Report	
Report title Investigation of unwanted incident at the Brage field on 21 November 2023 involving personal injury	Assignment no. 2023-1556

Classification	
☒ Public	☐ Exempt from public disclosure

Involved personnel	
Team A-2	Approved by / date Bjarte Rødne / 8 May 2024
Participants in the investigation team [redacted]	Investigation team leader [redacted]

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Table of Contents

1 Executive summary

In the course of a scheduled 6-monthly valve test at Well A-20 at OKEA's Brage facility, a serious work accident occurred on 21 November 2023.

The PSA was notified that at 07:37 a needle valve (Figure 1) on the tree cap of Well A-20 had detached. The needle valve was subject to a pressure of 80 bar, and the force of the impact resulted in serious injury to the face of an employee. Because the situation constituted a serious workplace accident, the PSA decided on 22 November to investigate the incident.

The injured person (IP1) was sent to Haukeland Hospital in Bergen by SAR helicopter on the day of the incident.

The actual consequence of the incident was a serious personal injury.

Marginally different circumstances could have resulted in death. The potential after-effects of the injury have not been considered in this report. Long-term injuries caused by exposure to hazardous gases and noise have not been ascertained but have been identified as a possible risk.
The direct cause of the incident was that the needle valve detached from the valve tree as a result of corrosion of the lowermost threaded part of the valve housing. The valve was under a pressure of 80 bar and the valve housing was held in place by only one or two turns of thread (see Chapter 3.3), when the employee involved commenced the job. The incident was triggered by the mechanical load to which the needle valve was subjected during the work.

DNV's damage analysis showed that the needle valve did not bear significant contact marks from tools, for example caused by dismantling the blind plug. It is likely that any similar mechanical load might have triggered an incident of this type. Corrosion, insufficient thread contact, and pressure exposure from beneath would sooner or later have resulted in the detachment of the valve housing.

Several similar needle valves were installed on valve trees at Brage and this could also have happened to any of these.

Figure 1 Kerotest needle valve

During the investigation, Havtil discovered 8 nonconformities (for details see Chapter 9).

1.1 Further information

The name of the Petroleum Safety Authority (PSA) was changed on 1 January 2024 to the Norwegian Ocean Industry Authority (Havindustritilsynet – Havtil). Hence, reference is made both to the PSA and to Havtil in this report.

2 Background information

Brage is located in the northerly part of the North Sea, ten kilometres east of the Oseberg field and 125 km west of Bergen. The water depth is 140 metres. The Brage field was discovered in 1980 and a Plan for Development and Operation (PDO) was approved in 1990. The field was developed using an integrated production, drilling and accommodation facility mounted on a steel jacket. Production commenced on 23 September 1993 and Brage is expected to be in operation until 2030. The current production capacity is:

- 6,000 Sm^3/sd of oil
- 2.5 MSm^3/sd of gas
- Total fluid capacity: 48,000 m^3/sd
- Produced water: 46000 m^3/sd

Brage has 40 wells, including 25 production wells, five water injectors, two wells producing water from the Utsira formation and a cuttings re-injection well. The produced oil is transported by pipeline to Oseberg and from there by the Oseberg Transport System, the OTS pipeline, to the Sture terminal. A gas pipeline is connected to Statpipe.

Norsk Hydro operated the facility from 1993 to 2007. Statoil was the operator from 2007 to 2013. In 2013 the licence and operatorship were transferred to Wintershall, later Wintershall DEA. Wintershall Dea was operator from 2013 to 2022. In November 2022 the field was transferred from Wintershall Dea to OKEA.

The valve tree at Brage was supplied by FMC in 1998. It is not known which company supplied the needle valve, or when it was installed. At the time of the incident, inspection activities were contracted out to Oceaneering. Odfjell Drilling was the drilling contractor at the facility.

2.1 The situation before the incident

The situation at the Brage facility on the morning of 21 November 2023 was normal, with no special incidents before work commenced on the valve tree. Brage was in normal operation as regards manpower, production and export. Production was shut down at the well in question due to production optimisation.

Yr.no (the Norwegian Meteorological Institute's weather website) reported a temperature of 5.6 °C and wind of 8.3 m/s during the day. The weather before and after the incident was similar.

2.2 Definitions and abbreviations

Term/abbreviation	Meaning
WP	Work Permit
DHSV	Down-Hole Safety Valve
C41	Basement deck, wellhead area
C42	Mezzanine deck, wellhead area
D&W	OKEA's Drilling and Well Section
DB&B	Double Block and Bleed, controlled pressure release equipment
Debriefing	A meeting to review a situation and to report on and discuss an incident
DNV	Det Norske Veritas
Operations	OKEA's offshore operational organisation at Brage
O&M	Operation and Maintenance
GA	General Alarm

Grating	Walkway constructed from steel grating
HMV	Hydraulic Master Valve
IP1	The injured person
IP2	A person immediately adjacent to the site of the accident scene (a trainee)
PCS	OKEA's Personnel Skills Management System
KV	Kill Valve
LQ1	Living Quarters Level 1
MMV	Manual Master Valve
Needle valve	Needle valve housing with spindle and attached blind plug
Needle valve housing	Outer covering of needle valve
Ops	OKEA's operational department
P&ID	Piping and Instrumentation Diagram
PI	Pressure Indicator
PIV	Platform Internal Verifications
PM	Rig Manager/OIM
PT	Pressure Transmitter
PDO	Plan for development and operation
PWV	Production Wing Valve
SAP	Maintenance system used by Wintershall Dea
SAR	Search and Rescue
SJA	Safe Job Analysis
ASM	Accident Scene Manager
CCR	Central Control Room
Spindle	Internal part of needle valve: shut-off mechanism and needle
STAR	Maintenance system used by OKEA
STEP	Sequential Timed Events Plotting (method of analysing causal effects)
SV	Swab Valve

3 Havtil's investigation

The investigation team consisted of three persons with relevant qualifications. In cases where the team lacked specific skills, relevant technical specialists at Havtil were consulted. Technical laboratory examination of the needle valves was carried out by Det Norske Veritas (DNV) by way of a contract administered by OKEA.

3.1 Procedure

The incident occurred on 21 November 2023. The PSA's investigation team was established on Wednesday, 22 November. An initial, digital interview with IP2 was carried out from onshore the same day. The investigation team travelled to Bergen on Wednesday afternoon for departure to Brage. Due to bad weather, departure was postponed until Friday 24 November at 13:30.

Because of the delay, a start-up meeting and two interviews were carried out in OKEA's offices in Bergen on Thursday 23 November.

An offshore start-up meeting took place on 24 November. The following activities were given priority during the period offshore:

- Interviews with offshore personnel who were involved in the incident, in emergency response activities or in normalisation following the incident
- Inspection of the area with relevant personnel
- A digital interview with IP1 and second digital interview with IP2

A summing-up meeting was carried out offshore on Monday 27 November, at which we reviewed current status and the observations we intended to continue to work on.

The investigation subsequently continued onshore. A large number of interviews were carried out, focusing mainly on OKEA's onshore organisation. The final interview was conducted on 17 January 2024 and the last information from OKEA was received on 1 February 2024.

3.2 Choice of investigation method

Several accident perspectives were discussed and evaluated. The information and decision-making perspective (system perspective) was considered the most appropriate and formed the basis of further analysis. Themes such as management, control, decision-making, information flow and situation awareness were focused on in our interviews and analyses. This perspective also lends itself well to consideration of the human factors.

STEP (Sequential Timed Events Plotting) was considered the most suitable method for structuring information about the chain of events. The large number of participants and the complex circumstances constituted the main argument.

Following the incident itself, there was some uncertainty regarding the timing of certain events since only very few of these were recorded by the operator. However, the sequence of events has now been documented with considerable confidence.

During this investigation, Havtil used a model and method for investigating and assessing which performance-influencing factors may have played a role in the situation awareness, decision-making and actions of those involved. The model has been developed to ensure the systematic examination of human factors in the investigation of accidents. The purpose of the method is to consider human factors in a systematic perspective and to understand better why people behave as they do.

The method was developed by SINTEF on behalf of the PSA and is based on a recognised model of situation awareness (Endsley, 1995).

