

Investigation report

Report	
Report title Incident with a fall from scaffolding involving personal injury and a steam escape at Mongstad on 27 June 2020	Activity number 001902053

Security grading		
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Involved	
Team T-Land	Approved by/date Kjell Arild Anfinsen/19 November 2020
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1 Summary

In connection with draining acid residues from low points after a project involving one of the CO boilers in the Mongstad cracker, an unexpected escape of steam occurred on 27 June 2020 with a temperature of 240°C and a pressure of 36 barg. The pressure and temperature, combined with a high noise level, created problems for one of the two operators in evacuating safely and he opted to escape over the edge of the scaffolding. He fell/slid down to the level below, a height of about four-five metres.

The Petroleum Safety Authority Norway (PSA) was notified of the incident on 29 June 2020. A meeting was held via Teams on 2 July 2020 to obtain more detailed information on the incident. The decision to investigate was taken by the PSA on the same day.

Actual and potential consequences

One person was sent to A&E, which found minor injuries to his upper body as well as a sprained ankle.

Under slightly different circumstances, the incident could have led to serious personal injury or death. The injured person fell/slid four-five metres via several pipes to the walkway below. He had zero vision and his route was arbitrarily chosen. A valve with spindle is positioned immediately adjacent to his line of descent. Had he struck this, it could have seriously injured or killed him.

Direct and underlying causes

The direct cause of the incident is that an operator fell/slid between pipes down to the level below (about four-five metres) while trying to evacuate from an area with steam.

Underlying causes relate primarily to:

- supervision of work and risk management
- compliance with procedures/requirements
- constricted workplace and difficult access.

Nonconformities and improvement points

The following nonconformities have been identified:

- compliance with the company's own procedures/requirements
- risk management when planning and executing work
- transfer of information following a personnel change in the work team.

An improvement point has also been proposed in relation to

- expertise and training.

2 Background information

In connection with draining acid residues from low points after a project involving one of the CO boilers in the Mongstad cracker, an unexpected escape of steam occurred on 27 June 2020 with a temperature of 240°C and a pressure of 36 barg. The pressure and temperature, combined with a high noise level, created problems for one of the two operators in evacuating safely and he opted to escape over the edge of the scaffolding. He fell/slid down to the level below, a height of about four-five metres.

2.1 Description of the plant and organisation

The Mongstad complex in Vestland county comprises an oil refinery, an NGL processing facility and a crude oil terminal. The refinery is Norway's largest and has an annual capacity of almost 10 million tonnes of crude. Operations at Mongstad are to a great extent automated. Abnormal operating conditions are detected by alarms in the control room, which monitors all the plants. Additional operational follow-up is performed by operators in the field. Maintenance is a significant activity, carried out by shift workers, maintenance personnel in the daytime organisation and external contractors.

Mongstad's first stage was constructed in 1974. The plant was expanded and upgraded in 1989, including construction of the catalytic cracker. This breaks down the bottom fraction from the distillation process into smaller molecules with the aid of catalysts and high temperature.

Air is added in the CO boilers to the flue gases, which contain CO, and these are then completely combusted to CO₂. The boilers are also used to maintain the right temperature in the combustion chamber. Heat already in the flue gases and from burning CO to CO₂ is used to produce steam. The gas has a temperature of 660°C at input and about 280°C at output.

The plant can produce 104 t/h of high-pressure steam per boiler. With normal good steam conditions, the CO boiler will generally be operated with minimum admission. That corresponds to an output of about 90 t/h steam from each boiler.

Operated in its entirety by Equinor, the Mongstad plant has 600 full-time-equivalent employees. Of these, about 310 are shift workers divided into six shifts responsible for safety, production, first-line emergency response and maintenance. Roughly 30 more are tug crew (two shifts). A shift system also applies in the laboratory. The remaining personnel are daytime resources with responsibilities in planning and development, operational follow-up, laboratory services, engineering and technical information support, maintenance support, stores, workshop services, procurement and administration. In addition, the company has about 70 apprentices.

