PETROLEUMSTILSYNET

# Investigation report

| **Report** | |
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| Report title<br>Report of the investigation into a hydrocarbon leak of 26 January 2014 on Statfjord C | Activity number<br>001037023 |

| **Security grading** | | |
|---|---|---|
| ☐ Public | ☐ Restricted | ☐ Strictly confidential |
| ☐ Not publicly available | ☐ Confidential | |

**Summary**


A hydrocarbon leak occurred on Statfjord C at 03.24 on Sunday 26 January 2014.

The incident occurred while stabilised oil was being transferred from Statfjord A to Statfjord C. At the same time, preparations were being made for maintenance work on a loading pump in the shaft. An isolation valve for the pump sprang a leak, causing the pump house to fill with oil. This oil drained to the sump tank at the base of the shaft via an open drain valve. When the level in the sump tank reached 70 per cent, the pump for transferring liquid from the sump tank to the oily water tank beneath the cellar deck started up. The valve controlling the level in the oily water tank failed to open, and oil escaped via fire seals on the cellar deck.

Transfer of stabilised oil from Statfjord A was halted immediately, and shutdown of the process plant on Statfjord C initiated. The emergency response organisation mobilised, and other personnel mustered to the lifeboats. A gale was blowing at the time.

There were 270 people on the installation, and no personal injuries have been reported as a result of the incident. Production was shut down for almost four days owing to the leak.

Statoil calculated that up to 42 $m^3$ of stabilised oil escaped in about 37 minutes, at a leak rate of 20.8 kg/s. Forty $m^3$ are estimated to have spilt to the sea, while two $m^3$ dispersed over the installation.

Potential consequences in the event of ignition are assessed to be a possible spray fire or combustion of oil drops/flowing oil for the duration of the leak.

In addition, the probability for a repetition of similar leaks was high immediately after the incident.


| **Involved** | |
|---|---|
| Main group<br>T-1 Statoil | Approved by/date<br>Kjell Marius Auflem |
| Members of the investigation team<br>Eivind Jåsund, Odd Tjelta, Aina Eltervåg | Investigation leader<br>Øyvind Lauridsen |

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# 1 Summary


**Course of events**
A hydrocarbon leak occurred on Statfjord C at 03.24 on Sunday 26 January 2014. The PSA was notified at 04.05.

The incident occurred while stabilised oil was being transferred from Statfjord A to Statfjord C. At the same time, preparations were being made for maintenance work on a loading pump in the shaft. An isolation valve for the pump sprang a leak, causing the pump house to fill with oil. This oil drained to the sump tank at the base of the shaft via an open drain valve. When the level in the sump tank reached 70 per cent, the pump for transferring liquid from the sump tank to the oily water tank beneath the cellar deck started up automatically. The valve controlling the level in the oily water tank failed to open, and oil escaped via fire seals on the cellar deck. A line detector on the cellar deck signalled a hydrocarbon leak at 03.24.

Transfer of stabilised oil from Statfjord A was halted immediately, and shutdown of the process plant on Statfjord C initiated. The emergency response organisation mobilised, and other personnel mustered to the lifeboats. A gale (17.2-20.7 metres per second) was blowing from the south-east when the incident occurred.

**Consequences**
Personnel were sent into the oily water tank at 05.06. The first leak point was found to be a defective gasket on a fire seal beneath the cellar deck.

Statoil calculated that up to 42 $m^3$ of stabilised oil escaped in about 37 minutes, at a leak rate of 20.8 kg/s. Forty $m^3$ is estimated to have spilt to the sea, while two $m^3$ dispersed over the installation. The leak ceased when the level in the sump tank reached 40 per cent.

There were 270 people on the installation, and no personal injuries have been reported as a result of the incident. Production was shut down for almost four days owing to the leak.

**Potential consequences**
Potential consequences in the event of ignition are assessed to be a possible spray fire or combustion of oil drops/flowing oil lasting for about 37 minutes, equal to the duration of the leak.

In addition, a high probability existed for repeated leaks of similar duration and scope if the level in the sump tank again reached 70 per cent. The open drain valve which supplied the sump tank with oil was closed at 05.49, when the tank level had risen to 62 per cent.

**Investigation**
The Petroleum Safety Authority Norway (PSA) resolved on Sunday 26 January 2014 to conduct its own investigation of the incident, with departure for Statfjord C on the evening of Monday 27 January.

The police decided to investigate the incident and requested assistance from the PSA. Its investigators travelled out to Statfjord C together with the PSA team.

**Nonconformities**
Six nonconformities were identified by the investigation. These related to:

- the original design solution for the drainage system
- the modified design solution for the drainage system
- consequence classification of the open drainage system
- preparations for maintenance
- management of simultaneous activities
- qualification and follow-up of contractor expertise.

Four improvement points were also identified, including one concerning Statoil’s own investigation.

## 2 Introduction

The Statfjord field has been developed with the Statfjord A, B and C production platforms. This field straddles the UK-Norwegian boundary in the Tampen area of the North Sea, in 150 metres of water. Statfjord C is a fixed concrete gravity base structure on stream since 1985. It produces oil and gas. The oil is held in storage cells before offloading to shuttle tankers, while the gas is piped to Kårstø and Scotland. The Statfjord North, Statfjord East and Sygna satellite fields are tied back to Statfjord C.

**Figure 1. Statfjord C. (Source: Statoil.com)**

A hydrocarbon leak was detected on Statfjord C at 03.24 on Sunday 26 January 2014. A gale was blowing from the south-east at 17-20.7 m/s, with significant wave heights of six-eight metres. Stabilised oil was being transferred from Statfjord A to Statfjord C when the incident occurred.

Notification of an HC leak was provided by a line detector on the cellar deck. The alarm and rescue team identified a leak via a defective gasket on fire seal 8.

In its notification to the PSA, Statoil estimated the spill to the sea at 32 $m^3$ of oil /7/.

The emergency response organisation mobilised, and other personnel mustered at the lifeboats. There were 270 people on board, and no personal injuries were reported from the incident.

The PSA resolved to carry out its own investigation of the incident on Sunday 26 January 2014, with departure for Statfjord C on the evening of Monday 27 January.

Composition of the investigation team:

- Eivind Jåsund — F- HSE management, maintenance management
- Odd Tjelta — F-Process integrity, technical safety
- Aina Eltervåg — F-Logistics and emergency preparedness, emergency preparedness
- Øyvind Lauridsen — F-Working environment, organisational safety, investigation leader

The investigation was conducted through interviews with personnel on land and in the offshore organisation, a verification on Statfjord C – including investigations at the incident site – and an assessment of governing documents and Statoil's own investigation report.

Mandate for the investigation

a. *Clarify the incident's scope and course of events, with an emphasis on safety, working environment and emergency preparedness aspects*
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, with the emphasis on human-technological-organisational (HTO) and operational conditions from a barrier perspective.*
d. *Discuss and describe possible uncertainties/unclear aspects*
e. *Identify nonconformities and improvement points related to the regulations (and internal requirements)*
f. *Discuss barriers which have functioned (in other words, those barriers which contributed to preventing a hazard from developing into an accident, or which have reduced the consequences of an accident)*
g. *Assess the player's own investigation report*
h. *Assess the incident in the light of the improvement initiative implemented by Statoil for reducing HC leaks*
i. *Prepare a report and a covering letter (possibly with proposals for the use of reactions) in accordance with the template*
j. *Recommend – and contribute to – further follow-up*

The police decided to investigate the incident and requested assistance from the PSA. Its investigators travelled out to Statfjord C together with the PSA team.