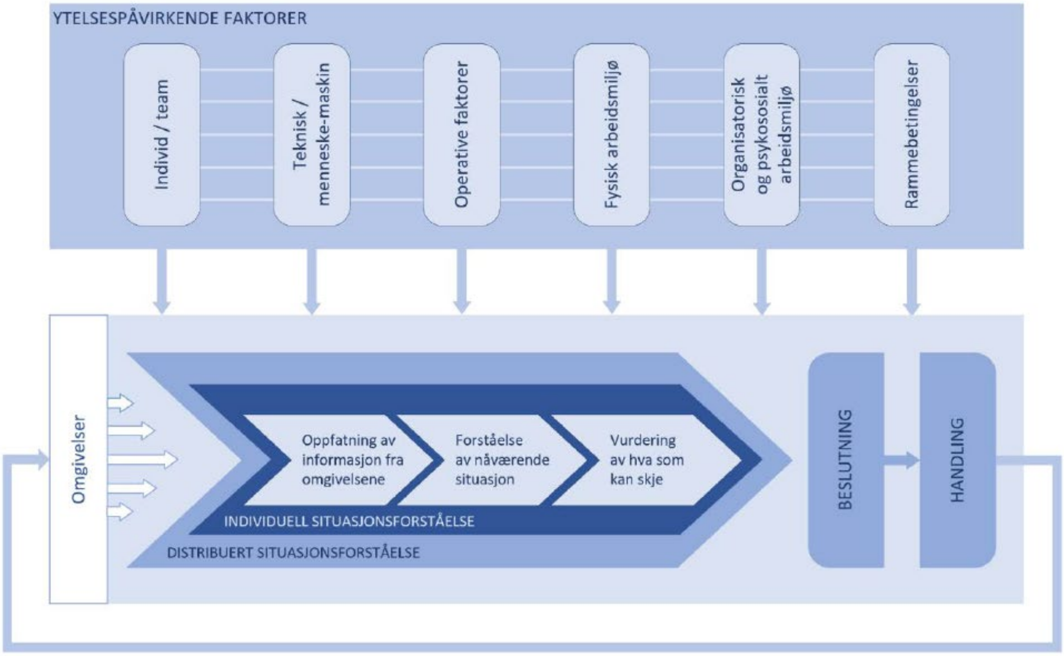


Figure 2 Human factors in investigations (Endsley, 1995)

3.3 External investigations

The needle valve from Well A-20 and the corresponding needle valve from well A-38 were sent to DNV in Bergen for examination. OKEA requisitioned and administered the DNV examination, with contributions from Havtil. The result of the examination showed that the threaded section of the needle valve housing from Well A-20 was shortened by about 8 mm by the effects of corrosion. DNV verified that the extent and rate of corrosion could indicate that the needle valve had been installed on the valve tree since 1998 (DNV AS Energy Systems, 2024). OKEA has been unable to document the date of installation of the needle valve.

DNV's examination indicates that at the time of the incident only one or two turns of thread on the valve housing were engaged and that little force was necessary to trigger the incident.

4 Sequence of events

Havtil has reconstructed the incident, based on its own information acquisition, conversations with personnel involved and data from OKEA's various safety systems.

IP1 and IP2 had just commenced their daytime shift at 06:45 and had performed the handover from the night shift in the observation room and with a brief conversation in the control room. The shift had completed most of the fourteen-day plan and had agreed to carry out a six-monthly periodic valve test during the day.

Well A-20 is located in the north-western corner of the process installation, adjacent to a walkway (Figure 3).

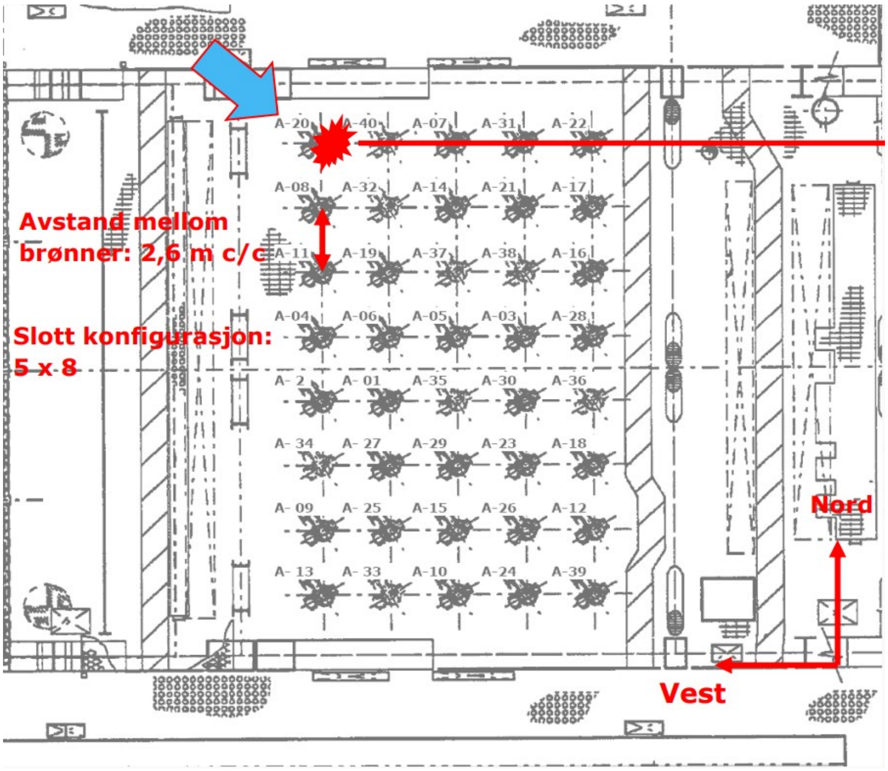
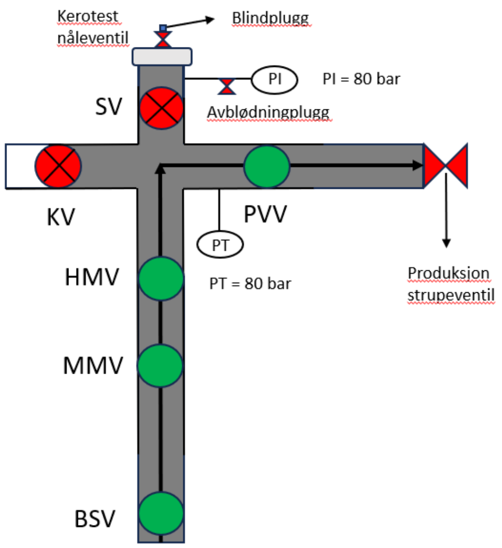


Figure 3 The wellhead deck layout

At this point the well had been shut down for some time. Several valve tests had been carried out in the preceding days and it was agreed that this was a suitable task for IP2, while IP1 could commence the usual inspection and supervise. In order to carry out the planned valve test there had to be differential pressure above the swab valve (SV). The pressure at the intersection beneath the SV (80 bar) was read off in the Central Control Room (CCR), while the pressure downstream of the SV needed to be read off manually at the valve tree (see Figure 4). IP2 read off the pressure as 80 bar also downstream of the SV and reported this over the radio to the CCR. It was discussed whether to bleed off the pressure above the SV using the valve at the pressure indicator (PI, see Figure 4) or through the needle valve in the tree cap. It was agreed that pressure release through the needle valve, draining to a closed system, should be possible. Figure 4 shows the valve status and read-off pressure in the valve tree before work commenced.



The black arrow indicates the flow direction.

Figure 4 Schematic diagram of the valve tree on Well A-20.

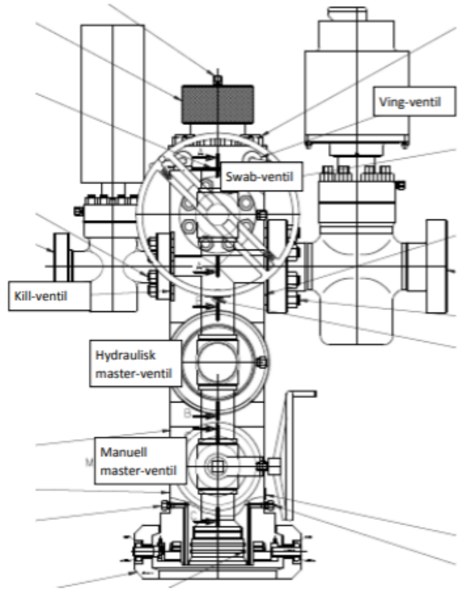


Figure 5 Technical drawing, valve tree, A-20

Since IP2 had limited experience with this task, IP1 was contacted and assistance was requested. IP1 was located on the basement deck, one level below IP2. IP1 had overheard the radio conversation between IP2 and the CCR. IP1 met IP2 by the wellhead and it was decided relatively quickly to bleed off the pressure at the top of the valve tree.

The exhaust outlet of the needle valve was closed by a blind plug which had to be dismantled before connecting a hose and bleeding off the pressure. In order to reach the needle valve and blind plug, IP1 climbed up on the actuator of the hydraulic master valve (HMV), about 1.25 metres above floor level. The height of the tree cap and needle valve above the deck is about 2.25 metres. Both the needle valve housing and the blind plug have right-handed threads. To loosen the blind plug without screwing the entire needle valve housing out of the tree cap, IP1 had to hold the needle valve housing steady using one spanner and unscrew the blind plug with another. Because of his position, outside the hand wheel on the SV, IP1 had to stand bent over the tree cap in order to access the blind plug (see Figure 6).

