PETROLEUMSTILSYNET

Investigation report

Report	
Report title Report of the investigation into an unplanned emergency shutdown and acute oil spill to the sea on the Eldfisk complex in the period 6-8 August 2014	Activity number 009018525

Security grading		
☑ Public	☐ Restricted	☐ Strictly confidential
☐ Not publicly available	☐ Confidential	

Summary

This investigation report covers two incidents on the Eldfisk complex during the period 6-8 August 2014. The first of these was an unplanned emergency shutdown (yellow ESD) caused by the technical failure of an ESD output card combined with a design error. Restarting production after this incident resulted in an acute oil spill to the sea via the drain system. The direct cause of the spill was that a blowdown valve remained in the open position while production was starting up.

Involved	
Main group T-2	Approved by/date Erik Hørnlund 2 June 2015
Members of the investigation team Irene B Dahle, Anthoni Larsen, Lin Silje Nilsen, Jorun Bjørvik	Investigation leader Bård Johnsen

Contents

1 SUMMARY

This investigation report covers the two undesirable incidents which occurred on the Eldfisk complex on 6-8 August 2014. The first of these was an unplanned emergency shutdown at yellow ESD level. Restarting production after this incident resulted in an acute oil spill to the sea via the drain system.

At the time of these incidents, the Eldfisk complex and Embla were in an interim phase characterised by a high level of activity with many jobs being pursued simultaneously. Regular operation was continuing at the same time as modifications were being made to Eldfisk A, E, FTP and Embla. The new Eldfisk S facility was to be phased in. In that connection, commissioning, and preparations for operation and to connect a jack-up drilling rig were under way. Embla was staffed and well intervention was taking place there.

Personnel on board (POB) the Eldfisk complex was about 750. To accommodate this large number, the *Haven* flotel was connected to Eldfisk S by a bridge. A number of the safety systems (such as PA, phone, APRS and SAS) had been modified to handle the interim phase with simultaneous operation of old and new equipment.

Course of events

Around 09.30 on 6 August 2014, the highest emergency shutdown level (yellow ESD – abandon platform) was initiated on the Eldfisk complex and Embla. This caused total loss of power and all systems shut down on Eldfisk A, FTP and Embla, while Eldfisk E lost main power. ConocoPhillips defines total loss of power as an emergency (DSHA 16).

The ESD was initially considered a technical failure rather than an emergency. That caused delays to and uncertainty about mustering. People were dispatched to the plant areas as roving patrols and some technical personnel mustered in the control room for troubleshooting. The mustering period lasted about three and a half hours.

Preparations for restarting production began on the Eldfisk complex when main power was restored in the afternoon of 6 August (about 15.30). At that time, the temperature in the central control room (CCR) on Eldfisk FTP was 35°C. Night-shift personnel who had participated in normalisation work departed to rest (night-shift personnel without emergency response functions in the control room went off duty at 13.30). It was decided to implement the planned shift change at 19.00. Because of the swing shift rota, the day shift was due to come on duty again at 03.00. Preparations for the restart continued during the evening in parallel with work aimed at restoring main power on Embla.

Three wells came back on stream at 22.30. Establishing pressure and level in the separator took time, and the oil outlet from the separator was largely closed until a little before 02.00. Soon after it had been opened for export, a high level was detected in the flare system's condensate pot. A low point exists in the header to the flare knockout drum which drains automatically via the condensate pot to the drain system. The condensate pot liquid outlet valve was observed to be closed, and was opened.

About 10 minutes after the valve was opened, an alarm indicated a high level in the oil sump. The plant operator went out to check, and observed at the same time that liquid was flowing from the hose connected to the siphon breaker on the overflow line from the collection sump. For about 90 minutes from 02.15, various level alarms were activated by liquid accumulation in the flare system and in drain system tanks. These alarms were contradictory at times. It was basically assumed that the liquid was a result of the blowdown in connection with the ESD earlier in the day and gas condensed owing to a high temperature in the separator. When piping from the condensate pot was reported to be hot around 03.45, troubleshooting began to

identify the source feeding the flare system. An open blowdown valve was identified and closed at 04.40. The position was then regarded as clarified.

At first light around 05.30 on 7 August, oil was observed on the sea. Suspicion eventually fell on the drain system as the source of this acute spill. The sea sump is the last collection tank for the drain system, and partially submerged with its lower end open to the sea. Sampling of the liquid content in the sea sump showed that the seawater had been displaced and the tank was full of oil. The sea sump pump was started to remove the oil. Production was not shut down until 13.30 on 7 August, when the size of the oil slick appeared to be increasing. The oil spill is estimated to have been in the order of 50-70 m^3.

Causes and factors influencing risk

The CCR for the Eldfisk complex is located on Eldfisk FTP and functions as a hub for monitoring and controlling operation of the complex, including production on Embla. Known challenges exist with human-machine interfaces and the level of staffing in the CCR. No total overview for the status of blowdown valves (BDVs) is available. Weaknesses also exist with regard to possibilities for erroneous operation of valves and presentation of alarms.

The direct cause of the yellow ESD was the technical failure of an output card in the ESD system, combined with a design error. A failure in a single output card should not normally result in a yellow ESD. An underlying design error (see figure 4), where the shutdown signals to the isolation breaker for both UPS A and UPS B were connected to the same output card in the ESD node, contributed to the failure of the output card causing a yellow ESD. The output card is located in a new local equipment room (LER) on Eldfisk A. Several incidents in recent years with yellow ESDs caused by technical failures are part of the backdrop for the way the incident on 6 August was handled.

Where the acute oil spill is concerned, the direct cause was a BDV which remained in the open position during production start-up. That caused produced oil to flow into the flare system, on into the drain system and from there to the sea. The failure of components in the drain system combined with limited opportunities for detecting and comprehending the incident in time are conditions which enable a single mistake to result in an acute oil spill.

The ESD and its consequences also formed of the backdrop to the acute oil spill. Work on restarting production began immediately after the emergency had been normalised. Assistance was provided for normalisation on Embla in parallel with production start-up on Eldfisk. Working conditions for the control room operators were burdensome during the emergency and subsequent normalisation. During planning of the production start-up, the decision was taken not to alter the shift rota. Personnel starting the night shift at 19.00 had not been given the opportunity for compensatory rest time.

Consequences

Acute oil spill to the sea, estimated at 50-70 m^3 of stabilised oil.

Potential consequences

- The decision to restart production from the Eldfisk complex without adequately checking the preconditions for start-up and operation, and confirming that these were fulfilled, could have had serious consequences for both the Eldfisk complex and Embla under different circumstances.
- A bigger acute oil spill if the leak source had been discovered at a later time.
- The liquid outlet from the condensate pot was shut in connection with the start-up. Had this not been discovered, the flare system could have filled with oil. A

simultaneous need for a blowdown with a sufficient quantity of gas and pressure potential would have caused pressure to build up in the flare system beyond its design level. That could have led to ruptured piping with a consequent hydrocarbon leak, fire or explosion.

Investigation

The Petroleum Safety Authority Norway (PSA) resolved on 7 August 2014 to investigate both these incidents, partly in order to identify possible connections between their causes and consequences.

Observations

Eleven non-conformities were identified by the investigation. These relate to:

- risk management during start-up of production after the emergency shutdown (yellow ESD)
- off-duty periods
- safety clearance when restarting production
- procedures
- robustness against single errors and faults in safety systems
- verification of design requirements for the safety systems before start-up and operation
- lack of independence between control and shutdown functions for level measurement
- barrier management, risk assessments and analyses in connection with modifications
- updating of documentation in connection with modifications
- consequence classification of systems and equipment
- maintenance programme for the drain system.

Two improvement points were also identified:

- performance requirements for emergency response
- training and drills.

Other comments

- Managing the risk of acute pollution
- Earlier and subsequent incidents with yellow ESD
- Routines for handover from project to operations
- Handover at shift change
- Notification and reporting of hazard and accident conditions to the regulator

2 DEFINITIONS AND ABBREVIATIONS

APRS	Automated personnel registration system
BDV	Blowdown valve
CoPSAS	ConocoPhillips Scandinavia AS
Criop	Crisis intervention and operability
DSHA	Defined situations of hazards and accidents
ELD	Eldfisk
ESD	Emergency shutdown
FeBS	Field emergency response centre
F&G	Fire and gas
FTP	Field terminal platform
Hazop	Hazard and operability analysis
HTO	Human, technology, organisation
LER	Local equipment room
LoBS	Local emergency response centre
LSH	Level switch high
LSHH	Level switch high high
LSLL	Level switch low low
NGL	Natural gas liquids
NO	Normally open
PA	Public address
PACOS	Public address communication system
PAGA	Public address and general alarm systems
P&ID	Piping and instrumentation diagram
PDO	Plan for development and operation
POB	Personnel on board
PSA	Petroleum Safety Authority Norway
PSD	Process shutdown
SAP	Systems, applications & products
SAS	Safety and automation system
CCR	Central control room
Swing shift	Established rota for control room operators moving from night to day shift after the first week offshore. It means less rest time and more shift handovers, but helps to reduce “jet lag” when arriving home.
TaBS	Tananger emergency response centre (onshore)
TER	Telecommunication equipment room
UPS	Uninterruptable power supply
WP	Work permit

3 INTRODUCTION

The Eldfisk oil field lies due south of Ekofisk at the southernmost end of the Norwegian North Sea. Oil and gas are carried through the export pipelines via the Ekofisk centre. Gas from the Ekofisk area is piped to Emden, while the oil – which contains the NGL fractions – travels by pipeline to Teesside.

Eldfisk was originally developed in 1979 with three installations:

- Eldfisk B, free-standing combined drilling, wellhead and process facility
- Eldfisk A, combined quarters, drilling, wellhead and process facility
- Eldfisk FTP, combined wellhead and process facility.

Eldfisk A and FTP are connected by a bridge.

Embla is a normally unstaffed installation located due south of Eldfisk. Installed in 1993, it is tied back to Eldfisk FTP via pipelines and submarine power cables.

Eldfisk E was installed on the field in 1999 to make provision for water injection. This facility also delivers a quantity of injection water to Ekofisk through a pipeline to Ekofisk K.

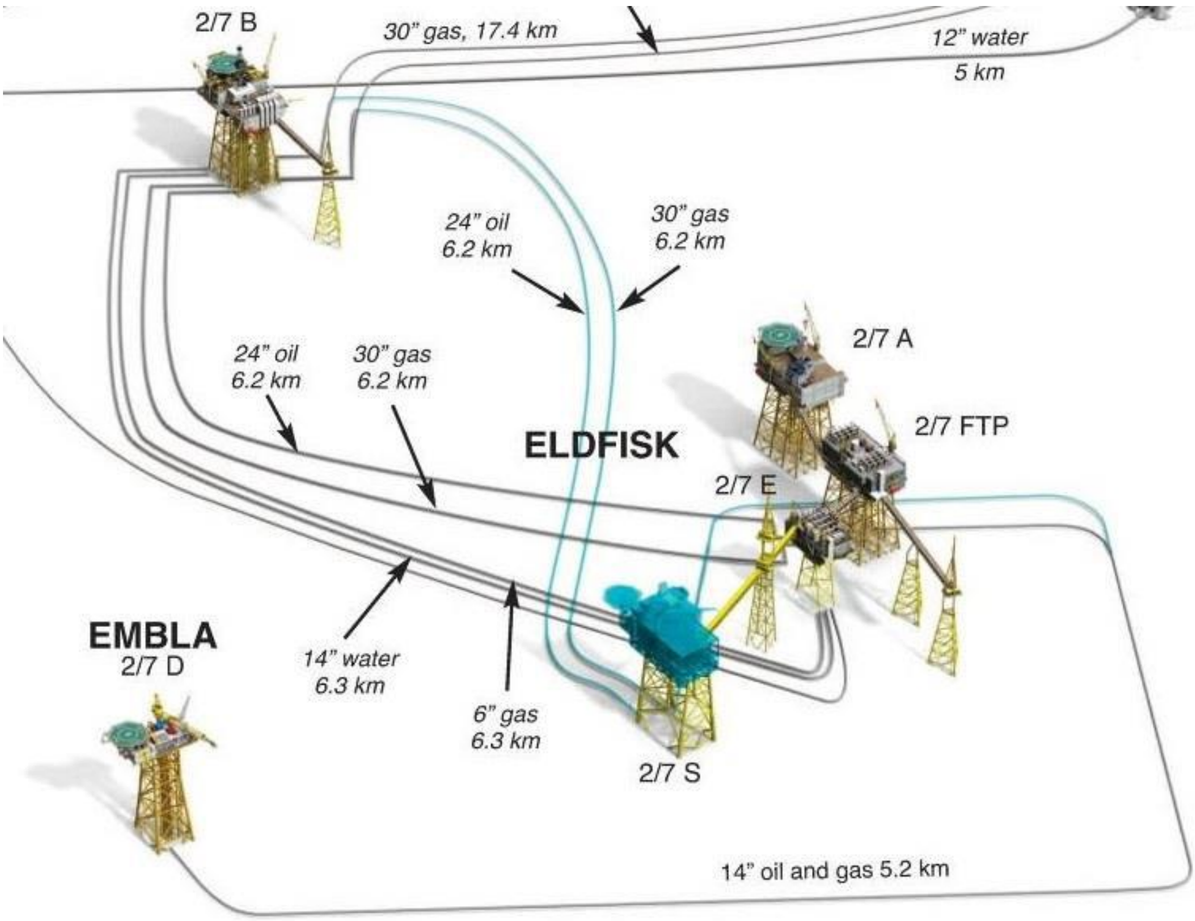

Figure 1: Overview of the Eldfisk area. **Source: ConocoPhillips**

CoPSAS was in the completion phase of the Eldfisk II project in August 2014 in order to adapt Eldfisk for future use. The project covered the installation of a new Eldfisk S platform with a flare stack on a new bridge support, and new bridges to Eldfisk E. In addition came modifications to Eldfisk A, FTP, E and Embla. The PDO for Eldfisk II was approved in June 2011.

The PSA gave consent to taking Eldfisk S into use on 2 July 2014, and the facility was in the offshore completion phase in August 2014. Eldfisk S is the new field centre for the Eldfisk complex, and the new CCR will take over all monitoring and control of the facilities in the complex. The *Haven* flotel was used to meet the required staffing level in the project completion and start-up phase, and linked by a bridge to Eldfisk S .

A yellow ESD was initiated on the Eldfisk complex and Embla on 6 August 2014. The direct cause of the incident was technical failure of an output card in the ESD system, located in a new LER on Eldfisk A. Yellow is the highest shutdown level in the ESD system and corresponds to abandon platform shutdown (APS). See Norsok S-001. Eldfisk A, FTP and Embla were shut down and Eldfisk E lost main power. Operational preparations were the only activity on Eldfisk S, which was therefore regarded as a “cold” platform – in other words, no hydrocarbons had been introduced – and was not affected by the incident.

At dawn on 7 August, an oil leak was observed in the sea at Eldfisk FTP. This is estimated to have been in the order of 50-70 m^3. The direct cause was that a BDV downstream of the oil metering package on Eldfisk FTP had remained in the open position during the start-up following the yellow ESD the day before. Produced oil thereby flowed into the flare system, on into the drain system and from there to the sea.

The Petroleum Safety Authority Norway (PSA) resolved on 7 August 2014 to investigate both these incidents, partly in order to identify possible connections between their causes and consequences.

