree. AT and ET verify ICC points and AT is present during splitting."

When preparing the WP, the isolation plan must be attached to it. As mentioned above, two isolation plans for M04 well B-18 were available in Permit Vision.

1. Status "active": ICC1575520 *M04 B-18 Dismantle hook-up spool*.
2. Status "temporarily change": ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list*.

A WP application cannot be approved in Permit Vision if the isolation plan status is "temporarily changed". The attached isolation plan's status must be "active" for approval to be possible in this IT tool.

The WP applicant contacted the operations department to clarify which isolation plan should be used for the job. Plan ICC1575520 *M04 B-18 Dismantle hook-up spool* was then attached to the WP by the applicant. This isolation plan was prepared and set as active on 21 January 2023 before the removal of water injection flowline 06''-WI-57118-FD230, which was hooked up to Xmas tree/XMT B-18 WAG (WAG well to be replaced by new B-18 production well). The plan was not relevant for the activity due to be carried out. It was not viewed (opened electronically) when preparing the WP.

Application for a WP assessed, given advance approval/coordinated with other activities, and approved

- The WP was assessed at the meeting where all WP applications were reviewed by the operations department. This meeting was attended by an area technician for each area, the production manager and the process discipline leader. The attached isolation plan was not viewed (opened electronically) at this assessment meeting (on neither 20 nor 21 April 2023).
- The WP received advance approval at the meeting where all WP applications where reviewed. The attached isolation plan was not viewed (opened electronically) at this assessment meeting (neither on 20 nor 21 April 2023).
- The WP was approved later that day when all WP applications were reviewed. The attached isolation plan was not viewed (opened electronically) at this meeting (on neither 20 nor 21 April 2023).

Activation of AT

The work operation to be executed on the day of the incident involved installing a new hook-up spool to connect the new production pipeline to well B-18. Before doing this, the blind hub on the new production line was to be split. The work team comprised two people (persons 1 and 2), who were both mechanics employed by Moreld Apply. A review of the job was conducted by the Moreld Apply foreman (WP applicant) and the executing personnel. In addition, the two executing mechanics carried out an A-standard review for the job. This covered only the work to be done by the two mechanics. Tools to be used in executing the work included a pneumatic impact wrench and a Hytorc hydraulic torque wrench.

Figure 9 Photograph of the incident site. It was taken before work on splitting the blind hub began on the day of the incident. (Source: Equinor)

The well area technician was called to M04M, the upper mezzanine well area, to prepare the job and activate the WP. They were accompanied by two trainee. The area technician was informed by radio that Class B hot work – a hot-air job – was under way on the level below. Pursuant to the *Work permit (WP)* work process (OM105.01), requirement R-12114, Class B hot work must be coordinated with jobs on hydrocarbon systems and may not be executed simultaneously with opening production pipelines. Since limited time was needed to finish it, the hot-air job was given priority ahead of splitting the blind hub.

Once the hot-air job had been completed, preparing the area began. The area technician, a trainee area technician and the executing personnel (persons 1 and 2) verified that the system was depressurised before splitting/removing the blind hub. This was done by opening a DB&B valve close to the splitting site and checking that the system was depressurised at the tie-in point (where the future tie-in was to be made). Neither hearing nor sensing pressure at the tie-in point, they concluded that the system was depressurised. It has subsequently transpired that the DB&B valve incorporates a check valve, which meant there was no outflow from the tie-in point and thereby no indication of pressure in the system. See figure 7. To verify a depressurised system with this type of DB&B valve, the bleed point (marked in figures 7 and 10) must be opened. No further verification of system depressurisation was conducted. The isolation plan attached to the WP was not opened/brought into the field to verify isolation/bleed points.

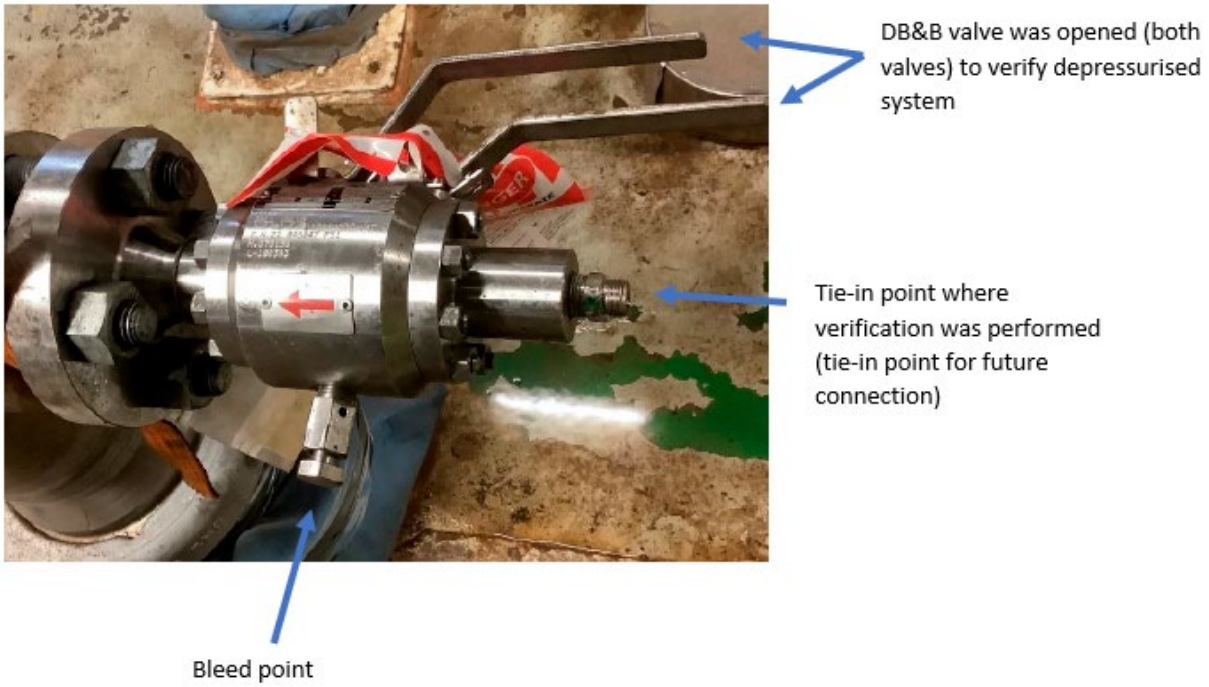

Figure 10 DB&B valve which was opened to verify system depressurisation. (Source: Police)

The isolation plan attached to the WP was not verified in the field.