Figure 6 The process technician's working position. Havtil reconstruction.

Shortly after IP1 commenced work on the blind plug, the needle valve detached from the tree cap and was blown out by the pressure. IP1 was hit in the face, either by the needle valve or by a spanner. The incident is estimated to have taken place at about 07:30. At the time, IP2 stood beside the valve tree, an estimated 2 metres away from it.

The immediate pressure release when the needle valve detached created a loud explosion, knocking off IP1's helmet and hearing protection. As far as can be determined, IP1 remained conscious during the incident. IP1 descended from the valve tree unaided, in spite of the facial injury. He then ran southwards along the walkway calling for the senior technical manager. IP2 followed him. The technical manager also acted as Accident Scene Manager for this shift. At the same time the CCR realised from IP2's radio transmissions that an incident had occurred in connection with A-20. Based on this 07:34 the CCR decided to shut off the production wing valve (PWV), hydraulic master valve (HMV) and down-hole safety valve (DHSV). The technical manager, who was located on the basement deck (C41), heard the explosion through double hearing protection and left the process area to assess the situation and locate IP1. When the technical manager spotted IP1 he notified the CCR of the personal injury (DFU6), requested the deployment of an SAR helicopter and that the first aid team should report to the Living Quarters Level 1 (LQ1). The technical manager immediately attended to IP1, assisted by IP2.

A general muster alarm was activated at 07:37. Emergency response managers assembled in their meeting room at 07:40. No gas alarm was activated.

IP1, IP2 and the technical manager took the lift from C21 to M11 South, proceeding to LQ1 where they met the first aid team. IP1 was taken into the break room on LQ1 where first aid was commenced. The HSE Manager and nurse arrived shortly afterwards. Since the incident occurred just after shift change, there were a large number of people in the area around the break room on LQ1. The extent of injuries was assessed by the nurse on the spot before IP1 was moved up to the hospital for further examination. Based on this initial examination, the SAR helicopter was cancelled at 07:50.

In connection with the cancellation, emergency response managers downgraded the incident from an emergency situation. Prior to this decision, the Accident Scene Manager had initiated the securing of the area around the accident scene by Well A-20.

Once in the sick bay, the onshore duty doctor was consulted and further examination of the patient was carried out. It became clear that the extent of injury called for evacuation (yellow response) and an SAR helicopter was called out again. Its advised ETA was 08:48. The status with regard to the emergency situation was not changed as a result of the renewed SAR helicopter requisition. The crew were not required to muster again.

Since the gas alarms around the accident scene were not activated, the understanding was that any leakage was relatively limited. Since the nurse did not have a portable radio to hand, the Accident Scene Manager decided to remain in the break room, while IP2, who was familiar with the accident scene, was sent out, accompanied by a mechanic to secure the scene and check for gas leakage from the well.

They found IP1's helmet at the incident site, and pieces of the helmet scattered around the accident scene. At this time, the needle valve lay where IP2 had stood during the incident. They decided to leave everything where it was. Soon afterwards, two representatives from the drilling and well section (D&W) arrived in the area, accompanied by the Accident Scene Manager. The Accident Scene Manager gave instructions for the area around the well to be cordoned off. IP2, the mechanic and the Accident Scene Manager then went to the control room, while the two persons from D&W remained to cordon off the area around the well.

At 10:50, the sequence of events, as recalled by the personnel involved, was reviewed and documented. IP2, the technical manager, the CCR staff, the Platform Manager (PM) and the O&M Manager participated in the meeting.

Following the incident, clean-up work was implemented at and around the accident scene. The incident had resulted in a blood spill, which was washed away. All objects except for the spanners were left untouched at the scene until weather conditions dictated that they be collected and preserved. The spanners were placed in plastic bags and brought to the living quarters.

A gas cloud was observed above the tree cap of Well A-20 at around 09:00 and 11:45. The entire wellhead area and the mezzanine deck were cordoned off at around 11:45. After lunch at about 12:00, a new needle valve was installed in the tree cap. No gas was detected in the area by the gas detectors.

5 The potential effects of the incident

5.1 Actual consequences

5.1.1 Injury to personnel

IP1 was struck in the face, either by the needle valve or by a spanner. It has not been possible to reconstruct or otherwise conclude which of these items caused the injury.

If the needle valve struck IP1, the force caused by the pressure underneath would be equivalent to a mass of 256 kg. The released energy is estimated at 1260 Joules. The object appears to have grazed the face of IP1 from bottom to top, causing serious injury. The pressure wave contributed to the facial injury.

5.2 Potential consequences

5.2.1 Potential for loss of life

It has not been possible to ascertain which object struck IP1 in the face. The object probably grazed his face because he stood partially bent over the valve tree cap. If the object had struck differently, for example if IP1 had bent further forward, the incident could have led to loss of life.

The object could also have injured IP2 or other nearby personnel if they had been hit.

5.2.2 Explosive atmosphere

Following the incident, the PWV, HMV and DHSV were closed and the pressure in the valve tree was reduced to around 2 bar. The SV was already closed. The well was left without a plug in the tree cap until gas was observed above the valve tree just before lunchtime, when it was decided to install a new needle valve. No gas alarms were activated in the area, and it was not possible to estimate the gas concentration in the air above the valve tree. Neither of the decks above or below the mezzanine deck, where the valve tree was located, was cordoned off. It cannot be ruled out that a gas cloud formed in the area, nor that parts thereof were in an area exposed to explosion risk.

5.2.3 Health impacts of exposure to hydrocarbons

When the needle valve detached, IP1 was exposed to gas from the well. The immediate gas cloud amounted to a volume of about 640 litres. IP1 probably inhaled gas containing hazardous components immediately after the incident. The exposure is assumed to have been of limited duration. Earlier measurements at other wells have revealed high concentrations of benzene. Exposure to hydrocarbons, including benzene, as a result of such incidents may have negative health impacts. Benzene is classified as carcinogenic, and inhalation is associated with leukaemia and other types of cancer. The incident resulted in significant sudden exposure, but of short duration. The pressure is likely to have contributed to the intensity of the exposure.

Following the incident, the PWV, HMV and DHSV were closed and the pressure in the valve tree was reduced to around 2 bar. The SV was already closed. In interviews it was revealed that several observations indicated that gas had leaked out of the tree cap following the incident. After lunch it was decided to install a new needle valve in the valve tree.
It must therefore be assumed that personnel who inspected the cap of the valve tree without using respiratory protection between 07:34 and the time when the needle valve was installed may have been exposed to hydrocarbons, including benzene, emitted from the well.

5.2.4 Health impacts of noise exposure

IP1 and IP2 wore hearing protection but were exposed to a sound level that most probably exceeded the limiting values for acceptable impulse noise. The limiting value is 130 dB and exposure to sound intensity above this level can result in serious hearing damage, such as tinnitus. Havtil has made no assessment as to whether the incident has caused hearing damage.

5.2.5 Injuries resulting from falls

Falling from the valve tree could have resulted in further injuries to IP1.

5.2.6 Damage to other equipment

The needle valve represented a projectile that shot out of the valve tree at high velocity. The object could potentially have damaged other equipment.

5.3 Temporary impairment of barriers

In the period between the detachment of the needle valve at 07:30 and the shut-down of the PWV, HMV and DHSV at 07:34, the well barrier was temporarily impaired. In this period, only the SV stood between the well pressure and the atmosphere. This could have led to an escalation of the seriousness of the incident.

6 Emergency response and normalisation

The emergency measures assessed in this investigation include actions and conduct from the moment of the incident until the situation was normalised. The assessments apply to emergency response training, procedures and equipment, as well as assessments and actions carried out by emergency response managers.

The principal elements of emergency response management are described in Chapter 4.

The investigation has resulted in the following observations connected with emergency response management:

- An accident scene was not established immediately after the incident. This was partly because the Accident Scene Manager accompanied IP1 into the LQ and emergency response actions were called off before an accident scene was established.
- The SAR helicopter was cancelled before sufficient information had been obtained about the incident and extent of injury, and before the duty doctor had been consulted.
- OKEA was unable to provide documentation as to whether exposure to hydrocarbons was considered in connection with the incident.
- Emergency response actions were called off and personnel were requested to return to work before the situation had been clarified and before thorough assessment had been made of the residual potential of the incident.
- The procedure for the use of an emergency response whiteboard was not followed. The action board in the emergency response room and documentation of the times of actions carried out were inadequate. The board did not display important elements of the incident and very few actions were logged.
- Emergency response managers at Brage use a recognised model known as Proactive Contingency Management. This model entails that continuous response management is based on the worst imaginable outcome of

hazardous situations and accidents. Neither the potential for injury to IP1 and IP2 nor the potential for hydrocarbon leakage from the valve tree, which had now lost the last barrier element to the external environment, were clarified before the emergency situation was called off.
- Personnel were sent into the area to check for gas leaks without hydrocarbon measurements being carried out.
- Normalisation and debriefing after the incident were inadequate. Several people had been exposed to psychological and physical stress during the incident. Procedures, structure and training in connection with debriefing, as an element of normalisation work, were inadequate. This led to a situation where managers at different levels held meetings and conversations following the incident that weren't necessarily experienced or understood to be debriefing.
- Emergency response training for several of the personnel involved was carried out in overtime, at 20:00 on the evening of the incident.