Composition of the investigation team

- Anthoni Larsen — F-logistics and emergency preparedness, emergency preparedness
- Jorun Bjørvik — F-process integrity, process safety
- Irene B Dahle — F-working environment, organisational safety
- Lin Silje Nilsen — F- HSE – management, risk management
- Bård Johnsen — F-process integrity, electrical/automation, investigation leader

The investigation has been conducted in the form of inspections, a review of governing documents, and interviews with personnel on the Eldfisk complex from 12-15 August 2014. Further information has been obtained through interviews with personnel at the CoPSAS operations organisation in Tanager on 28 August and 4 September 2014, and a review of CoPSAS’ investigations of the incidents.[1]

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.*

[1] While the investigation was under way, a similar yellow ESD incident occurred on 7 September 2014 on Eldfisk FTP, A, E and Embla. In view of the current investigation, CoPSAS was called to a meeting at the PSA’s premises on 10 September to provide a more detailed account of causes, measures and lessons learnt from the incident. See also appendix E.

c. *Assess direct and underlying causes, with an emphasis on human, technical, operational and organisational (HTO) aspects, 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 which have helped to prevent a hazard from developing into an accident, or which have reduced the consequences of an accident).*
g. *Assess the player's own investigation report (our assessment will be communicated in a meeting or by letter).*
h. *Prepare a report and a covering letter (possibly with proposals for the use of reactions) in accordance with the template.*
i. *Recommend – and contribute to – further follow-up.*
j. *Follow up investigations by ConocoPhillips of the ESD and discharge incidents.*

The police decided not to investigate the incident.

CoPSAS decided to conduct its own investigations of the incidents.

4 CONTEXT OF THE INCIDENTS – ELDFISK COMPLEX

In the period before the incident, the Eldfisk complex and Embla were in an interim phase, with normal production on existing facilities while completion and start-up activities were under way on Eldfisk S.

Staffing was high on the Eldfisk complex (POB about 750) and the *Haven* flotel was linked to Eldfisk S by a bridge. A number of players were represented, including operations personnel, Eldfisk II project staff, and employees from suppliers and contractors. Embla was staffed (POB 17).

The interim period was characterised by a high level of activity with many jobs being pursued simultaneously, such as:

- normal operation on Eldfisk A, FTP and E and Embla
- modifications to the existing Eldfisk A, FTP and E facilities as well as Embla to cater for life extension and the installation of Eldfisk S
- completion activities and preparations for start-up of Eldfisk S
- preparations to connect a jack-up rig for use on Eldfisk S during the 2015 drilling campaign
- well intervention work on Embla.

Figure 2: Overview of the Eldfisk complex. **Source: ConocoPhillipS**

The CCR for the Eldfisk complex is located on Eldfisk FTP and functions as a hub for monitoring and controlling operation of the complex, including production on Embla. Part of the Eldfisk II project involves replacing the CCR on Eldfisk FTP with a CCR on Eldfisk S as soon as the latter becomes operational.

Two workstations in the CCR are staffed at all times by control room operators. One of these is responsible for monitoring and controlling Eldfisk A and FTP as well as Embla. The other handles Eldfisk E in addition to serving as coordinator (leader) of the CCR. In addition, a plant operator monitors and operates systems and equipment in the plant.

Handover at shift changes largely takes place verbally, with some use of e-mail. A number of the safety systems (such as PA, phone, APRS and SAS) have been modified to handle the interim phase with simultaneous operation of old and new equipment until the Eldfisk S platform comes on line.

5 EMERGENCY SHUTDOWN WITH YELLOW ESD

A yellow ESD occurred on 6 August 2014 on the Eldfisk complex and Embla as the result of the technical failure of an output card in the ESD system in a new LER on Eldfisk A. CoPSAS has previously also experienced a number of similar incidents causing a yellow ESD with total loss of power on its facilities. See appendix E.

5.1 Course of events – chronologically

Wednesday, 6 August 2014
The course of events is based on logs from the local emergency response centre (LoBS) /6/, interviews and the list of alarms received /7/.

09.30 – CCR on Eldfisk FTP observed an abnormal increase in the number of alarms.

09.35 – A blue ESD occurred with the loss of main power on Eldfisk A, FTP and E, followed by a general alarm for the whole Eldfisk complex with the exception of *Haven*. No personnel with emergency response functions were accommodated on *Haven*, and general alarms were not distributed automatically to the flotel – only to its control room and the bridge. The CCR announced a blue ESD over the PA system, and told people to await further information. Soon afterwards, Eldfisk A and FTP went down with a yellow ESD. At that point, the CCR attributed this to a technical fault. POB on the Eldfisk was 743. The CCR reported on the position over the PA system and hot work ceased.

A yellow ESD on the Eldfisk complex activated a UPS yellow ESD on Embla with the loss of main and emergency power, including UPSs. That meant the absence of vital safety systems, local operator stations for monitoring and control and so forth. Embla had 17 people working on well intervention, but was not in a critical phase when the blackout occurred. No general alarm was initiated on Embla. Pursuant to its design, this happens only in the event of local incidents on the facility and not when these occur on the Eldfisk complex.

09.41 – Well-service personnel confirmed that no downhole activities were under way.

09.43 – LoBS established. Roving patrols were dispatched around the plant on Eldfisk A and a green light was given to start the emergency compressors on Eldfisk A to prevent an unwanted start to deluge. Confirmation was given that no loads were hanging in any crane on Eldfisk A, FTP or E.

09.45 – The emergency response leader decided to announce over the PA system (in Norwegian and English) that personnel should muster on the bridges. Because of a blown fuse in the power distribution to the PA system in the Eldfisk A radio room, only part of the message was relayed over the system. Personnel on Eldfisk S and *Haven* failed to muster. A general alarm sounded throughout the complex, with the exception of *Haven* and with reduced coverage of Eldfisk A because of the failure of the old PA system. See figure 5. The FeBS was notified.

09.50 – CCR initiated a review of start-up procedures following a yellow ESD on Eldfisk A and a black start of the emergency air compressor. The LoBS decided to post fire guards (with radios) in strategic areas of Eldfisk A, FTP and E to warn of possible other incidents.

09.56 – General alarm was still active and efforts were made to deactivate the alarm from the control panel in the radio room on Eldfisk A's deck 6. The general alarm is distributed via the new PACOS A and B in the new LER, and cannot be deactivated as long as the alarm signal from the ESD node remains active in the event of a power outage.

09.59 – The PA system on Eldfisk A was no longer active, and the LoBS accordingly could not use it for further announcements.

10.10 – Blue ESD verified. Emergency generator on Eldfisk E in operation.

10.12 – Muster call sent to TaBS.

10.25 – As a result of the power outage, the CCR had lost the systems for monitoring and control – operator stations, displays and the SAS, including ESD, fire and gas detection, and so forth. The CCR initiated a review of the start-up procedure for establishing emergency power, and several attempts were made to energise the "old" UPS B on Eldfisk A. Although the unit is designated for this duty, that proved impossible because of inadequate capacity. A forced start of the emergency generator on Eldfisk was accordingly implemented, primarily to energise control and monitoring systems in the CCR.

10.37 – APRS was not operational because the network server on Eldfisk A was down. The decision was accordingly taken to use couriers to transfer POB lists to Eldfisk S for manual checking in DaWinci. To establish control over POB, it was resolved to sound the muster alarm on Eldfisk S and *Haven*.

10.37 – Control room operators went to the new LER on Eldfisk A to start up the SAS nodes in order to restore the operator stations for control and monitoring in the CCR. To establish emergency power without UPS, an improvised solution for energising was adopted. Missing password (recently changed) and the time taken to obtain this meant it took about 30 minutes to log onto the operator stations.

11.07 – Servers, nodes and operator stations for Eldfisk A and FTP began to restart, but were somewhat unstable.

11.30 – The first POB status was provided, after almost two hours. This showed that 37 people were unaccounted for.

11.42 – A new POB status showed 31 people still unaccounted for. TaBS demobilises.

11.43 – Eldfisk complex up to blue ESD. Operator stations and displays in the CCR were now up, but all information was lacking from nodes and servers in the new LER.

11.49 – All control and monitoring systems in the Eldfisk FTP CCR were back in operation.

11.51 – A new POB status showed that 23 people were still unaccounted for.

Abt 12.30 – Both PA systems in the new LER on Eldfisk A were bypassed, which resulted in deactivation of the general alarm.

12.45 – Emergency response leader reviewed what might need to be done if the Eldfisk complex was not back in normal operation by 14.00.

Abt 1300 – General alarm deactivated on the whole Eldfisk complex, including Eldfisk S and *Haven*.

13.09 – Full POB reported for the Eldfisk complex, including Eldfisk S and *Haven*. The emergency response leader then announced information on the incident and the position.

13.10 – The defective output card in the ESD node was replaced and all faults in the new LER on Eldfisk A were corrected.

13.54 – Mustered personnel could move from the bridges to the mess to get a meal.

14.21 – Emergency power established on Eldfisk A and FTP.

15.21 – Main generator B in operation and main power partially established for Eldfisk A and FTP.

5.2 Emergency response conditions during the incident

According to the emergency preparedness plan for the Eldfisk complex /11/, incidents involving a loss of power must be treated as an emergency with a specific action plan.

This incident was not initially regarded as an emergency but as a technical failure. That perception meant it took 10 minutes (see chapter 5.1) before the emergency response leadership on the Eldfisk complex decided to muster personnel on board.

Because of the delay, uncertainty arose among personnel about whether they were supposed to muster. At this time, the LoBS assumed that the APRS was functioning normally and that data could be obtained from it on Eldfisk S and *Haven*. As a result, only personnel on Eldfisk A, FTP and E were told to muster. After an hour and seven minutes, it was verified that the APRS was not functioning on Eldfisk S and *Haven* either, which led to full mustering on these facilities as well.

To get control over POB, the LoBS decided to use yellow lists taken by couriers to Eldfisk S for manual personnel registration in DaWinci. The first POB status at 11.30, after almost two hours, showed that 37 people were unaccounted for. A further hour and 39 minutes passed before full control of POB was achieved.

Obtaining full POB control took three hours and 34 minutes in total. The performance requirement for this activity on the Eldfisk complex is 25 minutes.

The emergency preparedness analysis for the Eldfisk complex /12/ describes how the APRS is structured and also notes that the system will not function on any of the facilities in the event of a total loss of power on Eldfisk A and FTP. In addition, the emergency preparedness plan calls for drills to be conducted for muster checks without using the APRS in order to be prepared for an incident involving a total loss of power (DSHA 16).

It emerged from the response to the incident and during interviews with personnel on board that knowledge of and training for handling incidents with total loss of power were not good enough.

5.3 ESD system on the Eldfisk complex

Upgrading the SAS forms part of the modification work related to phasing in Eldfisk S and future operation of the Eldfisk complex. Among other activities, new digital output cards for the ESD system were installed in the new LER on Eldfisk A in 2013.

ESD is a separate system integrated in the SAS to initiate predefined actions automatically in order to ensure a controlled shutdown of the facility in the event of an undesirable incident. This is intended to prevent escalation of the incident and to reduce its consequences for personnel, the environment and material assets.

The ESD system comprises dedicated redundant nodes (programmable units) with single output cards for activating predefined shutdown signals to equipment and systems. It is hierarchically structured and comprises the following ESD levels. See also figure 3.

- **Yellow ESD** – the highest level, initiated either manually or automatically, covers full emergency shutdown, pressure blowdown, start-up of fire pumps, mustering and, if necessary, evacuation of the platform/complex. Initiation can be immediate or time-delayed, depending on criticality on board. Yellow ESD activates blue ESD.
- **Blue ESD** – next level down, initiated either manually or automatically, provides immediate disconnection of main electric power. Blue ESD activates red ESD.
- **Red ESD** – the lowest ESD level, also initiated either manually or automatically to provide production shutdown (PSD) and disconnection of ignition sources for non-critical equipment.

On Embla, a normally unstaffed facility, yellow ESD comprises the following levels.

- **UPS yellow ESD** – which involves total loss of main and emergency power.
- **Yellow ESD** – which results in full emergency shutdown with the exception of the UPS with four hours of battery capacity.

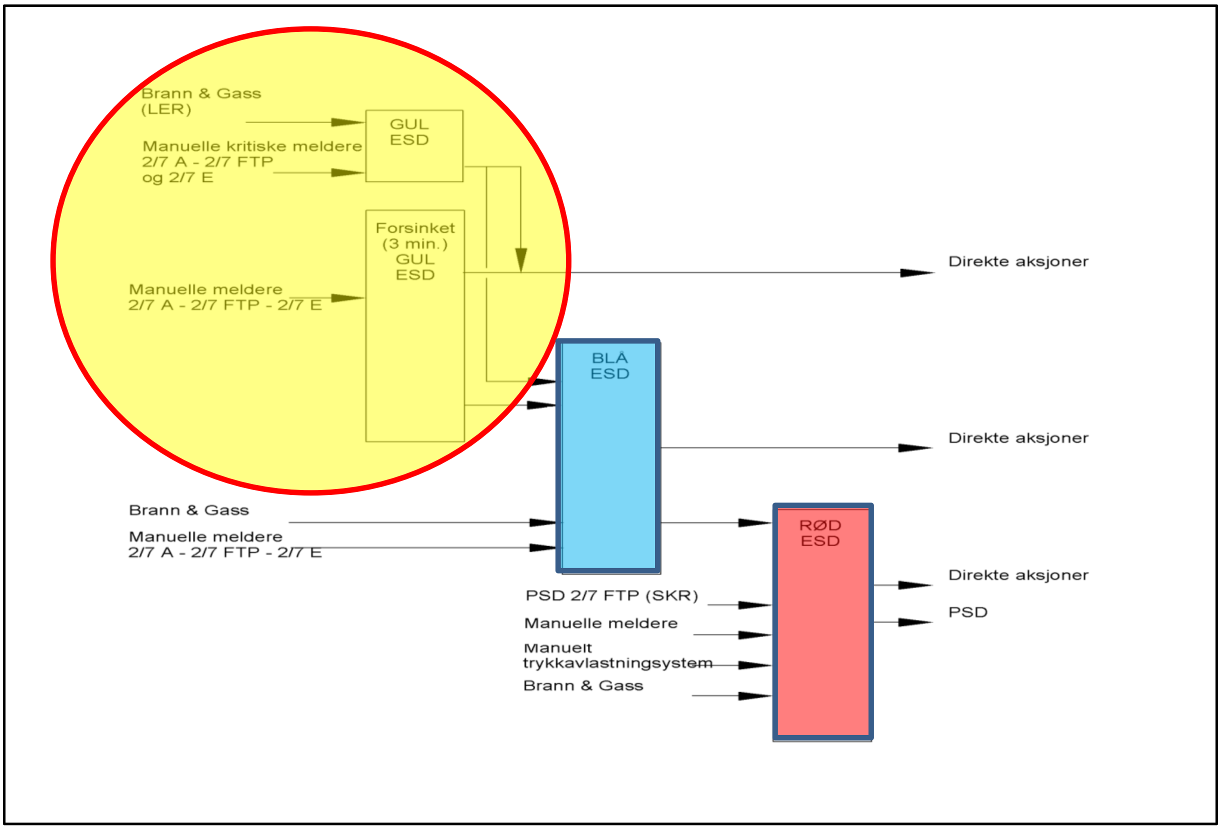

Figure 3 Diagram of the emergency shutdown logic for the Eldfisk complex. Source: ConocoPhillips

A yellow ESD means total loss of power throughout the facility/complex – in other words, all ignition sources are disconnected. The technical solution implemented for the Eldfisk complex to ensure that UPSs and batteries are dead in a yellow ESD is shown in figure 4. Note particularly that the battery breaker for both UPS A and UPS B is connected to the same single output card in the ESD node in the new LER on Eldfisk A. A failure or impairment of the output card accordingly leads immediately to a yellow ESD with a consequent cascade of shutdown actions. The same output card as the one shown in figure 4 is also used to disconnect the battery breakers for both UPS 1 and 2, which are dedicated to emergency power supply for the telecommunication systems.