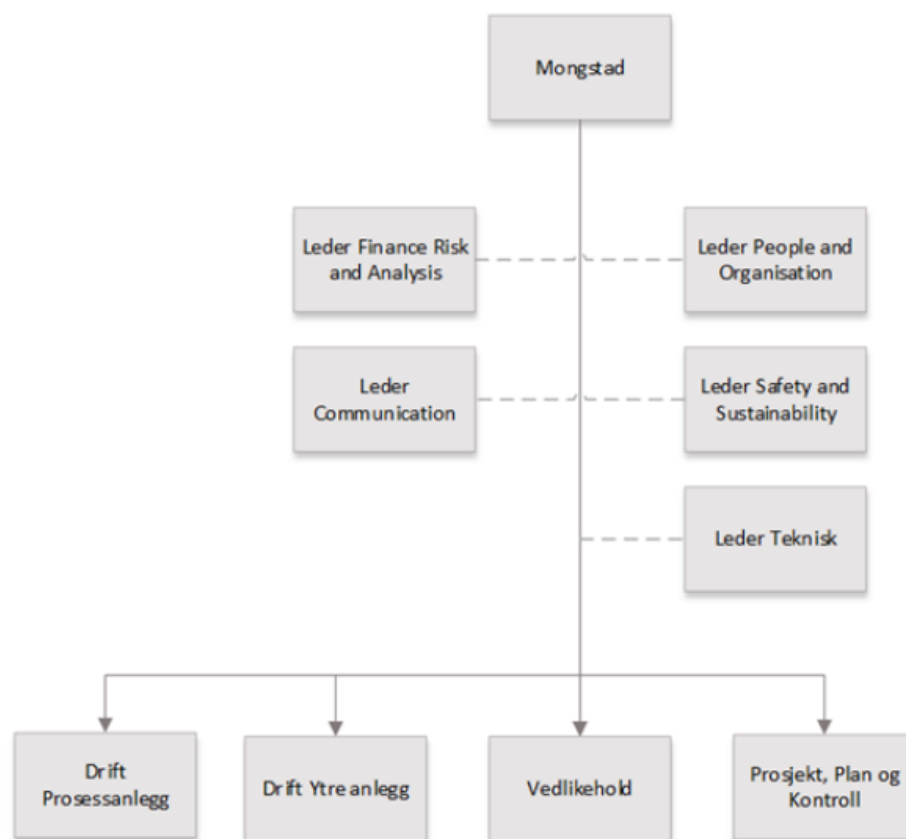


Figure 1. Mongstad organisation.

Key: Leder = Supervisor; Operations, process; Operations, external; Maintenance; Project, planning and control

In response to Covid-19, a number of infection control measures have been introduced at Mongstad. Among other moves, morning meetings are held with smaller groups and are less extensive than before. Conversations in the field are not permitted in noisy zones, and social distancing rules must be observed.

A special Covid-19 shift plan was introduced in March to ensure that sufficient personnel were available should potential infections affect one of the shifts. In order to implement summer holidays for shift workers, a special plan was instituted in the summer months. People then worked a 12-hour day shift for one week, had a week off, and then worked a 12-hour night shift for a week. The incident occurred on a Saturday morning.

2.2 Abbreviations

A&E	Accident and emergency department
C&L	Compliance and leadership
FHI	Norwegian Institute of Public Health
HSE	Health, safety and the environment
HTO	Human-technological-organisational
NGL	Natural gas liquids
RS19	Turnaround 2019
SG-1531	Steam/CO boiler
SJA	Safe job analysis
t/h	tonnes per hour
WP	Work permit

3 PSA investigation

Composition of the investigation team

Emilia Cristina Thingbø, occupational health and safety discipline area

Arne Johan Thorsen, process integrity discipline area

Espen Landro, process integrity discipline area, investigation leader.

The team has been assisted by Arnt Heikki Steinbakk in the logistics and emergency preparedness discipline area.

3.1 Procedure

The investigation was conducted through interviews with Equinor personnel at Mongstad, through verifications and inspections at the plant and through a review of governing documents and other documentation relevant to the incident.

The investigation team began work immediately with a review of available information, and more documentation was requested. For practical reasons, most interviews and inspections were conducted at Mongstad in the week of 7-11 September. A final interview was carried out via Teams in the week of 19-23 October because of holiday absences at Mongstad. Nine interviews/conversations were conducted in all.