7 Direct and underlying causes

7.1 Direct causes

7.1.1 Corrosion

DNV carried out material examinations of two needle valves from two wells (A-20 and A-38) at Brage.

The report from the investigations identifies two possible corrosion mechanisms. One is galvanic corrosion at the contact between stainless material and carbon steel. The other mechanism is CO_2 corrosion on the end surface of the threaded part of the intake side of the needle valve, resulting from possible contact with hydrocarbons, water, CO_2 and H_2S.

DNV concludes that CO_2 corrosion is the most likely and dominant mechanism in this case. This would seem probable in view of the data provided regarding operational conditions and the composition of the fluid in Well A-20. Corrosion research literature also supports this hypothesis. The temperature to which the threaded section has been subjected lies between 20 and 70 °C, at which one would expect relatively high rates of corrosion, cf. (DNV AS Energy Systems, 2024), (Shengxi & Et al., 2019), (Jones, 1992), (Vuppu & Jepsen, 1994).

DNV considers galvanic corrosion to be a less pervasive and non-dominant corrosion mechanism. This is supported by the fact that the threaded section of the needle valve from well A-38, which has been screwed into the stainless steel transition piece, is not significantly corroded. Chemical scale has also been observed in the internal thread of the stainless steel transition piece. Qualitative analysis of the scale shows high values of fluorine and carbon that indicate residues of thread tape. The presence of thread tape may have contributed to preventing galvanic coupling between the stainless steel transition piece and the needle valve. Galvanic coupling is necessary for galvanic corrosion to take place. At the same time, galvanic coupling may have been present through the water phase in contact with material in the needle valve and the stainless steel transition piece. However, in this case the corrosion would have been more localised around the threaded section itself, and not evenly distributed on the end surface of the intake.

7.1.2 Triggering cause

Large parts of the threaded section of the needle valve were corroded away. The examinations, both visual and technical, indicate that only one or two turns of thread were holding the needle valve in the tree cap. In time these thread turns would also have been corroded away and it was therefore only a matter of time before the needle valve would have detached as a result of the pressure beneath it or other forces.

The incident was triggered by work activity that subjected the needle valve to sufficient force to detach it.

7.2 Underlying causes

The investigation has revealed a number of underlying causes and performance-influencing factors that contributed to the incident. In general, inadequate management of risk, maintenance, personnel skills and the lack of procedures and work description must be said to be the main elements of the underlying causes which we will review in this chapter.

7.2.1 Modifications of the valve tree in conflict with industry standards

The valve tree on Well A-20 was supplied by FMC in 1998 and is of vertical type. The valve which detached was a needle valve, type Kerotest, made of carbon steel, see Figure 1. The downstream end of the needle valve was sealed with a stainless steel blind plug. The valve tree in which the needle valve was fitted was made of 13Cr chrome steel. This is in conflict both with NORSOK standard M-001 and with good design practice.

Documentation and interviews revealed that the when the valve tree was supplied by FMC in 1998 it was fitted with a bleed plug in its tree cap and that the needle valve actually fitted at the time of the incident was not original, nor part of FMC's delivery to the operator at the time (Norsk Hydro). Norsk Hydro operated the facility from 1993 to 2007, Statoil from 2007 to 2013 and Wintershall Dea from 2013 to 2022. OKEA has been the operator since 2022.

It has not been possible to ascertain when the needle valve was fitted to the valve tree on Well A-20, what assessments were carried out at the time, or which company or division installed it. Interviews have revealed that it was used by D&W in connection with well interventions. Before dismantling the tree cap and entering the well with, for example, wireline intervention equipment, the pressure under the cap must be relieved. Depressurisation using the original bleed plug in the tree cap would require equipment designed for this specific purpose. The question therefore arises whether the needle valve may have been fitted in connection with well intervention operations when this special equipment was not available.

The investigation team has not looked into the reasons for the possible lack of special equipment.

7.2.2 Inadequate maintenance and overview of technical condition

The needle valve was subject to extensive corrosion, both internally and externally. It was made of carbon steel and fitted in the tree cap, which was made of 13Cr chrome steel. In contact with corrosive well fluids it would have been subject to corrosion, cf. 7.1.1.

Technical examination of the needle valve housing revealed that the intake section was shortened. The end surface of the shortened threaded section showed signs of corrosion in the form of rust and pitting.

The investigation revealed that no personnel or technical group considered these needle valves to be included in their area of responsibility. Nor were they included in a maintenance programme or subject to assessment of technical condition. The contractor that carried out surface inspections at the platform had observed several rusty needle valves. Their condition was associated (by visual inspection) with galvanic corrosion with low potential risk and not considered critical. OKEA had been informed by e-mail of the observations in general terms (not associated with specific wells). This was not followed up by preventive or corrective actions as part of the maintenance programme.

Surface inspection would not have revealed internal corrosion, either of the needle valve housing or of the valve's internal spindle (see Chapter 2.2), but if these valves had been included in a technical condition monitoring programme, the external deterioration would probably have prompted further examination.

Following the incident, OKEA carried out a survey on board the Brage facility which revealed that several non-original needle valves of various types were fitted to valve trees.

7.2.3 Work on a pressurised system

During interviews, various methods of depressurisation of gas through the SV were described.
There was no common understanding among the different shifts of the procedure for bleeding off the pressure above the SV.

In this specific case it was decided to bleed off the pressure using the needle valve fitted to the top of the valve tree. In order to connect a hose to a closed disposal system, the blind plug on top of the needle valve had to be removed. To prevent loosening the needle valve, its housing had to be held with a fixed or adjustable spanner while the plug was screwed out with a second spanner.

A manometer showed a gas pressure of 80 bar above the SV at the time of the incident. The enclosed volume between the needle valve and the blind plug is very small and could not be measured. At the time of carrying out the work there was no documentation to indicate that the needle valve was sealed. Hence it was impossible to know with certainty whether one was working with a small, depressurised volume (between the needle valve and the blind plug), or with a larger, pressurised volume (the volume under the tree cap, 8 litres).

According to OKEA's management system, no work permit (WP) is necessary for routine work covered by procedures.
However, no procedure was in place for depressurisation in preparation for valve tests. The procedure in use dealt with valve testing, focusing on test criteria and acceptance criteria. This procedure was based on the differential pressure across the valves but did not address depressurisation to achieve the required differential pressure. It was left to each individual process technician to select a method.

Since no procedure was in place, the work should have been subject to a work permit.

Havtil identified conflicts between different requirements in OKEA's management system. This may have contributed to misinterpretations and misunderstandings related to criteria for the use of a work permit.

7.2.4 Risk assessments and organisation of work

As mentioned in Section 7.2.3, the process operators used different methods for depressurising the volume above the SV. OKEA had not carried out an assessment of the various methods or of the risks involved in each. No assessments had been carried out of the ergonomic conditions linked to this operation. In other words, there was no evaluation of how the operation should be organised to ensure the ergonomic safety of the process operators. The method chosen entailed, for example, climbing on the master valve, involving a risk of falling. The work also had to be carried out in a difficult working position (see Chapter 4). The method entailed the process operator positioning himself partly "in the line of fire" above a pressurised system. To reach the top of the master valve and maintain his balance while working, he had to step on the HMV actuator. It can also reasonably be assumed that in the event of a fall, damage could also occur to the instrumentation connected with the actuator.

In the course of interviews, it became evident that there was no common understanding in the company as to whether the method was fit for purpose. It must nevertheless be pointed out that several people shared the opinion that there were several alternative methods that could have been used. The choice of method was based on the individual shift and the personal experience of the process operators. No common training or verification had been established for the various methods, but it was felt that this was one of the skills that a process operator should have. OKEA had no documentation of which method was used in connection with different valve tests, nor of the reasons for choosing a method.

An underlying factor was that the company had made no provision for carrying out the work in such a way as to reduce the risk of injury and errors.
The company had not prepared job instructions or procedures based on studies and risk assessments for the implementation of the assignment which could facilitate the selection of the least risk-prone work method.

7.2.5 Roles and responsibilities

In 2023, OKEA carried out an internal audit of maintenance and barrier management. This recognised that responsibility and authority were not always unambiguously defined and co-ordinated. The recommendation was as a minimum to update job descriptions for all employees responsible for safety-critical equipment and activities. Our records show that the work commenced in November 2023, but that the activity had not been completed at the time of the incident. During the investigation it became obvious that ambiguities still existed regarding roles and responsibilities. For example, nobody at OKEA considered the needle valves to be included in their area of responsibility.