A toolbox talk was conducted with the personnel involved before activating the WP.

5.3 Executing work on hydrocarbon systems

5.3.1 Equinor's work processes

Bolt unscrewing

To split a blind hub, bolts must be unscrewed. Equinor has described this process in governing document OM105.07.04.01 – *Bolt tightening*, which is intended to provide important information on assembly, bolt tightening and where to obtain correct torque values. The process includes such requirements as "be sure that the clamp has loosened before the nuts are removed completely.

"If the clamp still cannot rotate freely, it could indicate the existence of tensions in the piping system or that pressure remains in the pipeline. In such cases, all work must cease and relevant technical personnel be contacted (R-14510)."

Working environment

To protect executing personnel from possible exposure to such hydrocarbons as benzene, recommendations from the emergency procedures checklist for crude oil were reportedly followed. The checklist is dated 18 August 2018, and specifies that PPE is not required in exposure conditions lasting less than 10 minutes. Respirators and gloves are recommended for work lasting more than an hour.

The work team had estimated exposure time related to this job as short (less than 10 minutes) and therefore utilised only standard PPE.

Removing the blind hub and then rigging and installing a new hook-up spool between production line and wellhead is expected to take more than 10 minutes. The choice of not using respirator and gloves could be thought to be not conservative. In addition, the limit value for benzene was reduced by 80 per cent in 2021. It is unclear whether this cut has been taken into account in the 2018 checklist, or whether its recommendations are based on significantly higher limit values for benzene exposure.

The incident meant that volume polluted with hydrocarbons was released in the area occupied by the mechanics. Estimating the scope of this exposure is challenging, but no form of PPE was used or other exposure-limiting measures implemented to protect personnel from exposure.

6 Course of events

Seven people were present in the M04 upper mezzanine area – Person 1 (mechanic), Person 2 (mechanic), area technician well area, two trainee area technicians, a field engineer from Moreld Apply and an electrician. In addition, an automation technician was present on the level below.

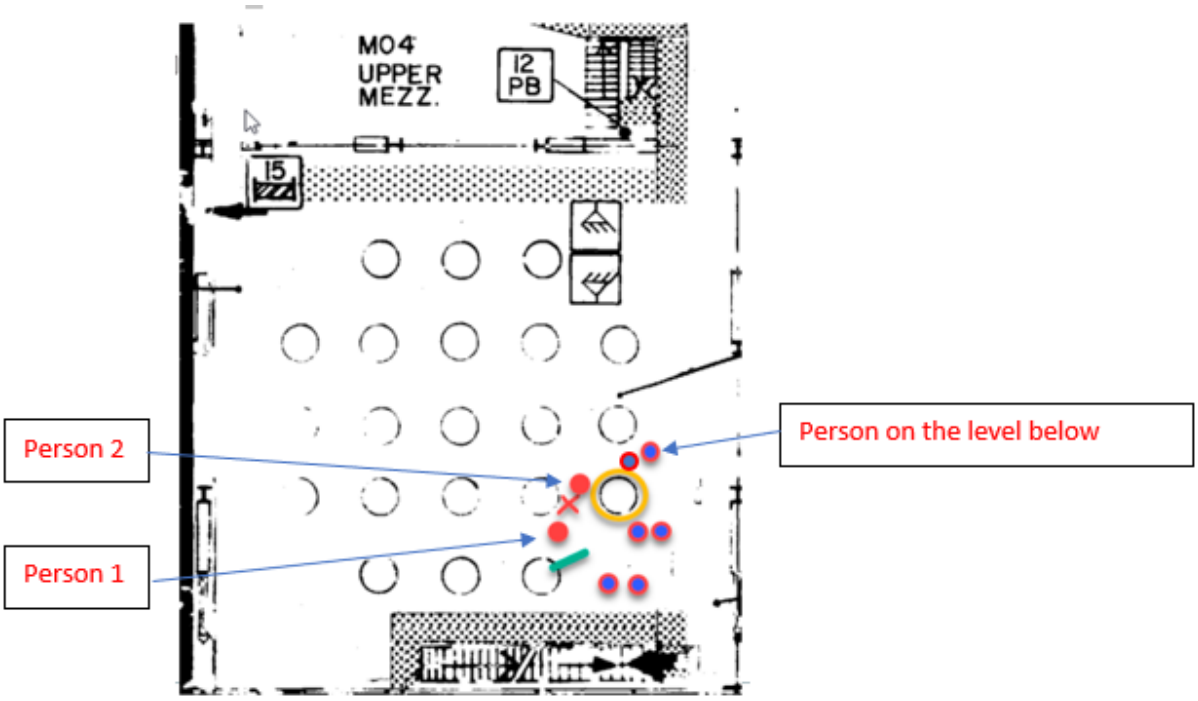

Figure 11 Overview of people in the area where the incident occurred and on the level below. (Source: Equinor)

The splitting job was initiated by loosening bolts which held the clamp with a pneumatic torque wrench. Two bolts were first unscrewed and removed, followed by loosening the two remaining bolts. The clamp was rotated with two loose bolts

before the latter were removed. While loosening the bolts, a check was conducted with personal gas meters without these activating. Person 2 lifted off one of the clamp shoes, but the other was a little stuck. Person 1 hit it cautiously with a bolt and it came free. A loud bang was heard and a white gas cloud emerged from the pipe. The 34-kg blind hub was also seen to be thrown about 1.5 metres into the air before hitting Person 1 on descending, and then rolling away to end up lying on the deck.