## 3 Course of events

Loading pump A had been isolated about a day earlier for maintenance. An isolation valve (HV30601) for the loading pump sprang a leak, which caused oil to fill the pump house. This oil was drained to the sump tank in the shaft. When the level in the sump tank reached 70 per cent, the pump for transferring liquid in the sump tank to the oily water tank beneath the cellar deck started up automatically. The valve controlling the level in the oily water tank failed to open, and oil escaped via fire seals on the cellar deck. See the simplified diagram (figure 2) for an overview of the drainage system and loading pump components involved.

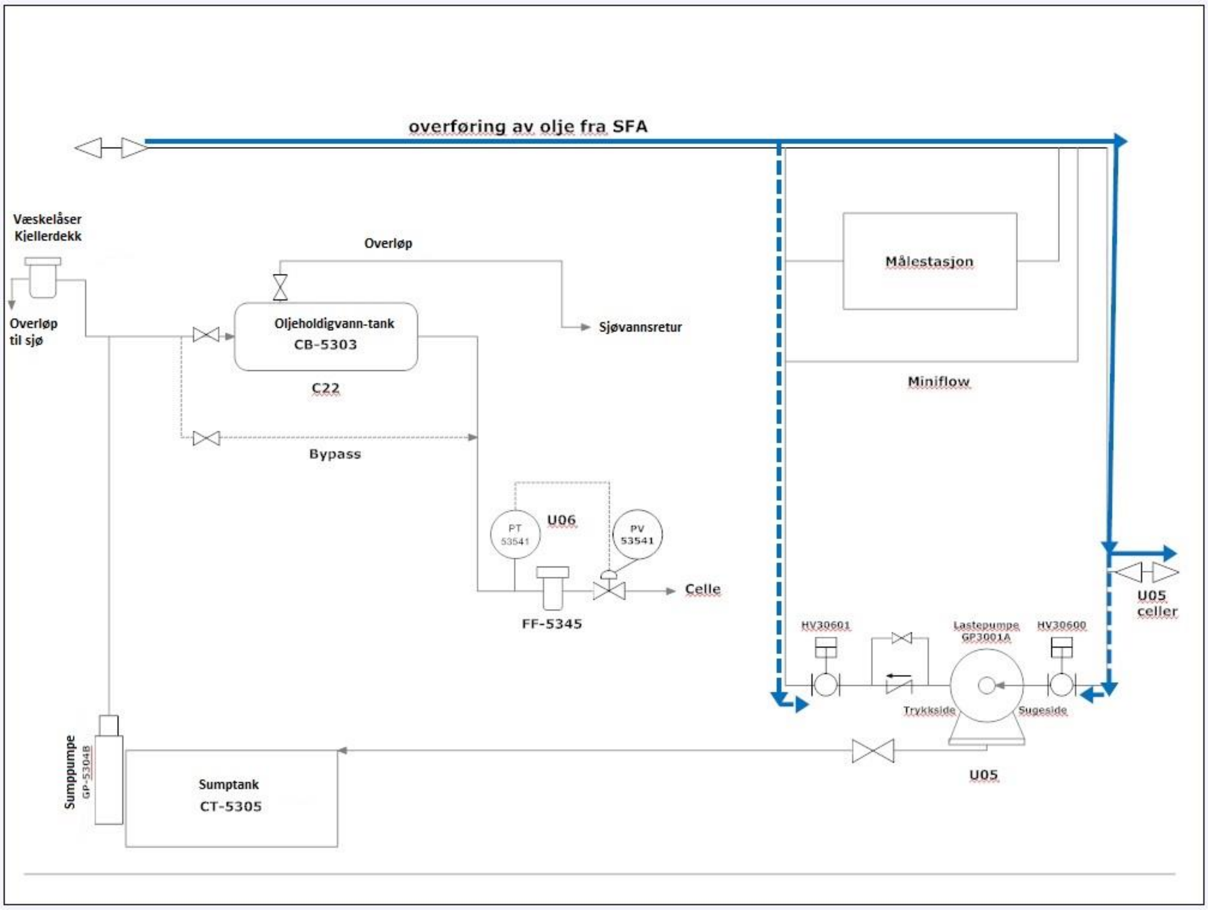


**Figure 2. Simplified diagram.**

It has been established that the leak occurred through the overflows from several fire seals beneath the cellar deck. Fire seal FS8 sprang a leak through a defective gasket in its cover (see figure 3). The overflow on FS8 was blocked by a welding rag. A possible leak to the sea via the overflow in the open drainage system (seawater return line) cannot be excluded.


**Figure 3. Photograph of fire seal FS8.**

Based on duration and pump capacity, Statoil has calculated that up to 42 $m^3$ of stabilised oil leaked out at a rate of 20.8 kg/s, with an estimated 40 $m^3$ spilling to the sea and two $m^3$ dispersed over the installation.

**Chronology**

1994-2011 – incidents registered in Synergi
Nine incidents related to oily water systems were recorded in 1994-2011. Seven of these were registered after 2006. /10/

2001 Removal of level meters and pumps
Three level meters and two pumps were removed from the oily water tank (CD5303)./23/

15 July 2006 Start/stop levels for the sump pumps changed
Action low (L) changed from 50 to 60 per cent. Action high (H) changed from 62 to 70 per cent. Experience over a number of years had revealed that sump pumps GP5304A/B began to suck in air, causing damage to the pumps, at a level of about 52 per cent in sump tank CT5305. /23/

2006-2007 Problems with oxygen in cell E-1.
Air was drawn down into the oily water tank and drain pots for storage cells. The oily water tank was modified so that all water from the open drainage system had to pass via the tank. The return line from the oily water tank was extended with 12-inch piping from the EL 152m level down to EL 127m in the utility shaft. /11/

2007 Preventive maintenance (PM) of fire seals
PM on fire seals was transferred from Statoil's mechanical department to ISS contractor Beerenberg. /20/

2008-13 PM of fire seals
Six work orders were registered in this period for 12-monthly PM of fire seals by Beerenberg. /20/

October 2010-October 2013 Inspections of oily water tank CD-5303
Annual non-destructive testing (NDT) and general visual inspection (GVI) of the oily water tank were carried out in 2010-13. Two cases of external corrosion were discovered in 2011 and rectified. In addition, a four-yearly internal inspection in October 2011 identified damage to the coating on three connectors. /20/

6 July 2013 Work order issued for rectifying a diffuse leak from instrument FT-30614 on loading pump A. The criticality of the work order was set at low – in other words, it was to be executed within six months. /23//20/

28 July 2013-28 August 3013 Work order 22751138 for rectifying diffuse leak on loading pump A was on the programme for the turnaround in 2013. A simplified valve and blind list was drawn up. An application was submitted for a work permit level 1 (HC system) as a night job in 20-23 August 2013, but the job was not carried out. /23/

12 December 2013 The set point for the level in sump tank CT-5305 was changed in the central control room (CCR).
The set point for stopping the sump pumps was changed from 60 to 40 per cent. The stop level for the sump pumps was not reset. /23/

21 January 14, 20.30 to 23 January 14,19.30 Water jetting of sump tank CT-5305
Automatic water jetting of the sump tank starts every 14th day and lasts for about two days. Stagnant water in the sump tank has a tendency to develop $H_2S$ and an unpleasant smell. /23/

15.09 on 22 January 2014 to 16.00 on 24 January 2014 Transfer of about 50 000 $m^3$ of oil from Statfjord A to Statfjord C. Storage cells on Statfjord A were almost full. Bad weather in the area meant that shuttle tankers could not connect to the loading buoys. /23/ and interviews.