7.2.6 Inadequate implementation of verification activities

The investigation showed the following shortcomings, among others:

- It had not been verified adequately that operative personnel were working according to governance documents. Senior personnel aboard the platform were thus not aware that there was no procedure for depressurisation in place.

- The PIV (Platform Internal Verification) programme was not implemented according to plan. This is a process whereby operational management shall ensure that governing requirements are adhered to.
    - There had been no nonconformity handling of inadequate implementation.
    - The results of completed verifications were not documented.
- It had not been satisfactorily verified that roles and responsibility in the onshore organisation were understood and unambiguously defined. Uncertainty regarding roles and responsibility was also evident from interviews.
- Five of twelve First Line of Defence (LOD1) items for 2023 had been postponed or cancelled.
- No Third Line of Defence (LOD3) Independent Corporate audits were planned for 2023.

7.2.7 Location of gas detectors

No gas detectors were activated either during the actual incident or subsequently, before the new needle valve was fitted. During the actual incident, approximately 0.6 Sm^3 of gas was emitted. Gas was also observed in the area above the well in the period until the new needle valve was fitted at about 11:45.

The relevant detectors in the area around Well A-20 were C4203203 (a line gas detector) and C420227 (a point detector).

Following a review of documents received it appears that no update or modification of the gas detection strategy had been carried out for some considerable time. The received documentation of performance requirements dates to 1995. Since then, the gas/oil ratio in the well has changed (more gas), the number of wells has changed and the amount of equipment in the area has increased. It is not clear that any gas detectors would have registered a leak resulting from the missing needle valve.

Several of the decisions made subsequent to the incident were probably prompted by the lack of alarms in the area. Reliance on the gas alarms may have influenced the situation awareness of personnel and hence hampered assessments of leak escalation. For example, the emergency situation was called off after the incident because the incident was interpreted merely as a personal injury and was therefore deemed to be under control. The risk of major leakage from the well was considered to be absent, even though gas was observed above the valve tree.
Reliance on gas alarms may have influenced assessments related to whether personnel were or could have been exposed to hydrocarbons, and subsequent assessments of the potential impact of the incident.

The gas detector system is an important safety system and correct detector location is crucial to receiving alarms when needed. Even though the gas concentration is under the alarm threshold, the presence of gas may constitute a health risk.

7.2.8 The transition from Wintershall Dea to OKEA

The incident occurred about one year after OKEA had acquired Brage from Wintershall Dea.
At the time of transfer of Brage, verifications were carried out of the correspondence between documentation and the installation. These could have revealed the above-mentioned shortcomings at the facility.

7.2.9 Observations related to procedures and processes

The investigation revealed several circumstances connected with a lack of governance documents, compliance with existing documentation and understanding thereof.

The circumstances described in the following chapters highlight the impression of shortcomings connected with the management of conditions affecting health, the environment and safety at the facility.

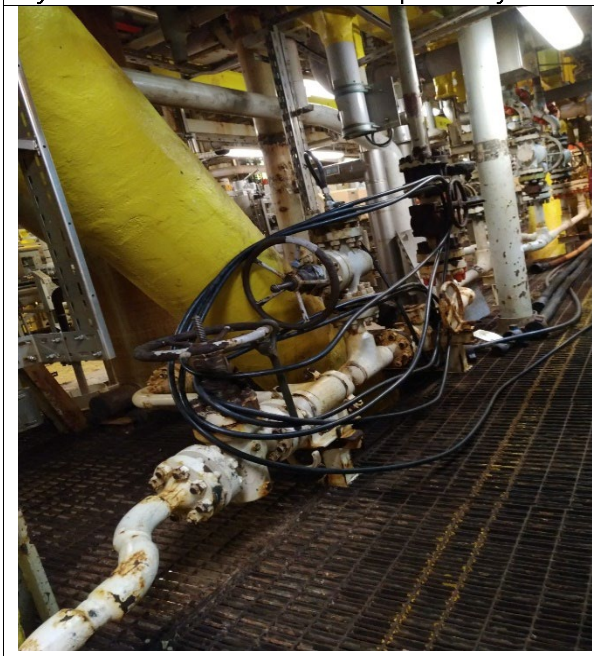
All documentation forming the basis of the investigation is listed in Attachment A.

Valve status of wells when shut down over a long period or for maintenance

When Brage is producing gas at close to maximum capacity, all the wells cannot produce simultaneously. Oil production is optimised on the basis of the available gas export capacity. Well A-20 had been shut down at the production throttle valve for several weeks at the time of the incident. With the permitted leak rates at the SV, this entailed that full well pressure was present between the SV and the needle valve. The needle valve was not identified, tested or subject to a maintenance programme. This meant that only one untested valve was in place, under well pressure. OKEA was unable to provide procedures or checklists for testing, shutdown and start-up of the well, or criteria for which valves should be closed during long-term shutdown.

Hoses and certification

The plan for depressurisation was to use a hose connected to a closed disposal system or a DB&B (double block and bleed) cart, with the bleed being directed to a safe area.

Showing the hose used to bleed hydrocarbons to closed disposal system.	Showing the DB&B cart for depressurisation to safe area.
 *Figure 7 Hose to closed disposal system*	 *Figure 8 DB&B cart*

There was no history for the hose connected to a closed disposal system. OKEA could not document when it was brought into use or by which unit. It had apparently been in use and connected as in the photograph for several years. The hose was of unknown type and was not certified or approved for use.

The same applies to the DB&B cart. It was not certified in accordance with OKEA's governance documents either.

OKEA had no governance documents or requirements associated with how or in which situations the method using the hose to a safe area, or the DB&B cart were to be used. At the same time, none of the hoses was approved for use according to OKEA's governance documents.

The investigation revealed a number of breaches of governing requirements associated with the use and maintenance of hoses. This is not discussed further in this report, since the circumstances are not directly relevant to the incident under investigation. However, the circumstances do substantiate shortcomings connected to the management of conditions affecting health, the environment and safety at the facility.

Shortcomings and faults in work orders

During the investigation, reference was made to a procedure for implementation of valve testing. This procedure was entitled '*Arbeidsbeskrivelse: Integritetstesting av brønnventiler*' (Work description: Integrity testing of well valves) – *OKEA-BRA.MNT.WIN-0294* and explained what should be achieved (a functional procedure) and not how the task was to be carried out. Comparison of the procedure with the work order prepared for valve testing revealed that there was little terminological correspondence. The terminology, references and abbreviations used in the work order to describe the various valves in the valve tree did not agree with the corresponding terminology in the valve testing procedure. This circumstance invites misunderstandings and errors.

8 Observations

In general, Havtil's observations fall into two categories:

Nonconformities: Observations whereby we demonstrate *breaches* of, or failure to comply with, regulations.

Item for improvement: Observations whereby we *believe we see* breaches of, or failure to comply with, regulations, but have insufficient information to be able to prove that they exist.

9 Nonconformities

9.1 Lack of verifications to demonstrate compliance with the HSE regulations

Nonconformity
OKEA had not adequately followed up elements of its own management system connected with verifications.

Argument
During the investigation it was revealed that OKEA had not adequately carried out evaluations that could have verified compliance with internal requirements, which had been implemented in order to comply with HSE regulations.

During interviews and document reviews the following shortcomings became evident:

- The PIV programme was not implemented according to plan. This is a process whereby operational management shall ensure that governing requirements are adhered to.
  - There had been no nonconformity handling of inadequate implementation.

    - The results of completed verifications were not documented.
- The only verification carried out that dealt with roles and responsibilities was '*Brage-AUD-23-0009101 – vedlikehold og barrierestyring*' (maintenance and barrier management). Its findings include shortcomings in the management of health, safety and environmental issues associated with roles, responsibility and job descriptions. This was carried out as a "2nd line of defence" (LOD2) verification. Uncertainty regarding roles and responsibility was also evident from several interviews.
- Five of twelve first-line verifications planned for 2023 were postponed or cancelled.

Requirements:
Section 21 of the Management Regulations relating to follow-up activities

9.2 Inadequate maintenance and overview of technical integrity

Nonconformity
Checks had not been carried out to ensure that needle valves in the tops of valve trees at Brage were being maintained so as to be capable of performing the functions required of them.

Argument
The needle valve in the tree cap of the valve tree was severely corroded (see Figure 1).

The needle valve was made of carbon steel. It was fitted into a termination made of 13Cr quality metal and had a blind plug of stainless steel fitted at the top (see Figure 1). Under the prevailing conditions, both internal and external parts of the needle valve were subject to corrosion. Examination of the needle valve housing showed that the end surface of the threaded section was subject to CO_2 corrosion. Approximately 8 mm of the threaded section was missing, and this was a decisive factor in the incident.