This solution deviates from the requirements in the regulations, which specify that a single error must not lead to a loss of safety functions.

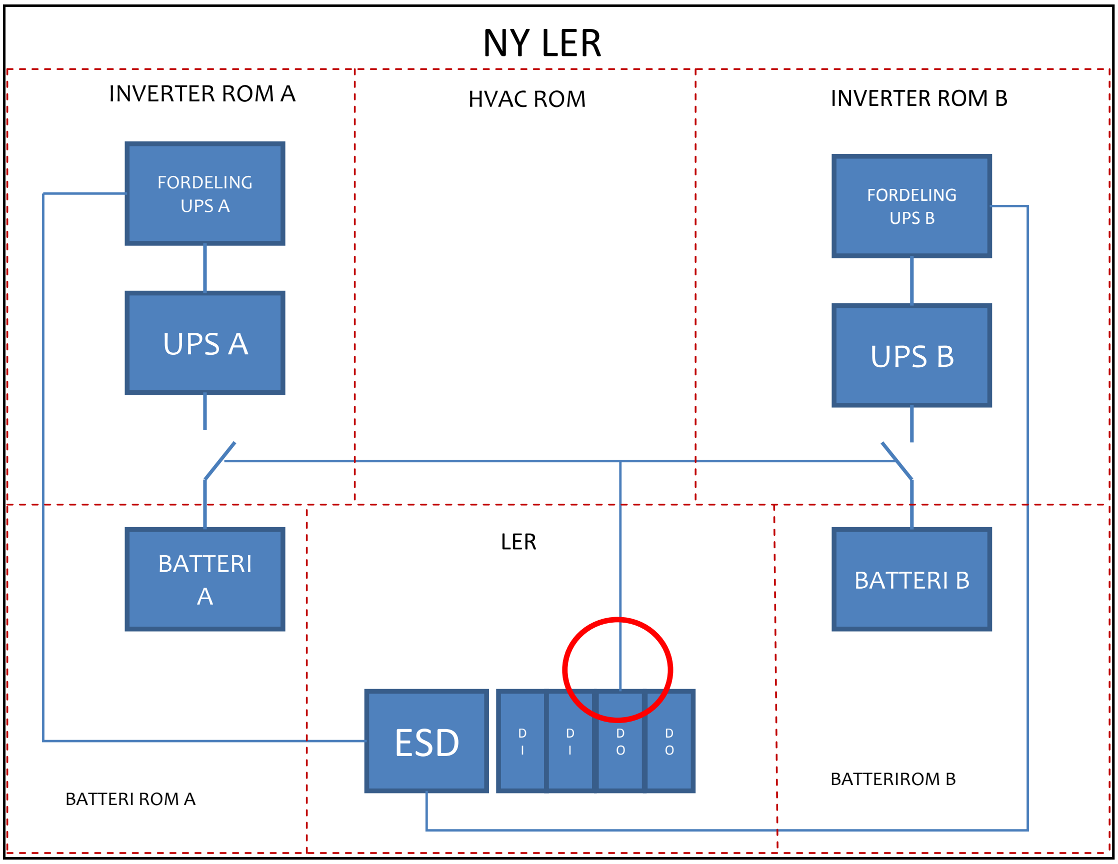

Figure 4 Diagram of ESD node and UPS A/B in the new LER on Eldfisk A.   Source: ConocoPhillips

5.4 Telecommunication systems on the Eldfisk complex

In the prevailing interim phase, the public address and general alarm systems (PAGA) for Eldfisk A comprises three systems with their own battery banks. One is located in the Eldfisk A radio room and is due to be phased out as part of the Eldfisk II project, while the two new systems (A and B) are located in the new LER module on Eldfisk A.

General alarm system (PAGA)
When a yellow ESD is initiated, a general alarm is activated in the PA system in the new LER on Eldfisk A and conveyed via the public address and alarm control system (PACOS) to all the other PAGA systems on the Eldfisk complex with the exception of *Haven*. No personnel with emergency response functions are accommodated on the latter.

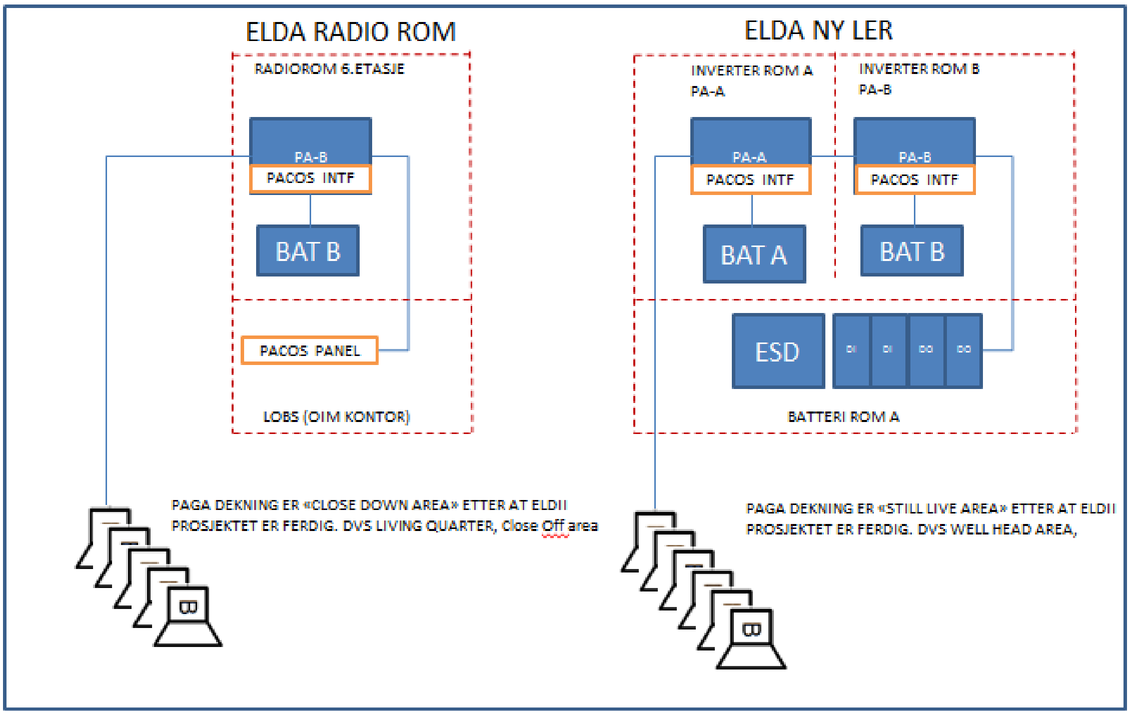

Figure 5 Diagrammatic presentation of the PAGA on Eldfisk A. Source: ConocoPhillips

As the emergency response manager in the LoBS was announcing a muster over the PA system, a fuse blew in the power supply for this system in the Eldfisk A radio shack and the announcement was cut off. The result was that all the PA loudspeakers in the close down area to be phased out after the Eldfisk II project ceased to function. That meant reduced loudspeaker coverage of Eldfisk A. See figure 5 above.

In the event of a yellow ESD, the PA system remains operative for only three minutes and must be manually reset for a further three. The reset button is located on the PA control panel in the radio shack on Eldfisk A's deck 6. It was pressed a number of times, but the blown fuse meant that this part of the PA system was already dead.

However, the other PA systems on the Eldfisk complex – Eldfisk A (LER), FTP, E and S – remained operative. The general alarm sounded continuously and was only interrupted when announcements were made via the loudspeakers.

Eldfisk FTP CCR and the LoBS made a number of attempts to stop the general alarm. In connection with the modifications for the Eldfisk II project, the PACOS was configured to distribute a general alarm to all the PA systems as long as the ESD signal remained active. No form of bypass had been installed to permit deactivation of the general alarm signal. With support from personnel in the Eldfisk S project, this alarm signal was later (13.01) deactivated by installing a provisional bypass of the signal termination. The blown fuse was also identified and replaced. All PA systems were thereby operational.

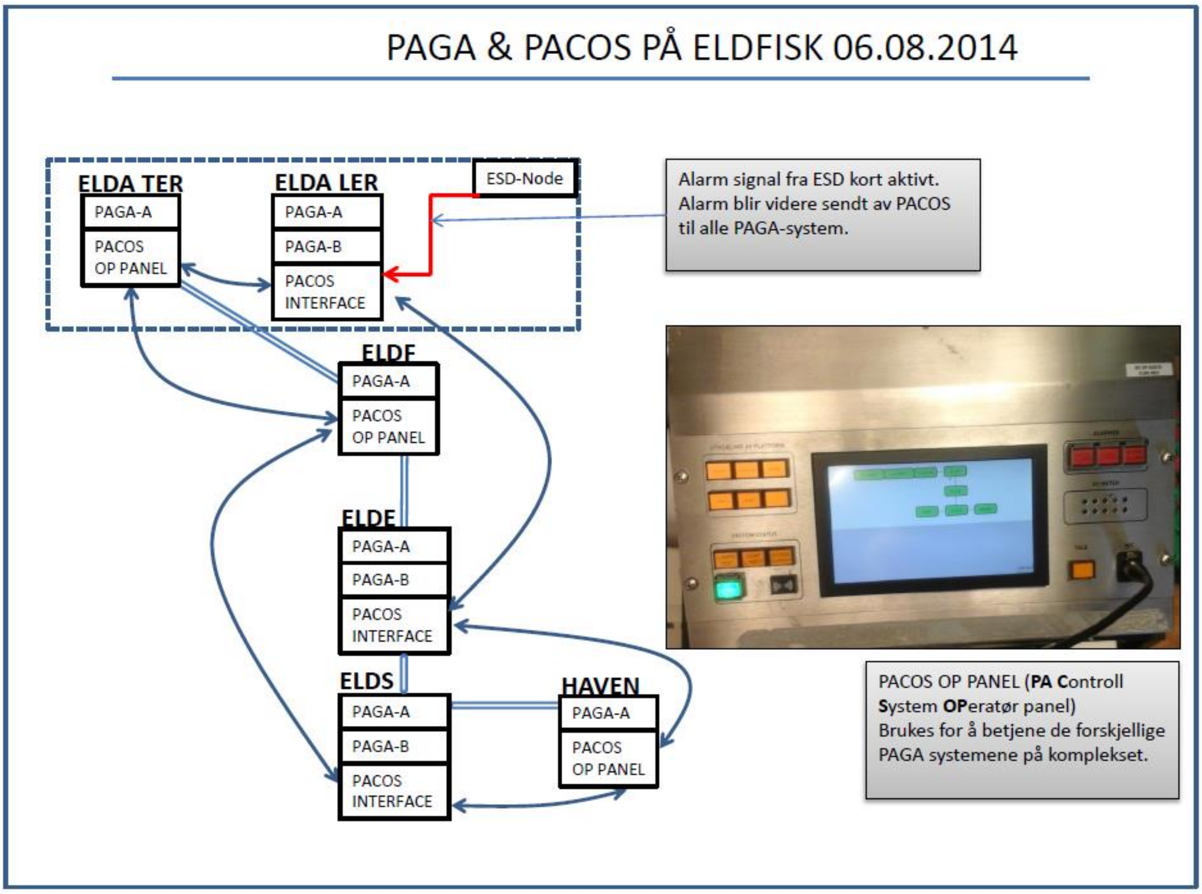

Figure 6 Diagram of the PAGA and PACOS on the Eldfisk complex. **Source: ConocoPhillips**

<u>System for personnel registration (APRS)</u>

Following a yellow ESD, only telecommunication systems with their own battery bank will be operational. The APRS portals have such banks, but the APRS server and client PC in the telecommunication equipment room (TER) on Eldfisk A were inoperative as a result of the yellow ESD. The APRS back-up server on Eldfisk E was supplied with back-up power and operational during the incident. To function, the APRS client on Eldfisk S depends on the computer network and firewall on Eldfisk A, but the latter was without power. See figure 7.

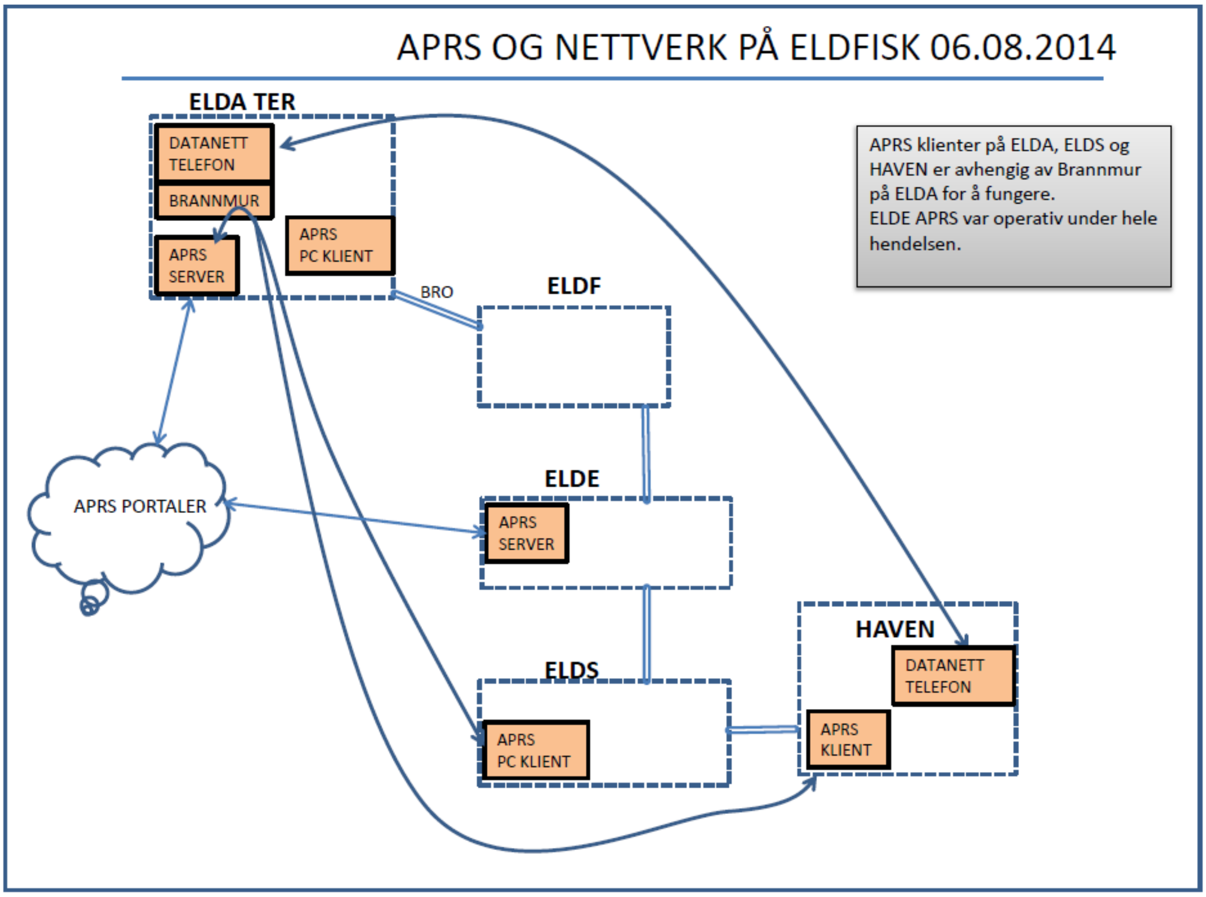

Figure 7 Diagram of the APRS and network on the Eldfisk complex. Source: ConocoPhillips

5.5 Direct and underlying causes

5.5.1 Direct causes

The direct cause of the yellow ESD incident on the Eldfisk complex and Embla on 6 August was the technical failure of a digital output card (A11-U4) belonging to the ESD node in the new LER on Eldfisk A. See figure 8. This caused the immediate activation of the highest shutdown level (yellow ESD) on the Eldfisk complex and Embla. The failure of a single output card should not normally result in a yellow ESD. An underlying design error (see figure 4), whereby the ESD signals to the isolation breakers for both UPS A and UPS B were connected to the same output card in the ESD node, helped to ensure that a failure of the output card caused an ESD at the highest level.