24 January 2014 Valve and blind list for execution of work order
Following platform internal verification (PIV), the operations and maintenance department established a new valve and blind list for execution of work order 22751138 on 26 January 14. Approved by department head. /14/

**25 January 2014**
Valves HV30600 and HV30601 were shut to isolate loading pump A GP3001A and prepare it for maintenance. /14/ and interview.

05.01 Drainage of oil from piping segment to loading pump A GP3001A started.
Oil from the piping segment to loading pump A had to be drained in order to prepare for repair of flow meter FT30614. The segment to be drained was about 5.5 $m^3$.
Pressure in the piping segment to loading pump A was just over six barg when drainage began, but sank to a little over three barg after just over an hour. /23/

06.24 Sump pump GP5304B began initial discharge of the sump tank to the open drainage system.
The level in sump tank CT5305 had risen to 70 per cent, and the pump started automatically. After three minutes, control valve PV53541 opened to admit liquid to the sludge cell from the oily water tank. After 36 minute, the first discharge ceased when the sump tank level reached 40 per cent. Statoil calculates that 64 $m^3$ was pumped to the oily water tank in this stage. The drain valve to discharge pump A remained open after the sump pump stopped. /15/ /23/

About 10.14 Sump pump GP5304B began the second discharge of the sump tank to the open drainage system. The level in sump tank CT5305 again rose to 70 per cent. With the second discharge, Statoil calculated that 56 $m^3$ was pumped to oily water tank CD5303. After three minutes, control valve PV53541 opened to admit liquid to the sludge cell from the oily water tank, but was open for a shorter time than with the first discharge. After about 37 minutes, the second discharge ceased when the sump tank level reached 40 per cent. /15/ /23/

12.40 to about 01.30 Level in sump tank CT5305 stable.
The drain valve for the piping segment to loading pump A was apparently closed around 12.40. /23/ /15/

During the day shift, Statfjord C received an enquiry from Statfjord A about opportunities for transferring oil to Statfjord C (interviews).

About 18:00. When the day shift left the workplace about 18.00, all drain valves were closed and pressure in the pump house was 0.7 bar. This pressure was entered in the plant information (PI) system, so that the trend was monitored right up to the shift change. No pressure increase was then observed. No test of actual pressure was conducted in connection with the transfer from Statfjord A. /21/

The day shift had not completed preparations, and the work continued on the night shift. /14/ and interviews.

Statfjord A contacted the CCR in the evening to transfer of 20 000 $m^3$ of oil to Statfjord C. Weather on the field was still bad, with no tanker loading possible (interviews).

26 January 2014
01.30 The drain valve on loading pump A was opened for further drainage as part of maintenance preparations. The piping segment for loading pump A contained 0.8 barg of nitrogen. The plot from PI shows that the valve was opened immediately before the transfer of stabilised crude from Statfjord A. Pressure in the pump house sank immediately off trend. /15/, /23/ and interviews.

About 01.55 Level in the sump tank began to rise. /15/

02.00 Transfer of oil from Statfjord A to Statfjord C started.
Stop test conducted at 01.59. Bad weather was the reason for the transfer. Interviews and /12/

About 02.15 Pressure in the pump house for loading pump A rose. /15/

03.13.27 Sump pump GP5304B began third discharge of the sump tank to the open drainage system. /15/

03.15.55 Gas detector W30-GD-101 A reported lens contamination. This may have been the first warning that liquid was emerging from the overflow and had activated the detector on W30. /22/

Between 03.13 and 03.24 Control valve PV53541 failed to open. Liquid was pumped up from sump tank CT-5305 and filled the oily water tank and its associated piping segment right up to the fire seals beneath the cellar deck. The oil escaped via the overflow for the fire seals and a leak in the cover on fire seal 8. /23/

03.24.50 Gas leak detected one LELm (lower explosive limit metre) C05-GD-112AR. Welding socket outlets disconnected automatically. /22//13/

About 03.25 CCR asked the alarm and rescue team (ART) to check area C05. Interviews

03.26.39 Gas detector C05-GD-112ARV blocked by the operations organisation. /13/

03.30 Oil/gas in area C05 confirmed.
The ART confirmed this after “check and report” in the field and asked the CCR to activate emergency shutdown (ESD) 2. Interviews and /23/.

03.30.16 ESD 2 initiated manually by the CCR.
Transfer of stabilised oil from Statfjord A halted, while shutdown of the Statfjord C process facilities began. The weather data display in the emergency response room went down with ESD 2. Interviews and /23/

03.30 General alarm initiated.
Mustering at lifeboats, oil/gas leak (defined hazard and accident condition – DHA1). Interviews and /18/

03.30 Logistics offshore air on Gullfaks C alerted.
Search and rescue (SAR) Tampen and Oseberg on stand-by at Flesland because of bad weather. Interviews and /18/ /23/

03.37.51 Pressure blowdown initiated at the request of the ART. Interviews and /21/

03.41 Statfjord C called in *Stril Herkules*.
Estimated arrival at Statfjord C was 04.20 – in other words, 40 minutes from the platform. /18/ /23/

03.45.16 Gas detector M10-GD-303AR notified 20 per cent LEL. /22/
Gas in analysis cabinet for gas export, checked out. /23/

03.45.43 Gas detector M10-GD-303AR notified 30 per cent LEL. /22/
Checked, but not reported to the emergency response leadership. /23/

03.4.44 Fire pump GP5001A started. /22/
The fire pump started automatically at 30 per cent LEL from gas detector M10-GD-303AR. /23/

03.46.23 Aqueous film-forming foam (AFFF) pump GP5004 started. /22/
Starts automatically at 30 per cent LEL. /23//22/ AFFF was later applied manually in the area (interviews).

03:48 POB overview established.
Established after 18 minutes. Status was 270 people on board and two missing.

A number of those who mustered had oil on their survival suits because drops of oil were suspended in the air at the lifeboat stations. Interview and /23/.

03.50.06 Third discharge halted after about 37 minutes, when the level in sump tank CT5305 reached 40 per cent. /15/

03.53 Second-line emergency response mobilised in the response centre at Sandsli.
Contacted the CCR on Statfjord C.
Volume of oil unknown owing to poor visibility on cellar deck.
*Stril Herkules*, which reported poor visibility and high seas, was asked to lie on the leeward side to observe when arriving at Statfjord C. New estimated arrival time 04.07. /18/

03.56 All personnel accounted for, POB of 270 OK. /18/

04.01 Process facilities depressurised. /18/

04.05 Statoil notified the PSA by phone. /25/

04.18 Began vacating all lifeboats on seventh floor. /18/ /23/ and interviews.

04.21 All lifeboats vacated. /18/

04.28 First status meeting between first- and second-line emergency response.
Statfjord C shut down and depressurised.
Leak traced to reclaim oil sump tank in area C22.
Operations personnel checked the leak and whether it had ceased. /18/

04.34 Reconnection of ignition sources. /18/
ART needed lighting in area C22 in order to search for faults. /23/

04.53 Second status meeting between first- and second-line emergency response.
Leak assumed to be associated with reclaim oil sump tank in area C22. /18/

04:55 Nurse to C-12 in connection with AFFF spills on ART members. /18/

04.58.06 ESD reset (display image presented during interview).

04.59 Area vessel *Stril Herkules* lights up beneath area C22.
Very poor visibility and high seas made observation difficult. /18/

05.06 SAR team investigates C22, secured with harness /18/.
Went beneath C22 to establish whether oily water tank CD5303 was damaged. No damage found. Then went to the fire-seal access platform beneath C22, where a leak point was identified. Interviews and /23/

05.42 Conversation between Statfjord C platform manager (PLS SFC) and second line.
Announced that second line took over responsibility for oil spill clean-up. /18/

Two people sent down the shaft for a check (interviews).