The practice of retrofitting with such needle valves was widespread, and several of the valve trees at Brage had similar valves fitted to their tree caps. Several of these had been subject to corrosion of the same type as the valve at Well A-20.

It is unclear whether the units in OKEA's organisation responsible for maintenance and technical integrity or the company holding the inspection contract for Brage were aware that needle valves were fitted to the tops of the valve trees. These needle valves were drawn neither in the piping and instrumentation diagram (P&ID) nor in the schematic diagrams of the valve trees. The needle valves were easily visible from floor level. "Tree caps with depressurisation valves" represented a separate item in the inspection checklist. Review of inspection logs shows that conflicting information was provided about the state of the valve tree following inspection. Whilst it was noted on the visual inspection form that the condition of the tree cap and bolts was "OK", it is clear from other electronic communications that the use of a combination of materials had been recognised and that corrosion had been identified at several of the Brage valve trees. However, these discoveries were not followed up in the form of work orders for corrective maintenance.

The needle valves were not included in the preventive maintenance programme nor part of the monitoring of technical integrity by onshore technical managers. The needle valve on the tree cap represented the final barrier against the external environment. Valves in valve trees in contact with the external environment shall exhibit zero leak rate (NORSOK D-010 Annex C, Table 33). To verify that a valve is leak-proof, it must be subject to a maintenance and verification process.

Requirements:
Section 45 of the Activities Regulations relating to maintenance
Section 12 of the Facilities Regulations relating to materials
Section 46 of the Activities Regulations relating to classification

9.3 Roles and responsibilities

Nonconformity
Roles and responsibilities were not adequately defined and understood by management and operational personnel with responsibility for the technical integrity of the valve tree.

Argument

- In 2023, OKEA carried out an internal audit of maintenance and barrier management in which shortcomings with respect to responsibility and authority were identified. This activity had not been completed at the time of the incident.
- The investigation revealed that no personnel or technical group considered the needle valves to be in their area of responsibility.
- Interviews indicated that there were differences in understanding of who was responsible for monitoring and maintaining the valve tree.
- There was no adequate specification of who was responsible for ensuring that there was an operational procedure for testing the valve tree. During interviews, offshore personnel referred to the procedure established by the onshore organisation. Personnel from the onshore organisation asserted that Operations was responsible for preparing the operational procedure (Section

Requirements
Section 6 subsection 2 of the Management Regulations relating to the management of health, safety and the environment

9.4 Inadequate procedures

Nonconformity
OKEA had not ensured that work procedures for depressurisation were formulated in such a way as to satisfy the intended functions.

Argument
The choice of depressurisation method entailed working on a potentially pressurised enclosure on top of the tree cap. According to OKEA's own requirements, this work should have been the subject of a separate procedure. The procedure in use dealt with valve testing, focusing on test criteria and acceptance criteria. This procedure was based on the differential pressure across the valves but did not address depressurisation to achieve the required differential pressure. This demonstrates that the procedure used was not appropriate for this type of work. For details, see Chapter 7.2.3.

Requirements
Section 24 of the Activities Regulations relating to procedures

9.5 Organisation of work

Nonconformity
OKEA had not ensured that work on the needle valve was organised in such a way that individual employees were not exposed to injury and unfortunate physical and psychological impacts, or in such a way as to reduce the potential for errors that could result in hazardous incidents or accidents.

Argument

- Interviews and the document review revealed that the work operation had not been assessed with regard to access, physical or chemical risk, ergonomic impacts, risk of falling or the risks inherent in work on a pressurised system.
- Risk factors relevant to the choice of how to carry out the assignment had not been identified.
- Inadequate risk assessment of the working environment entailed that OKEA had insufficient information to be able to formulate work instructions or a procedure.
- Inadequate consideration and risk assessment of the assignment must be said to have contributed to the lack of common understanding among individual

employees and shifts of how the work assignment should be carried out so as to involve the lowest possible risk.

The company had not prepared job instructions or procedures based on studies and risk assessments for the implementation of the assignment which could facilitate the selection of the least risk-prone work method.

Requirements
Section 33 of the Activities Regulations relating to the organisation of work

9.6 Inadequate emergency response management training and drills

Nonconformity
OKEA had not ensured that the necessary training and drills had been arranged for the management of risk and accident situations.

Argument
The investigation and document review revealed several shortcomings;

- The emergency response organisation had not trained or carried out drills in normalisation following an incident.
- The process of self-reporting of skills and verification of supervisors had not been followed up.
- Mustering did not take place according to the alarm instructions

Requirements
Section 23 of the Activities Regulations relating to training and drills
Section 77 of the Activities Regulations relating to handling hazard and accident situations, cf. item d)

9.7 Management of hazardous situations and accidents

Nonconformity
OKEA had not ensured that the necessary actions were initiated as quickly as possible in connection with the incident.

Argument

- The SAR helicopter was cancelled too early in the course of the emergency.
- The procedure for the use of an emergency response whiteboard was not followed.
- Since the nurse did not have a radio, he was not informed of the chain of events when he met IP1 on Level 1 of the LQ. The nurse was therefore not pre-informed about the cause of injury and the level of energy involved.
- Neither the potential for injury to IP1 and IP2 nor the potential for hydrocarbon leakage from the valve tree, which had now lost the last barrier element to the

external environment, were clarified before the emergency situation was called off. The cause of injury was not investigated so as to correctly evaluate the level of energy involved.
- Emergency response actions were called off and personnel were requested to return to work before the situation had been clarified and before a thorough assessment had been made of the residual potential of the incident.
- The emergency response plan contained a checklist for normalisation following an incident. This was not used by the emergency response organisation. Normalisation and debriefing after the incident were inadequate, poorly organised and unsatisfactory for several of the personnel directly involved, see Chapter 6.
- Action item No. 5 in the checklist for normalisation, which describes preparation before entering an exposed area, was not followed.

Requirements
Section 77, items d) and e) of the Activities Regulations relating to the handling of hazard and accident situations
Section 80 of the Activities Regulations relating to communications

10 Item for improvement

10.1 Recording of exposure to hydrocarbons.

It appears that OKEA did not adequately ensure the recording of employees who were exposed to carcinogenic or mutagenic chemicals.

Argument

Although OKEA's own guidelines stipulated requirements for the registration of employees who, as a result of accidents, unusual work operations, etc. had been exposed to carcinogenic chemicals such as benzene, the incident was not recorded. The response from the company was that their computations, given a conservative period of exposure of five minutes, indicated that it was unlikely that exposure had exceeded the limiting value (occupational hygiene limiting value for a 12-hour shift) and that for this reason, it was not mandatory to record the incident according to OKEA requirements.

Havtil's view is that OKEA's threshold for entering a record in the exposure register appears to be quite high.

In fact, the incident resulted in serious levels of exposure. Havtil's assessment is based on the highest levels stated in lists received in connection with this investigation.

Havtil has applied a rule of thumb for short-term limiting values as set out in the guidelines issued by the Norwegian Labour Inspection Authority which accompany the statutory regulations governing limiting and action values. Use of this rule of thumb, we calculate a short-term (15-minute) limiting value of 0.6 ppm for benzene.

These calculations, assuming an exposure time that is only half that of OKEA's five-minute estimate, and that the remainder of the 15-minute period involved no exposure, indicate an average level of exposure for the IP in question in excess of 1 ppm, which is significantly higher than the aforementioned short-term limiting value for benzene.

Requirements
Section 31, subsection 1, of the regulation relating to the registration of employees exposed to carcinogenic or mutagenic chemicals and lead.

11 Barriers that functioned

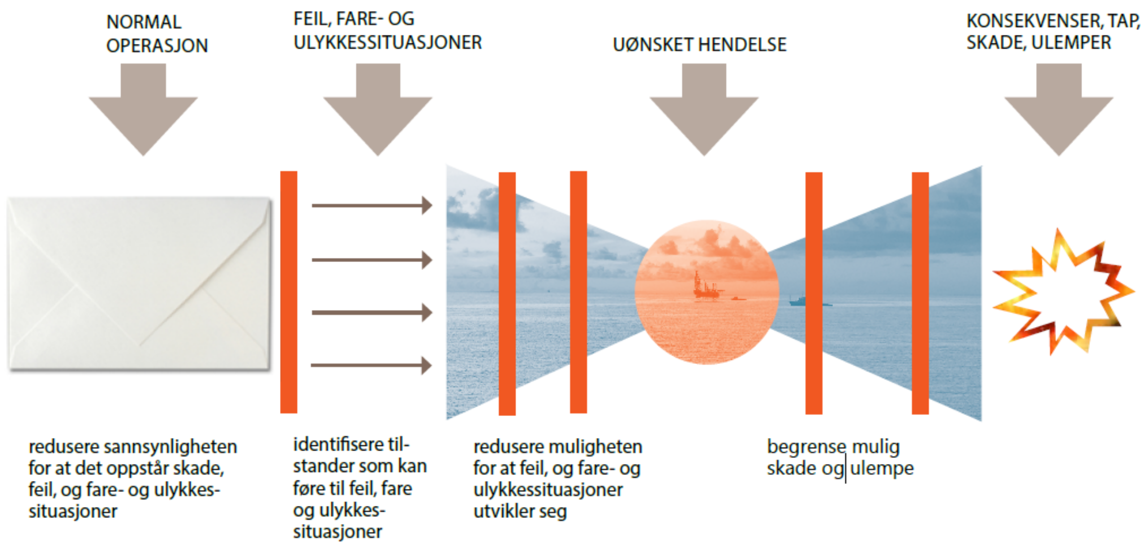


Figure 9 Traditional barrier diagram – from the PSA's barrier memorandum 2017.