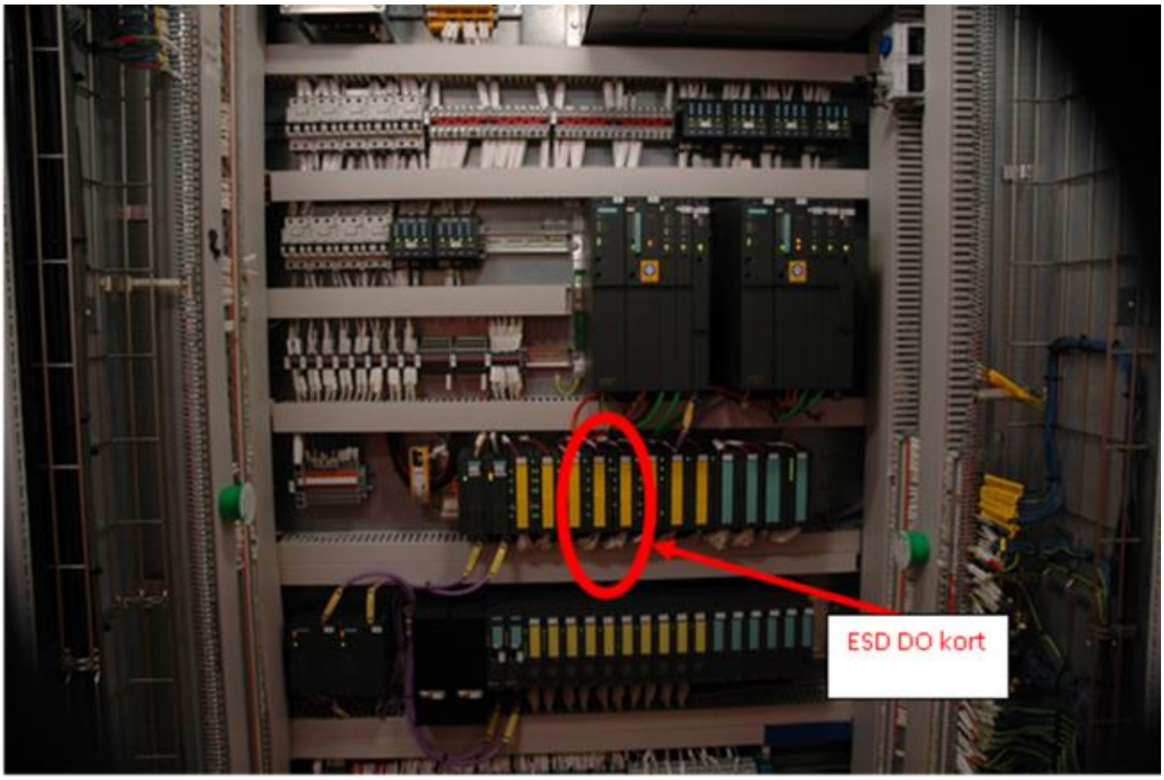

Figure 8 Overview of ESD cabinet with I/O cards in new LER, Eldfisk A. Source: ConocoPhillips

The technical failure of the output card caused the following outputs to be activated:

- A11-U4-Q8.0 Isolate UPS battery A (XS-06856E)
- A11-U4-Q8.0 Isolate UPS battery B (XS-06857E)
- A11-U4-Q8.0 Telecom UPS 1, battery breaker (43-XS-30926E)
- A11-U4-Q8.0 Telecom UPS 2, battery breaker (43-XS-30928E).

5.5.2 Underlying causes

As indicated in the introduction, this investigation has been confined to inspection and interviews with CoPSAS personnel, and no interviews were conducted with the Eldfisk II project organisation or the suppliers of the systems and equipment concerned. We would accordingly emphasise that the underlying causes are primarily based on CoPSAS' own investigative work and experience from similar incidents.

Underlying causes which could have contributed to both UPS A and UPS B being connected to the same output card include:

- inadequate or unclear specifications for ESD, UPS and telecommunication systems in the design phase
- inadequate knowledge of regulations, standards and established practice related to the design of ESD, UPS and telecommunication systems
- inadequate expertise/experience with the design of ESD, UPS and telecommunication systems
- inadequate quality assurance routines for technical solutions at various levels and phases of the project execution
- inadequate checking, testing, commissioning and verification before handover of the ESD, UPS and telecommunication systems from project to operations organisations.

CoPSAS' own investigations /21/, /22/ and /36/ provide further descriptions of causes and measures for learning and improvement.

5.6 Actual and potential consequences of the incident

5.6.1 Consequences of the actual sequence of events

The incident had no serious consequences for the Eldfisk complex or Embla. The ESD was implemented in accordance with the predefined shutdown sequence. However, it took a disproportionately long time before the position was clarified and normalised.

Repeated undesirable ESDs can undermine confidence in the emergency response, alarm and safety systems.

5.6.2 Potential consequences

The ESD system is based on a fail-safe principle, which means that the facility automatically defaults to a safe condition in accordance with a predefined shutdown sequence if, for example, the power supply to the ESD system is lost. For that reason, incidents involving ESD and the total loss of power will not normally lead to serious consequences for people, the environment or material assets.

An ESD is to be regarded as an emergency stop of the whole facility, something which imposes extra stresses and loads on process plants, systems and equipment. That can result in failures and reduced performance which must be identified and dealt with before a restart.

The decision to restart production on the Eldfisk complex without the requirements for start-up and operation being adequately checked and their fulfilment confirmed could, under different circumstances, have had serious consequences both for the Eldfisk complex and for Embla, including:

- gas leaks as a result of the production shutdown or during the subsequent start-up without an operational fire and gas detection system
- ignition of gas leaks as a result of running-in and energising potential ignition sources before the facility is confirmed to be gas-free. Compare the attempt at a black start of the emergency air compressor and the emergency generator on Eldfisk A.

6 ACUTE OIL SPILL TO THE SEA VIA THE DRAIN SYSTEM

6.1 Description of the main process, flare and drain system on Eldfisk FTP

The brief description below covers those parts of the main process and the connection between the flare and drain system on Eldfisk FTP which are relevant for the incident.

Eldfisk A's wellstream is sent to Eldfisk FTP for partial processing. Eldfisk FTP's process plant provides one-stage three-phase separation. The gas is sent to Eldfisk E and produced water to the produced-water treatment system before being routed overboard, while oil is metered and sent to Ekofisk J for further treatment. Normal operating pressure in the separator is 14.5 barg.

The drain system combines closed and open drainage from both classified and unclassified areas. Pressurised sources (closed drain) are routed via a degassing tank for pressure reduction and degassing before the liquid is routed to the oil sump.

The drain system also receives the following liquid sources from the flare system for return to the process:

- liquid outlet from the high-pressure flare knockout drum
- condensate pots on the flare header (high- and low-pressure).

The flare knockout drum is located at the end of a bridge from Eldfisk A. To compensate for the lack of slope in the flare header from the process plant to the knockout drum, a low point has been created on Eldfisk A with automatic drainage to the drain system on Eldfisk FTP via condensate pots.

Figure 9 presents a diagrammatic representation of relevant parts of the process, flare and drain system on Eldfisk FTP.

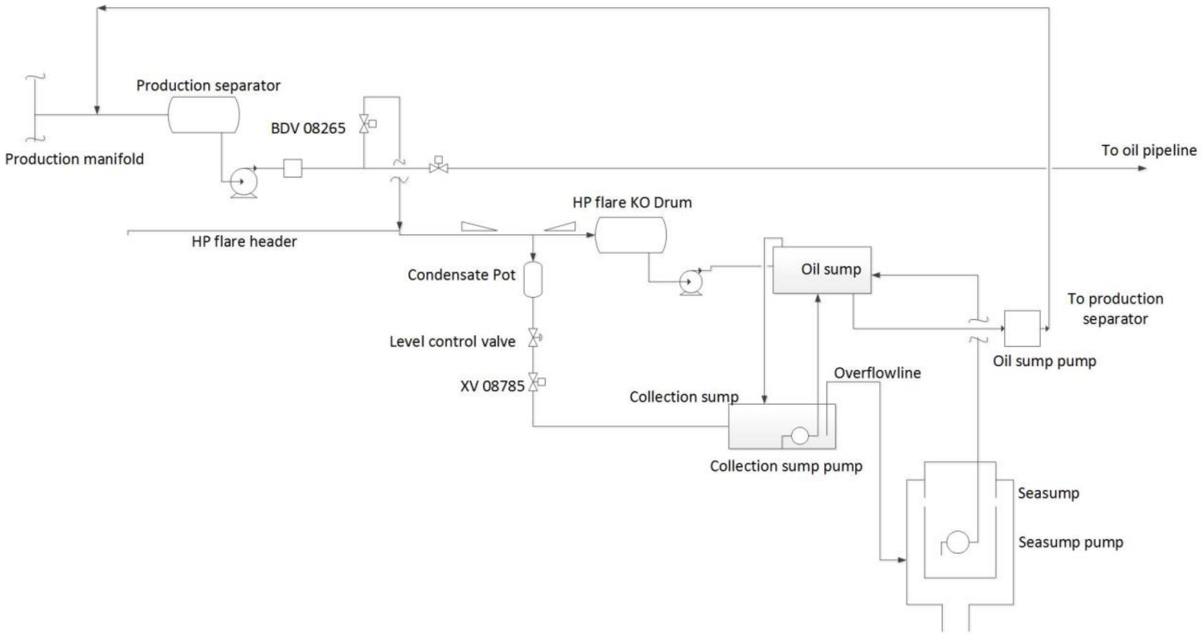

Figure 9 Process, flare and drain system on Eldfisk FTP.

Liquid from the high-pressure knockout drum is pumped to the oil sump, while liquid from condensate pots is routed to the collection sump. The oil sump and collection sump have no separation function, and all liquid entering them is pumped on. Liquid from the collection sump is pumped to the oil sump, while liquid from the latter goes to the production separator. The pump in the oil sump has a capacity of 13 m^3/h. Two pumps are installed in the collection sump, each with a capacity of 6 m^3/h. Starting and stopping pumps are controlled by level switches in the tanks. Both tanks are fitted with overflows. The oil sump overflow is routed to the collection sump, which in turn has an overflow routed to the sea sump. This means that, if the pumps in the oil and collection sumps lack sufficient capacity to handle the incoming quantity of liquid, the latter will eventually end up in the sea sump via the overflow from the collection sump.

In addition to overflow from the collection sump, the sea sump receives drainage from various areas of the platform. The sea sump is submerged and comprises outer and inner chambers. All incoming liquid goes to the outer chamber, which has one end open to the sea. The inner chamber will be filled from the outer one via connecting holes. Liquid in the inner chamber is pumped to the oil sump. The sea sump pump has a capacity of 17 m^3/h.

6.2 Context of the incident

The incident which resulted in an acute oil spill to the sea via the drain system occurred in connection with starting up after the yellow ESD on Eldfisk. Following the restoration of main electric power on Eldfisk A at 15.21 on 6 August, work began on resetting and preparing for production start-up.

Personnel with emergency response functions in the CCR who had participated in normalisation after the yellow ESD incident went off shift at 15.30. They had been on the night shift until 07.00 before the yellow ESD occurred (09.35). Night shift personnel without emergency response functions went to the quarters module at 13.30. It was decided that the production start-up would be carried out without changes to the planned shift rota, and no compensatory rest time was provided.

During the emergency and normalisation period, personnel had been subject to a high workload in a very hot control room. An ESD turns off the ventilation system, and the temperature in the CCR was measured to be about 35°C around 15.30.

High temperature, lack of rest, and preparations to restart the Eldfisk complex while conducting time-consuming communication with Embla contributed to particularly burdensome working conditions for the control-room operators.

6.3 Acute oil spill to the sea – chronologically

Wednesday 6 August to Thursday 7 August 2014
The course of events is based on LoBS /6/ logs, interviews and the alarm list /7/ received.

15.30: Start-up preparations began (resetting of ESD functions, line-up of manual valves, review of systems and so forth). In addition to work on starting up Eldfisk, activity took place with Embla where assistance was required to restore normal power.

Abt 18.30: Handover in connection with shift change at 19.00, including a review of the status of start-up preparations. These preparations continued after the shift change. A swing shift was to be implemented, with a new shift change at 03.00.

22.25: Production resumed from three wells which do not require gas lift. The stated rate was about 3 850 bbl/d. Well A29 also eventually came on stream, bringing the estimated rate of production to 4 120 bbl/d. Establishing pressure/level in the separator in connection with the start-up took time. Based on the alarm list, either ESDV 2373P on the oil outlet from the separator or XV 08284 on the oil export pump inlet was largely shut until about 01.52.

02.14: A high level was recorded in the condensate pot on the high-pressure flare header. The process shutdown valve (XV 08785) on the liquid outlet from the condensate pot had not been opened in connection with the start-up. It remained on manual and was closed. The operator opened the valve. The high level in the condensate pot was assumed to be liquid which had collected in flare piping from the blowdown initiated by the yellow ESD.

02.16: Alarm for low liquid level in the oil sump.

02.25: A high level of liquid was recorded in the oil sump. The plant operator went out to check, and also observed that liquid was flowing from a plastic hose mounted on the overflow from the collection sump. See figures 13 and 14. Start-up of well A29 increased the temperature in the production separator, and the liquid from the hose was assumed to reflect an increased volume of condensed gas from Eldfisk A to the drain system because of the high separator temperature. Production from A29 was halted, and it was reported back that the flow from the hose had stopped. The liquid level in the oil sump went from low to high in less than 10 minutes, even though no high level alarm had been received from upstream equipment (collection sump, flare knockout drum or sea sump).

02.48: Valve XV 08785 on the condensate pot was closed manually.

03.00: Shift change in the CCR with handover.

03.21: Valve XV 08785 on the condensate pot was opened.

03.25: High level of liquid in the oil sump.

03.27: Valve XV 08785 on the condensate pot closed manually.

03.30: Pipes from the condensate pot were reported to be “red-hot”, and piping both upstream and downstream of the oil and collection sumps were hotter than normal.

03.45: Manual opening of XV 08785 from the condensate pot, pump number two in the collection sump was started manually. Valves from the condensate pots continued to be operated manually, combined with visual inspection of the hose on the overflow from the collection sump. Fault-seeking began to identify the source feeding the drain system.