05.49 Drain valve for loading pump A found to be open and thereafter closed.
Level increase in sump tank CT5305 halted at 62 per cent. In the wake of the incident, the oil content which drained from GP3001A between the beginning of the valve leak to the start-up of the sump pump was estimated at 2.8 $m^3$. /23/ and interview

05.57 Third status meeting between first- and second-line emergency response.
New position overview presented. Personnel at the lifeboat station had got some oil on themselves, and oil could be smelt in the mustering area. Transfer of oil from Statfjord A to Statfjord C began at 01.39 and continued until the alarm sounded at 03.24. Estimated volume of oil transferred was 1 200-1 400 $m^3$. Efforts were still under way to identify possible leak points associated with C22. /18/

07.06 Second-line emergency response notified the Nofo duty officer that the discharge was no more than 32 $m^3$. /18/

08.30 Filter upstream from control valve on U06 cleaned. /12/ Considerable deposits were found in the filter (interview).

09.50 Check of pressure gauge for the control valve (PT53541).
Found to be OK. /12/

12.05 The PSA notified the second-line emergency response that it intended to investigate.
Expected equipment affected by the incident to be secured. /18/

12.30 Police contacted the second-line emergency response.
Requested that equipment which had caused the incident be “taken care of”, and that photographs be taken before the possible removal of damaged components. /18/

13.00 Normalisation on Statfjord C started.
No work permits issued on 26 and 27 January 2014. Cleaning of areas exposed to spilt oil. /23/

# 4 Direct and underlying causes

## 4.1 Direct causes

Loading pump A was isolated for maintenance. The isolation included a valve with an internal leak. This meant that a lot of oil drained to sump tank CT5305. Oil from the sump tank was automatically pumped up to the oily water tank when the sump tank level reached 70 per cent. A valve on the return line from the oily water tank to the sludge cell failed to open, which meant the oily water tank was not drained down as assumed in the design. The oily water tank and the overlying piping system became filled with oil, which leaked out via overflows on fire seals. Some of the oil escaped via a defective gasket in the cover on one fire seal. Bad weather meant that oil drops were carried away by the wind and onto the installation.

## 4.2 Underlying causes

### 4.2.1 Design, modifications and monitoring of the drainage system

The drainage system is not very robust, since it combines open and closed drainage without the fire seals being designed to prevent oil leaking to the sea. In addition, little difference in level is provided between the overflow from the oily water tank and the fire seals on the cellar deck. In cases where water exists in the liquid column in the overflow from the oily water tank, the small difference in level means that oil may be unable to escape via the tank overflow if the level is too high. Instead, the oil will run out of the fire seal overflows. The system also contains manual valves which do not have car seals.

In the original design of the drainage system, level metering and drain pumps were installed in the oily water tank. The level instrumentation and pumps were removed in 2001 and replaced with a solution where the liquid was conducted via a pressure-based level control to the sludge cell at the shaft base. This form of level control is unsuitable for a system where the density of the medium varies (varying composition of oil and water). Since level metering and high-level alarms were not installed, the CCR could not monitor whether the level in the oily water tank had risen beyond its normal position.

These system design weaknesses and the further weakening caused by the 2001 modifications have not been identified through analyses and assessments conducted before the latter changes, or during operation, maintenance and reviews of the drainage system. See nonconformities 6.1.1 and 6.1.2.

The incident demonstrates that equipment related to the open drainage system is highly significant for preventing acute discharges of oil to the sea. According to the existing consequence classification of the open drainage system, the oily water tank and control valve in U06 are considered to have low significance for safety (see nonconformity 6.1.3).

### 4.2.2 Preparations for maintenance

Isolation of loading pump A was not planned, executed, tested and supervised in a manner which satisfied internal requirements and ensured acceptable execution of the work. The investigation uncovered several errors and deficiencies in connection with the isolation work. See nonconformity 6.1.4.

Reference is also made to the HC leak on Gullfaks B of 4 December 2010, where a number of deficiencies were identified in preparing, verifying and approving the isolation plan, and to the measures described by Statoil for training and for follow-up of the work process for planning, setting and resetting isolation. /6/ The incident also shows that work is being not being done in accordance with the work process.

### 4.2.3 Management of simultaneous activities

Management of simultaneous activities was inadequate. Insufficient attention was paid to the possible consequences of transferring oil from Statfjord A to Statfjord C while loading pump A was simultaneously isolated for maintenance. See nonconformity 6.1.5.

# 5 Actual and potential consequences of the incident

## 5.1 Consequences of the actual course of events

The leak was detected at 03.24 on 26 January 2014. Stabilised oil from Statfjord A leaked out via fire seals to the cellar deck on Statfjord C.

Oil could also have been spilt to the sea via the overflow from the oily water tank in the open drainage system. See chapter 8 on uncertainty.

According to Statoil's investigation report, the total discharge is estimated to be about 42 $m^3$ of oil at a leak rate of 20.8 kg/s. /23/

Statoil's investigation report assumes that up to five per cent of the leak was dispersed over the installation, while the rest was spilt to the sea. The leak was detected by line detector C05-GD-112AR. See figure 4, taken from the Statoil investigation report. A gale (17.2-20.7 m/s) was blowing from the south-east when the incident occurred.

This means that the actual consequence was an HC leak with a rate of 20.8 kg/s, with about 40 $m^3$ discharged to the sea and roughly two $m^3$ dispersed over the platform.

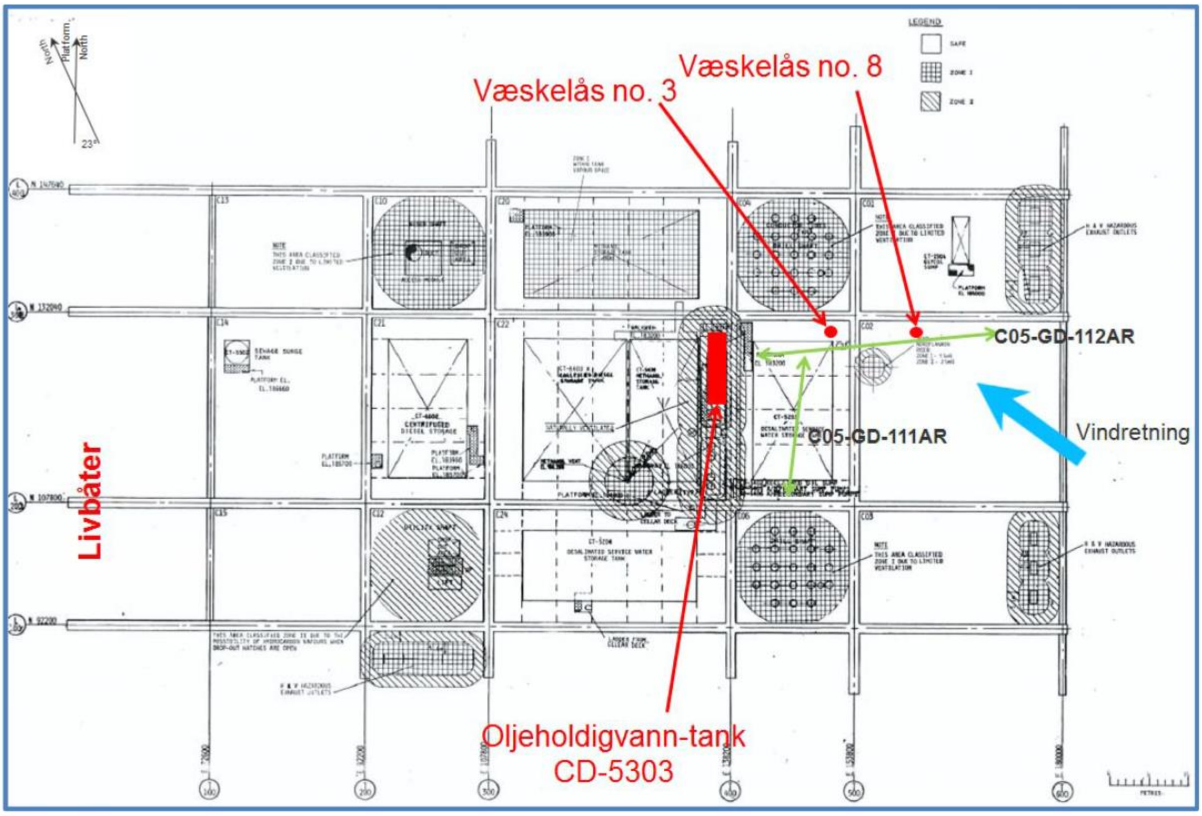


**Figure 4. Layout diagram showing the position of line detector C05-GD-112AR. (Source: Statoil's investigation report /23/)**