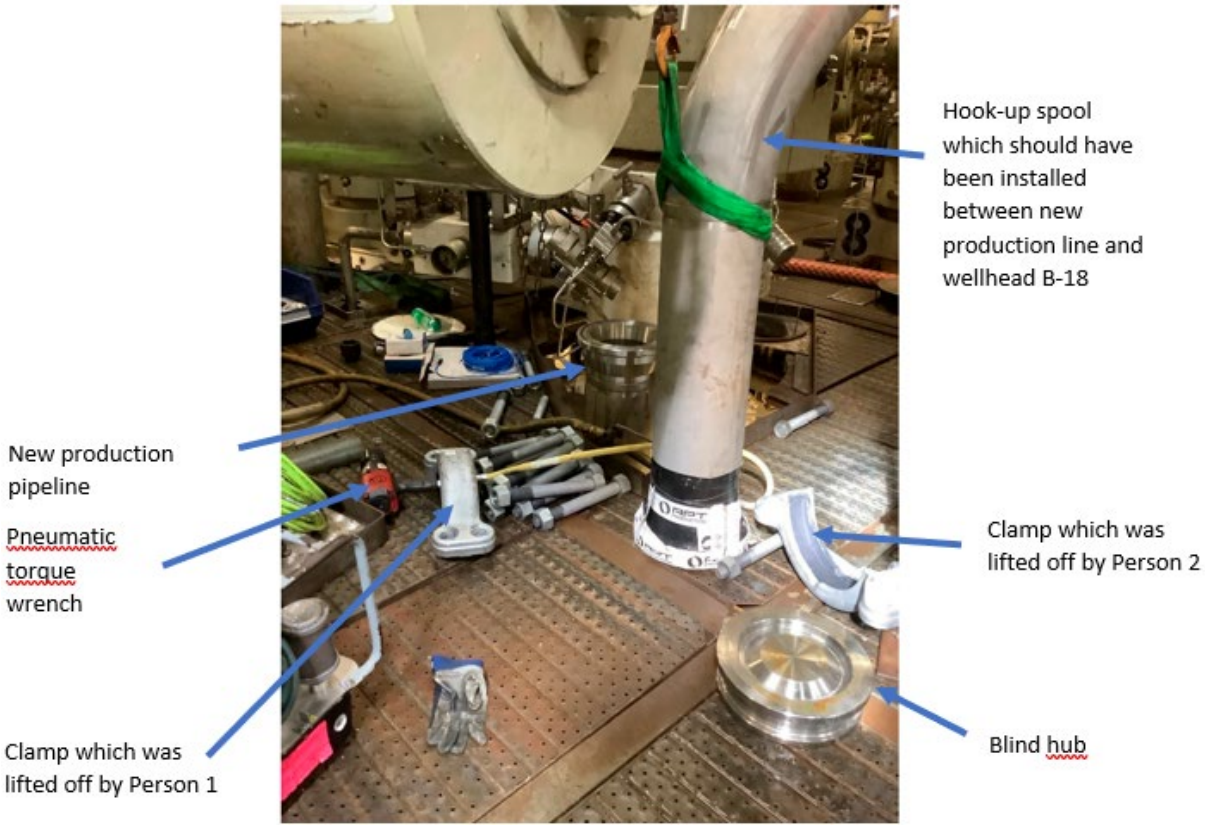

Figure 12 Photo of the workplace after the incident. (Source: Equinor)

Person 1 was injured and bled from the face. A nurse was alerted by radio, while fire water in the area was activated automatically. Person 2 helped Person 1 down the stairs and onward to the nurse. They arrived at the hospital, where the nurse was present. The injured person was sent ashore by SAR helicopter at 12.13, where a broken nose and jaw were confirmed.

Figure 13 Photo of the sealing ring which hit the person on the deck below the area where the incident occurred. (Source: Equinor)

The 2.15-kg sealing ring hit the arm of another person on the deck below.

6.1 The incident in chronological order

The incident occurred when splitting a blind hub on a new production pipeline. Activities which were or could have been of influence before the incident occurred, as well as during its actual course, are shown in the table below. Elements related to preceding activities which have been a contributory cause of the incident include:

- incorrect isolation plan attached to WP for splitting blind hub
- failure to verify the plan when preparing/processing and approving the WP for splitting the blind hub
- pressure transmitter PT 11809 was not opened to the production line
- failure to register leak challenges on valve HV11315 and the ICC with "temporarily changed" status in Shift Vision
- differing arrangements for injecting chemicals in old (unmodified) and new wells.

Time	What	Comments
Activities before the incident on 22 April 2023		
6 Jan 23	AO25501517 Dismantling of B13 piping/structure.	No information was logged in Shift Vision about leaks in the HP, LP and test manifold valves in connection with this

Time	What	Comments
		job.
21 Jan 23	AO26054173 Work on dismantling the hook-up spool for B18 WAG, and dismantling starts for parts of the flowline. Isolation plan *M04 B-18 Dismantle hook-up spool* (ICC1575520) set as active.	This is the same isolation plan used on the incident day.
7-18 Feb 23	AO26054239 Installation of new production line B-18 under way.	Installation of new production line from wellhead B-18 to the production, LP and test manifolds.
19 Feb 23, 13.25	AO26135943 Logging in Shift Vision related to leakage through the valve to the LP manifold.	In connection with preliminary work for this job, a slight leak in valve HV11315 (on LP manifold B13) was registered in Shift Vision and classified as "HSE barrier impairment". A flare hose was installed on the HV11315 bleed to check for pressure build-up. Mechanics would try to lubricate the valve tight when machining. Apply to check if it has the piping to be installed on HV11315.
21 Feb 23 17.51	AO26135943 Logging in Shift Vision: moved and lubricated both valves (HV11315 against LP manifold). Wheel fully open and lubricated while being closed on both valves. Appeared to be tight. Installed manometer on the blind.	Attempt to seal the valve.
23 Feb 23, 08.29	AO26135943 Logging in Shift Vision: Ring groove to be machined for HV11315. Discovered that HV11315 was leaking through both	Discovered that HV11315 leaked through both valves. Valves lubricated, but started leaking again.

Time	What	Comments
	valves.	No work thereby done that day on machining ring groove.
26 Feb 23	AO26135943 Logging in Shift Vision: Lubricated valve (HV11315). Mechanics adjusted the cones. Appeared tight now. Would monitor pressure in future	Attempt to seal the valve (HV11315).
27 Feb 23	Checked valve HV11315 for pressure buildup. Concluded that valve was tight.	Manometer installed on bleed.
2 Mar 23	AO26054239 New B-18 was to be connected to B-13 manifold valves (HV11313, HV11314 and HV11315).	Logging in Shift Vision: HV11315 leaking again (more than acceptable for splitting), lubricated and pressure-monitored overnight to assess leak rate.
4-9 Mar 23	AO26054239 New production lines hooked up to HV11313, HV11314 and HV11315 manifolds (test, production and LP respectively).	Blinding installed against test, production and LP manifolds. First flange after valves blinded off.
15 Mar 23	AO26054239 – Preliminary work N_2/helium leak test. Preparing to remove blinds for N_2/helium. ICC 1665597 *M04 – B18 Flowline/N_2 helium test valve list* set as active.	This is the isolation plan which was later temporarily changed.
16 Mar 23	AO26054239 – Preliminary work N_2/helium leak test. Logging in Shift Vision: - Apply was to remove blinds on the manifold the next morning. Since the LP manifold valve (HV11315) was leaking a little, it was desirable that it was bled off before 07.00 the following day.	Status for valve HV11315 was that there was a slight leak through it.
17 Mar 23	AO26054239 – Preliminary work for N_2/helium leak test. Blinds against manifold valves (HV11313, HV11314 and HV11315) removed. Logging in Shift Vision: Bleed open to flare on HV11315 since the	Blinds against the manifolds removed and measures taken on the LP manifold valve to stop hydrocarbons entering the production line.