Relevant alarms in the period until the blowdown valve was closed:

- 03.48: High level in condensate pot
- 03.53: High level in oil sump
- 04.19: High level in oil sump

- 04.25: Low level in collection sump.

04.39: Source to the flare system identified and BDV 08265 closed.

Abt 05.30: At dawn, oil was observed on the sea.

Abt 06.30: The sea sump was suspected to be full of oil. The pumps were started to empty it, and samples of the contents showed pure oil.

Abt 13.35: More oil appeared to be discharging to the sea. Production was shut down. Review of the facility began.

16.04: Report that nothing was found.

19.39: New samples of the oil sump content showed about 50 per cent oil.

Friday 8 August
12.30: Production started up.

Comments on the course of events.

- Opening valves from condensate pots resulted in a high level in the oil sump. It is uncertain whether the oil sump pump had started as expected.
- Although liquid was pouring from the overflow on the collection sump, no high level alarm in the collection sump was given during the incident.
- No alarm was registered for a high level in the sea sump during the incident. The sea sump pump does not appear to have started automatically.
- Production was not shut down when oil was observed on the sea.

Figure 10 Oil spill from Eldfisk FTP on 7 August, 07.00. Source: ConocoPhillips

6.4 Direct and underlying causes of the incident

6.4.1 Direct causes

During start-up after the yellow ESD, a BDV downstream of the oil metering package was left in the open position. This caused a continuous supply of produced hydrocarbons to the flare system during the time the oil outlet from the separator was open. Via the condensate pot on the flare header, the oil was routed to the drain system and from there to the sea. The BDV in the wrong position was the direct cause of the acute oil spill.

Liquid from the flare system is routed to the drain system as described in chapter 6.1. The failure of instrumentation for level measurement and pump control meant that oil return from the drain system to the production separator did not function as intended in the design. At the same time, pump capacity in the drain system appears unable to handle the maximum liquid quantity which could flow from the condensate pots.

The sea sump was eventually filled with oil via the collecting-sump overflow. Level measurement did not indicate that the sea sump had become oil-filled, and its pump failed to start. All water in the sea sump was eventually displaced by oil, which then escaped to the sea through the open end of the tank.

The fact that the drain system was filled with oil went unnoticed. That could reflect lack of, and occasionally conflicting, information from level switches in the drain system.

Printouts received of screenshots showing levels in the high-pressure flare knockout drum and the sea sump during the incident indicate that the pumps in this system were not operating before the sea sump pump was started manually. Figure 11 below illustrates the probable direction of flow for the bulk of the oil through the BDV, via the collection sump and the overflow line to the sea sump and from there to the sea.

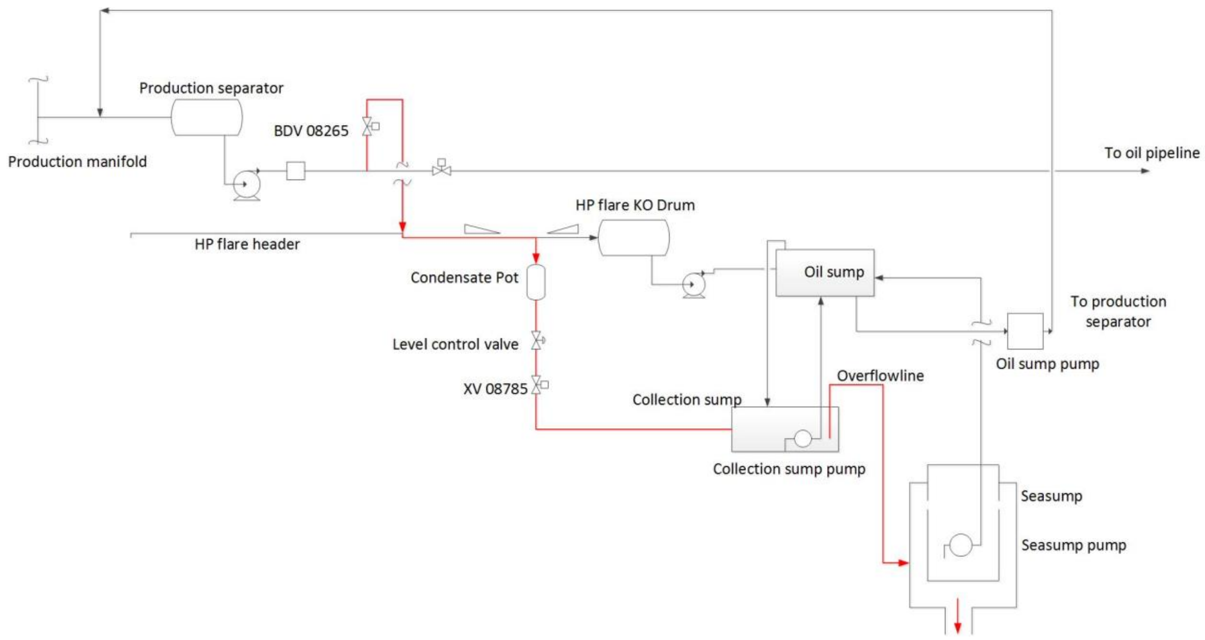

Figure 11 Liquid flow from the separator via the flare and drain system to the sea.

6.4.2 Underlying causes

The open drain system is intended to collect and carry away oil and chemicals so that the risk of fire, injury to personnel and pollution is reduced. In this case, the drain system functioned in the sense that oil which entered via the open BDV was carried away from the installation. But it did not function as a barrier against acute oil spills to the sea.

This chapter includes a description of the underlying causes of the following issues:

- why the BDV remained in the open position during production start-up
- why the drain system failed to handle the quantities from the flare system
- why the fact that the drain system was filled with oil went undiscovered.

6.4.2.1 Technical condition and function of components in the drain system

Information from alarm lists received and printouts of screenshots from the incident show that individual components, particularly for level measurement, failed to function as intended. Examples include:

- no alarms showing high levels in the collection sump were received, despite oil escaping from the overflow
- uncertainty over whether/when pump(s) in the collection sump started automatically at predefined levels
- uncertainty over whether the oil sump pump started as intended (when opening the valve from the condensate pot led to a high level in the oil sump)
- rapid (10 minutes) change from low to high level alarm in the oil sump – faster than was possible given the capacity of incoming sources, which could indicate that the low-level alarm was not genuine
- no alarm for high level in the sea sump, despite this being filled with oil
- sea sump pump failed to start even though the sea sump was filled with oil.

A review of the SAP system for managing maintenance and notifications reveals the following.

- Equipment and instrumentation in the drain system which could affect the latter’s barrier function and opportunity to detect an abnormal condition if they failed were not regarded as safety-critical. Examples include the LSHH 5586 level switch in the oil sump, the LS-6530 level switch in the collection sump and the 67-233 A/B pumps in the collection sump. Function testing of the level switches in the collection sump was not included in the maintenance programme.
- Problems with level measurement in the drain system and starting the collection sump pumps had been registered on a number of occasions. They primarily reflected floats getting stuck through the accumulation of impurities in the system. Proposals to change the measurement principle are registered in SAP but not implemented. A compensatory measure has been manual start of the collection sump pump on each shift.

Level measurement in the collection and oil sumps is based on switches, which makes it impossible to monitor level changes outside the predefined set points. Combined with occasional contradictory information from level switches in the drain system during the incident, this could have contributed to the control room operators being unable to acquire an unambiguous picture of the position and to fault-seeking taking a long time.

6.4.2.2 Level of detailing in the start-up procedure

A yellow ESD is the only ESD level which automatically initiates blowdown on Eldfisk. The procedure for starting up the production process after a yellow ESD refers to the start-up procedure for a red ESD (chapters 2.6 and 2.13 in the operating documentation for the ESD system) /14/. The procedure provides little detail on the resetting of ESD functions. The following is defined in the procedure: “Reset relevant ESD functions”. No checklists at tag level to ensure that all functions/valves are reset and placed in the correct position, and no checkpoint for verification is included. Nor is any description provided of differences in ESD functions which require resetting when a start-up is implemented after an ESD from an original yellow ESD. As described in chapter 6.4.2.3, no screen display provides a complete overview of the status of all BDVs.

The lack of detailing for resetting and line-up of valve positions, and of a verification checkpoint, could have contribute to increasing the risk of errors in connection with start-up. Opportunities for detecting an error are reduced.

6.4.2.3 Factors influencing risk – CCR

The investigation identified several unfortunate technical, operational and organisational factors in the CCR which individually or collectively could have influenced the risk of errors being made. Several factors affecting risk were uncovered in surveys and should therefore have been known and taken into account when planning work in the CCR during the interim period, with a high level of activity and an increased workload. The following factors can be mentioned.

- Control room operators were known to have a high workload /3/. The need had been reported for increased staffing in the form of a control room coordinator (leader), who does not have direct responsibility for an area/installation. Eldfisk E is particularly complex and demanding in terms of control and monitoring, and the most experienced control room operator needs to be dedicated to this task. That contributes to an inflexible solution, which is particularly vulnerable during increased activity and with demanding operations. We have requested risk assessments related to CCR staffing on Eldfisk FTP, but these have not been forthcoming.
- The CCR on Eldfisk FTP is old and has known weaknesses. These were identified, for example, in the crisis intervention and operability (Criop) analysis of the FTP CCR conducted in 2011 /4/ and the working environment gap analysis /5/ from 2006. The Criop analysis was carried out to assess possible improvements when designing and using the new CCR on Eldfisk S and necessary measures during the interim period. According to CoPSAS, no measures were taken after the analysis. All the findings were considered acceptable until the new CCR on Eldfisk S was taken into operation.
- Weaknesses related to the human-machine interface can be found in the CCR. The operators lack an overview of all the information they need from their workstations. Examples include:
    - no overall presentation (screen display) of BDV status for a better pre-start-up overview and for effective checking, as provided in newer control and monitoring systems

  - limited support for ESD/PSD actions, such as computer-based cause/effect diagrams
  - the human/machine interface is not sufficiently fault-tolerant, making it easy to activate the wrong valve or forget to confirm open/close functions
  - weaknesses exist in relation to alarm presentation (many alarms, alarm cascades/lack of a first-out function, and too much information on the screen displays which complicates the identification of changes/nonconformities).
- Both the 2011 Criop analysis /4/ and the working environment analysis conducted in 2006 /6/ noted weaknesses related to ventilation/temperature, noise and dust in the CCR on Eldfisk FTP.

In addition to the above, risk-influencing factors related to the specific conditions in the wake of the ESD were present during preparations for and start-up of production. The following could have increased the risk of committing errors:

- personnel came on shift without compensatory rest time
- the temperature in the CCR was high because of a lack of ventilation
- increased activity in handling the incidents on the Eldfisk complex and the need to communicate with Embla because of a full power shutdown.

6.4.2.4 Design of the process interface between flare and drain systems

The drain system on Eldfisk FTP combines open and closed drain as shown in figure 10. The original design dates from 1976, when the platform was built. Certain modifications have been made since it became operational, but the main principles of the original design are retained. The drain system is designed to handle limited quantities of oily water. With the exception of liquid flow from the flare system, other pressurised sources connected to the drain system are routed via a degassing tank. Liquid return from the flare system to the collection and oil sumps provides a possible source for large quantities of hydrocarbons entering the drain system. The result is a potential for acute oil spills to the sea via the sea sump if the liquid is not returned to the process facilities.

The flare knockout drum on Eldfisk is positioned at the end of a bridge leading from Eldfisk A, about 200m from Eldfisk FTP. Compensation for the lack of slope in the line from the flare header to the knockout drum is provided by a condensate pot at the low point of the line on Eldfisk A. This drains automatically to the collection sump on Eldfisk FTP.

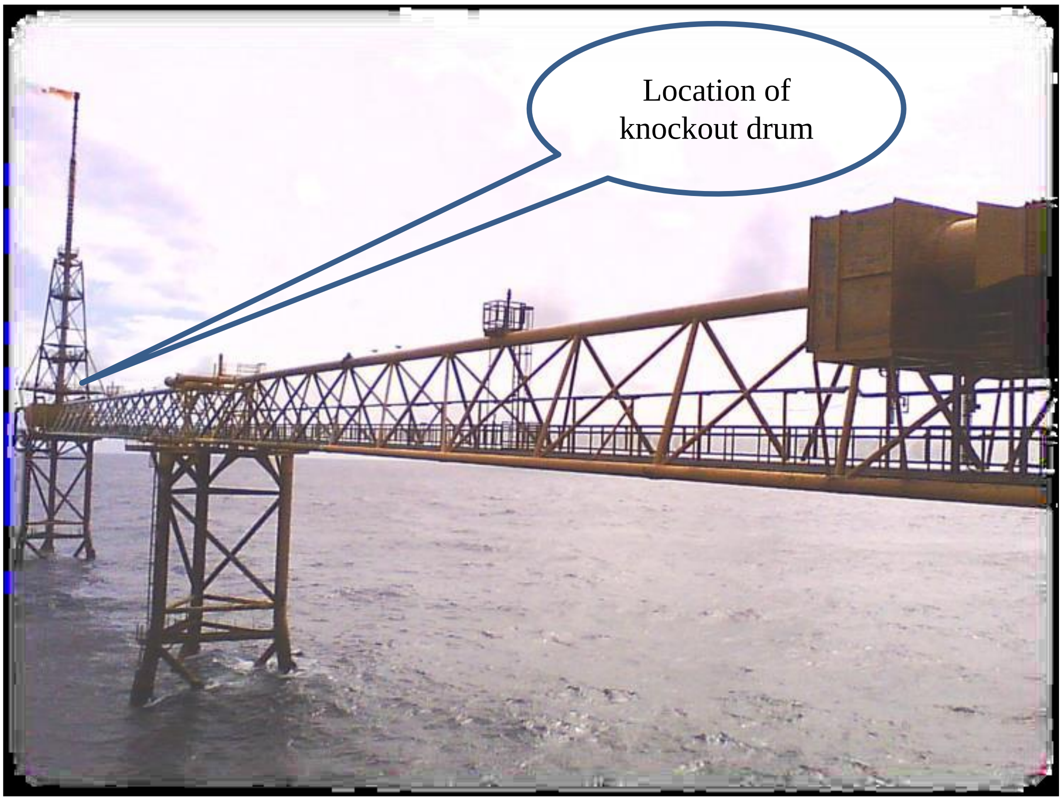

Figure 12 Location of knockout drum. **Source: ConocoPhillips**

Piping from flare sources to the knockout drum has a considerable volume. If a liquid source is admitted to the flare system by mistake, the liquid will largely drain via the condensate pot as long as the latter has the capacity to handle the incoming quantity. Should the quantity of liquid in the flare system exceed the drainage capacity in the condensate pot, the piping to the knockout drum and the drum itself will eventually become filled with liquid until production is shut down owing to a high level in the flare knockout drum. However, that could take a long time because of the big pipe volume between condensate pot and knockout drum.

Drainage capacity from the condensate pot appears to exceed pump capacity in the drain system. A constant input of liquid to the flare system could thereby lead to an acute discharge of liquid to the sea unless the source is identified in time and halted manually.

Originally, condensate-pot drainage was manual only. Operating documentation for the flare and drain system /14/ still describes drainage as manual.