Observations by the PSA team on Statfjord C show that large areas were soiled by oil droplets. It was also informed that personnel who mustered at the lifeboats had been exposed to oil droplets/spray during the incident. AFFF was also applied manually to parts of the cellar deck, and the personnel involved were therefore exposed to the foam. According to Statoil's investigation report, no health problems have been reported for the people exposed after the incident.

## 5.2 Potential consequences

### 5.2.1 Risk of further leaks

The drain valve from the loading pump to the sump tank in the shaft was found to be in the open position and closed at 05.49 – in other words, two hours and 25 minutes after the leak was detected. Statoil's investigation report states that the sump tank level at that time was 62 per cent. Had the level reached 70 per cent again, discharge pumping of the sump tank would have resumed and could have caused another leak of corresponding duration and scope.

### 5.2.2 Risk of fire or explosion

Estimating the risk of fire and explosion with a leak of stabilised oil at about 20 kg/s and with a wind strength of about 20 m/s is difficult. No work permits were reportedly active on Statfjord C around the time of the leak, and welding contacts were automatically disconnected when HCs were detected on the cellar deck. The PSA team has concluded that the incident timing is arbitrary and ignition sources could have been present in the area exposed.

Annex G to the draft IEC standard /1/ related to area classification speaks of "flammable mist". The standard describes two conditions where ignition is possible – a cloud of small oil droplets is ignited (corresponding to a dust explosion or fire), or oil drops encounter a hot surface and are ignited as a liquid.

A paper on spray formation from liquid leaks was presented to the 2014 Tekna conference on fire and explosion security in the petroleum industry. /2/

The actual discharge during the incident can be divided into two different leak scenarios.

1. Leak from the flange on the cover of fire seal 8
A leak through the flange is likely to have been a spray leak, with the small oil droplets dispersed over some distance. That also accords with observations on the platform, including at lifeboat stations and in the drilling derrick.

2. Leak through overflows in fire seals
Leaks through fire-seal overflows have a more local distribution, with larger oil drops which are not dispersed to the same extent. That also accords with observed oil on the cellar deck and the upper part of the shafts.

#### 5.2.2.1 Potential consequences of a fire

A possible fire could have been a spray type (scenario 1) or combustion of oil drops/flowing oil (scenario 2) lasting about 37 minutes – equal to the duration of the leak.

A spray fire caused by a spray leak through the fire-seal flange (scenario 1) and lasting for 37 minutes could have caused local damage in the worst case, but would not have led to dispersal/escalation out of the area. This is based on the ability of fire walls and structures to resist fires of this kind for more than two hours /5/.

A fire caused by ignition of oil droplets/flowing oil from the fire seals (scenario 2) would have discharged to the sea and could have caused a minor blaze on the water around the discharge point and no escalation of the incident.

#### 5.2.2.2 Potential opportunity for an explosion

The incident is not likely to have led to an explosion because the droplets formed were too large.

# 6 Observations

The PSA's observations fall generally into three categories:

- nonconformities: observations where the PSA believes that regulations have been breached
- improvement points: observations where deficiencies are found, but insufficient information is available to establish a breach of the regulations
- other observations.

## 6.1 Nonconformities

### 6.1.1 Original design solution for drainage system

**Nonconformity**
Inadequate design solution for the drainage system.

**Grounds**
An inadequate design solution for the drainage system meant that liquid pumped from the sump tank in the shaft leaked out onto the cellar deck and to the sea.

The original design for the drainage system incorporated level metering and pumps for emptying oily water tank CD5303 in the open drainage system. Liquid both drained from the deck of the installation and pumped from shaft sump tank CT5305 could be received by the oily water tank. /19/ /23/ and interviews.

According to the regulations which applied when the facility was designed, closed drainage might be "combined with the open deck-drainage system from classified areas, in this case the deck-drainage system is satisfactorily equipped with water [fire] seals". The leak occurred because oil was pumped up into fire seals which were not designed to prevent oil from spilling to the sea.

Little difference in level exists between the overflow from the oily water tank and the fire seal on the cellar deck. Documentation for the system indicates a height difference of about 15 cm /20/. The overflow from the oily water tank has probably also contained a water column which may have blocked the overflow function, since water is denser than oil. This is not a robust overflow function.

A blockage in the overflow from the oily water tank is regarded as a possibility in the post-incident notification /20/. This is because heavy particles entering the tank will sink to the bottom and build up, and could ultimately block the overflow pipe.

Manual valves are installed on the overflow, bypass, inlet and outlet for the oily water tank. The P&ID /19/ indicates the normal position of these valves, but no locking. It was reported in interviews that the bypass valve, which should normally be closed, was found after the incident to be in the open position. This is not a robust solution for valves with such safety-critical functions as overflow, inflow and outflow.

Weaknesses in the original design have not been identified during operation and maintenance of the facility.

**Requirements**

- *Section 5 of the management regulations on barriers*
- *Section 82, sub-section 2, of the facilities regulations, see section 10, sub-section 1, on installations, systems and equipment, see section 3.4.7 of the regulations for production and auxiliary systems (1978) concerning drainage systems*
- *Section 82, sub-section 2, of the facilities regulations, see section 40 on open drainage systems*

### 6.1.2 Modified design solution for drainage system

**Nonconformity**
Inadequate analyses and assessments of the design solution before modifying the drainage system. Nor have weaknesses been identified in following up the system.

**Grounds**
Statoil failed to conduct the necessary analyses and assessments ahead of the modifications to the drainage system in 2001. Analyses /3/ carried out failed to provide an adequate decision base for ensuring that the changes met relevant health, safety and environmental requirements. Nor was this later exposed during operation and maintenance of the drainage system.

The original design for the drainage system incorporated level metering and pumps for emptying oily water tank CD-5303. The pumps and level metering instrumentation in the oily water tank were removed and replaced with a solution where the liquid was conducted via a pressure-based level control to the sludge cell at the shaft base. This form of level control is unsuitable for a system where the density of the medium varies (varying composition of oil and water). Since level metering and high-level alarms were not installed in the tank, control-room personnel could not check if it was exceeding the normal level.

Today’s design incorporates an overflow from the oily water tank. This is considered by API analyses /3/ to satisfy the shutdown function for high level in the tank. The analyses have failed to identify weaknesses or deficiencies in the design.

Nor were deficiencies identified by Statoil’s condition monitoring of technical safety (TTS) review in 2012 /26/. A number of the registered incidents related to the oily water system have resulted in discharges to the sea. /10/. Historical data received from maintenance and inspections do not refer to insufficient robustness as a challenge with the system /20/. In interviews offshore, however, several people reported that weaknesses in the drainage system design were known about.