In connection with this incident there were breaches of several of the barriers on the left-hand side of the bow-tie diagram. On the right-hand side of the diagram, the following barrier elements functioned:

- The CCR understood the radio communications and followed up by immediately shutting down barrier valves at Well A-20.
- The CCR understood the radio notification and initiated a general alarm (GA) which mobilised the emergency response managers.
- The emergency response team and first-aid personnel mustered according to instructions and performance requirements.

- Communications with the SAR organisation followed the protocol.
- The SAR emergency response apparatus functioned and brought IP1 ashore for medical attention.

12 Discussion of uncertainties

12.1 Lacking and inadequate information provided by OKEA

An investigation requires a lot of information, and we did not obtain all that we requested. Some documents were scanned paper copies of poor quality. There was a lack of consistency between what the documents should contain and their actual content. Obtaining information from the operator was time-consuming.

12.2 Instrumentation and configuration of the valve tree

There was uncertainty regarding the instrumentation and configuration of the original valve tree, and about which company or division was responsible for the work at any time. In our opinion this is not significant to the lessons learned from this incident or the conclusion of this report.

12.3 The time of installation of the Kerotest needle valve

The Brage platform has changed ownership several times since its deployment. It was constructed by Norsk Hydro, which merged with Statoil (subsequently becoming StatoilHydro). The Brage field was then sold to Wintershall (subsequently Wintershall Dea) which in turn sold it to OKEA. The time of installation of the needle valve in question is uncertain.

12.4 Corrosion process

Materials investigations indicate that corrosion has always been present in the lower part of the threaded section of the needle valve. There is no evidence of widespread corrosion on the valve's other internal surfaces. A possible explanation is that moisture accumulates at the end surface because of the geometric design and orientation of the valve. Water droplets remain suspended in the lower part and CO_2 dissolved in the water leads to corrosion.

DNV's technical report bases its assessment on the needle valve having been fitted in 1998. As a result of uncertainty as to when it was fitted (see Chapter 11.3), the rate of corrosion may be far higher than is indicated in DNV's report. An awareness of this possibility is an important lesson to be learnt in order to avoid similar incidents in future.

12.5 The object that caused IP1's injury

It is uncertain whether it was the needle valve that struck IP1 in the face or one of the spanners he was using to do the job. Based on the injury, position and circumstances it is highly probable that it was the needle valve, and this is the conclusion of this report. In the opinion of the investigation team this has no significance for the findings, processing or assessments in this report.

12.6 Mustering and POB

It was stated that the POB form was made ready at 07:50, simultaneously with the cancellation of the SAR helicopter. Information that emerged during interviews indicates that personnel who were not part of the emergency response team were in LQ1 at this time to assist with the response effort. A certain amount of uncertainty therefore surrounds the time at which the POB was made ready.

12.7 Objects at the scene of the incident

When the investigation team arrived at the platform, the scene of the incident was cordoned off, but had been tidied up. Because of bad weather (strong winds) the operator had removed the spanners, needle valve and the remains of the damaged helmet. There is uncertainty associated with the exact location of the objects, and also with details of the chain of events. In our opinion this does not affect the findings in this report.

13 Assessment of the operator’s investigation report

It was not part of the team's mandate to assess OKEA's investigation report. OKEA conducted an investigation of the incident in accordance with its internal governance requirements. The results of the OKEA investigation were documented in the form of a PowerPoint presentation. Havtil has not carried out a subsequent assessment of this documentation.

Havtil talked to OKEA's investigation team prior to departure offshore.

14 Other remarks

14.1 The Pressure Equipment Directive (PED)

According to Section 3 of EU Directive 2014/68/EU relating to pressure equipment, the Directive does not apply to valve trees on hydrocarbon production wells.

15 References

DNV AS Energy Systems. (2024). *Skadeanalyse Trykkavlastningsventil Brage ventiltre A-20, Rev. Draft A.* DNV.

Endsley, M. R. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors Journal*.

Hendrick, K., & Benner, L. (1986). *Investigating accidents with STEP (Vol. 13).*

Jones, D. A. (1992). *Principles and prevention of corrosion.* Macmillan Publishing Company.

Shengxi, L., & Et al. (2019). *CO2 Corrosion of Low Carbon Steel Under the Joint Effect of Time-Temperature-Salt Concentration.* Frontiers in Materials.

Vuppu, A., & Jepsen, W. (1994). *The effect of Temperature in Sweet Corrsion of Horizontal Multiphase Carbon Steel Pipelines.* SPE.

16 List of figures

17 Attachments:

17.1 Documents forming part of the investigation

Title of document	Explanation
Brage ATer 20-22 november 2023.pdf	Overview of work permits
12 + 27. Beredskapsplan Brage.pdf	
14 dagers arbeidsplan.pdf	
Områdetegning 30-1A-KE-P16-00005.pdf	
Områdetegning 30-1A-KE-P16-00004_09_L_2023-06-20_01 (1).pdf	
23 05 11 Ptil tilsyn OKEA overtakelse av Brage - Oppsummert presentasjonsmateriale fra OKEA.pdf	
Sjekkliste A-20.pdf	Visual Inspection report
Utføre arbeid i høyden (1107).pdf	Governing documents
Plattforminterne verifikasjoner (PIV).pdf	
Bilder topp brønner.pdf	

Slanger og Kuplinger.pdf	Governing documents
Arbeidsordre 501314 slanger sykloner fra intervju.pdf	
Forbrukskontroll og koble til slange med kuplinger.pdf	Governing documents
Fremskaffe slange og kuplinger.pdf	Governing documents
Følge opp slange i midlertidig bruk.pdf	Governing documents
Koble fra og håndtere slange med koblinger etter bruk.pdf	Governing documents
Utføre periodisk kontroll av slange.pdf	Governing documents
Hand over well to Drilling or Well interventions (813).pdf	
Handover well to Operations.pdf	
Bilder A30 A38.pdf (Photographs, A-30, A-38)	
Hoke-Plug-Valves-7400-Series.pdf	Valve data sheet
Brage medarbeiderundersøkelse tilbakemelding Rapport_2023.pdf	
Brage_english_benchmar_41795_d4zt.pdf	Work Environment Survey 2017
Brage .pdf	General Information about Brage
Gassdetektorer 21.11.pdf	Gas detector indications
Granskingsrapport Gassutslipp (gasslekkasje fra spilloljetank) .pdf	
Samtlige skjema 2017-2023.pdf	Visual Inspection report
2377_001.pdf	Inspection form, Well A-20
2019_196_rapport-OKEA-vedlikeholdsstyring-draugen.pdf	PSA audit report
2023 Storulykketilsyn rev. 1 av 081123.pdf	Information from ongoing audits at Brage
Arbeide på instrumentrør fittings ventil-blokker og andre sammenkoblinger (1406).pdf	Governing documents
Arbeidsordre.pdf	Work order for implementing valve tests
Audit Brage-AUD-23-0009101.pdf	
Audit Brage-AUD-23-0009176.pdf	
B30_1555033.pdf	Schematic diagram of Brage wellhead
Beredskapsanalyse Brage.pdf	
Brenngass systemet.pdf	
Datablad på en ventil.pdf	
Deltagerliste åpning og avslutning.pdf	
Dieselsystemet.pdf	
DNV Rapport No 2023-5441 Skadeanalyse trykkavlastingsventil Brage A-20 RevA.pdf	Draft rapport
Fagansvarlig Prosess.pdf	
Fakkel vent og trykkavlastning.pdf	
Ferskvannsystemet.pdf	
Gasskompresjon tørking og eksport.pdf	
Generelt om brønner.pdf	
Gjennomgang av hendelse (1).pdf	
Glykol regenerering.pdf	
Handover mellom boring og drift 68. 2377_001.pdf	