An inquiry into the incident was launched by the Nordhordland sheriff's office, which wanted to participate in the inspection at Mongstad. The PSA team was asked to support the police inquiry as required, but did not contribute to its interviews in this case.

3.2 Methodology

To systematise the incident, its causes and the factual information, the investigation team chose to utilise an HTO analysis combined with a Five Whys analysis. A course of events was first established, based on information obtained from the interviews and the document review. Causes, nonconformities and barriers were then related to the relevant stages in the course of events. While causes and nonconformities were entered in the fields above the latter, the barriers are presented below it.

3.3 Mandate

The following mandate was given to the investigation team.

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

4 Course of events

The description of the course of events is based on interviews with personnel involved at Mongstad and a review of documents made available to the investigation.

6-10 April (week 15)

Hot spots were found on the reactor which indicated possible damage to masonry, and a shutdown team was established to look at this. The plant was to be ready for maintenance on 24 April 2020.

13 April 2020 (week 16)

The SG-1531 CO boiler was shut down on 13 April 2020 because of an internal leak.

13-20 April 2020 (week 16)

The boiler was opened for inspection by Equinor's team, which identified a substantial scope of repairs. The shutdown project leader was asked to head this work and include it in PS06-20 (unplanned shutdown to determine the cause of hot spots on riser R-1501 after the installation of a new reactor in RS19).

24 April 2020 (week 17)

SG-1531 was ready for maintenance by the shutdown organisation.

24 April-10 June (weeks 17-24)

Maintenance pursued on SG-1531: internal inspection, piping replacement and brickwork. The contractor (Wistrand) arrived at Mongstad at the start of week 23, which was used for planning, preparing the work and establishing procedures.

The rest of the workforce arrived on 8 June, was briefed on assignments and was taken on an HSE tour in the field. An SJA was conducted and reviewed by all relevant personnel in the field. Equipment was rigged in the field. Since residues in the low points after an acid wash could cause corrosion, all these points were to be drained. The project organisation already knew at this time that some points would remain undrained because of access difficulties and plugging in the pipes. It was decided that all low points would be drained after the boiler was started up for drying.

Friday 12 June 2020 (week 24)

Acid wash of SG-1531 began.

15-16 June 2020 (week 25)

The acid wash was completed as planned. Wistrand submitted a list of low points which it had been unable to drain. Its recommendation was to drain these points in parallel with pressure testing of the repair work. The operations department decided not to follow this advice. It did not want to maintain the pressure at 52 bar longer than necessary.

16-20 June 2020

Rigging down and disassembly of equipment, as well as punching and removal of blinds.

20 June 2020

All maintenance work on the boiler was completed and all blinds were punched and approved. The boiler was formally delivered to operations. In that context, operations would contact the project organisation if it had questions. None were asked in this case.

The plant and equipment were delivered to operations after all check-list items had been signed out in the schedule.

Sunday 21 June 2020

Operations began the check (punch) list activities. The level of activity was high, with many jobs being pursued simultaneously. The operations engineer decided to postpone his holiday to ensure that no misunderstandings would arise and to get the boiler back on line. The boiler began being heated up on Sunday afternoon, when the pipes were at zero barg.

Monday 22 June 2020

Operator 1 (the discipline lead) returned after time off. He reviewed what had happened in the previous weeks, and learnt that the drying process was underway and looked good. He found a file with information from Wistrand and was told by the operations engineer that remaining activities involved draining low points after the acid wash. The night shift would look at this.

Tuesday 23 Tuesday 2020

The operations engineer, discipline lead and operations supervisor met to review the check list. They discussed the importance of tackling the drain points as soon as possible. Pipe pressure and temperature were then low. They also discussed that the points might be blocked after being out of use, and that executing personnel had to be vigilant over possible plugs. It was agreed to enter this in the daily instruction to ensure that it reached the night shift, which was going to do the work. The operations engineer's substitute was not present, but he talked about this issue with the engineer during the hand-over before the latter went on holiday.

The operations engineer wrote in the daily instruction for 23-24 June that draining the remaining low points should continue, and that personnel should be on the lookout for plugs in the pipes. Draining the low points under low internal pressure was recommended (in red). At that point, the pipes were at about five barg and 150°C.

The operations engineer started his holiday on Tuesday evening.