**Requirements**
- *Section 5 of the management regulations on barriers*
- *Section 11, sub-section 1, of the management regulations on the basis for making decisions and decision criteria*
- *Section 16 of the management regulations on general requirements for analyses*
- *Section 21 of the management regulations on follow-up*
- *Section 82, sub-section 2, of the facilities regulations, see section 10, sub-section 1, on installations, systems and equipment, see section 3.4.7 of the regulations for production and auxiliary systems (1978) concerning drainage systems*
- *Section 82, sub-section 2, of the facilities regulations, see section 40 on open drainage systems*

### 6.1.3 Consequence classification of open drainage system

**Nonconformity**
Consequence classification of equipment related to the drainage system does not reflect its actual consequences for safety.

**Grounds**
The incident shows that equipment associated with the open drainage system is highly significant for preventing acute oil discharges to the sea. According to the existing consequence classification of the open drainage system, the oily water tank and control valve U06 are considered to have low significance for safety /21/.

*Requirement*
*Sections 46 and 49 of the activities regulations on classification and maintenance effectiveness respectively*

### 6.1.4 Preparations for maintenance

**Nonconformity**
Inadequate planning, execution, testing and supervision of work on isolating loading pump A.

**Grounds**
Isolation of loading pump A was not planned, executed, tested and supervised in a manner which satisfied internal requirements and ensured acceptable execution of the work. The isolation plan for loading pump A was prepared in connection with the August 2013 turnaround and later updated on 24 January 2014. See /14/.

The isolation plan was not prepared in accordance with Statoil's work process for planning, setting and resetting isolation /6/. The goal of the process is to plan, set and reset isolation in a secure manner. It contains the internal requirements which implements the requirements in the regulations, including such aspects as planning, barrier management and expertise.

According to this work process, a single valve should not be used against a pressurised piping system for import and export. The valve and blind list shows that isolation of loading pump A was planned on the basis of a single valve. Furthermore, no specifications were given for leak testing of the isolation valves or for how possible leaks and pressure build-up were to be identified.

The work process requires documented system knowledge and skills with the relevant system /6/. Statoil has not ensured that the personnel have adequate expertise for preparing and implementing the isolation plan. The PSA team has been told that people with a key role in preparing and implementing the isolation plan lacked the mandatory course in valve technology /27/.

Statoil's investigation report specifies that manometers were not installed on both sides of the isolation valves, so that only the downstream seat on HV30600 and the upstream seat on HV30601 were leak tested /23/. This was not identified when the work was being executed /14/. Statoil's investigation report states that the downstream seat in valve HV30601 was damaged, and that this was the cause of the leak through the valve.

The leak in isolation valve HV30601 was not identified. Statoil's investigation report estimates the leak rate through the valve at two-four litres per second. On that basis, the PSA team calculates that it would take 23-46 minutes to fill the piping and pump house for loading pump A (5.5 $m^3$). According to the work process, regular inspection is required when a single valve is used and the operating pressure is below 10 bar. The isolation plan did not specify regular inspection of the valves. It emerged from interviews that a check of pressure build-up in the pump house was conducted at the end of the day shift on 25 January 2014, but that this was not done regularly.

Work done on the isolation was not checked and approved. The night shift which began at 19.00 on 24 January 2014 shut valves for isolating loading pump A in preparation for correcting a diffuse leak on an orifice gauge. Drainage of oil from the piping segment and pump house for loading pump A began at 05.00 on 25 January 2014. The incident occurred almost a day after the isolation was set. No information was entered on the isolation plan to show that setting had been verified or that the operational system manager had approved the preparations.

Reference is also made to the hydrocarbon leak on Gullfaks B of 4 December 2010, where a number of deficiencies were identified in preparing, verifying and approving the isolation plan.

In a meeting with the PSA on 7 November 2013 /4/, Statoil described measures implemented by the company for training and for follow-up of the work process. The incident has demonstrated that work is still not being done in accordance with the work process.

**Requirements**
*Section 29 of the activities regulations on planning*
*Section 24 of the activities regulations on procedures*
*Section 5 of the management regulations on barriers*
*Section 14 of the management regulations on manning and competence*
*Section 21 of the management regulations on follow-up*
*Section 23 of the management regulations on continuous improvement*

### 6.1.5 Management of simultaneous activities

**Nonconformity**
Inadequate management of simultaneous activities. Activities which could be executed in combination with other activities were not defined.

**Grounds**
Interviews revealed that no assessment was made of the possible consequences of transferring oil from Statfjord A to Statfjord C while loading pump A was simultaneously isolated for maintenance.
The procedure for planning, setting and resetting isolation /6/ states that the applicable isolation plan must be checked against other active isolation plans to ensure that no conflicts arise between them. Nothing is said about assessing against other current activities on the system or facility.

Nor does the procedure for transferring oil from Statfjord A or B to Statfjord C /24/ contain requirements to assess such transfers against other current activities on the facility.

**Requirements**
*Sections 24 and 28 of the activities regulations on procedures and simultaneous activities respectively*

#### 6.1.6 Qualification and follow-up of expertise

**Nonconformity**
Inadequate qualification and follow-up of expertise.

**Grounds**
Inspection and interviews revealed that the contractor responsible for maintenance of fire seals had inadequate technical expertise. The cover of fire seal FS8 was installed with partly missing and defective bolts, a double set of gaskets, and strain washers between the gaskets. See figure 5. In the wake of the incident, Statoil's investigation team commissioned inspections of three fire seals and found that all had faulty gaskets and bolts /23/.

**Figure 5. FS8 – inadequate and defective bolts and a double set of gaskets in the cover, in addition to strain washers between the gaskets.**

**Requirements**
*Section 18 of the framework regulations on qualification and follow-up of other participants*
*Section 21 of the activities regulations on expertise*

### 6.2 Improvement points

#### 6.2.1 Technical operations documents

**Improvement point**

Technical operations documents have not been updated and formulated in such a way that they fulfil their intended functions. Nor were operations personnel sufficiently familiar with governing documents

**Grounds**
System and operations document SO0273 on water treatment – PD /16/ does not provide an adequate description of the function and operation of the drainage system for users and for training new personnel, as intended.

The level control function in the oily water tank, for example, is not described in section 2.2.6 on the open drainage system, but in section 2.2.9 on the system for treating recovered oil. Nor is a description provided of which valves are to be operated at start-up and in normal operation of the system. During the incident on 26 January 2014, a bypass valve for the oily water tank was open so that the liquid was not conducted via the collection tank as shown in the applicable P&ID /19/.

It emerged from interviews that procedure SO0281 for transferring oil from Statfjord A or B to Statfjord C /17/ /24/ was not known to a number of those involved with transferring oil.

**Requirements**
*Section 20 of the activities regulations on start-up and operation of facilities*

### 6.2.2 Disconnection of gas detection

**Improvement point**
Necessary measures and restrictions were not established when disconnecting detectors in the gas detection system in order to ensure that the barrier function was maintained.

**Grounds**
The alarm log /22/ shows that the gas detector which detected the leak (C05-GD-112AR) was blocked by the CCR at 03.26.39. The ART first confirmed the leak at 03.30, and then asked the CCR to activate ESD 2.

**Requirements**
*Sections 24 and 26 of the activities regulations on procedures and safety systems respectively*

### 6.2.3 ESD system did not prevent development of the hazard/accident

**Improvement point**
The discharging pump in the sump tank was not halted by activating the ESD system.

**Grounds**
Facilities must have an ESD system which prevents the development of hazards and accident conditions and limits the consequences of accidents.