Instrument fire and gas layout MSF C04 Level 1 North - 30-1A-KE-I52-00007.PDF	
Instrument fire and gas layout MSF C04 Level 1 South - 30-1A-KE-I52-00008.PDF	
Instrument fire and gas layout MSF C04 Level 2 North - 30-1A-KE-I52-00017.PDF	
Instrument fire and gas layout MSF C04 Level 2 South - 30-1A-KE-I52-00018.PDF	
Introduksjon Brage drift.pdf	
Kjemikaliesystemet klorering og metanol.pdf	
Normalt trykksatte systemutstyr (170).pdf	
Opplæring M10.pdf	
Opplæring MSF.pdf	
Opplæring SKR.pdf	
Oseberg SAR.jpg	Log from Oseberg SAR
Performance Standard no 3 Gas Detection.pdf	
PIV13 Inspection Brage-INS-23-0004848 .pdf	
Plattformstruktur utstyrsplassering.pdf	
Prosesstekniker.pdf	Training overview
Prosjektkoding.pdf	
Seperasjon og råoljestabilisering.pdf	
Sjøvannsystemet.pdf	
System for behandling av oljeholdig vann.pdf	
PXL_20231126_054644757.jpg	
Test M10 ute.pdf	
Test of Safety Critical Elements (SCE) (9836) - Brage.pdf	
Test SKR.pdf	Work descriptions, operation, Brage – theory questions
Trykkluftsystemet.pdf	
Utarbeide isoleringsplan (8859).pdf	
Utstyrsplassering.pdf	
Vanninjeksjon.pdf	
Åpent avløp.pdf	
Hydraulisk master og vingventil på brønn A-20.eml	Valve positions on the well
SV Informasjon om risikovurdering og målinger av eksponering.eml	
TAMPEN SAR.jpg	Log from Tampen SAR emergency response team
23. 24. Handover rapport Mikon 19112023 til 22112023.xls	
Utført Forebyggende vedlikehold Brønn A-20.xlsx	
Test_results from SAP_A-20.xlsx	
Rapportering av Svikt eller Feil Brønn A-20.xlsx	
Korrektive Arbeidsordre A-20.xlsx	Summary
M3 Activity Report brønn A-20.xlsx	
Endringsmeldinger Brønn A-20.xlsx	
FV-program og genererte åpne ordre Brønn A-20.xlsx	

WH_XT_oversikt.xlsx	
Brage_akseptkriterier.xlsx	Valve test requirements
14. 14. A-20 kjemikaliebruk.xlsx	
25. 2023 23 11 timerapport - tilsyn - driftspersonell.xlsx	
26 Oversikt faste møter Brage.xlsx	
37. Situasjonstavle 2.linje Brage hendelse.xlsx	
55. Logg egentrening 2023 fra DaWinci.xlsx	
2023 12 eksempel på Prosess-krav.xlsx	
2023 12 Kompetansestatus prosess.xlsx	
Annual Audit Plan 2023_ Brage.xlsx	
Brage_akseptkriterier_BRA_MNT_WIN_0498.xlsx	Valve test requirements
Kopi av Isoleringsplan - forenklet klargjøring.xlsx	
Hendelse Brage 21 november Beredskapstavler.pptx	
Gjennomgang av hendelse (1).pptx	
Forberede SJA.docx	
Forhåndsgodkjenne arbeidstillatelse (AT) (383).docx	
Følge opp arbeid og avslutte arbeidstillatelse (AT) (798).docx	
Gjennomføre SJA-møte.docx	
Gjennomføre SJA-tiltak ved utførelse av arbeid (1096).docx	
Arbeidsbeskrivelse - Integritetstesting av brønnventiler.docx	
Arbeidsdokument Brage granskning personskade.docx	
Tilsynsrapport - OKEA Brage overtakelse(1) (002).docx	PSA audit report
SV_ Informasjon.msg	
SV_ Dokumenter ifm. med gransking.msg	
vurdering.PNG	E-mail regarding assessment of valve on tree cap
A20 SAS HMI.PNG	Alarm overview for A-20
Intervjuer offshore.png	
Ventiltest_12mai_2023.pdf	
Ventiltest_29sept_2022.pdf	
DEV-21-0049_CtilD.pdf	Nonconformity report for A-20 annular space
02.NCR-23-0031857_kntrlASV.pdf	NCR report, A-20
Arbeidsordreplan for drift 08.11.23 - 21.11.23.pdf	
Performance standards 10 Passive Fire Protection.pdf	
Performance Standard no. 10 Passive Fire Protection.pdf	
Audit Brage-AUD-23-0009176	
DNV Rapport No 2023-5441 Rev0	Final version of materials report
Utrekk målinger fra C41, C42, MSF	

17.2 List of interviewed personnel and meeting participants

The information is confidential.

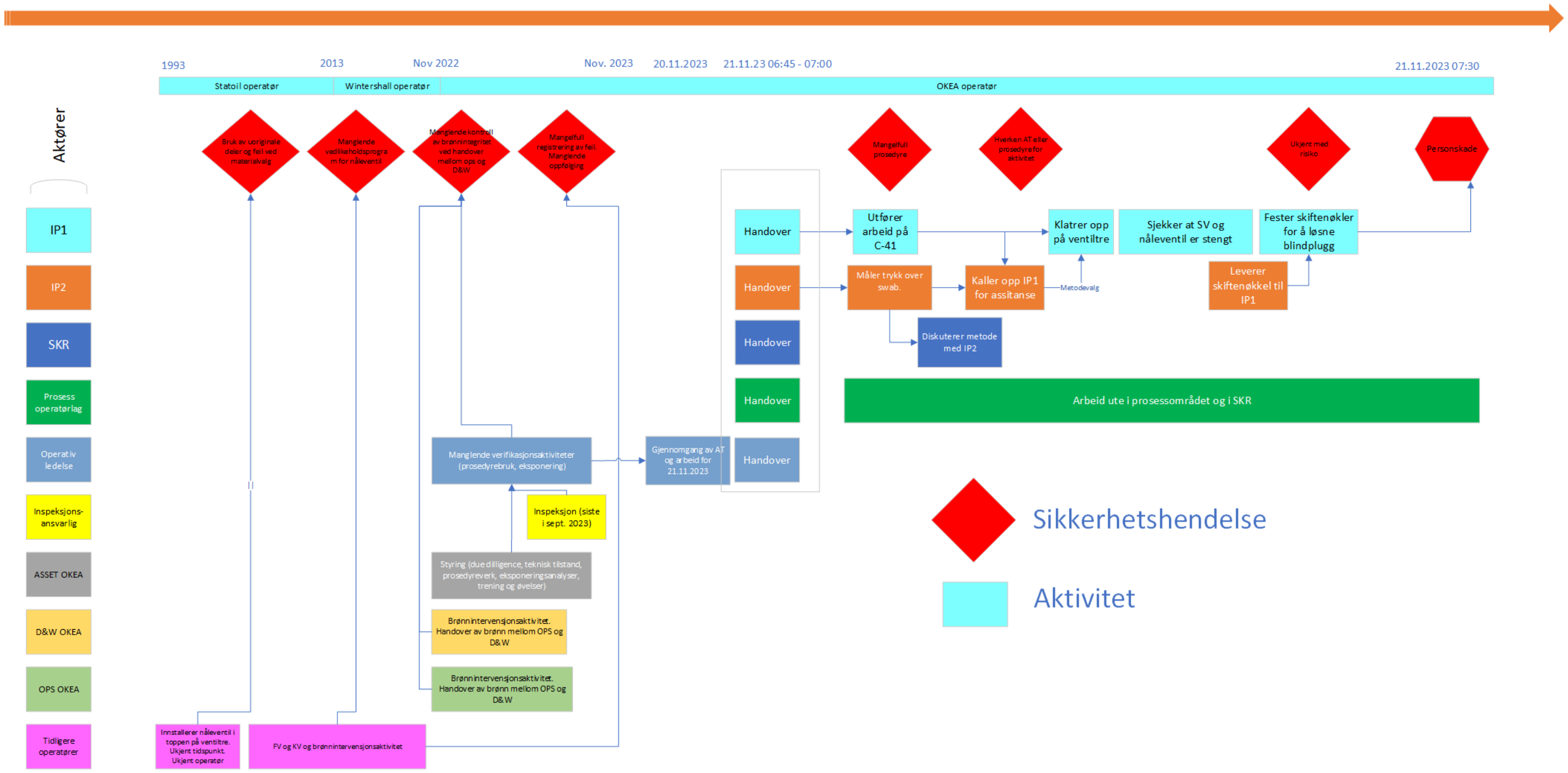
17.3 STEP Diagrams

The STEP Diagrams provide an overview of the chain of events and persons involved and were used by the investigation team as a tool for structuring information. The diagrams have been attached by way of illustration.

Underlying factors affecting performance that have influenced decisions and actions are not shown in the diagrams. The method used for this analysis is described in Chapter 3.2

Additional information about the STEP method may be found in references such as Hendrick & Benner (1986).

17.3.1 STEP Diagram for the incident prior to the personal injury



17.3.2 STEP Diagram for the incident following the personal injury.