Wednesday 24 June 2020

Lack of access meant the night shift failed to drain the two final low points. The substitute took over the job of operations engineer for the system. Operator 1 commissioned the construction of scaffolding to reach the two remaining low points.

Thursday 25 June 2020

The scaffolding had been erected but not yet approved. It was installed about five metres above the walkway, and was relatively small and narrow.

At this point, it was about 26 barg and 230°C in the piping. The substitute engineer decided to remove the recommendation in the daily instruction to drain the points under low internal pressure since the latter had risen. He marked the text about possible piping plugs in blue, in accordance with the procedure for daily instructions. This specifies red text for new additions and blue for entries up to 10 days old.

Friday 26 June 2020

Daily instruction 26-29 June: The substitute engineer changed the text about possible piping plugs from blue to red to continue underlining its importance. With the scaffolding approved, the night shift would tackle the two final drain points.

Saturday 27 June 2020

07.00-09.00 – It was noted that the night shift had not drained the two low points because of other jobs. The shift started with a morning meeting which reviewed planned work for the day. Operators 1 and 3 were to deal with the points during the morning. Operator 2 attended the meeting, but was together with another group and therefore did not participate in the conversation between operators 1 and 3.

The Covid-19 position led to changes in the way work was organised, with the morning meeting held in smaller groups than before. At the same time, conversations in the field were banned in noisy zones and social distancing rules had to be observed.

Operator 3 became unavailable just before the work was to start. Operator 2 was then called by walkie-talkie and asked if he would help operator 1. Operator 2 replied that he was unoccupied and would take part. This was the first time he had worked on the boiler.

About 09.00

Operators 1 and 2 found the equipment (hose) and the key to open the valve. A standard two-metre steel hose was connected to carry away possible acid residues.

The valve could be accessed from above, but operator 2 was unable to apply sufficient torque. Since the valve was fairly stiff, operator 2 moved under the piping and began opening it. The drain proved to be plugged. Dripping continued for a couple of minutes. The valve was cautiously opened more and more, and the plug in the pipe finally loosened. That resulted in a sudden powerful blowout of steam/hot water. Out of control for a few seconds, the hose then attached itself to the scaffolding. The jet from the hose pointed away from the two operators. Operator 1 had the opportunity to evacuate. Operator 2 experienced a very loud bang and a lot of steam. He lost vision and simply wanted to get away quickly from the hot steam. His entry route was blocked by the hose, and he had to escape past the railing on the outside of the scaffolding. He began to move towards the scaffolding edge between its floor and associated piping, and fell/slid down to the walkway below. His hard hat fell off when he threw himself backwards and wriggled out of the scaffolding. Operator 1 mounted the scaffolding and closed the valve once he had confirmed that operator 2 was on the ground. Operators 1 and 2 then went together to notify the operations supervisor of the incident.

From about 09.30

Operator 2 was sent to A&E in Knarvik for a check, where he was found to have minor injuries to his torso as well as a sprained ankle. No hearing test was conducted, but was postponed until later. He returned to work on the same day. A time-out and follow-up conversations took place during the day, when the incident was discussed.

Sunday 28 June 2020

Operator 2 remained at home because of a swollen ankle which could not bear his weight. The incident was classified as a lost-time injury with a potential seriousness of level 1: fatality.