The trend picture /15/ shows that the discharge pump in the sump tank was not halted by activating ESD 2 at 03.30, immediately after detection of the incident, but was stopped at 03.50 because the level in sump tank CT-5305 reached 40 per cent, after about 37 minutes.

**Requirements**

*Section 82, sub-section 2, of the facilities regulations, see section 33 on emergency shutdown system, see section 10 of the regulations for production and auxiliary systems (1978) concerning the emergency shutdown system*

### 6.2.4 Statoil's investigation

**Improvement point**
Causes of the HC leak have not been adequately clarified by the investigation, and the actual and potential course of events and consequences are insufficiently assessed.

**Grounds**
The PSA team considers that Statoil's investigation fails to address the underlying causes of the incident adequately. Reasons why weaknesses in the design of and modifications to the drainage system have not been identified in follow-up of the facility are not described. Not does the report discuss why a number of errors have again been committed in connection with preparing the loading pump for maintenance. Given earlier incidents where errors and deficiencies related to isolation of equipment have been revealed, and the measures taken by Statoil in recent years to reduce HC leaks, these causes should have been identified. The investigation also fails to address possible underlying causes for the failure of the operations organisation on Statfjord C to give adequate consideration to the possible consequences of simultaneous activities.

Statoil splits the leak of 20.8 kg/s into a discharge to the sea and an HC leak, and estimated that the latter accounts for five per cent of the total leak rate (1.04 kg/s). The leak has thereby been downgraded from larger than 10 kg/s (red 1) to between one and 10 kg/s (red 2). The PSA team takes the view that the leak rate must be independent of where the hydrocarbons ultimately end up. In its view, an HC leak has occurred with a rate of 20.8 kg/s, of which 40 $m^3$ were discharged to the sea and about two $m^3$ spilt on the facility.

Where the potential consequences are concerned, the PSA team does not agree with Statoil's assessments. In its view, the timing of the incident is arbitrary, and the possibility that ignition sources might have been present cannot be excluded. The potential course and consequences of HC spills should be mapped regardless of the probability of ignition. Statoil has not assessed the consequences of ignition with a view to identifying possible vulnerabilities on the facility.

**Requirement**
*Section 20 of the management regulations on registration, review and investigation of hazards and accidents*

## 6.3 Other comments

### 6.3.1 Securing the incident site

When the PSA team arrived on Statfjord C, equipment had been removed, the system water-jetted, filters cleaned, valves operated, and transmitters and control valves tested. In addition, system modifications had been initiated – including the installation of level meters. X-ray photographs were taken while water jetting of the system was under way, so that possible plugs in the system at the time of the incident could not be identified. The only action agreed with the PSA and the police was that fire seal 8 could be uninstalled and reinstalled, providing its condition was documented with photographs and any components replaced were preserved. Apart from FS8, the condition of the system was not documented.

This meant that the incident site was not intact, and it was not possible to achieve full certainty about the causes of the incident. See chapter 8 for a discussion of uncertainties.

### 6.3.2 Statoil's investigation

Statoil's investigation of the incident /23/ was conducted at level 2 of the corporate audit function (COA INV). The description of the course of events and the direct and underlying causes coincides by and large with the PSA team's own data and assessments. Where the quantity of oil discharged is concerned, the PSA team takes note of the assessments made and the calculations carried out for Statoil's investigation team.

However, the PSA team does not agree with Statoil's investigation team over classification of the leak. See also 6.3.2. Statoil divides the leak of 20.8 kg/s into a discharge to the sea and an HC leak, and estimates that the latter accounts for five per cent of the total leak rate. The PSA team believes the leak rate must be independent of where the hydrocarbons ultimately ended up. In its view, an HC leak at a rate of 20.8 kg/s has occurred, with 40 $m^3$ discharged to the sea and about two $m^3$ remaining as a spill on the actual installation.

Statoil does not classify the release of AFFF, since "this is not an accidental spill and should therefore not be classified according to the classification matrix for HSE incidents in UPN [Exploration and Production Norway]". In the PSA team's view, possible harm to the environment or personnel would be the same regardless of whether the release of AFFF resulted from an error or a conscious decision.

The PSA team does not agree with Statoil's assessments of the potential consequences. In its view, the timing of the incident is arbitrary and the possibility that ignition sources might be present cannot be excluded. Statoil should concentrate in its investigations on the consequences of ignition with a view to identifying possible vulnerabilities on the facilities. See section 20 of the management regulations on registration, review and investigation of hazards and accidents.

Section 6.3 of Statoil's investigation report on assessment of major accident risk does not give more detailed consideration to the possible consequences of "lighter wind and lower waves, corresponding work in the shaft which would have given corresponding pumping-up of oil from sump tank C5305, a similar wind direction and the time of day with less daylight". These factors should also have been assessed for their contribution to major accident risk.

Statoil writes that the downstream seat of HV30601 was damaged, so that oil ran from the loading manifold side down towards loading pump A. At the same time, the report notes that the seal in this type of valve is provided by the seat on the pressure side. The PSA team has been informed that no physical check had been made of the valve interior /27/. It is unclear whether the valve leaked because the valve was not designed to seal in the direction used during the isolation, or because the valve seat was damaged.

The Statoil investigation report does not comment on the uncertainty described in its appendix F, which includes uncertainty related to metering data and how the metered data should be assessed and interpreted. In addition, the summation in the appendix states that “no failure has been identified as the root cause”. This is also not commented upon in the report.

The PSA team considers that Statoil’s investigation does not adequately address the underlying causes of the incident. It does not describe the reasons why weaknesses in the design of and modifications to the drainage system have not been identified in follow-up of the facility. Not does it cover the reasons why a number of errors have again been committed in connection with preparing the loading pump for maintenance, given earlier incidents where errors and deficiencies related to isolation of equipment have been identified and the measures adopted by Statoil in recent years to reduce HC leaks. Moreover, the investigation does not look at the underlying reasons for the failure of the operations organisation on Statfjord C adequately to assess the possible consequences of simultaneous activities.

## 7 Barriers which failed to function

The PSA team has not identified barriers which failed other than those mentioned above. Feedback from those it talked with about the emergency response leadership’s handling of the incident was generally good.

# 8 Discussion of uncertainties

As mentioned in section 6.3.1, the incident site was not intact when the PSA team arrived on Statfjord C and it is not possible be fully certain about the causes of the incident. Uncertainties related to the course of events and the causes are discussed in order to assess which are the most probable.

## 8.1 Restrictions in the drainage system

The leak has been caused by restrictions in the drainage system. These could have been in the inlet, outlet or overflow for the oily water tank.

The inlet to the oily water tank could have been blocked because the manual inlet valve was in the closed position. The P&ID shows that this should normally be open, but not locked /19/. It was reported in interviews that the valve was found in the open position after the incident. The inlet could also have been wholly or partly blocked by deposition. The 2013 turnaround probably led to more sedimentation and deposition in the inlet chamber than during normal operation. Print-outs from the maintenance programme show that no internal inspection of the tank was conducted after the 2013 turnaround. This means that a blockage of the inlet by deposition cannot be excluded as a factor of some significance in the causes of the incident. This assumes that the bypass valve to the tank was closed at the time of the incident. It was reported in interviews that the bypass valve was found in the open position after the incident. Were the inlet to the oily water tank blocked, a larger proportion of the oil could have been discharged to the sea than Statoil has calculated.

The oily water tank has an overflow function to the seawater return system if the tank level becomes too high. This function was not operational when the incident occurred.