Time	What	Comments
	valve was leaking into the flowline (to prevent hydrocarbons entering flowline). Open drain was temporarily closed and ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list* was given the status "temporarily changed" in Permit Vision.	The measure involved connecting the bleed point on the valve to the flare by a hose. (This hose was attached at the time of the incident, but it is uncertain whether the bleed point was still open to the flare.)
18 Mar 23	AO26054239 – Preliminary work. Pressure transmitter PT11809 closed. Pressure transmitter PT11809 for the line was blinded ahead of the leak test and remained blinded thereafter.	Pressure transmitter was not opened towards new production line, and thereby did not register pressure in the line on the incident day.
19 Mar 23	Logging in Shift Vision: Owing to a small internal leak between the LP manifold valves, the bleed point (valve no 27 in ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list*) was connected to the flare. Open drain was closed (valve no 10 in ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list*). ICC was thereby placed in status "temporarily changed".	An ICC was given status "temporarily changed", and could thereby not be attached to a WP in Permit Vision. Only ICCs with active status can be attached to a WP. Open drain was closed. Bleed point connected to the flare because of a small internal leak between the LP manifold valves in order to prevent leakage to the flowline. Information to be used in part for handover to other shifts in relation to isolation plans.
22 Mar 23	Logging i Shift Vision: B-18: Apply had installed new flowline, which was leak-tested with N_2/helium and tied in to B-13 manifold valves. ICC	Information to be used in part for handover to other shifts in relation to status of isolation plans.

Time	What	Comments
	temporarily changed (closed open drain) until hook-up-spool to be reinstalled.	Information that bleed point was connected to the flare because of small internal leak between LP manifolds not included
29 Mar 23, 19.28	Logging in Shift Vision: B-18: Apply had installed new flowline, which was leak-tested with N_2/helium and tied in to B-13 manifold valves. ICC in place which was temporarily changed (closed open drain) until hook-up-spool reinstalled.	Information to be used in part for handover to other shifts in relation to status of isolation plans. Information that bleed point was connected to the flare because of small internal leak between LP manifolds not included.
29 Mar 23,19.37	Logging in Shift Vision: Because of a small internal leak between the LP manifold valves, the bleed (valve no 27 in ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list*) was connected to the flare. Open drain was closed (valve no 10 in ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list*). ICC was thereby placed in status "temporarily changed".	Information to be used in part for handover to other shifts in relation to status of isolation plans. Information that bleed point was connected to the flare because of small internal leak between LP manifolds not included.
5 April 2023	Logging in Shift Vision: B-18: Drilling was working on this now. Apply had installed a new flowline, which was leak-tested with N_2/helium and tied in to B-13 manifold valves. ICC in place which was temporarily changed (closed open drain) until hook-up-spool reinstalled.	Information to be used in part for handover to other shifts in relation to status of isolation plans. Information that bleed point was connected to the flare because of small internal leak between LP manifolds not included.
9 April 2023	AO26054177 Pressure transmitter PT11809 was tested against the CCR (AT1704266).	The Havtil team was informed that the transmitter was not open to the production line at the time of the incident. According to ICC

Time	What	Comments
		1665597, the DB&B valve ahead of the transmitter should have been car-sealed open to the production line. This change was not logged in Shift Vision in the documentation received by the team.
12 April 2023	Logging in Shift Vision: B-18: Drilling still working on this, tree expected to be installed around 17 April. ICC in place.	Information that ICC was given status "temporarily changed" (because open drain was closed) was removed from the shift log. Information that bleed point was connected to the flare because of small internal leak between LP manifolds not included.
19 April 2023	Logging in Shift Vision: B-18: Drilling still working on this, tree expected to be installed around 17 April. ICC in place.	Information that ICC was given status "temporarily changed" (because open drain was closed) was removed from the shift log. Information that bleed point was connected to the flare because of small internal leak between LP manifolds not included.
20 Apr 23, 05.48	Logging in Shift Vision: Heavy lift on the B18 riser carried out 06.00. Archer expected to set XMT in the afternoon.	New wellhead for B18 was lifted in.
20 Apr 23	AO26054174 A WP level 1 was sought for executing *Well B-18 Hook-up inst piping/structure* on 21 April 2023 (*M04 Apply – Splitting on B18 to remove blind hub* (AT1723701)).	The isolation plan attached to the WP was ICC1575520 *M04 B-18 Dismantle hook-up spool*. This was not relevant to

Time	What	Comments
	The isolation plan attached to the WP was ICC1575520 *M04 B-18 Dismantle hook-up spool*. The attached ICC plan was not opened either when preparing or processing the WP. The WP was quality-assured, raised at the coordination meeting and approved at the WP meeting.	the work to be done. The isolation plan was prepared and set as active on 21 January 2023, when work (AO2605417) related to dismantling piping ahead of installing a new production line to B-18 was to be done (see information under 21 January 2023 in this table). This was the only isolation plan with active status in Permit Vision for the relevant location of this work.
21 Apr 23, 02.08	Logging in Shift Vision: B-18: Tree was in place.	The Xmas tree was installed and the final work of installing the hook-up spool between the new production line and the tree could be executed.
21 Apr 23	AT1723701 *M04 Apply – Splitting on B18 to remove blind hub* was not executed since work on the XMT was unfinished.	
21 Apr 23	AO26054174 A WP level 1 was applied for executing *Well B-18 Hook-up inst piping/structure* on 21 April 2023 (*M04 Apply – Splitting on B18 to remove blind hub* (AT1723701)). The isolation plan attached to the WP was ICC1575520 *M04 B-18 Dismantle hook-up spool*. The attached ICC plan was not opened either when preparing or considering the WP. The WP was quality-assured, raised at the	The isolation plan attached to the WP was ICC1575520 *M04 B-18 Dismantle hook-up spool*. This was not relevant to the work to be done. The isolation plan was prepared and set as active on 21 January 2023, when work (AO2605417) related to dismantling piping ahead of installing a new