5 Potential of the incident

5.1 Actual consequence

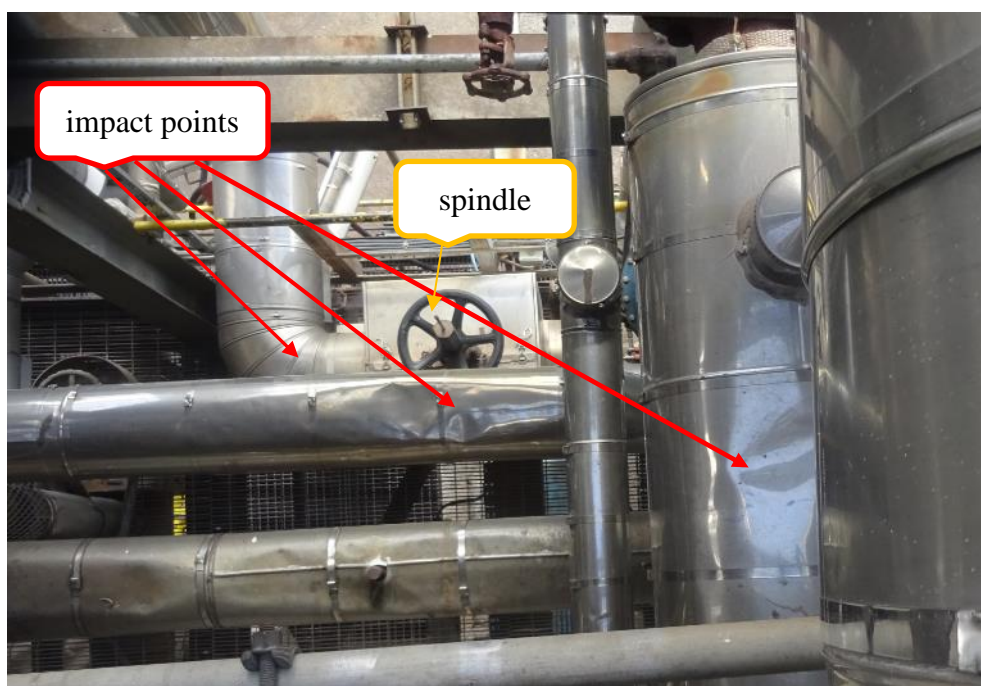
Operator 2 was sent to A&E, where minor injuries to his torso and a sprained ankle were identified. The incident was classified by Equinor as a lost time injury.

5.2 Potential consequences

Under slightly different circumstances, the incident could have led to serious personal injury or death.

Both operators were exposed to high-temperature steam which could have caused serious burns, and they could potentially have been struck by the uncontrolled hose as it was flung about by the high pressure.

Operator 2 fell/slid without a hard hat to a lower level on the walkway below. Fall height: four-five metres. He had zero vision and took an arbitrary route from the accident site. A valve with spindle was located immediately alongside his descent. Had the operator hit that, he could have suffered serious injury or been killed.



Photograph 1 Where operator 2 fell, with impact points and spindle. The view is from above down to the walkway below the scaffolding. Photo: Equinor Mongstad

6 Direct and underlying causes

6.1 Direct cause

The direct cause of the incident was that operator 2 fell/slid between piping and down to the level below (about four-five metres) as he attempted to escape from the area with steam.

The original evacuation route became unavailable to operator 2 when he lost vision because of the large quantities of steam coming from the hose. At that point, the hose had become attached to the scaffolding, and its jet was pointing at the evacuation route.

6.2 Underlying causes

The investigation has identified underlying causes which relate primarily to

- supervision of work and risk management
- compliance with procedures/requirements
- constricted workplace and difficult access.

6.2.1 Supervision of work and risk management

Information from interviews and the document review reveals inadequate management of risk and insufficient follow-up of changes which occurred between initial planning of the activity and its execution. The operations department was aware that pressure and temperature had changed along the way, but no assessment was made about the significance of these changes for the activity to be carried out.

The initial plan was that the work would be done by the night shift early on Wednesday 24 June 2020. It was then postponed several times for various reasons, including a lack of access (scaffolding) and other jobs. This led to inadequate planning and follow-up of the activity throughout 23-26 June. During that time, pressure and temperature in the piping rose from five barg and 150°C to 35 barg and 250°C.

Operator 2 was brought in when operator 3 became unavailable. According to interviewees, the executing personnel failed to devote sufficient time to work preparations. Operators 1 and 2 did not discuss the potential risk related to the activity with each other in either the planning or the execution phases. Equinor's C&L model describes how work should be planned, executed and evaluated. Emphasis is given to identifying and handling risk and changes which can arise during the execution of work. The model also gives weight to a correct and shared understanding of the assignment/activity as a crucial precondition for the ability to identify and handle risk. It is to be used as a basis for executing all activities, but was neither assessed nor implemented in connection with the drainage job.