6.4.2.5 Loss of function for siphon breaker on collection sump overflow line

The overflow line from the collection sump to the sea sump is submerged in the collection sump. The level of the submerged overflow corresponds to the set point for a low level (LSLL) alarm – in other words, below the set point for stopping the pumps. To prevent the collection sump being emptied to the sea sump via the overflow pipe, the latter was fitted in original design with a siphon breaker. Subsequently, however, a plastic hose has been fitted to the siphon breaker with an outlet below the elevation of the submerged overflow. See figures 13 and 14. The plastic hose means that the siphon breaker’s function is lost in the event of overfilling. Liquid flows out through this point and prevents air intake, so that the overflow pipe functions in practice as a siphon as long as liquid runs out of the plastic hose. This means that liquid continues to flow through the overflow even if the level in the collection sump is reduced.

Installation of the plastic hose is not documented in the P&ID. Its purpose, when it was installed and whether the consequences of the change have been assessed are uncertain.

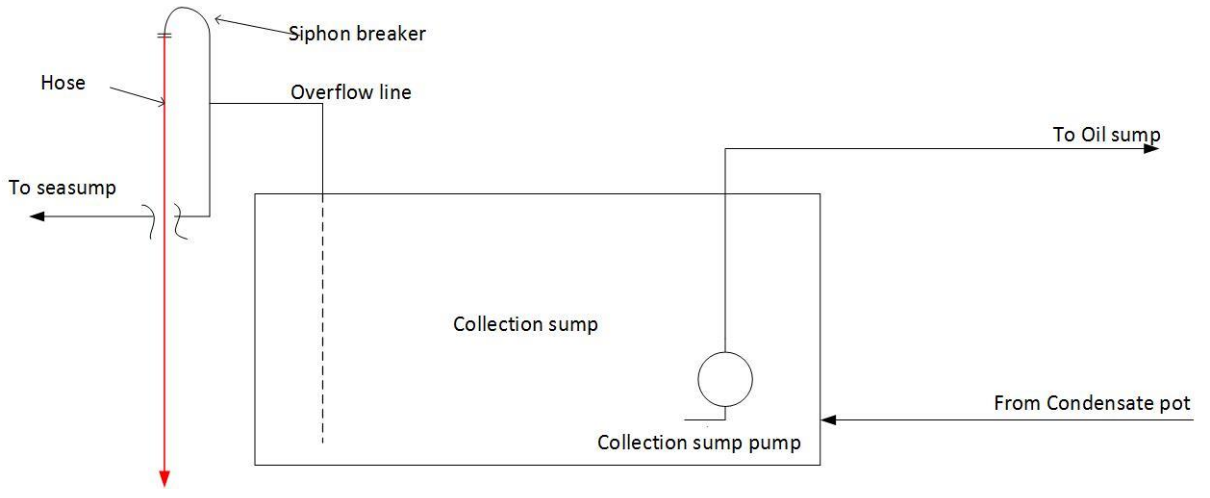

Figure 13 Simplified diagram of the collection sump with overflow.

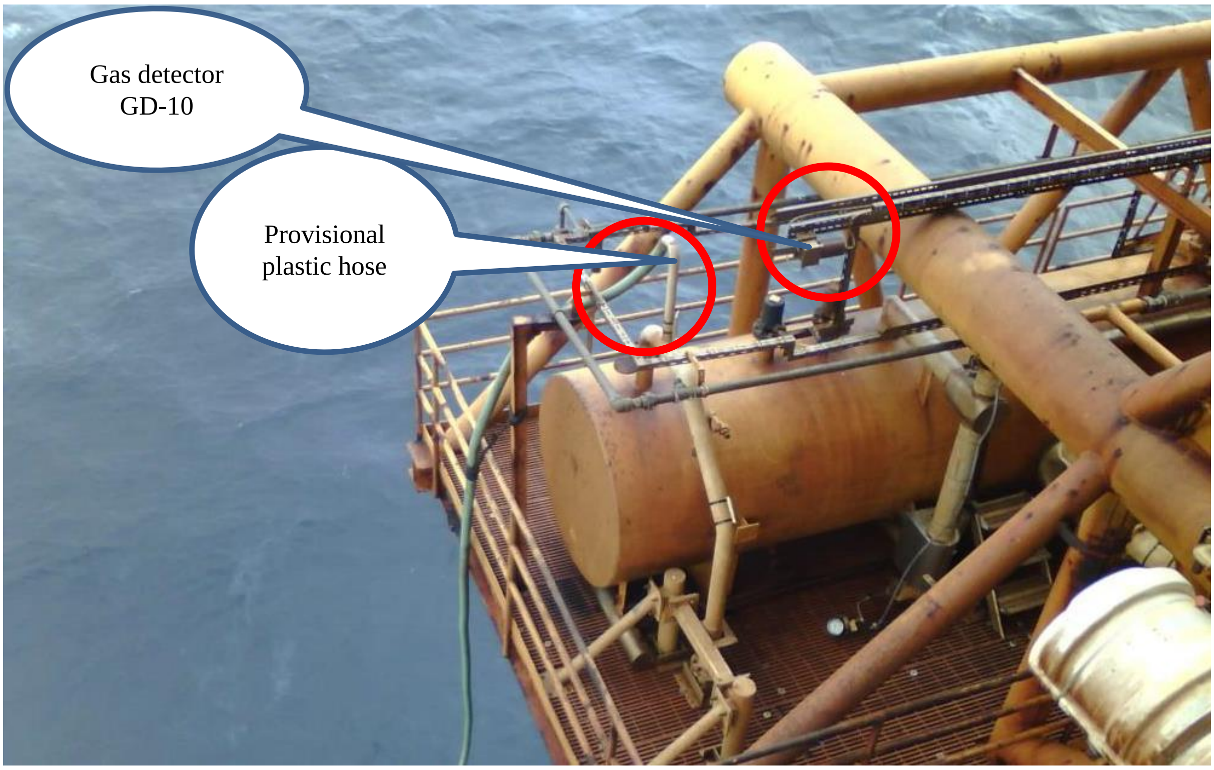

Figure 14: Gas detector GD-10 and provisional hose on collection sump. Source: ConocoPhillips

6.5 Actual and potential consequences of the incident

6.5.1 Consequences of the actual course of events

According to information from CoPSAS, an estimated 50-70 m^3 of stabilised oil were discharged to the sea via the sea sump.

6.5.2 Potential consequences

6.5.2.1 Risk of further leakage

If the BDV had not been closed, the leakage to the sea would have continued. After the BDV was closed and the oil content in the sea sump had been dealt with, no risk remained of continued leakage.

The potential for ignition was limited, since the oil was depressurised almost to atmospheric pressure in the flare/drain systems before discharge to the sea.

6.5.2.2 Closed liquid outlet from the condensate pot

In connection with this incident, yet another function was not reset during start-up. The process shutdown valve on the liquid outlet from the condensate pot was left on manual and in the closed position until a high level in the condensate pot initiated an alarm in the CCR. The operator noticed this and opened the valve. As described in chapter 6.4.2.2, the start-up procedures are described in general terms, and the one for the flare and drain is correspondingly short on detail. The procedure defines the following point: “Reset relevant PSD actions”. Both an overview of equipment at tag level and checklists are absent. Operating documentation for the flare has not been updated to reflect the change to automatic drainage of the condensate pot, and the PSD function on the liquid outlet from the condensate pot is not described in the documentation.

Had the valve on the liquid outlet from the condensate pot not been opened in time, a large quantity of liquid would have entered the flare system and piping to the flare knockout drum would have become liquid-filled.

According to information from CoPSAS’ investigation report, the flare system is not dimensioned to handle blowdown of the process plant while the system is filled with liquid. A simultaneous genuine need for blowdown or a pressure safety valve (PSV) with a sufficient quantity of gas and pressure potential would have resulted in a pressure build-up in the flare system which exceeded the design pressure. That could have caused a pipe to fracture with a consequent hydrocarbon leak, fire or explosion.

7 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 comments.

7.1 Nonconformities

7.1.1 Risk management during start-up of production after the emergency shutdown (yellow ESD)

Nonconformity

Insufficient attention was paid when planning the production start-up after the yellow ESD to keeping important risk contributors under control, both individually and collectively.

Grounds

The platform management decided to resume production without adequately checking and confirming that the conditions for start-up and operation were fulfilled. No action was taken to handle risk-affecting factors specific to the conditions, such as difficult working conditions, high workload and insufficient rest for control room operators. These factors must be viewed in relation to known challenges with operating parameters and the staffing level in the CCR on Eldfisk FTP.

The investigation revealed the following conditions which collectively support the nonconformity.

- Human factors (see chapter 6.2):
  - requirements for off-duty periods not met (see nonconformity 7.1.2)
  - difficult working conditions in the control room.
- Increased scope of work for control room operators. Assistance was given for normalisation on Embla in parallel with their own production start-up.
- Factors influencing risk – CCR (see chapter 6.4.2.3) combined with human factors and non-specific start-up procedures (see chapter 6.4.2.2).
- The facility, systems and equipment were not cleared in safety terms and systematically checked as gas-free before the decision was taken to resume production and introduce ignition sources. See nonconformity 7.1.3.

Requirements
Section 29 of the activities regulations on planning
Section 11 of the management regulations on basis for making decisions and decision criteria

7.1.2 Off-duty periods

Nonconformity

The requirements for off-duty periods in the framework regulations were not fulfilled in connection with starting up after the emergency shutdown.

Grounds

Employees must have a continuous off-duty period of least 11 hours in the course of a day. This off-duty period must fall between two main work periods. It can be reduced to eight hours if the employees are ensured compensating rest periods of a corresponding kind or, where this is not possible, other suitable protection.

It emerged during the investigation that personnel with emergency response functions in the CCR during the emergency and normalisation period were subject to a heavy workload, work beyond their normal shift and limited opportunities for rest. The swing shift rota, which in itself reduces time for rest and increases the number of shift handovers, also helped to strengthen the need for compensating rest periods in this context (see chapter 6.2).

However, work on normalisation and start-up after the yellow ESD was pursued without changes to the planned shift rota and without compensating rest periods. At the time, conditions permitting an exception from the working time provisions – see section 10-12, paragraph 3 of the Norwegian Working Environment Act – no longer prevailed. Personnel with emergency response functions on the night shift mobilised from 09.30 until the position was clarified at about 15.30 (see chapter 6.2). They then began their normal shift again at 19.00, which was a swing shift lasting until 03.00. Possible rest time for these people between the start of two shifts was limited to the 07.00-09.30 and 15.30-19.00 periods.

Nor do we consider that the overall load on personnel complied with section 10-2, paragraph 1 of the Working Environment Act.

Requirements
Section 39 of the framework regulations on off-duty periods
Section 10-2, paragraph 1 of the Working Environment Act on working hours arrangements and section 10-12, paragraph 3 on exceptions

7.1.3 Safety clearance when restarting production

Nonconformity

Inadequate safety clearance of the conditions for production start-up after the ESD.

Grounds

The decision to initiate work on resuming production was taken without a systematic verification that the facilities were gas-free and that potential ignition sources were under control as specified in the procedure for starting up after a yellow ESD /14/.

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

7.1.4 Procedures

Nonconformity

Inadequate compliance with procedures for dealing with a yellow ESD.

Grounds

It emerged that procedures have been drawn up, but we observed the following examples of lack of compliance.

- CoPSAS has established an action plan for total loss of power (DSHA 16), but this was not utilised in the initial phase after the yellow ESD occurred. It emerged from interviews that uncertainties prevailed initially over mustering. Most people mustered, but some technical personnel who believed the incident was caused by a technical failure failed to do so but went to the CCR on Eldfisk FTP.

- Compliance with the procedure for start-up following a yellow ESD /14/ was deficient. See nonconformity 7.1.3.

Requirement
Section 24 of the activities regulations on procedures

7.1.5 Robustness against single errors and faults in safety systems

Nonconformity
The design of the safety system on the facility is such that a failure in one component can have unacceptable consequences.

Grounds

The investigation identified the following examples of system solutions which deviated from the specified requirements.

- Both shutdown signals to the battery breakers for the USPs in the ESD system in the new LER on Eldfisk A (see figure 4) are sent to
    - safety systems connected to the same single digital output card in the ESD node, so that a fault with or failure of the card would result in disconnection of battery supply to the UPSs and a total loss of power
    - telecommunication systems connected to the same single digital output card in the ESD node, so that a fault with or failure of the card would result in disconnection of battery supply to the UPSs and the loss of parts of the telecommunication systems on Eldfisk A and FTP.
- The PA system in the TER on Eldfisk A ceased to function because a single 6A fuse for the battery charger blew while an important announcement was being made over the PA system soon after the ESD.

Requirements
Section 5 of the management regulations on barriers
Section 5 of the facilities regulations on design of facilities

7.1.6 Verification of design requirements for the safety systems before start-up and operation

Nonconformity

Inadequate verification of design requirements for the safety systems during planning and completion.

Grounds

The investigation revealed that individual faults in the safety systems could have unacceptable consequences. See nonconformity 7.1.4. The systems were taken into use without this being identified by quality assurance processes.

Requirements
Section 16 of the activities regulations on installation and commissioning
Section 21 of the management regulations on follow up

7.1.7 Lack of independence between control and shutdown functions for level measurement

Nonconformity

The process safety system is not independent of the regulation function for level measurement in the oil sump on Eldfisk FTP.

Grounds

Sensors and valves incorporated in the process safety system must be independent of and a supplement to the regulation function. Level switches for the control and shutdown functions on the oil sump are not separated, but hang on the same column.

Requirements
Section 82(2) of the facilities regulations on entry into force, see section 7.3 of the regulations for production and auxiliary systems on production installations, etc, for exploitation of petroleum resources on process safety equipment and functions

7.1.8 Barrier management, risk assessments and analyses in connection with modifications

Nonconformity

Modifications to process systems have been made and taken into use without adequate risk assessments and analyses of such aspects as the impact of the modifications on barriers.

Grounds

The responsible party must ensure that risk assessments/analyses are conducted which provide the necessary decision base for safeguarding health, safety and the environment. Criteria must be established for carrying out new and/or updating existing analyses when changes occur in conditions, assumptions, knowledge and delimitations which individually or collectively affect the risk associated with the activity.

Technical modifications have been made to safety-critical systems without the necessary risk assessments and analyses being conducted. The impact of these modifications on existing barrier elements has not been documented.

The following were identified.

- <u>Changes to level control between condensate pots and the collection sump</u>

  The drain system is connected to a pressurised source via the drain line from the condensate pot to the collection sump. Design pressure for the flare system is higher than for the drain system. Changes were made to the system in 2010 through the introduction of automatic level regulation in the condensate pots. Based on findings in the Hazop report, shutdown at low level was also implemented as the primary protection against blowby from the flare to the drain system. No assessment of secondary barriers against overpressure following blowby is documented, and it is uncertain whether the vent line on the collection sump has sufficient capacity in the event of blowby from the flare system.

- <u>Installation of plastic hose on the siphon breaker for the collection sump overflow</u>

  During an inspection in connection with the investigation, it emerged that a plastic hose had been installed on the siphon breaker on the overflow line from the collection sump to the sea sump. When this change was made is uncertain, but it appears to have been at least five-six years ago. Those present were unaware of the reason, but it was linked to actions from gas detector GD-10 (see figure 14). We were informed that no material exists which documents formal consideration of a change related to the modification/installation of the above-mentioned hose. The change is not described in operating documentation (P&ID), and it is unclear how far its consequences have been assessed in relation to the gas detection philosophy and the function of the siphon breaker. The modification means that the siphon breaker on the overflow pipe does not function as intended, and nothing has been done to compensate for this.