Time	What	Comments
	coordination meeting and approved at the WP meeting.	production line to B-18 was to be done (see under 21 January 2023 in this table). This was the only isolation plan with active status in Permit Vision for the relevant location of this work.
The incident, 22 April 2023		
	Review of the job between the Moreld Apply foreman (WP applicant) and the executing personnel.	
	A-standard review of the *Splitting flowline on B18* activity conducted by the two executing mechanics from Moreld Apply.	This is an internal A-standard for Moreld Apply. Equinor personnel did not conduct an A-standard review of the work.
	The well area technician was called for preparations in the field and activation of the WP.	
	They had to await completion of a hot work Class B hot-air job under way on the level below.	
	The AT and ET had to verify that the system was depressurised before splitting. The isolation plan was not brought into the field. After opening a bleed point near the splitting site, they concluded that the system was depressurised. No further steps were taken to verify this or the isolation plan in the field.	It transpired subsequently that the bleed point had a check valve and would not give any outflow.
10.49	WP activated.	
	Splitting job begun by opening a clamp with the aid of a pneumatic torque wrench.	
	The clamp was rotated with loose bolts before the latter were removed and Person 2 lifted away one clamp shoe.	

Time	What	Comments
	The other shoe was a little stuck. Person 1 hit it cautiously with a bolt and it came free. A loud bang was heard and a white gas cloud emerged from the pipe. The 34-kg blind hub was also seen to be thrown about 1.5 metres into the air, before hitting Person 1 on descending and then rolling away to end up lying on the deck.	
10.52.54	The first gas detector (line gas) initiated a high alarm.	
10.53.00	A second gas detector (point gas) initiated a high-high alarm.	
10.53.04	General alarm – DSHA1 Gas leak M04. NAS 2.0/ESD 2 activated.	Automatic activation following gas detection.
10.53.15	Deluge activated in the area.	Deluge activated automatically on gas detection.
	Emergency response leadership mustered in the CCR.	Informed that two gas detectors – one point and the other line – had initiated an alarm in M04M. The detector overview showed no more detectors with a detection. Both detectors initiating an alarm showed a declining detection trend. The decision was therefore taken not to activate general blowdown.
Abt 10.55	The injured person arrived at the hospital on the facility.	
11.14	Overview of people on board (POB) – one injured, one missing.	
11.14	Deluge halted.	From the panel in the emergency response room.
11.23	Normalisation preparations.	Full POB overview.

Time	What	Comments
12.13	Injured person sent ashore by SAR helicopter.	

7 Potential of the incident

7.1 Actual consequence

The actual consequence of the incident was that a person suffered facial injuries, with a broken nose and jaw. These injuries led to sickness absence. A person on the level below was also hit, but not injured, by the sealing ring located between the blind hub and the production pipeline.

Equinor had a gas hazard analysis done as part of its investigation. The gas leak which occurred was of short duration and comprised about 2.4 kg in all. Calculations carried out in the gas hazard analysis showed that the gas release rate increased quickly as the blind hub was thrown clear, and reached a peak after about 0.04 seconds with a rate of almost 12 kg/s. The release rate then declined rapidly as the pressure decreased, and most of the leak was over after about 0.4 seconds. Simulations carried out in the gas hazard analysis showed that the flammable cloud reached a maximum volume of some 28 m^3 after roughly 1.5 seconds. It then thinned out and all flammable concentrations had disappeared after about seven seconds.

Production on SFB was shut down for roughly half a day.

Material damage to equipment was insignificant in the area where the incident occurred.

7.2 Potential consequences

Seven people were present in the area where the job was carried out, and one person in the area below.

The Havtil team considers that, under slightly different circumstances, a person could have died in the incident if the blind hub had struck in a different way.

According to the gas hazard analysis carried out, a possible ignition of the gas cloud cannot be excluded. Such ignition might have caused second- and third-degree facial burns for several of the people in the immediate vicinity of the cloud. The analysis concluded that a short exposure time means that possible fatalities as a result of ignition can be excluded. The Havtil team concurs with this assessment.

8 Direct and underlying causes

8.1 Direct causes

The direct cause of the incident was that the hydrocarbon system (production pipeline) was not depressurised when the blind hub was split. Pressure in the production pipeline caused the blind hub to be thrown up by about 1.5 metres and to strike a person on the way down.

8.2 Underlying causes

The most important factors identified by the investigation which were or could have been significant for the incident are presented below. Each point is described in more detail in the following sub-sections.

8.2.1 Handover

Follow-up of ICC plans in operations

Shift Vision, used for crew change, states that the temporary changes to isolation plan ICC1665597 *M04 – B18 Flowline/N_2 helium test valve list* were intended to prevent hydrocarbons entering the production line, since a leak existed in valve HV11315 to the LP manifold. This valve was the barrier against the LP manifold. After 29 March 2023, nothing was logged in Shift Vision about the bleed point being connected to the flare owing to a small internal leak between the LP manifold valves. After 5 April 2023, no information was included that the isolation plan was "temporarily changed" (closed open drain). The only information was that the ICC was set. As a result, important information about changes to the isolation plan were not included in the crew handovers (logged in Shift Vision used with shift changes).

According to ICC 1665597, the DB&B valve ahead of pressure transmitter PT11809 should be car-sealed open towards the production line. In the information received by the Havtil team, this change was not logged in Shift Vision. The team was told that the transmitter was not open to the production line at the time of the incident.

Follow-up of internal valve leak (barrier against LP manifold)

A leak had been registered for a long period in valve HV11315 (barrier against the LP manifold). Logging in Shift Vision related to modification work for a new production line (B-18) revealed challenges with the valve leak from 19 February 2023. The final log entry in Shift Vision related to the leak was on 29 March 2023. From that date until the incident on 22 April 2023 nothing was registered about how the leak in valve HV11315 was followed up (no logging in Shift Vision related to valve leak). The status of the leaking valve which serves as a barrier against the LP manifold was thereby unknown on the incident day.

8.2.2 Isolation plan

No separate isolation plan was attached to the WP (AT17262884) *M04 Apply – Splitting on B18 to remove blind hub*.