6.2.2 Compliance with procedures/requirements

Equinor's OM202.05.01 procedure on obtaining and connecting hose – mid and downstream specifies that a hose which could be subject to movement or a hanging hose must be properly secured. The hose was not secured in accordance with the requirements in the procedure. When the plug in the pipe loosened, it caused a sudden release of steam/hot water with great force. The hose began to whip around uncontrollably for a few seconds before becoming arbitrarily attached to the scaffolding. Steam emerged from the hose in an unfortunate position, making the evacuation route inaccessible to operator 2 because of the quantity of steam and poor visibility.

6.2.3 Constricted workplace and difficult access

Operator 2 had to get under the piping to obtain more torque for opening the valve. Access was difficult and the workplace constricted. When the plug loosened, operator 2 was lying under the piping and crawling towards the edge of the scaffolding was his only evacuation option.

7 Emergency preparedness

The regulations require licensees and other participants in petroleum operations on the NCS and on land to maintain effective emergency preparedness at all times to deal with hazards and accidents which could cause loss of human life or personal injury, environmental pollution or extensive material damage. Those responsible must also establish barriers which reduce the probability that errors and/or hazards and accidents will develop, and which limit possible damage and inconvenience.

Mongstad's emergency response organisation was not mobilised for this incident.

8 Observations

The PSA's observations fall generally into two categories.

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

8.1 Nonconformities

8.1.1 Compliance with the company's own procedures/requirements

The company's own procedures/requirements were not followed when executing the work.

Ground

- The free end of the hose was not secured as described in Equinor's OM202.05.01 work process, where one of the requirements in R-109590 on control of hoses and couplings is that the hose's free end must be secured before pressurisation.
- C&L must be used as the basis for executing all activities. It was neither assessed nor implemented for the drainage activity. Pages 50-51 of the Equinor book require that risks are reviewed before work is carried out.

Requirement

Section 45 of the technical and operational regulations on procedures

8.1.2 Risk management when planning and executing work

Lack of risk management in connection with planning and executing work.

Grounds

- The activity was repeatedly postponed because of other priority jobs. It emerged from interviews that the operations department was aware that conditions had changed along the way, but no assessment was made about the significance of these changes for the activity to be done.
- It emerged from interviews that this activity was regarded as a routine job. However, views differed among interviewees over whether work on systems with high pressure and temperature should be defined as routine. Defining work on such systems as routine means that all risk will not necessarily be adequately identified.
- The executing personnel did not conduct a risk assessment when planning and doing the work. They neither assessed nor discussed possible risks related to execution.

Requirements

Section 53, paragraph 1 of the technical and operational regulations on risk information during work operations

Section 55, paragraph 1 of the technical and operational regulations on planning

Section 23-1 of the regulations concerning the performance of work (FOR-2011-12-06-1357) on risk assessment in connection with planning, design and execution of manual work

8.1.3 Transfer of information following a personnel change in the work team

A change was made in the personnel executing the work without ensuring that the necessary information was provided about work under way and other details of significance for HSE when carrying out the activity.

Grounds

When executing the work, a change was made in the personnel doing the job. No new review of the risks involved in the activity was carried out. It was reported during interviews that the injured person did not know what the job entailed and was not informed about the pressure and temperature in the piping.

Requirements

Section 15 of the management regulations on information

Section 54 of the technical and operational regulations on transfer of information at shift and crew changes

8.2 Improvement point**8.2.1 Expertise and training**

Ensure that executing personnel at all times have the expertise and experience required to carry out activities in accordance with the HSE legislation.

Grounds

It emerged from interviews that this was the first time the injured person had carried out a drainage job on the boiler under high pressure and temperature. Some training was given, primarily on executing the job, but not on the risks associated with such execution.

Requirements

Section 50 of the technical and operational regulations on competence

Section 8-1 of the regulations concerning organisation, management and employee participation (FOR-2011-12-06-1355) on general requirements for training

9 Barriers**9.1 Barriers which have functioned****Organisational and operational**

Organisation and coordination of activities by operations engineer 1 during the overlap with his substitute. The operations instruction contained information that the low points should be drained at a low temperature and that plugs might form in the piping.

Operational

Operator 1 mounted the scaffolding, closed the valve and removed the hose after confirming that operator 2 was on the ground. This action prevented the uncontrolled release of hot steam and the risk of further exposure to steam and noise.