The inlet to the overflow for the oily water tank is located near the bottom of the tank prechamber. The overflow function could have been blocked by deposition caused, for example, by the 2013 turnaround as mentioned above.

A manual valve is also installed on the overflow for the oily water tank. The P&ID indicates that this should normally be open but not locked /19/. This valve could have been closed during the incident. It was reported in interviews that the overflow valve was found in the open position after the incident.

Because the inlet chamber to the oily water tank normally contains mainly water, the overflow from the tank could have been blocked to oil because of the difference in density between oil and water. The PSA team considers that the height difference between the overflows on the fire seals and on the oily water tank could have been sufficient to press the water out of the tank overflow, particularly if the water column in the overflow comprised a mix of oil and water. Should the overflow function have functioned wholly or in part during the incident, a proportion of the oil might have been discharged directly to the sea via the seawater return.

Oil pumped from the sump tank in the shaft can flow to the storage cell via either the oily water tank or the tank bypass. The P&ID for the oily water tank shows that the bypass valve should be normally closed (NC) /19/. It was reported in interviews that the valve was found in the open position after the incident. This could have meant that a large volume of foreign bodies were not separated out, and increased the probability of a blocked filter upstream from the control valve in the shaft.

The outlet for the oily water tank also has a manual valve, which should normally be in the open position according to the P&ID, but not locked /19/. It was reported in interviews that the valve was found in the open position after the incident.

As mentioned above, the position of manual valves at the time of the incident was not reported in interviews with the personnel involved. The PSA team was unable to verify the actual position of the valves during the incident. See section 6.3.1. It has assumed that the information from the interviews is correct.

A blocked filter in the shaft could mean that the liquid in the oily tank was not drained to the storage cell. The filter is located between the transmitter for measuring liquid pressure and the valve. If the filter was wholly or partly blocked, some of the oil from the two first oil pump-outs of the sump tank could also have been discharged to the sea, since Statoil’s calculation of the oil quantities assumes that the oil has flowed to the storage cell when the control valve was in the open position. It was reported in interviews that a good deal of rubbish was found in the filter after the incident.

## 8.2 Other uncertainties

Sump pump GP5304B began the third discharge from the sump tank to open drainage at 03.13.27. About 2 ½ minutes later, at 03.15.55, gas detector W30-GD-101 A reported contamination. This could have been the first warning that liquid was emerging from fire-seal overflows, which again caused contamination of this detector on W30. The leak was first detected with certainty at 03.24.50 in C-05. This could mean that the leak began about nine minutes earlier.

As mentioned in section 6.2.4, uncertainty prevails about whether the downstream seat of HV30601 was damaged or the valve used for isolation was designed to seal against the pressure side. The PSA team has been told that no physical check was made of the valve interior /27/. Whatever the cause of the leak through the valve, however, the outcome would have been the same.

The hydraulic evaluation commissioned by Statoil’s investigation team /23/ notes that measured values for pressure and pumping rates are difficult to interpret on the basis of simple hydraulic assessments. This could mean that some uncertainty exists about whether all contributory causes have been identified.

# 9 Appendices

## 9.1 Appendix A: The following documents have been used in the investigation


/1/ Explosive atmospheres, part 10-1: Classification of areas – Explosive gas atmospheres 60079-10-1/Ed 2/CDV IEC

/2/ Spraydannelse ved væskelekkasjer, Jan A Pappas, Tekna conference on fire and explosion security in the petroleum industry 2014

/3/ Analyses, design, installation and testing of basic surface safety systems on offshore production platforms, API RP 14C

/4/ Minutes of meeting on 7 November 2013 – audit of preventive measures for HC leaks (activity no 001000090), case no: 2011/1043

/5/ Spesifikasjon for dimensjonerende ulykkeslaster – Statfjord, TR1069, version 1

/6/ OM 05 July 2001 – Planlegg, sett og tilbakestill isolering, revisjon 1.7

/7/ Varsel om uønsket hendelse forurensing utslipp HC lekkasje - Statoil Statfjord C - Oljeutslipp 26 January 2014. Vedlegg 1 - Oversendelsesmelding.

/8/ Oppsummert forberedelser og tiltak før produksjonsstart - Mandat for arbeidsgruppe - Informasjon ifm uønsket hendelse forurensing utslipp Statoil Statfjord C - Lekkasje fra åpent dreneringssystem til sjø 26 January 2014.

/9/ Verification of the drainage system 30 January 2014.

/10/ Overview of Synergi cases – oily water 31 January 2014.

/11/ Presentation pack O2 in E1 – Statfjord B-C (2)

/12/ CCR shift log 25012014 - 26912914 - operations log Statfjord C.

/13/ Vedlegg 6 - 4A Hendelsesliste 26012014 Statfjord C - 4B Alarmlogg brann og gass.

/14/ Isolation plan, WO no 22751138

/15/ Trend images

/16/ OMM SO0273 Vannbehandling PD Statfjord C - Advisory document Statoil.

/17/ SO0281 Kap 2 systembeskrivelse - Lastesystem for råolje PE - Statfjord C - Advisory document Statoil.

/18/ Gransking Statfjord C - Beredskapslogg. Vedlegg 4 - SFC oljelekkasje logg 2 linje. 17 February 2014.

/19/ Piping and instrument drawings (P&ID) – Dokumenter ifm uønsket hendelse forurensing utslipp HC lekkasje oljeutslipp Statfjord C 26 January 2014.

/20/ Periodisk vedlikehold - Dokumenter ifm uønsket hendelse forurensing utslipp HC lekkasje oljeutslipp Statfjord C 26 January 2014.

/21/ Responses to questions related to undesirable incident HC leak - Statfjord C investigation of oil leak 26 January 2014. E-mail dated 17 March 2014

/22/ Alarm log, pages 1-6,

/23/ Granskingsrapport etter uønsket hendelse utslipp oljeutslipp til sjø fra Statfjord C 26.1.2014. Vedlegg 1 - Granskningsrapport Oljeutslipp SFC 260114.

/24/ Opplysninger vedr Statfjord C uønsket hendelse oljeutslipp 26.1.2014. Vedlegg 1 - CP_B00_BB_215_002.

/25/ PSA's internal incident base

/26/ Application to the PSA for consent to extended operation of Statfjord C and the Statfjord satellites AU-DPN OS SF-00067

**/27/** E-mail dated 15 July 2014 from Statoil

## 9.2 Appendix B: Overview of personnel interviewed

This list is not published on the internet and is included in a separate document.

## 9.3 Appendix D: Abbreviations

AFFF – Aqueous film-forming foam
API – American Petroleum Institute
ART - Alarm and rescue team
CCR – Central control room
COA INV – Corporate audit investigations
DFU – Defined hazard and accident condition
ESD – Emergency shutdown
F&G – Fire & gas
FS – Fire seal
GVI – General visual inspection
HC – Hydrocarbon
HSE – Health, safety and the environment
HTO – Human-technological-organisational
$H_2S$ – Hydrogen sulphide
IEC – International Electrotechnical Commission
ISS – Insulation, scaffolding and surface treatment trades
NO – Normally open
NC – Normally closed
LEL – Lower explosive limit
LELm – Lower explosive limit metre
NDT – Non-destructive testing
Nofo –Norwegian Clean Seas Association for Operating Companies
O&M – Operation and maintenance
PI - Plant information
PIV – Platform internal verification
PM – Platform manager
POB – Personnel on board
P&ID – Piping and instrumentation diagram
PSA – Petroleum Safety Authority Norway
PT – Pressure transmitter
SAR – Search and rescue
SFA – Statfjord A
SFC – Statfjord C
STC – Statfjord C
TTS - Condition monitoring of technical safety
We – Weber number
WO – Work order