The isolation plan attached to the WP *M04 Apply – Splitting on B18 to remove blind hub* was ICC1575520 *M04 B-18 Dismantle hook-up spoo*l. This was not relevant to the work to be done. It was prepared and set as active on 21 January 2023, when the work related to dismantling piping ahead of installing a new production line to B-18 (AO2605417) was to be executed. This was the only isolation plan with the status active in Permit Vision for the area where splitting on B-18 to remove the blind hub was to be executed. Isolation plan ICC1575520 should have been reinstated. The change should have been reported as M5, and the P&ID (with red-line markup showing the change) delivered to the CCR.

The isolation plan attached to *M04 Apply – Splitting on B18 to remove blind hub* was not opened during the preparation, assessment, advance approval, approval or activation of the WP. It was not verified in the field. If the isolation plan had been brought along and used when verifying mechanical isolation points, the area technician would have discovered that it was wrong. A new isolation plan tailored to the work to be done would then have been established.

8.2.3 Verification that hydrocarbon system is depressurised

The area technician, trainee area technicians and executing personnel (Persons 1 and 2) verified that the system was depressurised before splitting/removing the blind hub. They opened a DB&B valve close to the splitting site and checked that the system was depressurised at the tie-in point (where the future tie-in was to be made). Neither hearing nor sensing pressure at the tie-in point, they concluded that the system was depressurised. It has subsequently transpired that the DB&B valve incorporates a check valve, which meant there was no outflow from the tie-in point and thereby no indication of pressure in the system.

System depressurisation was only checked at one point, and not for at least two as specified in Equinor's work process.

The isolation plan was not brought into the field. Doing this for use when verifying system depressurisation would have revealed that it was wrong. A new isolation plan would thereby have been established, showing that the point where verification of system depressurisation was being attempted was a DB&B valve with a check valve.

8.2.4 Monitoring pressure in the production line

The pressure transmitter (PT11809) for monitoring pressure in the production pipeline was not operational at the time of the incident. Installation and testing of the transmitter was completed on 9 April 2023. It was shut off on 18 March 2023 ahead

of a leak test of the new production line. The transmitter was not opened for verifying pressure in the production pipeline before the incident occurred.

8.2.5 Differing arrangements for injecting chemicals in old (unmodified) and new wells

Differing technical arrangements are installed on lines where chemicals are to be injected (such as corrosion or scale inhibitors). Old wells (which have not been modified) have a solution with no check valve on the line downstream of the tie-in point for injection. New wells (where older production pipelines in carbon steel are replaced by corrosion-resistant piping) have the "new" type of DB&B valve with a built-in check valve downstream of the tie-in point. This check valve means that system depressurisation cannot be checked via the tie-in point, but can still be checked via the bleed point on the DB&B valve. The technical arrangement (with or without check valve) on lines where chemicals are to be injected are shown on the P&ID. This change was unknown to a number of the people interviewed by the Havtil team during its investigation.

Ignorance about the check valve downstream from the tie-in point meant that people thought the hydrocarbon system was depressurised even though pressure remained.

8.2.6 Work and resources

Overviews received by the investigation revealed, and interviews confirmed, the use of both overtime and extended offshore periods for the personnel categories of process and CCR operators in order to cover shortfalls such as sickness absence. For May 2022-23, these overviews show that process and CCR operators working more than 14 days at a stretch averaged 19.8 extra days (including extended periods owing to helicopter traffic delays).

Long work periods are known to be a potential contributor to increased risk of errors and faults, hazards and accidents. At the same time, a concentration on and hours devoted to handling absences and ensuring adequate manning throughout will cut into the time available for the work of identifying and assessing risk conditions and implementing risk-reduction measures. That becomes particularly challenging when work and resources are out of alignment (nonconformity 5.1.1 in Havtil case 2023/698). Time constraints owing to such non-alignment may have contributed to:

- information on minor leaks was not retained in Shift Vision (ref section 8.2.1)
- inadequate reviewing and checking of the isolation plan attached to AT17262884 (ref section 8.2.2)
- verification of system depressurisation was only checked at one point (ref section 8.2.3)
- the pressure transmitter for monitoring pressure in the production pipeline was not reopened (ref section 8.2.4)
- personnel lacked sufficient time to become familiar with changes to the valve arrangement on new chemical injection lines (ref section 8.2.5).

9 Emergency response

When the general alarm was sounded, the emergency response organisation mustered as planned and remaining personnel mustered to the lifeboats. The injured person was accompanied to the nurse by their colleague and later sent ashore by SAR helicopter.

The Havtil team takes the view that the emergency response functioned well.

10 Chemical working environment

R-21938 - *Requirements for use of respirator* in Equinor's Aris requirements (SF312) specifies that respirators must be used in work operations which pose a risk of exposure to gases and vapours which could be injurious to health, and where the concentration of such pollution is unknown.

AT 1726284 referred to checklists and risk assessments from Equ!chem, which were attached. The checklist for natural gas (appendix 1 – updated 2021) recommends at a minimum using an air-supplied respirator, but does not specify benzene as a relevant component when exposed to natural gas. The checklist for crude oil (appendix 2, dated 2018) states that a respirator is not mandatory for short jobs (lasting less than 10 minutes), but specifies benzene as an exposure factor. However, it is unclear whether the checklist has been updated in accordance with the applicable limit value for benzene. This was reduced from 0.6 ppm to 0.12 ppm at 1 July 2021.

A chemical risk assessment (natural gas – dated 2021) was not attached to AT 1726284. This states that benzene can be a risk factor when working on hydrocarbon systems and recommends the use of filter masks for short jobs. It also recommends measuring benzene levels with direct-reading meters during the work and recording the measurements obtained.

The job of removing the blind hub was classified as work on a hydrocarbon system. However, none of those involved used respirators when dismantling the hub.

A register of workers who are or could be exposed to carcinogenic chemicals such as benzene is a regulatory requirements (chapter 31 of the regulations concerning the performance of work). In GL0650, Equinor has described inclusion criteria for personnel to be placed on this register. It is unclear how far this guideline was observed after the incident. Based on information provided during interviews and the document review, it might seem that chemical exposure was not assessed for those personnel who were in the immediate vicinity of the splitting point on well B-18.

11 Observations

Havtil's observations fall generally into two categories.

Nonconformities: this category embraces observations which Havtil believes to be 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.