Organisational and operational

Operators 1 and 2 went together to report the incident to the operations supervisor. Operator 2 was sent immediately to A&E for investigation and further follow-up.

Organisational and operational

Several conversations were held with those involved as well as a time out and review of the incident with relevant personnel to ensure that lessons were learnt and to prevent recurrence. When draining the last remaining low point, measures were taken on the basis of lessons learnt from the incident. The activity was executed as planned and without further incidents.

Technical

The evacuation route functioned for operator 1.

9.2 Barriers which have failed**Operational**

The original recommendation of blowdown to low pressure was not followed up.

Organisational and operational

Communication and planning of activities at morning meetings as a result of infection control measures. The new way of organising these meetings is intended to prevent and control Covid-19 infections. The barrier functioned for that purpose.

The barrier failed with regard to the review and communication of planned activities if personnel changes were made in the teams. Activities were only planned and discussed by the people executing them. In this case, operator 2 did not participate in the discussion between operators 1 and 2 because he was taking part in a different group.

Organisational and operational

Insufficient time for work preparations, in that operator 2 was chosen to do the work operation.

Organisational and operational

Inadequate planning and communication of the work operation.

Technical

The evacuation route failed for operator 2.

9.3 Missing barriers**Organisational and operational**

Potential risk not discussed by the executing personnel. Risk assessment (C&L) not done.

Technical

Hose not secured in accordance with requirements in the procedure.

10 Discussion of uncertainties

Some uncertain factors could influence the findings in the investigation report.

Little technical evidence

The nature of the incident means the investigation has been based primarily on information obtained from interviews. Few or any traces of the incident are to be found in logs or the like, but it has been possible to verify some information through WPs, daily instructions and procedures. A good deal of time has been devoted to clarifying unclear timings and events before the actual incident occurred.

Memory

For various reasons, most interviews took place more than two months after the incident. Witnesses remember more accurately and completely soon after the event. The more time passes, the more memories of an incident can be influenced by others and their perception of the event. Generally speaking, people often have great faith in their own recall and many believe eyes and brain work like a camera. In truth, people construct stories around incidents and fill in details with known circumstances, stereotypes and hindsight – known as cognitive editing. The consequences, for example, can influence memory and be a source of error. (Source: Olsen, K H, “Granskingsintervjuet og vitners troverdighet”. Draft book chapter [Book]. 2014.)

- Trauma related to the incident.
- Guilt feelings, either internal or through placing the blame on others. “Super memory”, which focuses on some impressions and completely ignores others.
- Perception of time – either too fast or standing still.

Covid-19

It is difficult to determine how great an impact infection control related to Covid-19 has had on the incident. The investigation team has seen that changes to the form and content of morning meetings for shifts and conversations in the field may have affected communication between operators.

11 Assessment of the player’s investigation report.

Equinor itself has investigated the incident at level 2 (second highest) because of its fatal accident potential. Due on 25 September 2020, the final report was delayed by Covid-19. It has been further delayed and is now scheduled for the end of November. The investigation team does not believe there is any reason to await the Equinor findings, and has decided to publish its own report without assessing the outcome of the Equinor investigation. This will be assessed when it becomes available.

12 Appendices

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

- Photographs
- Data sheet on hydrochloric acid
- Operating log, week 26
- Daily instruction B1 26-29 June 2020
- Daily instruction B1 25-26 June 2020

- Daily instructions for 19-25 June 2020
- Obtain and connect hose
- Chemical wash of SG-1531
- Layout A-1500
- List of drainage jobs to be checked by the operations department and EFD
- Investigation mandate, incident report 1620876
- Agenda – meeting with the PSA on the incident with fall from scaffolding 2 July 2020
- Operations document for hoses
- Organisation chart, B area, F shift
- Overview of personnel involved in work preparation
- Potential ignition sources in B1
- Presentations from meeting with the PSA on the incident with fall from scaffolding
- Risk assessment in connection with drainage of low point outlet header P-
- Piping diagram with drain valve marked in yellow
- Safety alert 1620876 fall from scaffolding 27 June 2020
- Safety plot B1
- Shift plan for the F shift in August 2020
- Zone map
- System description of the steam system
- Trend plot SG1531
- Safety report from 2017

B: Overview of personnel interviewed.

C: HTO/5H diagram