Requirements
Section 5 of the management regulations on barriers and section 16 on general requirements for analyses

7.1.9 Updating of documentation in connection with modifications

Nonconformity

Modifications to process systems have been implemented and put into operation without updating the operating documentation.

Grounds

Technical modifications have been made to systems without updating the technical documentation. Examples include:

- technical operating documents for the flare and the drain system have not been updated to reflect automatic drainage of the condensate pots (carried out in 2010), including a new PSD level to prevent gas blowby from the flare to the drain system
- the design report for the flare does not cover the whole flare system and has not been updated after 2013
- modifying the siphon breaker on the overflow line from the collection sump by installing a plastic hose is not described in technical operating documents.

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

7.1.10 Consequence classification of systems and equipment

Nonconformity

The consequence classification of equipment connected to the drain system does not reflect the actual consequences for safety.

Grounds

Systems and equipment on facilities must be classified with regard to the health, safety and environmental consequences of potential functional failures. Open drain systems must function as a barrier which reduces the risk of fire, personal injury and pollution on an installation,

The incident shows that equipment connected to the open drain system also has relevance for preventing and limiting acute oil spills to the sea. A review of the maintenance system revealed that such equipment (listed below) was considered to have a low significance for safety:

- level switches LS 6530 and LS 6595 in the collection sump
- pumps (F-67-233A/B) in the collection sump
- pump (F-67-204) in the sea sump.

Requirement
Section 46 of the activities regulations on classification

7.1.11 Maintenance programme for the drain system

Nonconformity

The responsible party did not ensure that equipment in the drain system was maintained so that it was capable of carrying out its intended function.

Grounds

Equipment in the drain system which could have helped to prevent or limit the acute oil spill failed during the incident.

A review of the system for maintenance management and notifications revealed deficiencies. These included the absence of defined function tests for collection sump level switches LS 6530 and LS 6595 in the maintenance programme.

The system also revealed repeated notifications related to problems experienced with level measurement and proposals for alternative measurement principles which had been under consideration for years.

Requirement
Section 47 of the activities regulations on maintenance programme

7.2 Improvement points

7.2.1 Performance requirements for emergency response

Improvement point

Performance requirements set for checking POB were not met.

Grounds

The company’s requirement for a POB check within 25 minutes was not met. The POB check was only completed after three hours and 34 minutes. The APRS failed to function because of power loss, and compensatory measures taken to speed up the check had little effect.

Requirement
Section 77 of the activities regulations on handling hazard and accident situations

7.2.2 Training and drills

Improvement point

Lack of training in and drills with handling operational disturbances and hazard and accident conditions.

Grounds

The responsible party must ensure that the necessary training and drills are provided to ensure that personnel are able at all times to handle operational disturbances and hazard and accident conditions in an efficient manner. Training, for example, must be provided when equipment is changed and when new technology is introduced, must be tailored to new or changed risk in the activity, and must be repeated when necessary.

Based on information from interviews and documentation received, the following examples emerged to support these comments.

- Inadequate training in and drills with emergency response handling of hazard and accident conditions relevant to the interim phase before Eldfisk S was phased in, such as DSHA 16 (total loss of power).
- The prevailing interim phase, with simultaneous operation of both new and old facilities, systems and equipment, made extra demands on training and drills.
- Inadequate training in and knowledge of technical solutions and the use of the telecommunication systems among the operating personnel concerned. See the operating problems which arose with the PAGA, the PACOS and the APRS in connection with the ESD. That applies particularly to the temporary solutions for the interim period.

Requirements
Section 21 of the activities regulations on competence
Section 23 of the activities regulations on training and drills

8 OTHER COMMENTS

8.1 Managing the risk of acute pollution

A single mistake – a valve left in the open position, as was the case here – must not lead to a large acute oil spill. The incident shows that the drain system in this case has a function as a barrier against acute oil spills to the sea. The investigation identified the following nonconformities related to follow-up and maintenance of equipment in the drain system:

- 7.1.8 on barrier management, risk assessments and analyses in connection with modifications
- 7.1.10 on consequence classification of systems and equipment
- 7.1.11 on maintenance and the maintenance programme for the drain system.

The drain system also has known faults and weaknesses related to instrumentation for control and monitoring. This affects opportunities for the operators to identify and understand conditions which could lead to hazards and accidents. The review of the maintenance system also revealed repeated notifications of problems with level measurement in the oil sump. Proposals for alternative measurement principles, which would have improved opportunities to monitor level changes in the drain system, were not acted upon after long consideration.

No specific measures have been taken to improve opportunities for identifying abnormal conditions and to reduce the risk of acute oil spills to the sea as a result of the connection between flare and drain systems.

Had the drain system on Eldfisk FTP possessed the status of a barrier against acute oil spills, with a reasonable level of follow-up and maintenance, the acute oil spill might have been prevented or restricted.

8.2 Earlier and subsequent incidents with yellow ESD

Experience shows that unplanned yellow ESD incidents with total loss of power resulting from technical faults or human error occur relatively often on the Eldfisk complex. See appendix E. This history may both have influenced the rapid conclusion that technical failure was to blame and the decision to start up production without adequate verification that the facility was gas-free or taking special account of the need to ensure alert personnel.

Another yellow ESD incident occurred on Eldfisk A, FTP and Embla on Sunday 7 September. This incident was also caused by the failure of an output card in the ESD node in the new LER on Eldfisk A (similar to the output card which failed in the 6 August incident).

Repeated unplanned ESDs caused by technical failures could lead to personnel losing respect for safety systems, alarms and mustering instructions.

8.3 Routines for handover from project to operations

Responsibilities and roles for operating systems and equipment must be clarified and known at all times. Interviews and a review the maintenance system revealed that ownership ambiguities existed, including in relation to the new LER on Eldfisk A. It also emerged that operators involved lacked information about new technical solutions and training in the use of new equipment and systems in use during the interim period before Eldfisk S start-up.

8.4 Handover at shift change

Where shift and crew changes are concerned, the responsible party is required to ensure the necessary transfer of information on the status of safety systems and ongoing work as well as other details of significance for health, safety and the environment when conducting the activity. Little written documentation was available in the CCR on Eldfisk which documented the handover.

8.5 Notification and reporting of hazard and accident conditions to the regulator

The operator must ensure coordinated and immediate notification of hazard and accident conditions which could cause the loss of safety-related functions and barriers, so that the installation's integrity is threatened.

The PSA was not immediately notified about the yellow ESD incident. Notification was first received the following day at the same time as the notification of the incident with an acute oil spill to the sea. Mustering and total loss of power on Embla as a result of the yellow ESD on the Eldfisk complex was not notified or reported to the PSA as required by the regulations.

9 COPSAS' OWN INVESTIGATIONS

CoPSAS initially conducted two internal investigations of the incidents. One covered the yellow ESD incidents of 6 August and 7 September 2014 /21/. The other dealt with the acute oil spill to the sea /22/. Both were carried out in accordance with *6443 Incident Investigation, Reporting and Tracking*, which is CoPSAS' own investigation procedure.

In collaboration with the design contractor and equipment suppliers, CoPSAS has subsequently had a further five investigations conducted /36/ to clarify direct and underlying causes. These covered the following conditions:

- quality assurance at the contractor during the design phase
- electro-technical analyses and assessments of the ESD system offshore
- electro-technical investigations by the supplier of the power supply units for the ESD system
- electro-technical measurements and analyses by the supplier of the earthing system
- detailed technical investigations by the supplier of the output cards in the ESD system.

The investigation into quality assurance at the design contractor identified some improvement areas related to routines for identifying, handling and checking in order to ensure compliance in a better way with requirements for segregation and robustness against individual faults. A further conclusion is that a number of potential causes have been eliminated, but the direct reason for the technical failure of the output cards has not been identified so far. CoPSAS has therefore decided that all output cards in the positions which failed are to be replaced and investigated during the 2015 turnaround.

Descriptions of the course of events and the direct and underlying causes related to technical conditions largely coincide with our observations and assessments. Recommended improvement measures related to technical conditions appear to be well defined and justified.

However, only limited attention has been paid in the investigation reports to operational and organisational conditions. That applies particularly to the background for the management's decision to restart after the yellow ESD, given that known weaknesses exist with the ESD and telecommunication systems and that no compensatory rest was provided for the operators involved.

10 BARRIERS WHICH FUNCTIONED

- The ESD system functioned as intended in the event of a total loss of power, and ensured that the facilities automatically shut down and remained in a safe condition (fail-safe).
- The general alarm functioned.
- The open drain system functioned in so far as it routed oil away from the facility.

11 DISCUSSION OF UNCERTAINTIES

11.1 Underlying causes of the yellow ESD

Uncertainties exist with regard to the underlying causes, and we cannot draw any conclusions on this point at present. See chapter 5.5.2.

11.2 Plastic hose installed on the siphon breaker for the collection sump

Based on interviews with operators and the CoPSAS investigation report /22/, divergent information emerged about the background for and purpose of the plastic hose installed on the siphon breaker on the collection sump (to reduce the odour of hydrogen sulphide (H_2S) or with regard to operating regularity). As far as we know, no modification records are available which could help to clarify this uncertainty.

11.3 UPS yellow ESD incident on Embla

Uncertainty exists over the direct reason why the yellow ESD on the Eldfisk complex led to a complete loss of power (UPS yellow ESD) on Embla while it was staffed. See chapter 7.1.9.

12 APPENDICES

A: References
B: Flow chart - description of emergency response on the Eldfisk complex
C: Flow chart - notification of an incident in CoPSAS
D: Overview of personnel interviewed
E: Historical incidents of power failure
F: Historical incidents of acute oil spills

12.1 Appendix A: References

/1/ CoPSAS plan for development and operation – Eldfisk II, February 2011

/2/ CoPSAS application for consent to take Eldfisk 2/7 S into use, 19 March 2014

/3/ Workload analysis Eldfisk FTP control room, Eldfisk II modifications project IFE/HR/F-2011/1527, 2011

/4/ Criop analysis, Eldfisk FTP control room, Eldfisk II modifications project, IFE/HR/F-2011/1536, 2012

/5/ Eldfisk complex working environment gap analysis OHS-11-0012-4, 2006

/6/ Working environment summary report – ELDF, ELDF-AK-F-00002, rev 01B

/7/ Emergency response logs from the LoBS, 6 August 2014

/8/ Alarm printout from the SAS in the 6-7 August 2014 period

/9/ Alarm report Eldfisk complex, July 2014

/10/ Printout of screenshots (SAS) for the drain system

/11/ Emergency response plan, Eldfisk complex, July 2014

/12/ Emergency response analysis, Eldfisk complex, modifications phases 3A and 3B, ST-04600-4, February 2014

/13/ QRA – Eldfisk 2/7A, 2/7FTP og 2/7E – Main report ST-02526-2, January 2010

/14/ Operating documentation, Eldfisk complex, doc no 6382/25

- Operational procedure for bypass of equipment, OP-G00-07, 8.7.2014
- System 520 – drain, 18.7.2014
- System 750 – ESD emergency shutdown, 14.7.2014
- System 510 – flare, 18.7.2014

/15/ Operating documentation for Embla, doc no 6383/09

- System 750 – ESD, 7.5.2014

/16/ Mechanical completion, commissioning and handover, doc no 6325E/03, 18.10.2012

/17/ Safety and automation system (SAS), doc no 6249E/04, 11.12.2012

/18/ Safety system bypass logbook, 7-8 August 2014

/19/ ESD block logic diagram EMBL-PP-I-00004, sh 001-005

/20/ Mechanical flowsheet oily water drain system, Eldfisk FTP, FDSD-27-MF-00124, sh. 001, rev. 17

/21/ CoPSAS investigation report – *Total bortfall av strøm på Eldfisk A, Eldfisk FTP og Embla, bortfall av hovedstrøm Eldfisk E 6.8 og 7.9. 2014*, rev 3, Impact no 235416

/22/ CoPSAS incident investigation report – discharge of oil into the sea from Eldfisk Complex (Eldfisk FTP) 7.8.2014, Impact no 235305, 11.11.2014

/23/ Mechanical flowsheet oil to oil heaters, Eldfisk FTP, FDSD-27-MF-00024, sh 001, rev 56

/24/ Mechanical flowsheet production separator, Eldfisk FTP, FDSD-27-MF-00026, sh 001, rev 72

/25/ Mechanical flowsheet production separator pumps, Eldfisk FTP, FDSD-27-MF-00026, sh 002, rev 19

/26/ Mechanical flowsheet HP & LP flare system, Eldfisk FTP, FDSD-27-MF-00061, sh 001, rev 58

/27/ Mechanical flowsheet oil sump, Eldfisk FTP, FDSD-27-MF-00103, sh 001, rev 36

/28/ Mechanical flowsheet oil sump pumps, Eldfisk FTP, FDSD-27-MF-00104, sht 001, rev 15

/29/ Mechanical flowsheet sea sump, Eldfisk FTP, FDSD-27-MF-00126, sh 001, rev 54

/30/ Mechanical flowsheet corrugated plate separator, Eldfisk FTP, FDSD-27-MF-00124, sht 001, rev 17
/31/ Mechanical flowsheet collection sump, Eldfisk FTP, FDSD-27-MF-00125, sht 001, rev 15
/32/ Mechanical flowsheet oily water drain system, Eldfisk FTP, FDSD-27-MF-00125, sht 001, rev 17
/33/ Eldfisk 2/7A, 2/7B, and 2/7 FTP flare study, ELDF-AB-U-00020, rev 01
/34/ 2/7FTP API RP 14C analysis, C512, AE-U-27053, rev 03
/35/ Hazop study open & closed drain – Eldfisk complex, PRI-30332, rev 02 + relevant close-out comments.
/36/ Summary report, F-DO card failure, Eldfisk II modifications, ELDA-AK-G-10501, rev 01A

12.2 Appendix B: Flow chart - description of emergency response Eldfisk complex

CoPSAS' emergency response for handling hazard and accident conditions for the Eldfisk complex.

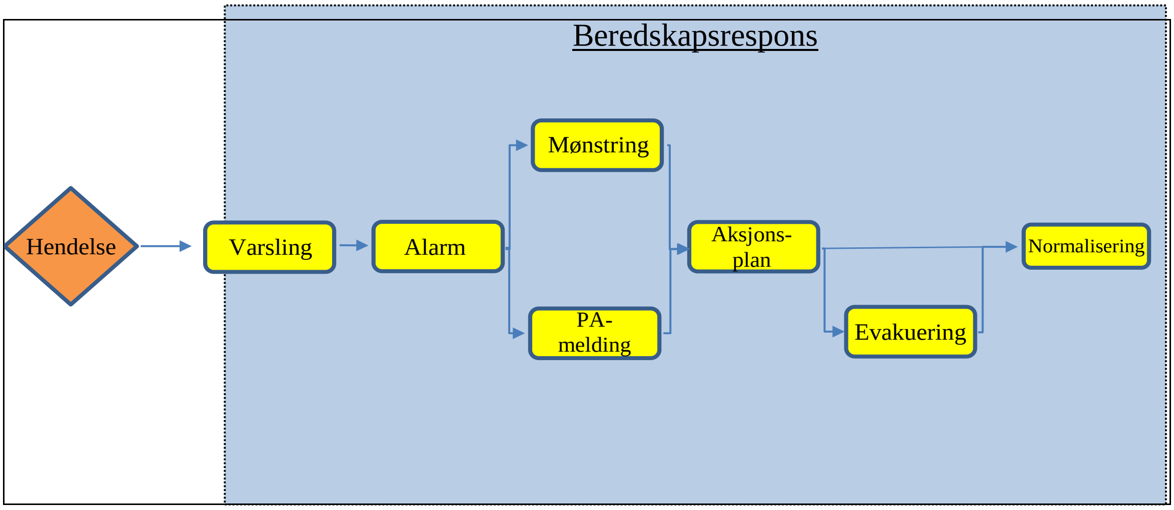

Figure 15 Diagram showing how a hazard and/or accident condition is to be handled.