11.1 Nonconformities

11.1.1 Inadequate safety-clearance of activities

Nonconformity
The planned splitting of the production pipeline for well B-18 had not been safety-cleared before execution.

Grounds
The WP and the work on safety-clearance before splitting the production pipeline for well B-18 had the following deficiencies.

a) A separate isolation plan was not established in relation to the WP for splitting the B-18 production pipeline when dismantling the blind hub.
b) The isolation plan attached to the WP had been prepared for an earlier job of dismantling the hook-up spool when B-18 was a WAG injection well. This plan did not contain the valves and blinds relevant for the new job.
c) When preparing and processing the WP, the attached isolation plan was not looked at by those involved in safety-clearance of the activity.
d) The isolation plan was not verified in the field while preparing the area immediately before splitting. The preparation done involved opening a valve near the work site. It subsequently transpired that this valve incorporated a check valve and that opening it did not verify that the production pipeline was depressurised. No further verification of system depressurisation was conducted.

It emerged during the investigation that isolation plan ICC 1665597 *M04 – B18 Flowline/N_2 helium test valve list* was inaccurate in terms of labelling in the field. This related to point no 9 scale inhibitor valve where the label tag was hung on the wrong valve. The tag was on the DB&B valve for future tie-in, a corresponding valve not included in the isolation plan. This was the valve used in the attempt to verify that the system was depressurised

Requirement
Section 30 of the activities regulations on safety-clearance of activities

11.1.2 Inadequate information transfer at shift and crew changes

Nonconformity
Equinor had failed to ensure that shift and crew changes received the necessary information transfer of significance for HSE when splitting production pipelines.

Grounds
The Shift Vision data tool was used on SFB to communicate important information at shift and crew changes. The following important details concerning the status of isolation plan ICC 1665597 *M04 – B18 Flowline/N_2 helium test valve list* was not logged in Shift Vision.

a) The isolation plan was temporarily changed because of a registered leak in valve HV11315 to the LP manifold. As a result, the bleed point on this DB&B valve was connected to the flare. Logging of information about this alteration was not included after 29 March 2023.
b) The valve to the open drain was the bleed point in this isolation plan, and should have been open. This was logged as closed in Shift Vision from 17 March 2023 to 5 April 2023. After that date, logging in Shift Vision said nothing about the isolation plan being temporarily changed, but only that it was set.
c) According to ICC 1665597, the DB&B valve ahead of the pressure transmitter (PT11809) should have been car-sealed open to the production line. The Havtil team was informed that the transmitter was not open to the production line at the time of the incident. Logging that the transmitter is not open to the production line was not included in Shift Vision.

Requirement
Section 32 of the activities regulations on transfer of information at shift and crew changes

11.1.3 Lack of information for the relevant users

Nonconformity
Equinor had not identified and communicated the information required for relevant users to be able to execute activities related to using the new type of DB&B valve for verifying that plant is depressurised.

Grounds
Design solutions for chemical injection lines differ on SFB. Old wells (unmodified) have a solution where the line has no check valve between the tie-in point and the production pipeline. New wells have DB&B valves (incorporating a check valve) on chemical injection lines. The check valve is then between the injection point and the production line.

A number of people in operations were unaware of this equipment change. It was not included, for example, in SO00131 - *System WA - Wellheads and manifolds – System description*. However, P&ID were updated with information on DB&B valves with built-in check valve.

Requirement
Section 15, paragraphs 1 and 2 of the management regulations on information

11.1.4 Planning of the work failed to identify important contributors to ignition source risk

Nonconformity
Assurance was not secured when planning the job of splitting the production pipeline that important contributors to ignition source risk were kept under control.

Grounds
The clamp holding the blind hub in place was split using an pneumatic torque wrench. Photographs of the work site reveal that no air isolation valve was connected to halt air supply to the tool if gas were detected. Nor was such a valve specified in the WP.

Equinor's governing document (OM105.01) related to WPs specifies that all portable hand-held pneumatic tools must be connected to a shutdown connection box so that air supply ceases on a single gas detection.

Requirement
Section 29, paragraph 1 of the activities regulations on planning, see section 7, paragraph 1, point 2, of framework regulations on responsibilities pursuant to these regulations, see section 8, paragraph 1, point 1 of the management regulations on internal requirements.

11.2 Improvement point

11.2.1 Lack of capacity for executing planned activities

Improvement point
Equinor does not appear to have made available the resources required to execute the operations organisation's planned activities.

Grounds
- Overviews from April 2022 to April 2023 show that process operators and CCR personnel collectively had 198 days of extended offshore service (including extensions caused by disruptions in helicopter traffic).
- According to overviews received, one CCR operator had 31 days of extended offshore time spread over four tours from April 2022 to April 2023. Several of

these periods lasted more than seven days. Another operator spent extended time offshore on six of eight tours in the same period, totalling 28 days.
- It emerged from the investigation that lack of manning robustness contributed to much time being spent on finding replacements for personnel who were unable for one reason or another to work their agreed shift – and that extended offshore time was often used.

A lack of alignment between manning and work has been found both in this investigation and subsequent audits. Identifying direct links between that condition and the underlying causes of this incident is challenging. But it would be problematic to assess the decisions taken and the way removal of the blind hub was planned, approved and executed without seeing these in relation to the admission by most of those involved that they experienced pressure of time and an excessive level of activity compared with the resources made available.

Requirement
Section 12 of the management regulations on planning

12 Barriers which have functioned

Gas detection

The philosophy for activating confirmed gas detection on SFB is two gas detectors in the same fire area initiating an alarm, either high + high or high + low.

Two gas detectors – one line and the other point – detected the gas leak in M04M. The line gas detector registered 1.63 LELm and the point gas detector 58% LEL.

Confirmed gas detection was activated with the following actions.

Fire extinguishing

In M04, automatic deluge will be activated with confirmed fire and/or confirmed gas detection. A general alarm based on confirmed gas detection was activated at 10.53.04. The deluge in MO4 was activated in the area at 10.53.15, which is within the performance requirement for response time in the fire water system.

ESD

Confirmed gas detection automatically initiates emergency shutdown (ESD 2). Supply and transport of flammable liquids and gas was thereby halted on SFB.

Blowdown

With ESD 2, the CCR operator can open the blowdown valves from relevant segments individually or simultaneously. When circumstances call for blowdown of SFB as a whole, such as confirmed gas in classified areas, the CCR operator must manually initiate blowdown as quickly as possible from the CAP panel.

Blowdown was not initiated manually for the gas leak on 22 April 2023 because the leak was of short duration. The trend reports for the gas detectors which initiated an alarm showed a gap of only 39 seconds between first and last detection. Given that information, manual activation of blowdown was not undertaken.

Ignition source disconnection

The alarm log shows that automatic ignition source disconnection was activated as a result of the gas detection.

13 Discussion of uncertainties

During its investigation, the Havtil team was told that equipment in the incident area had been moved before its inspection. That included weighing the blind hub, clamp shoe, sealing ring and bolts. As a result, the team failed to form a correct picture of the position at the work site immediately after the incident.

One technical aspect which the investigation was unable to establish is the status of the bleed point on the HV11315 valve at the time of the incident. It has presumably not been open to the flare.

14 Assessment of the player's investigation report

Equinor established an investigation team with participation from Moreld Apply. Its investigation report was received by Havtil on 24 September 2023. The description of the course of events and the direct and underlying causes coincide with the Havtil team's observations and assessments.

As part of its assessment, Equinor also had a gas hazard analysis done which was utilised to assess the size of the gas leak and the potential of the incident should the gas cloud have ignited. This analysis has also formed the basis for the Havtil team's assessment of the incident's potential.

15 Appendices

A: The following documents have been utilised in the investigation

Mottatt varselskjema om hendelsen fra Equinor den 22 April 2023
Presentasjon fra møte 24.4.23 med Equinor om hendelsen den 22 April 2023
Områdekompetanse BP-ZZ-Z-DU-006 Brønnområdet
I-105961 – Metoder for testing av barrierer – Upstream offshore
Loggføringer i Shift Vision knyttet til B13
Huskeliste for setting og tilbakestilling
OM105.07.01.02 – Sett, verifiser og godkjenn isolering – Upstream offshore

OM105.01 – Arbeidstillatelse (AT) – Upstream offshore
OM105.07 April 2001 – Utfør boltetrekking
OM105.07.01.01 – Utarbeide isoleringsplan
Oversikt område M04M
AT og A-standard Apply Moreld
ICC STB-0001575520-B-18
Offshore organisasjonskart
EXT-000736 – Full isoleringsplan mal (OM100)
EXT-001442 – ICC-Beste praksis Permit Vision
Rutiner for oppfølging av aktive ICC planer Statfjord C
Bilder som viser merking i felt
IKM B18 N2He Lekkasjetesting av FLX brønn 18
R19031 sjekke og bekrefte at systemet, utstyret er nedstengt
EXT- 000570 - En enkel ventil – NO
EXT – 000571 – Dobbel barriere ved hjelp av en ventil med to seter
EXT – 000572 – Dobbel barriere ved hjelp av 2 ventiler med avblødning mellom – NO
AO 26054173
Vedlegg AO 26054173
SO 00131 – System WA- Brønnhode og manifolder systembeskrivelse
I110258 – Bruk av arbeidstillatelse i Permit Vision
Vedlegg til I -110258
Bilder knyttet til spørsmål om nedstengingsboks for luftdrevet verktøy
Dokument med beskrivelse av utkoblede sikkerhetssystemer den 22 April 2023 kl. 10.53
Vekt bolt og klammer
B&G Alarm og eventlog
PCDA Alarm og eventlog
B 13 Brønntest 30122022
Illustrasjonsbilder fra 22 April 2023
Oversikt over bruk av utvidet oppholdstid for prosessoperatører
Bilder av tavlene til beredskapsledelsen offshore, 1.linje
Logg fra luft – incident register 24 April 2023
Tiltakskort råolje
Tiltakskort naturgass
Risk assessment/safe work instructions (Chemirisk report ver. 03.00.01)
AO 260054173
Vedlegg i AO 260054173
AO 26054239
Vedlegg 1 i AO 26054239, rutiner bytte av sealringer Statfjord
Vedlegg 2 AO 26054239
AT som ble behandlet og godkjent 20 og 21.04
AT STB-0001723701
AT STB-0001723701 vedlegg 1
AT STB-0001723701 vedlegg 2

AT STB-0001723701 vedlegg 3
AT STB-0001726284- B-18 Arbeid på hydrokarbonførende system: M04 Apply: Splitting på B18 for fjerne blindhub
Vedlegg 1 AT STB-0001726284- B-18
Vedlegg 2a AT STB-0001726284- B-18
Vedlegg 2b AT STB-0001726284- B-18
Vedlegg 3 AT STB-0001726284- B-18
ICC B18 Flowline- N2H test STB-0001665597
P&ID B18 Flowline N2He test STB-00016665597
Diverse bilder etter hendelsen
Tekst tatt ut fra Shift Vision som omhandler B18 og endret ICC
Morled Apply jobbpakke
ATEX muttertrekker info
ATEX muttertrekker
P&ID med plassering av PT B18
Trend PT11809 B18 etter hendelse
Presentasjon: Avklaringsmøte med Havtil 31.05.23
B-18 Lekkasjetest manifoldventiler – skift visjon oversikt
Stb-0001623705 – Maskinering flens HV11315 AO26135943
Stb-0001623705 – ICC for maskinering av flens på HV11315 23.02.23
Stb-0001694684 – Brønn B18 Hook-up Inst Pping struktur
Stb-0001665597 -ICC på HV11315 for montering av B18
Stb-0001651423 – Montering av choke B-13
Stb-0001654847 Fjerne blindlokk og montere B18 flowling mot HV11314 produksjon manifold
Stb-0001738783 – M04 B18 Montering av hook- up spool
Stb-0001694684-B18 Montere gassløft hook-up spool
Stb-0001543455 – M04 Blindingsliste riving av flowlineB13
Stb-0001538011- M04- Demontere og bytte flowline
PT11809 trend 22 April 2023
PT11809 trend fra 22 April 2023-27 April 2023
Hendelseslogg ICC 1665597
Plot av HP LP og Test manifold kl. 10.53
Utskrift av AO 26054174
Oversikt opphold utover 14 dager
Oversikt over utkoblede sikkerhetssystem
Epost mottatt 06.10.23 med svar på oversendte spørsmål angående legende P&ID, betydning av rød pil på DB&B ventil og langtidsisoleringer
Statfjord standard drafting symbols multidicipline for flow diagrams

B: Overview of participants from Equinor and Moreld Apply