Source: Eldfisk emergency response plan

12.3 Appendix C: Flow chart – notification of incidents in CoPSAS

The emergency response plan for the Eldfisk complex specifies than the person who observes an emergency must notify the radio/control room, primarily by phone (112) or possibly via radio. Furthermore, the radio/control room operator must notify all personnel by sounding the alarm and a subsequent PA announcement. The LoBS must notify FeBS (Ekofisk tower). Further notification to the TaBS on land is carried out in accordance with the emergency response plan for the FeBS and the TaBS.

The figure below presents a general outline of notification in ConocoPhillips. It describes the various functions will mobilise in the event of an emergency.

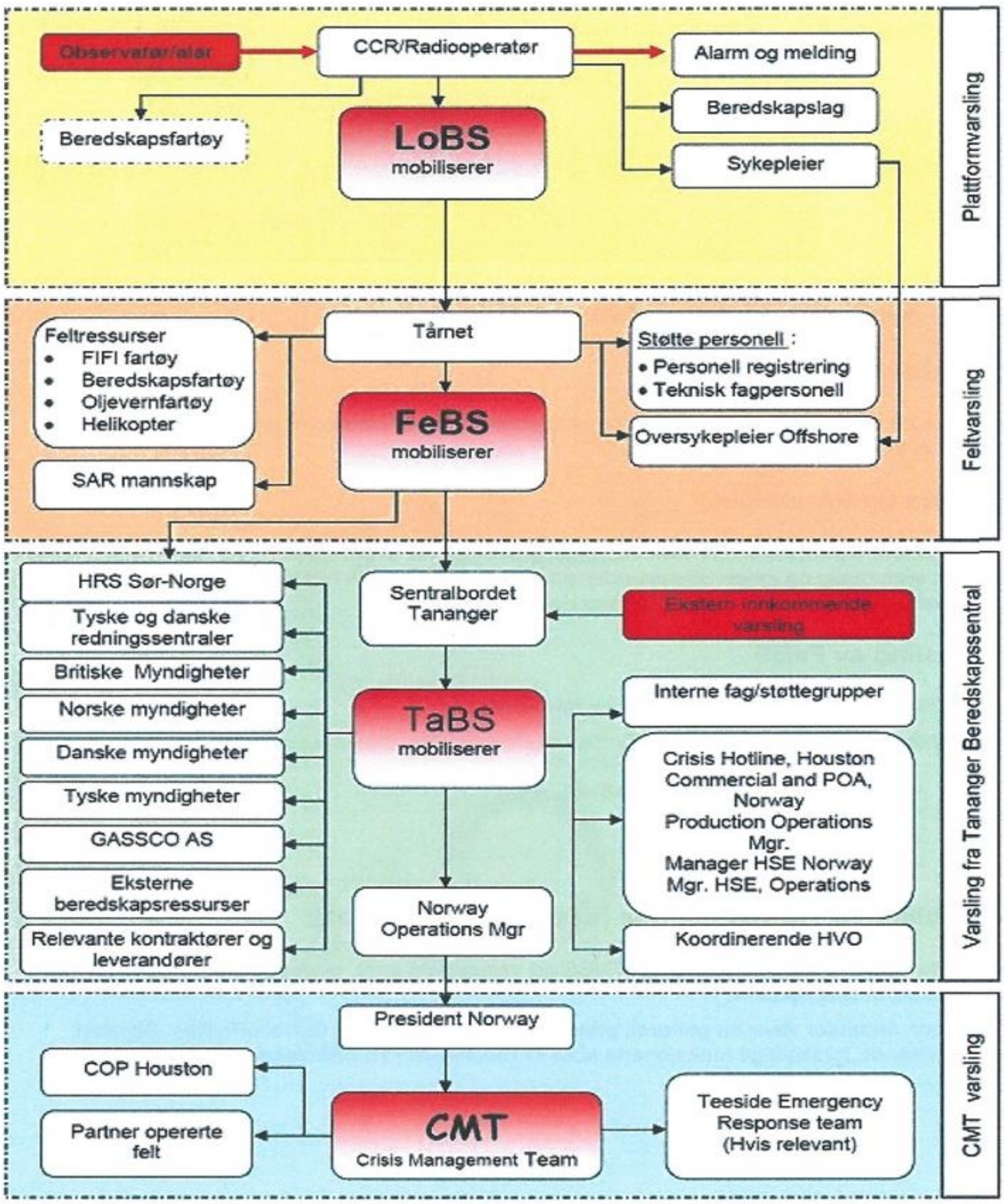

Figure 16 Diagrammatic presentation of notification in ConocoPhillips.

Source: Eldfisk emergency response plan

12.4 Appendix D: Overview of personnel interviewed

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

12.5 Appendix E: History – incidents involving a total loss of power

Facility	Date	Incident
Eldfisk FTP	18.6.10	A delayed yellow ESD at 22.15 and an immediate yellow ESD three minutes later occurred on Eldfisk A/FTP. The facility was reset and the emergency generator started. Normal power supply was restored at 02.50. The incident will be followed up. Production on the platform was halted because of a turnaround.
	7.9.14	A yellow ESD affected the Eldfisk complex at 01.50 on 2/7 Eldfisk A, 2/7 Elda FTP and 2/7 Embla. The ESD was initially blue on 2/7 Eldfisk A, later yellow. 2/7 Eldfisk S, *Haven* and *Maersk Innovator* had normal power supply. Mustering initiated throughout the Eldfisk complex. Manual headcount, since the APRS was down. Fault-seeking in connection with start-up showed that the SAS card in the new LER on 2/7 Eldfisk A caused the yellow ESD, card replaced. Shuttle cancelled Sunday morning to devote full attention to the condition. Loss of rest time for mustered and mobilised personnel was met by setting the crew change in operations at 11.00. The day shift initiated production start-up. Normal power supply has been restored on the Eldfisk complex and 2/7 Embla, and the position is normalised.
Eldfisk E	27.2.12	Emergency generators failed to start up on Eldfisk A and E after the main generator on Eldfisk E suffered a blackout (blue ESD throughout the Eldfisk complex). Electricians succeeded in starting the emergency generators and powering up the emergency switchboards. Main generator back on line. The incident will be investigated to identify the causes.
	9.10.14	General alarm and fire pump start-up at 15.48 because gas detector tripped on Eldfisk FTP top deck. Mustering of whole Eldfisk complex (incl *Maersk Innovator*) initiated by the LoBS. Mustering terminated at 16.10 after condition clarified. At 16.12, the LoBS notified about a yellow ESD on 2/7 Ester. Local blowdown and deluge automatically initiated on Ester. Normal power on all other facilities. Total evacuation of Ester initiated, mustering of emergency response team and of all personnel from the Eldfisk complex in the living quarters. Normal PA turned off. Initial PA announcements accordingly made from lifeboat station 1 on Eldfisk A. The APRS functioned normally. Roving patrols established on Ester, barriers on both bridges to the platform. Full POB of 831, including *Maersk Innovator*, achieved after 20 minutes. The Eldfisk complex launching a normalisation phase at time of writing. Normal monitoring restored on 2/7 Ester at 20.00, F&G nodes operational.
Eldfisk B	29.8.00	Platform management, in consultation with the Eldfisk A safety delegates, resolved to shut down the drilling operation on the installation. The well was safeguarded with two barriers. The shutdown decision was taken because the automatically operated valve supplying the deluge system on the drilling rig was not functioning satisfactorily in automatic mode. Spare parts for the valve will reach the platform during the evening, with replacement and testing to be conducted immediately after installation.
	25.7.04	In connection with a job on an ultraviolet detector, it was discovered around 17.00

Facility	Date	Incident
		that no fire detectors were operational in the plant area. These devices cover the technical room in the process area. Fault-seeking in the central fire station identified a loose wire to one of the battery poles supplying the cabinet in the event of power loss. The detectors were back in operation about 19.20. All deluge and sprinkler systems were operational. It was assumed that the detectors ceased to function during test operation of the emergency generator around 17.45 on 24 July. When the position was discovered, all level 1 work permits were withdrawn, roving patrols established and crane operation halted.
	5.7.12	Total loss of power on Eldfisk B (yellow ESD) resulted in loss of production and injection, as well as production shutdown on Eldfisk A. The incident occurred in connection with uploading to an F&G node as part of the commissioning of a new inergen facility. New software was 99 per cent uploaded when the node ceased functioning. We do not know so far why the node stopped. The old software was reinstalled and the node restarted. Main power restored 18.15.
Eldfisk A	2.12.01	Main generator A suddenly stopped during normal operation, initiating a general alarm. Rising heat from the generator triggered the heat detector, which in turn initiated the water mist system over the generator. A 10cm hole was observed in the induction manifold. Three pieces lay on the deck two-eight metres from the generator.
	25.10.03	Main and emergency power and UPS were lost at 19.40 for no known reason. Emergency power and UPS were restored within about an hour. The underlying cause has still not been clarified but will be investigated. The fire pumps, emergency lighting and PA system functioned as intended.
	2.3.06	A yellow ESD occurred in connection with a test of the platform's ESD system after cancelling activated in/out signal bypasses in the relevant function block (dib-dop). Preliminary investigation indicated a system fault in this function block As a result of the incident, and in accordance with the established ESD logic, the platform's production and utility systems shut down and were supplied for a period only with battery power. Oil/gas production and water injection cease, as do exports of lift gas and injection water. The platform's systems were run up in accordance with established and approved start-up procedures from the relevant ESD level. An investigation team has been established, and further investigation will identify details/course of the incident.
	1.10.10	Yellow ESD initiated on the Eldfisk complex as the result of a short circuit in a power transistor in the UPS on Eldfisk A. The emergency response team was mustered immediately. Well intervention on well A-26 was in a non-critical phase (out of hole) when the incident occurred. Emergency power established at 03.15. The incident will be investigated and registered in SAP.
	11.1.11	2/7 Eldfisk A and 2/7 FTP suffered a total loss of power at 15.09. 2/7 Eldfisk E retained emergency power. Production on the platforms was basically shut down at the time because of an earlier production shutdown involving the loss of main power, but basically had normal power supply. All normal communication was also lost in connection with the total loss of power. The Ekofisk tower was notified via Ex mobile phone. Personnel quartered on *COSL Rival* were sent back there. Roving patrols were established. Emergency power was restored on 2/7 Eldfisk A and 2/7 FTP at 16.56. Normal power supply restored 19.58.

Facility	Date	Incident
	13.1.11	2/7 Eldfisk A and 2/7 FTP had a total loss of power at 16.59. 2/7 Eldfisk E maintained emergency power. The platforms had normal power supply and production. All normal communication was also lost in connection with the total loss of power. The Ekofisk tower was notified via Ex mobile phone. Personnel quartered on *COSL Rival* were sent back there. Emergency power was restored on 2/7 Eldfisk A and 2/7 FTP at 18.02. Normal power supply restored 18.55. A similar incident occurred on the Eldfisk complex on 11 January 2011 and is under investigation. The investigation team was on the Ekofisk complex when the incident of 13 January 2011 occurred, and will include this in their work.
	17.1.11	Power failure. This incident is likely to be connected with the incident dated 11 January 2011. The PSA will receive feedback from ConocoPhillips as soon as the reason for the failure has been identified.

12.6 Appendix F: History – incidents involving acute oil spills

A total of 15 incidents related to acute discharges were registered on the Eldfisk complex in 1998-2013. The table below presents the facility, date and a brief description of these incidents.

Facility	Date	Incident
Eldfisk A	8.11.00	Acute spill of about 10 barrels of oil-based drilling fluid to the sea.
	23.9.03	When oil-based drilling mud was being pumped from Eldfisk A to a ship (*Havila Eko*), about one-two cubic metres of mud spilt from the tank on the vessel. People were not aware that pumping was under way before the tank overflowed.
	6.2.09	Within the 500m zone around Eldfisk A, the discharge occurred from the vessel (*Aries Girl*) on its way to deliver diesel to the platform. A valve leading to tank WT3 was not properly closed. The tank eventually became completely filled and diesel emerged from the overflow line, with some 200 litres entering the sea.
	19.10.09	*Island Commander* was pumping acid into well A-14 when a leak occurred in a three-inch valve. It was subsequently estimated that a barrel of 28 per cent hydrochloric acid leaked to the deck. The line was immediately flushed with drilling water. The spill on the deck was diluted with seawater and hosed overboard.
	14.1.12	Some loss of mud had been observed from 03.15 the day before, which was assumed to have gone down the well. Additional data from the well eventually indicated that the losses were not downhole. A leak in the seawater-cooled mud cooler was identified as the cause of the losses. Fifty barrels of mud were estimated to have leaked into the return line for seawater discharged to the sea beneath the surface. No visible traces of oil were seen on the surface.
Eldfisk B	15.4.98	Unplanned discharge of 9.2 m^3 of Novapluss-type mud to the sea, owing to a failure to reconnect a hose to the tank after maintenance.
	5.8.00	Leak of 65-80 barrels of oil-based mud to the sea. Ten barrels were recovered. Cause identified and corrected. Everything under control.
	13.2.04	Well B5 slugging, difficult to maintain levels in the process. Resulted in oil spilling to the sea via produced water. Estimated at about four m^3. Under way since early on 13 February. Quantity estimated with the aid of helicopter. Sea calm.
	13.4.07	During bunkering of diesel oil from *Viking Swan* on the eastern side of the platform, the hose was holed by the ship’s stern. Estimated 10-20 litres diesel oil to the sea.
	8.6.07	In connection with the triennial production shutdown of Ekofisk and Eldfisk, oily water was spilt to the sea from 2/7 Eldfisk B. This occurred during running down and emptying of the facility. The discharge was estimated at 500 litres of oil. The incident is under investigation and will be followed up via Impact.
	28.10.08	A low oil level was discovered in the oil cooler for the Dyna-Brake. Closer investigation revealed a hole in the oil cooler, and about 300 litres of gear oil had leaked to sea with the coolant water.
	5.9.10	Following installation of a new spool on the flow line for well B9, the split point was to be leak-tested with glycol at 3 500 psi. During the pressure build-up, a bleed plug came loose on the axial flow valve (AFV).

Facility	Date	Incident
Eldfisk E	6.11.99	Biocide discharge from 2/7 Eldfisk E, no damage, everything went into the sea. CoPSAS has a discharge permit for one tonne, this incident appears to have involved six tonnes. The discharge had occurred early on Saturday morning, but was not notified until 23.10. CoPSAS will investigate this, and what actually happened.
	18.6.07	High-pressure hydraulic oil on hand. Hytorc equipment was used to loosen bolts during replacement of seals on a six-inch valve. The injured person had their right hand on the Hytorc equipment when a leak suddenly occurred in the tool (wrench). High-pressure hydraulic oil hit the right-hand palm of the injured person between forefinger and middle finger.
Embla	15.6.13	Oil was observed on the sea when personnel mobilised to Embla today. On closer inspection, a thin jet of hydraulic oil was found to be escaping from the filter house on LCV-2037 (water from the test separator). The supply was immediately turned off and the leak halted.